Dashboard and Wireless Transfer Module

For the University of Rochester SAE Baja Team

Project Advisor:

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Abstract
The University of Rochester SAE Baja Team competes in multiple events each year. These events require students to design and build off road vehicles, using creative and cost effective techniques. In an effort to increase the ability to display, monitor and record the cars velocity and engine speed, equipment was designed, built, and testing to provide such ability.

One of the most important factors in Baja design is reliability. The Dashboard and Wireless Transfer Module was thoroughly tested and examined in order to provide the simplest, reliable, accurate, and most compact method for operation. It was crucial that the circuitry and wiring could withstand the wear and tear of the Baja competitions, including mud, water, and extreme vibration. Also, it was desired that the systems could be improved and built upon in the future.

A display program was written in order to accurately display the sampled data on a remote computer. This program is also capable of logging the sampled data (engine speed, wheel speed, fuel status) for later analysis.

Discussion

Much of the mechanical calibration for the Baja Vehicle relies upon engine and CVT speed. While portable electronics have been sufficient in the past, a more complete and dedicated system was desired. The designed system is comprised of a speedometer, engine tachometer, fuel level, distress signal and simple communication with the vehicle driver. All of this data is transferred wirelessly to a remote computer using the Arduino Fio and Digi XBee wireless modules. All of the data is then displayed on a graphical display. This gives the team the ability to log and analyze crucial performance data in real time, allowing advanced tuning ability and detailed monitoring during competition.

The data display program is written in the Processing programming language [1]. This language was chosen because of its easy incorporation of serial communication. Data logging of wheel speed and engine speed can be initiated when the user desires and the data can be imported into a spreadsheet program in order to be plot.

Tachometer

To determine the revolutions-per-minute (RPM) of the engine, a wire was coiled around the base of the spark plug. Each time the engine crankshaft rotates, the sparkplug fires, generating a magnetic field, which causes a voltage potential on the wire. Since the sparkplug is firing on regular intervals, a frequency is generated.

This signal is sent to a frequency to a voltage converter IC (LM2917) that generates a variable voltage output in response to a change in frequency. The variable voltage output is sent to the Arduino to be wirelessly displayed on a remote computer as well as an LED driver IC (LM3914) to illuminate the LED array on the dashboard of the vehicle. Initial testing of the circuit occurred on a protoboard (Fig. 1) and a signal generator was used to simulate different engine speeds (Fig. 2).

