Trans Control

"Microsquirt trans firmware"

Dated: 2015-03-25

This version of the documentation applies to:

- MicroSquirt V3

  AND

- Running firmware "Trans controller release 1.0.0" or later (not Mshift)

Does not apply to other Megasquirt products or other firmware versions.

Hardware information for using the Trans firmware on GPIO and MS2 is contained in a supplement manual.

Please report any errors or omissions to contact@megasquirt.co.uk

Table of Chapters

Contents

1 Introduction

The Transmission control system gives laptop tunable electronic control over shift points, convertor lockup and line pressure. Integration with Megasquirt and Microsquirt ECUs using CAN is available to reduce wiring by sharing sensors.

The application is primarily targetted at the Microsquirt hardware, but may also be implemented on GPIO or MS2. This is the core manual and will focus on the Microsquirt. A supplementary manual is provided for the alternative hardware.

1.1 Emissions and disclaimer

All parts are sold for OFF ROAD RACE-ONLY ground-vehicle use only, or vehicles that pre-date any federal and state emissions control requirements. Aftermarket EFI/EMS systems are not for sale or use on pollution controlled vehicles. Alteration of emission related components constitutes tampering under the US EPA guidelines and can lead to substantial fines and penalties. Your country/state/district may also have specific rules restricting your tampering with your vehicle’s emissions system.

Race parts are inherently dangerous and may cause injury or damage if improperly modified or altered before use. The publishers of this manual will not be held liable for and will not pay you for any injuries or damage caused by misuse, modification, redesign, or alternation of any of our products. The publishers of this manual will not be held in any way responsible for any incidental or consequential damages including direct or indirect labor, towing, lodging, garage, repair, medical, or legal expense in any way attributable to the use of any item in our catalog or to the delay or inconvenience caused by the necessity of replacing or repairing any such item.

1.2 Required tools

Tuning laptop

Multi-meter (volts, ohms)

Screwdrivers

Wire cutters

Terminal crimpers

Soldering iron and solder

Heat-shrink tubing

Fire extinguisher

Although not essential, the following are highly recommended:

Oscilloscope or scope-meter or soundcard scope

Test light

Power probe

1.3 How to use this manual

This guide includes a number of notes which are indicated as follows:

This symbol indicates an “Information” note.

This symbol indicates a “Caution” note.

This symbol indicates a “Warning” note.

Installing or tuning your Microsquirt incorrectly can potentially cause damage to your engine, the Microsquirt or external hardware. Warning notes indicate specific areas where you need to exercise extreme care.

Do not rely on these warnings as your only criteria for taking care !

For additional help and support, visit the website **www.msextra.com**

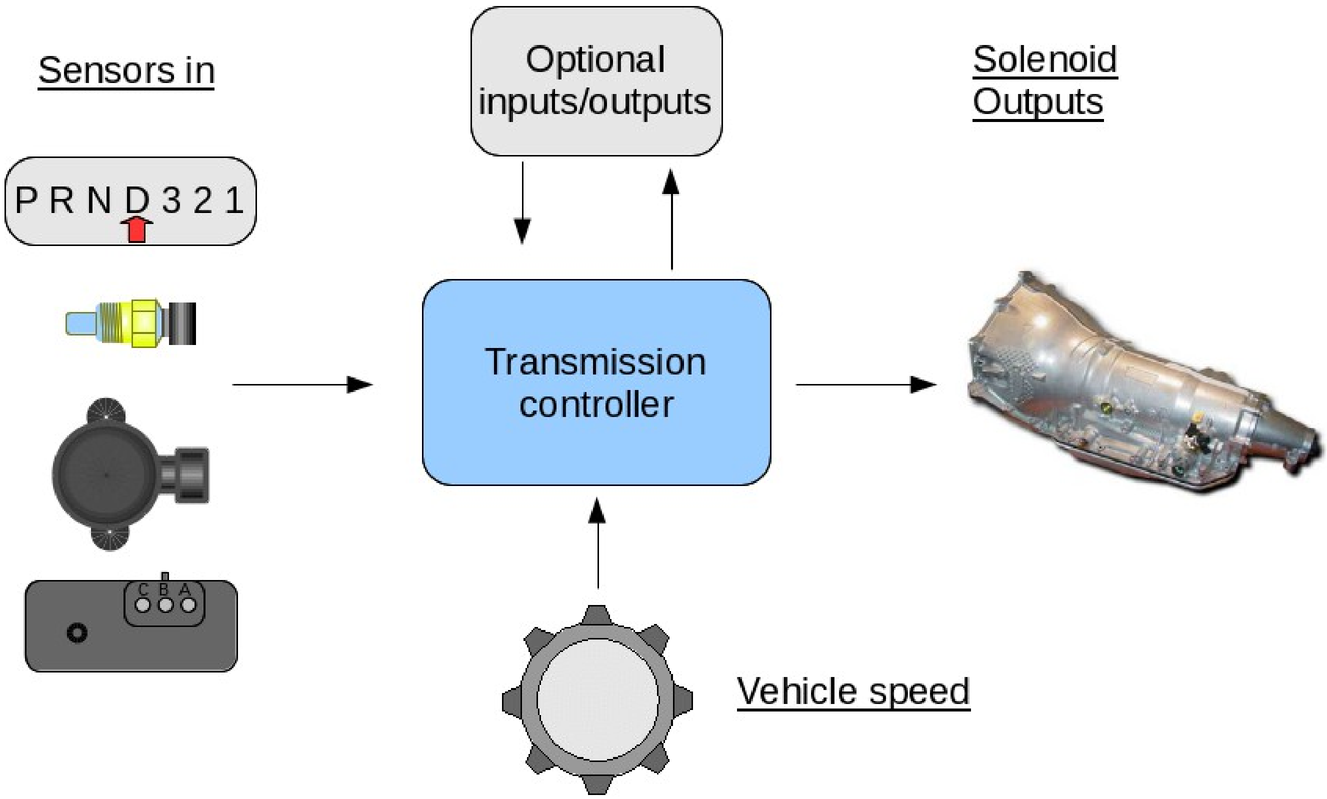
1.4 Comparison to GPIO

Another option for transmission control from Megasquirt is the "GPIO board". There are number of key differences between the two products that will suit different customers.

The following table compares the two offerings with Microsquirt transmission code running on a Microsquirt and GPIO 'MShift' transmission running on a GPIO board.

Item	Microsquirt Transmission	GPIO Transmission
Software	Support for transmissions as a "built in recipe" with wiring choices pre-determined. Documented in this manual.	Offers a generic approach that can support more user-defined configurations. Wiring and configuration is user determined.
Assembly	Microsquirt is pre-assembled.	GPIO is a DIY product requiring end-user assembly.
Wiring	Pre-made pigtail harness available. Needs splicing to transmission connectors. Off the shelf plug and play wiring planned for Q2 2015.	Wiring requires complete assembly.
Expansion capability	Pre-assembled Microsquirt hardware is not intended to be modified. Small number of spare inputs/outputs.	Skilled DIYers can add additional circuits. A number of spare inputs/outputs could be utilised.
End-user software customisation	Source code is provided allowing skilled customers to extend functionality if desired.	No source code available to customers.

2 Transmission System Hardware



2.1 Overview

The transmission controller receives signals from the various input sensors and then controls the solenoid outputs to operate the automatic transmission.

Most of the connections will be to the transmission itself. A few additional connections to the engine or main ECU are also required.

For engines running Megasquirt, a simple 2-wire CAN connection allows the sensor data to be shared.

For engines that have different fuel injection installed, you will likely be able to tap into the existing sensors.

For engines that do not have existing fuel injection, review the available options in this manual and select the most suitable components to complete your install.

2.2 Trans controller (TCU) installation

The Megasquirt products uses automotive grade electronic components internally, however, they are not designed to be installed in the engine compartment. Typically they will be installed under the dash in a car or under the seat on a bike - but away from direct engine temperatures. The temperature must not exceed 185°F (85°C.)

For reference, the dimensions of the Microsquirt mounting hole pattern are 4.20" by 2.14" (107 x 54mm). The hole diameters are 0.20" (5mm.) If full water resistance is desired, the case can be dismantled and sealed with a silicone sealant. The wiring plug (AMPSEAL) is an automotive grade sealed connector.

2.3 Wiring Harness and fuses

At this point in time, the transmission controllers are available with "pigtail" wiring harness for you to splice into the existing wiring on your transmission.

In the future "drop-on" wiring may be available.

2.4 Sensor Inputs

The sensor inputs provide the TCU with information about current engine operating conditions and are used to calculate the solenoid outputs.

The primary inputs are engine speed sensor, speed sensor, gear selector position and TPS/MAP sensor.

2.5 Speed Sensor Input

The TCU needs a connection to read vehicle speed. On most transmissions this is integral with the output shaft, but some installs may have a connection on a transfer case, differential or on the wheel hub.

2.6 Outputs

The primary outputs are the shift, line pressure and convertor lock-up solenoids.

2.7 Tuning interface

The Megasquirt products use an RS232 interface for tuning. Your computer will likely require a USB-serial adapter also. Adapter cables based on the FTDI chipset are recommended - some customers have reported unreliability with Prolific based cables.

3 Wiring and Sensors

A main step in your TCU installation is connecting up the wiring. Be sure to follow the guidance here to avoid common mistakes that will often lead to problems.

3.1 Best Practices

3.1.1 Wire and connector choice

For many first-time users, it may be tempting to re-use old connectors and wiring. While this may sometimes be cost-effective, beware of false economy. Using fresh connectors and suitable automotive grade wiring can save many a headache. Be particularly aware of using wire or components that are not temperature rated high enough, engines get HOT and the insulation on sub-standard wires can melt or degrade leading to erratic connections or short circuits. All components must be rated for 105°C / 220°F as a minimum.

There are many suppliers dedicated to supplying the required items to construct wiring harnesses.

3.1.2 Soldering or crimping

This is mainly down to personal choice, some installers prefer a soldered joint, others swear that crimped connections are superior. The key task is to make a reliable connection.

In your wiring harness you will need to ensure that all joints are effective both electrically and mechanically. Always test by tugging on the wires to ensure that they are not loose. Use heat-shrink tubing over connections to insulate them and prevent shorts.

With the correct crimpers, uninsulated crimp terminals with a slide on cover will usually give a more professional and reliable connection than pre-insulated type crimp connectors.

Don't even think about using scotch blocks - they are bad enough for installing a radio or trailer plug!

3.1.3 Re-pinning AMPSEAL

Optionally, to create the smallest wiring harness possible, the AMPSEAL connector may be carefully dismantled and unused spare wires removed. Generally it is advised to leave spare wires in place with the ends taped up.

Removing wires from the AMPSEAL connector will make it non-sealed, so this should not be done when the sealing is required.

3.1.4 Fusing

It is required that the system be fused - as shown in the general wiring diagram. Remember that an automotive battery is capable of supplying hundreds of amps into a short circuit which can easily melt wires or start a fire. Appropriate fuses can help reduce this risk and save component damage.

If there is a risk of the connections becoming damp then it can be worth applying petroleum jelly (e.g. Vaseline) to the connections to slow the corrosion.

3.1.5 Making the harness

When building the wiring harness, it is strongly advised to run all cables first before attaching ends. Neaten up the cable runs and wrap or otherwise attach in place. Only once all the lengths are known and everything is in place should ends be crimped. It also helps to make the wiring in one direction. i.e. work inwards towards the ECU or outwards towards the accessories - not both.

3.1.6 4-pin relay pin-out note

Be aware that there are two incompatible "standards" for four-pin automotive relays. Mixing them up will usually cause a short-circuit in your wiring harness. The type where pin 85 is opposite 86 is preferred as this is the same as 5-pin relays.

It is highly recommended to use relay-bases, these are easier to mount, look tidier and there is no problem of mixing up the wires if a relay is unplugged.

3.1.7 Relay and accessory power routing

Any relays, solenoids or lamps operated by the TCU must only be powered when the TCU is on. Typically it is easiest to take their power from the "fuel pump relay" of the main ECU so they are only powered when the engine is running. Miswiring accessories can cause power to backfeed into the TCU causing unexpected behaviour.

3.2 Grounding (Earthing) Schemes

Implementing a correct grounding scheme is critical to a successful TCU install.

Connecting sensors to the wrong ground, using corroded ground points or dubious original wiring are sure-fire ways to give you a headache.

There are two key rules:

1. All sensors must ground at the TCU

2. Ground the TCU at the engine block/head using all available power ground wires.

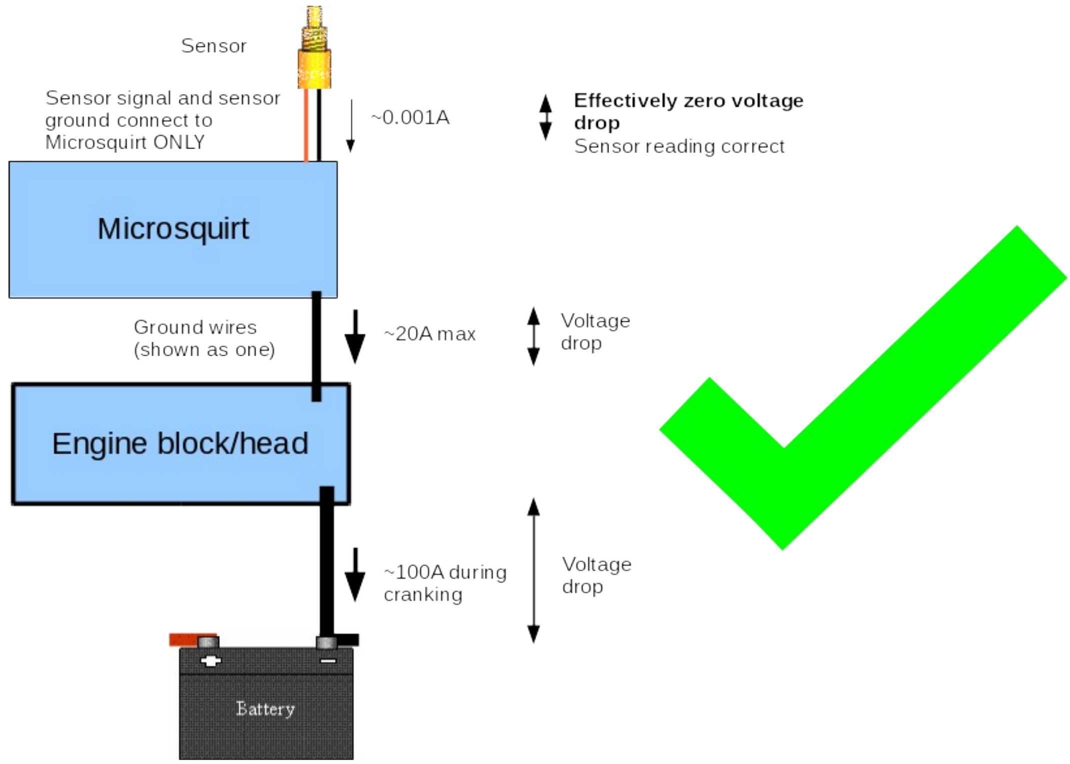
Reasoning:

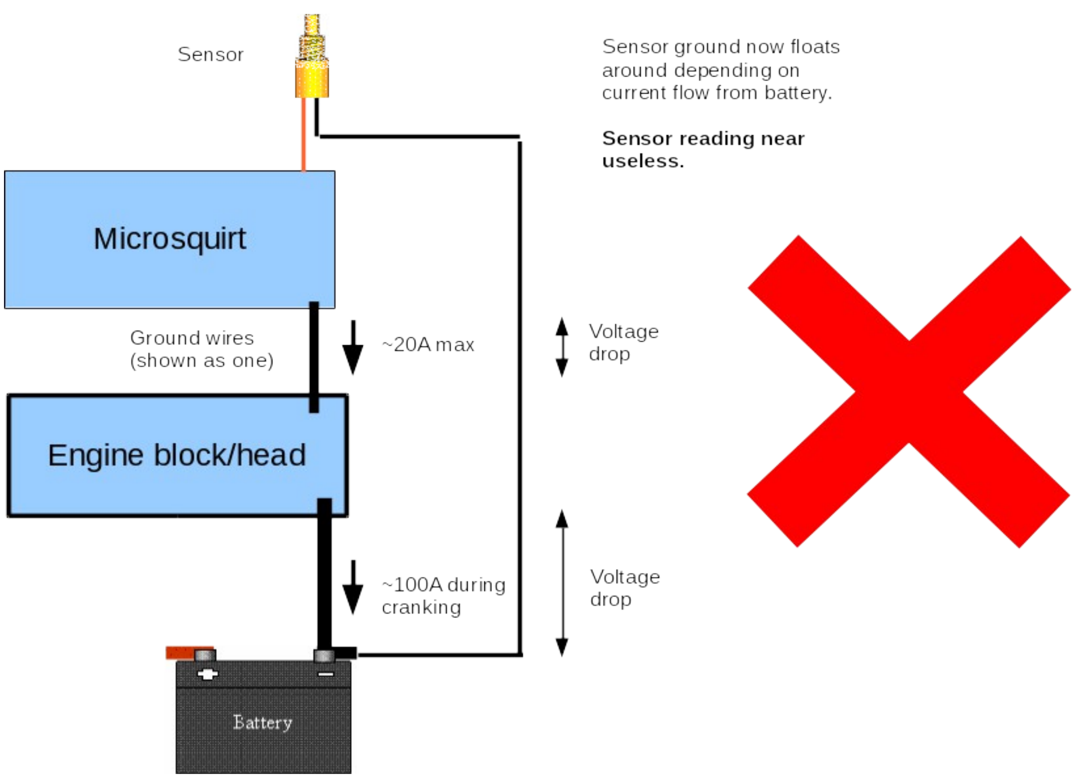
When a current flows through a wire there is always a voltage drop, the bigger the current, the bigger the drop (this is ohm's law.) During cranking there is a very large current flowing through the ground strap from battery to engine and perhaps a few volts may be dropped across it. Even during running, a number of amps will flow through the TCU grounds to the engine.

