WIKI

Electronics Department

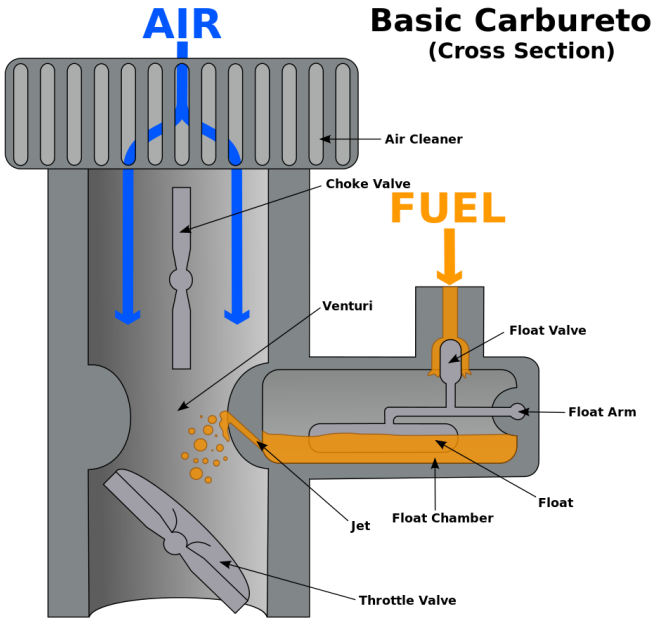
Summary

EMS

1.1 Context

There are two types of fuel/air injection systems : Carburetted and Electronic Fuel Injection.

The carbureted engines (triumph 675 is **NOT** carburated) use as the name suggests a carburetor to approximate and mix the correct air-fuel mixer The carburetor works on Bernoulli's principle.

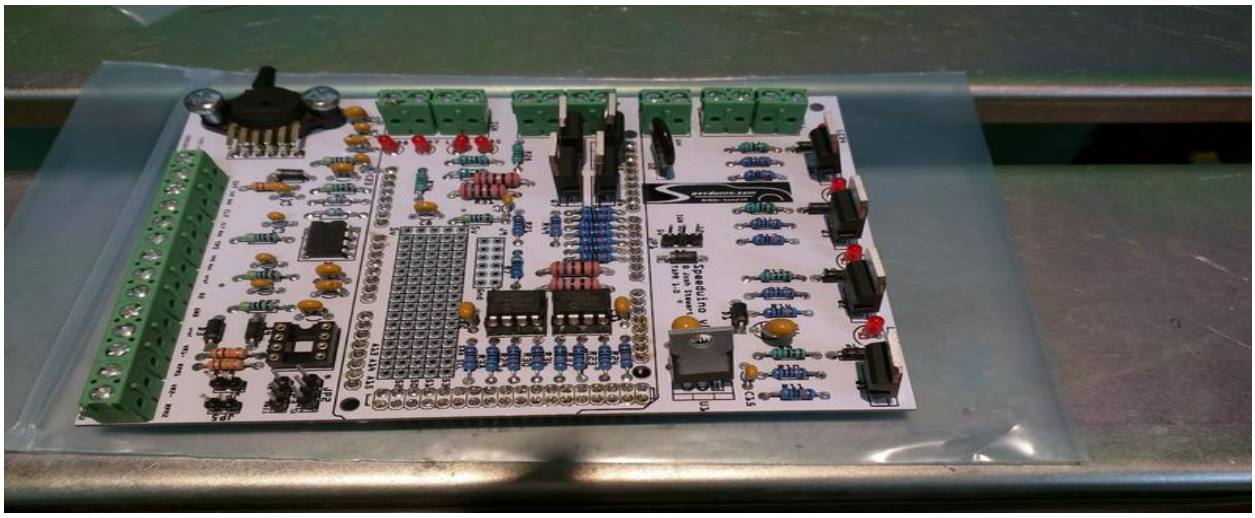


Electronic Fuel Injection is where data from number of sensors are used by electronic control unit to calculate and control the frequency of fuel injection and ignition in the engine.

1.2 ECU

An engine control unit (ECU), also commonly called an engine control module (ECM) is the electronic computing unit described above. It interprets the data using multidimensional performance maps (called lookup tables), and adjusting the engine actuators.

The ecu we are using is the **speeduino** (manual) which is based on the low cost and open s Arduino platform.



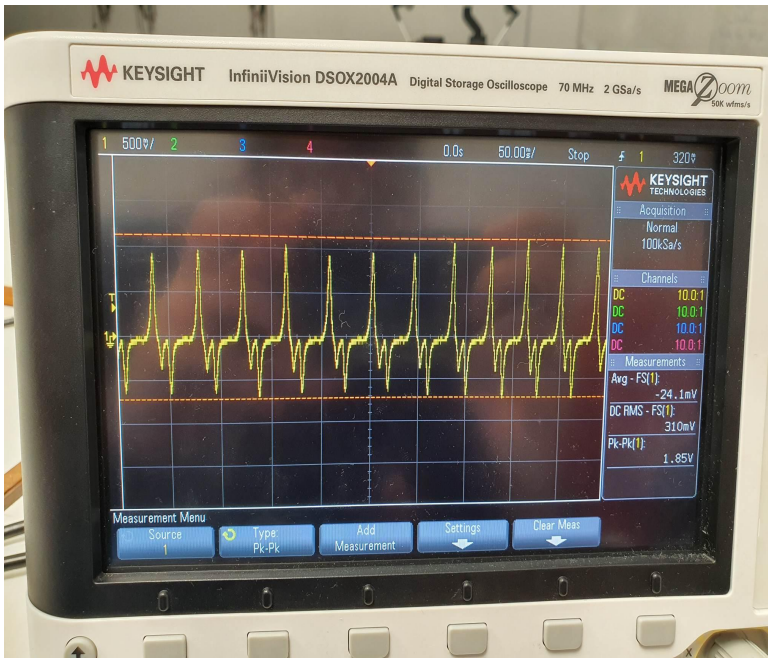
Positive: its cheap, opensource, wiki with all information.

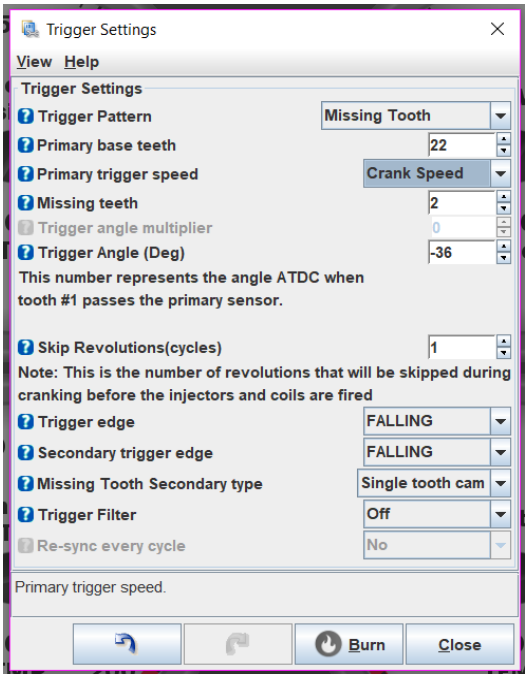
Negative: require a lot of know how.

1.3 ECU INPUTS

a. **Crank position sensor**: This is arguably the most important sensor for Speeduino to function correctly. The signal going to the Arduino must be a 0v-5v square wave series of pulses representing teeth on a wheel running at crank (or cam) speed. The type of sensor on engine is a variable reluctance sensor (it needs a VR conditioner to transform ac signal to square wave pulses. The VR conditioner used is the MAX9926 ic).Our crank is a 24 with 2 missing tooth wheel which means that 2 of the 24 teeth are missing. Ignition Timing is the timing of the ignition spark relative to the position of the crankshaft. The angle for this is normally before top dead centre BTDC (as opposed to after top dead centre, ATDC) and in the case of our engine it is around 36° BTDC (depending on the fuel used).

