California Polytechnic State University, San Luis Obispo
Electrical Engineering Department

Senior Project Report

HVAC Fan Cooling System using Modicon M580

June 15th, 2023

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Acknowledgments

We would like to give our thanks to many people for the success of our senior project. We would first like to thank our advisor Jason Poon for a resource of guidance for a successful timeline for completing our project. We would also like to thank Professor Taufik for setting us up with Schneider Electric who donated the PLCs and provided us with hands-on seminars. We would also like to thank Darrick Baker from Schneider Electric for leading these seminars and being the representative for Schneider Electric to have these PLC labs. We would also like to thank those who worked on this PLC lab before us and those who are also implementing the PLC in other ways to create new innovative labs with the Modicon M580 PLC.

Abstract

A common problem that many devices have when operating is overheating. Whether it is operating at full capacity or idle, those devices that we use exert heat to some type of extent. The physical and electronic components of the device can only withstand so much heat before the component becomes damaged. This product provides a method of preventing overheating by being a cooling system for your device. A solution for preventing overheating of the components in these electronic devices is by having some sort of cooling system. Our product's cooling system will be based on energy efficiency, which means that there would not be any unnecessary cooling on components that don't need to be cooled down; the product will be able to drop the temperature of the overall system to the desired temperature by cooling down specific components that are undergoing extraneous processes and exerting large amounts of heat. Another way our product targets energy efficiency is by turning on/using a certain number of fans based on the temperature difference, with each fan operating at variable speeds to achieve optimal cooling. These points of efficiency will allow the product to not pull too much power. The key features of this fan cooling system are three 12V fans and a sensor that can analyze temperature. The operation of this product is powered by the M580's variable data types. This aims to achieve a cooling system that detects when the device or certain components within that device are overheating and adjusts the motors of the fans to regulate and maintain a certain temperature.

Chapter 1: Introduction

This project is an important aspect of learning about PLCs (programmable logic controllers), PLCs are currently used in many industries such as electrical, systems, and industrial engineering. PLCs are becoming an essential aspect in these industries as they are more reliable and smaller than previous electro-mechanical automators [3]. PLCs were introduced to eliminate many different issues such as the high power consumption and the high cost of its predecessors.

There have been many different versions of PLCs the most recent being the Modicon M580 ePAC, this new PLC allows for much larger applications and created the ePAC (programmable automation controller). Knowing how to perform different projects through the programmable logic in a PLC is important knowledge to have when working in industry as PLCs are commonly used to perform logic on inputs and output the logic results to ports that connect to motors and other various systems. PLCs are relevant to students today as they are commonly used in industry when working with logic ladders, functional block diagrams, sequential function charts, structured text, and instruction lists.

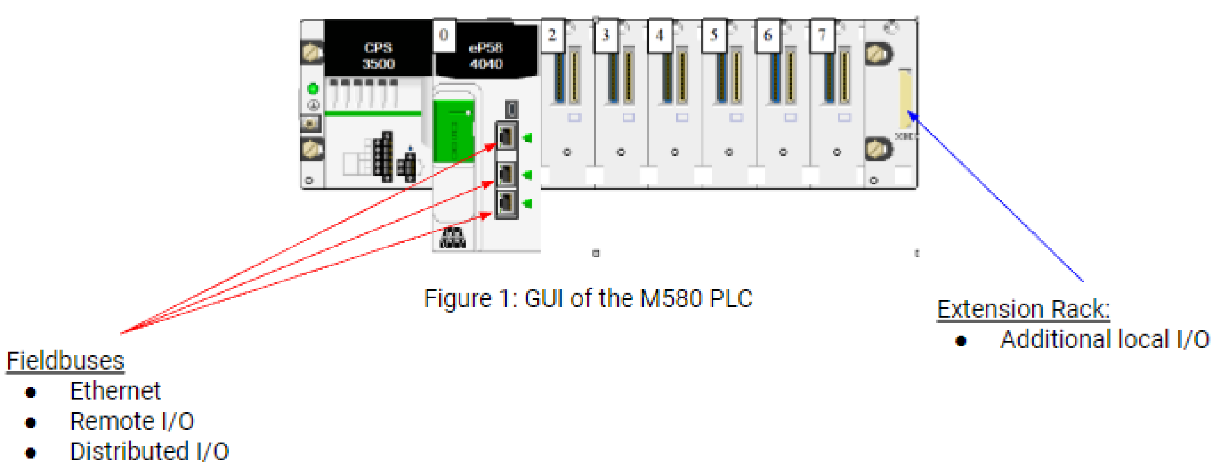


Figure 1: GUI of the M580 PLC

Figure 1.1: GUI of the M580 PLC

Logic ladders are used for control systems such as our fan cooling system that relies on temperature feedback into the controller, and functional block diagrams are used concurrently with logic ladders as a method to describe the transfer function between input and output. [4]

Using this project, there will be a new Electrical Engineering lab course implemented and listed as EE 435: Industrial Power Control and Automation. This lab course will be an introduction to programmable automation controllers; we will be using Schneider Electric's Modicon M580 programmable logic controllers (PLC) to perform the lab. Functions of the PLC in the lab course consist of custom-developed functions, electrical hardware interfaces, communications networking to intelligent electronic devices, and machine operator interface terminals. Using the PLC, we will also have applications of industrial power control and automation systems including protection equipment, motor controllers, renewable energy, and sensors.

Chapter 2: Background

This project considers the design of a fan cooling system using the Modicon M580 ePAC programmable logic controller for an undergraduate electrical engineering course on industrial automation. Taking into account projects performed in a course, projects created in clubs, or company-sponsored projects, at Cal Poly, there currently is not a project that is close to the project that we are working on right now. Electrical engineering courses that are somewhat related to the process and methods that we are using are in the EE 329 course, where we had to use a Nucleo Board from STMicroelectronics. Using the microcontroller in the EE 329 course, we had various pins that could be configured as an input or output; this was done by programming the Nucleo microcontroller to operate this way using C programming on STMicroelectronics. By operating these pins as an input or output, we used various electronic components that perform certain tasks throughout the quarter, and with these various tasks, larger projects were eventually created that were built off of those various processes[5].

Comparing EE 329 to the current project that we are currently performing it is somewhat similar. In both cases, they are a quarter-long course utilizing a controller of some sort that will be powering/operating a set of electronic components to operate in some type of way depending on the task that needs to be completed. In EE 329, we used various electronic components that each had a part of making sure the system worked correctly; this project we are working on is no different, as we are using fans and a temperature sensor to complete the task of cooling.
A particular distinction between the use of the Nucleo microcontroller and the M580 logic controller is the idea of input and output pins; the Nucleo board utilized the options to set its pins to input/output that operate in specific conditions through the code and logic ladders that are

implemented by the students in the lab, whereas the M580 controller will simply be powering the fans along with having the temperature sensor to regulate the environment through code.

The results of the EE 329's use of the Nucleo board and our project will be different, in the sense that there are various projects and tasks that can be done using the Nucleo board, whereas our use of the M580 in this project is to create a fan cooling system. We also plan to have the project to be used for various types of situations and focus on energy efficiency, rather than building some system for the fun of it.

However, this laboratory will be different as this lab is three hours straight which is a different variation of a lecture and lab that EE 329 is. Therefore the fan cooling experiment must be able to be completed in a three-hour session in groups of two to three people. Typical projects using a PLC are creating an automated system that once logic ladders are created and hardware is correctly wired the PLC should be able to correctly adjust variables through provided logic in software and then hardware through I/O pins to fulfill the automation requirements.

Chapter 3: Design Requirements

Design requirements that will need to be met for the students taking this lab, requirements such as changing the fan count and speed within one second of temperature changing thresholds. The system created by students should be intelligent in how the fans are used, fans speed and count should factor in the total power being pulled by the system and change accordingly to have the best efficiency for the temperature difference. Certain requirements listed are requirements that we have as designers of this lab, those requirements are the size and cost of the overall system since the system will need to be distributed to approximately 10 different lab groups while fitting into our senior project budget. The fans that we obtain should be low-power consumption fans with a wide range of voltage so that the speed of the fans can be variable based on the voltage being sent to each fan.

Student Requirements

a) Smart - number of fans in use is adaptive
b) Fast - system should cool quickly
c) Efficient - not over-consuming power

Student Requirements	**Justification**	**Engineering Specification**
a	Once the temperature reaches a certain point another fan will turn on and once another threshold is met the 3rd fan will also turn on to reduce power consumption	Fan speed and the count is adjusted correctly based on temperature above user thresholds
b, c	Fan system should be able to cool the target system quickly and efficiently within a certain threshold of time based on the internal temperature	Delay between temperature change and fan speed & count change < 1 second

Table 3.1: Student Requirements and Specifications

Although the focus of our senior project is solely focused on implementing the M580 PLC into our labs at Cal Poly, we chose to do an analysis also on design requirements in the industry by taking into account customer requirements.