The sensors (coolant, air temp, throttle position, wideband, tach input) all use low current, low voltage signals. The TCU measures the voltage from the sensor and converts it into a temperature, position etc. reading. If that sensor is grounded to anything other than the ECU itself, then that input voltage will be altered by any external voltage drops. For a sensitive measurement this can be a real problem.

Speed input sensors are also sensitive and may show a false speed in the case of poor grounding.

The following two diagrams illustrate good and bad wiring schemes showing where the troublesome voltage drops are created and how that would cause sensor readings to be garbage.





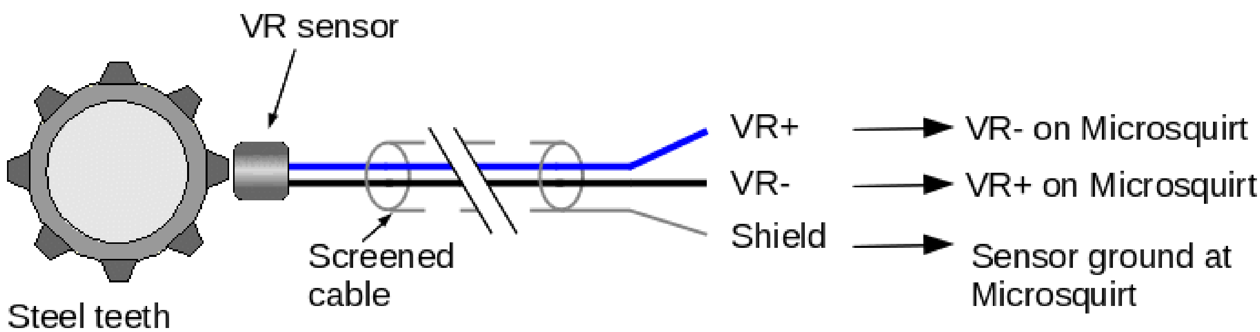
If re-using or splicing into OEM wiring, do not assume that their wiring is OK. Always follow the above principles.

As a check, with the TCU connector unplugged, ensure that the sensor grounds have no continuity to engine/body ground. Your sensor readings will be junk if they do have continuity - the sensors must ground at the TCU **only**.

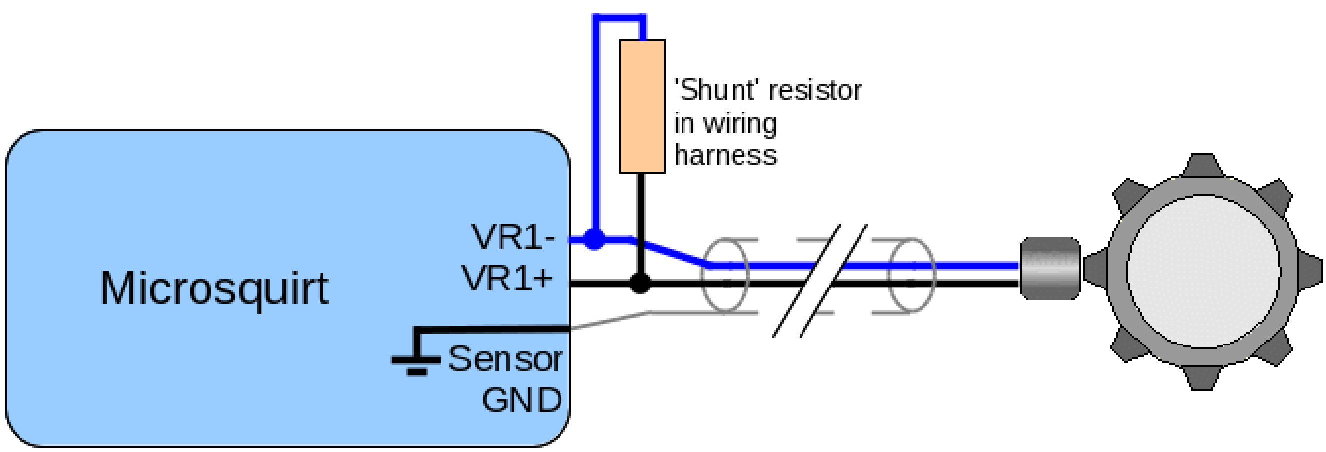
3.3 Inputs

3.3.1 Speed sensor inputs

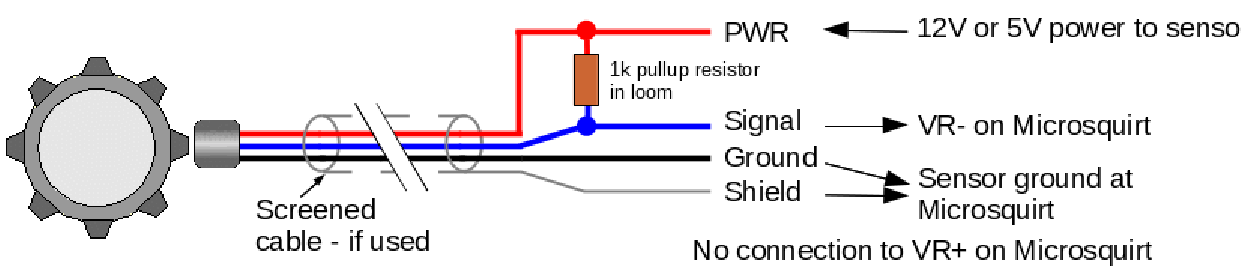
Most transmissions use an inductive (VR) type speed sensor that takes a single from an internal reluctor wheel ("tone ring"). This input is essential.



On the Microsquirt it will likely be necessary to install a 10k "shunt" resistor across VR+/-.



In retro-fit installations, gear-tooth or hall sensors can also be used. (More detail on different options are covered in the Microsquirt Hardware manual.) The following shows an open-collector type geartooth sensor that requires a pullup resistor in the harness.



The TCU can accommodate a speed sensor in different parts of the drivetrain. Identifying the correct location is necessary to enable correct speed and output shaft RPMs to be calculated. (The setting names are covered again in section 6.3.2.1.)

Wheel

The speed sensor is picking up on a shaft spinning at the same speed as the wheels. e.g. ABS ring, differential ring-gear, wheel studs etc.

The tyre/tire diameter (circumference) is factored in to calculate road speed.

The trans output shaft speed is calculated by multiplying by the final drive ratio.

Driveline

The speed sensor reads output shaft speed directly. (Common on 2WD RWD trans.)

The final drive ratio and tyre/tire diameter (circumference) are factored in to calculate road speed.

Pulses per mile/km

Provides a direct measure of road speed, but accuracy will vary if tyres/tires are changed etc.

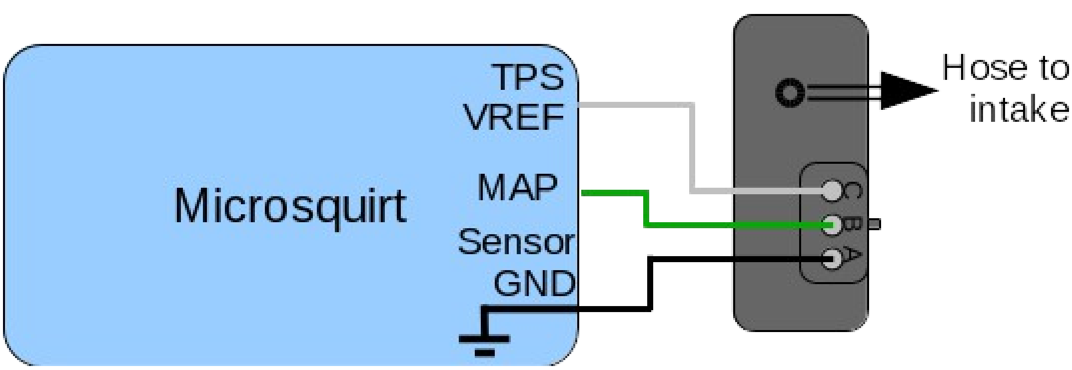
The final drive ratio and tyre/tire diameter (circumference) are factored in to calculate trans output shaft speed.

3.3.2 MAP (Manifold Absolute Pressure) sensor

This sensor measures air pressure on absolute scale where zero is a complete vacuum and sea-level ambient pressure is around 101kPa.

This sensor is optionally used as a load input. (The TCU requires either TPS or MAP for load.)

When using a Megasquirt to operate the engine, use the CAN interface instead of directly wiring the MAP sensor.

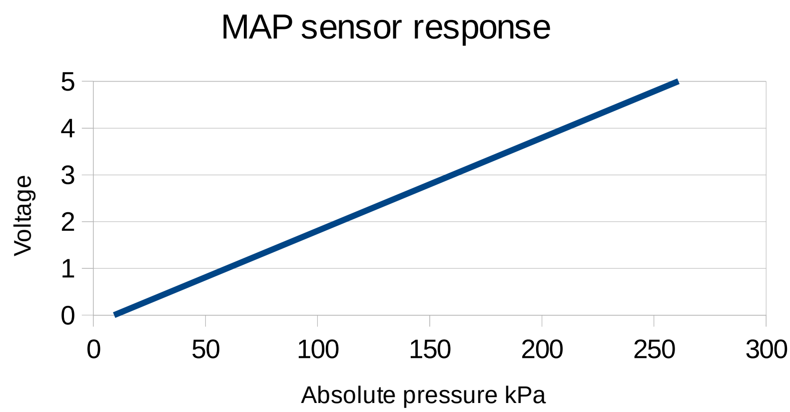


The sensor has three connections:

- A. Ground (sensor return ground)
- B. 0-5V analog signal to Microsquirt
- C. 5V supply (TPSVREF)

The pressure barb is connected to a full-vacuum source at the intake manifold. When tapping into any existing vacuum ports on a throttle body be sure to select one that gives full vacuum when the throttle is closed. (i.e. not a "ported vacuum" source that would connect to a distributor.)

The GM sensors are designed to be installed on the engine, Northstar and LS1 style sensors clip directly into the top of the plastic intake.

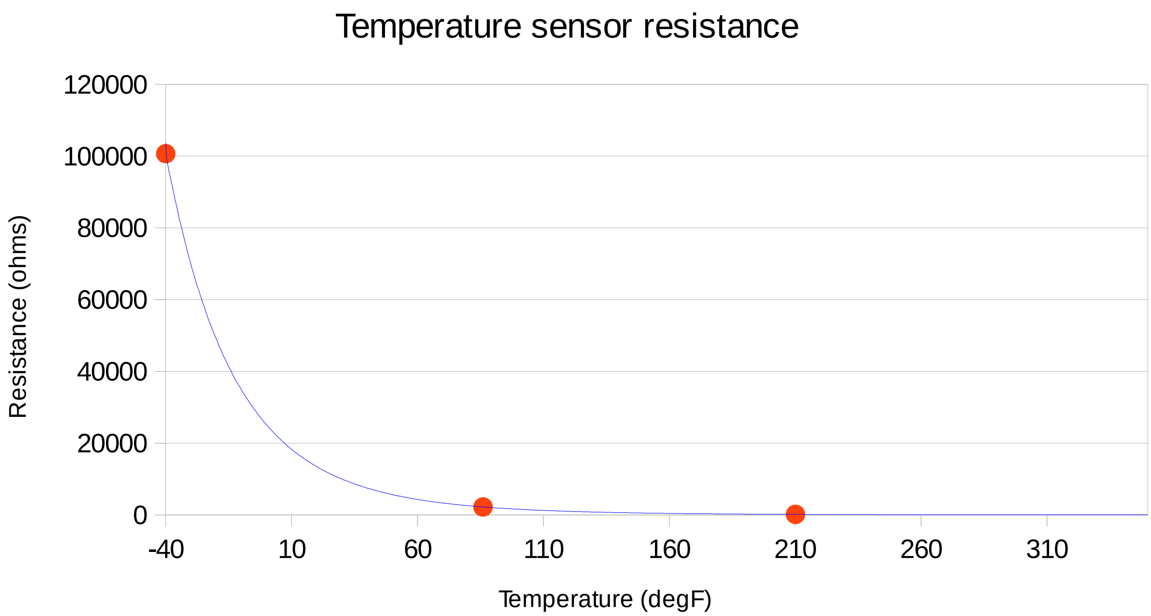


3.3.3 Transmission temperature sensor

This sensor measures the temperature of the fluid in the transmission and could in the future be used to alter lockup and shift behaviour. It is not currently used by the TCU software, but is datalogged.

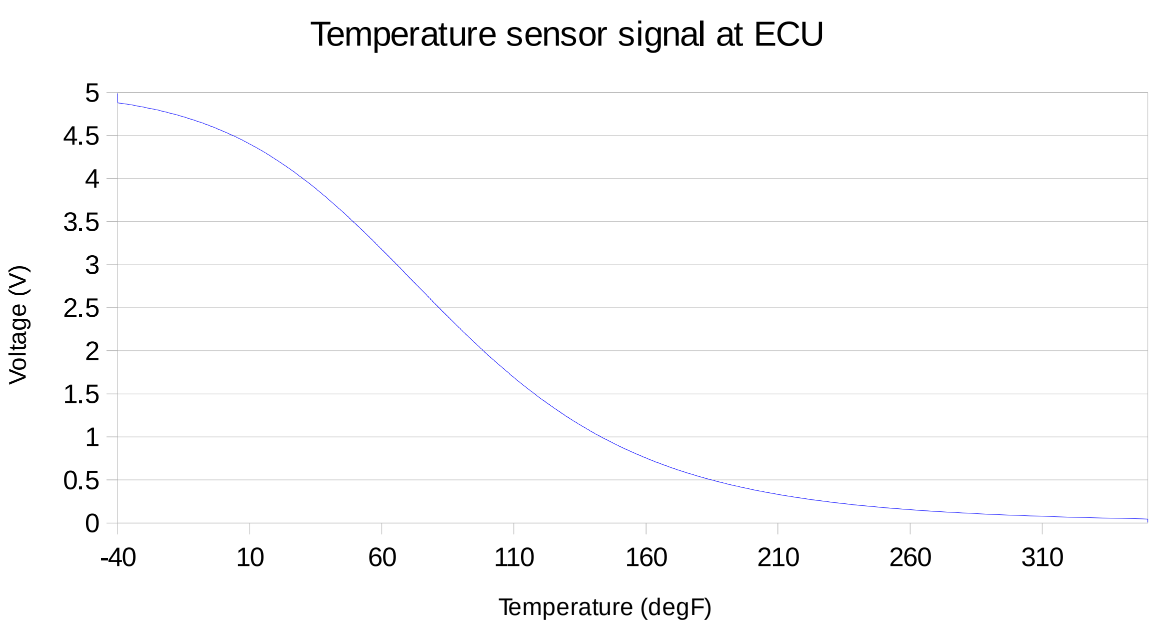
The temperature sensor is a variable resistor (a thermistor). Higher temperatures give a lower resistance, the response is non-linear.