   Two types of CPS Hall effect sensor or Variable reluctance sensor.





a) Raw output of cps b) Trigger Settings

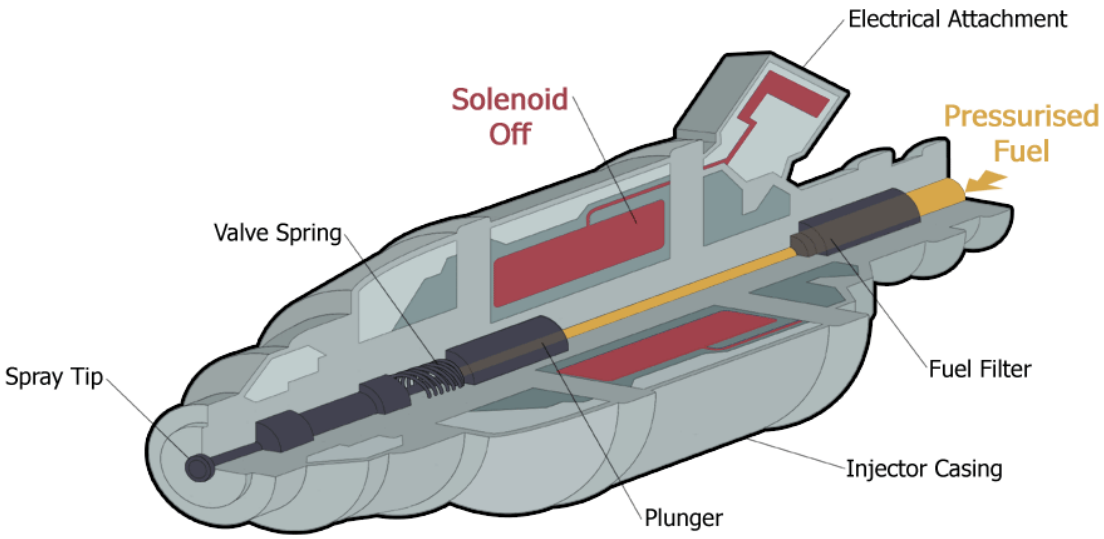
b. **Throttle position sensor**: TPS sensor must be of the 3 wire potentiometer type. The TPS functions by sending an analog variable voltage signal to Speeduino in order to report the current position of the throttle. It is typically supplied with V+ of 5V and ground (GND, signal ground, or signal return), routing through an internal potentiometer to output a low voltage at low throttle opening, and a rising voltage with greater throttle opening.

   If using a TPS with unknown connections.

c. **MAP (Manifold Absolute Pressure)**:MAP sensor data can be converted to air mass data using the speed-density method. Engine speed (RPM) and air temperature are also necessary to complete the speed-density calculation.
d. **Temperature Sensors(Coolant Temperature Sensor (CLT);Intake Air Temp Sensor (IAT)):** Any standard 2-wire thermistor sensor can be used for these temperature functions. The sensors have 1 side connected to a ground (Preferably from the ECU) and the other running to the signal line. These sensors have no polarity, so the orientation of these wires does not matter.
e. **Exhaust Gas Oxygen Sensors (O2 and WBO2):** By measuring the proportion of oxygen in the remaining exhaust gas. It could be determined if the engine is running lean(not enough fuel injected) or rich(a lot of unburned fuel in the exhaust). wide/narrow band.

1.4 ECU OUTPUTS

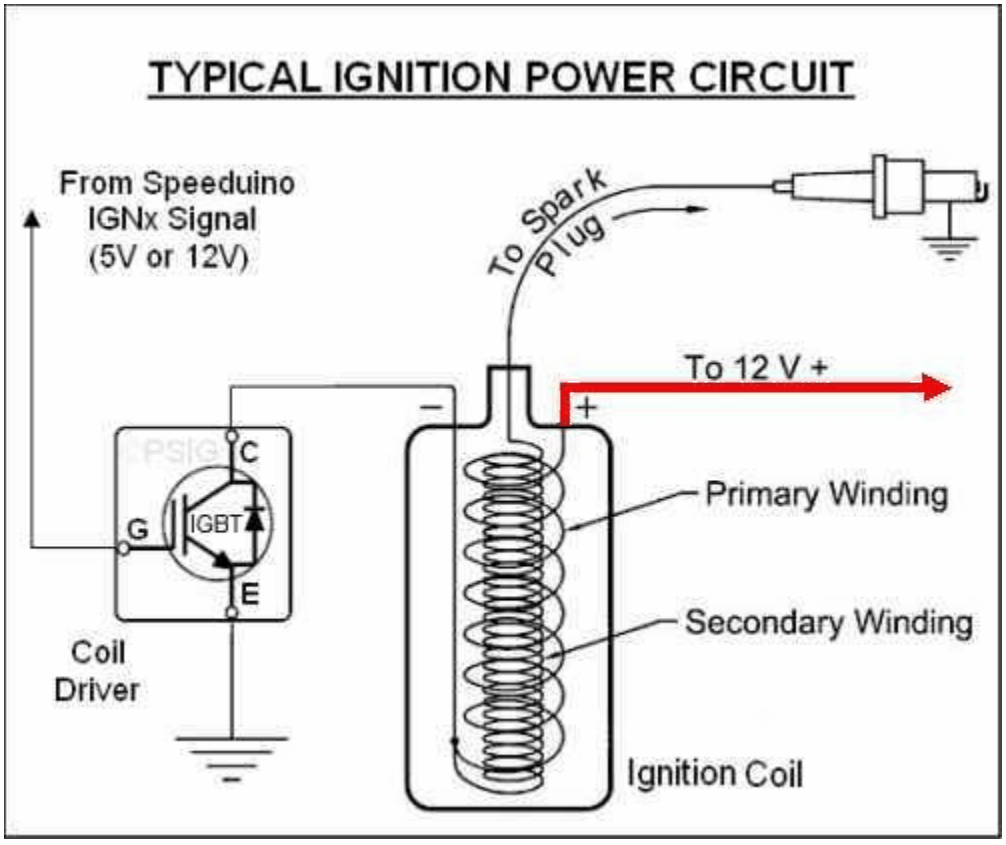
a. **Injectors**:When signaled by the engine control unit the fuel injector opens and sprays the pressurised fuel into the engine. The duration that the injector is open (called the pulse width) is proportional to the amount of fuel delivered. Depending on the system design, the timing of when injector opens is either relative each individual cylinder (for a sequential fuel injection (SFI) system), or injectors for multiple cylinders may be signalled to open at the same time (in a batch fire system). video



b. **Coils**: is an induction coil in an automobile's ignition system that transforms the battery's low voltage to thousands of volts needed to create an electric spark in the spark plugs to ignite the fuel. Some coils have an internal resistor while others rely on a resistor wire or an external resistor to limit the current flowing into the coil from the car's 12-volt supply. Current versions of the Speeduino use low-power output signals, designed to work with external small-signal ignition coil drivers. whether a separate type (module or ICM, igniter, IGBT, etc.), or built into the coil assembly ('smart' coils). This method permits Speeduino to have great flexibility to control most types of ignition systems. **Attaching the Speeduino outputs directly to a traditional high current passive ("dumb" or 2-pin(what our coils are)) ignition coil without an ignition coil driver WILL cause damage to your Arduino**. Ignition Latency video

In the example animated image below, the Speeduino ignition signal is normally low (near ground or 0V) while Speeduino calculates the time to the next coil firing. At the proper time, Speeduino switches the ignition output to high (near 5V or 12V selectable) in order to switch the coil driver (example IGBT) on, allowing current to flow through the coil to ground. This is called the 'dwell' period. During dwell an increasing energy field is generated around the ignition coil core and wire windings.

