5-2009

Plug-in hybrid electric vehicle emissions impacts on control strategy and fuel economy

David Estes Smith
University of Tennessee

To the Graduate Council:

I am submitting herewith a dissertation written by David Estes Smith entitled "Plug-in hybrid electric vehicle emissions impacts on control strategy and fuel economy." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Mechanical Engineering.

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We have read this dissertation and recommend its acceptance:

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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PLUG-IN HYBRID ELECTRIC VEHICLE EMISSIONS IMPACTS ON CONTROL STRATEGY AND FUEL ECONOMY

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

David Estes Smith

May 2009

Dedication

This dissertation is dedicated to my loving wife, Robin, who has endured the seemingly endless path to the completion of this work and has demonstrated great resolve in remaining supportive throughout all of my endeavors.

Acknowledgements

Special thanks are extended to Dr. David K. “Butch” Irick for his endless patience, technical expertise, and friendship over the years as my doctoral program developed. He has made my graduate stay at the University of Tennessee very rewarding and has equipped me with valuable professional tools, most notably the practice of *expectation management*. There could not have been a finer mentor.

There are several other people for whom I am extremely grateful. First of all, I would like to thank Henning Lohse-Busch of Argonne National Laboratory for his constant sacrifice of time and energy in getting the experimental portion of this research completed. I would also like to thank Mike Kern of Argonne National Laboratory for his tireless efforts, pleasant demeanor, and assistance throughout the dissertation research. In addition, I am grateful to Dr. Donald Hillebrand, also of Argonne National Laboratory, for his insight and generous support of the research.

Finally, I would like to thank Dr. William R. Hamel, Dr. Leon M. Tolbert, and Dr. Robert M. Wagner for agreeing to be a part of my graduate experience through service on my doctoral committee.

Abstract

Plug-in hybrid electric vehicle (PHEV) technologies have the potential for considerable petroleum consumption reductions, at the expense of increased tailpipe emissions due to multiple "cold" start events and improper use of the engine for PHEV specific operation. PHEVs operate predominantly as electric vehicles (EVs) with intermittent assist from the engine during high power demands. As a consequence, the engine can be subjected to multiple cold start events. These cold start events have a significant impact on the tailpipe emissions due to degraded catalyst performance and starting the engine under less than ideal conditions. On current hybrid electric vehicles (HEVs), the first *cold* start of the engine dictates whether or not the vehicle will pass federal emissions tests. PHEV operation compounds this problem due to infrequent, multiple engine cold starts.

The dissertation research focuses on the design of a vehicle supervisory control system for a pre-transmission parallel PHEV powertrain architecture. . Energy management strategies are evaluated and implemented in a virtual environment for preliminary assessment of petroleum displacement benefits and rudimentary drivability issues. This baseline vehicle supervisory control strategy, developed as a result of this assessment, is implemented and tested on actual hardware in a controlled laboratory environment over a baseline test cycle.

Engine cold start events are aggressively addressed in the development of this control system, which lead to enhanced pre-warming and energy-based engine warming algorithms that provide substantial reductions in tailpipe emissions over the baseline supervisory control strategy. The flexibility of the PHEV powertrain allows for decreased emissions during any engine starting event through powertrain "torque shaping" algorithms that eliminate high engine torque transients during these periods.

The results of the dissertation research show that PHEVs *do* have the potential for substantial reductions in fuel consumption, while remaining environmentally friendly. Tailpipe emissions from a representative PHEV test platform have been reduced to acceptable levels through the development and refinement of vehicle supervisory control methods *only*. Impacts on fuel consumption are minimal for the emissions reduction techniques that are implemented, while in some cases, substantial fuel consumption reductions are observed.

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Nomenclature

A	ampere(s)
A*hr	ampere × hour(s)
C	Celsius
E_{tot}	cumulative mechanical engine energy
F_x	dynamometer coastdown coefficients
g/mi	grams per mile
g/s	gram(s) per second
J	joule(s)
kg	kilogram(s)
km	kilometer(s)
kW	kilowatt(s)
kW*hr	kilowatt × hour(s)
L	liter(s)
m	meter(s)
mg	milligram(s)
mg/s	milligram(s) per second
MJ	megajoule(s)
MPH	mile(s) per hour
ms	millisecond(s)
N_{energy}	scaling factor based on mechanical engine energy
N*m (Nm)	newton meter(s)
N_{tot}	total maximum engine power scaling factor
N_{veh_speed}	scaling factor based on vehicle speed
P_{charge_limit}	energy storage system charge power limitation
$P_{discharge\_limit}$	energy storage system discharge power limitation
P_{drv}	driver demanded power

P_{drv_mod}	modified driver demanded power, with limitations
P_{elec}	temporary desired electrical power of traction motor
P_{elec_des}	desired electrical power of traction motor
P_{eng_des}	desired engine power
P_{eng_max}	maximum available engine power
P_{eng_min}	minimum available engine power
$P_{eng\_optimal}$	optimal engine power (most efficient at current speed)
P_{SOC}	state of charge maintenance power
P_{tot}	total requested power of engine
RPM	revolution(s) per minute
sec	second(s)
$T_{catalyst}$	actual primary catalyst temperature
$T_{catalyst\_cold}$	primary catalyst temperature “cold” threshold
V	volt(s)
VDC	volt(s) direct current
W*hr	watt × hour(s)

Abbreviations

ABS	anti-lock braking system
AC	alternating current
AER	all electric range
ANL	Argonne National Laboratory
APRF	Advanced Powertrain Research Facility
BMCP	Battery Mode Control Process
CD	charge depleting (or charge depletion)
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide

CP	charge preservation
CS	charge sustaining
ECU	engine control unit
EMCP	Energy Management Control Process
EV	electric vehicle
GPS	global positioning system
HC	hydrocarbon(s)
HEV	hybrid electric vehicle
HIL	hardware-in-the-loop
HV	high voltage
HWFET	Highway Fuel Economy Test
MATT	Mobile Advanced Technology Testbed
NEDC	New European Drive Cycle
NMOG	non-methane organic gases
NO_x	nitrogen oxides (oxides of nitrogen)
NREL	National Renewable Energy Laboratory
O_2	oxygen
OCV	open circuit voltage
OEM	original equipment manufacturer
ORNL	Oak Ridge National Laboratory
PHEV	plug-in hybrid electric vehicle
PSAT	Powertrain Systems Analysis Toolkit
PSAT-PRO	PSAT rapid control prototyping software
RBCP	Regenerative Braking Control Process
SOC	state of charge
SULEV	super ultra low emissions vehicle
SUV	sport utility vehicle
THC	total hydrocarbons

UDDS	Urban Dynamometer Driving Schedule
VMCP	Vehicle Mode Control Process
VSCM	Vehicle System Control Module
ZEV	zero emissions vehicle

Chapter 1: Introduction

Introduction

Hybrid vehicles, with the ability to operate in an electric-only mode and recharge from an electric outlet, have received a great deal of attention recently because of the potential benefits of substantially shifting their energy source from petroleum to electricity. Plug-in hybrid electric vehicles (PHEVs) are described in the Advanced Energy Initiative (announced in President George W. Bush's 2006 State of the Union Address) as a way to dramatically increase fuel efficiency and utilize spare electric generating capacity at night as well as being "a practical step toward hydrogen fuel-cell vehicles, which have some of the same electric-drive and power-management technologies" (Advanced Energy Initiative 2006).

The White House has high expectations for PHEVs, as expressed in the press release regarding the President's message, as a means for "drivers to meet most of their urban commuting needs with virtually no gasoline use." President Bush has stated publicly that PHEVs will have a range of 40 miles "operating solely on battery charge" (Plug-In Hybrid Electric Vehicle R&D Plan February 2007). This expectation poses a substantial technological challenge since currently available hybrid vehicles are not designed to be operated in an electric-only mode for any substantial period of time and would be capable of only a few miles of electric range with reduced performance. In addition, consumers currently pay a premium for hybrids and additional electric range (i.e., requiring a higher energy battery and higher power electric drive components) would likely increase the cost differential, reduce the likelihood of high volume sales, and consequently, the intended benefits.

One of the main concerns with PHEVs is the potential increase in carbon dioxide emissions from powerplants due to the increased load on the electric utilities for recharging of the high energy capacity battery packs. In addition, there is the potential for increased tailpipe emissions from these vehicles due to more engine cold starts and infrequent engine operation.

Background

What is a PHEV?

According to the United States Department of Energy Office of Energy Efficiency and Renewable Energy Vehicle Technologies Program (United States Department of Energy Office of Energy Efficiency and Renewable Energy Vehicle Technologies Program 2008), a PHEV is defined as:

"A plug-in hybrid electric vehicle (PHEV) combines the propulsion capabilities of a traditional combustion engine with an electric motor. The PHEV uses essentially the same technology as an HEV but uses much larger high-voltage batteries to power the electric motor and has a longer all-electric range. But, unlike the batteries in the HEV, which are recharged by only the internal combustion engine, and other technologies, the

batteries in PHEVs can also be recharged by using an external power source, such as a home electrical outlet."

Certainly, PHEVs are not a new concept. However, advances in the state-of-the-art of battery technology, particularly with lithium chemistries, have propelled the PHEV to the forefront of advanced powertrain research. Preliminary investigations into the characterizations of PHEV powertrain architectures and respective vehicle control philosophies have been conducted by a host of sources. A variety of advanced powertrain configurations has been proposed to address what a PHEV should be. Early adopters of the technology have resorted to creating conversions of existing HEVs (A123 Systems 2008) (Energy Control Systems Engineering, Inc. 2008). The approach taken by these vehicle converters varies, ranging from supplementation of the existing energy storage system with an additional battery to complete replacement of the energy storage system with a larger, single battery pack.

Whether or not PHEV acceptance increases in the future is highly dependent upon how the state-of-the-art in energy storage systems progresses. It is apparent that PHEVs of the future will resemble all electric vehicles more closely, with small heat engine range extending capabilities in the form of a series hybrid configuration. General Motors has alluded to this fact with the introduction of the Chevrolet Volt concept PHEV.

Modern approaches to PHEV control

Various research groups, including national laboratories, have conducted numerous analyses in order to determine the merits of potential operational strategies for PHEVs. These analyses are based upon different control strategy philosophies and all electric range (AER) capabilities. There has been much debate about how to design the energy management system for these vehicles. Researchers at the National Renewable Energy Laboratory (NREL) provide a brief overview of three (3) basic energy management strategies for PHEVs (Gonder and Markel, Energy Management Strategies for Plug-In Hybrid Electric Vehicles April 2007). The first, referred to as "AER focused," describes the powertrain as operating electrically and having substantial electric drive capabilities for the entire charge depleting region of the energy storage system. The down side here is that the vehicle would most likely cost more and be heavier due to the substantial electric drive sizing requirements. The second energy management strategy, referred to as the engine-dominant blended strategy, uses the electric system to supplement the engine. Subsequently, there is heavier reliance on the engine in this strategy than any of the others. The supervisory controller tries to operate the engine in its most efficient operating regimes, maximizing fuel economy as best it can. The third approach, called the electric-dominant blended strategy, relies on the electric drive to propel the vehicle. The engine is used only when the electric drive cannot meet the demands of the driver. The reasoning behind this strategy is that even though the engine only fills transient gaps, and may not be operating at its most efficient points, the relatively infrequent engine operation means very little fuel is used. This type of operation would most likely have a very significant impact on tailpipe emissions due to the potential for multiple cold starts, and the fact that the engine would be operating during transients under presumably high loads.

Regardless of the different methods and theories researchers have for controlling a PHEV, all would agree there are two (2) distinct regions of operation for any plug-in hybrid vehicle (Gonder and Markel, Energy Management Strategies for Plug-In Hybrid Electric Vehicles April 2007) (Sharer, et al. 2008). These modes of operation are referred to as charge-depleting (CD) and charge-sustaining (CS). In their basic forms, charge-depleting operation refers to a net decrease in the overall energy content of the battery pack, while CS operation refers to a net zero change in the energy contained in the battery pack. CS operation is how traditional HEVs operate. Figure 1 shows a generic graphical representation of how the state-of-charge (SOC) of a PHEV changes for each of these modes.

CD operation can be accomplished by two (2) methods, which have been identified as all-electric CD and blended CD. Argonne National Laboratory (ANL) researchers show that blended CD operation provides the most efficient means of operating the PHEV, given that the travel distance is known *a priori* (Sharer, et al. 2008). The basic difference in the two (2) approaches is that the all-electric case depletes the battery from a high SOC to a minimum SOC utilizing only the traction motor as the source of power.

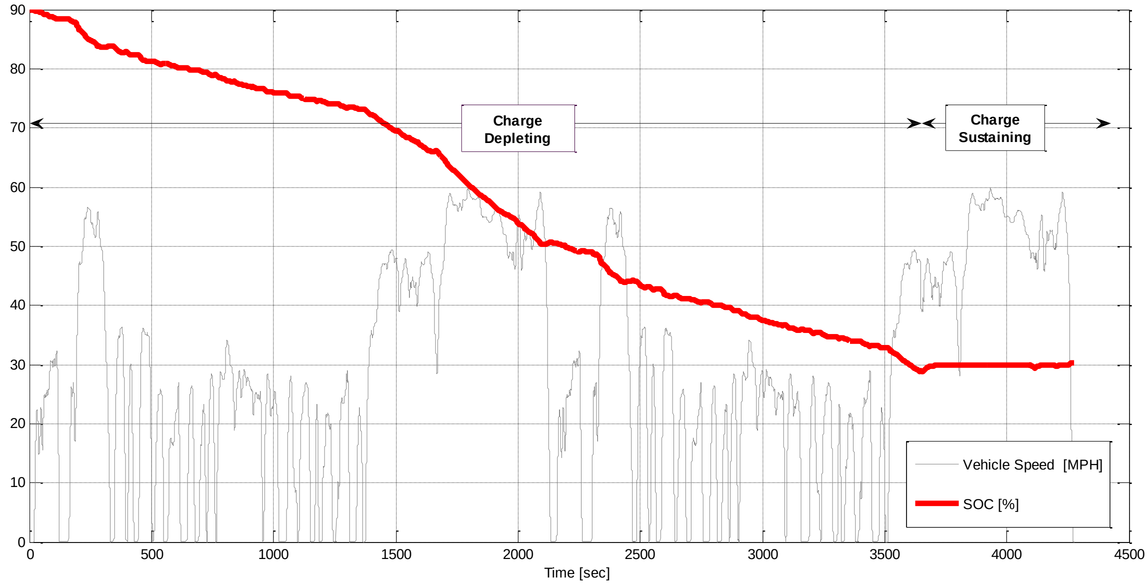


Figure 1. Graphical representation of PHEV SOC change for charge-depleting and charge-sustaining operation

The blended strategy allows intermittent use of the engine to supplement the motor during periods of high power demand. The blended strategy offers a wide range of possible control laws.

ANL researchers have identified that the blended mode of operation offers more efficient operation possibilities through global optimization techniques, the potential for component size reduction (downsizing of the electric drive system), and an ultimate cost savings due to reduced power requirements and increased packaging efficiency.

A recent ANL study stresses the use of global optimization to compare various PHEV component sizes and their impacts on fuel consumption (Karbowski, Haliburton and Rousseau 2008). The technique used in this study was based on the Bellman Principle of Optimization. The study suggests that the global optimization techniques that were employed are not useful for application to real-time control systems, unless the exact route or driving cycle is known prior to the operator moving the vehicle. This technique allows for better comparisons of various powertrains since each is operated at its (claimed) most optimal operating points over that particular driving cycle. All findings reported in this study were based entirely on simulation, and no experimental data is presented. The baseline vehicle model used in this study is based on the powertrain components currently being used on the Mobile Advanced Technology Testbed (MATT) platform at ANL.

Another exploration into the optimization of PHEV control parameters was performed at ANL using a different approach. The use of a non-derivative based algorithm was presented to optimize control strategy parameters for a predefined control system for a parallel pre-transmission PHEV (Rousseau, Pagerit and Gao 2008). Basic HEV control strategy was employed for energy management, including power and SOC thresholds for turning the engine on, and high driver demand situations. Two basic modes were employed for hybrid operation: CD and CS. SOC maintenance power was determined by using a linear look-up table (maintenance power versus SOC). One important note was that when the engine was on, it was controlled to operate at its highest efficiency. The paper did not mention whether or not excessive charging and high throughput to the battery were addressed as part of the control strategy. The results showed that there were two (2) basic parameters that were highly influential on minimizing fuel consumption: the power threshold for turning the engine on, and the minimum time that the engine was required to remain on. Another important finding was that since all of the optimization was based on trip distance and *a priori* knowledge of the trip, determination of optimal control parameters for a general case would diverge. However, the results indicate the best choice for a single, universal set of parameters would be to optimize over a medium to long distance.

Another study conducted at the National Renewable Energy Laboratory (NREL) investigated using dynamic programming techniques for PHEV energy use optimization (O'Keefe and Markel November 2006). The simulation results indicated that a half-size

PHEV using a smaller motor and low power-to-energy ratio batteries has nearly the same fuel consumption of a full-size PHEV (and in some cases, can have an even lower fuel consumption), but uses components that can be of lower cost. In addition, when the trip distance is not known, it is better to operate as an electric-centric vehicle as opposed to utilizing a blended control strategy.

Optimization is often a nebulous term when dealing with complex systems, such as PHEV control systems. Clearly, much of the optimization work rests on the fact that *a priori* knowledge of the drive cycle must exist. Researchers at NREL are conducting an ongoing project to determine the merits of employing global positioning system (GPS) based data into a HEV control system (J. D. Gonder January 2008). However, the study clearly states that drive quality and emissions are ignored in this study. One important bit of information presented in the paper was that the New European Drive Cycle (NEDC) provides a very sound means of tuning a static vehicle supervisory controller, with good results across many subsequent tests on different drive cycles. The results indicate that for the example case studied, fuel savings were achieved that were 2-4% better than for static tuning when using route-based control. Here again, this paper did *not* present any experimental data to substantiate these claims, nor did they address any drive quality or emissions issues.

The problem with PHEVs: Emissions

While the basic framework for how to control a PHEV has now been firmly established, there has been no mention in the literature thus far of addressing the vehicle emissions issue. A group of researchers at The Ohio State University performed a study on the control of HEVs that took into account engine out emissions as part of determining the optimal point to operate the engine in a parallel HEV architecture (Rajagopalan, Rizzoni and Guezennec December 2003). Cost functions were employed which were based on maps for fuel efficiency and basic emissions data. These maps were then weighted based on the current operating state of the vehicle. Cold starts were included as a separate state and the study claimed that cold start emissions were greatly reduced. However, there was no experimental data to support this claim. In addition, the fuel and emissions maps were static maps, and no transients were addressed. Engine data used in the study was reported to come from Oak Ridge National Laboratory (ORNL) tests, which substantiate the theory that transients were disregarded. Modest improvements in fuel efficiency and slight reductions in emissions were shown. All results came from simulation using the ADVISOR model (a backward facing simulation tool developed by NREL). Simulated emissions results based upon quasi-static maps generally exhibit a substantial margin of error due to the fact that transients and thermal effects are neglected. Experimental testing is more reliable for emissions prediction due to the inherent inclusion of these transients, thermal characteristics of the engine and exhaust aftertreatment system, and chemical kinetics in the catalysts.

There have also been numerous studies on the impacts that PHEVs will have on the emissions produced from power plants due to increased grid electricity generation. While these studies are certainly pertinent, they do not address the emissions impacts of PHEVs from a vehicle system perspective, and are not within the scope of this study.

In addition to modeling and simulation activities, laboratory testing and field evaluations have been carried out on recently available PHEV conversion vehicles. These vehicles are second generation Toyota Prius models retrofitted with auxiliary battery packs, or fitted with completely new, larger capacity battery packs. Preliminary laboratory testing results from the Advanced Powertrain Research Facility (APRF) at ANL indicate these vehicles suffer from increased emissions due to initial cold starts and multiple "restarts" of the engine (Carlson 2007). Figure 2 illustrates a nitrogen oxides (NO_x) and total hydrocarbon (THC) emissions comparison between one of the conversion PHEV vehicles and an unmodified Toyota Prius hybrid for multiple consecutive Urban Dynamometer Driving Schedules (UDDS). The testing suggested that the engine start-up controls were not calibrated for CD operation, with times where the engine was started under high load and high speed conditions. It is important to understand that these conversion vehicles do not have access to the engine or supervisory control of the original vehicle. Therefore, these issues certainly have not been addressed by the original equipment manufacturer (OEM), and the conversion companies cannot change any of the current HEV strategy that is in the vehicle.

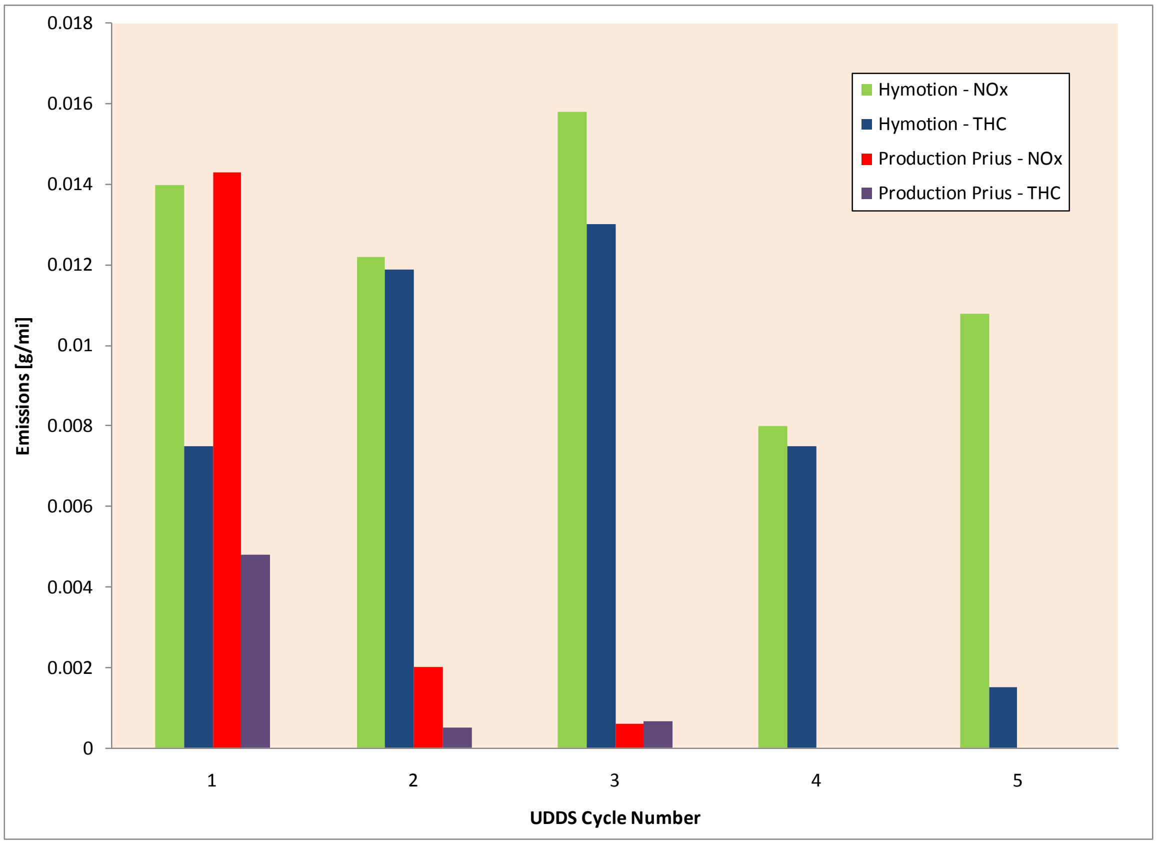


Figure 2. PHEV conversion emissions results for multiple UDDS drive cycles (with permission from ANL)

The emissions for the first UDDS cycle are approximately the same. This is due to the first cold start of the engine on this cycle for both vehicles. However, during the next few cycles, the emissions for the unmodified Toyota Prius are greatly reduced while the emissions levels for the PHEV conversion remain high. Based upon this data, there is sufficient work to be done in the area of PHEV emissions control and subsequent vehicle supervisory control strategies.

More recent data produced at the APRF suggests that supervisory controls can have a large impact on emissions reduction. One conversion company was able to reduce the tailpipe emissions from their converted vehicle back to “near stock vehicle” emissions levels simply by modifying their battery management system. Unfortunately, based on this testing, there is still much work to be done in this area.

Figure 3 illustrates the measured emissions of some of the currently available PHEV conversion vehicles. This data set was taken at the Advanced Powertrain Test Facility at ANL, and is presented as non-methane organic gases (NMOG) versus NO_x. None of the current PHEV conversion Toyota Prius vehicles is able to match stock Toyota Prius emissions values, as shown in the figure. All of the vehicles that are able to attain super ultra low emissions vehicle (SULEV) status do not modify the engine operating strategy of the base production vehicle, i.e., the engine starts when the key is switched on. The EnergyCS, Kokam Hymotion Prius, and HybridsPlus Prius all modify this base strategy and do not allow the engine to start upon a key-on event.

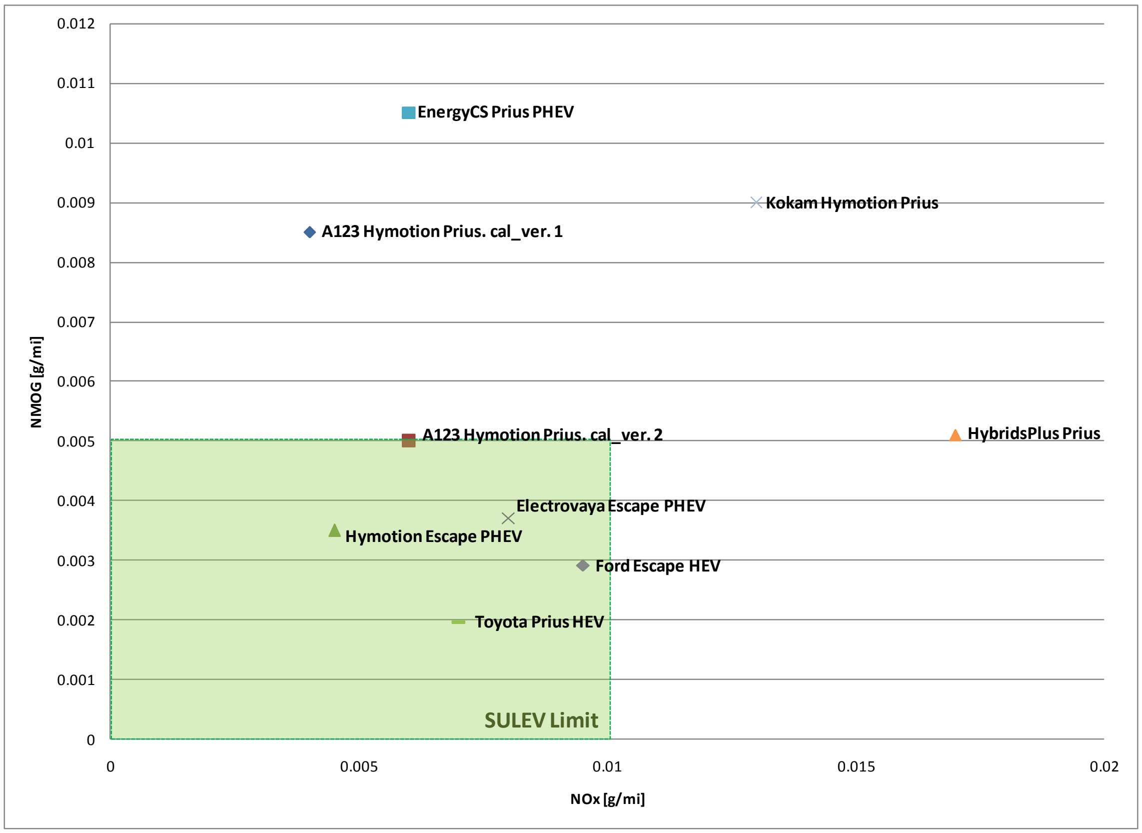


Figure 3. Emissions of some current PHEV conversion vehicles

The PHEV conversion vehicle data is provided as a reference and to gauge the current state-of-the-art in PHEV technology since no OEM PHEVs were available for test at the time of this research. The data suggests that improvements in supervisory control could further reduce the tailpipe emissions of PHEVs.

Contributions to the field of PHEV research

Most recent studies on PHEV technologies have been focused on the potential positive impacts on oil consumption reduction, as well as the negligible impacts on power plant emissions from increased electric utility generation. Such studies have been mostly analytical in nature, and have provided minimal experimental data. In addition, little emphasis has been placed on potential tailpipe emissions impacts of PHEVs, as evidenced by the lack of published information in this area. This is a key factor when assessing the mass production and marketability of these vehicles from an OEM perspective, particularly when considering federal test procedures and emissions regulations.

Impacts of intermittent PHEV engine operation on the overall vehicle control strategy, tailpipe emissions, and oil consumption effects are addressed as part of this dissertation research. *Identification* and *mitigation* of tailpipe emissions from a PHEV are central themes in this research, and fill a void in the available research data in this area. Analytical techniques are coupled with experimental and empirical methods to address the potential tailpipe emissions problems associated with multiple engine cold starts of

PHEVs, and to quantify the effects of these on energy consumption. Futhermore, a vast amount of experimental data is generated for PHEV emissions and energy conmsumption, including both transient and thermal performance of a representative internal combustion engine and exhaust aftertreatment system.

Chapter 2: Approach and Methodology

Approach

Both analytical and experimental tools are employed to develop, implement, and verify the necessary PHEV control strategies that form the basis of this research. Vehicle level modeling tools are developed such that energy management strategies can be verified and ultimately validated through experimental testing of a complete PHEV powertrain in a chassis dynamometer laboratory. The approach and corresponding methodologies applied during this study are described in greater detail in the following sections.

Vehicle attributes/characteristics

A suitable, representative vehicle platform must be selected for the purpose of modeling, simulation, and emulation on a chassis dynamometer. Current PHEV conversions are based on existing production level HEVs, such as the Toyota Prius and the Ford Escape HEV. However, extensive data is available on a subcompact conventional vehicle (Ford Focus) at ANL, and available test equipment, such as the MATT, is setup to emulate this vehicle. Therefore, this vehicle platform will provide the basis for developing the PHEV powertrain as part of this research.

The vehicle platform provides a base for developing the advanced powertrain necessary for creating a PHEV. There are several powertrain configurations that could be implemented. Current conversion vehicles are based on a power-split powertrain.

However, future PHEV vehicle designs are leaning more toward a series hybrid electric vehicle with range extending capabilities in the form of a small heat engine, as is the case for the Chevrolet Volt.

For the purpose for this study, a pre-transmission parallel hybrid electric vehicle will be used as the powertrain architecture for PHEV implementation. This selection was made based on the fact that the test platform (MATT) that was chosen for the experimental phases of this research was already configured as a pre-transmission parallel.

A pre-transmission parallel HEV powertrain is designed such that both of the propulsion sources for the vehicle, in this case a heat engine and a traction motor, are located prior to the transmission. These components can be used individually to power the vehicle. This allows for an all electric mode of operation, commonly referred to as zero emissions vehicle (ZEV) mode. The engine can be used separately to power the vehicle much like a conventional powertrain. Both the heat engine and the traction motor can be combined in a variety of ways to jointly propel the vehicle, or to charge the energy storage system during periods of low power demand.

Research structure/flow

The research is conducted in a structured approach, consisting of two (2) distinct phases. Phase I establishes the baseline vehicle model and corresponding energy management strategy. The baseline energy management strategy is designed such that full CD and CS operation is possible, with no consideration giving to emission impacts or exhaust aftertreatment performance. Phase I of the research also produces experimental laboratory data taken from actual hardware for model validation purposes and identification of relevant emissions constraints for proceeding into Phase II.

Phase II is the focus of the research where emissions are directly addressed and mitigated through the use of supervisory control strategy methods. Thorough analysis of Phase I experimental data is used to develop emissions reduction algorithms that will be integrated into the baseline control strategy to reduce tailpipe emissions. An assessment of the impacts on the overall energy consumption of the new strategies is performed to understand the trade-offs between emissions reductions and energy consumption. The term energy consumption, both electrical and fuel, is relevant in the context of a PHEV since the energy storage system is depleted during normal operation of the vehicle. Figure 4 depicts how the respective stages are linked together and the order in which events will occur.

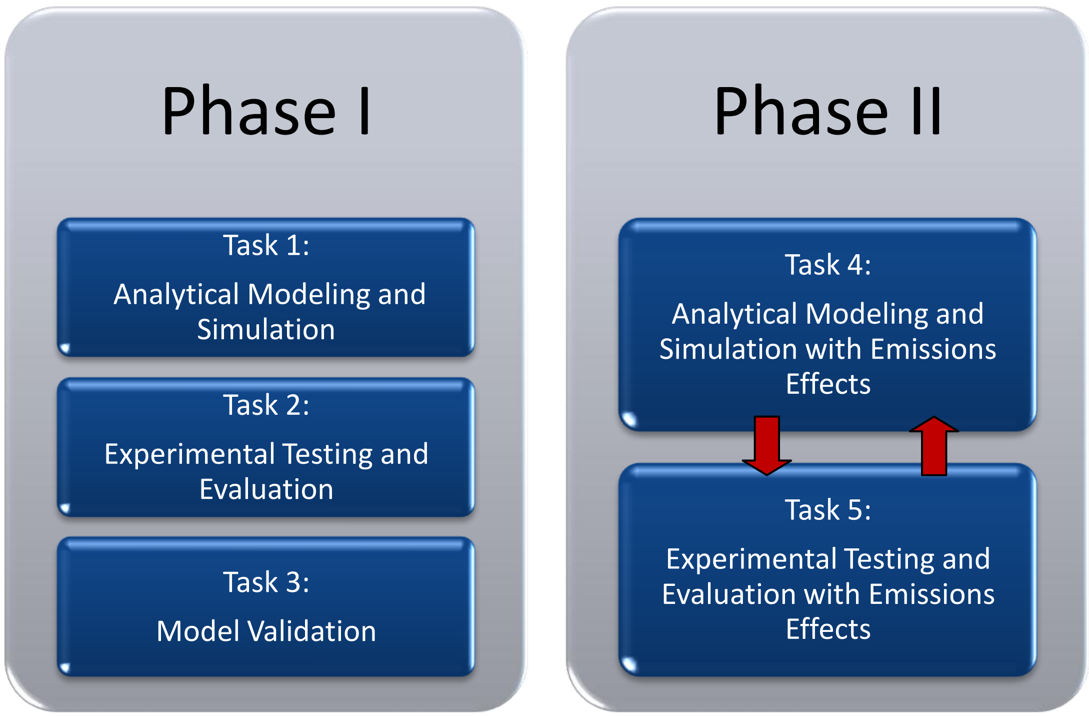


Figure 4. Research work flow diagram

Phase I Research

Task 1: Analytical Modeling and Simulation

Task 1 is perhaps the most important area of the research. Since the research is centered on the supervisory control system and development of energy management strategies, a robust vehicle model is key to the investigation. The analytical portion of Phase I begins with the development of a traditional HEV powertrain. As described earlier, the powertrain is based on a pre-transmission parallel HEV architecture due to the relevancy to current PHEV design concepts and existing laboratory hardware considerations. Since a PHEV is, in essence, a special case of a traditional HEV, the same pre-transmission parallel powertrain is used for the PHEV model. Differences in the energy storage capacity and controls philosophy (energy management strategy) differentiate the two. Figure 5 represents a Powertrain Systems Analysis Toolkit (PSAT) block diagram of the proposed powertrain architecture. This configuration provides a compromise to existing and proposed PHEV powertrain designs.

Ideally, each of the pertinent vehicle components must be appropriately identified and sized to meet the performance requirement of the vehicle. The engine size, in this case, is fixed due to hardware limitations and availability. In addition, the high voltage traction drive system (electric machine and energy storage system) are also fixed in size due to hardware constraints.

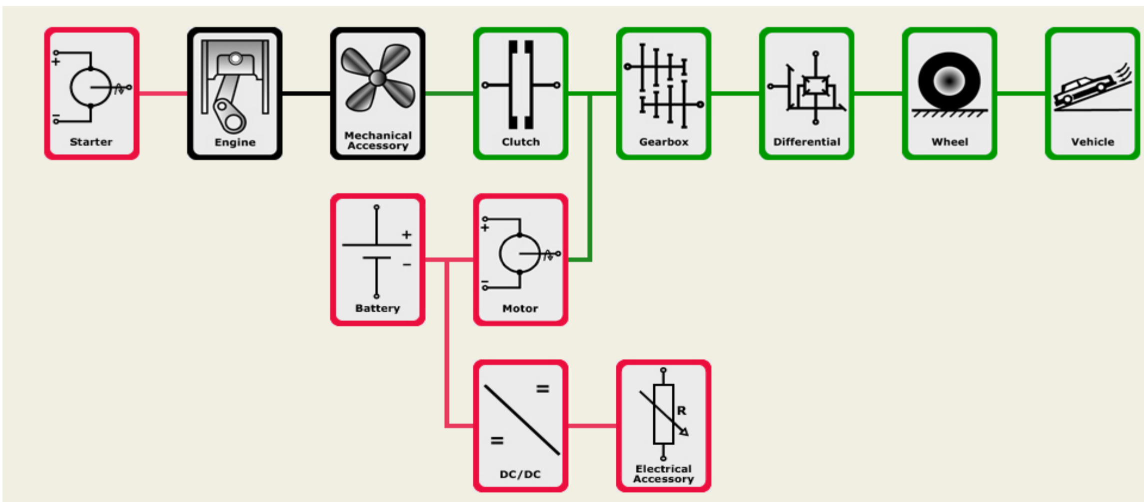


Figure 5. PSAT block diagram representation of the vehicle powertrain architecture chosen for research

The thorough development of a suitable control strategy during this task is paramount to the success of the research. Therefore, a brief outline of the basic requirements of the control system is presented.

The overall function of the control system is to coordinate the interaction of the heat engine, the traction motor, and the energy storage system. The manner in which the control system carries out this function relies on many factors. The following paragraphs outline the three (3) primary objectives for the functionality of the supervisory control system.

1. ***Translate driver intent.*** The most fundamental objective of the vehicle system control is to translate the intent of the driver. The control system must interpret what the driver is trying to do, and to deliver what is expected up to the limitations of the entire system. The primary interfaces for the driver to the vehicle are the accelerator and brake pedals. These inputs are transformed into control signals for the traction motor and heat engine. These two primary motive forces work together to provide the necessary torque to satisfy the demands of the driver.
2. ***Maintain SOC of energy storage system.*** Since the design philosophy of this control system employs both a CD and a CS approach, the hybrid control system must maintain the SOC of the high voltage (HV) battery pack. This function must be integral to the control algorithm and, more importantly, be transparent to the

driver. Fluctuations in the delivered torque to the drive wheels are not desired from a consumer acceptability and drivability point-of-view.

CS operation is perhaps the more complicated of the two (2) SOC maintenance philosophies (the other being the CD approach). There are two (2) basic methods, or sources of energy in the powertrain, to charge the battery pack. The first method, referred to as regenerative braking, is to make use of the otherwise wasted kinetic energy from a braking event. Regenerative braking can lead to a more efficient drivetrain. Regenerative braking can be applied in two (2) basic versions. The most efficient means of regenerative braking is referred to as series regenerative braking. In this approach, the traction motor absorbs all of the energy from the wheels to slow the vehicle up to a charge limitation on the battery. At this point, the foundation brakes are then applied. While this is the best system to use, it is inherently more difficult to implement. The second implementation technique for regenerative braking is referred to as parallel regenerative braking. The basic difference with this version versus the series approach is that the traction motor and foundation brakes work in parallel to slow the vehicle down. For this reason, it is less efficient since less energy is returned to the HV battery pack. However, parallel regenerative braking is much easier to implement.

The second method for charging the battery pack is to use the traction motor as a generator that utilizes energy from the heat engine during low power demand, such as during vehicle cruise conditions. Idle charging of the HV battery pack is also possible in this vehicle powertrain configuration, and falls into this category.

3. ***Protect HV battery.*** The most critical item for PHEV durability is the life span of the HV battery pack. The vehicle control system should provide a means of limiting available battery power based on the limitations of the pack itself. In order for the battery to survive for a predetermined warranty period, strict adherence to battery pack manufacturer limitations should be maintained. Such items as charge and discharge limitations, maximum module temperature, and SOC limitations must be taken into account when coordinating the interactions of the traction motor and the heat engine.

Custom developed control system software is created in PSAT and refined as necessary to verify proper functionality. The control system must address the three (3) basic control objectives outlined earlier. The study begins by looking at the traditional HEV control strategy and respective battery pack in order to establish a baseline for determining the merits of PHEV operation. The CS HEV control strategy is developed first and functionally verified through simulation since this is a fundamental building block for creating the PHEV control strategy. The CS strategy is then simulated over a host of driving cycles and tuned to minimize fuel consumption.

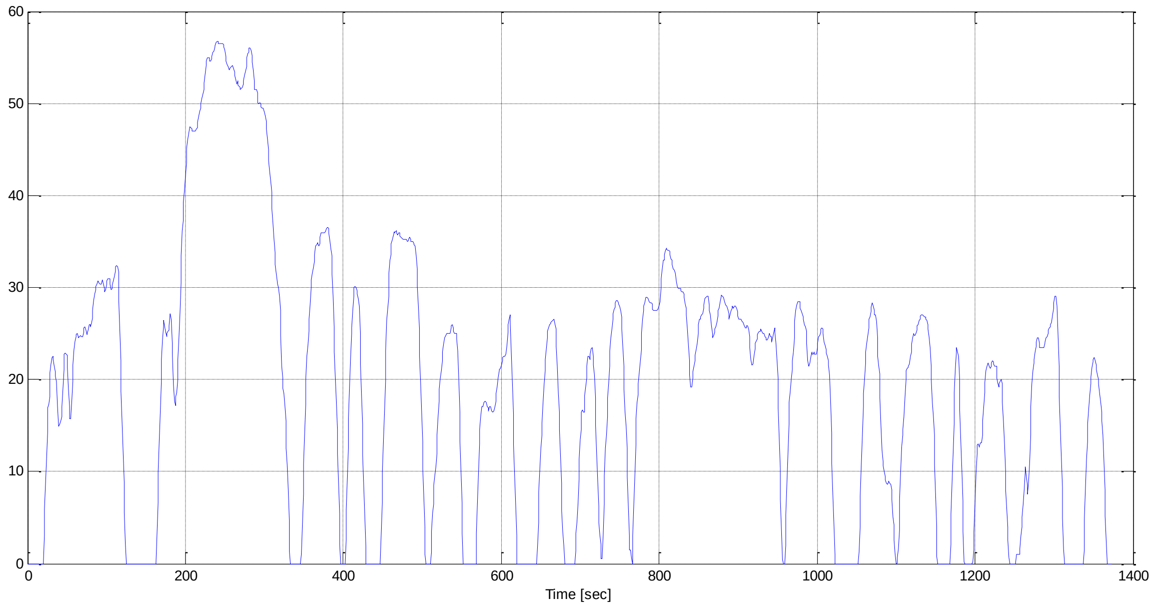
The PHEV control strategy builds upon the results of the HEV strategy. A CD strategy is developed and added to the CS HEV strategy. The CD strategy includes two (2) distinct approaches as suggested by the literature. These include a full electric-only mode, referred to as maximum depletion, and a blended strategy. The blended strategy is flexible enough to provide a variety of different operational possibilities of the engine. An engine dominant strategy, as well as an electric dominant strategy, is also investigated.

A general, or universal, control strategy is developed with the goal of minimizing fuel consumption. In this first round of control strategy development, possible constraints that may be implemented to reduce emissions are ignored in order to give the lowest possible fuel consumption. Drivability issues, such as number and duration of engine start/stops, and emissions impacts are assessed during the experimental application of this preliminary control strategy on a full hybrid powertrain installed on a chassis dynamometer.

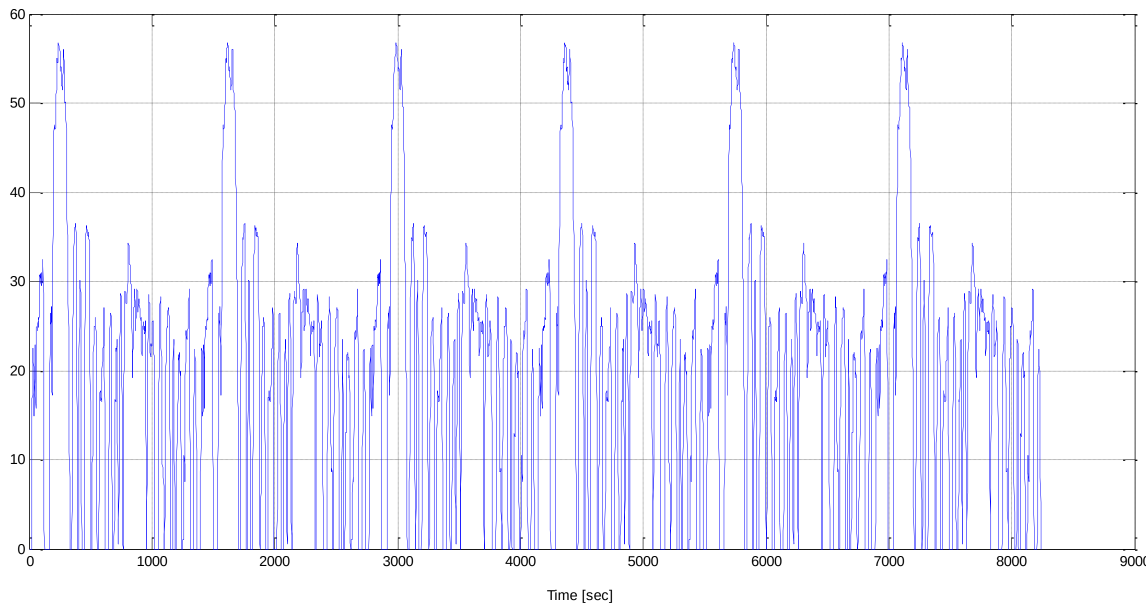
Several drive cycles can be used in order to tune each of the control strategies. The Environmental Protection Agency (EPA) fuel economy test cycles, such as the UDDS and Highway Fuel Economy Test (HWFET), are typically used extensively for this type of development. For the purpose of this research, the UDDS drive cycle is the focus for development and testing since it involves multiple vehicle stops. The intended purpose of the PHEV is to provide electric-only operation during urban driving at low speeds/loads. For highway driving cycles, the engine would operate continuously in order to preserve electrical energy for urban driving situations. Multiple UDDS cycles are used repetitively such that the fully charged energy storage system is fully depleted for each control strategy investigated. An example of a single and multiple UDDS drive cycle is shown in Figure 6.

Task 2: Experimental Hardware Testing and Evaluation

This experimental phase implements the work accomplished during the Analytical Phase I aspect of the research into actual hardware. The Phase I control strategy will be targeted to real-time hardware to control the powertrain described in Figure 5. The multiple UDDS drive cycle test plan described previously will be executed on the MATT at the ANL APRF, which is described in more detail later in this document. A battery of data will be logged as various drive cycles are traversed on the chassis dynamometer at the APRF, focusing on engine operation (emissions, start/stop frequency) and battery usage. The data logged here is used to feed the efforts of analytical portion of Phase II.



a). A single Urban Dynamometer Driving Schedule (UDDS)



b). Multiple UDDS driving cycles used for PHEV simulation and testing

Figure 6. Vehicle speed traces used for vehicle supervisory control system calibration and tuning

Task 3: Model Validation

Upon successful completion of Phase I, data taken during the experimental portion will be used to validate the PSAT model being used for fuel economy prediction and control strategy development. Component behaviors observed during the hardware testing phase are incorporated into the PSAT model, such that the simulation results are more consistent with the actual experimental results. Once the model has been successfully validated, Phase II of the research begins.

Phase II Research

Phase II continues development of the control strategy developed in Phase I, but addresses the emissions issues determined during dynamometer testing. Careful analysis of the powertrain operational data and associated emissions characteristics observed in Phase I provide the basis for control strategy adaptation and improvement to successfully reduce the emissions of MATT operating as a PHEV.

Task 4: Analytical Modeling and Simulation with Emissions Constraints

Upon successful completion of the first experimental phase, the results are examined to arrive at a set of emissions-related constraints that must be met in order to satisfy certain emissions regulations. These constraints must be defined at the outset, but the preliminary idea would be for the PHEV to meet the same level of emissions as today's best hybrid technology (Toyota Prius, for example). These constraints are translated into parameterized software and inserted as appropriate into the baseline controls architecture. Once these constraints have been formulated, inserted into the code, and successfully debugged, a new control strategy that theoretically provides for the most fuel efficient operation of the candidate powertrain while maintaining acceptable emissions levels is tested on the experimental powertrain. The baseline simulations performed during the analytical portion of Phase I are repeated for comparison of performance and fuel economy impacts. It is important to note that PSAT does *not* have the ability to model the thermal characteristics of the exhaust aftertreatment system of the heat engine. Therefore, Phase II will be an iterative process between the modeling and simulation environment and the hardware test environment.

Task 5: Experimental Hardware Testing and Evaluation with Emissions Constraints

The final task of the proposed research focuses on validation of the final optimized control strategy with emissions constraints enforced, as determined in Task 4. Task 5 is an iterative process with the analytical portion of Phase II in order to reduce the emissions of the engine to acceptable levels.

In addition to the primary objective of this research, a secondary related topic is investigated in parallel. The goal of this parallel sub-task is the characterization of the thermal/temperature profile of the catalyst (three-way catalyst for the purpose of the spark-ignition engine being proposed for this research) subjected to multiple cold starts. This data will be collected concurrently with the rest of the data being logged during the respective experimental phases of the primary research. This data provides valuable insight into the thermal signature of the catalyst, and yields data for further aftertreatment development specific to PHEVs. This data is integral to the development of the Phase II supervisory control strategy.

Once the supervisory control strategy has been exercised in both simulation and experimentally over the multiple UDDS drive cycles, conclusions are drawn as to the impacts of emissions control on the overall perceived advantages of PHEVs. In addition, insight into some of the technical barriers that manufacturers might face when producing a marketable vehicle that meets EPA regulations is provided.

Research tools

The research utilizes both analytical and experimental methods to develop and validate supervisory control strategies and energy management algorithms for a candidate PHEV powertrain. The following sections describe the modeling and simulation tools used to design and verify the respective control algorithms in software, as well as the hardware tools to experimentally validate the impacts on emissions and fuel economy.

Software

Vehicle modeling and simulation is accomplished using DOE-developed PSAT. PSAT allows dynamic analysis of vehicle performance and efficiency to support detailed design, hardware development, and validation. A driver model attempts to follow a driving cycle, sending a power demand to the vehicle controller which, in turn, sends a demand to the propulsion components (commonly referred to as “forward-facing” simulation). Dynamic component models react to the demand (using transient equation-based models) and feed back their status to the controller. The process iterates on a sub-second basis to achieve the desired result (similar to the operation of a real vehicle). The forward architecture is suitable for detailed analysis of vehicles/propulsion systems and the realistic command-control-feedback capability is directly translatable to PSAT rapid control PROtotyping (PSAT-PRO) control software for testing in the laboratory. Capabilities include transient performance, efficiency and emissions (conventional, hybrid, and fuel cell vehicles), development and optimization of energy management strategies, and identification of transient control requirements. In 2004, PSAT received an R&D 100 award, which highlights the 100 best products and technologies newly available for commercial use from around the world. This is the 41st year the technology awards have been given by R&D Magazine to recognize the "100 most technologically significant new products" of the entries the magazine receives.

PSAT-PRO allows dynamic control of components and subsystems in hardware-in-the-loop (HIL) testing. Real hardware components are controlled in an emulated vehicle environment (i.e., a controlled dynamometer and driveline components) according to the control strategy, control signals, and feedback of the components and vehicle as determined using PSAT. The combination of PSAT-PRO and HIL is suitable for propulsion system integration and control system development, as well as rigorous validation of control strategies, components, or subsystems in a vehicle context (without building a vehicle). Capabilities include transient component, subsystem and dynamometer control with hardware operational safeguards compatible with standard control systems.

MATT: The Mobile Advanced Technology Testbed

A modular component powertrain testbed is an alternative solution for testing different technologies in a hybrid vehicle environment while keeping the cost and required resources relatively low. This research utilizes the MATT platform developed by researchers at ANL (Lohse-Busch 2009). This testbed is composed of physical hardware component modules including an internal combustion engine and a transmission as well as emulated component modules such an energy storage systems. Figure 7 shows the modular concept of MATT.

MATT is modular in nature and composed of various “plug and play” modules. The base is a ladder type frame with wheels. Different component modules are bolted to the frame and connected with shafts to compose the hybrid powertrain. The modules are built on ¾ inch thick steel plates with a bolt-hole pattern for mounting. Each subsystem module is composed of the main system subcomponent, as well as all the necessary support systems required for its operation.

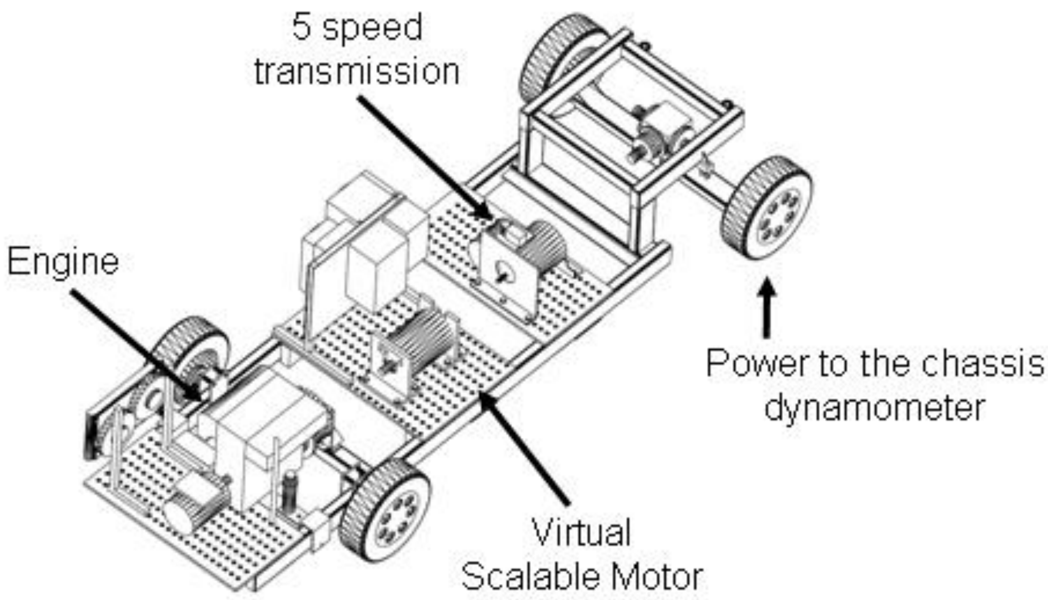


Figure 7. Illustration of the MATT (with permission from ANL)

For example, the engine powertrain module has an engine with its engine control unit (ECU), wiring, cooling system, clutch actuation system, and extensive instrumentation.

These modules can be 'real' physical components such as an engine or they can emulate hardware such as a battery pack and electric traction motor combination. The real components capture those effects that simulation may not accurately represent, such as variable losses in components based on temperatures and/or emissions from the engine. The emulated components are defined by models running in a real-time simulation based on physical inputs from sensors. These emulated components use physical hardware to add or subtract torque from the driveline based on the real-time simulation and the energy management strategy. For example, a single electric motor is used to emulate a multitude of energy storage systems of varying capacities as well as an electric traction motor model.

The components and subsystems on the modules are easy to instrument since all parts are open and not constrained by packaging constraints or sheet metal. The instrumentation is individual to each specific module and can be put in place before implementing the new module onto MATT. The minimum instrumentation requirement is torque, and speed sensors are installed between each component so that torque-speed performance and the losses of each module can be assessed on transient drive cycles. MATT is tested on a chassis dynamometer with emissions equipment at the APRF.

The high level controller that is interfacing with all the modules, including their subsystems, commands the components according to an energy management strategy. The controller has three (3) functions:

1. ***Lower level component control.*** The purpose of the lower level component control is to interface with the actuators of the different modules to assure their proper operation. An example of lower level component control is the dry clutch actuator to enable the launch in a conventional vehicle.
2. ***Energy management and torque split strategy.*** The energy management strategy can also be referred to as the hybrid control strategy. This part of the controller decides how to split the torque request from the driver between the engine and high voltage drive system.
3. ***Component Emulation***. In some modules, the controller also computes a real-time simulation using models for energy storage systems and electric machines. These simulations use sensor inputs and generate outputs that are added to the driveline using physical hardware.

MATT can emulate different vehicle sizes using a modern chassis dynamometer. Specific vehicle characteristics such as test weight and losses enable chassis dynamometers to apply appropriate force at the wheels as shown in the equation below. The vehicle is tested using coast-down techniques on a level test track to derive the vehicle loss coefficients. On the dynamometer, the coast down test is repeated and the dynamometer controller adjusts to accurately represent the vehicle as tested on the track.

$$F_{dynamometer} = m \times \frac{\partial (V)}{\partial t} + (A + B \times V + C \times V^2)$$

where,

m is the vehicle test mass,

A, *B*, and *C* are the vehicle loss coefficients, and

V is the vehicle speed.

To summarize, the modular approach makes it possible to test a wide variety of different technologies and combinations without having to rebuild the entire vehicle. The physical elements provide the additional advantage of being able to test emissions and thermal effects, which are both difficult to model accurately in computer simulations. All of the components can be highly instrumented since the modules are open on the testbed and the packaging is not limited by a vehicle body shell. The high level controller is open and can be programmed with any hybrid energy management strategy. This feature makes MATT the perfect testbed for assessing different PHEV control strategies and determining emissions impacts. On the dynamometer, MATT can even be configured and tested as different vehicle sizes.

MATT Hardware and Capabilities

The current configuration of MATT is as a pre-transmission parallel hybrid electric vehicle. The current setup is composed of a conventional gasoline powered 2.3 liter gasoline engine, an emulated electric propulsion system and a 5 speed automatic transmission. Figure 8 shows a picture of MATT's current configuration.

The engine has a conventional dry clutch and thus can be disengaged from the rest of the driveline. The physical electric motor is only used to provide torque based on the real-time simulation of an energy storage and traction motor model. The automatic transmission has been modified to transfer reverse torque for regenerative braking and to allow electric launch with the traction motor only. Together, these components enable different vehicle operating modes.

The operating modes available to MATT are:

The conventional vehicle. By using the engine, the conventional clutch, and the transmission while bypassing the motor, MATT operates as a conventional gasoline vehicle. The conventional vehicle sets the baseline for fuel economy and emission data to compare to hybrid operation.

The electric vehicle. By disengaging the engine with the clutch, MATT operates as a pure EV. Using the onboard real-time hardware to emulate small and large motors as well as different battery technologies, various capacities and power levels can be tested. MATT can emulate both small EVs and those with infinite electrical range.

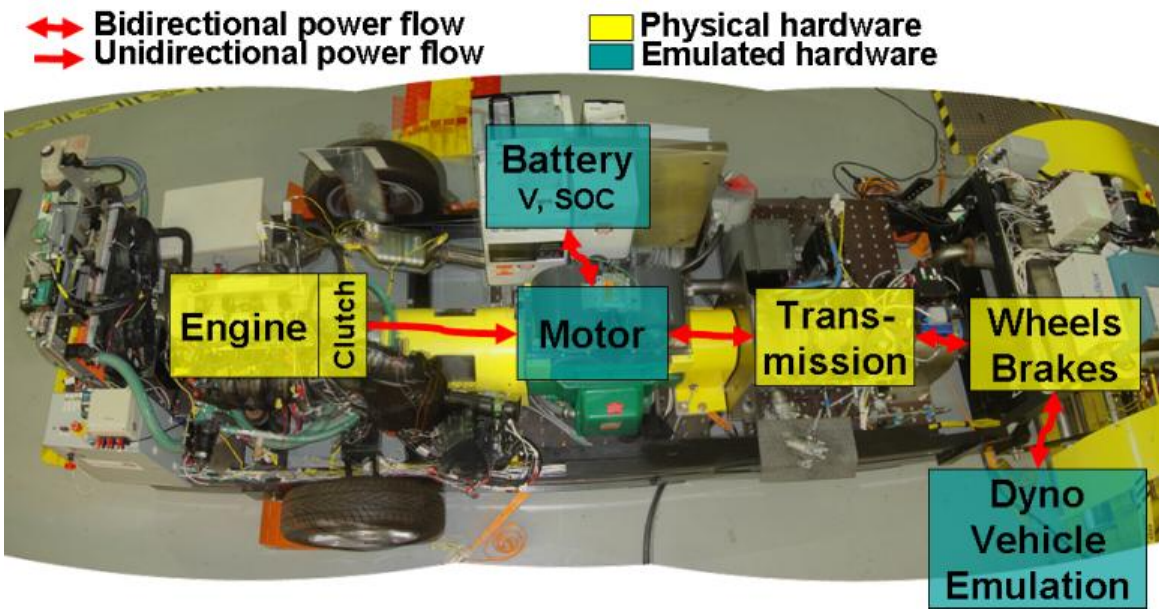


Figure 8. Top view of MATT with component schematic overlay (with permission from ANL)

The hybrid electric vehicle. By using the virtual scalable motor capability, different types of HEVs can be emulated, ranging from a mild assist hybrid with engine start-stop to a full EV capable hybrid. PHEVs are also possible since MATT can easily emulate the large battery pack required.

MATT Hardware Modules

The gasoline engine module

The engine module is composed of a spark ignited gasoline engine with corresponding ECU, two-stage exhaust aftertreatment system, coolant system, clutch actuator, 12V starter, and all necessary instrumentation. The engine module layout is presented in Figure 9.

The engine is a production engine with its stock ECU. This is important when considering the duty cycles that this engine will be subjected to as part of this research. For hybrid operation, each engine start event will actually be accomplished by cycling the key switch. This means that the normal engine start algorithm in the ECU will be executed at every engine start, which normally includes a short period of open loop operation and slight fuel enrichment to start the engine. It would not be unusual to expect a spike of hydrocarbon and/or carbon monoxide emissions with each engine start. The electronic throttle is controlled by the ECU based on the acceleration pedal position and engine feedback. MATT's high level controller commands engine torque by sending the pedal position signal to the ECU.

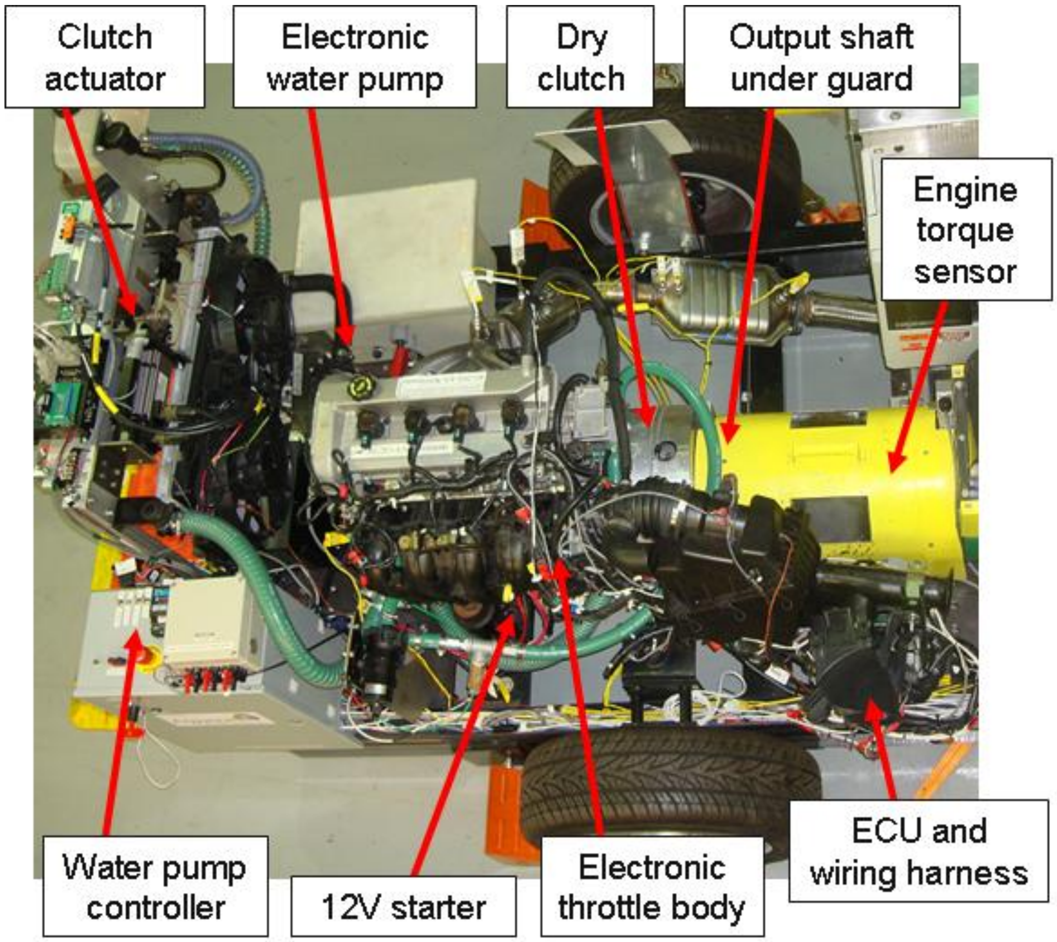


Figure 9. Top view of the gasoline engine module (with permission from ANL)

The engine uses a standard automotive 12V starter for cranking. The starter is wired to the computer controller. The crank time is limited in the software to prevent hardware damage. The controller switches the ignition to the ECU for engine start and stop. In hybrid mode, the engine can also be bump started by engaging the clutch while the electric motor is already spinning.

The engine exhaust system is built with all of the components used in a production vehicle. From the exhaust manifold, the gases run through two (2) catalytic converters, then through the exhaust pipe under the vehicle, and finally through a silencer and muffler before coming out at the end of the testbed. The catalytic converters are instrumented with thermocouples, as well as a wide band oxygen sensor. The exhaust setup is presented in Figure 10.

During the tests the exhaust gases are collected and analyzed in a Pierburg AMA 4000 5 gas analyzer (HC, CH_4, CO_2, CO, NO_x). During the test, diluted exhaust gases are sampled to fill the exhaust sample bags. At the end of the test, the bags are analyzed to provide the total emissions and the carbon balance fuel economy. The exhaust gases are also continuously analyzed during a test, providing modal information that gives insight into the transient engine emissions behavior. This becomes increasingly important for hybrid operation, especially PHEV operation where the engine starts several times during a test cycle and may not reach operating temperature rapidly or at all. Typically the emissions from an engine start can be responsible for 90% of the total emissions.

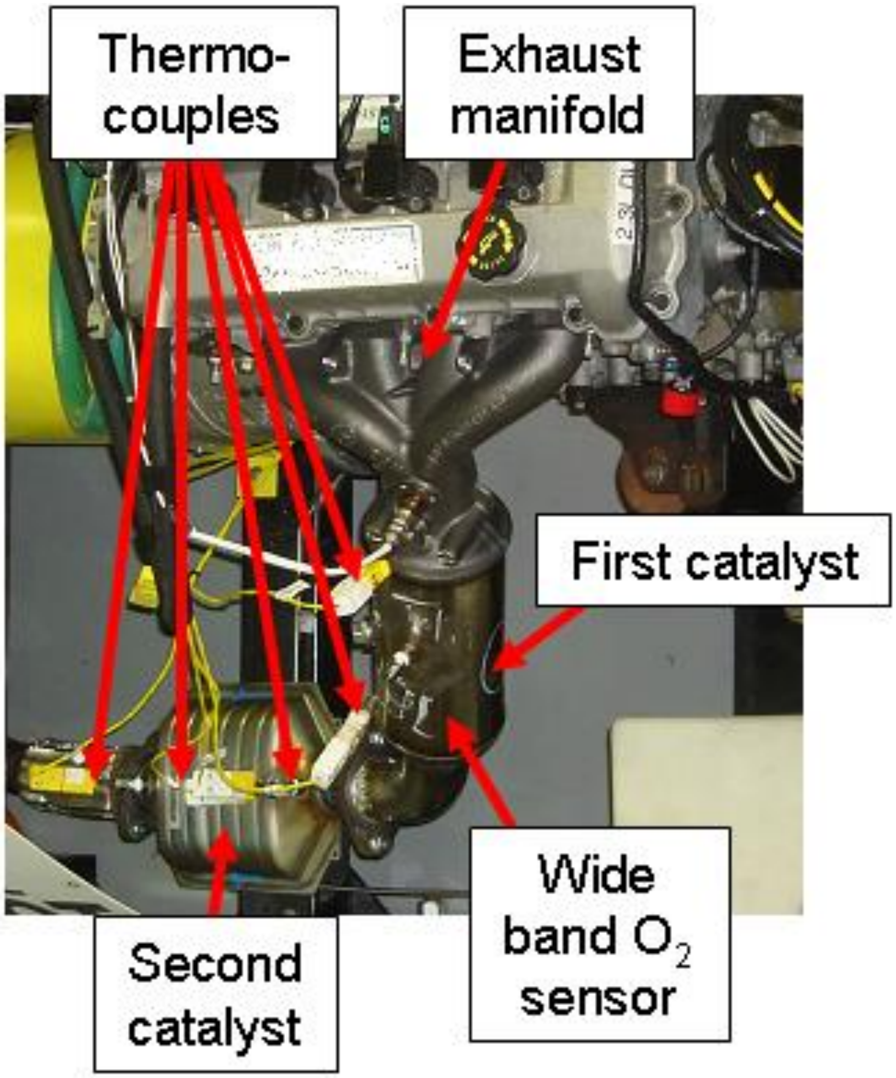


Figure 10. The engine exhaust setup and instrumentation (with permission from ANL)

The virtual scalable energy storage system and motor module

A key feature of MATT is the virtual scalable inertia motor module. A physical motor on the module provides positive or negative torque to the driveline just as it would in a hybrid powertrain. The physical motor drives get their power from the power grid in the test facility instead of a battery pack, which is the power source in most hybrids. The motor is an AC induction machine selected for its fast transient response. The motor was modified to be double ended so that the engine is coupled to the input of the shaft and the transmission is directly coupled to the output. Figure 11 shows a picture of the physical hardware of the motor module.

The virtual scalable energy storage system and the virtual scalable motor are defined in a real-time simulation in the hybrid vehicle controller. The principles of component HIL are used here. The hardware interacts in parallel with a real-time simulation of component models. Figure 12 illustrates this interaction. When the energy management system requests a given torque from the motor, the controller first verifies that the virtual motor and the virtual battery pack can provide the requested current and the torque. The controller then sends the torque command or the maximum available torque command to the physical motor. Next, the virtual current is derived from the commanded torque based on the motor model. That current is applied to the virtual battery pack model where the controller tracks voltage and SOC.

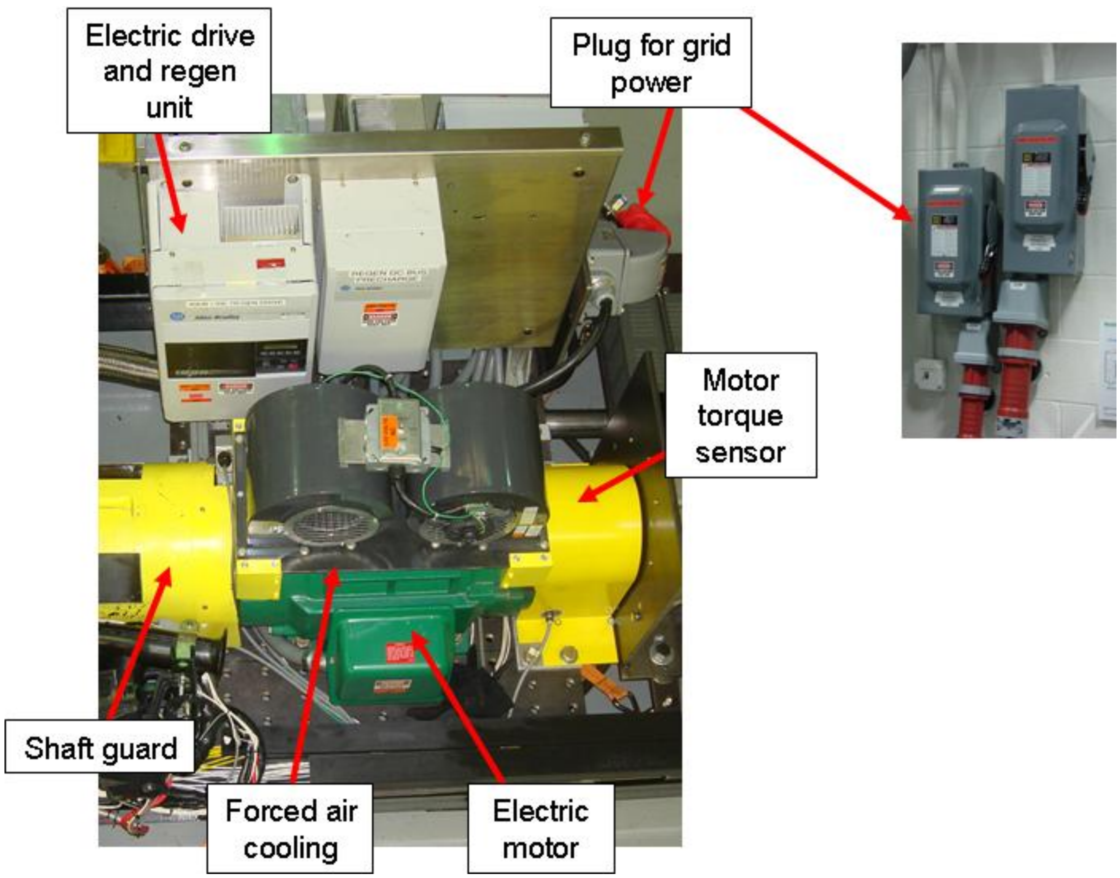


Figure 11. Top view of virtual scalable motor module (with permission from ANL)

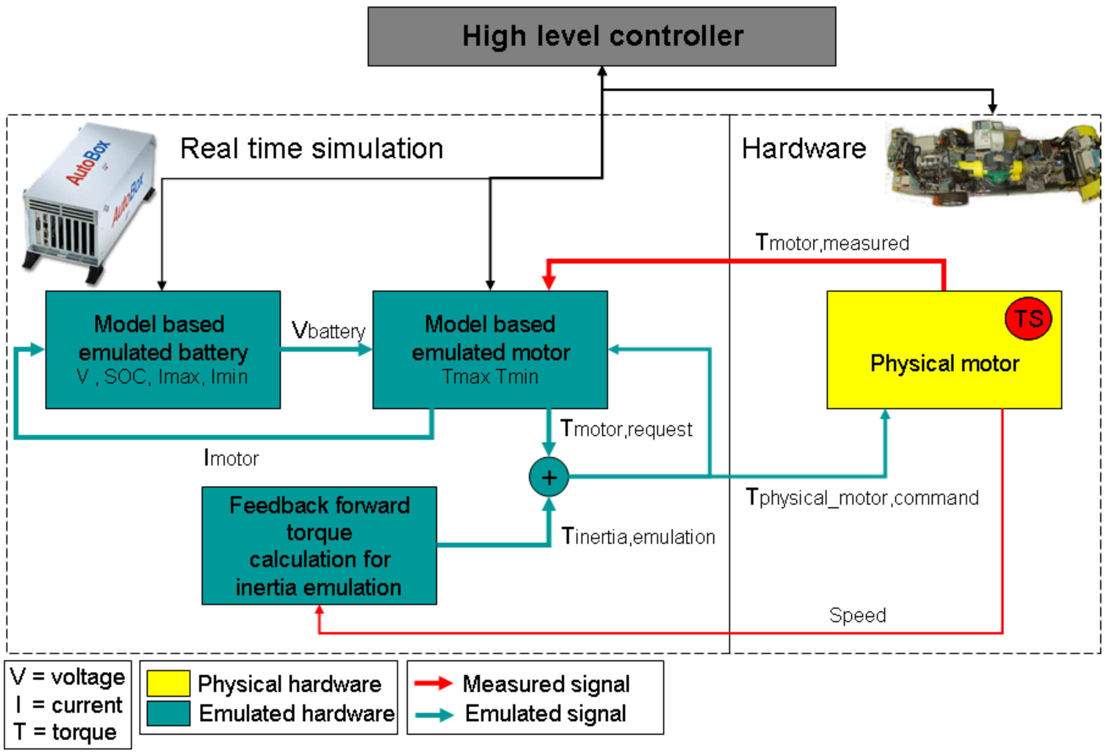


Figure 12. Component HIL logic for the virtual scalable motor module (with permission from ANL)

Another notable aspect of the virtual scalable motor module is the motor inertia emulation mode. The controller measures motor speed and acceleration to calculate the torque required to cancel the physical motor's inertia as well as the resistive torque that inertia of the virtual motor would add to the driveline. The inertia emulation brings the virtual scalable motor module a step closer to reality. During extremely fast transients, such as gear shifts, both the physical and emulated inertia torques are too high for the physical motor to always accurately execute the emulation.

The limitation of the virtual scalable energy storage system and motor module are defined in the capability of the physical motor. The physical motor is an AC induction limited to a maximum torque of 200 N*m and a base speed to 2880 RPM. The maximum electric power from the test facility is 48 kW. To return power to the grid, a regenerative unit is used which is limited to 36 kW.

The current hardware is sized to emulate an EV from a small compact sedan up to a small sport utility vehicle (SUV) on the UDDS. The propulsion system cannot supply quite enough power for the US06 which is the most aggressive standard drive cycle.

Although the motor is not rated for a continuous 60 kW, the propulsion system is adequate since the drive cycles are transient in nature. In other words, higher power demands only occur during high-speed accelerations. For example, the peak power for a small SUV traversing the UDDS drive cycle is close to 50 kW, which occurs during the high speed acceleration of the 2nd "hill" on the UDDS. Conversely, the average positive propulsion power on the cycles is 10 kW for the small SUV, which is well within the continuous rating of the physical electric machine.

The virtual scalable energy storage system and motor module can actually emulate a motor that is larger than the actual physical hardware as long as the torque-speed profile is within the operating envelope of the physical machine. The torque-speed envelope is determined by the vehicle characteristics and the drive cycle.

An essential element of the emulation is based on the simulation and the fidelity of the component models. The real-time simulation occurs in the controller that manages the higher level energy management and torque split strategy as well as the lower level component control. The code is based on PSAT, which is a forward looking vehicle simulation tool. Currently, the electric motor is based on a UQM 75 kW motor and the energy storage system model emulates a 41A*hr lithium ion battery pack intended for PHEV applications. Both models have been validated against physical hardware. The models include efficiency maps as well as constraints that limit the component operation to the limits of the physical hardware. The whole EV emulation has been correlated to hardware in ANL's APRF.

The key feature of this virtual inertia scalable motor module is the flexibility to emulate different battery technologies and electric motors. The energy storage system can be changed to facilitate different technologies and capacities in software without having to change any hardware. The motor emulation capability ranges from no motor or a small hybrid assist motor to a full EV capable electric machine. This module is extremely useful for PHEV studies.

The automatic transmission module

This module uses a 5-speed automatic transmission. For the EV and HEV application on MATT, the automatic transmission is modified to accommodate two (2) additional functions:

Electric vehicle launch. An automatic transmission launches the vehicle using the torque converter with the engine idling. In the electric launch mode it would be very inefficient to run the motor at 1000 rpm and launch using the torque converter. Thus, the torque converter was removed. An auxiliary pump provides the pressure required to close the clutches and hold the commanded gear until the input shaft spins and thus the internal pump spins fast enough to provide the transmission line pressure.

Reverse torque transmission during regenerative braking. To allow reverse torque transfer all the way to zero vehicle speed in 3^{rd}, 4^{th}, and 5^{th} gear, some mechanical modifications were implemented, thus enabling regenerative braking.

A solid axle rear end holds the differential that is paired with the automatic transmission module. The final drive ratio in the differential can be changed to accommodate different overall gearing. A 5000 N*m torque-speed sensor is installed between the output of the transmission and the input to the differential. Figure 13 shows the hardware implementation of the automatic transmission module.

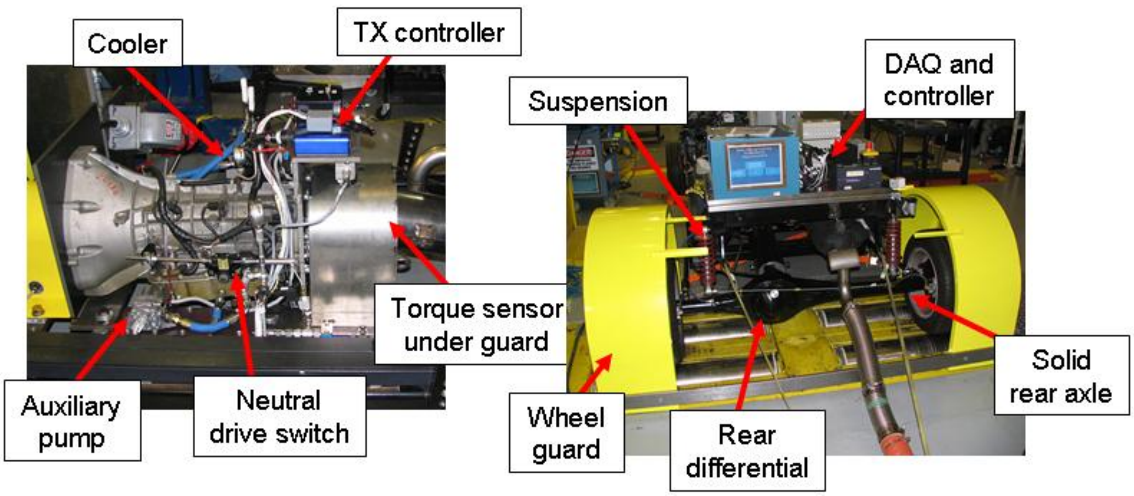


Figure 13. Automatic transmission module and rear end hardware (with permission from ANL)

An aftermarket transmission control module was incorporated and has digital inputs for the up-shift and down-shift commands. Thus, the lower level control of the transmission is much easier and faster. During shifts, the control forces the torque from the motor or the engine to be reduced to 15% of the driver demand to facilitate the shift. When the engine is engaged, the clutch is partially disengaged so the engine is pulled up to the transmission input speed. Since the clutch slips, the inertia forces are softened. Shift times with the automatic transmission are about 400 ms with continuous lower torque transfer.

As a safety feature, the transmission mechanical gear select switch needs to be actively shifted to “drive” using an air solenoid. In case of an emergency stop or power loss, the transmission will automatically return to neutral.

The transmission controller requires a torque input signal to adjust the clamping pressure on the appropriate clutches to hold the torque transferred across the transmission. Since MATT has two (2) possible power sources (the engine and the motor), the signal sent to the transmission controller is the sum of the torque requests. During braking, the signal is the regenerative torque requested from the motor. In some cases of extreme regenerative braking at lower input speeds, the transmission fluid pressure was not high enough to maintain the required clamping force on the clutches. This was resolved by increasing the turn-on threshold of the auxiliary pump and, if needed, applying mechanical braking to reduce the regenerative braking. This is only necessary on aggressive cycles such as the US06.

The data acquisition system and instrumentation summary

Most of the instrumentation has been covered in the module-specific sections. The data collection from a single test comes from the instrumentation on MATT, data saved in the high level controller (control data and emulated component data), the dynamometer data, the test cell data, and the emissions bench and optional systems such as the engine pressure trace indicating system. The facility data acquisition system, as well as MATT's onboard system, is designed to be very flexible in adding instrumentation. Another great advantage is the open component module approach which makes the instrumentation and sensors easily accessible. Most of the data is recorded by the APRF main host computer and some MATT-specific information is merged in post-processing after the test.

The sensors on MATT are wired into signal conditioning boxes. These boxes condition the incoming signal to a standard isolated 0 to 5VDC signal. Each signal has two (2) output connectors in order to share the signal between the high level controller and the data acquisition system. The high level controller uses the signals for component control and energy management strategies. The data acquisition system is dedicated to recording the data.

Beyond individual component investigations, the major goal is to understand the performance and the efficiency of the components in a HEV system environment and their effect on the system. A requirement of the instrumentation is to be able to track power and energy in the driveline throughout and over the test cycles. Figure 14 summarizes the instrumentation that enables this analysis.

The data is also used to debug, understand and recalibrate the component control as well as the energy management strategies.

Driving MATT

A proportional-integral-derivative (PID) loop is used to emulate a driver. A pre-programmed drive cycle starts once the virtual key is turned on. Once started, the PID loop adjusts the driver torque request to minimize the speed difference between the actual wheel speed and the desired wheel speed required by the drive trace. The gains for the PID loops have different calibrations at low and high vehicle speed. The PID loop does look ahead on the trace by one (1) second. Only the driver PID loop uses the look-ahead technique. It is not used to influence the energy management strategy. In real vehicle testing on a dynamometer, a driver also looks ahead and can anticipate required changes in accelerator or brake pedal position on the trace ahead. The PSAT-PRO "driver" has extra features which include cruise control from any target speed as well as a "pulse and glide" mode. The "pulse and glide mode" was developed to emulate and investigate hypermiler driving techniques.

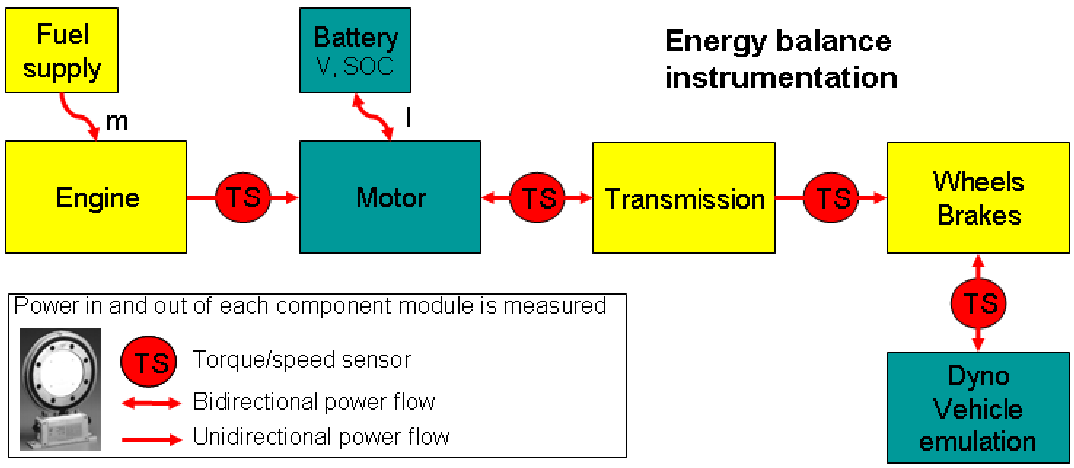


Figure 14. Instrumentation summary with respect to power and energy flows between the modules (with permission from ANL)

Another useful feature is a pedal set that can replace the software PID loop driver in the code. A user can use an accelerator pedal and a brake pedal to drive MATT. This capability is very useful during initial troubleshooting phases when a new hardware module is put in place. It is also useful to compare a human driver input to the PSAT-Pro PID driver to ensure that the computer driver is realistic.

The driver, be it the virtual driver or a human driver, ultimately closes the loop on powertrain torque control to meet the desired vehicle speed dictated by the drive cycle.

The graphical user interface

During testing the user has access to the visual feedback and calibration possibilities in the ControlDesk© interface. Any control parameter can be calibrated in real time as MATT is running a test. The interface has two modes. First is the actual test mode, where a virtual key is turned on to start the automated drive cycle test with the current energy management strategy. Second is manual override mode, where the user can command all of the actuators on MATT independently. The second mode accesses a special section in the code which allows the user to override the output commands to components in order to test individual operation of actuators for debugging purposes. Figure 15 shows an example of the ControlDesk© user interface.

Figure 15. Screen shot of MATT's test mode interface (with permission from ANL)

The Advanced Powertrain Research Facility

The APRF at ANL will be used in conjunction with the MATT HIL system. The APRF features a four wheel drive chassis dynamometer, with a complete data acquisition and emissions measurement system. Component, subsystem, and vehicle test facilities support HIL testing, control system development, and technology validation. The APRF allows researchers to test vehicles and components to provide configurations without building and then tearing apart an entire vehicle each time a component is changed. The facility is completely modular, so parts can be interchanged quickly, for rapid, standardized assessment. Components can be benchmarked individually or as part of a system. Figure 16 represents a computer generated layout of the APRF.

The following list outlines the basic specifications and capabilities of the APRF:

Dynamometer

- 4WD capable from 90- to 180-inch wheelbase
- 250-hp, 14,000-lb inertia emulation
- Modes: road load, speed mode, coastdown

Test Cell

- Large 26,000-cfm test cell climate control with 150-ton cooling
- 150-kW DC bus feed for motors and battery connections
- Hydrogen fuel feed from outside storage integrated with 2-range mass measurement system
- Custom data acquisition control designed for flexibility and analysis of advanced vehicles

Figure 16. The Advanced Powertrain Research Facility (with permission from ANL)

Emissions

- Gasoline, diesel, hydrogen, and natural gas
- Capable of resolving emissions from SULEV vehicles
- Full dilution tunnel for diesel vehicles
- Fast response 2-channel THC and NO_x analyzers
- Filtered and dehumidified dilution air (HC < 1ppm, H2O < 10 grains/lb)

Testing Considerations

For the purposes of this research, certain testing limitations exist that must be considered due to the multiple UDDS test cycles needed for complete CD for a full charge test. Due to limitations of emissions measurement (tedlar bag volume, data acquisition, etc.), the multiple UDDS must be broken up into individual UDDS cycles and run back to back. In order for emissions to be measured and analyzers zeroed and spanned prior to each run, a finite amount of soak time exists between each test. Approximately 10 minutes are needed to reset the equipment for a new test. This means there is a short soak time between cycles, and cooling of the engine and the exhaust aftertreatment system will occur. Therefore, the test data is not 100% representative of a continuous drive schedule consisting of 6 UDDS drive cycles. All efforts will be made to minimize this soak time so that the results are not adversely affected.

Chapter 3: Phase I Research

Analytical

The research begins by developing a suitable vehicle model, complete with an appropriate powertrain configuration and baseline control strategy. Each individual component model must be populated with performance data in order to adequately characterize the dynamics and efficiencies of the powertrain. The following sections develop the vehicle level model and first attempt at a reasonable control strategy for conventional, HEV, and PHEV operation.

Vehicle modeling

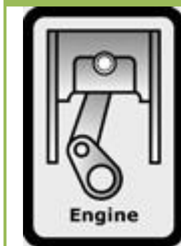
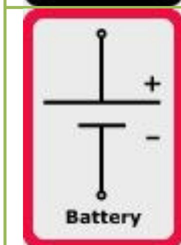
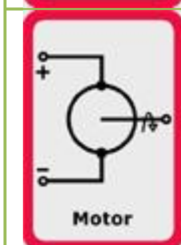
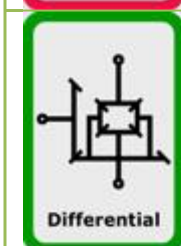
The vehicle chosen for this study is based on a compact sedan, a 2002 Ford Focus. This vehicle has been tested extensively in the APRF and has been validated using PSAT. Therefore, validated test data for the vehicle is readily available for use and provides an excellent basis to begin modeling. The composition of the vehicle model can be broken down into two (2) basic constituents: mechanical components that comprise the physical vehicle, and the supervisory control strategies that manage the interactions of all relevant components within the vehicle. A complete summary of the hardware components and relevant data is presented in the next section, followed by a detailed description of the development of the control strategy.

Components

In order to successfully create a viable vehicle level model, powertrain components must be identified and respective data gathered. PSAT organizes the creation of an advanced powertrain vehicle model into a logical sequence of events, beginning with the selection of a powertrain configuration. As noted earlier, a pre-transmission parallel hybrid electric powertrain with single energy storage system provides the foundation from which to build the virtual vehicle. This is consistent with the powertrain configuration of MATT. Subsystem models are then chosen to populate each of the components of the powertrain. Corresponding initialization files provide the necessary interface for component characterization via data maps and variables.

The most important component models for this study are the engine, traction motor, and energy storage system. The energy storage system model is based on a proprietary model developed by researchers at ANL. The engine model is based upon an existing PSAT engine model that is scaled to match the characteristics of the gasoline engine currently in use on MATT. Table 1 outlines the pertinent components used to create the vehicle model in PSAT. A brief summary of the distinguishing characteristics of each powertrain component is provided in the table. Once each of the powertrain components has been identified and populated with the relevant data maps and variables, the control strategy must be developed and implemented.

Table 1. Vehicle component specifications for the PSAT model

COMPONENT	DESCRIPTION
	Manufacturer: Ford Motor Company Maximum power output: 104 kW Maximum efficiency: 37% Displacement: 2.4 liter Configuration: Overhead cam 4 cylinder
	Manufacturer: Johnson Controls SAFT Energy storage capacity (PHEV): 10.6 kW*hr Nominal voltage: 260VDC Chemistry: Lithium-ion
	Manufacturer: UQM Technologies Continuous power: 53 kW Maximum power: 75 kW Maximum efficiency: 92% Details: Permanent magnet synchronous machine
	Final drive ratio: Estimated efficiency: 95%
	Tire size: 265/50R15 Rolling radius: 0.33m Rolling resistance: 0.007
	Vehicle mass: 1685 kg Frontal area: 2.2 m^2 Drag coefficient: 0.33 Dynamometer coefficients: F_0 = 145 kg F_1 = 7 kg/(m/sec) F_2 = 0.6 kg/(m/sec)^2

PSAT model initialization files for each relevant component are located in the Appendix. It should be noted that data associated with the engine model and lithium battery model are proprietary and, therefore, not located in this document.

Control Strategy: Development of the Vehicle System Control Module

The Vehicle System Control Module (VSCM) dictates how each of the powertrain components behaves, as well as how each subsystem interacts with other onboard systems in order to meet basic operator demands. PSAT has a basic selection of powertrain supervisory control strategies to select from. These control strategies provide basic functionality and are excellent for use in directional or trade-off studies. While these control models are useful, a custom control model was created that offered full flexibility and adaptability for later stages of the research where emissions constraints would be considered. In addition, development of a custom control strategy was warranted in order to provide essential calibrateable parameters that would make the transition from simulation to real time hardware quick and easy.

The VSCM model was developed in a modular fashion in order to readily accept additional code insertion where necessary. The control system architecture is comprised of various c*ontrol processes*. The primary control processes of the VSCM are the Vehicle Mode Control Process (VMCP), the Energy Management Control Process (EMCP), the Regenerative Braking Control Process (RBCP), and the Battery Mode Control Process (BMCP). Each of these processes and their functional responsibilities is illustrated in Figure 17. Each of these control processes communicates with each other in order to facilitate the operation and interaction of the traction motor, energy storage system, and the engine. All calculations within the VSCM are power based. This ensures consistency throughout each process of the VSCM, and minimizes error due to missed gear ratios that are necessary for torque calculations.

A detailed explanation of the overall function and model development is presented in the following sections.

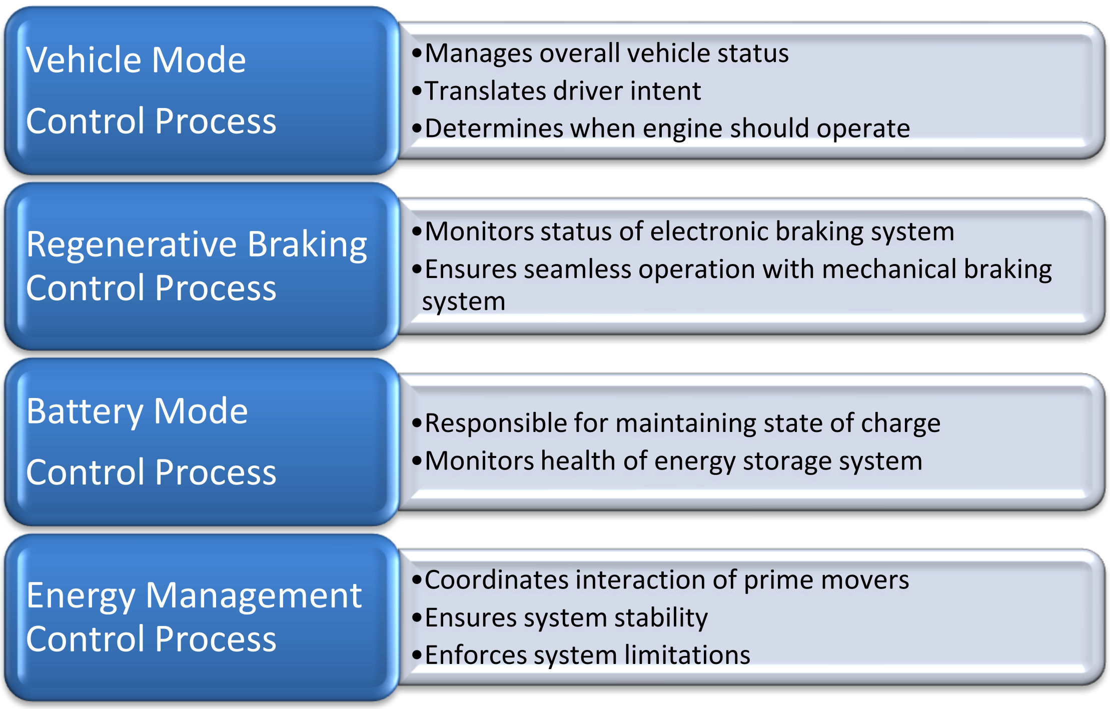


Figure 17. Control processes developed for implementation of the VSCM

Vehicle Mode Control Process

The Vehicle Mode Control Process (VMCP) is responsible for the overall status of the vehicle. The VMCP constantly monitors the status of driver (through the key switch and pedal inputs), as well as the operational status of all the powertrain subsystems (high voltage traction drive, energy storage system, engine control module, etc.). The VMCP determines the operational mode, or status, of the vehicle and cascades this information to subsequent control mode processes within the VSCM. High level operating modes of the powertrain include electric mode, hybrid electric vehicle operation with provisions for CS or CD modes, and regenerative braking mode.

One of the most important functions of the VMCP is to determine when to operate the vehicle as an EV, or as an HEV. Figure 18 represents a Stateflow© graphical representation of this primary responsibility of the VMCP. There are a variety of circumstances that would demand the engine to operate. Demanded engine power is the primary factor to turn the engine on. This demanded engine power, which consists of driver demanded power and energy storage SOC maintenance power, is developed in more detail in the EMCP section. Other factors that influence engine operation are vehicle speed, high driver power demand, and various overrides for conventional or electric only operation. Hysteresis is built into each respective condition in order to reduce any unwanted oscillations with the engine starting and stopping.

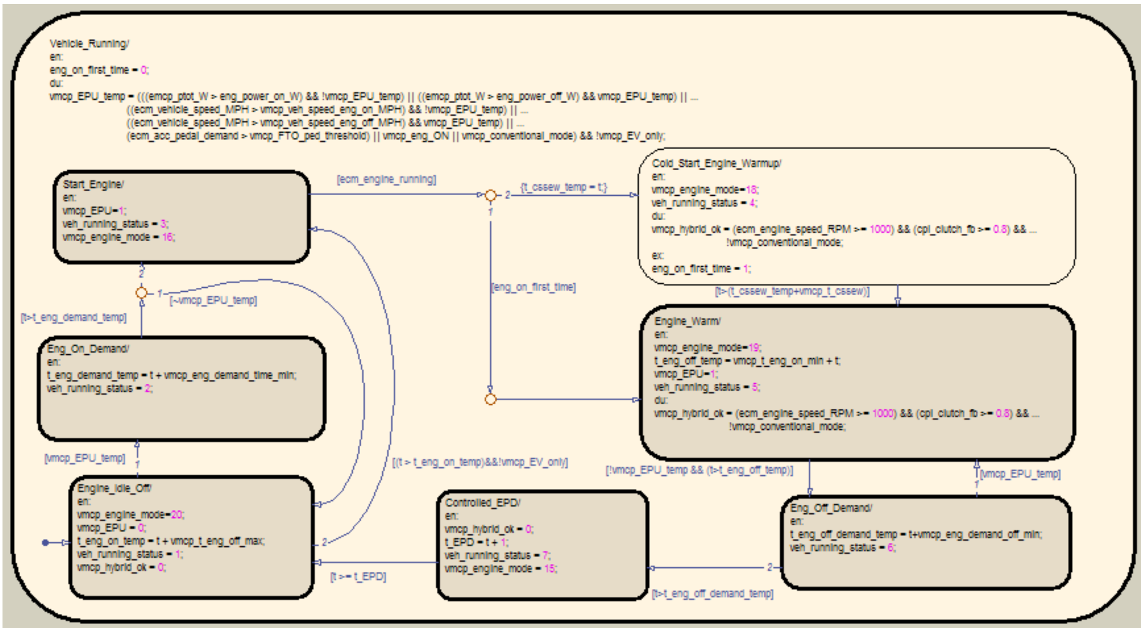


Figure 18. Graphical representation of the Vehicle Mode Control Process engine operation functionality

Regenerative Braking Control Process

The Regenerative Braking Control Process (RBCP) is responsible for coordinating the necessary traction motor braking torque values during braking events. The RBCP must monitor such vehicle parameters as wheel speed, SOC, and brake pedal demands to determine the appropriate amount of negative torque to request from the motor. The RBCP blends the braking effects of the traction motor and the mechanical brakes of the vehicle in a seamless manner. Regenerative braking can be faded out as the vehicle approaches zero linear speed for drivability reasons. For the purpose of maximizing overall vehicle efficiency for this research, regenerative braking is employed to its fullest potential, even to very low vehicle speeds. The output of the RBCP is a braking power demand that is propagated to the EMCP for further processing and integration into the overall energy management strategy

As a side note, if this control system were installed in an actual vehicle, the RBCP would constantly monitor the existing anti-lock braking system (ABS). The RBCP would cancel any traction motor brake torque request during an ABS event so that the positive effects of ABS are not cancelled and no wheel lock-up occurs. While not actually implemented in this research, this is an important feature of any proper HEV control system from a safety perspective.

Battery Mode Control Process

The Battery Mode Control Process (BMCP) interfaces with the energy storage system and receives critical information pertaining to the health and operation of the battery pack. HV battery charge and discharge power limitations are received from the energy storage subsystem and further modified based on the current operating conditions of the powertrain and overall vehicle.