The connections to the temperature sensor will be in the transmission multi-plug.



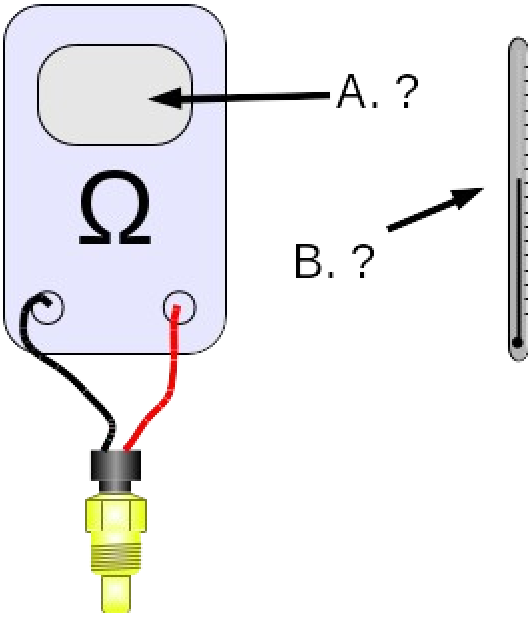
The red dots are the three standard calibration points for GM sensors.

The TCU uses a circuit to convert the resistance into a voltage that it measures.



Sensor calibration

TunerStudio includes many predefined calibration curves to select from, but for other "unknown" sensors the three calibration points can be determined.



The manual calibration process requires the use of a multimeter set to measure resistance and ideally a thermometer. Without a thermometer your calibration will be fairly close but not perfect.

1. Set the meter to ohms and connect the meter to the two terminals on the MAT or CLT sensor.
2. Allow the sensor to reach room temperature.
3. Take the resistance reading.
4. Measure room temperature using a thermometer (typically 20°C / 68°F)
5. Place the end of the sensor in a mixture of ice melting in water and allow it to stabilise.
6. Take the resistance reading.
7. Measure the ice/water temperature using a thermometer (typically 0°C / 32°F)
8. Place the end of the sensor in a pan of boiling water and allow it to stabilise.
9. Take the resistance reading.
10. Measure the boiling water temperature using a thermometer (typically 100°C / 212°F)

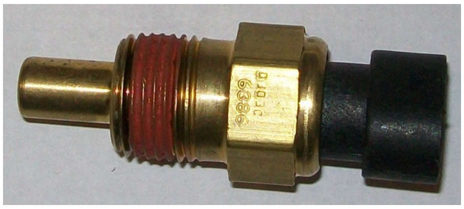
You now have the three calibration points for TunerStudio.

For a GM sensors these should be close to:

Where	°C	°F	Ohms
Ice/water	0	32	9441
Room temp.	20	68	3518
Boiling water	100	212	172

Note that the default calibration data in TunerStudio goes down to -40° but that's rather difficult to measure in the normal workshop.

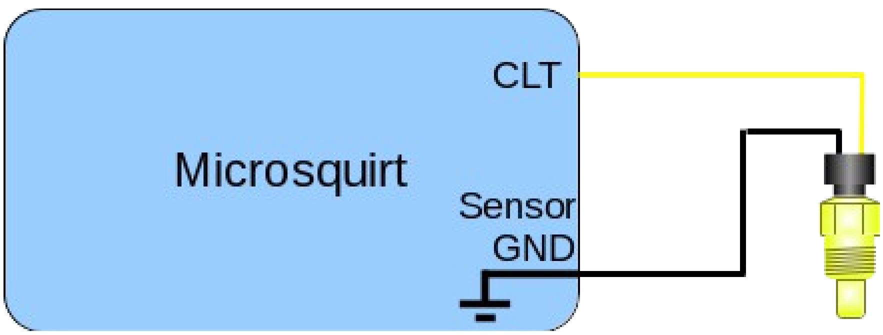
3.3.4 Engine Temperature (CLT) sensor



This external sensor measures the temperature of the engine coolant (or cylinder head for air-cooled engines.) It is not currently used by the TCU software, but is datalogged.

The coolant temperature is a thermistor and works in the same way as the air temperature sensor.

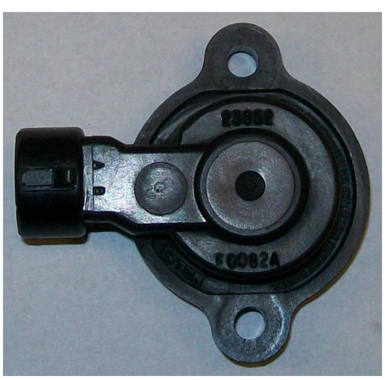
When using a Megasquirt to operate the engine, use the CAN interface instead of directly wiring the engine CLT sensor.

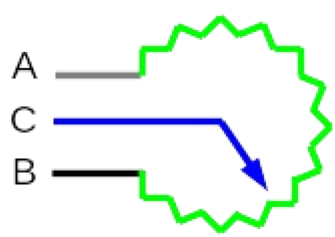


A good sensor will have two wires, one wire connects to sensor ground, the other to the CLT input on the ECU.

One-wire sensors are not recommended.

3.3.5 TPS (Throttle Position Sensor)

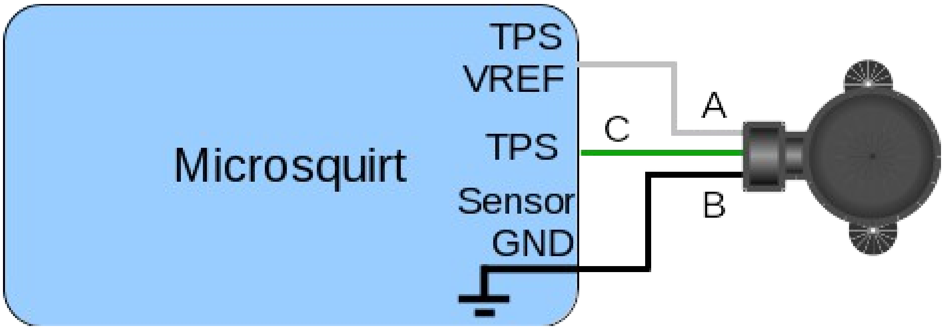




This external sensor measures the position of the throttle plate. It is a variable resistor (potentiometer) and sends a 0-5V signal back to the TCU. The sensor has three wires, 5V supply (TPSVREF), Ground (sensor ground return) and signal. The TCU converts the signal to a 0-100% scale using your calibration numbers. 0% corresponds to fully closed, 100% to fully open.

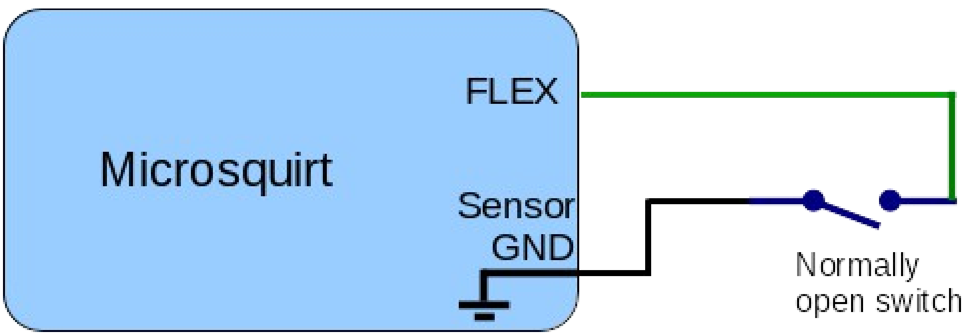
This sensor is optionally used as a load input. (The TCU requires either TPS or MAP for load.)

When using a Megasquirt to operate the engine, use the CAN interface instead of directly wiring the TPS.



3.3.6 Brake Switch input

The optional brake-switch input is used to unlock the convertor during braking for smoother operation. On the Microsquirt the "FLEX" input is used.

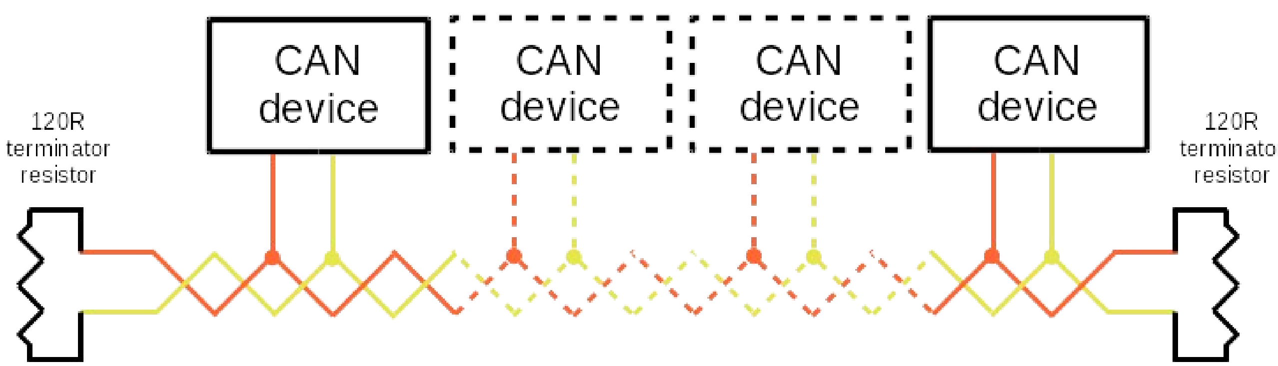


3.3.7 CAN comms

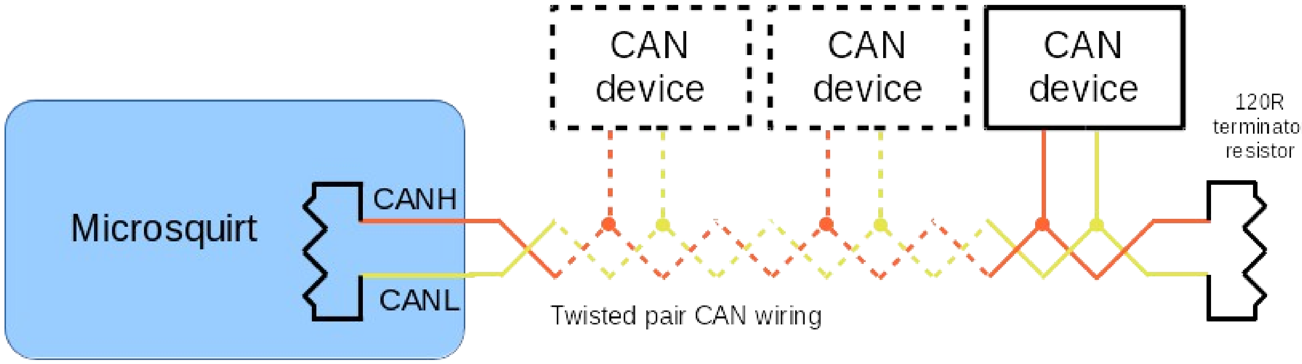
The CANH/L wires are used to connect the TCU to a master Megasquirt ECU to share data and reduce redundant wiring.

The following diagram illustrates the basic CAN wiring principles.

In general, CAN forms a bus network with a 120R terminator at each end and devices wired as short 'drops' off the network.



The Megasquirt-3 and Microsquirt include terminating resistors internally, so can be used at the ends of the network. However, if additional devices are connected to the network, they must not have terminating resistors ! i.e. one at each end only.



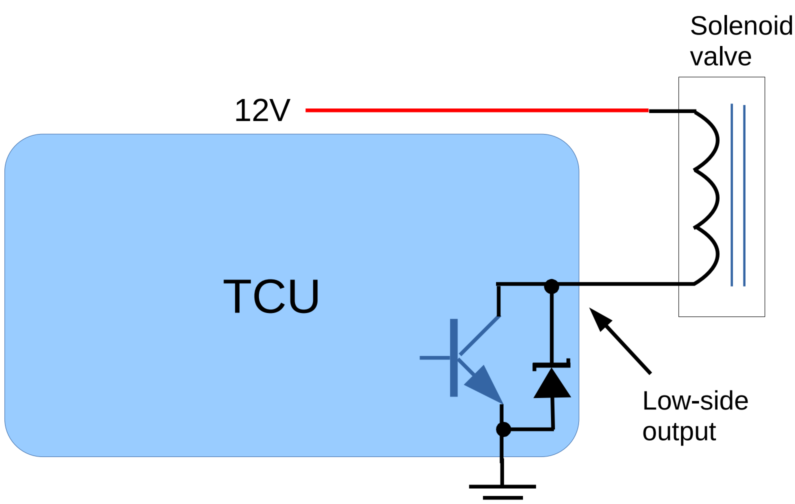
Connect:

Microsquirt CANH -> ECU CANH

Microsquirt CANL -> ECU CANL

3.4 Outputs

The main outputs from the TCU are low-side drivers for the transmission solenoids. Refer to the wiring tables for exact connections.



Some transmissions require high-side drivers in their factory configuration i.e. the solenoids are grounded and the ECU provides 12V to activate them. It may be possible to re-wire as low-side or you may need a high-side driver circuit.

4 TCU Wiring Tables

Each hardware variant has its own wiring table, be sure to refer to the correct one! Transmission wiring is covered in the next section.

4.1 Microsquirt V3 trans wiring

To use the Microsquirt V3 as a transmission controller, no internal modifications or customisation is required.

Pin#	Name	Color	In/Out	Function	Max current
1	+12V In	Red	In	Main power feed	< 1A
2	CANH	Blue/Yellow	Comms	CAN communications	-
3	CANL	Blue/Red	Comms	CAN communications	-
4	VR2+	VR2	In	Engine speed signal. Connect to tacho or crank sensor. OR Input shaft speed sensor. *2	-
5	SPAREADC2 (MAF)	Pink/Black	In	Spare analogue input.	-
6	FLEX	Purple/White	In	Brake switch GND signal. Do not apply 12V to this pin.	-
7	FIDLE	Green	Out	Solenoid B	3A
8	FP (pump)	Purple	Out	Solenoid A	3A
9	INJ 1	Thick Green	Out	TCC (LU) Solenoid	5A
10	INJ 2	Thick Blue	Out	EPC solenoid	5A
11	SPK B (IGN2)	Thick White/Red	In	Selector pos B	-
12	SPK A (IGN 1)	Thick White	In	Selector pos A	-
13	RX	-	Comms	RS232 communications	-
14	TX	-	Comms	RS232 communications	-
15	BOOT LOAD	Purple/Black	In	Bootloader GND enable input	-
16	ALED	Yellow/Black	Out	Solenoid D	3A
17	WLED	Yellow/White	Out	Solenoid C	3A
18	Sensor Ground	-	GND	Not installed	-
19	Serial Ground	-	GND	Serial Ground	-
20	Sensor Ground	White/Black	GND	Sensor GND (temp,TPS)	-
21	VR2-	VR2	In	Engine Speed signal OR Input shaft speed sensor. *2	-
22	POWER GROUND	Thick Black	GND	POWER GROUND	-
23	POWER GROUND	Thick Black	GND	POWER GROUND	-
24	MAP	Green/Red	In	Optional input. *3	-
25	CLT	Yellow	In	Engine Temp Sensor (if used) *3	-
26	MAT	Orange	In	Trans temp sensor	-
27	TPS	Blue	In	TP Sensor input (if used) *3	-

Pin#	Name	Color	In/Out	Function	Max current
28	TPS VREF (5V) *1	Gray	Out	5V supply for TPS	0.1A
29	SPAREADC	Orange/Green	In	Selector pos C or Analogue gear pos	-
30	OPTO+	Grey/Red	In	Do not connect	-
31	OPTO-	Grey/Black	In	Do not connect	-
32	VR1+	VR1	In	VSS (rear/side of trans or transfer case)	-
33	VR1-	VR1	In	VSS (rear/side of trans or transfer case)	-
34	O2	Pink	In	Selector pos D (OD)	-
35	TACHO	Green/Yellow	Out	Optional output.	0.3A

Note *1

TPSVREF is used to power TPS

- Connect to TPS if using it standalone. Do not connect if sharing TPS with another ECU.

