

STEMSEL Automotive Project 5 – Intercooler spray controller

Problem

A turbo charger is a device used to increase the troling power from an engine, for example on an emergency vehicle. However, they become very hot so we need to design a device to control a cooling system that comes on when required.

Background

We know that our cars get their energy by burning petrol or diesel, but in order to burn anything we also need to supply oxygen. Some types of car want to generate more power from their engines, such as fast high performance cars, or heavy off road vehicles. Emergency vehicles also want to maximise engine power, so they can get to their destination a quickly as possible, or to carry the extra equipment they need when they arrive. One way they can get more power is to burn more fuel in the engine, but this requires more air to be added as well. But how can we accomplish this? A common way is to use a turbocharger, which acts basically like a fan to force more air into the engine. It will also compress and pressurize the air, squeezing more air into the engine’s cylinders. For this reason, modern diesel engines are almost always turbocharged, since they actually use the heating effect of compressing air to ignite the fuel.

However, the turbo also needs power to make it spin around. A turbo charger uses the exhaust gasses coming out of the engine to turn a turbine at speeds over 100,000 RPM, which is connected via a shaft to another turbine which pulls fresh air into the engine. This high speed causes a lot of friction, which combined with the hot exhaust gases causes the turbo to become very, very hot, so it needs to have its own cooling system.

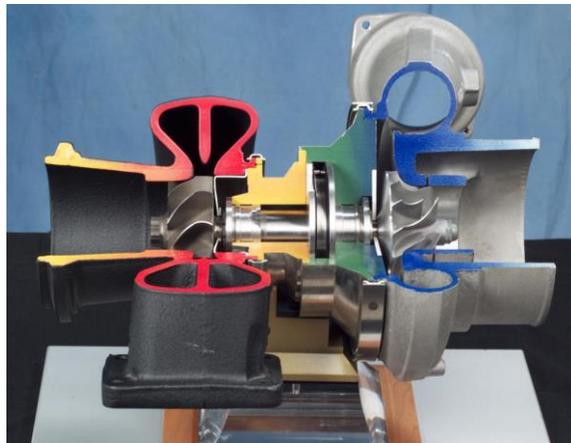


Figure 1: Exhaust gas spins the turbine on the left, causing the other turbine to spin and draw more air into the engine

An intercooler powers a water-pump to cool the turbo down, so it can continue operating properly. To do this the intercooler uses a predictive system to cool the turbo down before it heats up too much. The intercooler computes the difference between the ambient temperature outside the turbo and the temperature inside of the turbo. If the difference between the outside and inside of the turbo is too great and the driver is accelerating, the intercooler will activate the water pump to spray water onto the turbo. As the water evaporates, it takes the heat away with it. You can feel this for yourself by wetting part of the back of your hand, and blowing across it; you should notice the wet area feels much cooler than the dry area.

The aim is to simulate the pump operating only when a car is accelerating and the turbo temperature is greater than the ambient temperature.

Ideas

What should be used as the water pump? What can be used for the accelerator? What can be used to read the temperature? How can we check two conditions at once, and only turn on the pump when both of them are met?

Plan

We know that water and electronic circuits don't mix, so for this workshop we won't use actual water. Instead a motor will be used to take the place of the water-pump, just to demonstrate when it will be switched on. For the accelerator, a potentiometer is used. Assuming the automobile is travelling at a constant speed the potentiometer is set at a threshold. When the potentiometer is turned past the threshold, this indicates that the automobile is accelerating. As for the temperature readings, a thermistor is used as the input temperature sensor.

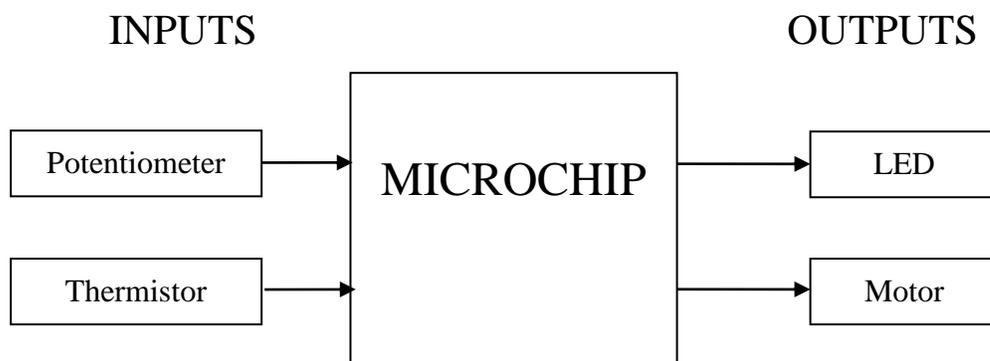


Figure 2: Inputs and Outputs

Design

Open ezCircuit Designer and start a new project. Add a thermistor, LED, a potentiometer and a motor input to the schematic. The label of the component can be renamed to something more intuitive than the preset names by simply right-clicking on the label and selecting rename. As an example for this project the motor can be renamed “Water_Pump”. When the motor driver icon is selected choose the “DC Motor” option. Follow the schematic below as a template for the project.