The primary objective of the BMCP is to regulate the SOC of the energy storage system. The BMCP provides an output to the rest of VSCM control process to accomplish this task. The power necessary to maintain the SOC for the vehicle, referred to as P_{SOC}, becomes a modifier to the required engine power during HEV modes of operation. The determination of P_{SOC} is shown graphically in Figure 19 as a simple look-up table based on SOC. Additional methods could be used for determining the value of P_{SOC}.

Energy Management Control Process

The Energy Management Control Process (EMCP) is the most critical process within the VSCM. The EMCP is responsible for coordinating the interaction of the heat engine and the traction motor. The EMCP must ensure that the driver demanded power is satisfied while at the same time maintaining the SOC of the HV battery pack (either in a CS mode or a CD mode).

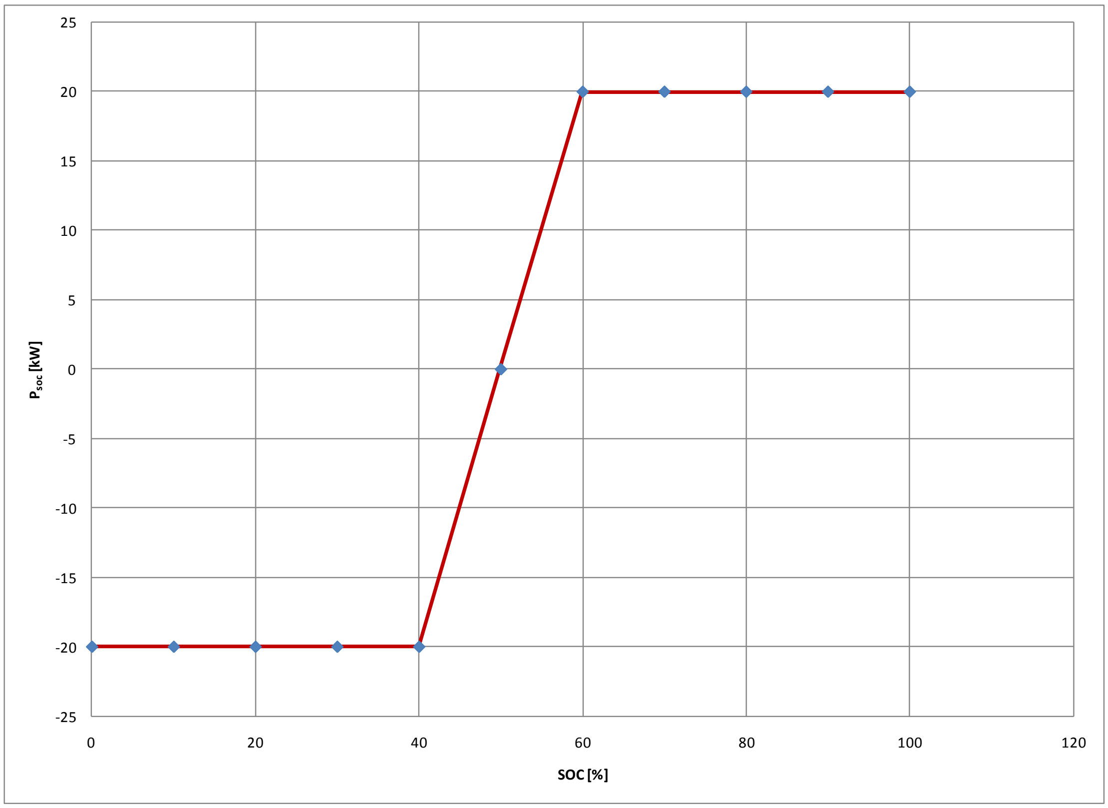


Figure 19. Determination of SOC maintenance power request of the engine

The EMCP must deliver these items while also administering overall system limitations for subsystem component protection. The EMCP joins the outputs from the BMCP, the VMCP, and the RBCP to determine what is required of the heat engine and the traction motor.

The design of the EMCP begins with the development of the simplest mode of vehicle operation, referred to as EV mode. EV mode is generally a low power demand regime associated with lower vehicle speeds. However, for a fully capable high voltage powertrain, such as the case for MATT, the electric mode of operation becomes substantial even during high power operation. The EMCP works in concert with the other mode control processes to operate the vehicle. The root output of the VMCP is the driver demanded power, referred to as P_{drv}. During EV operation, P_{drv} is compared to energy storage system limitations that are supplied by the BMCP. A flow diagram of the EV mode of operation is shown in Figure 20. It is important to note that the desired power from the engine is zeroed out at the beginning of the sequence. This is for safety concerns as well as completeness. Basically, the driver demanded power, P_{drv}, is compared to the incoming energy storage system limitations from the BMCP and adjusted accordingly to ensure system integrity and protection of critical HV components.

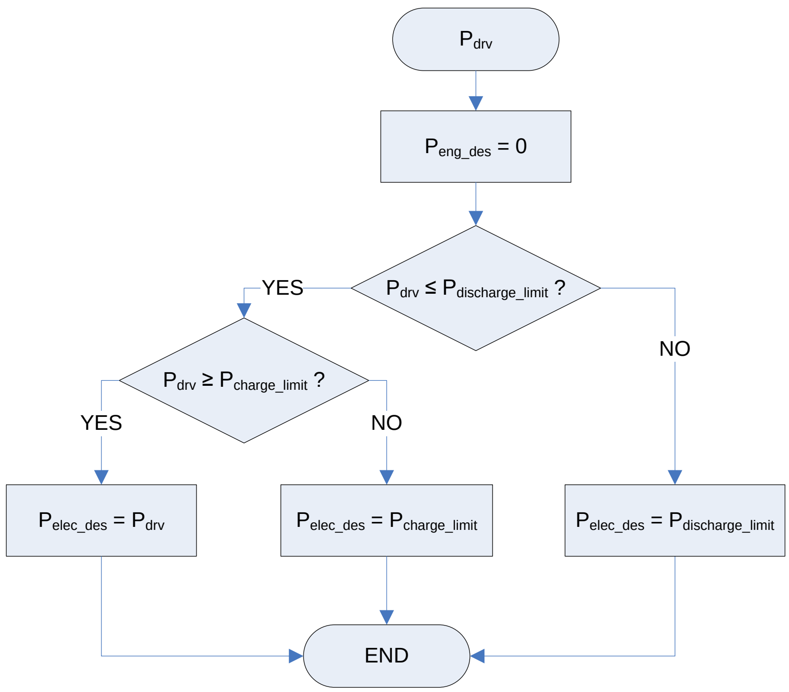


Figure 20. Electric only methodology for the EMCP

As described earlier, the prime output of the BMCP is the power necessary to maintain the SOC of the HV battery pack, referred to as P_{SOC}. These variables together form the total power required of the engine in HEV mode. It is worth noting that P_{SOC} is ignored during the EV mode. The total engine power desired, designated P_{tot}, thus becomes

$$P_{tot} = P_{drv} - P_{SOC}$$

where,

$P_{SOC} < 0$ indicates power to CHARGE battery, and

$P_{SOC} > 0$ indicates power to DISCHARGE battery.

The primary function of the EMCP is to deliver the appropriate torque commands to the engine and traction motor that a) satisfy the driver demand and SOC maintenance demand, and b) apply overall system limitations and constraints. Figure 21 is a flow diagram that outlines how the respective system limitations are applied in a hybrid mode of operation. The flow diagram starts with P_{drv}, since meeting the driver demand is the most important characteristic of the VSCM as a whole.

For a ZEV mode of operation, the flow diagram shown in Figure 21 is modified to remove references to the engine. Basically, the bottom half of the diagram is used. The general outputs from this flow diagram are the modified engine power desired and traction motor power desired (filtered through the system limitations).

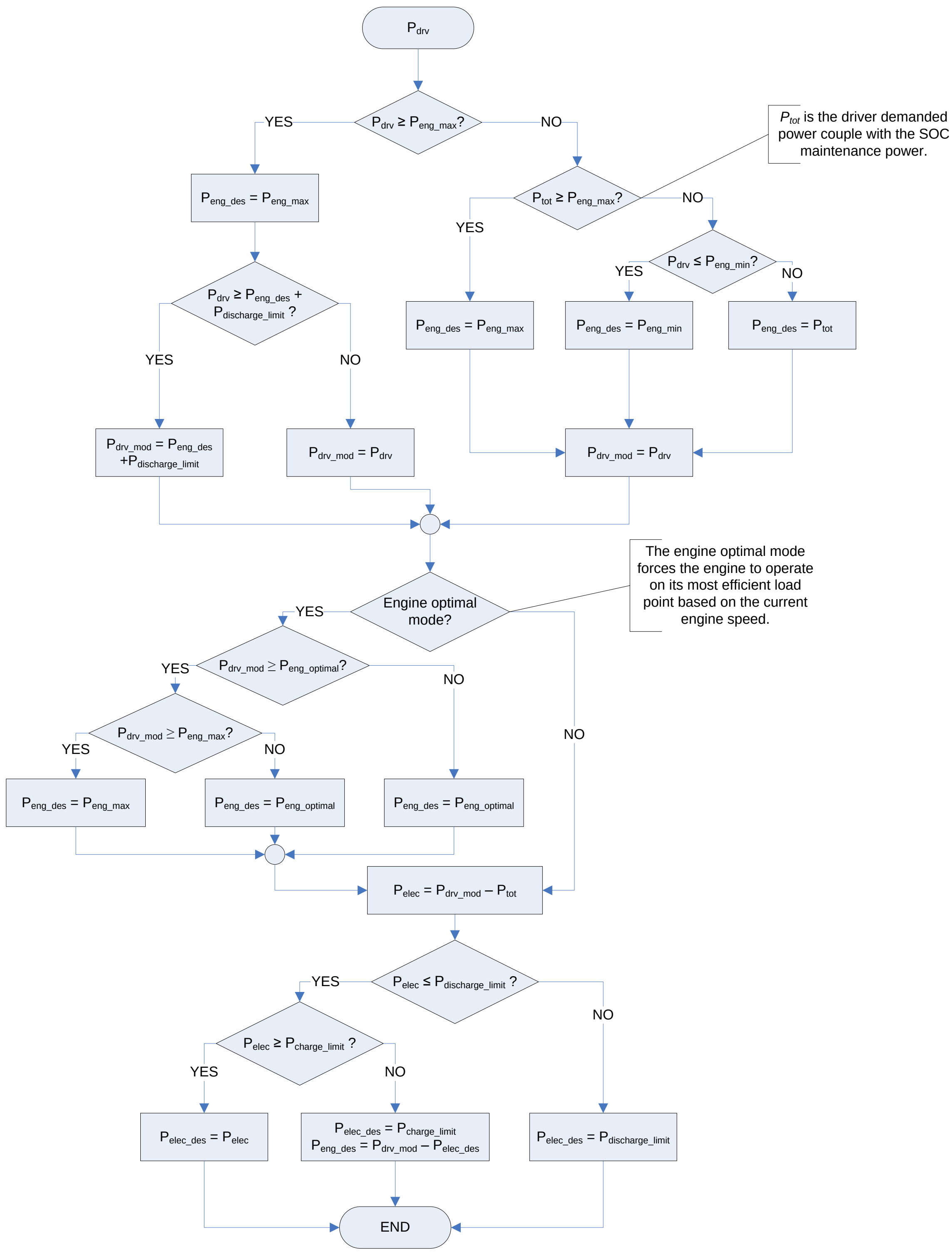


Figure 21. CS hybrid methodology for the EMCP

These values are divided by each respective speed to give a torque command to the engine and traction motor. However, certain further adjustments to these values must be made in order to compensate for electrical system power losses (conversion of electrical energy to mechanical energy). This is also accomplished in the EMCP. One of the most important functions that the EMCP must include is to protect the HV system, particularly the battery pack. The EMCP utilizes the modified charge and discharge power limitations determined in the BMCP and calculates the corrected traction motor torque command, based on the previously determined P_{elec_des}, to ensure that the current drawn from the battery pack does not violate its maximum system limits. The EMCP offsets the P_{elec_des} command by filtering P_{elec_des} (set-point) and $P_{battery\_actual}$ (response) through a PI controller. The resulting desired electrical power is what is actually requested from the traction motor. This approach ensures that the HV system limitations are never exceeded.

PHEV Control Strategy Approaches

The supervisory control system of the PHEV powertrain must allow for both CD and CS operation as appropriate over the entire usable SOC range of the energy storage system. While there are literally endless possibilities for energy management strategies to be implemented into the VSCM, four (4) distinct supervisory control algorithms will be evaluated as part of this research.

Charge Depleting Operation

The two (2) main approaches for PHEV CD operation are the ***maximum depletion*** and the ***blended mode***. The maximum depletion approach is the simplest control method and strives to discharge the battery pack as quickly as possible by operating in all-electric mode until the lower SOC bound is reached.

The blended strategy makes use of the engine during the CD region of operation. The blended strategy applied in this research makes use of what will be referred to as charge preservation (CP) operation when the engine is running during CD. The distinction between CP and CS is that the VSCM does not allow any charging of the battery pack by the engine (using extra fuel) and does not use the motor for any propulsion (no discharge of the battery pack is allowed). The engine operates just as in a conventional powertrain and provides all propulsion for the vehicle. In this way, the energy in the battery pack is preserved until the engine shuts off and electric operation resumes where it “left off.” Another important concept applied in this strategy is that if the engine is commanded to operate, then it should be used to provide useful work. This is another reason why no discharging of the battery pack is allowed during CP operation (reduction of the required power from the engine). The CP mode is accomplished by temporarily setting the target SOC to the current SOC at the point when the engine was commanded to engage. P_{SOC} is then set equal to zero such that no charging or discharging of the energy storage occurs.

Charge Sustaining Operation

For this particular pre-transmission parallel powertrain architecture, there are two (2) approaches to CS operation that cover a majority of the functional envelopes of the subsystem components, with emphasis on the engine.

The first approach, referred to herein as the ***load following*** strategy, operates the engine much like a conventional vehicle where the commanded engine torque closely follows the demanded torque. Excess engine power can be used to charge the battery pack during periods of low power demand, such as cruising. The SOC is held tightly around a target SOC during CS operation. In this approach during HEV operation, the *traction motor* is operated in a more constant regime, whereas the *engine* manages all the transients.

The second approach, referred to herein as the ***engine optimal*** strategy, operates the engine much differently compared to the load following case. Here, the engine is commanded to operate at its most efficient load point based on the current engine speed. The motor acts as a generator and charges virtually all the time while the engine is running. SOC maintenance is handled by operating the vehicle in electric mode for a larger percentage of the time, particularly during urban styles of driving. In this approach during HEV operation, the *engine* is operated in a more constant regime, whereas the *traction motor* manages all the transient behavior necessary to adequately traverse the drive cycle.

Simulation results

The following plots represent a comparison of the two (2) distinct CS, or HEV, operating strategies applied in this research, described previously as the ***load following*** strategy and the ***engine optimal*** strategy. Figure 22 illustrates a comparison of the engine torque produced during a portion of the UDDS driving cycle for each of the two (2) respective HEV control strategies compared to a conventional vehicle. The load following strategy tracks the conventional torque, while adding additional torque to charge the on-board energy storage system.

The engine optimal approach operates on its most efficient load point, regardless of the driver demanded torque. The more constant operation of the engine is evident here, which is in stark contrast to the transient operation of the engine for the load following case. The traction motor is controlled to manage the transients, mostly acting as a generator to absorb excess torque which is used to charge the battery. This approach to running the engine as efficiently as possible in this powertrain architecture subjects the energy storage system to reasonably high charging currents, and possibly could lead to shortened useful battery pack life.

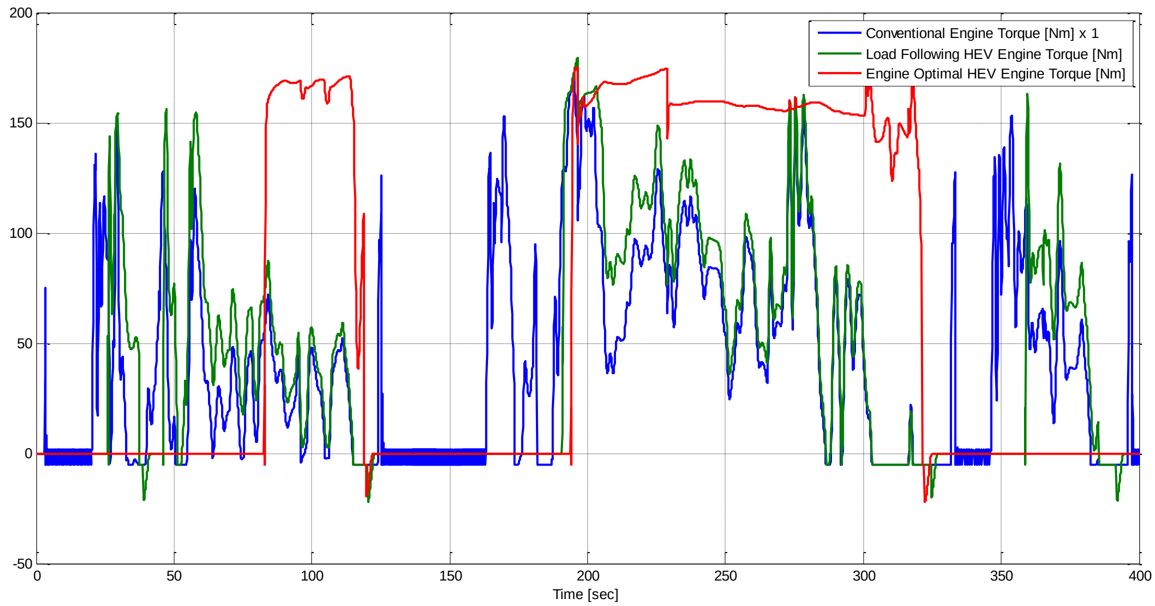


Figure 22. Engine torque comparison for conventional, load following HEV, and engine optimal HEV

Figure 23 further illustrates the fundamental difference in component operation for the respective hybrid control strategies by showing the traction motor torque for the same portion of the UDDS drive cycle. Here, the load following case operates the motor in a much smoother, constant manner as compared to the more transient operation of the traction motor for the engine optimal case. Note the substantially higher negative torque (charging) that the motor exhibits during engine optimal operation. This "excessive" charging leads to more electric-only operation over the drive. This is easily seen in Figure 24 where the SOC of each respective control strategy is compared.

The HEV powertrain affords flexibility in the operation of the engine. This can lead to substantial gains in the overall efficiency of the vehicle. Figure 25 represents a walk from the conventional operation of the engine through each respective HEV strategy. From the figure it is clear that the engine can be operated very efficiently in parallel pre-transmission hybrid as compared to the conventional powertrain. An progressive increase in engine efficiency is evident in the transition from the conventional, to the load following, and finally to the engine optimal strategy.

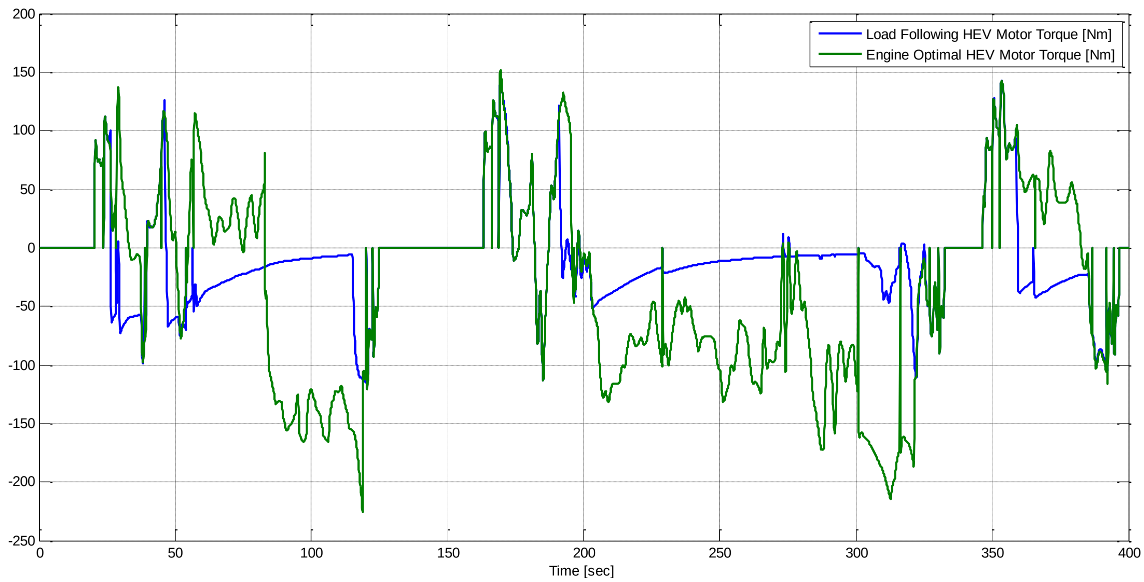


Figure 23. Motor torque comparison of load following and engine optimal HEV control strategies

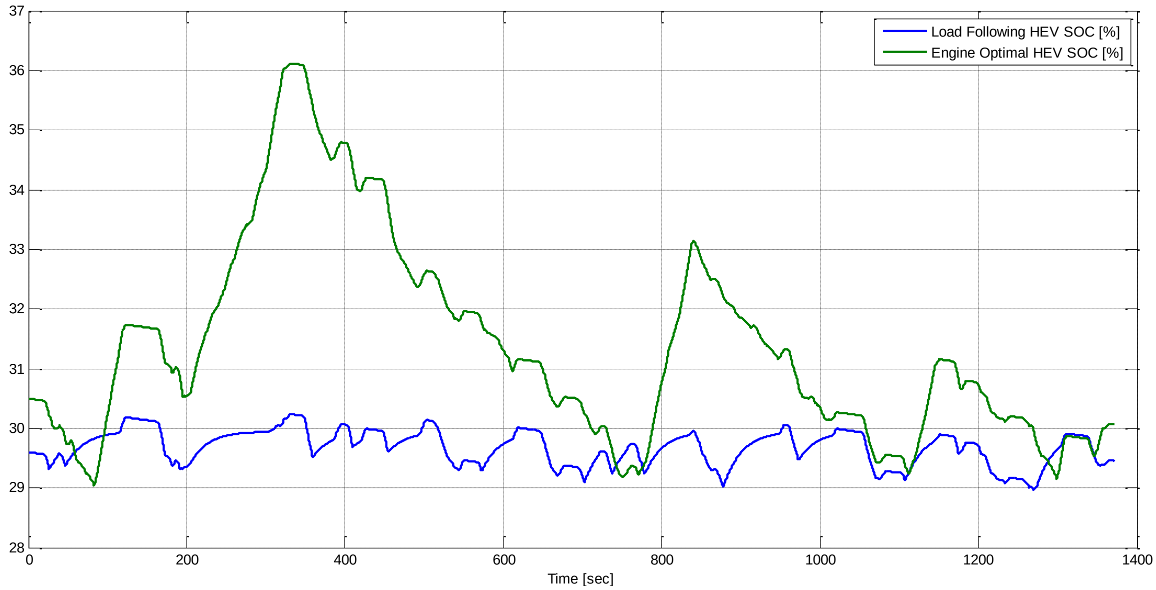
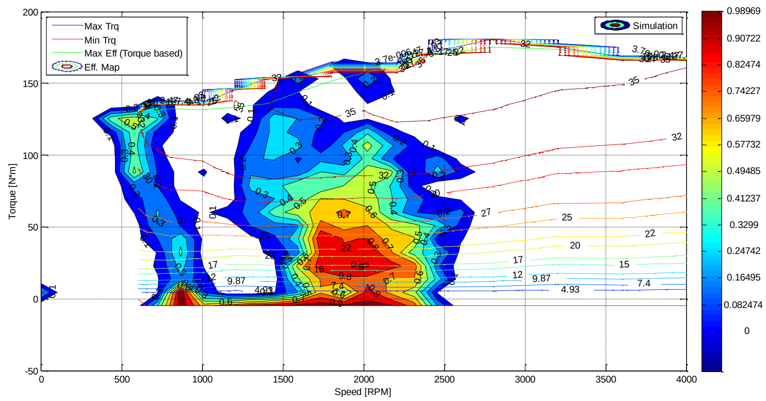
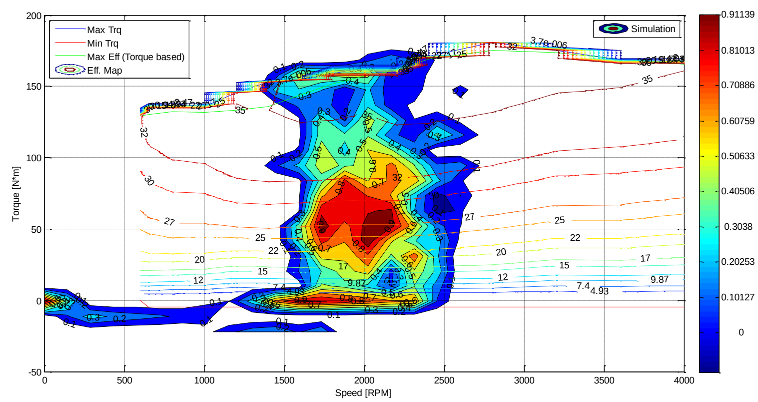


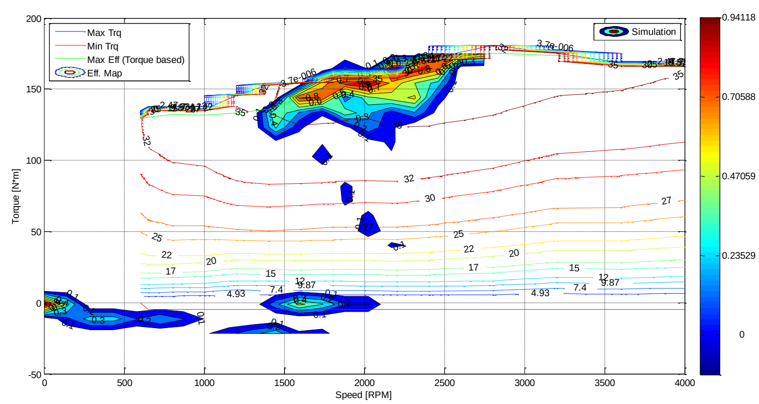
Figure 24. SOC comparison for load following and engine optimal HEV strategies



a). Conventional mode



b). Load following HEV mode



c). Engine optimal HEV mode

Figure 25. Engine operational torque density plots for three (3) basic modes of vehicle operation

Both the load following and engine optimal CS strategies were incorporated into the controller and expanded for PHEV operation. Figure 26 through Figure 29 represent a graphical summary of the fundamental operation of each case of the maximum depletion and blended strategies.

Figure 26 and Figure 27 illustrate the engine operation for the maximum depletion/load following case and the maximum depletion/engine optimal case, respectively. The maximum depletion cases feature all electric operation during the CD portion of the strategy, followed by either a load following or engine optimal charge sustaining phase. The load following case maintains the SOC tightly around the target SOC of 30%, as shown in Figure 26. As a consequence, the engine turns on much more frequently. The SOC for the engine optimal case, illustrated in Figure 27, is allowed to vary much more greatly around the target SOC.

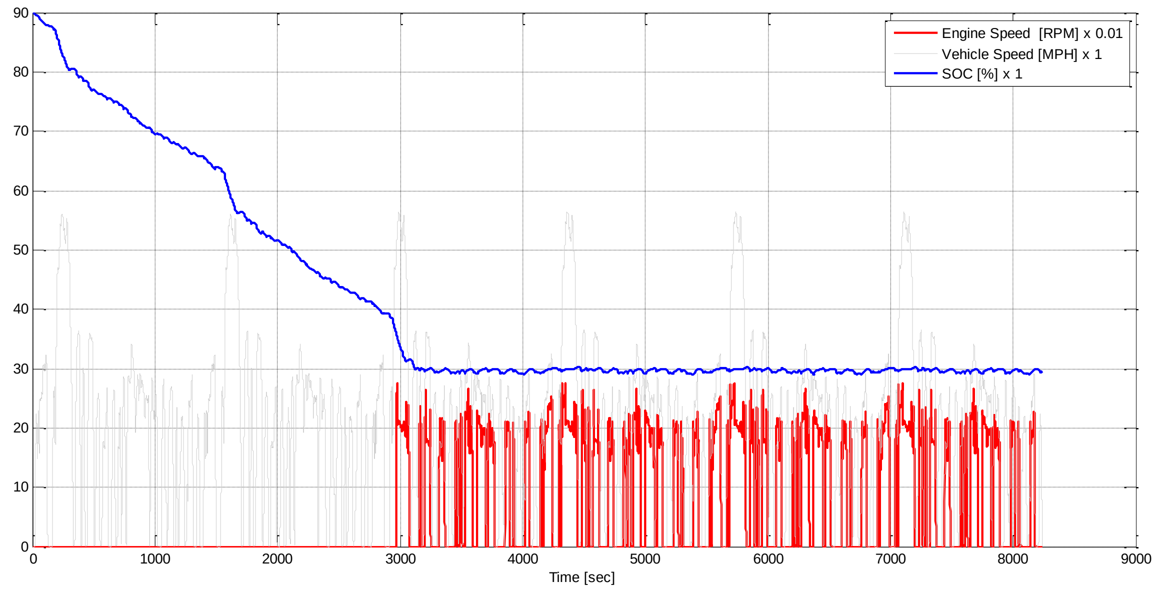


Figure 26. Phase I maximum depletion load following operating summary

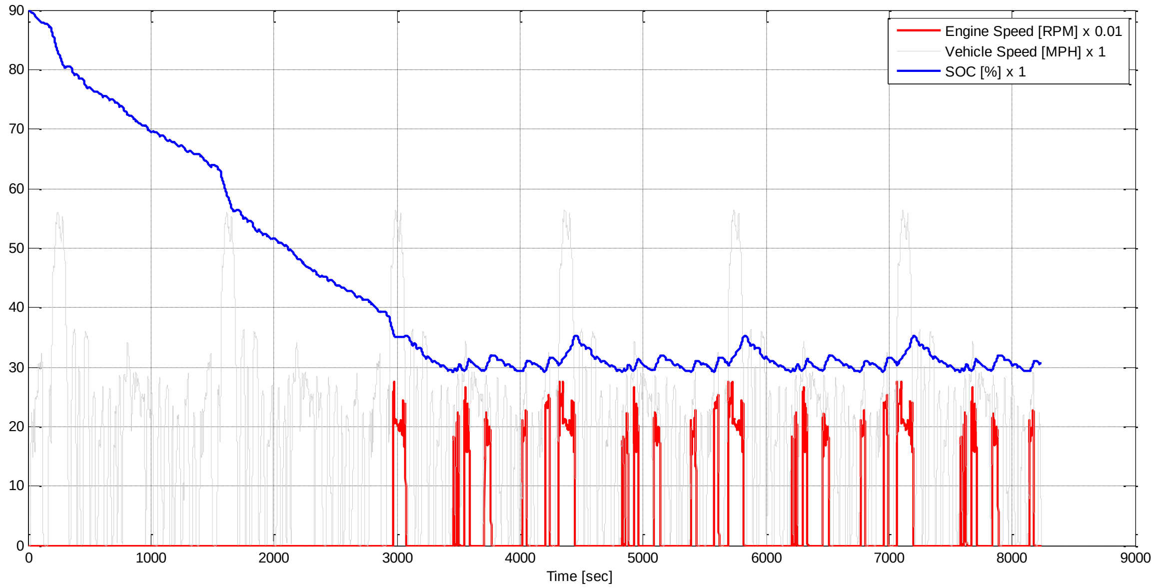


Figure 27. Phase I maximum depletion engine optimal operating summary

This is due to the engine operating on its most efficient point, and consequently charges the battery to a much greater degree. As a result, the engine does not have to turn on as frequently, and makes use of the excess stored electrical energy to propel the vehicle. Less engine starts are desirable in order to potentially reduce THC and CO emissions.

Figure 28 and Figure 29 represent the blended control strategy cases. The CD phase for both the load following and engine optimal strategies are identical. The philosophy for the blended CD operation is to operate in a CP mode. When the engine is requested to provide power during higher demands, the engine is operated much like a conventional, load following strategy. No charging or discharging of the energy storage system is allowed during CP mode. The concept is to load the engine when it is requested to operate such that it operates more efficiently, hence no discharging of the battery. Conversely, the purpose of CD is to rely mostly on electric power, so extra fuel should not be consumed to charge the battery pack. This approach is shown in the figures as a flat SOC line during engine operation for the CD portion of the simulation, such that the SOC of the battery pack is “preserved.”

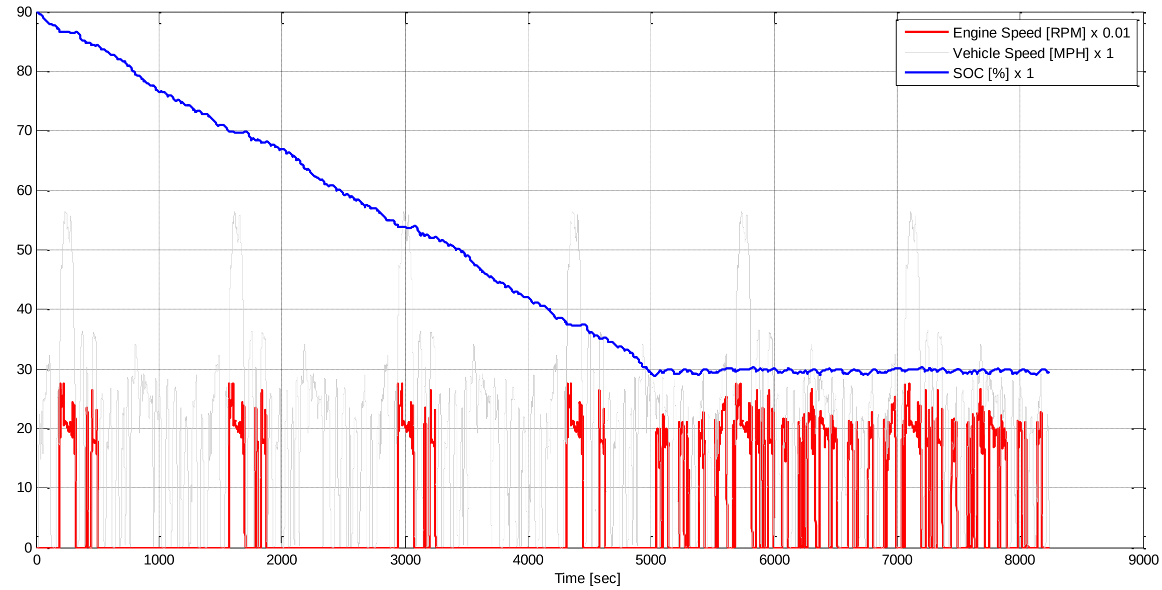


Figure 28. Phase I blended load following operating summary

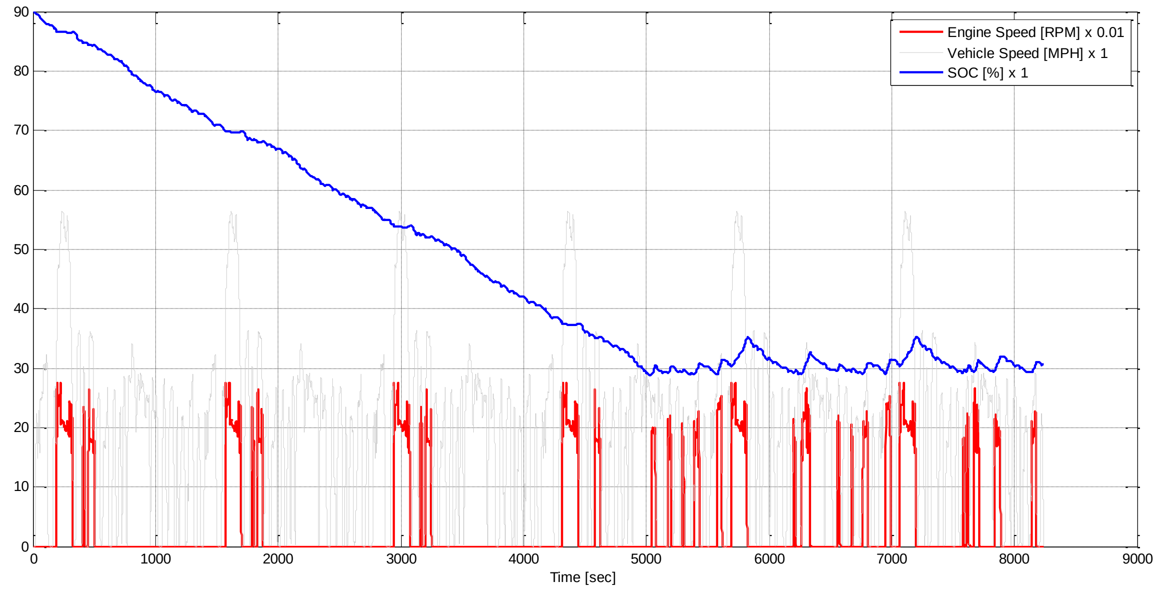


Figure 29. Phase I blended engine optimal operating summary

Figure 30 represents a comparison of the energy consumption for each individual strategy that was simulated. The energy consumption presented here is aggregated for the entire test regimen (6 consecutive UDDS driving cycles). For both the load following and engine optimal approaches, the fuel consumption of the vehicle is reduced in going from the maximum depletion case to the blended case. The engine optimal strategy provides marginally lower fuel consumption over the load following algorithm. The electrical energy consumption is slightly lower for both of the engine optimal cases, due mainly to the excessive charging of the energy storage system during engine operation. An important consideration when considering energy consumption (particularly fuel consumption) is that due to PSAT limitations, the simulations only predict hot start energy consumption.

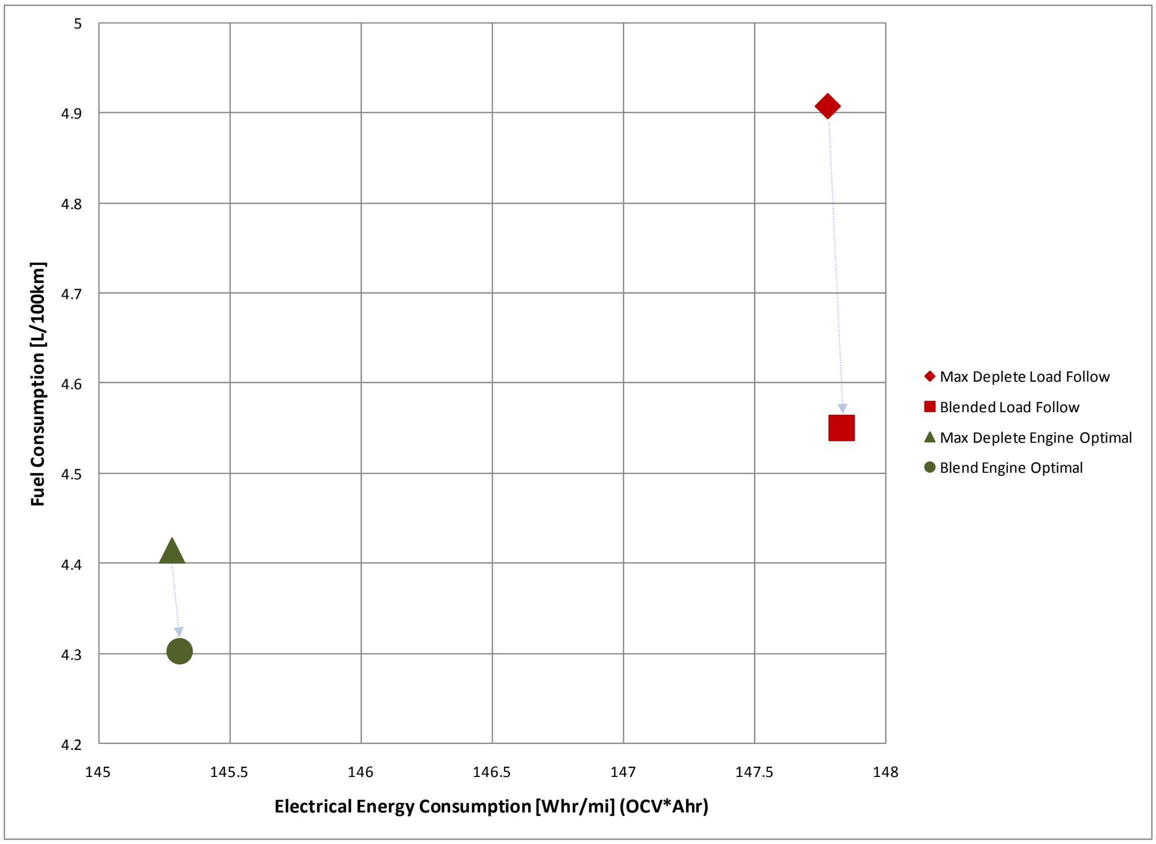


Figure 30. Simulation energy consumption results for Phase I

Phase I Experimental

Model validation

Simulation data produced as a result of Phase I was used in conjunction with corresponding MATT test data from the APRF to perform validation of the PSAT model. It is important to note that a rigorous validation of the PSAT model is not required, particularly since the model does not have the capability of predicting (engine-out or tailpipe) emissions, thermal aspects of the engine and exhaust aftertreatment system, or catalytic conversion efficiencies. The PSAT model is used to rapidly develop, verify, and debug control strategy for proper functionality prior to testing on real hardware.

The conventional mode was simulated and tested in order to validate the performance of the engine model and respective fuel use map. Figure 31 illustrates predicted versus actual engine speed after tuning of the model had been performed for the first 800 seconds of the UDDS drive cycle. There is a discrepancy in engine speed at approximately 570 seconds into the cycle. This is due to the difference in the shifting algorithm used in the PSAT model and that used on MATT. Figure 32 and Figure 33 represent the same portion of the UDDS, depicting predicted versus actual engine torque and engine fuel rate, respectively. The results indicate a good fit of the data, and validate the ability of the PSAT model to predict the performance and efficiency of the engine. The predicted fuel economy of the PSAT model for this data was 24.68 MPG, and the actual hot start fuel economy as produced by MATT was 25.28 MPG. This represents a difference of only -2.4%.

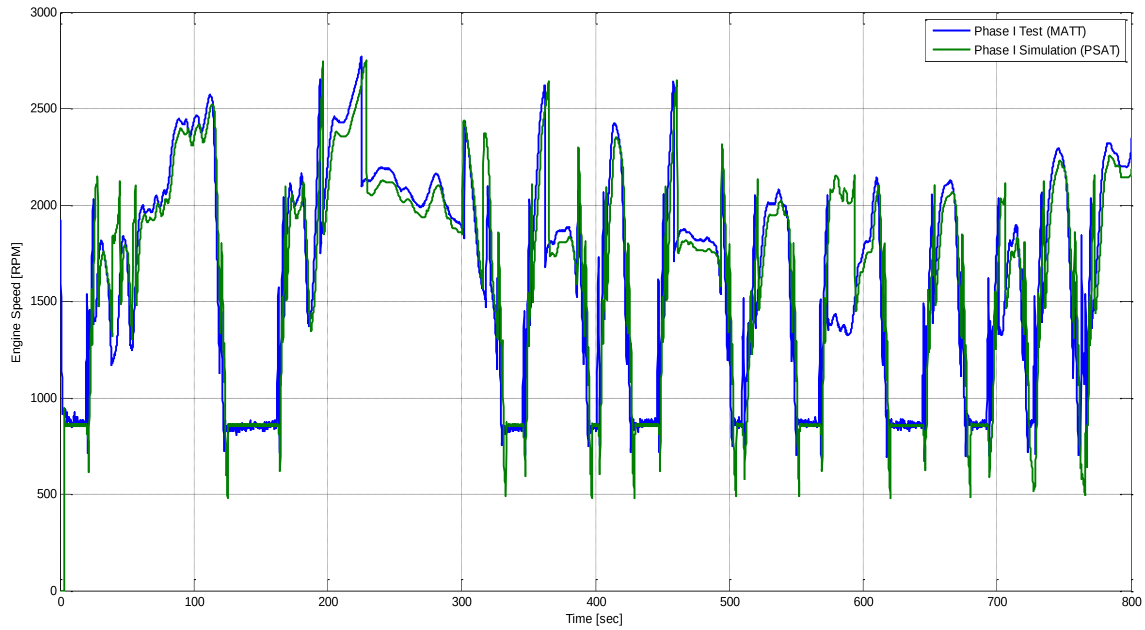


Figure 31. Conventional - engine speed comparison of simulation to actual test data

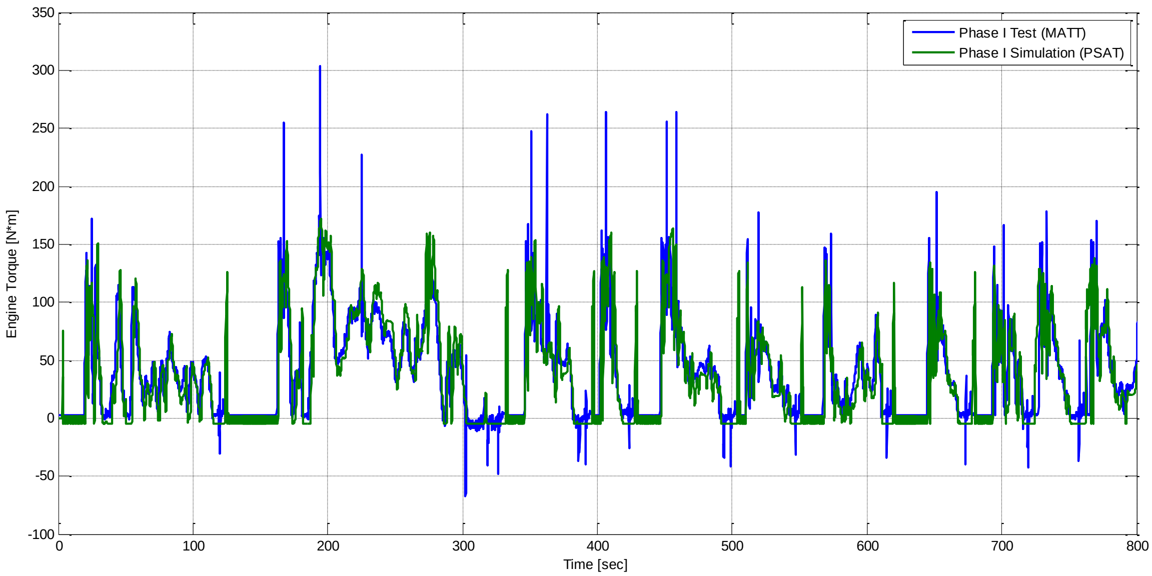


Figure 32. Conventional - engine torque comparison of simulation to actual test data

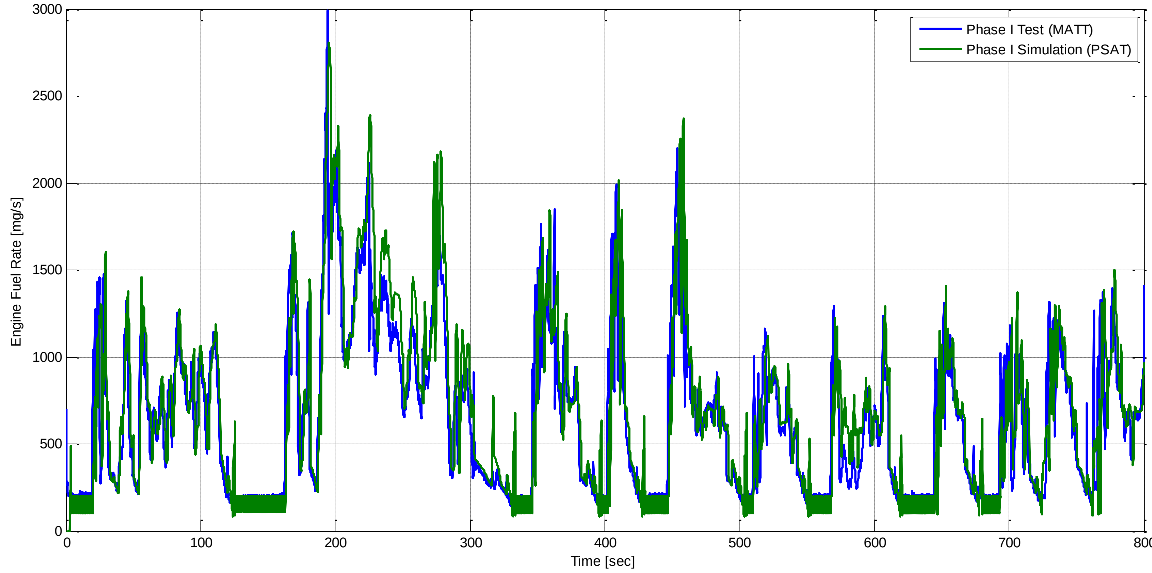


Figure 33. Conventional - engine fuel rate comparison of simulation to actual test data

The energy storage system model was validated using simulated and actual test data for the load following HEV case, since this control approach does quite a bit of charging and discharging of the HV battery pack. Figure 34 shows the predicted versus actual energy storage system voltage for the same 800 second portion of the UDDS drive cycle. Good correlation is achieved, with a few notable exceptions. In certain places, the voltage is not predicted as well as it could be. This is due in part to the engine starting at slightly different times during the test because of high power demands associated with gear shifting on MATT. The driver model used in MATT is tuned to a point where shifts cause torque fluctuations, resulting in rapid changes in the driver response.

Figure 35 illustrates the validation of the battery pack current against MATT data. Just as with the pack voltage, the current is slightly off certain portions of the drive cycle due to unexpected engine starts and differences in requested charging power. This is shown more clearly in Figure 36 where the SOC of the battery pack is plotted for both the test and simulation cases. Around the 50 second mark, the engine starts in the simulated case, and the VSCM commands a lower charging rate. From the test data, the SOC dips even lower until the engine comes on. Due to the lower SOC, the VSCM commands a higher charging rate, as indicated by the steeper slope of the SOC in this region for the test case.

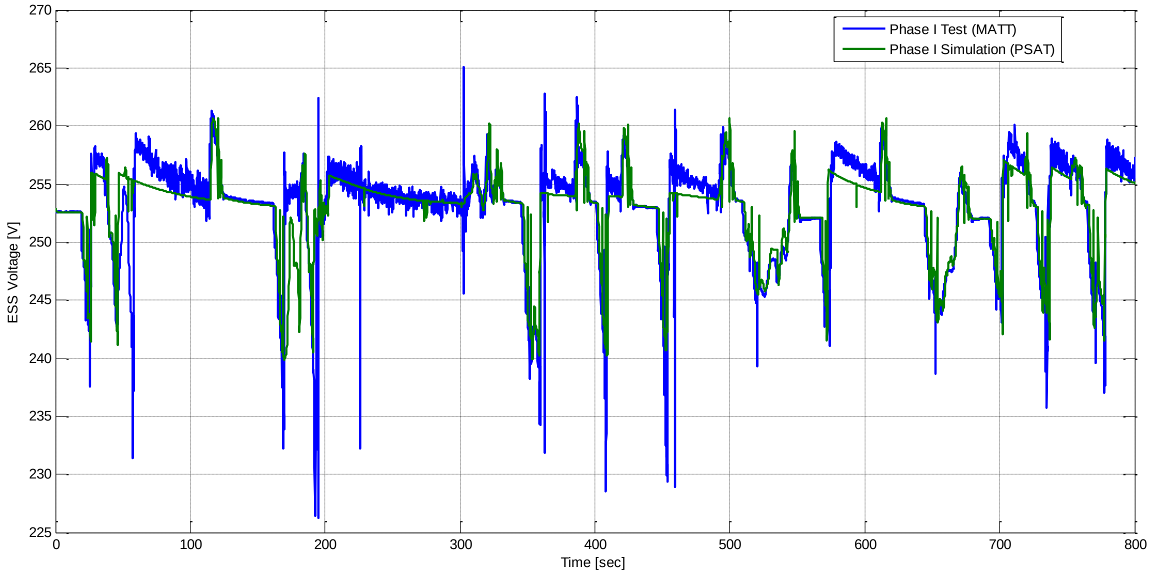


Figure 34. Load following HEV – energy storage system voltage comparison of simulation to actual test data

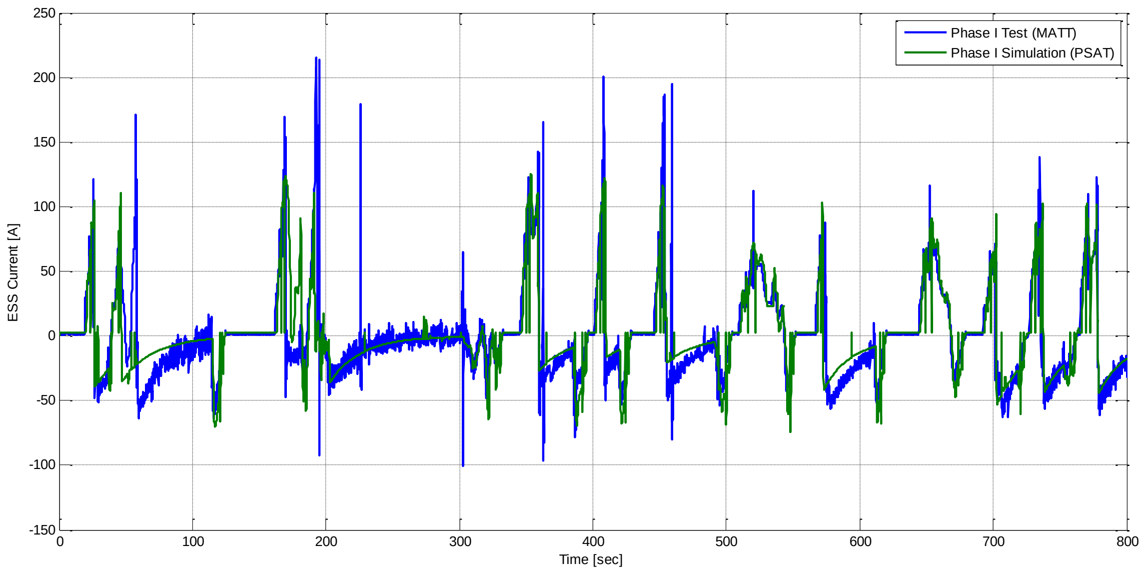


Figure 35. Load following HEV – energy storage system current comparison of simulation to actual test data

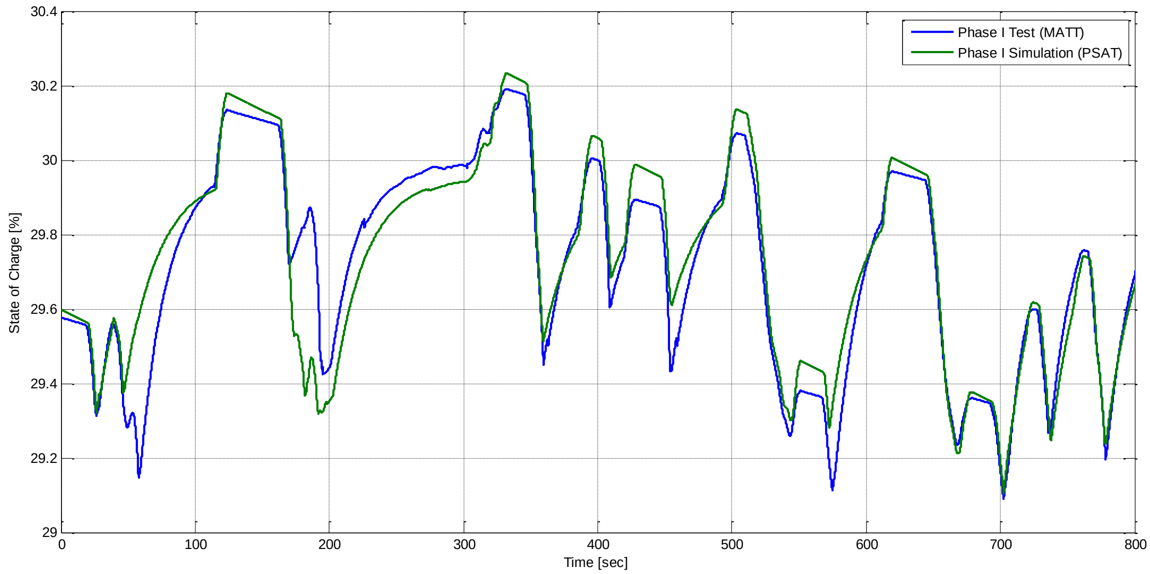


Figure 36. Load following HEV – energy storage system SOC comparison of simulation to actual test data

The traction motor model was validated using simulated and actual data for engine optimal HEV operation. The engine optimal HEV data was chosen here since the traction motor is controlled to operate frequently in both motoring and generating modes. Figure 37 illustrates the validation of the rotational speed for the traction motor model. There is strong agreement of the simulation to the actual test data, and it resembles the engine speed trace shown previously. The traction motor and engine are directly coupled during HEV operation, and hence operate at the same rotational speeds. Figure 38 represents a comparison of traction motor torque for the same time span for a portion of the UDDS. It is important that the traction motor model accurately predict the applied torque during generating (both for charging during engine optimal operation and for regenerative braking events) and motoring while in electric only or electric launch operation, respectively. Again, very strong agreement in the prediction is illustrated.

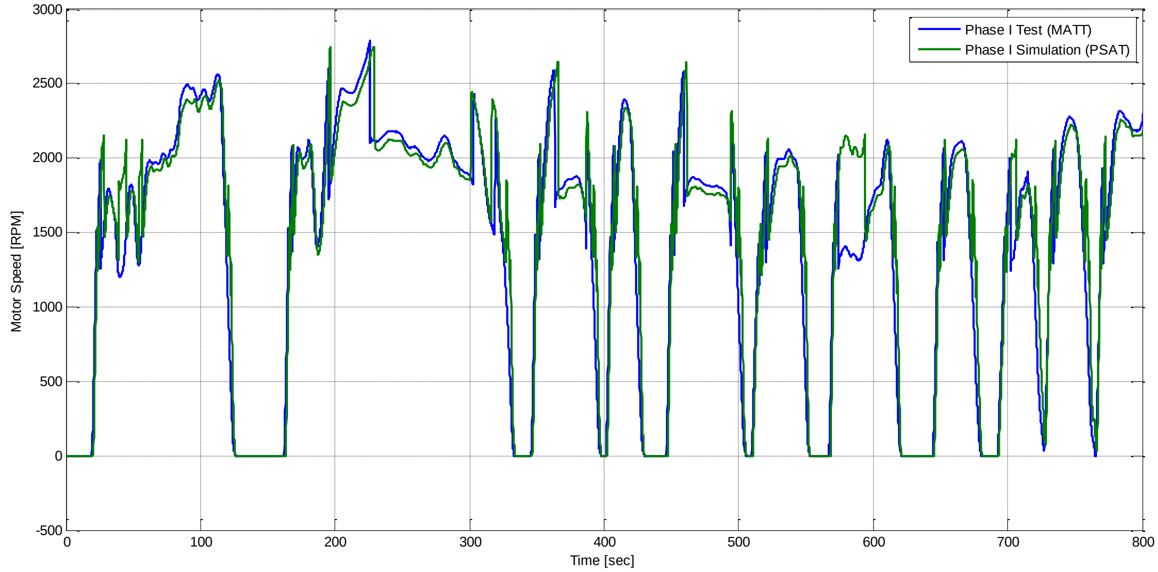


Figure 37. Engine optimal HEV – traction motor speed comparison of simulation to actual test data

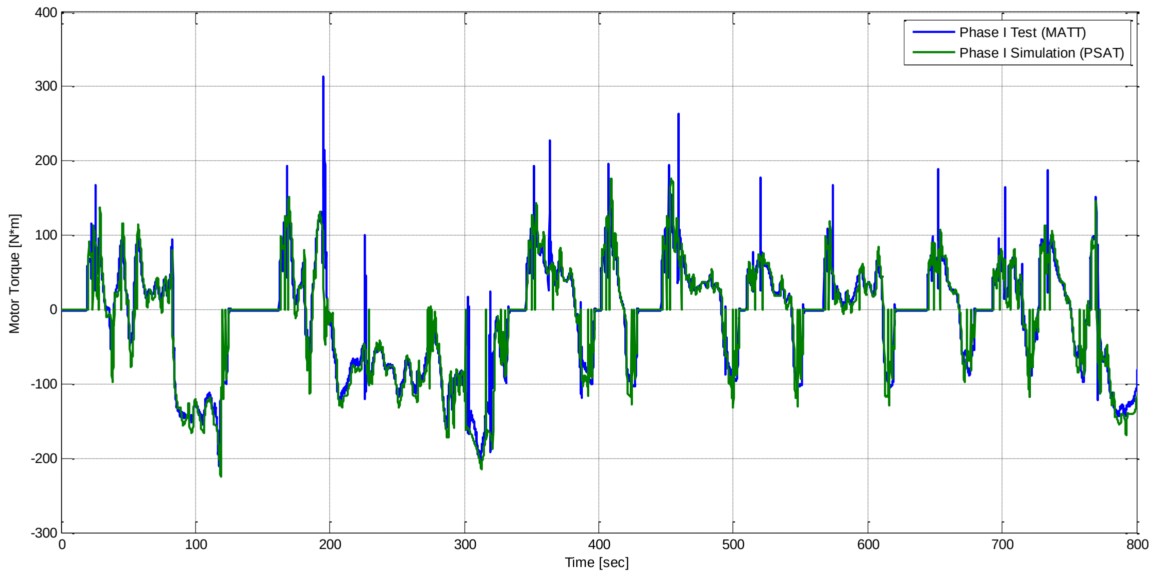


Figure 38. Engine optimal HEV – traction motor torque comparison of simulation to actual test data

Phase I Energy Consumption Results

Figure 39 represent the total test cycle energy consumption results for Phase I. A reduction in fuel consumption is shown in transitioning from the maximum depletion load following strategy to the blended load following strategy, with a slight increase in electrical energy consumption. A small increase in fuel consumption is shown when moving from the maximum depletion engine optimal strategy to the blended engine optimal strategy, with a corresponding increase in electrical consumption.

Figure 40 is an energy consumption plot that summarizes the PHEV maximum depletion operation of the test platform over the individual UDDS drive cycles. This type of energy consumption plot represents the consumption results for each cycle of the complete test series. Each data point represents one (1) complete UDDS cycle in the test series. Note that some data points may fall on top of each other. The test progresses from right to left in these plots. Conventional cold and hot start data are also included as reference points. The points where the lines cross the *x*-axis represent all electric operation, while the *y*-intercept represents charge-balanced operation. Note that conventional operation also falls on the *y*-axis since this type of control strategy is a special case of charge-balanced operation. Any point that falls in between these points is considered to be in the CD region. The closer the line gets towards the origin, the more efficient the vehicle operation is.

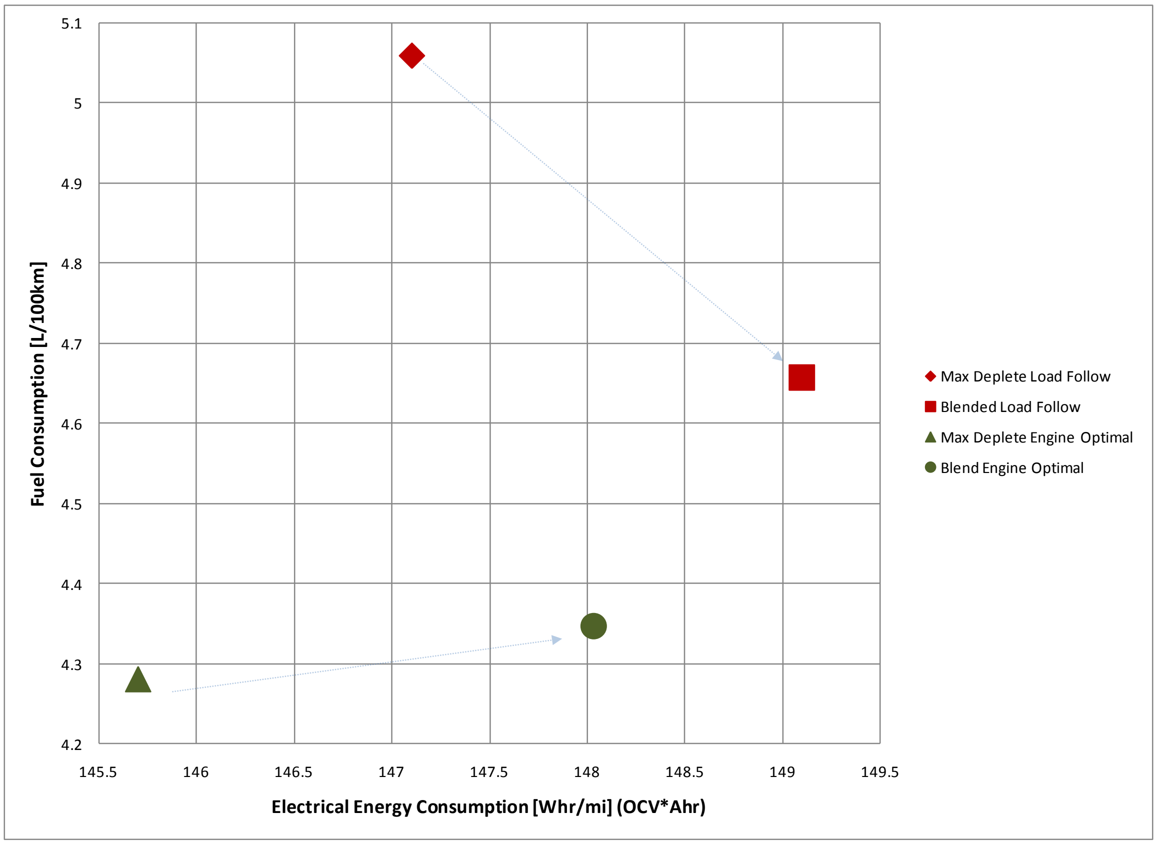


Figure 39. Phase I aggregate energy consumption test results

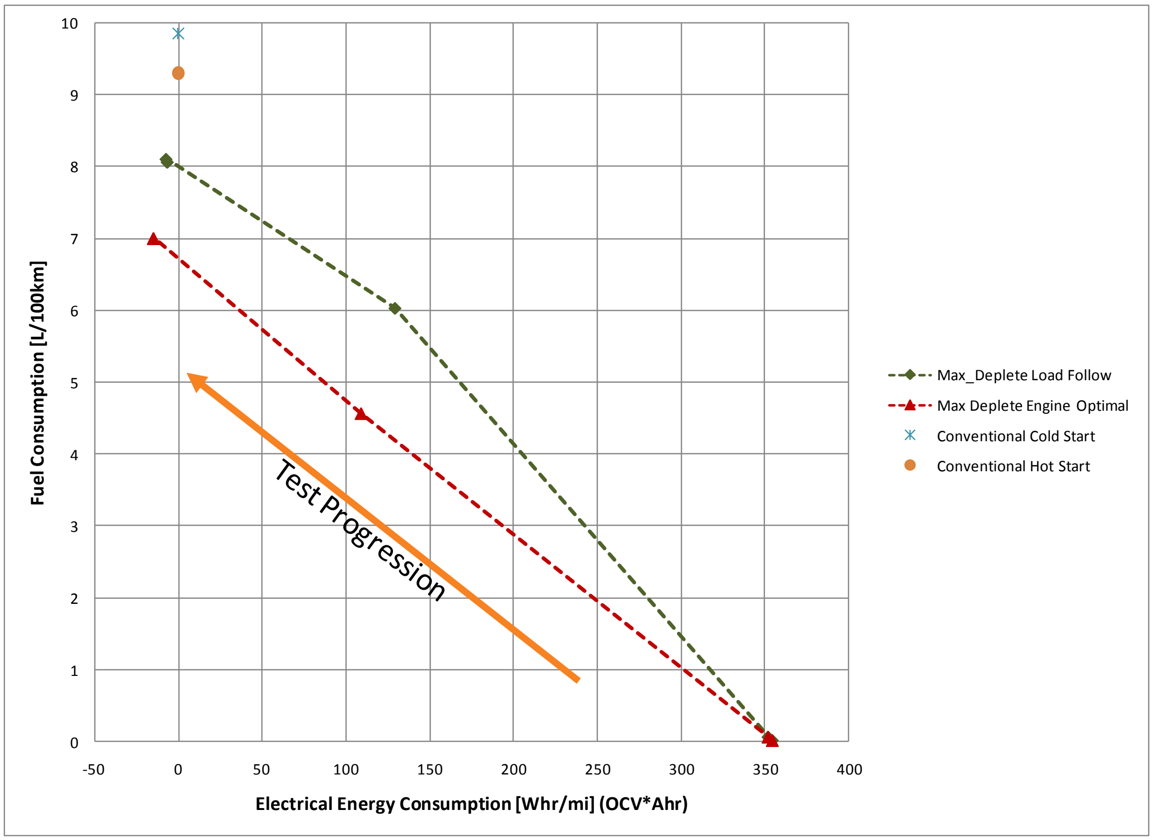


Figure 40. Phase I energy consumption for maximum depletion PHEV operation

The slight bend in the data in this CD region is due to the cold start of the engine, and the extra fuel consumed by the engine during open loop fuel control as the engine warms up to normal temperatures. Clearly, the engine optimal CS control algorithm is more fuel efficient, as shown in the figure.

Figure 41 depicts the energy consumption results for the PHEV blended cases, both for engine optimal and load following CS operation. There are more visible data points in the CD region due to the engine being used more frequently throughout the SOC range of the energy storage system. The engine cold starts are more pronounced in this plot since they happen near the beginning of the test regimen. The “L–shaped” bend on the right represents the cold start and the extra fuel required during open loop operation as the engine warms up to normal temperatures. The first three (3) points on the far right are identical, since the blended methodology relies upon a CP strategy during CD operation. The divergence as the data approaches CS operation is due to the change in operating philosophy as the engine optimal approach opts for engine optimal operation for the CS region only.

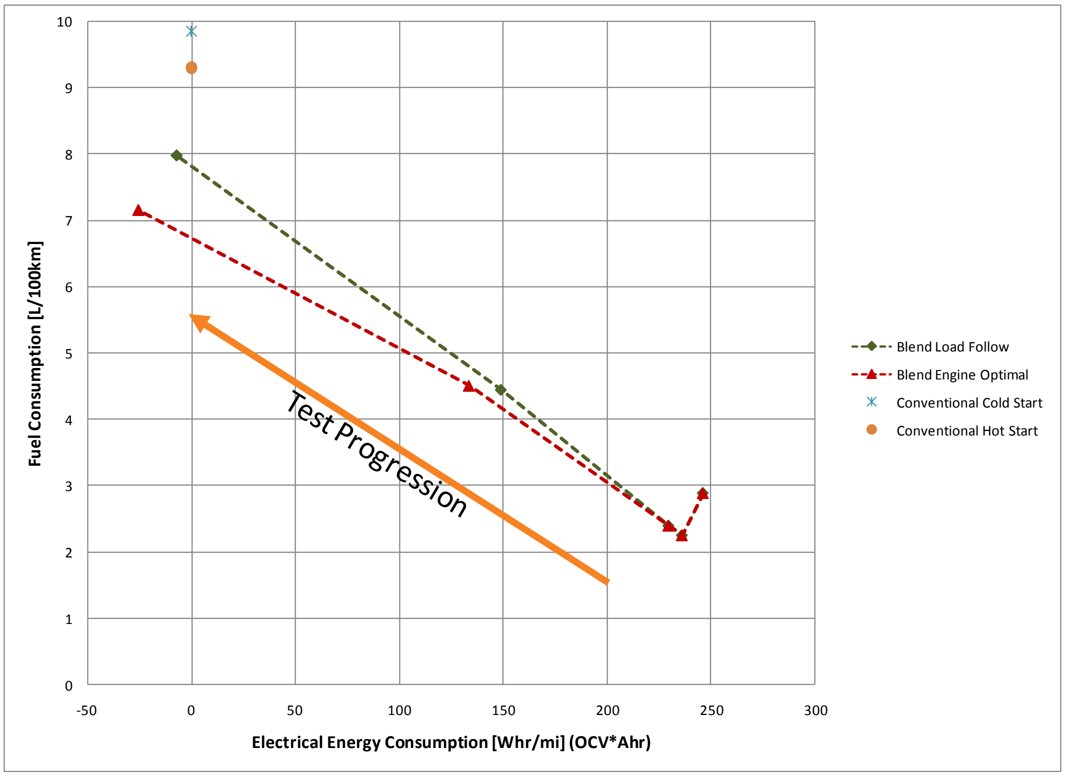


Figure 41. Phase I energy consumption for blended PHEV operation

Phase I Tailpipe Emissions

Tailpipe emissions were collected and measured during each set of tests. Figure 42 represents an overall summary of the regulated tailpipe emissions, reported on a grams per mile basis, for each of the four (4) strategies evaluated. The *x*-axis represents NO_x emissions, while the *y*-axis represents NMOG emissions. The conventional case, i.e. running MATT in a conventional "engine only" mode with the same set of dynamometer target coefficients, is given as a point of reference to show the test unit is capable of attaining SULEV emissions. As expected, the maximum depletion cases provided the highest level of tailpipe emissions. Moreover, the maximum depletion engine optimal strategy created much higher concentrations of NO_x emissions as compared to the blended strategy. This is due primarily to the first engine starting event, where the engine is started cold and commanded to produce very high output torque immediately.

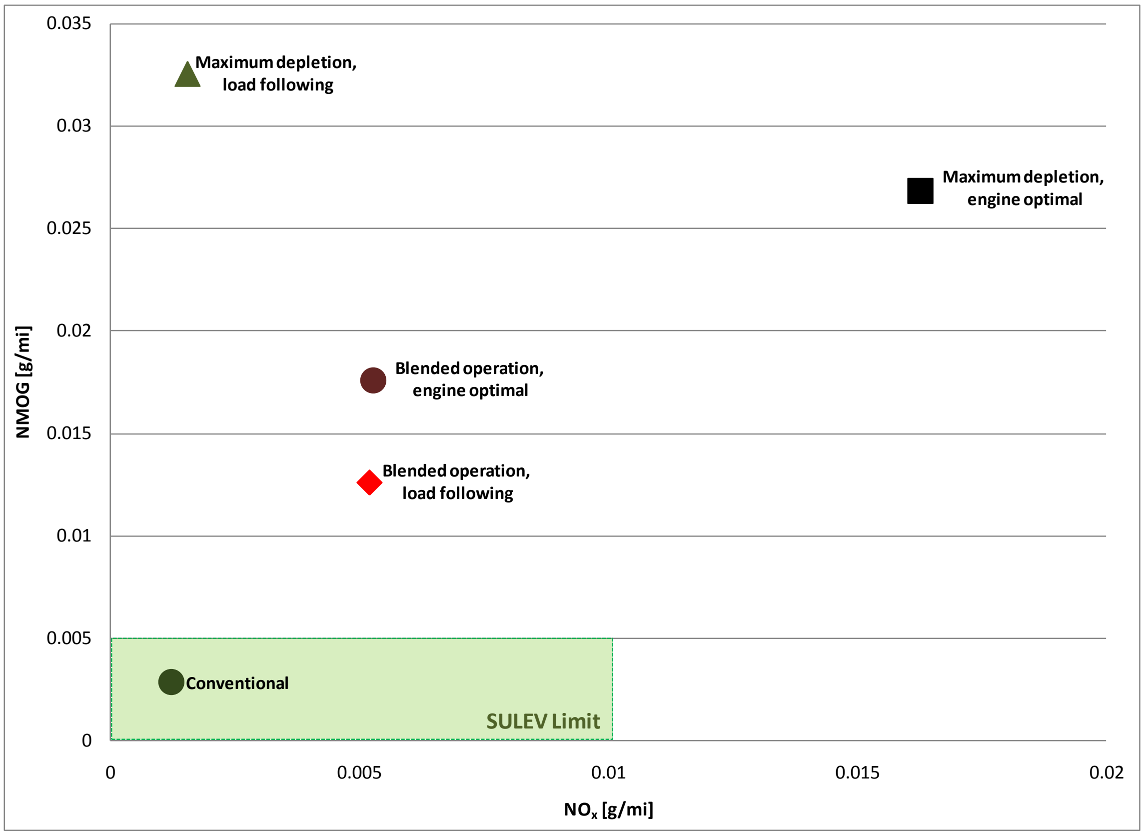


Figure 42. Total emissions summary for Phase I testing

Phase I Maximum Depletion Emissions Results

In order to understand the total emissions results presented earlier in Figure 42, cycle by cycle emissions for each respective UDDS drive schedule are examined. Figure 43 illustrates THC emissions on a per cycle basis. For the maximum depletion strategy, no emissions occur during the first two (2) consecutive UDDS drive cycles due to all electric operation, as shown by the data points on the *x*-axis around 350 W*hr/mile. During the third test, both the load following and maximum depletion strategies exhibit large spikes in THC emissions. This is simply due to the first (cold) engine start. Each control strategy approach reaches the lower SOC threshold of 30% during this test, and transition into full CS operation. The last three (3) cycles are repetitive full CS runs, and consequently produce far lower emissions due to normal operating conditions achieved for the engine.

Figure 44 represents the cycle by cycle NO_x emissions results for both maximum depletion cases. The same trend is evident here just as for THC emissions. The first engine start produces higher emissions that taper as full CS operation is achieved. The effects of engine optimal operation are readily apparent here. During the first engine start, the engine is commanded immediately to a very high load where efficiency is at its peak. Clearly, this operating strategy is not appropriate from an emissions perspective.

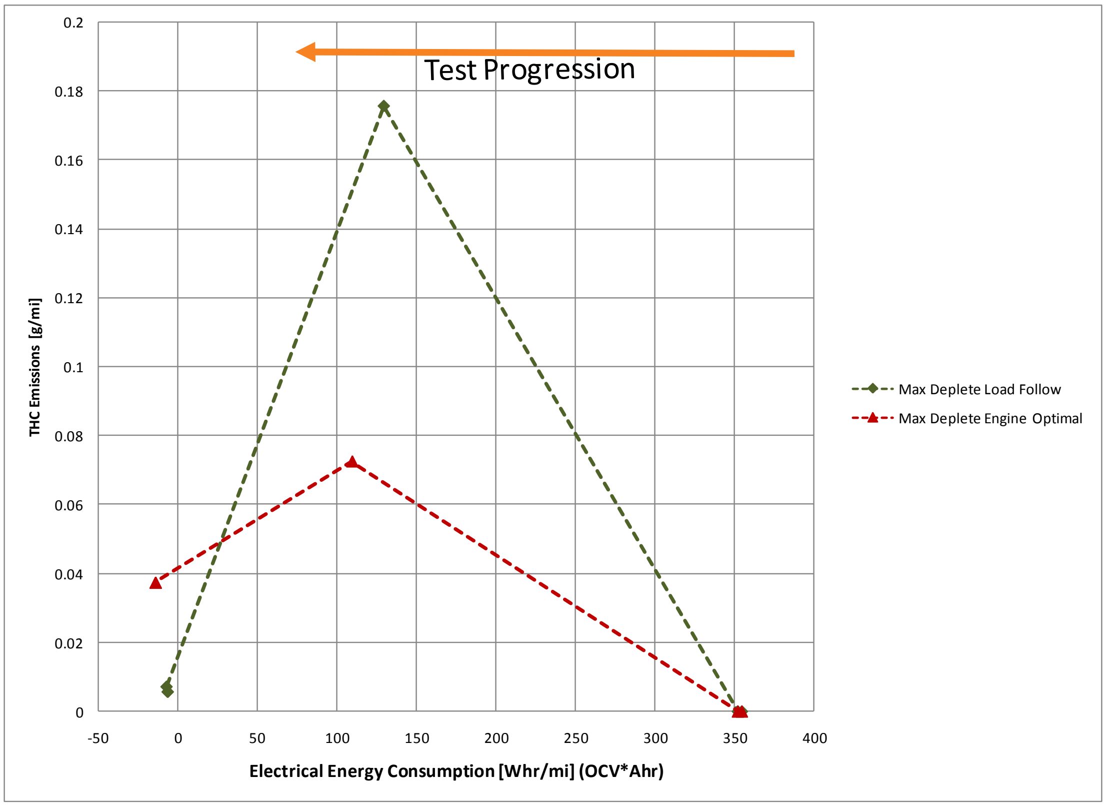


Figure 43. Summary of cycle THC emissions, Phase I maximum depletion PHEV operation

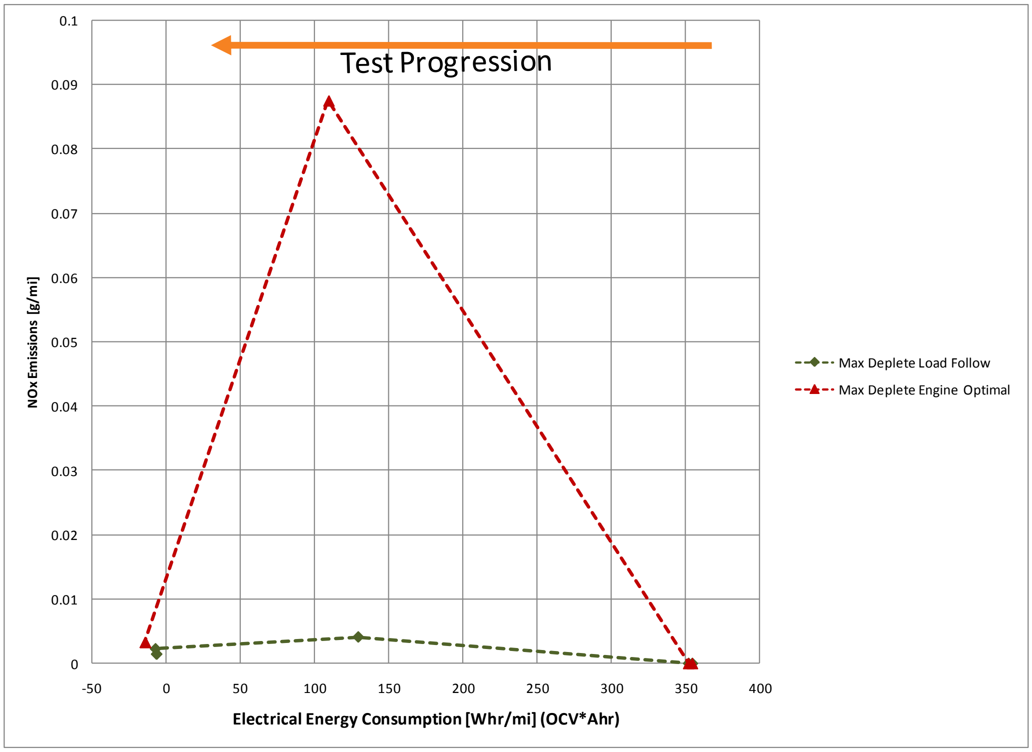


Figure 44. Summary of cycle NO_x emissions, Phase I maximum depletion PHEV operation

NO_x emissions were found to be much less for the load following approach. Very high, sustained torque is not requested of the engine during this cold start instance.

Figure 45 shows the cycle to cycle CO emissions data for the maximum depletion trials of Phase I. These plots exhibit a slightly different trend than the THC and NO_x emissions results. The initial cold start of the emission produces high CO emissions for both the load following and engine optimal cases. However, as the SOC decreases and the powertrains approach full CS operation, the emissions do not fall back down. Instead, the CO emissions for the engine optimal case fall only slightly, while the CO emissions actually increase more for the load following case. The rise of CO emissions has been determined to be directly linked to the number of engine starts for this test platform, as shown in the inset of Figure 45 where cumulative CO emissions and engine speed are shown. A slight increase in CO occurs with every engine start, due most likely to the non-hybrid calibration of the engine and key cycling. The CO emissions are less for the engine optimal case simply due to less engine starts during the cycle.

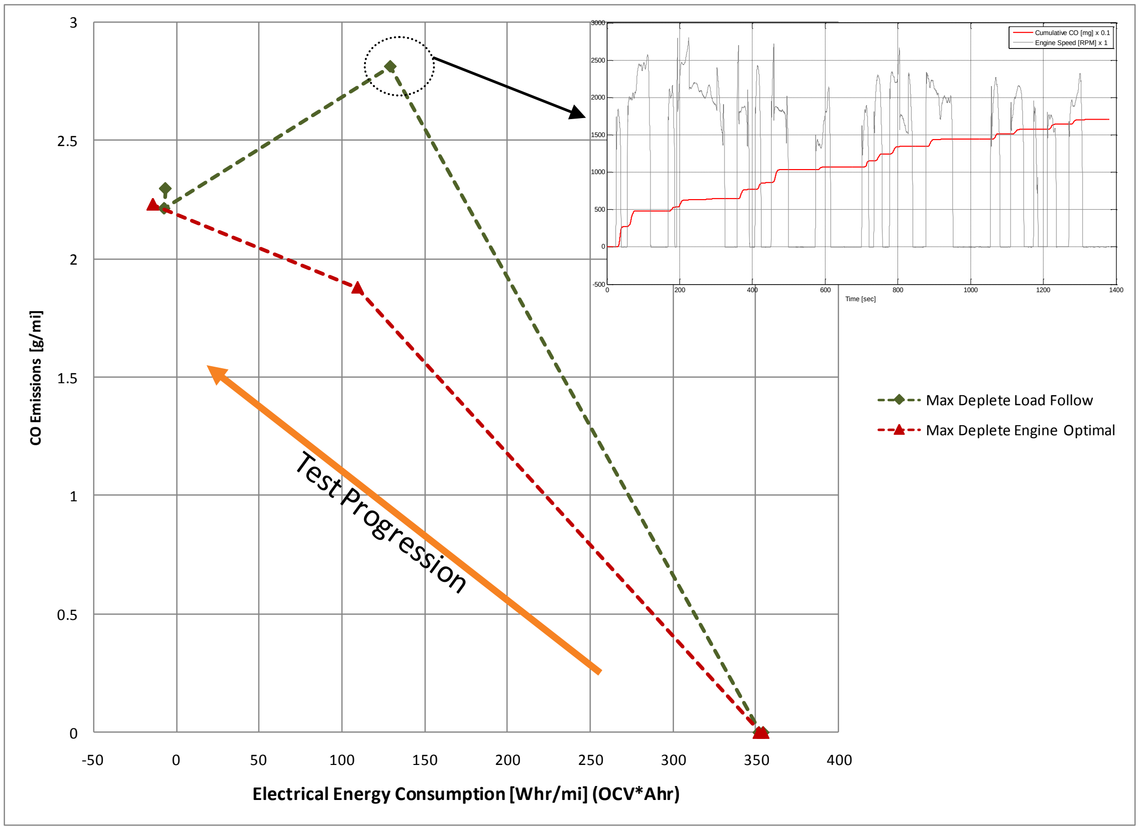


Figure 45. Summary of cycle CO emissions, Phase I maximum depletion PHEV operation

Phase I Blended Strategy Emissions Results

Similar plots were produced for the blended cases in order to understand the fundamental differences between the emissions signatures for the Phase I maximum depletion and blended strategies. Figure 46 represents a summary of the cycle by cycle THC emissions data for the blended approach. Since the engine is used more throughout the test sequence, the cold start is evident on the far right as the highest spike in THC emissions. The THC emissions tend to drop dramatically as engine temperatures approach normal conditions for subsequent test runs, and level out as full CS operation is achieved. Recall that the engine is controlled to operate in a CP mode until the transition SOC is reached. For this reason, the first three (3) data points starting from the right are identical for the load following and engine optimal approaches.

The emissions then diverge for each strategy as the transition to CS operation is attained in the test. However, both strategies produce a slight increase in THC emission during the transition. This can be attributed to the fact that the engine is being operated more often during the transition, and the emissions are reported on a grams per mile basis. The engine optimal strategy produces higher emissions during full CS operation, while the load following tends to fall off to acceptable values. The engine optimal case produces higher THC emissions due to the high loading imposed immediately upon an engine start.

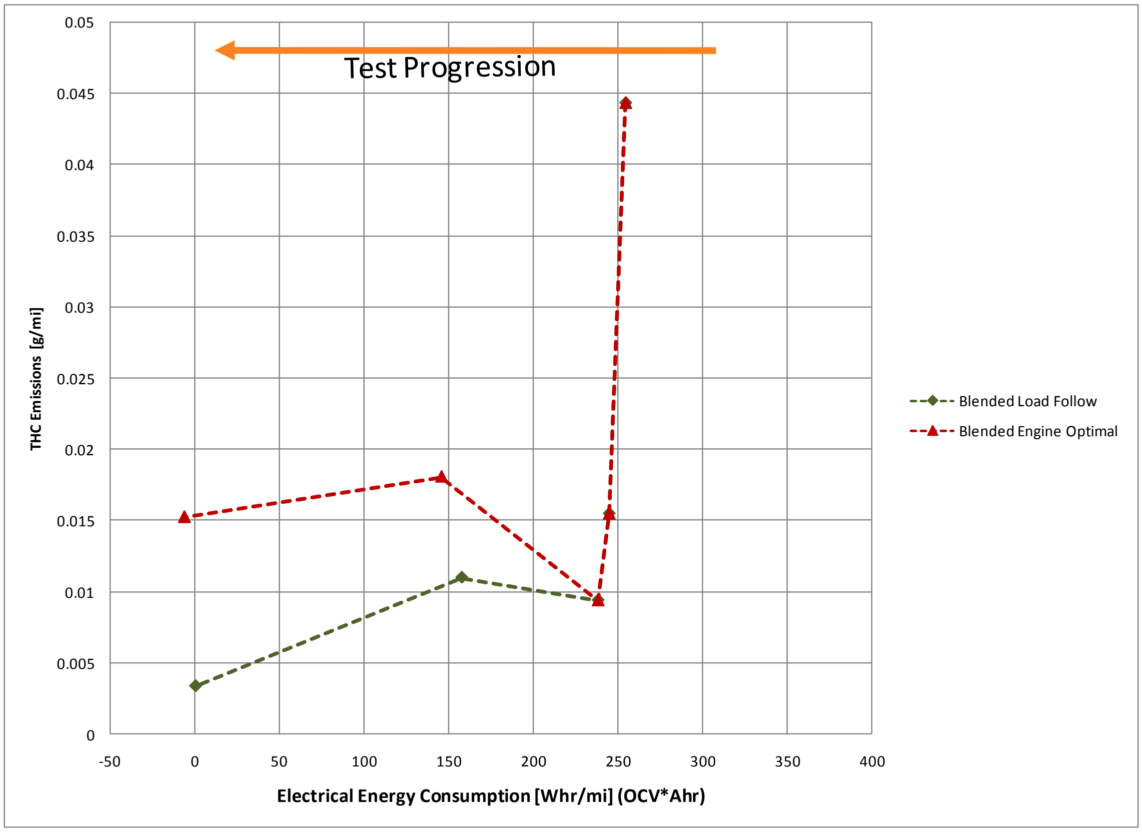


Figure 46. Summary of cycle THC emissions, Phase I blended PHEV operation

Figure 47 summarizes the cycle NO_x emission data for the Phase I blended tests. The peak in NO_x emissions during the second test does not follow the expected trend, since the peak should occur during the first test cycle as a result of the first engine start. Figure 48 illustrates the engine torque, mass flow rate of NO_x, and pre-catalyst temperature for the first two (2) cycles of the blended test. Here, an unexpected engine start during hill #1 of the UDDS occurs in cycle 2, resulting in a lower torque demand. The engine starts during hill #2 of cycle 1, at a very high torque demand. This high demand, coupled with a cold engine and exhaust aftertreatment system, creates a larger spike in NOx emissions than during the first start of cycle 2. Another important item observed from this plot is that the exhaust gas temperature has cooled almost completely back to "cold" conditions at the beginning of the second test.

Figure 49 summarizes the Phase I blended strategy results for CO emissions. Typical behavior is exhibited here, with a high spike, shown to the far right of the plot, during the first cold engine start. The CO emissions drop sharply during the second cycle, and then begin to steadily increase during subsequent cycles of the CD region. This is due in part to the number of engine starts that increase as operation transitions out of the CD region into the full CS region. As described earlier, the CO emissions for the load following case are higher during full CS operation due to the higher number of engine starting events.

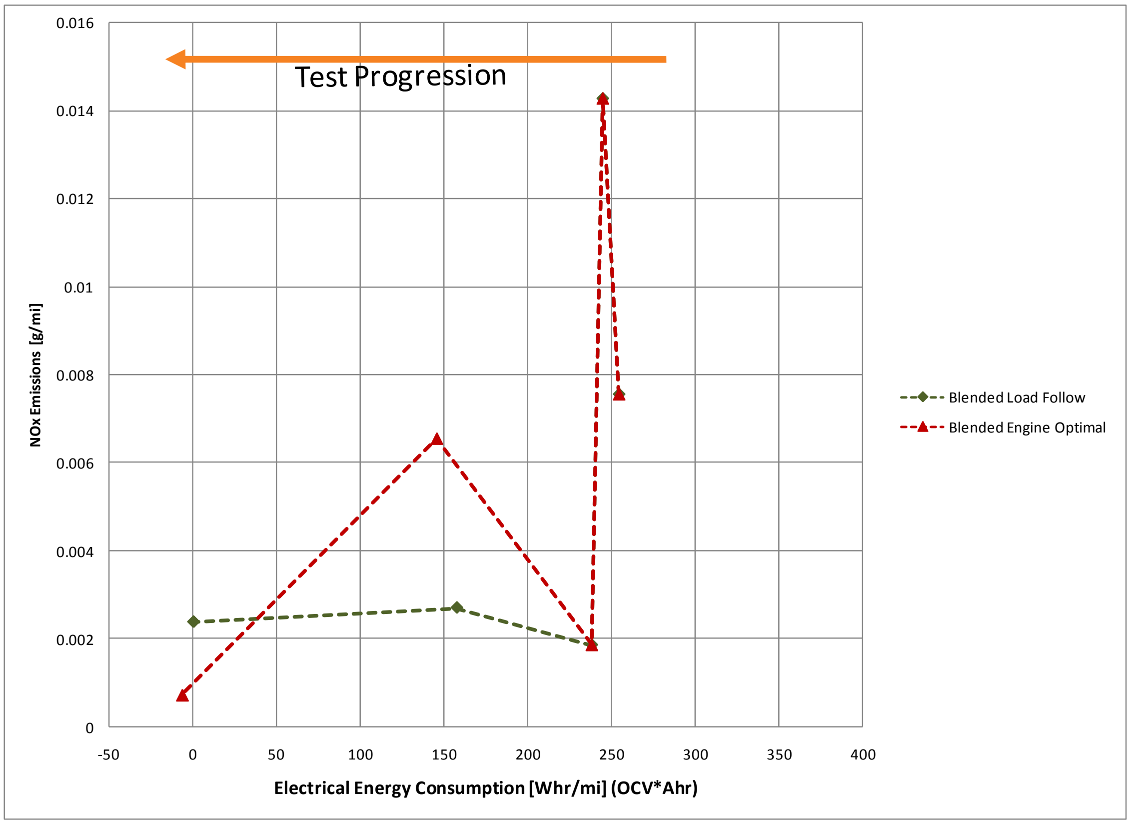


Figure 47. Summary of cycle NO_x emissions, Phase I blended PHEV operation

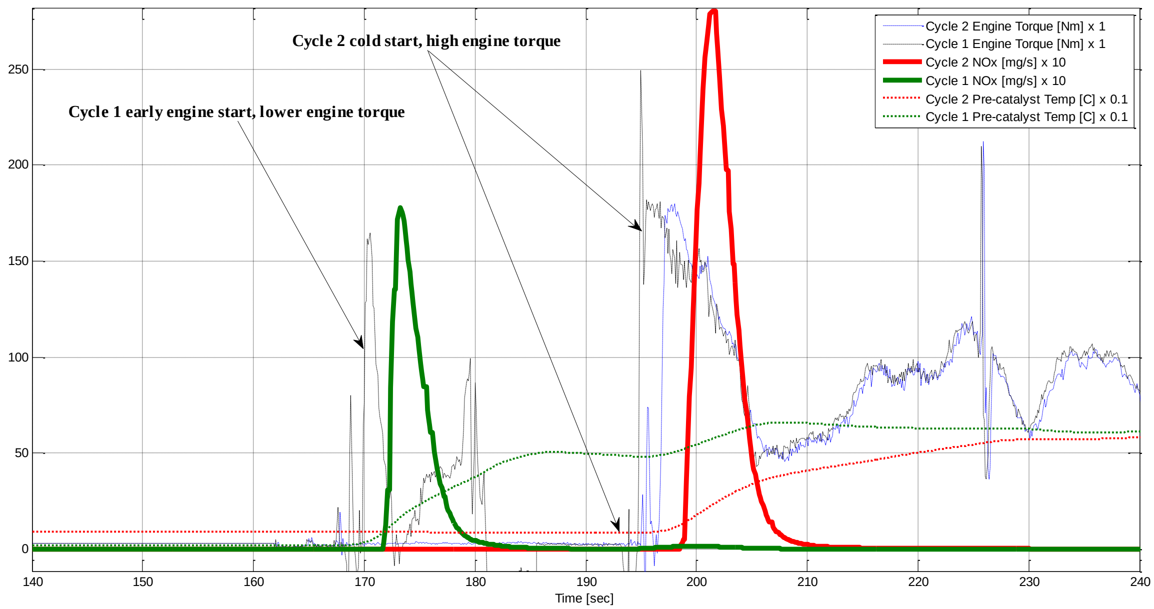


Figure 48. Explanation of NO_x emissions during Phase I, Cycle 2 of the blended load following test

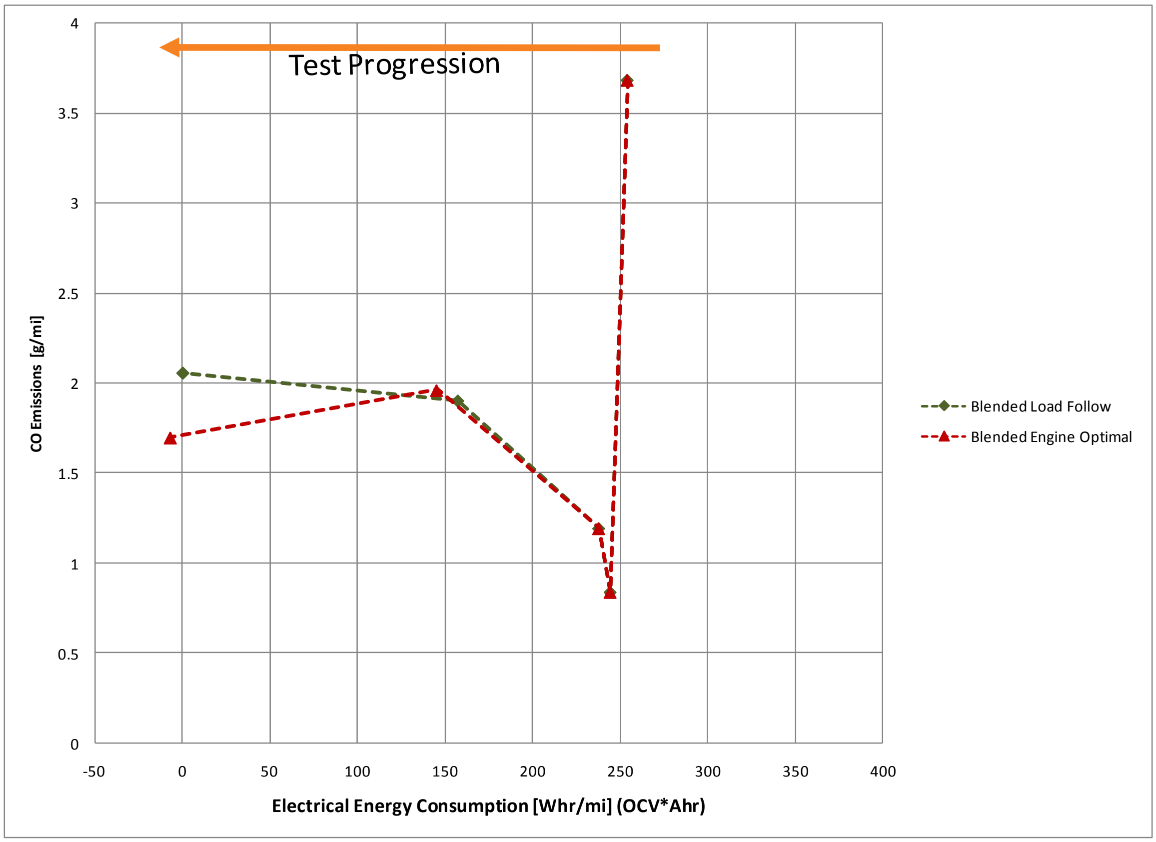


Figure 49. Summary of cycle CO emissions, Phase I blended PHEV operation

Chapter 4: Phase II Research

Analytical

Phase I Data Analysis

Identification of emissions control restraints

In order to understand what the most influential operating characteristics are with respect to emissions, the conventional vehicle operation was first examined. As was previously shown in Figure 42, conventional operation offered the lowest tailpipe emissions over the test cycle. The first (cold) start of the engine characterizes the emissions footprint of most vehicles. Therefore, cold start data from a conventional vehicle test was examined to gain a better understanding of what the critical parameters associated with emissions production are. The blue colored curves in Figure 50 represent the actual temperatures of the primary and secondary catalysts, respectively. The primary catalyst heats very quickly, and reaches a normal operating temperature range within the first 100 seconds. However, the secondary catalyst takes substantially longer, around 275 seconds into the UDDS cycle. The engine coolant temperature, shown as a red dashed line in the figure, tracks very closely with the secondary catalyst temperature. The dark green line represents the actual integrated engine power during the test. The figure shows that the cumulative engine energy approaches around 3 MJ at the point when both catalysts, as well as the engine coolant temperature, are all within normal operating ranges.

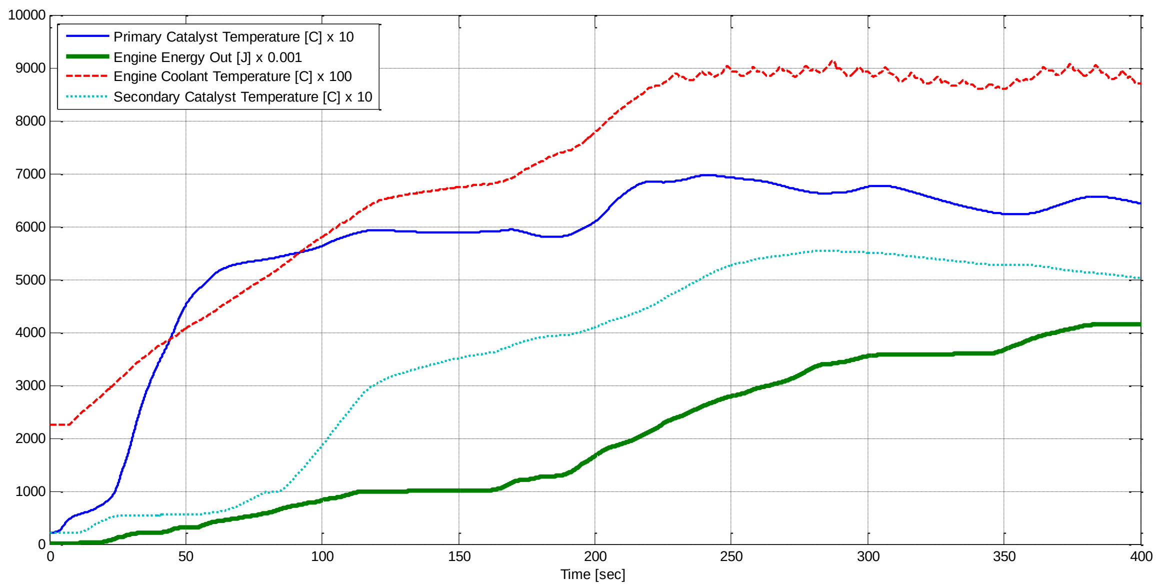


Figure 50. Cold start catalyst and coolant temperature profiles for conventional operation

This information will be used to develop an engine warm up strategy for the Phase II implementation of the control strategy.