Note *2

VR2+/- is used for either engine speed or input shaft speed.

- When fetching data from a Megasquirt ECU over CAN, these inputs are available for an input shaft speed sensor
- When operating standalone without a CAN connection, these inputs must be used as an engine speed input.

Note *3

When fetching data from a Megasquirt ECU over CAN the following wired connections are not needed to the trans controller.

- Engine TPS
- Engine MAP
- Engine CLT

The "BOOTLOAD" wire should not be connect to anything - leave it safely taped up.

4.2 Microsquirt V1, V2, MS2, GPIO trans wiring

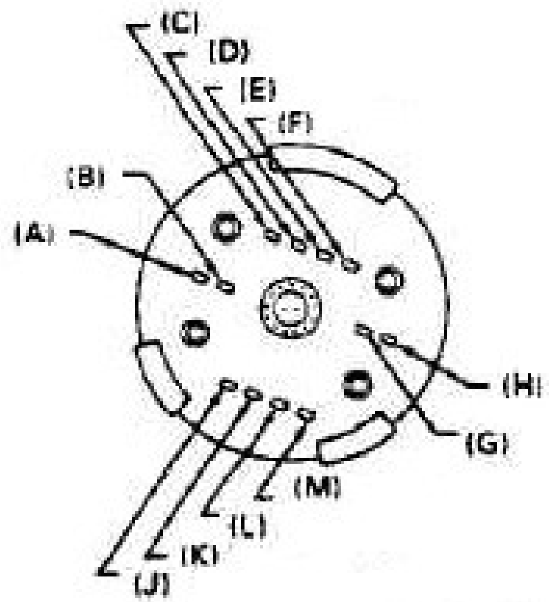
Wiring and customisation for these alternative hardware platforms is covered in the supplementary manual.

5 Transmission Specific Wiring

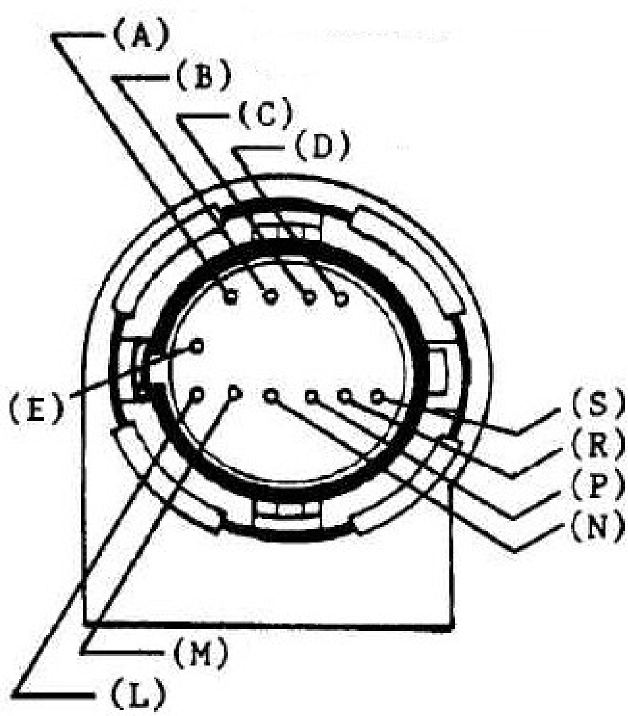
Each transmission has its own wiring. These tables cross reference the input and output names used in the previous section.

5.1.1 GM 4L80E

Fully supported.



Early connector (prone to leakage)



Later connector (1993+)

Function / TCU connection	Early 4L80E	Late 4L80E
Solenoid A	A	A (Light Green)
Solenoid B	B	B (Yellow/Black)
+12 Power	C & K	E (Pink/Black)
Selector pos A	D	N (Pink)
Selector pos B	E	R (Blue)
Selector pos C	F	P (Red)
Temp Sensor GND	H	M (Purple)
Temp Sensor	G	L (Black/Yellow)
LU Sol Switched Gnd	J	S (Brown/Black)
EPC +12V	L	C (Red/Black)
EPC Switched Gnd	M	D (Grey/White)

The transmission requires a fused 12V supply. A 10A fuse to supply both +12V and EPC is recommended.

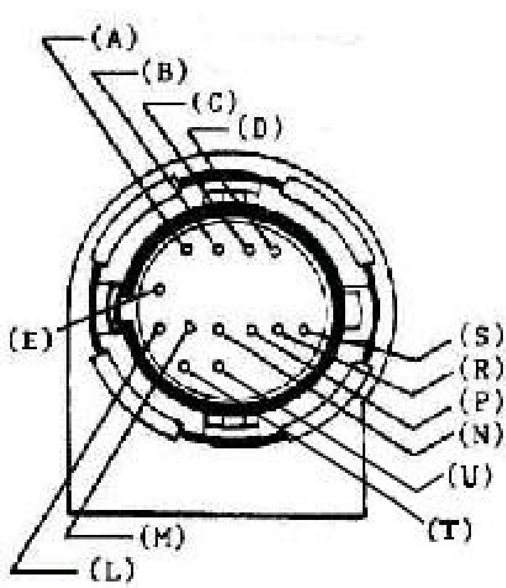
The output shaft VSS VR sensor (the one near the rear of the trans) is connected to VR1

The input shaft VR sensor (the one near the middle of the trans) is connected to VR2 when running alongside a Megasquirt ECU and fetching engine RPM over CAN. (In standalone mode, VR2 is used for engine RPM and the input shaft VR sensor cannot be used.) The input shaft speed sensor is mounted 'downstream' of the 4th gear overdrive gearset, so reported convertor slip will include any overdrive clutch slippage.

Built-in gear ratios: 2.48,1.48,1.00,0.75

5.1.2 GM 4L60E

Supported.



Function	4L60E
Solenoid A	A
Solenoid B	B
+12 Power	E
Selector pos A	N
Selector pos B	R
Selector pos C	P
Temp Sensor GND	M
Temp Sensor	L
LU Sol Switched Gnd	T
EPC +12V	C
EPC Switched Gnd	D
3-2 solenoid switched Gnd (Solenoid C)	S
Lock up feel solenoid switched Gnd (later models) (Solenoid D)	U

The transmission requires a fused 12V supply. A 15A fuse to supply both +12V and EPC is recommended.

The "3-2 solenoid" connects to "Solenoid C"

On 1993+ models, "Lockup feel solenoid" connects to "Solenoid D". Be sure to enable LUF on the lockup menu. Without this additional solenoid control, very slow lockup can burnup the lockup clutch.

Built-in gear ratios: 3.06,1.63,1.00,0.70

5.1.3 Toyota A340/A341E

This application expects high-side gear position switches. i.e. they provide a 5V signal instead of a ground.

May also include A340.

Built-in gear ratios: 2.53,1.53,1.00,0.71

5.1.4 Chrysler 41TE

The support for the 41TE is considered experimental. Further development is required before this is fully usable. This transmission uses a far more complex shift strategy than the other transmissions covered here and the solenoid timing is critical.

Built-in gear ratios: 2.82,1.57,1.00,0.69

5.1.5 Ford 4R70W

This transmission operates in a similar fashion to the GM 4L80E, but has the choice of either an analogue gear position input or a set of switches.

Built-in gear ratios: 2.84,1.55,1.00,0.70

5.1.6 GM 4T40E

Fully supported. Uses switch inputs B&C only.

Built-in gear ratios: 2.95,1.62,1.00,0.68

5.1.7 GM 5L40E

In development, testers required.

Built-in gear ratios: 3.42,2.21,1.60,1.00, 0.75

5.1.8 Ford E4OD

This has the choice of either an analogue gear position input or a set of switches. Drive should be defined as gear 4.

The coast clutch connects to 'Solenoid C' output

The OD cancel switch connects to input 'Selector D'

Built-in gear ratios: 2.71,1.54,1.00,0.71

5.1.9 Subaru W4A33

From the factory this uses multiple switches to determine level position. A resistor network is required to generate a 0-5V analog signal to the TCU. 'Drive' should be defined as gear 3.

The OD cancel switch connects to input 'Selector D' This will allow the shift into 4th gear.

The solenoids are designed to be fed 12V. Either these need re-wiring to be ground switched or PNP drivers (e.g. TIP125) used to power them.

Built-in gear ratios: 2.55,1.49,1.00,0.69

5.1.10 Other applications

To follow. Please engage with the developers on the www.msextra.com forum or through your supplier.

6 Software

This section covers loading the firmware to your TCU and basic configuration settings.

6.1 Firmware

6.1.1 Installing firmware

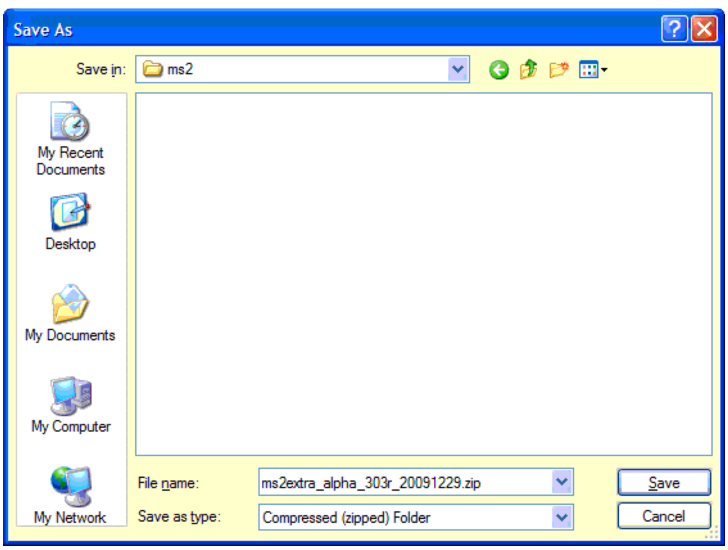
Skip this step if your TCU was supplied with the firmware pre-loaded.

The latest versions can be downloaded from www.msextra.com/downloads

i. Create a folder/directory for tcu. e.g. C:\TCU

(Use "My Computer" or "Windows Explorer", open Local Disk C: and Create New Folder, name it MS2).

ii. Download the firmware zip file from the downloads page. Right click and Save Target As into the C:\TCU folder.

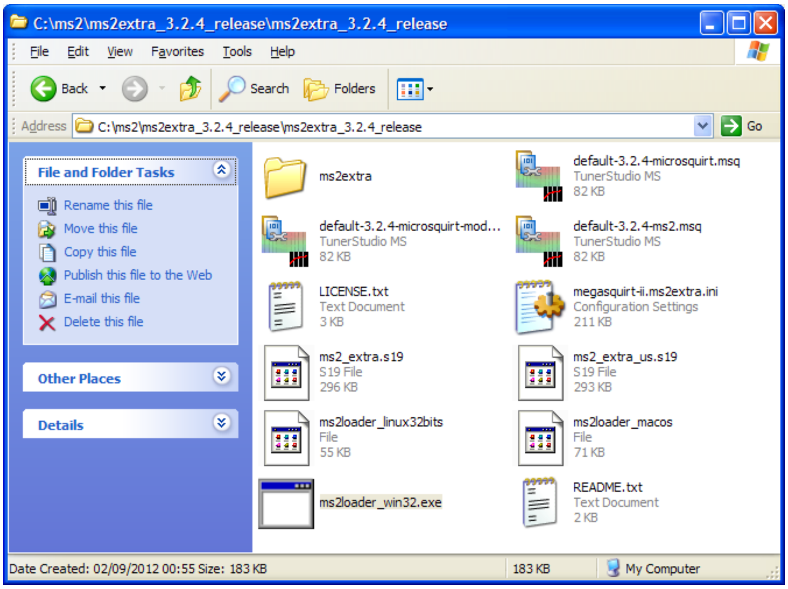


iii. Use My Computer / Windows Explorer and browse to this folder (e.g. C:\TCU)

iv. Right click on the file you saved and choose Extract All

v. The defaults are OK, and just click next. (Note that Windows adds a second level of directory.)

vi. You should now find the files have been extracted. Open up the folders until you see this:



vii. Users loading firmware for the first time can skip to viii.

Upgrade users should ensure that you have used Save Tune As to save your existing tune settings.

viii. Exit your tuning software and ensure nothing is using the serial port.

ix. Double click on ms2loader_win32.exe (If you get a security warning, click Run)

The loader is text based. Answer all of the questions by pressing the required key on your keyboard.

Example:

```
MegaSquirt-2 Firmware Loader 3.34 2014-01-21
------------------------------------------------------------------------
This firmware loader is only licensed for loading Megasquirt firmware onto
official Megasquirt hardware.

Using Megasquirt firmware on un-approved devices is in breach of copyright.
Visit http://www.msextra.com to check the validity of your hardware.
------------------------------------------------------------------------

Remove the fuse powering your ignition coils.
(Spark outputs may be undefined until you re-load your settings.)
Press enter to continue...
.
Ensure that your Megasquirt/Microsquirt/ECU is
-connected to your computer
-has fused 12V power connected.
Press enter to continue...
.
Ensure that no tuning software is running.
Be sure to Quit the software, not just minimise it..
Press enter to continue...
.
Debug message Level:
1: Normal
2: More detail
```

```
3: + serial comms
4: + the s19 file as parsed
Selection (default: 1):
.
Do you want to scan your serial ports automatically? (y/n default y)
.
COM1 MS2/Microsquirt-type ECU detected
.
Do you want to use COM1 (y/n default = y)
.
.
The following s19 files were found, type in the filename you require.

trans.s19
.
.
File to upload (1, 2, filename, default= trans.s19):
Fetching format
Checking serial format
New serial format >= 001 detected
.
Preserve sensor calibrations (only for MS2/Extra) (y/n, default: n)?
.
=========================================================
Settings selected:
Serial port: COM1
S19 File: trans.s19
Debug level: 1
Jumperless reflash enabled
Not preserving sensors calibrations
=========================================================
Press enter to continue...
Sending jumperless flash command
Attempting Wakeup...
Fetching : sensor calibrations
Erasing main flash!
Erased.
Sending firmware to controller...
[=========================================================>]100.0%
Sending : sensor calibrations
Wrote 30127 bytes
*** Settings not preserved. Please re-load your MSQ / tuning settings ***
Press enter to continue...
.
```

If this takes long than a minute then you likely need to adjust the port settings of your USB-serial adapter to reduce the latency setting.

The first time you install firmware it might be necessary to use the boot jumper (MS2) or ground the BOOTLOAD wire (Microsquirt).