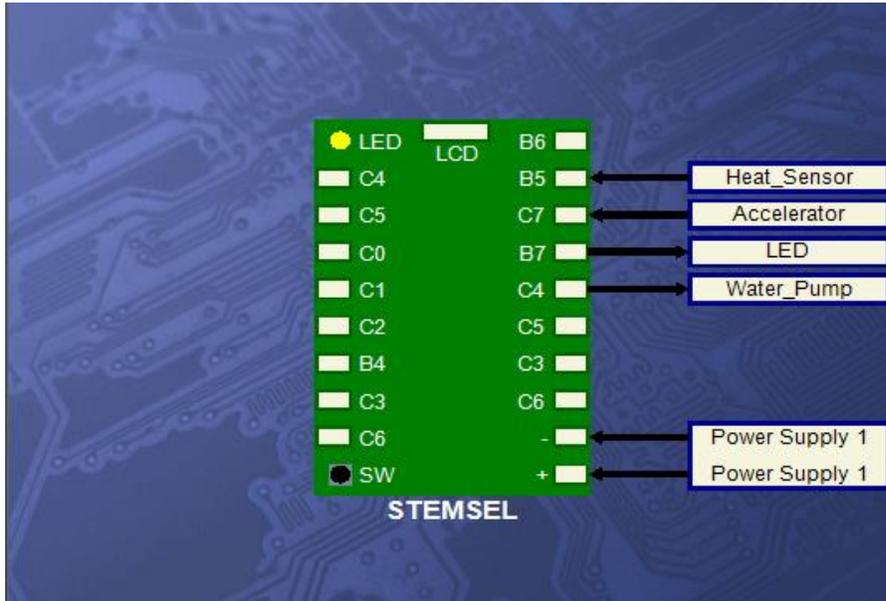


Figure 3: Circuit Design

Build

Now it is time to construct the circuit. Insert the white wires into the terminals designated in the circuit design, and tighten the screws. For the DC motor, one wire will go into C4, but the other should also be placed into the negative terminal along with all of the black wires. Red wires should be placed in the positive port.

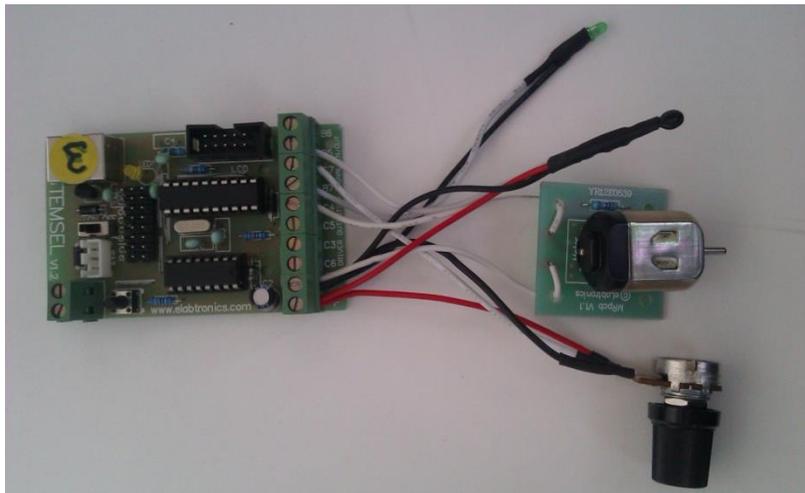


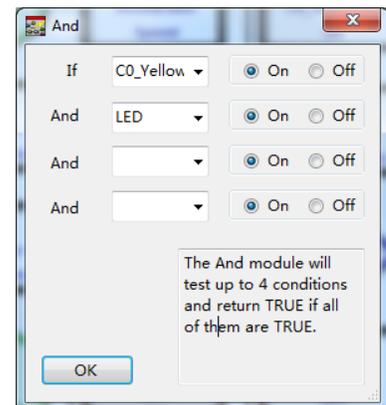
Figure 4: Circuit

Programming

Once the circuit has been assembled, send the design to CoreChart by clicking the “Send to CoreChart” button, then click the “Send Program To Chip” button to program the chip with the test program. Once you have verified your outputs are working, delete the test routines.

The water pump needs to turn on if the car is accelerating and the turbo temperature is greater than the temperature reading of the surrounding environment.