When modeling HEVs, one of the most often overlooked aspects of engine operation is when the engine is commanded to turn on and produce torque. The engine is turned on when extra torque is needed for propulsion, or when the energy storage system is at a relatively low SOC. This occurs at times when the engine speed is reasonably high when it is engaged (greater than idle speed), and commanded to produce torque instantly. If the engine is requested to perform in this manner from a “cold” state, THC and NO_x emissions can be substantial. Figure 51 represents actual test data of such engine operation during the maximum depletion load following control strategy. The engine is engaged and ramped quickly to high speed, and commanded almost instantly to produce torque to provide traction power and charge the energy storage system. The result is a large spike in NO_x production, shown in the figure with a slight transport delay due to sampling through the CVS system to the emissions analyzers.

Figure 52 represents data for the first engine start during Phase I maximum depletion blended operation. Even though the engine produces relatively low power output (on the order of about 10 kW), the torque is requested instantly upon engine start. The result is large spikes of both THC and NO_x emissions.

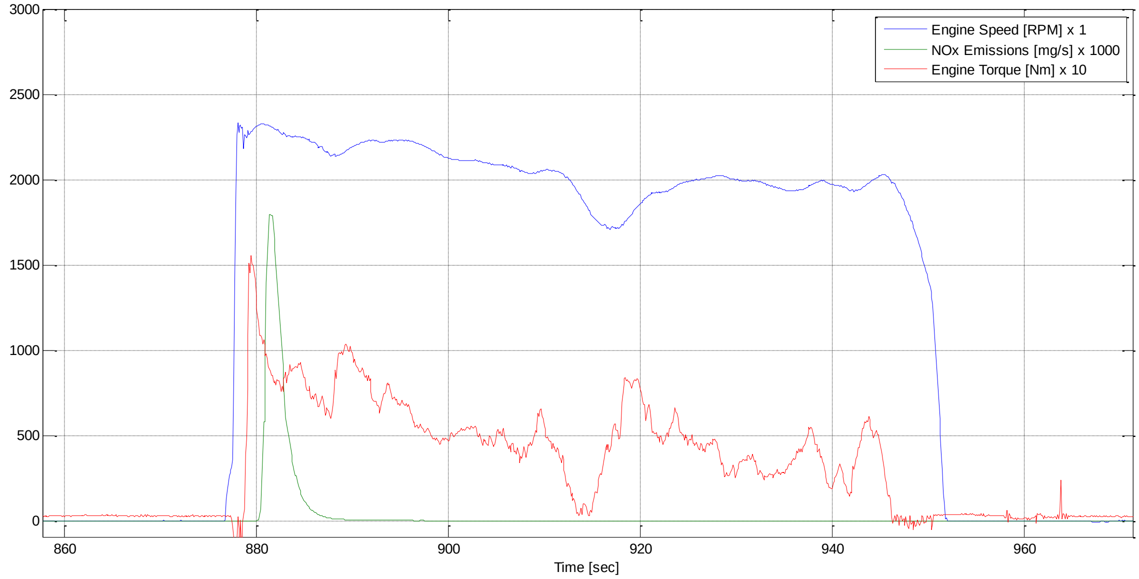


Figure 51. Example of NO_x production during charge sustaining portion of maximum depletion PHEV test

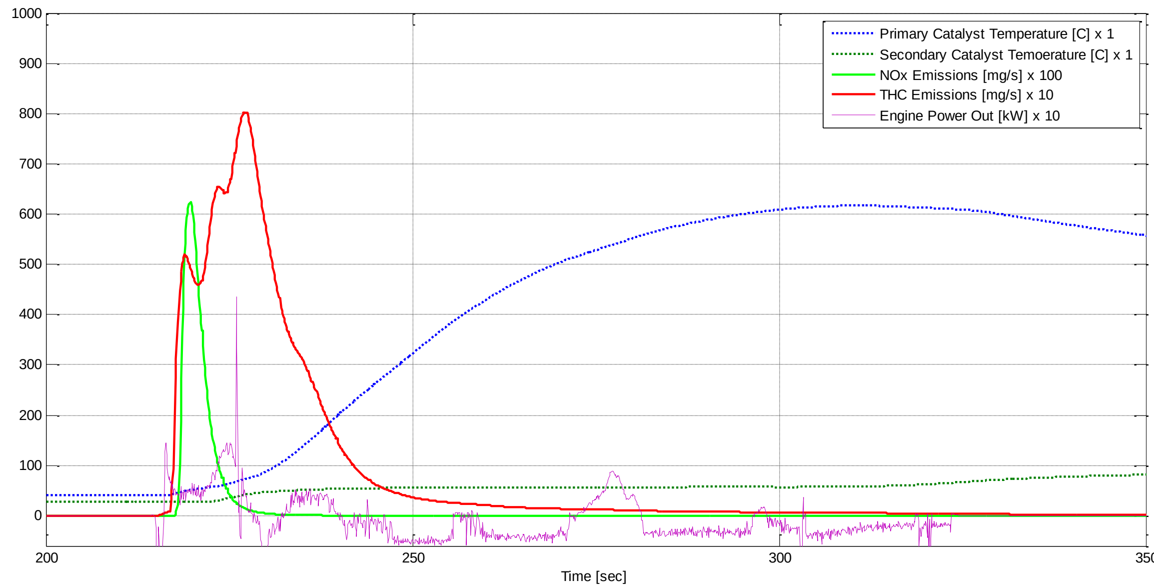


Figure 52. Emissions production for low power first time engine start during Phase I maximum depletion PHEV test

Figure 53 illustrates the first cold engine start and subsequent second engine start during hill #2 of the UDDS for the blended load following data set. THC, NO_x, and CO emissions are shown along with appropriate exhaust aftertreatment temperatures. As the primary catalyst temperature increases during the second engine start, the THC and NO_x emissions are reduced due to catalyst light-off and conversion efficiency rapidly increasing. However, CO emissions are virtually unchanged as far as peak production for each engine start. Cold engine starting coupled with the non-hybrid engine calibration of the engine (repeated key cycling) are credited with the CO production. Another issue apparent in Figure 53 appears during the second engine start. The output torque of the engine is immediately commanded to near maximum output. This type of engine operation exacerbates the THC and CO problem further. NO_x is not affected due to the initial warm up of the engine (as evidenced by the pre-catalyst temperature). Once both primary and secondary catalysts reach normal operating temperatures (> 400°C), all emissions virtually disappear, even for changing engine load.

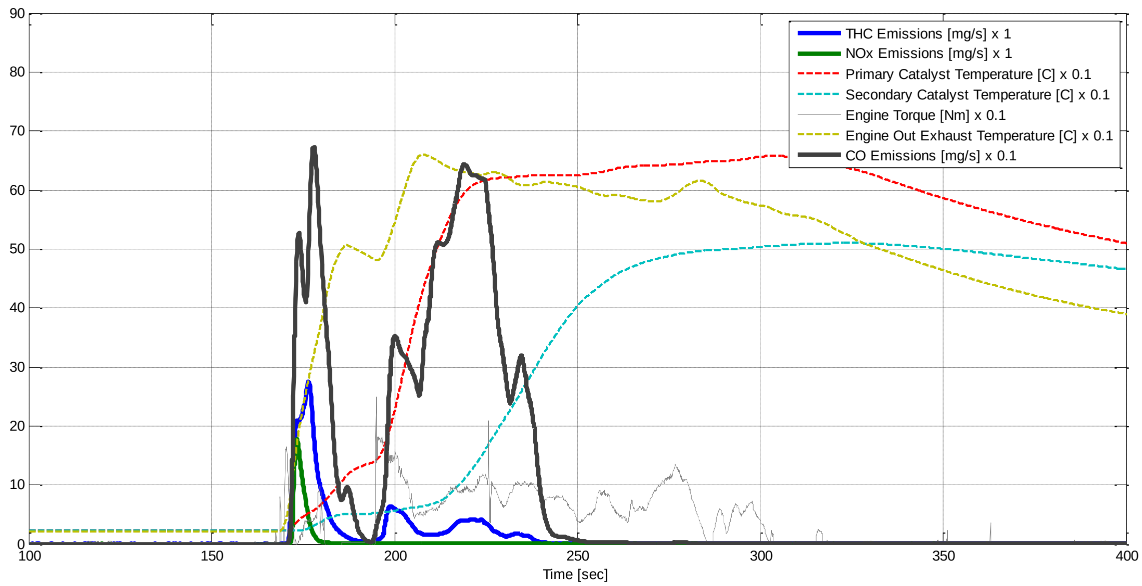


Figure 53. Cold start emissions during Phase I blended load following PHEV test

Control strategy modifications

Engine Pre-Warming Strategy

The maximum depletion cases are addressed first. Here, all-electric operation from key switch on is maintained. However, a smoother transition strategy must be implemented that heats the engine at low loading prior to being relied upon as the primary power source. A key-on engine start strategy is not a desired option, but does provide a sound basis for an engine heating transition strategy in moving from CD mode into full CS operation.

At moderately low SOC values, in this case below 40%, a SOC transition strategy is implemented. A pre-warm up routine has been developed where the vehicle continues to function in a CD mode, relying on all electric power for propulsion. During this transition, the CP mode is activated. Upon reaching an engine start condition, the engine will start and be operated at a constant low torque command, in this case 15 N*m. As a first attempt, the pre-warm up routine is time based, and limited to operate for a total of 120 seconds. The pre-warm up routine resembles a conventional key-on engine start and idle period which is slightly accelerated by applying a light load to the engine to heat critical exhaust aftertreatment components. However, the traction motor is actuated to handle the transient power demands of the operator. PSAT simulation results for this strategy are shown graphically in Figure 54 compared to Phase I results for the same portion of the multiple UDDS drive cycle.

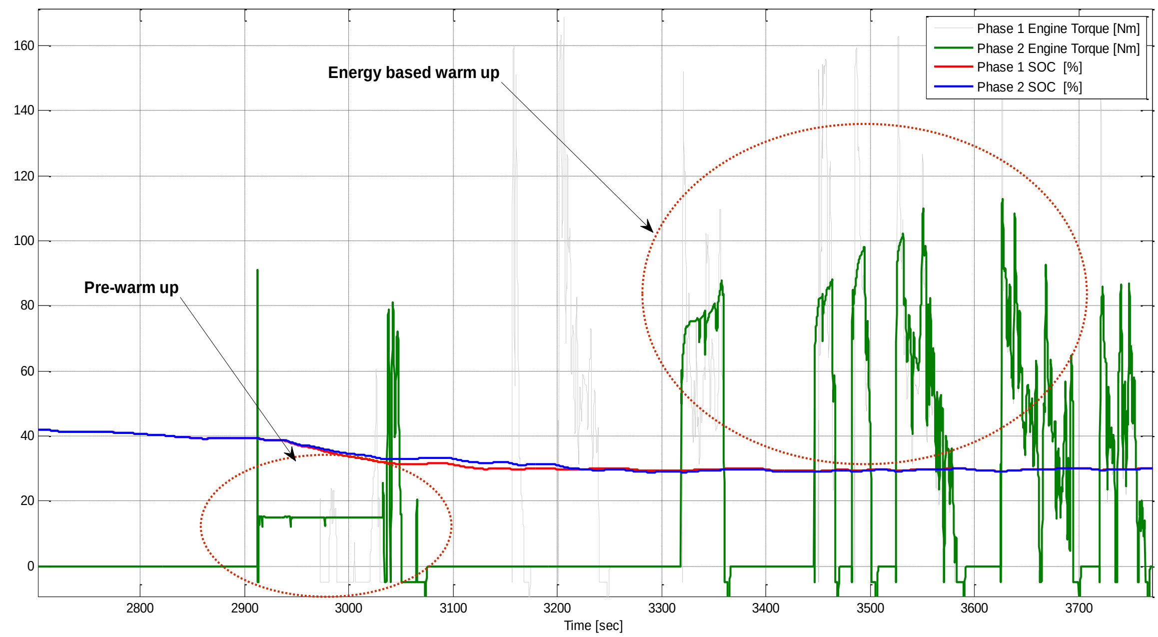


Figure 54. Maximum depletion pre-warm up and engine energy based warm up routines

The light loading of the engine actually reduces the commanded power of the traction motor, which in turn slightly "preserves" the SOC of the battery pack. This creates a delay in the next required engine start, which is the beginning of full CS operation of the PHEV powertrain.

Main Energy-Based Warming Strategy

Once the engine passes out of the pre-warm up routine, a main energy-based torque limiting routine is employed to further warm the engine and exhaust aftertreatment system in a gradual manner. This approach effectively reduces high torque spike demands of the engine. In essence, the main engine warm up concept is a scaling factor that modifies the maximum available engine power consisting of two (2) primary components.

The first component of the energy based torque limiting scaling factor is derived from analysis of the conventional vehicle cold start, as shown previously in Figure 50. The cumulative engine output energy, E_{tot}, is calculated and normalized based on the 3 MJ value for successful conventional vehicle engine warm up, and is given by the expression

$$N_{energy} = \frac{\int_0^{E_{tot}} P_{eng\_des}(t)\, dt}{E_{tot}}$$

where,

N_{energy} is the engine energy based scaling factor,

E_{tot} is the total energy required for successful engine warm up, and

P_{eng_des} is the commanded engine power from the VSCM.

Modern ECUs have internal algorithms that can infer actual engine output, however, *desired* engine output was used in this research to demonstrate the concept. The energy-based torque limiting strategy is shown graphically on the right side of Figure 54.

The second component of the energy based torque limiting scaling factor is based on vehicle speed. The engine torque is limited more at lower vehicle speeds where typically wheel torque requests are greater to accelerate the vehicle. This approach is based on a calibrated one-dimensional look-up table, shown in Figure 55, and accounts for up to a maximum value of 0.5 for the scaling factor of the torque limiting routine developed for Phase II.

Finally, the total scaling factor, N_{total}, for the torque limiting engine warm up routine is given by the expression below. N_{total} never can reach unity until N_{energy} saturates and N_{veh_speed} is greater the maximum speed threshold (40 MPH in this case).

$$N_{total} = N_{veh\_speed} + \frac{1}{2} N_{energy}, N_{total}\ between\ \{0, 1\}.$$

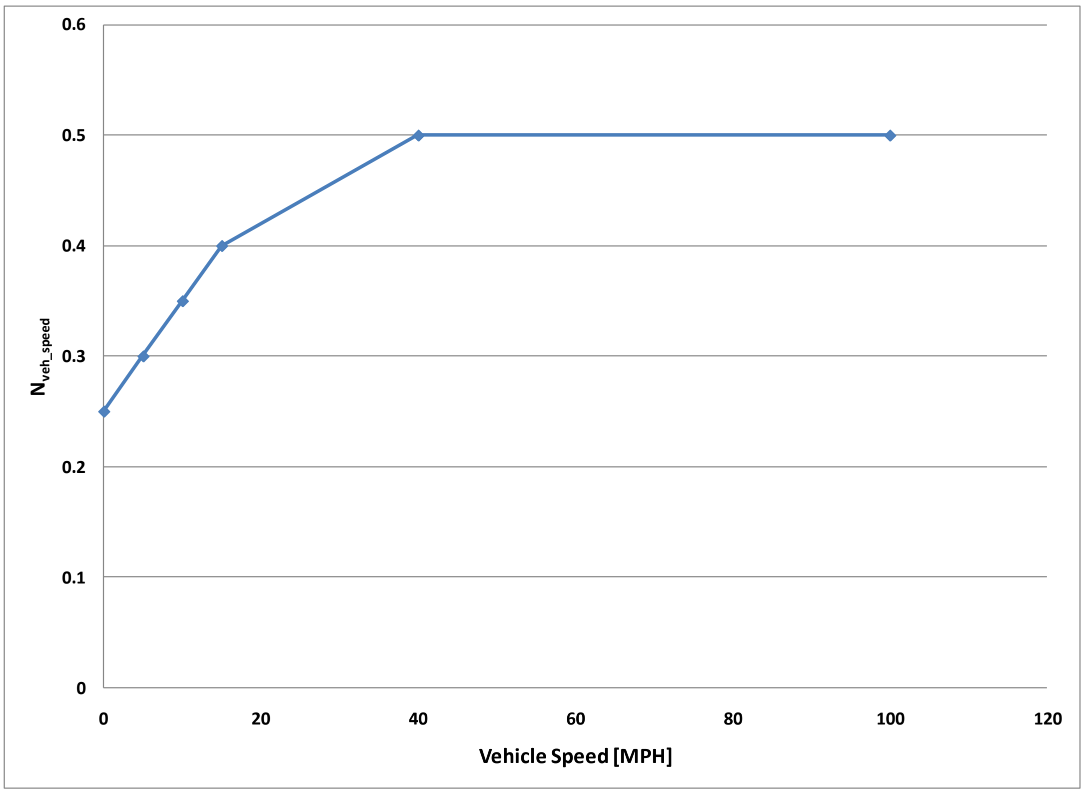


Figure 55. Vehicle speed based component of torque limiting routine

Once the engine has completed both the pre-warm up and main engine energy based warm up algorithms, normal HEV operation of the powertrain resumes, with the addition of a new feature for Phase II. One of the issues identified during the analysis of the Phase I data was excessive engine torque spikes, particularly during engine starting events. This type of engine operation has been shown to contribute significantly to the production of CO and THC. Fortunately, the HEV powertrain offers a high degree of flexibility for shaping both the commanded engine and traction motor torque values to deliver the proper wheel torque demanded by the operator.

During hot starts of the engine, a ramp based blending of the engine with the traction motor torque has been implemented to remove these short periods of high engine torque demands. The behavior of the algorithm functions much like a signal rate limiter, but offers more flexibility to actually shape the engine torque for best performance and lowest emissions. As a starting point for assessment of the algorithm, a linear ramp has been implemented for testing during Phase II. Figure 56 illustrates simulation results for the engine torque ramp algorithm compared against previous Phase I results. For the purpose of this example, the torque is ramped up over a period of seven (7) seconds. This relatively long ramp time actually removes the majority of high load peaks with respect to the UDDS test cycles.

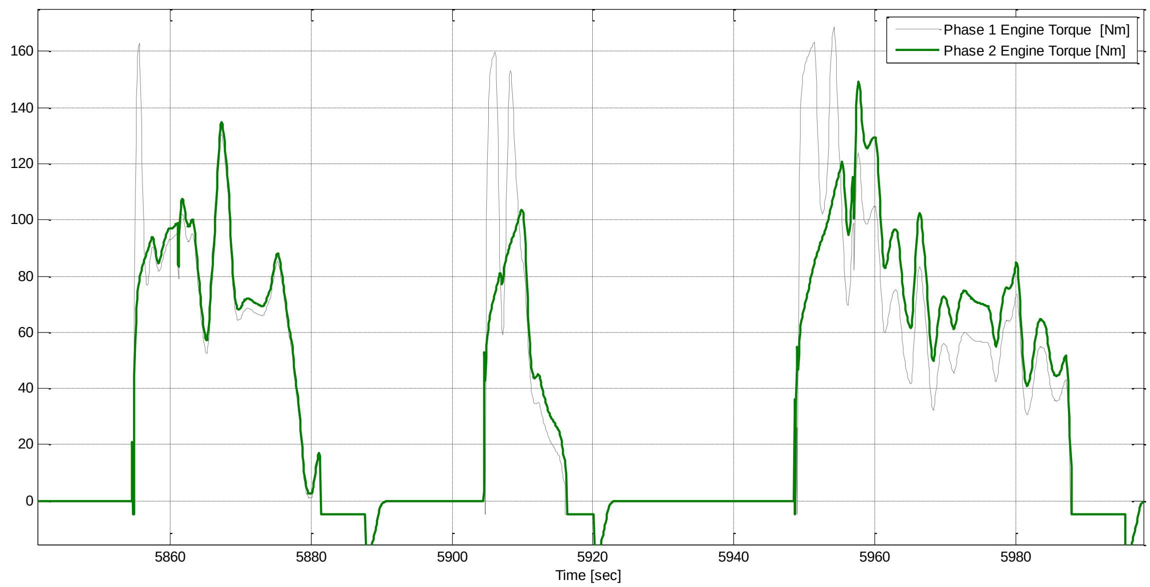


Figure 56. Engine ON torque ramp routine

Figure 57 represents a more detailed view of the hybrid operation of one (1) of the events depicted in Figure 56. Traction motor torque is included to show how the perceived loss of powertrain torque due to torque limiting of the engine is replaced by traction motor torque during these transients. The progression of hybrid functionality is outlined in this figure from left to right as:

Electric launch – the traction motor provides all of the necessary power to propel the vehicle.

Engine start with electric assist – as the engine torque is ramped up, the traction motor provides auxiliary torque to provide the required total wheel torque.

Normal hybrid operation with cruise charging – the engine torque has been fully ramped up and becomes the primary source of propulsion. Excess available engine torque is used to charge the battery pack in order to replenish electrical energy consumed during electric launch and assist.

Regenerative braking – the engine is shut off to conserve fuel during decelerations to vehicle idle. The traction motor is used to recover mechanical energy from the vehicle to further replenish electrical energy that will be used to repeat the process upon the next driver request.

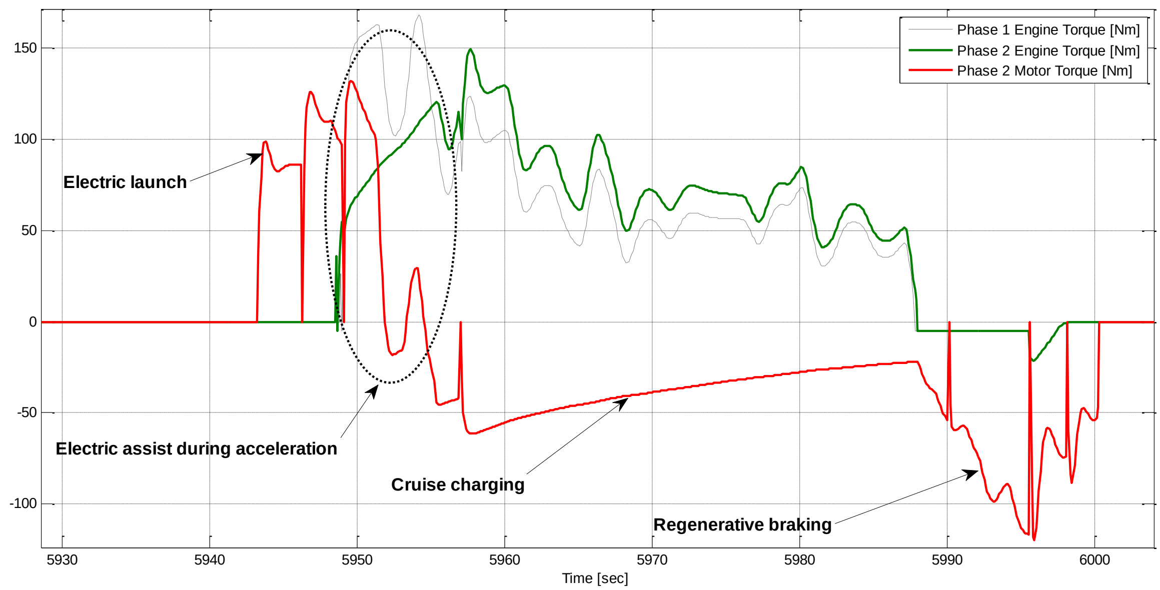


Figure 57. HEV component operation during engine start and torque limiting routine

Blended Strategy Modifications for Emissions

The blended strategy builds upon the concepts developed to reduce the emissions of the HEV powertrain. All current production level HEVs function similarly to their conventional vehicle counterparts with respect to key-on events –their engines are commanded to turn on immediately. The reason for such blatant consumption of fuel is two-fold. The first reason is the focus of this research – to reduce emissions. The second reason is qualitative, which is that consumers are accustomed to the engine starting when they turn the key on, and expect the same no matter whether the vehicle can operate all electrically or not.

Therefore, the VMCP has been modified in Phase II to command an engine start upon a *perceived* key-on signal. However, this command is not tied *directly* to the key-on signal. A cold start flag has been added to the strategy such that when "cold" engine conditions are detected, the engine is commanded to turn on. This can be either from a first time engine on, or from a prolonged period of low power electric driving. In the case of a true cold start, the engine is switched on and goes into the pre-warm up routine and is followed by the main energy based warm up routine discussed previously. The difference in the blended case is that the engine is not allowed to shut off until both warm up constraints have been completely satisfied.

In the later case, the exhaust aftertreatment system may not necessarily be at ambient temperatures, but still may be at or near conditions that would adversely affect emissions conversion efficiency. Here, a modified energy based warm up strategy is engaged, and is triggered by the primary catalyst brick temperature. Most modern ECUs have catalyst models that can predict catalyst temperature and performance. As a surrogate for a complex thermal catalyst model (which is outside the scope of this research), the actual measured catalyst temperature will be used. The total engine energy requirement, E_{tot}, is reduced far below the 3 MJ limit previously established. The torque limiting period is substantially reduced during restart conditions such as this in order to minimize discharging the battery unnecessarily while the engine is operating during CD operation. Figure 58 illustrates the main and secondary engine energy based cold start algorithm used for the blended strategy of Phase II.

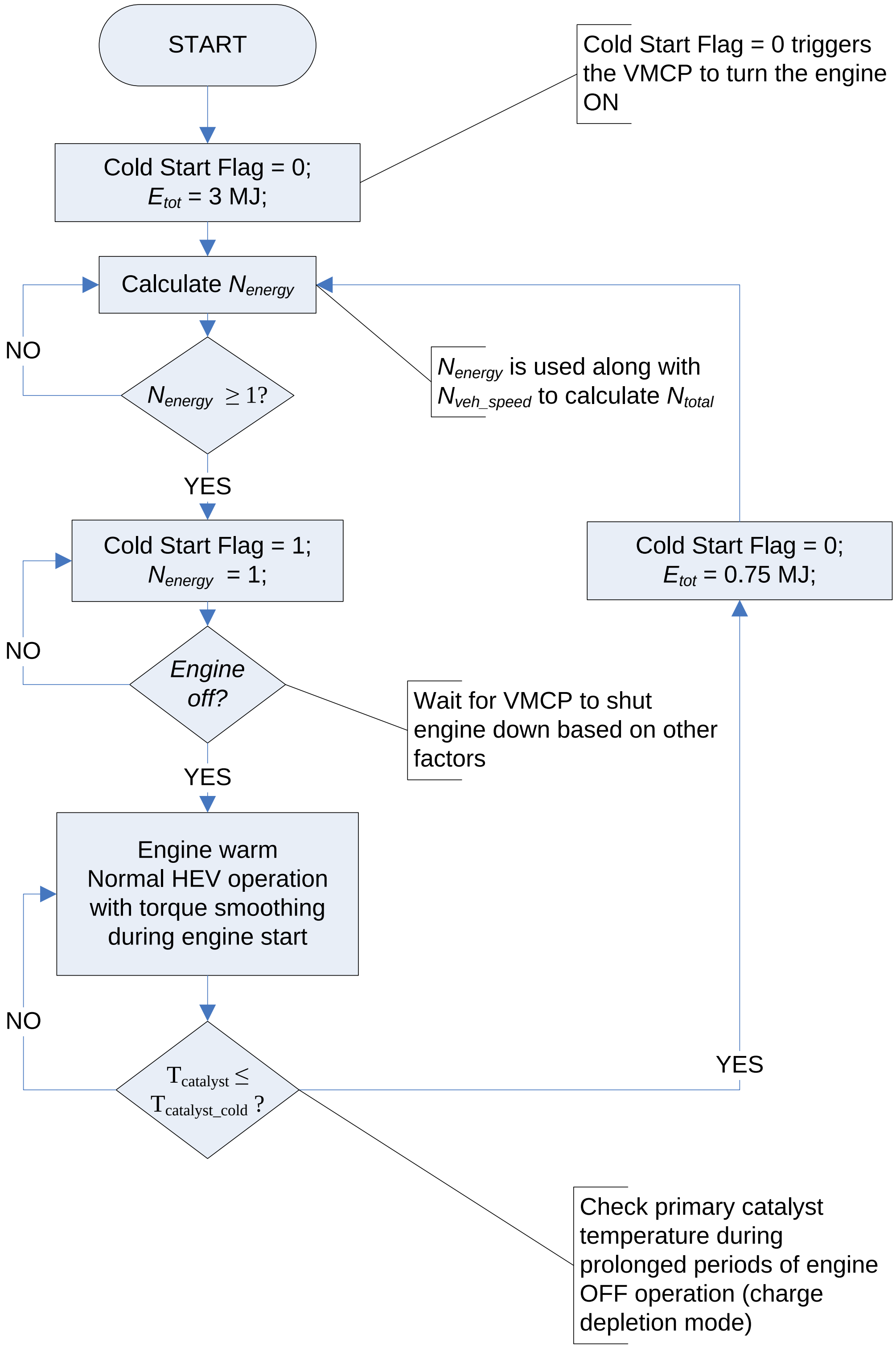


Figure 58. Engine energy based cold starting algorithm for Phase II blended strategy

Another important change to the CD operation of the blended strategy is the use of a variable engine power threshold to start the engine. During Phase I, the total engine power threshold was calculated as a fixed percentage of the maximum available motor power for a given motor speed. The fixed percentage used during Phase I was 50%. In the interest of the engine running more frequently, a variable maximum motor power percentage was implemented using SOC as an input.

A linear ramp was used in the form of a look-up table, such that any shape could be more easily implemented later. The Phase II engine power threshold to command an engine start is given by the simple expression

$$P_{eng\_on\_CD} = N_{eng\_on\_CD} \times P_{motor\_max}$$

where $N_{eng\_on\_CD}$ is a function of the SOC of the battery pack and is shown graphically in Figure 59 .

A complete detailed report of the VSCM model used for Phase II of the research can be found in Appendix A.

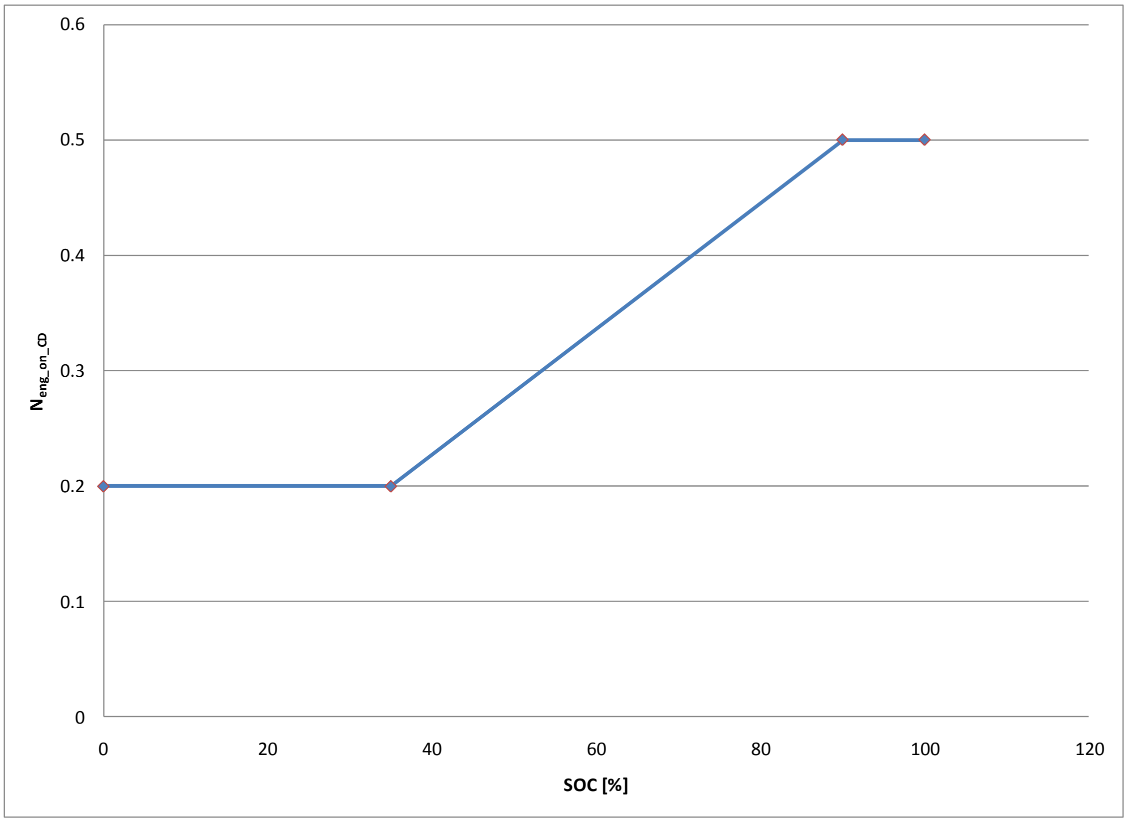


Figure 59. Graphical representation of the Phase II engine power on threshold factor, $N_{eng\_on\_CD}$

Phase II Experimental

All of the aforementioned control strategy changes for emissions reductions were added to the Phase I VSCM and targeted to the real-time control system on MATT for verification on actual hardware. Figure 60 represents the functional summary for the Phase II maximum depletion load following case. The maximum depletion engine warming strategy engages at just below 40% SOC. The CP accomplished as a result allows the vehicle to operate for a short period in an all-electric mode until finally entering into full CS operation. The engine warming strategy for this test operates the engine in a load following manner.

Figure 61 represents the functional summary for the maximum depletion engine optimal case. Just as in the load following case described above, the engine warming strategy is engaged just below 40% SOC. The main difference here is that the engine is allowed to operate in a (modified) engine optimal manner during engine warm up, as is shown by the slight increase in SOC above 40% during the first engine on event. The vehicle is allowed to operate in all-electric mode after the engine warm up strategy is complete, due to the increased amount of stored electrical energy from the engine optimal approach. This increased electric operation after the engine warm up may appear self defeating, however, the temperatures reached by the primary and secondary catalysts for this type of operation are much greater since the engine is operated at high loads at all times when the engine is running. This increased stored

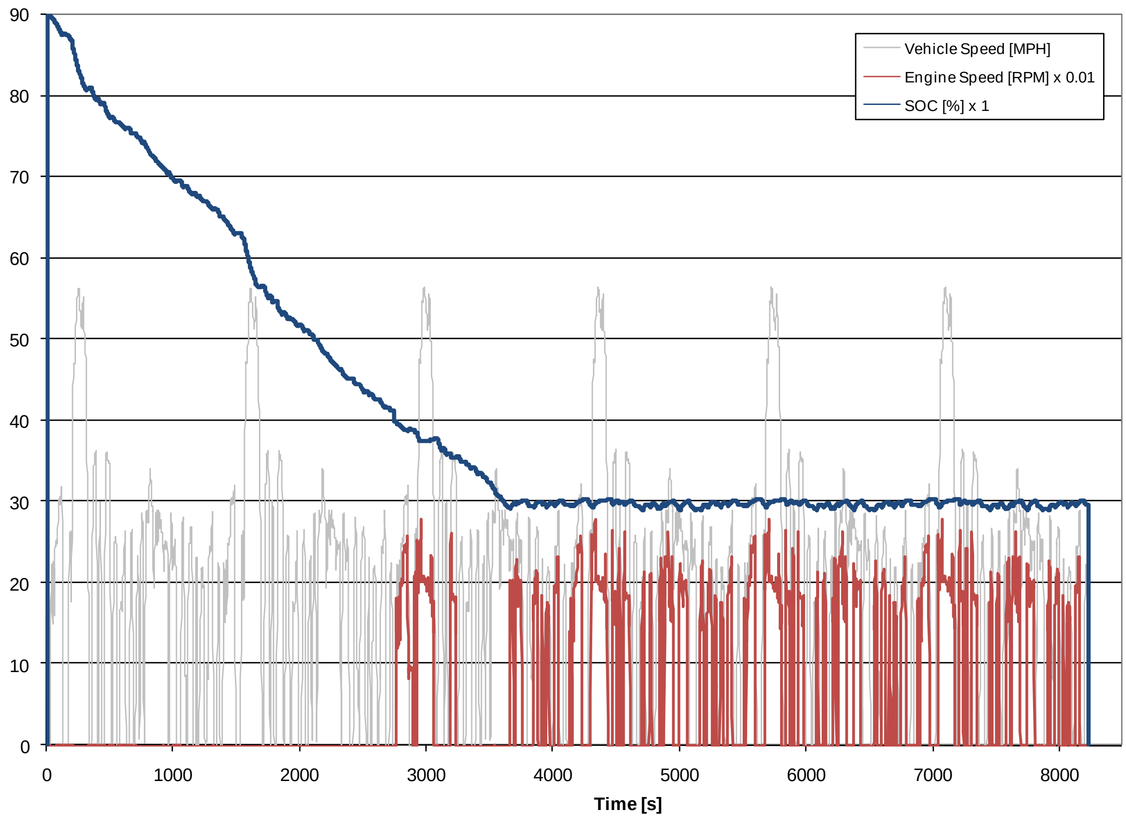


Figure 60. Maximum depletion load following operational summary for Phase II

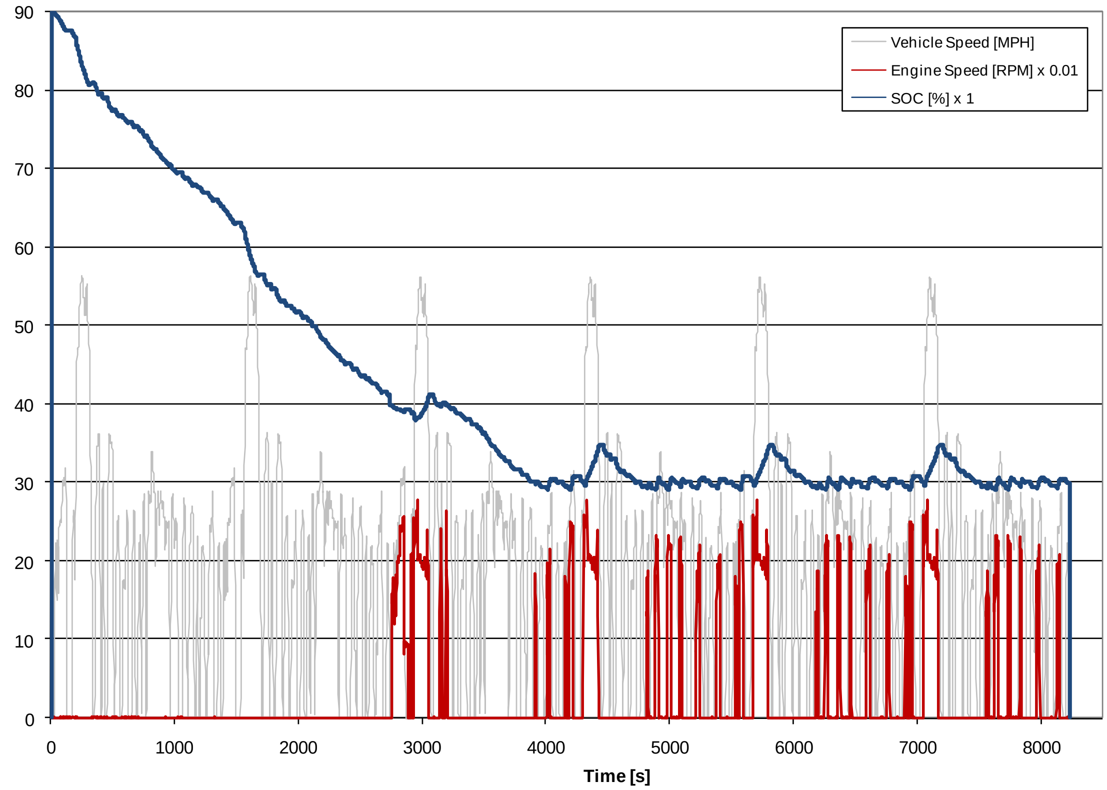


Figure 61. Maximum depletion engine optimal operational summary for Phase II

thermal energy inside the catalysts allows the engine extra time to remain off without substantial impacts on catalytic conversion efficiency.

Figure 62 represents the functional summary of the blended load following case for Phase II. The engine is turned on immediately due to the “cold” catalyst. The secondary warming strategy can be seen to engage around the second series of engine operation near the 1500 second mark, and again around the 3000 second mark. The effect of the variable CD engine-on power threshold can be seen as the frequency of engine operation increases as time moves forward. A period of electric operation is observed when the SOC depletes to approximately 35%. At this point, full CS operation begins and causes a rapid depletion of the battery in order to maintain tight control of the SOC about its 30% target.

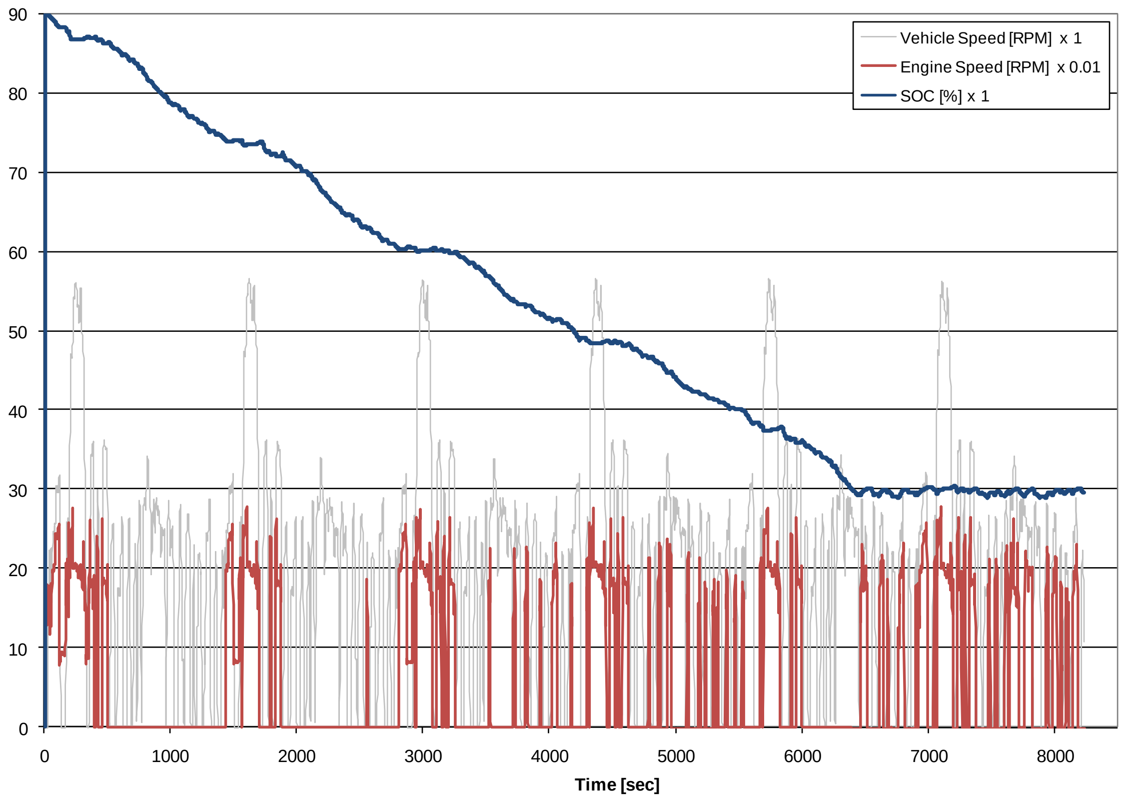


Figure 62. Blended load following operational summary for Phase II

Figure 63 represents the functional summary of the blended engine optimal case for Phase II. The CD region is identical to the load following as described previously. The engine is turned on right away due to the "cold" catalyst. The secondary warming strategy can be seen to engage around the second series of engine operation near the 1500 second mark, and again around the 3000 second mark. The effect of the variable CD engine on power threshold can be seen as the frequency of engine operation increases as time moves forward. During the transition into CS operation, the engine optimal control strategy engages, as can be seen by the increase in SOC due to excess charging. As a result, a longer period of electric operation is observed as compared to the load following case in Figure 62. Another period of electric operation is observed as a result of excess charging during the last high speed section of the drive cycle. In general, less frequent engine operation is required during this series of testing.

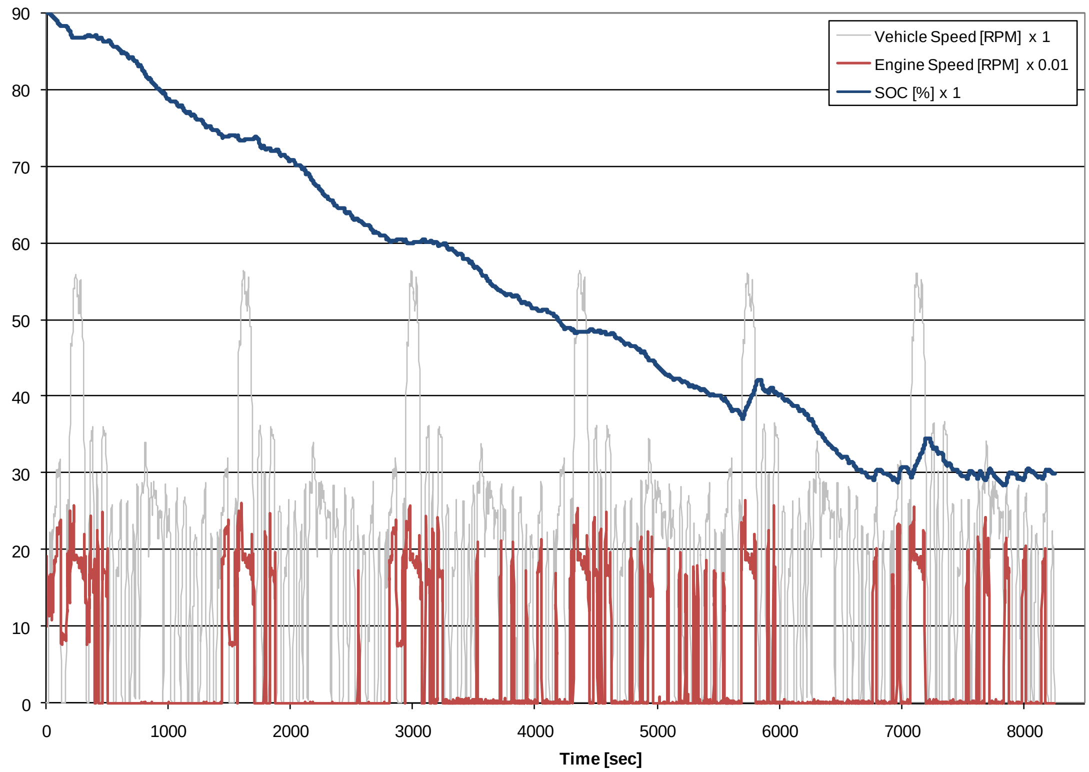


Figure 63. Blended engine optimal operational summary for Phase II

Phase II Energy Consumption Results

The improved control strategy was implemented into MATT, and subjected to the same test regimen as in Phase I. Figure 64 represents the aggregate energy consumption for the combined set of six (6) UDDS drive cycles. Both engine optimal strategies yielded results that were expected, which are highlighted in red in the figure and summarized in the bulleted list below:

- The maximum depletion engine optimal case did not vary substantially in going from Phase I to Phase II. This is due to the all electric CD phase being the same. There is a slight increase in electrical consumption, due to the extra electric operation required during the transition phase for the engine warming strategy, and the warm engine start torque smoothing algorithm.
- The blended engine optimal case consumed slightly more fuel in Phase II, resulting from the key-on engine warming strategy at the beginning of the test regimen, and continuous engine running until the pre-warm up and main engine warming phases are complete. There is also a slight decrease in the electrical energy consumption, due to the slight charge preservation mode of operation during the engine warm up period.

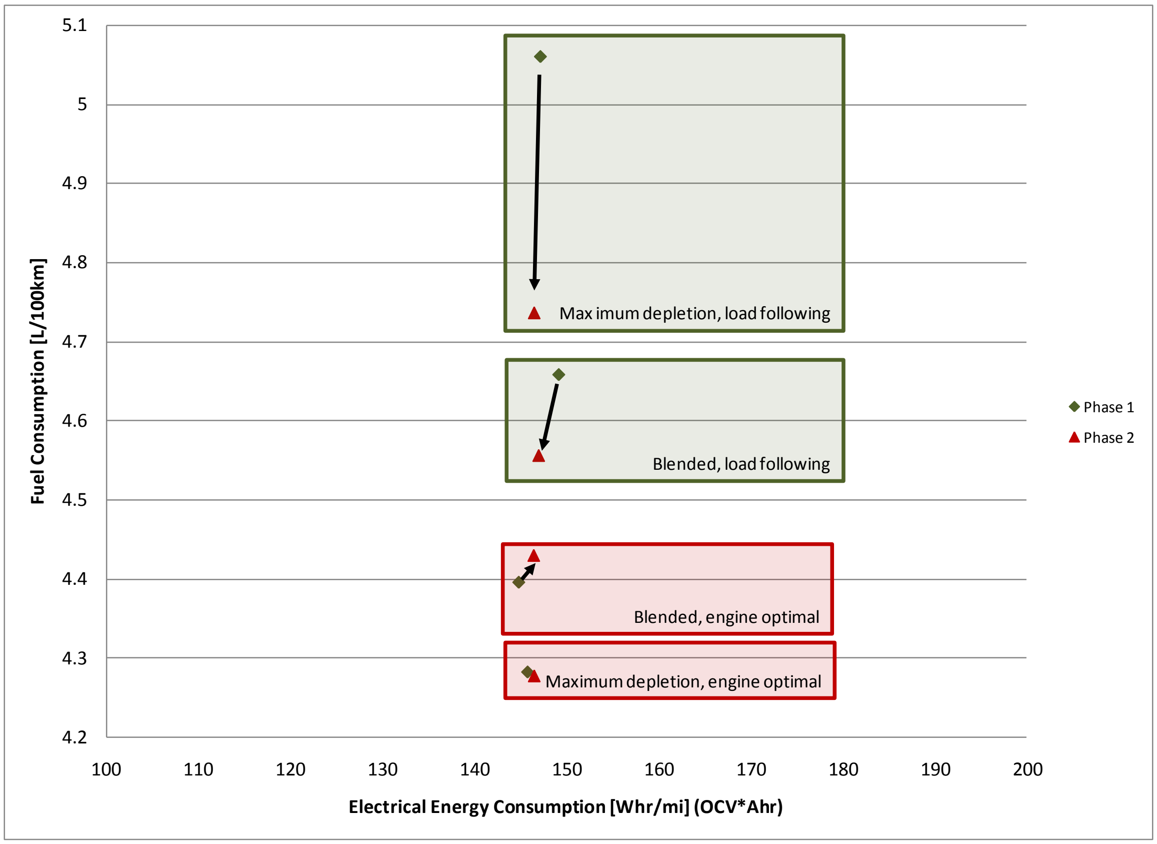


Figure 64. Energy consumption results for Phase II compared to Phase I (aggregate for 6 UDDS cycles)

The most interesting result of Phase II is the substantial reduction in fuel consumption for the load following strategies. Referring to the green highlighted rectangles in Figure 64, a substantial ***reduction*** in fuel consumption is observed. This is counter-intuitive when considering the added engine warming strategies and the perceived increase in inefficient use of the engine.

Phase II Maximum Depletion Energy Consumption Results

Figure 65 represents a comparison of actual energy consumption data for Phase II maximum depletion tests, shown as solid lines, to the original Phase I results. Charge balanced operation has not affected fuel consumption substantially, as shown by the coincident *y*-intercepts. However, there is a pronounced decrease in fuel consumption around the transition point, with a smaller increase visible around the CS region. A closer look into the transition and full CS portions of the test regimen reveals the source of the fuel consumption benefits associated with the emissions reduction algorithms that were implemented for Phase II.

Figure 66 illustrates the cumulative fuel used for the transition and full CS operation tests for the maximum depletion load following cases of both Phase I and Phase II. The full CS operation for both phases, shown as dotted lines, are virtually identical and offer no insight into the fuel savings offered by Phase II. However, there is a distinct amount of fuel saved during the Phase II transition test even though more fuel is consumed at the beginning of the cycle for the engine warming routines.

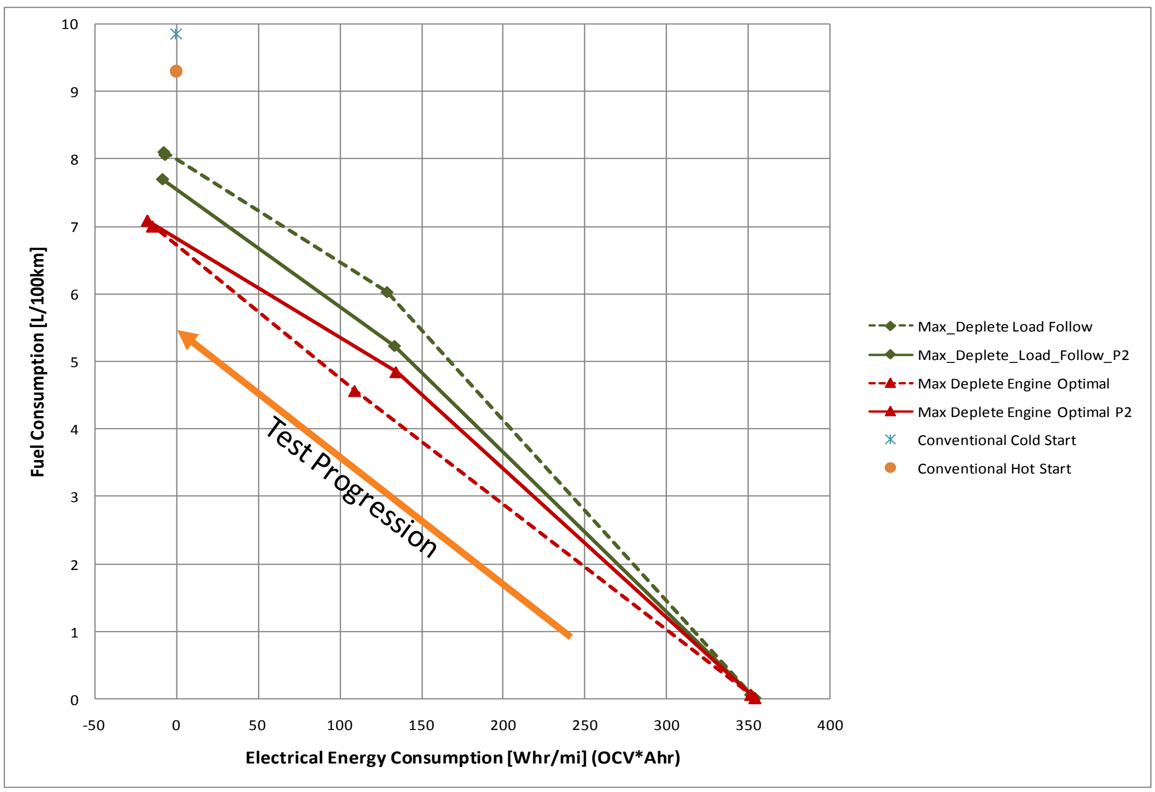


Figure 65. PHEV maximum depletion energy consumption results for Phase II

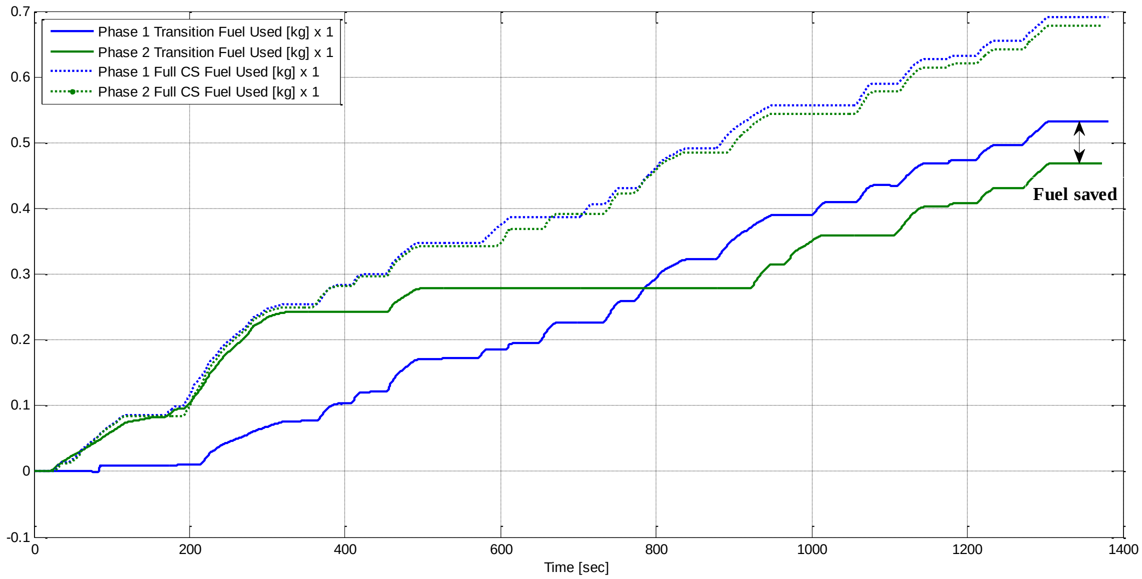


Figure 66. Investigation of fuel consumption reduction for maximum depletion load following strategy

Figure 67 shows the SOC for the same transition test cycle for both Phase I and Phase II. During the transition in Phase II, there is an increase in CP of the battery pack during the engine warming period that is not present in Phase I. This creates the opportunity for a prolonged period of electric only operation that leads into full CS operation later in the test cycle. Therefore, a unique benefit for reduced fuel consumption of PHEVs exists when considering emissions reduction techniques.

The fuel consumption for the maximum depletion engine optimal case exhibits a small *increase* during the transition cycle as shown in Figure 65. This is due to the cold start warm up routine employed, and the extra fuel required. Figure 68 illustrates actual test data for the cold start events of both Phase I and Phase II. The cumulative fuel data during each cycle clearly shows that even while the Phase II cold start warm up routine consumes more fuel, it is consumed at a much lower rate than for Phase I. Unfortunately, the same fuel consumption benefit is not seen when considering engine optimal operation during the transition period.

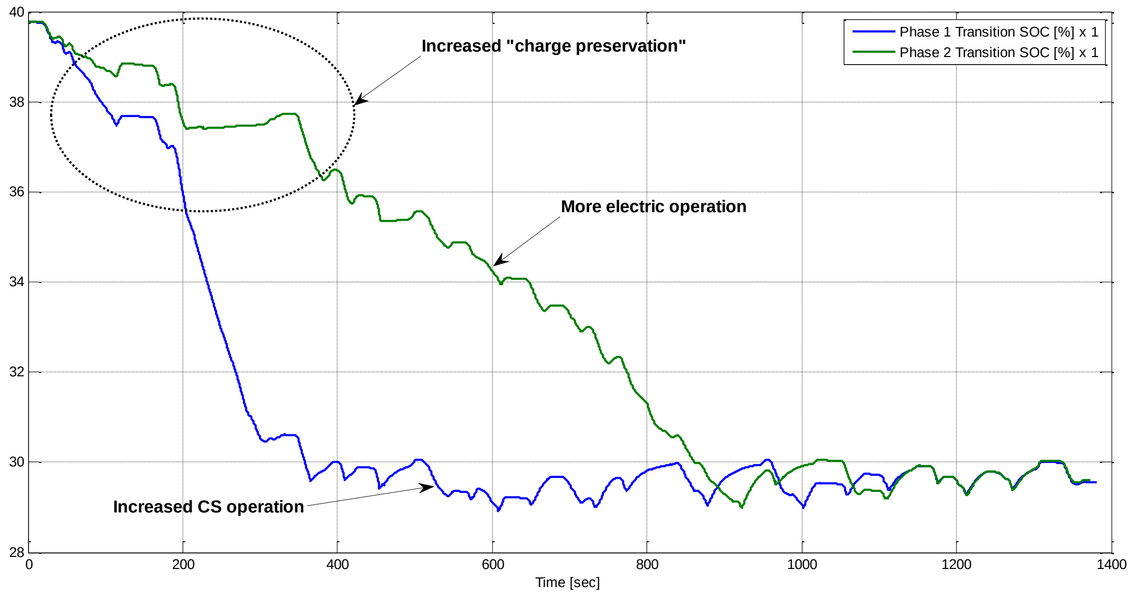


Figure 67. Maximum depletion load following SOC comparison during transition period

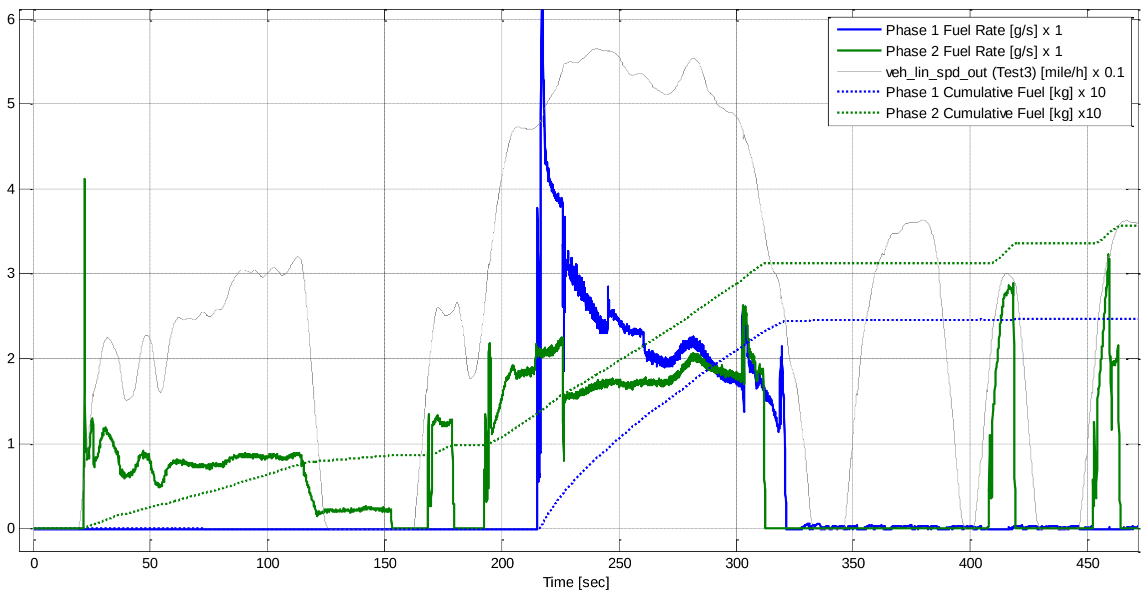


Figure 68. Phase II maximum depletion cold start warm up routine fuel comparison to Phase I (actual test data)

The CP notion does not apply in this case. Figure 69 shows a comparison of the SOC during the transition cycle for both Phase I and Phase II maximum depletion engine optimal tests. While there is still a CP period observed here, it is cancelled out due to the fact that during Phase I the engine is commanded to operate on its most efficient load point. This in turn leads to a very high charge rate for the battery pack. During the same time for the Phase II test, the engine torque is still being limited by the energy based warming strategy, and not charging the battery as quickly. As shown in the figure, the SOC during Phase I almost recovers completely to the level of Phase II, negating the CP region. Each test then exhibits a prolonged period of electric only operation. The fuel penalty for the engine warming strategy is never recovered for the engine optimal case.

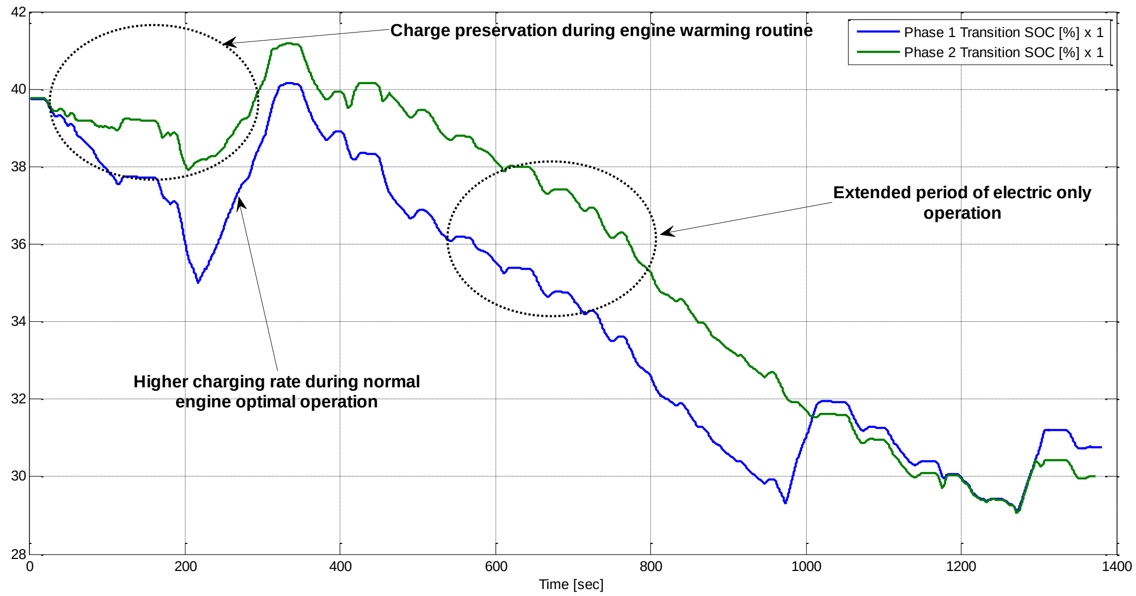


Figure 69. Maximum depletion engine optimal SOC comparison for Phase I and Phase II

Phase II Blended Operation Energy Consumption Results

Figure 70 represents a comparison of actual energy consumption data for Phase II blended operation tests, shown as solid lines, to the original Phase I results. For both engine optimal and load following cases, the Phase II cold start consumes more fuel as compared to Phase I results. This is due to the engine warming strategy and the associated continuous operation of the engine until completely warm. Also, there is more engine operation due to the variable CD engine power on threshold. This creates more CP periods during CD operation. This has divergent effects on the load following and engine optimal approaches.

Since more time is now spent in the CD region, there is less full CS operation. Recall that for the engine optimal blended cases, the modified load following algorithm is used during CD operation. Thus, if more time is spent in the CD region, a greater percentage of the total operating regime is load following, and not engine optimal. This leads to the increased fuel consumption demonstrated in Figure 70.

This has the exact opposite effect when considering the load following case. More time in the CD region means more electric operation and less time spent in the CS region. From a load following perspective, this is more efficient. Obviously, less fuel is burned in the CD region for the load following strategy, meaning that more time spent in the CD region is advantageous.

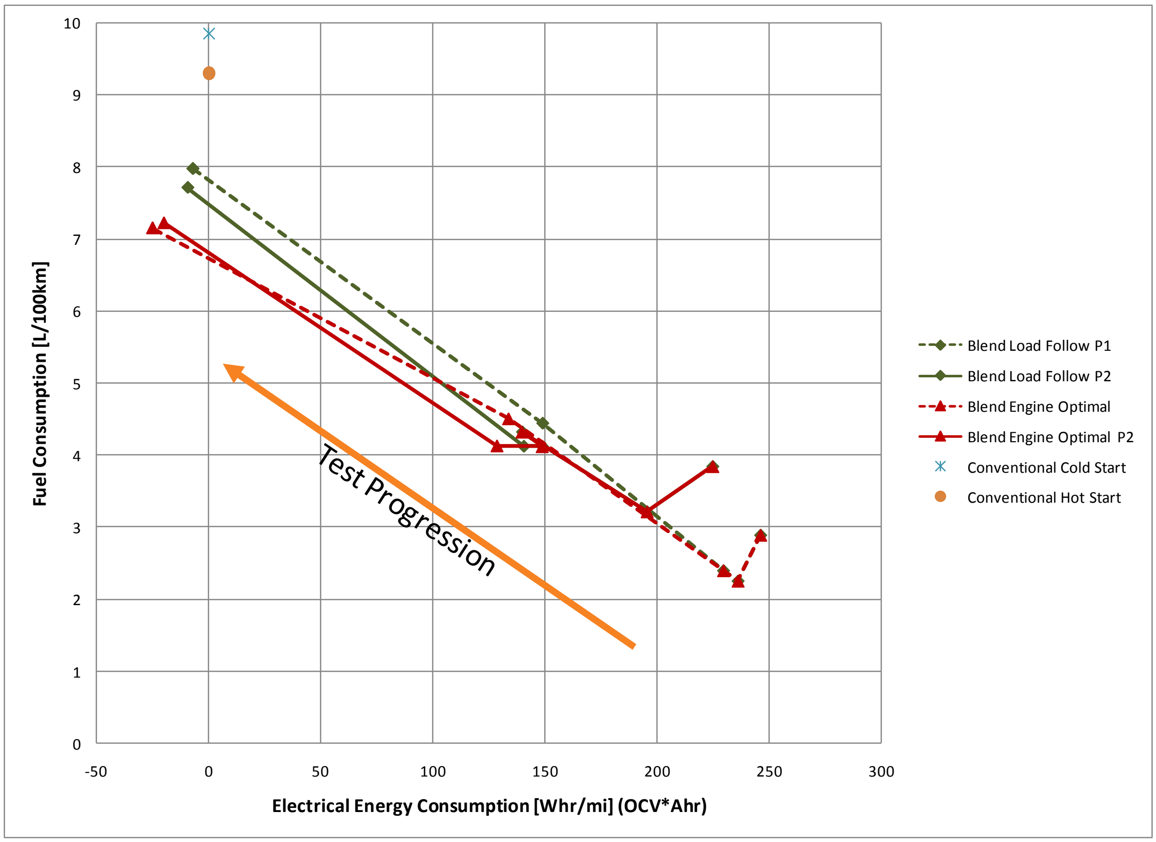


Figure 70. Energy PHEV blended energy consumption results for Phase II

Phase II Tailpipe Emissions

Now that the energy consumption effects have been identified, the emissions impacts can be explored to determine if the applied cold start algorithms and emissions reduction techniques provide “greener” operation for this test platform.

Figure 71 represents the culmination of Phase I and Phase II in terms of the actual emissions impacts of the improved control strategies. Clearly, the emission reduction methods implemented into each of the control strategies have led to a substantial reduction in both NMOG and NO_x emissions from the test platform. Each of the four (4) strategies now attains SULEV emissions levels, with minimal negative effects on energy consumption as outlined in the previous section. In addition, all four (4) strategies result in NO_x emissions below that of the conventional vehicle.

The following sections discuss the emissions reductions, on a cycle by cycle basis, associated with each version of the maximum depletion and blended control strategy approaches.

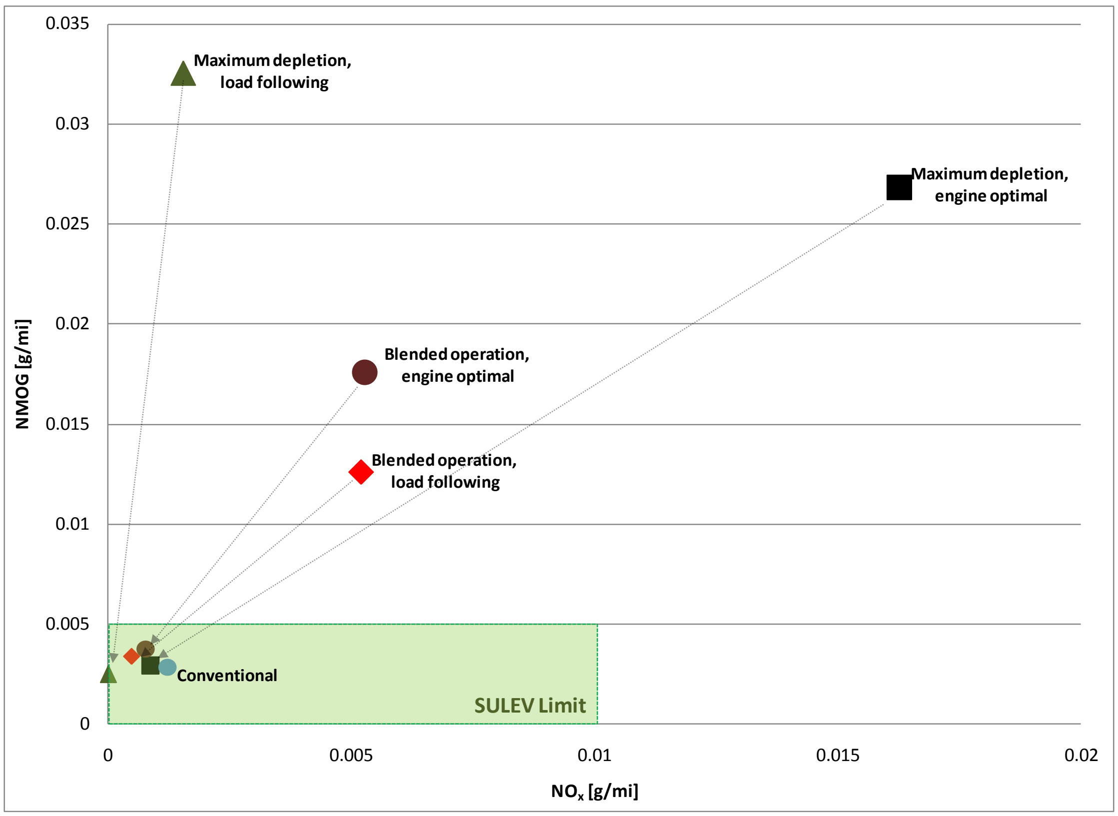


Figure 71. Emissions results summary for Phase II showing overall improvements over Phase I

Phase II Maximum Depletion Emissions Results

Beginning with the maximum depletion cases, Figure 72 presents the cycle by cycle Phase II THC emissions results. The Phase II results, shown by the solid lines, are plotted against the Phase I results discussed earlier. It is clear that the THC emissions levels are significantly reduced, but still exhibit the same trend during the transition cycle due to the first engine cold start.

The engine warming algorithms have the greatest impact on the maximum depletion load following strategy, with a reduction in THC emissions by a factor of approximately ten (10) on a grams per mile basis. Figure 73 shows a comparison of the cold start for this strategy in both Phases I and II. The pre-warm up strategy lightly loads the engine and allows the exhaust temperature to rise to its normal working temperature (the primary catalyst temperature was not logged since it was being used as an input to the VSCM for the purposes of the revised Phase II strategy). For this reason, the THC emissions are very low for the Phase II approach. When the engine starts for Phase I, under high engine speed conditions, a substantial amount of THC emissions are produced for a relatively low load on the engine. This is due to the fact that the engine is being operated under cold conditions at high speeds. Once the exhaust temperature rises, the THC emissions output is reduced.

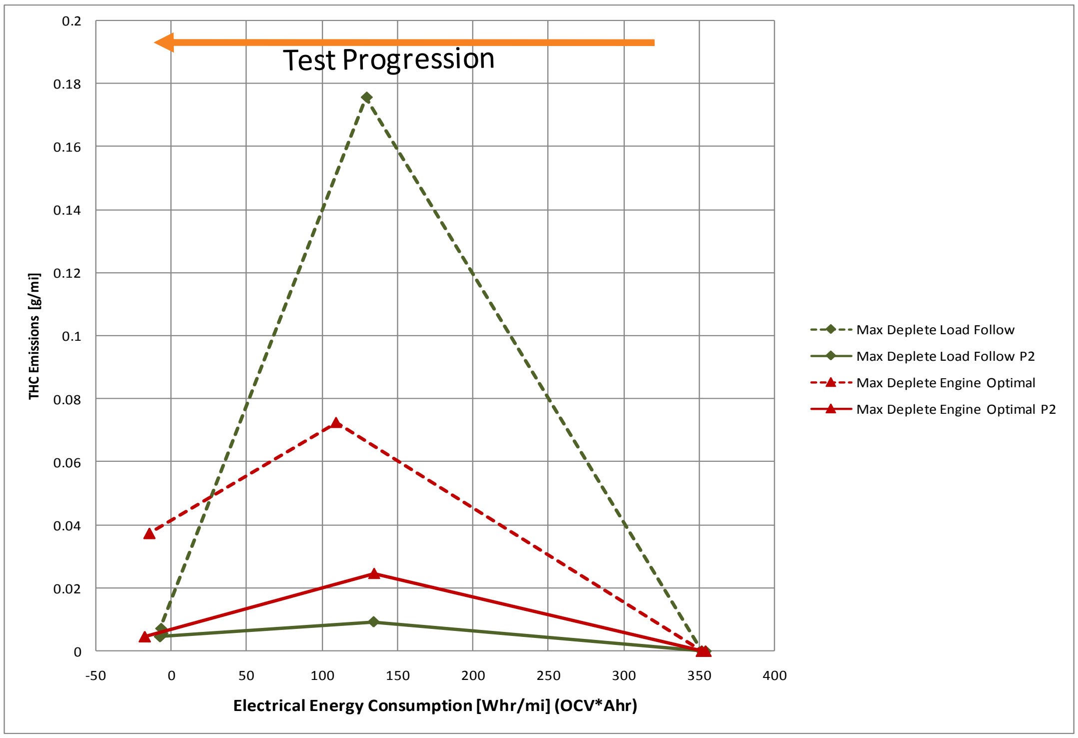


Figure 72. Comparison of THC emissions results for maximum depletion PHEV operation of Phase II to Phase I

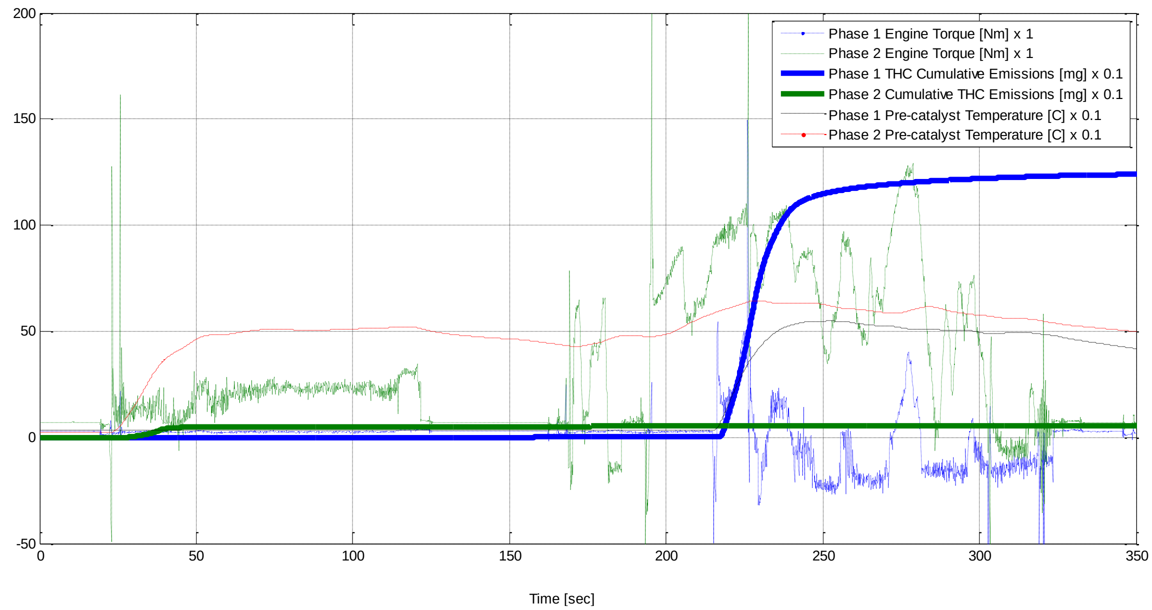


Figure 73. Comparison of THC emissions for Phase I and Phase II maximum depletion load following strategy

The full CS operation THC emissions have also been reduced as shown in Figure 72. The engine and relevant subsystems are all up to normal operating temperatures for this stage of the test. The hot start engine torque ramping algorithm can be credited with the reduced THC emissions for Phase II. Figure 74 shows a magnified portion of the UDDS during CS operation. Here, the Phase II engine torque is ramped up more gradually, as compared to the almost immediate torque output of the engine for Phase I. A very large spike in THC emissions results from the immediate loading of the engine, even under warm conditions. The THC emissions associated with Phase II are far lower, indicating the positive effects of engine torque ramping on the reduction of THC emissions.

It should also be pointed out that there are drivability concerns with the engine optimal operation, particularly with Phase I. The sudden torque demand was noticeably rough. The torque ramping algorithm provided a much smoother transition of the engine torque to the wheels, and did not seem as “violent” or aggressive as Phase I.

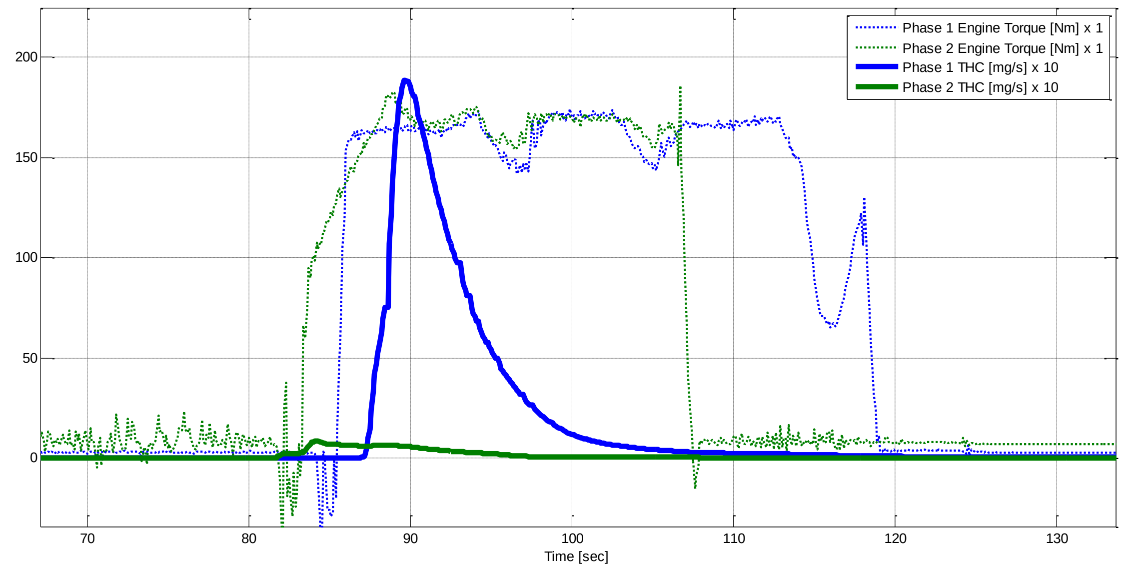


Figure 74. Engine optimal full CS operation showing benefits of engine torque ramping on THC emissions

Figure 75 depicts the NO_x results on a cycle by cycle basis for the maximum depletion tests ran for Phase II, and plots them against Phase I for comparison. Here, the NO_x emissions were virtually eliminated for all portions of the test. The reduced loading of the engine during the main warm up and subsequent torque smoothing are very effective for reducing NO_x emissions.

Figure 76 illustrates the CO emissions results for Phase II. The load following strategy exhibits typical CO producing behavior, and appears to still be proportionate to the number of engine starts. The engine optimal case actually exhibits a reduction in CO emissions for full CS operation. CO typically follows the same trends as THC, and as such, the engine torque smoothing algorithm is credited with this reduction.

It is worth noting that the reduction in tailpipe emissions for the maximum depletion cases was achieved while simultaneously preserving the all electric CD operation. Assuming the operator commutes a distance of no greater than 15 miles of urban driving, these algorithms would provide zero emissions and infinite fuel economy (with the cost of grid electricity being ignored) due to all-electric operation and an assumed fully charged battery pack. In addition, should the driver desire to drive further, SULEV emissions are attainable with no preliminary engine start at key-on.

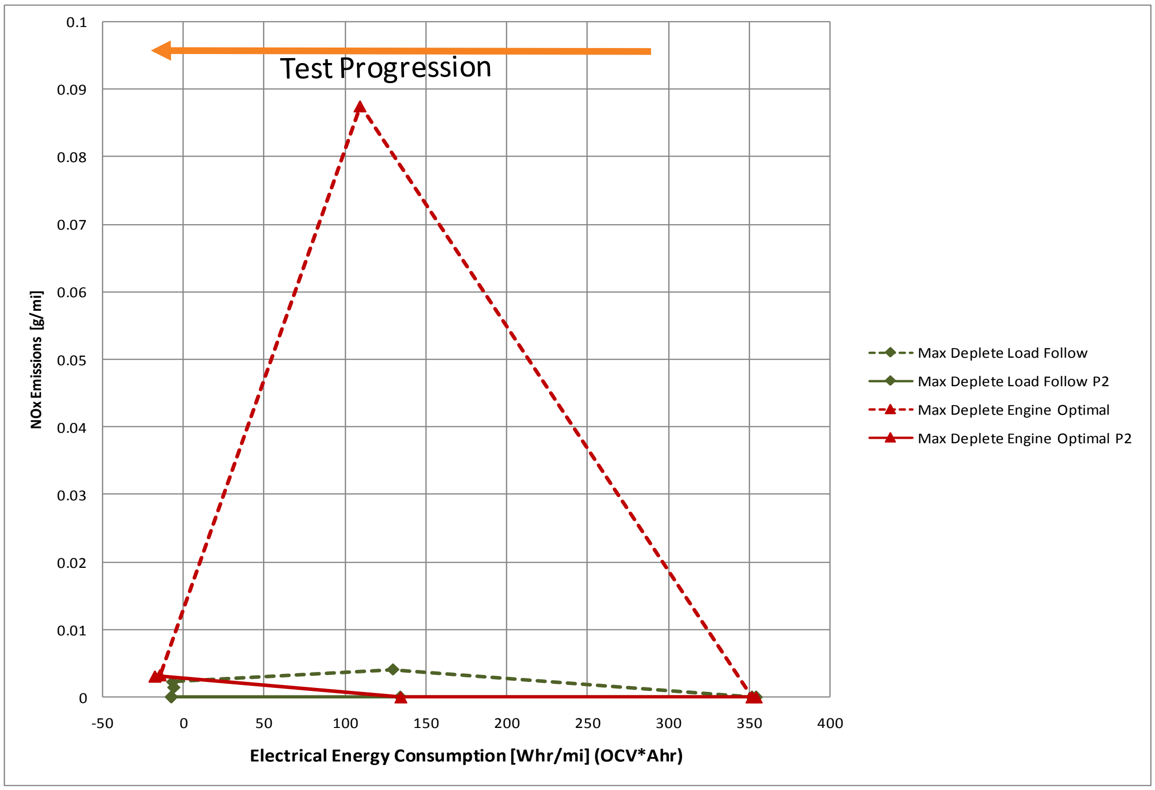


Figure 75. Comparison of NO_x emissions results maximum depletion PHEV operation of Phase II to Phase I

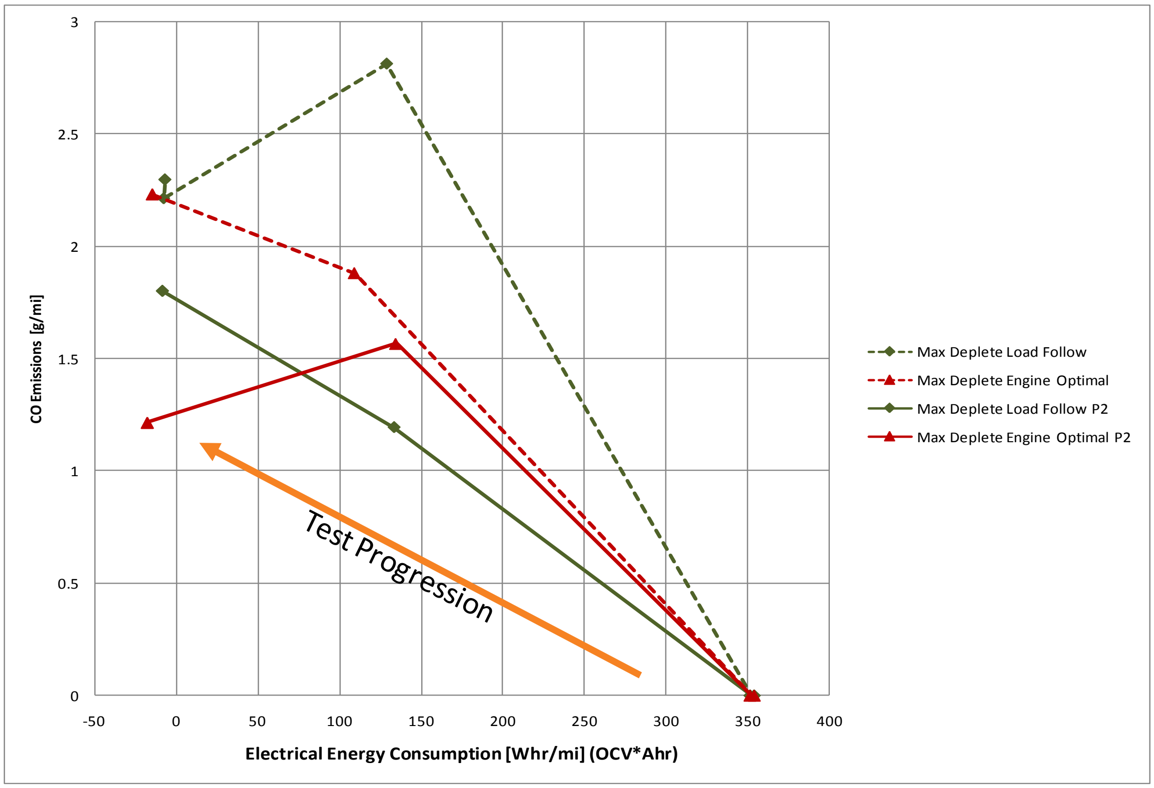


Figure 76. Comparison of CO emissions results maximum depletion PHEV operation of Phase II to Phase I

Phase II Blended Strategy Emissions Results

As shown earlier, the blended strategy offers superior fuel economy for the load following case, and comparable fuel economy for the engine optimal case when compared to the maximum depletion strategies. Figure 77 shows the THC emissions for Phase II blended strategies compared against Phase I. Dramatic reductions in THC emissions are achieved, particularly with respect to the first engine cold start. The effects of the engine warm up strategy can also be seen as a reduction in the electrical energy consumption, represented by a shift of the first cycle data point on the far right of the graph. This is simply due to the more frequent use of the engine, and the additional CP periods provided by this strategy. Another interesting characteristic of this control strategy is the “zig-zag” in the trace as the test cycle progresses from right to left. This is where the control strategy transitions from CD operation into full CS operation.

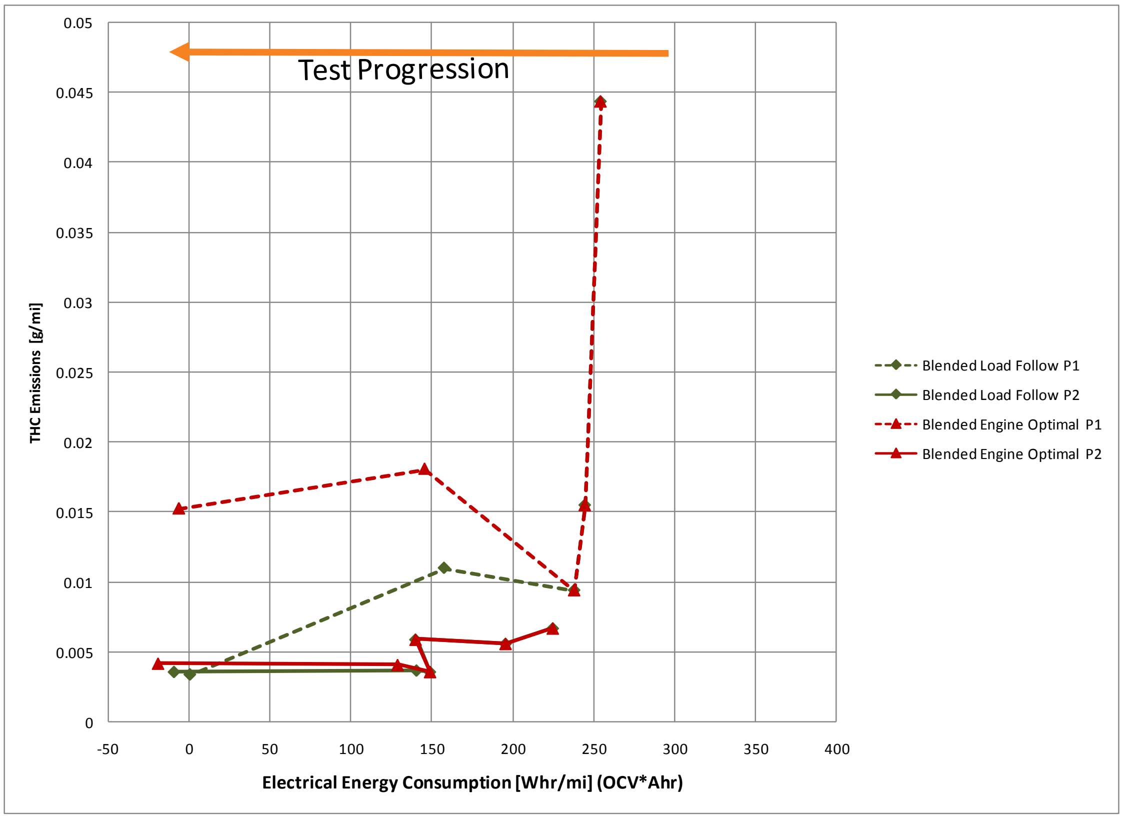


Figure 77. Comparison of THC emissions results blended PHEV operation of Phase II to Phase I

Figure 78 summarizes the NO_x emissions results for each of the Phase II blended strategies. Again, superior reductions in NO_x emissions are achieved. This is due primarily to the gradual warming of the engine through the pre-warm strategy and energy based main warming strategy coupled with torque smoothing during engine starts. The large spike in NO_x, as a result of the cold engine start from Phase I, has been eliminated.

Figure 79 illustrates the carbon monoxide results for the Phase II blended strategies. Here, a large reduction in CO emissions is evident, particularly with respect to the first engine cold start of Phase I. The load following case for Phase II still exhibits the increasing CO emissions trend as the SOC approaches full CS operation. This is attributed again to the increasing number of engine starts for each successive test cycle.

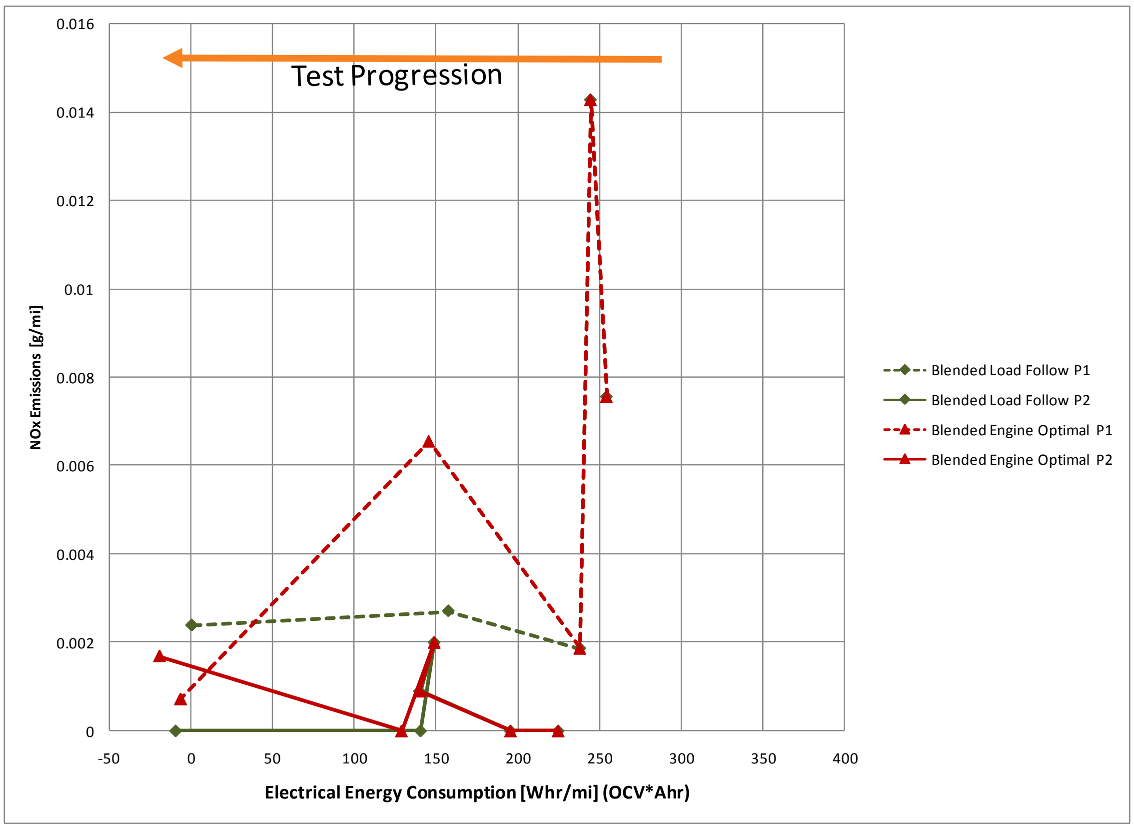


Figure 78. Comparison of NOx emissions results blended PHEV operation of Phase II to Phase I

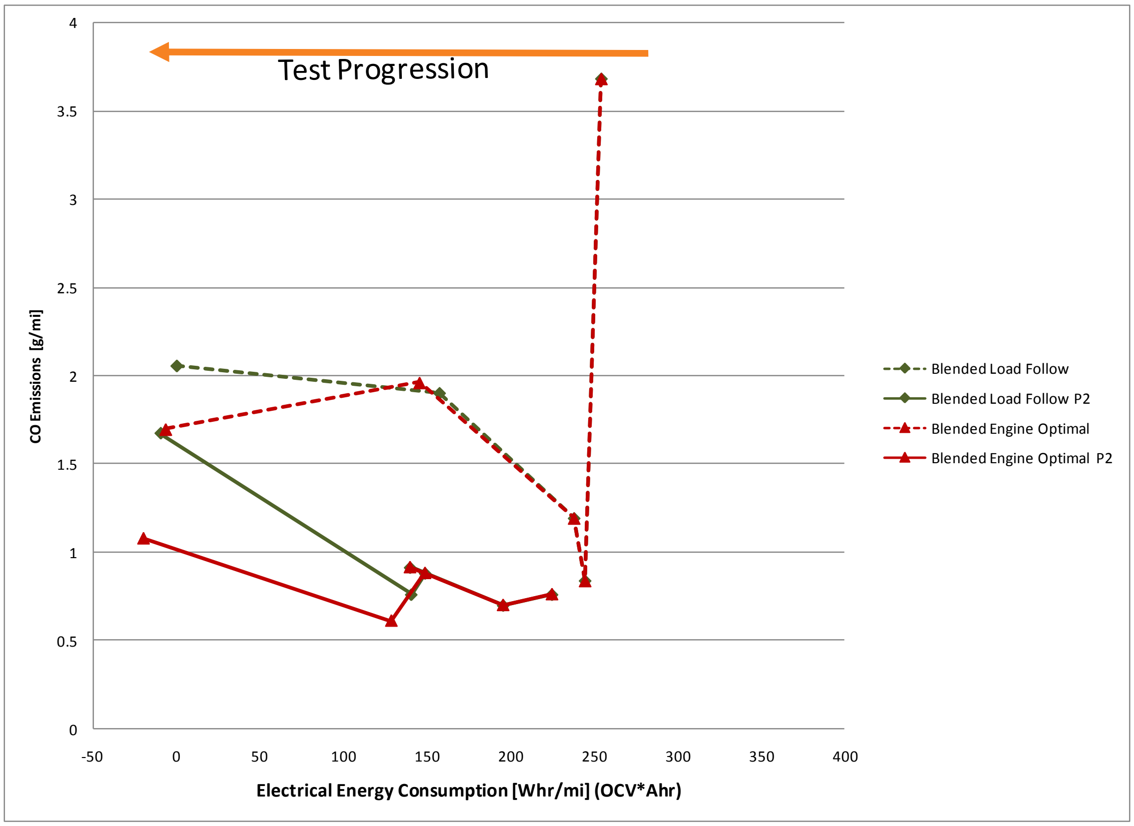


Figure 79. Comparison of CO emissions results blended PHEV operation of Phase II to Phase I

The engine warming algorithms implemented into the VSCM produce much lower tailpipe emissions than the Phase I approach for these blended strategies. The net effect of these algorithms is two-fold. The first benefit of this approach is to reduce and smooth the loading of the engine during both cold and hot engine starts. The second effect is to operate the engine *more frequently*. In doing so, the operating temperatures of the engine system remain higher during the test cycles, allowing for increased conversion efficiencies in the primary and secondary catalysts.

Figure 80 illustrates the comparison of pre-catalyst exhaust gas temperatures for the blended load following strategies implemented for Phase I and Phase II, respectively. The effects of the pre-warming strategy can be clearly seen at the beginning of the test cycle. During CD operation, the pre-catalyst temperature stays significantly higher for the Phase II application, and the secondary catalyst warming strategy is shown taking effect when the gas temperature drops below 200 °C. The pre-catalyst exhaust gas temperature is higher throughout all of the UDDS drive cycles for Phase II, indicating that the primary and secondary catalysts remain effective for a greater percentage of the time (due to the thermal mass of the catalyst bricks, the catalysts cool much slower than the pre-catalyst exhaust gas).

