

RADIATION HARDENED POWER ELECTRONICS

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ABSTRACT

Previous options for radiation-hardened power electronics have been mostly limited to expensive, bulky discrete designs or modules, typically built from up-screened commercial devices. The Intersil Rad-Hard Silicon Gate (RSG) process has been used to design the industry's first family of guaranteed Rad-Hard Power Management "building block" ICs for use in all forms of radiation environments. These devices are capable of providing highly reliable performance in critical power control circuits at reduced cost and size.

1. INTRODUCTION

A new family of devices is under development at Intersil that provides the basic functions needed for power switching, DC-DC conversion and motor control circuits[1]. Most are designed to be guaranteed Rad-Hard (300Krad (Si) minimum), enhanced performance replacements for their commercial equivalents, which are commonly used in many rad-hard applications. The last device that will be described, the HS-802805RH, combines several of these "building blocks" to provide a new solution for radiation-hardened power supply problems.

2. RSG PROCESS DESCRIPTION

The process that will be used for most of these products, RSG (**Rad-Hard Silicon Gate**), offers a large variety of MOS and bipolar devices suitable for medium to high voltage analog, mixed signal and power applications. RSG is a fully complementary BiCMOS-on-insulator process which uses Intersil's dielectric isolation (DI) starting material to produce high quality vertical complementary bipolars, medium voltage CMOS, high voltage bipolar and MOS devices and a variety of signal and reference diodes, thin film and diffused resistors and capacitors.

3. PRODUCT DESCRIPTIONS

This family of products, listed in Tables 1 and 2, and briefly described here, are intended to provide explicitly

radiation hardened equivalents to industry standard IC types and provide new levels of combined hardness, integration and overall reliability. The 110V CMOS and DMOS transistors available on the RSG process enable the direct control of high voltage power MOSFETs. Dielectric Isolation, SOI technology provides Single Event Latch-Up (SEL) immunity, and vertical PNP and NPN geometries virtually eliminate the radiation effects common in many commercial, lateral PNP structures.

Table 1: Available Intersil Rad-Hard Power Products

Device #	Description
HS-1840ARH	16-Channel Mux
HS-139RH	Quad Voltage Comparator
HS-3530ARH	Programmable Op-Amp
HS-4423RH	Dual Inverting Dual FET Driver
HS-4424RH	Dual Non-Inverting Dual FET Driver
HS-1825ARH	Pulse Width Modulator
HS-2100RH	Half Bridge Driver
HS-117RH	Linear Regulator
HS-4080ARH	Full Bridge Driver

Table 2: Intersil Rad-Hard Power Roadmap

Device #	Description	Available
HS-705RH	Power Down Reset	Q3, 99
HS-201HSRH	Quad SPST Switch	Q3, 99
HS-1009RH	2.5V Voltage Reference	Q3, 99
HS-DG403RH	Dual SPDT Switch	Q4, 99
HS-DG405RH	Dual DPST Switch	Q4, 99
HS-1715ARH	Switch FET Driver	Q4, 99
HS-1845ARH	Pulse Width Modulator	Q4, 99
HS-2981RH	8 Channel Source Driver	Q4, 99
HS-802805RH	80W DC-DC Converter	Q1, 00

The following descriptions are of the products that are currently available[2].

3.1 HS-1840ARH

The HS-1840ARH, a 16 channel analog multiplexer, is a redesign of the HS-1840RH with improved performance, including improved analog input overvoltage protection and input impedance during power loss. It is designed to provide a high input impedance to the analog source if device power fails (open), or the analog signal voltage inadvertently exceeds the supply by up to 35V, regardless of whether the device is powered on or off.

The HS-1840ARH is excellent for use in redundant applications, since the secondary device can be operated in a standby unpowered mode affording no additional power drain. More significantly, a very high impedance exists between the active and inactive devices preventing any interaction. One of sixteen channel selection is controlled by a 4-bit binary address plus an Enable-Inhibit input which conveniently controls the ON/OFF operation of several multiplexers in a system. The device is available in a 28 lead side-brazed DIP and a 28 lead ceramic Flatpack.

