CAN-EGT by DIYAutoTune.com

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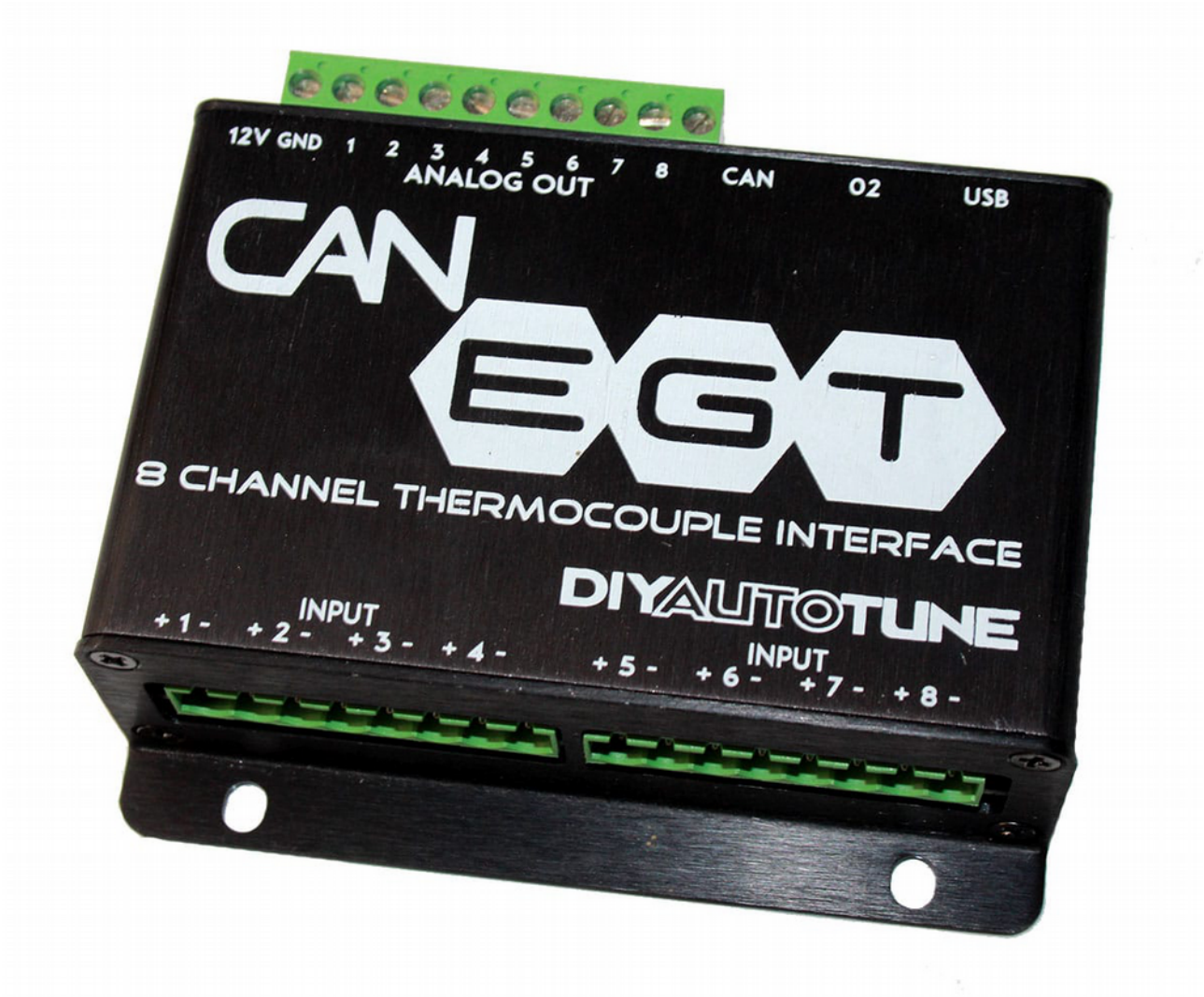
0.1.5 firmware



1 Introduction

The first question you may have is, “Why have a special board for EGT sensors?” Many other sensors can be wired straight to a MegaSquirt, including throttle position sensors, coolant temperature sensors, and narrow band oxygen sensors. What makes EGT different?

Most automotive sensors are designed to work on a zero to five volt scale, since automotive microcontrollers typically have built in analog to digital converter circuits that can read a zero to five volt output. However, the only sensor type that holds up well to the intense heat in exhaust gas is a thermocouple, and these put out a signal in the millivolt range. Even the hottest EGT readings you can produce on an engine are not likely to push the output over 0.05 volts. So converting these signals into something a 5 volt electronics system can use requires a precision amplifier.