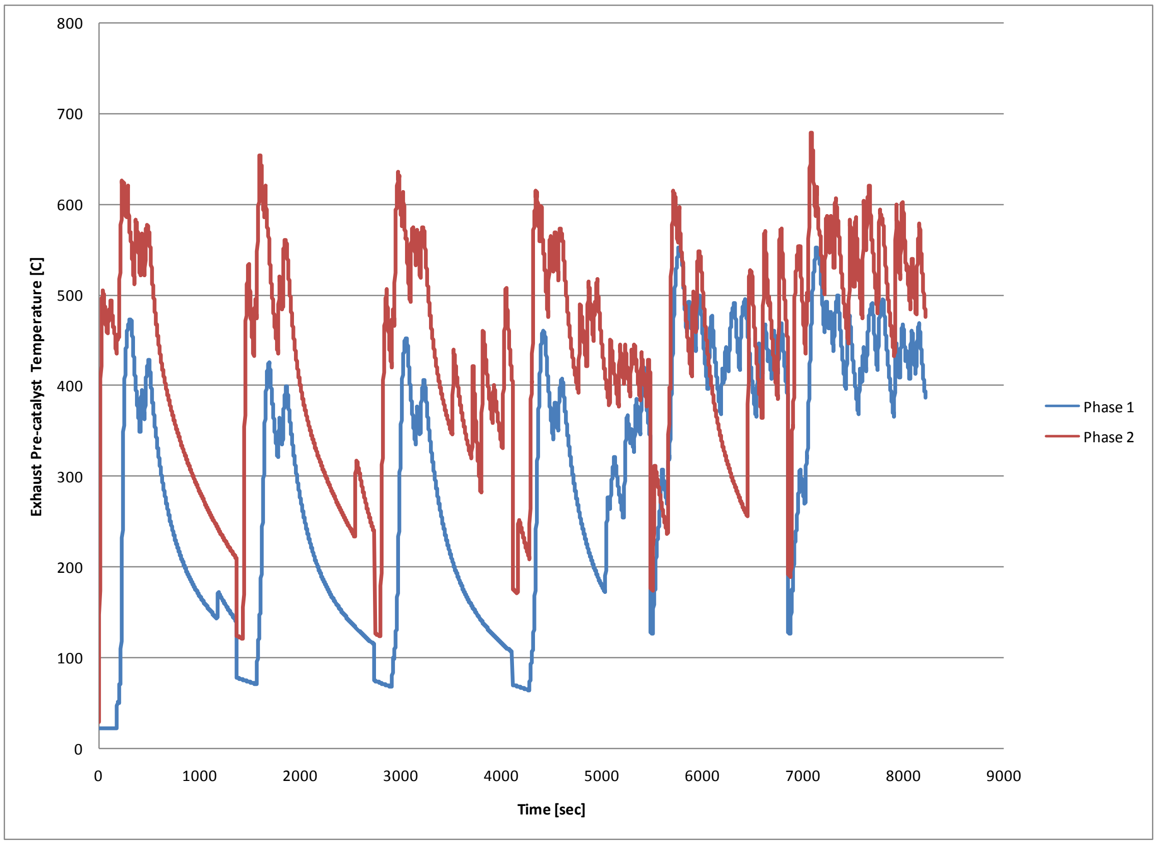


Figure 80. Comparison of pre-catalyst exhaust gas temperatures for blended load following PHEV operation

Chapter 5: Conclusions

PHEVs do have the potential for substantial reductions in fuel consumption for the transportation sector. However, care must be taken when designing and implementing PHEV supervisory control strategies such that the tailpipe emissions are not adversely effected. *When* and *how* the engine is operated in PHEVs is critical to the success of these perceived “green” vehicles.

In this research, tailpipe emissions from a PHEV test platform have been reduced through the development and refinement of vehicle supervisory control methods. Baseline energy management strategies were developed with respect to maximizing fuel economy alone. These strategies include “cold” engine starting under high load demands, which was verified to be ineffective with respect to emissions reduction. Lower emissions were achieved with improved control algorithms for this representative PHEV with substantial EV operation over that of a conventional vehicle.

Engine cold start events were aggressively addressed, which led to enhanced engine warming and pre-warming algorithms. Key–on engine starting was employed to mimic conventional vehicle operation; however, the results of this research indicate that this is not mandatory for successful reduction of tailpipe emissions. The engine pre-warming and warming techniques provided substantial reductions in emissions over the baseline PHEV control strategies.

The flexibility of the PHEV powertrain allowed for decreased emissions during engine starting events through powertrain "torque shaping" algorithms. The focus of these enhancements was to replace high engine torque demands during starting with "clean" electric motor torque. This approach proved very effective for the reduction of NO_x emissions.

The results of the research indicate that the impacts on fuel consumption were minimal for the emissions reduction techniques that were applied. In fact, the engine start torque ramping and warming strategies actually decreased fuel consumption for each of the load following strategies due to "engine optimal" like operation.

Chapter 6: Recommendations

Based on the results of this study the following recommendations are proposed:

1. Further explore the development of the engine warming strategies to further reduce emissions and increase fuel efficiency.
2. Evaluate the performance of the vehicle supervisory control system on drive cycles other than the UDDS. Such drive cycles should include more aggressive styles of driving, as well as highway modes of operation.
3. Perform parametric studies on the engine start up torque shaping algorithms to determine the effects of different approaches.
4. Incorporate advanced control strategy approaches, such as artifical intelligence and neural networks, to further increase the efficiency of the strategies, and form the basis for adaptive strategies.
5. Investigate the modification of engine operating strategies, coupled with supervisory control strategies, to further reduce emissions, particularly CO emissions (e.g., incorporate engine calibrations that are specific for hybrid applications as opposed to the conventional calibration currently being used on MATT).
6. Examine the effects of advanced combustion (low temperature combustion, etc.) on the mitigation of tailpipe emissions, and the corresponding effects on fuel consumption.

7. Explore novel exhaust aftertreatment devices and approaches that are specifically targeted at engine cold starts. This should include studies of the effects on overall energy consumption when employing electrically heated catalysts.

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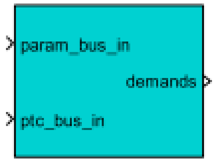
Appendices

Appendix A: Detail of VSCM Model

lib_p_par_pre_tx_DES_dissertation_MATT

Details for lib_p_par_pre_tx_DES_dissertation_MATT and below



p_par_pre_tx_DES_dissertation_MATT

DSmith

13-Mar-2009 09:08:20

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Model - lib_p_par_pre_tx_DES_dissertation_MATT

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Full Model Hierarchy

Simulation Parameter	Value
Solver	ode1
RelTol	1e-3
Refine	1
MaxOrder	5
FixedStep	0.001
ZeroCross	on

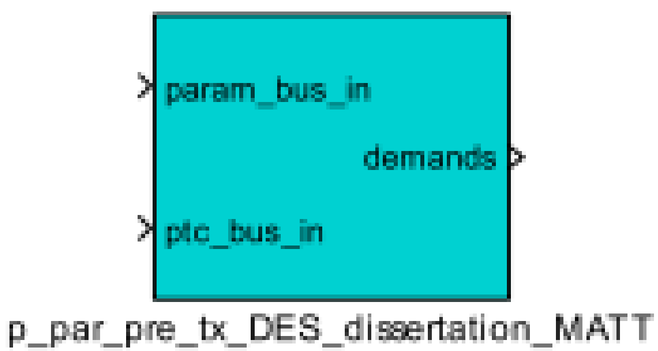
[more info]

Machine - lib_p_par_pre_tx_DES_dissertation_MATT

Machine	lib_p_par_pre_tx_DES_dissertation_MATT
Creation Date	11-Jun-2008 17:02:45
Charts	Energy Management Strategy Vehicle Mode Control Process Cold_Start_Logic_Chart

[more info]

System - lib_p_par_pre_tx_DES_dissertation_MATT



System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT

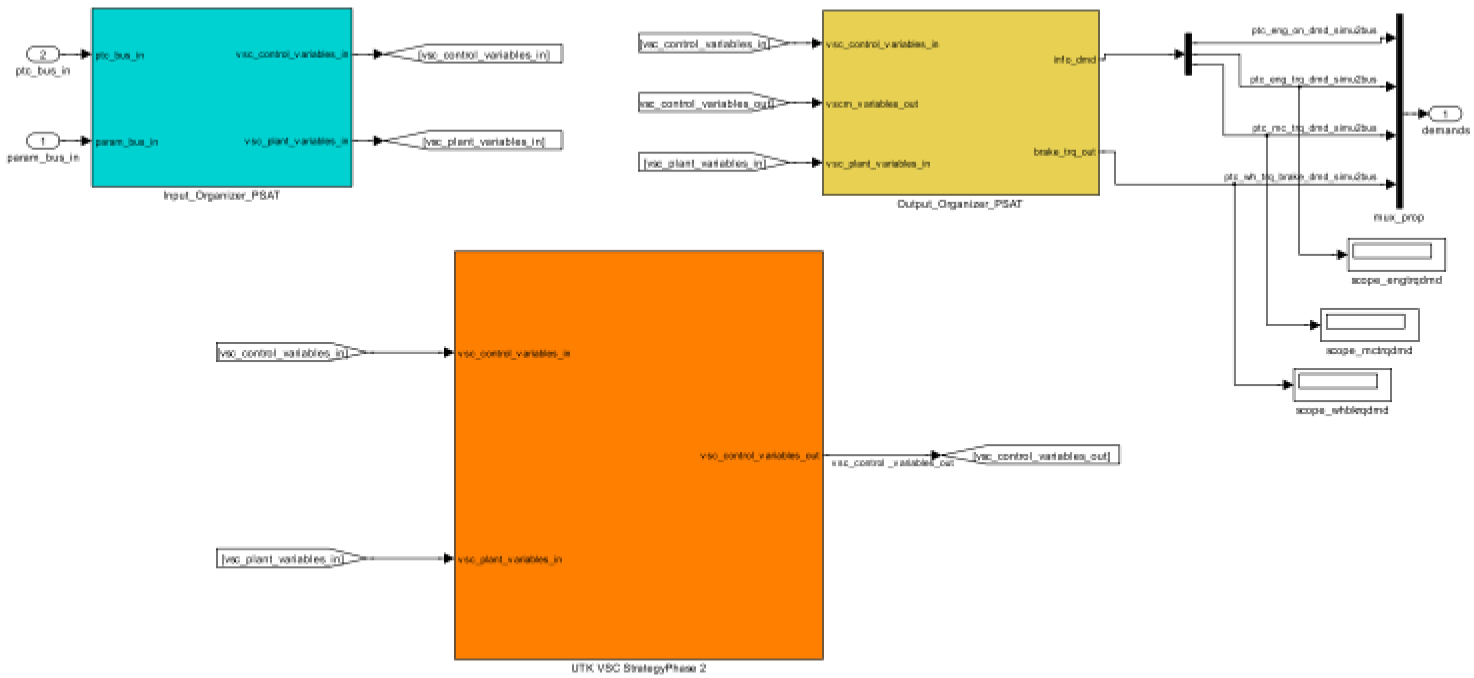


Table 1. Demux Block Properties

Name	Outputs	Display Option	Bus Selection Mode
Demux	3	bar	off

Table 2. Display Block Properties

Name	Format	Decimation	Floating
scope_engtrqdmd	short	1	off
scope_mctrqdmd	short	1	off
scope_whbkrqdmd	short	1	off

Table 3. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
From	vsc_control_variables_in	Tag	Saturation, Gain1, Gain3, Gain4, Gain5, Divide6, Gain7, Gain8, Gain9, Gain10, Gain11, Gain12, Constant, Saturation1, ptc_mc_trq_max_reg_cstr_simu, Lookup Table, Lookup Table1, ptc_mc_trq_max_pro_cstr_simu4, Gain, mem_ptc_sft_in_progress_trs_simu
From1	vsc_plant_variables_in	Tag	Gain14, Gain15, Gain16, Gain17, Gain18, Gain19, Gain20, Gain21, Gain22, Gain23, Lookup Table2, Gain13, Gain25, Gain2
From2	vsc_control_variables_out	Tag	SFunction , Product, Product
From3	vsc_control_variables_in	Tag	Saturation, Gain1, Gain3, Gain4, Gain5, Divide6, Gain7, Gain8, Gain9, Gain10, Gain11, Gain12, Constant, Saturation1, ptc_mc_trq_max_reg_cstr_simu, Lookup Table, Lookup Table1, ptc_mc_trq_max_pro_cstr_simu4, Gain, mem_ptc_sft_in_progress_trs_simu
From4	vsc_plant_variables_in	Tag	Gain14, Gain15, Gain16, Gain17, Gain18, Gain19, Gain20, Gain21, Gain22, Gain23, Lookup Table2, Gain13, Gain25, Gain2

Table 4. Goto Block Properties

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto	vsc_control_variables_in	Tag	local	Non-positive, Fcn, Relational Operator1, Saturation1, SFunction , SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), Product, Product, Product, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), Divide1, Divide2, SFunction , SFunction , Bus Selector, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), Divide1, Switch, Add, SFunction , Product, Add, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), Product, Switch2, LowerRelop1, Switch, UpperRelop, MinMax, emcp_eng_max_trq, SFunction
Goto1	vsc_plant_variables_in	Tag	local	Product10, Gain1, to percent, Terminator1, Gain, to percent, Lookup Table1, Relational Operator, SFunction , Divide, Divide, lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction , Saturation, lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), mps to MPH, MPS_2_MPH, MPS_2_MPH, mps to MPH2, mps to MPH, mps to MPH, SFunction , emcp_engine_lugging_modifier_table, Saturation1, RPM_to_RPS, Saturation1, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction
Goto2	vsc_control_variables_out	Tag	local	Demux, Product10

Table 5. Inport Block Properties

Name	Port	Defined In Blk
param_bus_in	1	Unconnected
ptc_bus_in	2	Unconnected

Table 6. Mux Block Properties

Name	Inputs	Display Option
mux_prop	4	bar

Table 7. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
demands	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Unconnected

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/Input_Organizer_PSAT

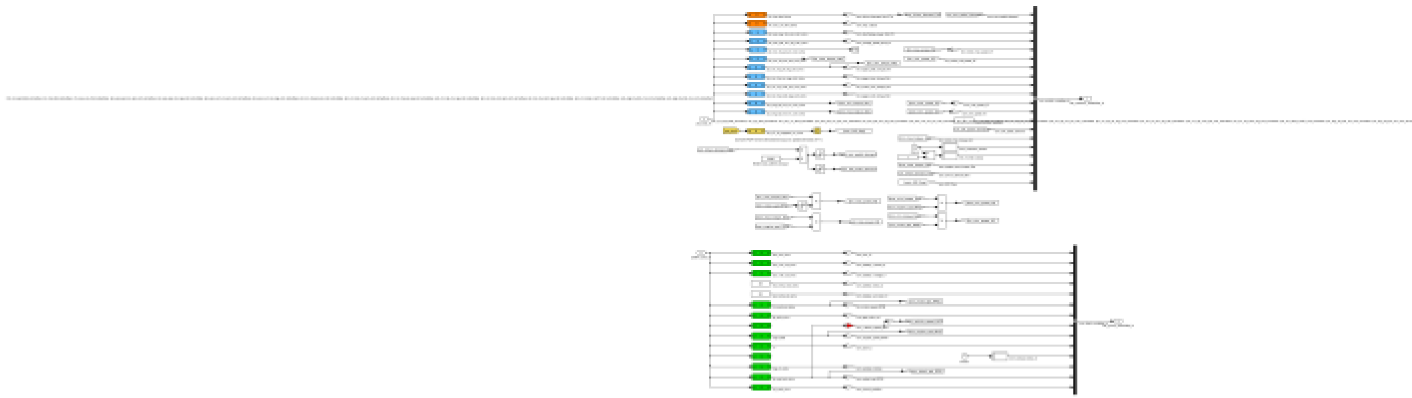


Table 8. BusCreator Block Properties

Name	Inputs	Display Option
Bus Creator	20	bar
Bus Creator1	14	bar

Table 9. Clock Block Properties

Name	Display Time	Decimation
Clock	off	10
Clock1	off	10

Table 10. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
Constant	1	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Constant1	1	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Constant2	25	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Constant3	25	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
ECM_max_wheel_torque	2000	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 11. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
From1	ecm_acc_pedal_demand	Tag	Saturation
From10	ecm_min_power_W	Tag	Divide1
From11	ecm_max_torque_Nm	Tag	ptc_mc_trq_max_pro_cstr_simu4
From12	ecm_SIP_flag	Tag	mem_ptc_sft_in_progress_trs_simu
From13	tim_max_power_W	Tag	Divide4
From14	tim_motor_spd_RPS	Tag	gb_ratio_simu2
From15	tim_min_torque_Nm	Tag	ptc_mc_trq_max_pro_cstr_simu1
From16	tim_min_power_W	Tag	Divide6
From17	ecm_engine_spd_RPS	Tag	eng_spd_simu
From2	ecm_brk_pedal_demand	Tag	Saturation1
From20	ecm_max_torque_Nm	Tag	ptc_mc_trq_max_pro_cstr_simu4
From3	tim_motor_spd_RPS	Tag	gb_ratio_simu2
From30	ecm_driver_demand_Nm	Tag	Gain
From4	tim_max_torque_Nm	Tag	ptc_mc_trq_max_reg_cstr_simu
From5	ecm_driver_demand_Nm	Tag	Gain
From6	ecm_engine_spd_RPS	Tag	eng_spd_simu
From7	tim_max_torque_Nm	Tag	ptc_mc_trq_max_reg_cstr_simu
From8	ecm_min_torque_Nm	Tag	ptc_mc_trq_max_pro_cstr_simu2
From9	ecm_max_power_W	Tag	Divide8
from_ptc_eng_on_sur_simu1	ptc_bus	Tag	lib_p_par_pre_tx_DES_dissertation_MATT (model)

Table 12. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
Gain	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain1	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain10	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain11	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain12	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain13	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain14	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain15	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain16	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain17	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain18	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
Gain19	30/pi	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain2	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain20	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain21	wh.init.radius	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain22	30/pi	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain23	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain25	30/pi	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain3	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain4	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain5	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain6	2.237	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain7	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain8	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
Gain9	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 13. Goto Block Properties

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto1	ecm_driver_demand_Nm	Tag	local	Non-positive, Fcn, Bus Selector, Divide5
Goto10	ecm_vehicle_speed_MPH	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto11	tim_min_power_W	Tag	local	Bus Selector, lib_p_par_pre_tx_DES_dissertation_MATT (model), Product
Goto12	tim_min_torque_Nm	Tag	local	Divide6, Gain7
Goto13	ecm_SIP_flag	Tag	local	Bus Selector, SFunction
Goto15	ecm_max_power_W	Tag	local	Gain11
Goto2	ecm_max_torque_Nm	Tag	local	Divide8, Bus Selector, MinMax, emcp_eng_max_trq
Goto23	ecm_acc_pedal_demand	Tag	local	Bus Selector, Relational Operator1, Saturation1, SFunction
Goto24	ecm_brk_pedal_demand	Tag	local	Bus Selector, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), Product
Goto3	ecm_wheel_spd_RPS	Tag	local	Gain21, Gain25, lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto4	ecm_engine_spd_RPS	Tag	local	Divide1, Divide8, Gain22
Goto5	ecm_min_torque_Nm	Tag	local	Divide1
Goto6	tim_max_power_W	Tag	local	Gain5
Goto7	ecm_min_power_W	Tag	local	Gain12
Goto8	tim_motor_spd_RPS	Tag	local	Saturation4, Divide6, Gain19
Goto9	tim_max_torque_Nm	Tag	local	Divide4, Bus Selector, Switch2, LowerRelop1

Table 14. Inport Block Properties

Name	Port	Defined In Blk
param_bus_in	2	Unconnected
ptc_bus_in	1	Unconnected

Table 15. Lookup Block Properties

Name	Input Values	Table	Look Up Meth	Out Min	Out Max	Out Data Type Str
Lookup Table	[0 2 2.1 10000]	[0 0 1 1]	Interpolation-Extrapolation	[]	[]	Inherit: Same as input
Lookup Table1	[0 2 2.1 10000]	[0 0 1 1]	Interpolation-Extrapolation	[]	[]	Inherit: Same as input
Lookup Table2	[0 100 100.1 10000]	[100 200 500 500]	Interpolation-Extrapolation	[]	[]	Inherit: Same as input

Table 16. Memory Block Properties

Name	X0	Inherit Sample Time	Linearize Memory	Linearize As Delay
mem_ptc_sft_in_progress_trs_simu	0	off	off	off

Table 17. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
vsc_control_variables_in	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Non-positive, Fcn, Relational Operator1, Saturation1, SFunction , SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), Product, Product, Product, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), Divide1, Divide2, SFunction , SFunction , Bus Selector, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), Divide1, Switch, Add, SFunction , Product, Add, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), Product, Switch2, LowerRelop1, Switch, UpperRelop, MinMax, emcp_eng_max_trq, SFunction
vsc_plant_variables_in	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Product10, Gain1, to percent, Terminator1, Gain, to percent, Lookup Table1, Relational Operator, SFunction , Divide, Divide, lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction , Saturation, lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), mps to MPH, MPS_2_MPH, MPS_2_MPH, mps to MPH2, mps to MPH, mps to MPH, SFunction , emcp_engine_lugging_modifier_table, Saturation1, RPM_to_RPS, Saturation1, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction

Table 18. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Divide1	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Divide4	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Divide5	*/	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Divide6	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Divide8	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 19. Saturate Block Properties

Name	Upper Limit	Lower Limit	Linearize As Gain	Zero Cross	Out Min	Out Max	Out Data Type Str
Saturation	1	0	on	on	[]	[]	Inherit: Same as input
Saturation1	0	-1	on	on	[]	[]	Inherit: Same as input
Saturation4	inf	10	on	on	[]	[]	Inherit: Same as input

Table 20. Selector Block Properties

Name	Number Of Dimensions	Index Mode	Index Option Array	Index Param Array	Output Size Array	Input Port Width	Index Options	Indices	Output Sizes
drv_key_on_dmd_hist1	1	One-based	Index vector (dialog)	nb.drv_key_on_dmd_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.drv_key_on_dmd_simu	[(-2)]
drv_trq_dmd_simu	1	One-based	Index vector (dialog)	nb.drv_trq_dmd_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.drv_trq_dmd_simu	[(-2)]
eng_spd_simu	1	One-based	Index vector (dialog)	nb.eng_spd_out_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.eng_spd_out_simu	[(-2)]
eng_spd_simu1	1	One-based	Index vector (dialog)	nb.eng_exterior_temp_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.eng_exterior_temp_simu	[(-2)]
gb_ratio_simu	1	One-based	Index vector (dialog)	nb.gb_ratio_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.gb_ratio_simu	[(-2)]
gb_ratio_simu10	1	One-based	Index vector	nb.wh_spd_out_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.wh_spd_out_simu	[(-2)]

Name	Number Of Dimensions	Index Mode	Index Option Array	Index Param Array	Output Size Array	Input Port Width	Index Options	Indices	Output Sizes
			(dialog)						
gb_ratio_simu2	1	One-based	Index vector (dialog)	nb.mc_spd_out_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.mc_spd_out_simu	[(-2)]
gb_ratio_simu3	1	One-based	Index vector (dialog)	nb.veh_lin_spd_out_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.veh_lin_spd_out_simu	[(-2)]
gb_ratio_simu4	1	One-based	Index vector (dialog)	nb.eng_on_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.eng_on_simu	[(-2)]
gb_ratio_simu5	1	One-based	Index vector (dialog)	nb.ess_soc_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.ess_soc_simu	[(-2)]
gb_ratio_simu6	1	One-based	Index vector (dialog)	nb.ess_curr_out_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.ess_curr_out_simu	[(-2)]
gb_ratio_simu7	1	One-based	Index vector (dialog)	nb.ess_volt_out_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.ess_volt_out_simu	[(-2)]
gb_ratio_simu8	1	One-based	Index vector (dialog)	nb.cpl_cmd_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.cpl_cmd_simu	[(-2)]
gb_ratio_simu9	1	One-based	Index vector (dialog)	nb.eng_ex_gas_temp_simu	[(-2)]	nb.pwt_variables	Index vector (dialog)	nb.eng_ex_gas_temp_simu	[(-2)]
ptc_mc_trq_max_pro_cstr_simu	1	One-based	Index vector (dialog)	nb.ptc_mc_trq_mx_reg_cstr_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.ptc_mc_trq_mx_reg_cstr_simu	[(-2)]
ptc_mc_trq_max_pro_cstr_simu1	1	One-based	Index vector (dialog)	nb.ptc_mc_trq_pk_reg_cstr_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.ptc_mc_trq_pk_reg_cstr_simu	[(-2)]

Name	Number Of Dimensions	Index Mode	Index Option Array	Index Param Array	Output Size Array	Input Port Width	Index Options	Indices	Output Sizes
ptc_mc_trq_max_pro_cstr_simu2	1	One-based	Index vector (dialog)	nb.ptc_eng_trq_hot_mn_cstr_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.ptc_eng_trq_hot_mn_cstr_simu	[(-2)]
ptc_mc_trq_max_pro_cstr_simu3	1	One-based	Index vector (dialog)	nb.ptc_mc_trq_cont_reg_cstr_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.ptc_mc_trq_cont_reg_cstr_simu	[(-2)]
ptc_mc_trq_max_pro_cstr_simu4	1	One-based	Index vector (dialog)	nb.ptc_eng_trq_hot_mx_cstr_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.ptc_eng_trq_hot_mx_cstr_simu	[(-2)]
ptc_mc_trq_max_reg_cstr_simu	1	One-based	Index vector (dialog)	nb.ptc_mc_trq_mx_pro_cstr_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.ptc_mc_trq_mx_pro_cstr_simu	[(-2)]
ptc_mc_trq_max_reg_cstr_simu1	1	One-based	Index vector (dialog)	nb.ptc_ess_pwr_mx_pro_cstr_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.ptc_ess_pwr_mx_pro_cstr_simu	[(-2)]
ptc_mc_trq_max_reg_cstr_simu2	1	One-based	Index vector (dialog)	nb.ptc_ess_pwr_mx_reg_cstr_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.ptc_ess_pwr_mx_reg_cstr_simu	[(-2)]
ptc_mc_trq_max_reg_cstr_simu3	1	One-based	Index vector (dialog)	nb.ptc_mc_trq_pk_pro_cstr_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.ptc_mc_trq_pk_pro_cstr_simu	[(-2)]
ptc_mc_trq_max_reg_cstr_simu4	1	One-based	Index vector (dialog)	nb.ptc_mc_trq_cont_pro_cstr_simu	[(-2)]	nb.in_dmd_variables	Index vector (dialog)	nb.ptc_mc_trq_cont_pro_cstr_simu	[(-2)]
ptc_sft_in_progress_trs_simu	1	One-based	Index vector (dialog)	nb.ptc_gb_sft_in_progress_trs_simu	[(-2)]	nb.ptc_variables	Index vector (dialog)	nb.ptc_gb_sft_in_progress_trs_simu	[(-2)]

Table 21. Sum Block Properties

Name	Icon Shape	Inputs	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Subtract	rectangular	+-	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 22. Terminator Block Properties

Name
Terminator

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/Output_Organizer_PSAT

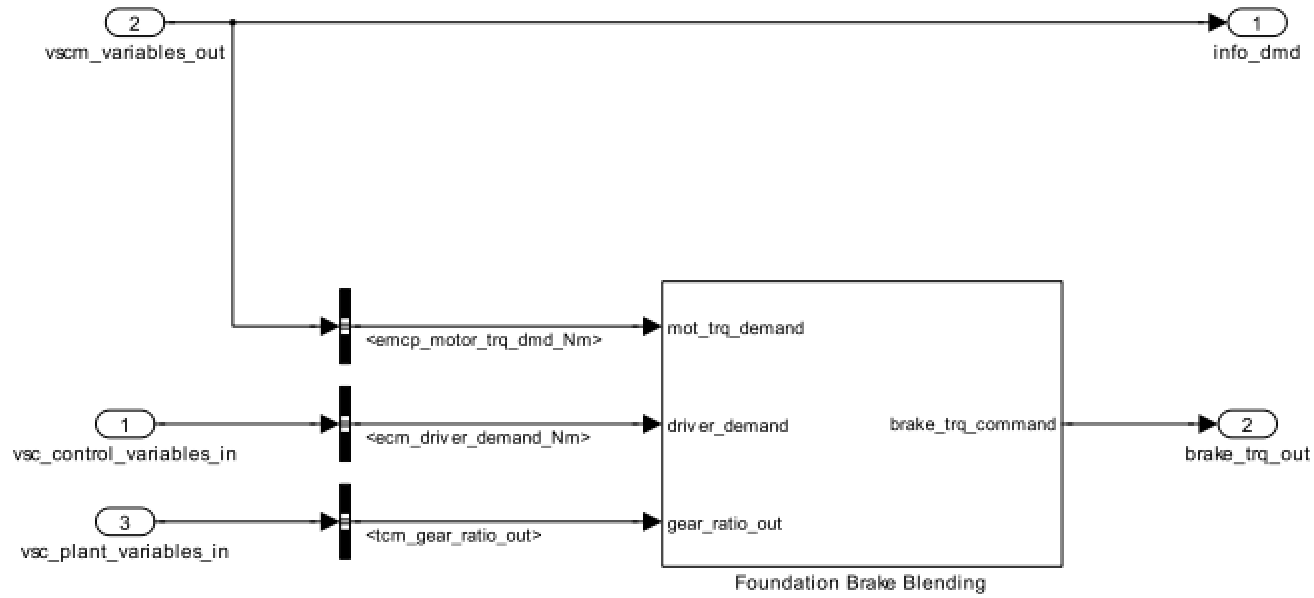


Table 23. BusSelector Block Properties

Name	Output Signals	Output As Bus	Input Signals
Bus Selector	ecm_driver_demand_Nm	off	ecm_acc_pedal_demand ecm_key_status bcm_discharge_power_limit_W bcm_charge_power_limit_W tim_motor_max_power_W tim_motor_min_power_W tim_regen_peak_torque_Nm

Name	Output Signals	Output As Bus	Input Signals
			tim_regen_max_torque_Nm tim_motor_cont_torque_Nm tim_regen_cont_torque_Nm ecm_max_power_W ecm_min_power_W ecm_PRNDL_position ecm_brk_pedal_demand tim_motor_max_torque_Nm bcm_contactor_status tim_inverter_status ecm_engine_max_torque_Nm ecm_driver_demand_Nm ecm_SIP_flag
Bus Selector1	emcp_motor_trq_dmd_Nm	off	vmcp_EPU emcp_eng_trq_dmd_Nm emcp_motor_trq_dmd_Nm
Bus Selector2	tcm_gear_ratio_out	off	bcm_soc_% bcm_battery_current_A bcm_battery_voltage_V bcm_battery_temp_C bcm_battery_air_temp_C tim_motor_speed_RPM tcm_gear_ratio_out ecm_vehicle_speed_MPS ecm_engine_speed_RPM ecm_ECT_C ecm_exhaust_temp_C ecm_engine_running ecm_wheel_spd_RPM

Name	Output Signals	Output As Bus	Input Signals
			ecm_clutch_position

Table 24. Inport Block Properties

Name	Port	Defined In Blk
vsc_control_variables_in	1	Saturation, Gain1, Gain3, Gain4, Gain5, Divide6, Gain7, Gain8, Gain9, Gain10, Gain11, Gain12, Constant, Saturation1, ptc_mc_trq_max_reg_cstr_simu, Lookup Table, Lookup Table1, ptc_mc_trq_max_pro_cstr_simu4, Gain, mem_ptc_sft_in_progress_trs_simu
vsc_plant_variables_in	3	Gain14, Gain15, Gain16, Gain17, Gain18, Gain19, Gain20, Gain21, Gain22, Gain23, Lookup Table2, Gain13, Gain25, Gain2
vscm_variables_out	2	SFunction , Product, Product

Table 25. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
brake_trq_out	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	scope_whbkrqdmd
info_dmd	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Demux, Product10

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/Output_Organizer_PSAT/Foundation Brake Blending

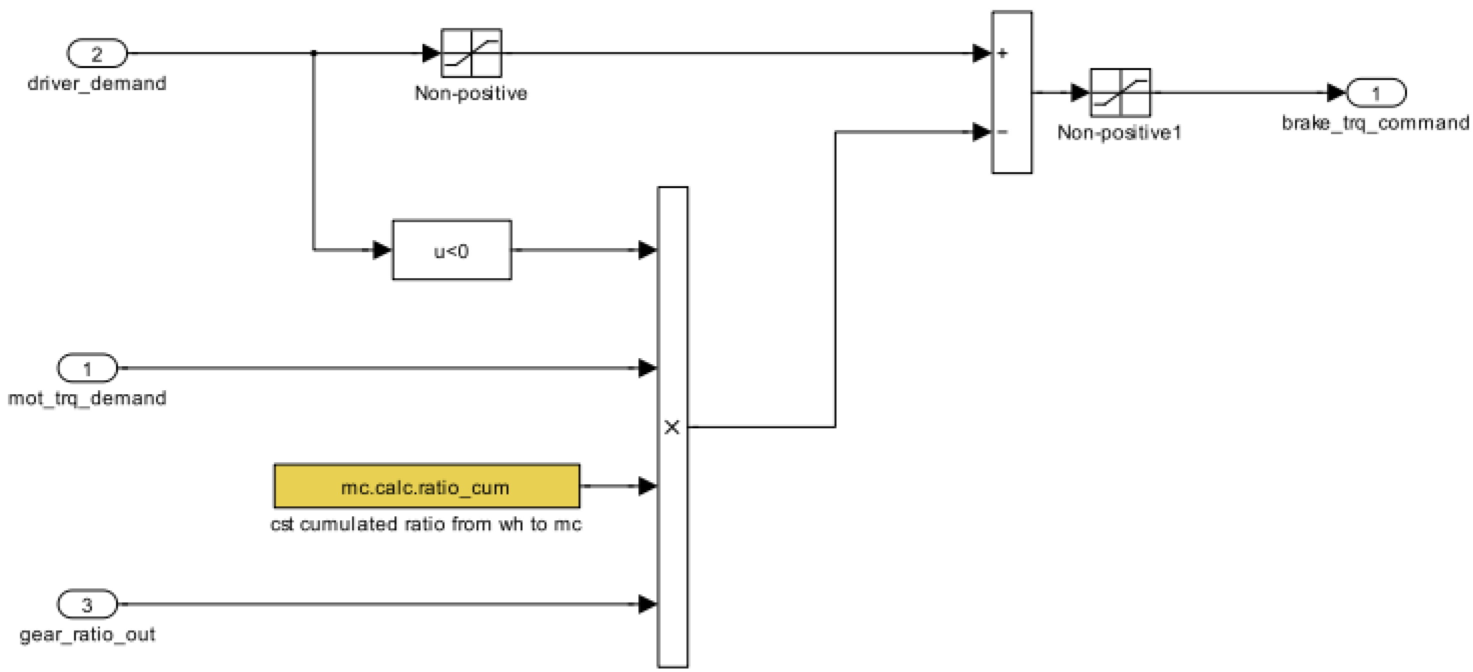


Table 26. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
cst cumulated ratio from wh to mc	mc.calc.ratio_cum	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 27. Fcn Block Properties

Name	Expr
Fcn	u<0

Table 28. Inport Block Properties

Name	Port	Defined In Blk
driver_demand	2	Gain
gear_ratio_out	3	Gain20
mot_trq_demand	1	Product

Table 29. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
brake_trq_command	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	scope_whbkrqdmd

Table 30. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Product10	4	Element-wise(.*)	All dimensions	1	on	[]	[]	Inherit: Same as first input

Table 31. Saturate Block Properties

Name	Upper Limit	Lower Limit	Linearize As Gain	Zero Cross	Out Min	Out Max	Out Data Type Str
Non-positive	0	-inf	on	on	[]	[]	Inherit: Same as input
Non-positive1	0	-inf	on	on	[]	[]	Inherit: Same as input

Table 32. Sum Block Properties

Name	Icon Shape	Inputs	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Sum8	rectangular	+-	All dimensions	1	on	[]	[]	Inherit: Same as first input

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Battery Mode Control Process

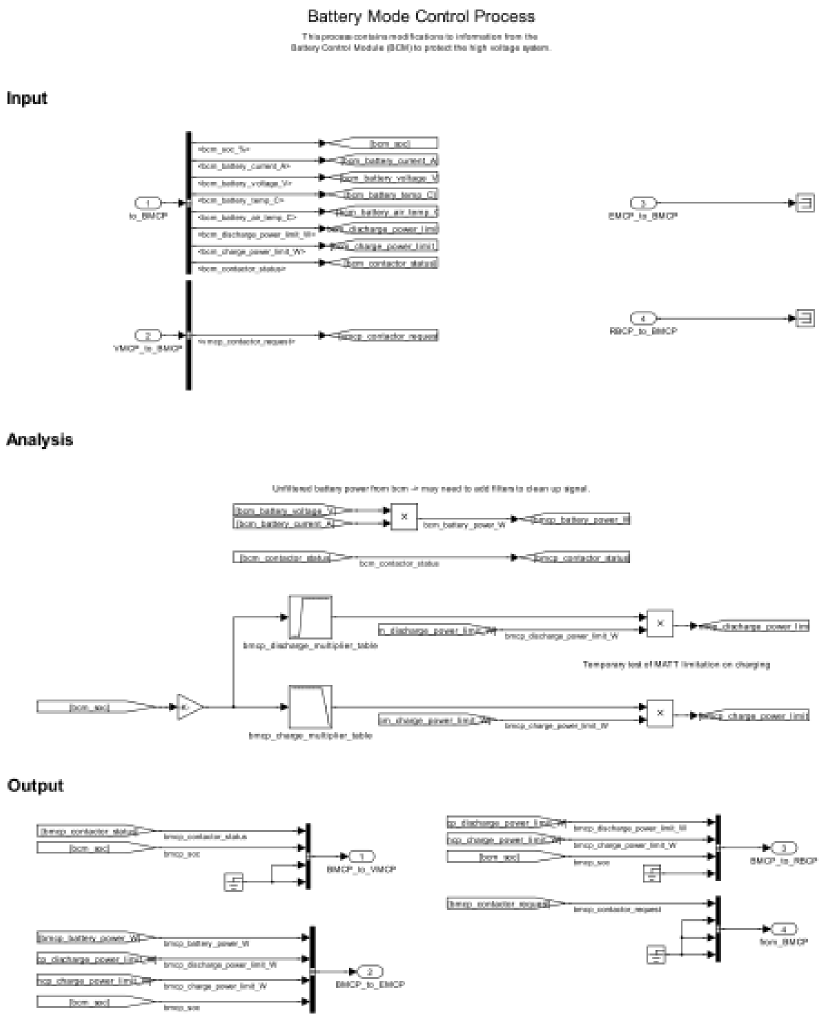


Table 33. BusCreator Block Properties

Name	Inputs	Display Option
Bus Creator	4	bar
Bus Creator1	4	bar
Bus Creator2	4	bar
Bus Creator3	4	bar

Table 34. BusSelector Block Properties

Name	Output Signals	Output As Bus	Input Signals
Bus Selector	bcm_soc_%,bcm_battery_current_A,bcm_battery_voltage_V,bcm_battery_temp_C,bcm_battery_air_temp_C,bcm_discharge_power_limit_W,bcm_charge_power_limit_W,bcm_contactor_status	off	bcm_soc_% bcm_battery_current_A bcm_battery_voltage_V bcm_battery_temp_C bcm_battery_air_temp_C bcm_discharge_power_limit_W bcm_charge_power_limit_W bcm_contactor_status
Bus Selector1	vmcp_contactor_request	off	vmcp_contactor_request vmcp_soft_start_request

Table 35. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
From	bcm_battery_voltage_V	Tag	Gain16
From1	bcm_battery_current_A	Tag	Gain15
From10	bmcp_charge_power_limit_W	Tag	Divide2
From11	bmcp_discharge_power_limit_W	Tag	Divide1
From12	bmcp_charge_power_limit_W	Tag	Divide2
From13	bcm_soc	Tag	Gain14

Name	Goto Tag	Icon Display	Defined In Blk
From14	bcm_contactor_status	Tag	Lookup Table
From16	bcm_soc	Tag	Gain14
From2	bcm_soc	Tag	Gain14
From3	bmcp_battery_power_W	Tag	Divide
From4	bcm_soc	Tag	Gain14
From5	bcm_discharge_power_limit_W	Tag	Gain3
From6	bcm_charge_power_limit_W	Tag	Gain4
From7	bmcp_contactor_request	Tag	lib_p_par_pre_tx_DES_dissertation_MATT (model)
From8	bmcp_contactor_status	Tag	Lookup Table
From9	bmcp_discharge_power_limit_W	Tag	Divide1

Table 36. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
Gain	100	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 37. Goto Block Properties

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto	bcm_soc	Tag	local	Gain1, to percent, Terminator1, Gain, to percent, Lookup Table1, Relational Operator, SFunction
Goto1	bcm_battery_current_A	Tag	local	Divide
Goto10	bcm_contactor_status	Tag	local	SFunction
Goto11	bmcp_charge_power_limit_W	Tag	local	Terminator1, SFunction
Goto12	bmcp_contactor_status	Tag	local	SFunction
Goto2	bcm_battery_voltage_V	Tag	local	Divide
Goto3	bcm_battery_temp_C	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto4	bcm_battery_air_temp_C	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto5	bcm_discharge_power_limit_W	Tag	local	Divide1
Goto6	bcm_charge_power_limit_W	Tag	local	Divide2
Goto7	bmcp_battery_power_W	Tag	local	mps to MPH3
Goto8	bmcp_discharge_power_limit_W	Tag	local	SFunction , Terminator1
Goto9	vmcp_contactor_request	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)

Table 38. Ground Block Properties

Name
Ground
Ground1

Name
Ground2

Table 39. Inport Block Properties

Name	Port	Defined In Blk
EMCP_to_BMCP	3	Ground
RBCP_to_BMCP	4	Ground1
to_BMCP	1	Gain14, Gain15, Gain16, Gain17, Gain18, Gain3, Gain4, Lookup Table
VMCP_to_BMCP	2	SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model)

Table 40. Lookup Block Properties

Name	Input Values	Table	Look Up Meth	Out Min	Out Max	Out Data Type Str
bmcp_charge_multiplier_table	ptc.prop.init.bmcp_soc_index	ptc.prop.init.bmcp_charge_power_multiplier	Interpolation-Extrapolation	[]	[]	Inherit: Same as input
bmcp_discharge_multiplier_table	ptc.prop.init.bmcp_soc_index	ptc.prop.init.bmcp_discharge_power_multiplier	Interpolation-Extrapolation	[]	[]	Inherit: Same as input

Table 41. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
BMCP_to_EMCP	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	mps to MPH3, Gain1, to percent, SFunction , SFunction
BMCP_to_RBCP	3	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Terminator1
BMCP_to_VMCP	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction , to percent, Lookup Table1, Relational Operator, SFunction
from_BMCP	4	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Unconnected

Table 42. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Divide	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Divide1	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Divide2	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 43. Terminator Block Properties

Name
Terminator
Terminator1

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Energy Management Control Process

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Energy Management Control Process

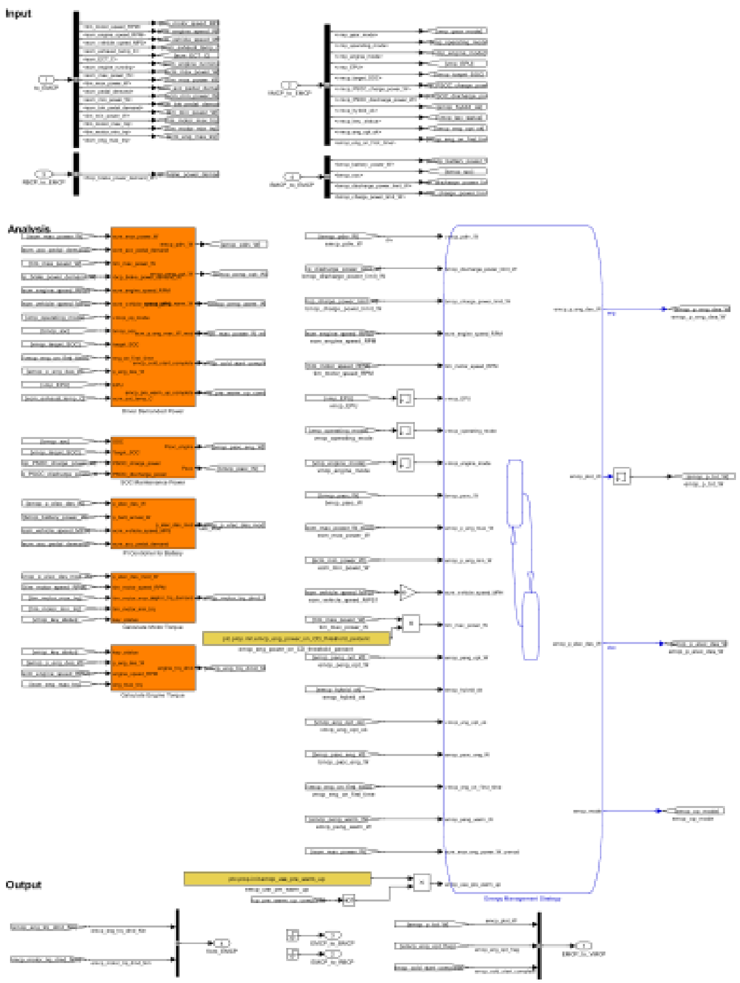


Table 44. BusCreator Block Properties

Name	Inputs	Display Option
Bus Creator1	3	bar
Bus Creator2	2	bar

Table 45. BusSelector Block Properties

Name	Output Signals	Output As Bus	Input Signals
Bus Selector	tim_motor_speed_RPM,ecm_engine_speed_RPM,ecm_vehicle_speed_MPS,ecm_exhaust_temp_C,ecm_ECT_C,ecm_engine_running,ecm_max_power_W,tim_max_power_W,ecm_pedal_demand,ecm_min_power_W,ecm_brk_pedal_demand,tim_min_power_W,tim_motor_max_trq,tim_motor_min_trq,ecm_eng_max_trq	off	ecm_ECT_C ecm_exhaust_temp_C ecm_vehicle_speed_MPS ecm_engine_speed_RPM tim_motor_speed_RPM ecm_engine_running ecm_min_power_W ecm_max_power_W tim_min_power_W tim_max_power_W ecm_pedal_demand ecm_brk_pedal_demand tim_motor_max_trq

Name	Output Signals	Output As Bus	Input Signals
			tim_motor_min_trq ecm_eng_max_trq
Bus Selector 1	vmp_gear_mode,vmp_operating_mode,vmp_engine_mode,vmp_EPU,vmcp_target_SOC,vmcp_PSOC_charge_power_W,vmcp_PSOC_discharge_power_W,vmcp_hybrid_ok,vmcp_key_status,vmcp_eng_opt_ok,emcp_eng_on_first_time	off	vmp_gear_mode vmp_operating_mode vmp_engine_mode vmp_EPU vmcp_target_SOC vmcp_PSOC_charge_power_W vmcp_PSOC_discharge_power_W vmcp_hybrid_ok vmcp_key_status vmcp_eng_opt_ok emcp_eng_on_first_time
Bus Selector 2	bmcp_battery_power_W,bmcp_soc,bmcp_discharge_power_limit_W,bmcp_charge_power_limit_W	off	bmcp_battery_power_W bmcp_discharge_power_limit_W bmcp_charge_power_limit_W

Name	Output Signals	Output As Bus	Input Signals
			bmcp_soc
Bus Selector 3	rbcp_brake_power_demand_W	off	rbcp_brake_power_demand_W signal2

Table 46. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
emcp_eng_power_on_CD_threshold_percent	ptc.prop.init.emcp_eng_power_on_CD_threshold_percent	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
emcp_use_pre_warm_up	ptc.prop.init.emcp_use_pre_warm_up	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 47. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
bmcp_charge_power_limit_W	bmcp_charge_power_limit_W	Tag	Divide2
bmcp_discharge_power_limit_W	bmcp_discharge_power_limit_W	Tag	Divide1
bmcp_psoc_eng_W	bmcp_psoc_eng_W	Tag	Product
bmcp_psoc_W	bmcp_psoc_W	Tag	Dynamic PSOC Table
ecm_engine_speed_RPM	ecm_engine_speed_RPM	Tag	Gain22
ecm_max_power_W	ecm_max_power_W_mod	Tag	Switch
ecm_min_power_W	ecm_min_power_W	Tag	Gain12
ecm_vehicle_speed_MPS	ecm_vehicle_speed_MPS	Tag	Gain21
ecm_vehicle_speed_MPS1	ecm_vehicle_speed_MPS	Tag	Gain21
emcp_hybrid_ok	emcp_hybrid_ok	Tag	SFunction
emcp_pdrv_W	emcp_pdrv_W	Tag	Switch1
emcp_peng_opt_W	emcp_peng_opt_W	Tag	Switch1
emcp_peng_warm_W	emcp_peng_warm_W	Tag	Multiply
From1	bmcp_soc	Tag	Gain14
From10	ecm_engine_speed_RPM	Tag	Gain22
From11	tim_motor_speed_RPM	Tag	Gain19

Name	Goto Tag	Icon Display	Defined In Blk
From12	emcp_p_elec_des_mod_W	Tag	Switch
From13	vmcp_target_SOC	Tag	SFunction
From14	emcp_p_eng_des_W	Tag	SFunction
From15	ecm_max_power_W	Tag	Gain11
From16	emcp_motor_trq_dmd_Nm	Tag	Product
From17	ecm_acc_pedal_demand	Tag	Saturation
From18	ecm_max_power_W	Tag	Gain11
From19	tim_max_power_W	Tag	Gain5
From2	tim_motor_min_trq	Tag	Gain8
From20	emcp_eng_trq_dmd_Nm	Tag	Product
From21	emcp_p_tot_W	Tag	Memory5
From22	emcp_cold_start_complete	Tag	SFunction
From23	emcp_pre_warm_up_complete	Tag	SFunction
From24	rbcp_brake_power_demand_W	Tag	Product1
From26	vmcp_target_SOC	Tag	SFunction
From27	emcp_p_elec_des_W	Tag	SFunction
From28	bmcp_battery_power_W	Tag	Divide
From29	ecm_vehicle_speed_MPS	Tag	Gain21
From3	tim_motor_max_trq	Tag	ptc_mc_trq_max_reg_cstr_simu
From30	vmcp_PSOC_charge_power_W	Tag	SFunction
From31	ecm_acc_pedal_demand	Tag	Saturation
From32	vmcp_PSOC_discharge_power_W	Tag	SFunction
From34	ecm_engine_speed_RPM	Tag	Gain22
From4	ecm_eng_max_trq	Tag	ptc_mc_trq_max_pro_cstr_simu4
From5	vmcp_key_status	Tag	Gain1
From6	vmcp_key_status	Tag	Gain1
From7	emcp_eng_opt_flag	Tag	lib_p_par_pre_tx_DES_dissertation_MATT (model)
From8	bmcp_soc	Tag	Gain14
From9	emcp_p_eng_des_W	Tag	SFunction
tim_max_power_W	tim_max_power_W	Tag	Gain5
tim_motor_speed_RPM	tim_motor_speed_RPM	Tag	Gain19
vmcp_eng_on_first_time	vmcp_eng_on_first_time	Tag	SFunction
vmcp_eng_on_first_time1	vmcp_eng_on_first_time	Tag	SFunction
vmcp_eng_opt_ok	vmcp_eng_opt_ok	Tag	SFunction

Name	Goto Tag	Icon Display	Defined In Blk
vmcp_engine_mode	vmp_engine_mode	Tag	SFunction
vmcp_EPU	vmp_EPU	Tag	SFunction
vmcp_EPU1	vmp_EPU	Tag	SFunction
vmcp_EPU2	ecm_exhaust_temp_C	Tag	Lookup Table2
vmcp_operating_mode	vmp_operating_mode	Tag	Memory1
vmcp_operating_mode1	vmp_operating_mode	Tag	Memory1

Table 48. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
mps to MPH	2.237	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 49. Goto Block Properties

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
emcp_op_mode	emcp_op_mode	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
emcp_p_elec_des_W	emcp_p_elec_des_W	Tag	local	Switch, Product2, Subtract
emcp_p_eng_des_W	emcp_p_eng_des_W	Tag	local	Divide, Sum
emcp_p_tot_W	emcp_p_tot_W	Tag	local	Memory
Goto	tim_motor_speed_RPM	Tag	local	SFunction , Saturation
Goto1	ecm_engine_speed_RPM	Tag	local	SFunction , emcp_engine_lugging_modifier_table, Saturation1, RPM_to_RPS, Saturation1
Goto10	bmcp_soc	Tag	local	Gain1, to percent
Goto11	bmcp_discharge_power_limit_W	Tag	local	SFunction
Goto12	bmcp_charge_power_limit_W	Tag	local	SFunction
Goto13	ecm_max_power_W	Tag	local	Divide1, Switch, Add, SFunction
Goto14	ecm_engine_running	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto15	emcp_hybrid_ok	Tag	local	SFunction
Goto16	tim_motor_max_trq	Tag	local	Switch2, LowerRelop1
Goto17	emcp_eng_trq_dmd_Nm	Tag	local	Demux, Bus Selector1
Goto18	emcp_motor_trq_dmd_Nm	Tag	local	Demux, Product10
Goto19	bmcp_psoc_W	Tag	local	SFunction
Goto2	ecm_vehicle_speed_MPS	Tag	local	mps to MPH, MPS_2_MPH, MPS_2_MPH, mps to MPH2
Goto20	tim_max_power_W	Tag	local	Product, Add
Goto21	emcp_pdrv_W	Tag	local	SFunction
Goto22	tim_motor_min_trq	Tag	local	Switch, UpperRelop
Goto23	ecm_acc_pedal_demand	Tag	local	Relational Operator1, Saturation1
Goto24	ecm_min_power_W	Tag	local	SFunction

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto25	emcp_p_elec_des_mod_W	Tag	local	Divide1
Goto26	rbcp_brake_power_demand_W	Tag	local	Sum
Goto27	ecm_brk_pedal_demand	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto28	tim_min_power_W	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto29	vmcp_target_SOC	Tag	local	to percent1, to percent1
Goto3	ecm_exhaust_temp_C	Tag	local	SFunction
Goto30	vmcp_PSOC_charge_power_W	Tag	local	Gain
Goto31	vmcp_PSOC_discharge_power_W	Tag	local	Matrix Concatenate, Matrix Concatenate
Goto32	emcp_peng_opt_W	Tag	local	SFunction
Goto33	ecm_eng_max_trq	Tag	local	MinMax, emcp_eng_max_trq
Goto34	vmcp_key_status	Tag	local	Product, Product
Goto35	vmcp_eng_opt_ok	Tag	local	SFunction
Goto36	bmcp_psoc_eng_W	Tag	local	SFunction
Goto37	vmcp_eng_on_first_time	Tag	local	SFunction , SFunction
Goto38	emcp_peng_warm_W	Tag	local	SFunction
Goto39	ecm_max_power_W_mod	Tag	local	SFunction
Goto4	ecm_ECT_C	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto40	emcp_cold_start_complete	Tag	local	Memory2
Goto41	emcp_pre_warm_up_complete	Tag	local	Logical Operator
Goto5	vmp_gear_mode	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto6	vmp_operating_mode	Tag	local	Compare, Memory4
Goto7	vmp_engine_mode	Tag	local	Memory3
Goto8	vmp_EPU	Tag	local	SFunction , Divide3, Memory2
Goto9	bmcp_battery_power_W	Tag	local	mps to MPH3

Table 50. Ground Block Properties

Name
Ground
Ground1

Table 51. Inport Block Properties

Name	Port	Defined In Blk
BMCP_to_EMCP	4	Divide, Divide1, Divide2, Gain14
RBCP_to_EMCP	3	Product1, Ground
to_EMCP	1	Gain23, Lookup Table2, Gain21, Gain22, Gain19, Gain13, Gain12, Gain11, Divide6, Gain5, Saturation, Saturation1, ptc_mc_trq_max_reg_cstr_simu, Gain8,

Name	Port	Defined In Blk
		ptc_mc_trq_max_pro_cstr_simu4
VMCP_to_EMCP	2	lib_p_par_pre_tx_DES_dissertation_MATT (model), Memory1, SFunction , SFunction , SFunction , SFunction , SFunction , SFunction , Gain1, SFunction , SFunction

Table 52. Logic Block Properties

Name	Operator	Inputs	Icon Shape	All Ports Same DT	Out Data Type Str
Logical Operator	NOT	2	rectangular	off	boolean

Table 53. Memory Block Properties

Name	X0	Inherit Sample Time	Linearize Memory	Linearize As Delay
Memory2	0	off	off	off
Memory3	0	off	off	off
Memory4	0	off	off	off
Memory5	0	off	off	off

Table 54. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
EMCP_to_BMCP	3	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Terminator1
EMCP_to_RBCP	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Terminator
EMCP_to_VMCP	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Memory, Memory2
from_EMCP	4	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Demux, Bus Selector1, Demux, Product10

Table 55. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Product	2	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Product1	2	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 56. Stateflow Block Properties

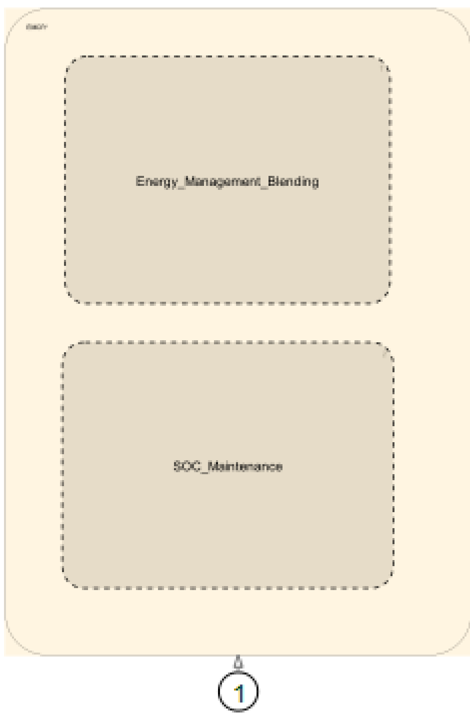
Name	Chart
Energy Management Strategy	Energy Management Strategy

Chart - Energy Management Strategy

Chart	lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy
States	EMCP
Data	vmcp_pdrv_W bmcp_discharge_power_limit_W

Chart	lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy
	bmcp_charge_power_limit_W ecm_engine_speed_RPM tim_motor_speed_RPM vmcp_EPU vmcp_operating_mode vmcp_engine_mode emcp_p_drv_mod_W emcp_p_eng_des_W emcp_ptot_W emcp_ptot_temp_W emcp_p_elec_des_W emcp_p_elec_W bmcp_psoc_W emcp_psoc_W Cruise_Charge Engine_Only Full_Power Idle_Charge emcp_p_elec_des emcp_p_eng_max_W emcp_p_eng_min_W Normal Regen ecm_vehicle_speed_MPH tim_max_power_W Charge_Sustaining emcp_peng_opt_W emcp_hybrid_ok emcp_mode vmcp_eng_opt_ok

Chart	lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy
	emcp_psoc_eng_W emcp_ptot_eng_W vmcp_eng_on_first_time emcp_peng_warm_W ecm_max_eng_power_W_unmod emcp_use_pre_warm_up



(1) EMCP

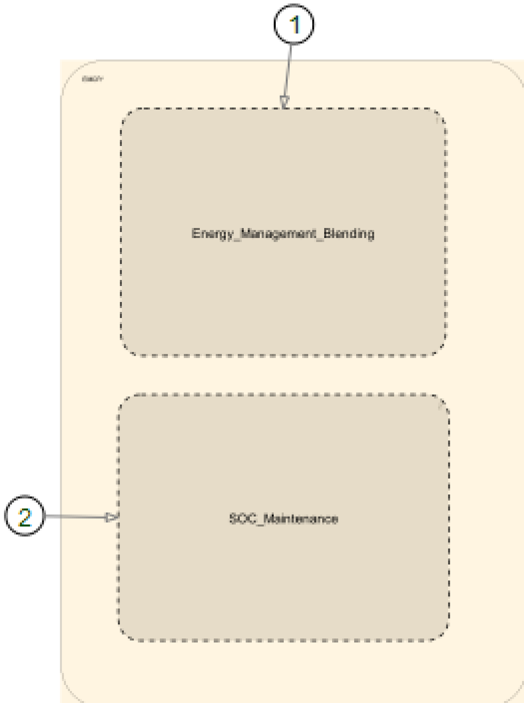
Stateflow Hierarchy

1. lib_p_par_pre_tx_DES_dissertation_MATT
    1. Cold_Start_Logic_Chart
    2. Vehicle Mode Control Process
    3. *Energy Management Strategy*
        1. Data: vmcp_pdrv_W, bmcp_discharge_power_limit_W, bmcp_charge_power_limit_W, ecm_engine_speed_RPM, tim_motor_speed_RPM, vmcp_EPU, vmcp_operating_mode, vmcp_engine_mode, emcp_p_drv_mod_W, emcp_p_eng_des_W, emcp_ptot_W, emcp_ptot_temp_W, emcp_p_elec_des_W, emcp_p_elec_W, bmcp_psoc_W, emcp_psoc_W, Cruise_Charge, Engine_Only, Full_Power, Idle_Charge, emcp_p_elec_des, emcp_p_eng_max_W, emcp_p_eng_min_W, Normal, Regen, ecm_vehicle_speed_MPH, tim_max_power_W, Charge_Sustaining, emcp_peng_opt_W, emcp_hybrid_ok, emcp_mode, vmcp_eng_opt_ok, emcp_psoc_eng_W, emcp_ptot_eng_W, vmcp_eng_on_first_time, emcp_peng_warm_W, ecm_max_eng_power_W_unmod, emcp_use_pre_warm_up
        2. EMCP
            1. Energy_Management_Blending
                1. Transition: [emcp_hybrid_ok], [!emcp_hybrid_ok], [vmcp_operating_mode == 50], [vmcp_operating_mode != 50]
                2. Electric_Mode
                    1. Transition: [vmcp_pdrv_W >= bmcp_discharg..., [vmcp_pdrv_W <= bmcp_charge_p..., {emcp_p_elec_des_W = vmcp_pdr..., {emcp_p_elec_des_W = bmcp_dis..., {emcp_p_elec_des_W = bmcp_cha..., [vmcp_operating_mode == 60], {emcp_p_elec_des_W = 0;}
                3. Conventional_Mode
                    1. Transition: [vmcp_pdrv_W >= ecm_max_eng_p..., {emcp_p_eng_des_W = ecm_max_e..., {emcp_p_eng_des_W = vmcp_pdrv...
                4. Hybrid_Mode
                    1. Transition: [Charge_Sustaining]
                    2. Charge_Depleting_Mode
                        1. Transition: [vmcp_pdrv_W >= tim_max_power_W], {emcp_p_drv_mod_W = vmcp_pdrv..., {emcp_p_drv_mod_W = vmcp_pdrv..., {emcp_p_elec_W = tim_max_powe..., {emcp_p_eng_des_W = emcp_p_dr..., [emcp_p_elec_W >= bmcp_discha..., [emcp_p_elec_W <= bmcp_charge..., {emcp_p_elec_des_W = bmcp_dis..., {emcp_p_elec_des_W = bmcp_cha..., {emcp_p_elec_des_W = emcp_p_e..., [vmcp_pdrv_W >= emcp_p_eng_ma..., {emcp_p_drv_mod_W = emcp_p_en..., {emcp_p_elec_W = vmcp_pdrv_W;}, [vmcp_operating_mode == 60], {emcp_p_eng_des_W = 0;}, {emcp_p_elec_des_W = 0;}
                    3. Charge_Sustaining_Mode
                        1. Transition: {emcp_p_elec_des_W = bmcp_dis..., {emcp_p_elec_W = emcp_p_drv_m..., {emcp_p_eng_des_W = emcp_p_dr..., [emcp_p_elec_W >= bmcp_discha..., {emcp_p_elec_des_W = bmcp_cha..., [emcp_p_elec_W <= bmcp_charge..., {emcp_p_elec_des_W = emcp_p_e..., [vmcp_pdrv_W >= emcp_p_eng_ma..., [vmcp_pdrv_W >= emcp_p_eng_ma..., {emcp_p_drv_mod_W = vmcp_pdrv..., {emcp_p_drv_mod_W = vmcp_pdrv..., {emcp_p_drv_mod_W = emcp_p_en..., {emcp_p_eng_des_W = emcp_p_en..., [emcp_ptot_W >= emcp_p_eng_ma..., {emcp_p_eng_des_W=emcp_p_eng_..., [emcp_ptot_W <= 0], {emcp_p_eng_des_W = emcp_ptot..., {emcp_p_eng_des_W = 0;}, [vmcp_eng_opt_ok && vmcp_eng_..., {emcp_p_eng_des_W = emcp_peng..., [emcp_p_drv_mod_W >= emcp_pen..., {emcp_p_eng_des_W=emcp_p_drv_..., [emcp_p_drv_mod_W >= emcp_p_e..., {emcp_p_eng_des_W=emcp_p_eng_..., [vmcp_operating_mode == 60],

{emcp_p_eng_des_W = 0;}, {emcp_p_elec_des_W = 0;}, [emcp_p_drv_mod_W < 0], {emcp_p_eng_des_W = emcp_peng..., [!vmcp_eng_on_first_time && (..., {emcp_p_eng_des_W=emcp_peng_w...

2. SOC_Maintenance
    1. Transition: [Charge_Sustaining], [Engine_Only], [Full_Power], [Regen]
    2. Electric_Mode_Active
    3. Charge_Sustaining_Mode
        1. Transition: {emcp_psoc_W = bmcp_psoc_W;}, [vmcp_operating_mode == 30], {emcp_psoc_W = 0;}
    4. Engine_Only_Active
    5. Regen_Active
    6. Full_Power_Active

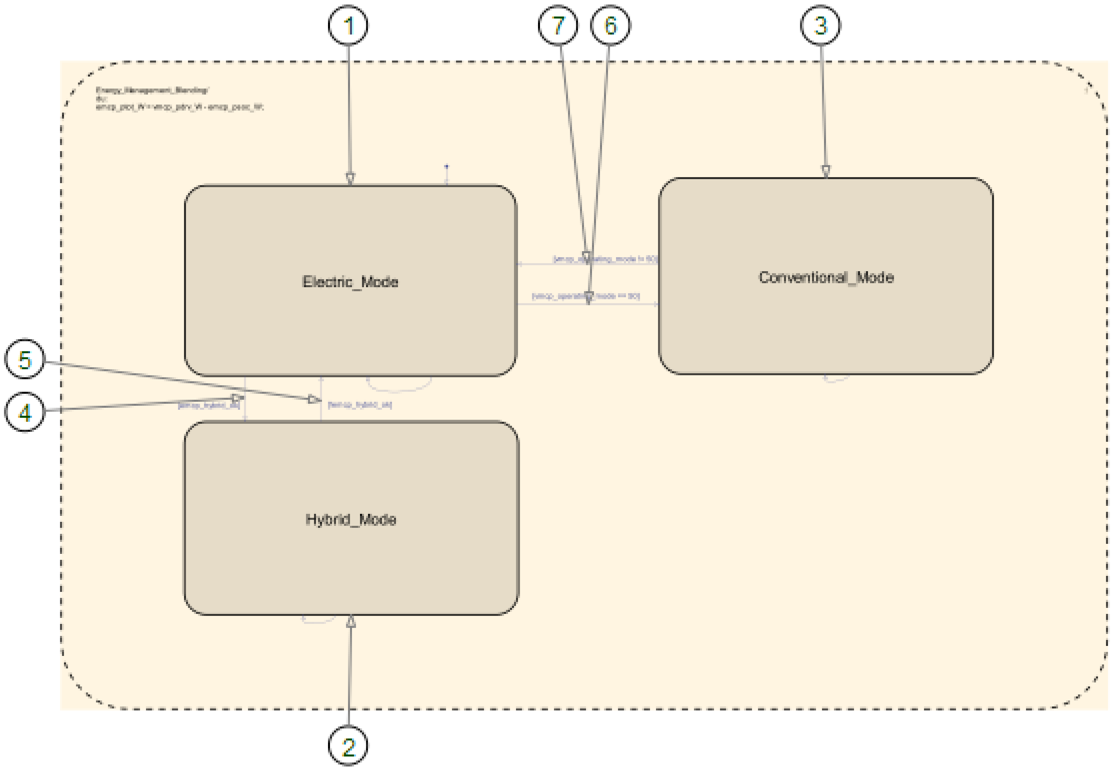
OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP**
Label	EMCP/



(1) Energy_Management_Blending

(2) SOC_Maintenance

AND State	**lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/Energy_Management_Blending**
Label	Energy_Management_Blending/ du: emcp_ptot_W = vmcp_pdrv_W - emcp_psoc_W;



(1) Electric_Mode

(2) Hybrid_Mode

(3) Conventional_Mode

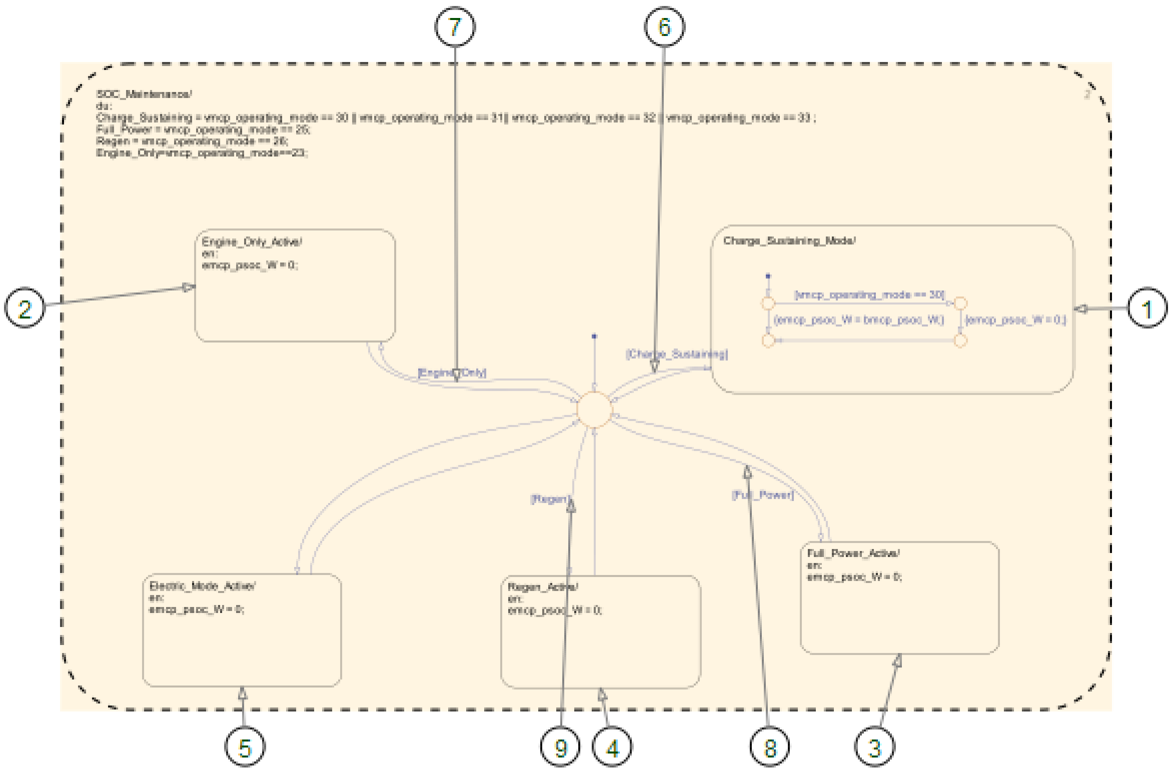
(4) [emcp_hybrid_ok]

(5) [!emcp_hybrid_ok]

(6) [vmcp_operating_mode == 50]

(7) [vmcp_operating_mode != 50]

AND State	lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/SOC_Maintenance
Label	SOC_Maintenance/ du: Charge_Sustaining = vmcp_operating_mode == 30 || vmcp_operating_mode == 31|| vmcp_operating_mode == 32 || vmcp_operating_mode == 33 ; Full_Power = vmcp_operating_mode == 25; Regen = vmcp_operating_mode == 26; Engine_Only=vmcp_operating_mode==23;



(1) Charge_Sustaining_Mode

(2) Engine_Only_Active

(3) Full_Power_Active

(4) Regen_Active

(5) Electric_Mode_Active

(6) [Charge_Sustaining]

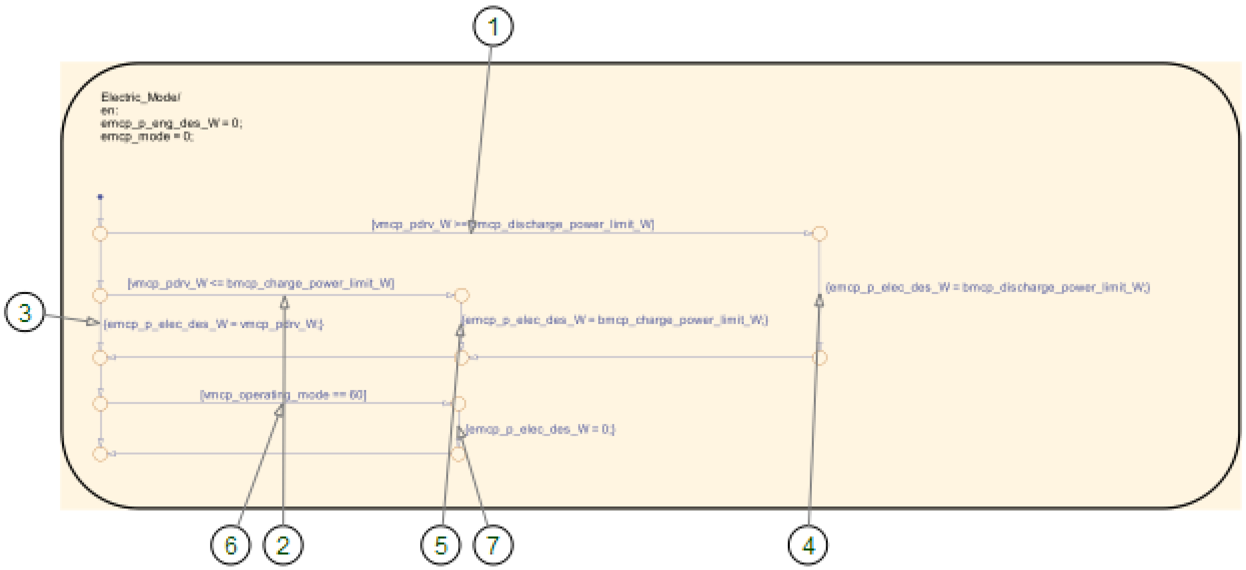
(7) [Engine_Only]

(8) [Full_Power]

(9) [Regen]

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/Energy_Management_Blending/Electric_Mode**

Label	Electric_Mode/
	en:
	emcp_p_eng_des_W = 0;
	emcp_mode = 0;



(1) [vmcp_pdrv_W >= bmcp_discharg...

(2) [vmcp_pdrv_W <= bmcp_charge_p...

(3) {emcp_p_elec_des_W = vmcp_pdr...

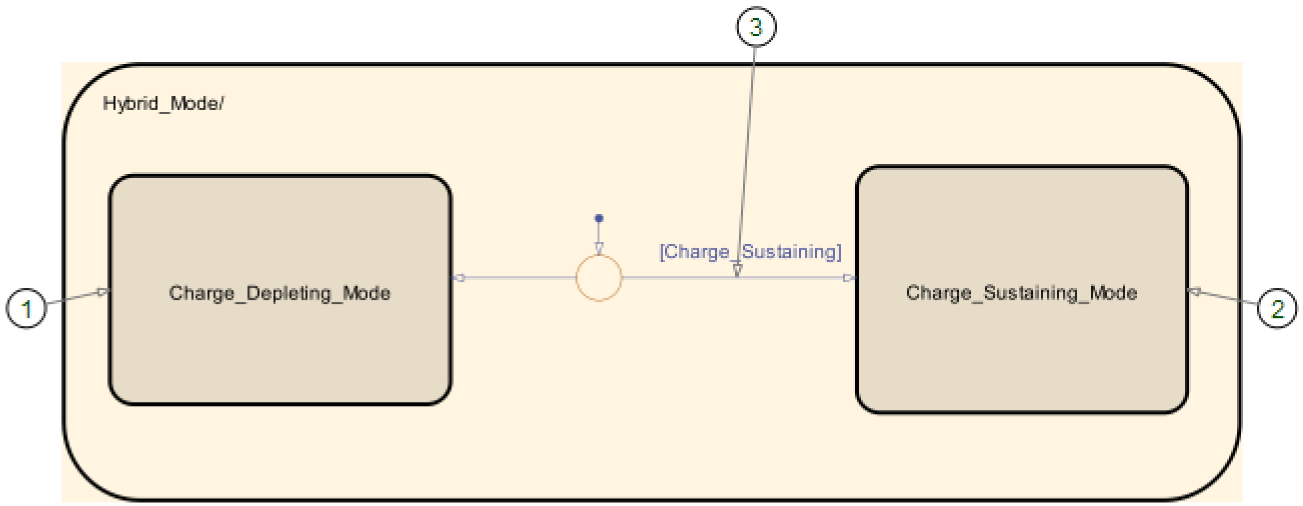
(4) {emcp_p_elec_des_W = bmcp_dis...

(5) {emcp_p_elec_des_W = bmcp_cha...

(6) [vmcp_operating_mode == 60]

(7) {emcp_p_elec_des_W = 0;}

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/Energy_Management_Blending/Hybrid_Mode**
Label	Hybrid_Mode/



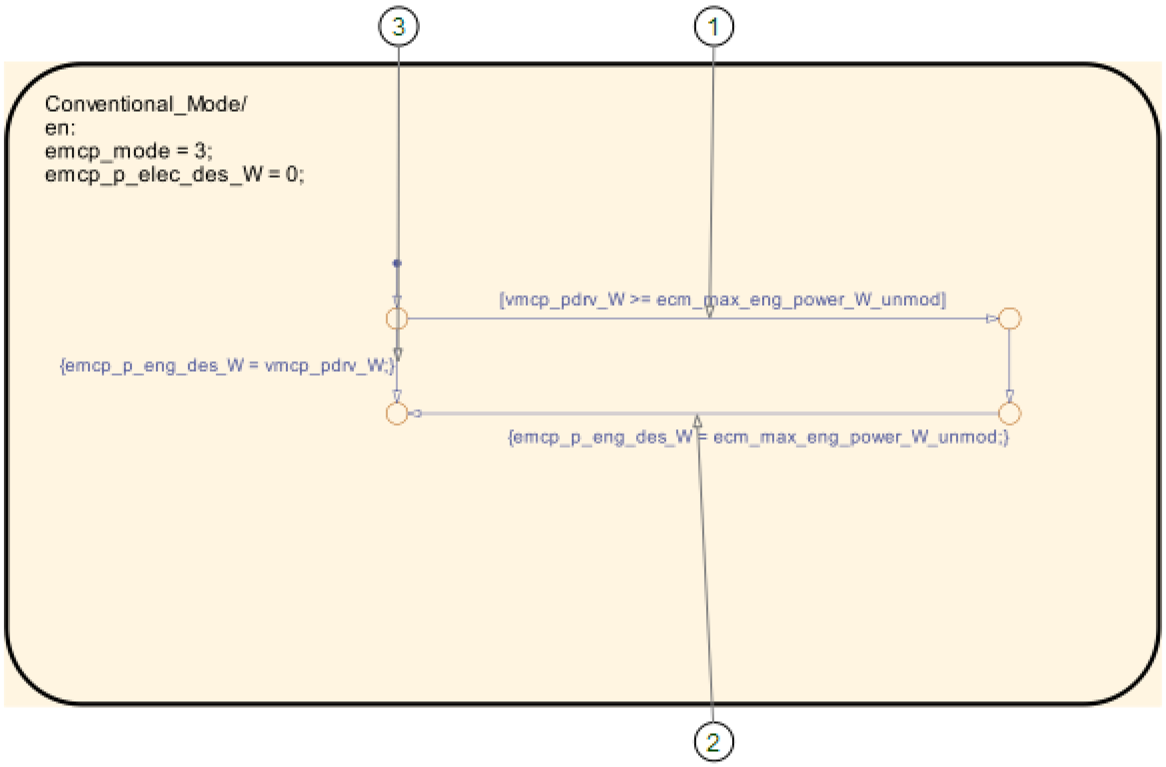
(1) Charge_Depleting_Mode

(2) Charge_Sustaining_Mode

(3) [Charge_Sustaining]

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/Energy_Management_Blending/Conventional_Mode

Label	Conventional_Mode/
	en:
	emcp_mode = 3;
	emcp_p_elec_des_W = 0;

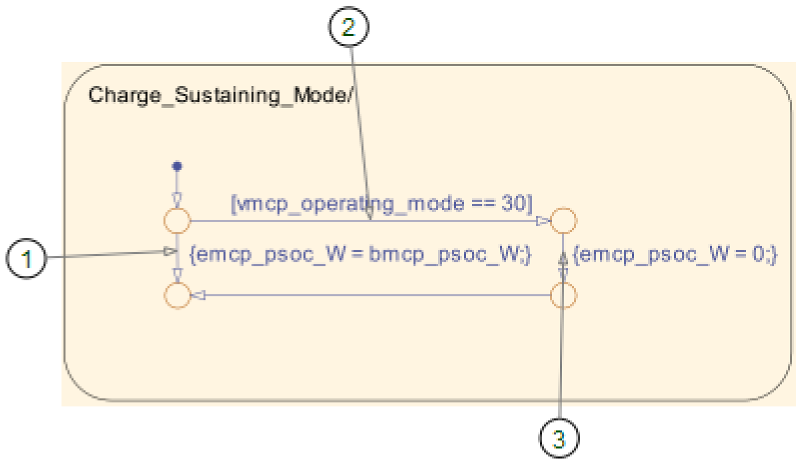


(1) [vmcp_pdrv_W >= ecm_max_eng_p...

(2) {emcp_p_eng_des_W = ecm_max_e...

(3) {emcp_p_eng_des_W = vmcp_pdrv...

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/SOC_Maintenance/**Charge_Sustaining_Mode**
Label	Charge_Sustaining_Mode/



(1) {emcp_psoc_W = bmcp_psoc_W;}

(2) [vmcp_operating_mode == 30]

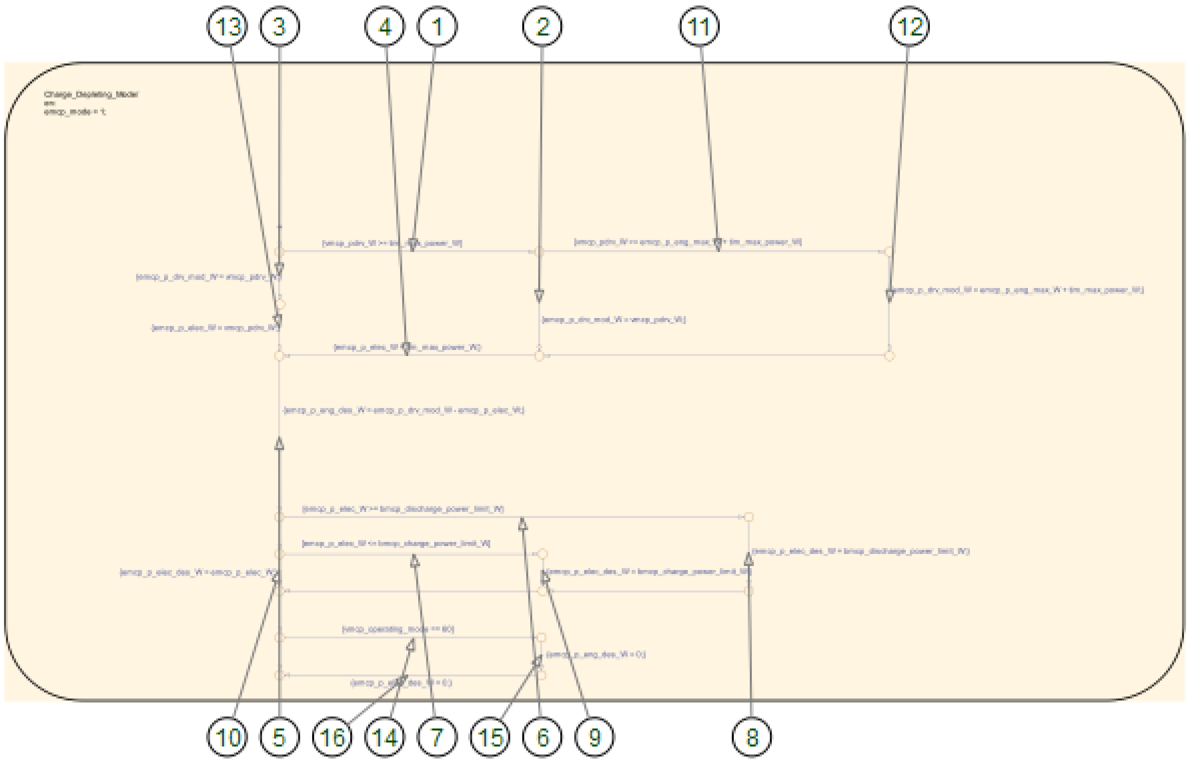
(3) {emcp_psoc_W = 0;}

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/SOC_Maintenance/**Engine_Only_Active**
Label	Engine_Only_Active/ en: emcp_psoc_W = 0;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/SOC_Maintenance/**Full_Power_Active**
Label	Full_Power_Active/ en: emcp_psoc_W = 0;
OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/SOC_Maintenance/**Regen_Active**
Label	Regen_Active/ en: emcp_psoc_W = 0;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/SOC_Maintenance/**Electric_Mode_Active**

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/SOC_Maintenance/Electric_Mode_Active**
Label	Electric_Mode_Active/ en: emcp_psoc_W = 0;
OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/Energy_Management_Blending/Hybrid_Mode/Charge_Depleting_Mode**
Label	Charge_Depleting_Mode/ en: emcp_mode = 1;



(1) [vmcp_pdrv_W >= tim_max_power_W]

(2) {emcp_p_drv_mod_W = vmcp_pdrv...

(3) {emcp_p_drv_mod_W = vmcp_pdrv...

(4) {emcp_p_elec_W = tim_max_powe...

(5) {emcp_p_eng_des_W = emcp_p_dr...

(6) [emcp_p_elec_W >= bmcp_discha...

(7) [emcp_p_elec_W <= bmcp_charge...

(8) {emcp_p_elec_des_W = bmcp_dis...

(9) {emcp_p_elec_des_W = bmcp_cha...

(10) {emcp_p_elec_des_W = emcp_p_e...

(11) [vmcp_pdrv_W >= emcp_p_eng_ma...

(12) {emcp_p_drv_mod_W = emcp_p_en...

(13) {emcp_p_elec_W = vmcp_pdrv_W;}

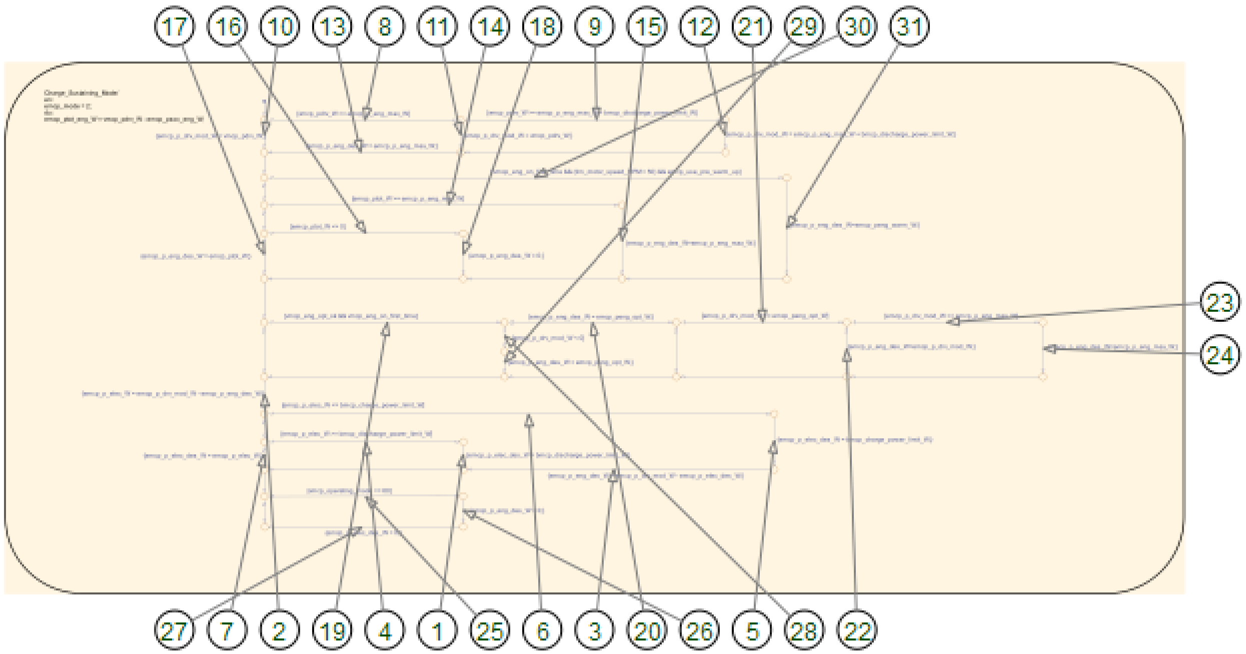
(14) [vmcp_operating_mode == 60]

(15) {emcp_p_eng_des_W = 0;}

(16) {emcp_p_elec_des_W = 0;}

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Energy Management Strategy/EMCP/Energy_Management_Blending/Hybrid_Mode/Charge_Sustaining_Mode**

Label	Charge_Sustaining_Mode/
	en:
	emcp_mode = 2;
	du:
	emcp_ptot_eng_W = vmcp_pdrv_W - emcp_psoc_eng_W;



(1) {emcp_p_elec_des_W = bmcp_dis...

(2) {emcp_p_elec_W = emcp_p_drv_m...

(3) {emcp_p_eng_des_W = emcp_p_dr...

(4) [emcp_p_elec_W >= bmcp_discha...

(5) {emcp_p_elec_des_W = bmcp_cha...

(6) [emcp_p_elec_W <= bmcp_charge...

(7) {emcp_p_elec_des_W = emcp_p_e...

(8) [vmcp_pdrv_W >= emcp_p_eng_ma...

(9) [vmcp_pdrv_W >= emcp_p_eng_ma...

(10) {emcp_p_drv_mod_W = vmcp_pdrv...

(11) {emcp_p_drv_mod_W = vmcp_pdrv...

(12) {emcp_p_drv_mod_W = emcp_p_en...
(13) {emcp_p_eng_des_W = emcp_p_en...
(14) [emcp_ptot_W >= emcp_p_eng_ma...
(15) {emcp_p_eng_des_W=emcp_p_eng_...
(16) [emcp_ptot_W <= 0]
(17) {emcp_p_eng_des_W = emcp_ptot...
(18) {emcp_p_eng_des_W = 0;}
(19) [vmcp_eng_opt_ok && vmcp_eng_...
(20) {emcp_p_eng_des_W = emcp_peng...
(21) [emcp_p_drv_mod_W >= emcp_pen...
(22) {emcp_p_eng_des_W=emcp_p_drv_...
(23) [emcp_p_drv_mod_W >= emcp_p_e...
(24) {emcp_p_eng_des_W=emcp_p_eng_...
(25) [vmcp_operating_mode == 60]
(26) {emcp_p_eng_des_W = 0;}
(27) {emcp_p_elec_des_W = 0;}
(28) [emcp_p_drv_mod_W < 0]
(29) {emcp_p_eng_des_W = emcp_peng...
(30) [!vmcp_eng_on_first_time && (...
(31) {emcp_p_eng_des_W=emcp_peng_w...