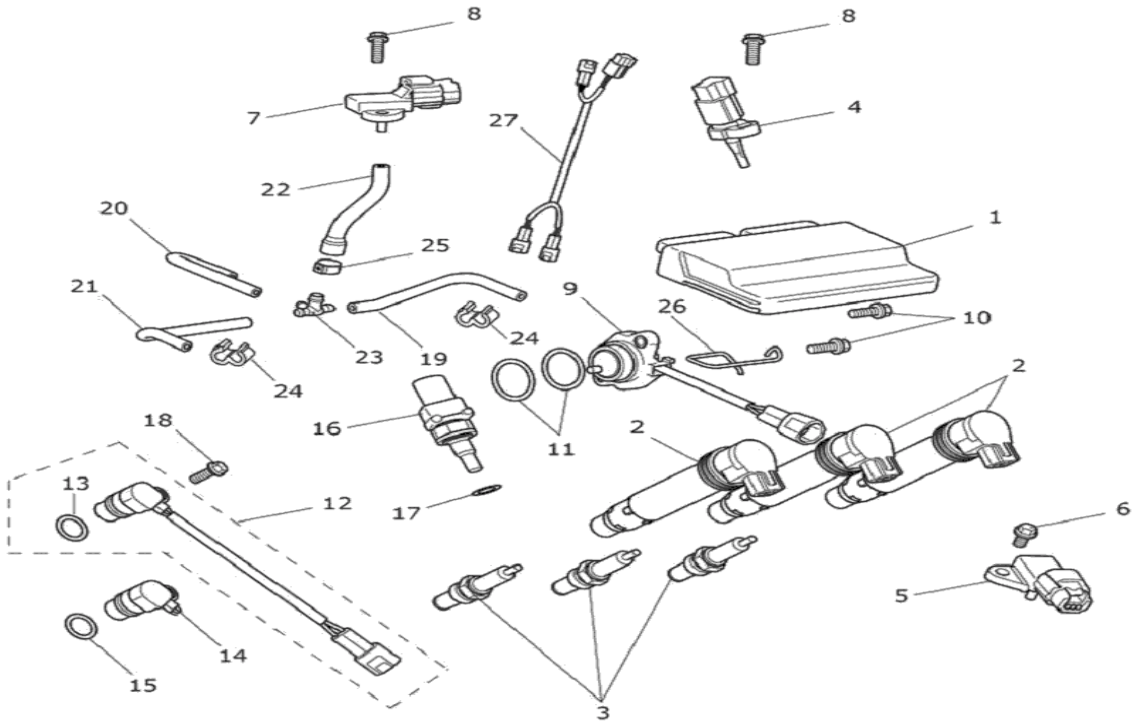
At the end of the dwell period and therefore at the proper time for spark; Speeduino switches the coil driver off, stopping current flow, which collapses the energy field to create high voltage and the resulting spark:
https://www.rmcybernetics.com/science/diy-devices/diy-ignition-coil-driver



The IGBT transistor used is the 25N120FL3

Note: speeduino controls by grounding parts.

2013 Triumph Daytona 675 R - 564948 > ENGINE MANAGEMENT SYSTEM Parts & OEM Diagram:



ENGINE MANAGEMENT SYSTEM

show BB#

	Description	Manufacturer Part #	# Required Per Assembly	Qty	Availability	Retail Price	Our Price
1:	ECU,BASE,H SERIES	T1290281	1	0	Ships within 1 to 2 business weeks	$1,663.41	$1,663.41
2:	COIL, IGNITION, 1.4OHM > Eng No 616002	T1291503	3	0	Ships within 1 to 2 business weeks	$129.80	$129.80
3:	SPARK PLUG, M10 CR9EIA-9	T1291023	3	0	Ships within 1 to 2 business weeks	$10.95	$10.95
4:	SENSOR, AIR TEMPERATURE 446599 >	T1290088	1	0	Ships within 1 to 2 business weeks	$53.68	$53.68
5:	SENSOR, AIR PRESSURE	T1290975	1	0	Ships within 1 to 2 business weeks	$85.97	$85.95
6:	SCREW,BUT/HD,M5X0.8X20,S/S	T3338989	1	0	Ships within 1 to 2 business weeks	$4.16	$4.16
7:	SENSOR, AIR PRESSURE	T1290975	1	0	Ships within 1 to 2 business weeks	$85.97	$85.95
8:	SCREW,S/TAP,HHF,5X20.5 > 672095	T3332427	2	0	Ships within 1 to 2 business weeks	$1.09	$1.09
9:	SENSOR, GEAR POSITION	T1290660	1	0	Ships within 1 to 2 business weeks	$76.13	$76.13
9:	SPARES KIT, GEAR POS SENSOR > Eng No 598653	T1294242	1	0	Ships within 1 to 2 business weeks	$91.88	$91.88
10:	BOLT,HHF,LGHTD,M6X1.0X20,SLV	T3205066	2	0	Ships within 1 to 2 business weeks	$3.41	$3.41
11:	O-RING,26.65IDX2.62DIA	T3600267	2	0	Ships within 1 to 2 business weeks	$0.99	$0.99
12:	SENSOR, ROAD SPEED	T1290221	1	0	Ships within 1 to 2 business weeks	$182.15	$182.15
13:	O-RING,15 X 2.4 Non ABS Version Only	T1290054	1	0	Ships within 1 to 2 business weeks	$1.06	$1.06
14:	PLUG,BLANKING,RD SPD SENSOR ABS Models Only	T1164500	1	0	Ships within 1 to 2 business weeks	$1.61	$1.61
15:	O-RING,ID 14.6,SD 2.4 ABS Models Only	T3600085	1	0	Ships within 1 to 2 business weeks	$2.82	$2.82
16:	SENSOR, ENGINE COOLANT	T2100807	1	0	Ships within 1 to 2 business weeks	$45.98	$45.95
17:	WASHER,CU,OD16.0,ID12.5,1.0	T3550571	1	0	Ships within 1 to 2 business weeks	$0.99	$0.99
18:	BOLT,HHF,LGHTD,M6X1.0X16,ENG	T3205064	1	0	Ships within 1 to 2 business weeks	$2.44	$2.44
19:	HOSE, THROTTLE BODY, CYL1	T1292075	1	0	Ships within 1 to 2 business weeks	$2.44	$2.44
20:	HOSE, THROTTLE BODY, CYL2	T1292076	1	0	Ships within 1 to 2 business weeks	$2.44	$2.44
21:	HOSE, THROTTLE BODY, CYL3	T1292077	1	0	Ships within 1 to 2 business weeks	$2.44	$2.44
22:	HOSE, MAP SENSOR	T1290280	1	0	Ships within 1 to 2 business weeks	$2.25	$2.25
23:	CONNECTOR, 4-WAY	T1242929	1	0	Ships within 1 to 2 business weeks	$7.25	$7.25
24:	TWIN CLIP, BRAKE HOSE	T2040811	2	0	Ships within 1 to 2 business weeks	$2.00	$1.95
25:	CLIP, 10.5 GER OETIKER ~~USCAL, CA, HK, BR & TH Only~~	T3700077	1	0	Ships within 1 to 2 business weeks	$3.70	$3.70
26:	GUIDE,HOSE > 354281	T3700154	1	0	Ships within 1 to 2 business weeks	$4.66	$4.66
27:	FLYLEAD, GEAR POSITION SENSOR Eng No 598654 > 630953	T2509323	1	0	Ships within 1 to 2 business weeks	$14.24	$14.24

Data Management System

2.1 Serial

The Arduino Mega2560 version of Speeduino supports the use of serial communication. It uses Serial3 for supplementary IO.On a Mega 2560 Serial3 can be found on the board at pins 14 and 15.The connection speed is 115200baud. **Instructions**

