Microsquirt as I/O box

Dated: 2014-12-27

This version of the documentation applies to:

- MicroSquirt V3 as shown above running IObox firmware 1.002

used with:

- MS3 or MS3-Pro running firmware pre-1.4 alpha9 or later.

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

Table of Contents

1 Introduction

The IObox firmware allows the use of a Microsquirt as an I/O box with minimal D.I.Y. and straightforward software configuration. When used with MS3 or MS3-Pro it can offer a useful I/O addition:

7 Analog inputs (0-5V variable)

2 Wheel speed inputs (VR or hall type)

2 Wheel speed (hall type) or ground-switch inputs

1 dedicated ground-switch input

2 high current PWM/switch ground-switching outputs

4 mid current PWM/switch ground-switching outputs

1 low current PWM/switch 0-12V outputs

By design, the inputs and outputs have a fixed function to simplify configuration. All configuration is performed through TunerStudio in the MS3/MS3-Pro settings pages.

2 Scope of use

The IObox is suitable for general functions such as fan control, table-switching, shift lights and analog data capture. The inputs and outputs will have a short delay (0.01-0.02 seconds) due to the way the data is sent over the CAN wires. Therefore, it is not intended to be used for time-critical inputs or outputs such as launch control, throttle-stops or transbrake control.

The IObox expects a continual stream of data - should the communications be interrupted for more than 0.5 seconds all outputs will be turned off and the IObox will await fresh data. This is intended as a fail-safe situation.

3 Setting up

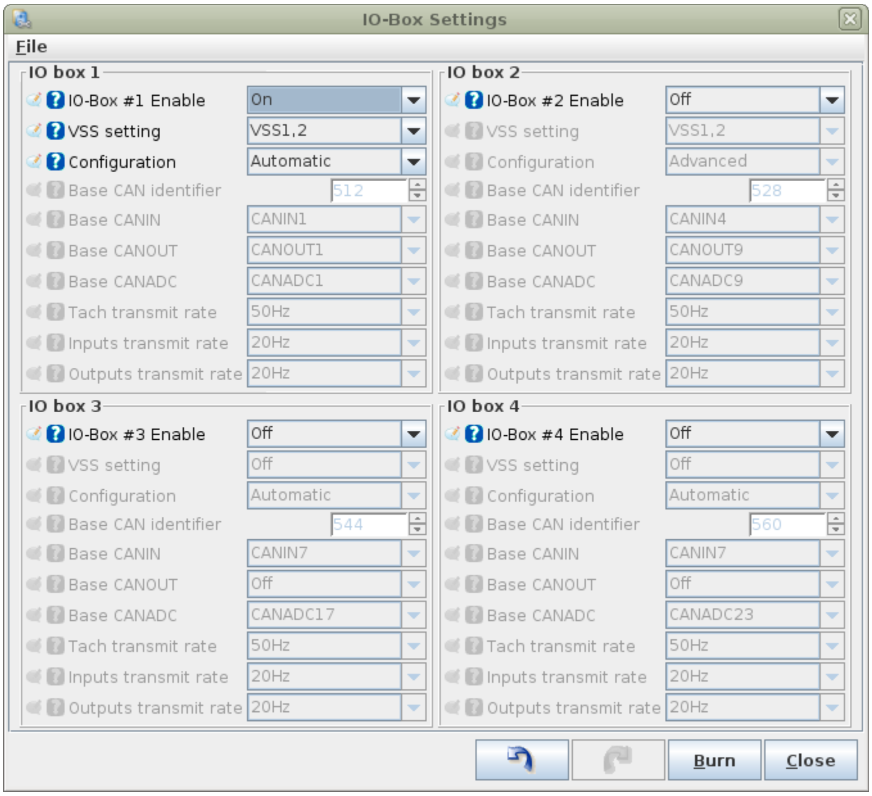
1. Connect your computer to the serial port on the Microsquirt.

2. Load the IO-box firmware using the ms2loader programme provided with the firmware files. Follow the prompts on the screen.

3. Disconnect your computer from the Microsquirt. There is no configuration here.

4. Connect your computer to the MS3 or MS3-Pro and open TunerStudio. Check the title bar and confirm that you are running firmware version pre-1.4 alpha6+ or later.

5. Go to CAN-bus/Testmodes > IObox Settings



6. Set IO-Box #1 Enable to "On"

7. The basic IO-box configuration is now complete. Click Close.

8. The CANIN, CANADC, CANOUT settings can now be used on the various settings through Megasquirt-3, these are covered in section 5.

4 Wiring

Pin#	Name	Color	In/Out	Function	Max amp
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	Wheel speed in 2 (-ve)	-
5	SPAREADC2 (MAF)	Pink/Black	In	0-5V Analog input (ADC7)	-
6	FLEX	Purple/White	In	Switch input 1	-
7	FIDLE	Green	Out	Output 3 (low side, mid current)	3A
8	FP (pump)	Purple	Out	Output 4 (low side, mid current)	3A
9	INJ 1	Thick Green	Out	Output 1 (low side, high current)	5A
10	INJ 2	Thick Blue	Out	Output 2(low side, high current)	5A
11	SPK B (IGN2)	Thick White/Red	In	Switch input 2 / Wheel speed in 3	-
12	SPK A (IGN 1)	Thick White	In	Switch input 3 / Wheel speed in 4	-
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	Output 5 (low side, mid current)	3A
17	WLED	Yellow/White	Out	Output 6 (low side, mid current)	3A
18	Sensor Ground	-	GND	-	-
19	Serial Ground	-	GND	Serial Ground	-
20	Sensor Ground	White/Black	GND	Sensor GND (temp,TPS)	-
21	VR2-	VR2	In	Wheel speed in 2 (+ve)	-
22	POWER GROUND	Thick Black	GND	POWER GROUND	-
23	POWER GROUND	Thick Black	GND	POWER GROUND	-
24	MAP	Green/Red	In	0-5V Analog input (ADC1)	-
25	CLT	Yellow	In	Temp. / 0-5V Analog input (ADC3)	-
26	MAT	Orange	In	Temp. / 0-5V Analog input (ADC2)	-
27	TPS	Blue	In	0-5V Analog input (ADC4)	-
28	TPS VREF (5V)	Gray	Out	5V supply for sensors	0.1A
29	SPAREADC	Orange/Green	In	0-5V Analog input (ADC6)	-
30	OPTO+	Grey/Red	In	Do not connect	-
31	OPTO-	Grey/Black	In	Do not connect	-
32	VR1+	VR1	In	Wheel speed in 1 (-ve)	-
33	VR1-	VR1	In	Wheel speed in 1 (+ve)	-
34	O2	Pink	In	0-5V Analog input (ADC5)	-
35	TACHO	Green/Yellow	Out	Output 7 (0-12V low current)	0.3A

5 Inputs and Outputs

The following sections below list the standard input/output names for IO-box#1

By default, subsequent IO-boxes (2,3) use higher numbers as shown in the following table.

Customers using other CAN devices configured through the "CAN Parameters" page may need to select Advanced mode for the IO-box and alter the base numbers to avoid conflicting with existing devices.

Input / output on each IObox	MS3 name from IObox#1	MS3 name from IObox#2	MS3 name from IObox#3
ADC1	CANADC1	CANADC9	CANADC17
ADC2	CANADC2	CANADC10	CANADC18
ADC3	CANADC3	CANADC11	CANADC19
ADC4	CANADC4	CANADC12	CANADC20
ADC5	CANADC5	CANADC13	CANADC21
ADC6	CANADC6	CANADC14	CANADC22
ADC7	CANADC7	CANADC15	CANADC23
Input 1	CANIN1	CANIN4	CANIN7
Input 2	CANIN2	CANIN5	CANIN8
Input 3	CANIN3	CANIN6	*
Output 1	CANOUT1	CANOUT9	*
Output 2	CANOUT2	CANOUT10	*
Output 3	CANOUT3	CANOUT11	*
Output 4	CANOUT4	CANOUT12	*
Output 5	CANOUT5	CANOUT13	*
Output 6	CANOUT6	CANOUT14	*
Output 7	CANOUT7	CANOUT15	*
Speed in 1	VSSx	VSSx	*
Speed in 2	VSSx	VSSx	*
Speed in 3	VSSx	VSSx	*
Speed in 4	VSSx	VSSx	*

* Not available at this time. May be supported by a future Megasquirt-3 firmware.