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Energy Management Control Process/Calculate Engine Torque

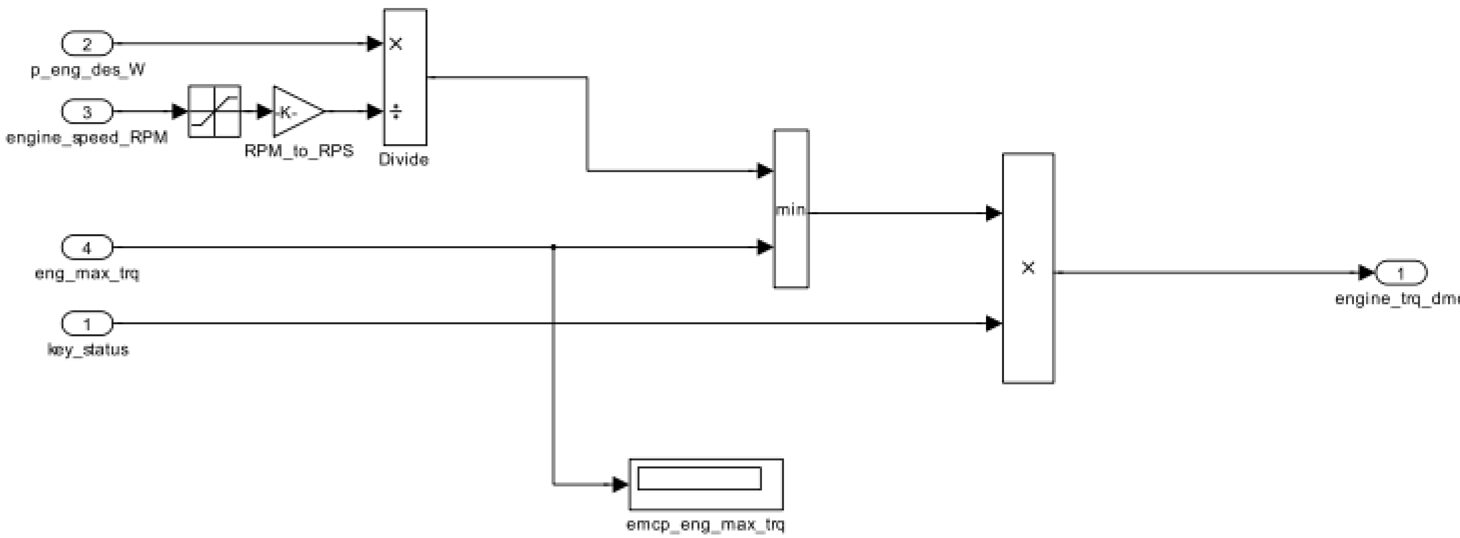


Table 57. Display Block Properties

Name	Format	Decimation	Floating
emcp_eng_max_trq	short	1	off

Table 58. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
RPM_to_RPS	pi/30	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 59. Inport Block Properties

Name	Port	Defined In Blk
eng_max_trq	4	ptc_mc_trq_max_pro_cstr_simu4
engine_speed_RPM	3	Gain22
key_status	1	Gain1
p_eng_des_W	2	SFunction

Table 60. MinMax Block Properties

Name	Function	Inputs	Input Same DT	Out Min	Out Max	Out Data Type Str	Zero Cross

Name	Function	Inputs	Input Same DT	Out Min	Out Max	Out Data Type Str	Zero Cross
MinMax	min	2	off	[]	[]	Inherit: Inherit via internal rule	on

Table 61. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
engine_trq_dmd	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Demux, Bus Selector1

Table 62. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Divide	*/	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Product	2	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 63. Saturate Block Properties

Name	Upper Limit	Lower Limit	Linearize As Gain	Zero Cross	Out Min	Out Max	Out Data Type Str
Saturation1	inf	1	on	on	[]	[]	Inherit: Same as input

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Energy Management Control Process/Calculate Motor Torque

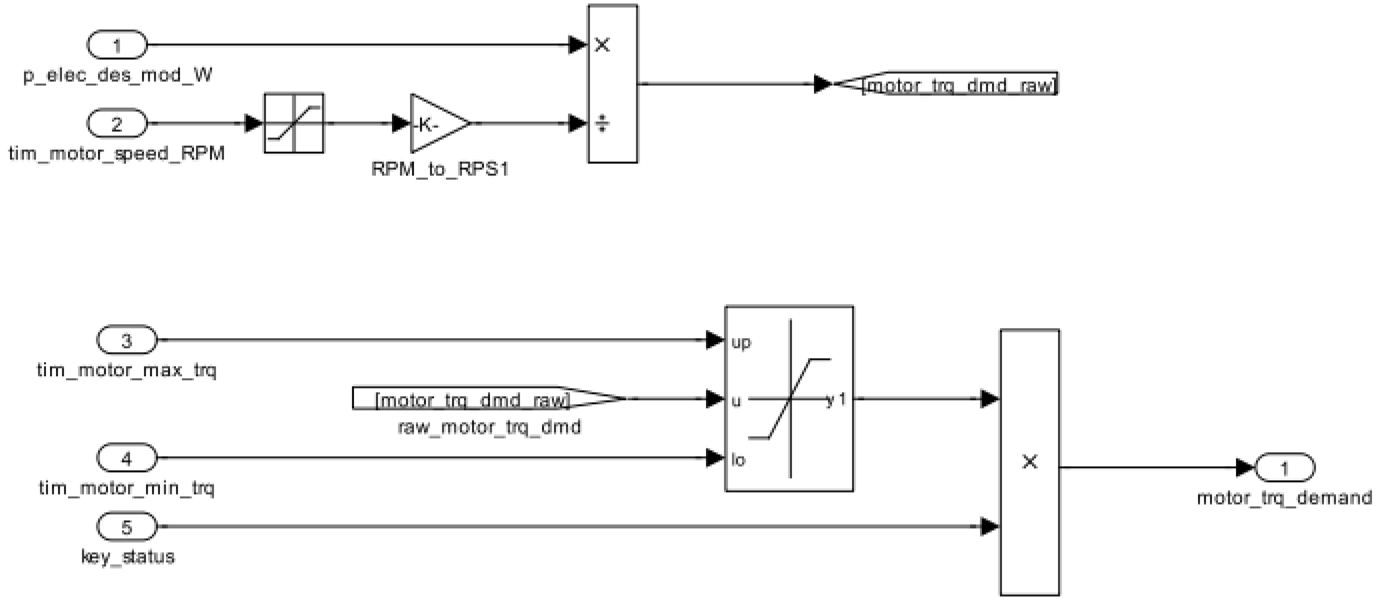


Table 64. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
raw_motor_trq_dmd	motor_trq_dmd_raw	Tag	Divide1

Table 65. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
RPM_to_RPS1	pi/30	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 66. Goto Block Properties

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto18	motor_trq_dmd_raw	Tag	local	Data Type Propagation, Data Type Propagation, LowerRelop1, Switch, UpperRelop

Table 67. Inport Block Properties

Name	Port	Defined In Blk
key_status	5	Gain1

Name	Port	Defined In Blk
p_elec_des_mod_W	1	Switch
tim_motor_max_trq	3	ptc_mc_trq_max_reg_cstr_simu
tim_motor_min_trq	4	Gain8
tim_motor_speed_RPM	2	Gain19

Table 68. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
motor_trq_demand	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Demux, Product10

Table 69. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Divide1	*/	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Product	2	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 70. Saturate Block Properties

Name	Upper Limit	Lower Limit	Linearize As Gain	Zero Cross	Out Min	Out Max	Out Data Type Str
Saturation	inf	100	on	on	[]	[]	Inherit: Same as input

Table 71. Saturation Dynamic Block Properties

Name	Out Min	Out Max	Out Data Type Str	Output Data Type Scaling Mode	Out Data Type	Out Scaling	Lock Scale	Rnd Meth	Do Satur
Saturation Dynamic	[]	[]	Inherit: Same as second input	Same as second input	sfix(16)	2^-10	off	Floor	off

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Energy Management Control Process/Driver Demanded Power

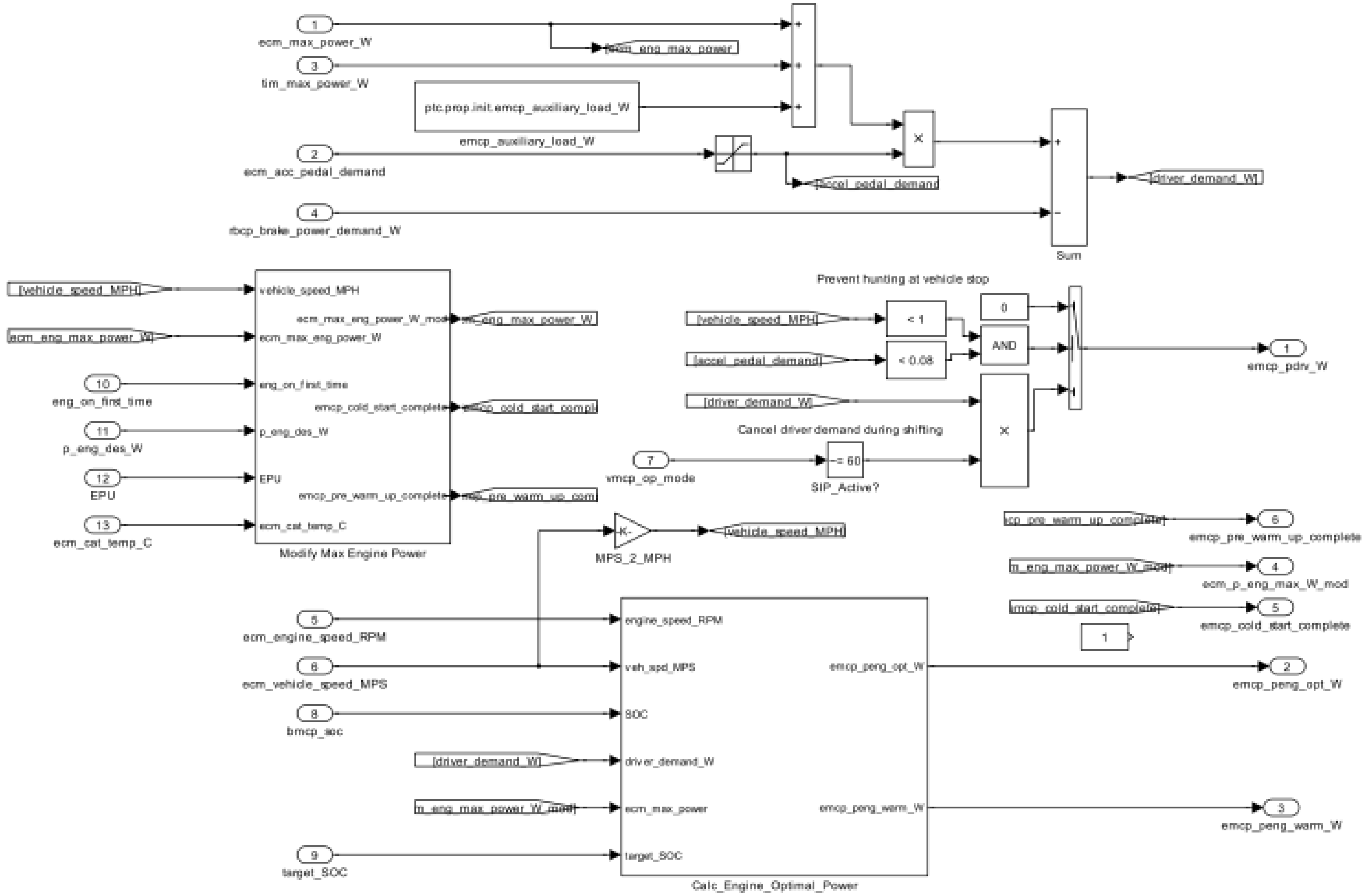


Table 72. Compare To Constant Block Properties

Name	Relop	Const	Logic Out Data Type Mode	Zero Cross
accel_threshold	<	.08	uint8	off
SIP_Active?	~=	60	uint8	off
veh_speed_threshold	<	1	uint8	off

Table 73. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
emcp_auxiliary_load_W	ptc.prop.init.emcp_auxiliary_load_W	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
speed_reduction_enable1	0	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
speed_reduction_enable2	1	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 74. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
From1	accel_pedal_demand	Tag	Saturation1
From18	vehicle_speed_MPH	Tag	MPS_2_MPH
From2	driver_demand_W	Tag	Sum
From3	driver_demand_W	Tag	Sum
From4	ecm_eng_max_power_W_mod	Tag	Switch
From5	vehicle_speed_MPH	Tag	MPS_2_MPH
From6	ecm_eng_max_power_W	Tag	Gain11
From7	ecm_eng_max_power_W_mod	Tag	Switch
From8	emcp_cold_start_complete	Tag	SFunction
From9	emcp_pre_warm_up_complete	Tag	SFunction

Table 75. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
MPS_2_MPH	2.237	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 76. Goto Block Properties

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto1	accel_pedal_demand	Tag	local	Compare, Divide2
Goto2	driver_demand_W	Tag	local	Terminator, Divide3
Goto26	vehicle_speed_MPH	Tag	local	ecm_max_eng_power_modifier, Compare
Goto3	ecm_eng_max_power_W	Tag	local	Divide1, Switch, Add
Goto4	ecm_eng_max_power_W_mod	Tag	local	SFunction , Switch1, Relational Operator

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto5	emcp_cold_start_complete	Tag	local	Memory2
Goto6	emcp_pre_warm_up_complete	Tag	local	Logical Operator

Table 77. Inport Block Properties

Name	Port	Defined In Blk
bmcp_soc	8	Gain14
ecm_acc_pedal_demand	2	Saturation
ecm_cat_temp_C	13	Lookup Table2
ecm_engine_speed_RPM	5	Gain22
ecm_max_power_W	1	Gain11
ecm_vehicle_speed_MPS	6	Gain21
eng_on_first_time	10	SFunction
EPU	12	SFunction
p_eng_des_W	11	SFunction
rbcp_brake_power_demand_W	4	Product1
target_SOC	9	SFunction
tim_max_power_W	3	Gain5
vmcp_op_mode	7	Memory1

Table 78. Logic Block Properties

Name	Operator	Inputs	Icon Shape	All Ports Same DT	Out Data Type Str
Logical Operator	AND	2	rectangular	off	boolean

Table 79. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
ecm_p_eng_max_W_mod	4	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction
emcp_cold_start_complete	5	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Memory2
emcp_pdrv_W	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction
emcp_peng_opt_W	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction
emcp_peng_warm_W	3	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction
emcp_pre_warm_up_complete	6	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Logical Operator

Table 80. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Divide2	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Divide3	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 81. Saturate Block Properties

Name	Upper Limit	Lower Limit	Linearize As Gain	Zero Cross	Out Min	Out Max	Out Data Type Str
Saturation1	1	0	on	on	[]	[]	Inherit: Same as input

Table 82. Sum Block Properties

Name	Icon Shape	Inputs	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Add	rectangular	+++	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Sum	rectangular	+-	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 83. Switch Block Properties

Name	Criteria	Threshold	Input Same DT	Out Min	Out Max	Out Data Type Str	Zero Cross
Switch1	u2 >= Threshold	.5	off	[]	[]	Inherit: Inherit via internal rule	on

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Energy Management Control Process/Driver Demanded Power/Calc_Engine_Optimal_Power

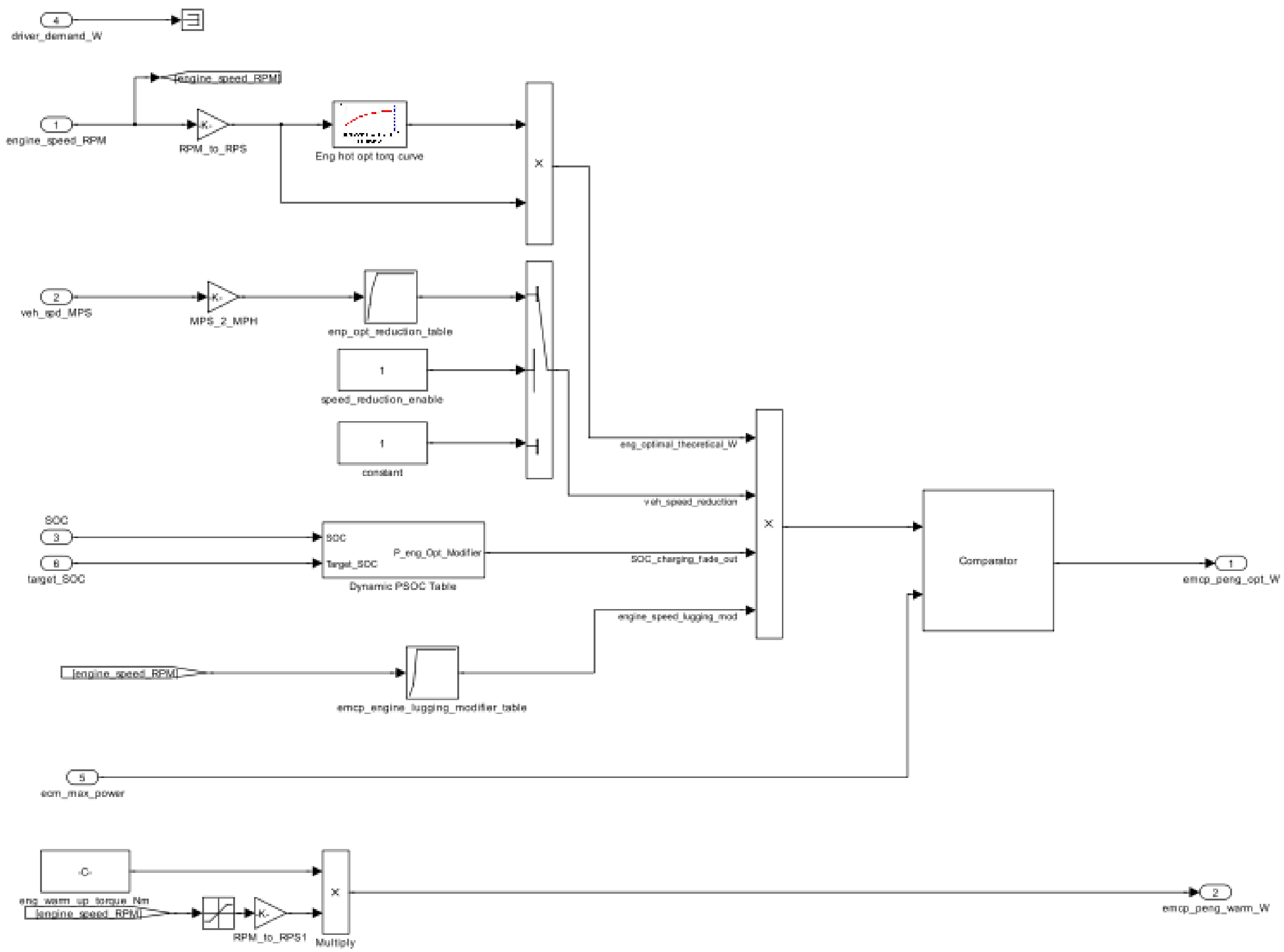


Table 84. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
constant	1	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
eng_warm_up_torque_Nm	ptc.prop.init.emcp_eng_warm_up_trq_Nm	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
speed_reduction_enable	1	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 85. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
From1	engine_speed_RPM	Tag	Gain22
From2	engine_speed_RPM	Tag	Gain22

Table 86. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
MPS_2_MPH	2.237	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
RPM_to_RPS	pi/30	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
RPM_to_RPS1	pi/30	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 87. Goto Block Properties

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto26	engine_speed_RPM	Tag	local	emcp_engine_lugging_modifier_table, Saturation1, RPM_to_RPS

Table 88. Inport Block Properties

Name	Port	Defined In Blk
driver_demand_W	4	Sum
ecm_max_power	5	Switch
engine_speed_RPM	1	Gain22
SOC	3	Gain14
target_SOC	6	SFunction
veh_spd_MPS	2	Gain21

Table 89. Lookup Block Properties

Name	Input Values	Table	Look Up Meth	Out Min	Out Max	Out Data Type Str
emcp_engine_lugging_modifier_table	[0 1000 1200 1500 10000]	[0 .25 .5 1 1]	Interpolation-Extrapolation	[]	[]	Inherit: Same as input
enp_opt_reduction_table	[0 5 10 20 100]	[.25 .5 .75 1 1]	Interpolation-Extrapolation	[]	[]	Inherit: Same as input

Table 90. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
emcp_peng_opt_W	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction
emcp_peng_warm_W	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction

Table 91. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Divide1	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Divide2	****	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Multiply	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 92. Saturate Block Properties

Name	Upper Limit	Lower Limit	Linearize As Gain	Zero Cross	Out Min	Out Max	Out Data Type Str
Saturation1	inf	1	on	on	[]	[]	Inherit: Same as input

Table 93. Switch Block Properties

Name	Criteria	Threshold	Input Same DT	Out Min	Out Max	Out Data Type Str	Zero Cross
Switch	u2 >= Threshold	.5	off	[]	[]	Inherit: Inherit via internal rule	on

Table 94. Terminator Block Properties

Name
Terminator

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Energy Management Control Process/Driver Demanded Power/Calc_Engine_Optimal_Power/Comparator

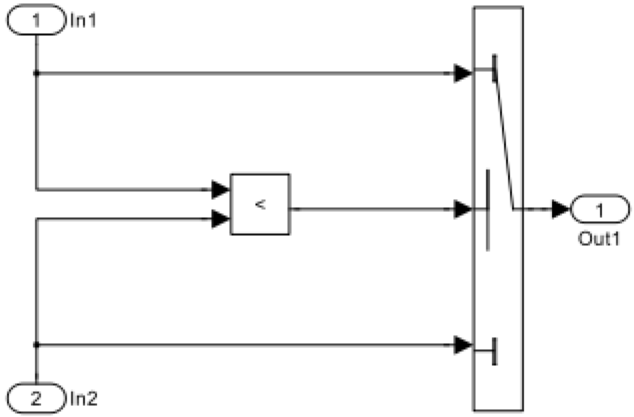


Table 95. Inport Block Properties

Name	Port	Defined In Blk
In1	1	Divide2
In2	2	Switch

Table 96. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
Out1	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction

Table 97. RelationalOperator Block Properties

Name	Operator	Input Same DT	Out Data Type Str	Zero Cross
Relational Operator	<	off	boolean	on

Table 98. Switch Block Properties

Name	Criteria	Threshold	Input Same DT	Out Min	Out Max	Out Data Type Str	Zero Cross
Switch1	u2 >= Threshold	.5	off	[]	[]	Inherit: Inherit via internal rule	on

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Energy Management Control Process/Driver Demanded Power/Calc_Engine_Optimal_Power/Dynamic PSOC Table

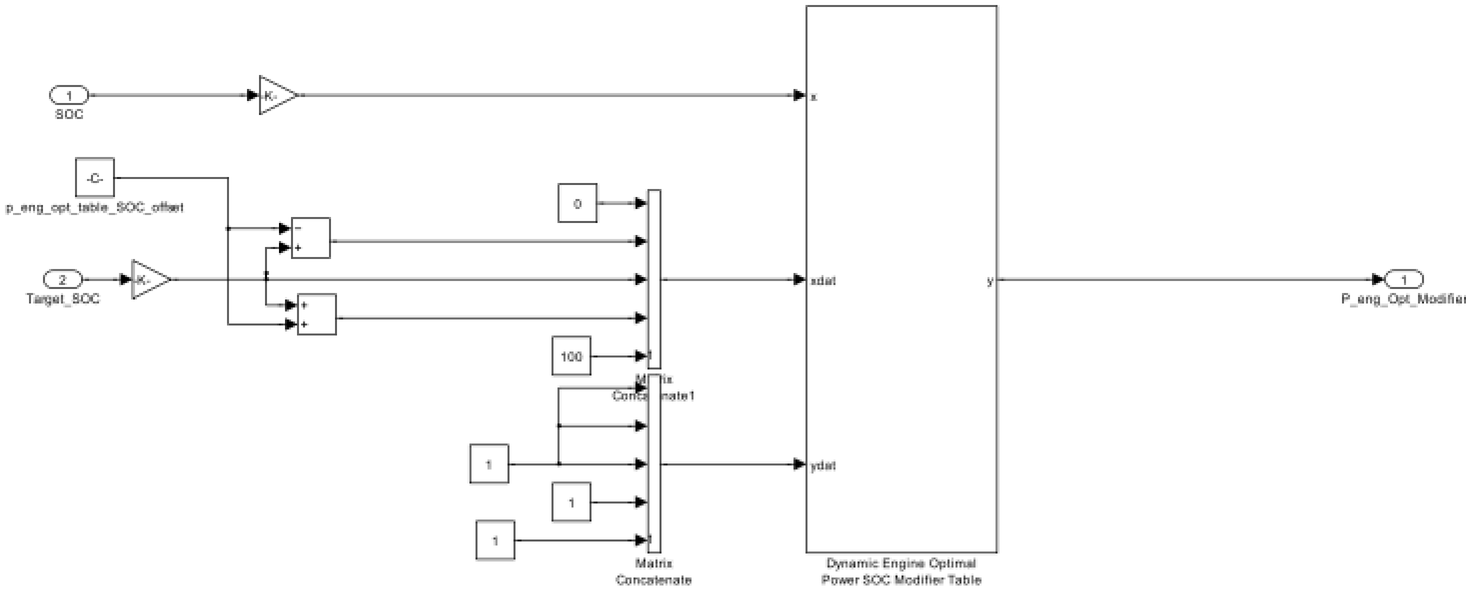


Table 99. Concatenate Block Properties

Name	Num Inputs	Mode	Concatenate Dimension
Matrix Concatenate	5	Multidimensional array	1
Matrix Concatenate1	5	Multidimensional array	1

Table 100. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
Constant1	1	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Constant2	0	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Constant3	100	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Constant4	1	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Constant5	1	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
p_eng_opt_table_SOC_offset	ptc.prop.init.emcp_p_eng_opt_table_SOC_offset	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 101. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
Gain1	100	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
to percent1	100	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 102. Inport Block Properties

Name	Port	Defined In Blk
SOC	1	Gain14
Target_SOC	2	SFunction

Table 103. Lookup Table Dynamic Block Properties

Name	Look Up Meth	Out Data Type Str	Output Data Type Scaling Mode	Out Data Type	Out Scaling	Lock Scale	Rnd Meth	Do Satur
Dynamic Engine Optimal Power SOC Modifier Table	Interpolation-Use End Values	float('double')	Specify via dialog	float('double')	2^-10	off	Floor	off

Table 104. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
P_eng_Opt_Modifier	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Divide2

Table 105. Sum Block Properties

Name	Icon Shape	Inputs	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Add	rectangular	-+	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Add1	rectangular	++	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Energy Management Control Process/Driver Demanded Power/Modify Max Engine Power

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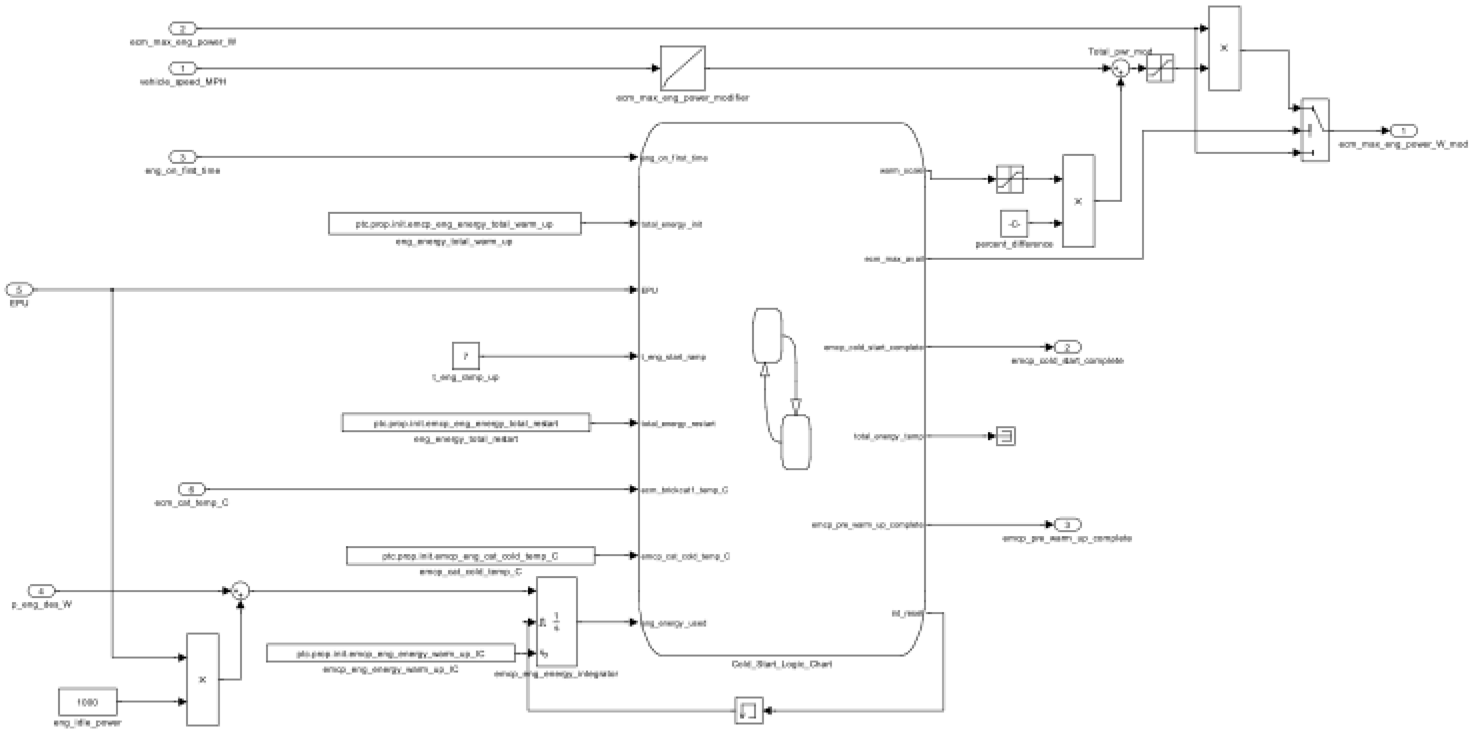


Table 106. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
emcp_cat_cold_temp_C	ptc.prop.init.emcp_eng_cat_cold_temp_C	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
emcp_eng_energy_warm_up_IC	ptc.prop.init.emcp_eng_energy_warm_up_IC	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
eng_energy_total_restart	ptc.prop.init.emcp_eng_energy_total_restart	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
eng_energy_total_warm_up	ptc.prop.init.emcp_eng_energy_total_warm_up	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
eng_idle_power	1000	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
percent_difference	1-ptc.prop.init.emcp_eng_max_p_modifier	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
t_eng_ramp_up	7	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 107. Inport Block Properties

Name	Port	Defined In Blk
ecm_cat_temp_C	6	Lookup Table2
ecm_max_eng_power_W	2	Gain11
eng_on_first_time	3	SFunction
EPU	5	SFunction
p_eng_des_W	4	SFunction
vehicle_speed_MPH	1	MPS_2_MPH

Table 108. Integrator Block Properties

Name	External Reset	Initial Condition Source	Initial Condition	Upper Saturation Limit	Lower Saturation Limit	Zero Cross	Continuous State Attributes
emcp_eng_energy_integrator	level	external	ptc.prop.init.emcp_eng_energy_warm_up_IC	100000	-60000	on	''

Table 109. Lookup Block Properties

Name	Input Values	Table	Look Up Meth	Out Min	Out Max	Out Data Type Str
ecm_max_eng_power_modifier	[0 5 10 20 100]	[.25 .30 .35 .40 ptc.prop.init.emcp_eng_max_p_modifier]	Interpolation-Extrapolation	[]	[]	Inherit: Same as input

Table 110. Memory Block Properties

Name	X0	Inherit Sample Time	Linearize Memory	Linearize As Delay
Memory	0	off	off	off

Table 111. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
ecm_max_eng_power_W_mod	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction , Switch1, Relational Operator
emcp_cold_start_complete	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Memory2
emcp_pre_warm_up_complete	3	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Logical Operator

Table 112. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Divide1	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Divide2	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Divide3	**	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 113. Saturate Block Properties

Name	Upper Limit	Lower Limit	Linearize As Gain	Zero Cross	Out Min	Out Max	Out Data Type Str
Saturation	1	0	on	on	[]	[]	Inherit: Same as input
Saturation1	1	0	on	on	[]	[]	Inherit: Same as input

Table 114. Stateflow Block Properties

Name	Chart
Cold_Start_Logic_Chart	Cold_Start_Logic_Chart

Table 115. Sum Block Properties

Name	Icon Shape	Inputs	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Sum	round	|++	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Total_pwr_mod	round	|++	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 116. Switch Block Properties

Name	Criteria	Threshold	Input Same DT	Out Min	Out Max	Out Data Type Str	Zero Cross
Switch	u2 >= Threshold	0.5	off	[]	[]	Inherit: Inherit via internal rule	on

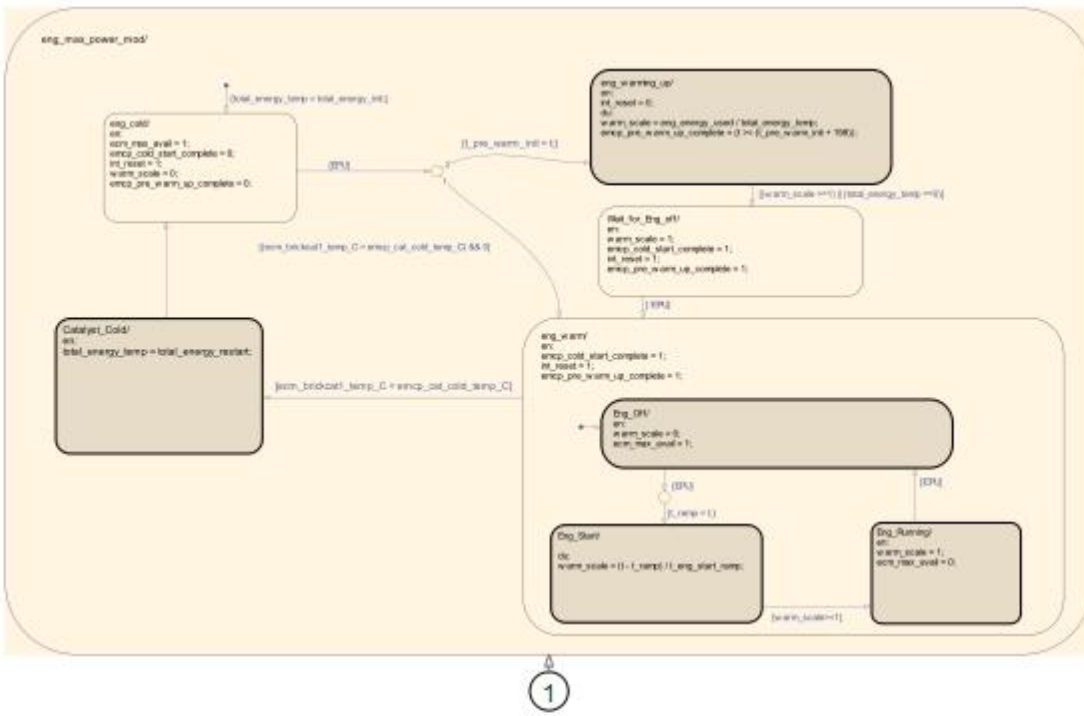
Table 117. Terminator Block Properties

Name
Terminator

Chart - Cold_Start_Logic_Chart

Chart	lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart
States	eng_max_power_mod
Data	eng_on_first_time total_energy_init t_warm_up t_init_warm_up warm_scale ecm_max_avail t_ramp EPU t_eng_start_ramp emcp_cold_start_complete total_energy_temp total_energy_restart ecm_brickcat1_temp_C

Chart	lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart
	emcp_cat_cold_temp_C eng_energy_used t_pre_warm_init emcp_pre_warm_up_complete int_reset

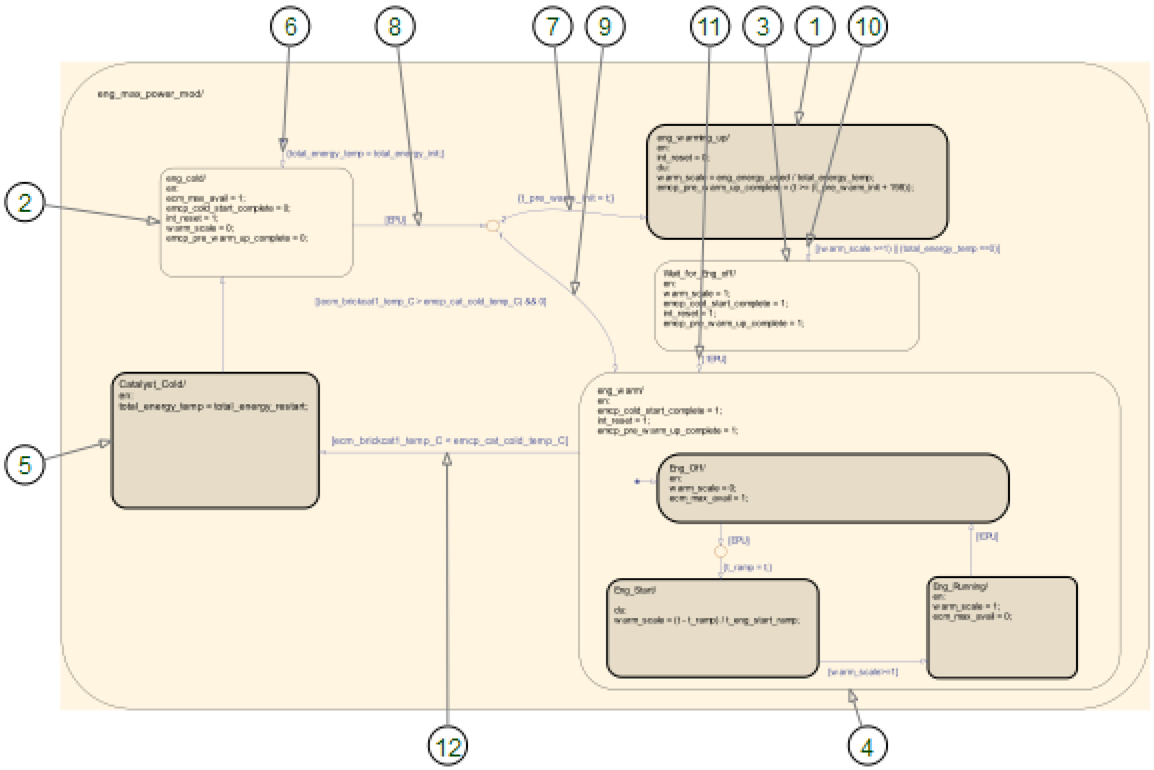


(1) eng_max_power_mod

Stateflow Hierarchy

1. lib_p_par_pre_tx_DES_dissertation_MATT
    1. *Cold_Start_Logic_Chart*
        1. Data: eng_on_first_time, total_energy_init, t_warm_up, t_init_warm_up, warm_scale, ecm_max_avail, t_ramp, EPU, t_eng_start_ramp, emcp_cold_start_complete, total_energy_temp, total_energy_restart, ecm_brickcat1_temp_C, emcp_cat_cold_temp_C, eng_energy_used, t_pre_warm_init, emcp_pre_warm_up_complete, int_reset
        2. eng_max_power_mod
            1. Transition: {total_energy_temp = total_en..., {t_pre_warm_init = t;}, [EPU], [(ecm_brickcat1_temp_C > emcp..., [(warm_scale >=1) || (total_e..., [!EPU], [ecm_brickcat1_temp_C < emcp_...
            2. Catalyst_Cold
            3. Wait_for_Eng_off
            4. eng_warm
                1. Transition: [EPU], [!EPU], {t_ramp = t;}, [warm_scale>=1]
                2. Eng_Start
                3. Eng_Off
                4. Eng_Running
            5. eng_warming_up
            6. eng_cold
    2. Energy Management Strategy
    3. Vehicle Mode Control Process

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart/eng_max_power_mod**
Label	eng_max_power_mod/



(1) eng_warming_up

(2) eng_cold

(3) Wait_for_Eng_off

(4) eng_warm

(5) Catalyst_Cold

(6) {total_energy_temp = total_en...

(7) {t_pre_warm_init = t;}

(8) [EPU]

(9) [(ecm_brickcat1_temp_C > emcp...

(10) [(warm_scale >=1) || (total_e...

(11) [!EPU]

(12) [ecm_brickcat1_temp_C < emcp_...

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart/eng_max_power_mod/eng_warming_up**

Label	eng_warming_up/
	en:
	int_reset = 0;
	du:
	warm_scale = eng_energy_used / total_energy_temp;
	emcp_pre_warm_up_complete = (t >= (t_pre_warm_init + 198));

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart/eng_max_power_mod/eng_cold**

Label	eng_cold/
	en:
	ecm_max_avail = 1;
	emcp_cold_start_complete = 0;
	int_reset = 1;
	warm_scale = 0;
	emcp_pre_warm_up_complete = 0;

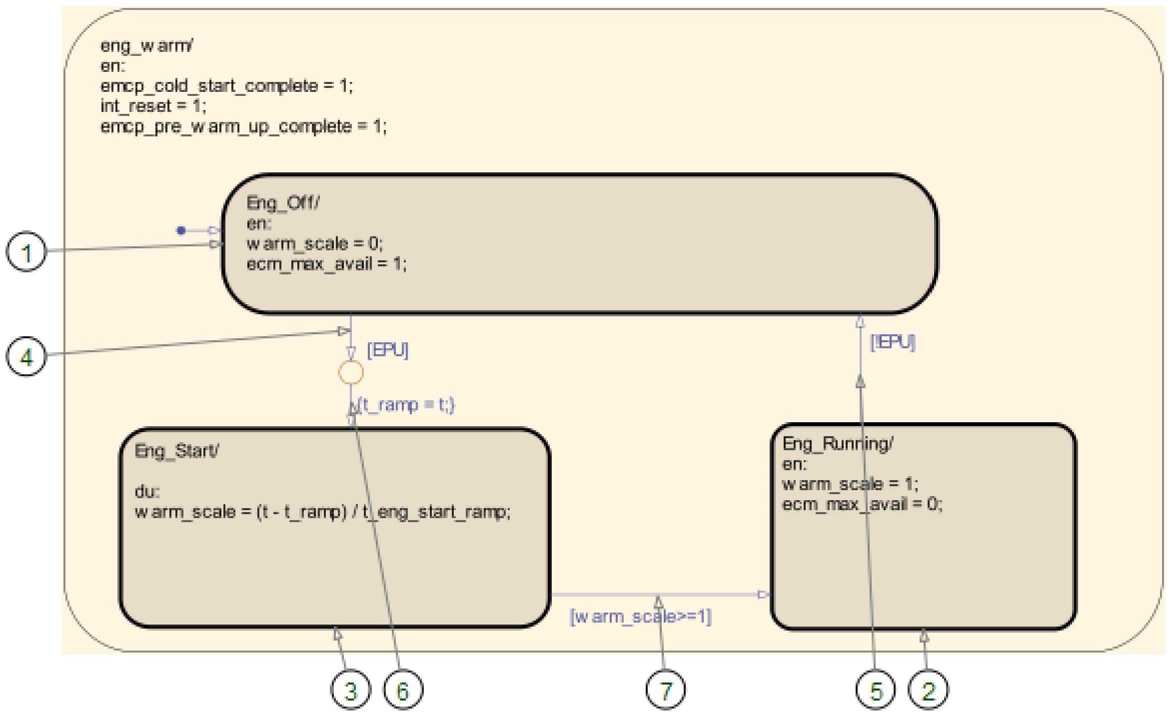
OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart/eng_max_power_mod/Wait_for_Eng_off**

Label	Wait_for_Eng_off/
	en:
	warm_scale = 1;
	emcp_cold_start_complete = 1;
	int_reset = 1;
	emcp_pre_warm_up_complete = 1;

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart/eng_max_power_mod/eng_warm**
Label	eng_warm/ en:

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart/eng_max_power_mod/eng_warm

	emcp_cold_start_complete = 1;
	int_reset = 1;
	emcp_pre_warm_up_complete = 1;



(1) Eng_Off

(2) Eng_Running

(3) Eng_Start

(4) [EPU]

(5) [!EPU]

(6) {t_ramp = t;}

(7) [warm_scale>=1]

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart/eng_max_power_mod/**Catalyst_Cold**
Label	Catalyst_Cold/ en: total_energy_temp = total_energy_restart;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart/eng_max_power_mod/eng_warm/**Eng_Off**

Label	Eng_Off/
	en:
	warm_scale = 0;
	ecm_max_avail = 1;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart/eng_max_power_mod/eng_warm/**Eng_Running**

Label	Eng_Running/
	en:
	warm_scale = 1;
	ecm_max_avail = 0;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Cold_Start_Logic_Chart/eng_max_power_mod/eng_warm/**Eng_Start**
Label	Eng_Start/ du: warm_scale = (t - t_ramp) / t_eng_start_ramp;

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Energy Management Control Process/PI Controller for Battery

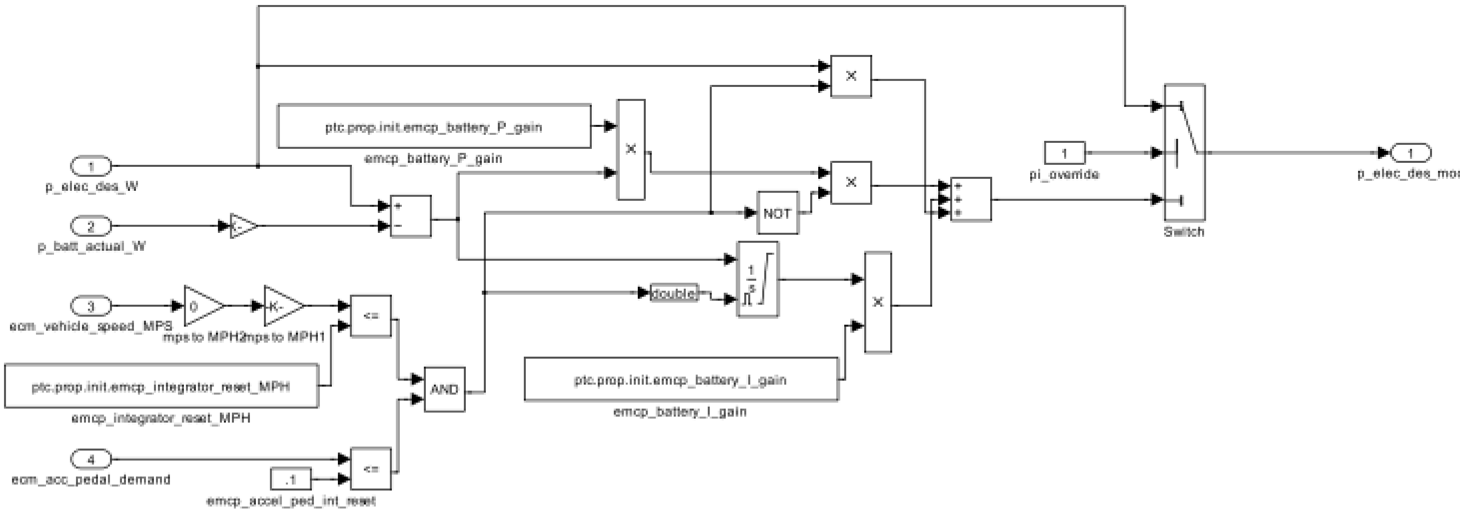


Table 118. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
emcp_accel_ped_int_reset	.1	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
emcp_battery_I_gain	ptc.prop.init.emcp_battery_I_gain	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
emcp_battery_P_gain	ptc.prop.init.emcp_battery_P_gain	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
emcp_integrator_reset_MPH	ptc.prop.init.emcp_integrator_reset_MPH	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
pi_override	1	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 119. DataTypeConversion Block Properties

Name	Out Min	Out Max	Out Data Type Str	Convert Real World
Data Type Conversion	[]	[]	double	Real World Value (RWV)

Table 120. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
mps to MPH1	2.237	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
mps to MPH2	0	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
mps to MPH3	1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 121. Inport Block Properties

Name	Port	Defined In Blk
ecm_acc_pedal_demand	4	Saturation
ecm_vehicle_speed_MPS	3	Gain21
p_batt_actual_W	2	Divide
p_elec_des_W	1	SFunction

Table 122. Integrator Block Properties

Name	External Reset	Initial Condition Source	Limit Output	Upper Saturation Limit	Lower Saturation Limit	Zero Cross	Continuous State Attributes
Integrator	level	internal	on	100000	-60000	on	''

Table 123. Logic Block Properties

Name	Operator	Inputs	Icon Shape	All Ports Same DT	Out Data Type Str
Logical Operator	NOT	2	rectangular	off	boolean
Logical Operator1	AND	2	rectangular	off	boolean

Table 124. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
p_elec_des_mod	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Divide1

Table 125. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Product1	2	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Product2	2	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Product3	2	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Product4	2	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 126. RelationalOperator Block Properties

Name	Operator	Input Same DT	Out Data Type Str	Zero Cross
Relational Operator	<=	off	Inherit: Logical (see Configuration Parameters: Optimization)	on
Relational Operator1	<=	off	Inherit: Logical (see Configuration Parameters: Optimization)	on

Table 127. Sum Block Properties

Name	Icon Shape	Inputs	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Subtract	rectangular	+-	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Subtract1	rectangular	+++	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 128. Switch Block Properties

Name	Criteria	Threshold	Input Same DT	Out Min	Out Max	Out Data Type Str	Zero Cross
Switch	u2 >= Threshold	.5	off	[]	[]	Inherit: Inherit via internal rule	on

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Energy Management Control Process/SOC Maintenance Power

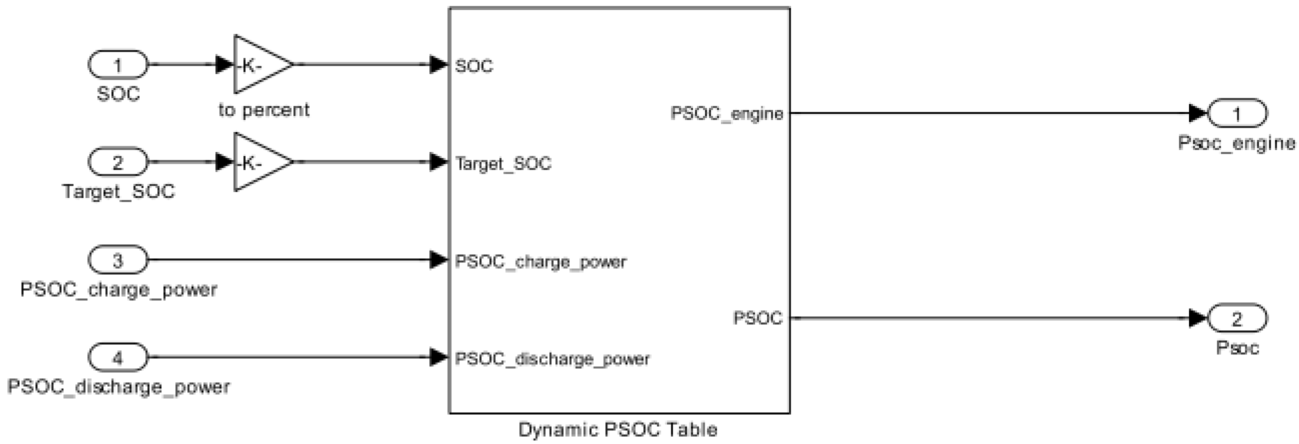


Table 129. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
to percent	100	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
to percent1	100	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 130. Inport Block Properties

Name	Port	Defined In Blk
PSOC_charge_power	3	SFunction
PSOC_discharge_power	4	SFunction
SOC	1	Gain14
Target_SOC	2	SFunction

Table 131. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
Psoc	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction
Psoc_engine	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Energy Management Control Process/SOC Maintenance Power/Dynamic PSOC Table

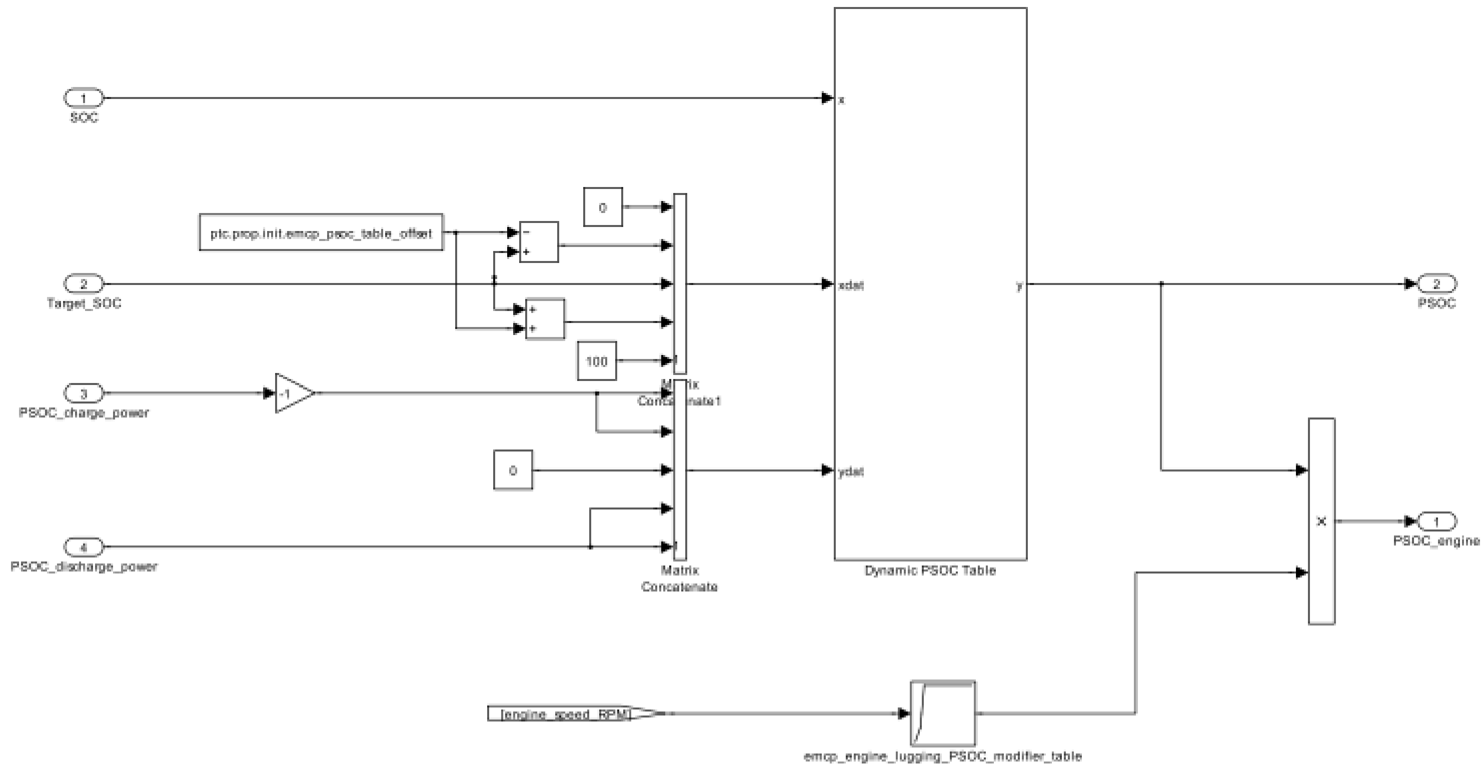


Table 132. Concatenate Block Properties

Name	Num Inputs	Mode	Concatenate Dimension
Matrix Concatenate	5	Multidimensional array	1
Matrix Concatenate1	5	Multidimensional array	1

Table 133. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
Constant1	0	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Constant2	0	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Constant3	100	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
psoc_table_SOC_offset	ptc.prop.init.emcp_psoc_table_offset	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 134. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
From2	engine_speed_RPM	Tag	lib_p_par_pre_tx_DES_dissertation_MATT (model)

Table 135. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
Gain	-1	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 136. Inport Block Properties

Name	Port	Defined In Blk
PSOC_charge_power	3	SFunction
PSOC_discharge_power	4	SFunction
SOC	1	to percent
Target_SOC	2	to percent1

Table 137. Lookup Block Properties

Name	Input Values	Table	Look Up Meth	Out Min	Out Max	Out Data Type Str
emcp_engine_lugging_PSOC_modifier_table	[0 1000 1200 1500 10000]	[0 .25 .5 1 1]	Interpolation-Extrapolation	[]	[]	Inherit: Same as input

Table 138. Lookup Table Dynamic Block Properties

Name	Look Up Meth	Out Data Type Str	Output Data Type Scaling Mode	Out Data Type	Out Scaling	Lock Scale	Rnd Meth	Do Satur
Dynamic PSOC Table	Interpolation-Use End Values	float('double')	Specify via dialog	float('double')	2^-10	off	Floor	off

Table 139. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
PSOC	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction , Product
PSOC_engine	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction

Table 140. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Product	2	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 141. Sum Block Properties

Name	Icon Shape	Inputs	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Add	rectangular	-+	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Add1	rectangular	++	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Input_Organizer

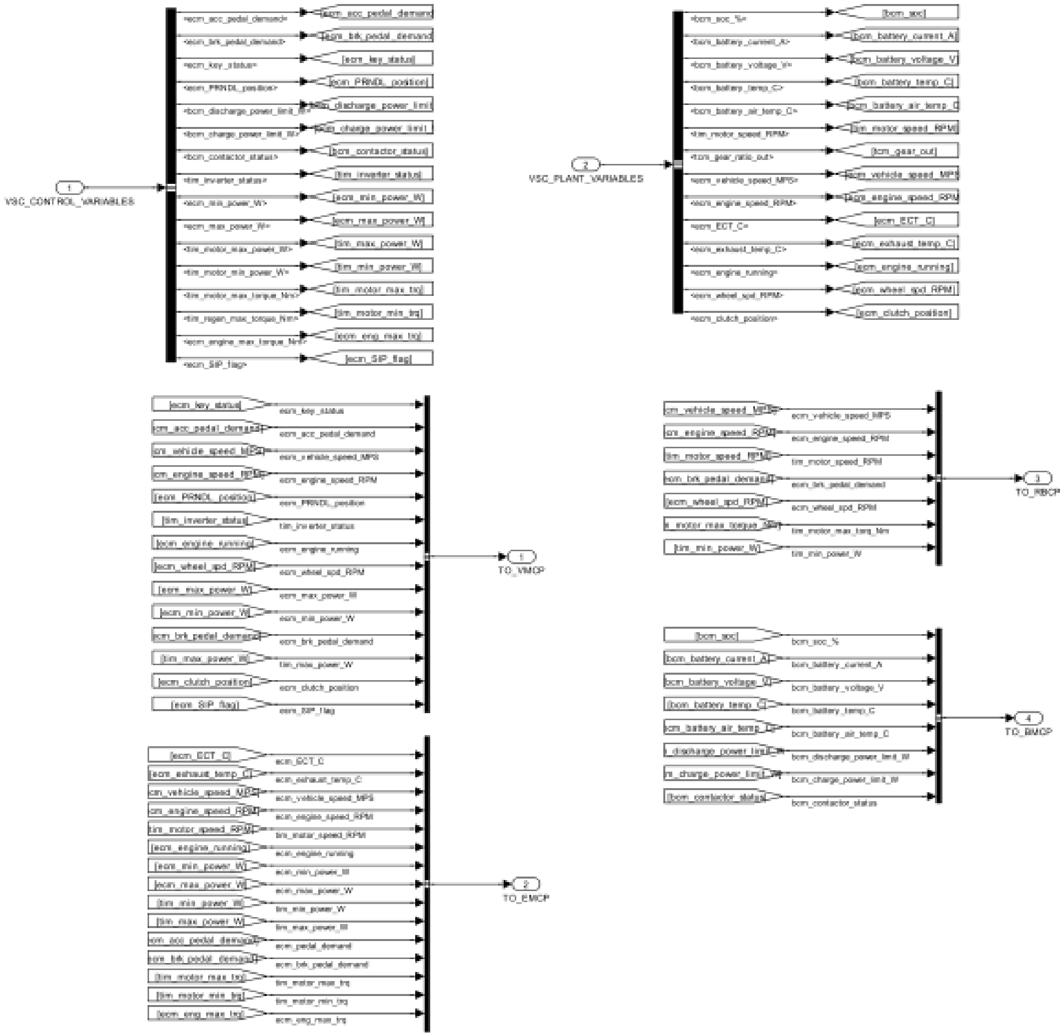


Table 142. BusCreator Block Properties

Name	Inputs	Display Option
Bus Creator	14	bar
Bus Creator1	15	bar
Bus Creator2	8	bar
Bus Creator3	7	bar

Table 143. BusSelector Block Properties

Name	Output Signals	Output As Bus	Input Signals
Bus Selector	ecm_acc_pedal_demand,ecm_brk_pedal_demand,ecm_key_status,ecm_PRNDL_position,bcm_discharge_power_limit_W,bcm_charge_power_limit_W,bcm_contactor_status,tim_inverter_status,ecm_min_power_W,ecm_max_power_W,tim_motor_max_power_W,tim_motor_min_power_W,tim_motor_max_torque_Nm,tim_regen_max_torque_Nm,ecm_engine_max_torque_Nm,ecm_SIP_flag	off	ecm_acc_pedal_demand ecm_key_status bcm_discharge_power_limit_W bcm_charge_power_limit_W tim_motor_max_power_W tim_motor_min_power_W tim_regen_peak_torque_Nm tim_regen_max_torque_Nm tim_motor_c

Name	Output Signals	Output As Bus	Input Signals
			ont_torque_Nm tim_regen_cont_torque_Nm ecm_max_power_W ecm_min_power_W ecm_PRNDL_position ecm_brk_pedal_demand tim_motor_max_torque_Nm bcm_contactor_status tim_inverter_status ecm_engine_max_torque_Nm ecm_driver_demand_Nm ecm_SIP_flag
BusSelector1	bcm_soc_%,bcm_battery_current_A,bcm_battery_voltage_V,bcm_battery_temp_C,bcm_battery_air_temp_C,tim_motor_speed_RPM,tcm_gear_ratio_out,ecm_vehicle_speed_MPS,ecm_engine_speed_RPM,ecm_ECT_C,ecm_exhaust_temp_C,ecm_engine_running,ecm_wheel_spd_RPM,ecm_clutch_position	off	bcm_soc_% bcm_battery_current_A

Name	Output Signals	Output As Bus	Input Signals
			bcm_battery_voltage_V bcm_battery_temp_C bcm_battery_air_temp_C tim_motor_speed_RPM tcm_gear_ratio_out ecm_vehicle_speed_MPS ecm_engine_speed_RPM ecm_ECT_C ecm_exhaust_temp_C ecm_engine_running ecm_wheel_spd_RPM ecm_clutch_position

Table 144. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
From	ecm_key_status	Tag	Gain1
From1	ecm_acc_pedal_demand	Tag	Saturation
From10	bcm_soc	Tag	Gain14
From11	bcm_battery_current_A	Tag	Gain15

Name	Goto Tag	Icon Display	Defined In Blk
From12	bcm_battery_voltage_V	Tag	Gain16
From13	ecm_vehicle_speed_MPS	Tag	Gain21
From14	bcm_battery_air_temp_C	Tag	Gain18
From15	bcm_discharge_power_limit_W	Tag	Gain3
From16	bcm_charge_power_limit_W	Tag	Gain4
From17	bcm_battery_temp_C	Tag	Gain17
From18	tim_inverter_status	Tag	Lookup Table1
From19	bcm_contactor_status	Tag	Lookup Table
From2	ecm_vehicle_speed_MPS	Tag	Gain21
From20	ecm_engine_speed_RPM	Tag	Gain22
From21	tim_motor_speed_RPM	Tag	Gain19
From22	ecm_brk_pedal_demand	Tag	Saturation1
From23	ecm_engine_running	Tag	Gain13
From24	ecm_engine_running	Tag	Gain13
From25	ecm_max_power_W	Tag	Gain11
From26	ecm_min_power_W	Tag	Gain12
From27	ecm_brk_pedal_demand	Tag	Saturation1
From28	tim_max_power_W	Tag	Gain5
From29	tim_min_power_W	Tag	Divide6
From3	ecm_engine_speed_RPM	Tag	Gain22
From30	ecm_wheel_spd_RPM	Tag	Gain25
From31	ecm_wheel_spd_RPM	Tag	Gain25
From32	ecm_max_power_W	Tag	Gain11
From33	ecm_eng_max_trq	Tag	ptc_mc_trq_max_pro_cstr_simu4
From34	tim_motor_max_trq	Tag	ptc_mc_trq_max_reg_cstr_simu
From35	tim_motor_min_trq	Tag	Gain8
From36	tim_max_power_W	Tag	Gain5
From37	tim_min_power_W	Tag	Divide6
From38	ecm_acc_pedal_demand	Tag	Saturation
From39	ecm_min_power_W	Tag	Gain12
From4	ecm_PRNDL_position	Tag	Constant
From40	ecm_brk_pedal_demand	Tag	Saturation1
From41	ecm_clutch_position	Tag	Gain2
From42	ecm_SIP_flag	Tag	mem_ptc_sft_in_progress_trs_simu

Name	Goto Tag	Icon Display	Defined In Blk
From43	tim_motor_max_torque_Nm	Tag	lib_p_par_pre_tx_DES_dissertation_MATT (model)
From5	ecm_ECT_C	Tag	Gain23
From6	ecm_exhaust_temp_C	Tag	Lookup Table2
From7	ecm_vehicle_speed_MPS	Tag	Gain21
From8	ecm_engine_speed_RPM	Tag	Gain22
From9	tim_motor_speed_RPM	Tag	Gain19

Table 145. Goto Block Properties

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto	bcm_soc	Tag	local	Gain1, to percent, Terminator1, Gain, to percent, Lookup Table1, Relational Operator, SFunction
Goto1	bcm_battery_current_A	Tag	local	Divide
Goto10	ecm_exhaust_temp_C	Tag	local	SFunction
Goto11	ecm_wheel_spd_RPM	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto12	ecm_key_status	Tag	local	Product, Product, SFunction
Goto13	ecm_PRNDL_position	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto14	bcm_discharge_power_limit_W	Tag	local	Divide1
Goto15	bcm_charge_power_limit_W	Tag	local	Divide2
Goto16	bcm_contactor_status	Tag	local	SFunction
Goto17	tim_inverter_status	Tag	local	SFunction
Goto18	ecm_engine_running	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction
Goto19	ecm_min_power_W	Tag	local	Bus Selector, SFunction
Goto2	bcm_battery_voltage_V	Tag	local	Divide
Goto20	ecm_max_power_W	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model), Divide1, Switch, Add, SFunction
Goto21	tim_motor_max_trq	Tag	local	Switch2, LowerRelop1
Goto22	tim_motor_min_trq	Tag	local	Switch, UpperRelop
Goto23	ecm_eng_max_trq	Tag	local	MinMax, emcp_eng_max_trq
Goto24	ecm_clutch_position	Tag	local	SFunction
Goto25	ecm_acc_pedal_demand	Tag	local	Relational Operator1, Saturation1, SFunction
Goto26	ecm_brk_pedal_demand	Tag	local	SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), Product
Goto27	tim_max_power_W	Tag	local	Product, Add, SFunction
Goto28	tim_min_power_W	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model), Product
Goto29	ecm_SIP_flag	Tag	local	SFunction
Goto3	bcm_battery_temp_C	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto4	bcm_battery_air_temp_C	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto5	tim_motor_speed_RPM	Tag	local	SFunction , Saturation, lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto6	tcm_gear_out	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto7	ecm_vehicle_speed_MPS	Tag	local	mps to MPH, MPS_2_MPH, MPS_2_MPH, mps to MPH2, mps to MPH, mps to MPH
Goto8	ecm_engine_speed_RPM	Tag	local	SFunction , emcp_engine_lugging_modifier_table, Saturation1, RPM_to_RPS, Saturation1, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto9	ecm_ECT_C	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)

Table 146. Inport Block Properties

Name	Port	Defined In Blk
VSC_CONTROL_VARIABLES	1	Saturation, Gain1, Gain3, Gain4, Gain5, Divide6, Gain7, Gain8, Gain9, Gain10, Gain11, Gain12, Constant, Saturation1, ptc_mc_trq_max_reg_cstr_simu, Lookup Table, Lookup Table1, ptc_mc_trq_max_pro_cstr_simu4, Gain, mem_ptc_sft_in_progress_trs_simu
VSC_PLANT_VARIABLES	2	Gain14, Gain15, Gain16, Gain17, Gain18, Gain19, Gain20, Gain21, Gain22, Gain23, Lookup Table2, Gain13, Gain25, Gain2

Table 147. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
TO_BMCP	4	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Gain1, to percent, Terminator1, Gain, to percent, Lookup Table1, Relational Operator, SFunction , Divide, Divide, lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), Divide1, Divide2, SFunction
TO_EMCP	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction , Saturation, SFunction , emcp_engine_lugging_modifier_table, Saturation1, RPM_to_RPS, Saturation1, mps to MPH, MPS_2_MPH, MPS_2_MPH, mps to MPH2, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), Divide1, Switch, Add, SFunction , Product, Add, Relational Operator1, Saturation1, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), Switch2, LowerRelop1, Switch, UpperRelop, MinMax, emcp_eng_max_trq
TO_RBCP	3	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Product, lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), mps to MPH, lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), Product
TO_VMCP	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Product, Product, SFunction , SFunction , mps to MPH, SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction , SFunction , lib_p_par_pre_tx_DES_dissertation_MATT (model), lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction , SFunction , SFunction , SFunction

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Output_Organizer

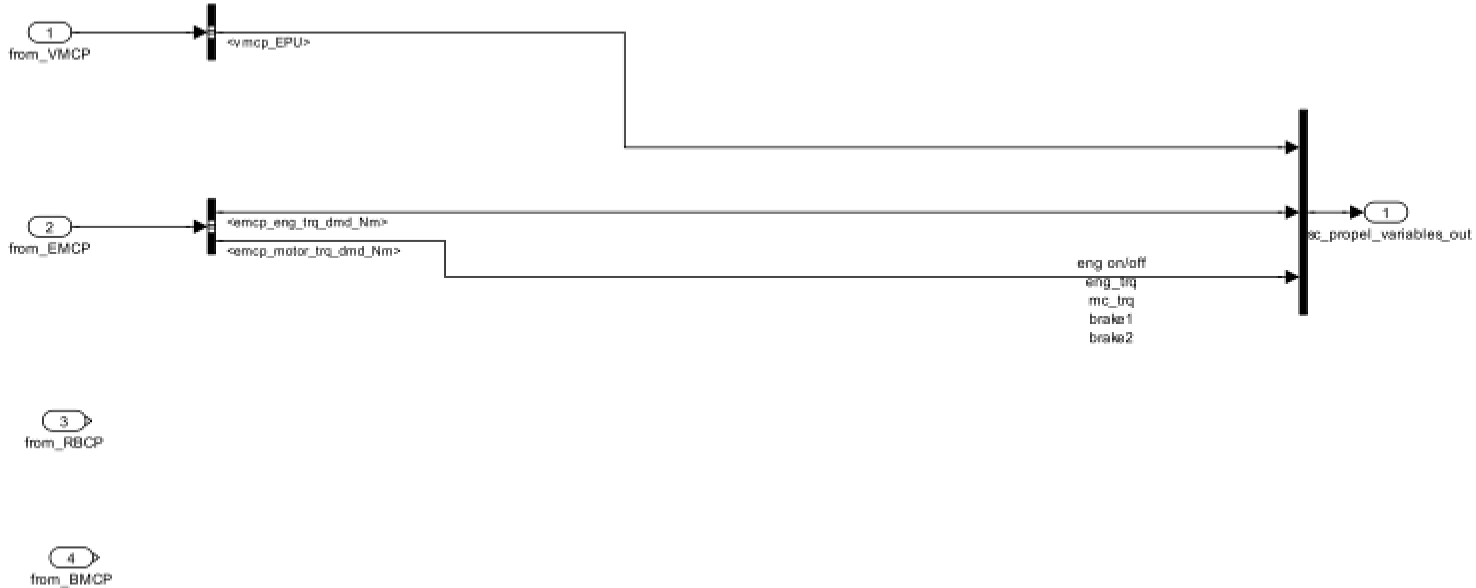


Table 148. BusSelector Block Properties

Name	Output Signals	Output As Bus	Input Signals
Bus Selector	vmcp_EPU	off	vmcp_inverter_request vmcp_EPU
Bus Selector1	emcp_eng_trq_dmd_Nm,emcp_motor_trq_dmd_Nm	off	emcp_eng_trq_dmd_Nm emcp_motor_trq_dmd_Nm

Table 149. Inport Block Properties

Name	Port	Defined In Blk
from_BMCP	4	Unconnected
from_EMCP	2	Product, Product
from_RBCP	3	Unconnected
from_VMCP	1	SFunction , SFunction

Table 150. Mux Block Properties

Name	Inputs	Display Option
Mux	3	bar

Table 151. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
vsc_propel_variables_out	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Demux, Product10

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Regenerative Braking Control Process

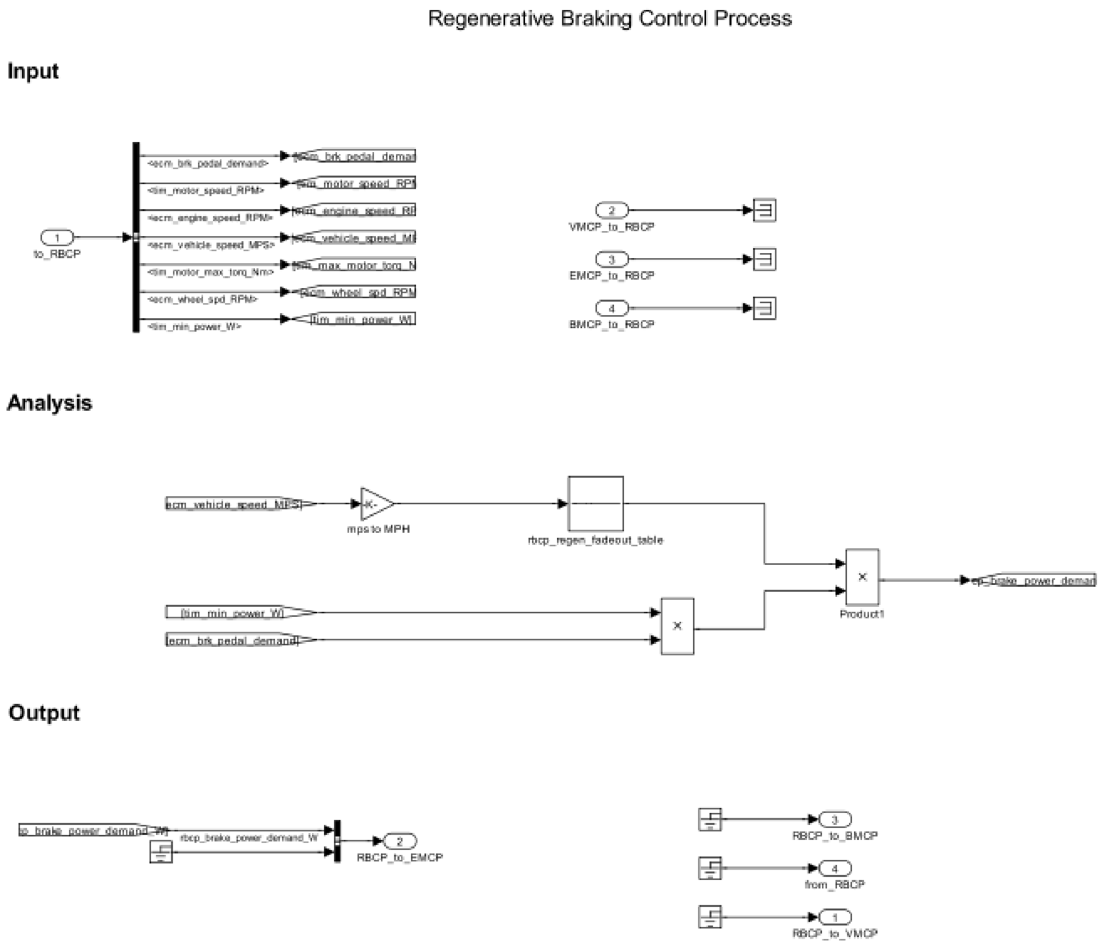


Table 152. BusCreator Block Properties

Name	Inputs	Display Option
Bus Creator	2	bar

Table 153. BusSelector Block Properties

Name	Output Signals	Output As Bus	Input Signals
Bus Selector	ecm_brk_pedal_demand,tim_motor_speed_RPM,ecm_engine_speed_RPM,ecm_vehicle_speed_MPS,tim_motor_max_torq_Nm,ecm_wheel_spd_RPM,tim_min_power_W	off	ecm_vehicle_speed_MPS ecm_engine_speed_RPM tim_motor_speed_RPM ecm_brk_pedal_demand ecm_wheel_spd_RPM tim_motor_max_torq_Nm tim_min_power_W

Table 154. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
From1	rbcp_brake_power_demand_W	Tag	Product1
From2	tim_min_power_W	Tag	Divide6
From27	ecm_vehicle_speed_MPS	Tag	Gain21
From3	ecm_brk_pedal_demand	Tag	Saturation1

Table 155. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
mps to MPH	2.237	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 156. Goto Block Properties

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto1	rbcp_brake_power_demand_W	Tag	local	Sum
Goto2	tim_max_motor_torq_Nm	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto3	ecm_wheel_spd_RPM	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto4	tim_min_power_W	Tag	local	Product
Goto5	ecm_brk_pedal_demand	Tag	local	Product

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto6	tim_motor_speed_RPM	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto7	ecm_engine_speed_RPM	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto8	ecm_vehicle_speed_MPS	Tag	local	mps to MPH

Table 157. Ground Block Properties

Name
Ground
Ground1
Ground2
Ground3

Table 158. Inport Block Properties

Name	Port	Defined In Blk
BMCP_to_RBCP	4	Divide1, Divide2, Gain14, Ground1
EMCP_to_RBCP	3	Ground1
to_RBCP	1	Gain21, Gain22, Gain19, Saturation1, Gain25, lib_p_par_pre_tx_DES_dissertation_MATT (model), Divide6
VMCP_to_RBCP	2	Ground

Table 159. Lookup Block Properties

Name	Input Values	Table	Look Up Meth	Out Min	Out Max	Out Data Type Str
rbcp_regen_fadeout_table	ptc.prop.init.rbcp_max_regen_soc_index	ptc.prop.init.rbcp_max_regen_percent	Interpolation-Extrapolation	[]	[]	Inherit: Same as input

Table 160. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
from_RBCP	4	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Unconnected
RBCP_to_BMCP	3	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Terminator
RBCP_to_EMCP	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Sum
RBCP_to_VMCP	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Terminator

Table 161. Product Block Properties

Name	Inputs	Multiplication	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Product	2	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Product1	2	Element-wise(.*)	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

Table 162. Terminator Block Properties

Name

Name
Terminator
Terminator1
Terminator2

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Vehicle Mode Control Process

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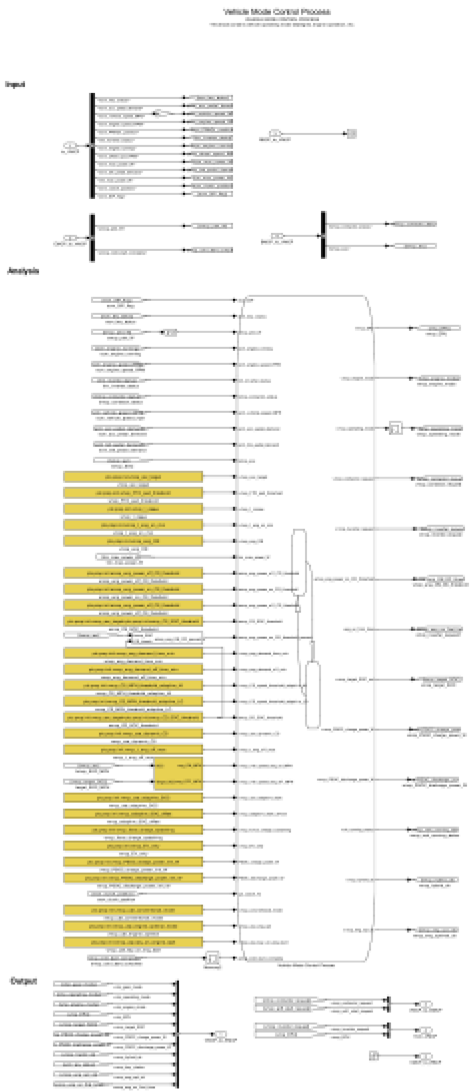

Vehicle Mode Control Process
Input
Analysis
Output

Table 163. BusCreator Block Properties

Name	Inputs	Display Option
Bus Creator	2	bar
Bus Creator1	11	bar
Bus Creator2	2	bar

Table 164. BusSelector Block Properties

Name	Output Signals	Output As Bus	Input Signals
Bus Selector	ecm_key_status,ecm_acc_pedal_demand,ecm_vehicle_speed_MPS,ecm_engine_speed_RPM,ecm_PRNDL_position,tim_inverter_status,ecm_engine_running,ecm_wheel_spd_RPM,ecm_max_power_W,ecm_brk_pedal_demand,tim_max_power_W,ecm_clutch_position,ecm_SIP_flag	off	ecm_key_status ecm_acc_pedal_demand ecm_vehicle_speed_MPS ecm_engine_speed_RPM ecm_PRNDL_position tim_inverter_status ecm_engine_running ecm_wheel_spd_RPM ecm_max_power_W ecm_min_power_W ecm_brk_pedal_demand tim_max_power_W ecm_clutch_po

Name	Output Signals	Output As Bus	Input Signals
			sition ecm_SIP_flag
Bus Selector1	emcp_ptot_W,emcp_cold_start_complete	off	emcp_ptot_W emcp_eng_opt_flag emcp_cold_start_complete
Bus Selector3	bmcp_contactor_status,bmcp_soc	off	bmcp_contactor_status bmcp_soc signal3 signal4

Table 165. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
emcp_CD_SOC_threshold	ptc.prop.init.vmcp_soc_target+ptc.prop.init.emcp_CD_SOC_threshold	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
emcp_CS_SOC_threshold	ptc.prop.init.vmcp_soc_target+ptc.prop.init.emcp_CS_SOC_threshold	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
emcp_eng_power_off_CD_threshold	ptc.prop.init.emcp_eng_power_off_CD_threshold	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
emcp_eng_power_off_CS_threshold	ptc.prop.init.emcp_eng_power_off_CS_threshold	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
emcp_eng_power_on_CS_threshold	ptc.prop.init.emcp_eng_power_on_CS_threshold	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_adaptive_SOC_offset	ptc.prop.init.vmcp_adaptive_SOC_offset	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_CS_MPH_threshold_adaptive_HI	ptc.prop.init.vmcp_CS_MPH_threshold_adaptive_HI	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_CS_MPH_threshold_adaptive_LO	ptc.prop.init.vmcp_CS_MPH_threshold_adaptive_LO	Sample based	[]	[]	Inherit: Inherit from	inf	inf

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
					'Constant value'		
vmcp_eng_demand_off_time_min	ptc.prop.init.vmcp_eng_demand_off_time_min	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_eng_demand_time_min	ptc.prop.init.vmcp_eng_demand_time_min	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_eng_ON	ptc.prop.init.vmcp_eng_ON	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_EV_only	ptc.prop.init.vmcp_EV_only	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_force_charge_sustaining	ptc.prop.init.vmcp_force_charge_sustaining	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_FTO_ped_threshold	ptc.prop.init.vmcp_FTO_ped_threshold	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_PSOC_charge_power_init_W	ptc.prop.init.vmcp_PSOC_charge_power_init_W	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_PSOC_discharge_power_init_W	ptc.prop.init.vmcp_PSOC_discharge_power_init_W	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_soc_target	ptc.prop.init.vmcp_soc_target	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_t_cssew	ptc.prop.init.vmcp_t_cssew	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_t_eng_off_max	ptc.prop.init.vmcp_t_eng_off_max	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_t_eng_on_min	ptc.prop.init.vmcp_t_eng_on_min	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_use_adaptive_SOC	ptc.prop.init.vmcp_use_adaptive_SOC	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_use_conventional_mode	ptc.prop.init.vmcp_use_conventional_mode	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_use_dynamic_CS	ptc.prop.init.vmcp_use_dynamic_CS	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_use_engine_optimal	ptc.prop.init.vmcp_use_engine_optimal_mode	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
vmcp_use_key_on_eng_start	ptc.prop.init.vmcp_use_key_on_engine_start	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 166. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
bmcp_contactor_status	bmcp_contactor_status	Tag	Lookup Table
bmcp_SOC	bmcp_soc	Tag	Gain14
bmcp_SOC1	bmcp_soc	Tag	Gain14
bmcp_SOC_MPH	bmcp_soc	Tag	Gain14
ecm_acc_pedal_demand	ecm_acc_pedal_demand	Tag	Saturation
ecm_brk_pedal_demand	ecm_brk_pedal_demand	Tag	Saturation1
ecm_cluch_position	ecm_clutch_position	Tag	Gain2
ecm_engine_running	ecm_engine_running	Tag	Gain13
ecm_engine_speed_RPM	ecm_engine_speed_RPM	Tag	Gain22
ecm_key_status	ecm_key_status	Tag	Gain1
ecm_key_status1	ecm_key_status	Tag	Gain1
ecm_key_status2	vmcp_eng_opt_ok	Tag	SFunction
ecm_SIP_flag	ecm_SIP_flag	Tag	mem_ptc_sft_in_progress_trs_simu
ecm_vehicle_speed_mph	ecm_vehicle_speed_MPH	Tag	mps to MPH
emcp_cold_start_complete	emcp_cold_start_complete	Tag	SFunction
emcp_ptot_W	emcp_ptot_W	Tag	Memory5
From	vmcp_contactor_request	Tag	SFunction
From1	vmcp_hybrid_ok	Tag	SFunction
From10	vmp_operating_mode	Tag	Memory1
From11	vmp_engine_mode	Tag	SFunction
From12	vmp_EPU	Tag	SFunction
From14	vmcp_inverter_request	Tag	SFunction
From16	vmp_EPU	Tag	SFunction
From19	vmcp_target_SOC	Tag	SFunction
From2	emcp_eng_on_first_time	Tag	SFunction
From20	vmcp_PSOC_charge_power_W	Tag	SFunction
From21	vmcp_PSOC_discharge_power_W	Tag	SFunction
From8	vmcp_soft_start_request	Tag	lib_p_par_pre_tx_DES_dissertation_MATT (model)
From9	vmp_gear_mode	Tag	lib_p_par_pre_tx_DES_dissertation_MATT (model)
target_SOC_MPH	vmcp_target_SOC	Tag	SFunction
tim_inverter_status	tim_inverter_status	Tag	Lookup Table1
tim_max_power_W	tim_max_power_W	Tag	Gain5

Table 167. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
mps to MPH	2.237	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 168. Goto Block Properties

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
Goto	ecm_key_status	Tag	local	Product, Product, SFunction
Goto1	ecm_acc_pedal_demand	Tag	local	SFunction
Goto10	emcp_cold_start_complete	Tag	local	Memory2
Goto13	ecm_brk_pedal_demand	Tag	local	SFunction
Goto14	bmcp_soc	Tag	local	to percent, Lookup Table1, Relational Operator, SFunction
Goto15	emcp_ptot_W	Tag	local	Memory
Goto16	ecm_wheel_speed_RPM	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto17	ecm_max_power_W	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto18	tim_max_power_W	Tag	local	SFunction
Goto2	ecm_vehicle_speed_MPH	Tag	local	SFunction
Goto3	ecm_engine_speed_RPM	Tag	local	SFunction
Goto4	ecm_PRNDL_position	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
Goto5	tim_inverter_status	Tag	local	SFunction
Goto6	ecm_engine_running	Tag	local	SFunction
Goto7	bmcp_contactor_status	Tag	local	SFunction
Goto8	ecm_clutch_position	Tag	local	SFunction
Goto9	ecm_SIP_flag	Tag	local	SFunction
vmcp_contactor_request	vmcp_contactor_request	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
vmcp_eng_ON_DC_threshold	vmcp_eng_ON_DC_threshold	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)
vmcp_eng_optimal_ok	vmcp_eng_opt_ok	Tag	local	SFunction
vmcp_engine_mode	vmp_engine_mode	Tag	local	Memory3
vmcp_EPU	vmp_EPU	Tag	local	Demux, Bus Selector1, SFunction , Divide3, Memory2
vmcp_hybrid_ok	vmcp_hybrid_ok	Tag	local	SFunction
vmcp_inverter_request	vmcp_inverter_request	Tag	local	Bus Selector
vmcp_inverter_request1	emcp_eng_on_first_time	Tag	local	SFunction , SFunction
vmcp_operating_mode	vmp_operating_mode	Tag	local	Compare, Memory4
vmcp_PSOC_charge_power_W	vmcp_PSOC_charge_power_W	Tag	local	Gain
vmcp_PSOC_discharge_power_W	vmcp_PSOC_discharge_power_W	Tag	local	Matrix Concatenate, Matrix Concatenate
vmcp_target_SOC	vmcp_target_SOC	Tag	local	Memory1, to percent1, to percent1
vmcp_veh_running_status	vmcp_veh_running_status	Tag	local	lib_p_par_pre_tx_DES_dissertation_MATT (model)

Table 169. Ground Block Properties

Name
Ground

Table 170. Inport Block Properties

Name	Port	Defined In Blk
BMCP_to_VMCP	4	Lookup Table, Gain14, Ground
EMCP_to_VMCP	2	Memory5, lib_p_par_pre_tx_DES_dissertation_MATT (model), SFunction
RBCP_to_VMCP	3	Ground3
to_VMCP	1	Gain1, Saturation, Gain21, Gain22, Constant, Lookup Table1, Gain13, Gain25, Gain11, Gain12, Saturation1, Gain5, Gain2, mem_ptc_sft_in_progress_trs_simu

Table 171. Memory Block Properties

Name	X0	Inherit Sample Time	Linearize Memory	Linearize As Delay
Memory	0	off	off	off
Memory1	0	off	off	off
Memory2	0	off	off	off

Table 172. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
from_VMCP	4	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Demux, Bus Selector1
VMCP_to_BMCP	3	Port number	BusObject	[]	[]	Inherit: auto	held	[]	lib_p_par_pre_tx_DES_dissertation_MATT (model)
VMCP_to_EMCP	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	lib_p_par_pre_tx_DES_dissertation_MATT (model), Compare, Memory4, Memory3, SFunction , Divide3, Memory2, to percent1, to percent1, Gain, Matrix Concatenate, Matrix Concatenate, SFunction , Product, Product, SFunction , SFunction , SFunction
VMCP_to_RBCP	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	Terminator2

Table 173. Stateflow Block Properties

Name	Chart
Vehicle Mode Control Process	Vehicle Mode Control Process

Table 174. Terminator Block Properties

Name

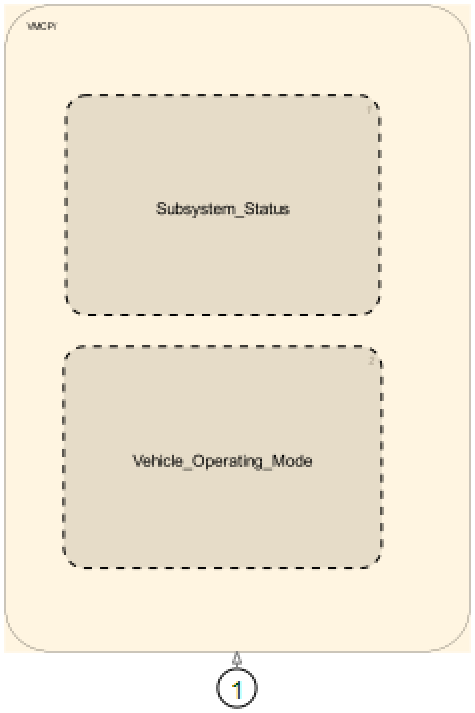
Name
Terminator

Chart - Vehicle Mode Control Process

Chart	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process
States	VMCP
Data	ecm_SIP ecm_key_status emcp_ptot_W ecm_engine_running ecm_engine_speed_RPM tim_inverter_status bmcp_contactor_status ecm_vehicle_speed_MPH vmcp_EPU vmcp_engine_mode vmcp_operating_mode vmcp_contactor_request vmcp_inverter_request ecm_acc_pedal_demand ecm_brk_pedal_demand bmcp_soc Cruise_Charge_Available Engine_Only_Active Full_Power_Active Regen_Active Cruise_Charge_Active vmcp_soc_target vmcp_FTO_ped_threshold t_cssew_temp t_eng_off_demand_temp vmcp_EPU_temp

Chart	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process
	vmcp_t_cssew vmcp_t_eng_on_min Electric_Only vmcp_eng_ON tim_max_power_W Charge_Sustaining eng_power_on_W eng_power_off_W emcp_eng_power_on_CD_threshold emcp_eng_power_off_CD_threshold emcp_eng_power_on_CS_threshold emcp_eng_power_off_CS_threshold emcp_CS_SOC_threshold t_eng_off_temp emcp_eng_power_on_CD_threshold_percent eng_on_first_time vmcp_eng_demand_time_min t_eng_demand_temp vmcp_eng_demand_off_min vmcp_CS_speed_threshold_adaptive_HI vmcp_CS_speed_threshold_adaptive_LO vmcp_target_SOC_out emcp_CD_SOC_threshold vmcp_use_dynamic_CS vmcp_t_eng_off_max t_eng_on_temp vmcp_veh_speed_eng_on_MPH vmcp_veh_speed_eng_off_MPH vmcp_use_adaptive_SOC vmcp_adaptive_SOC_offset

Chart	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process**
	t_contactor_fault vmcp_force_charge_sustaining vmcp_PSOC_charge_power_W vmcp_PSOC_discharge_power_W vmcp_EV_only veh_running_status vmcp_hybrid_ok PSOC_charge_power_W PSOC_discharge_power_W cpl_clutch_fb vmcp_conventional_mode t_EPD vmcp_use_eng_opt vmcp_eng_opt_ok vmcp_use_key_on_eng_start emcp_cold_start_complete



(1) VMCP

Stateflow Hierarchy

1. lib_p_par_pre_tx_DES_dissertation_MATT
    1. Cold_Start_Logic_Chart
    2. *Vehicle Mode Control Process*
        1. Data: ecm_SIP, ecm_key_status, emcp_ptot_W, ecm_engine_running, ecm_engine_speed_RPM, tim_inverter_status, bmcp_contactor_status, ecm_vehicle_speed_MPH, vmcp_EPU, vmcp_engine_mode, vmcp_operating_mode, vmcp_contactor_request, vmcp_inverter_request, ecm_acc_pedal_demand, ecm_brk_pedal_demand, bmcp_soc, Cruise_Charge_Available, Engine_Only_Active, Full_Power_Active, Regen_Active, Cruise_Charge_Active, vmcp_soc_target, vmcp_FTO_ped_threshold, t_cssew_temp, t_eng_off_demand_temp, vmcp_EPU_temp, vmcp_t_cssew, vmcp_t_eng_on_min, Electric_Only, vmcp_eng_ON, tim_max_power_W, Charge_Sustaining, eng_power_on_W, eng_power_off_W,

emcp_eng_power_on_CD_threshold, emcp_eng_power_off_CD_threshold, emcp_eng_power_on_CS_threshold, emcp_eng_power_off_CS_threshold, emcp_CS_SOC_threshold, t_eng_off_temp, emcp_eng_power_on_CD_threshold_percent, eng_on_first_time, vmcp_eng_demand_time_min, t_eng_demand_temp, vmcp_eng_demand_off_min, vmcp_CS_speed_threshold_adaptive_HI, vmcp_CS_speed_threshold_adaptive_LO, vmcp_target_SOC_out, emcp_CD_SOC_threshold, vmcp_use_dynamic_CS, vmcp_t_eng_off_max, t_eng_on_temp, vmcp_veh_speed_eng_on_MPH, vmcp_veh_speed_eng_off_MPH, vmcp_use_adaptive_SOC, vmcp_adaptive_SOC_offset, t_contactor_fault, vmcp_force_charge_sustaining, vmcp_PSOC_charge_power_W, vmcp_PSOC_discharge_power_W, vmcp_EV_only, veh_running_status, vmcp_hybrid_ok, PSOC_charge_power_W, PSOC_discharge_power_W, cpl_clutch_fb, vmcp_conventional_mode, t_EPD, vmcp_use_eng_opt, vmcp_eng_opt_ok, vmcp_use_key_on_eng_start, emcp_cold_start_complete

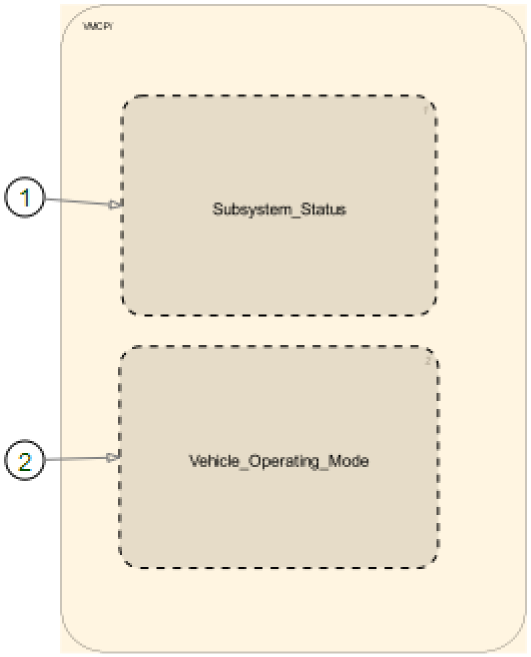
2. VMCP
    1. Subsystem_Status
        1. Transition: [~bmcp_contactor_status || ~e..., [~ecm_key_status]
        2. Vehicle_Shutdown
            1. Transition: [~tim_inverter_status]
            2. Initialize_HV_Battery
            3. Shutdown_Traction_Inverter_Module
        3. Vehicle_Startup
            1. Transition: [ecm_key_status], [~ecm_key_status], [tim_inverter_status], [(t-t_contactor_fault)>20]
            2. Key_Off
            3. Initialize_Electric_Drive
                1. Transition: [bmcp_contactor_status]
                2. Initialize_HV_Battery
                3. Initialize_Traction_Inverter_Module
            4. Contactor_Fault
            5. Inverter_Fault
        4. Vehicle_Running
            1. Transition: {t_cssew_temp = t;}, [(t>(t_cssew_temp+vmcp_t_csse..., [ecm_engine_running], [!vmcp_EPU_temp && (t>t_eng_o..., [vmcp_EPU_temp], [eng_on_first_time && emcp_co..., [t>t_eng_demand_temp], [~vmcp_EPU_temp], [t>t_eng_off_demand_temp], [vmcp_EPU_temp], [(t > t_eng_on_temp) && !vmcp..., [t >= t_EPD]
            2. Start_Engine
            3. Cold_Start_Engine_Warmup
            4. Engine_Warm
            5. Engine_Idle_Off
            6. Eng_On_Demand
            7. Eng_Off_Demand
            8. Controlled_EPD
    2. Vehicle_Operating_Mode
        1. Transition: [Charge_Sustaining], [!Charge_Sustaining], [ecm_SIP], [Full_Power_Active], [!Full_Power_Active], [!ecm_SIP], [Electric_Only], {eng_power_on_W = emcp_eng_po..., [!Electric_Only], [!vmcp_conventional_mode], [vmcp_conventional_mode], [Regen_Active], [!Regen_Active]
        2. Electric_Mode
        3. Charge_Sustaining_Mode

1. Transition: [!vmcp_EPU], [vmcp_EPU && vmcp_use_adaptiv..., [vmcp_use_dynamic_CS && ......, [!vmcp_EPU && bmcp_soc < (emc...
2. Adaptive_Target_SOC
3. Fixed_Target_SOC
    1. Transition: [vmcp_force_charge_sustaining], [bmcp_soc <= emcp_CS_SOC_thre...
    2. Force_Charge_Sustain
    3. Normal
4. Dynamic_CS_Algorithm

4. Engine_On_Active
5. Full_Power_Active
6. Conventional_Active
7. SIP_Active
8. Regen_Active

3. Energy Management Strategy

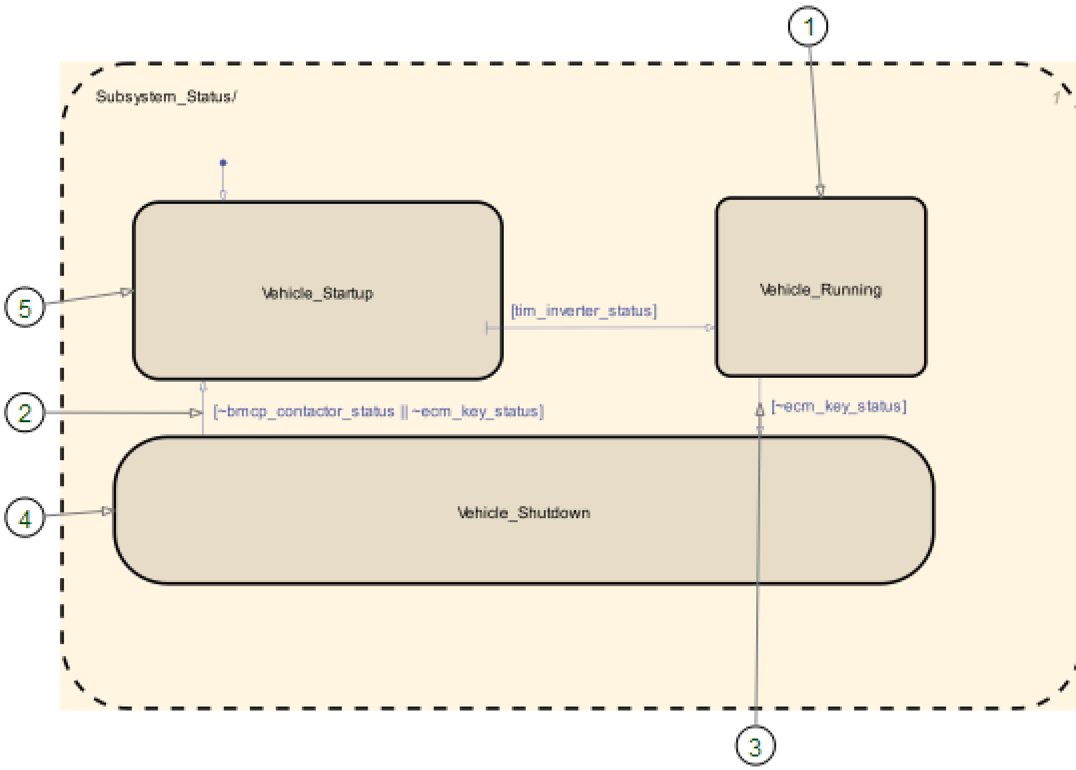
OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP**
Label	VMCP/



(1) Subsystem_Status

(2) Vehicle_Operating_Mode

AND State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status**
Label	Subsystem_Status/



(1) Vehicle_Running

(2) [~bmcp_contactor_status || ~e...

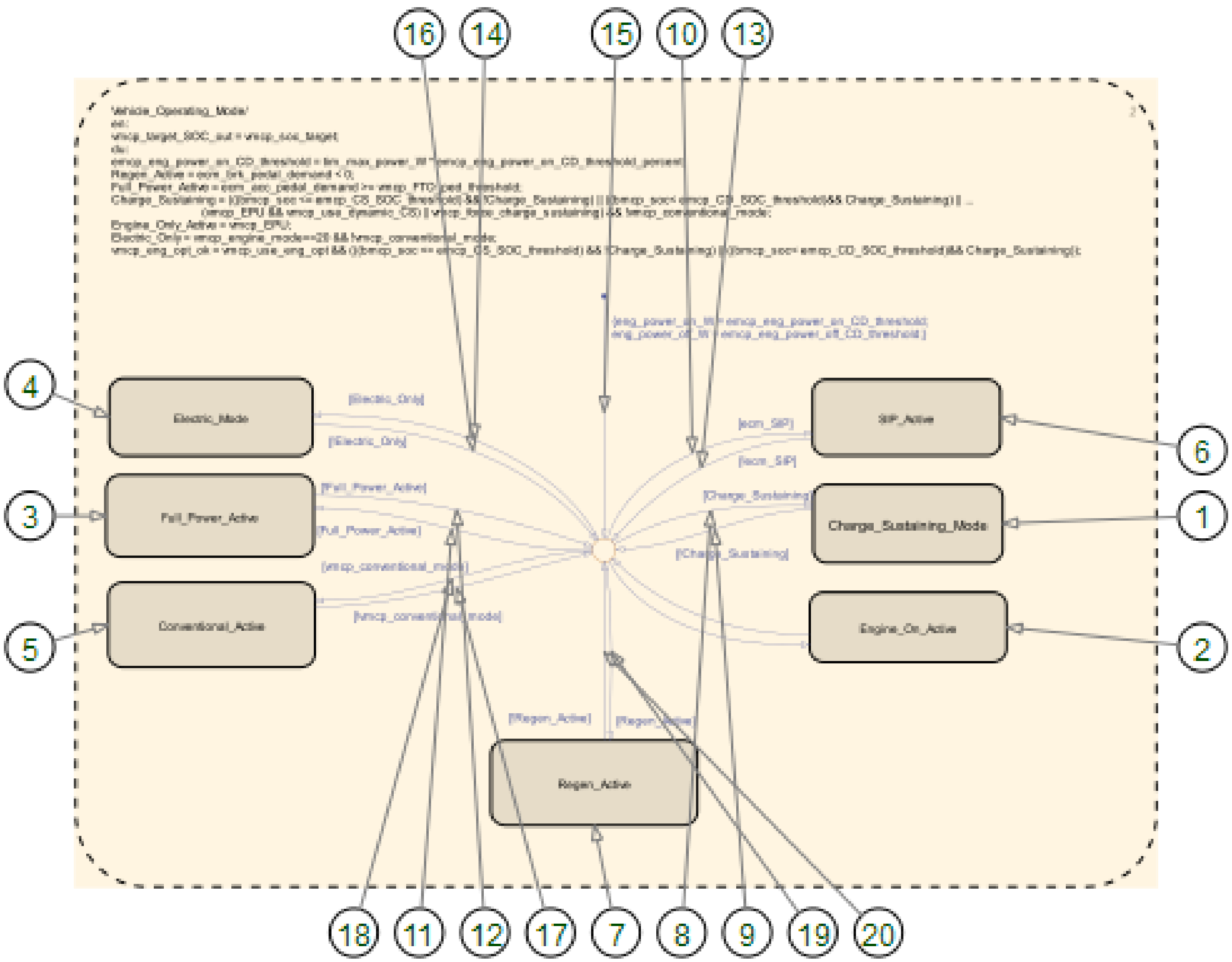
(3) [~ecm_key_status]

(4) Vehicle_Shutdown

(5) Vehicle_Startup

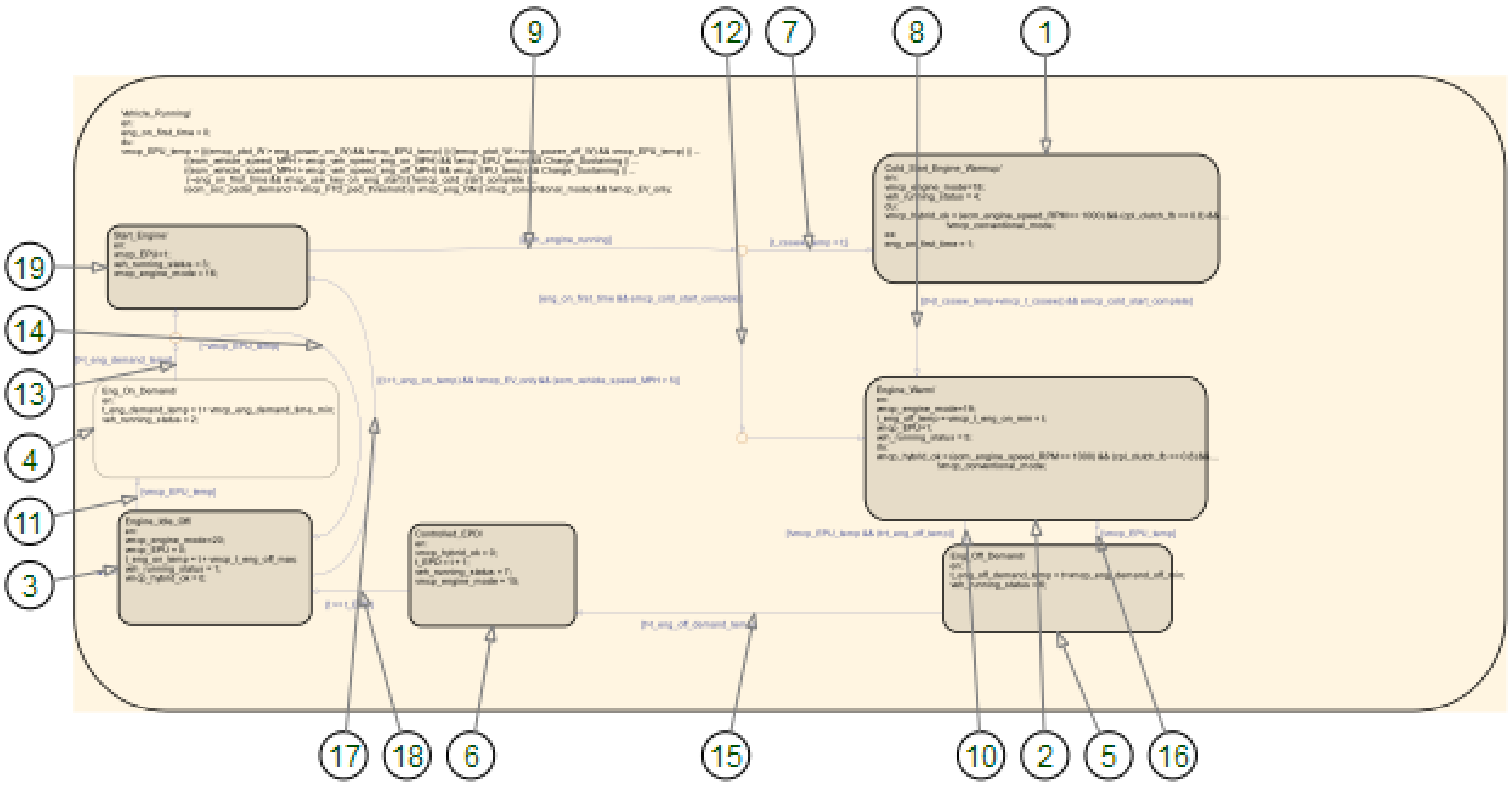
AND State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode**
Label	Vehicle_Operating_Mode/

	en:
	vmcp_target_SOC_out = vmcp_soc_target;
	du:
	emcp_eng_power_on_CD_threshold = tim_max_power_W * emcp_eng_power_on_CD_threshold_percent;
	Regen_Active = ecm_brk_pedal_demand < 0;
	Full_Power_Active = ecm_acc_pedal_demand >= vmcp_FTO_ped_threshold;
	Charge_Sustaining = (((bmcp_soc <= emcp_CS_SOC_threshold) && !Charge_Sustaining) || ((bmcp_soc< emcp_CD_SOC_threshold)&& Charge_Sustaining) || ...
	(vmcp_EPU && vmcp_use_dynamic_CS) || vmcp_force_charge_sustaining) && !vmcp_conventional_mode;
	Engine_Only_Active = vmcp_EPU;
	Electric_Only = vmcp_engine_mode==20 && !vmcp_conventional_mode;
	vmcp_eng_opt_ok = vmcp_use_eng_opt && (((bmcp_soc <= emcp_CS_SOC_threshold) && !Charge_Sustaining) || ((bmcp_soc< emcp_CD_SOC_threshold)&& Charge_Sustaining));


Electric_Mode
Full_Power_Active
Conventional_Active
SIP_Active
Charge_Sustaining_Mode
Engine_On_Active
Regen_Active
16
14
15
10
13
4
3
5
6
1
2
18
11
12
17
7
8
9
19
20

(1) Charge_Sustaining_Mode
(2) Engine_On_Active
(3) Full_Power_Active
(4) Electric_Mode
(5) Conventional_Active
(6) SIP_Active
(7) Regen_Active
(8) [Charge_Sustaining]
(9) [!Charge_Sustaining]
(10) [ecm_SIP]
(11) [Full_Power_Active]
(12) [!Full_Power_Active]
(13) [!ecm_SIP]
(14) [Electric_Only]
(15) {eng_power_on_W = emcp_eng_po...
(16) [!Electric_Only]
(17) [!vmcp_conventional_mode]
(18) [vmcp_conventional_mode]
(19) [Regen_Active]
(20) [!Regen_Active]

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Running**
Label	Vehicle_Running/ en: eng_on_first_time = 0; du: vmcp_EPU_temp = (((emcp_ptot_W > eng_power_on_W) && !vmcp_EPU_temp) || ((emcp_ptot_W > eng_power_off_W) && vmcp_EPU_temp) || ... ((ecm_vehicle_speed_MPH > vmcp_veh_speed_eng_on_MPH) && !vmcp_EPU_temp) && Charge_Sustaining || ... ((ecm_vehicle_speed_MPH > vmcp_veh_speed_eng_off_MPH) && vmcp_EPU_temp) && Charge_Sustaining || ... (~eng_on_first_time && vmcp_use_key_on_eng_start) || !emcp_cold_start_complete ||... (ecm_acc_pedal_demand > vmcp_FTO_ped_threshold) || vmcp_eng_ON || vmcp_conventional_mode) && !vmcp_EV_only;



(1) Cold_Start_Engine_Warmup

(2) Engine_Warm

(3) Engine_Idle_Off

(4) Eng_On_Demand

(5) Eng_Off_Demand

(6) Controlled_EPD

(7) {t_cssew_temp = t;}

(8) [(t>(t_cssew_temp+vmcp_t_csse...