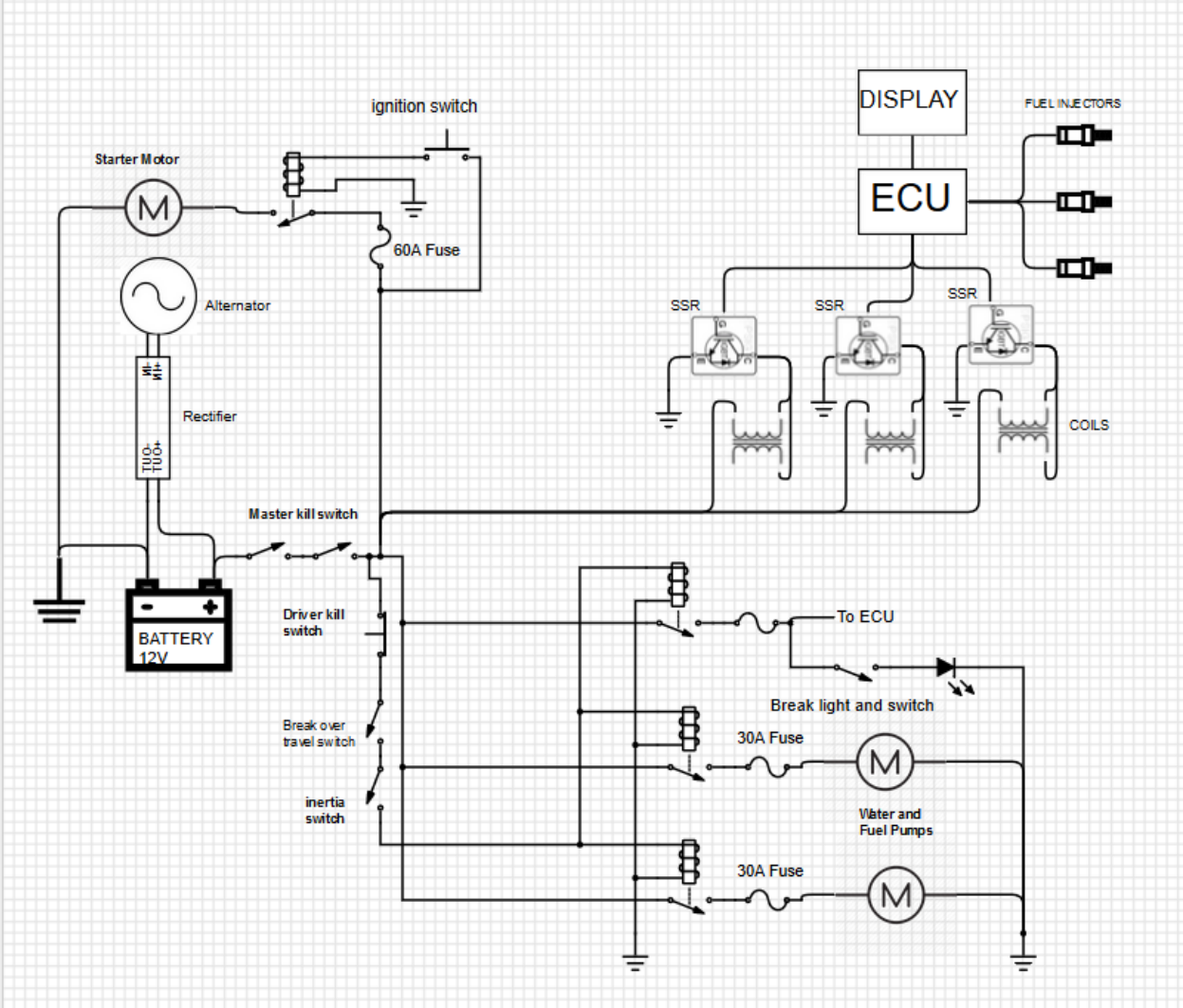
2.2 comms code guide

"===List of Commands===\n\n"
"A - Displays 31 bytes of currentStatus values in binary (live data)\n"
"B - Burn current map and configPage values to eeprom\n"
"C - Test COM port. Used by Tunerstudio to see whether an ECU is on a given serial \n"
" port. Returns a binary number.\n"
"N - Print new line.\n"
"P - Set current page. Syntax: P+<pageNumber>\n"
"R - Same as A command\n"
"S - Display signature number\n"
"Q - Same as S command\n"
"V - Display map or configPage values in binary\n"
"W - Set one byte in map or configPage. Expects binary parameters. \n"
" Syntax: W+<offset>+<newbyte>\n"
"t - Set calibration values. Expects binary parameters. Table index is either 0, \n"
" 1, or 2. Syntax: t+<tble_idx>+<newValue1>+<newValue2>+<newValueN>\n"
"Z - Display calibration values\n"
"T - Displays 256 tooth log entries in binary\n"
"r - Displays 256 tooth log entries\n"
"U - Prepare for firmware update. The next byte received will cause the Arduino to reset.\n"
"? - Displays this help page"

2.3 arduino to speeduino comms

To get the real time information an arduino is used (connected through serial pins) using the commands mentioned above real time information is obtained and parsed where it is saved on SD card using a card Memory Shield Module pic below for examination later and some info is sent to be displayed eg rpm or monitored if exceeded certain value to display warning.

Safety shutdown system



T 11.1.2 The maximum permitted voltage that may occur between any two electrical connections in the LVS is 60 VDC or 25 VACRMS.

T 11.1.3 [CV ONLY] The following systems are excluded from the LVS voltage limit, see T 11.1.2:

- High voltage systems for ignition
- High voltage systems for injectors
- Voltages internal to OEM charging systems designed for <60 VDC output.

3.1 shutdown system

CV 4 SHUTDOWN SYSTEM

CV 4.1 Shutdown Circuit

CV 4.1.1 The shutdown circuit directly controls all electrical power to the ignition, fuel injectors and all fuel pumps. It must act through a minimum of two mechanical relays. One relay for the fuel pump and at least one relay for injection and ignition.

An explanatory schematic of the required shutdown circuit, is shown in Figure 19.

CV 4.1.2 The shutdown circuit is defined as a series connection of at least the LVMS, see T 11.3, the BSPD, see T 11.6, three shutdown buttons, see T 11.4, the BOTS, see T 6.2 and the inertia switch, see T 11.5.

CV 4.1.3 All circuits that are part of the shutdown circuit must be designed in a way, that in the de-energized/disconnected state they open the shutdown circuit.

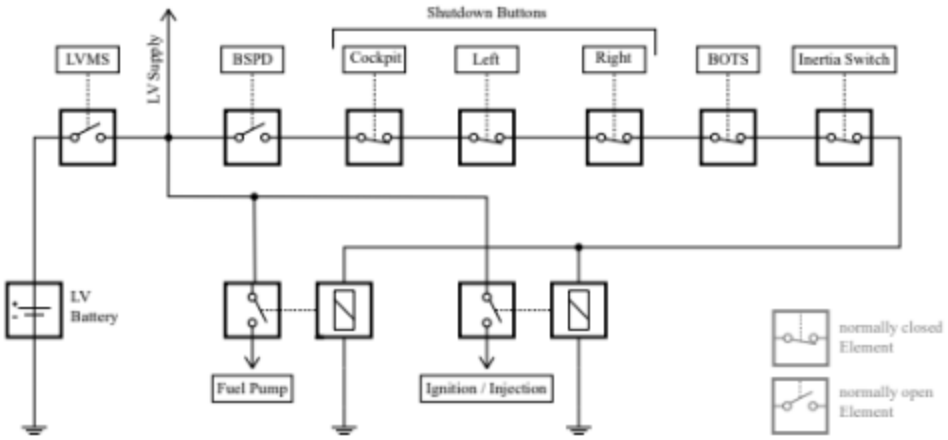


Figure 19: Explanatory example schematic of the required shutdown circuit

3.2 break over travel switch:

T7.3 Brake Over-Travel Switch

T7.3.1 A brake pedal over-travel switch must be installed on the car as part of the shutdown system and wired in series with the shutdown buttons. This switch must be installed so that in the event of brake system failure such that the brake pedal over travels it will result in the shutdown system being activated and controlling the systems as defined in Part IC Article 4 (IC vehicles).