5.1 Analog Inputs

There are seven analog inputs. All have a maximum of 5V input allowed.

Pin #	Wire color	Wire name (currently)	Function	MS3 name
24	Green/Red	MAP	0-5V Analog input	CANADC1
26	Orange	MAT	Temperature sensor	CANADC2
25	Orange	CLT	Temperature sensor	CANADC3

27	Blue	TPS	0-5V Analog input	CANADC4
34	Pink	O2	0-5V Analog input	CANADC5
29	Orange/Green	SPAREADC	0-5V Analog input	CANADC6
5	Pink/Black	SPAREADC2(MAF)	0-5V Analog input	CANADC7

5.1.1 Temperature sensor

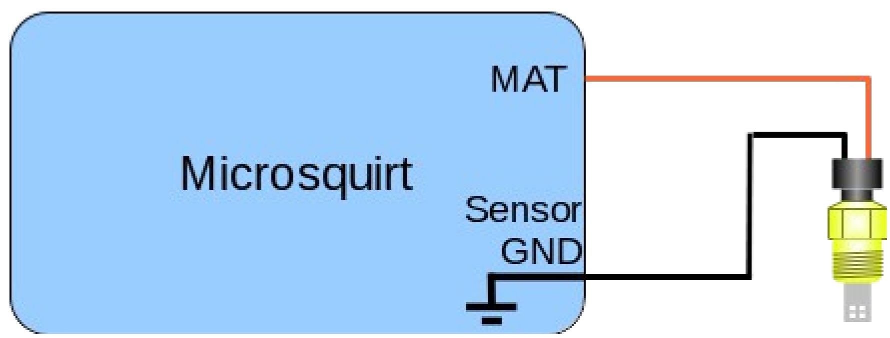
Open-element sensor suitable for air temperature.

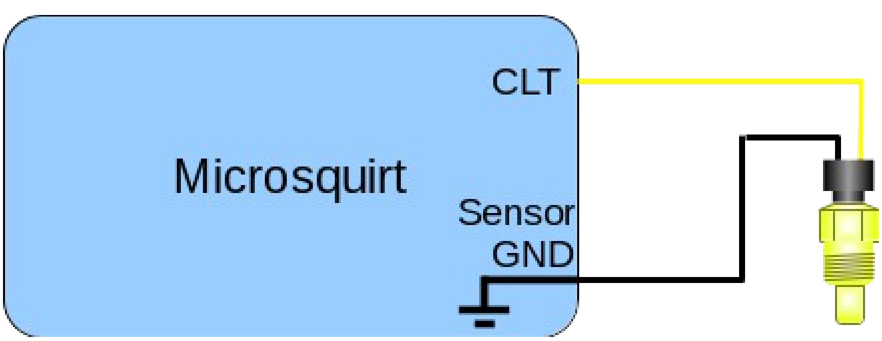
Closed-element sensor suitable for fluids.

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

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

One-wire sensors are not recommended.

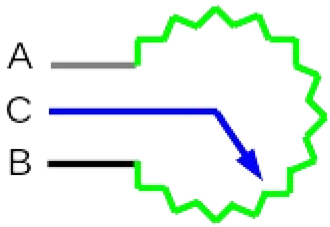


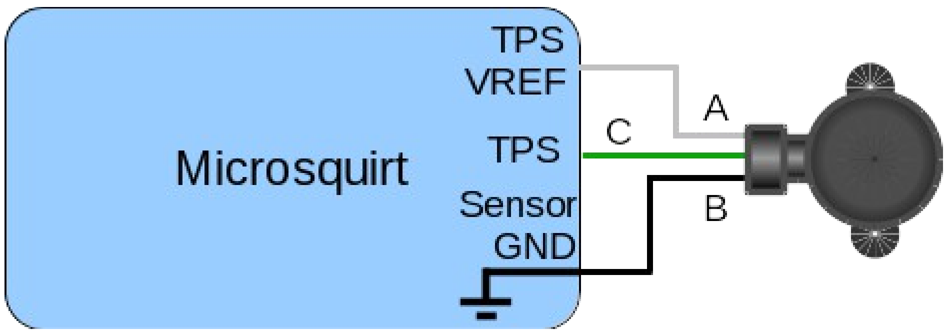


5.1.2 0-5V sensor inputs

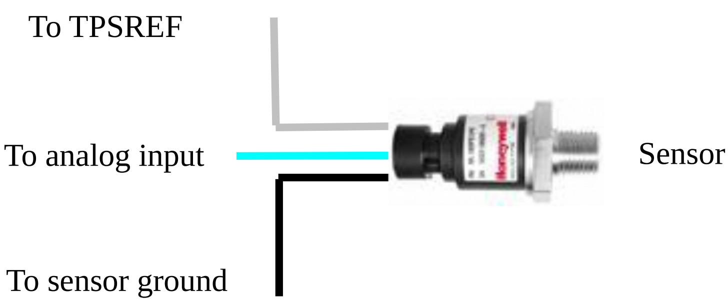
These inputs can be used with potentiometers, pressure sensors or any other sensor that puts out a 0-5V variable signal.