3.2 HS-139RH

The HS-139RH is a quad voltage comparator that is a pin for pin replacement for the industry standard 139. It consists of four independent single or dual supply voltage comparators on a single monolithic substrate. The common mode input voltage range includes ground, even when operated from a single supply, and the low supply current (< 2mA) makes these comparators suitable for low power level shifting or analog to digital conversion applications. The HS-139RH is available in either a 14 lead side-brazed DIP or a 14 lead ceramic flatpack.

3.3 HS-3530ARH

The HS-3530ARH is a Low Power Operational Amplifier which is an internally compensated monolithic device offering a wide range of performance specifications. Parameters such as power dissipation, slew rate, bandwidth, noise and input DC parameters are programmed by selecting an external resistor or current source. Supply voltages as low as 3V may be used with little degradation of AC performance.

A major advantage of the HS-3530ARH is that operating characteristics remain virtually constant over a wide supply range (3V to 15V), allowing the amplifier to offer maximum performance in almost any system, including battery operated equipment. A primary application for this device is in active filtering and conditioning for a wide variety of signals that differ in frequency and amplitude.

Also, by modulating the set current, it can be used for designs such as current controlled oscillators/modulators, sample and hold circuits and variable active filters. This device is available in either an 8 lead CAN or a 10 lead ceramic flatpack.

3.4 HS-442xRH Family

The HS-4423RH and HS-4424RH are the base products of a family of dual FET Drivers. The HS-4423RH is a pin for pin replacement for the Micrel 4423, a dual inverting 3A FET Driver. However, the HS-4423RH is designed to convert TTL signals into high current output that can drive up to a 4300pF load from 0V to 18V in less than 50ns. The fast rise and fall times and high current outputs allow very quick control of high gate capacitance power MOSFETs, thus minimizing switching power losses. The HS-4424RH, a non-inverting dual FET driver with the same ac and dc specifications, is also available and, if there is sufficient customer demand, a complementary version, the HS-4425RH can be made available with a very short lead time.

The HS-442xRH family also features several Low Voltage Lock Out (LVLO) options that put the outputs into a tri-state mode if the power supply dips below a certain voltage, preventing the possibility of MOSFET burnout. These dual devices can also have their inputs and outputs paralleled in order to create a single 6A driver. The HS-442xRH family is available in a 16 pin ceramic flatpack that is outline compliant with the industry standard 16 pin SOIC.

3.5 HS-1825ARH

The HS-1825ARH Regulating Pulse Width Modulator (PWM) is an enhanced replacement for several industry standard types and is specially designed for switching power supply and servo applications. It can be used in either current-mode or voltage-mode operation, and is especially well suited for single-ended boost converter applications.

Device features include a precision voltage reference, low power start-up circuitry, a high frequency oscillator, a wide-band error amplifier, and a fast current-limit comparator. The BiCMOS design results in fast propagation delays times and high output current over a wide range of output voltages. The HS-1825ARH is available in a 16 lead ceramic flatpack.

3.6 HS-2100RH

The HS-2100RH is a high frequency, 100V Half Bridge Driver that is a rad-hard pin-for-pin version of the Intersil HIP2500 Half Bridge Driver and a replacement for the IR2110. Its targeted applications include PWM

amplifiers/servodrivers and synchronous rectified power converters. It also features 2A output drive and a high side output that can be offset to 120V. The low-side and high-side gate drivers are independently controlled, giving the user maximum flexibility in dead-time selection and driver protocol.

In addition, the HS-2100RH has on-chip error detection and correction circuitry which monitors the state of the high-side latch and compares it to the HIN signal. If they disagree, a SET or RESET pulse is generated to correct the high-side latch, thus protecting the high-side latch from single event upsets. This prevents both the high-side and low-side MOSFETs from being on at the same time. The HS-2100RH is available in a 16 lead ceramic flatpack.