Customer Requirements

a) Size - fans must be small enough to connect with M580
b) Inexpensive - overall cost of a cooling system is cheap
c) Quantity - must have enough sets to be able to fill an entire lab

Customer Requirements	**Justification**	**Engineering Specification**
a	Fans must be able to connect with the M580.	M580 has connections of ethernet and series pin connection.[8]
b	Fans, although they are important, should not be a large budget for the entire system. A typical range of CPU cooling fans is around $50 for a fan cooling system.[1]	Fans provide 0-12V adjustable range Cost of fans and drivers < $50
c	Every group will need a lab kit to be able to perform labs in separate groups.	There will be approximately 8-10 different groups so there will need to be equally as many separate kits.

Table 3.2: Customer Requirements and Specifications

The target parameter table below overviews the target units for each parameter such as cost, number of fans, and time. Along with each parameter is a tolerance and risk factor that associates with the different parameters, a higher tolerance means that there is not much room for error in the target of the parameter and a lower tolerance means that there is some room to have variation in the suggested target. The compliance column of the target parameter table is a list of methods for requirement verification, those five key requirements are: inspection, demonstration, test, analysis, and similarity.

Parameter	Target	Tolerance	Risk (H,M,L)	Compliance (A,T,S,I)	Test Equipment Needed
How fast the fan changes speed when there is a difference in temperature change.	< 1 second	Min	H	A,I,T	N/A
Maximum amount of fans running at max efficiency	3 fans	Min	H	A,T	N/A
Minimum amount of fans running at lowest efficiency (idle)	0 fans	Max	L	A,T	N/A
Overall cost of parts	$50	Max	M	S,I	N/A

Table 3.3: Target Parameter Table

Inspection is the nondestructive examination using one or more of the five senses. The demonstration is production manipulation as it is intended to be used to verify that the results are as planned or expected. The test is applying controlled and predefined stimuli to ensure that the system will produce a specific and predefined output. The analysis is verification using models, calculations, and testing equipment. Often used to predict the breaking point or failure by nondestructive tests. The similarity is verification used usually in combination with analysis to show that an article is similar to another article that has already been qualified to equivalent or more stringent criteria[7].

Figure 3.1: Level 0 Functional Decomposition

Figure 3.1 displays the level 0 functional decomposition; there are three inputs and 2 outputs for the fan cooling system module, and those are listed below in Table 3.4.

Inputs	**Outputs**
User-defined control parameters	Operation indicator
Temperature	Cooling
Electrical Energy	

Table 3.4: Fan Cooling System Module

The “user-defined control parameters” input would come from the student (or customer) programming certain constraints and tolerances on how and when the fans will operate, and at what speeds they will operate. Along with that, the “temperature” input would be modeled as some sort of thermistor that can be attached and read by the PLC as digital to analog values. The two inputs “user-defined control parameters” and “temperature” will be working in conjunction with each other; the temperature readings will decide the tolerance and constraints that the students will program onto the PLC. The “electrical energy” input would be a 120V AC source that would be provided by utility equipment in the PLC room.

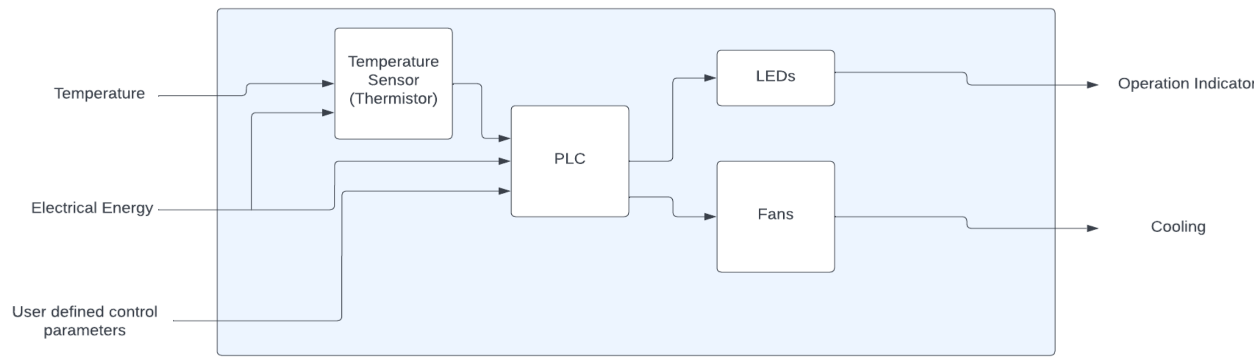


Figure 3.2: Level 1 Functional Decomposition

Figure 3.2 displays the level 1 functional decomposition. Within the "fan cooling system" module we see 4 modules with their inputs and outputs. The tables below provide the inputs and outputs for each of the 4 modules presented within the "fan cooling system" module.

Inputs	**Outputs**
Temperature	Voltage
Electrical Energy	

Table 3.5: Temperature Sensor (Thermistor) Module

Inputs	**Outputs**
Electrical Energy	LED Logic
Thermocouple voltage	Fan Logic
User-defined control parameters	

Table 3.6: PLC Module

Inputs	**Outputs**
LED Logic	Current to LEDS

Table 3.7: LEDs Module

Inputs	**Outputs**
Fan Logic	Current to Fans

Table 3.8: Fans Module

Chapter 4: Design

The design of our 3 cooling fan motor control consists of two sections: a temperature sensor to sense the temperature of the object and fans to cool the object in question.

Figure 4.1: Three-Fan Cooling System

The materials used for temperature sensing are a thermocouple and a resistance temperature detector (RTD). A thermocouple is a sensor for measuring temperature and consists of two dissimilar metal wires. An RTD is a sensor whose resistance changes as the temperature changes; the resistance is proportional to temperature, meaning that resistance increases as the temperature increases; this specific RTD is a three-wire RTD.

Figure 4.2: K-Type Thermocouple

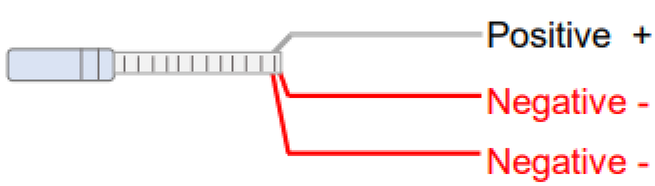


Figure 4.3: Three-Wire Resistance Temperature Detector (RTD)

As stated before, the three-fan will turn on and off depending on temperature increases and decreases over time. Figure 4.3 displays a graph of how the fans turn on and off based on temperature over time.

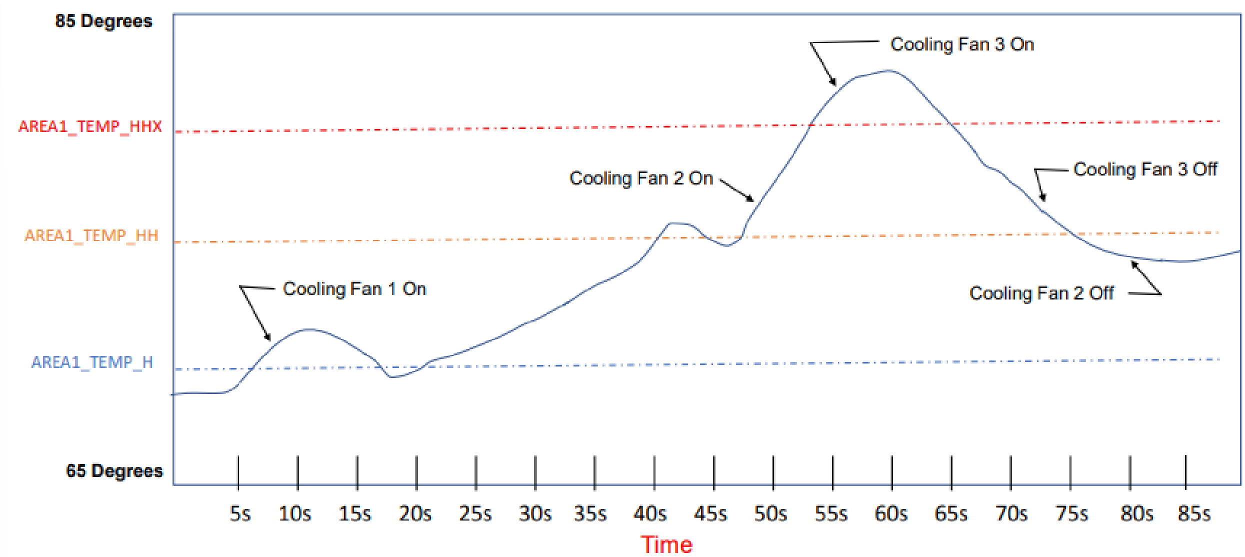


Figure 4.4: Temperature Rise Graph

Here are the setpoints for when each of the fans turns on and off:

- AREA1_TEMP_H = COOLING_FAN1 Running (72.5-degree setpoint)
- AREA1_TEMP_HH = COOLING_FAN2 Running (75.5-degree setpoint)
- AREA1_TEMP_HHX = COOLING_FAN3 Running (79.3-degree setpoint)

To prevent large inrush currents during extreme temperature changes, we will stagger the delay times for each of the fans. Below are the "ON" delays for the fans:

- 2.5 sec for Fan 1
- 3.5 sec for Fan 2
- 4.5 sec for Fan 3

Below are the "OFF" delays for the fans:

- 6.0 sec for Fan 1
- 6.0 sec for Fan 2
- 6.0 sec for Fan 3

If the HVAC system is above the "AREA1_TEMP_HHX" setpoint (79.3 degrees), we would like for an alarm "AREA1_ALARM" to go off if the system has reached that setpoint for more than 10 seconds. We have this precaution because if the device at hand is at this constant temperature, the device may be damaged for being that high of a temperature.