0-5V potentiometer input

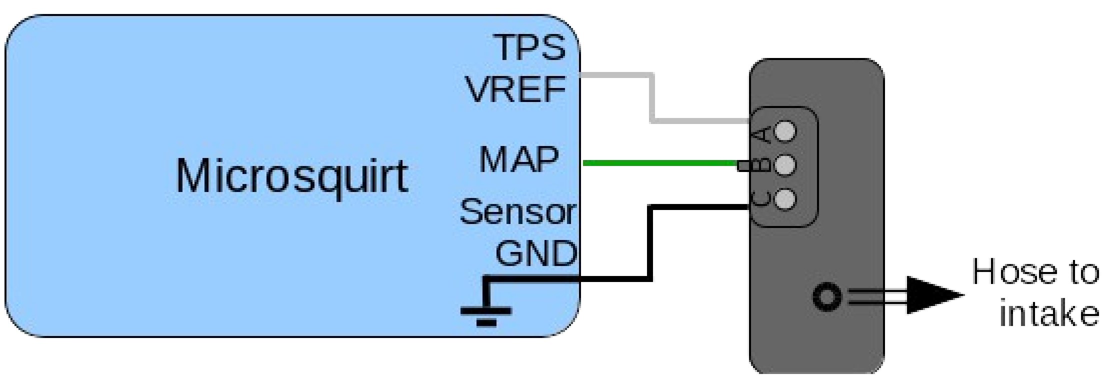




Honeywell style pressure sensor



GM type pressure (MAP) sensor

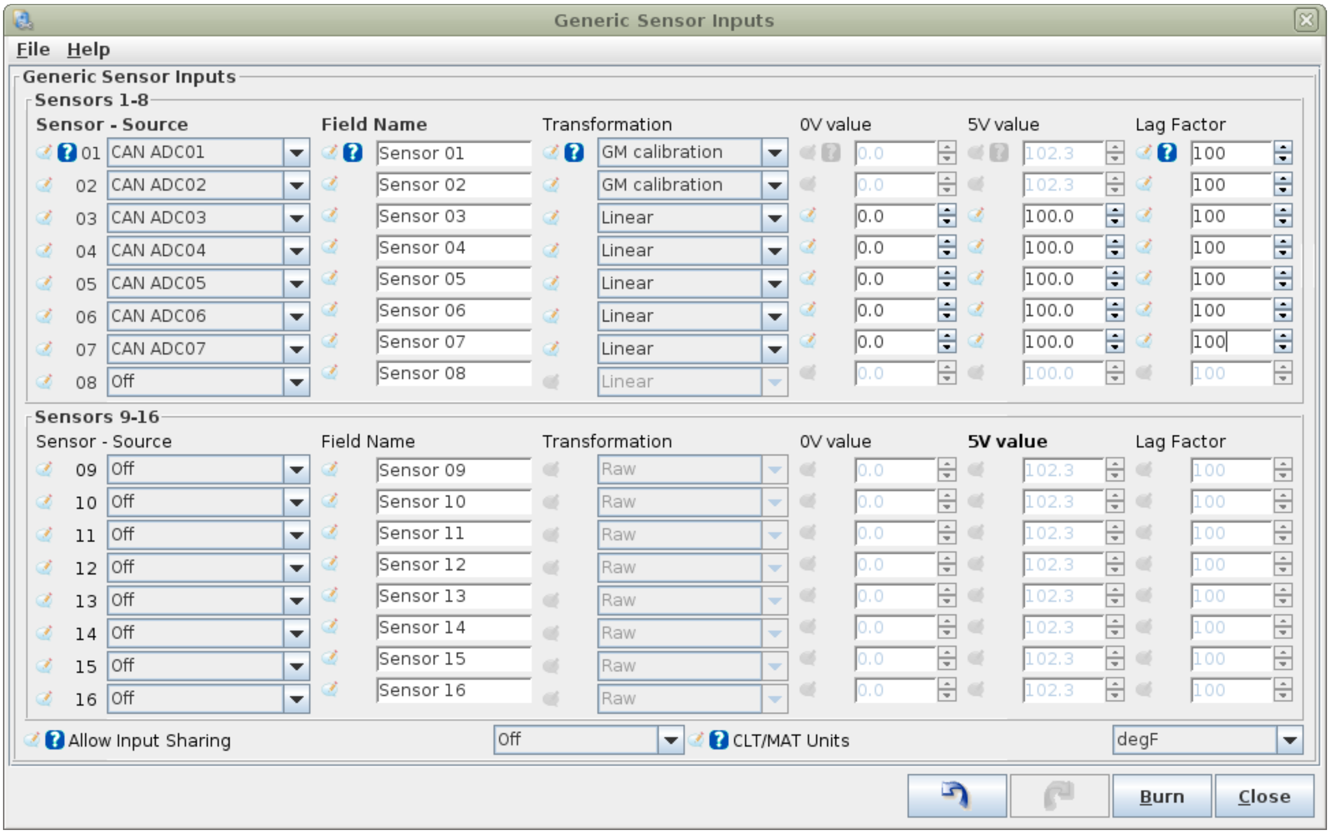


All five of the variable inputs (Input3,4,5,6,7) work the same.

5.1.3 Settings

All analog inputs are stored inside the Megasquirt-3 as a "CANADC" which holds the raw digital value representing the analog 0-5V input. These must be converted into real values using the Generic Sensors system.

Go to Advanced Engine > Generic Sensors



The above is an example for the Generic Sensors. It reads the first two analog inputs as GM type temperature sensors. The other 5 sensor inputs are converted to a linear scale 0-100%.

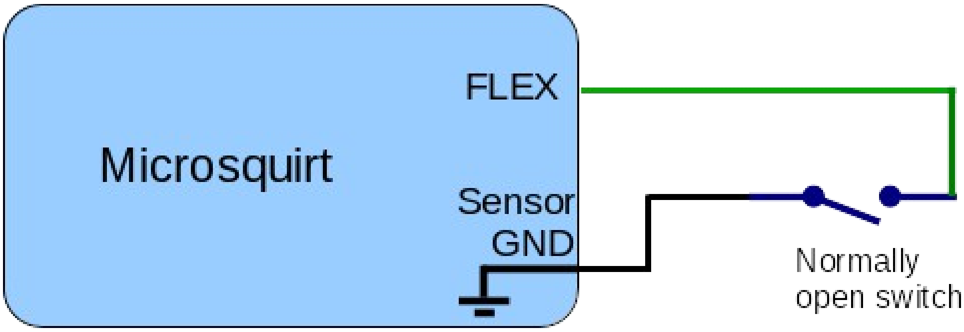
5.2 Switch inputs

There are 1 or 3 switch inputs. All have a maximum of 5V input allowed.

Pin #	Wire color	Wire name (currently)	Function	MS3 name
6	Purple/white	FLEX	Ground switch in	CANIN1
12	Thick white	IGN1	Ground switch in	CANIN2
11	Thick white/Red	IGN2	Ground switch in	CANIN3

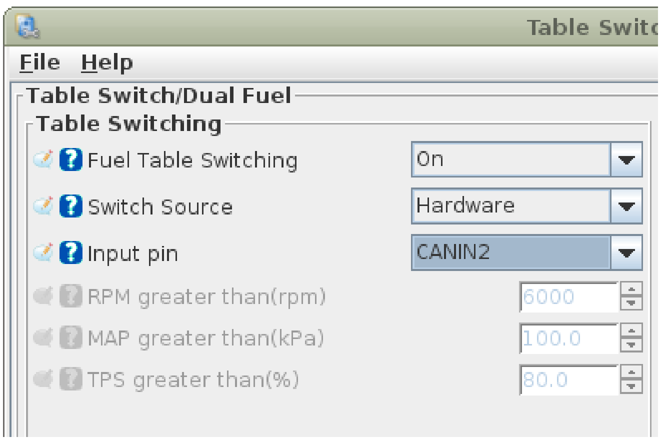
The second and third inputs can be used for VSS instead.

The switch inputs can be used instead of local switch inputs for functions such as table-switching, idle-up etc.



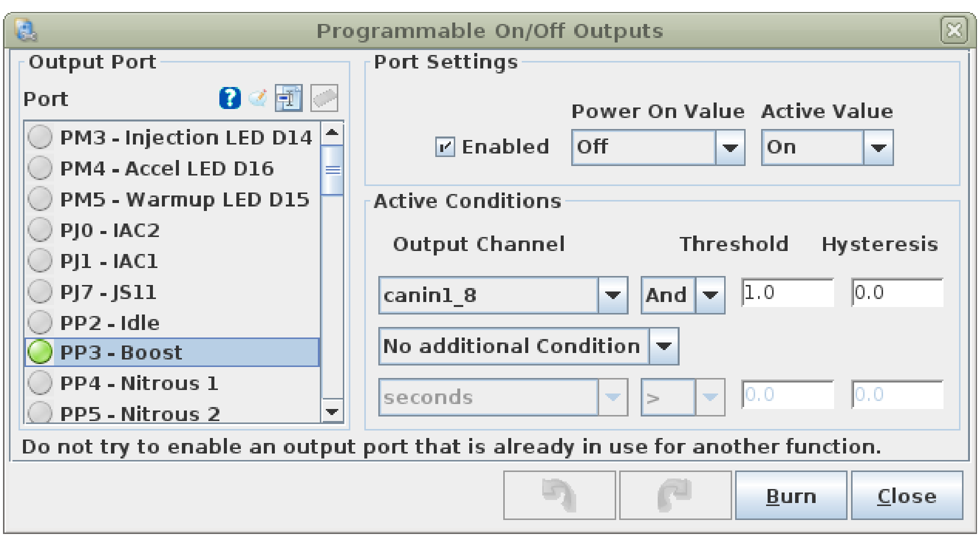
5.2.1 Examples

a. Table switch input



In the above example, CANIN2 is used as a Hardware switch input to control fuel table switching.

b. Switch input to activate a programmable on/off output



In the above example CANIN1 is used to control the "Boost" On/Off output.