T7.3.2 Repeated actuation of the switch must not restore power to these components, and it must be designed so that the driver cannot reset it.

T7.3.3 The switch must be implemented with analog components, and not through recourse to programmable logic controllers, engine control units, or similar functioning digital controllers.

T7.3.4 The Brake Over-Travel switch must be a mechanical single pole, single throw (commonly known as a two-position) switch (push-pull or flip type) as shown below.

(2018)rules

3.3 Brake Light:

T7.4.1 The car must be equipped with a red brake light. The brake light itself has to have a black background and a rectangular, triangular or near round shape with a minimum shining surface of at least 15cm2. The brake light must be clearly visible from the rear in very bright sunlight. When LED lights are used without a diffuser, they may not be more than 20mm apart. If a single line of LEDs is used, the minimum length is 150mm.

T7.4.2 This light must be mounted between the wheel centerline and driver's shoulder level vertically and approximately on vehicle centerline laterally.

(2018)rules

3.3 Master Switches:

IC4.1.1 The vehicle must be equipped with two (2) master switches which form part of the shutdown system. Actuating either switch must stop the engine.

IC4.1.2 The international electrical symbol consisting of a red spark on a white-edged blue triangle must be affixed in close proximity to each switch.

Any alternator field wire must also be disabled by each master switch to prevent any possible feedback through the field coil circuit.

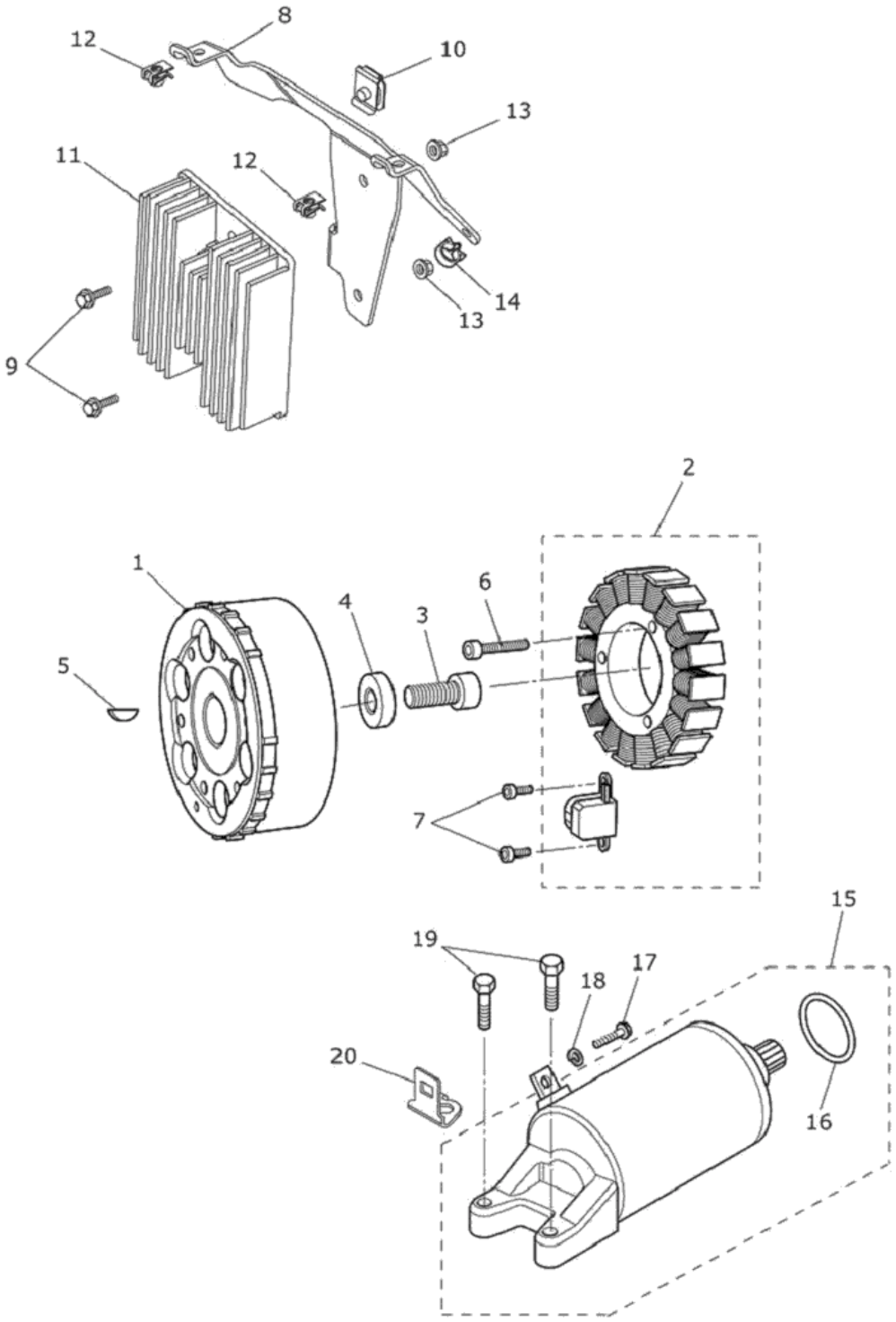
Disable power to ALL electrical circuits, including the battery, alternator, lights, fuel pump(s),ignition and electrical controls.

c. All battery current must flow through this switch.

d. Be of a rotary type and must be direct acting, i.e. it must not act through a relay.

Silverstone 2019 pictures

https://w



STARTER & ALTERNATOR

show BB#

	Description	Manufacturer Part #	# Required Per Assembly	Qty	Availability	Retail Price	Our Price
1:	ALTERNATOR, ROTOR Eng No 616233 >	T1300182	1	0	Ships within 1 to 2 business weeks	$637.92	$637.92
2:	ALTERNATOR, STATOR	T1300181	1	0	Ships within 1 to 2 business weeks	$407.54	$407.54
3:	BOLT, OIL FEED, M12X1.25X40 Eng No 406288>	T3330833	1	0	Ships within 1 to 2 business weeks	$9.27	$9.27
4:	WASHER,M 12 X 30 X 8	T3550846	1	0	Ships within 1 to 2 business weeks	$9.16	$9.16
5:	KEY,WOODRUFF	T1300807	1	0	Ships within 1 to 2 business weeks	$10.26	$10.26
6:	CAPSCREW.SKT HD,M6X1X35,RAW	T3050302	3	0	Ships within 1 to 2 business weeks	$0.99	$0.99
7:	SCREW,CAP/HD,M6X1X16,ENC,RAW	T3051063	2	0	Ships within 1 to 2 business weeks	$0.99	$0.99
8:	BRACKET, REGULATOR	T1300048	1	0	Ships within 1 to 2 business weeks	$15.46	$15.46
9:	SCREW,TX,PAN/HD,M6X1.0X16,SLV	T3330334	2	0	Ships within 1 to 2 business weeks	$2.56	$2.56
10:	NUT,CAPTIVE M6	T3350111	1	0	Ships within 1 to 2 business weeks	$3.37	$3.37
11:	REGULATOR RECTIFIER, 40A	T1305123	1	0	Ships within 1 to 2 business weeks	$306.83	$306.83
12:	NUT, CAPTIVE, M5	T3350129	2	0	Ships within 1 to 2 business weeks	$2.17	$2.17
13:	FLANGED LOCK NUT, M6	T3350003	2	0	Ships within 1 to 2 business weeks	$1.00	$1.00
14:	CLIP,OMEGA,18MMX14MM	T3700182	1	0	Ships within 1 to 2 business weeks	$2.87	$2.87
14:	CLIP,CABLE, 14.3 X 107 All Except HK & US CAL	T3700108	1	0	Ships within 1 to 2 business weeks	$3.18	$3.18
15:	STARTER MOTOR	T1311111	1	0	Ships within 1 to 2 business weeks	$418.82	$418.82
16:	'O' RING	T3600807	1	0	Ships within 1 to 2 business weeks	$2.35	$2.35
17:	BOLT, RHHF, M5X0.8X12, S5041	T3330891	1	0	Ships within 1 to 2 business weeks	$3.00	$2.95
18:	WASHER, SPRING, M5	T3555007	1	0	Ships within 1 to 2 business weeks	$0.99	$0.99
19:	BOLT,HHF,LGHTD,M6X1.0X25,SLV	T3205067	2	0	Ships within 1 to 2 business weeks	$1.55	$1.55
20:	TAB,CONNECTOR,CRANK POS	T2508250	1	0	Ships within 1 to 2 business weeks	$5.73	$5.73

https://www.youtube.com/watch?v=h9xW07Zt6hk

PARTS

https://www.bikebandit.com/oem-parts/2013-triumph-daytona-675-r-564948/o/m155155?a=1#sch785761

