THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

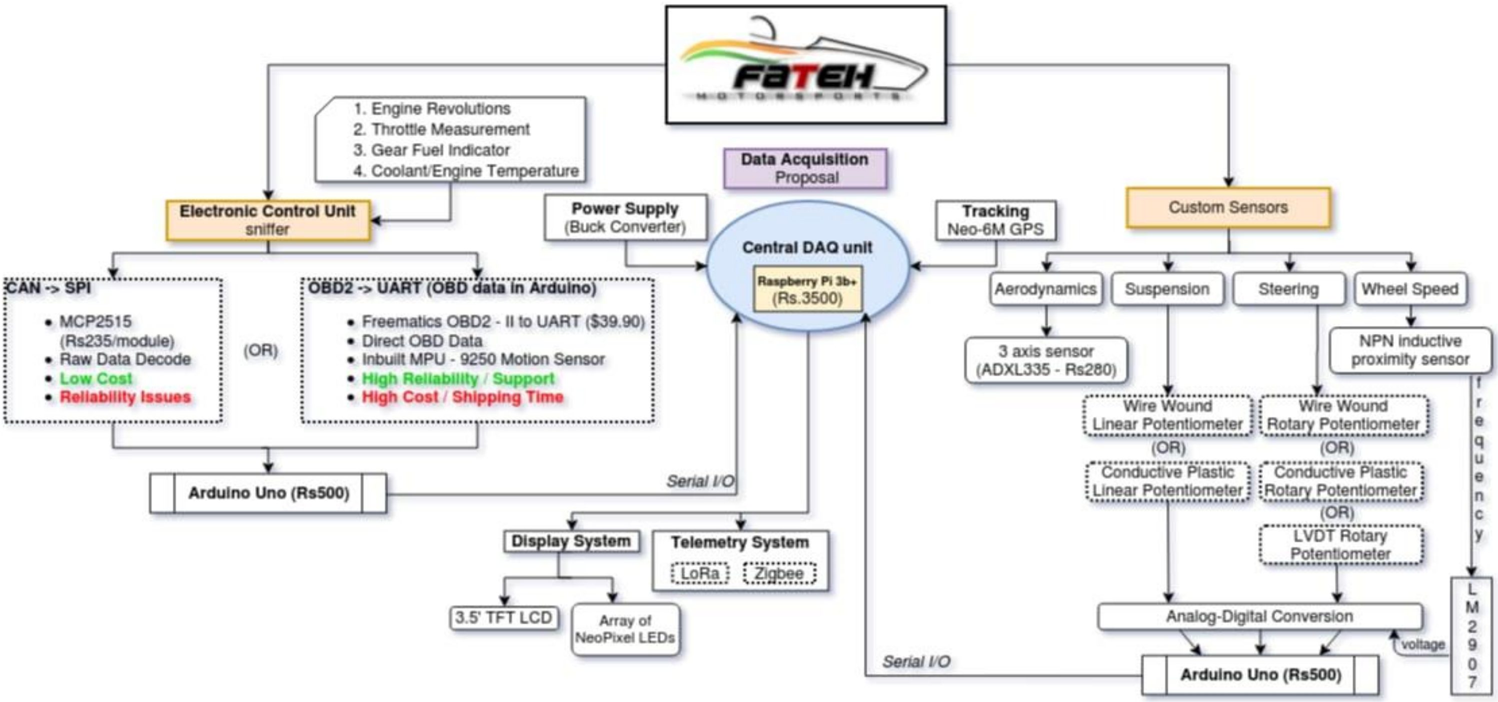
Data Acquisition report

Content

INTRODUTION

Fateh motorsports is the formula SAE team of Thapar Institute of Engineering and Technology. The goal of the team has since been to make significant improvements on its systems and designs. One such improvement has been the implementation data acquisition system. A data acquisition system allows for the collection and interpretation of data from sensors on the car, which enables the team to not only diagnose and solve issues with the other systems of the car, but to fine-tune and optimize the geometry of the mechanical systems as well as making suggestions to the driver based on data. A sub-team of the Purdue Northwest Formula SAE team was tasked with the creation of a telemetry and data acquisition system that fits within budgetary constraints. The team wished to measure various parameters including, but not limited to: suspension travel of all 4 wheels, throttle and brake position, steering angle, fuel pressure, lateral/longitude/vertical acceleration, engine/coolant temperature, and other sensor values from the Engine Control Module (ECU). To accomplish this task, various devices and computer programming tools and software were used. The system in the car is based largely on an Arduino uno and raspberry pi microcontroller and compatible shields. Some devices used in this project were not necessarily made to be used together, but through the use of communication protocols such as CAN-BUS, I2C, and SPI, the system was able to produce a reliable flow of data. This data is then transmitted via wireless communications and displayed graphically using LabVIEW. The end result was a reliable, affordable data acquisition system.