Below in Table 4.1 and Table 4.2 provides the bill of materials along with their purchase links and appropriate datasheets.

Item	Description	Link	Count	Price ($)
Modicon M580 ePAC	Ethernet Programmable Automation Controller	Schneider M580	1	0
PC Fan	Panaflo FBA08T12L 79mA 12V	(already acquired)	3	0
Thermocouple	Thermocouple Type-K Glass Braid Insulate	Mouser	1	$17.50
Three-Wire Resistance Temperature Detector	RTD Pt100 Temperature Sensor	Sparkfun	1	$16.50
LED	3mm and 5mm LED Lights Emitting Diodes Assortment Set Kit	Amazon	1	$12.40
			TOTAL PRICE ($)	$46.40

Table 4.1: Bill of Materials and Purchase Links

PC Fan Datasheet	https://datasheetspdf.com/pdf-file/613208/ETC/FBA08T12L/1
Three-Wire Resistance Temperature Detector	https://cdn.sparkfun.com/assets/2/4/2/1/c/PT100_DATA_SHEET.pdf

Table 4.2: Component Datasheets

Chapter 5: Simulation

For the simulation, we will be using the Unity Pro XLS programming software provided by Schneider Electric. We will be building a Function Block Diagram using these steps:

1. Open Unity Pro XLS and create a new project under the file tab.
2. Under Modicron M580, select “BME P58 4040”
3. In the Project Browser shown in Figure 5.1, click Programs -> Tasks -> MAST -> right-click Logic, and create a new section.

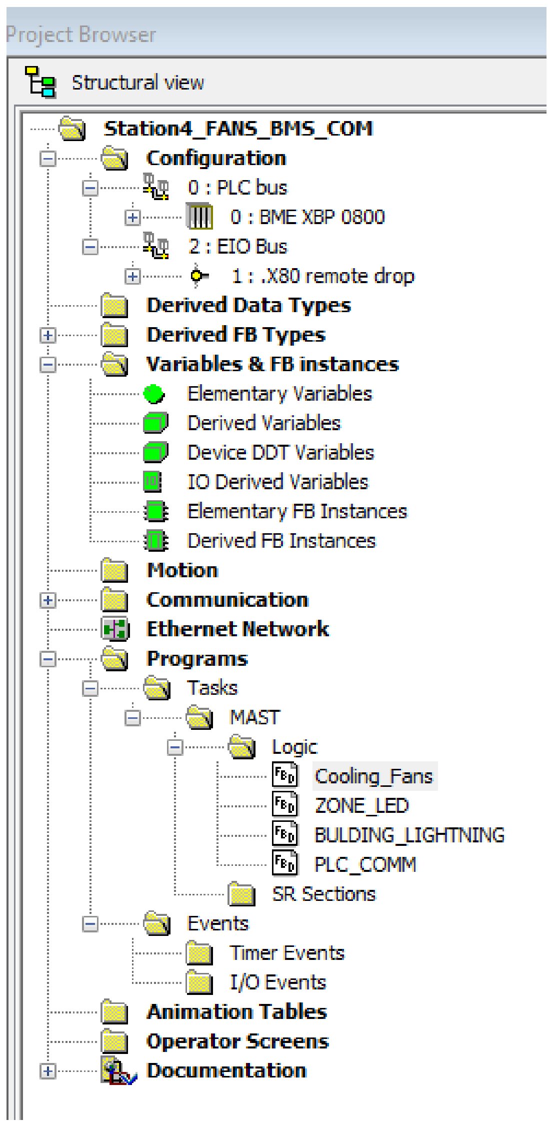
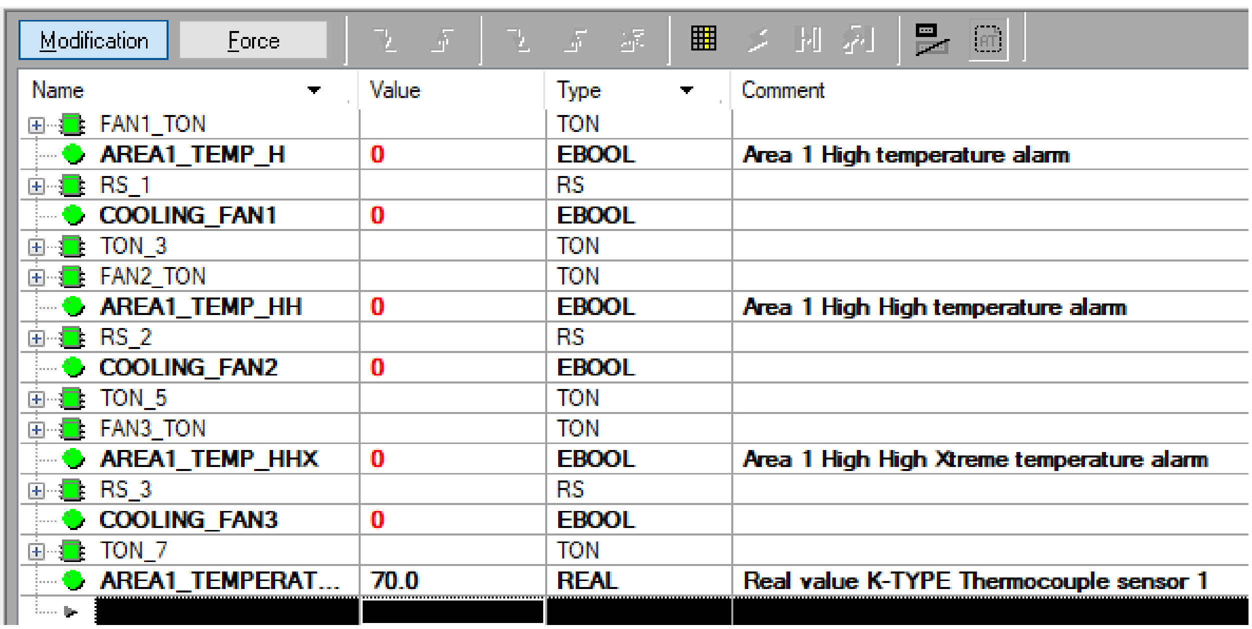


Figure 5.1: Project Browser for Simulation Setup

4. From there, you can name your file and start adding/creating function blocks by selecting “Data Selection” and using the appropriate function blocks.

Looking at Figure 5.2, we see various inputs along with their value types. The variables that we will be focusing on are: "AREA1_TEMP_H", "COOLING_FAN1", "AREA1_TEMP_HH", "COOLING_FAN2", "AREA1_TEMP_HHX", "COOLING_FAN3", AND "AREA1_TEMPERATURE", where "AREA1_TEMPERATURE" is the input that we will be altering for this simulation.



Name	Value	Type	Comment
FAN1_TON		TON	
AREA1_TEMP_H	0	EBOOL	Area 1 High temperature alarm
RS_1		RS	
COOLING_FAN1	0	EBOOL	
TON_3		TON	
FAN2_TON		TON	
AREA1_TEMP_HH	0	EBOOL	Area 1 High High temperature alarm
RS_2		RS	
COOLING_FAN2	0	EBOOL	
TON_5		TON	
FAN3_TON		TON	
AREA1_TEMP_HHX	0	EBOOL	Area 1 High High Xtreme temperature alarm
RS_3		RS	
COOLING_FAN3	0	EBOOL	
TON_7		TON	
AREA1_TEMPERAT...	70.0	REAL	Real value K-TYPE Thermocouple sensor 1

Figure 5.2: Simulation Variables

In Figure 5.3, we see three "greater than" blocks comparing two inputs: "AREA1_TEMPERATURE" and some set value, which is the threshold value. What these functional logic blocks are essentially doing is comparing room temperature with some threshold value; if the "AREA1_TEMPERATURE" value is greater than the threshold value, the output "AREA1_TEMP_H", "AREA1_TEMP_HH", or "AREA1_TEMP_HHX" will go high.