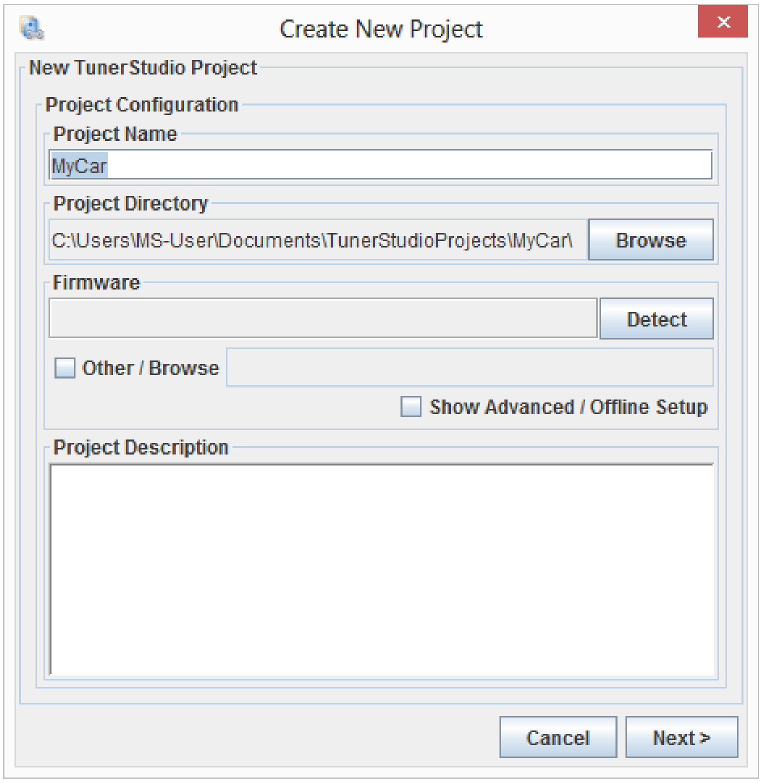
6.2 Get your tuning computer to talk to the ECU

i. Start TunerStudio

ii. Create a new project.

From the Start Screen select File > New Project

or from the Main Screen select File > Project > New Project.

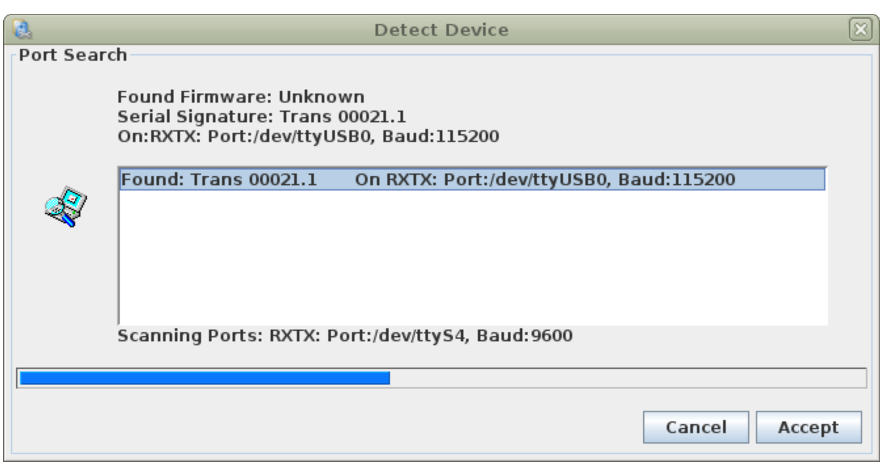


In the Project Name box you can give the project a meaningful name if wish.

Double check that your TCU is powered up and connected to your computer by serial.

iii. Click on **Detect**

When you click the “Detect” button a “Detect Device” screen will appear and TunerStudio will attempt to find your TCU and its firmware version. If successful it will list your TCU, firmware version and Baud rate. Check to see that these appear to match your TCU and then click “Accept” to continue. If the “Detect Device” screen reports “No controller found” check the connection between your computer and your TCU and ensure that your TCU has power and try again. If this still does not resolve the problem move on to the “Other / Browse” method described below to set the firmware up manually.



If your TCU is identified correctly, clicking “Accept” should load the necessary firmware version. Click Next and you can now move on to step v.

If your TCU is identified correctly but clicking “Accept” displays a message that reports “TunerStudio does not have a configuration to support the found hardware” then it is likely either that you are running an older version of TunerStudio, or you are running a beta version of the firmware. If you are running an older version of TunerStudio you are strongly advised to update to the latest version. If you are using a beta version of the firmware you will need to use the “Other / Browse” method described below to set up your firmware manually.

iv. **Other / Browse**

This method is recommended only if TunerStudio is not able to detect your TCU, or if you are using a beta version of the firmware.

The firmware on your TCU may have been provided on a disk or downloaded as a .zip file from the www.msextra.com website. If you have downloaded your firmware and haven't done so already extract the contents of the zip file to a directory of your choice.

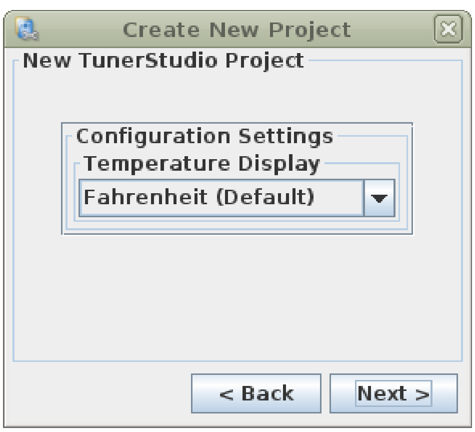
Clicking in the box next to “Other / Browse” opens a screen which lets you browse to your firmware folder. From here you should be able to select the .ini file that you want to use. It is essential that you use the .ini file that is appropriate to your TCU.

The .ini file you are looking for is called trans.ini

(Your computer may hide the .ini part from you - if this is the case, go to Folder Options and ensure there is no tick beside "Hide known file extensions". Unticking this can help protect against accidentally running viruses too.)

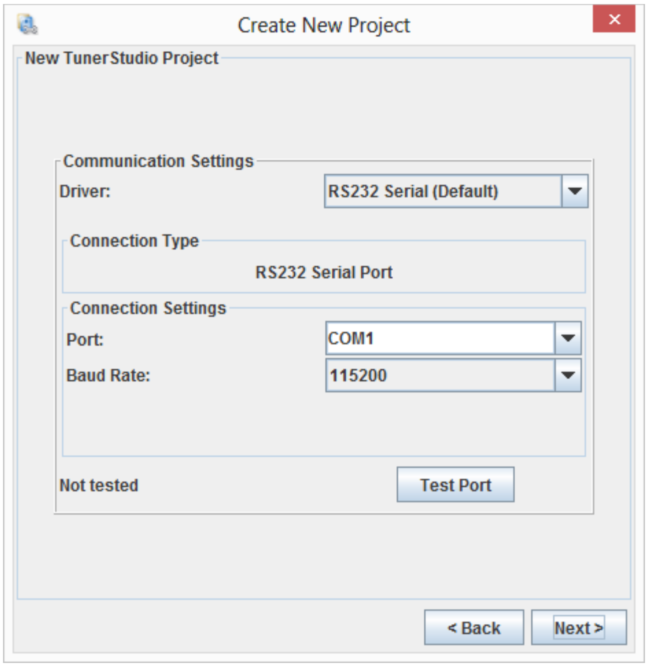
Select the file and then click Next.

v. Project Settings



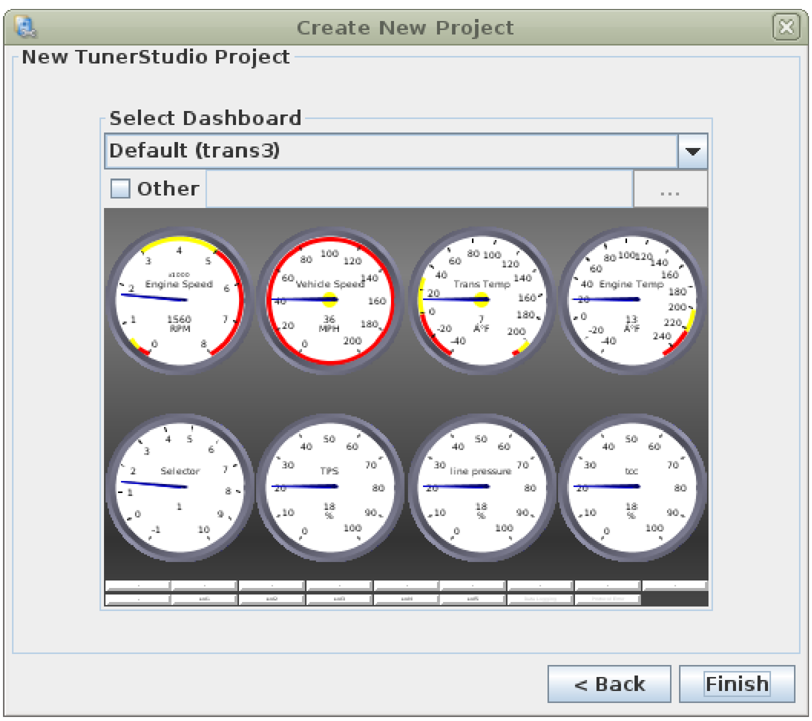
The settings available on this list may vary based on your firmware. Verify that what they are configured to match your set up. If you are unsure, the default values are likely to work well. These settings can be changed after your project has been created.

vi. Comms parameters



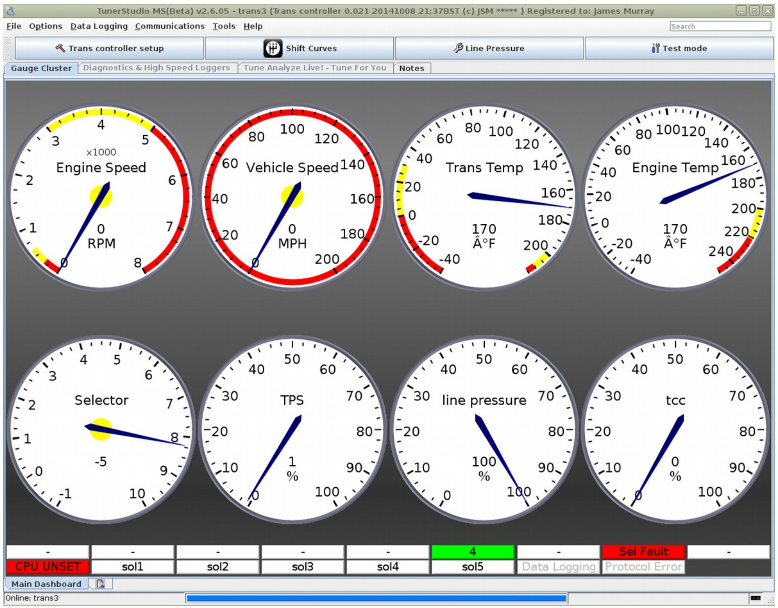
Generally these can be left alone. Click Next.

vii. Dash



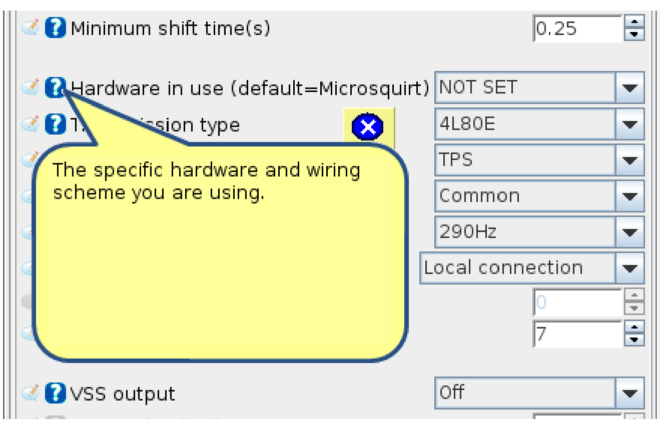
Click Finish.

The standard dash should display.



6.2.1 TunerStudio Tooltips

Throughout the software you will find Tooltips - clicking on the [?] will bring up explanatory text.



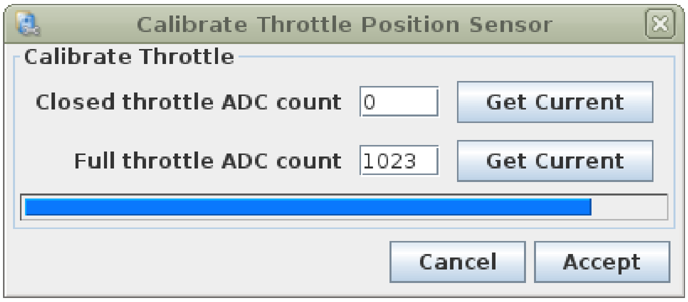
6.3 Tuning menus

The following sections show some of the tuning screens. These may be subject to change due to on-going software enhancements.

6.3.1 Tools menu

6.3.1.1 Calibrate TPS

This only applies if you are using a directly connected TPS. It is not required if you are using TPS data from the master ECU over CAN.

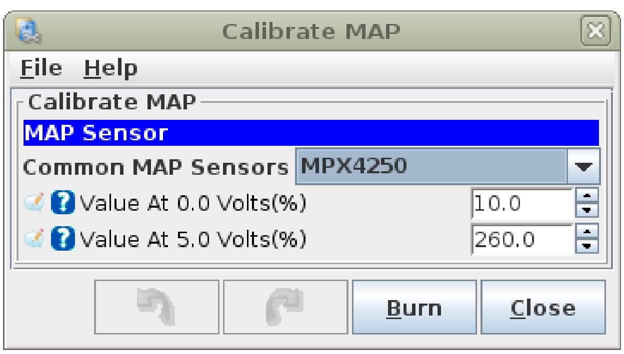


To calibrate the throttle position sensor do the following:

1. Ensure that your TCU is connected and the engine is not running (i.e., KOEO).
2. Ensure that the throttle is closed;
3. Click the “Get Current” button to the right of “Closed throttle ADC count”;
4. Fully open the throttle;
5. Click the “Get Current” button to the right of “Full throttle ADC count”;
6. Click Accept and your throttle sensor will be calibrated.

6.3.1.2 Calibrate MAP sensor

This only applies if you are using a directly connected MAP sensor. It is not required if you are using MAP data from the master ECU over CAN.

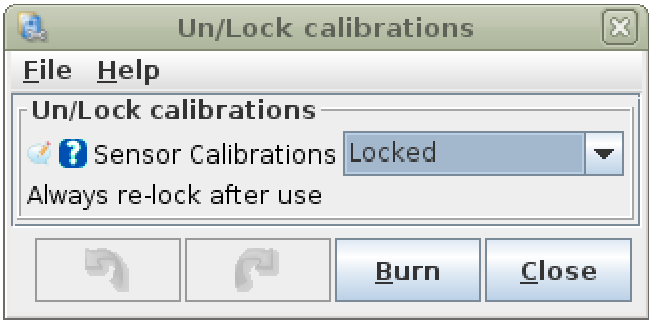


The Common MAP Sensors gives a list of the commonly used MAP Sensors. If you are using one of these sensors select if from the drop down list, otherwise select “Custom” and enter the required numbers.

(MS2 kits are usually supplied with a MPX4250AP sensor.)

6.3.1.3 Un/Lock Calibrations

The calibration settings for Thermistor Tables can be locked or unlocked to prevent them from being changed accidentally.