System Description and Layout



The data acquisition is done by a two different systems, Electronic control unit sniffer and the custom sensors unit, Electronic control unit sniffers is used to receiver the data from the ECU using the CAN module to receiver data such as Engine Revolutions, Throttle measurement, Gear Fuel Indicator . Coolant/Engine temperature. The custom sensor system is used to read the data such as suspension travel. Steering position, vehicle speed, acceleration and braking forces from the sensor from sensor placed in the car. The data from both the systems are sent to the central DAQ unit , all the relevant data is displayed on a TFT LCD to the driver, a telemetry system (ZigBee) is used to live transmit data that can be viewed on the LabVIEW.

- The Arduino Mega 2560

a microcontroller board based on ATmega2560, controls the collection of data for the PNW telemetry system through measurements taken by the potentiometers and data logged and transmitted through the shields. The Arduino Mega 2560 is 101.52mm long, 53.3mm wide, and weighs in at 37g. The microcontroller has 54 digital input/output pins (15 provide PWM output), 16 analog input pins, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ISCP header, and a reset button. It operates at 5VDC, and its recommended input voltage is 7-12V, but it has a limit of 6- 20V. The DC current per input/output pin is 20 mA, while the DC current for the 3.3V pin is 50 mA. It has a flash memory of 256 KB of which 8KB is used by the bootloader. It has a static random access memory (SRAM) of 8 KB, while its read only memory (EEPROM) size is 4 KB. Its clock operates at a speed of 16 MHz (Arduino, 2016).

- Buck Converter Voltage Regulator

A DROK 090029 regulated Buck Converter power supply is used to provide power to the critical data collection devices. Steady and constant voltage is very important since variation of supply voltage can cause error in data collection and transmission. This power supply can have an input of 5-32 V DC and maintain a regulated output of 0-30 VDC. It is rated at 30 W with the maximum output current of 1.5 A. The output voltage preset resolution is 0.1 V DC. The voltage testing accuracy is (± 1%, + 2) digits. The output is set to a constant 5 V DC which should not change as the system load changes drastically (DROK, 2013).

- CAN-BUS

The CAN-BUS shield for Arduino allows for the logging of data from the ECU of the vehicle. This data can then be stored and displayed on a screen. The CAN-BUS shield is 101.6 mm long, 6.35 mm tall and 101.6 mm wide. The shield features CAN v2.0B up to 1 Mb/s. It uses the Microchip MCP2515 CAN controller and the MCP 2551 CAN-BUS The CAN-BUS shield for Arduino allows for the logging of data from the ECU of the vehicle. This data can then be stored and displayed on a screen. The CAN-BUS shield is 101.6 mm long, 6.35 mm tall and 101.6 mm wide. The shield features CAN v2.0B up to 1 Mb/s. It uses the Microchip MCP2515 CAN controller and the MCP 2551

- Triple-Axis Accelerometer Breakout

The triple-axis accelerometer is used to determine acceleration forces in longitude, latitude, and vertical directions within the FSAE car. The accelerometer has a supply voltage of 1.95 V to 3.6 V. Its interface voltage is 1.6 V to 3.6 V. Its current consumption is 6 µA to 165 µA. The accelerometer possesses an I²C digital output interface that operates to 2.25 MHz with a 4.7 kΩ pullup. It is manufactured by Adafruit Part identification number: MMA8451QT.

- UartSBee v4.0 Shield

The UartSBee v4.0 connects the XBee-Pro 900 HP RF module to the universal serial interface of the computer (USB). The UartSBee v4.0 shield, connected to the XBeePro 900 HP RF module, is used to transmit and receive data collected by the Arduino Mega 2560. The data, which is stored on an SD card of the data logging shield, is also transmitted a computer running LabView software which simulates a virtual instrument panel for displaying types of data. The printed circuit board shown in figure 6 is 3.1 cm by 4.1 cm. Its microprocessor is FT232RL. The shield's interface is a mini-B USB and a 2.54 mm pitch pin header. The communication protocols for this shield are UART, eight Bit-bang inputs/outputs, and SPI. Its adapter socket is XBee compatible with a 2.0 mm pitch female pin header. The shield is FTDI compatible and has a USB 2.0 compatible Serial Interface. It has 3.3V and 5V inputs/outputs and 3.3V and 5V dual power outputs. Its typical and maximum input voltage is 5Vdc, and it has a current consumption of 500 mA. Its minimum output voltage is 3.3 Vdc, while its maximum output voltage is 5 Vdc (Seeed Development Limited, 2016) Manufacturer: Seeed Studio Part identification number: INT110B2P