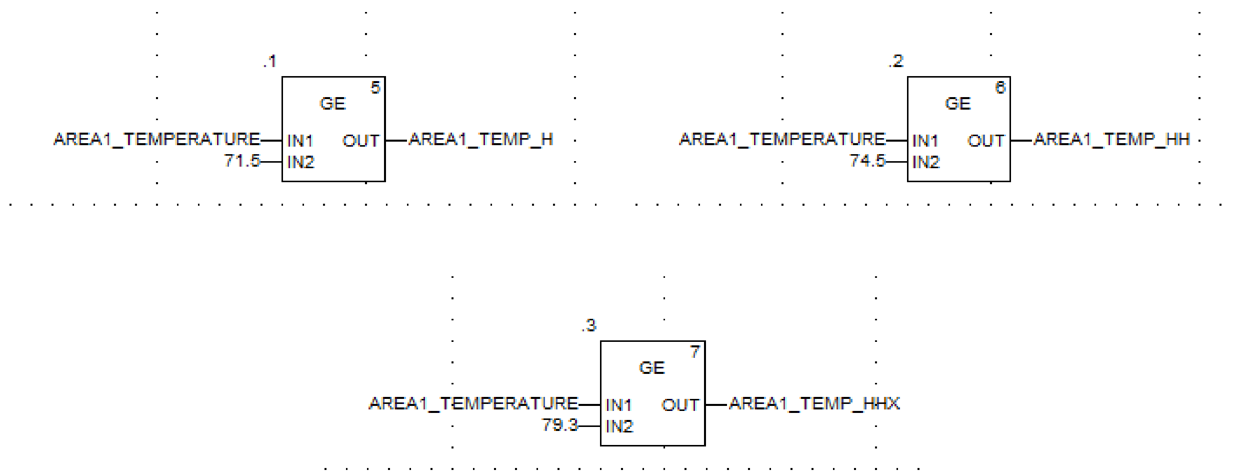


Figure 5.3: Temperature Threshold Functional Logic

The functional logic for each of the cooling fans is shown below in Figure 5.4. When "AREA1_TEMP_H" is high, fan 1 turns on after a 2.5s delay, but when "AREA1_TEMP_H" is low, fan 1 turns off after a 6s delay. When "AREA1_TEMP_HH" is high, fan 2 turns on after a 3.5s delay, but when "AREA1_TEMP_HH" is low, fan 2 turns off after a 6s delay. When "AREA1_TEMP_HHX" is high fan 3 turns on after a 4.5s, but when "AREA1_TEMP_HHX" is low, fan 2 turns off after a 6s delay.

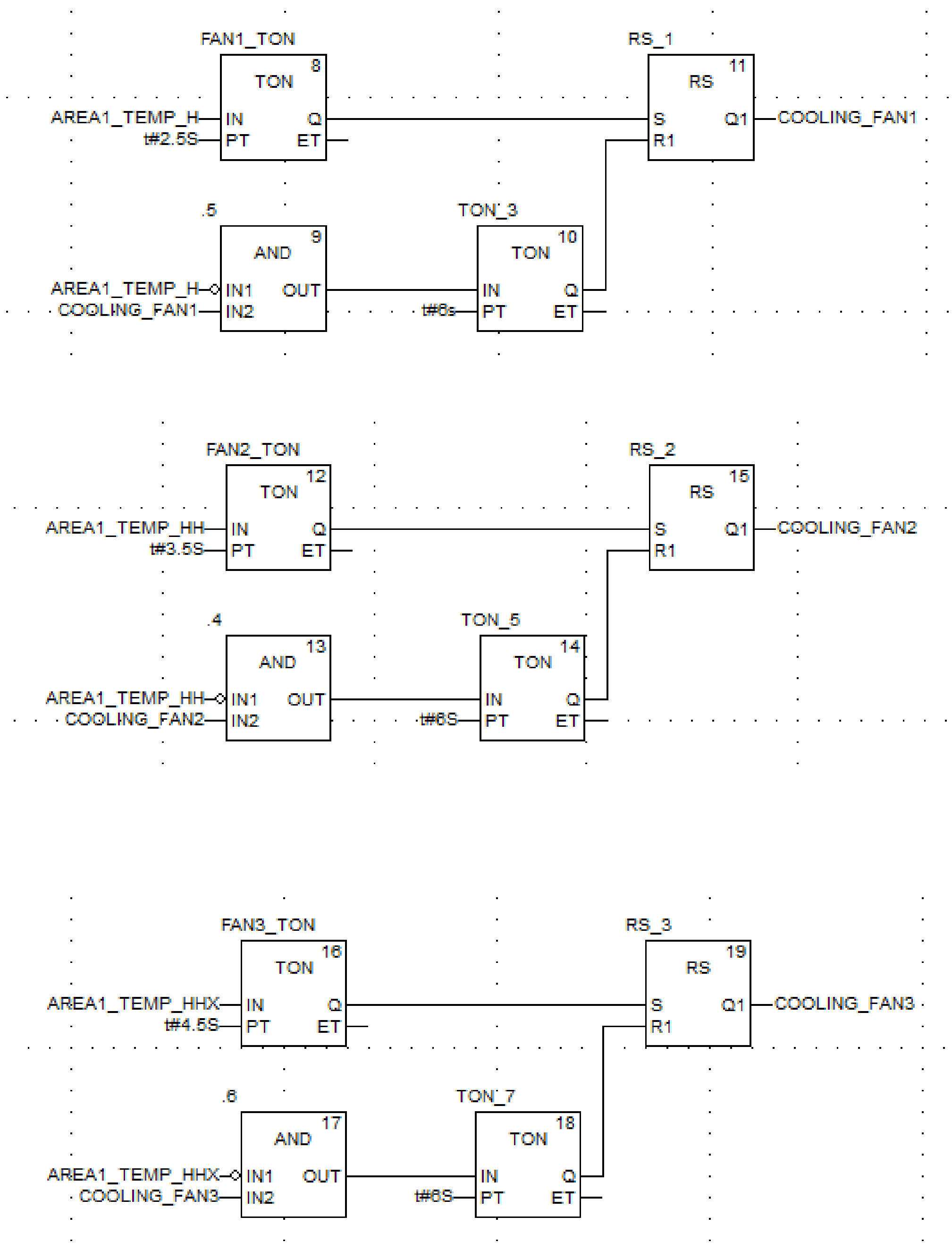


Figure 5.4: Functional Logic for All 3 Cooling Fans

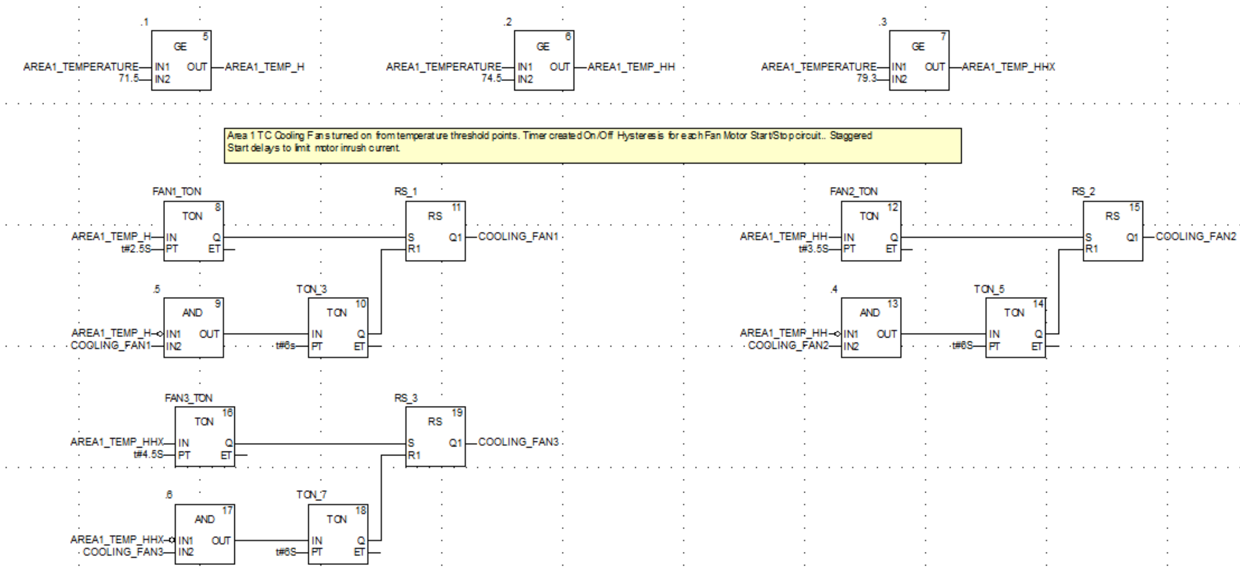


Figure 5.5: Complete Functional Logic Diagram for Simulation

The next step is to analyze the logic diagram under different temperature inputs. In Figure 5.6, we tested the temperature increase to 70 degrees, which resulted in no fans turning on.