(9) [ecm_engine_running]

(10) [!vmcp_EPU_temp && (t>t_eng_o...

(11) [vmcp_EPU_temp]

(12) [eng_on_first_time && emcp_co...

(13) [t>t_eng_demand_temp]

(14) [~vmcp_EPU_temp]

(15) [t>t_eng_off_demand_temp]

(16) [vmcp_EPU_temp]

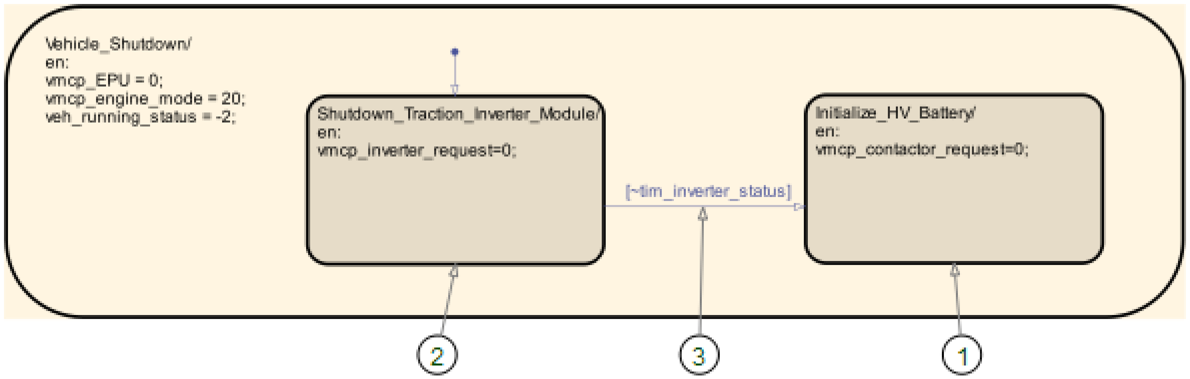
(17) [(t > t_eng_on_temp) && !vmcp...

(18) [t >= t_EPD]

(19) Start_Engine

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Shutdown**

Label	Vehicle_Shutdown/
	en:
	vmcp_EPU = 0;
	vmcp_engine_mode = 20;
	veh_running_status = -2;

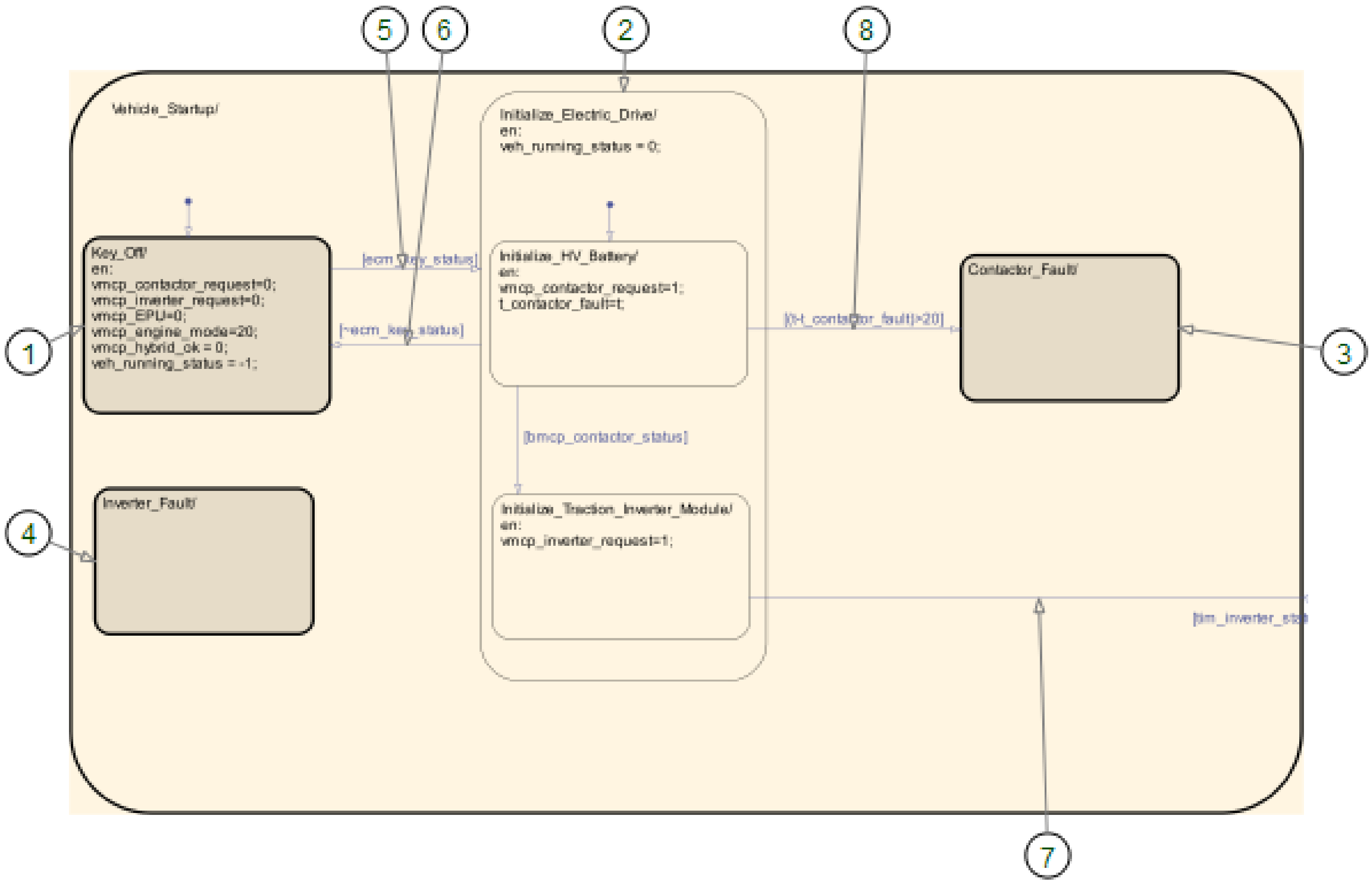


(1) Initialize_HV_Battery

(2) Shutdown_Traction_Inverter_Module

(3) [~tim_inverter_status]

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Startup**
Label	Vehicle_Startup/



(1) [Key_Off]

(2) [Initialize_Electric_Drive]

(3) Contactor_Fault

(4) Inverter_Fault

(5) [ecm_key_status]

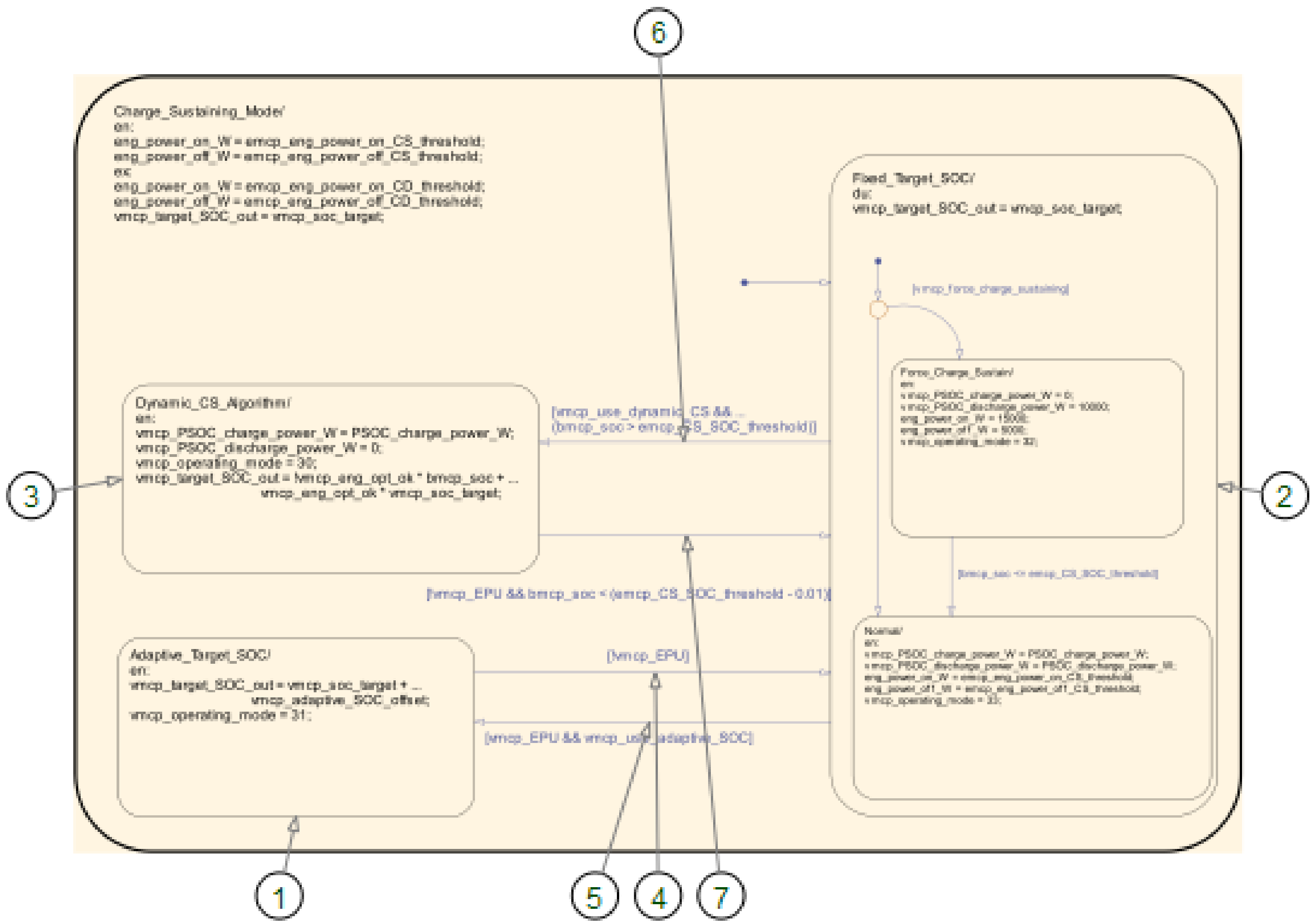
(6) [~ecm_key_status]

(7) [tim_inverter_status]

(8) [(t-t_contactor_fault)>20]

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/Charge_Sustaining_Mode**

Label	Charge_Sustaining_Mode/
	en:
	eng_power_on_W = emcp_eng_power_on_CS_threshold;
	eng_power_off_W = emcp_eng_power_off_CS_threshold;
	ex:
	eng_power_on_W = emcp_eng_power_on_CD_threshold;
	eng_power_off_W = emcp_eng_power_off_CD_threshold;
	vmcp_target_SOC_out = vmcp_soc_target;



6
Charge_Sustaining_Mode/
en:
eng_power_on_W = emcp_eng_power_on_CS_threshold;
eng_power_off_W = emcp_eng_power_off_CS_threshold;
ex:
eng_power_on_W = emcp_eng_power_on_CD_threshold;
eng_power_off_W = emcp_eng_power_off_CD_threshold;
vmcp_target_SOC_out = vmcp_soc_target;
Fixed_Target_SOC/
du:
vmcp_target_SOC_out = vmcp_soc_target;
Force_Charge_Sustain/
Dynamic_CS_Algorithm/
en:
vmcp_PSOC_charge_power_W = PSOC_charge_power_W;
vmcp_PSOC_discharge_power_W = 0;
vmcp_operating_mode = 30;
vmcp_target_SOC_out = !vmcp_eng_opt_ok * bmcp_soc + ...
vmcp_eng_opt_ok * vmcp_soc_target;
[vmcp_use_dynamic_CS && ...
(bmcp_soc > emcp_CS_SOC_threshold)]
3
2
[!vmcp_EPU && bmcp_soc < (emcp_CS_SOC_threshold - 0.01)]
Normal/
Adaptive_Target_SOC/
en:
vmcp_target_SOC_out = vmcp_soc_target + ...
vmcp_adaptive_SOC_offset;
vmcp_operating_mode = 31;
[!vmcp_EPU]
[vmcp_EPU && vmcp_use_adaptive_SOC]
1
5
4
7

(1) Adaptive_Target_SOC

(2) Fixed_Target_SOC

(3) Dynamic_CS_Algorithm

(4) [!vmcp_EPU]

(5) [vmcp_EPU && vmcp_use_adaptiv...

(6) [vmcp_use_dynamic_CS && ......

(7) [!vmcp_EPU && bmcp_soc < (emc...

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/Engine_On_Active**

Label	Engine_On_Active/
	du:
	vmcp_operating_mode=23;
	eng_power_on_W = emcp_eng_power_on_CD_threshold;
	eng_power_off_W = emcp_eng_power_off_CD_threshold;

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/Full_Power_Active**
Label	Full_Power_Active/ en: vmcp_operating_mode=25;
OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/Electric_Mode**

Label	Electric_Mode/
	du:
	vmcp_operating_mode=10;
	eng_power_on_W = emcp_eng_power_on_CD_threshold;
	eng_power_off_W = emcp_eng_power_off_CD_threshold;

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/Conventional_Active**
Label	Conventional_Active/ en: vmcp_operating_mode = 50;
OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/SIP_Active**
Label	SIP_Active/ en:

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/**Conventional_Active**
	vmcp_operating_mode = 60;
OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/**Regen_Active**
Label	Regen_Active/ en: vmcp_operating_mode = 26;
OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Running/**Cold_Start_Engine_Warmup**

Label	Cold_Start_Engine_Warmup/
	en:
	vmcp_engine_mode=18;
	veh_running_status = 4;
	du:
	vmcp_hybrid_ok = (ecm_engine_speed_RPM >= 1000) && (cpl_clutch_fb >= 0.8) && ...
	!vmcp_conventional_mode;
	ex:
	eng_on_first_time = 1;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Running/**Engine_Warm**

Label	Engine_Warm/
	en:
	vmcp_engine_mode=19;
	t_eng_off_temp = vmcp_t_eng_on_min + t;
	vmcp_EPU=1;
	veh_running_status = 5;
	du:
	vmcp_hybrid_ok = (ecm_engine_speed_RPM >= 1000) && (cpl_clutch_fb >= 0.8) && ...
	!vmcp_conventional_mode;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Running/**Engine_Idle_Off**
Label	Engine_Idle_Off/ en: vmcp_engine_mode=20;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Running/**Engine_Warm**

	vmcp_EPU = 0;
	t_eng_on_temp = t + vmcp_t_eng_off_max;
	veh_running_status = 1;
	vmcp_hybrid_ok = 0;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Running/**Eng_On_Demand**

Label	Eng_On_Demand/
	en:
	t_eng_demand_temp = t + vmcp_eng_demand_time_min;
	veh_running_status = 2;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Running/**Eng_Off_Demand**

Label	Eng_Off_Demand/
	en:
	t_eng_off_demand_temp = t+vmcp_eng_demand_off_min;
	veh_running_status = 6;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Running/**Controlled_EPD**

Label	Controlled_EPD/
	en:
	vmcp_hybrid_ok = 0;
	t_EPD = t + 1;
	veh_running_status = 7;
	vmcp_engine_mode = 15;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Running/**Start_Engine**

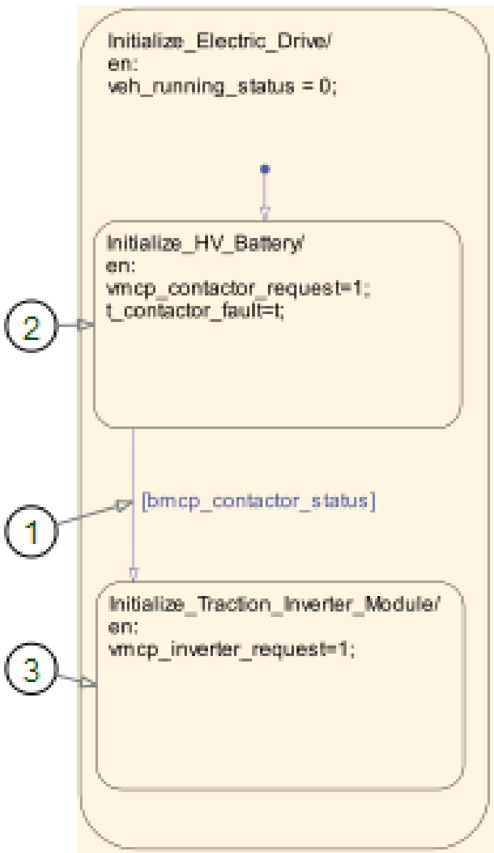
Label	Start_Engine/
	en:
	vmcp_EPU=1;
	veh_running_status = 3;
	vmcp_engine_mode = 16;

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Shutdown/**Initialize_HV_Battery**
Label	Initialize_HV_Battery/

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Shutdown/Initialize_HV_Battery**
	en: vmcp_contactor_request=0;
OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Shutdown/Shutdown_Traction_Inverter_Module**
Label	Shutdown_Traction_Inverter_Module/ en: vmcp_inverter_request=0;
OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Startup/Key_Off**

Label	Key_Off/
	en:
	vmcp_contactor_request=0;
	vmcp_inverter_request=0;
	vmcp_EPU=0;
	vmcp_engine_mode=20;
	vmcp_hybrid_ok = 0;
	veh_running_status = -1;

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Startup/Initialize_Electric_Drive**
Label	Initialize_Electric_Drive/ en: veh_running_status = 0;


Initialize_Electric_Drive/
en:
veh_running_status = 0;
Initialize_HV_Battery/
en:
vmcp_contactor_request=1;
t_contactor_fault=t;
[bmcp_contactor_status]
Initialize_Traction_Inverter_Module/
en:
vmcp_inverter_request=1;
1
2
3

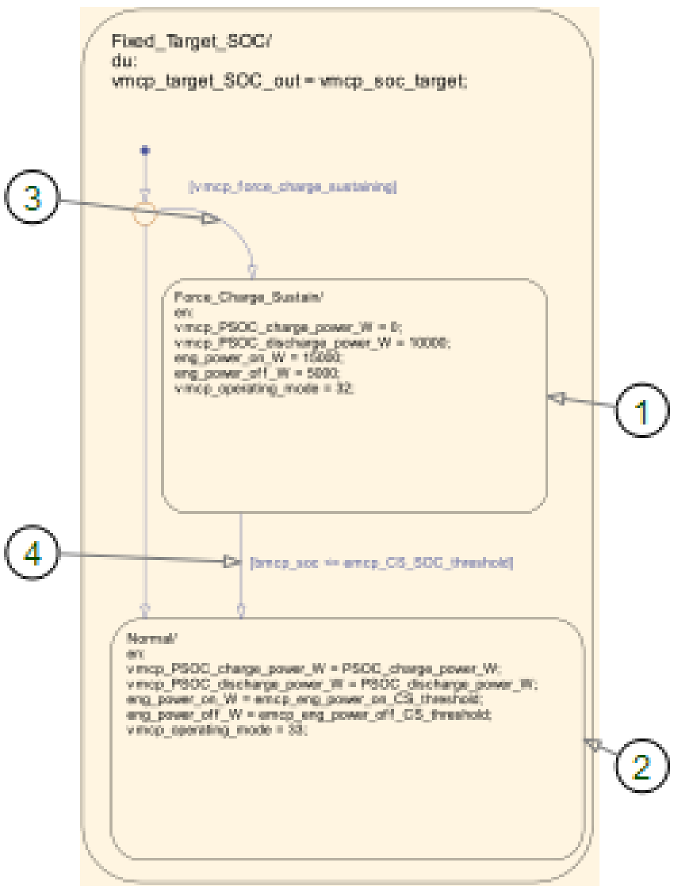
(1) [bmcp_contactor_status]

(2) Initialize_HV_Battery

(3) Initialize_Traction_Inverter_Module

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Startup/**Contactor_Fault**
Label	Contactor_Fault/

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Startup/**Inverter_Fault**
Label	Inverter_Fault/
OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/Charge_Sustaining_Mode/**Adaptive_Target_SOC**
Label	Adaptive_Target_SOC/ en: vmcp_target_SOC_out = vmcp_soc_target + ... vmcp_adaptive_SOC_offset; vmcp_operating_mode = 31;
OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/Charge_Sustaining_Mode/**Fixed_Target_SOC**
Label	Fixed_Target_SOC/ du: vmcp_target_SOC_out = vmcp_soc_target;



Fixed_Target_SOC/
du:
vmcp_target_SOC_out = vmcp_soc_target;
[vmcp_force_charge_sustaining]
Force_Charge_Sustain/
en:
vmcp_PSOC_charge_power_W = 0;
vmcp_PSOC_discharge_power_W = 10000;
eng_power_on_W = 10000;
eng_power_off_W = 5000;
vmcp_operating_mode = 32;
[bmcp_soc <= emcp_CS_SOC_threshold]
Normal/
en:
vmcp_PSOC_charge_power_W = PSOC_charge_power_W;
vmcp_PSOC_discharge_power_W = PSOC_discharge_power_W;
eng_power_on_W = emcp_eng_power_on_CS_threshold;
eng_power_off_W = emcp_eng_power_off_CS_threshold;
vmcp_operating_mode = 33;
1
2
3
4

(1) Force_Charge_Sustain

(2) Normal

(3) [vmcp_force_charge_sustaining]

(4) [bmcp_soc <= emcp_CS_SOC_thre...

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/Charge_Sustaining_Mode/Dynamic_CS_Algorithm**

Label	Dynamic_CS_Algorithm/
	en:
	vmcp_PSOC_charge_power_W = PSOC_charge_power_W;
	vmcp_PSOC_discharge_power_W = 0;
	vmcp_operating_mode = 30;
	vmcp_target_SOC_out = !vmcp_eng_opt_ok * bmcp_soc + ...
	vmcp_eng_opt_ok * vmcp_soc_target;

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Startup/Initialize_Electric_Drive/Initialize_HV_Battery**

Label	Initialize_HV_Battery/
	en:
	vmcp_contactor_request=1;
	t_contactor_fault=t;

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Subsystem_Status/Vehicle_Startup/Initialize_Electric_Drive/Initialize_Traction_Inverter_Module**
Label	Initialize_Traction_Inverter_Module/ en: vmcp_inverter_request=1;

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/Charge_Sustaining_Mode/Fixed_Target_SOC/Force_Charge_Sustain**

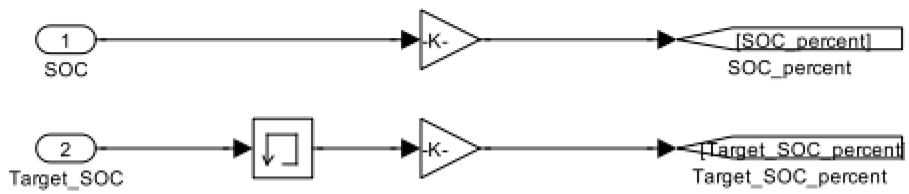
Label	Force_Charge_Sustain/
	en:
	vmcp_PSOC_charge_power_W = 0;
	vmcp_PSOC_discharge_power_W = 10000;
	eng_power_on_W = 15000;
	eng_power_off_W = 5000;
	vmcp_operating_mode = 32;

OR State	**lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/Charge_Sustaining_Mode/Fixed_Target_SOC/Normal**

OR State	lib_p_par_pre_tx_DES_dissertation_MATT/Vehicle Mode Control Process/VMCP/Vehicle_Operating_Mode/Charge_Sustaining_Mode/Fixed_Target_SOC/Force_Charge_Sustain

Label	Normal/
	en:
	vmcp_PSOC_charge_power_W = PSOC_charge_power_W;
	vmcp_PSOC_discharge_power_W = PSOC_discharge_power_W;
	eng_power_on_W = emcp_eng_power_on_CS_threshold;
	eng_power_off_W = emcp_eng_power_off_CS_threshold;
	vmcp_operating_mode = 33;

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Vehicle Mode Control Process/Subsystem



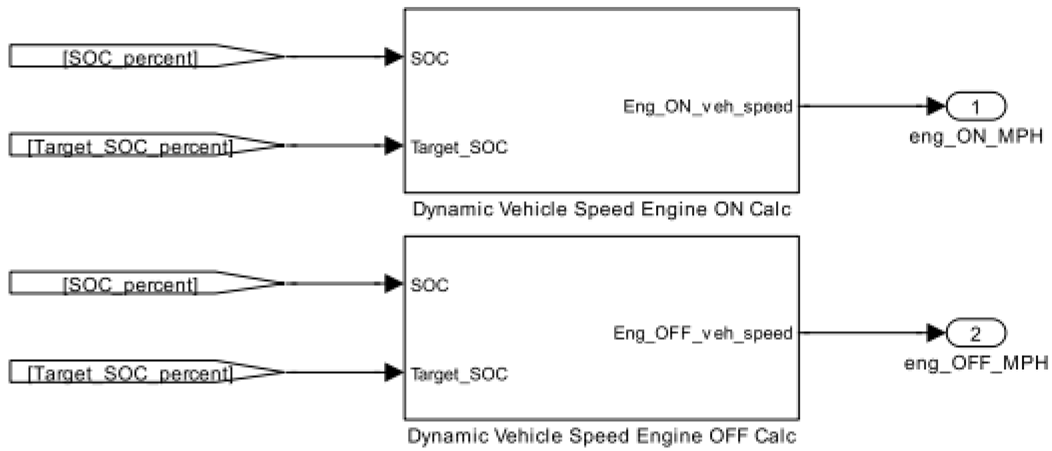


Table 175. From Block Properties

Name	Goto Tag	Icon Display	Defined In Blk
From1	Target_SOC_percent	Tag	to percent1
From2	SOC_percent	Tag	to percent
From3	Target_SOC_percent	Tag	to percent1

Name	Goto Tag	Icon Display	Defined In Blk
From9	SOC_percent	Tag	to percent

Table 176. Gain Block Properties

Name	Gain	Multiplication	Param Min	Param Max	Param Data Type Str	Out Min	Out Max	Out Data Type Str
to percent	100	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule
to percent1	100	Element-wise(K.*u)	[]	[]	Inherit: Inherit via internal rule	[]	[]	Inherit: Inherit via internal rule

Table 177. Goto Block Properties

Name	Goto Tag	Icon Display	Tag Visibility	Used By Blk
SOC_percent	SOC_percent	Tag	local	Dynamic Vehicle Speed Engine ON Table, Dynamic Vehicle Speed Engine OFF Table
Target_SOC_percent	Target_SOC_percent	Tag	local	Add1, Matrix Concatenate1, Add, Add, Add1, Matrix Concatenate1

Table 178. Inport Block Properties

Name	Port	Defined In Blk
SOC	1	Gain14
Target_SOC	2	SFunction

Table 179. Memory Block Properties

Name	X0	Inherit Sample Time	Linearize Memory	Linearize As Delay
Memory1	0	off	off	off

Table 180. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
eng_OFF_MPH	2	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction
eng_ON_MPH	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Vehicle Mode Control Process/Subsystem/Dynamic Vehicle Speed Engine OFF Calc

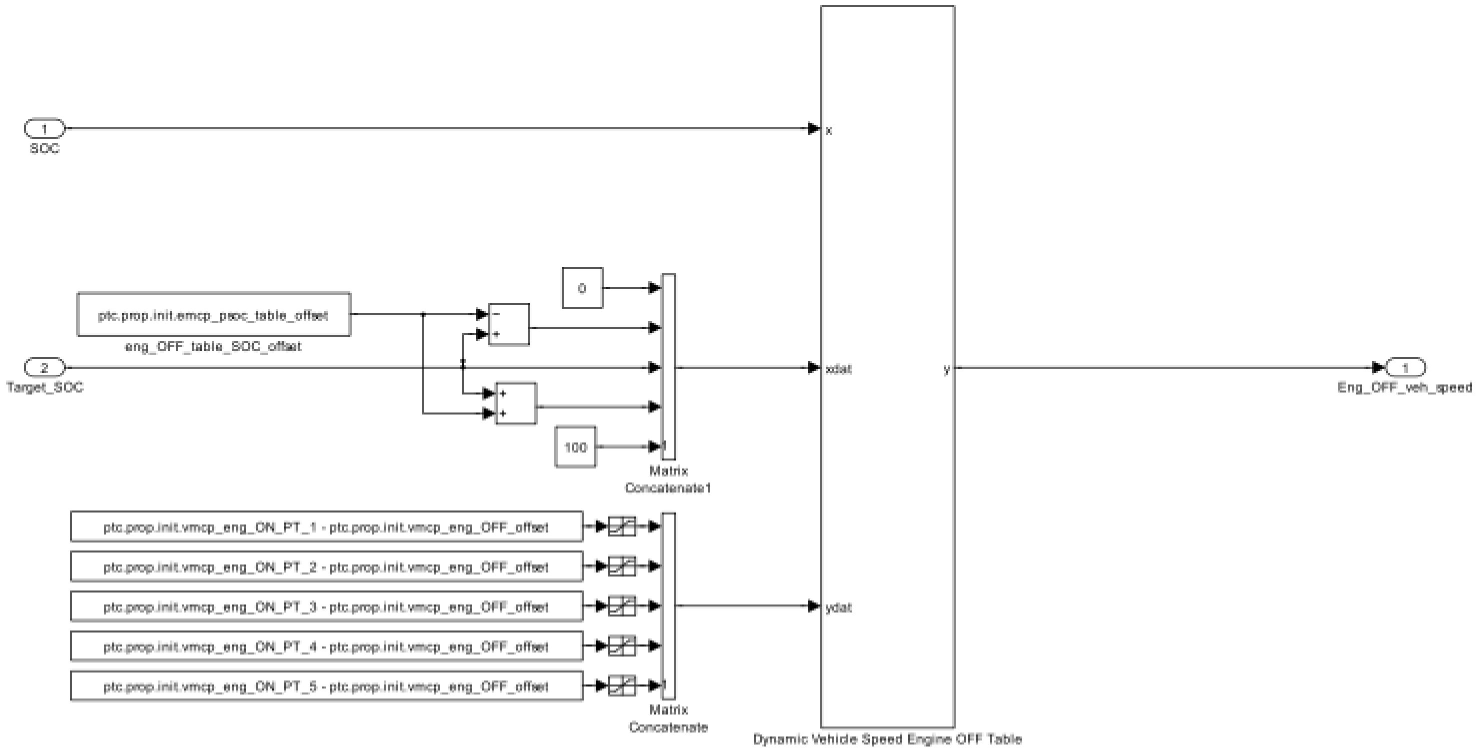


Table 181. Concatenate Block Properties

Name	Num Inputs	Mode	Concatenate Dimension
Matrix Concatenate	5	Multidimensional array	1
Matrix Concatenate1	5	Multidimensional array	1

Table 182. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
Constant2	0	Sample based	[]	[]	Inherit: Inherit from 'Constant	inf	inf

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
					value'		
Constant3	100	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Eng_OFF_Pt_1	ptc.prop.init.vmcp_eng_ON_PT_1 - ptc.prop.init.vmcp_eng_OFF_offset	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Eng_OFF_Pt_2	ptc.prop.init.vmcp_eng_ON_PT_2 - ptc.prop.init.vmcp_eng_OFF_offset	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Eng_OFF_Pt_3	ptc.prop.init.vmcp_eng_ON_PT_3 - ptc.prop.init.vmcp_eng_OFF_offset	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Eng_OFF_Pt_4	ptc.prop.init.vmcp_eng_ON_PT_4 - ptc.prop.init.vmcp_eng_OFF_offset	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Eng_OFF_Pt_5	ptc.prop.init.vmcp_eng_ON_PT_5 - ptc.prop.init.vmcp_eng_OFF_offset	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
eng_OFF_table_SOC_offset	ptc.prop.init.emcp_psoc_table_offset	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 183. Inport Block Properties

Name	Port	Defined In Blk
SOC	1	to percent
Target_SOC	2	to percent1

Table 184. Lookup Table Dynamic Block Properties

Name	Look Up Meth	Out Data Type Str	Output Data Type Scaling Mode	Out Data Type	Out Scaling	Lock Scale	Rnd Meth	Do Satur
Dynamic Vehicle Speed Engine OFF Table	Interpolation-Use End Values	float('double')	Specify via dialog	float('double')	2^-10	off	Floor	off

Table 185. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
Eng_OFF_veh_speed	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction

Table 186. Saturate Block Properties

Name	Upper Limit	Lower Limit	Linearize As Gain	Zero Cross	Out Min	Out Max	Out Data Type Str
Saturation	100	5	on	on	[]	[]	Inherit: Same as input
Saturation1	100	5	on	on	[]	[]	Inherit: Same as input
Saturation2	100	5	on	on	[]	[]	Inherit: Same as input
Saturation3	100	5	on	on	[]	[]	Inherit: Same as input

Name	Upper Limit	Lower Limit	Linearize As Gain	Zero Cross	Out Min	Out Max	Out Data Type Str
Saturation4	100	5	on	on	[]	[]	Inherit: Same as input

Table 187. Sum Block Properties

Name	Icon Shape	Inputs	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Add	rectangular	-+	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Add1	rectangular	++	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Vehicle Mode Control Process/Subsystem/Dynamic Vehicle Speed Engine ON Calc

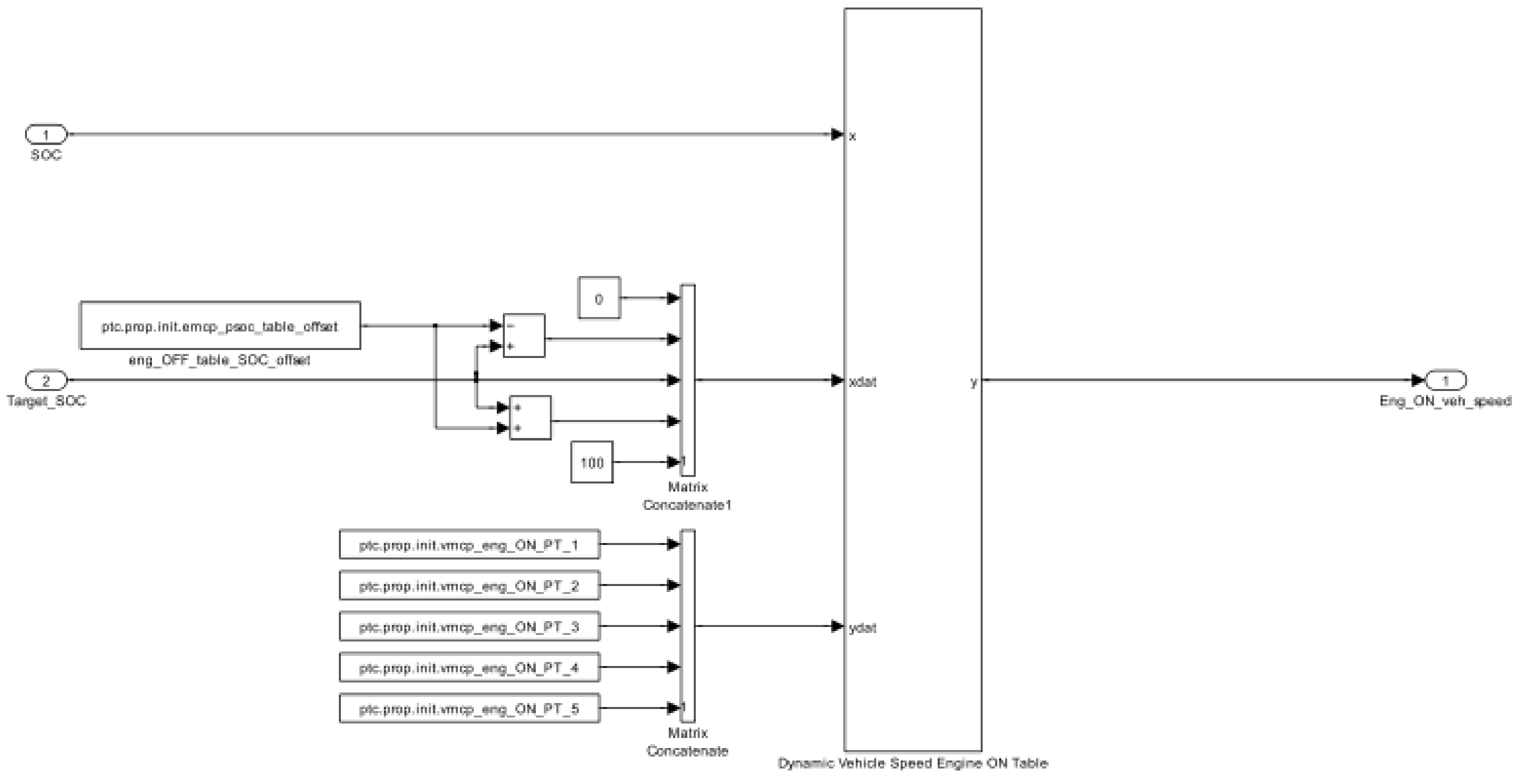


Table 188. Concatenate Block Properties

Name	Num Inputs	Mode	Concatenate Dimension
Matrix Concatenate	5	Multidimensional array	1
Matrix Concatenate1	5	Multidimensional array	1

Table 189. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
Constant2	0	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Constant3	100	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
eng_OFF_table_SOC_offset	ptc.prop.init.emcp_psoc_table_offset	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Eng_ON_Pt_1	ptc.prop.init.vmcp_eng_ON_PT_1	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Eng_ON_Pt_2	ptc.prop.init.vmcp_eng_ON_PT_2	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Eng_ON_Pt_3	ptc.prop.init.vmcp_eng_ON_PT_3	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Eng_ON_Pt_4	ptc.prop.init.vmcp_eng_ON_PT_4	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
Eng_ON_Pt_5	ptc.prop.init.vmcp_eng_ON_PT_5	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 190. Inport Block Properties

Name	Port	Defined In Blk
SOC	1	to percent
Target_SOC	2	to percent1

Table 191. Lookup Table Dynamic Block Properties

Name	Look Up Meth	Out Data Type Str	Output Data Type Scaling Mode	Out Data Type	Out Scaling	Lock Scale	Rnd Meth	Do Satur
Dynamic Vehicle Speed Engine ON Table	Interpolation-Use End Values	float('double')	Specify via dialog	float('double')	2^-10	off	Floor	off

Table 192. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
Eng_ON_veh_speed	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction

Table 193. Sum Block Properties

Name	Icon Shape	Inputs	Collapse Mode	Collapse Dim	Input Same DT	Out Min	Out Max	Out Data Type Str
Add	rectangular	-+	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule
Add1	rectangular	++	All dimensions	1	off	[]	[]	Inherit: Inherit via internal rule

System - lib_p_par_pre_tx_DES_dissertation_MATT/p_par_pre_tx_DES_dissertation_MATT/UTK VSC StrategyPhase 2/Vehicle Mode Control Process/Subsystem1

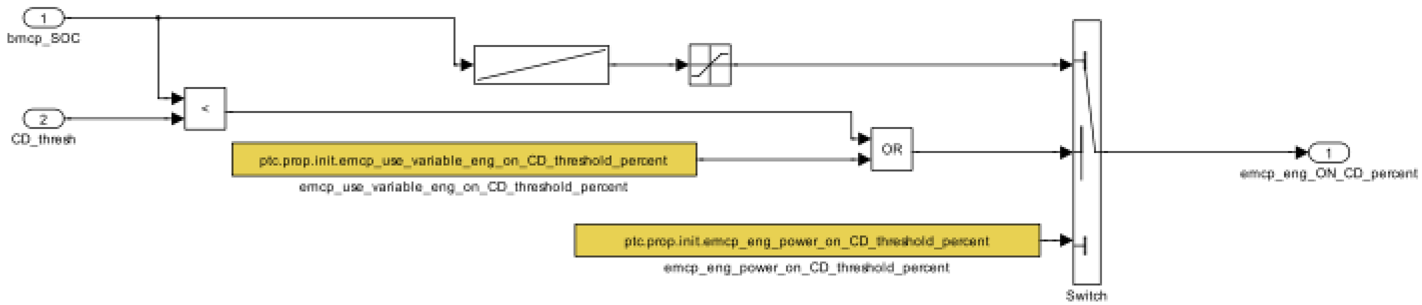


Table 194. Constant Block Properties

Name	Value	Sampling Mode	Out Min	Out Max	Out Data Type Str	Sample Time	Frame Period
emcp_eng_power_on_CD_threshold_percent	ptc.prop.init.emcp_eng_power_on_CD_threshold_percent	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf
emcp_use_variable_eng_on_CD_threshold_percent	ptc.prop.init.emcp_use_variable_eng_on_CD_threshold_percent	Sample based	[]	[]	Inherit: Inherit from 'Constant value'	inf	inf

Table 195. Inport Block Properties

Name	Port	Defined In Blk
bmcp_SOC	1	Gain14
CD_thresh	2	emcp_CD_SOC_threshold

Table 196. Logic Block Properties

Name	Operator	Inputs	Icon Shape	All Ports Same DT	Out Data Type Str
Logical Operator	OR	2	rectangular	off	boolean

Table 197. Lookup Block Properties

Name	Input Values	Table	Look Up Meth	Out Min	Out Max	Out Data Type Str
Lookup Table1	[ptc.prop.init.vmcp_soc_target+ptc.prop.init.emcp_CS_SOC_threshold 0.9]	[ptc.prop.init.emcp_eng_per_on_CD_LO ptc.prop.init.emcp_eng_per_on_CD_HI]	Interpolation-Extrapolation	[]	[]	Inherit: Same as input

Table 198. Outport Block Properties

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk

Name	Port	Icon Display	Bus Object	Out Min	Out Max	Out Data Type Str	Output When Disabled	Initial Output	Used By Blk
emcp_eng_ON_CD_percent	1	Port number	BusObject	[]	[]	Inherit: auto	held	[]	SFunction

Table 199. RelationalOperator Block Properties

Name	Operator	Input Same DT	Out Data Type Str	Zero Cross
Relational Operator	<	off	boolean	on

Table 200. Saturate Block Properties

Name	Upper Limit	Lower Limit	Linearize As Gain	Zero Cross	Out Min	Out Max	Out Data Type Str
Saturation1	inf	0.2	on	on	[]	[]	Inherit: Same as input

Table 201. Switch Block Properties

Name	Criteria	Threshold	Input Same DT	Out Min	Out Max	Out Data Type Str	Zero Cross
Switch	u2 >= Threshold	0.5	off	[]	[]	Inherit: Inherit via internal rule	on

Appendix

Table 202. Block Type Count

BlockType	Count	Block Names
From	195	From, From1, From2, From3, From4, From1, From10, From11, From12, From13, From14, From15, From16, From17, From2, From20, From3, From30, From4, From5, From6, From7, From8, From9, from_ptc_eng_on_sur_simu1, From, From1, From10, From11, From12, From13, From14, From16, From2, From3, From4, From5, From6, From7, From8, From9, raw_motor_trq_dmd, From1, From2, From1, From18, From2, From3, From4, From5, From6, From7, From8, From9, From1, From10, From11, From12, From13, From14, From15, From16, From17, From18, From19, From2, From20, From21, From22, From23, From24, From26, From27, From28, From29, From3, From30, From31, From32, From34, From4, From5, From6, From7, From8, From9, From2, bmcp_charge_power_limit_W, bmcp_discharge_power_limit_W, bmcp_psoc_W, bmcp_psoc_eng_W, ecm_engine_speed_RPM, ecm_max_power_W, ecm_min_power_W, ecm_vehicle_speed_MPS, ecm_vehicle_speed_MPS1, emcp_hybrid_ok, emcp_pdrv_W, emcp_peng_opt_W, emcp_peng_warm_W, tim_max_power_W, tim_motor_speed_RPM, vmcp_EPU, vmcp_EPU1, vmcp_EPU2, vmcp_eng_on_first_time, vmcp_eng_on_first_time1, vmcp_eng_opt_ok, vmcp_engine_mode, vmcp_operating_mode, vmcp_operating_mode1, From, From1, From10, From11, From12, From13, From14, From15, From16, From17, From18, From19, From2, From20, From21, From22, From23, From24, From25, From26, From27, From28, From29, From3, From30, From31, From32, From33, From34, From35, From36, From37, From38, From39, From4, From40, From41, From42, From43, From5, From6, From7, From8, From9, From1, From2, From27, From3, From, From1, From10, From11, From12, From14, From16, From19, From2, From20, From21, From8, From9, From1, From2, From3, From9, bmcp_SOC, bmcp_SOC1, bmcp_SOC_MPH, bmcp_contactor_status, ecm_SIP_flag, ecm_acc_pedal_demand, ecm_brk_pedal_demand, ecm_cluch_position, ecm_engine_running, ecm_engine_speed_RPM, ecm_key_status, ecm_key_status1, ecm_key_status2, ecm_vehicle_speed_mph, emcp_cold_start_complete, emcp_ptot_W, target_SOC_MPH, tim_inverter_status, tim_max_power_W
Goto	157	Goto, Goto1, Goto2, Goto1, Goto10, Goto11, Goto12, Goto13, Goto15, Goto2, Goto23, Goto24, Goto3, Goto4, Goto5, Goto6, Goto7, Goto8, Goto9, Goto, Goto1, Goto10, Goto11, Goto12, Goto2, Goto3, Goto4, Goto5, Goto6, Goto7, Goto8, Goto9, Goto18, Goto26, Goto1, Goto2, Goto26, Goto3, Goto4, Goto5, Goto6, Goto, Goto1, Goto10, Goto11, Goto12, Goto13, Goto14, Goto15, Goto16, Goto17, Goto18, Goto19, Goto2, Goto20, Goto21, Goto22, Goto23, Goto24, Goto25, Goto26, Goto27, Goto28, Goto29, Goto3, Goto30, Goto31, Goto32, Goto33, Goto34, Goto35, Goto36, Goto37, Goto38, Goto39, Goto4, Goto40, Goto41, Goto5, Goto6, Goto7, Goto8, Goto9, emcp_op_mode, emcp_p_elec_des_W, emcp_p_eng_des_W, emcp_p_tot_W, Goto, Goto1, Goto10, Goto11, Goto12, Goto13, Goto14, Goto15, Goto16, Goto17, Goto18, Goto19, Goto2, Goto20, Goto21, Goto22, Goto23, Goto24, Goto25, Goto26, Goto27, Goto28, Goto29, Goto3, Goto4, Goto5,

BlockType	Count	Block Names
		Goto6, Goto7, Goto8, Goto9, Goto1, Goto2, Goto3, Goto4, Goto5, Goto6, Goto7, Goto8, Goto, Goto1, Goto10, Goto13, Goto14, Goto15, Goto16, Goto17, Goto18, Goto2, Goto3, Goto4, Goto5, Goto6, Goto7, Goto8, Goto9, SOC_percent, Target_SOC_percent, vmcp_EPU, vmcp_PSOC_charge_power_W, vmcp_PSOC_discharge_power_W, vmcp_contactor_request, vmcp_eng_ON_DC_threshold, vmcp_eng_optimal_ok, vmcp_engine_mode, vmcp_hybrid_ok, vmcp_inverter_request, vmcp_inverter_request1, vmcp_operating_mode, vmcp_target_SOC, vmcp_veh_running_status
Inport	90	param_bus_in, ptc_bus_in, driver_demand, gear_ratio_out, mot_trq_demand, vsc_control_variables_in, vsc_plant_variables_in, vscm_variables_out, EMCP_to_BMCP, RBCP_to_BMCP, VMCP_to_BMCP, to_BMCP, BMCP_to_EMCP, eng_max_trq, engine_speed_RPM, key_status, p_eng_des_W, key_status, p_elec_des_mod_W, tim_motor_max_trq, tim_motor_min_trq, tim_motor_speed_RPM, In1, In2, SOC, Target_SOC, SOC, driver_demand_W, ecm_max_power, engine_speed_RPM, target_SOC, veh_spd_MPS, EPU, EPU, ecm_cat_temp_C, ecm_max_eng_power_W, eng_on_first_time, p_eng_des_W, vehicle_speed_MPH, bmcp_soc, ecm_acc_pedal_demand, ecm_cat_temp_C, ecm_engine_speed_RPM, ecm_max_power_W, ecm_vehicle_speed_MPS, eng_on_first_time, p_eng_des_W, rbcp_brake_power_demand_W, target_SOC, tim_max_power_W, vmcp_op_mode, ecm_acc_pedal_demand, ecm_vehicle_speed_MPS, p_batt_actual_W, p_elec_des_W, RBCP_to_EMCP, PSOC_charge_power, PSOC_discharge_power, SOC, Target_SOC, PSOC_charge_power, PSOC_discharge_power, SOC, Target_SOC, VMCP_to_EMCP, to_EMCP, VSC_CONTROL_VARIABLES, VSC_PLANT_VARIABLES, from_BMCP, from_EMCP, from_RBCP, from_VMCP, BMCP_to_RBCP, EMCP_to_RBCP, VMCP_to_RBCP, to_RBCP, BMCP_to_VMCP, EMCP_to_VMCP, RBCP_to_VMCP, SOC, Target_SOC, SOC, Target_SOC, SOC, Target_SOC, CD_thresh, bmcp_SOC, to_VMCP, param_bus_in, ptc_bus_in
Constant	79	Constant, Constant1, Constant2, Constant3, ECM_max_wheel_torque, cst cumulated ratio from wh to mc, Constant1, Constant2, Constant3, Constant4, Constant5, p_eng_opt_table_SOC_offset, constant, eng_warm_up_torque_Nm, speed_reduction_enable, emcp_cat_cold_temp_C, emcp_eng_energy_warm_up_IC, eng_energy_total_restart, eng_energy_total_warm_up, eng_idle_power, percent_difference, t_eng_ramp_up, emcp_auxiliary_load_W, speed_reduction_enable1, speed_reduction_enable2, emcp_accel_ped_int_reset, emcp_battery_I_gain, emcp_battery_P_gain, emcp_integrator_reset_MPH, pi_override, Constant1, Constant2, Constant3, psoc_table_SOC_offset, emcp_eng_power_on_CD_threshold_percent, emcp_use_pre_warm_up, Constant2, Constant3, Eng_OFF_Pt_1, Eng_OFF_Pt_2, Eng_OFF_Pt_3, Eng_OFF_Pt_4, Eng_OFF_Pt_5, eng_OFF_table_SOC_offset, Constant2, Constant3, Eng_ON_Pt_1, Eng_ON_Pt_2, Eng_ON_Pt_3, Eng_ON_Pt_4, Eng_ON_Pt_5, eng_OFF_table_SOC_offset, emcp_eng_power_on_CD_threshold_percent, emcp_use_variable_eng_on_CD_threshold_percent, emcp_CD_SOC_threshold, emcp_CS_SOC_threshold, emcp_eng_power_off_CD_threshold, emcp_eng_power_off_CS_threshold, emcp_eng_power_on_CS_threshold, vmcp_CS_MPH_threshold_adaptive_HI, vmcp_CS_MPH_threshold_adaptive_LO, vmcp_EV_only, vmcp_FTO_ped_threshold, vmcp_PSOC_charge_power_init_W, vmcp_PSOC_discharge_power_init_W, vmcp_adaptive_SOC_offset, vmcp_eng_ON, vmcp_eng_demand_off_time_min, vmcp_eng_demand_time_min, vmcp_force_charge_sustaining, vmcp_soc_target, vmcp_t_cssew, vmcp_t_eng_off_max, vmcp_t_eng_on_min, vmcp_use_adaptive_SOC, vmcp_use_conventional_mode, vmcp_use_dynamic_CS, vmcp_use_engine_optimal, vmcp_use_key_on_eng_start
Outport	52	vsc_control_variables_in, vsc_plant_variables_in, brake_trq_command, brake_trq_out, info_dmd, BMCP_to_EMCP, BMCP_to_RBCP, BMCP_to_VMCP, from_BMCP, engine_trq_dmd, motor_trq_demand, Out1, P_eng_Opt_Modifier, emcp_peng_opt_W, emcp_peng_warm_W, ecm_max_eng_power_W_mod, emcp_cold_start_complete, emcp_pre_warm_up_complete, ecm_p_eng_max_W_mod, emcp_cold_start_complete, emcp_pdrv_W, emcp_peng_opt_W, emcp_peng_warm_W, emcp_pre_warm_up_complete, EMCP_to_BMCP, EMCP_to_RBCP, EMCP_to_VMCP, p_elec_des_mod, PSOC, PSOC_engine, Psoc, Psoc_engine, from_EMCP, TO_BMCP, TO_EMCP, TO_RBCP, TO_VMCP, vsc_propel_variables_out, RBCP_to_BMCP, RBCP_to_EMCP, RBCP_to_VMCP, from_RBCP, Eng_OFF_veh_speed, Eng_ON_veh_speed, eng_OFF_MPH, eng_ON_MPH, emcp_eng_ON_CD_percent, VMCP_to_BMCP, VMCP_to_EMCP, VMCP_to_RBCP, from_VMCP, demands
Gain	45	Gain, Gain1, Gain10, Gain11, Gain12, Gain13, Gain14, Gain15, Gain16, Gain17, Gain18, Gain19, Gain2, Gain20, Gain21, Gain22, Gain23, Gain25, Gain3, Gain4, Gain5, Gain6, Gain7, Gain8, Gain9, Gain, RPM_to_RPS, RPM_to_RPS1, Gain1, to percent1, MPS_2_MPH, RPM_to_RPS, RPM_to_RPS1, MPS_2_MPH, mps to MPH1, mps to MPH2, mps to MPH3, Gain, to percent, to percent1, mps to MPH, mps to MPH, to percent, to percent1, mps to MPH
Product	30	Divide1, Divide4, Divide5, Divide6, Divide8, Product10, Divide, Divide1, Divide2, Divide, Product, Divide1, Product, Divide1, Divide2, Multiply, Divide2, Divide3, Divide1, Divide2, Divide3, Product1, Product2, Product3, Product4, Product, Product1, Product, Product, Product1

BlockType	Count	Block Names
SubSystem	26	p_par_pre_tx_DES_dissertation_MATT, Input_Organizer_PSAT, Output_Organizer_PSAT, Foundation Brake Blending, UTK VSC StrategyPhase 2, Battery Mode Control Process, Energy Management Control Process, Calculate Engine Torque, Calculate Motor Torque, Driver Demanded Power, Calc_Engine_Optimal_Power, Comparator, Dynamic PSOC Table, Eng hot opt torq curve, Modify Max Engine Power, PI Controller for Battery, SOC Maintenance Power, Dynamic PSOC Table, Input_Organizer, Output_Organizer, Regenerative Braking Control Process, Vehicle Mode Control Process, Subsystem, Dynamic Vehicle Speed Engine OFF Calc, Dynamic Vehicle Speed Engine ON Calc, Subsystem1
Selector	25	drv_key_on_dmd_hist1, drv_trq_dmd_simu, eng_spd_simu, eng_spd_simu1, gb_ratio_simu, gb_ratio_simu10, gb_ratio_simu2, gb_ratio_simu3, gb_ratio_simu4, gb_ratio_simu5, gb_ratio_simu6, gb_ratio_simu7, gb_ratio_simu8, gb_ratio_simu9, ptc_mc_trq_max_pro_cstr_simu, ptc_mc_trq_max_pro_cstr_simu1, ptc_mc_trq_max_pro_cstr_simu2, ptc_mc_trq_max_pro_cstr_simu3, ptc_mc_trq_max_pro_cstr_simu4, ptc_mc_trq_max_reg_cstr_simu, ptc_mc_trq_max_reg_cstr_simu1, ptc_mc_trq_max_reg_cstr_simu2, ptc_mc_trq_max_reg_cstr_simu3, ptc_mc_trq_max_reg_cstr_simu4, ptc_sft_in_progress_trs_simu
Saturate	17	Saturation, Saturation1, Saturation4, Non-positive, Non-positive1, Saturation1, Saturation, Saturation1, Saturation, Saturation1, Saturation1, Saturation, Saturation1, Saturation2, Saturation3, Saturation4, Saturation1
BusSelector	17	Bus Selector, Bus Selector1, Bus Selector2, Bus Selector, Bus Selector1, Bus Selector, Bus Selector1, Bus Selector2, Bus Selector3, Bus Selector, Bus Selector1, Bus Selector, Bus Selector1, Bus Selector, Bus Selector, Bus Selector1, Bus Selector3
Sum	16	Subtract, Sum8, Add, Add, Add1, Sum, Total_pwr_mod, Sum, Subtract, Subtract1, Add, Add1, Add, Add1, Add, Add1
BusCreator	16	Bus Creator, Bus Creator1, Bus Creator, Bus Creator1, Bus Creator2, Bus Creator3, Bus Creator1, Bus Creator2, Bus Creator, Bus Creator1, Bus Creator2, Bus Creator3, Bus Creator, Bus Creator, Bus Creator1, Bus Creator2
Lookup	11	Lookup Table, Lookup Table1, Lookup Table2, bmcp_charge_multiplier_table, bmcp_discharge_multiplier_table, emcp_engine_lugging_modifier_table, enp_opt_reduction_table, ecm_max_eng_power_modifier, emcp_engine_lugging_PSOC_modifier_table, rbcp_regen_fadeout_table, Lookup Table1
Memory	10	mem_ptc_sft_in_progress_trs_simu, Memory, Memory2, Memory3, Memory4, Memory5, Memory, Memory1, Memory2, Memory1
Ground	10	Ground, Ground1, Ground2, Ground, Ground1, Ground, Ground1, Ground2, Ground3, Ground
Terminator	9	Terminator, Terminator, Terminator1, Terminator, Terminator, Terminator, Terminator1, Terminator2, Terminator
Concatenate	8	Matrix Concatenate, Matrix Concatenate1, Matrix Concatenate, Matrix Concatenate1, Matrix Concatenate, Matrix Concatenate1, Matrix Concatenate, Matrix Concatenate1
Switch	6	Switch1, Switch, Switch, Switch1, Switch, Switch
Logic	5	Logical Operator, Logical Operator, Logical Operator, Logical Operator1, Logical Operator
RelationalOperator	4	Relational Operator, Relational Operator, Relational Operator1, Relational Operator
Lookup Table Dynamic (m)	4	Dynamic Engine Optimal Power SOC Modifier Table, Dynamic PSOC Table, Dynamic Vehicle Speed Engine OFF Table, Dynamic Vehicle Speed Engine ON Table
Display	4	emcp_eng_max_trq, scope_engtrqdmd, scope_mctrqdmd, scope_whbkrqdmd
Stateflow (m)	3	Cold_Start_Logic_Chart, Energy Management Strategy, Vehicle Mode Control Process
Compare To Constant (m)	3	SIP_Active?, accel_threshold, veh_speed_threshold
Mux	2	Mux, mux_prop
Integrator	2	emcp_eng_energy_integrator, Integrator
Clock	2	Clock, Clock1

BlockType	Count	Block Names
Saturation Dynamic (m)	1	Saturation Dynamic
MinMax	1	MinMax
Fcn	1	Fcn
Demux	1	Demux
DataTypeConversion	1	Data Type Conversion

Table 203. Model Variables

Variable Name	Parent Blocks	Calling string	Value
dialog	drv_key_on_dmd_hist1	Index vector (dialog)	6.3400e+003
	drv_trq_dmd_simu	Index vector (dialog)	
	eng_spd_simu	Index vector (dialog)	
	eng_spd_simu1	Index vector (dialog)	
	gb_ratio_simu	Index vector (dialog)	
	gb_ratio_simu10	Index vector (dialog)	
	gb_ratio_simu2	Index vector (dialog)	
	gb_ratio_simu3	Index vector (dialog)	
	gb_ratio_simu4	Index vector (dialog)	
	gb_ratio_simu5	Index vector (dialog)	
	gb_ratio_simu6	Index vector (dialog)	
	gb_ratio_simu7	Index vector (dialog)	
	gb_ratio_simu8	Index vector (dialog)	
	gb_ratio_simu9	Index vector (dialog)	
	ptc_mc_trq_max_pro_cstr_simu	Index vector (dialog)	
	ptc_mc_trq_max_pro_cstr_simu1	Index vector (dialog)	
	ptc_mc_trq_max_pro_cstr_simu2	Index vector (dialog)	
	ptc_mc_trq_max_pro_cstr_simu3	Index vector (dialog)	
	ptc_mc_trq_max_pro_cstr_simu4	Index vector (dialog)	
	ptc_mc_trq_max_reg_cstr_simu	Index vector (dialog)	
	ptc_mc_trq_max_reg_cstr_simu1	Index vector (dialog)	
	ptc_mc_trq_max_reg_cstr_simu2	Index vector (dialog)	

Variable Name	Parent Blocks	Calling string	Value
	ptc_mc_trq_max_reg_cstr_simu3 ptc_mc_trq_max_reg_cstr_simu4 ptc_sft_in_progress_trs_simu	Index vector (dialog) Index vector (dialog)	
eng	Eng hot opt torq curve Eng hot opt torq curve	eng.calc.spd_hot_opt_trq_idx eng.calc.trq_hot_opt_map	list: [1x1 struct] init: [1x1 struct] scale: [1x1 struct] calc: [1x1 struct]
inf	Constant Constant Constant1 Constant1 Constant2 Constant2 Constant3 Constant3 ECM_max_wheel_torque ECM_max_wheel_torque Saturation4 Non-positive Non-positive1 cst cumulated ratio from wh to mc cst cumulated ratio from wh to mc Saturation1 Saturation Constant1 Constant1 Constant2 Constant2	inf inf inf inf inf inf inf inf inf inf inf -inf -inf inf inf inf inf inf inf inf inf inf	Inf

Variable Name	Parent Blocks	Calling string	Value
	Constant3	inf	
	Constant3	inf	
	Constant4	inf	
	Constant4	inf	
	Constant5	inf	
	Constant5	inf	
	p eng opt table SOC offset	inf	
	p eng opt table SOC offset	inf	
	Saturation1	inf	
	constant	inf	
	constant	inf	
	eng warm up torque Nm	inf	
	eng warm up torque Nm	inf	
	speed reduction enable	inf	
	speed reduction enable	inf	
	emcp cat cold temp C	inf	
	emcp cat cold temp C	inf	
	emcp eng energy warm up IC	inf	
	emcp eng energy warm up IC	inf	
	eng energy total restart	inf	
	eng energy total restart	inf	
	eng energy total warm up	inf	
	eng energy total warm up	inf	
	eng idle power	inf	
	eng idle power	inf	
	percent difference	inf	
	percent difference	inf	
	t eng ramp up	inf	
	t eng ramp up	inf	
		inf	
		inf	

Variable Name	Parent Blocks	Calling string	Value
	emcp_auxiliary_load_W	inf	
	emcp_auxiliary_load_W	inf	
	speed_reduction_enable1	inf	
	speed_reduction_enable1	inf	
	speed_reduction_enable2	inf	
	speed_reduction_enable2	inf	
	emcp_accel_ped_int_reset	inf	
	emcp_accel_ped_int_reset	inf	
	emcp_battery_I_gain	inf	
	emcp_battery_I_gain	inf	
	emcp_battery_P_gain	inf	
	emcp_battery_P_gain	inf	
	emcp_integrator_reset_MPH	inf	
	emcp_integrator_reset_MPH	inf	
	pi_override	inf	
	pi_override	inf	
	Constant1	inf	
	Constant1	inf	
	Constant2	inf	
	Constant2	inf	
	Constant3	inf	
	Constant3	inf	
	psoc_table_SOC_offset	inf	
	psoc_table_SOC_offset	inf	
	emcp_eng_power_on_CD_threshold_percent	inf	
	emcp_eng_power_on_CD_threshold_percent	inf	
	emcp_use_pre_warm_up	inf	
	emcp_use_pre_warm_up	inf	
	Constant2	inf	
		inf	
		inf	

Variable Name	Parent Blocks	Calling string	Value
	Constant2	inf	
	Constant3	inf	
	Constant3	inf	
	Eng_OFF_Pt_1	inf	
	Eng_OFF_Pt_1	inf	
	Eng_OFF_Pt_2	inf	
	Eng_OFF_Pt_2	inf	
	Eng_OFF_Pt_3	inf	
	Eng_OFF_Pt_3	inf	
	Eng_OFF_Pt_4	inf	
	Eng_OFF_Pt_4	inf	
	Eng_OFF_Pt_5	inf	
	Eng_OFF_Pt_5	inf	
	eng_OFF_table_SOC_offset	inf	
	eng_OFF_table_SOC_offset	inf	
	Constant2	inf	
	Constant2	inf	
	Constant3	inf	
	Constant3	inf	
	Eng_ON_Pt_1	inf	
	Eng_ON_Pt_1	inf	
	Eng_ON_Pt_2	inf	
	Eng_ON_Pt_2	inf	
	Eng_ON_Pt_3	inf	
	Eng_ON_Pt_3	inf	
	Eng_ON_Pt_4	inf	
	Eng_ON_Pt_4	inf	
	Eng_ON_Pt_5	inf	
	Eng_ON_Pt_5	inf	

Variable Name	Parent Blocks	Calling string	Value
	eng_OFF_table_SOC_offset	inf	
	eng_OFF_table_SOC_offset	inf	
	Saturation1	inf	
	emcp_eng_power_on_CD_threshold_percent	inf	
	emcp_eng_power_on_CD_threshold_percent	inf	
	emcp_use_variable_eng_on_CD_threshold_percent	inf	
	emcp_use_variable_eng_on_CD_threshold_percent	inf	
	emcp_CD_SOC_threshold	inf	
	emcp_CD_SOC_threshold	inf	
	emcp_CS_SOC_threshold	inf	
	emcp_CS_SOC_threshold	inf	
	emcp_eng_power_off_CD_threshold	inf	
	emcp_eng_power_off_CD_threshold	inf	
	emcp_eng_power_off_CS_threshold	inf	
	emcp_eng_power_off_CS_threshold	inf	
	emcp_eng_power_on_CS_threshold	inf	
	emcp_eng_power_on_CS_threshold	inf	
	vmcp_CS_MPH_threshold_adaptive_HI	inf	
	vmcp_CS_MPH_threshold_adaptive_HI	inf	
	vmcp_CS_MPH_threshold_adaptive_LO	inf	
	vmcp_CS_MPH_threshold_adaptive_LO	inf	
	vmcp_EV_only	inf	
	vmcp_EV_only	inf	
	vmcp_FTO_ped_threshold	inf	
	vmcp_FTO_ped_threshold	inf	
	vmcp_PSOC_charge_power_init_W	inf	
	vmcp_PSOC_charge_power_init_W	inf	
	vmcp_PSOC_discharge_power_init_W	inf	
	vmcp_PSOC_discharge_power_init_W	inf	
		inf	

Variable Name	Parent Blocks	Calling string	Value
	vmcp_adaptive_SOC_offset vmcp_adaptive_SOC_offset vmcp_eng_ON vmcp_eng_ON vmcp_eng_demand_off_time_min vmcp_eng_demand_off_time_min vmcp_eng_demand_time_min vmcp_eng_demand_time_min vmcp_force_charge_sustaining vmcp_force_charge_sustaining vmcp_soc_target vmcp_soc_target vmcp_t_cssew vmcp_t_cssew vmcp_t_eng_off_max vmcp_t_eng_off_max vmcp_t_eng_on_min vmcp_t_eng_on_min vmcp_use_adaptive_SOC vmcp_use_adaptive_SOC vmcp_use_conventional_mode vmcp_use_conventional_mode vmcp_use_dynamic_CS vmcp_use_dynamic_CS vmcp_use_engine_optimal vmcp_use_engine_optimal vmcp_use_key_on_eng_start vmcp_use_key_on_eng_start	inf inf inf inf inf inf inf inf inf inf inf inf inf inf inf inf inf inf inf	
mc	cst cumulated ratio from wh to mc	mc.calc.ratio_cum	list: [1x1 struct]

Variable Name	Parent Blocks	Calling string	Value
			init: [1x1 struct] scale: [1x1 struct] calc: [1x1 struct]
pi	Gain19 Gain22 Gain25 RPM_to_RPS RPM_to_RPS1 RPM_to_RPS RPM_to_RPS1	30/pi 30/pi 30/pi pi/30 pi/30 pi/30 pi/30	3.1416
ptc	bmcp_charge_multiplier_table bmcp_charge_multiplier_table bmcp_discharge_multiplier_table bmcp_discharge_multiplier_table p_eng_opt_table_SOC_offset eng_warm_up_torque_Nm ecm_max_eng_power_modifier emcp_cat_cold_temp_C emcp_eng_energy_integrator emcp_eng_energy_warm_up_IC eng_energy_total_restart eng_energy_total_warm_up percent_difference emcp_auxiliary_load_W emcp_battery_I_gain emcp_battery_P_gain emcp_integrator_reset_MPH psoc_table_SOC_offset	ptc.prop.init.bmcp_soc_index ptc.prop.init.bmcp_charge_power_multiplier ptc.prop.init.bmcp_soc_index ptc.prop.init.bmcp_discharge_power_multiplier ptc.prop.init.emcp_p_eng_opt_table_SOC_offset ptc.prop.init.emcp_eng_warm_up_trq_Nm [.25 .30 .35 .40 ptc.prop.init.emcp_eng_max_p_modifier] ptc.prop.init.emcp_eng_cat_cold_temp_C ptc.prop.init.emcp_eng_energy_warm_up_IC ptc.prop.init.emcp_eng_energy_warm_up_IC ptc.prop.init.emcp_eng_energy_total_restart ptc.prop.init.emcp_eng_energy_total_warm_up 1-ptc.prop.init.emcp_eng_max_p_modifier ptc.prop.init.emcp_auxiliary_load_W ptc.prop.init.emcp_battery_I_gain ptc.prop.init.emcp_battery_P_gain ptc.prop.init.emcp_integrator_reset_MPH ptc.prop.init.emcp_psoc_table_offset ptc.prop.init.emcp_eng_power_on_CD_threshold_percent	trs: [1x1 struct] prop: [1x1 struct] brake: [1x1 struct] shift: [1x1 struct]

Variable Name	Parent Blocks	Calling string	Value
	emcp_eng_power_on_CD_threshold_percent emcp_use_pre_warm_up rbcp_regen_fadeout_table rbcp_regen_fadeout_table Eng_OFF_Pt_1 Eng_OFF_Pt_2 Eng_OFF_Pt_3 Eng_OFF_Pt_4 Eng_OFF_Pt_5 eng_OFF_table_SOC_offset Eng_ON_Pt_1 Eng_ON_Pt_2 Eng_ON_Pt_3 Eng_ON_Pt_4 Eng_ON_Pt_5 eng_OFF_table_SOC_offset Lookup Table1 Lookup Table1 emcp_eng_power_on_CD_threshold_percent emcp_use_variable_eng_on_CD_threshold_percent emcp_CD_SOC_threshold emcp_CS_SOC_threshold emcp_eng_power_off_CD_threshold emcp_eng_power_off_CS_threshold emcp_eng_power_on_CS_threshold vmcp_CS_MPH_threshold_adaptive_HI vmcp_CS_MPH_threshold_adaptive_LO vmcp_EV_only vmcp_FTO_ped_threshold	ptc.prop.init.emcp_use_pre_warm_up ptc.prop.init.rbcp_max_regen_soc_index ptc.prop.init.rbcp_max_regen_percent ptc.prop.init.vmcp_eng_ON_PT_1 - ptc.prop.init.vmcp_eng_OFF_offset ptc.prop.init.vmcp_eng_ON_PT_2 - ptc.prop.init.vmcp_eng_OFF_offset ptc.prop.init.vmcp_eng_ON_PT_3 - ptc.prop.init.vmcp_eng_OFF_offset ptc.prop.init.vmcp_eng_ON_PT_4 - ptc.prop.init.vmcp_eng_OFF_offset ptc.prop.init.vmcp_eng_ON_PT_5 - ptc.prop.init.vmcp_eng_OFF_offset ptc.prop.init.emcp_psoc_table_offset ptc.prop.init.vmcp_eng_ON_PT_1 ptc.prop.init.vmcp_eng_ON_PT_2 ptc.prop.init.vmcp_eng_ON_PT_3 ptc.prop.init.vmcp_eng_ON_PT_4 ptc.prop.init.vmcp_eng_ON_PT_5 ptc.prop.init.emcp_psoc_table_offset [ptc.prop.init.vmcp_soc_target+ptc.prop.init.emcp_CS_SOC_threshold 0.9] [ptc.prop.init.emcp_eng_per_on_CD_LO ptc.prop.init.emcp_eng_per_on_CD_HI] ptc.prop.init.emcp_eng_power_on_CD_threshold_percent ptc.prop.init.emcp_use_variable_eng_on_CD_threshold_percent ptc.prop.init.vmcp_soc_target+ptc.prop.init.emcp_CD_SOC_threshold ptc.prop.init.vmcp_soc_target+ptc.prop.init.emcp_CS_SOC_threshold ptc.prop.init.emcp_eng_power_off_CD_threshold ptc.prop.init.emcp_eng_power_off_CS_threshold ptc.prop.init.emcp_eng_power_on_CS_threshold ptc.prop.init.vmcp_CS_MPH_threshold_adaptive_HI ptc.prop.init.vmcp_CS_MPH_threshold_adaptive_LO ptc.prop.init.vmcp_EV_only ptc.prop.init.vmcp_FTO_ped_threshold ptc.prop.init.vmcp_PSOC_charge_power_init_W ptc.prop.init.vmcp_PSOC_discharge_power_init_W	

Variable Name	Parent Blocks	Calling string	Value
	vmcp_PSOC_charge_power_init_W vmcp_PSOC_discharge_power_init_W vmcp_adaptive_SOC_offset vmcp_eng_ON vmcp_eng_demand_off_time_min vmcp_eng_demand_time_min vmcp_force_charge_sustaining vmcp_soc_target vmcp_t_cssew vmcp_t_eng_off_max vmcp_t_eng_on_min vmcp_use_adaptive_SOC vmcp_use_conventional_mode vmcp_use_dynamic_CS vmcp_use_engine_optimal vmcp_use_key_on_eng_start	ptc.prop.init.vmcp_adaptive_SOC_offset ptc.prop.init.vmcp_eng_ON ptc.prop.init.vmcp_eng_demand_off_time_min ptc.prop.init.vmcp_eng_demand_time_min ptc.prop.init.vmcp_force_charge_sustaining ptc.prop.init.vmcp_soc_target ptc.prop.init.vmcp_t_cssew ptc.prop.init.vmcp_t_eng_off_max ptc.prop.init.vmcp_t_eng_on_min ptc.prop.init.vmcp_use_adaptive_SOC ptc.prop.init.vmcp_use_conventional_mode ptc.prop.init.vmcp_use_dynamic_CS ptc.prop.init.vmcp_use_engine_optimal_mode ptc.prop.init.vmcp_use_key_on_engine_start	
wh	Gain21	wh.init.radius	list: [1x1 struct] init: [1x1 struct] calc: [1x1 struct]

Table 204. Model Functions

Function Name	Parent Blocks	Calling string
boolean	Relational Operator Logical Operator Logical Operator Logical Operator Logical Operator1 Logical Operator Relational Operator	boolean boolean boolean boolean boolean boolean boolean

Function Name	Parent Blocks	Calling string
double	Dynamic Engine Optimal Power SOC Modifier Table Data Type Conversion Dynamic PSOC Table Dynamic Vehicle Speed Engine OFF Table Dynamic Vehicle Speed Engine ON Table	float('double') double float('double') float('double') float('double')
input	Lookup Table Lookup Table1 Lookup Table2 Saturation Saturation1 Saturation4 Non-positive Non-positive1 Product10 Sum8 bmcp_charge_multiplier_table bmcp_discharge_multiplier_table Saturation1 Saturation Saturation1 emcp_engine_lugging_modifier_table enp_opt_reduction_table Saturation Saturation1 ecm_max_eng_power_modifier Saturation1 emcp_engine_lugging_PSOC_modifier_table rbcp_regen_fadeout_table Saturation Saturation1	Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as first input Inherit: Same as first input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input Inherit: Same as input

Function Name	Parent Blocks	Calling string
	Saturation2	Inherit: Same as input
	Saturation3	Inherit: Same as input
	Saturation4	Inherit: Same as input
	Lookup Table1	Inherit: Same as input
	Saturation1	

Table 205. Count: lib_p_par_pre_tx_DES_dissertation_MATT

<table>
<tr><th>Type</th><th>Count</th><th>Objects</th></tr>
<tr><td>Transition</td><td>183</td><td>[emcp_hybrid_ok], [!emcp_hybrid_ok], Transition1216, Transition1217, [vmcp_operating_mode == 50], [vmcp_operating_mode != 50], Transition1259, DefaultTransition1260, Transition1205, DefaultTransition1208, [Charge_Sustaining], Transition1210, [Engine_Only], Transition1212, [Full_Power], Transition1214, [Regen], Transition1219, Transition1220, [~bmcp_contactor_status || ~e..., DefaultTransition1377, [~ecm_key_status], [Charge_Sustaining], [!Charge_Sustaining], Transition1369, [ecm_SIP], [Full_Power_Active], [!Full_Power_Active], [!ecm_SIP], [Electric_Only], {eng_power_on_W = emcp_eng_po..., [!Electric_Only], [!vmcp_conventional_mode], [vmcp_conventional_mode], Transition1394, [Regen_Active], [!Regen_Active], {total_energy_temp = total_en..., {t_pre_warm_init = t;}, [EPU], [(ecm_brickcat1_temp_C > emcp..., [(warm_scale >=1) || (total_e..., Transition1059, [!EPU], [ecm_brickcat1_temp_C < emcp_..., DefaultTransition1173, [vmcp_pdrv_W >= bmcp_discharg..., Transition1175, [vmcp_pdrv_W <= bmcp_charge_p..., {emcp_p_elec_des_W = vmcp_pdr..., {emcp_p_elec_des_W = bmcp_dis..., {emcp_p_elec_des_W = bmcp_cha..., Transition1180, Transition1252, Transition1275, [vmcp_operating_mode == 60], {emcp_p_elec_des_W = 0;}, Transition1278, Transition1279, DefaultTransition1239, Transition1240, [Charge_Sustaining], Transition1170, DefaultTransition1253, [vmcp_pdrv_W >= ecm_max_eng_p..., {emcp_p_eng_des_W = ecm_max_e..., {emcp_p_eng_des_W = vmcp_pdrv..., DefaultTransition1280, {emcp_psoc_W = bmcp_psoc_W;}, [vmcp_operating_mode == 30], {emcp_psoc_W = 0;}, Transition1284, {t_cssew_temp = t;}, [(t>(t_cssew_temp+vmcp_t_csse..., [ecm_engine_running], [!vmcp_EPU_temp && (t>t_eng_o..., [vmcp_EPU_temp], DefaultTransition1395, Transition1396, [eng_on_first_time && emcp_co..., [t>t_eng_demand_temp], [~vmcp_EPU_temp], [t>t_eng_off_demand_temp], [vmcp_EPU_temp], [(t > t_eng_on_temp) && !vmcp..., [t >= t_EPD], Transition1417, [~tim_inverter_status], DefaultTransition1393, [ecm_key_status], DefaultTransition1376, [~ecm_key_status], [tim_inverter_status], [(t-t_contactor_fault)>20], [!vmcp_EPU], [vmcp_EPU && vmcp_use_adaptiv..., DefaultTransition1404, [vmcp_use_dynamic_CS && ......, [!vmcp_EPU && bmcp_soc < (emc..., DefaultTransition1047, [EPU], [!EPU], {t_ramp = t;}, [warm_scale>=1], DefaultTransition1181, [vmcp_pdrv_W >= tim_max_power_W], {emcp_p_drv_mod_W = vmcp_pdrv..., {emcp_p_drv_mod_W = vmcp_pdrv..., {emcp_p_elec_W = tim_max_powe..., Transition1189, {emcp_p_eng_des_W = emcp_p_dr..., Transition1198, [emcp_p_elec_W >= bmcp_discha..., [emcp_p_elec_W <= bmcp_charge..., {emcp_p_elec_des_W = bmcp_dis..., {emcp_p_elec_des_W = bmcp_cha..., Transition1203, {emcp_p_elec_des_W = emcp_p_e..., Transition1207, Transition1218, [vmcp_pdrv_W >= emcp_p_eng_ma..., {emcp_p_drv_mod_W = emcp_p_en..., {emcp_p_elec_W = vmcp_pdrv_W;}, [vmcp_operating_mode == 60], {emcp_p_eng_des_W = 0;}, {emcp_p_elec_des_W = 0;}, Transition1274, {emcp_p_elec_des_W = bmcp_dis..., {emcp_p_elec_W = emcp_p_drv_m..., Transition1187, {emcp_p_eng_des_W = emcp_p_dr..., Transition1191, Transition1192, Transition1193, [emcp_p_elec_W >= bmcp_discha..., {emcp_p_elec_des_W = bmcp_cha..., [emcp_p_elec_W <= bmcp_charge..., {emcp_p_elec_des_W = emcp_p_e..., DefaultTransition1221, [vmcp_pdrv_W >= emcp_p_eng_ma..., [vmcp_pdrv_W >= emcp_p_eng_ma..., {emcp_p_drv_mod_W = vmcp_pdrv..., {emcp_p_drv_mod_W = vmcp_pdrv..., {emcp_p_drv_mod_W = emcp_p_en..., {emcp_p_eng_des_W = emcp_p_en..., Transition1228, Transition1229, [emcp_ptot_W >= emcp_p_eng_ma..., Transition1231, {emcp_p_eng_des_W=emcp_p_eng_..., [emcp_ptot_W <= 0], {emcp_p_eng_des_W = emcp_ptot..., {emcp_p_eng_des_W = 0;}, Transition1236, Transition1243, [vmcp_eng_opt_ok && vmcp_eng_..., {emcp_p_eng_des_W = emcp_peng..., [emcp_p_drv_mod_W >= emcp_pen..., Transition1247, Transition1248, Transition1249, {emcp_p_eng_des_W=emcp_p_drv_..., Transition1251, [emcp_p_drv_mod_W >= emcp_p_e..., {emcp_p_eng_des_W=emcp_p_eng_..., Transition1263, Transition1264, [vmcp_operating_mode == 60], {emcp_p_eng_des_W = 0;}, {emcp_p_elec_des_W = 0;}, [emcp_p_drv_mod_W < 0], Transition1269, {emcp_p_eng_des_W = emcp_peng..., Transition1285, [!vmcp_eng_on_first_time && (..., {emcp_p_eng_des_W=emcp_peng_w..., Transition1288, [bmcp_contactor_status], DefaultTransition1408, [vmcp_force_charge_sustaining], Transition1411, DefaultTransition1412, [bmcp_soc <= emcp_CS_SOC_thre...</td></tr>
</table>

Type	Count	Objects
Data	128	vmcp_pdrv_W, bmcp_discharge_power_limit_W, bmcp_charge_power_limit_W, ecm_engine_speed_RPM, tim_motor_speed_RPM, vmcp_EPU, vmcp_operating_mode, vmcp_engine_mode, emcp_p_drv_mod_W, emcp_p_eng_des_W, emcp_ptot_W, emcp_ptot_temp_W, emcp_p_elec_des_W, emcp_p_elec_W, bmcp_psoc_W, emcp_psoc_W, Cruise_Charge, Engine_Only, Full_Power, Idle_Charge, emcp_p_elec_des, emcp_p_eng_max_W, emcp_p_eng_min_W, Normal, Regen, ecm_vehicle_speed_MPH, tim_max_power_W, Charge_Sustaining, emcp_peng_opt_W, emcp_hybrid_ok, emcp_mode, vmcp_eng_opt_ok, emcp_psoc_eng_W, emcp_ptot_eng_W, vmcp_eng_on_first_time, emcp_peng_warm_W, ecm_max_eng_power_W_unmod, emcp_use_pre_warm_up, ecm_SIP, ecm_key_status, emcp_ptot_W, ecm_engine_running, ecm_engine_speed_RPM, tim_inverter_status, bmcp_contactor_status, ecm_vehicle_speed_MPH, vmcp_EPU, vmcp_engine_mode, vmcp_operating_mode, vmcp_contactor_request, vmcp_inverter_request, ecm_acc_pedal_demand, ecm_brk_pedal_demand, bmcp_soc, Cruise_Charge_Available, Engine_Only_Active, Full_Power_Active, Regen_Active, Cruise_Charge_Active, vmcp_soc_target, vmcp_FTO_ped_threshold, t_cssew_temp, t_eng_off_demand_temp, vmcp_EPU_temp, vmcp_t_cssew, vmcp_t_eng_on_min, Electric_Only, vmcp_eng_ON, tim_max_power_W, Charge_Sustaining, eng_power_on_W, eng_power_off_W, emcp_eng_power_on_CD_threshold, emcp_eng_power_off_CD_threshold, emcp_eng_power_on_CS_threshold, emcp_eng_power_off_CS_threshold, emcp_CS_SOC_threshold, t_eng_off_temp, emcp_eng_power_on_CD_threshold_percent, eng_on_first_time, vmcp_eng_demand_time_min, t_eng_demand_temp, vmcp_eng_demand_off_min, vmcp_CS_speed_threshold_adaptive_HI, vmcp_CS_speed_threshold_adaptive_LO, vmcp_target_SOC_out, emcp_CD_SOC_threshold, vmcp_use_dynamic_CS, vmcp_t_eng_off_max, t_eng_on_temp, vmcp_veh_speed_eng_on_MPH, vmcp_veh_speed_eng_off_MPH, vmcp_use_adaptive_SOC, vmcp_adaptive_SOC_offset, t_contactor_fault, vmcp_force_charge_sustaining, vmcp_PSOC_charge_power_W, vmcp_PSOC_discharge_power_W, vmcp_EV_only, veh_running_status, vmcp_hybrid_ok, PSOC_charge_power_W, PSOC_discharge_power_W, cpl_clutch_fb, vmcp_conventional_mode, t_EPD, vmcp_use_eng_opt, vmcp_eng_opt_ok, vmcp_use_key_on_eng_start, emcp_cold_start_complete, eng_on_first_time, total_energy_init, t_warm_up, t_init_warm_up, warm_scale, ecm_max_avail, t_ramp, EPU, t_eng_start_ramp, emcp_cold_start_complete, total_energy_temp, total_energy_restart, ecm_brickcat1_temp_C, emcp_cat_cold_temp_C, eng_energy_used, t_pre_warm_init, emcp_pre_warm_up_complete, int_reset
Junction	84	Junction1093, Junction1362, Junction1045, Junction1094, Junction1095, Junction1096, Junction1097, Junction1098, Junction1099, Junction1144, Junction1159, Junction1160, Junction1161, Junction1162, Junction1135, Junction1145, Junction1146, Junction1147, Junction1148, Junction1163, Junction1164, Junction1165, Junction1166, Junction1364, Junction1365, Junction1366, Junction1046, Junction1100, Junction1101, Junction1103, Junction1107, Junction1109, Junction1112, Junction1113, Junction1114, Junction1115, Junction1116, Junction1117, Junction1119, Junction1120, Junction1134, Junction1136, Junction1156, Junction1157, Junction1158, Junction1102, Junction1104, Junction1105, Junction1106, Junction1108, Junction1110, Junction1111, Junction1118, Junction1121, Junction1122, Junction1123, Junction1124, Junction1125, Junction1126, Junction1127, Junction1128, Junction1129, Junction1130, Junction1131, Junction1132, Junction1133, Junction1137, Junction1138, Junction1139, Junction1140, Junction1141, Junction1142, Junction1143, Junction1149, Junction1150, Junction1151, Junction1152, Junction1153, Junction1154, Junction1155, Junction1167, Junction1168, Junction1169, Junction1363
State	55	EMCP, VMCP, Energy_Management_Blending, SOC_Maintenance, Subsystem_Status, Vehicle_Operating_Mode, eng_max_power_mod, Electric_Mode, Hybrid_Mode, Conventional_Mode, Charge_Sustaining_Mode, Engine_Only_Active, Full_Power_Active, Regen_Active, Electric_Mode_Active, Vehicle_Running, Vehicle_Shutdown, Vehicle_Startup, Charge_Sustaining_Mode, Engine_On_Active, Full_Power_Active, Electric_Mode, Conventional_Active, SIP_Active, Regen_Active, eng_warming_up, eng_cold, Wait_for_Eng_off, eng_warm, Catalyst_Cold, Charge_Depleting_Mode, Charge_Sustaining_Mode, Cold_Start_Engine_Warmup, Engine_Warm, Engine_Idle_Off, Eng_On_Demand, Eng_Off_Demand, Controlled_EPD, Start_Engine, Initialize_HV_Battery, Shutdown_Traction_Inverter_Module, Key_Off, Initialize_Electric_Drive, Contactor_Fault, Inverter_Fault, Adaptive_Target_SOC, Fixed_Target_SOC, Dynamic_CS_Algorithm, Eng_Off, Eng_Running, Eng_Start, Initialize_HV_Battery, Initialize_Traction_Inverter_Module, Force_Charge_Sustain, Normal
Chart	3	Energy Management Strategy, Vehicle Mode Control Process, Cold_Start_Logic_Chart
Target	1	sfun
Machine	1	lib_p_par_pre_tx_DES_dissertation_MATT

Table 206. Data Properties

Name	Parent	Data Type

Name	Parent	Data Type
vmcp_pdrv_W	Energy Management Strategy	Inherit: Same as Simulink
bmcp_discharge_power_limit_W	Energy Management Strategy	Inherit: Same as Simulink
bmcp_charge_power_limit_W	Energy Management Strategy	Inherit: Same as Simulink
ecm_engine_speed_RPM	Energy Management Strategy	Inherit: Same as Simulink
tim_motor_speed_RPM	Energy Management Strategy	Inherit: Same as Simulink
vmcp_EPU	Energy Management Strategy	Inherit: Same as Simulink
vmcp_operating_mode	Energy Management Strategy	Inherit: Same as Simulink
vmcp_engine_mode	Energy Management Strategy	double
emcp_p_drv_mod_W	Energy Management Strategy	double
emcp_p_eng_des_W	Energy Management Strategy	double
emcp_ptot_W	Energy Management Strategy	double
emcp_ptot_temp_W	Energy Management Strategy	double
emcp_p_elec_des_W	Energy Management Strategy	double
emcp_p_elec_W	Energy Management Strategy	double
bmcp_psoc_W	Energy Management Strategy	Inherit: Same as Simulink
emcp_psoc_W	Energy Management Strategy	double
Cruise_Charge	Energy Management Strategy	double
Engine_Only	Energy Management Strategy	double
Full_Power	Energy Management Strategy	double
Idle_Charge	Energy Management Strategy	double
emcp_p_elec_des	Energy Management Strategy	double
emcp_p_eng_max_W	Energy Management Strategy	double
emcp_p_eng_min_W	Energy Management Strategy	double
Normal	Energy Management Strategy	double
Regen	Energy Management Strategy	double
ecm_vehicle_speed_MPH	Energy Management Strategy	Inherit: Same as Simulink
tim_max_power_W	Energy Management Strategy	Inherit: Same as Simulink
Charge_Sustaining	Energy Management Strategy	double
emcp_peng_opt_W	Energy Management Strategy	Inherit: Same as Simulink
emcp_hybrid_ok	Energy Management Strategy	Inherit: Same as Simulink
emcp_mode	Energy Management Strategy	double
vmcp_eng_opt_ok	Energy Management Strategy	Inherit: Same as Simulink
emcp_psoc_eng_W	Energy Management Strategy	Inherit: Same as Simulink
emcp_ptot_eng_W	Energy Management Strategy	double

Name	Parent	Data Type
vmcp_eng_on_first_time	Energy Management Strategy	Inherit: Same as Simulink
emcp_peng_warm_W	Energy Management Strategy	Inherit: Same as Simulink
ecm_max_eng_power_W_unmod	Energy Management Strategy	Inherit: Same as Simulink
emcp_use_pre_warm_up	Energy Management Strategy	Inherit: Same as Simulink
ecm_SIP	Vehicle Mode Control Process	Inherit: Same as Simulink
ecm_key_status	Vehicle Mode Control Process	Inherit: Same as Simulink
emcp_ptot_W	Vehicle Mode Control Process	Inherit: Same as Simulink
ecm_engine_running	Vehicle Mode Control Process	Inherit: Same as Simulink
ecm_engine_speed_RPM	Vehicle Mode Control Process	Inherit: Same as Simulink
tim_inverter_status	Vehicle Mode Control Process	Inherit: Same as Simulink
bmcp_contactor_status	Vehicle Mode Control Process	Inherit: Same as Simulink
ecm_vehicle_speed_MPH	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_EPU	Vehicle Mode Control Process	double
vmcp_engine_mode	Vehicle Mode Control Process	double
vmcp_operating_mode	Vehicle Mode Control Process	double
vmcp_contactor_request	Vehicle Mode Control Process	double
vmcp_inverter_request	Vehicle Mode Control Process	double
ecm_acc_pedal_demand	Vehicle Mode Control Process	Inherit: Same as Simulink
ecm_brk_pedal_demand	Vehicle Mode Control Process	double
bmcp_soc	Vehicle Mode Control Process	Inherit: Same as Simulink
Cruise_Charge_Available	Vehicle Mode Control Process	double
Engine_Only_Active	Vehicle Mode Control Process	double
Full_Power_Active	Vehicle Mode Control Process	double
Regen_Active	Vehicle Mode Control Process	double
Cruise_Charge_Active	Vehicle Mode Control Process	double
vmcp_soc_target	Vehicle Mode Control Process	double
vmcp_FTO_ped_threshold	Vehicle Mode Control Process	double
t_cssew_temp	Vehicle Mode Control Process	double
t_eng_off_demand_temp	Vehicle Mode Control Process	double
vmcp_EPU_temp	Vehicle Mode Control Process	double
vmcp_t_cssew	Vehicle Mode Control Process	double
vmcp_t_eng_on_min	Vehicle Mode Control Process	double
Electric_Only	Vehicle Mode Control Process	double
vmcp_eng_ON	Vehicle Mode Control Process	double

Name	Parent	Data Type
tim_max_power_W	Vehicle Mode Control Process	Inherit: Same as Simulink
Charge_Sustaining	Vehicle Mode Control Process	double
eng_power_on_W	Vehicle Mode Control Process	double
eng_power_off_W	Vehicle Mode Control Process	double
emcp_eng_power_on_CD_threshold	Vehicle Mode Control Process	double
emcp_eng_power_off_CD_threshold	Vehicle Mode Control Process	double
emcp_eng_power_on_CS_threshold	Vehicle Mode Control Process	double
emcp_eng_power_off_CS_threshold	Vehicle Mode Control Process	double
emcp_CS_SOC_threshold	Vehicle Mode Control Process	double
t_eng_off_temp	Vehicle Mode Control Process	double
emcp_eng_power_on_CD_threshold_percent	Vehicle Mode Control Process	Inherit: Same as Simulink
eng_on_first_time	Vehicle Mode Control Process	double
vmcp_eng_demand_time_min	Vehicle Mode Control Process	Inherit: Same as Simulink
t_eng_demand_temp	Vehicle Mode Control Process	double
vmcp_eng_demand_off_min	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_CS_speed_threshold_adaptive_HI	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_CS_speed_threshold_adaptive_LO	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_target_SOC_out	Vehicle Mode Control Process	double
emcp_CD_SOC_threshold	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_use_dynamic_CS	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_t_eng_off_max	Vehicle Mode Control Process	Inherit: Same as Simulink
t_eng_on_temp	Vehicle Mode Control Process	double
vmcp_veh_speed_eng_on_MPH	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_veh_speed_eng_off_MPH	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_use_adaptive_SOC	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_adaptive_SOC_offset	Vehicle Mode Control Process	Inherit: Same as Simulink
t_contactor_fault	Vehicle Mode Control Process	double
vmcp_force_charge_sustaining	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_PSOC_charge_power_W	Vehicle Mode Control Process	double
vmcp_PSOC_discharge_power_W	Vehicle Mode Control Process	double
vmcp_EV_only	Vehicle Mode Control Process	Inherit: Same as Simulink
veh_running_status	Vehicle Mode Control Process	double
vmcp_hybrid_ok	Vehicle Mode Control Process	double
PSOC_charge_power_W	Vehicle Mode Control Process	Inherit: Same as Simulink

Name	Parent	Data Type
PSOC_discharge_power_W	Vehicle Mode Control Process	Inherit: Same as Simulink
cpl_clutch_fb	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_conventional_mode	Vehicle Mode Control Process	Inherit: Same as Simulink
t_EPD	Vehicle Mode Control Process	double
vmcp_use_eng_opt	Vehicle Mode Control Process	Inherit: Same as Simulink
vmcp_eng_opt_ok	Vehicle Mode Control Process	double
vmcp_use_key_on_eng_start	Vehicle Mode Control Process	Inherit: Same as Simulink
emcp_cold_start_complete	Vehicle Mode Control Process	Inherit: Same as Simulink
eng_on_first_time	Cold_Start_Logic_Chart	Inherit: Same as Simulink
total_energy_init	Cold_Start_Logic_Chart	Inherit: Same as Simulink
t_warm_up	Cold_Start_Logic_Chart	double
t_init_warm_up	Cold_Start_Logic_Chart	double
warm_scale	Cold_Start_Logic_Chart	double
ecm_max_avail	Cold_Start_Logic_Chart	double
t_ramp	Cold_Start_Logic_Chart	double
EPU	Cold_Start_Logic_Chart	Inherit: Same as Simulink
t_eng_start_ramp	Cold_Start_Logic_Chart	Inherit: Same as Simulink
emcp_cold_start_complete	Cold_Start_Logic_Chart	double
total_energy_temp	Cold_Start_Logic_Chart	double
total_energy_restart	Cold_Start_Logic_Chart	Inherit: Same as Simulink
ecm_brickcat1_temp_C	Cold_Start_Logic_Chart	Inherit: Same as Simulink
emcp_cat_cold_temp_C	Cold_Start_Logic_Chart	Inherit: Same as Simulink
eng_energy_used	Cold_Start_Logic_Chart	Inherit: Same as Simulink
t_pre_warm_init	Cold_Start_Logic_Chart	double
emcp_pre_warm_up_complete	Cold_Start_Logic_Chart	double
int_reset	Cold_Start_Logic_Chart	double

Target	**lib_p_par_pre_tx_DES_dissertation_MATT/sfun**
Description	Default Simulink S-Function Target.