- XBee-Pro 900 HP RF Module

The XBee-Pro 900 HP RF module allows wireless connectivity to devices. Connected to the UartSBee v4.0 shield, the RF module will receive and transmit data from the Arduino Mega 2560. The data will be stored on the SD card of the data logging shield and simultaneously transmitted to a computer running LabView software which simulates a virtual instrument panel for displaying types of data. To set up the XBee-Pro 900 HP RF module shown in figure 7, XCTU software is used. The specified antenna used is RP-MSA. It has fifteen digital inputs/outputs, four 10-bit ADC inputs, and two PWM outputs. The RF module transmits data at a rate of 10Kbps or 200 Kbps. The lower the transmit speed, the longer the range and the slower the transmission and collection of data. The higher the transmit speed, the shorter the range and the faster the transmission and collection of data. The data rate will operate in between those values for the purposes of the PNW Formula SAE vehicle. The frequency range needed is 902-928 MHz. The supply voltage is 3.6 Vdc. The transmit power is 250 mW. Its transmit current is 215 mA. Its reception current is 29 mA. Its outdoor/line-of-sight range is 10 Kbps or up to 9 miles (15.5 km)

Sensors

- Linear potentiometer (for suspension)

A linear potentiometer is a type of position sensor. They are used to measure displacement along a single axis, either up and down or left and right. Linear potentiometers are often rod actuated and connected to an internal slider or wiper carrier. The rod will be connected to a device or object which requires measurement. The linear potentiometer proportionally divides an applied regulated voltage over its operational range and provides a proportional voltage output relevant to the position of the wiper.Linear potentiometers are a contacting type of sensor which means that the moving parts make contact with each other during use. This makes them sufficiently robust to be used within a variety of applications whilst remaining relatively inexpensive. They are able to function in wide temperature ranges and offer long life, high accuracy and repeatability. Linear potentiometer is used with the suspension to record the travel.

- 3 axis accelerometer\ gyro meter (for steering wheel)

By measuring the amount of acceleration due to gravity, an accelerometer can figure out the angle it is tilted at with respect to the earth. By sensing the amount of dynamic acceleration, the accelerometer can find out how fast and in what direction the car is moving. Using these two properties, we can deduce the turning angle of the steering wheel and the acceleration of the car. The 3-axis accelerometer module carries an MMA7361 chip from Freescale. The 3-Axis Accelerometer sensor will operate between 2.2 and 6 volts. Because the MMA7361 chip only will deal with 3.6 volts maximum, the sensor is equipped with a low-dropout regulator so the sensor will work, out of the box with an Arduino or other 5 volt microcontroller. At 5 volts the sensor draws around 50 uA with the shunt off and 100 uA with the shunt on. The current draw at 3.3 V is 150 / 200 uA respectively.

- Hall sensor (for vehicle speed)

The hall effect sensor Module interfacing with Arduino This module is used to detect the presence of magnetic. Whenever, it will be placed in the region of magnetic field then it will detect it and will give us the output. The module consists of a hall sensor which detects the presence of magnetic field. This module is placed near the tire rim and a small Neodymium magnet is place on the spinning tire, the magnet will come near to the module, so it will detect the magnet. It can be used in making speedometer for the car. We can know the time taken to complete a cycle and by doing further calculation, we can calculate the speed.

The hall sensor works on the principle of Hall Effect, which states the whenever a magnetic field is applied in perpendicular direction to the flow of the current, then a potential difference is induced. We can use this voltage to detect that whether the magnetic is placed near the sensor or not.