T8.1 Coolant Fluid Limitations

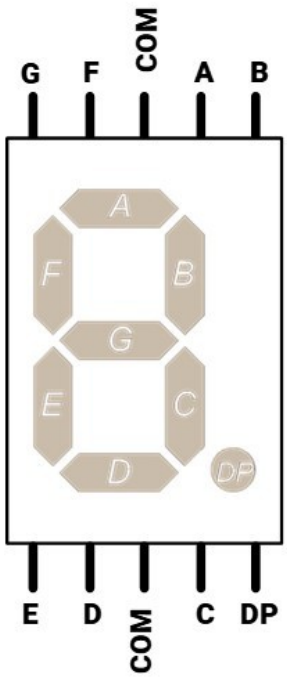
Water-cooled engines must only use plain water. Electric motors, accumulators or HV electronics may use plain water or oil as the coolant. Glycol-based antifreeze, “water wetter”, water pump lubricants of any kind, or any other additives are strictly prohibited.

Display

Motorcycle sensor installer:
https://www.youtube.com/channel/UCEtTRp79a0cYQbiOmMtMiGA/playlists

4.1 Essential Display Systems/Tasks:

- RPM bar display - page 8.
- ~~7 segment~~ Dot Matrix gear display.
- Coolant/ engine temperature LED indicator.
- Oil pressure LED indicator.
- Speedometer (not on display).
- ~~Electronics master switch (SPST)~~
- ~~Push-button engine starter switch.~~
- Design dashboard to house all display components.



4.2 GPS:

7Segment possibly used to display the current gear, by taking and decoding gear position sensor data.

Datasheet of SA40-19EWA 4 inch seven segment.

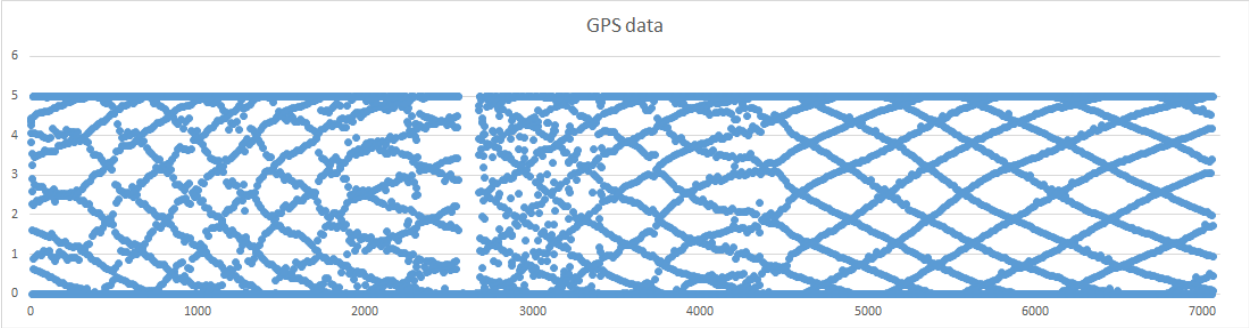
Necessary positions of the 7 seg.

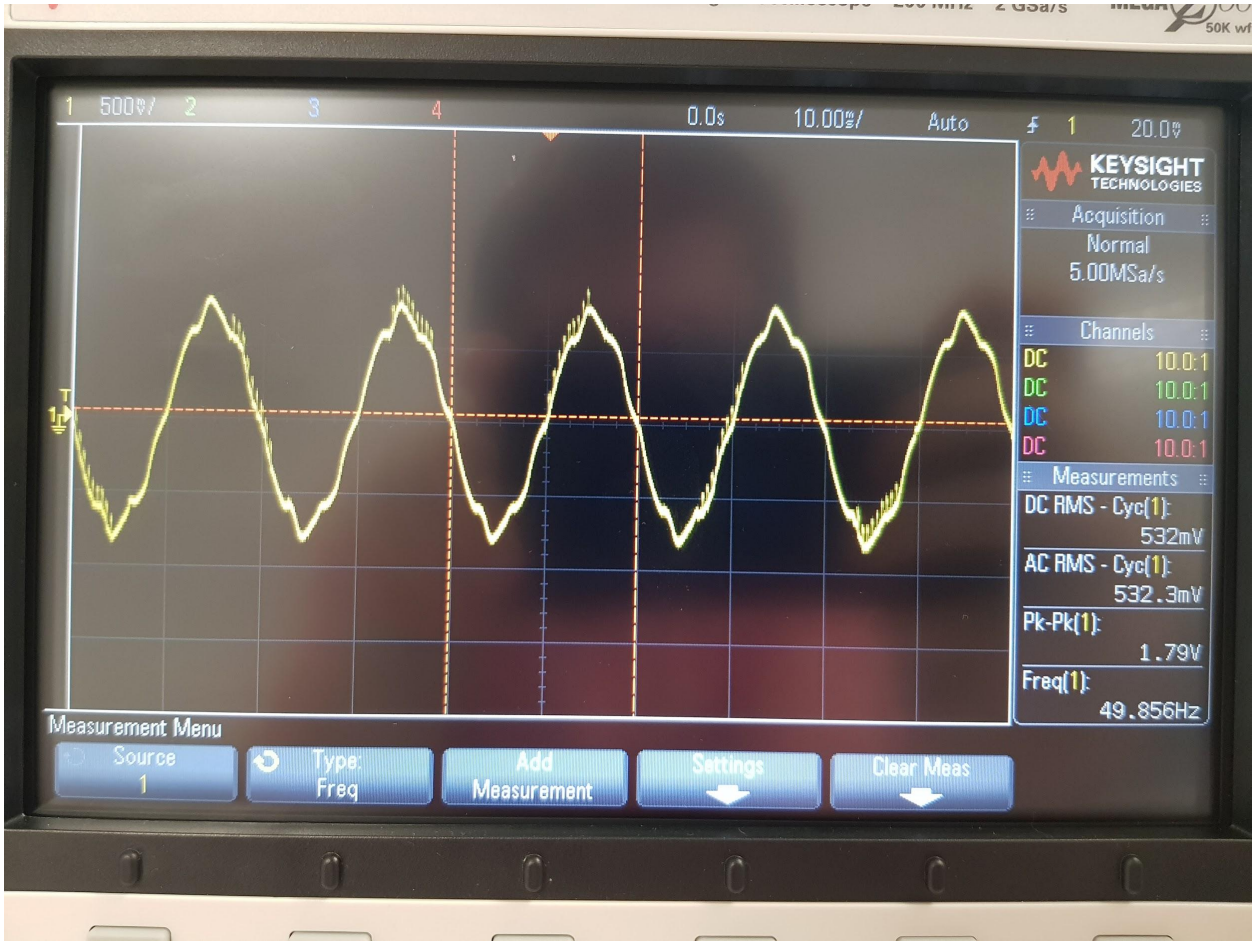
1	2	3	4	5	6	7?

BC	ABGED	ABCGD	FGBC	AFGCD	AFGCDE	ABC

DP unused.

Our GPS is a [non-contacting GPS].