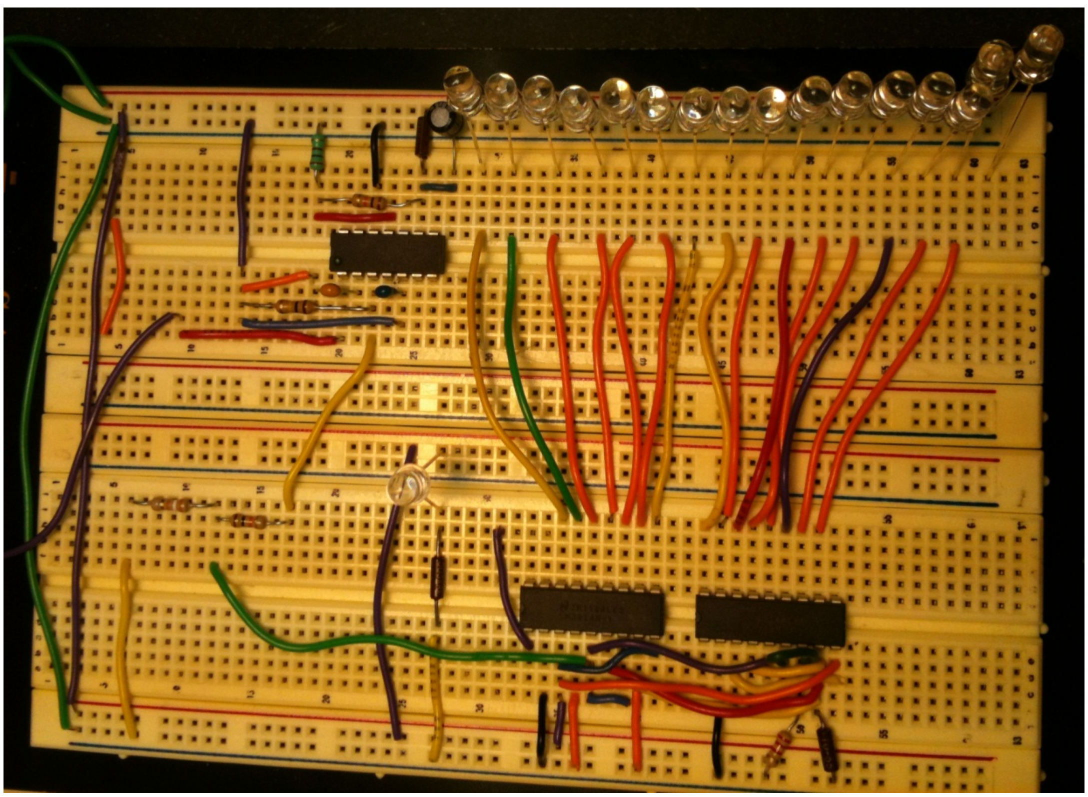


Figure 1 – Protoboard testing for tachometer circuitry

Figure 2 – Illumination patterns exhibited by different engine speeds (frequency)

Speedometer

To determine the speed of the vehicle, the RPM of the one of the wheels is captured. A magnetic reed switch is mounted near the wheelbase and 4 rare earth magnets are glued to the inside of the hubcap to trigger the reed switch. Since the rotation of the wheel is on a regular interval, a frequency is generated. Besides some minor changes, the speedometer circuit is identical to the one described above for the tachometer. The following table (Fig. 3) was used to estimate the frequency of the signal from the reed switch in order to tune the frequency to voltage IC.

v (mi/hr)	v (m/hr)	freq. (Hz)
1	1609	0.937851322
5	8045	4.689256609
10	16090	9.378513219
15	24135	14.06776983
20	32180	18.75702644
25	40225	23.44628305
30	48270	28.13553966
35	56315	32.82479627
40	64360	37.51405287
45	72405	42.20330948
50	80450	46.89256609

Figure 3 – Conversion table of miles per hour of the wheel to frequency

Note: Speedometer and tachometer circuits were adapted from sources [2] and [3].