Input	Output Channel	Threshold	Hysteresis
CANIN1	canin1_8	1	0
CANIN2	canin1_8	2	0

CANIN3	canin1_8	4	0

In the case of "And" conditions (bitwise AND) the Threshold is set to the bit value of the input and the Hysteresis is set to zero as the inputs are ground switching. Follow the table for the correct values.

5.3 Speed sensor tach inputs

There are two dedicated speed sensor inputs that can be interfaced to VR sensor or 0-5V hall sensors.

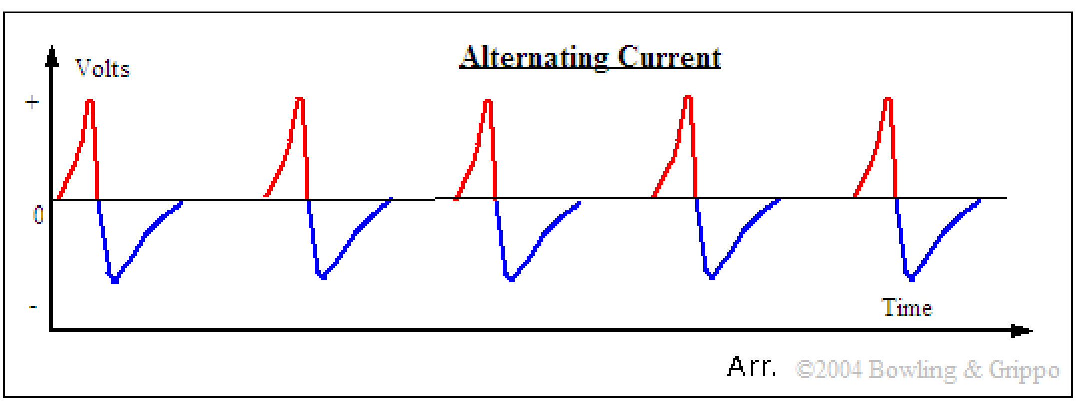
Pin #	Wire color	Wire name (currently)	Function	MS3 name
33,32	Screened crank	VR1- / VR+	VR or hall sensor in	*
21,4	Screened cam	VR2- / VR2+	VR or hall sensor in	*

Speed sensor inputs are only supported in Megasquirt-3 from the first two IOboxes.

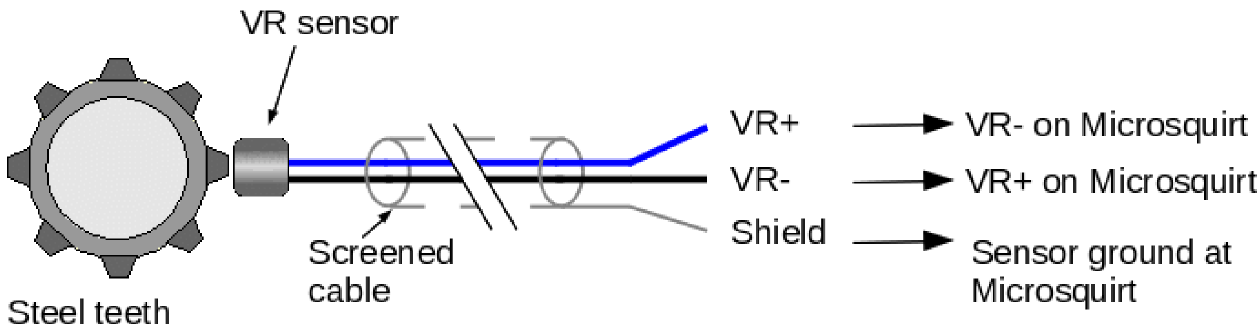
5.3.1 VR (magnetic) sensor input

The VR sensor is a very commonly used sensor. Usually it is seen as a two wire sensor although some manufacturers install a screen on the cable, so yours may have three wires. The sensor itself generates an AC voltage when a piece of steel (the trigger) moves past it. Non-ferrous trigger wheels will not work. The voltage varies from less than a volt during cranking to tens of volts at higher revs.

Typically it is suggested that the magnetic tip of the sensor is around the same size as the teeth on the wheel.

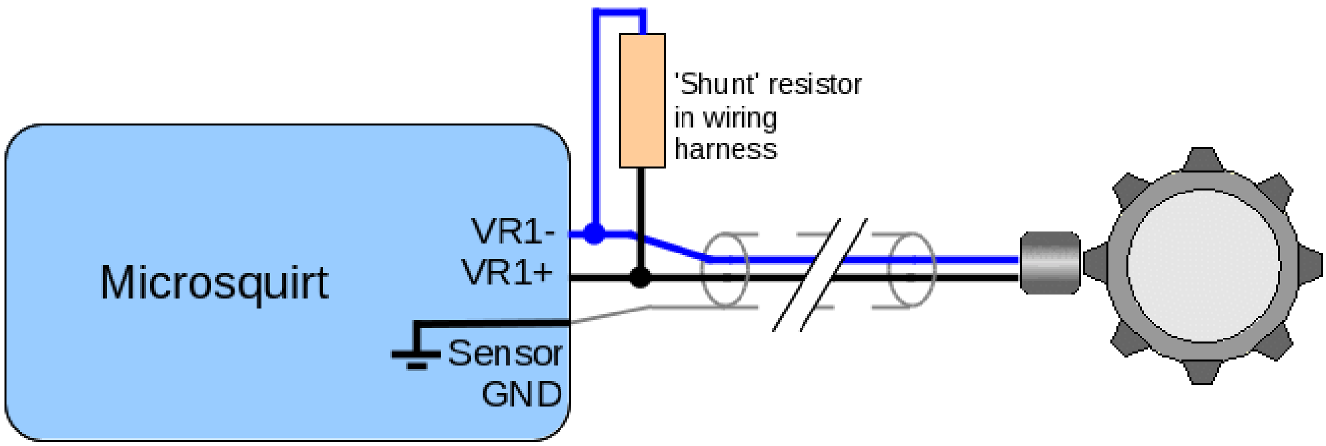


In order to use a VR sensor a "conditioner" circuit is required to convert the AC voltage into a DC square wave signal while retaining the timing information. The Microsquirt has this conditioner built in. The two signal wires from the VR sensor are connected to the VR+/- inputs at the Microsquirt. Ideally use a screened twisted pair cable and connect the screen to sensor ground at the Microsquirt end only.



Some installs may find it necessary to install a "shunt" resistor between VR+ and VR- to reduce the signal voltage at higher RPMs. A 1/4W resistor is sufficient and values in the range of 1k to 10k.

For the second tach input, apply the resistor between VR2+ and VR2-



5.3.2 Hall sensor / gear-tooth sensor input

The Hall sensor is another commonly used category of sensor. These are almost exclusively a three wire sensor.

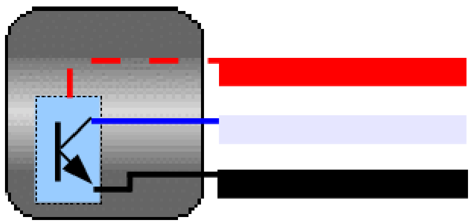
True Hall sensors require an external magnet to operate.

Gear tooth sensors have a built-in magnet and are used to detect ferrous (steel) trigger wheels.