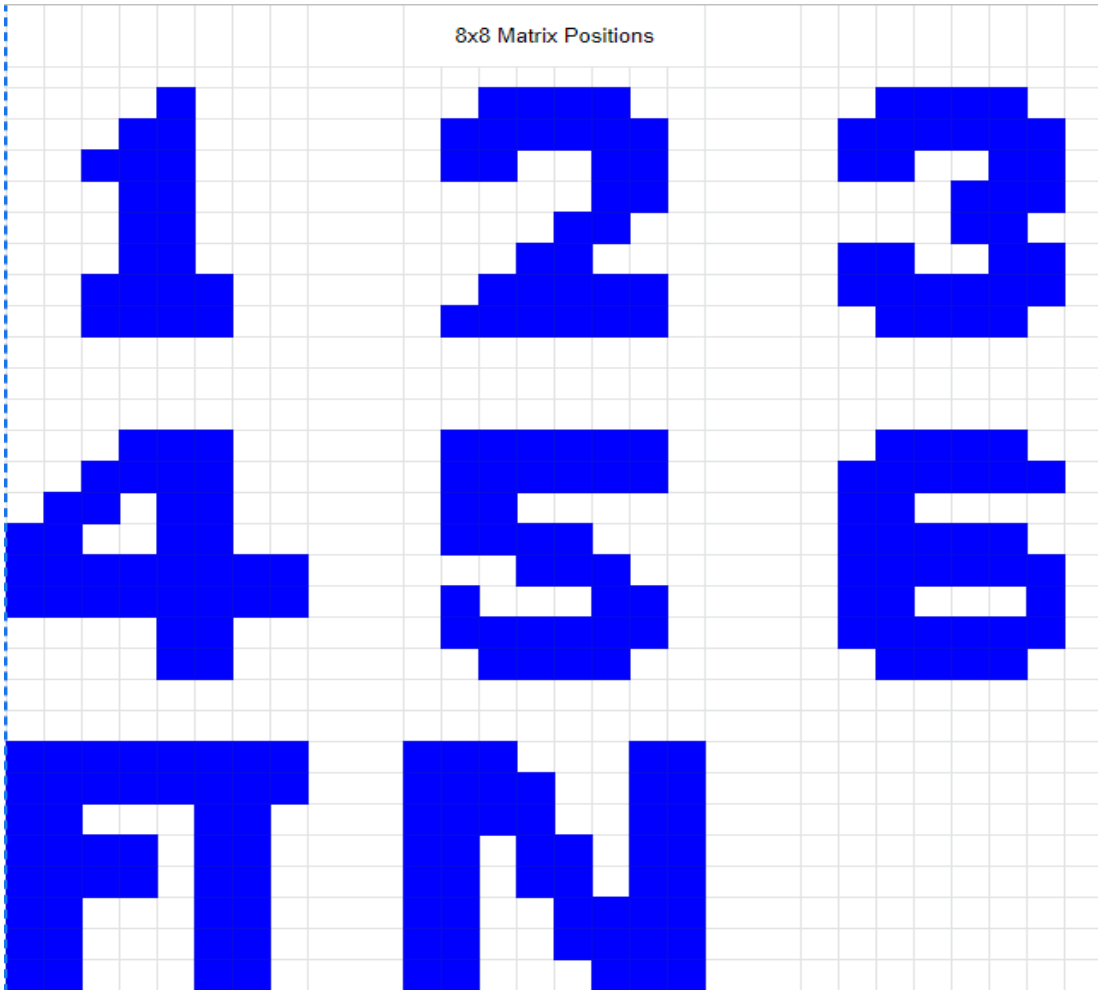




Discovered how to read: resistive difference between black/white wire [B/W] & blue and red wires. B/W to blue gives gears, B/W to red give neutral.

Black/White & Blue	1st	2nd	3rd	4th	5th	6th	Else
Ohms approx	220	475	820	1505	2730	6800	0
Arduino analogRead	1003	981	955	909	855	795	0
Arduino diff	22	26	46	54	60	60	0
Arduino analogRead	1001	977	948	891	805	610	0
Arduino diff	24	29	57	86	195	195	
Black/White & Red	Neutral	Else					
	1023	0					

Using Dot matrix to display:

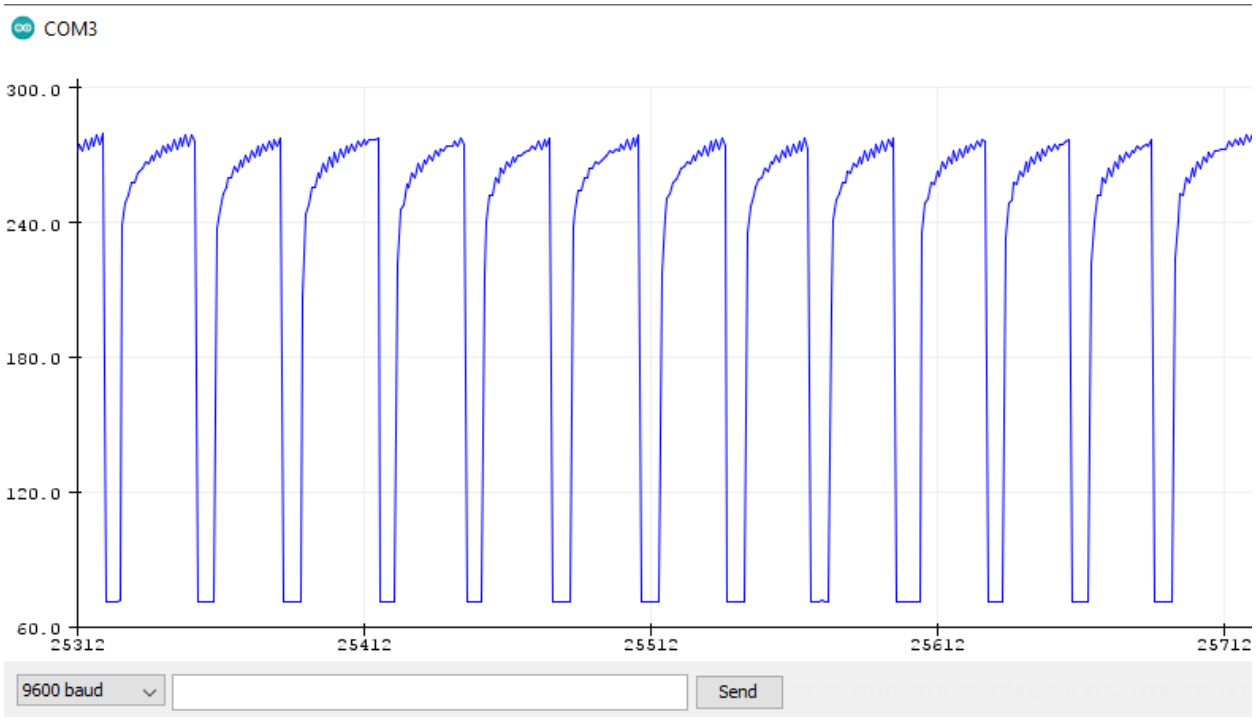


https://www.velleman.eu/downloads/29/infosheets/vmp502_led8x8_1088as.pdf

4.3 Vehicle Speed Sensor (VSS)

The VSS is a sensor located in the transmission, which measures the speed at which the driveshaft rotates. A ferromagnetic toothed reluctor ring on the driveshaft is read by the VSS (Hall Effect) and outputs an (almost) square wave whose frequency is used to find the speed of the vehicle.

VSS at high voltage when in close proximity (air gap 1-2mm) to ferromagnetic tooth. Low otherwise. Sensor has tendency to 'invert' this result spontaneously in testing, effect should be minimal with small amount of signal conditioning (e.g smoothing).



Cycle is measured by measuring time above certain voltage (pulse width) and measuring time below certain voltage and adding together.