Appendix B: PSAT Model Initialization Files

Initialization file for PSAT MATT complete vehicle model

```
% \gui_par_ANL_Ford_Focus_Dissertation_Phase2_Automatic_dynoABC_in.m PSAT
V6.2  input file created: 2/20/2009 10:26 AM
% simulate a par_2wd_p2_au vehicle

global simulation

simulation.vehicle.name='gui_par_ANL_Ford_Focus_Dissertation_Phase2_Automatic_d
ynoABC_in';
simulation.vehicle.type='Light';
simulation.building.name = 'par_2wd_p2_au';
simulation.building.pos2 = '';
simulation.building.pos1 = 'Pre-transmission';
simulation.building.trans = 'au';
simulation.building.axle = '2 wheel drive';
simulation.building.pwt = 'Parallel Hybrid';
simulation.building.name_compo={...
'drv';...
'str';...
'accmech';...
'cpl';...
'ess';...
'mc';...
'gb';...
'fd';...
'wh';...
'veh';...
'ex';...
'pc_accelec';...
'accelec';...
'eng'};

simulation.building.pos_compo={...
[-2,1]',{[],{},{}};...
[1,1]',{'eng',{[2 2]},{[3 3]}};...
[1,3]',{'cpl',{[2 2]},{[3 3]}};...
[1,4]',{'gb',{[2 2]},{[3 3]}};...
[2,3]',{...
'mc',{[2 2]},{[3 3]};...
```

```
'pc_accelec',{[2 2]},{[3 3]}};...
[2,4]',{'gb',{[2 2]},{[3 3]}};...
[1,5]',{'fd',{[2 2]},{[3 3]}};...
[1,6]',{'wh',{[2 2]},{[3 3]}};...
[1,7]',{'veh',{[2 2]},{[3 3]}};...
[1,8]',{'.',{[2 2]},{[3 3]}};...
[-1,1]',{[],{},{}};...
[3,4]',{'accelec',{[2 2]},{[3 3]}};...
[3,5]',{'.',{[0 0]},{[0 0]}};...
[1,2]',{'accmech',{[2 2]},{[3 3]}}};

% Load the Components
simulation.drivetrain.drv.model = 'drv_engine_gear_f0f1f2';
simulation.drivetrain.drv.technology = '';
simulation.drivetrain.drv.init = 'drv_normal_1000_05';
simulation.drivetrain.drv.param_var = [];
simulation.drivetrain.drv.scale = '';
simulation.drivetrain.drv.calc = {''};
simulation.drivetrain.drv.variables.name = {};
simulation.drivetrain.drv.variables.extension = {};

simulation.drivetrain.str.model = 'str_map';
simulation.drivetrain.str.technology = '';
simulation.drivetrain.str.init = 'str_2_10';
simulation.drivetrain.str.param_var = [];
simulation.drivetrain.str.trs.model = 'lib_trs_str';
simulation.drivetrain.str.trs.init = '';
simulation.drivetrain.str.scale = '';
simulation.drivetrain.str.calc = {''};
simulation.drivetrain.str.variables.name = {...
'str_trq_out';...
'str_spd_out';...
'str_cmd';...
'str_curr_in'};
simulation.drivetrain.str.variables.extension = {...
'simu';'simu';'simu';'simu'};

simulation.drivetrain.accmech.model = 'accmech_constant_pwrloss_trq_in';
simulation.drivetrain.accmech.technology = '';
simulation.drivetrain.accmech.init = 'accmech_0';
simulation.drivetrain.accmech.param_var = [];
simulation.drivetrain.accmech.scale = '';
```

```
simulation.drivetrain.accmech.calc = {''};
simulation.drivetrain.accmech.variables.name = {...
'accmech_pwr';...
'accmech_trq_out';...
'accmech_spd_out';...
'accmech_trq_in';...
'accmech_spd_in';...
'accmech_trq'};
simulation.drivetrain.accmech.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu'};

simulation.drivetrain.cpl.model = 'cpl_clutch_map';
simulation.drivetrain.cpl.technology = '';
simulation.drivetrain.cpl.init = 'clutch_1';
simulation.drivetrain.cpl.param_var = [];
simulation.drivetrain.cpl.scale = '';
simulation.drivetrain.cpl.calc = {''};
simulation.drivetrain.cpl.variables.name = {...
'cpl_slip_spd';...
'cpl_lock';...
'cpl_inertia_out';...
'cpl_spd_out';...
'cpl_trq_out';...
'cpl_inertia_in';...
'cpl_cmd';...
'cpl_trq_in';...
'cpl_spd_in'};
simulation.drivetrain.cpl.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu'};

simulation.drivetrain.ess.model = 'ess_pngv_map_anl_PI_cstr';
simulation.drivetrain.ess.technology = 'liion';
simulation.drivetrain.ess.init = 'ess_li_41_54_PNGVanl_SaftVL41M_PI_cstr';
simulation.drivetrain.ess.param_var(1).name = 'ess.init.soc_init';
simulation.drivetrain.ess.param_var(1).value = 0.296;
simulation.drivetrain.ess.scale = 'ess_cap_erg2pwr_ratio_s_lin';
simulation.drivetrain.ess.scale_var(1).name = 'ess.scale.pwr_max_des';
simulation.drivetrain.ess.scale_var(1).value = 1220;
simulation.drivetrain.ess.calc = {'ess_calculation'};
simulation.drivetrain.ess.variables.name = {...
'ess_curr_pol2';...
'ess_curr_pol1';...
```

```
'ess_rpol2';...
'ess_rpol1';...
'ess_volt_out';...
'ess_curr_out';...
'ess_rint';...
'ess_voc';...
'ess_soc'};
simulation.drivetrain.ess.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu'};

simulation.drivetrain.mc.model = 'mc_map_Pelec_funTW_volt_in';
simulation.drivetrain.mc.technology = 'pm';
simulation.drivetrain.mc.init = 'mc_pm_30_75_UQM_intets';
simulation.drivetrain.mc.param_var(1).name = 'mc.init.coeff_regen';
simulation.drivetrain.mc.param_var(1).value = 0.5;
simulation.drivetrain.mc.trs.model = 'lib_trs_mc_nostr_sip';
simulation.drivetrain.mc.trs.init = '';
simulation.drivetrain.mc.scale = 'mc_s';
simulation.drivetrain.mc.scale_var(1).name = 'mc.scale.eff_max_des';
simulation.drivetrain.mc.scale_var(1).value = 0.88;
simulation.drivetrain.mc.calc = {...
'mc_pre_calculation';...
'mc_calculation'};
simulation.drivetrain.mc.variables.name = {...
'mc_temp_coeff';...
'mc_cmd';...
'mc_trq_out';...
'mc_volt_in';...
'mc_curr_in';...
'mc_spd_out'};
simulation.drivetrain.mc.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu'};

simulation.drivetrain.gb.model = 'gb_automatic_map_trqloss_funTWratio';
simulation.drivetrain.gb.technology = '';
simulation.drivetrain.gb.init = 'gb_5_au_322_241_155_1_075';
simulation.drivetrain.gb.param_var = [];
simulation.drivetrain.gb.trs.model = 'lib_trs_tx_au_par_p2';
simulation.drivetrain.gb.trs.init = 'trs_tx_cpl';
simulation.drivetrain.gb.trs.param_var(1).name='ptc.trs.tx.init.gb_t_shift';
simulation.drivetrain.gb.trs.param_var(1).value=0.1;
simulation.drivetrain.gb.scale = '';
```

```
simulation.drivetrain.gb.calc = {''};
simulation.drivetrain.gb.variables.name = {...
'gb_sft_in_progress';...
'gb_gear';...
'gb_ratio';...
'gb_inertia_in';...
'gb_inertia_out';...
'gb_trq_in';...
'gb_trq_out';...
'gb_spd_in';...
'gb_spd_out'};
simulation.drivetrain.gb.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu'};

simulation.drivetrain.fd.model = 'fd_map_trqloss_funTW';
simulation.drivetrain.fd.technology = '';
simulation.drivetrain.fd.init = 'fd_355_4WD_explorer';
simulation.drivetrain.fd.param_var = [];
simulation.drivetrain.fd.scale = '';
simulation.drivetrain.fd.calc = {''};
simulation.drivetrain.fd.variables.name = {...
'fd_inertia_in';...
'fd_inertia_out';...
'fd_trq_in';...
'fd_trq_out';...
'fd_spd_in';...
'fd_spd_out'};
simulation.drivetrain.fd.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu'};

simulation.drivetrain.wh.model = 'wh_2wd_f0f1f2';
simulation.drivetrain.wh.technology = '';
simulation.drivetrain.wh.init = 'wh_03175_P195_60_R15';
simulation.drivetrain.wh.param_var = [];
simulation.drivetrain.wh.trs.model = 'lib_trs_wh';
simulation.drivetrain.wh.trs.init = '';
simulation.drivetrain.wh.scale = '';
simulation.drivetrain.wh.calc = {...
'wh_calculation';...
'wh_calculation'};
simulation.drivetrain.wh.variables.name = {...
'wh_mass_out';...
```

```
'wh_inertia_in';...
'wh_trq_brake';...
'wh_trq_in';...
'wh_trq_out';...
'wh_spd_out';...
'wh_spd_in';...
'wh_cmd_brake'};
simulation.drivetrain.wh.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu'};

simulation.drivetrain.veh.model = 'veh_curve_fit_losses_f0f1f2';
simulation.drivetrain.veh.technology = '';
simulation.drivetrain.veh.init = 'veh_800_f0f1f2_ford_focus';
simulation.drivetrain.veh.param_var(1).name = 'veh.init.f0';
simulation.drivetrain.veh.param_var(1).value = 145;
simulation.drivetrain.veh.param_var(2).name = 'veh.init.f1';
simulation.drivetrain.veh.param_var(2).value = 7;
simulation.drivetrain.veh.param_var(3).name = 'veh.init.f2';
simulation.drivetrain.veh.param_var(3).value = 0.6;
simulation.drivetrain.veh.scale = '';
simulation.drivetrain.veh.calc = {''};
simulation.drivetrain.veh.variables.name = {...
'veh_lin_spd_out';...
'veh_mass_static';...
'veh_force_in';...
'veh_force_grade';...
'veh_force_loss';...
'veh_lin_accel';...
'veh_mass';...
'veh_grade'};
simulation.drivetrain.veh.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu'};

simulation.drivetrain.ex.model = 'ex_3way_cat_map';
simulation.drivetrain.ex.technology = '3c';
simulation.drivetrain.ex.init = 'ex_3c';
simulation.drivetrain.ex.param_var = [];
simulation.drivetrain.ex.scale = '';
simulation.drivetrain.ex.calc = {'ex_calculation'};
simulation.drivetrain.ex.variables.name = {...
'ex_hc';...
'ex_co';...
```

```
'ex_nox';...
'ex_pm';...
'ex_temp';...
'ex_co2'};
simulation.drivetrain.ex.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu'};

simulation.drivetrain.pc_accelec.model = 'pc_accelec_V2V_constant_eff';
simulation.drivetrain.pc_accelec.technology = '';
simulation.drivetrain.pc_accelec.init = 'pc_090_12';
simulation.drivetrain.pc_accelec.param_var = [];
simulation.drivetrain.pc_accelec.scale = '';
simulation.drivetrain.pc_accelec.calc = {''};
simulation.drivetrain.pc_accelec.variables.name = {...
'pc_accelec_volt_out';...
'pc_accelec_volt_in';...
'pc_accelec_curr_in';...
'pc_accelec_curr_out'};
simulation.drivetrain.pc_accelec.variables.extension = {...
'simu';'simu';'simu';'simu'};

simulation.drivetrain.accelec.model = 'accelec_constant_pwrloss_volt_in';
simulation.drivetrain.accelec.technology = '';
simulation.drivetrain.accelec.init = 'accelec_600';
simulation.drivetrain.accelec.param_var = [];
simulation.drivetrain.accelec.scale = '';
simulation.drivetrain.accelec.calc = {''};
simulation.drivetrain.accelec.variables.name = {...
'accelec_pwr';...
'accelec_volt_out';...
'accelec_curr_out';...
'accelec_curr_in';...
'accelec_curr';...
'accelec_volt_in'};
simulation.drivetrain.accelec.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu'};

simulation.drivetrain.eng.model = 'eng_map_hot';
simulation.drivetrain.eng.technology = 'si';
simulation.drivetrain.eng.init = 'eng_si_2800_123_LK5';
simulation.drivetrain.eng.param_var = [];
simulation.drivetrain.eng.trs.model = 'lib_trs_eng_au';
```

```
simulation.drivetrain.eng.trs.init = 'trs_eng_au';
simulation.drivetrain.eng.scale = 'eng_s_lin';
simulation.drivetrain.eng.scale_var(1).name = 'eng.scale.eff_max_des';
simulation.drivetrain.eng.scale_var(1).value = 0.37;
simulation.drivetrain.eng.calc = {...
'eng_calculation';...
'eng_calculation_SAAB'};
simulation.drivetrain.eng.variables.name = {...
'eng_on';...
'eng_cmd';...
'eng_stat';...
'eng_hc';...
'eng_co';...
'eng_nox';...
'eng_pm';...
'eng_o2';...
'eng_ex_gas_flow';...
'eng_ex_equiv';...
'eng_fuel_rate';...
'eng_fuel_cum';...
'eng_htrej_rate';...
'eng_htrej_cum';...
'eng_exterior_temp';...
'eng_temp_coeff';...
'eng_ex_gas_temp';...
'eng_spd_out';...
'eng_trq_out'};
simulation.drivetrain.eng.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'si
mu';'simu';'simu';'simu';'simu';'simu'};


%------------------------------
% Controller
% Strategy

simulation.controller.strategy.prop.model = 'p_par_pre_tx_DES_dissertation_MATT';
simulation.controller.strategy.prop.init = 'p_par_pre_tx_DES_dissertation_MATT';
simulation.controller.strategy.prop.param_var(1).name =
'ptc.prop.init.emcp_eng_per_on_CD_LO';
simulation.controller.strategy.prop.param_var(1).value = 0.5;
```

```
simulation.controller.strategy.prop.param_var(2).name =
'ptc.prop.init.emcp_eng_per_on_CD_HI';
simulation.controller.strategy.prop.param_var(2).value = 0.2;
simulation.controller.strategy.prop.param_var(3).name =
'ptc.prop.init.emcp_eng_power_off_CS_threshold';
simulation.controller.strategy.prop.param_var(3).value = 5000;
simulation.controller.strategy.prop.param_var(4).name =
'ptc.prop.init.vmcp_t_eng_off_max';
simulation.controller.strategy.prop.param_var(4).value = 1500;
simulation.controller.strategy.prop.param_var(5).name =
'ptc.prop.init.vmcp_use_engine_optimal_mode';
simulation.controller.strategy.prop.param_var(5).value = 0;
simulation.controller.strategy.prop.param_var(6).name =
'ptc.prop.init.vmcp_eng_OFF_offset';
simulation.controller.strategy.prop.param_var(6).value = 20;
simulation.controller.strategy.shift.model = 's_stf_au_eng_veh_spd_accel_pedal';
simulation.controller.strategy.shift.init = 'tx_stf_shift_n_gen_eng';
simulation.controller.strategy.shift.param_var(1).name =
'ptc.shift.init.eng_spd_upshift_highest_gear';
simulation.controller.strategy.shift.param_var(1).value = 283.318;
simulation.controller.strategy.shift.param_var(2).name =
'ptc.shift.init.min_time_for_shift_dmd';
simulation.controller.strategy.shift.param_var(2).value = 0.3;

simulation.drivetrain.ptc.variables.name = {...
'drv_lin_spd_dmd';'drv_trq_dmd';'drv_key_on_dmd';...
'ptc_str_trs';...
'ptc_ess_curr_mx_reg_cstr';'ptc_ess_curr_mx_pro_cstr';'ptc_ess_pwr_mx_reg_cstr';'ptc
_ess_pwr_mx_pro_cstr';...
'ptc_mc_temp_coeff_cstr';'ptc_mc_trq_cont_reg_cstr';'ptc_mc_trq_cont_pro_cstr';'ptc
_mc_trq_pk_reg_cstr';'ptc_mc_trq_mx_reg_cstr';'ptc_mc_trq_mx_pro_cstr';'ptc_mc_tr
q_pk_pro_cstr';'ptc_mc_trq_trs';'ptc_mc_trq_dmd';...
'ptc_gb_sft_in_progress_trs';'ptc_gb_gear_trs';'ptc_cpl_trs';'ptc_gb_gear_dmd';...
'ptc_wh_trq_brake_dmd';...
'ptc_eng_trq_hot_mn_cstr';'ptc_eng_trq_hot_mx_cstr';'ptc_eng_on_trs';'ptc_eng_trq_t
rs';'ptc_eng_trq_dmd';'ptc_eng_on_dmd'};
simulation.drivetrain.ptc.variables.extension = {...
'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'si
mu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu';'simu
';'simu'};
```

Initialization file for powertrain controller model

```
%% File description
% Name : p_par_pre_tx_DES_dissertation_MATT
% Author : D. Smith - UTK
% Description : This is the intialization file for the UTK VSCM
% Proprietary : D. Smith
% Model :  lib_p_par_posttx_1mc_UTK, lib_p_par_posttx_1mc_utk,
lib_p_par_pre_tx_DES_dissertation_MATT
% Vehicle Type : Light, Heavy
%% File content
ptc.prop.list.init =
{'emcp_battery_P_gain';'emcp_battery_I_gain';'emcp_integrator_reset_MPH';'emcp_us
e_variable_eng_on_CD_threshold_percent';...

'emcp_eng_power_on_CD_threshold_percent';'emcp_eng_per_on_CD_LO';'emcp_eng_
per_on_CD_HI';'emcp_eng_power_off_CD_threshold';'emcp_eng_power_on_CS_thresh
old';'emcp_eng_power_off_CS_threshold';...
   'emcp_CS_SOC_threshold';'emcp_CD_SOC_threshold';...

'emcp_eng_trq_rate_limit_HI_Nm_per_s';'emcp_eng_trq_rate_limit_LO_Nm_per_s';'e
mcp_psoc_table_offset';'emcp_auxiliary_load_W';...

'emcp_p_eng_opt_table_SOC_offset';'emcp_eng_max_p_modifier';'emcp_eng_energy_
total_warm_up';'emcp_eng_energy_total_restart';'emcp_eng_warm_up_trq_Nm';'emc
p_eng_cat_cold_temp_C';'emcp_eng_ramp_up_time''emcp_use_pre_warm_up';...

'vmcp_use_key_on_engine_start';'vmcp_CS_MPH_threshold_adaptive_HI';'vmcp_CS_M
PH_threshold_adaptive_LO';...

'vmcp_soc_target';'vmcp_t_cssew';'vmcp_t_eng_on_min';'vmcp_t_eng_off_max';'vmcp
_eng_ON';...

'vmcp_eng_demand_time_min';'vmcp_eng_demand_off_time_min';'vmcp_FTO_ped_th
reshold';'vmcp_use_dynamic_CS';...

'vmcp_use_adaptive_SOC';'vmcp_adaptive_SOC_offset';'vmcp_force_charge_sustaining
';'vmcp_EV_only';...

'vmcp_PSOC_charge_power_init_W';'vmcp_PSOC_discharge_power_init_W';'vmcp_use
_conventional_mode';'vmcp_use_engine_optimal_mode';...
```

'vmcp_eng_ON_PT_1';'vmcp_eng_ON_PT_2';'vmcp_eng_ON_PT_3';'vmcp_eng_ON_PT_4';'vmcp_eng_ON_PT_5';'vmcp_eng_OFF_offset';'vmcp_eng_ON_table_offset'};

```
ptc.prop.init.emcp_battery_P_gain                        = 0.5;    %EMCP proportional gain for the EMCP closed loop battery PI controller
ptc.prop.init.emcp_battery_I_gain                        = 10;     %EMCP integral gain for the EMCP closed loop battery PI controller
ptc.prop.init.emcp_integrator_reset_MPH                  = 0.01;   %EMCP vehicle speed integrator reset reset threshold for close loop battery PI controller
ptc.prop.init.emcp_use_variable_eng_on_CD_threshold_percent  = 1;  %EMCP use variable, SOC based engine power on CD threshold percentage
ptc.prop.init.emcp_eng_power_on_CD_threshold_percent     = 1.00;   %EMCP fraction of max motor power in which engine is forced to assist powertrain during charge depleting operation
ptc.prop.init.emcp_eng_per_on_CD_LO                      = 0.0;    %EMCP variable fraction of max motor power in which engine is forced to assist powertrain during charge depleting operation LO
ptc.prop.init.emcp_eng_per_on_CD_HI                      = 1.0;    %EMCP variable fraction of max motor power in which engine is forced to assist powertrain during charge depleting operation HI
ptc.prop.init.emcp_eng_power_off_CD_threshold            = 20000;  %EMCP power demand at which engine is allowed to turn off in charge depleting mode
ptc.prop.init.emcp_eng_power_on_CS_threshold             = 30000;  %EMCP power demand at which engine is forced on during charge sustaining
ptc.prop.init.emcp_eng_power_off_CS_threshold            = 0;      %EMCP power demand at which engine is allowed to turn off during charge sustaining operation
ptc.prop.init.emcp_CS_SOC_threshold                      = 0.05;   %EMCP threshold for entering charge sustaining mode (above target SOC)
ptc.prop.init.emcp_CD_SOC_threshold                      = 0.10;   %EMCP threshold for exiting charge sustaining mode back into charge depleting mode (above target SOC)
ptc.prop.init.emcp_eng_trq_rate_limit_HI_Nm_per_s        = 100;    %EMCP engine torque rising rate limit
ptc.prop.init.emcp_eng_trq_rate_limit_LO_Nm_per_s        = -100;   %EMCP engine torque falling rate limit
ptc.prop.init.emcp_psoc_table_offset                     = 1;      %EMCP PSOC table SOC offset around the target state of charge
ptc.prop.init.emcp_auxiliary_load_W                      = 600;    %EMCP estimated auxiliary load (low voltage system) (W)
ptc.prop.init.emcp_p_eng_opt_table_SOC_offset            = 10;     %EMCP engine optimal power modifier table offset value based on SOC
```

```
ptc.prop.init.emcp_eng_max_p_modifier                    = 0.75    %EMCP engine
maximum power modifier for warm up strategy between 0.5 and 1
ptc.prop.init.emcp_eng_energy_total_warm_up              = 3000000; %EMCP engine
maximum energy consumed for warm up strategy
ptc.prop.init.emcp_eng_energy_total_restart              = 750000;  %EMCP engine
maximum energy consumed for restart strategy
ptc.prop.init.emcp_eng_energy_warm_up_IC                 = 0;       %EMCP engine
maximum energy consumed integrator IC
ptc.prop.init.emcp_eng_warm_up_trq_Nm                    = 15;      %EMCP engine warm
up torque (constant) for pre-warm up period (tssew)
ptc.prop.init.emcp_eng_cat_cold_temp_C                   = 200;     %EMCP catalyst cold
temp C
ptc.prop.init.emcp_eng_ramp_up_time                      = 7;       %EMCP engine
maximum power ramp up time (sec)
ptc.prop.init.emcp_use_pre_warm_up                       = 0;       %EMCP use pre warm up
routine to warm engine at very low power (emcp_warm_up_trq_Nm)

ptc.prop.init.vmcp_use_key_on_engine_start               = 0;       %VMCP use engine
start at key ON
ptc.prop.init.vmcp_soc_target                            = 0.3;     %VMCP SOC target for high
voltage battery pack
ptc.prop.init.vmcp_CS_MPH_threshold_adaptive_HI          = 40;      %VMCP vehicle
speed threshold (MPH) for entering adpative target SOC mode
ptc.prop.init.vmcp_CS_MPH_threshold_adaptive_LO          = 5;       %VMCP vehicle
speed threshold (MPH) for exiting adaptive target SOC mode
ptc.prop.init.vmcp_cruise_threshold                      = 20;      %VMCP cruise charge
available threshold (MPH)
ptc.prop.init.vmcp_FTO_ped_threshold                     = 0.95;    %VMCP pedal demand
threshold for entering power assist region for traction motor
ptc.prop.init.vmcp_t_cssew                               = 0;       %VMCP cold start time for
engine to warmup to normal operating temperature
ptc.prop.init.vmcp_t_eng_on_min                          = 10;      %VMCP minimum engine
on running time
ptc.prop.init.vmcp_t_eng_off_max                         = 1000;    %VMCP maximum engine
off time
ptc.prop.init.vmcp_eng_ON                                = 0;       %VMCP engine ON all the time
flag
ptc.prop.init.vmcp_eng_demand_time_min                   = 0.1;     %VMCP engine on
minimum demand time for engine start
ptc.prop.init.vmcp_eng_demand_off_time_min               = 0.1;     %VMCP engine off
minimum demand time for engine stop
```

```
ptc.prop.init.vmcp_use_dynamic_CS                    = 0;      %VMCP use dynamic
charge sustaining algorithm
ptc.prop.init.vmcp_use_adaptive_SOC                  = 0;      %VMCP use adaptive SOC
target algorithm
ptc.prop.init.vmcp_adaptive_SOC_offset               = 0.05;   %VMCP offset for target
SOC during adaptive SOC algorithm
ptc.prop.init.vmcp_force_charge_sustaining           = 0;      %VMCP force use of
charge sustaining mode
ptc.prop.init.vmcp_EV_only                           = 0;      %VMCP force electric only
mode of operation
ptc.prop.init.vmcp_PSOC_charge_power_init_W          = 20000;  %VMCP PSOC
charge power initialization (W)
ptc.prop.init.vmcp_PSOC_discharge_power_init_W       = 20000;  %VMCP PSOC
discharge power initialization (W)
ptc.prop.init.vmcp_use_conventional_mode             = 0;      %VMCP use
conventional mode of operation
ptc.prop.init.vmcp_use_engine_optimal_mode           = 1;      %VMCP use engine
optimal mode of operation
ptc.prop.init.vmcp_eng_ON_PT_1                       = 40;     %VMCP dynamic engine
ON vehicle speed threshold POINT 1 (MPH)
ptc.prop.init.vmcp_eng_ON_PT_2                       = 40;     %VMCP dynamic engine
ON vehicle speed threshold POINT 2 (MPH)
ptc.prop.init.vmcp_eng_ON_PT_3                       = 40;     %VMCP dynamic engine
ON vehicle speed threshold POINT 3 (MPH) at target SOC
ptc.prop.init.vmcp_eng_ON_PT_4                       = 55;     %VMCP dynamic engine
ON vehicle speed threshold POINT 4 (MPH)
ptc.prop.init.vmcp_eng_ON_PT_5                       = 60;     %VMCP dynamic engine
ON vehicle speed threshold POINT 5 (MPH)
ptc.prop.init.vmcp_eng_OFF_offset                    = 5;      %VMCP dynamic engine
OFF vehicel speed offset (MPH)
ptc.prop.init.vmcp_eng_ON_table_offset               = 5;      %VMCP dynamic engine
ON/OFF table SOC offset (%)

%Regenerative braking phase out map based on vehicle speed (MPH)
ptc.prop.init.rbcp_max_regen_soc_index=[0 5 10 30 40 100];
ptc.prop.init.rbcp_max_regen_percent=[1 1 1 1 1 1];

%BMCP charge and discharge power limitations, used to further modify
%incoming power limitations form the battery control module (BCM)
ptc.prop.init.bmcp_soc_index =              [0 10 20 30 40 50 60 70 80 90 100];
ptc.prop.init.bmcp_charge_power_multiplier =    [1  1  1  1  1  1  1  1  1  0.5 0];
ptc.prop.init.bmcp_discharge_power_multiplier = [0  0  0  1  1  1  1  1  1  1   1];
```

```
if strcmp(simulation.building.trans,'ct'),%need to define here as no sft files for ct - AYR
   [ptc.prop.tmp.spd_index,
ptc.prop.tmp.trq_index]=find(max(max(eng.calc.eff_hot_map))==eng.calc.eff_hot_map)
;
   ptc.prop.init.sft_spd_op_max =
min((eng.init.spd_fuel_hot_index(ptc.prop.tmp.spd_index) +
100),(max(eng.init.spd_max_hot_index)));
end

%These items take care of foundation braking strategy
ptc.brake.init.wh_percent_front_mechanical_brake=0;
ptc.brake.init.mc_percent_brake_trq=1;
ptc.brake.init.wh_percent_mechanical_brake_trq=0;
```

Initialization file for shifting model

```
%% File description
% Name : tx_stf_shift_n_gen
% Author : Dominik Karbowski - Argonne National Laboratory
%
% Description : generic shifting law based on vehicle speed and acceleration - works for both FE and performance
% To be used in conventional, parallel hybrid and series-parallel, either automatic or manual
% Maps are defined by:
%  - engine shifting speeds at acceleration pedal position=0 for each gear (eco mode),
%  - vehicle shifting speed at acceleration pedal position=1 for each gear (perfo mode)
%  - accelerator pedal position thresholds.
%
% Proprietary : Public
% Model : lib_s_stf_au_eng_veh_spd_accel_pedal,lib_s_stf_dm_eng_veh_spd_accel_pedal,lib_s_stf_au_eng_veh_spd_accel_pedal_accel_in
% Vehicle Type : Light, Heavy


%% File content
if exist('ptc','var')
   if isfield(ptc,'shift')
      ptc = rmfield(ptc,'shift');
   end
end

ptc.shift.list.init = {'percent_eng_spd_idle','percent_eng_spd_max','percent_eng_spd_between_up_and_dn',...

'eng_spd_dnshift_lowest_gear','eng_spd_dnshift_highest_gear','eng_spd_upshift_lowest_gear','eng_spd_upshift_highest_gear',...

'acc_below_eco_up','acc_below_eco_dn','acc_above_perfo','ratio_veh_sp_diff_acc1_and_acc0','acc_below_no_timer','min_time_for_shift_dmd'};

%INIT Parameters
%%%%%%%%%%%%%%%%%%
% Simulink
```

```
ptc.shift.init.percent_eng_spd_idle             = 1.1;  % percentage of engine idle speed
that is considered as minimal speed
ptc.shift.init.percent_eng_spd_max              = 0.98; % percentage of
max(eng.init.spd_max_hot_index(1:end-2)) that is taken as maximal speed
ptc.shift.init.percent_eng_spd_idle             =
overwrite_parameters('simulation.controller.strategy.shift','percent_eng_spd_idle',ptc.s
hift.init.percent_eng_spd_idle);
ptc.shift.init.percent_eng_spd_max              =
overwrite_parameters('simulation.controller.strategy.shift','percent_eng_spd_max',ptc.
shift.init.percent_eng_spd_max);


% Shifting Map
ptc.shift.init.acc_above_perfo                  =.8; % [0->1] when the accelerator pedal
position is higher than this value, "performance" up- and down- shfting speeds are used
ptc.shift.init.acc_below_eco_dn                 =.6; % [0->1] when the accelerator pedal
position is lower than this value, "economy" down-shifting speed is used (downshift
curve only)
ptc.shift.init.acc_below_eco_up                 =.2; % [0->1] when the accelerator pedal
position is lower than this value, "economy" up-shifting speed is used (upshift curve
only)
ptc.shift.init.percent_eng_spd_between_up_and_dn    =.1; % [0->inf] minimal
overlaping between up- and down- shifting curves
ptc.shift.init.ratio_veh_sp_diff_acc1_and_acc0     =2;  % ]0->inf]ratio of vehicle speed
difference between up- and down- shifting curves at acc=1 and the one at acc=0

ptc.shift.init.acc_above_perfo                  =
overwrite_parameters('simulation.controller.strategy.shift','acc_above_perfo',ptc.shift.i
nit.acc_above_perfo);
ptc.shift.init.acc_below_eco_up                 =
overwrite_parameters('simulation.controller.strategy.shift','acc_below_eco_up',ptc.shif
t.init.acc_below_eco_up);
ptc.shift.init.acc_below_eco_dn                 =
overwrite_parameters('simulation.controller.strategy.shift','acc_below_eco_dn',ptc.shif
t.init.acc_below_eco_dn);
ptc.shift.init.percent_eng_spd_between_up_and_dn    =
overwrite_parameters('simulation.controller.strategy.shift','percent_eng_spd_between
_up_and_dn',ptc.shift.init.percent_eng_spd_between_up_and_dn);
ptc.shift.init.ratio_veh_sp_diff_acc1_and_acc0     =
overwrite_parameters('simulation.controller.strategy.shift','ratio_veh_sp_diff_acc1_an
d_acc0',ptc.shift.init.ratio_veh_sp_diff_acc1_and_acc0);
```

```
% Stateflow
ptc.shift.init.min_time_for_shift_dmd            = 1;  % [s] minimal time the up- or down-shifting request has to be constant before performing the shifting
ptc.shift.init.acc_below_no_timer               = 0.5;  % [0->1] if the accelerator pedal position is below this value, the timer is by-passed

% For init calculation only
ptc.shift.init.percent_eng_spd_idle_additional     = 0.05; % percentage of engine idle speed that is added to ptc.shift.init.percent_eng_spd_idle in calculation of downshifting speeds

%Remove neutral gear if there is one
ptc.shift.tmp.gear_ratio=gb.init.ratio_map;
ptc.shift.tmp.gear_index=gb.init.gear_index;

if min(gb.init.ratio_map)==0
   ptc.shift.tmp.gear_ratio(1)='';
   ptc.shift.tmp.gear_index(1)='';
end

%Set torque coupling ratio to 1 in case it doesn't exist
if strcmp(simulation.building.axle,'4 wheel drive')
   ptc.shift.tmp.trc_ratio=trc.init.ratio;
else
   ptc.shift.tmp.trc_ratio=1;
end


%Vehicle speed below which neutral gear can be requested (for manual tx)
ptc.shift.init.veh_spd_max_neutro=(eng.init.spd_idle*ptc.shift.init.percent_eng_spd_idle+10)*wh.init.radius/fd.init.ratio/ptc.shift.tmp.gear_ratio(1)/ptc.shift.tmp.trc_ratio;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%INITITIALIZE VARIABLES FOR SHIFTING MAPS
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%We downshift from 2nd to 1st when engine speed is idle rad/s
ptc.shift.init.eng_spd_dnshift_lowest_gear=eng.init.spd_idle*(ptc.shift.init.percent_eng_spd_idle+ptc.shift.init.percent_eng_spd_idle_additional);

%upshift from 1st to 2nd, making sure that upshift_spd>dnshift_spd
```

```
ptc.shift.init.eng_spd_upshift_lowest_gear=max(ptc.shift.init.eng_spd_dnshift_lowest_gear*ptc.shift.tmp.gear_ratio(1)/ptc.shift.tmp.gear_ratio(2)*(1+ptc.shift.init.percent_eng_spd_between_up_and_dn),eng.init.spd_idle*(ptc.shift.init.percent_eng_spd_idle+ptc.shift.init.percent_eng_spd_idle_additional) +60);

%upshift to highest gear at the best efficiency point
[ptc.shift.tmp.spd_index,
ptc.shift.tmp.trq_index]=find(max(max(eng.calc.eff_hot_map))==eng.calc.eff_hot_map);
ptc.shift.tmp.spd_index = ptc.shift.tmp.spd_index(1); %In case there is more than one optimal point. Just take the first one.
ptc.shift.init.eng_spd_upshift_highest_gear=eng.init.spd_fuel_hot_index(ptc.shift.tmp.spd_index);
ptc.shift.init.eng_spd_dnshift_highest_gear=max(ptc.shift.init.eng_spd_upshift_highest_gear-100,eng.init.spd_idle*(ptc.shift.init.percent_eng_spd_idle+ptc.shift.init.percent_eng_spd_idle_additional));


%upshift engine speed is an affine function of gear number
ptc.shift.init.eng_spd_eco_dn_index=interp1([2,max(ptc.shift.tmp.gear_index)],[ptc.shift.init.eng_spd_dnshift_lowest_gear,ptc.shift.init.eng_spd_dnshift_highest_gear],ptc.shift.tmp.gear_index(2:end));
ptc.shift.init.eng_spd_eco_up_index=interp1([1,max(ptc.shift.tmp.gear_index)-1],[ptc.shift.init.eng_spd_upshift_lowest_gear,ptc.shift.init.eng_spd_upshift_highest_gear],ptc.shift.tmp.gear_index(1:end-1));

%make sure the upshift is high enough not to have overlapping down- and up- shifting curves
ptc.shift.init.eng_spd_eco_up_index=max(ptc.shift.init.eng_spd_eco_dn_index.*ptc.shift.tmp.gear_ratio(1:end-1)./ptc.shift.tmp.gear_ratio(2:end)*(1+ptc.shift.init.percent_eng_spd_between_up_and_dn),ptc.shift.init.eng_spd_eco_up_index);

%overwrite init variables
ptc.shift.init.eng_spd_upshift_highest_gear=ptc.shift.init.eng_spd_eco_up_index(end);
ptc.shift.init.eng_spd_upshift_lowest_gear=ptc.shift.init.eng_spd_eco_up_index(1);
ptc.shift.init.eng_spd_dnshift_highest_gear=ptc.shift.init.eng_spd_eco_dn_index(end);
ptc.shift.init.eng_spd_dnshift_lowest_gear=ptc.shift.init.eng_spd_eco_dn_index(1);


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
%UP AND DOWN SHIFTING SPEEDS (pedal position=0)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%

ptc.shift.init.eng_spd_dnshift_lowest_gear    =
overwrite_parameters('simulation.controller.strategy.shift','eng_spd_dnshift_lowest_ge
ar',ptc.shift.init.eng_spd_dnshift_lowest_gear);
ptc.shift.init.eng_spd_dnshift_highest_gear    =
overwrite_parameters('simulation.controller.strategy.shift','eng_spd_dnshift_highest_g
ear',ptc.shift.init.eng_spd_dnshift_highest_gear);
ptc.shift.init.eng_spd_upshift_lowest_gear    =
overwrite_parameters('simulation.controller.strategy.shift','eng_spd_upshift_lowest_ge
ar',ptc.shift.init.eng_spd_upshift_lowest_gear);
ptc.shift.init.eng_spd_upshift_highest_gear    =
overwrite_parameters('simulation.controller.strategy.shift','eng_spd_upshift_highest_g
ear',ptc.shift.init.eng_spd_upshift_highest_gear);

%upshift engine speed is an affine function of gear number
ptc.shift.init.eng_spd_eco_dn_index=interp1([2,max(ptc.shift.tmp.gear_index)],[ptc.shif
t.init.eng_spd_dnshift_lowest_gear,ptc.shift.init.eng_spd_dnshift_highest_gear],ptc.shif
t.tmp.gear_index(2:end));
ptc.shift.init.eng_spd_eco_up_index=interp1([1,max(ptc.shift.tmp.gear_index)-
1],[ptc.shift.init.eng_spd_upshift_lowest_gear,ptc.shift.init.eng_spd_upshift_highest_ge
ar],ptc.shift.tmp.gear_index(1:end-1));

%make sure the upshift is high enough not to have overlapping down- and up- shifting
curves
ptc.shift.init.eng_spd_eco_up_index=max(ptc.shift.init.eng_spd_eco_dn_index.*ptc.shif
t.tmp.gear_ratio(1:end-
1)./ptc.shift.tmp.gear_ratio(2:end)*(1+ptc.shift.init.percent_eng_spd_between_up_and
_dn),ptc.shift.init.eng_spd_eco_up_index);

%overwrite init variables
if ptc.shift.init.eng_spd_eco_up_index(length(ptc.shift.tmp.gear_index)-
1)~=ptc.shift.init.eng_spd_upshift_highest_gear ||
ptc.shift.init.eng_spd_upshift_lowest_gear~=ptc.shift.init.eng_spd_eco_up_index(1)
   warndlg('Shifting engine speeds as defined in the GUI result in overlapping up- and
down- shifting curves. PSAT has automatically modified those values to avoid that
problem.')
end

ptc.shift.init.eng_spd_upshift_highest_gear=ptc.shift.init.eng_spd_eco_up_index(end);
```

```
ptc.shift.init.eng_spd_upshift_lowest_gear=ptc.shift.init.eng_spd_eco_up_index(1);

ptc.shift.init.eng_spd_eco_dn_index=[0 ptc.shift.init.eng_spd_eco_dn_index];
ptc.shift.init.eng_spd_eco_up_index=[ptc.shift.init.eng_spd_eco_up_index 0];

% Calculation of up and down shifting vehicle speeds in economy mode(pedal
position=0)
ptc.shift.init.veh_spd_eco_up_index=ptc.shift.init.eng_spd_eco_up_index.*wh.init.radiu
s/fd.init.ratio/ptc.shift.tmp.trc_ratio./ptc.shift.tmp.gear_ratio;
ptc.shift.init.veh_spd_eco_dn_index=ptc.shift.init.eng_spd_eco_dn_index.*wh.init.radiu
s/fd.init.ratio/ptc.shift.tmp.trc_ratio./ptc.shift.tmp.gear_ratio;


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%
%PERFORMANCE UP AND DOWN SHIFTING SPEEDS (pedal position=1)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%

%maximal wheel torque curves take into account both mc and eng max torque curves


%Load mc data; if no mc, create mc variables
if strcmp(simulation.building.pos1,
'Starter_motor_alternator')|strcmp(simulation.building.pos1, 'Pre-
transmission')|strcmp(simulation.building.pos1,'Starter position');
   mc.tmp.spd_max_index=mc.init.spd_prop_max_index;
   mc.tmp.trq_max_map=mc.init.trq_prop_max_map;
   mc.tmp.spd_max=mc.calc.spd_max;

   if exist('tc_mc','var')
      ptc.shift.tmp.tc_mc_ratio=tc_mc.init.ratio;
   else
      ptc.shift.tmp.tc_mc_ratio=1;
   end

else
   mc.tmp.spd_max_index=[0 10^10];
   mc.tmp.trq_max_map=[0 0];
   ptc.shift.tmp.tc_mc_ratio=1;
   mc.tmp.spd_max=inf;
end
```

```
%Calculate maximal and minimal speed @ gb input
eng_mc.tmp.spd_min=eng.init.spd_idle;
eng_mc.tmp.spd_max=min(eng.init.spd_max*ptc.shift.init.percent_eng_spd_max,mc.t
mp.spd_max/ptc.shift.tmp.tc_mc_ratio);

%Calculate speed and max torque @ gb input
N= 100;
eng_mc.tmp.spd_max_index_intp = [eng_mc.tmp.spd_min:(eng_mc.tmp.spd_max-
eng_mc.tmp.spd_min)/(N-1):eng_mc.tmp.spd_max];
eng.tmp.trq_max_map_intp =
interp1(eng.init.spd_max_hot_index,eng.init.trq_max_hot_map,eng_mc.tmp.spd_max_
index_intp);
mc.tmp.trq_max_map_intp=interp1(mc.tmp.spd_max_index,mc.tmp.trq_max_map,eng
_mc.tmp.spd_max_index_intp*ptc.shift.tmp.tc_mc_ratio);

%Add eng and mc max torque @ gb input
eng_mc.tmp.trq_max_map_intp=eng.tmp.trq_max_map_intp+mc.tmp.trq_max_map_i
ntp*ptc.shift.tmp.tc_mc_ratio;
eng_mc.tmp.spd_max_index_intp=[eng_mc.tmp.spd_max_index_intp
eng_mc.tmp.spd_max_index_intp(end)+.001];
eng_mc.tmp.trq_max_map_intp=[eng_mc.tmp.trq_max_map_intp 0];

%Calculate speed and max torque @ wheels
ptc.shift.tmp.veh_spd_max_ratio_map = (1./ ptc.shift.tmp.gear_ratio(:)) *
eng_mc.tmp.spd_max_index_intp * wh.init.radius / fd.init.ratio /ptc.shift.tmp.trc_ratio;
ptc.shift.tmp.wh_trq_max_ratio_map = ptc.shift.tmp.gear_ratio(:) *
eng_mc.tmp.trq_max_map_intp * fd.init.ratio * ptc.shift.tmp.trc_ratio;

ptc.shift.init.veh_spd_perfo_dn_index=1; %init
%Find up-shifting speed
for cpt_shift=1:length(ptc.shift.tmp.gear_ratio)-1,
   eng.tmp.indexes = find( ptc.shift.tmp.veh_spd_max_ratio_map(cpt_shift+1,:) < max(
ptc.shift.tmp.veh_spd_max_ratio_map(cpt_shift,:)));
   eng.tmp.wh_trq_max_ratio_map_next = interp1(
ptc.shift.tmp.veh_spd_max_ratio_map(cpt_shift+1,eng.tmp.indexes),ptc.shift.tmp.wh_t
rq_max_ratio_map(cpt_shift+1,eng.tmp.indexes),
ptc.shift.tmp.veh_spd_max_ratio_map(cpt_shift,:),'linear','extrap');
   eng.tmp.D = ptc.shift.tmp.wh_trq_max_ratio_map(cpt_shift,:) -
eng.tmp.wh_trq_max_ratio_map_next;
   eng.tmp.negative_indexes = find(eng.tmp.D < 0);
   eng.tmp.first_negative_index = eng.tmp.negative_indexes(1);
```

```
   eng.tmp.last_positive_index = eng.tmp.negative_indexes(1) - 1;

   eng.tmp.veh_spd_at_zero_D = interp1([eng.tmp.D(eng.tmp.last_positive_index)
eng.tmp.D(eng.tmp.first_negative_index)],[
ptc.shift.tmp.veh_spd_max_ratio_map(cpt_shift,eng.tmp.last_positive_index)
ptc.shift.tmp.veh_spd_max_ratio_map(cpt_shift,eng.tmp.first_negative_index)],0);
   eng.tmp.wh_trq_at_zero_D = interp1(
ptc.shift.tmp.veh_spd_max_ratio_map(cpt_shift+1,:),ptc.shift.tmp.wh_trq_max_ratio_
map(cpt_shift+1,:),eng.tmp.veh_spd_at_zero_D);
   ptc.shift.init.veh_spd_perfo_up_index(cpt_shift) =  eng.tmp.veh_spd_at_zero_D;

ptc.shift.init.veh_spd_perfo_dn_index(cpt_shift+1)=ptc.shift.init.veh_spd_perfo_up_ind
ex(cpt_shift)-
ptc.shift.init.ratio_veh_sp_diff_acc1_and_acc0*(ptc.shift.init.veh_spd_eco_up_index(cp
t_shift)-ptc.shift.init.veh_spd_eco_dn_index(cpt_shift+1));
end

ptc.shift.init.veh_spd_perfo_up_index =  [ ptc.shift.init.veh_spd_perfo_up_index 0];

clear cpt_shift;
clear eng_mc;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% SHIFTING CURVES
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%Initialize parameters
ptc.shift.tmp.veh_spd_index=[0:.5:70];
ptc.shift.init.veh_spd_upshift_index=[ptc.shift.tmp.veh_spd_index
ptc.shift.init.veh_spd_eco_up_index ptc.shift.init.veh_spd_perfo_up_index];
ptc.shift.init.veh_spd_upshift_index=unique(ptc.shift.init.veh_spd_upshift_index);
ptc.shift.init.veh_spd_dnshift_index=[ptc.shift.tmp.veh_spd_index
ptc.shift.init.veh_spd_eco_dn_index ptc.shift.init.veh_spd_perfo_dn_index];
ptc.shift.init.veh_spd_dnshift_index=unique(ptc.shift.init.veh_spd_dnshift_index);
ptc.shift.init.acc_up_index=[0:.01:1];
ptc.shift.init.acc_dn_index=ptc.shift.init.acc_up_index;

%upshifting curve
for cpt_shift=1:length(ptc.shift.tmp.gear_ratio)-1

   ptc.shift.tmp.veh_index=[0, ptc.shift.init.veh_spd_eco_up_index(cpt_shift)-.01 ,
ptc.shift.init.veh_spd_eco_up_index(cpt_shift) , ...
```

```
       ptc.shift.init.veh_spd_perfo_up_index(cpt_shift)-.01 ,
ptc.shift.init.veh_spd_perfo_up_index(cpt_shift),max(ptc.shift.init.veh_spd_upshift_ind
ex)+.001];
    ptc.shift.tmp.acc_map=[-1, -
1,ptc.shift.init.acc_below_eco_up,ptc.shift.init.acc_above_perfo,1,1];


ptc.shift.tmp.acc_up_cmd_map(cpt_shift,:)=interp1(ptc.shift.tmp.veh_index,ptc.shift.tm
p.acc_map,ptc.shift.init.veh_spd_upshift_index);

end
clear cpt_shift;

%downshifting curve
for cpt_shift=2:length(ptc.shift.tmp.gear_ratio)

   ptc.shift.tmp.veh_index=[0, ptc.shift.init.veh_spd_eco_dn_index(cpt_shift)-.01 ,
ptc.shift.init.veh_spd_eco_dn_index(cpt_shift) , ...
       ptc.shift.init.veh_spd_perfo_dn_index(cpt_shift)-.01 ,
ptc.shift.init.veh_spd_perfo_dn_index(cpt_shift),max(ptc.shift.init.veh_spd_dnshift_ind
ex)+.001];
    ptc.shift.tmp.acc_map=[-1, -
1,ptc.shift.init.acc_below_eco_dn,ptc.shift.init.acc_above_perfo,1,1];


ptc.shift.tmp.acc_dn_cmd_map(cpt_shift,:)=interp1(ptc.shift.tmp.veh_index,ptc.shift.tm
p.acc_map,ptc.shift.init.veh_spd_dnshift_index);

end
clear cpt_shift;


%UPSHIFTING MAP
%%%%%%%%%%%%%%%%%
ptc.shift.init.gear_upshift_map=(ptc.shift.init.acc_up_index'*ptc.shift.init.veh_spd_upsh
ift_index)*0+1;
ptc.shift.tmp.Y=ptc.shift.init.acc_up_index'*(ptc.shift.init.veh_spd_upshift_index*0+1);

for gear=1:length(ptc.shift.tmp.gear_ratio)-1

ptc.shift.tmp.FX1=(ptc.shift.init.acc_up_index'*0+1)*ptc.shift.tmp.acc_up_cmd_map(ge
ar,:);
```

```
   ptc.shift.tmp.idx=find(ptc.shift.tmp.Y<=ptc.shift.tmp.FX1);
   ptc.shift.init.gear_upshift_map(ptc.shift.tmp.idx)= gear+1;
end

clear gear;

%DOWNSHIFTING MAP
%%%%%%%%%%%%%%%%

ptc.shift.init.gear_dnshift_map=(ptc.shift.init.acc_dn_index'*ptc.shift.init.veh_spd_dnsh
ift_index)*0+1;
ptc.shift.tmp.Y=ptc.shift.init.acc_dn_index'*(ptc.shift.init.veh_spd_dnshift_index*0+1);

for gear=2:length(ptc.shift.tmp.gear_ratio)

ptc.shift.tmp.FX1=(ptc.shift.init.acc_dn_index'*0+1)*ptc.shift.tmp.acc_dn_cmd_map(ge
ar,:);
   ptc.shift.tmp.idx=find(ptc.shift.tmp.Y<=ptc.shift.tmp.FX1);
   ptc.shift.init.gear_dnshift_map(ptc.shift.tmp.idx)= gear;
end
clear gear;

%Remove temporary variables
%%%%%%%%%%%%%%%%%%%%%%%%%%

if exist('ptc','var')
   if isfield(ptc.shift,'tmp')
      ptc.shift = rmfield(ptc.shift,'tmp');
   end
end

if exist('eng','var')
   if isfield(eng,'tmp')
      eng = rmfield(eng,'tmp');
   end
end

if exist('mc','var')
   if isfield(mc,'tmp')
      mc = rmfield(mc,'tmp');
   end
end
```

Initialization file for starter model

```
%% File description
% Name : str_2_10
% Author : Gilles Monnet - ANL
% Description : Initialize a 2kW starter model
% Ratio = 10
% Data from Iskra Web Sites
% Proprietary : Public
% Model : lib_str_map
% Vehicle Type : Light

%% File content
str.list.init = {'mass','ratio','inertia'};

str.init.ratio      = 10;   % transmission ratio between engine ring gear and the starter pinion (usually between 10:1 and 15:1)
str.init.mass       = 3;    % mass of the starter
str.init.inertia    = 0;

%Look up table torque = f(speed)
str.init.spd_index  = [0 500 1000 1500 2000 2500 3000 3500 4000 4500 5500 ]*(pi/30);
str.init.trq_map    = [28.5 25 20.4 15.8 11.1 7.8 5.4 3.75 2.43 1.54 0];
str.init.current    = 100;
```

Initialization file for mechanical accessories model

```
%% File description
% Name : accmech_0
% Author : A.Rousseau - ANL
% Description : Initialize the mechanical accessory power losses to 0W
% Proprietary : Public
% Model : lib_accmech_constant_pwrloss_trq_in
% Vehicle Type : Light

%% File content
accmech.list.init      = {'mass','pwr','spd_min','mass'};

accmech.init.pwr       = 0.0;
accmech.init.mass      = 35;
accmech.init.spd_min   = conversion_calc('rotational_speed','rpm','rad/s',500);
```

Initialization file for torque converter model

```
%% File description
% Name : clutch_1
% Author : A.Rousseau - ANL
% Description : Initialize the parameters used in the clutch model
% Proprietary: Public
% Model : lib_cpl_clutch_map
% Vehicle Type : Heavy, Light

%% File content
cpl.list.init       = {'inertia','lock_thresh','mass'};

cpl.init.inertia     = 0.004;
cpl.init.lock_thresh = 5.0;
cpl.init.mass        = 25;
```

Initialization file for motor model

```
%% File description
% Name : mc_pm_30_75_uqm_intets
% Author : G. Monnet - ANL
% Description : Initialize a permanent magnet electric motor from Unique
% Continuous Power = 30kW, Peak Power = 75kW
% Data provided by Unique Mobility specification sheet for the INTETS
% motor/controller combination (from www.uqm.com)
% Efficiencies have been approximated
% Model : lib_mc_map_Pelec_funTW_volt_in,lib_mc_map_Pelec_funTW_pwr_in
% Technology : pm
% Vehicle Type : Light, Heavy

%% File content
mc.list.init =
{'motor_mass','controller_mass','inertia','tau','coeff_regen','volt_min','curr_max'};

mc.init.inertia          = 0.047;
mc.init.coeff_regen      = 0.94;
mc.init.volt_min         = 250; % (V), minimum voltage allowed by the controller and
motor
mc.init.volt_max         = 400;
mc.init.tau              = .05; % from 0 to 100 % of the torque in 50 ms
mc.init.time_response    = mc.init.tau;
mc.init.t_max_trq        = 60; % Time the motor can remain at max torque

mc.init.motor_mass       = 74;
mc.init.controller_mass  = 16;

mc.init.curr_max         = 400; % (A), maximum current allowed by the controller and
motor
mc.init.spd_base         = conversion_calc('rotational_speed','rpm','rad/s',3000);% rad/s

mc.init.spd_cont_index   = conversion_calc('rotational_speed','rpm','rad/s',[0 500
1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6200 6300]);
mc.init.trq_cont_map     = [120 120 120 120 120 112 92 78 66 56 49 41 39 0 0]; %
(N*m)

mc.init.spd_max_index    = mc.init.spd_cont_index;
mc.init.trq_max_map      = [382 373 367 361 353 277 224 187 158 139 124 114 102 0
0];
```

```
mc.init.spd_min_index      = mc.init.spd_max_index; % rad/s
mc.init.trq_min_map        = -mc.init.trq_max_map;

mc.init.spd_eff_index      =
conversion_calc('rotational_speed','rpm','rad/s',[0:100:1300]*4.54);
mc.init.trq_eff_index      = [0:200:1800]/4.54;
mc.init.eff_trq_map        = [...
0.1 0.1    0.1    0.1    0.1    0.1    0.1    0.1    0.1    0.1    0.1    0.1    0.1    0.1
0.1 0.38   0.65   0.75   0.78   0.8    0.82   0.845  0.845  0.825  0.8    0.8    0.8    0.75
0.1 0.4    0.66   0.8    0.835  0.84   0.86   0.89   0.91   0.9    0.88   0.875  0.86   0.85
0.1 0.35   0.65   0.77   0.835  0.86   0.875  0.9    0.91   0.9    0.88   0.7    0.7    0.7
0.1 0.31   0.66   0.78   0.83   0.875  0.85   0.88   0.89   0.7    0.7    0.7    0.7    0.7
0.1 0.3    0.58   0.75   0.825  0.89   0.88   0.87   0.7    0.7    0.7    0.7    0.7    0.7
0.1 0.35   0.63   0.73   0.85   0.91   0.9    0.7    0.7    0.7    0.7    0.7    0.7    0.7
0.1 0.3    0.66   0.81   0.83   0.88   0.7    0.7    0.7    0.7    0.7    0.7    0.7    0.7
0.1 0.35   0.65   0.78   0.83   0.7    0.7    0.7    0.7    0.7    0.7    0.7    0.7    0.7
0.1 0.3    0.7    0.7    0.7    0.7    0.7    0.7    0.7    0.7    0.7    0.7    0.7
0.7]'/0.94;%take out the final drive efficiency to have only the motor/controller
efficiency

mc.init.spd_prop_cont_index = [-fliplr(mc.init.spd_cont_index(2:end)) -eps 0 eps
mc.init.spd_cont_index(2:end)];
mc.init.trq_prop_cont_map   = [-fliplr(mc.init.trq_cont_map(2:end))  -
mc.init.trq_cont_map(2) mc.init.trq_cont_map(2) mc.init.trq_cont_map(2)
mc.init.trq_cont_map(2:end)];
mc.init.pwr_prop_cont_map =
mc.init.spd_prop_cont_index.*mc.init.trq_prop_cont_map;

mc.init.spd_prop_max_index  = [-fliplr(mc.init.spd_max_index(2:end)) -eps 0 eps
mc.init.spd_max_index(2:end)];
mc.init.trq_prop_max_map    = [-fliplr(mc.init.trq_max_map(2:end))   -
mc.init.trq_max_map(2) mc.init.trq_max_map(2) mc.init.trq_max_map(2)
mc.init.trq_max_map(2:end)];
mc.init.pwr_prop_max_map    =
mc.init.spd_prop_max_index.*mc.init.trq_prop_max_map;

mc.init.spd_reg_cont_index  = [-fliplr(mc.init.spd_cont_index(2:end)) -eps 0 eps
mc.init.spd_cont_index(2:end)];
mc.init.trq_reg_cont_map    = [fliplr(mc.init.trq_cont_map(2:end))
mc.init.trq_cont_map(2) -mc.init.trq_cont_map(2) -mc.init.trq_cont_map(2)  -
mc.init.trq_cont_map(2:end)];
mc.init.pwr_reg_cont_map = mc.init.spd_reg_cont_index.*mc.init.trq_reg_cont_map;
```

```
mc.init.spd_reg_max_index   = [-fliplr(mc.init.spd_max_index(2:end)) -eps 0 eps
mc.init.spd_max_index(2:end)];
mc.init.trq_reg_max_map     = [fliplr(mc.init.trq_max_map(2:end))
mc.init.trq_max_map(2) -mc.init.trq_max_map(2) -mc.init.trq_max_map(2) -
mc.init.trq_max_map(2:end)];
mc.init.pwr_reg_max_map     = mc.init.spd_reg_max_index.*mc.init.trq_reg_max_map;

mc.init.spd_eff_index       = [-fliplr(mc.init.spd_eff_index(2:end)) mc.init.spd_eff_index];
mc.init.trq_eff_index       = [-fliplr(mc.init.trq_eff_index(2:end)) mc.init.trq_eff_index];
mc.init.eff_trq_map         = [flipud(fliplr(mc.init.eff_trq_map(2:end,2:end)))
flipud(mc.init.eff_trq_map(2:end,:));fliplr(mc.init.eff_trq_map(:,2:end))
mc.init.eff_trq_map];
```

Initialization file for transmission model

```
%% File description
% Name : gb_5_au_322_241_155_1_075
% Author : C.Haliburton - ANL
% Description : Initialize 5 speed gearbox for Matt, maps taken from Accord
% Gear ratios 3.22, 2.41, 1.55, 1.00, 0.75
% Gear efficiencies have been estimated
% Proprietary : Public
% Model : lib_gb_automatic_map_trqloss_funTWratio
% Vehicle Type : Crossover


%% File content
gb.list.init = {'mass','inertia_in','inertia_out','spd_thr'};

if isfield(gb,'init')
   if isfield(gb.init,'trq_loss_map')
      gb.init = rmfield(gb.init,'trq_loss_map');
   end
end

gb.init.inertia_in        = 0.003;         % kg m^2
gb.init.inertia_out       = 0;             % kg m^2
gb.init.mass              = 75.0;    %kg
gb.init.spd_thr           = 10;
gb.init.shift_time        = 0.6;
gb.init.nb_ratio          = 5;
gb.init.gear_index        = [0,1,2,3,4,5];
gb.init.ratio_map         = [0, 3.22, 2.41, 1.55, 1.0, 0.75];

gb.init.trq_eff_index = [
0.500,6.000,33.90,67.80,101.7,135.6,169.5,203.4,237.3,271.2,305.1,339];% input trq in
Nm
gb.init.spd_eff_index =
[51.40,52.40,104.7,157.1,209.4,261.8,314.2,366.5,418.9,471.2,523.6];% input speeds in
rd/s

gb.init.eff_trq_ratio1_map = ...       % Gear1 Efficiencies
[  0.8093   0.8093   0.8907   0.8962   0.8982   0.8982   0.8982   0.8972   0.8962
0.8954   0.8944   0.8934
```

```
  0.8093   0.8093   0.8907   0.8962   0.8982   0.8982   0.8982   0.8972   0.8962
0.8954   0.8944   0.8934
  0.8113   0.8113   0.8907   0.8972   0.8982   0.8982   0.8982   0.8972   0.8962
0.8954   0.8944   0.8934
  0.8131   0.8131   0.8916   0.8972   0.8982   0.8982   0.8982   0.8972   0.8962
0.8954   0.8944   0.8934
  0.8149   0.8149   0.8916   0.8972   0.8982   0.8982   0.8982   0.8972   0.8962
0.8962   0.8954   0.8944
  0.8169   0.8169   0.8925   0.8972   0.8990   0.8990   0.8982   0.8972   0.8972
0.8962   0.8954   0.8944
  0.8187   0.8187   0.8925   0.8982   0.8990   0.8990   0.8982   0.8982   0.8972
0.8962   0.8954   0.8944
  0.8206   0.8206   0.8925   0.8982   0.8990   0.8990   0.8982   0.8982   0.8972
0.8962   0.8954   0.8944
  0.8224   0.8224   0.8934   0.8982   0.8990   0.8990   0.8990   0.8982   0.8972
0.8962   0.8954   0.8944
  0.8243   0.8243   0.8934   0.8982   0.8990   0.8990   0.8990   0.8982   0.8972
0.8962   0.8954   0.8944
  0.8262   0.8262   0.8934   0.8990   0.9000   0.8990   0.8990   0.8982   0.8972
0.8962   0.8954   0.8944]';


gb.init.eff_trq_ratio2_map = ...       % Gear2 Efficiencies
[  0.8031   0.8031   0.9104   0.9180   0.9190   0.9190   0.9180   0.9171   0.9162
0.9152   0.9133   0.9123
  0.8031   0.8031   0.9104   0.9180   0.9190   0.9190   0.9180   0.9171   0.9162
0.9152   0.9133   0.9123
  0.8041   0.8041   0.9104   0.9180   0.9190   0.9190   0.9180   0.9171   0.9162
0.9152   0.9133   0.9123
  0.8051   0.8051   0.9104   0.9180   0.9190   0.9190   0.9190   0.9180   0.9162
0.9152   0.9133   0.9123
  0.8060   0.8060   0.9104   0.9180   0.9200   0.9200   0.9190   0.9180   0.9162
0.9152   0.9142   0.9123
  0.8070   0.8070   0.9113   0.9180   0.9200   0.9200   0.9190   0.9180   0.9171
0.9152   0.9142   0.9123
  0.8080   0.8080   0.9113   0.9190   0.9200   0.9200   0.9190   0.9180   0.9171
0.9152   0.9142   0.9123
  0.8089   0.8089   0.9113   0.9190   0.9200   0.9200   0.9190   0.9180   0.9171
0.9152   0.9142   0.9123
  0.8099   0.8099   0.9113   0.9190   0.9200   0.9200   0.9190   0.9180   0.9171
0.9162   0.9142   0.9133
```

```
  0.8108   0.8108   0.9113   0.9190   0.9200   0.9200   0.9190   0.9180   0.9171
0.9162   0.9142   0.9133
  0.8118   0.8118   0.9123   0.9190   0.9209   0.9200   0.9200   0.9180   0.9171
0.9162   0.9142   0.9133]';

gb.init.eff_trq_ratio3_map = ...      % Gear3 Efficiencies
[ 0.7356   0.7356   0.9159   0.9314   0.9352   0.9371   0.9371   0.9371   0.9371
0.9362   0.9362   0.9352
  0.7356   0.7356   0.9159   0.9314   0.9352   0.9371   0.9371   0.9371   0.9371
0.9362   0.9362   0.9352
  0.7453   0.7453   0.9178   0.9314   0.9352   0.9371   0.9371   0.9371   0.9371
0.9362   0.9362   0.9352
  0.7549   0.7549   0.9188   0.9323   0.9362   0.9371   0.9381   0.9381   0.9371
0.9371   0.9362   0.9352
  0.7646   0.7646   0.9207   0.9333   0.9362   0.9381   0.9381   0.9381   0.9371
0.9371   0.9362   0.9352
  0.7732   0.7732   0.9217   0.9342   0.9371   0.9381   0.9381   0.9381   0.9381
0.9371   0.9362   0.9352
  0.7829   0.7829   0.9237   0.9342   0.9371   0.9381   0.9391   0.9381   0.9381
0.9371   0.9362   0.9362
  0.7925   0.7925   0.9246   0.9352   0.9381   0.9391   0.9391   0.9391   0.9381
0.9371   0.9371   0.9362
  0.8021   0.8021   0.9266   0.9362   0.9381   0.9391   0.9391   0.9391   0.9381
0.9381   0.9371   0.9362
  0.8109   0.8109   0.9275   0.9362   0.9391   0.9391   0.9391   0.9391   0.9381
0.9381   0.9371   0.9362
  0.8205   0.8205   0.9285   0.9371   0.9391   0.9400   0.9400   0.9391   0.9391
0.9381   0.9371   0.9362]';

gb.init.eff_trq_ratio4_map = ...      % Gear4 Efficiencies
[ 0.7526   0.7526   0.9383   0.9531   0.7812   0.9600   0.9610   0.9610   0.9610
0.9610   0.9610   0.9600
  0.7526   0.7526   0.9383   0.9531   0.7812   0.9600   0.9610   0.9610   0.9610
0.9610   0.9610   0.9600
  0.7516   0.7516   0.9383   0.9531   0.9580   0.9600   0.9610   0.9610   0.9610
0.9610   0.9610   0.9600
  0.7516   0.7516   0.9374   0.9531   0.9580   0.9600   0.9610   0.9610   0.9610
0.9610   0.9610   0.9600
  0.7516   0.7516   0.9374   0.9531   0.9580   0.9600   0.9610   0.9610   0.9610
0.9610   0.9600   0.9600
  0.7516   0.7516   0.9374   0.9531   0.9580   0.9600   0.9600   0.9610   0.9610
0.9610   0.9600   0.9600
```

```
  0.7507   0.7507   0.9374   0.9531   0.9580   0.9590   0.9600   0.9610   0.9610
0.9610   0.9600   0.9600
  0.7507   0.7507   0.9374   0.9531   0.9571   0.9590   0.9600   0.9610   0.9610
0.9600   0.9600   0.9600
  0.7507   0.7507   0.9374   0.9531   0.9571   0.9590   0.9600   0.9610   0.9610
0.9600   0.9600   0.9600
  0.7507   0.7507   0.9374   0.9521   0.9571   0.9590   0.9600   0.9600   0.9600
0.9600   0.9600   0.9600
  0.7507   0.7507   0.9374   0.9521   0.9571   0.9590   0.9600   0.9600   0.9600
0.9600   0.9600   0.9590]';

gb.init.eff_trq_ratio5_map = ...       % Gear5 Efficiencies
[  0.7683   0.7683   0.9579   0.9730   0.7975   0.9800   0.9810   0.9810   0.9810
0.9810   0.9810   0.9800
  0.7683   0.7683   0.9579   0.9730   0.7975   0.9800   0.9810   0.9810   0.9810
0.9810   0.9810   0.9800
  0.7673   0.7673   0.9579   0.9730   0.9779   0.9800   0.9810   0.9810   0.9810
0.9810   0.9810   0.9800
  0.7673   0.7673   0.9569   0.9730   0.9779   0.9800   0.9810   0.9810   0.9810
0.9810   0.9810   0.9800
  0.7673   0.7673   0.9569   0.9730   0.9779   0.9800   0.9810   0.9810   0.9810
0.9810   0.9800   0.9800
  0.7673   0.7673   0.9569   0.9730   0.9779   0.9800   0.9800   0.9810   0.9810
0.9810   0.9800   0.9800
  0.7664   0.7664   0.9569   0.9730   0.9779   0.9790   0.9800   0.9810   0.9810
0.9810   0.9800   0.9800
  0.7664   0.7664   0.9569   0.9730   0.9770   0.9790   0.9800   0.9810   0.9810
0.9800   0.9800   0.9800
  0.7664   0.7664   0.9569   0.9730   0.9770   0.9790   0.9800   0.9810   0.9810
0.9800   0.9800   0.9800
  0.7664   0.7664   0.9569   0.9719   0.9770   0.9790   0.9800   0.9800   0.9800
0.9800   0.9800   0.9800
  0.7664   0.7664   0.9569   0.9719   0.9770   0.9790   0.9800   0.9800   0.9800
0.9800   0.9800   0.9790]';


%Add zero torque to the torque index
if min(gb.init.trq_eff_index)>0
  for cpt=1:gb.init.nb_ratio,
    eval(['gb.init.eff_trq_ratio',num2str(cpt),'_map =
[gb.init.eff_trq_ratio',num2str(cpt),'_map(1,:);gb.init.eff_trq_ratio',num2str(cpt),'_map]
;']);
```

```
   end
   gb.init.trq_eff_index=[0,gb.init.trq_eff_index];
end


for cpt=1:gb.init.nb_ratio,
   gb.init.eff_trq_map(:,:,cpt) =
eval(['gb.init.eff_trq_ratio',num2str(cpt),'_map']);%create the 3 dimensions (trq, spd,
ratio) map for trq loss
end
% calculate the torque losses
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
gb.init.trq_loss_index = gb.init.trq_eff_index;
gb.init.spd_loss_index = gb.init.spd_eff_index;
gb.init.coeff = gb.init.trq_eff_index(:)*ones(1,length(gb.init.spd_eff_index));
for cpt=1:gb.init.nb_ratio,
   eval(['gb.init.trq_loss_ratio',num2str(cpt),'_map = (1 -
gb.init.eff_trq_ratio',num2str(cpt),'_map) .* gb.init.coeff;']);%calculate trq loss per ratio
   gb.init.trq_loss_map(:,:,cpt) =
eval(['gb.init.trq_loss_ratio',num2str(cpt),'_map']);%create the 3 dimensions (trq, spd,
ratio) map for trq loss
end

% calculate the maximum efficiency
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
for cpt=1:gb.init.nb_ratio,
  gb.init.eff(cpt)=max(max(eval(['gb.init.eff_trq_ratio',num2str(cpt),'_map'])));
end
gb.init.eff_max=max(gb.init.eff);
clear cpt
```

Initialization file for final drive model

```
%% File description
% Name : fd_355_4WD_explorer
% Author : A.Rousseau - ANL
% Description : Initialize the final drive of the 4WD explorer
% Ratio = 3.55
% Proprietary : Public
% Model : lib_fd_map_trqloss_funTW
% Vehicle Type : Light

%% File content
fd.list.init = {'mass','ratio','inertia','spd_thresh'};

fd.init.ratio          = 3.55;
fd.init.inertia        = 0;
fd.init.mass           = 25;
fd.init.spd_thresh     = 10;

fd.init.trq_eff_index   =
[51.40,52.40,104.7,157.1,209.4,261.8,314.2,366.5,418.9,471.2,523.6];
fd.init.spd_eff_index   =
[0.500,6.000,33.90,67.80,101.7,135.6,169.5,203.4,237.3,271.2,305.1,339];
fd.init.eff_trq_map     = ones(size(fd.init.trq_eff_index,2),size(fd.init.spd_eff_index,2)).*
0.97;

fd.init.trq_loss_index  = fd.init.trq_eff_index;
fd.init.spd_loss_index  = fd.init.spd_eff_index;
fd.init.trq_loss_map    = zeros(length(fd.init.trq_loss_index),
length(fd.init.spd_loss_index));

% create final drive loss tables
for count=1:size(fd.init.trq_loss_index,2)
  for count2=1:size(fd.init.spd_loss_index,2)
    fd.init.trq_loss_map(count,count2) = (1-
fd.init.eff_trq_map(count,count2))*fd.init.trq_loss_index(count);
  end
  clear count2
end
clear count

% calculate the maximum efficiency
fd.init.eff_max=max(max(fd.init.eff_trq_map));
```

Initialization file for wheel/axle model

```
%% File description
% Name : wh_0305_P205_50_R16
% Author : Neeraj Shidore(ANL)
% Description : Initialize the P 195/60 R15
% Used for MATT
% Proprietary : Public
% Rolling resistance coefficients are estimated
% Proprietary : Public
% Model : lib_wh_2wd,lib_2wd_f0f1f2
% Vehicle Type : Light

%% File content
wh.list.init =
{'number_wheels','mass_per_wheel','trq_brake_max','inertia_per_wheel','theoretical_r
adius','radius_correction_factor','radius','coeff_roll1','coeff_roll2','coeff_roll3','coeff_roll
4'};

if strcmp(simulation.building.axle,'2 wheel drive'),
   wh.init.number_wheels = 4;
else
   wh.init.number_wheels = 2;
end

wh.init.trq_brake_max      = 2000;           % N-m
wh.init.inertia_per_wheel   = 1.0;           % kg-m^2
wh.init.theoretical_radius  =
overwrite_parameters('simulation.drivetrain.wh','theoretical_radius',0.3175);   % m
wh.init.radius_correction_factor = 0.95;      % correction factor used to take into
account the impact of vehicle weight on actual radius
wh.init.radius            = wh.init.theoretical_radius*wh.init.radius_correction_factor;
% m
wh.init.mass_per_wheel     = 25;            % kg
wh.init.spd_thresh        = 0.01;          % Parameter for the blending block used in rolling
resistance calculation.

% Rolling Resistance Coefficient as a polynomial function of speed.
% wh.init.coeff_roll1 + wh.init.coeff_roll2*w + wh.init.coeff_roll3*w^2 +
wh.init.coeff_roll4*w^3
wh.init.coeff_roll1 = 0.009;
wh.init.coeff_roll2 = 0.0003;
wh.init.coeff_roll3 = 0;
```

```
wh.init.coeff_roll4 = 0;

wh.init.friction_coefficient = [0.97 0.97 0.95 0.9 0.85  0.65 0.5 0.5 0.5 0.5];% values for
Dry Alsphalt
wh.init.vehicle_speed = conversion_calc('linear_speed','mile/h','m/s',[0 10 20 30 40 50
60 70 80 90]);
```

Initialization file for vehicle model

```
%% File description
% Name : veh_800_f0f1f2_ford_focus
% Author : A.Rousseau (ANL) % ABC modified by Neeraj 06/2004
% Description : Initialize the ford focus vehicle
% Body mass = 800 kg
% Proprietary : Public
% Model : lib_veh_curve_fit_losses_f0f1f2
% Vehicle Type : Light

%% File content
veh.list.init = {'body_mass','cargo_mass','f0','f1','f2','cg_height','ratio_weight_front'};

veh.init.body_mass              = 800;
veh.init.axle_base              = 2.7432;% Vehicle wheel base, (m)
veh.init.cg_height              = 0.508; % Vehicle CG height, (m)
veh.init.ratio_weight_front     = 0.65;%ratio of the weight to the front wheels
veh.init.ratio_weight_front     =
overwrite_parameters('simulation.drivetrain.veh','ratio_weight_front',veh.init.ratio_wei
ght_front);
veh.init.ratio_weight_rear      = (1-veh.init.ratio_weight_front);
veh.init.cargo_mass             = 136;

veh.init.f0 = 137.26;% Change made for the h2 ice focus- temporary
veh.init.f1 = 5.0545;
veh.init.f2 = 0.3670;
```

Initialization file for exhaust aftertreatment model

```
%% File description
% Name : ex_3c
% Author : A.Rousseau - ANL
% Description : Initialize the 3 way exhaust catalyst model
% Proprietary : Public
% Model :  lib_ex_3way_cat_map
% Technology : eh, 3c
% Vehicle Type : Light, Heavy

%% File content
ex.list.init =      {'ex_mass','temp_hot','on_temp','time_hot','time_cold','pwr'};

ex.init.temp_hot       = 450;  % temperature constant
ex.init.on_temp        = 290;  % catalyst ligth-off temperature in Degrees Celcius
ex.init.time_hot       = 20;       % time to reach light off (seconds)
ex.init.time_cold      = 3600; % time to cool down (seconds)
ex.init.ex_mass        = 30;
ex.init.pwr            = 500;

% Catalyst Data-preliminary internal
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%
ex.init.temp_eff_index  = [100:20:460];% Catalyst temperature (degrees Celcius)
ex.init.flow_coeff      = [1.0,1.01,1.12];% Exhaust equivalence ratio

% Efficiency Tables (HC, CO, NOx)
ex.init.hc_eff_map =...
      [0.00, 0.00, 0.00;
       0.00, 0.00, 0.00;
       0.00, 0.00, 0.00;
       0.00, 0.00, 0.00;
       0.00, 0.00, 0.00;
       0.00, 0.00, 0.00;
       0.01, 0.00, 0.00;
       0.04, 0.01, 0.01;
       0.13, 0.03, 0.03;
       0.36, 0.07, 0.07;
       0.68, 0.14, 0.14;
       0.88, 0.18, 0.18;
       0.95, 0.19, 0.19;
       0.97, 0.20, 0.20;
```

```
        0.98, 0.20, 0.20;
        0.98, 0.20, 0.20;
        0.98, 0.20, 0.20;
        0.98, 0.20, 0.20;
        0.98, 0.20, 0.20];

ex.init.co_eff_map =...
       [0.00, 0.00, 0.00;
        0.00, 0.00, 0.00;
        0.00, 0.00, 0.00;
        0.00, 0.00, 0.00;
        0.00, 0.00, 0.00;
        0.00, 0.00, 0.00;
        0.01, 0.00, 0.00;
        0.04, 0.00, 0.00;
        0.13, 0.00, 0.00;
        0.36, 0.00, 0.00;
        0.67, 0.00, 0.00;
        0.86, 0.00, 0.00;
        0.94, 0.00, 0.00;
        0.96, 0.00, 0.00;
        0.96, 0.00, 0.00;
        0.96, 0.00, 0.00;
        0.97, 0.00, 0.00;
        0.97, 0.00, 0.00;
        0.97, 0.00, 0.00];

ex.init.nox_eff_map =...
       [0.00, 0.00, 0.00;
        0.00, 0.00, 0.00;
        0.00, 0.00, 0.00;
        0.00, 0.00, 0.00;
        0.00, 0.00, 0.00;
        0.00, 0.00, 0.00;
        0.01, 0.01, 0.01;
        0.04, 0.03, 0.03;
        0.13, 0.11, 0.11;
        0.35, 0.30, 0.30;
        0.65, 0.56, 0.56;
        0.84, 0.73, 0.73;
        0.91, 0.79, 0.79;
        0.93, 0.81, 0.81;
```

0.93, 0.81, 0.81;
0.94, 0.82, 0.82;
0.94, 0.82, 0.82;
0.94, 0.82, 0.82;
0.94, 0.82, 0.82];

Initialization file for power converter model

```
%% File description
% Name : pc_090_12
% Author : Francois Besnier - ANL
% Description : Initialize the power converter model
% Efficiency = 0.9, Output voltage = 12V
% Proprietary : Public
% Model :
lib_pc_P2P_constant_eff,lib_pc_V2V_constant_eff,lib_pc_perc_constant_eff,lib_pc_P2V
_constant_eff
% Vehicle Type : Light

%% File content
pc.list.init = {'mass','eff','volt_out'};

pc.init.mass = 0;
pc.init.eff = 0.9;
pc.init.volt_out = 12;
```

Initialization file for electrical accessory model

```
%% File description
% Name : accelec_600
% Author : A.Rousseau - ANL
% Description : Initialize the electrical accessory power losses to 600W
% Proprietary: Public
% Model : lib_accelec_constant_pwrloss_volt_in,lib_accelec_constant_pwrloss_pwr_in
% Vehicle Type : Light

%% File content
accelec.list.init       = {'pwr','ess_12v_mass','acc_mass'};
accelec.init.pwr         = 600.0;
accelec.init.ess_12v_mass = 18;
accelec.init.acc_mass     = 0;
%accelec.init.mass       = 20;
```

Appendix C: Phase I Emissions Results

```
Test Info
   Test ID:                    60809016
   Test Start Time:            09/09/2008, 08:36:21 AM
   Test name:                  MATT
   Test Cycle File Name:       J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
   Test Save Location:         J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
   Dyno Config:      Rear                                          Vehicle Info
   Dyno Mode:   Road Load                                             Vehicle Name:          MATT
   Test Wt[lb]:      3125                                             Vehicle Odometer:         1
   Dyno Set A:    6.4842   Dyno Target A:  30.8500                    Vehicle Table #:         25
   Dyno Set B:    0.5415   Dyno Target B:   0.5080                    Vehicle VIN:            001
   Dyno Set C:    0.0145   Dyno Target C:   0.0165

Personel Info                         CVS Info                        Fuel Info
   Test Operator:      HLB               Bag Sample Flow #:       2      Fuel Name:    EPA Tier 2 EEE Cert Gasoline
   Test Driver:      dSPACE              Venturi #:               2      CWF:          0.8640
   Driver Error:     0.4756 MPH                                          Density:      0.7410 [g/ml]
                                                                         Net HV:     18386.00 [BTU/lbm]
------------------------------------------------------------------------------------------------------------------------------
Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi
------------------------------------------------------------------------------------------------------------------------------

Summary Info:        THC        CH4        NMHC        NOx        COlow      COmid      CO2        HTHC     FE [MPG]
---[g/mi]----    ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
1                  -0.0002    -0.0000    -0.0002    -0.0002     0.0015     0.0047      -0.08        NaN  -107151.9
2                  -0.0000     0.0001    -0.0001    -0.0003     0.0004     0.0134      -0.30        NaN  -29822.65
1+2                -0.0001     0.0000    -0.0001    -0.0002     0.0010     0.0092      -0.20        NaN  -45679.89
------------------------------------------------------------------------------------------------------------------------------

                 THC        CH4        NMHC        NOx       COlow      COmid       CO2       HTHC        Phase 1 Results           Phase 1 Weather Info
Bag 1          [ppmC3]     [ppm]                  [ppm]      [ppm]      [ppm]      [ppm]      [ppm]     -----------------------   ----------------------
---------    ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------    Vmix[m^3]    =   45.4220   Baro[mmHg] =    749.56
Ambient:        0.8454     1.9736  ---------     0.0171     0.1556     1.0959     401.80     1.1298    1-1/DF       =    0.9970   Temp[C]    =     22.50
Sample:         0.8166     1.9644  ---------     0.0094     0.2574     1.4063     396.97        NaN    Elapsed[s]   =    506.00   Rel Hum[%] =     43.87
-----------------------------------------------------------------------------------------------------  Dist [mi]    =    3.5614   NOx Corr   =    0.9058
g/mi:          -0.0002    -0.0000    -0.0002    -0.0002     0.0015     0.0047      -0.08    -0.0083    F.E. [MPG]   = -107151.9
------------------------------------------------------------------------------------------------------------------------------

                 THC        CH4        NMHC        NOx       COlow      COmid       CO2       HTHC        Phase 2 Results           Phase 2 Weather Info
Bag 2          [ppmC3]     [ppm]                  [ppm]      [ppm]      [ppm]      [ppm]      [ppm]     -----------------------   ----------------------
---------    ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------    Vmix[m^3]    =   77.7950   Baro[mmHg] =    749.64
Ambient:        0.8093     1.9604  ---------     0.0179     0.1901     0.6109     400.46     1.1298    1-1/DF       =    0.9971   Temp[C]    =     22.48
Sample:         0.8027     1.9619  ---------     0.0092     0.2075     1.1778     391.22        NaN    Elapsed[s]   =    866.80   Rel Hum[%] =     43.61
-----------------------------------------------------------------------------------------------------  Dist [mi]    =    3.8426   NOx Corr   =    0.9044
g/mi:          -0.0000     0.0001    -0.0001    -0.0003     0.0004     0.0134      -0.30    -0.0131    F.E. [MPG]   = -29822.65
------------------------------------------------------------------------------------------------------------------------------

Modal Calcs           THC        CH4        NMHC        NOx       COlow      COmid       CO2        HTHC    Fuel Econ [MPG]
------------      ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Backgrd [ppm]:       0.8816     1.9570  ---------     0.0303     0.1837    -0.6805     400.74  ---------
------------      ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Phase 1 [g/mi:      -0.0006     0.0000    -0.0006    -0.0003    -0.0001     0.0115       0.01    -0.0083  1830307.9
Phase 2 [g/mi:      -0.0011     0.0001    -0.0012    -0.0007    -0.0012     0.0331      -0.11    -0.0131  -77881.68
------------------------------------------------------------------------------------------------------------------------
Start Comments:

Full charge test / Max depletion / Load following
```

Test Info
Test ID: 60809017
Test Start Time: 09/09/2008, 09:07:00 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.5136 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 2

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	1.1333	0.0003	1.1332	-0.0002	0.0030	0.0027	0.19	NaN	2287.68
2	0.0430	0.0002	0.0429	-0.0003	0.0008	-0.0013	0.08	NaN	39923.77
1+2	0.5676	0.0002	0.5675	-0.0003	0.0019	0.0006	0.13	NaN	4478.12

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7974	1.9362	---------	0.0107	0.1929	-0.0896	403.90	0.8612
Sample:	155.1100	1.9607	---------	0.0012	0.3923	0.0963	409.33	NaN
g/mi:	1.1333	0.0003	1.1332	-0.0002	0.0030	0.0027	0.19	-0.0063

Phase 1 Results
Vmix[m^3] = 45.4270
1-1/DF = 0.9935
Elapsed[s] = 506.00
Dist [mi] = 3.5672
F.E. [MPG] = 2287.68

Phase 1 Weather Info
Baro[mmHg] = 749.69
Temp[C] = 22.53
Rel Hum[%] = 42.26
NOx Corr = 0.8986

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7901	1.9333	---------	0.0108	0.1617	-0.8270	394.90	0.8612
Sample:	4.4734	1.9398	---------	0.0013	0.1971	-0.8802	395.89	NaN
g/mi:	0.0430	0.0002	0.0429	-0.0003	0.0008	-0.0013	0.08	-0.0100

Phase 2 Results
Vmix[m^3] = 77.7980
1-1/DF = 0.9969
Elapsed[s] = 866.80
Dist [mi] = 3.8471
F.E. [MPG] = 39923.77

Phase 2 Weather Info
Baro[mmHg] = 749.72
Temp[C] = 22.40
Rel Hum[%] = 43.31
NOx Corr = 0.9019

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7894	1.9521	---------	0.0117	0.1698	0.2456	405.39	---------	
Phase 1 [g/mi:	1.1387	0.0001	1.1387	-0.0001	0.0025	-0.0045	0.04	-0.0063	2369.24
Phase 2 [g/mi:	0.0412	-0.0001	0.0413	-0.0003	-0.0009	-0.0159	-0.25	-0.0100	-78433.77

Start Comments:

Max depletion / Load Flowwing / SOC in it 65.4%

Test Info
Test ID: 60809018
Test Start Time: 09/09/2008, 09:48:48 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.4673 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 2

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.3465	0.0103	0.3430	0.0058	2.8689	2.8770	134.23	NaN	63.58
2	0.0110	0.0036	0.0098	0.0023	2.8651	2.8809	305.23	NaN	28.71
1+2	0.1724	0.0068	0.1701	0.0040	2.8669	2.8790	222.96	NaN	39.00

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.8097	1.9297	---------	0.0243	0.3453	0.6323	405.13	0.8820
Sample:	47.9570	3.0422	---------	0.2910	193.8500	194.6700	6147.50	NaN
g/mi:	0.3465	0.0103	0.3430	0.0058	2.8689	2.8770	134.23	-0.0062

Phase 1 Results
Vmix[m^3] = 45.4430
1-1/DF = 0.9516
Elapsed[s] = 506.00
Dist [mi] = 3.5691
F.E. [MPG] = 63.58

Phase 1 Weather Info
Baro[mmHg] = 749.80
Temp[C] = 22.49
Rel Hum[%] = 41.72
NOx Corr = 0.8957

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.8025	1.9223	---------	0.0264	0.3984	0.3521	391.46	0.8820
Sample:	1.6921	2.0652	---------	0.0915	122.0600	122.6900	8615.80	NaN
g/mi:	0.0110	0.0036	0.0098	0.0023	2.8651	2.8809	305.23	-0.0096

Phase 2 Results
Vmix[m^3] = 77.8400
1-1/DF = 0.9348
Elapsed[s] = 866.80
Dist [mi] = 3.8493
F.E. [MPG] = 28.71

Phase 2 Weather Info
Baro[mmHg] = 749.81
Temp[C] = 22.65
Rel Hum[%] = 42.15
NOx Corr = 0.8995

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8120	1.9330	---------	0.0344	0.2863	-0.2384	390.85	---------	
Phase 1 [g/mi:	0.3578	0.0105	0.3543	0.0059	2.7979	2.8754	135.29	-0.0062	63.13
Phase 2 [g/mi:	0.0067	0.0034	0.0056	0.0024	2.8268	2.8739	304.59	-0.0096	28.77

Start Comments:

Max depletion / Load following / SOC init 39.8

Test Info
Test ID: 60809019
Test Start Time: 09/09/2008, 10:21:30 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.3814 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 2

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0185	0.0079	0.0159	0.0006	2.7368	2.7451	312.19	NaN	28.09
2	0.0013	0.0016	0.0008	0.0041	1.8087	1.8279	294.66	NaN	29.89
1+2	0.0096	0.0047	0.0081	0.0024	2.2553	2.2693	303.10	NaN	29.00

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7596	1.9241	---------	0.0244	0.2867	0.5323	404.79	0.8562
Sample:	3.2033	2.6575	---------	0.0481	184.9400	185.7200	13769.00	NaN
g/mi:	0.0185	0.0079	0.0159	0.0006	2.7368	2.7451	312.19	-0.0056

Phase 1 Results		
Vmix[m^3]	=	45.4570
1-1/DF	=	0.8958
Elapsed[s]	=	506.00
Dist [mi]	=	3.5715
F.E. [MPG]	=	28.09

Phase 1 Weather Info		
Baro[mmHg]	=	750.03
Temp[C]	=	22.21
Rel Hum[%]	=	44.26
NOx Corr	=	0.9039

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7517	1.9130	---------	0.0201	0.1972	0.0629	408.76	0.8562
Sample:	0.8191	1.9115	---------	0.1378	76.9930	77.6820	8346.10	NaN
g/mi:	0.0013	0.0016	0.0008	0.0041	1.8087	1.8279	294.66	-0.0094

Phase 2 Results		
Vmix[m^3]	=	77.8700
1-1/DF	=	0.9371
Elapsed[s]	=	866.90
Dist [mi]	=	3.8503
F.E. [MPG]	=	29.89

Phase 2 Weather Info		
Baro[mmHg]	=	750.09
Temp[C]	=	22.40
Rel Hum[%]	=	43.20
NOx Corr	=	0.9014

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8907	1.9333	---------	0.0319	0.2580	0.2004	393.19	---------	
Phase 1 [g/mi]:	0.0154	0.0080	0.0127	0.0005	2.6824	2.7278	314.76	-0.0056	27.87
Phase 2 [g/mi]:	-0.0004	0.0013	-0.0009	0.0039	1.7764	1.8098	293.73	-0.0094	29.99

Start Comments:

Max depletion test / Load following / SOC init 29.7%

Test Info
- Test ID: 60809020
- Test Start Time: 09/09/2008, 11:07:34 AM
- Test name: MATT
- Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
- Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
- Dyno Config: Rear
- Dyno Mode: Road Load
- Test Wt[lb]: 3125
- Dyno Set A: 6.4842 Dyno Target A: 30.8500
- Dyno Set B: 0.5415 Dyno Target B: 0.5080
- Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
- Vehicle Name: MATT
- Vehicle Odometer: 1
- Vehicle Table #: 25
- Vehicle VIN: 001

Personel Info
- Test Operator: HLB
- Test Driver: dSPACE
- Driver Error: 0.3828 MPH

CVS Info
- Bag Sample Flow #: 2
- Venturi #: 2

Fuel Info
- Fuel Name: EPA Tier 2 EEE Cert Gasoline
- CWF: 0.8640
- Density: 0.7410 [g/ml]
- Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0118	0.0070	0.0095	0.0001	2.9664	2.9674	308.97	NaN	28.35
2	0.0009	0.0017	0.0003	0.0027	1.7615	1.7623	294.20	NaN	29.94
1+2	0.0062	0.0042	0.0047	0.0015	2.3412	2.3422	301.30	NaN	29.15

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7590	1.9183	---------	0.0164	0.2096	0.9601	390.85	0.8470
Sample:	2.2922	2.5414	---------	0.0194	200.4800	201.2200	13626.00	NaN
g/mi:	0.0118	0.0070	0.0095	0.0001	2.9664	2.9674	308.97	-0.0056

Phase 1 Results	
Vmix[m^3] =	45.4300
1-1/DF =	0.8968
Elapsed[s] =	506.00
Dist [mi] =	3.5715
F.E. [MPG] =	28.35

Phase 1 Weather Info	
Baro[mmHg] =	750.15
Temp[C] =	22.18
Rel Hum[%] =	41.85
NOx Corr =	0.8926

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7522	1.8973	---------	0.0160	0.1884	-0.0073	381.20	0.8470
Sample:	0.7832	1.9038	---------	0.0933	75.0070	74.8600	8310.50	NaN
g/mi:	0.0009	0.0017	0.0003	0.0027	1.7615	1.7623	294.20	-0.0092

Phase 2 Results	
Vmix[m^3] =	77.8600
1-1/DF =	0.9374
Elapsed[s] =	866.80
Dist [mi] =	3.8511
F.E. [MPG] =	29.94

Phase 2 Weather Info	
Baro[mmHg] =	750.04
Temp[C] =	22.35
Rel Hum[%] =	41.44
NOx Corr =	0.8927

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7698	1.9176	---------	0.0242	0.1715	-0.6861	378.52	---------	
Phase 1 [g/mi:	0.0112	0.0072	0.0088	0.0001	2.9046	2.9601	311.30	-0.0056	28.15
Phase 2 [g/mi:	0.0006	0.0014	0.0001	0.0027	1.7313	1.7686	293.23	-0.0092	30.05

Start Comments:

Max depletion / Load following / SOC init 29.7 same as last time

Test Info

- Test ID: 60809023
- Test Start Time: 09/10/2008, 08:39:15 AM
- Test name: MATT
- Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
- Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup

- Dyno Config: Rear
- Dyno Mode: Road Load
- Test Wt[lb]: 3125
- Dyno Set A: 6.4842 Dyno Target A: 30.8500
- Dyno Set B: 0.5415 Dyno Target B: 0.5080
- Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info

- Vehicle Name: MATT
- Vehicle Odometer: 1
- Vehicle Table #: 25
- Vehicle VIN: 001

Personel Info

- Test Operator: HLB
- Test Driver: dSPACE
- Driver Error: 0.4426 MPH

CVS Info

- Bag Sample Flow #: 2
- Venturi #: 2

Fuel Info

- Fuel Name: EPA Tier 2 EEE Cert Gasoline
- CWF: 0.8640
- Density: 0.7410 [g/ml]
- Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0764	0.0390	0.0634	0.0137	8.2017	8.3347	239.14	NaN	35.25
2	0.0034	0.0020	0.0028	-0.0002	0.2738	0.2881	5.34	NaN	1537.35
1+2	0.0386	0.0198	0.0320	0.0065	4.0877	4.1591	117.82	NaN	71.50

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.8124	2.0381	---------	0.0252	0.2359	1.3697	410.71	1.0691
Sample:	11.1150	6.4339	---------	0.6444	551.4800	561.4600	10605.00	NaN
g/mi:	0.0764	0.0390	0.0634	0.0137	8.2017	8.3347	239.14	-0.0072

Phase 1 Results	
Vmix[m^3] =	45.5010
1-1/DF =	0.9165
Elapsed[s] =	506.00
Dist [mi] =	3.5608
F.E. [MPG] =	35.25

Phase 1 Weather Info	
Baro[mmHg] =	751.61
Temp[C] =	22.66
Rel Hum[%] =	43.19
NOx Corr =	0.9040

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.8093	2.0286	---------	0.0191	0.2893	0.9360	409.08	1.0691
Sample:	1.1000	2.1659	---------	0.0121	11.8640	13.1100	551.07	NaN
g/mi:	0.0034	0.0020	0.0028	-0.0002	0.2738	0.2881	5.34	-0.0125

Phase 2 Results	
Vmix[m^3] =	78.0410
1-1/DF =	0.9958
Elapsed[s] =	866.90
Dist [mi] =	3.8411
F.E. [MPG] =	1537.35

Phase 2 Weather Info	
Baro[mmHg] =	751.60
Temp[C] =	22.39
Rel Hum[%] =	44.23
NOx Corr =	0.9056

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8188	2.0462	---------	0.0280	0.1885	0.1575	402.87	---------	
Phase 1 [g/mi:	0.0782	0.0400	0.0649	0.0144	8.1369	8.4437	242.54	-0.0072	34.79
Phase 2 [g/mi:	0.0028	0.0017	0.0023	-0.0006	0.2721	0.2956	4.45	-0.0125	1821.25

Start Comments:

Max depletion / Eng pot / SOC init 90%

Test Info

Test ID: 60809024
Test Start Time: 09/10/2008, 09:21:54 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup

Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info

Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info

Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.4086 MPH

CVS Info

Bag Sample Flow #: 2
Venturi #: 2

Fuel Info

Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0318	0.0072	0.0294	0.0292	1.7897	1.7937	171.78	NaN	50.90
2	0.0004	0.0002	0.0003	-0.0003	0.0073	0.0357	2.09	NaN	4233.24
1+2	0.0155	0.0036	0.0143	0.0139	0.8652	0.8819	83.77	NaN	104.39

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7891	2.0029	---------	0.0243	0.3618	-0.4140	405.12	0.9081
Sample:	5.0622	2.7275	---------	1.3610	120.8400	120.3800	7741.50	NaN
g/mi:	0.0318	0.0072	0.0294	0.0292	1.7897	1.7937	171.78	-0.0063

Phase 1 Results	
Vmix[m^3] =	45.5090
1-1/DF =	0.9412
Elapsed[s] =	506.00
Dist [mi] =	3.5676
F.E. [MPG] =	50.90

Phase 1 Weather Info	
Baro[mmHg] =	751.49
Temp[C] =	22.23
Rel Hum[%] =	42.50
NOx Corr =	0.8958

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7875	1.9801	---------	0.0239	0.2720	-1.1766	397.27	0.9081
Sample:	0.8152	1.9871	---------	0.0150	0.5780	0.3358	452.14	NaN
g/mi:	0.0004	0.0002	0.0003	-0.0003	0.0073	0.0357	2.09	-0.0106

Phase 2 Results	
Vmix[m^3] =	78.0300
1-1/DF =	0.9966
Elapsed[s] =	866.80
Dist [mi] =	3.8440
F.E. [MPG] =	4233.24

Phase 2 Weather Info	
Baro[mmHg] =	751.53
Temp[C] =	22.39
Rel Hum[%] =	43.12
NOx Corr =	0.9004

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8058	2.0073	---------	0.0403	0.2974	-0.2739	395.87	---------	
Phase 1 [g/mi:	0.0324	0.0073	0.0299	0.0306	1.7414	1.7660	171.15	-0.0063	51.11
Phase 2 [g/mi:	-0.0002	-0.0002	-0.0001	-0.0009	0.0029	-0.0029	1.91	-0.0106	4638.47

Start Comments:

Start SOC 74.1

Test Info

Test ID: 60809025
Test Start Time: 09/10/2008, 10:01:53 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup

Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info

Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info

Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.5170 MPH

CVS Info

Bag Sample Flow #: 2
Venturi #: 2

Fuel Info

Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

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Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0202	0.0092	0.0171	0.0044	2.5563	2.5745	182.62	NaN	47.63
2	0.0001	0.0001	0.0000	-0.0004	0.0049	0.0045	1.48	NaN	5992.93
1+2	0.0097	0.0045	0.0082	0.0019	1.2331	1.2417	88.67	NaN	98.10

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7770	1.9645	---------	0.0167	0.3319	0.4169	400.99	0.9041
Sample:	3.4717	2.9215	---------	0.2167	172.4800	173.7900	8202.90	NaN
g/mi:	0.0202	0.0092	0.0171	0.0044	2.5563	2.5745	182.62	-0.0062

Phase 1 Results	
Vmix[m^3] =	45.5120
1-1/DF =	0.9374
Elapsed[s] =	506.00
Dist [mi] =	3.5690
F.E. [MPG] =	47.63

Phase 1 Weather Info	
Baro[mmHg] =	751.56
Temp[C] =	22.86
Rel Hum[%] =	42.30
NOx Corr =	0.9023

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7667	1.9350	---------	0.0199	0.3783	0.9771	407.74	0.9041
Sample:	0.7698	1.9384	---------	0.0095	0.5853	1.1651	446.12	NaN
g/mi:	0.0001	0.0001	0.0000	-0.0004	0.0049	0.0045	1.48	-0.0105

Phase 2 Results	
Vmix[m^3] =	78.0330
1-1/DF =	0.9966
Elapsed[s] =	866.80
Dist [mi] =	3.8451
F.E. [MPG] =	5992.93

Phase 2 Weather Info	
Baro[mmHg] =	751.56
Temp[C] =	22.38
Rel Hum[%] =	41.92
NOx Corr =	0.8948

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7928	1.9707	---------	0.0295	0.3240	0.4587	403.07	---------	
Phase 1 [g/mi:	0.0199	0.0094	0.0167	0.0045	2.4757	2.5252	180.54	-0.0062	48.20
Phase 2 [g/mi:	-0.0003	-0.0004	-0.0002	-0.0006	0.0031	0.0045	1.62	-0.0105	5467.53

Start Comments:

EV full test / Load following / SOC init 5

Test Info
Test ID: 60809026
Test Start Time: 09/10/2008, 10:40:28 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.4295 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 2

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0202	0.0087	0.0173	0.0041	2.5620	2.5849	186.24	NaN	46.72
2	0.0028	0.0043	0.0014	0.0013	1.4172	1.4019	145.01	NaN	60.39
1+2	0.0112	0.0064	0.0091	0.0027	1.9680	1.9711	164.85	NaN	52.94

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7492	1.8999	---------	0.0126	0.3835	0.1985	354.17	0.8778
Sample:	3.4520	2.8060	---------	0.1986	173.0200	174.3900	8319.00	NaN
g/mi:	0.0202	0.0087	0.0173	0.0041	2.5620	2.5849	186.24	-0.0060

Phase 1 Results	
Vmix[m^3] =	45.5140
1-1/DF =	0.9365
Elapsed[s] =	506.00
Dist [mi] =	3.5714
F.E. [MPG] =	46.72

Phase 1 Weather Info	
Baro[mmHg] =	751.45
Temp[C] =	22.10
Rel Hum[%] =	43.11
NOx Corr =	0.8970

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7390	1.8998	---------	0.0156	0.3597	1.0814	347.82	0.8778
Sample:	0.9588	2.1576	---------	0.0534	60.4310	60.4820	4248.80	NaN
g/mi:	0.0028	0.0043	0.0014	0.0013	1.4172	1.4019	145.01	-0.0099

Phase 2 Results	
Vmix[m^3] =	78.0070
1-1/DF =	0.9678
Elapsed[s] =	866.90
Dist [mi] =	3.8507
F.E. [MPG] =	60.39

Phase 2 Weather Info	
Baro[mmHg] =	751.33
Temp[C] =	22.29
Rel Hum[%] =	42.77
NOx Corr =	0.8977

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7556	1.9078	---------	0.0257	0.2076	-1.4770	382.77	---------	
Phase 1 [g/mi]:	0.0202	0.0088	0.0173	0.0043	2.4646	2.5400	185.22	-0.0060	47.01
Phase 2 [g/mi]:	0.0025	0.0043	0.0010	0.0012	1.3810	1.4473	147.03	-0.0099	59.60

Start Comments:

start SOC 40.9

Test Info
Test ID: 60809027
Test Start Time: 09/10/2008, 11:11:23 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.3757 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 2

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

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Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0065	0.0056	0.0046	0.0021	2.2453	2.2527	307.96	NaN	28.55
2	0.0009	0.0021	0.0002	0.0024	1.9613	1.9385	289.21	NaN	30.42
1+2	0.0036	0.0038	0.0023	0.0023	2.0979	2.0897	298.23	NaN	29.49

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7465	1.8910	---------	0.0121	0.2266	0.4453	386.56	0.8838
Sample:	1.5546	2.3528	---------	0.1072	151.6400	152.3400	13565.00	NaN
g/mi:	0.0065	0.0056	0.0046	0.0021	2.2453	2.2527	307.96	-0.0058

Phase 1 Results
Vmix[m^3] = 45.4970
1-1/DF = 0.8976
Elapsed[s] = 506.00
Dist [mi] = 3.5729
F.E. [MPG] = 28.55

Phase 1 Weather Info
Baro[mmHg] = 751.19
Temp[C] = 22.61
Rel Hum[%] = 43.35
NOx Corr = 0.9043

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7499	1.8883	---------	0.0131	0.1573	1.1471	383.72	0.8838
Sample:	0.7796	1.9280	---------	0.0800	83.3750	83.3380	8170.00	NaN
g/mi:	0.0009	0.0021	0.0002	0.0024	1.9613	1.9385	289.21	-0.0097

Phase 2 Results
Vmix[m^3] = 77.9750
1-1/DF = 0.9384
Elapsed[s] = 866.80
Dist [mi] = 3.8527
F.E. [MPG] = 30.42

Phase 2 Weather Info
Baro[mmHg] = 751.09
Temp[C] = 22.64
Rel Hum[%] = 44.61
NOx Corr = 0.9107

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7557	1.8965	---------	0.0167	0.2052	0.2536	377.04	---------	
Phase 1 [g/mi:	0.0063	0.0056	0.0044	0.0022	2.1896	2.2279	310.48	-0.0058	28.32
Phase 2 [g/mi:	0.0007	0.0020	0.0000	0.0025	1.9325	1.9533	288.49	-0.0097	30.50

Start Comments:

start SOC 29.5

Test Info
Test ID: 60809028
Test Start Time: 09/10/2008, 01:52:04 PM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.5106 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 2