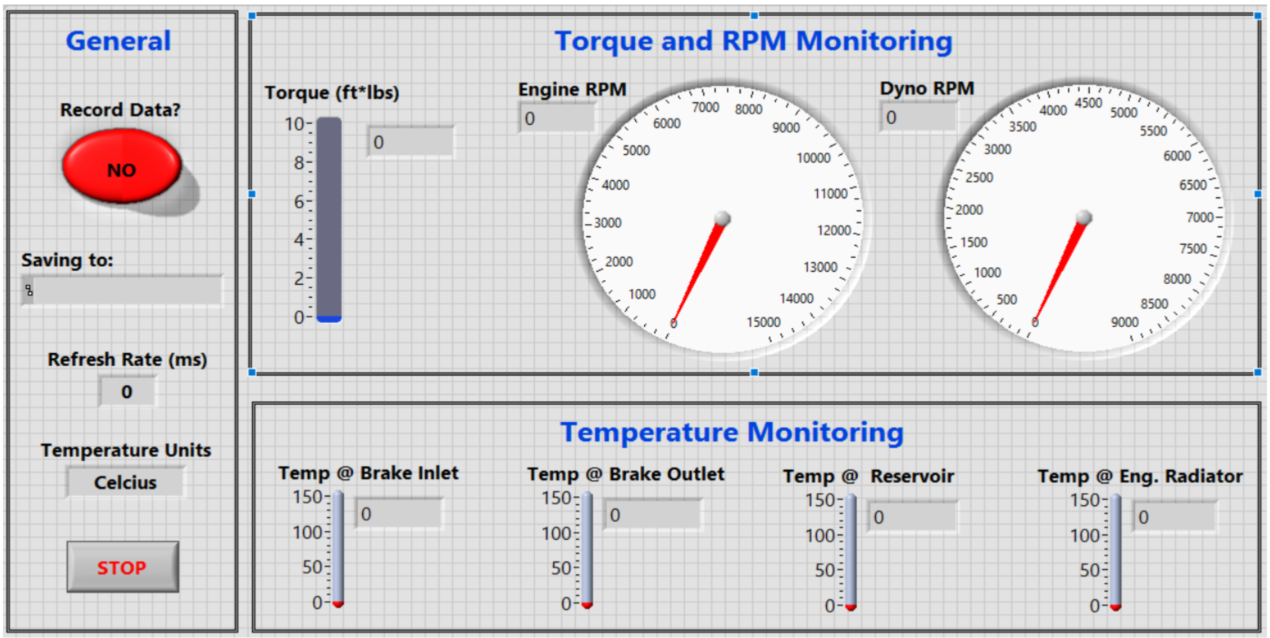
The pin out of the hall sensor module from left to right is as follows

Ground: The first pin from the left is the ground pin and it will be connected to the ground of the Arduino.
+5V: The middle pin is the 5V pin and it will be connected to the +5V of the Arduino.
Signal: The right pin is the output pin which will give us the output whenever the magnet will be placed near it. This will be connected to the digital pin of the Arduino.
If you want to power the module from external power, then you can power it by giving 3.3 to 5V.
There are actually, two different types of Hall sensors one is Digital Hall sensor and the other is Analog Hall sensor. The digital Hall sensor can only detect if a magnet is present or not (0 or 1) but an analog hall sensor's output varies based on the magnetic field around the magnet that is it can detect how strong or how far the magnet is. In this project will aim only at the digital Hall sensors for they are the most commonly used ones.

when we bring the magnet close to sensor the sensor changes its state. This change is sensed by the interrupt pin which will call the toggle function inside which we change the variable "state" from 0 to 1. Now, when we move the magnet away from the sensor, again the output of sensor will change. This change is again noticed by our interrupt statement and hence the variable "state" will be changed from 1 to 0. =The same repeats every time you bring a magnet close to the sensor. Therefore, from this time the rpm of the wheel is calculated first them multiplying with the perimeter of the tire we receive the speed of the vehicle.

Signal Processing

LabView is an electrical simulation and data display software produced by National Instruments. The software utilizes graphical code to ease the process of programming its functions. The LabView Front Panel is functioning as the graphical user interface for the system shown in figure 8. It is displaying the gauges and readings of each data channel being obtained from the vehicle. LabView receives a custom string of bits over a serial COM port and imports the string into this program. After the string data was obtained through the designated COM port and the VISA function shown in figure 9, it was later sent to be processed and dissected into its intended custom sections. Each section starts at an offset value and extends to a designated length. The offset determines how many bits from the beginning of the string shall be skipped, and the length determines the bit count of usable data for a specific channel. The string section is then processed and then sent to be displayed.



System Impact

The design relies heavily on dynamics simulations performed on specific software. Data acquired from these simulations are then saved and reference for future designs. However, with the introduction of a data acquisition system incorporated into our FSAE car, real time data can be analysed and collected to improve the handling of the car. Sensors such as the shock, the linear variable differential transformer (LVDT) and accelerometer will display what roll gradient the car experiences when driving around sharp corners and can be adjusted for quicker or slower damper response. Based on data collected, different suspension setups can be prepared ahead of time for each dynamic event at the FSAE Bharat event. The addition of a data acquisition system will aid in verifying computer simulation designs and provide data to improve immediate handling as well as future suspension designs.

The data acquisition system not only helps fine-tune and adjust the mechanical systems of the vehicle, it also allows our FSAE team to diagnose any faults that may occur especially the ones that may lead to catastrophic failures. For instance, detecting abnormally high engine temperature readings or low oil pressure readings at the right time can help avert a major engine failure.

References