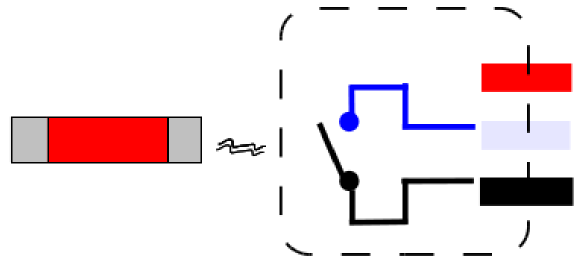
There are two main categories of hall sensor

- open-collector (needs a pull-up resistor)
- built-in pull-up resistor (covered in next section)

Hall sensor (open collector)



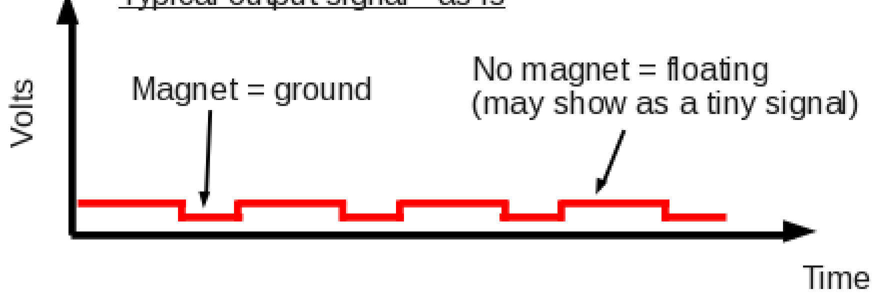
Equivalent circuit



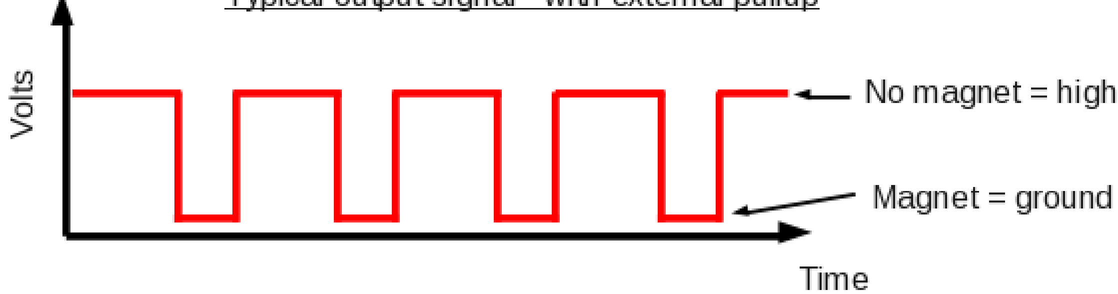
Sensor gives a ground in presence of a magnet.
Gives floating (no output) with no magnet.

Pullup resistor REQUIRED.
(Either in loom or inside ECU.)

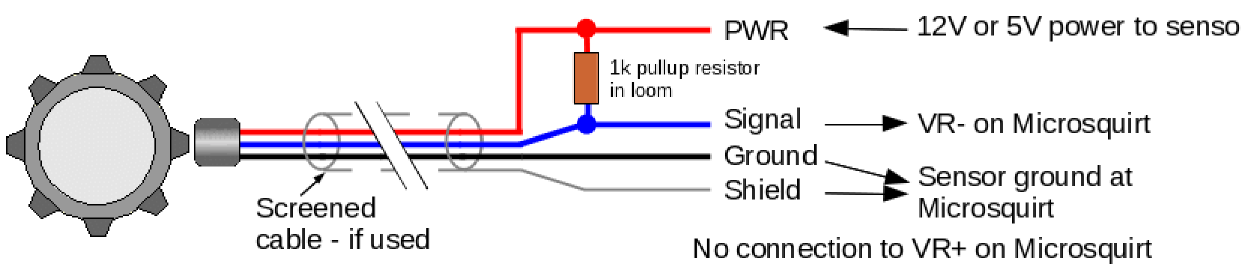
Typical output signal - as-is



Typical output signal - with external pullup

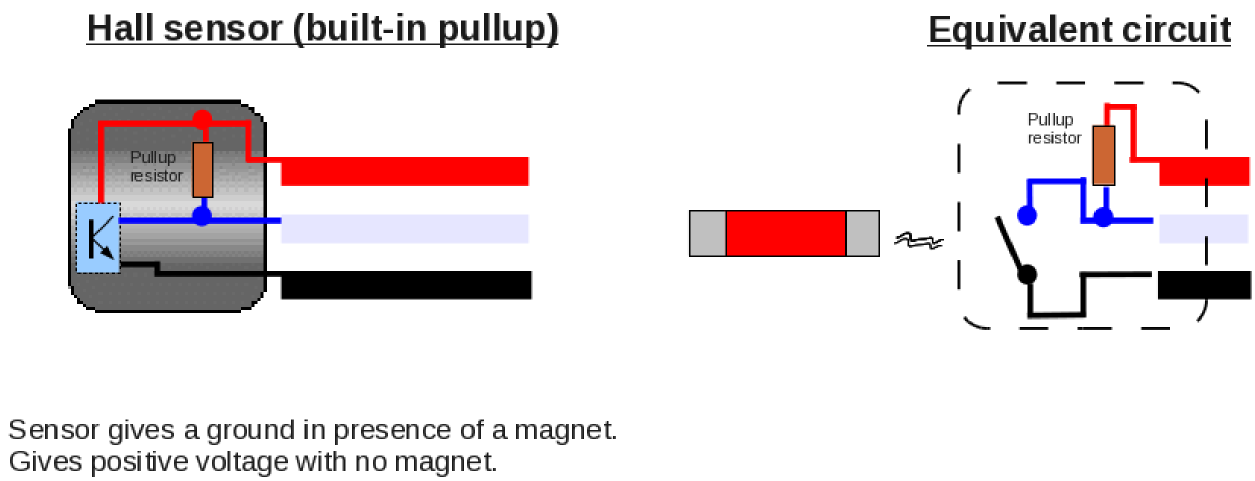


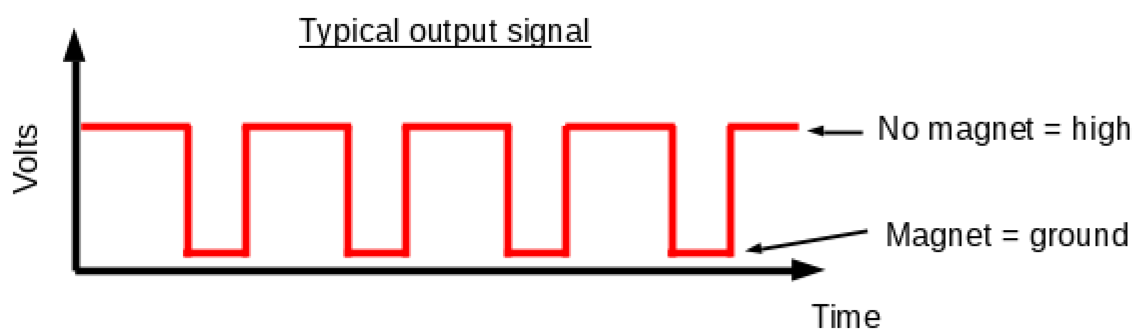
The hall sensor requires a supply voltage which is usually 12V from a fused 12V supply or 5V from the TPSREF output of the Microsquirt. The sensor is then grounded at the Microsquirt sensor ground and the signal wire connects to the VR- tach input. A pull-up resistor is required in the wiring harness.



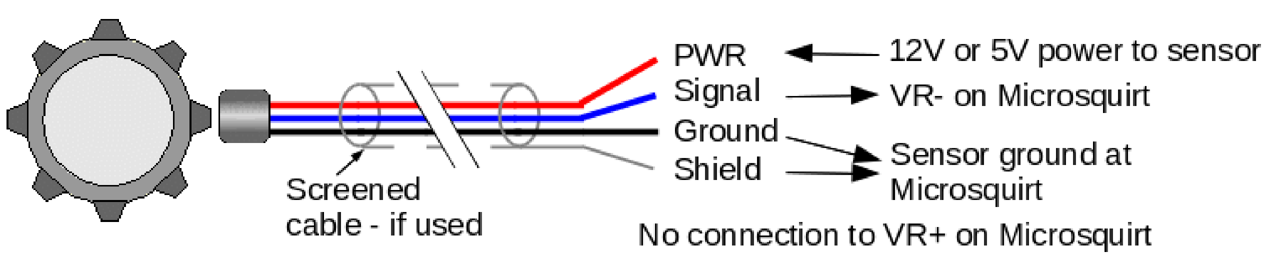
5.3.3 Hall sensor input (built-in pull-up)

These sensors operate similarly to the hall sensors in section 5.2.3 but include the pull-up resistor internally so they give a 0V or 5V signal.