3.7 HS-117RH

The HS-117RH Voltage Regulator, a radiation hardened equivalent to the industry standard LM-117, is an adjustable positive voltage linear regulator capable of operating up to 40VDC. The output voltage is adjustable from 1.2V to 50V with two external resistors. The device is capable of sourcing from 50mA to over 1.25A peak current. Protection is provided by the on-chip thermal shutdown and output current limiting circuitry. The HS-117RH is available in a 3 terminal TO-257 package.

3.8 HS-4080ARH

The HS-4080ARH is a rad-hard version of the Intersil HIP4080A Full Bridge Driver. It features 2A outputs that drive 4 external N-Channel MOSFETs in a full bridge configuration, with user programmable dead time to decrease switching power loss. An on-board charge-pump can maintain an upper supply maximum voltage of 95V while operating from a single 12V supply. Its targeted applications are PWM motion/motor control and dc-dc converters, but it can also drive medium voltage motors.

The HS-4080ARH includes a TTL-level input comparator with an output pin (OUT), which can be used to facilitate hysteresis and PWM modes of operation. The DIS pin disables gate drive to all outputs regardless of the command states of the input pins, IN+ and IN-. Its HEN input can force current to freewheel in the bottom two external power MOSFETs, maintaining the upper power MOSFETs off. To simultaneously modulate both upper and lower drivers, HEN is continuously held high while modulating the IN+ and IN- pins.

A combination of bootstrapping and internal charge pumps allow for use as drivers for simple N-Channel high-side switches. The bootstrap technique supplies the high instantaneous current needed for turning on the power devices, while the charge pump provides enough

current to maintain bias voltage on the upper driver sections and MOSFETs. There are two charge pump circuits in the HS-4080ARH, one for each of the two upper logic and driver circuits. Each charge pump uses a switched capacitor doubler to provide about 50uA to 75uA of gate load current. The sourcing current charging capability drops off as the floating supply voltage increases. Eventually the gate voltage approaches the level set by an internal zener clamp (< 15V).

Each of the four output drivers are comprised of bipolar high speed NPN transistors for both sourcing and sinking gate charge to and from the MOSFET switches. In addition, the sink driver incorporates a parallel-connected N-channel MOSFET to enable the gate of the power switch gate-source voltage to be brought completely to 0V. The gate driver design allows for very short propagation delays while nearly eliminating all gate driver shoot-through which significantly reduces IC power dissipation.

The HS-4080ARH also incorporates a Low Voltage Lockout (LVLO) feature that disables the outputs if the supply voltage drops below 9V. The outputs are re-enabled when the supply voltage returns to above 9.5V. This device is packaged in a 20 lead ceramic flatpack.

The following devices are currently under development at Intersil and should all be available in the next few months.

3.9 HS-705RH

The HS-705RH Power Down Reset is pin for pin compatible with industry standard types will be available in a 14 lead ceramic flatpack. It monitors the power supply and battery voltages in microprocessor systems and provides a reset signal during power-up and power-down and features a "watchdog" circuit and a power fail threshold detector. The threshold detector input (PFI) may be used to monitor power supply failure or low battery conditions.

The HS-705RH will be built on a sub-micron CMOS process in order to achieve 3.3V operation, and is radiation-hardened by design to 300Krad (Si).

3.10 HS-201HSRH

The HS-201HSRH Quad SPST Switch is the first in a planned family of high-speed, rad-hard, analog switches with very low ON resistance. The four switches are independently selectable and pin compatible with the industry standard HI-201HS switch. The part is designed to accept CMOS as well as TTL-level input signals while passing a wide analog signal range of +/-15V. Overvoltage protection/power down high impedance and ESD protection is also incorporated into the design.