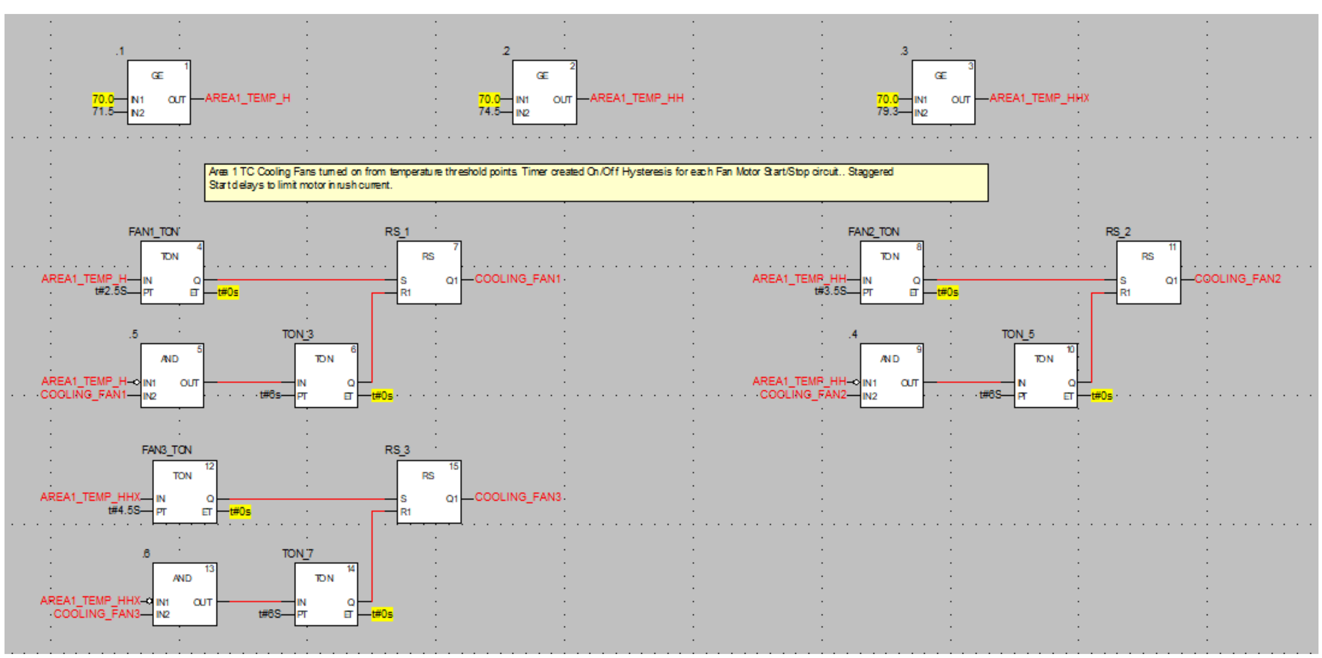


Figure 5.6: Simulation for Temperature Increase to 70 Degrees

In Figure 5.7, we tested the temperature increase to 72 degrees, which resulted in fan 1 turning on.

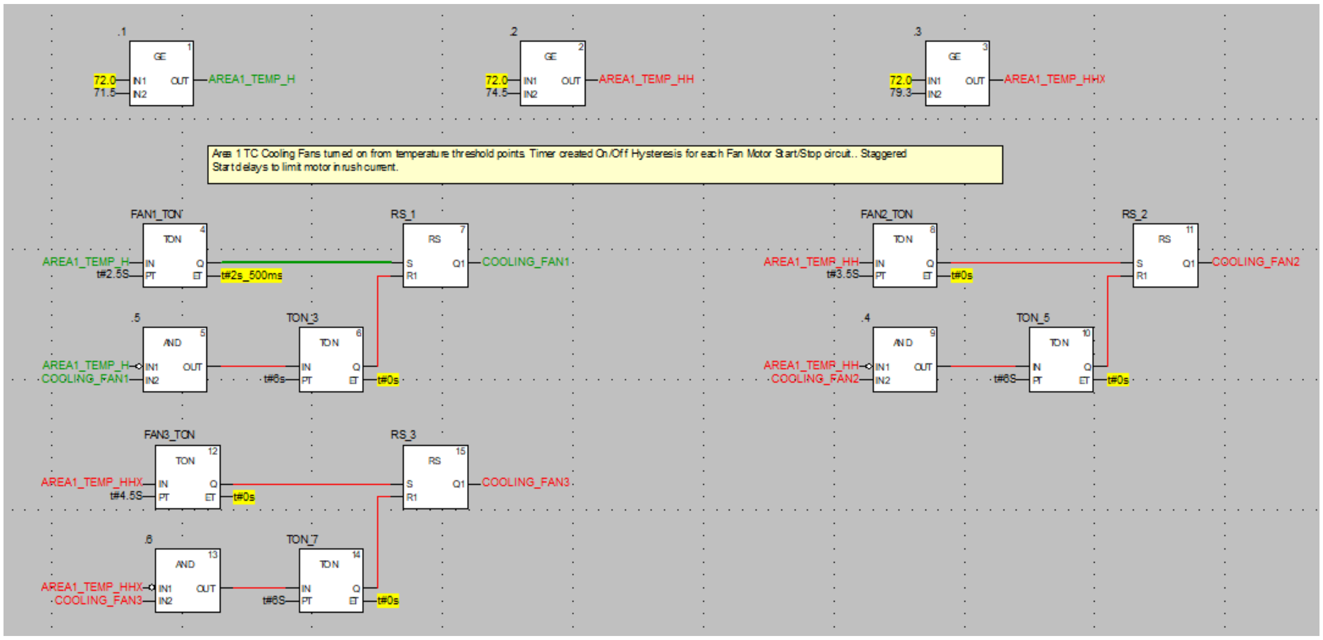


Figure 5.7: Simulation for Temperature Increase to 72 Degrees

In Figure 5.8, we tested the temperature increase to 75 degrees, which resulted in fan 2 turning on.

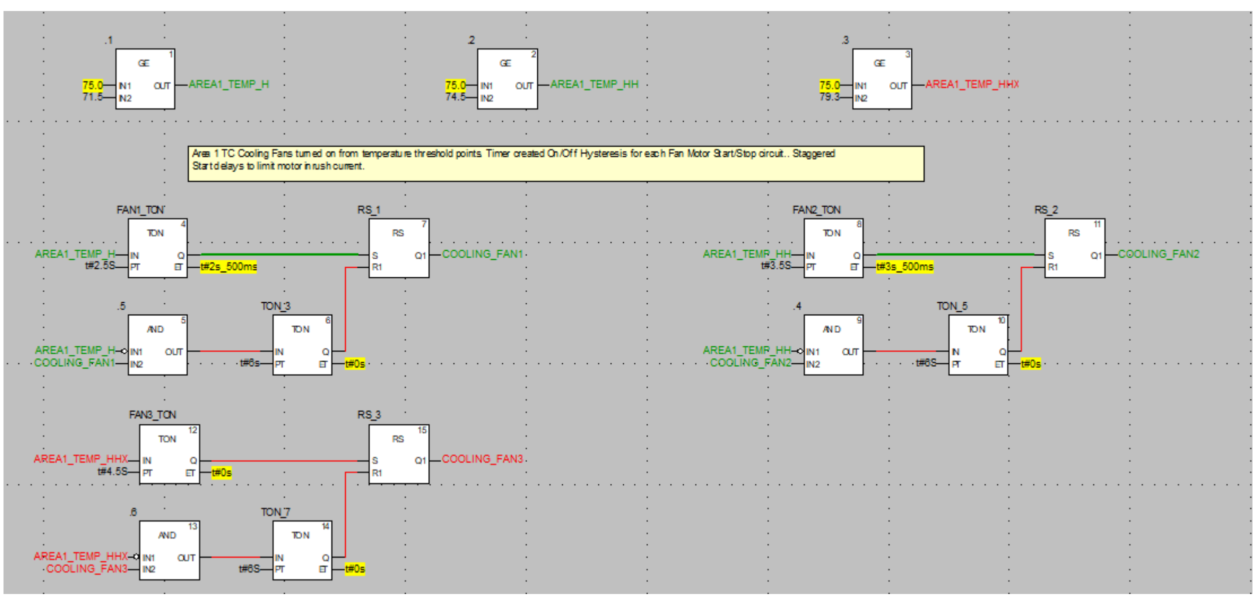


Figure 5.8: Simulation for Temperature Increase to 75 Degrees

In Figure 5.9, we tested the temperature increase to 80 degrees, which resulted in fan 3 turning on.