The hall sensor requires a supply voltage which is usually 12V from a fused 12V supply or 5V from the TPSREF output of the Microsquirt. The sensor is then grounded at the Microsquirt sensor ground and the signal wire connects to the VR- tach input.



5.3.4 Optional speed sensor inputs

There are two optional speed sensor inputs that can be used with 0-5V hall sensors only. These are enabled through the MS3 IObox Settings menu.

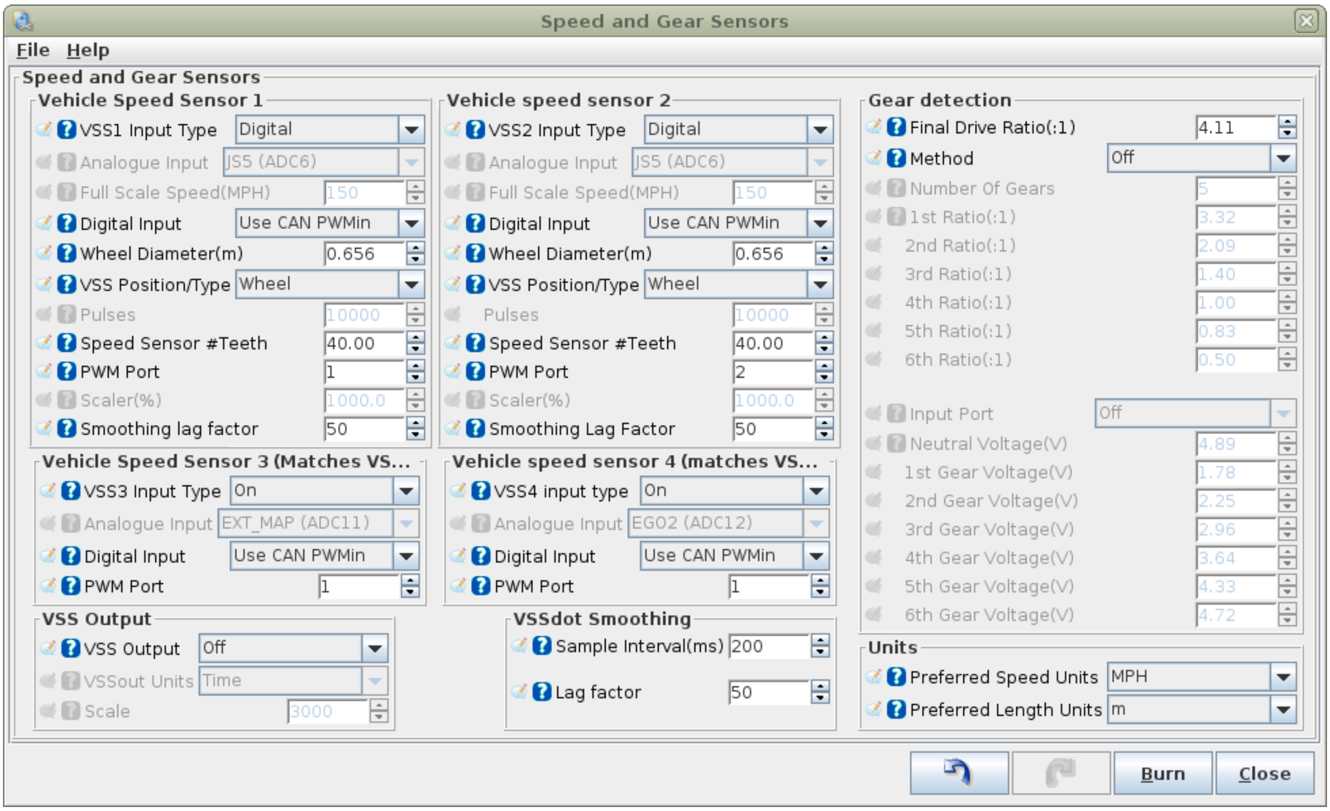
Pin #	Wire color	Wire name (currently)	Function	MS3 name
12	Thick white	IGN1	Ground switch in	*
11	Thick white/Red	IGN2	Ground switch in	*

5.3.5 Settings

The MS3 names for these speed sensor inputs depend on two sets of settings.

a. the VSS selection on the IObox settings page

b. the VSS configuration on the Speed and Gear Sensors Settings.



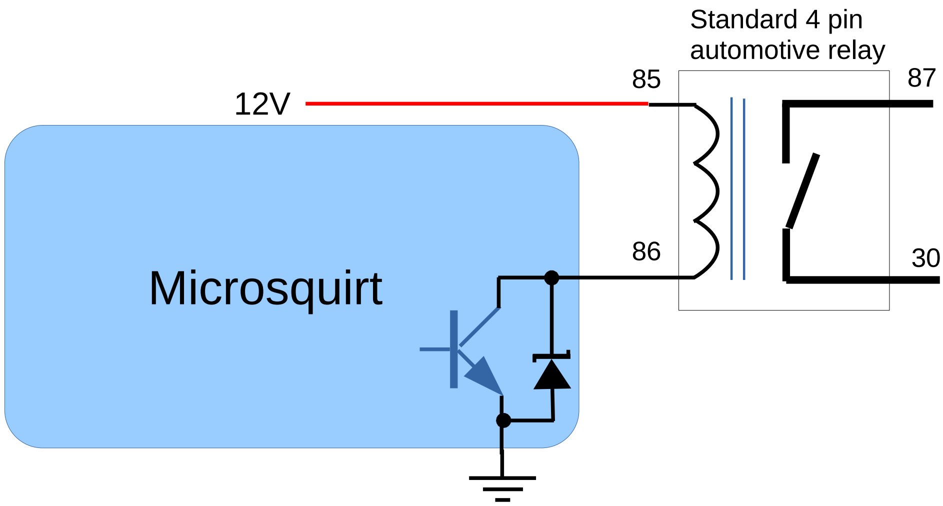
To use the speed sensor inputs from the IObox "Use CAN PWMin" needs to be selected. The "PWM Port" setting is not used.

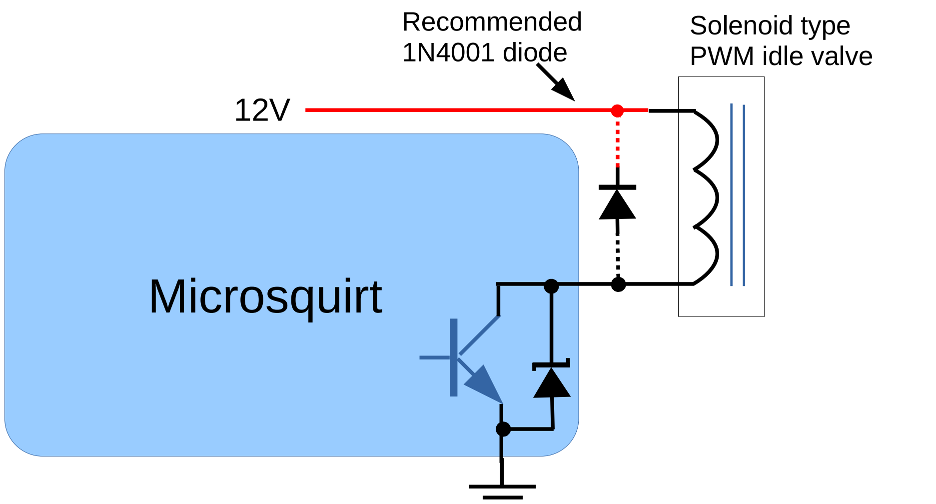
5.4 Outputs

There are seven low-side outputs.

