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UNH FSAE 2014 Electronics Subgroup Final Report

The Electronics subgroup to some degree accomplished all of its goals set from the beginning of the year. The custom wiring harness was mostly completed within a short time and modified according to accommodate other subgroup’s ideas that came up after. The dashboard design proved to be the most challenging part which included designing and printing a custom circuit board to fit many specifications. The data acquisition was created on a different platform than was originally planned for but it worked to collect the data that was planned for.

 The wiring harness, shown in figure 1, was completed to power the engine, ECU, and all other necessary components to make the car run how it should. The engine is the Yamaha YFZ450R that was used for the first time in last year’s car. The harness most importantly connects the Vehicle Engine Management System (VEMS) to the engine to make it run according to the engine tune. The VEMS collects the data from the throttle position sensor, crank sensor, manifold air pressure, manifold air temperature, and exhaust oxygen. It also controls the fuel injector and spark coil to ensure the correct amount of fuel is injected and ignited in the engine at the proper time. The VEMS collects the data on the input and the output is the ignition signal and coil signal which run the engine efficiently. Grounding is the most important step in wiring the VEMS because the sensors need to be connected to it appropriately to receive accurate data which makes the engine run how it should.



Figure 1, Wiring Harness Schematic.

The wiring for the harness is multiple gauges of stranded wire depending on the current drawn from each component. The wire loom used in the engine compartment is made from flame retardant polyester. It properly protects the shielding on the wires from abrasion which occurs from vibration in the engine compartment. The wire loom keeps the high heat from reaching the wires as well which could damage important connections. Adhesive heatshrink of various sizes keeps the loom from splitting at the ends and holds it from sliding around on the wires. Almost every connection on the vehicle is made with weatherproof motorcycle connectors. This keeps short circuits from happening and holds the wiring in place while making it removable if necessary.

The protection methods used are fusing, kill switches, and relays. The fuses are typical protection for vehicles where excessive current spikes are possible. By fusing every connection which draws current, if there is a current spike the fuse will blow instead of overheating or possibly melting the wiring which causes potentially dangerous situations. Relays are also used in the fuse box to separate circuits which draw low current from circuits which draw high current. This separates the high current drawing fan motor and starter motor from the low current drawing switches which control them. All current flows through the master kill switch which is the only connection from the positive terminal of the battery to the rest of the vehicle. The other two kill switches are required in the rules of the competition to kill power to the fuel pump and the engine. These kill switches are the push-pull knob on the dashboard and the brake overthrow switch which are in series. Those two kill switches complete the circuit of the coil of the VEMS relay from battery to ground. By energizing the coil, the switch contact in the relay closes connecting power to the VEMS. So when one of the switches is open, the VEMS doesn’t get power and therefore stops the engine from running and stops the fuel pump from working.

The dashboard of the vehicle was changed this year to include a more versatile display while maintaining functionality of last year’s design. Created in the Fritzing beta software, the dashboard PCB, shown in Figure 2, was created to fit snugly on the back of the dashboard panel located appropriately so the driver could easily see information on the display. The central component of the board is an Arduino Micro. The Arduino Micro has enough digital input and output pins to handle the serial data input, shift registers, and LCD screen. The VEMS sends out data on specified pins in a protocol called AIM protocol which is a constant stream of data which is sent on specific frequencies in five byte packets. The data is sent from the VEMS on an RS232 female connection and connects to the dashboard which has an RS232 male connection. Data over the RS232 from the VEMS is 12V for a high bit and -12V for a low bit so data conversion from this voltage level to TTL levels is necessary. The MAX232 chip was integrated in the design to handle the voltage level conversion. The serial data output from the MAX232 then goes directly to the Arduino whose program handles the data appropriately and displays it on the screen and lights up LEDs according to engine RPM input. The engine RPM data is processed in the Arduino program which sends bytes to the 74HC595 shift registers to light up 3mm LEDs which indicate when the driver is nearing the power band and should shift. The dashboard is powered from the battery which is 12V which is a problem when dealing with digital TTL voltage level components. The 12 volts from the battery is regulated down to 5 volts by the V7805 switching voltage regulator. A switching regulator was used instead of a linear one to reduce heat which is already an issue in vehicle compartments. The Arduino also controls a light on the dashboard which indicates whether the engine is in neutral or not. That signal comes from the engine itself. The housing was designed in SolidWorks and 3D printed to hold the PCB in tightly and fit on the back of the dash panel in the frame.



Figure 2, Dashboard PCB.

 Data acquisition was done in Arduino using a variety of devices. The main device used was an Arduino Uno which got its power from an external battery supply. The main aspects of the vehicle we wanted to test were the change in suspension action and acceleration with the introduction of front and rear wings which the UNH FSAE has never done before. The wings should create downforce which the suspension will react to as well as change the acceleration of the vehicle. We used suspension position sensors, which are linear potentiometers specifically for suspension measurements, to measure the changes in suspension movement. A three axis accelerometer called an ADXL335 measured the acceleration in the racecar. All the data collected from the sensors is written to text files and stored on an SD card for later analysis. The data can be plotted in MatLab or Microsoft Excel to obtain intuitive graphs and analyze the data to look for changes or trends.

 The Michigan FSAE competition brought challenges which tested the troubleshooting knowledge I gained throughout the past four years. At competition every team is required to pass a technical inspection to make sure all of the rules in the rulebook are adhered to. This includes having a working brake light which when tested at tech inspection did not turn on when the brake pedal was pushed. This required the troubleshooting of the circuit within the vehicle. First a multimeter was used to test the brake light switch to ensure it was not broken by measuring resistance when the switch was pushed. When open it was infinite and when closed it was very close to zero so it was determined the switch was functioning properly. Next I checked to ensure the pin connecting to the fuse box was getting 12 volts. It wasn’t, so the problem was further up the circuit. As it turns out the pin on the fuse box connector was forcefully pushed out of place when the secondary firewall went in. The pin was put back where it belonged and we passed that part of tech inspection and moved on to the next part of the safety inspection.