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0879	0.0448	0.0730	0.0158	7.5119	7.6393	208.52	NaN	40.31
2	0.0030	0.0021	0.0023	0.0002	0.3243	0.3496	5.39	NaN	1504.34
1+2	0.0438	0.0227	0.0363	0.0077	3.7817	3.8560	103.10	NaN	81.44

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7515	1.9188	---------	-0.0127	0.2626	1.1813	405.65	0.9470
Sample:	12.6600	7.0406	---------	0.7107	506.4200	515.8500	9317.30	NaN
g/mi:	0.0879	0.0448	0.0730	0.0158	7.5119	7.6393	208.52	-0.0064

Phase 1 Results	
Vmix[m^3] =	45.4230
1-1/DF =	0.9264
Elapsed[s] =	506.00
Dist [mi] =	3.5637
F.E. [MPG] =	40.31

Phase 1 Weather Info	
Baro[mmHg] =	749.98
Temp[C] =	22.40
Rel Hum[%] =	42.27
NOx Corr =	0.8970

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7534	1.9135	---------	-0.0187	0.1427	1.3506	397.41	0.9470
Sample:	1.0047	2.0637	---------	-0.0121	13.8980	16.1740	541.29	NaN
g/mi:	0.0030	0.0021	0.0023	0.0002	0.3243	0.3496	5.39	-0.0110

Phase 2 Results	
Vmix[m^3] =	77.8550
1-1/DF =	0.9958
Elapsed[s] =	866.80
Dist [mi] =	3.8450
F.E. [MPG] =	1504.34

Phase 2 Weather Info	
Baro[mmHg] =	749.88
Temp[C] =	22.50
Rel Hum[%] =	42.06
NOx Corr =	0.8973

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7421	1.9121	---------	-0.0029	0.2797	0.6471	405.70	---------	
Phase 1 [g/mi:	0.0894	0.0458	0.0741	0.0161	7.3251	7.6252	207.95	-0.0064	40.46
Phase 2 [g/mi:	0.0027	0.0021	0.0020	-0.0004	0.3119	0.3405	4.93	-0.0110	1637.87

Start Comments:

Repeat of first CS from AM

Test Info
- Test ID: 60809029
- Test Start Time: 09/10/2008, 02:38:09 PM
- Test name: MATT
- Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
- Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
- Dyno Config: Rear
- Dyno Mode: Road Load
- Test Wt[lb]: 3125
- Dyno Set A: 6.4842 Dyno Target A: 30.8500
- Dyno Set B: 0.5415 Dyno Target B: 0.5080
- Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
- Vehicle Name: MATT
- Vehicle Odometer: 1
- Vehicle Table #: 25
- Vehicle VIN: 001

Personel Info
- Test Operator: HLB
- Test Driver: dSPACE
- Driver Error: 0.3708 MPH

CVS Info
- Bag Sample Flow #: 2
- Venturi #: 2

Fuel Info
- Fuel Name: EPA Tier 2 EEE Cert Gasoline
- CWF: 0.8640
- Density: 0.7410 [g/ml]
- Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

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Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0331	0.0103	0.0297	0.0130	2.6533	2.6796	187.99	NaN	46.25
2	0.0041	0.0040	0.0028	0.0003	1.4295	1.4602	147.73	NaN	59.28
1+2	0.0181	0.0070	0.0157	0.0064	2.0180	2.0466	167.09	NaN	52.21

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7592	1.9068	---------	0.0128	0.2579	-0.4456	400.26	0.8868
Sample:	5.2264	2.9898	---------	0.6019	179.3900	180.5100	8451.90	NaN
g/mi:	0.0331	0.0103	0.0297	0.0130	2.6533	2.6796	187.99	-0.0061

Phase 1 Results	
Vmix[m^3] =	45.3990
1-1/DF =	0.9355
Elapsed[s] =	506.00
Dist [mi] =	3.5690
F.E. [MPG] =	46.25

Phase 1 Weather Info	
Baro[mmHg] =	749.66
Temp[C] =	22.44
Rel Hum[%] =	44.06
NOx Corr =	0.9059

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7559	1.9136	---------	0.0073	0.1504	-0.1055	393.90	0.8868
Sample:	1.0852	2.1486	---------	0.0165	60.9340	61.9930	4378.70	NaN
g/mi:	0.0041	0.0040	0.0028	0.0003	1.4295	1.4602	147.73	-0.0100

Phase 2 Results	
Vmix[m^3] =	77.8160
1-1/DF =	0.9668
Elapsed[s] =	866.80
Dist [mi] =	3.8529
F.E. [MPG] =	59.28

Phase 2 Weather Info	
Baro[mmHg] =	749.59
Temp[C] =	22.23
Rel Hum[%] =	44.21
NOx Corr =	0.9040

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7654	1.9133	---------	0.0162	0.1607	0.5315	382.04	---------	
Phase 1 [g/mi:	0.0336	0.0104	0.0301	0.0137	2.5617	2.6295	187.08	-0.0061	46.50
Phase 2 [g/mi:	0.0038	0.0042	0.0024	-0.0000	1.4053	1.4113	151.59	-0.0100	57.81

Start Comments:

Lower depletion rate cont with eng opt (part3 revious UDDS / start part2)

Test Info
Test ID: 60809030
Test Start Time: 09/10/2008, 03:13:49 PM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.3922 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 2

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0305	0.0092	0.0274	0.0016	2.8941	2.9057	410.44	NaN	21.42
2	0.0009	0.0017	0.0004	0.0003	0.6213	0.6245	135.11	NaN	65.34
1+2	0.0152	0.0053	0.0134	0.0009	1.7157	1.7230	267.69	NaN	32.88

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7485	1.9022	---------	0.0093	0.3329	-0.3883	377.46	0.9271
Sample:	4.8090	2.7293	---------	0.0830	196.0500	196.2100	17993.00	NaN
g/mi:	0.0305	0.0092	0.0274	0.0016	2.8941	2.9057	410.44	-0.0058

Phase 1 Results	
Vmix[m^3] =	45.4270
1-1/DF =	0.8642
Elapsed[s] =	506.00
Dist [mi] =	3.5776
F.E. [MPG] =	21.42

Phase 1 Weather Info	
Baro[mmHg] =	749.29
Temp[C] =	22.17
Rel Hum[%] =	43.33
NOx Corr =	0.8993

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7532	1.8888	---------	0.0110	0.1865	0.1547	386.01	0.9271
Sample:	0.8094	1.9539	---------	0.0181	26.5900	26.6990	4029.20	NaN
g/mi:	0.0009	0.0017	0.0004	0.0003	0.6213	0.6245	135.11	-0.0105

Phase 2 Results	
Vmix[m^3] =	77.8300
1-1/DF =	0.9697
Elapsed[s] =	866.80
Dist [mi] =	3.8522
F.E. [MPG] =	65.34

Phase 2 Weather Info	
Baro[mmHg] =	749.21
Temp[C] =	22.22
Rel Hum[%] =	42.93
NOx Corr =	0.8981

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7498	1.8893	---------	0.0172	0.1916	-1.2902	403.81	---------	
Phase 1 [g/mi:	0.0310	0.0095	0.0278	0.0015	2.8718	2.9128	418.25	-0.0058	21.03
Phase 2 [g/mi:	0.0006	0.0015	0.0001	-0.0000	0.6079	0.6372	136.92	-0.0105	64.49

Start Comments:

Lower depletion rat cont with eng opt / SOC init 30.5

Test Info
- Test ID: 60809031
- Test Start Time: 09/11/2008, 09:01:21 AM
- Test name: MATT
- Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
- Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
- Dyno Config: Rear
- Dyno Mode: Road Load
- Test Wt[lb]: 3125
- Dyno Set A: 6.4842 Dyno Target A: 30.8500
- Dyno Set B: 0.5415 Dyno Target B: 0.5080
- Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
- Vehicle Name: MATT
- Vehicle Odometer: 1
- Vehicle Table #: 25
- Vehicle VIN: 001

Personel Info
- Test Operator: HLB
- Test Driver: dSPACE
- Driver Error: 0.3588 MPH

CVS Info
- Bag Sample Flow #: 2
- Venturi #: 2

Fuel Info
- Fuel Name: EPA Tier 2 EEE Cert Gasoline
- CWF: 0.8640
- Density: 0.7410 [g/ml]
- Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.1371	0.0382	0.1244	0.1836	3.4184	3.4500	211.76	NaN	40.87
2	0.0073	0.0046	0.0058	-0.0009	0.6980	0.7151	129.92	NaN	67.86
1+2	0.0698	0.0208	0.0629	0.0879	2.0073	2.0314	169.31	NaN	51.49

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7804	1.8900	---------	-0.0017	0.3089	-0.0007	399.97	1.0679
Sample:	19.4450	6.2507	---------	8.3547	231.5100	233.3600	9485.70	NaN
g/mi:	0.1371	0.0382	0.1244	0.1836	3.4184	3.4500	211.76	-0.0072

Phase 1 Results
- Vmix[m^3] = 45.3920
- 1-1/DF = 0.9270
- Elapsed[s] = 506.00
- Dist [mi] = 3.5748
- F.E. [MPG] = 40.87

Phase 1 Weather Info
- Baro[mmHg] = 748.87
- Temp[C] = 22.15
- Rel Hum[%] = 44.57
- NOx Corr = 0.9049

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7725	1.8941	---------	0.0536	0.3834	-0.3481	408.25	1.0679
Sample:	1.3791	2.1815	---------	0.0251	30.0900	30.1070	3916.10	NaN
g/mi:	0.0073	0.0046	0.0058	-0.0009	0.6980	0.7151	129.92	-0.0120

Phase 2 Results
- Vmix[m^3] = 77.7290
- 1-1/DF = 0.9705
- Elapsed[s] = 866.90
- Dist [mi] = 3.8530
- F.E. [MPG] = 67.86

Phase 2 Weather Info
- Baro[mmHg] = 748.84
- Temp[C] = 22.10
- Rel Hum[%] = 44.94
- NOx Corr = 0.9059

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7590	1.8824	---------	-0.0012	0.4074	-1.9395	392.45	---------	
Phase 1 [g/mi:	0.1436	0.0398	0.1304	0.1811	3.1722	3.4117	214.01	-0.0072	40.52
Phase 2 [g/mi:	0.0066	0.0047	0.0050	0.0008	0.6853	0.7222	132.80	-0.0120	66.41

Start Comments:

Max depletion (take EV runs from first full charge) / did an EV warm up 50-60 mph for 5-10 min / Soc init 39.7

Test Info

Test ID: 60809032
Test Start Time: 09/11/2008, 09:41:08 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup

Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info

Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info

Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.3956 MPH

CVS Info

Bag Sample Flow #: 2
Venturi #: 2

Fuel Info

Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0780	0.0464	0.0625	0.0041	4.1093	4.1441	404.17	NaN	21.64
2	0.0016	0.0028	0.0007	0.0029	0.8731	0.8476	128.14	NaN	68.66
1+2	0.0384	0.0238	0.0305	0.0035	2.4316	2.4352	261.07	NaN	33.55

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7755	1.9394	---------	0.0170	0.3359	0.6273	400.02	0.9271
Sample:	11.3310	7.1553	---------	0.2025	278.4000	281.0100	17753.00	NaN
g/mi:	0.0780	0.0464	0.0625	0.0041	4.1093	4.1441	404.17	-0.0059

Phase 1 Results	
Vmix[m^3] =	45.4150
1-1/DF =	0.8652
Elapsed[s] =	506.00
Dist [mi] =	3.5787
F.E. [MPG] =	21.64

Phase 1 Weather Info	
Baro[mmHg] =	748.62
Temp[C] =	22.37
Rel Hum[%] =	44.53
NOx Corr =	0.9075

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7677	1.9408	---------	0.0132	0.2846	0.7983	393.13	0.9271
Sample:	0.8816	2.0886	---------	0.0946	37.4420	36.8520	3852.60	NaN
g/mi:	0.0016	0.0028	0.0007	0.0029	0.8731	0.8476	128.14	-0.0105

Phase 2 Results	
Vmix[m^3] =	77.7290
1-1/DF =	0.9710
Elapsed[s] =	866.80
Dist [mi] =	3.8522
F.E. [MPG] =	68.66

Phase 2 Weather Info	
Baro[mmHg] =	748.52
Temp[C] =	22.36
Rel Hum[%] =	44.84
NOx Corr =	0.9090

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8015	1.9526	---------	0.0218	0.2857	0.5784	386.21	---------	
Phase 1 [g/mi:	0.0767	0.0468	0.0611	0.0039	3.7219	4.0082	411.66	-0.0059	21.29
Phase 2 [g/mi:	0.0008	0.0026	-0.0001	0.0028	0.8481	0.8491	130.25	-0.0105	67.58

Start Comments:

Max depletion eng opt / SOC init 30.7

Test Info

- Test ID: 60809045
- Test Start Time: 09/17/2008, 07:52:33 AM
- Test name: MATT
- Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
- Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup

- Dyno Config: Rear
- Dyno Mode: Road Load
- Test Wt[lb]: 3125
- Dyno Set A: 6.4842 Dyno Target A: 30.8500
- Dyno Set B: 0.5415 Dyno Target B: 0.5080
- Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info

- Vehicle Name: MATT
- Vehicle Odometer: 1
- Vehicle Table #: 25
- Vehicle VIN: 001

Personel Info

- Test Operator: HLB
- Test Driver: dSPACE
- Driver Error: 0.3942 MPH

CVS Info

- Bag Sample Flow #: 1
- Venturi #: 4

Fuel Info

- Fuel Name: EPA Tier 2 EEE Cert Gasoline
- CWF: 0.8640
- Density: 0.7410 [g/ml]
- Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Printout 1.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0000	0.0001	0.0000	0.0000	0.0029	0.0040	0.23	NaN	37205.29

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.8076	2.0416	---------	0.0134	0.2079	0.5766	408.89	1.1226
Sample:	0.8077	2.0430	---------	0.0133	0.2997	0.7003	412.36	NaN
g/mi:	0.0000	0.0001	0.0000	0.0000	0.0029	0.0040	0.23	-0.0016

Phase 1 Results

- Vmix[m^3] = 200.1000
- 1-1/DF = 0.9969
- Elapsed[s] = 1372.00
- Dist [mi] = 7.4014
- F.E. [MPG] = 37205.29

Phase 1 Weather Info

- Baro[mmHg] = 749.99
- Temp[C] = 22.55
- Rel Hum[%] = 44.17
- NOx Corr = 0.9078

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8139	2.0581	---------	0.0325	0.3496	-0.7302	423.25	---------	
Phase 1 [g/mi:	-0.3466	-0.0046	-0.3451	-0.0049	-0.0014	0.0025	-1.90	-0.0016	-2929.14

Start Comments:

Cold start EV / Full charge AER test 1

End Comments:

SOC final 65.1

Misc Data:

Direct Fuel Scale Result Phase 1 = 0.5656 MPG

```
Test Info
   Test ID:                  60809046
   Test Start Time:          09/17/2008, 08:22:06 AM
   Test name:                MATT
   Test Cycle File Name:     J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
   Test Save Location:       \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
   Dyno Config:      Rear                                                  Vehicle Info
   Dyno Mode:   Road Load                                                     Vehicle Name:     MATT
   Test Wt[lb]:      3125                                                     Vehicle Odometer:        1
   Dyno Set A:   6.4842   Dyno Target A:  30.8500                             Vehicle Table #:        25
   Dyno Set B:   0.5415   Dyno Target B:   0.5080                             Vehicle VIN:           001
   Dyno Set C:   0.0145   Dyno Target C:   0.0165

Personel Info                      CVS Info                               Fuel Info
   Test Operator:      HLB            Bag Sample Flow #:        1            Fuel Name:    EPA Tier 2 EEE Cert Gasoline
   Test Driver:     dSPACE            Venturi #:                4            CWF:          0.8640
   Driver Error:    0.3805 MPH                                               Density:      0.7410 [g/ml]
                                                                             Net HV:     18386.00 [BTU/lbm]
Host Process Files:

Driver Error.vi,Printout 1.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info:      THC        CH4       NMHC        NOx       COlow      COmid       CO2       HTHC     FE [MPG]
---[g/mi]----   ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
1                #1Emiss Mass Bag THC [g/mi]#  #1Emiss Mass Bag CH4 [g/mi]#  #1Emiss Mass Bag NMHC [g/mi]#  #1Emiss Mass Bag NOx [g/mi]#  #1Emiss Mass

               THC        CH4        NMHC        NOx       COlow      COmid       CO2       HTHC      Phase 1 Results         Phase 1 Weather Info
Bag 1        [ppmC3]     [ppm]                  [ppm]      [ppm]      [ppm]      [ppm]      [ppm]    ----------------------   ----------------------
---------   ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------   Vmix[m^3]  =  200.1000   Baro[mmHg] =    749.96
Ambient:       0.8076     2.0416  ---------     0.0134     0.2079     0.5766     408.89     1.1226   1-1/DF     = #11-1/DF#   Temp[C]    =     22.61
Sample:        0.8077     2.0430  ---------     0.0133     0.2997     0.7003     412.36        NaN   Elapsed[s] =   1372.00   Rel Hum[%] =     44.15
--------------------------------------------------------------------------------------------------   Dist [mi]  =    7.4146   NOx Corr   =    0.9084
g/mi:      #1Emiss Mass Bag THC [g/mi]#  #1Emiss Mass Bag CH4 [g/mi]#  #1Emiss Mass Bag NMHC [g/mi]#  #1Emiss Mass Bag NOx [g/mi]#  #1Emiss Mass Bag C

Modal Calcs       THC        CH4       NMHC        NOx       COlow      COmid       CO2       HTHC   Fuel Econ [MPG]
------------   ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Backgrd [ppm]: #Emiss ModalBkgd Dilute THC [ppm]#  #Emiss ModalBkgd Dilute CH4 [ppm]#  ---------  #Emiss ModalBkgd Dilute NOx [ppm]#  #Emiss ModalBkgc
------------   ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Phase 1 [g/mi: #1Emiss Mass Modal THC [g/mi]#  #1Emiss Mass Modal CH4 [g/mi]#  #1Emiss Mass Modal NMHC [g/mi]#  #1Emiss Mass Modal NOx [g/mi]#  #1Emis
Start Comments:

SOC init 65.1 / EV part 2

End Comments:

SOC end 41.1

Misc Data:

Direct Fuel Scale Result Phase 1 =    0.4357 MPG
```

```
Test Info
   Test ID:                  60809047
   Test Start Time:          09/17/2008, 08:49:11 AM
   Test name:                MATT
   Test Cycle File Name:     J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
   Test Save Location:       \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
   Dyno Config:      Rear                                                  Vehicle Info
   Dyno Mode:   Road Load                                                     Vehicle Name:     MATT
   Test Wt[lb]:      3125                                                     Vehicle Odometer:        1
   Dyno Set A:   6.4842   Dyno Target A:  30.8500                             Vehicle Table #:        25
   Dyno Set B:   0.5415   Dyno Target B:   0.5080                             Vehicle VIN:           001
   Dyno Set C:   0.0145   Dyno Target C:   0.0165

Personel Info                      CVS Info                                Fuel Info
   Test Operator:      HLB            Bag Sample Flow #:        1             Fuel Name:    EPA Tier 2 EEE Cert Gasoline
   Test Driver:     dSPACE            Venturi #:                4             CWF:          0.8640
   Driver Error:    7.2908 MPH                                                Density:      0.7410 [g/ml]
                                                                              Net HV:     18386.00 [BTU/lbm]
______________________________________________________________________________________________________________________
Host Process Files:

Driver Error.vi,Printout 1.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi
______________________________________________________________________________________________________________________

Summary Info:       THC        CH4       NMHC        NOx       COlow      COmid      CO2        HTHC     FE [MPG]
---[g/mi]----    ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
1                #1Emiss Mass Bag THC [g/mi]#  #1Emiss Mass Bag CH4 [g/mi]#  #1Emiss Mass Bag NMHC [g/mi]#  #1Emiss Mass Bag NOX [g/mi]#  #1Emiss Mas
______________________________________________________________________________________________________________________

              THC       CH4        NMHC        NOx       COlow      COmid       CO2       HTHC      Phase 1 Results        Phase 1 Weather Info
Bag 1       [ppmC3]    [ppm]                 [ppm]      [ppm]      [ppm]      [ppm]      [ppm]    ----------------------  ----------------------
---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  Vmix[m^3]  =  200.1000  Baro[mmHg] =    749.99
Ambient:      0.8076     2.0416  ---------     0.0134     0.2079     0.5766     408.89     1.1226  1-1/DF     = #11-1/DF#  Temp[C]    =     22.57
Sample:       0.8077     2.0430  ---------     0.0133     0.2997     0.7003     412.36        NaN  Elapsed[s] =   1372.00  Rel Hum[%] =     44.41
---------------------------------------------------------------------------------------------------  Dist [mi]  =    6.4042  NOx Corr   =    0.9091
g/mi:     #1Emiss Mass Bag THC [g/mi]#  #1Emiss Mass Bag CH4 [g/mi]#  #1Emiss Mass Bag NMHC [g/mi]#  #1Emiss Mass Bag NOX [g/mi]#  #1Emiss Mass Bag
______________________________________________________________________________________________________________________

Modal Calcs        THC        CH4        NMHC        NOx       COlow      COmid       CO2        HTHC    Fuel Econ [MPG]
------------   ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Backgrd [ppm]: #Emiss ModalBkgd Dilute THC [ppm]#  #Emiss ModalBkgd Dilute CH4 [ppm]#  ---------  #Emiss ModalBkgd Dilute NOx [ppm]#  #Emiss ModalBkg
------------   ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Phase 1 [g/mi: #1Emiss Mass Modal THC [g/mi]#  #1Emiss Mass Modal CH4 [g/mi]#  #1Emiss Mass Modal NMHC [g/mi]#  #1Emiss Mass Modal NOX [g/mi]#  #1Emi
______________________________________________________________________________________________________________________
Start Comments:

AER EV UDDS 3 SOC init 41.1
______________________________________________________________________________________________________________________
End Comments:

Final SOC 19.7
______________________________________________________________________________________________________________________
Misc Data:

Direct Fuel Scale Result Phase 1 =    0.3421 MPG
```

Test Info
Test ID: 60809048
Test Start Time: 09/17/2008, 09:21:28 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.4752 MPH

CVS Info
Bag Sample Flow #: 1
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Printout 1.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

---

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0258	0.0067	0.0235	0.0397	0.7801	0.8277	242.85	NaN	36.42

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7831	1.9911	---------	0.0174	0.3764	2.0070	411.40	0.9460
Sample:	2.4086	2.2859	---------	0.8558	25.1930	28.2740	5314.10	NaN
g/mi:	0.0258	0.0067	0.0235	0.0397	0.7801	0.8277	242.85	-0.0041

Phase 1 Results
Vmix[m^3] = 200.1500
1-1/DF = 0.9601
Elapsed[s] = 1372.00
Dist [mi] = 7.4176
F.E. [MPG] = 36.42

Phase 1 Weather Info
Baro[mmHg] = 749.87
Temp[C] = 22.82
Rel Hum[%] = 45.53
NOx Corr = 0.9179

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7746	1.9692	---------	0.0420	0.2967	0.2328	396.68	---------	
Phase 1 [g/mi:	-1.0527	-0.0136	-1.0482	-0.0148	-0.0037	-0.0009	-5.42	-0.0041	-1004.08

Start Comments:

SOC initial 41.1%, EV start, switch to conventional at 30% SOC

End Comments:

Final SOC 30%, Fuel consumption .799 liters

Misc Data:

Direct Fuel Scale Result Phase 1 = 0.4015 MPG

```
Test Info
   Test ID:                 60809049
   Test Start Time:         09/17/2008, 09:56:05 AM
   Test name:               MATT
   Test Cycle File Name:    J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
   Test Save Location:      \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
   Dyno Config:      Rear                                             Vehicle Info
   Dyno Mode:    Road Load                                               Vehicle Name:     MATT
   Test Wt[lb]:      3125                                                Vehicle Odometer:        1
   Dyno Set A:    6.4842   Dyno Target A:  30.8500                       Vehicle Table #:        25
   Dyno Set B:    0.5415   Dyno Target B:   0.5080                       Vehicle VIN:           001
   Dyno Set C:    0.0145   Dyno Target C:   0.0165

Personel Info                     CVS Info                         Fuel Info
   Test Operator:      HLB           Bag Sample Flow #:       1        Fuel Name:    EPA Tier 2 EEE Cert Gasoline
   Test Driver:     dSPACE           Venturi #:               4        CWF:          0.8640
   Driver Error:    0.7351 MPH                                         Density:      0.7410 [g/ml]
                                                                       Net HV:     18386.00 [BTU/lbm]
______________________________________________________________________________________________________________
Host Process Files:

Driver Error.vi,Printout 1.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi
______________________________________________________________________________________________________________

Summary Info:       THC       CH4       NMHC       NOx       COlow      COmid      CO2       HTHC     FE [MPG]
---[g/mi]----   ---------  --------- ---------  ---------  ---------  ---------  ---------  ---------  ---------
1                  0.0034    0.0029    0.0024    0.0015     0.1873     0.1759    356.92       NaN     24.89
______________________________________________________________________________________________________________

               THC       CH4        NMHC       NOx      COlow     COmid      CO2       HTHC      Phase 1 Results          Phase 1 Weather Info
Bag 1        [ppmC3]    [ppm]                 [ppm]     [ppm]     [ppm]     [ppm]     [ppm]     ---------------------    ---------------------
---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  Vmix[m^3]  =  200.2000   Baro[mmHg] =    749.93
Ambient:     0.7593    1.9525   ---------    0.0195    0.3696    0.7969    407.66     0.9832    1-1/DF     =    0.9431   Temp[C]    =     22.62
Sample:      0.9319    2.0016   ---------    0.0507    6.3096    6.3502   7614.90        NaN    Elapsed[s] =   1372.00   Rel Hum[%] =     46.04
--------------------------------------------------------------------------------------------  Dist [mi]  =    7.4204   NOx Corr   =    0.9177
g/mi:        0.0034    0.0029     0.0024    0.0015    0.1873    0.1759    356.92    -0.0016    F.E. [MPG] =     24.89
______________________________________________________________________________________________________________

Modal Calcs       THC        CH4        NMHC       NOx       COlow      COmid       CO2        HTHC    Fuel Econ [MPG]
------------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Backgrd [ppm]:   0.7896     1.9625  ---------    0.0308     0.2394     1.1439    406.42   ---------
------------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Phase 1 [g/mi:  -0.4007    -0.0052    -0.3990    -0.0055    -0.0013    -0.0034     -2.11    -0.0016   -2599.03
______________________________________________________________________________________________________________
Start Comments:

2nd CS conventional UDDS
______________________________________________________________________________________________________________
End Comments:

Fuel used 1.139 liter
______________________________________________________________________________________________________________
Misc Data:

Direct Fuel Scale Result Phase 1 =    0.4081 MPG
```

Test Info

Test ID: 60809058
Test Start Time: 09/18/2008, 09:23:15 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup

Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info

Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info

Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.5687 MPH

CVS Info

Bag Sample Flow #: 1
Venturi #: 2

Fuel Info

Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Printout 1.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

---

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0224	0.0088	0.0194	0.0240	2.1305	2.1155	165.51	NaN	52.64

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.8125	2.0417	---------	0.0227	0.5059	1.1452	418.64	1.0254
Sample:	3.1023	2.7429	---------	0.8347	110.0900	109.9300	5818.70	NaN
g/mi:	0.0224	0.0088	0.0194	0.0240	2.1305	2.1155	165.51	-0.0094

Phase 1 Results		
Vmix[m^3]	=	123.8000
1-1/DF	=	0.9557
Elapsed[s]	=	1372.00
Dist [mi]	=	7.4157
F.E. [MPG]	=	52.64

Phase 1 Weather Info		
Baro[mmHg]	=	753.37
Temp[C]	=	23.14
Rel Hum[%]	=	46.39
NOx Corr	=	0.9257

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8116	2.0393	---------	0.0301	0.4187	0.7034	417.88	---------	
Phase 1 [g/mi:	0.0227	0.0090	0.0197	0.0260	2.0937	2.1299	168.62	-0.0094	51.70

Start Comments:

EV warmed up (previous test) / Engine cold start - CS

End Comments:

Eng opt SCO 30.8% fuel used 555

Misc Data:

Direct Fuel Scale Result Phase 1 = 52.4651 MPG

Test Info
Test ID: 60809059
Test Start Time: 09/18/2008, 10:04:15 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.3794 MPH

CVS Info
Bag Sample Flow #: 1
Venturi #: 2

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Printout 1.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0094	0.0055	0.0076	0.0049	2.1797	2.1879	272.11	NaN	32.27

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7929	1.9928	---------	0.0189	0.3759	0.5686	411.75	1.0324
Sample:	1.7117	2.3426	---------	0.1830	112.5700	113.1700	9298.00	NaN
g/mi:	0.0094	0.0055	0.0076	0.0049	2.1797	2.1879	272.11	-0.0092

Phase 1 Results		
Vmix[m^3]	=	123.8300
1-1/DF	=	0.9297
Elapsed[s]	=	1372.00
Dist [mi]	=	7.4229
F.E. [MPG]	=	32.27

Phase 1 Weather Info		
Baro[mmHg]	=	753.41
Temp[C]	=	23.09
Rel Hum[%]	=	46.47
NOx Corr	=	0.9254

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7998	2.0120	---------	0.0264	0.3731	0.0276	425.58	---------	
Phase 1 [g/mi:	0.0095	0.0054	0.0077	0.0046	2.1145	2.1849	273.66	-0.0092	32.10

Start Comments:

EV then CS 58 (was transition cycle) now CS eng opt

End Comments:

Final SOC 31.1, Fuel used .881 liters

Misc Data:

Direct Fuel Scale Result Phase 1 = 33.7991 MPG

Test Info

```
Test ID:                60809060
Test Start Time:        09/18/2008, 10:49:19 AM
Test name:              MATT
Test Cycle File Name:   J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
Test Save Location:     \\wales\APTF Docs\All Data\Cell 6 4WD
```

Dyno Setup

```
Dyno Config:    Rear
Dyno Mode:   Road Load
Test Wt[lb]:    3125
Dyno Set A:   6.4842   Dyno Target A:  30.8500
Dyno Set B:   0.5415   Dyno Target B:   0.5080
Dyno Set C:   0.0145   Dyno Target C:   0.0165
```

Vehicle Info

```
Vehicle Name:     MATT
Vehicle Odometer:       1
Vehicle Table #:       25
Vehicle VIN:          001
```

Personel Info

```
Test Operator:     HLB
Test Driver:     dSPACE
Driver Error:    0.5627 MPH
```

CVS Info

```
Bag Sample Flow #:       1
Venturi #:               2
```

Fuel Info

```
Fuel Name:     EPA Tier 2 EEE Cert Gasoline
CWF:           0.8640
Density:       0.7410 [g/ml]
Net HV:     18386.00 [BTU/lbm]
```

Host Process Files:

Driver Error.vi,Printout 1.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

---

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0052	0.0055	0.0033	0.0032	2.8947	2.9040	264.75	NaN	33.02

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7782	1.9603	---------	0.0234	0.3429	0.0557	404.84	1.0135
Sample:	1.2604	2.3157	---------	0.1318	149.4300	149.6400	9055.40	NaN
g/mi:	0.0052	0.0055	0.0033	0.0032	2.8947	2.9040	264.75	-0.0091

Phase 1 Results

```
Vmix[m^3]  =  123.7900
1-1/DF     =    0.9313
Elapsed[s] =   1372.00
Dist [mi]  =    7.4244
F.E. [MPG] =     33.02
```

Phase 1 Weather Info

```
Baro[mmHg]  =    753.44
Temp[C]     =     22.62
Rel Hum[%]  =     46.57
NOx Corr    =    0.9192
```

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7791	1.9836	---------	0.0345	0.3402	-0.3328	410.13	---------	
Phase 1 [g/mi:	0.0052	0.0054	0.0034	0.0034	2.7976	2.8878	265.79	-0.0091	32.91

Start Comments:

2nd CS UDDS

End Comments:

SOC final 30.4, fuel used .858 liters

Misc Data:

Direct Fuel Scale Result Phase 1 =   34.8537 MPG

Test Info
Test ID: 60809068
Test Start Time: 09/19/2008, 08:28:04 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.4615 MPH

CVS Info
Bag Sample Flow #: 1
Venturi #: 2

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Printout 1.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi,MATT_ QA Signal Printout v2.vi

---

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0572	0.0133	0.0528	0.0357	4.3796	4.4215	328.26	NaN	26.52

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7496	1.9188	---------	-0.0249	0.3339	-0.0169	410.07	0.9689
Sample:	6.6306	2.9464	---------	1.2191	225.7400	227.5800	11128.00	NaN
g/mi:	0.0572	0.0133	0.0528	0.0357	4.3796	4.4215	328.26	-0.0085

Phase 1 Results		
Vmix[m^3]	=	123.5400
1-1/DF	=	0.9151
Elapsed[s]	=	1372.00
Dist [mi]	=	7.4041
F.E. [MPG]	=	26.52

Phase 1 Weather Info		
Baro[mmHg]	=	751.90
Temp[C]	=	23.25
Rel Hum[%]	=	40.99
NOx Corr	=	0.9007

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7384	1.9054	---------	-0.0298	0.2748	-0.0353	407.79	---------	
Phase 1 [g/mi]:	0.0588	0.0135	0.0542	0.0381	4.3181	4.4097	333.31	-0.0085	26.13

Start Comments:

Cold start / PHEV Charge sustaining Load following SOC init 29.6

End Comments:

OK, Final SOC 29.5, Fuel used 1.094 liters

Misc Data:

Direct Fuel Scale Result Phase 1 = 26.9666 MPG

Test Info
Test ID: 60809069
Test Start Time: 09/19/2008, 09:01:36 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.4214 MPH

CVS Info
Bag Sample Flow #: 1
Venturi #: 2

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Printout 1.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi,MATT_ QA Signal Printout v2.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0039	0.0049	0.0023	0.0024	2.8659	2.8772	305.52	NaN	28.68

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7439	1.8980	---------	0.0139	0.3040	0.0498	406.06	0.8530
Sample:	1.0945	2.1854	---------	0.0974	148.1100	148.4600	10403.00	NaN
g/mi:	0.0039	0.0049	0.0023	0.0024	2.8659	2.8772	305.52	-0.0075

Phase 1 Results
Vmix[m^3] = 123.5000
1-1/DF = 0.9212
Elapsed[s] = 1372.00
Dist [mi] = 7.4174
F.E. [MPG] = 28.68

Phase 1 Weather Info
Baro[mmHg] = 751.75
Temp[C] = 23.26
Rel Hum[%] = 41.85
NOx Corr = 0.9050

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7657	1.9081	---------	0.0248	0.3321	-0.9736	402.71	---------	
Phase 1 [g/mi:	0.0035	0.0049	0.0019	0.0022	2.8103	2.8620	306.90	-0.0075	28.56

Start Comments:

UDDS#2 HS, load following, Initial SOC 29.5

End Comments:

OK, end SOC 29.5, fuel used .994 liters

Misc Data:

Direct Fuel Scale Result Phase 1 = 29.8344 MPG

```
Test Info
   Test ID:                 60809070
   Test Start Time:         09/19/2008, 02:50:12 PM
   Test name:               MATT
   Test Cycle File Name:    J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
   Test Save Location:      \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
   Dyno Config:      Rear                                            Vehicle Info
   Dyno Mode:    Road Load                                              Vehicle Name:     MATT
   Test Wt[lb]:      3125                                               Vehicle Odometer:        1
   Dyno Set A:   6.4842   Dyno Target A:  30.8500                       Vehicle Table #:        25
   Dyno Set B:   0.5415   Dyno Target B:   0.5080                       Vehicle VIN:           001
   Dyno Set C:   0.0145   Dyno Target C:   0.0165

Personel Info                         CVS Info                          Fuel Info
   Test Operator:      HLB               Bag Sample Flow #:       1        Fuel Name:     EPA Tier 2 EEE Cert Gasoline
   Test Driver:     dSPACE               Venturi #:               2        CWF:           0.8640
   Driver Error:    0.7930 MPH                                             Density:       0.7410 [g/ml]
                                                                           Net HV:     18386.00 [BTU/lbm]
------------------------------------------------------------------------------------------------------------------
Host Process Files:

Driver Error.vi,Printout 1.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi,MATT_ QA Signal Printout v2.vi
------------------------------------------------------------------------------------------------------------------

Summary Info:      THC        CH4       NMHC        NOx      COlow      COmid        CO2       HTHC    FE [MPG]
---[g/mi]----  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
1                 0.1057     0.0329     0.0948     0.0237     4.8345     4.8701     299.73        NaN      28.90
------------------------------------------------------------------------------------------------------------------

                 THC        CH4       NMHC        NOx      COlow      COmid        CO2       HTHC        Phase 1 Results          Phase 1 Weather Info
Bag 1        [ppmC3]      [ppm]                 [ppm]      [ppm]      [ppm]      [ppm]      [ppm]     ----------------------    ---------------------
---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------     Vmix[m^3]   =  123.0900    Baro[mmHg]  =    749.24
Ambient:      0.7906     1.9395  ---------    -0.0022     0.2506     1.7095     386.60     0.9840     1-1/DF      =    0.9216    Temp[C]     =     22.96
Sample:      11.7700     4.7552  ---------     0.8030   250.2600   253.4500   10221.00        NaN     Elapsed[s]  =   1372.00    Rel Hum[%]  =     46.81
------------------------------------------------------------------------------------------------     Dist [mi]   =    7.4121    NOx Corr    =    0.9264
g/mi:         0.1057     0.0329     0.0948     0.0237     4.8345     4.8701     299.73    -0.0087     F.E. [MPG]  =     28.90
------------------------------------------------------------------------------------------------------------------

Modal Calcs        THC        CH4       NMHC        NOx      COlow      COmid        CO2       HTHC   Fuel Econ [MPG]
------------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Backgrd [ppm]:   0.7425     1.9271  ---------     0.0012     0.2475     0.4471     381.38  ---------
------------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Phase 1 [g/mi:   0.1110     0.0343     0.0996     0.0247     4.6548     4.8915     302.97    -0.0087      28.63
------------------------------------------------------------------------------------------------------------------
Start Comments:

Cold start / Eng opt SOC init 30.7
------------------------------------------------------------------------------------------------------------------
End Comments:

soc end 31.0% fuel used 1.000 liters
------------------------------------------------------------------------------------------------------------------
Misc Data:

Direct Fuel Scale Result Phase 1 =   29.5069 MPG
```

Test Info

Test ID: 60809071
Test Start Time: 09/19/2008, 03:22:37 PM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup

Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info

Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info

Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.5380 MPH

CVS Info

Bag Sample Flow #: 1
Venturi #: 4

Fuel Info

Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Printout 1.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi,MATT_ QA Signal Printout v2.vi

---

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0086	0.0055	0.0068	0.0024	2.7746	2.7898	265.21	NaN	32.98

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7602	1.9160	---------	0.0113	0.3638	0.7674	401.02	0.9021
Sample:	1.2807	2.1380	---------	0.0608	88.8510	89.7210	5766.80	NaN
g/mi:	0.0086	0.0055	0.0068	0.0024	2.7746	2.7898	265.21	-0.0134

Phase 1 Results		
Vmix[m^3]	=	199.9400
1-1/DF	=	0.9563
Elapsed[s]	=	1372.00
Dist [mi]	=	7.4257
F.E. [MPG]	=	32.98

Phase 1 Weather Info		
Baro[mmHg]	=	749.01
Temp[C]	=	23.18
Rel Hum[%]	=	45.94
NOx Corr	=	0.9253

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8043	1.9240	---------	0.0242	0.3359	1.0398	393.86	---------	
Phase 1 [g/mi:	0.0073	0.0054	0.0055	0.0020	2.6828	2.7449	265.74	-0.0134	32.94

Start Comments:

Eng opt SOC init 31.0% - UDDS2 cold start CS

End Comments:

SOC end 30.6 fuel used 0.863 liters

Misc Data:

Direct Fuel Scale Result Phase 1 = 34.6034 MPG

Test Info
Test ID: 60809072
Test Start Time: 09/19/2008, 04:03:26 PM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.5707 MPH

CVS Info
Bag Sample Flow #: 1
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Printout 1.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi,MATT_ QA Signal Printout v2.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0051	0.0040	0.0038	0.0047	2.2783	2.2880	272.79	NaN	32.17

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7551	1.9089	---------	0.0216	0.3723	0.9397	384.64	-0.1931
Sample:	1.0491	2.0459	---------	0.1196	73.0250	73.8770	5904.50	NaN
g/mi:	0.0051	0.0040	0.0038	0.0047	2.2783	2.2880	272.79	0.0029

Phase 1 Results	
Vmix[m^3] =	199.9500
1-1/DF =	0.9554
Elapsed[s] =	1372.00
Dist [mi] =	7.4258
F.E. [MPG] =	32.17

Phase 1 Weather Info	
Baro[mmHg] =	748.88
Temp[C] =	22.94
Rel Hum[%] =	46.31
NOx Corr =	0.9237

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7536	1.9067	---------	0.0221	0.3702	0.6554	398.70	---------	
Phase 1 [g/mi:	0.0049	0.0041	0.0036	0.0045	2.2173	2.2468	273.68	0.0029	32.08

Start Comments:

SOC init 30.6 UDDS 3 eng opt

End Comments:

SOC end 31.1% fuel used 0.886 liter

Misc Data:

Direct Fuel Scale Result Phase 1 = 33.6816 MPG

Test Info
Test ID: 60809073
Test Start Time: 09/22/2008, 09:37:54 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.7724 MPH

CVS Info
Bag Sample Flow #: 1
Venturi #: 3

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Printout 1.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi,MATT_ QA Signal Printout v2.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0117	0.0080	0.0090	0.0021	2.7540	2.7668	204.26	NaN	42.62

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.8211	2.0513	---------	0.0141	0.3886	2.1841	432.49	1.4539
Sample:	1.6817	2.4940	---------	0.0646	104.9800	107.1900	5352.10	NaN
g/mi:	0.0117	0.0080	0.0090	0.0021	2.7540	2.7668	204.26	-0.0182

Phase 1 Results		
Vmix[m^3]	=	167.6800
1-1/DF	=	0.9592
Elapsed[s]	=	1372.00
Dist [mi]	=	7.4158
F.E. [MPG]	=	42.62

Phase 1 Weather Info		
Baro[mmHg]	=	753.93
Temp[C]	=	23.07
Rel Hum[%]	=	48.53
NOx Corr	=	0.9354

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8134	2.0512	---------	0.0259	0.4565	1.6000	429.25	---------	
Phase 1 [g/mi:	0.0116	0.0078	0.0090	0.0017	2.6979	2.7676	207.95	-0.0182	41.90

Start Comments:

EV warm up / SOC init 41.1% Load following

End Comments:

SOC end 29.5% fuel used 0.687 liters (that was engine cold start)

Misc Data:

Direct Fuel Scale Result Phase 1 = 42.9135 MPG

Test Info
Test ID: 60809074
Test Start Time: 09/22/2008, 10:17:35 AM
Test name: MATT
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\UDDS CYCLES\UDDS 1Bag 5spd 1372.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 6.4842 Dyno Target A: 30.8500
Dyno Set B: 0.5415 Dyno Target B: 0.5080
Dyno Set C: 0.0145 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT
Vehicle Odometer: 1
Vehicle Table #: 25
Vehicle VIN: 001

Personel Info
Test Operator: HLB
Test Driver: dSPACE
Driver Error: 0.7654 MPH

CVS Info
Bag Sample Flow #: 1
Venturi #: 3

Fuel Info
Fuel Name: EPA Tier 2 EEE Cert Gasoline
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Printout 1.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi,MATT_ QA Signal Printout v2.vi

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Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0036	0.0055	0.0018	0.0015	3.5784	3.5839	303.04	NaN	28.81

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7927	2.0141	---------	0.0229	0.3576	1.0820	405.19	1.0091
Sample:	1.0231	2.2628	---------	0.0594	136.3300	137.2200	7710.20	NaN
g/mi:	0.0036	0.0055	0.0018	0.0015	3.5784	3.5839	303.04	-0.0124

Phase 1 Results
Vmix[m^3] = 167.7600
1-1/DF = 0.9414
Elapsed[s] = 1372.00
Dist [mi] = 7.4232
F.E. [MPG] = 28.81

Phase 1 Weather Info
Baro[mmHg] = 754.02
Temp[C] = 23.20
Rel Hum[%] = 48.31
NOx Corr = 0.9361

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8006	2.0161	---------	0.0259	0.3052	1.0985	416.48	---------	
Phase 1 [g/mi:	0.0034	0.0055	0.0016	0.0014	3.5248	3.5648	301.78	-0.0124	28.93

Start Comments:

UDDS engine load following / SOC init 29.5

End Comments:

SOC end 29.5 fuel used 0.983 liters

Misc Data:

Direct Fuel Scale Result Phase 1 = 30.1918 MPG

Conventional Vehicle – Phase 1

Test Info

Test ID:	60809038
Test Start Time:	09/12/2008, 08:17:09 AM
Test name:	MATT
Test Cycle File Name:	J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location:	J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup

Dyno Config:	Rear		
Dyno Mode:	Road Load		
Test Wt[lb]:	3125		
Dyno Set A:	6.4842	Dyno Target A:	30.8500
Dyno Set B:	0.5415	Dyno Target B:	0.5080
Dyno Set C:	0.0145	Dyno Target C:	0.0165

Vehicle Info

Vehicle Name:	MATT
Vehicle Odometer:	1
Vehicle Table #:	25
Vehicle VIN:	001

Personel Info

Test Operator:	HLB
Test Driver:	dSPACE
Driver Error:	0.3909 MPH

CVS Info

Bag Sample Flow #:	2
Venturi #:	4

Fuel Info

Fuel Name:	EPA Tier 2 EEE Cert Gasoline
CWF:	0.8640
Density:	0.7410 [g/ml]
Net HV:	18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,HTML_QC_Channels_For_Host_blue.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0206	0.0097	0.0174	0.0449	1.2894	1.2898	370.41	NaN	23.87
2	0.0006	0.0007	0.0004	0.0007	0.1747	0.1773	387.67	NaN	22.92
1+2	0.0102	0.0050	0.0085	0.0219	0.7108	0.7123	379.37	NaN	23.37

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7989	1.9570	---------	-0.0295	0.5436	0.8660	428.10	1.1251
Sample:	2.4774	2.5130	---------	1.1732	54.4170	54.7290	10251.00	NaN
g/mi:	0.0206	0.0097	0.0174	0.0449	1.2894	1.2898	370.41	-0.0123

Phase 1 Results		Phase 1 Weather Info	
Vmix[m^3] =	73.2490	Baro[mmHg] =	744.70
1-1/DF =	0.9230	Temp[C] =	22.86
Elapsed[s] =	506.00	Rel Hum[%] =	51.53
Dist [mi] =	3.5660	NOx Corr =	0.9511
F.E. [MPG] =	23.87		

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7813	1.9576	---------	-0.0272	0.3407	1.0155	430.74	1.1251
Sample:	0.7721	1.8867	---------	-0.0140	4.9246	5.6324	6905.20	NaN
g/mi:	0.0006	0.0007	0.0004	0.0007	0.1747	0.1773	387.67	-0.0200

Phase 2 Results		Phase 2 Weather Info	
Vmix[m^3] =	125.5600	Baro[mmHg] =	744.66
1-1/DF =	0.9484	Temp[C] =	22.46
Elapsed[s] =	866.90	Rel Hum[%] =	52.51
Dist [mi] =	3.8499	NOx Corr =	0.9495
F.E. [MPG] =	22.92		

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	2.4764	1.9838	---------	0.0538	0.6573	0.8983	431.41	---------	
Phase 1 [g/mi:	0.0018	0.0094	-0.0013	0.0432	1.2546	1.2811	372.80	-0.0123	23.73
Phase 2 [g/mi:	-0.0301	0.0002	-0.0302	-0.0041	0.1642	0.1806	390.12	-0.0200	22.78

Start Comments:

Cold start conventional / UDDS CS1

```
Test Info
   Test ID:                    60809039
   Test Start Time:            09/12/2008, 08:56:20 AM
   Test name:                  MATT
   Test Cycle File Name:       J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
   Test Save Location:         J:\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
   Dyno Config:      Rear                                             Vehicle Info
   Dyno Mode:    Road Load                                               Vehicle Name:         MATT
   Test Wt[lb]:      3125                                                Vehicle Odometer:        1
   Dyno Set A:    6.4842    Dyno Target A:  30.8500                      Vehicle Table #:        25
   Dyno Set B:    0.5415    Dyno Target B:   0.5080                      Vehicle VIN:           001
   Dyno Set C:    0.0145    Dyno Target C:   0.0165

Personel Info                        CVS Info                            Fuel Info
   Test Operator:      HLB              Bag Sample Flow #:        2         Fuel Name:    EPA Tier 2 EEE Cert Gasoline
   Test Driver:     dSPACE              Venturi #:                4         CWF:          0.8640
   Driver Error:    0.4226 MPH                                              Density:      0.7410 [g/ml]
                                                                            Net HV:     18386.00 [BTU/lbm]
_______________________________________________________________________________________________________________________
Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,HTML_QC_Channels_For_Host_blue.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi
_______________________________________________________________________________________________________________________

Summary Info:        THC        CH4       NMHC        NOx       COlow      COmid       CO2       HTHC      FE [MPG]
---[g/mi]----    ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
1                   0.0049     0.0045     0.0034     0.0006     0.1741     0.1470     334.14        NaN      26.59
2                   0.0009     0.0005     0.0007     0.0006     0.1801     0.2116     376.26        NaN      23.62
1+2                 0.0028     0.0024     0.0020     0.0006     0.1772     0.1806     356.00        NaN      24.96
_______________________________________________________________________________________________________________________

               THC        CH4       NMHC        NOx       COlow      COmid       CO2       HTHC       Phase 1 Results         Phase 1 Weather Info
Bag 1        [ppmC3]    [ppm]                  [ppm]      [ppm]      [ppm]      [ppm]      [ppm]     ----------------------   ----------------------
---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------     Vmix[m^3]   =   73.3100   Baro[mmHg] =     744.60
Ambient:      0.7799     1.9637  ---------     0.0096     0.4165     0.5906     429.29     1.0288     1-1/DF      =    0.9305   Temp[C]    =      22.33
Sample:       1.1405     2.1537  ---------     0.0259     7.6724     6.7018    9296.00        NaN     Elapsed[s]  =    506.00   Rel Hum[%] =      51.63
-----------------------------------------------------------------------------------------------     Dist [mi]   =    3.5713   NOx Corr   =     0.9430
g/mi:         0.0049     0.0045     0.0034     0.0006     0.1741     0.1470     334.14    -0.0113     F.E. [MPG]  =     26.59
_______________________________________________________________________________________________________________________

               THC        CH4       NMHC        NOx       COlow      COmid       CO2       HTHC       Phase 2 Results         Phase 2 Weather Info
Bag 2        [ppmC3]    [ppm]                  [ppm]      [ppm]      [ppm]      [ppm]      [ppm]     ----------------------   ----------------------
---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------     Vmix[m^3]   =  125.5600   Baro[mmHg] =     744.54
Ambient:      0.7809     1.9799  ---------     0.0110     0.3949    -0.7218     420.13     1.0288     1-1/DF      =    0.9499   Temp[C]    =      22.78
Sample:       0.7886     1.9029  ---------     0.0202     5.1215     4.8908    6708.00        NaN     Elapsed[s]  =    866.80   Rel Hum[%] =      50.46
-----------------------------------------------------------------------------------------------     Dist [mi]   =    3.8520   NOx Corr   =     0.9442
g/mi:         0.0009     0.0005     0.0007     0.0006     0.1801     0.2116     376.26    -0.0184     F.E. [MPG]  =     23.62
_______________________________________________________________________________________________________________________

Modal Calcs         THC        CH4        NMHC        NOx       COlow      COmid       CO2        HTHC    Fuel Econ [MPG]
------------    ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Backgrd [ppm]:     0.7916     1.9603  ---------     0.0176     0.3663    -0.9875     406.71  ---------
------------    ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Phase 1 [g/mi:     0.0046     0.0046     0.0031     0.0005     0.1742     0.1894     332.86    -0.0113       26.69
Phase 2 [g/mi:     0.0003     0.0010    -0.0001     0.0002     0.1826     0.2055     378.22    -0.0184       23.49
_______________________________________________________________________________________________________________________
Start Comments:

Conventional cold star t/ UDDS cs2
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Appendix D: Phase II Emissions Results

Test Info
Test ID: 60902060
Test Start Time: 02/18/2009, 08:30:34 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.5093 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0162	0.0096	0.0130	-0.0007	1.6017	0.0899	239.42	NaN	36.75
2	-0.0000	-0.0000	-0.0000	-0.0008	0.0025	-0.0001	0.77	NaN	11439.37
1+2	0.0078	0.0046	0.0062	-0.0007	0.7721	0.0432	115.62	NaN	76.10

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.8313	2.0609	---------	0.0420	0.2176	0.0446	437.43	0.9580
Sample:	2.1816	2.6687	---------	0.0199	68.5010	3.8770	6911.10	NaN
g/mi:	0.0162	0.0096	0.0130	-0.0007	1.6017	0.0899	239.42	-0.0105

Phase 1 Results		Phase 1 Weather Info	
Vmix[m^3] =	71.6890	Baro[mmHg] =	727.11
1-1/DF =	0.9479	Temp[C] =	22.42
Elapsed[s] =	506.00	Rel Hum[%] =	41.75
Dist [mi] =	3.5591	NOx Corr =	0.9009
F.E. [MPG] =	36.75		

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.8271	2.0240	---------	0.0263	0.2377	0.0572	426.99	0.9580
Sample:	0.8229	2.0161	---------	0.0124	0.3037	0.0540	438.78	NaN
g/mi:	-0.0000	-0.0000	-0.0000	-0.0008	0.0025	-0.0001	0.77	-0.0176

Phase 2 Results		Phase 2 Weather Info	
Vmix[m^3] =	122.9100	Baro[mmHg] =	727.08
1-1/DF =	0.9967	Temp[C] =	22.46
Elapsed[s] =	866.80	Rel Hum[%] =	42.92
Dist [mi] =	3.8368	NOx Corr =	0.9070
F.E. [MPG] =	11439.37		

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8424	2.0692	---------	0.0600	0.3238	0.0235	433.13	---------	
Phase 1 [g/mi:	0.0155	0.0097	0.0123	-0.0010	1.5362	0.4963	239.29	-0.0105	36.78
Phase 2 [g/mi:	-0.0007	-0.0009	-0.0004	-0.0024	-0.0026	0.0008	0.16	-0.0176	59356.35

Start Comments:

Full charge test

Test Info
Test ID: 60902061
Test Start Time: 02/18/2009, 09:03:00 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.4792 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

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Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0186	0.0098	0.0153	0.0001	2.7195	0.1757	217.71	NaN	40.05
2	0.0042	0.0030	0.0032	-0.0005	0.3436	0.0169	10.11	NaN	834.02
1+2	0.0111	0.0063	0.0090	-0.0002	1.4873	0.0934	110.05	NaN	79.10

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7953	1.9849	---------	0.0162	0.2332	-0.0472	424.64	0.9075
Sample:	2.3563	2.6182	---------	0.0170	116.3200	7.4577	6318.80	NaN
g/mi:	0.0186	0.0098	0.0153	0.0001	2.7195	0.1757	217.71	-0.0100

Phase 1 Results	
Vmix[m^3] =	71.7000
1-1/DF =	0.9519
Elapsed[s] =	506.00
Dist [mi] =	3.5640
F.E. [MPG] =	40.05

Phase 1 Weather Info	
Baro[mmHg] =	727.05
Temp[C] =	22.43
Rel Hum[%] =	42.75
NOx Corr =	0.9059

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7976	1.9752	---------	0.0216	0.3616	-0.0408	421.76	0.9075
Sample:	1.0218	2.1067	---------	0.0125	9.5781	0.4139	592.45	NaN
g/mi:	0.0042	0.0030	0.0032	-0.0005	0.3436	0.0169	10.11	-0.0167

Phase 2 Results	
Vmix[m^3] =	122.9000
1-1/DF =	0.9955
Elapsed[s] =	866.80
Dist [mi] =	3.8395
F.E. [MPG] =	834.02

Phase 2 Weather Info	
Baro[mmHg] =	727.05
Temp[C] =	22.67
Rel Hum[%] =	42.72
NOx Corr =	0.9089

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7993	1.9841	---------	0.0316	0.2723	-0.0208	425.22	---------	
Phase 1 [g/mi:	0.0182	0.0099	0.0149	-0.0004	2.6445	0.6356	218.24	-0.0100	39.97
Phase 2 [g/mi:	0.0037	0.0027	0.0028	-0.0010	0.3429	0.0307	9.66	-0.0167	871.12

Start Comments:

Full charge #2

Test Info
Test ID: 60902062
Test Start Time: 02/18/2009, 09:39:11 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.4936 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0127	0.0075	0.0102	-0.0001	2.1422	0.1293	218.86	NaN	40.01
2	0.0017	0.0045	0.0002	0.0022	0.3784	0.0171	84.69	NaN	104.26
1+2	0.0070	0.0060	0.0050	0.0011	1.2273	0.0711	149.27	NaN	58.80

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7926	1.9761	---------	0.0172	0.3021	0.0092	435.58	0.9119
Sample:	1.8520	2.4397	---------	0.0131	91.6640	5.5254	6355.50	NaN
g/mi:	0.0127	0.0075	0.0102	-0.0001	2.1422	0.1293	218.86	-0.0101

Phase 1 Results
Vmix[m^3] = 71.7720
1-1/DF = 0.9518
Elapsed[s] = 506.00
Dist [mi] = 3.5645
F.E. [MPG] = 40.01

Phase 1 Weather Info
Baro[mmHg] = 727.26
Temp[C] = 22.48
Rel Hum[%] = 42.79
NOx Corr = 0.9067

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7897	1.9831	---------	0.0129	0.1943	0.0301	414.80	0.9119
Sample:	0.8724	2.1665	---------	0.0525	10.3440	0.4877	1855.10	NaN
g/mi:	0.0017	0.0045	0.0002	0.0022	0.3784	0.0171	84.69	-0.0166

Phase 2 Results
Vmix[m^3] = 122.9500
1-1/DF = 0.9861
Elapsed[s] = 866.80
Dist [mi] = 3.8412
F.E. [MPG] = 104.26

Phase 2 Weather Info
Baro[mmHg] = 727.33
Temp[C] = 22.71
Rel Hum[%] = 43.30
NOx Corr = 0.9121

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7911	1.9876	---------	0.0205	0.2327	-0.0057	425.26	---------	
Phase 1 [g/mi:	0.0125	0.0075	0.0100	-0.0001	2.1005	0.3279	219.11	-0.0101	39.97
Phase 2 [g/mi:	0.0015	0.0044	0.0000	0.0019	0.3751	0.0264	83.16	-0.0166	106.17

Start Comments:

full charge #3

Test Info
Test ID: 60902063
Test Start Time: 02/18/2009, 10:17:39 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.5808 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

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Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0051	0.0066	0.0029	-0.0002	1.2917	0.0676	232.61	NaN	37.90
2	0.0012	0.0034	0.0001	0.0065	0.3877	0.0187	81.46	NaN	108.35
1+2	0.0031	0.0049	0.0014	0.0033	0.8228	0.0422	154.21	NaN	57.18

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7846	1.9698	---------	0.0146	0.2754	0.0351	414.79	0.8889
Sample:	1.1832	2.3643	---------	0.0082	55.3610	2.9165	6707.90	NaN
g/mi:	0.0051	0.0066	0.0029	-0.0002	1.2917	0.0676	232.61	-0.0098

Phase 1 Results
Vmix[m^3] = 71.7950
1-1/DF = 0.9495
Elapsed[s] = 506.00
Dist [mi] = 3.5657
F.E. [MPG] = 37.90

Phase 1 Weather Info
Baro[mmHg] = 727.57
Temp[C] = 22.44
Rel Hum[%] = 42.54
NOx Corr = 0.9049

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7788	1.9583	---------	0.0155	0.3233	0.0270	405.26	0.8889
Sample:	0.8353	2.0887	---------	0.1318	10.7230	0.5293	1790.80	NaN
g/mi:	0.0012	0.0034	0.0001	0.0065	0.3877	0.0187	81.46	-0.0162

Phase 2 Results
Vmix[m^3] = 122.9800
1-1/DF = 0.9865
Elapsed[s] = 866.80
Dist [mi] = 3.8423
F.E. [MPG] = 108.35

Phase 2 Weather Info
Baro[mmHg] = 727.71
Temp[C] = 22.70
Rel Hum[%] = 42.83
NOx Corr = 0.9096

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7790	1.9669	---------	0.0195	0.2995	-0.0149	413.56	---------	
Phase 1 [g/mi:	0.0049	0.0067	0.0027	-0.0001	1.2577	0.1070	231.07	-0.0098	38.15
Phase 2 [g/mi:	0.0010	0.0032	-0.0000	0.0066	0.3895	0.0260	79.89	-0.0162	110.45

Start Comments:

full charge #4

Test Info

Test ID: 60902064
Test Start Time: 02/18/2009, 10:58:16 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup

Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info

Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info

Test Operator: HLB
Test Driver: HLB
Driver Error: 0.4370 MPH

CVS Info

Bag Sample Flow #: 2
Venturi #: 4

Fuel Info

Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0116	0.0090	0.0086	-0.0002	1.8692	0.1070	216.49	NaN	40.52
2	0.0017	0.0038	0.0004	-0.0001	0.9174	0.0460	161.76	NaN	54.49
1+2	0.0065	0.0063	0.0044	-0.0002	1.3757	0.0754	188.10	NaN	46.73

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7833	1.9621	---------	0.0173	0.2937	0.0186	430.85	0.8780
Sample:	1.7463	2.5383	---------	0.0101	79.9570	4.5775	6282.60	NaN
g/mi:	0.0116	0.0090	0.0086	-0.0002	1.8692	0.1070	216.49	-0.0097

Phase 1 Results

Vmix[m^3] = 71.8460
1-1/DF = 0.9525
Elapsed[s] = 506.00
Dist [mi] = 3.5657
F.E. [MPG] = 40.52

Phase 1 Weather Info

Baro[mmHg] = 728.23
Temp[C] = 22.42
Rel Hum[%] = 41.50
NOx Corr = 0.8994

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7813	1.9598	---------	0.0133	0.3346	0.0012	427.42	0.8780
Sample:	0.8548	2.0916	---------	0.0107	24.9060	1.2334	3175.10	NaN
g/mi:	0.0017	0.0038	0.0004	-0.0001	0.9174	0.0460	161.76	-0.0158

Phase 2 Results

Vmix[m^3] = 123.1100
1-1/DF = 0.9761
Elapsed[s] = 866.90
Dist [mi] = 3.8404
F.E. [MPG] = 54.49

Phase 2 Weather Info

Baro[mmHg] = 728.31
Temp[C] = 22.66
Rel Hum[%] = 42.68
NOx Corr = 0.9082

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7753	1.9613	---------	0.0213	0.2295	-0.0145	416.98	---------	
Phase 1 [g/mi:	0.0111	0.0090	0.0081	-0.0001	1.8201	0.1822	216.13	-0.0097	40.60
Phase 2 [g/mi:	0.0016	0.0039	0.0002	-0.0005	0.9210	0.0821	161.77	-0.0158	54.48

Start Comments:

full charge #5

Test Info
Test ID: 60902065
Test Start Time: 02/18/2009, 11:39:10 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.5261 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0070	0.0075	0.0045	-0.0003	2.0682	0.1232	301.70	NaN	29.16
2	0.0012	0.0032	0.0002	-0.0002	1.9059	0.0992	280.41	NaN	31.38
1+2	0.0040	0.0053	0.0022	-0.0003	1.9841	0.1107	290.66	NaN	30.27

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7862	1.9545	---------	0.0160	0.3317	-0.0275	426.10	0.8833
Sample:	1.3348	2.3872	---------	0.0061	88.4290	5.2216	8578.60	NaN
g/mi:	0.0070	0.0075	0.0045	-0.0003	2.0682	0.1232	301.70	-0.0096

Phase 1 Results
Vmix[m^3] = 71.8810
1-1/DF = 0.9353
Elapsed[s] = 506.00
Dist [mi] = 3.5658
F.E. [MPG] = 29.16

Phase 1 Weather Info
Baro[mmHg] = 728.61
Temp[C] = 22.50
Rel Hum[%] = 41.87
NOx Corr = 0.9021

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7779	1.9551	---------	0.0134	0.2931	0.0130	428.93	0.8833
Sample:	0.8142	2.0286	---------	0.0088	51.3400	2.6688	5192.50	NaN
g/mi:	0.0012	0.0032	0.0002	-0.0002	1.9059	0.0992	280.41	-0.0157

Phase 2 Results
Vmix[m^3] = 123.1400
1-1/DF = 0.9608
Elapsed[s] = 866.80
Dist [mi] = 3.8409
F.E. [MPG] = 31.38

Phase 2 Weather Info
Baro[mmHg] = 728.55
Temp[C] = 22.83
Rel Hum[%] = 43.44
NOx Corr = 0.9140

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7788	1.9711	---------	0.0214	0.3370	-0.0853	424.97	---------	
Phase 1 [g/mi:	0.0068	0.0074	0.0043	-0.0002	2.0288	0.2155	299.26	-0.0096	29.40
Phase 2 [g/mi:	0.0012	0.0030	0.0002	-0.0005	1.8754	0.1627	280.13	-0.0157	31.41

Start Comments:

full charge #6

Test Info
Test ID: 60902068
Test Start Time: 02/19/2009, 08:31:02 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.5476 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0138	0.0075	0.0113	-0.0005	1.5803	0.0847	298.70	NaN	29.52
2	0.0001	0.0003	0.0000	-0.0010	0.0032	-0.0010	0.61	NaN	14375.68
1+2	0.0067	0.0038	0.0055	-0.0007	0.7620	0.0402	144.04	NaN	61.22

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7509	1.8715	---------	0.0586	0.2436	0.0347	414.45	0.9298
Sample:	1.8772	2.3063	---------	0.0421	66.6890	3.5937	8382.30	NaN
g/mi:	0.0138	0.0075	0.0113	-0.0005	1.5803	0.0847	298.70	-0.0103

Phase 1 Results		Phase 1 Weather Info	
Vmix[m^3] =	72.7980	Baro[mmHg] =	743.67
1-1/DF =	0.9369	Temp[C] =	22.46
Elapsed[s] =	506.00	Rel Hum[%] =	42.50
Dist [mi] =	3.5647	NOx Corr =	0.9005
F.E. [MPG] =	29.52		

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7432	1.8702	---------	0.0490	0.1720	0.0488	411.76	0.9298
Sample:	0.7475	1.8780	---------	0.0306	0.2570	0.0220	420.79	NaN
g/mi:	0.0001	0.0003	0.0000	-0.0010	0.0032	-0.0010	0.61	-0.0173

Phase 2 Results		Phase 2 Weather Info	
Vmix[m^3] =	124.6800	Baro[mmHg] =	743.75
1-1/DF =	0.9968	Temp[C] =	22.51
Elapsed[s] =	866.90	Rel Hum[%] =	43.01
Dist [mi] =	3.8440	NOx Corr =	0.9035
F.E. [MPG] =	14375.68		

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7795	1.8634	---------	0.1856	0.4967	0.0002	405.13	---------	
Phase 1 [g/mi:	0.0127	0.0076	0.0102	-0.0046	1.5329	0.4328	299.10	-0.0103	29.49
Phase 2 [g/mi:	-0.0009	0.0004	-0.0011	-0.0086	-0.0099	0.0011	0.70	-0.0173	13054.43

Start Comments:

PHEV Full charge using TC on thermo-couple to control engine on

Test Info
Test ID: 60902069
Test Start Time: 02/19/2009, 09:11:57 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.4027 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0111	0.0068	0.0089	-0.0006	1.4179	0.0735	245.66	NaN	35.87
2	0.0004	0.0008	0.0001	-0.0013	0.0346	0.0017	3.88	NaN	2260.73
1+2	0.0056	0.0037	0.0043	-0.0010	0.7009	0.0363	120.34	NaN	73.21

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7690	1.8855	---------	0.0530	0.1057	-0.0209	422.56	0.8145
Sample:	1.6750	2.2832	---------	0.0320	59.8570	3.0790	6988.90	NaN
g/mi:	0.0111	0.0068	0.0089	-0.0006	1.4179	0.0735	245.66	-0.0091

Phase 1 Results
Vmix[m^3] = 72.8300
1-1/DF = 0.9474
Elapsed[s] = 506.00
Dist [mi] = 3.5738
F.E. [MPG] = 35.87

Phase 1 Weather Info
Baro[mmHg] = 744.05
Temp[C] = 22.46
Rel Hum[%] = 42.26
NOx Corr = 0.8993

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7679	1.8892	---------	0.0506	0.1268	-0.0356	423.34	0.8145
Sample:	0.7862	1.9181	---------	0.0268	1.0436	0.0101	487.14	NaN
g/mi:	0.0004	0.0008	0.0001	-0.0013	0.0346	0.0017	3.88	-0.0152

Phase 2 Results
Vmix[m^3] = 124.7200
1-1/DF = 0.9963
Elapsed[s] = 866.80
Dist [mi] = 3.8458
F.E. [MPG] = 2260.73

Phase 2 Weather Info
Baro[mmHg] = 744.16
Temp[C] = 22.63
Rel Hum[%] = 42.68
NOx Corr = 0.9033

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7793	1.8921	---------	0.0713	0.2691	-0.0649	426.53	---------	
Phase 1 [g/mi:	0.0106	0.0067	0.0084	-0.0010	1.3850	0.1501	243.97	-0.0091	36.12
Phase 2 [g/mi:	-0.0001	0.0008	-0.0003	-0.0022	0.0307	0.0036	4.02	-0.0152	2186.34

Start Comments:

PHEV full charge #2 w/ TC to control engine on

Test Info
Test ID: 60902070
Test Start Time: 02/19/2009, 09:49:11 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.3845 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0106	0.0053	0.0089	-0.0002	1.5256	0.0805	271.41	NaN	32.47
2	0.0015	0.0052	-0.0002	0.0018	0.3476	0.0164	60.20	NaN	146.36
1+2	0.0059	0.0052	0.0042	0.0009	0.9148	0.0473	161.90	NaN	54.43

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7789	1.8816	---------	0.0317	0.3160	0.0051	419.63	0.8073
Sample:	1.6399	2.1620	---------	0.0250	64.6000	3.3961	7675.00	NaN
g/mi:	0.0106	0.0053	0.0089	-0.0002	1.5256	0.0805	271.41	-0.0089

Phase 1 Results
Vmix[m^3] = 72.8580
1-1/DF = 0.9422
Elapsed[s] = 506.00
Dist [mi] = 3.5754
F.E. [MPG] = 32.47

Phase 1 Weather Info
Baro[mmHg] = 744.31
Temp[C] = 22.49
Rel Hum[%] = 42.77
NOx Corr = 0.9019

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7727	1.8826	---------	0.0204	0.3189	-0.0179	434.22	0.8073
Sample:	0.8469	2.1013	---------	0.0529	9.5279	0.4179	1444.90	NaN
g/mi:	0.0015	0.0052	-0.0002	0.0018	0.3476	0.0164	60.20	-0.0149

Phase 2 Results
Vmix[m^3] = 124.7600
1-1/DF = 0.9891
Elapsed[s] = 866.90
Dist [mi] = 3.8500
F.E. [MPG] = 146.36

Phase 2 Weather Info
Baro[mmHg] = 744.32
Temp[C] = 22.65
Rel Hum[%] = 42.64
NOx Corr = 0.9032

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7930	1.8769	---------	0.0672	0.2692	-0.0114	416.46	---------	
Phase 1 [g/mi:	0.0102	0.0053	0.0084	-0.0012	1.4915	0.1471	268.85	-0.0089	32.78
Phase 2 [g/mi:	0.0008	0.0053	-0.0009	-0.0005	0.3503	0.0219	60.28	-0.0149	146.16

Start Comments:

PHEV full charge #3, TC to control engine starts

Test Info
Test ID: 60902071
Test Start Time: 02/19/2009, 10:27:17 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.5140 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0067	0.0066	0.0045	-0.0004	1.4021	0.0734	219.57	NaN	40.09
2	0.0008	0.0035	-0.0003	0.0043	0.4001	0.0210	93.86	NaN	94.11
1+2	0.0036	0.0050	0.0020	0.0020	0.8821	0.0462	154.33	NaN	57.10

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7784	1.8871	---------	0.0337	0.3675	-0.0050	424.32	0.8100
Sample:	1.3105	2.2856	---------	0.0198	59.6030	3.0962	6309.00	NaN
g/mi:	0.0067	0.0066	0.0045	-0.0004	1.4021	0.0734	219.57	-0.0090

Phase 1 Results
Vmix[m^3] = 72.8850
1-1/DF = 0.9524
Elapsed[s] = 506.00
Dist [mi] = 3.5862
F.E. [MPG] = 40.09

Phase 1 Weather Info
Baro[mmHg] = 744.44
Temp[C] = 22.49
Rel Hum[%] = 41.99
NOx Corr = 0.8982

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7763	1.8915	---------	0.0430	0.3505	-0.0324	419.04	0.8100
Sample:	0.8096	2.0277	---------	0.1191	10.9980	0.5272	2003.10	NaN
g/mi:	0.0008	0.0035	-0.0003	0.0043	0.4001	0.0210	93.86	-0.0148

Phase 2 Results
Vmix[m^3] = 124.7800
1-1/DF = 0.9850
Elapsed[s] = 866.90
Dist [mi] = 3.8686
F.E. [MPG] = 94.11

Phase 2 Weather Info
Baro[mmHg] = 744.48
Temp[C] = 22.61
Rel Hum[%] = 43.13
NOx Corr = 0.9051

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7970	1.8981	---------	0.0378	0.3298	-0.0229	416.96	---------	
Phase 1 [g/mi:	0.0062	0.0066	0.0040	-0.0005	1.3726	0.1390	220.16	-0.0090	39.99
Phase 2 [g/mi:	0.0003	0.0034	-0.0008	0.0046	0.4025	0.0262	93.73	-0.0148	94.23

Start Comments:

PHEV full charge test #4, TC to control engine starts

Test Info
Test ID: 60902072
Test Start Time: 02/19/2009, 11:07:37 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.4173 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0061	0.0080	0.0035	0.0000	1.0765	0.0536	187.54	NaN	46.99
2	0.0015	0.0031	0.0004	-0.0007	0.4707	0.0218	124.11	NaN	71.22
1+2	0.0037	0.0054	0.0019	-0.0004	0.7621	0.0371	154.62	NaN	57.06

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7796	1.8872	---------	0.0427	0.2848	0.0287	426.63	0.7972
Sample:	1.2715	2.3953	---------	0.0418	45.7460	2.2910	5450.30	NaN
g/mi:	0.0061	0.0080	0.0035	0.0000	1.0765	0.0536	187.54	-0.0090

Phase 1 Results
Vmix[m^3] = 72.9080
1-1/DF = 0.9590
Elapsed[s] = 506.00
Dist [mi] = 3.5857
F.E. [MPG] = 46.99

Phase 1 Weather Info
Baro[mmHg] = 744.65
Temp[C] = 22.44
Rel Hum[%] = 42.07
NOx Corr = 0.8980

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7722	1.8851	---------	0.0523	0.2090	0.0172	431.47	0.7972
Sample:	0.8359	1.9910	---------	0.0386	12.7350	0.5966	2525.60	NaN
g/mi:	0.0015	0.0031	0.0004	-0.0007	0.4707	0.0218	124.11	-0.0145

Phase 2 Results
Vmix[m^3] = 124.8300
1-1/DF = 0.9810
Elapsed[s] = 866.80
Dist [mi] = 3.8688
F.E. [MPG] = 71.22

Phase 2 Weather Info
Baro[mmHg] = 744.65
Temp[C] = 22.62
Rel Hum[%] = 43.05
NOx Corr = 0.9048

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7892	1.8777	---------	0.0550	0.1775	-0.0150	411.62	---------	
Phase 1 [g/mi:	0.0057	0.0081	0.0031	-0.0003	1.0588	0.0875	187.90	-0.0090	46.90
Phase 2 [g/mi:	0.0009	0.0032	-0.0002	-0.0008	0.4646	0.0409	124.68	-0.0145	70.90

Start Comments:

PHEV full charge test #5, tc to control engine starts

Test Info
Test ID: 60902073
Test Start Time: 02/19/2009, 11:46:57 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.3696 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0060	0.0079	0.0034	-0.0006	1.6433	0.0886	305.51	NaN	28.86
2	0.0013	0.0043	-0.0001	-0.0007	1.7038	0.0859	273.67	NaN	32.18
1+2	0.0036	0.0060	0.0015	-0.0006	1.6747	0.0872	288.98	NaN	30.49

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7773	1.8754	---------	0.0495	0.3610	-0.0131	441.40	0.7970
Sample:	1.2358	2.3306	---------	0.0284	69.4150	3.7107	8585.00	NaN
g/mi:	0.0060	0.0079	0.0034	-0.0006	1.6433	0.0886	305.51	-0.0088

Phase 1 Results
Vmix[m^3] = 72.9400
1-1/DF = 0.9354
Elapsed[s] = 506.00
Dist [mi] = 3.5698
F.E. [MPG] = 28.86

Phase 1 Weather Info
Baro[mmHg] = 744.72
Temp[C] = 22.46
Rel Hum[%] = 40.62
NOx Corr = 0.8916

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7677	1.8727	---------	0.0414	0.2910	-0.0042	428.29	0.7970
Sample:	0.8074	1.9991	---------	0.0279	45.4110	2.2719	5025.10	NaN
g/mi:	0.0013	0.0043	-0.0001	-0.0007	1.7038	0.0859	273.67	-0.0143

Phase 2 Results
Vmix[m^3] = 124.8500
1-1/DF = 0.9621
Elapsed[s] = 866.80
Dist [mi] = 3.8506
F.E. [MPG] = 32.18

Phase 2 Weather Info
Baro[mmHg] = 744.70
Temp[C] = 22.67
Rel Hum[%] = 37.52
NOx Corr = 0.8798

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7951	1.8817	---------	0.0593	0.3604	-0.0445	429.88	---------	
Phase 1 [g/mi:	0.0055	0.0078	0.0029	-0.0007	1.6087	0.1675	302.55	-0.0088	29.15
Phase 2 [g/mi:	0.0008	0.0043	-0.0007	-0.0014	1.6786	0.1384	272.67	-0.0143	32.30

Start Comments:

Test Info
Test ID: 60902076
Test Start Time: 02/19/2009, 05:35:19 PM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.4901 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0051	0.0069	0.0028	0.0004	0.9806	0.0486	277.48	NaN	31.87
2	0.0031	0.0025	0.0023	-0.0003	0.2720	0.0113	42.03	NaN	209.39
1+2	0.0041	0.0046	0.0025	0.0000	0.6124	0.0292	155.16	NaN	56.95

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7309	1.9090	---------	-0.0256	0.3792	-0.0134	388.69	0.8058
Sample:	1.1178	2.2994	---------	-0.0133	41.2840	2.0161	7736.20	NaN
g/mi:	0.0051	0.0069	0.0028	0.0004	0.9806	0.0486	277.48	-0.0090

Phase 1 Results	
Vmix[m^3] =	73.5000
1-1/DF =	0.9419
Elapsed[s] =	506.00
Dist [mi] =	3.5719
F.E. [MPG] =	31.87

Phase 1 Weather Info	
Baro[mmHg] =	745.17
Temp[C] =	22.72
Rel Hum[%] =	37.07
NOx Corr =	0.8782

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7272	1.9111	---------	-0.0271	0.3486	-0.0102	395.47	0.8058
Sample:	0.8858	2.0087	---------	-0.0322	7.5053	0.2873	1096.30	NaN
g/mi:	0.0031	0.0025	0.0023	-0.0003	0.2720	0.0113	42.03	-0.0150

Phase 2 Results	
Vmix[m^3] =	126.0000
1-1/DF =	0.9917
Elapsed[s] =	866.80
Dist [mi] =	3.8620
F.E. [MPG] =	209.39

Phase 2 Weather Info	
Baro[mmHg] =	745.23
Temp[C] =	22.65
Rel Hum[%] =	36.19
NOx Corr =	0.8735

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7063	1.8862	---------	-0.0246	0.2477	0.0035	392.99	---------	
Phase 1 [g/mi:	0.0049	0.0070	0.0026	0.0005	0.9673	0.0896	276.66	-0.0090	31.96
Phase 2 [g/mi:	0.0032	0.0030	0.0022	-0.0001	0.2718	0.0229	41.20	-0.0150	213.59

Start Comments:

restart

Test Info
Test ID: 60902077
Test Start Time: 02/19/2009, 06:05:33 PM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.5574 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

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Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0300	0.0072	0.0276	0.0030	1.0409	0.0522	301.81	NaN	29.29
2	0.0012	0.0018	0.0006	0.0028	1.0923	0.0538	243.58	NaN	36.25
1+2	0.0151	0.0044	0.0136	0.0029	1.0676	0.0530	271.59	NaN	32.53

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7386	1.9002	---------	0.0095	0.1005	0.0290	424.51	0.8291
Sample:	3.2271	2.3081	---------	0.0947	43.6310	2.2088	8431.10	NaN
g/mi:	0.0300	0.0072	0.0276	0.0030	1.0409	0.0522	301.81	-0.0092

Phase 1 Results	
Vmix[m^3] =	73.5990
1-1/DF =	0.9367
Elapsed[s] =	506.00
Dist [mi] =	3.5844
F.E. [MPG] =	29.29

Phase 1 Weather Info	
Baro[mmHg] =	745.37
Temp[C] =	22.54
Rel Hum[%] =	39.33
NOx Corr =	0.8864

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7484	1.9097	---------	0.0142	0.1327	0.0461	417.91	0.8291
Sample:	0.7863	1.9285	---------	0.0647	28.9080	1.4609	4487.70	NaN
g/mi:	0.0012	0.0018	0.0006	0.0028	1.0923	0.0538	243.58	-0.0150

Phase 2 Results	
Vmix[m^3] =	126.0100
1-1/DF =	0.9663
Elapsed[s] =	866.80
Dist [mi] =	3.8656
F.E. [MPG] =	36.25

Phase 2 Weather Info	
Baro[mmHg] =	745.42
Temp[C] =	22.67
Rel Hum[%] =	36.48
NOx Corr =	0.8750

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7355	1.8770	---------	0.0150	0.1282	0.0436	412.08	---------	
Phase 1 [g/mi:	0.0294	0.0075	0.0269	0.0033	1.0134	0.1016	300.34	-0.0092	29.44
Phase 2 [g/mi:	0.0011	0.0026	0.0003	0.0031	1.0975	0.0896	244.57	-0.0150	36.10

Start Comments:

Phase 2 Conventional Emissions Results

Test Info
Test ID: 60902050
Test Start Time: 02/17/2009, 08:23:20 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.4258 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v1.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0165	0.0098	0.0133	0.0109	1.1478	0.0585	384.54	NaN	23.01
2	0.0038	0.0034	0.0027	0.0001	0.1417	0.0064	392.59	NaN	22.64
1+2	0.0099	0.0065	0.0078	0.0053	0.6257	0.0315	388.72	NaN	22.82

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7493	1.9121	---------	0.0063	0.2396	0.0513	418.55	0.9622
Sample:	2.0858	2.4750	---------	0.3127	48.1880	2.4929	10612.00	NaN
g/mi:	0.0165	0.0098	0.0133	0.0109	1.1478	0.0585	384.54	-0.0105

Phase 1 Results	
Vmix[m^3] =	73.3720
1-1/DF =	0.9204
Elapsed[s] =	506.00
Dist [mi] =	3.5703
F.E. [MPG] =	23.01

Phase 1 Weather Info	
Baro[mmHg] =	744.07
Temp[C] =	22.46
Rel Hum[%] =	42.68
NOx Corr =	0.9013

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7520	1.9062	---------	0.0082	0.2332	0.0674	405.04	0.9622
Sample:	0.9162	1.9621	---------	0.0103	3.9480	0.2312	6954.50	NaN
g/mi:	0.0038	0.0034	0.0027	0.0001	0.1417	0.0064	392.59	-0.0172

Phase 2 Results	
Vmix[m^3] =	125.7600
1-1/DF =	0.9481
Elapsed[s] =	866.80
Dist [mi] =	3.8509
F.E. [MPG] =	22.64

Phase 2 Weather Info	
Baro[mmHg] =	743.97
Temp[C] =	22.61
Rel Hum[%] =	43.55
NOx Corr =	0.9073

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7461	1.8962	---------	0.0154	0.1829	-0.0274	405.93	---------	
Phase 1 [g/mi:	0.0159	0.0100	0.0126	0.0121	1.1150	0.3048	388.04	-0.0105	22.81
Phase 2 [g/mi:	0.0036	0.0036	0.0024	-0.0004	0.1476	0.0089	398.26	-0.0172	22.31

Start Comments:

cold start conv

Test Info
Test ID: 60902051
Test Start Time: 02/17/2009, 08:56:08 AM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.4403 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v1.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0035	0.0038	0.0023	0.0008	0.0945	0.0035	341.16	NaN	26.05
2	0.0017	0.0018	0.0011	0.0001	0.0963	0.0060	387.93	NaN	22.91
1+2	0.0026	0.0028	0.0017	0.0004	0.0955	0.0048	365.42	NaN	24.32

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7623	1.9205	---------	0.0111	0.2165	-0.0393	424.34	0.8528
Sample:	1.0073	2.0623	---------	0.0337	4.1615	0.1102	9488.50	NaN
g/mi:	0.0035	0.0038	0.0023	0.0008	0.0945	0.0035	341.16	-0.0094

Phase 1 Results
Vmix[m^3] = 73.3650
1-1/DF = 0.9291
Elapsed[s] = 506.00
Dist [mi] = 3.5782
F.E. [MPG] = 26.05

Phase 1 Weather Info
Baro[mmHg] = 743.74
Temp[C] = 22.45
Rel Hum[%] = 41.72
NOx Corr = 0.8967

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7620	1.9180	---------	0.0128	0.1158	-0.0792	430.98	0.8528
Sample:	0.8139	1.9011	---------	0.0138	2.6470	0.0824	6912.90	NaN
g/mi:	0.0017	0.0018	0.0011	0.0001	0.0963	0.0060	387.93	-0.0152

Phase 2 Results
Vmix[m^3] = 125.7000
1-1/DF = 0.9484
Elapsed[s] = 866.80
Dist [mi] = 3.8561
F.E. [MPG] = 22.91

Phase 2 Weather Info
Baro[mmHg] = 743.44
Temp[C] = 22.70
Rel Hum[%] = 42.67
NOx Corr = 0.9043

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7546	1.9151	---------	0.0248	0.1025	-0.0374	418.59	---------	
Phase 1 [g/mi:	0.0034	0.0040	0.0021	0.0007	0.0966	0.0043	337.81	-0.0094	26.31
Phase 2 [g/mi:	0.0017	0.0018	0.0010	-0.0007	0.1025	0.0039	388.89	-0.0152	22.86

Start Comments:

UDDS conv #2

```
Test Info
   Test ID:                  60902055
   Test Start Time:          02/17/2009, 06:27:42 PM
   Test name:                UDDS
   Test Cycle File Name:     J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
   Test Save Location:       \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
   Dyno Config:      Rear                                             Vehicle Info
   Dyno Mode:    Road Load                                               Vehicle Name:     MATT (new
   Test Wt[lb]:      3125                                                Vehicle Odometer:         0
   Dyno Set A:  10.7400   Dyno Target A:  30.8500                        Vehicle Table #:         25
   Dyno Set B:   0.1075   Dyno Target B:   0.5080                        Vehicle VIN:              1
   Dyno Set C:   0.0194   Dyno Target C:   0.0165

Personel Info                         CVS Info                           Fuel Info
   Test Operator:      HLB               Bag Sample Flow #:        2        Fuel Name:    EPA Tier II EEE Cert
   Test Driver:        HLB               Venturi #:                4        CWF:            0.8640
   Driver Error:    0.4079 MPH                                              Density:        0.7410 [g/ml]
                                                                            Net HV:     18386.00 [BTU/lbm]
---------------------------------------------------------------------------------------------------------------------
Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi
---------------------------------------------------------------------------------------------------------------------

Summary Info:        THC        CH4       NMHC        NOx      COlow      COmid        CO2       HTHC   FE [MPG]
---[g/mi]----  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
1                 0.0472     0.0094     0.0441     0.0002     2.7651     0.1801     336.08        NaN      26.11
2                 0.0035     0.0036     0.0023    -0.0003     0.4551     0.0202      35.60        NaN     244.81
1+2               0.0246     0.0064     0.0224    -0.0001     1.5683     0.0973     180.40        NaN      48.61
---------------------------------------------------------------------------------------------------------------------

             THC        CH4        NMHC        NOx      COlow      COmid        CO2       HTHC      Phase 1 Results           Phase 1 Weather Info
Bag 1     [ppmC3]      [ppm]                  [ppm]      [ppm]      [ppm]      [ppm]      [ppm]    ----------------------    ---------------------
---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  Vmix[m^3]   =   72.6540   Baro[mmHg] =    735.87
Ambient:      0.7743     1.9407  ---------     0.0088     0.3514     0.0858     429.55     0.9157  1-1/DF      =    0.9285   Temp[C]    =     22.43
Sample:       4.7528     2.4935  ---------     0.0136   117.3000     7.6988    9446.30        NaN  Elapsed[s]  =    506.00   Rel Hum[%] =     42.32
---------------------------------------------------------------------------------------------  Dist [mi]   =    3.5786   NOx Corr   =    0.9013
g/mi:         0.0472     0.0094     0.0441     0.0002     2.7651     0.1801     336.08    -0.0100  F.E. [MPG]  =     26.11
---------------------------------------------------------------------------------------------------------------------

             THC        CH4        NMHC        NOx      COlow      COmid        CO2       HTHC      Phase 2 Results           Phase 2 Weather Info
Bag 2     [ppmC3]      [ppm]                  [ppm]      [ppm]      [ppm]      [ppm]      [ppm]    ----------------------    ---------------------
---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  Vmix[m^3]   =  124.3900   Baro[mmHg] =    735.67
Ambient:      0.7719     1.9392  ---------     0.0088     0.2705     0.0913     416.76     0.9157  1-1/DF      =    0.9923   Temp[C]    =     22.67
Sample:       0.9519     2.0887  ---------     0.0034    12.3570     0.6281    1015.30        NaN  Elapsed[s]  =    866.80   Rel Hum[%] =     43.06
---------------------------------------------------------------------------------------------  Dist [mi]   =    3.8473   NOx Corr   =    0.9079
g/mi:         0.0035     0.0036     0.0023    -0.0003     0.4551     0.0202      35.60    -0.0169  F.E. [MPG]  =    244.81
---------------------------------------------------------------------------------------------------------------------

Modal Calcs          THC        CH4       NMHC        NOx      COlow      COmid        CO2       HTHC  Fuel Econ [MPG]
------------   ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Backgrd [ppm]:    0.7561     1.9267  ---------     0.0111     0.2246     0.0546     414.44  ---------
------------   ---------  ---------  ---------  ---------  ---------  ---------  ---------  ---------
Phase 1 [g/mi:    0.0502     0.0095     0.0471     0.0003     2.6842     0.9635     332.39    -0.0100      26.40
Phase 2 [g/mi:    0.0033     0.0038     0.0021    -0.0002     0.4506     0.0444      34.36    -0.0169     253.51
---------------------------------------------------------------------------------------------------------------------
Start Comments:

Cold start PHEV cont'd
```

Test Info
Test ID: 60902057
Test Start Time: 02/17/2009, 07:53:19 PM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.4427 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0064	0.0058	0.0045	0.0029	1.0237	0.0512	314.44	NaN	28.13
2	0.0029	0.0029	0.0020	0.0033	1.3952	0.0688	220.85	NaN	39.87
1+2	0.0046	0.0043	0.0032	0.0031	1.2164	0.0603	265.91	NaN	33.20

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7493	1.9003	---------	0.0047	0.1282	-0.0259	413.13	0.8510
Sample:	1.2491	2.2026	---------	0.0880	43.4390	2.1408	8853.00	NaN
g/mi:	0.0064	0.0058	0.0045	0.0029	1.0237	0.0512	314.44	-0.0093

Phase 1 Results	
Vmix[m^3] =	72.5670
1-1/DF =	0.9336
Elapsed[s] =	506.00
Dist [mi] =	3.5753
F.E. [MPG] =	28.13

Phase 1 Weather Info	
Baro[mmHg] =	734.86
Temp[C] =	22.47
Rel Hum[%] =	41.61
NOx Corr =	0.8988

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7450	1.9062	---------	0.0084	0.2008	-0.0152	412.41	0.8510
Sample:	0.8800	1.9816	---------	0.0667	37.3590	1.8184	4143.20	NaN
g/mi:	0.0029	0.0029	0.0020	0.0033	1.3952	0.0688	220.85	-0.0153

Phase 2 Results	
Vmix[m^3] =	124.1900
1-1/DF =	0.9688
Elapsed[s] =	866.80
Dist [mi] =	3.8516
F.E. [MPG] =	39.87

Phase 2 Weather Info	
Baro[mmHg] =	734.69
Temp[C] =	22.70
Rel Hum[%] =	43.12
NOx Corr =	0.9089

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.8781	1.9154	---------	0.0166	0.1492	-0.0293	424.85	---------	
Phase 1 [g/mi:	0.0054	0.0058	0.0035	0.0030	0.9991	0.0849	309.97	-0.0093	28.54
Phase 2 [g/mi:	-0.0010	0.0028	-0.0019	0.0030	1.3654	0.1138	219.63	-0.0153	40.10

Start Comments:

part 2 again

Test Info
Test ID: 60902066
Test Start Time: 02/18/2009, 03:36:41 PM
Test name: UDDS
Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup
Dyno Config: Rear
Dyno Mode: Road Load
Test Wt[lb]: 3125
Dyno Set A: 10.7400 Dyno Target A: 30.8500
Dyno Set B: 0.1075 Dyno Target B: 0.5080
Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info
Vehicle Name: MATT (new
Vehicle Odometer: 0
Vehicle Table #: 25
Vehicle VIN: 1

Personel Info
Test Operator: HLB
Test Driver: HLB
Driver Error: 0.4447 MPH

CVS Info
Bag Sample Flow #: 2
Venturi #: 4

Fuel Info
Fuel Name: EPA Tier II EEE Cert
CWF: 0.8640
Density: 0.7410 [g/ml]
Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

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Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0170	0.0093	0.0139	0.0005	1.9292	0.1117	311.99	NaN	28.22
2	0.0043	0.0051	0.0026	-0.0003	0.5506	0.0278	52.17	NaN	167.61
1+2	0.0104	0.0072	0.0080	0.0001	1.2146	0.0682	177.31	NaN	49.61

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7718	1.9774	---------	-0.0081	0.2308	0.0384	415.55	0.9177
Sample:	2.1797	2.5370	---------	0.0073	82.2300	4.7834	8828.30	NaN
g/mi:	0.0170	0.0093	0.0139	0.0005	1.9292	0.1117	311.99	-0.0100

Phase 1 Results
Vmix[m^3] = 72.1370
1-1/DF = 0.9335
Elapsed[s] = 506.00
Dist [mi] = 3.5707
F.E. [MPG] = 28.22

Phase 1 Weather Info
Baro[mmHg] = 731.39
Temp[C] = 22.44
Rel Hum[%] = 41.38
NOx Corr = 0.8983

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7743	1.9690	---------	-0.0057	0.3012	0.0260	429.94	0.9177
Sample:	0.9965	2.1887	---------	-0.0102	14.9900	0.7676	1311.60	NaN
g/mi:	0.0043	0.0051	0.0026	-0.0003	0.5506	0.0278	52.17	-0.0169

Phase 2 Results
Vmix[m^3] = 123.6900
1-1/DF = 0.9901
Elapsed[s] = 866.80
Dist [mi] = 3.8427
F.E. [MPG] = 167.61

Phase 2 Weather Info
Baro[mmHg] = 731.55
Temp[C] = 22.68
Rel Hum[%] = 42.93
NOx Corr = 0.9087

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7651	1.9318	---------	-0.0051	0.1781	0.0482	414.98	---------	
Phase 1 [g/mi:	0.0166	0.0099	0.0133	0.0005	1.8743	0.5681	311.88	-0.0100	28.24
Phase 2 [g/mi:	0.0041	0.0058	0.0022	-0.0002	0.5493	0.0499	51.78	-0.0169	168.88

Start Comments:

max depletion / engine optimum redux

Test Info

- Test ID: 60902067
- Test Start Time: 02/18/2009, 04:05:59 PM
- Test name: UDDS
- Test Cycle File Name: J:\APTF Docs\Vehicle Testing\Drive Cycles\EPA Drive Cycles\UDDS 2Bags 5spd 1373.txt
- Test Save Location: \\wales\APTF Docs\All Data\Cell 6 4WD

Dyno Setup

- Dyno Config: Rear
- Dyno Mode: Road Load
- Test Wt[lb]: 3125
- Dyno Set A: 10.7400 Dyno Target A: 30.8500
- Dyno Set B: 0.1075 Dyno Target B: 0.5080
- Dyno Set C: 0.0194 Dyno Target C: 0.0165

Vehicle Info

- Vehicle Name: MATT (new
- Vehicle Odometer: 0
- Vehicle Table #: 25
- Vehicle VIN: 1

Personel Info

- Test Operator: HLB
- Test Driver: HLB
- Driver Error: 0.3850 MPH

CVS Info

- Bag Sample Flow #: 2
- Venturi #: 4

Fuel Info

- Fuel Name: EPA Tier II EEE Cert
- CWF: 0.8640
- Density: 0.7410 [g/ml]
- Net HV: 18386.00 [BTU/lbm]

Host Process Files:

Driver Error.vi,Combine Phases 1&2.vi,Printout 1&2+.vi,MATT_ QA Signal Printout v2.vi,Test_Cell_Enviro_Conditions.vi,HTML_QC_Channels_For_Host_blue.vi

Summary Info: ---[g/mi]----	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	FE [MPG]
1	0.0074	0.0060	0.0054	0.0018	0.9904	0.0500	301.33	NaN	29.36
2	0.0012	0.0022	0.0005	0.0017	1.1587	0.0573	223.25	NaN	39.51
1+2	0.0042	0.0040	0.0029	0.0017	1.0777	0.0538	260.84	NaN	33.87

Bag 1	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7796	1.9608	---------	0.0160	0.2862	0.0447	415.82	0.8843
Sample:	1.3668	2.2766	---------	0.0657	42.2790	2.1618	8523.60	NaN
g/mi:	0.0074	0.0060	0.0054	0.0018	0.9904	0.0500	301.33	-0.0097

Phase 1 Results

- Vmix[m^3] = 72.2460
- 1-1/DF = 0.9360
- Elapsed[s] = 506.00
- Dist [mi] = 3.5683
- F.E. [MPG] = 29.36

Phase 1 Weather Info

- Baro[mmHg] = 731.88
- Temp[C] = 22.41
- Rel Hum[%] = 42.20
- NOx Corr = 0.9017

Bag 2	THC [ppmC3]	CH4 [ppm]	NMHC	NOx [ppm]	COlow [ppm]	COmid [ppm]	CO2 [ppm]	HTHC [ppm]
Ambient:	0.7804	1.9615	---------	0.0152	0.3312	0.0575	422.18	0.8843
Sample:	0.8197	1.9999	---------	0.0451	31.2250	1.5850	4197.90	NaN
g/mi:	0.0012	0.0022	0.0005	0.0017	1.1587	0.0573	223.25	-0.0159

Phase 2 Results

- Vmix[m^3] = 123.7600
- 1-1/DF = 0.9684
- Elapsed[s] = 866.90
- Dist [mi] = 3.8432
- F.E. [MPG] = 39.51

Phase 2 Weather Info

- Baro[mmHg] = 731.98
- Temp[C] = 22.68
- Rel Hum[%] = 42.42
- NOx Corr = 0.9060

Modal Calcs	THC	CH4	NMHC	NOx	COlow	COmid	CO2	HTHC	Fuel Econ [MPG]
Backgrd [ppm]:	0.7764	1.9562	---------	0.0237	0.2328	0.0442	407.21	---------	
Phase 1 [g/mi:	0.0071	0.0061	0.0051	0.0017	0.9551	0.1019	298.99	-0.0097	29.59
Phase 2 [g/mi:	0.0010	0.0025	0.0001	0.0011	1.1498	0.0998	225.39	-0.0159	39.14

Start Comments:

part 2

Appendix E: Test Cycle Statistics

Cycle Time	1372	sec	Distance	7.4499	mile

	Maximum	Average	Standard Deviation	Unit
Speed	56.6691	19.5336	14.7092	mile/h
Acceleration	1.6111	0.51229	0.45326	m/s2
Deceleration	-1.5	-0.57539	0.51847	m/s2

	Number	Frequency	Duration	Percent of Cycle
Stop	17	0.0014179139	262	19.09621
		stop / mile	seconds	%

Cycle data for the UDDS

Cycle Time	8237	sec	Distance	44.6995	mile

	Maximum	Average	Standard Deviation	Unit
Speed	56.6691	19.5336	14.7048	mile/h
Acceleration	1.6111	0.51229	0.45291	m/s2
Deceleration	-1.5	-0.57539	0.51802	m/s2

	Number	Frequency	Duration	Percent of Cycle
Stop	102	0.0014179139	1572	19.084618
		stop / mile	seconds	%

Cycle data for the test cycle – 6 consecutive UDDS

Vita

David Estes Smith was born in Knoxville, TN on December 3, 1972. He continued to reside in Knoxville throughout his childhood. David attended Shannondale Elementary School and Gresham Middle School. He graduated fifth in his class from Central High School in Knoxville in May of 1991. At this point, David received a full tuition, four year academic scholarship to pursue an engineering degree at the University of Tennessee, Knoxville. As an undergraduate, he attained many honors, including induction into such engineering honoraries as Tau Beta Pi and Pi Tau Sigma. He received his Bachelor of Science degree in Mechanical engineering, Cum Laude, in May of 1995. After working the summer after graduation for Battelle Memorial Institute, Mr. Smith accepted a research assistantship at the University of Tennessee, Knoxville, to begin work towards a Master of Science degree in Mechanical engineering degree with a concentration in thermal sciences. As he continued work in the Graduate School at UTK, David entered into matrimony with Robin Renee Howell. David received his Master of Science degree in Mechanical Engineering in December of 1996. Upon graduating, David began his professional life as an engineer, developing expertise in hybrid electric powertrain control. David returned to the University of Tennessee to begin work towards a doctorate in Mechanical Engineering, while continuing to further his professional experiences. David received his Doctor of Philosophy degree in Mechanical Engineering in May of 2009 at the ripe old age of 36.