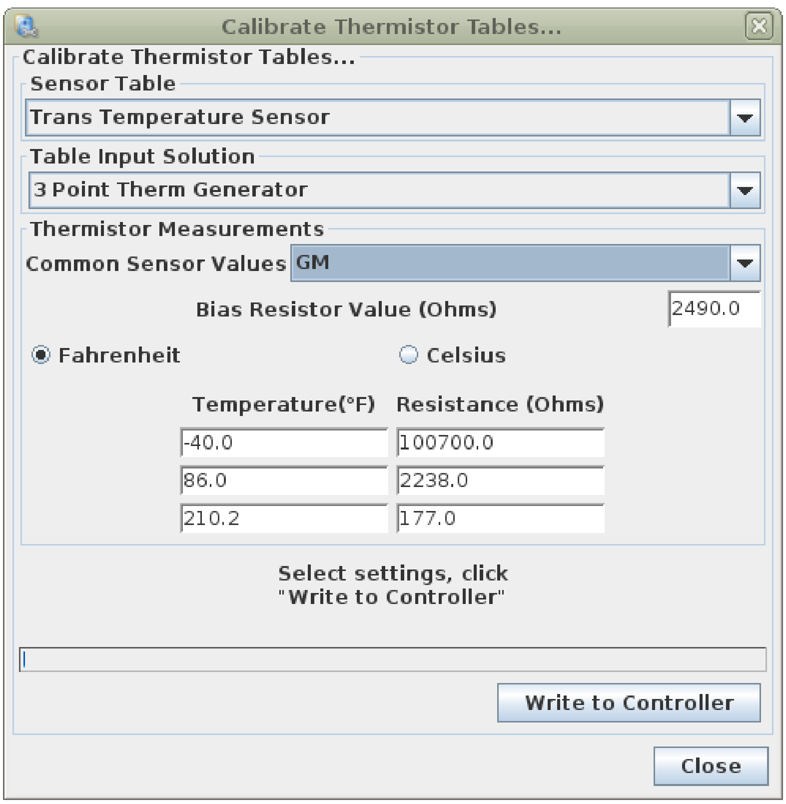


Select Unlocked and then Close.

6.3.1.4 Calibrate Thermistor Tables

Megasquirt ECUs are supplied loaded with the correct calibrations for GM temperature sensors. You only need to go through this calibration process if you are using different sensors.

A process for determining the calibration numbers is shown in the inputs section of this manual.



Sensor Table

Select whether you are using a “Local Engine Temperature Sensor” or a “Trans Temperature Sensor”.

Table Input Solution

This value will normally be set to “3 Point Therm Generator”.

Common Sensor Values

From this option you can select your sensor type. You can select from a predefined list of common sensors from the drop down list, or leave this option unselected if you are using custom settings specific to an unlisted sensor.

Bias Resistor Value (Ohms)

This is 2490 ohms unless you or your vendor have changed the resistors inside the TCU.

Temperature Settings (°C or °F)

Again, if you have selected one of the common sensors these values should be set for you. If you are using a custom sensor enter the three measured temperature and resistance value pairs.

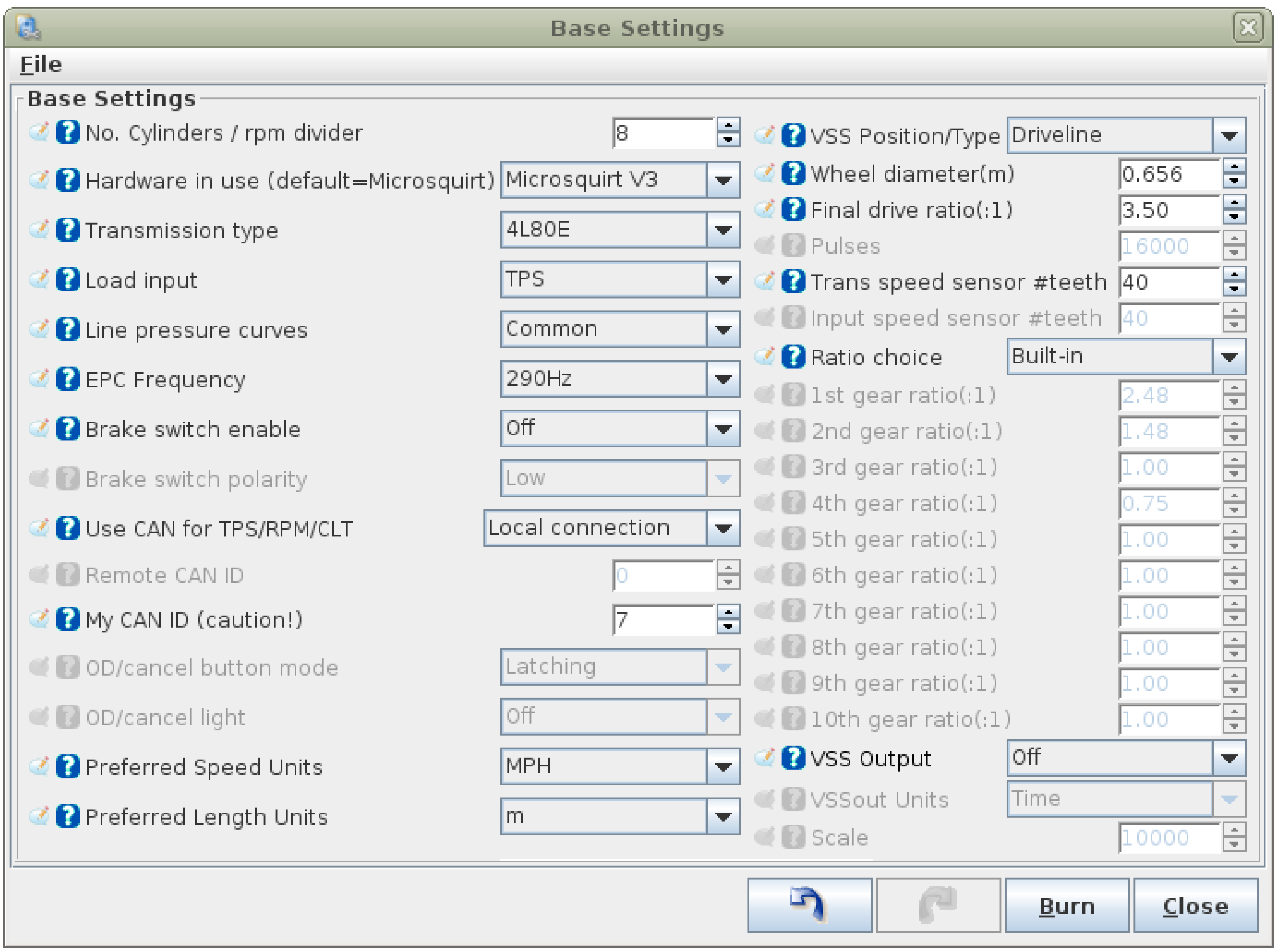
Write to Controller

Once you have completed the settings in this screen click the “Write to controller” button to burn these settings to your TCU.

Repeat for the both sensors if required.

6.3.2 Trans Controller Setup

6.3.2.1 Base Settings



No. Cylinders / rpm divider: Set this to give the correct engine RPM. Typically this is the number of cylinders. Only used when not fetching engine RPM via CAN.

Hardware in use: The specific hardware and wiring scheme you are using.

Transmission type: The automatic transmission/gearbox type in use.

Load input: Whether to use TPS or MAP as the load index in the line pressure and shift curves.

Line pressure curves: Whether to use a common line pressure curve (recommended) or individual curves per gear.

EPC frequency: Later 4L80E use 595Hz (most common), early used 297Hz

Brake Switch Enable: Whether to use the optional brake switch input (cancels lockup.)

Brake Switch Polarity: Whether a high (5V) or low (ground) input means the pedal is pressed.

Use CAN for TPS/RPM/CLT: Whether TPS and engine RPM are connected directly to the trans controller or if they are fetched over CAN from a Megsquirt ECU.

Remote CAN ID: The CANid of a Megasquirt ECU to fetch TPS and engine RPM from. Typically 0.

My CAN ID: Set to 7 for normal operation.

OD cancel button mode: Selects how the overdrive (OD) cancel switch/button operates.

- **Latching:** An on/off switch the cancels or allows overdrive.
- **Momentary:** A push-button. Requires the TCU to latch the on/off state.

OD/cancel light: Enables an OD mode light output and selects the raw output pin to use.

Preferred Speed Units: Chooses the speed units - either Mile-per-hour or Kilometres-per-hour. Close the page and re-open after changing.

Preferred Length Units: Chooses the size units - either metres or inches. Close the page and re-open after changing.

VSS Position/Type: Where the speed sensor is mounted (See also section 3.3.1)

- **Wheel**: Directly on the wheel/hub. Select this when your sensor is picking up on a shaft spinning at the same speed as the wheels. e.g. ABS ring or wheel studs.
- **Driveline**: on the driveline/trans. Select this when your sensor is picking up on a shaft before the final drive gear. e.g. gearbox output shaft, propshaft. (This is most likely the setting to use for RWD transmission mounted sensors e.g. 4L80E, 4L60E etc..)
- **Pulses per mile**: a sensor that provides a pulses-per-mile signal
- **Pulse per km**: a sensor that provides a pulses-per-mile signal

Wheel diameter: The rolling diameter for wheel and tire/tyre. (Check your units are set correctly.)

Final drive ratio: Differential ratio or any gear reduction between transmission output shaft speed sensor and wheel speed.

Pulses: Number of pulses per mile/km when pulses per mile or km is selected.

Trans speed sensor # teeth: Effective number of teeth on VSS.

Input speed sensor # teeth: Effective number of teeth on input shaft speed sensor.

Ratio Choice: Use built-in standard gear ratios for this transmission or select custom ratios.

1st gear ratio: The ratio of each gear in the transmission.

VSS Output: Enables a VSS output (for dash speedo) and selects the raw output pin to use.

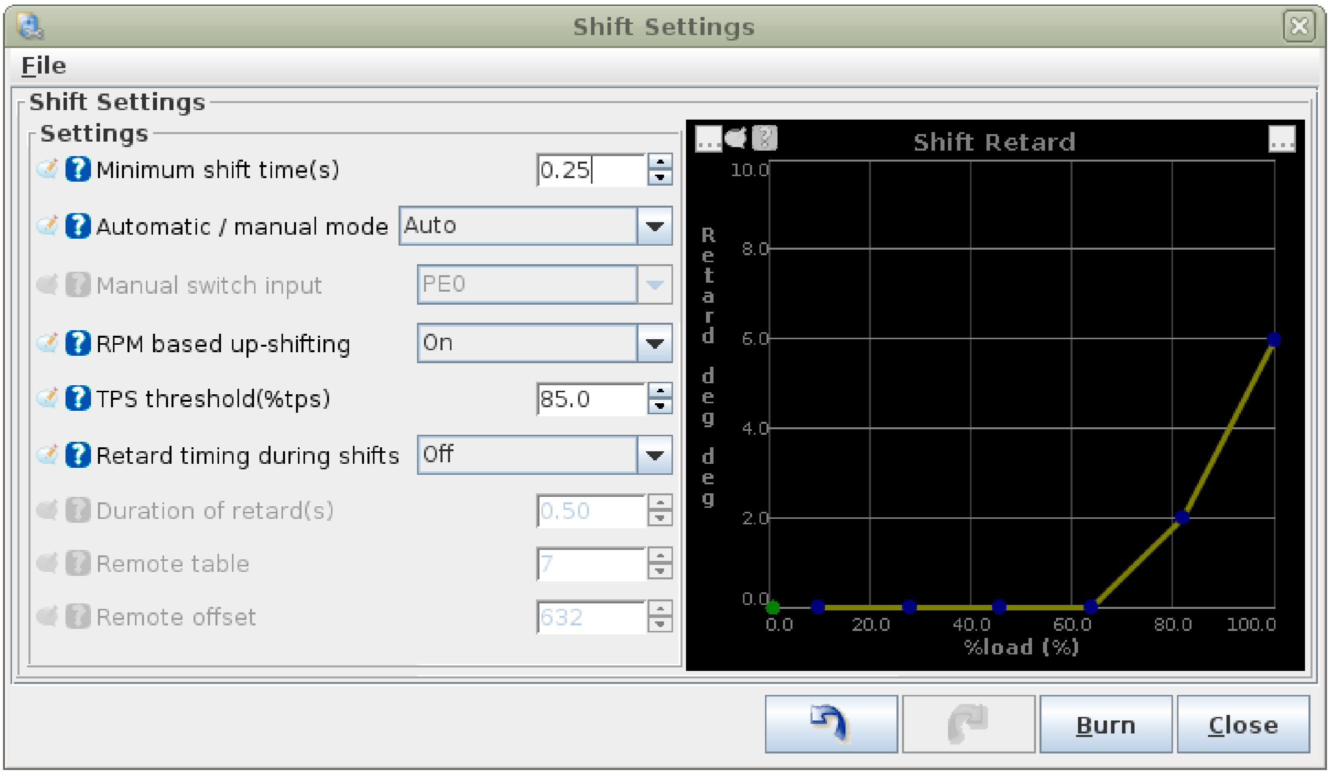
VSSout Units: Chooses between:

- **time -** user customisable scaling factor entered in the next box
- **pulses per mile -** standard pulses per mile entered in the next box

- **pulses per km** - standard pulses per km entered in the next box

VSS out scaling: Pulses per mile/km or time scaling factor.

6.3.2.2 Shift Settings



Settings

Minimum shift time: Minimum time for a gear-change to take place. i.e. delay before trying another shift.

Automatic / manual mode: Selects between:

- **Auto** - standard automatic mode using shift curves
- **Manual** - full manual, gear is determined by selector only
- **Manual - selectable** - an input is used to switch between full manual and automatic modes

Manual input switch: where a ground-switch input is used. Grounded = manual mode.

RPM based up-shifting: Selects to use RPM limits instead of VSS shift-curves above set TPS.

TPS threshold: Above this TPS threshold the RPM limits will be used only.

Retard timing during shifts: Enables sending a CAN command to retard engine timing during shift. (Requires a CAN connection to a Megasquirt ECU controlling the engine.)

Duration of retard: Duration of timing retard.

Remote table: CAN parameter for remote table. Standard is 7 for MS3 and MS2/Extra.

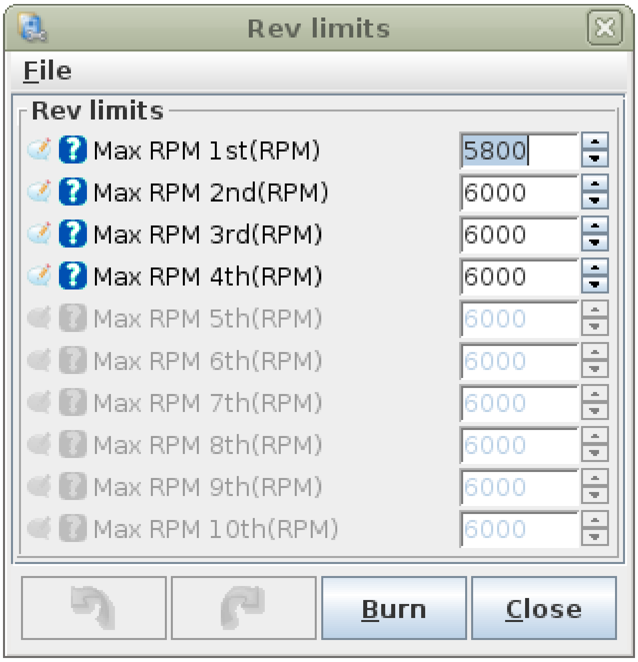
Remote offset: CAN parameter for remote offset. At time of writing, MS3 1.3 is 632, MS3 1.4 is 1144, MS2/Extra is 514.

Shift Retard

The curve specifies how much to retard the ignition timing by during the shift based on the load (TPS or MAP)

Some weaker transmissions may require timing to be retarded during high load shifts. Shifts at low loads are unlikely to need any retard.