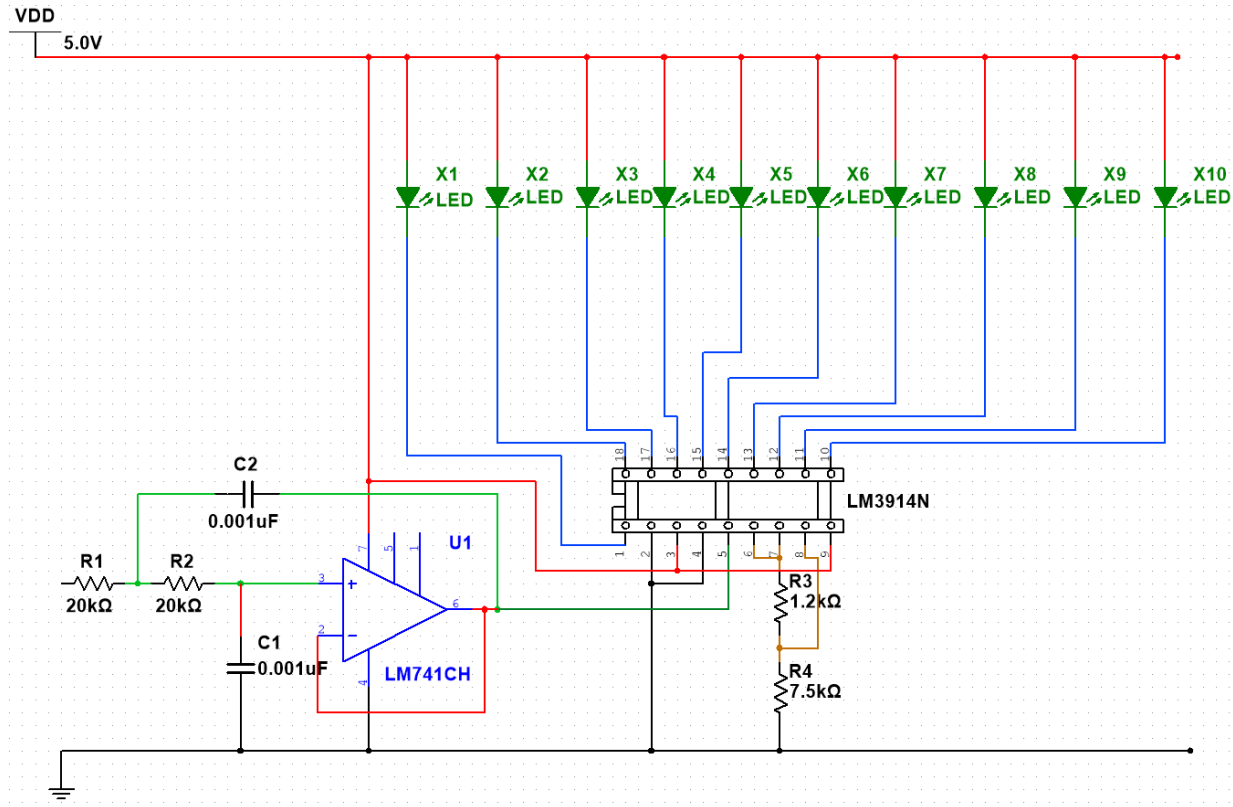
4.3 RPM Bar display

In order to use bar display the rpm obtained needs to be a voltage value between 0v and 5v however arduino does not output true analog signal instead a PWM signal is outputted. in order turn the PWM to a voltage a low pass filter is used in this case we used a sallen-key low pass filter

(see pic below for values) the cut off frequency is 8000Hz (do not know the actual rev of the engine).

Vid calculator

The lm3914 was used to drive the leds.



Useful resources :

- https://www.hackster.io/JorisH/gear-indicator-project-0926d8
- http://www.electronics-lab.com/project/motorcycle-universal-gear-indicator/
- https://www.youtube.com/watch?v=AbLSNcKhkuE
- https://gearingo.com/gearposn.html

4.3 Coolant, Engine & Oil Indicators:

Coolant sensor is resistive. As temperature increases, resistance drops.

2.14kΩ ≈ 23℃

Data sheet for the bosch air temperature sensor:

http://www.bosch-motorsport.de/content/downloads/Raceparts/Resources/pdf/Data%20Sheet_70129803_Temperature_Sensor_NTC_M12-L.pdf

Data sheet for the bosch fluid temperature sensor e.g. oil, water, or fuel.

http://www.bosch-motorsport.de/content/downloads/Raceparts/Resources/pdf/Data%20Sheet_70115595_Temperature_Sensor_NTC_M12-H.pdf

Testing Coolant Sensor:

https://www.youtube.com/watch?v=eXNBlH0c4_U

4.4 Switches

T flip-flop master to start and shutdown car

Switches

https://docs-emea.rs-online.com/webdocs/1403/0900766b814036f0.pdf

4.5 CAN communication

The Controller Area Network allows for ECUs to communicate with each other without any form of complicated wiring between them. This form of communication allows for several features to be added via software allone. They communicate via a single CAN interface which makes this

form of communication of low cost. Used in vehicles for communications between ECU, sensors and actuators.

The CAN frame is composed of 8 different components. SOF, this is known as the start of frame. Its main function is to tell all fellow nodes that the CAN node intends to talk. CAN-ID is the frame identifier. RTR, stands for the remote transmission request. This is where it is decided whether or not a node needs to send or request data. Control, informs us of the length of data in bytes. Data , is the actual data itself which needs to be either scaled or converted so as to be analysed. CRC, this is the cyclic redundancy check used to ensure data integrity. ACK, finds out if the node has been receiving data correctly. EOF, the end of the CAN frame.

CAN Bus Explained // Tutorial // video explanation

CAN-ID, Control and data are the only three relevant fields needed for logging data. This is done by using a CAN bus data logger. We receive raw CAN messages which are then recorded onto an SD card, for example, for further analysis. This recording of data can also be done wirelessly by pushing the data to a server.

CAN data can be composed of several parameters. To decode this one needs to know the offset and scaled values for each of these parameters. For each CAN signal, you take the decimal value of the data bits and multiply it by the offset and scale to get your scaled data value.

4.6 I2C communication

I2C is a serial protocol for two-wire interface to connect low speed devices. It is used by many integrated circuits and is the most popular serial interface to connect integrated circuits on the board. It is based off of the idea of one master device with several slave devices. Each I2C slave device needs its own unique address. This allows it to transfer to and from the master device in

serial form. It is very simple to use and implement. Uses only two wires with pull-resistors needed to connect almost an unlimited number of I2C devices. You only need two free I/O pins and a few simple I2C routines to send and receive components. There is also no need for microcontrollers to communicate with devices of special I2C interface.

Interface: The I2C consists of two wires. The SCL which is known as the serial clock and the SDA which is known as the serial data. Both wires must be pulled up with a resistor to +Vdd. I2C level shifters are used when two I2C buses with different voltages are connected.

Addresses: Each slave device has a 7-bit address which needs to be unique on the bus. Some slaves have a 10-bit address by specification. The 7-bit address represents bits 7 to 1. The bit 0 is used to indicate reading from or writing to the slave device. If bit 0 is set to 1 then the master device will read from the slave device. The master needs no address because it generates a clock via the serial clock wire and addresses individual slave devices.

Protocol: In the normal state both wires are set to high. Communication is started and ended by the master device itself. When the start condition (S) is generated the first slave device (B1) is generated which is the address of the slave device. If bit 0 is set to 0 then the master device will write to the following slave (B2). Once all bytes are read or written the stop condition is initialised. This condition tells the other devices to use the bus interface as the communication for the previous device has ended.

4.6 SPI communication

Configuring the Engine:

5.1 Tuner studio

https://www.youtube.com/watch?v=hQfOUXFzBk0

5.1 LT spice

Fuses and relays

Fuse

Coil protection circuit is needed

https://www.youtube.com/watch?v=gn9PE-T7Cy8

Electromechanical Relays (EMR's)