Pin #	Wire color	Wire name (currently)	Function	Max amps	MS3 name
9	INJ 1	Thick Green	Output 1 (low side, high current)	5A	CANOUT1
10	INJ 2	Thick Blue	Output 1 (low side, high current)	5A	CANOUT2
7	FIDLE	Green	Output 3 (low side, mid current)	3A	CANOUT3
8	FP (pump)	Purple	Output 4 (low side, mid current)	3A	CANOUT4
16	ALED	Yellow/Black	Output 5 (low side, mid current)	3A	CANOUT5
17	WLED	Yellow/White	Output 6 (low side, mid current)	3A	CANOUT6
35	TACHO	Green/Yellow	Output 7 (0-12V low current)	0.3A	CANOUT7

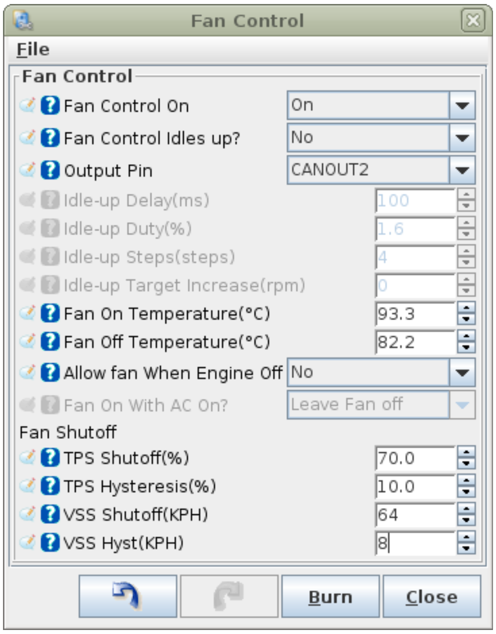
The outputs can be used for on/off or pulsed (e.g. Generic PWM).





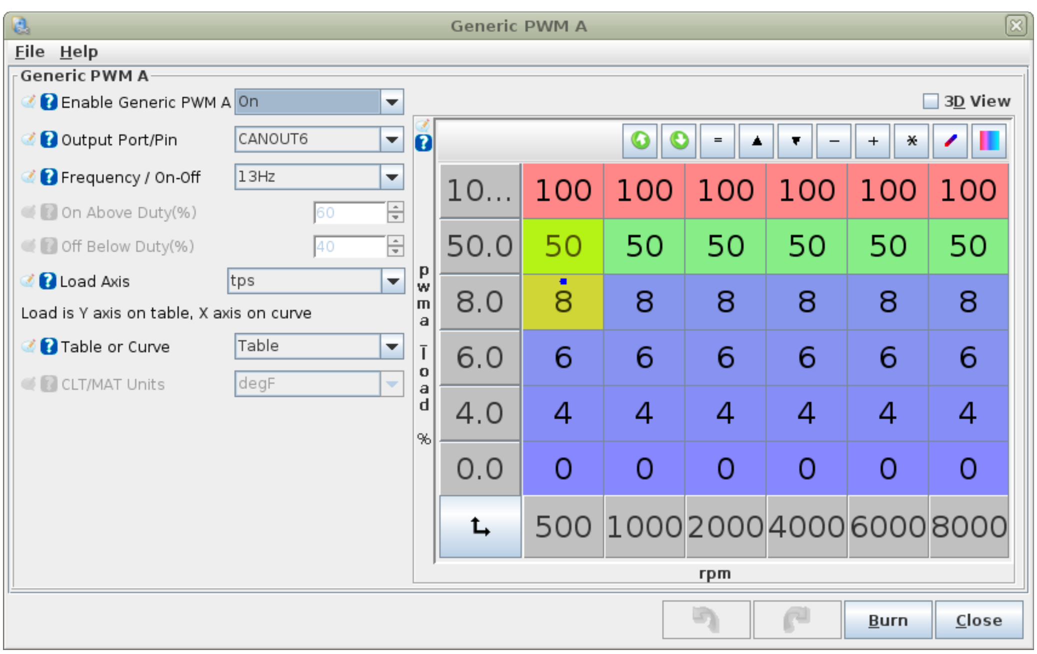
5.4.1 Examples

a. Fan control



In the above example, CANOUT2 is used as an on-off output to control a fan relay.

b. Generic PWM



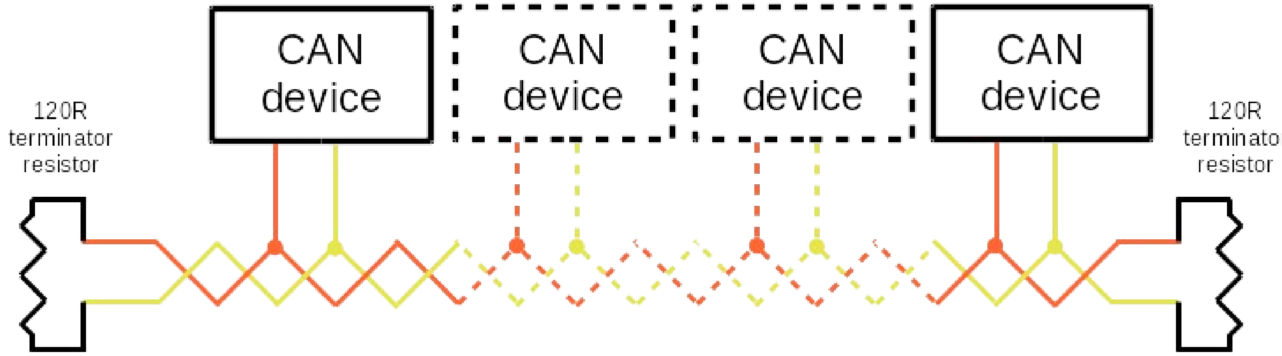
In the above example, CANOUT6 is being used as a PWM output with frequency of 13Hz. The duty cycle is controlled by the duty table of TPS vs RPM.

5.5 CAN comms

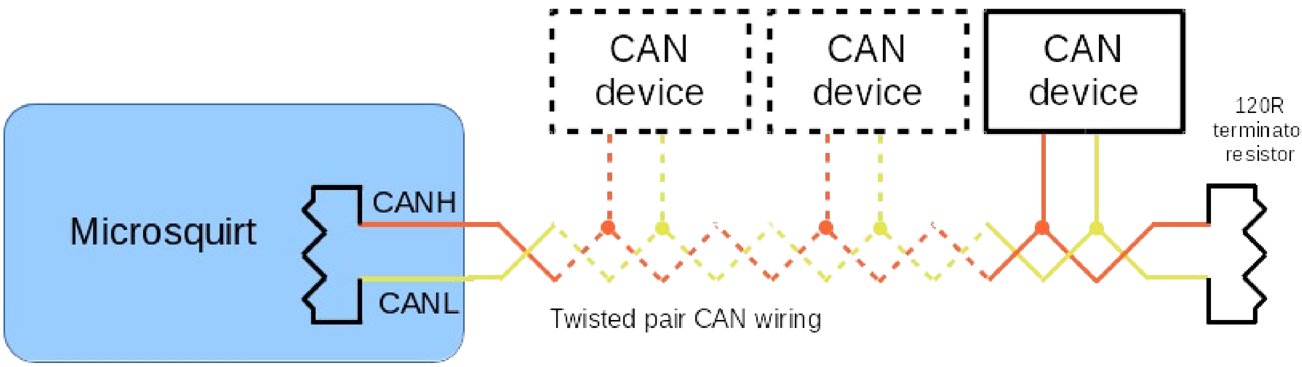
The CANH/L wires are used to connect to the master Megasquirt-3.

They MUST be connected!

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 -> Megasquirt CANH

Microsquirt CANL -> Megasquirt CANL

5.6 BOOTLOAD input

The bootload wire is used to force the Microsquirt into "bootloader" monitor mode. This is only typically needed when loading the firmware for the first time. It can optionally be used if the firmware has become corrupted (e.g. an ignition spike got into the wiring harness) and the normal firmware loading will not function.