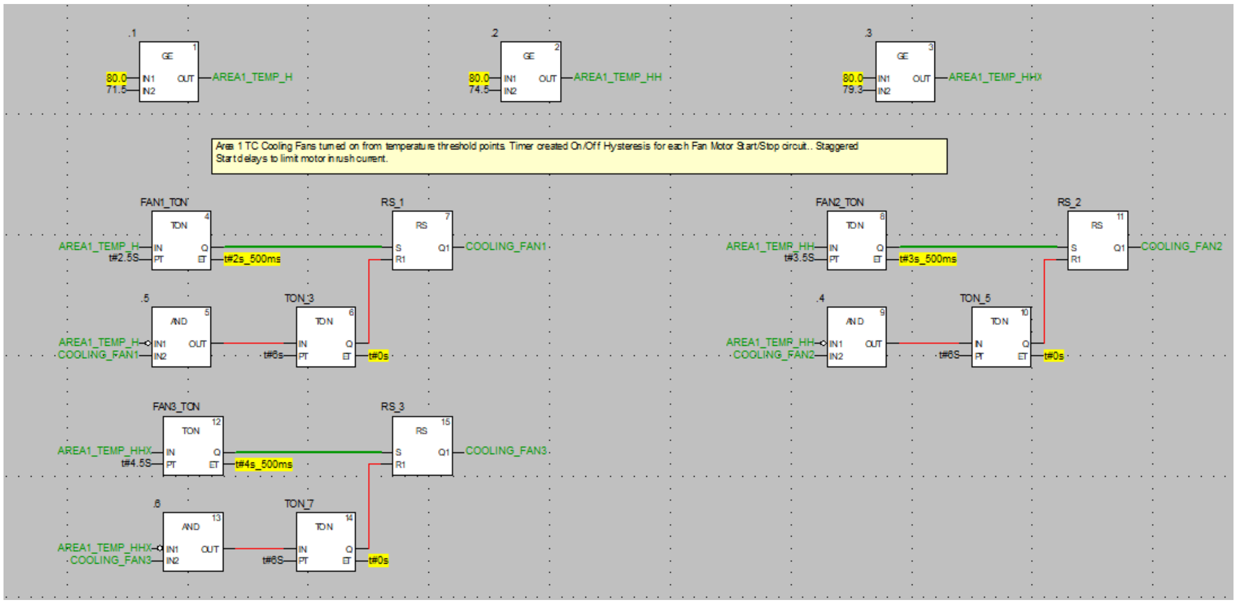


Figure 5.9: Simulation for Temperature Increase to 80 Degrees

In Figure 5.10, we tested the temperature decrease from 80 degrees to 75 degrees, which resulted in fan 3 turning off.

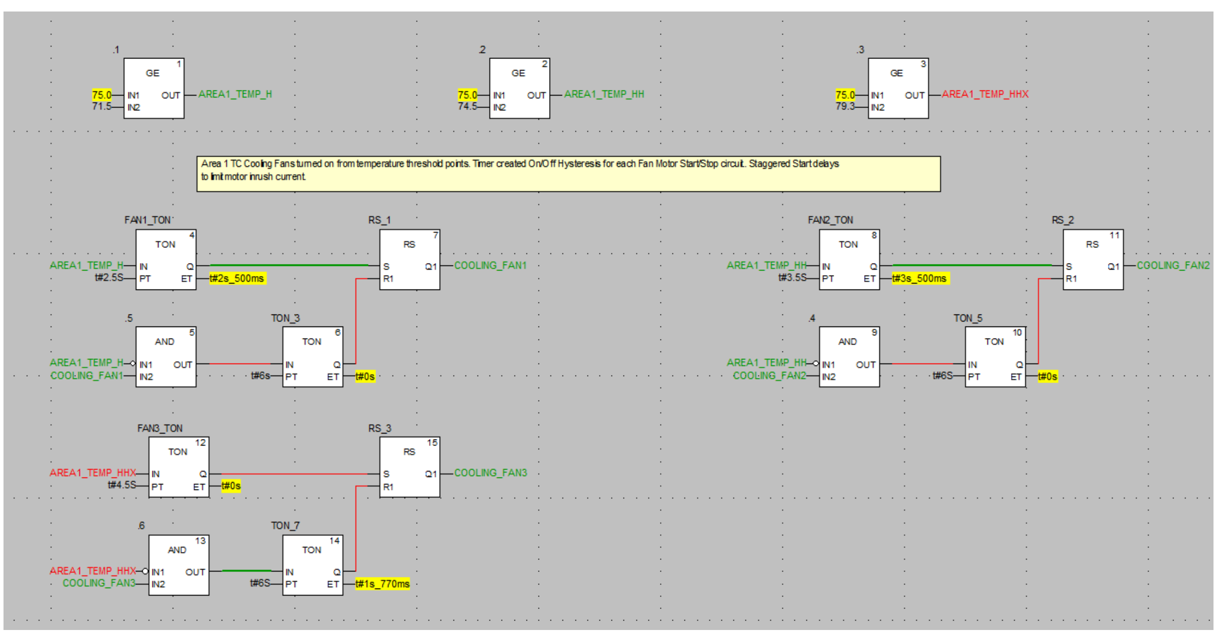


Figure 5.10: Simulation for Temperature Decrease from 80 to 75 Degrees

In Figure 5.11, we tested the temperature decrease from 75 degrees to 72 degrees, which resulted in fan 2 turning off.

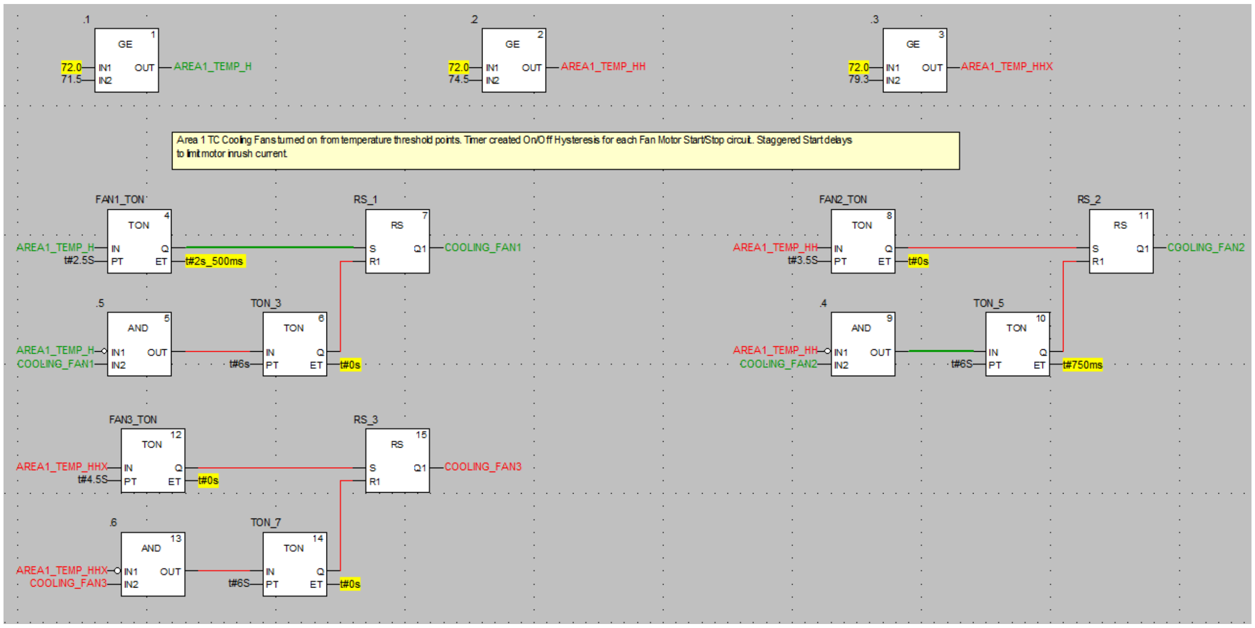


Figure 5.11: Simulation for Temperature Decrease from 75 to 72 Degrees

In Figure 5.12, we tested the temperature decrease from 72 degrees to 70 degrees, which resulted in fan 1 turning off.