Other planned switches for this family include a dual SPDT (HS-DG403RH) and a dual DPST (HS-DG405RH). These parts will be packaged in both a 16 lead side-brazed DIP and a 16 pin ceramic flatpack.

3.11 HS-1009RH

The HS-1009RH is a 2.5V shunt regulator diode designed to provide an exceptionally stable 2.5V reference over a wide current range and to maintain that stability over the full military temperature range and over time. A 0.2% reference tolerance is achieved by on-chip trimming. An adjustment terminal is provided to allow for the calibration of system errors. The use of this terminal to adjust the reference voltage does not affect the temperature coefficient. The HS-1009RH will be available in a TO-46 3-terminal package.

3.12 HS-1715ARH

The HS-1715ARH Complementary Switch FET Driver is an enhanced replacement for the UC1715. It generates true and complement signals from a single input that is PWM and TTL compatible, with user-programmable dead time between the outputs. The HS-1715ARH will also have 1A minimum output drive from both outputs, with both outputs also being tri-stateable.

The HS-1715ARH is designed to provide drive waveforms for complementary switches, which are commonly used in synchronous rectification circuits and active clamp/reset circuits. In order to facilitate zero-voltage switching, independently programmable delays between the two output waveforms are provided. This device will be packaged in a 16 pin ceramic flatpack.

3.13 HS-1845ARH

The HS-1845ARH, a current mode Pulse Width Modulator, is designed to be a radiation hardened pin for pin replacement for the UC1845. This PWM controller provides the necessary features to implement off-line or DC-DC fixed frequency current mode control schemes with a minimal external parts count. Features include Low Voltage Lock Out (LVLO) with a start up current of less than 1mA, a precision reference trimmed for accuracy at the error amp input, logic to insure latched operation, a PWM comparator which also provides current limit control, and an output stage designed to source or sink high peak current. The HS-1845ARH will be packaged in 14 lead ceramic flatpack.

3.14 HS-2981RH

The HS-2981RH, an 8-channel source driver replacement for the UDN2981, is recommended for high-side switching applications that benefit from separate logic and

load grounds. This device, which is built on a high voltage bipolar process, and is only hard to 100Krad (Si), encompasses load supply voltages to 80V and output currents to -500mA. This 8-channel source driver is useful for interfacing between low-level logic and high-current loads, such as relays, solenoids, lamps, and stepper/servo motors. The HS-2981RH will be packaged in an 18 lead ceramic flatpack.

3.15 HS-802805RH

The HS-802805RH 80W DC-DC power converter is the first in a series of radiation-hardened, high reliability power supplies to be offered by Intersil[3]. These power supplies utilize several of the circuits previously discussed as part of a single transistor forward topology with synchronous rectification to obtain the highest possible efficiency (near 90%) and best dynamic performance.

The HS-802805RH utilizes two DC-DC converters to optimize power conversion efficiency and facilitate voltage sequencing necessary to protect other circuits during power-up and power-down. It has a supply range of 18 to 40 volts, and can generate an adjustable main output voltage of 4 to 6 volts, at up to 16A, and a nominal -5 volts and up to 500mA at the auxiliary terminal.

Also provided are output inhibit functions referenced to either input or output and synchronization capability that allow these units to be easily integrated into larger distributed power systems. These supplies are targeted to be approximately 6 in³ and weigh less than 250 grams.

SUMMARY

A new family of devices is under development at Intersil that provides the basic functions needed for power switching, DC-DC conversion and motor control circuits. They are designed to be guaranteed rad-hard, enhanced performance replacements for their commercial equivalents, which are commonly used in many rad-hard applications.

More information about these products can be found on the Intersil homepage, <http://www.intersil.com>.

REFERENCES

1. J. W. Swonger, B. P Alaskiewicz, "Rad Hard Power Control ICs For Satellite Designs," presented at the 1999 Government Microelectronic Conference (GOMAC).
2. Intersil Data Sheets.
3. Intersil Rad Hard DC-DC Converter Brochure.