It is connected to ground when required. At all other times it must be taped up and kept away from any high voltage noise sources. Never apply a voltage to this wire.

6 Programmers reference to CAN communications

11bit header broadcast packets are used. All numbers are big-endian.

The base CAN identifier is hard-coded into the IObox firmware (S19). By default:

iobox1 = 0x200 (512)

iobox2 = 0x220 (544)

iobox3 = 0x240 (576)

Packets broadcasted from MS3 to device:

ID = base+0

"Are you there?". Remote replies with base+8

#bytes	0	1	2	3	4	5	6	7
0	-	-	-	-	-	-	-	-

ID = base+1

Config message. Sent after base+8

#bytes	0	1	2	3	4	5	6	7
8	On/Off (0) vs. PWM (1) config bitfield	-	Tach-in config bitfield	-	ADC broadcast interval (ms)	Tach broadcast interval (ms)	-	-

ID = base+2

PWM1,2 periods - sent if PWMs in use

#bytes	0	1	2	3	4	5	6	7
8	PWM1 "On" period.		PWM1 "Off" period.		PWM2 "On" period.		PWM2 "Off" period.	

ID = base+3

PWM3,4 periods - sent if PWMs in use

#bytes	0	1	2	3	4	5	6	7
8	PWM3 "On" period.		PWM3 "Off" period.		PWM4 "On" period.		PWM4 "Off" period.	

ID = base+4

PWM5,6 periods - sent if PWMs in use

#bytes	0	1	2	3	4	5	6	7
8	PWM5 "On" period.		PWM5 "Off" period.		PWM6 "On" period.		PWM6 "Off" period.	

ID = base+5

PWM7 periods and on/off outputs bitfield - sent always

#bytes	0	1	2	3	4	5	6	7
5	PWM7 "On" period.		PWM7 "Off" period.		On/off outputs bitfield	-	-	-

Packets broadcasted from device:

ID = base+8

Version and capability. Sent after base+0. Remote replies with base+1

#bytes	0	1	2	3	4	5	6	7
8	Version	-	-	-	PWM clock period in		Tach-in clock period in	

	no. (1)				0.01us (5000)		0.01us (66)	

ID = base+9

10bit ADC values broadcast at set interval. Defaults to 20ms

#bytes	0	1	2	3	4	5	6	7
8	ADC1		ADC2		ADC3		ADC4	

ID = base+10

10bit ADC values broadcast at set interval. Defaults to 20ms

#bytes	0	1	2	3	4	5	6	7
8	Inputs bitfield	-	ADC5		ADC6		ADC7	

ID = base+11

Tach input broadcast at set interval if enabled. Defaults to 20ms
For higher precision, the speed sensor tach inputs accumulate up to the broadcast interval. The accumulated time and number of teeth is reported. Time per tooth = Period / No. teeth.

#bytes	0	1	2	3	4	5	6	7
8	Tach 1 period over X teeth				No. teeth		Total tooth counter	

ID = base+12

Tach input broadcast at set interval if enabled. Defaults to 20ms
For higher precision, the speed sensor tach inputs accumulate up to the broadcast interval. The accumulated time and number of teeth is reported. Time per tooth = Period / No. teeth.

#bytes	0	1	2	3	4	5	6	7
8	Tach 2 period over X teeth				No. teeth		Total tooth counter	

ID = base+13

Tach input broadcast at set interval if enabled. Defaults to 20ms
For higher precision, the speed sensor tach inputs accumulate up to the broadcast interval. The accumulated time and number of teeth is reported. Time per tooth = Period / No. teeth.

#bytes	0	1	2	3	4	5	6	7
8	Tach 3 period over X teeth				No. teeth		Total tooth counter	

ID = base+14

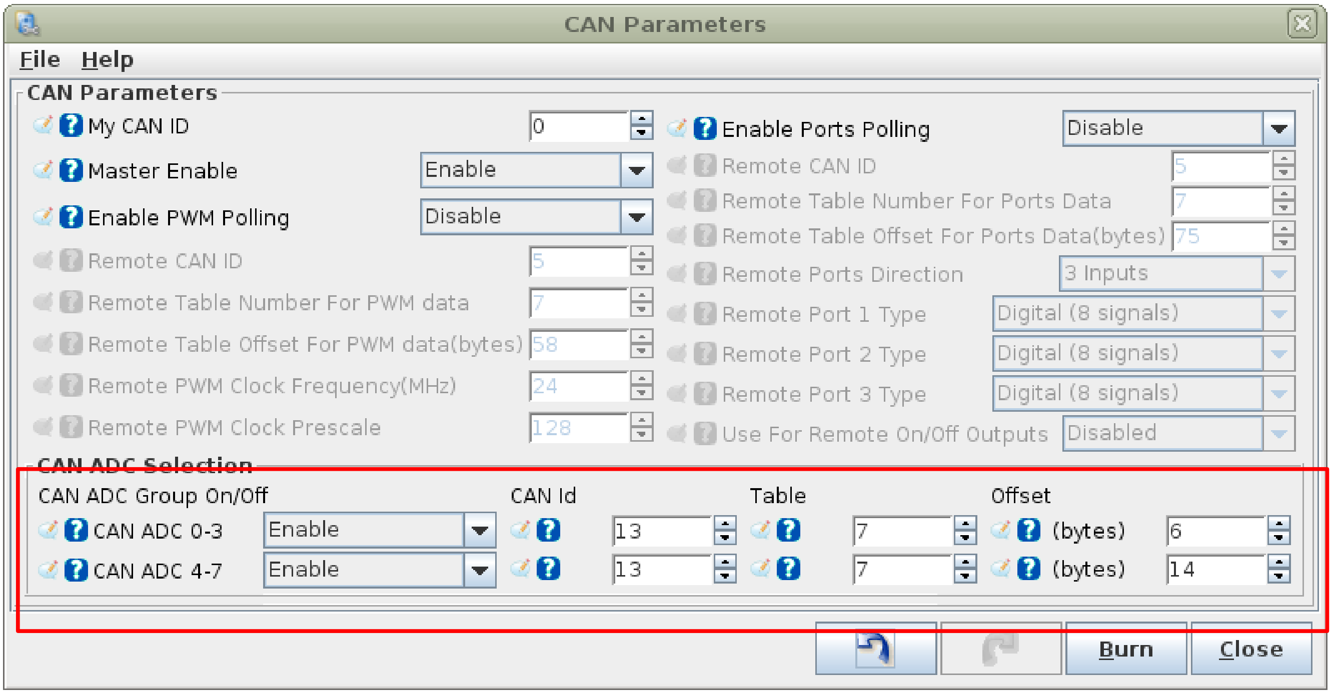
Tach input broadcast at set interval if enabled. Defaults to 20ms
For higher precision, the speed sensor tach inputs accumulate up to the broadcast interval. The accumulated time and number of teeth is reported. Time per tooth = Period / No. teeth.

#bytes	0	1	2	3	4	5	6	7
8	Tach 4 period over X teeth				No. teeth		Total tooth counter	

7 Megasquirt-2 compatability

The IObox solution is presently designed primarily to interface with Megasquirt-3 that has the capability to take advantage of the additional I/O. However, it is possible to collect the analogue data from the Microsquirt IObox onto a Megasquirt-2.

On the CAN parameters screen, enable ADC polling.



Set the CANid to 13, table to 7 and offsets to 6 and 14.

The raw ADC data (0-1023 counts) will now be collected and displayed in variables gpioadc0 - gpioadc7

Megasquirt-2 does not have a method to scale or process this data internally, but custom "ini" files for TunerStudio can be created. The format of the custom.ini is beyond the scope of this document.

gpioadc5 represents the digital switch inputs * 256.