6.3.2.3 Rev Limits

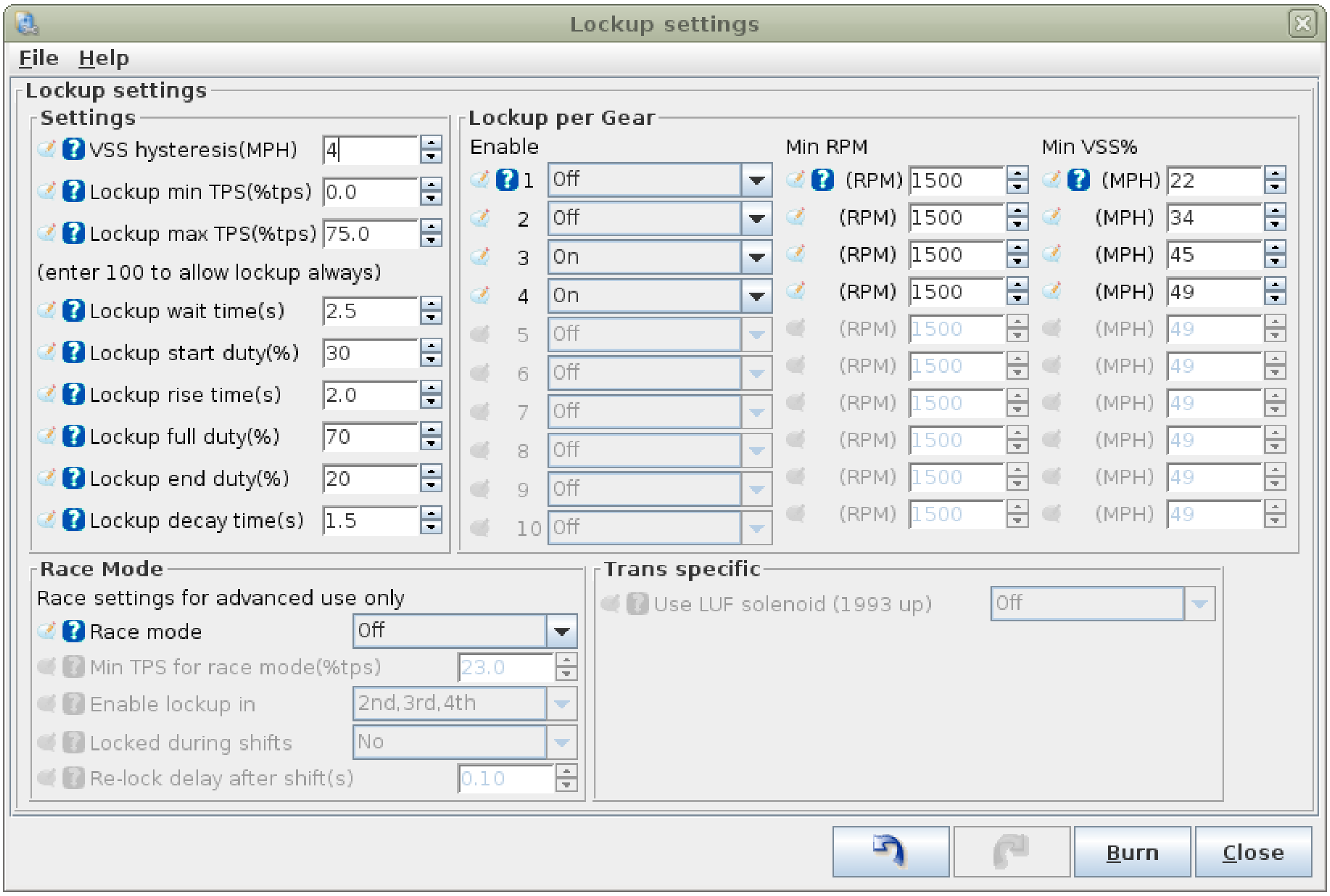


For each gear you can set a maximum RPM.

- In automatic mode, if the engine RPMs reach the maximum for that gear, the controller will upshift if possible - even if the upshift wheel speed is not met.
- In RPM-based upshift mode, the limits are used as the shift point.
- In full manual mode, the RPM limits will not trigger a shift.

6.3.2.4 Lockup Settings

These settings control the behaviour of the lockup torque convertor. Locking the convertor reduces slip, power loss and heat generation. Typically the convertor will be locked in high gears at during cruise.



Settings

VSS hysteresis: Hysteresis (deadband) in wheel speed for lockup.

Lockup min TPS: Minimum TPS to lockup convertor.

Lockup max TPS: Maximum TPS to lockup convertor.

Lackup wait time: Delay before starting lockup cycle.\n\nA few seconds is typical.

Lockup start duty: TCC solenoid duty at start of lockup cycle.

Lockup rise time: Time to ramp up TCC duty.

Lockup full duty: TCC solenoid duty when locked.

Lockup end duty: TCC solenoid duty after unlock.

Lockup decay time: Time to ramp down TCC duty.

Lockup per Gear

This allows the individual lockup parameters per gear to be set. Lockup can be enabled or disabled for each gear and minimum RPM and wheel speeds set.

Enable: Enables or disables lockup in this gear.

Min RPM: The minimum RPM to allow lockup.

Min VSS: The minimum VSS to allow lockup.

Race Mode

Race mode: Enables race-only lockup settings.

Min TPS for race mode: Minimum TPS to lockup convertor when in race mode.

Enable lockup in: Selects which gears to allow lockup in.

Locked during shifts: Whether to stay locked during shifts.

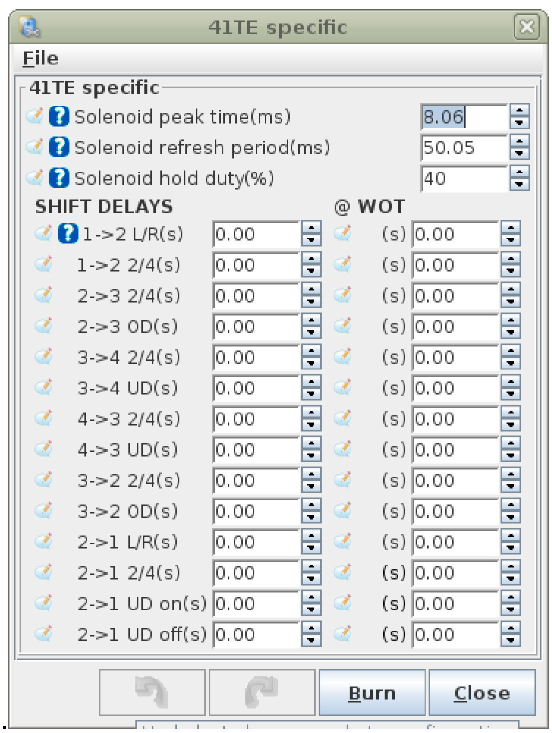
Re-lock delay after shift: Delay before re-locking after a shift

Trans Specific

Use LUF solenoid: For 1993+ 4L60E, enable this setting and wire up the LUF solenoid.

6.3.2.5 41TE Specific

The 41TE needs very specific delays on each shift as it handles the hydraulics directly.



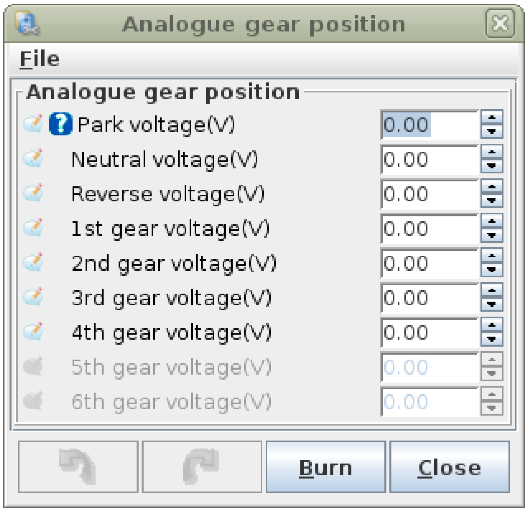
Solenoid peak time: Peak time for peak+hold solenoids.

Solenoid refresh period: How often to re-apply full duty.

Solenoid hold duty: Duty cycle in hold period on solenoids.

Shift delays: Delays between shifts for each solenoid. Very specific to each transmission.

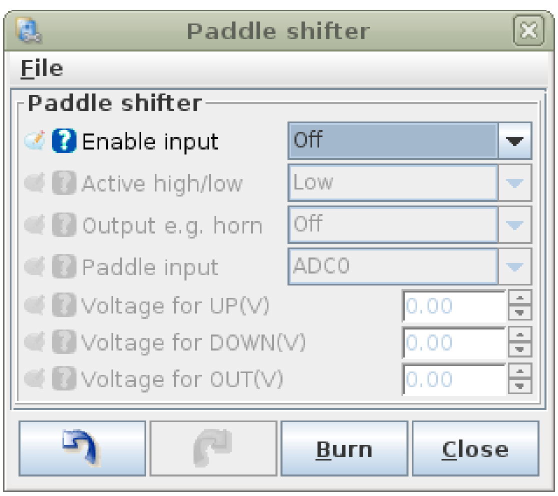
6.3.2.6 Gear Position



For each gear, specify the analogue voltage at the processor.

Some selectors already provide a 0-5V signal from the factory. In other installs, a series of resistors are installed to generate a suitable 0-5V signal from the standard selector switches.

6.3.2.7 Paddle Shifter



Enable input: Enables paddle-shifting and selects the 'enable' input switch.

Active high/low: Selects polarity of paddle enable switch.

Output: Selects paddle output, typically this is for the horn.

Paddle input: Selects analogue input for paddle shifter.

Voltage for UP: Voltage on paddle input to indicate an up-shift.

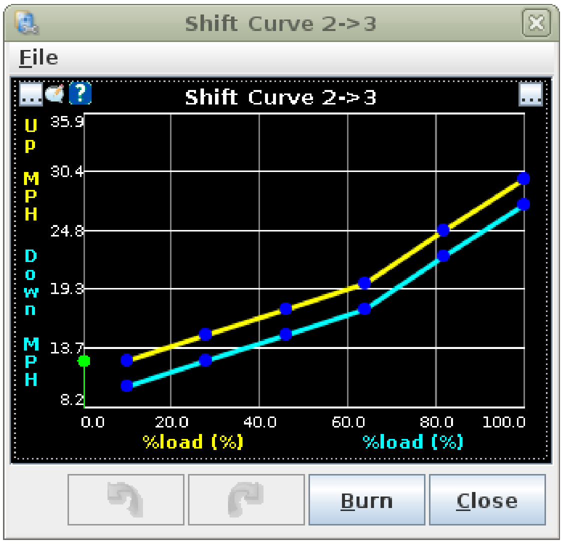
Voltage for DOWN: Voltage on paddle input to indicate an down-shift.

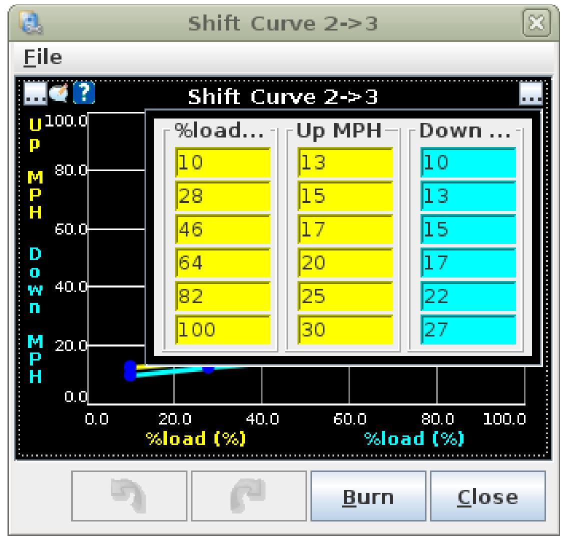
Voltage for OUT: Voltage on paddle input to indicate that the output (horn) should be operated.

6.3.3 Shift Curves

The shift curves are the main settings for controlling how the transmission behaves and when gear shifts occur.

There is a curve for each gear except top. The curve can be adjusted by dragging the dots or by clicking on the [...] in the top right, the data table open up as shown.





In the above screenshot at 64% load, the transmission will upshift (change from 2nd to 3rd) if the speed exceeds 20MPH or downshift (change from 3rd to 2nd) if it drops below 17MPH.

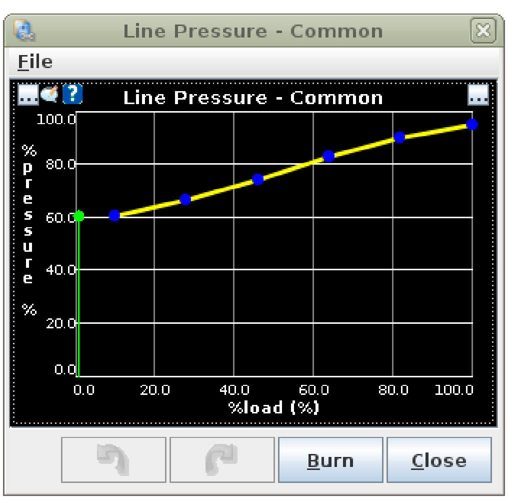
6.3.4 Line Pressure

The Line Pressure curves control the pressure solenoid in the transmission which influences shift speed, holding power and shift harshness.

Depending on the option selected in the base settings, you can use either a single line pressure curve (recommended) or an individual curve for each gear.

0% is least line pressure, 100% is max line pressure. (Conversion to solenoid duty for transmission is handled internally.)

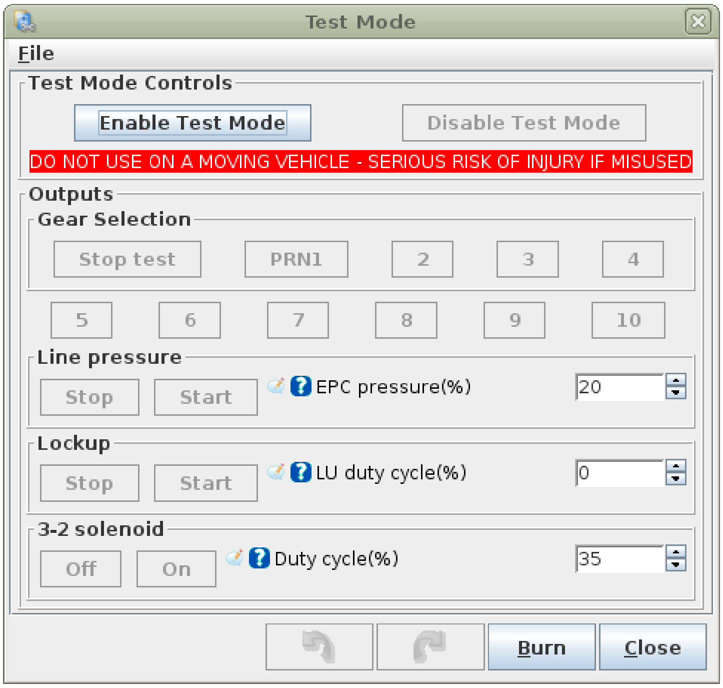
6.3.4.1 Line Pressure (Common)



6.3.5 Test Mode

This menu gives access to test facilities.

6.3.5.1 Test Mode



This allows direct control over the gear selected and solenoid output duties. It should only be used with the car on stands for transmission testing purpose.

Do not use on a moving vehicle - risk of injury!

Test Mode Controls

The "Enable Test Mode" and "Disable Test Mode" buttons are a master enable/diable for testing.

Gear Selection

Clicking on a gear number will force selection of that gear. (The output solenoids will be set to the pre-programmed pattern.)

Line Pressure

This allows you to override the line pressure curve and test out different pressure solenoid duties. The entry here matches the pressure curves where 0% is minimum pressure and 100% is maximum pressure.

(For GM transmissions the output duty is actually the opposite, this conversion is handled internally.)

Lockup

This allows you to override the lockup output and test out different solenoid duties.

3-2 solenoid

Some of the supported transmissions PWM the 3-2 solenoid. This allows that to be tested.