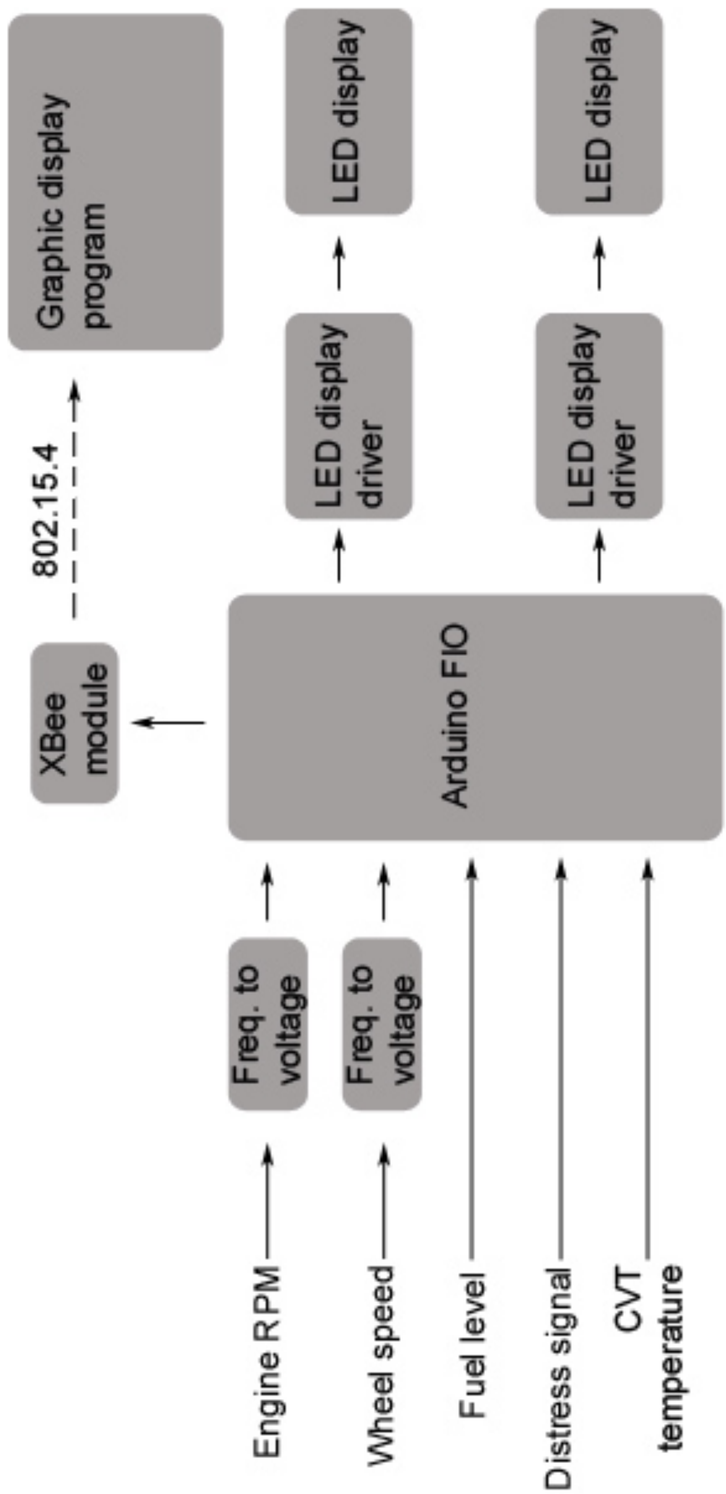
Wireless Data Transmission

The Arduino platform was chosen due to its easily customizable interfacing and amount of information readily available online. Also, many different peripherals for the Arduino are available and make future modifications and additions easily possible. In order to provide wireless data transfer, the Digi XBee wireless module was chosen, as it is one of the most simplest and reliable options for use with the Arduino platform and can transmit data up to one mile. While other commercial products are able to transmit at faster speeds, they are much more expensive and could easily be damaged during competition events.

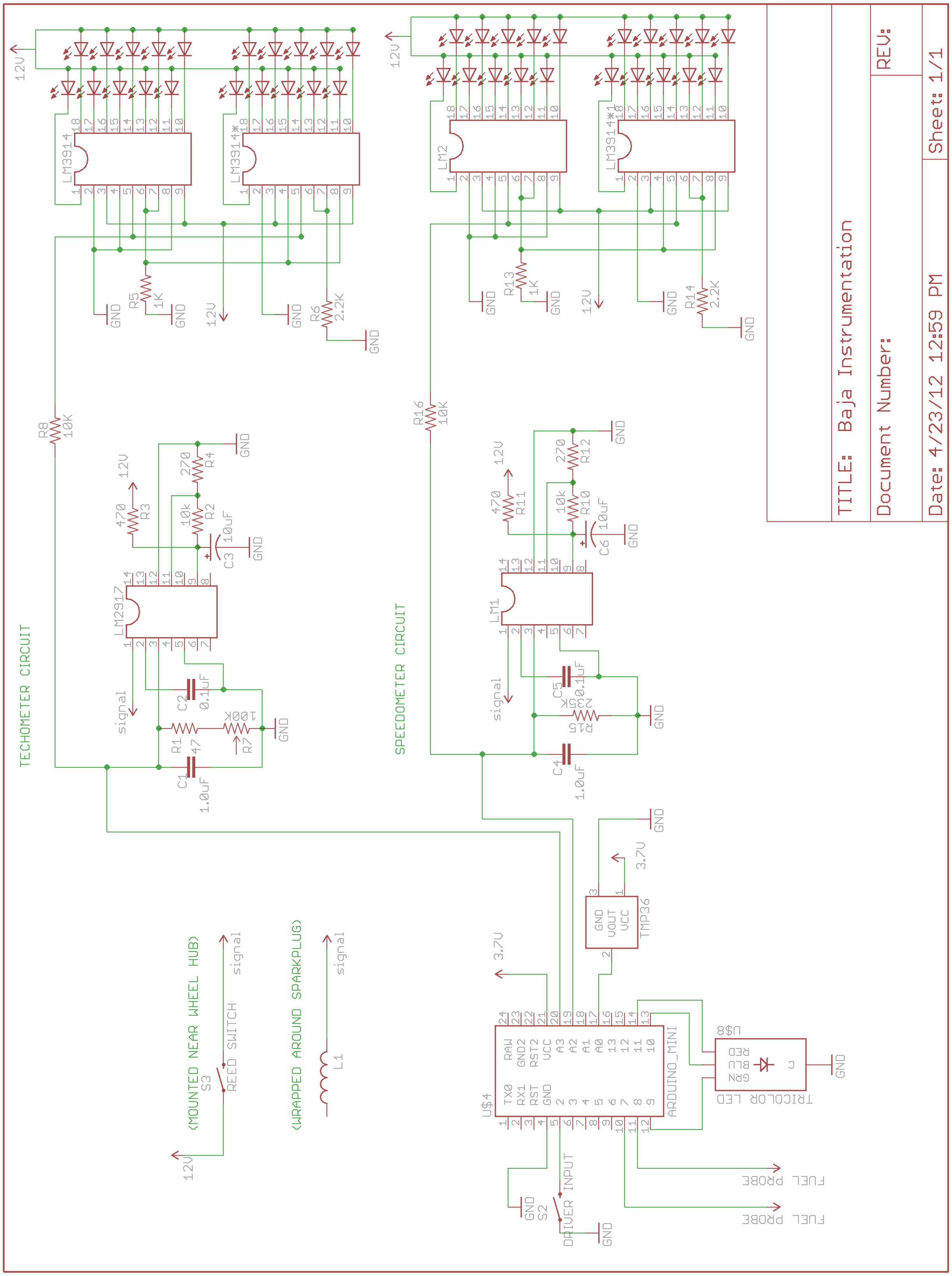
The distress signal is used to communicate with the crew. When the driver activates the distress button, a signal is transmitted to a remote computer using the Arduino and XBee module. By alerting the team when the driver is in possible need of aid, the response can be quicker, repairs can be made, and the car can get running sooner.