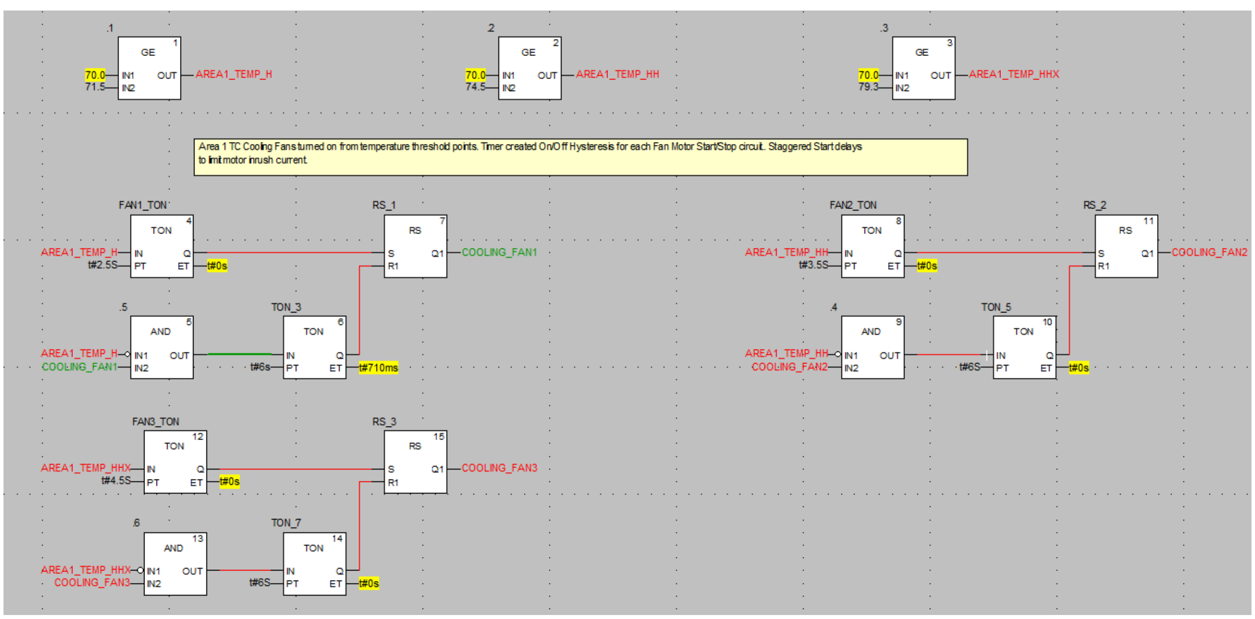


Figure 5.12: Simulation for Temperature Decrease from 72 to 70 Degrees

Temperature (°C)	Increase/Decrease	Fan 1	Fan 2	Fan 3
70	Increase	off	off	off
72	Increase	on	off	off
75	Increase	on	on	off
80	Increase	on	on	on
75	Decrease	on	on	off
72	Decrease	on	on	off
70	Decrease	off	off	off

Table 5.1 Temperature Increase/Decrease Results

Based on our tabulated data in Table 5.1 of the simulation and our expected results, everything matched up, meaning our Functional Logic for our HVAC system is efficient.

Chapter 6: Conclusion

We highlighted a particular design using the PLC, which is the "Three Fan Temperature Controller". The use of this cooling system is to replicate the idea of an HVAC temperature control in an industrial setting. Such HVAC systems are implemented in large data centers needed to monitor and control the temperature of internet-connected server racks. Monitoring the facility's utility power, power quality, generator back, uninterruptible power supply systems (UPS), lighting, and temperature control are all part of standard HVAC systems.

Even though the "three-fan cooling system" is being built on a small scale, the project is a good introduction to automation and control logic in an industrial setting. This EE course will also be a way for students to practice using a PLC and writing some logic for whatever project they are doing. Utilizing Schneider Electric's Unity Pro XLS program to simulate their design before physically creating it is also a great skill and practice for engineers in both labs and work.

Appendix A: Scheduling

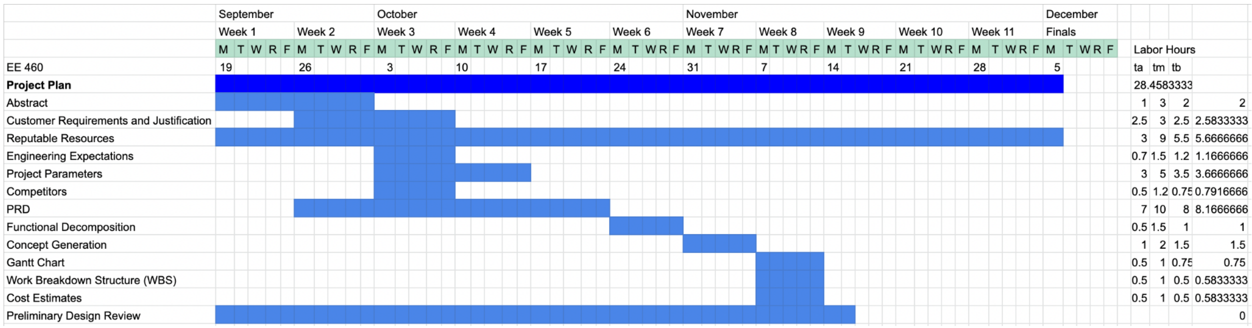


Figure A-1: Fall Quarter 2022 Gantt Chart

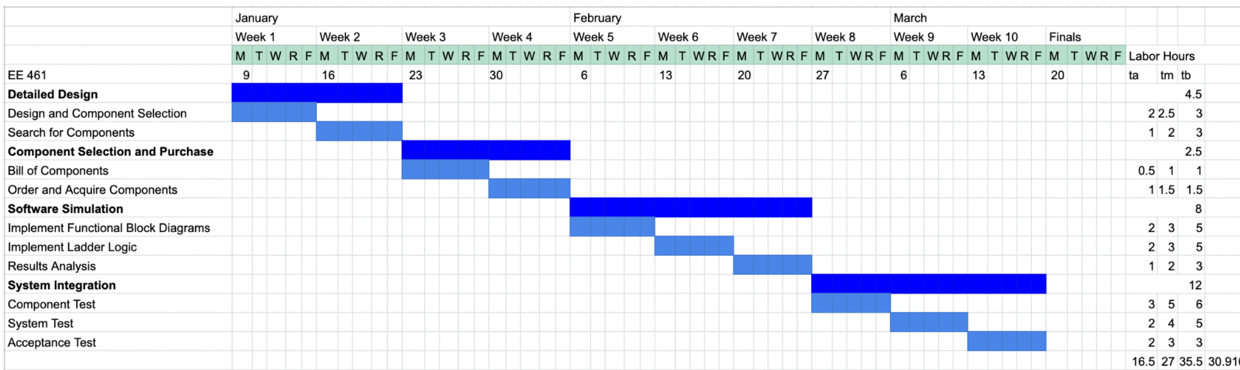


Figure A-2: Winter Quarter 2023 Gantt Chart

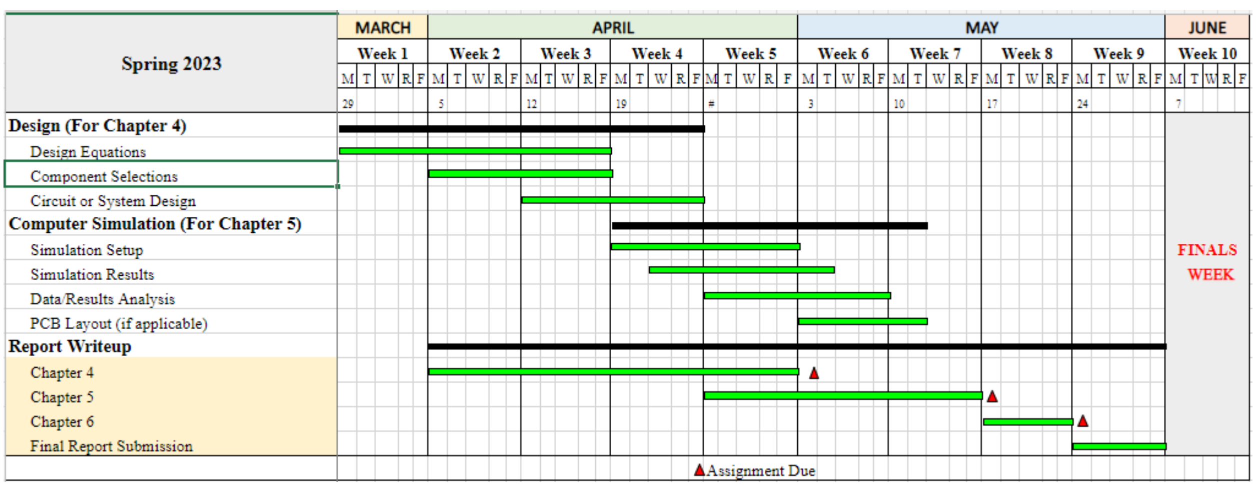


Figure A-3: Spring Quarter 2023 Gantt Chart

Appendix B: Bill of Materials

The whole function was decomposed into smaller singular elements which we either already have the parts or can purchase the parts to build the whole system.