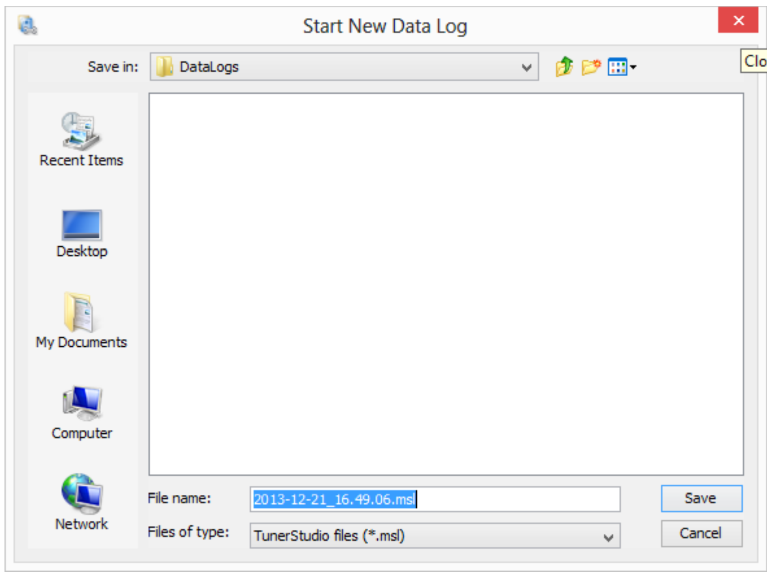
6.4 Data Logging Menu

The Data Logging Menu allows you to:

- Stop and Start logging data from your TCU;
- View your saved log files using the accompanying MegaLogViewer software.

6.4.1 Start Logging

Clicking Data Logging > Start will display the Start New Data Log screen as shown below:



This will prompt you to save a new TunerStudio .msl file which will contain the data that is logged from your Megasquirt. By default this file will be saved in the DataLogs directory within the current project directory, although you can choose to browse and save it elsewhere if you prefer. As soon as you click “Save” the software will start to log data from your Megasquirt into this new file.

When data logging is running the “Data Logging” indicator label at the bottom of the gauge cluster will turn green.

6.4.2 Stop

Data Logging > Stop will cease data logging and the collated data file selected in the above section will be closed. Your data is now ready to be reviewed using MegaLogViewer.

At this stage the “Data Logging” indicator label at the bottom of the gauge cluster will return to its usual color.

6.4.3 Logging Profiles

Data Logging > Logging Profiles is a feature of the Upgrade version of the software which allows customization of the data collected. The standard format used for data logging will be sufficient to analyze the data collected from your Megasquirt.

6.4.4 Automatic Logging

Data Logging > Automatic Logging is also another Upgrade feature and is not documented in this guide.

6.4.5 Import / Conversion

The "Import / Conversion" options allow data to be be imported from two other sources, but is not covered here.

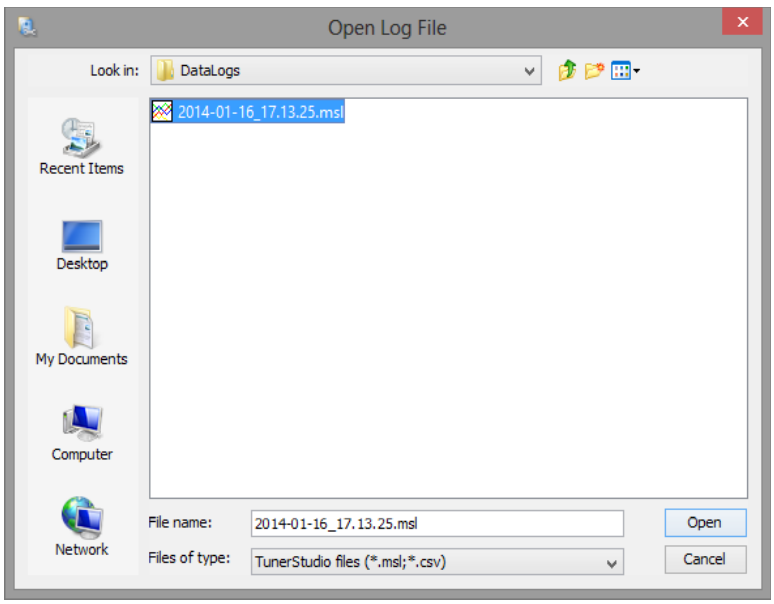
6.4.6 View with MegaLogViewer

MegaLogViewer is an analysis application which accompanies TunerStudio, and for which a license is included along with your Megasquirt. **MegaLogViewer needs to be installed for this option to work.**

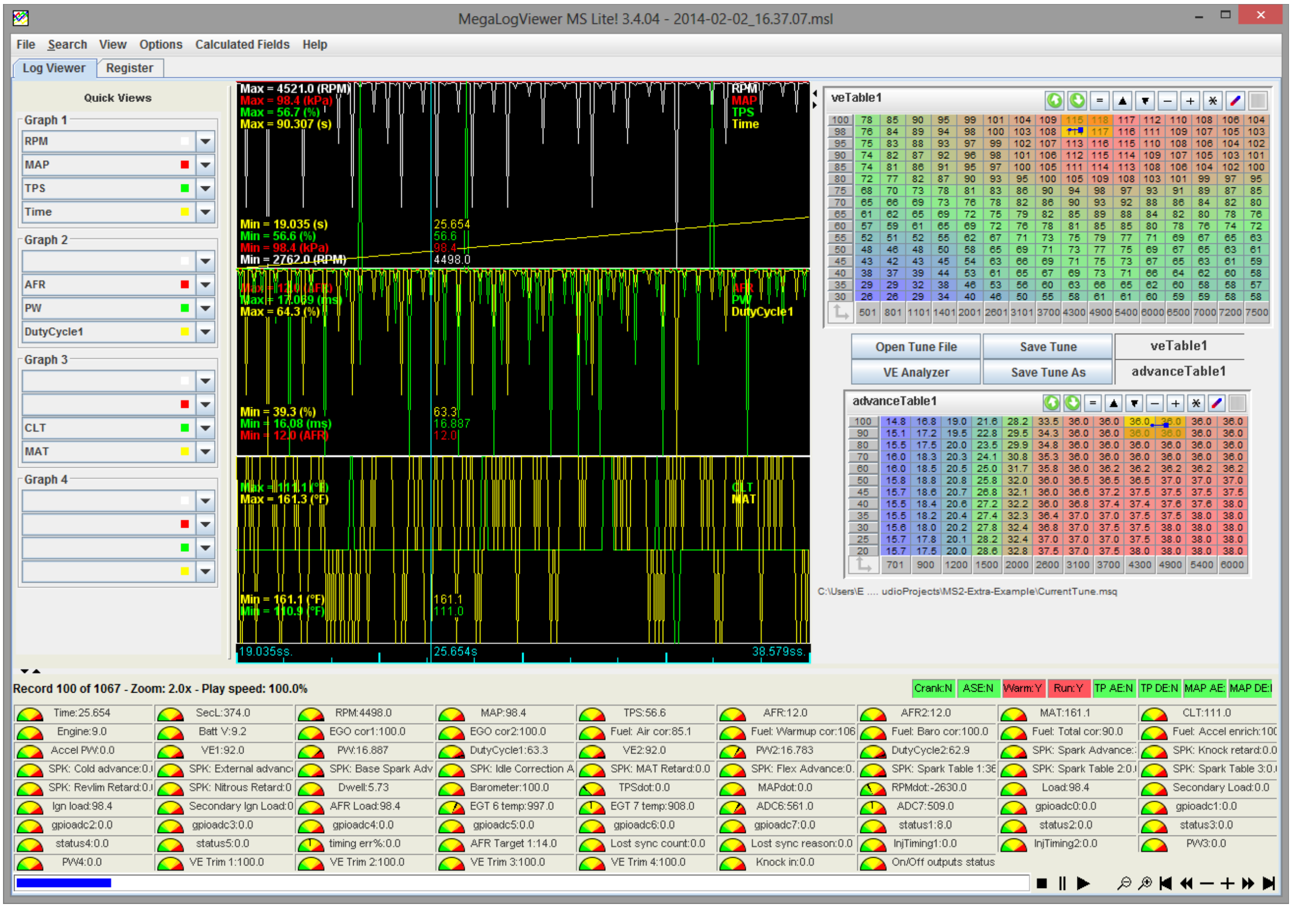
MegaLogViewer can be downloaded from: http://www.tunerstudio.com/index.php/downloads.

Complete documentation of MegaLogViewer falls outside the scope of this guide, although the key datalog fields that are relevant to your Megasquirt are documented in Section 6.4.7.

Clicking Data Logging > Import / Conversion > View with MegaLogViewer will display the Open Log File screen as shown below:



Selecting the data log file that you want to view and clicking "Open" will start MegaLogViewer with the data from your log file loaded in. A sample of the main MegaLogViewer screen is shown below:



From this screen you can review many of the sensor outputs and other readings from your Megasquirt. The “Quick View” graphs are especially useful and are easily customized using the options on the left hand side of the screen.

6.4.7 Transmission Control MegaLogViewer Datalog Fields

Below are listed the main datalog fields for MegaLogViewer.

ADC0-7

These are the raw ADC counts on the analogue inputs. May be useful during initial setup to confirm that the sensor inputs are working correctly.

CLT

The engine coolant temperature.

Convertor Slip

Where input shaft speed is available, this is a calculation comparing engine RPM to input shaft RPM.

EPC%

The percentage line pressure.

Gear

Currently selected gear.

gearselin

Raw bitfield of selector input signals.

Input RPM

The input shaft RPM speed, if the transmission is fitted with that sensor. (e.g. 4L80E)

MAP

The engine manifold pressure.

Output RPM

The output shaft RPM speed. Either directly measured or back-calculated from wheel speed.

RPM

Engine RPM.

Seconds

Number of seconds that the TCU has been switched on.

Selector

Current gear selector position.

Sol 3-2 %

PWM duty cycle applied to the 3-2 solenoid (if fitted.)

SolStat

A bitfield representing the solenoid outputs.

Status1

A status bitfield.

TCC%

The duty cycle applied to the torque convertor lockup clutch.

Time

Elapsed time in datalog.

TPS

Engine throttle position percentage.

Transmission Slip

Compares output shaft RPM with input shaft RPM. Could indicate slipping clutches. Will be undefined during a gear-shift.

Trans temp

Transmission temperature.

VSS 1

Vehicle speed.

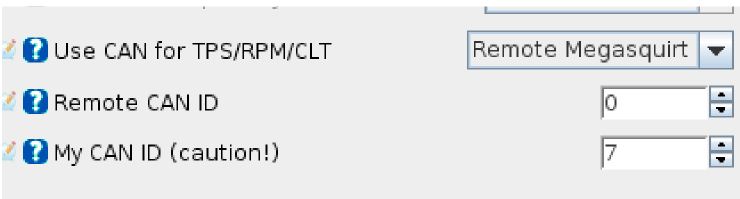
7 ECU integration

The transmission controller can be used standalone, but will frequently be used in conjunction with a main Megasquirt ECU that runs the engine.

7.1 Collecting data from Megasquirt ECU

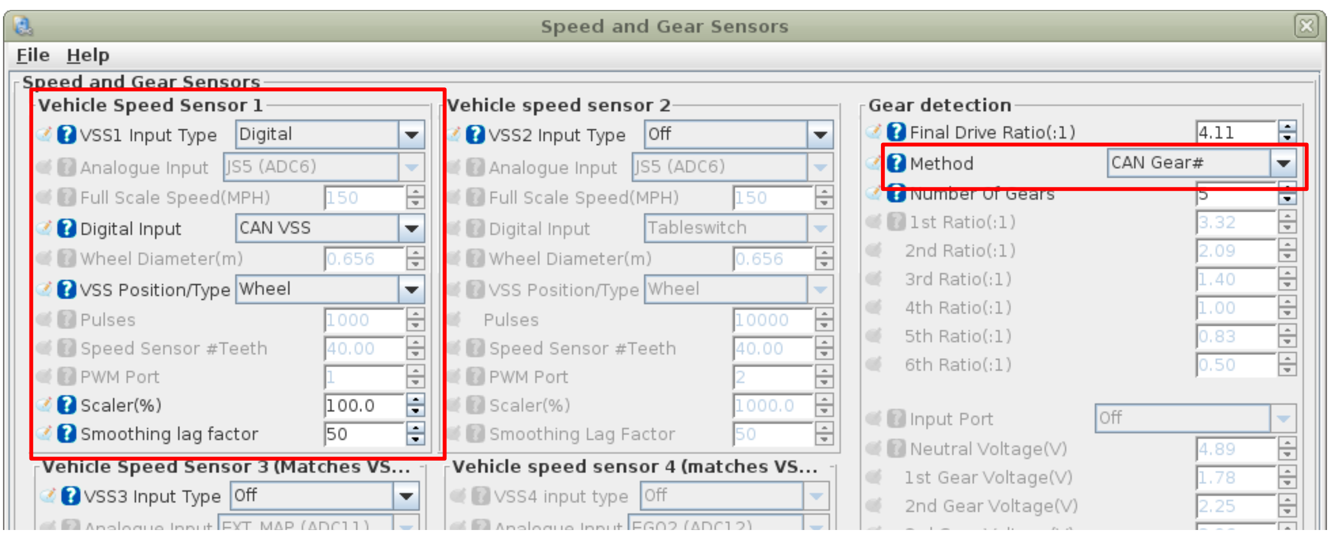
This is the recommended configution - it uses common data, reduces wiring and frees up some connections on the transmission controller for spare purposes.

The CANbus must be connected between the trans controller and the Megasquirt ECU. See section 3.3.7.



7.2 Sharing data to Megasquirt ECU

The Megasquirt-3 has provision for wheel speed and current gear. These can be collected from the transmission controller over CAN. Configuration is at the Megasquirt-3 end.



Vehicle Speed Sensor 1

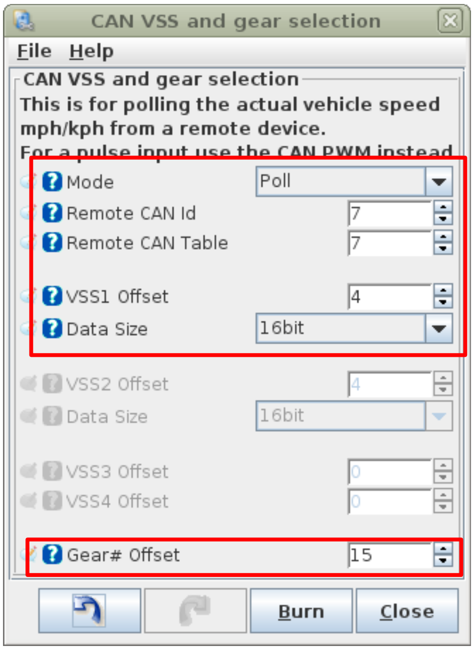
VSS input type = Digital

Digital input = CAN VSS

Scaler% = 100%

Gear Detection

Method = CAN Gear #



Mode = Poll

Remote CAN ID = 7

Remote CAN Table = 7

VSS 1 Offset = 4

Data Size = 16bit

Gear # offset = 15

The VSS and gear data can then be used within the Megasquirt-3 for datalogging to the internal SDcard, to the laptop or for features such as boost vs. gear etc.

7.3 Other ECU or dash integration

At this time, the CAN messages are Megasquirt specific. Future releases may support 11bit broadcast messaging. If you have additional applications in mind, please send an email to contact@megasquirt.co.uk to discuss.

8 Revision history

2014-09-05	Started.
2014-10-23	Re-do wiring tables, add GPIO, MS2. Add most content.
2014-11-19	Add comparison table.
2014-12-10	Update user interface for 0024.
2014-12-12	Update user interface for 0025. Add ECU integration section.
2014-12-26	Updated CAN wiring diagrams.
2014-12-27	Add more trans specific notes. Add LUF.
2014-12-30	More notes and diagrams about speed sensor inputs.
2014-12-31	OD cancel. Add datalog fields section.
2015-01-11	Updates for 0028
2015-01-20	RPM upshift note for 0029.
2015-02-01	LUF/sol D note.
2015-02-13	MS2 SelD pin change.
2015-03-11	Broke out Microsquirt V1, V2, MS2, GPIO hardware into supplement manual. Added PDF bookmarks/anchors. Updated lockup screenshot.
2015-03-24	Updates ref VR2+/- and ISS.
2015-03-25	Tweaks. Fix MAP sensor diagram.