The fuel level is also collected and sent wirelessly back to a remote computer. By measuring the capacitance between two aluminum cylinders inserted into the base of the fuel tank, the level can be measured without the need for fragile and possibly expensive brackets, floats, and levers [4]. As the level of the fuel changes, the capacitance changes and can be read by the Arduino using the CapSense library [5]. Damage to the fuel tank or supply lines can also be detected in the event of a resulting fuel leak.

Block Diagram



Schematic



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Sheet: 1/1
TECHOMETER CIRCUIT
SPEEDOMETER CIRCUIT
LM3914
LM2917
LM1
LM2
(MOUNTED NEAR WHEEL HUB)
REED SWITCH
(WRAPPED AROUND SPARKPLUG)
ARDUINO_MINI
TMP36
TRICOLOR LED
FUEL PROBE
FUEL PROBE
DRIVER INPUT

Conclusion

One unexpected problem that occurred was that the LED displays were difficult to see in direct sunlight. This issue could be corrected with the addition of a sun visor over the dashboard. But during the competition, we realized that it is not very useful to present the driver with a speedometer and tachometer because it is difficult to glance down during the race and the driver has to focus more on the course layout than the vehicle data.

For future iterations, we will simply have status LED's and buttons for the driver and crew to communicate with. This will simplify the dashboard, which would conserve space, battery power, and be more practical.

We would like to thank Professor Derefinko, Professor Fauchet, Paul Osborne, Jim Lindner, and the Department of Electrical and Computer Engineering for all their help with this project as well as the University of Rochester SAE Baja team for the opportunity to develop this system.

Parts List				
Product	**Vendor**	**Vendor part #**	**Quantity**	**Price**
Arduino Fio	Sparkfun	DEV-10116	1	$24.95
Li-Ion battery	Sparkfun	PRT-00339	1	$11.95
Xbee wireless module	Sparkfun	WRL-08742	2	$75.90
Xbee to USB	Sparkfun	WRL-08687	1	$24.95
LM3914	FutureElectronics	LM3914N-1/NOPB	2	$1.85
LM2917	FutureElectronics	LM2917N/NOPB	2	$1.72
Green LED	Sparkfun	COM-09661	25	$7.95
Red LED	Sparkfun	COM-09660	25	$7.95
RGB LED	Sparkfun	COM-09264	1	$1.95
Reed switch	Sparkfun	COM-10601	1	$1.95
Rare earth magnets	Sparkfun	COM-08643	4	$6.00

Temperature sensor	Sparkfun	SEN-10988	1	$1.50
47 Ohm resistor	Mouser	291-47-RC	2	$0.11
270 Ohm resistor	Mouser	291-270-RC	2	$0.11
470 Ohm resistor	Mouser	291-470-RC	2	$0.11
1 kOhm resistor	Mouser	291-1K-RC	2	$0.11
2.2 kOhm resistor	Mouser	291-2.2K-RC	2	$0.11
10 kOhm resistor	Mouser	291-10K-RC	4	$0.22
470 kOhm resistor	Mouser	291-470K-RC	2	$0.11
100 kOhm trimpot	Sparkfun	COM-08647	2	$1.00
0.1 uF capacitor	Mouser	810-FK28X7S2A104K	2	$0.42
1 uF capacitor	Mouser	810-FK14X5R1E105K	2	$0.42
10 uF capacitor	Mouser	647-UKT1C100MDD	2	$0.24
				$171.56

Sources

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3. http://www.murata-ps.com/data/meters/dms-an9.pdf
4. http://www.instructables.com/id/Building-a-Capacitive-Liquid-Sensor
5. http://www.arduino.cc/playground/Main/CapSense