The partial functions of the system are going to be implemented using the EcoStruxure control expert app to interface with the PLC. Other partial functions are going to hardware such as an RTD (resistive temperature detector) and fans to implement the actual cooling system

Table 9: Cost Estimates

Partial Function	Most Likely	Most Pessimistic	Most Optimistic	PERT Estimate
M580 PLC (already supplied)	xx	xx	xx	xx
Temperature Sensor (RTD) (RTDs and Thermocouples supplied)	$4.50 / part	$7.00 / part	$2.00 / part	$4.50 / part
Fans (3 fans per set)(8 sets)	$11.95 / part	$13.31 / part	$9.75 / part	$12.49 / part
Power Supply (voltage supplied from M580)	xx	xx	xx	xx

Estimate = (optimal + 4*likely + pessimistic)/6 [6]

Appendix C: ABET Analysis for Cooling Fan System

Functional Requirements

The purpose of my project is to create a fan-cooling system that will be used to cool down electronic components. The fan-cooling system will have three fans that will operate at 12V each. The fans will vary at different speeds and will turn on and off appropriately depending on the temperature of the component that is being cooled. An M580 PLC from Schneider Electric will power these varying speeds through the programmed logic. All functionality, from the varying fan speed to sensing the temperature of the electric component, will be controlled and programmed from the M580 PLC.

Primary Constraints

Some constraints that may be applied to my project may be the range of control we can have using the program offered by Schneider Electric on the M580 PLC. Generally, my project is focused on displaying the power of the M580 PLC, and how effective PLCs are in the industry. Since I am specifically designing a fan-cooling system using the PLC, I have to consider exactly what the PLC is capable of doing for the fan-cooling system to function properly. Constraints such as how easy it is for the PLC to vary the voltage for each of the fans to operate through code. Along with that, how we can connect a temperature sensor to the PLC, and how easy it will be to program the PLC to respond/react with the temperature sensor.

Economic

This project has an interesting economic effect. Although the fans are the most important part of the project, the fans and the temperature are very cheap compared to the PLC itself. Comparing the fans to fans similar to those used in PCs, the fans will cost at most $35. A temperature sensor won't cost that much either; assuming we are using something similar to a thermistor, at most the temperature sensor will cost at most $5. The PLC itself is worth at least $5,000, which is to be expected for most PLCs. The M580 PLC will be manufactured and provided to us all by Schneider Electric; a device of such high cost will be built to be very durable. The components/devices that will be connected to the PLC will most likely be replaced quicker than the PLC itself, in this case, the fans and the temperature sensor. There will most likely be no need to replace or get rid of the PLC if the project is not needed anymore; we can just disconnect the components and use the PLC for another project. The PLC is capable of adding additional ports that can be used to add more components to the controller, so the usability of the PLC is immeasurable. With this being said, the reusability of the PLC for projects other than a fan cooling system is easily possible.

Commercial Basis

Although PLCs may seem like a very small mechanism, the device is capable of doing many different types of functions. The range of ways this PLC device can be used is beyond measurable; as with any controller that could be programmed to do certain functions, this PLC is capable of doing that and more. Since PLCs are so expensive, Schneider Electric can't pump out as many devices as they would like as freely as they want. With that said, the M580 PLC won't be manufactured on a commercial basis due to the high cost of these devices. PLCs in general are typically not manufactured on a commercial basis, they are more-so produced for industry use due to how powerful they are and the range of functionality they can be programmed to do, and the M580 PLC will be no exception. Since the PLC won't be produced on a commercial basis, the cost of the PLC will most likely be fixed. This will be favorable for the targeted customers, which are those in the industry since they won't have to worry about sudden price increases. The only time the price will increase will be when there is a shortage of the parts needed to build the device; this will likely occur during a pandemic, where it is hard for the manufacturers to obtain the parts to build the device. There will most likely not be a large-scale production of these devices, just necessary purchases at a certain amount that is ordered from certain companies. These devices will most likely not be on much retail due to how limited the devices will be produced from Schneider themselves; but if/when they are put on retail, the price may most likely increase due to how rare it would be to an average consumer.

Environmental

My project will have hardly any effect on the environment, both good and bad. As stated in the economic section, the PLC itself will be re-used for another project other than the current project it will be used for. The components that are connected to the PLC will be the only variables affecting the environment. The components attached to the PLC can be reused for other applications and applicable devices. For my project, the fans and the thermistor will be the only components that will be replaced/disposed of. The fans can be attached to another PLC or another allowable device but at the expense of any wear or tear of the fans themselves. The thermistor can also be re-used on another device, but will also be at the expense of the gradual deterioration of the thermistor after prolonged use. PLCs can be used for any sort of project, so the effect of reusability determines what type of project the PLC is a base of. But if we are speaking based on simply the PLC being reproduced on a small/large scale, we won't have to worry much about any negative effects on the environment, simply because the M580 PLC can be re-used for limitless projects.

Manufacturability

As stated before, Schneider Electric is the company sponsoring the project and providing us with the PLC that will be used as the base of my project. The external parts that will be connected to the PLC, which are the three fans and thermistors, will be pre-bought by other manufacturers. For our project, we won't have to worry about personally welding any certain plastics or metals. For this project, we won't have to worry about any sort of tolerances, operating temperatures, or voltage ranges with our components, since the PLC can handle most types of voltage conditions. All that we have to worry about is making sure we don't provide too much power to our components and overheating the components to the point where they won't operate properly or can't be reused anymore.

Sustainability

This project does promote the idea of sustainability due to the reusability of the PLC. The project will have hardly any harmful effects to the environment since you can reuse the fans, the temperature sensor, and the PLC. The economic effect of the project is not much either; as stated before, the PLC is the main part of the project and is mostly manufactured for industry use and not for the average consumer. The societal effects won't be much either, since a fan cooling system at this measure won't be used commonly for normal cooling of electronic components.

Ethical

This project won't have to worry about any ethical problems at all. A fan cooling system used to cool down overheating electronic components will not harm any sort of group in any fashion. The only application this project will be used for is cooling down electronic components in a confined space. This project will also have no violation in regard to the IEEE Code of Ethics either. The first code for the IEEE Code of Ethics talks about paramount the "safety, health, and welfare of the public". This project will have no effect, good or bad, on the general health, safety, and welfare. The sixth code for the IEEE Code of Ethics talks about maintaining and improving "technical competence and to undertake technological tasks for others only if qualified". This project uses the M580 as the base of power and requires no specific certification to use this controller. The project is meant to be a simple use device that most people can use without worrying about any potential harm to themselves.

Health and Safety

Those using this project won't have to worry much about safety measures before using the system. The PLC is capable of powering up to 120V, which is a large amount of voltage that some people will have to notice. For this particular project, the fans will be using at most 12V to operate and power appropriately. And for the temperature sensor, if we are using a thermistor, there will hardly be any sort of current going through it at all. The only safety precaution the user will have to worry about with this fan cooling system is the speed of the fans. Any electronic device that is rotating at high speeds is very dangerous, as it can cut or severely harm anyone who touches it. Along with that, the fans themselves possibly malfunction due to any sort of mishap within the PLC, which is very unlikely due to how the PLC is built and will be programmed. The disposal factors of this project won't have any health effects due to all of the parts being reusable, so these parts will most likely not be dumped anywhere.

Social and Political

There are three stakeholders for this project: Schneider Electric, the professor being sponsored to display this device, and the students who are using the device. Schneider Electric is a stakeholder because they are the manufacturers of the device who allow us to use their device. The professor displaying this device is another stakeholder since they are being sponsored to use this device and display its functionality and power. The students are another stakeholder since they are the ones using the device and understanding the power of the device in the labs. The project will have little to no effect on the societal and political realm. Society will not have to worry about this project affecting them due to the fact the PLC is not always available to the average consumer. There are hardly any political effects due to the PLC not having hardly any economic effects. There will also be no harmful environmental effects due to the reusability of the components in the fan cooling system. The concept of NIMBY applies here because this project won't be a device that an average person will have. The PLC is a large costing device, if a consumer would like to purchase a fan cooling system for specific small electronic components they would purchase a much cheaper and smaller fan cooling system.

Development

The development of this project does require some knowledge of how the system should work along with some knowledge of coding. We would need to know how to use the programming software offered by Schneider Electric, as that is the software that will be needed to program the PLC to use the fans. Some techniques that will be needed is understanding how the fans work; knowing that a certain voltage will produce a certain fan speed needs to be understood for developing this project. Knowing these techniques and understanding what needs to be done for this project to be successful is crucial and sufficient for this project to work smoothly

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