1. First, we need to get a base reading for our temperature. Use an AnalogIn icon to read in the temperature, saving it as Ambient_Temp.
2. So that the temp can fall below the Ambient_Temp, use an Add icon and add 2 to Ambient_Temp
3. Ambient_Temp should not be changed when we loop back, so add an address and call it Loop.
4. Now we need to check the turbo’s temperature. Read in the temperature again using a new AnalogIn icon and call it Turbo_Temp.
5. We also need to read the car’s speed, so add another AnalogIn icon to check the accelerator, saving it as Speed.
6. We now need to check whether either the speed, temperature or both are too high. We will start with Speed, so use a Compare icon to check if Speed is above 100. If it is above, turn the on-board C0_YellowLED on, or turn it off if Speed is below 100.
7. Add another Compare icon to check the Turbo_Temp in a similar manner, using the Ambient_Temp as the threshold. Turn on the LED if Turbo_Temp is above, or off if Turbo_Temp is below.
8. Now we need to see if the pump should come on, which should only happen if both the Speed and Turbo_Temp are above their respective thresholds, i.e. if both LEDs are on. Click on the Numbers button and add an AND icon to the program.
9. Modify the AND icon to check if the C0_YellowLED is on and the LED is on. The remaining two fields should be left blank.
10. If they are both on, use OnOffPin and TimeDelay icons to turn on the Pump_Motor for 10 hundredths of a second then turn it off. You will also need to group these icons so they fit underneath the AND’s Decision icon.
11. Put a GOTO icon at the end of the program to jump back to the Loop address we added earlier, then send the program to the chip and test it.



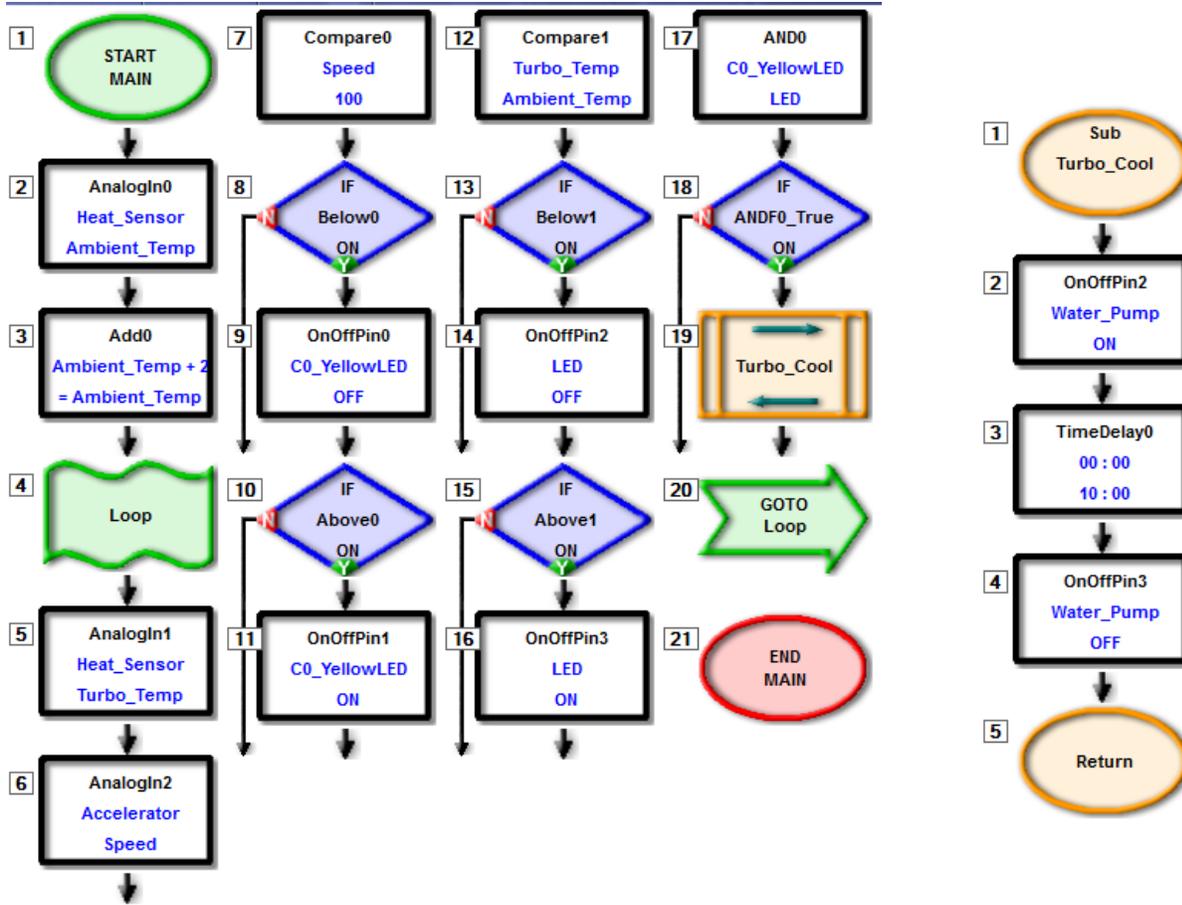


Figure 5: Intercooler Program Code

Extension

Are you able to modify the program to only activate the motor when there is a certain difference between the ambient and turbo temperatures rather than just when it's greater than?

Summary

Turbo chargers can be very useful devices to increase engine power by forcing more air into the engine so that more fuel can be burned. However, since they also generate a lot of heat, they also need to have a cooling system to prevent overheating, as this can cause serious damage to the engine.