The CAN-EGT board lets you collect input from EGT probes and bring it in to a MegaSquirt through the CAN connection, or allows you to log the EGT readings through TunerStudio over USB. It is compatible with MS2, MS3, DIYPNP, MicroSquirt, MSPNP Gen 2, and MS3Pro systems as well as other standalone ECUs that support custom 11 bit CAN receiving. The CAN-EGT also has analog outputs that allow it to serve as an EGT amplifier for other devices that can only accept 0-5 volt signals.

CAN-EGT features:
• 8 inputs for K-type thermocouples
• Cold junction compensation
• 0-1250 ºC input range
• Measures both exhaust gas and cylinder head temperature
• 8 analog 0-5 volt outputs
• CANbus connection for connecting to MegaSquirt
• RS232 connection that connects to an Innovate LogChain - currently supports up to 8 Innovate wideband O2 sensors per CAN-EGT module
• USB port for laptop connection
• Multiple CAN-EGT units can be daisy chained together

2 Installation

2.1 EGT probes

The CAN-EGT module uses standard K-type thermocouples, such as the DIYAutoTune.com Red Avenger or Black Stinger EGT probes. These attach to the numbered screw terminals under the text reading “Thermocouple Interface by DIYAutoTune.com”. K-type thermocouples have an industry standard marking in North America: Red is negative, yellow is positive. This can be a bit confusing as a lot of equipment uses red for positive. The yellow terminals go to the + inputs, and the red terminals to the -. If you encounter EGT probes that use different colors on their wires and are not certain which terminals it uses, you will need to contact the manufacturer of the probe. There are a number of other standards that exist in Europe and Asia.

Note that you must connect the actual thermocouple wire to the input terminals. Do not attempt to extend a thermocouple’s wiring with copper wire; this will throw off the reading.

2.2 Power and ground

You can supply power to the CAN-EGT through either the CAN plug or the 10 pin terminal block. For the CAN plug, the tip is 12 volt power and the sleeve is ground. For the 10 pin terminal block, the 12 volt power and ground pins are marked on the case lid. It should receive switched 12 volt power with a 2 amp fuse. We recommend grounding the CAN-EGT unit to the cylinder head or engine block, preferably close to the location of one of the EGT probes. Grounding the CAN-EGT to the same location as the probe bodies will make for a more accurate reading.

2.3 Connecting to a MegaSquirt

The 4 pin barrel plug included with the CAN-EGT unit allows using a single point for power, ground, and CAN connections. The wires are color coded, as follows:

Color	Function
Green	Ground to engine block
Red	12 volt power
Black	CAN H
Yellow	CAN L

If you are wiring up a 4 pin barrel plug from scratch, use these connection points:

- The tip is for 12 volt power. Use the same source as the MegaSquirt.
- The sleeve connects to ground.
- The ring next to the tip connects to CANH.
- The ring next to the sleeve connects to CANL.

Note: The CAN connection is not “hot-swappable” - you must not have the CAN-EGT powered up when connecting or disconnecting the CAN cable.

2.4 Connecting to data logging devices with 0-5 volt analog inputs

The CAN-EGT board has 8 linear analog outputs for use with other devices, under the numbered terminals on the 10 pin connector. These put out 0 volts at 0 °C and 5 volts at 1250 °C, with a slope of 4 mV/°C.

2.5 Connecting an Innovate LC-1 or LC-2

The CAN-EGT board can talk to Innovate LC-1s or LC-2s as well as MXL wideband gauges directly over serial, bypassing any digital to analog conversions. Simply connect the wideband controller’s OUT serial connection to the WB port on the CAN-EGT board, using a standard Innovate serial patch cable. You may connect up to 8 Innovate controllers with current firmware, daisy chained together. Make sure to insert the terminator plug is on the IN connection of the first control unit in the chain.

2.6 Internal switches

There is a 3 position DIP switch inside the CAN-EGT board. Here is what the switches do. By default, they are all set to ON.

V+ and GND: These should be set to ON if you are powering the CAN-EGT through the 10 position screw terminal and using the CAN cable to power a second CAN device (maximum current 100 mA). They should also be set to ON if you are powering the CAN-EGT board through the CAN cable. Under any other circumstances, set this to OFF.

R: Termination resistor. Switch this ON if the CAN-EGT is the last node on the CAN network, OFF if there are other ones down the line.

3 TunerStudio settings

The CAN-EGT board can talk to TunerStudio either directly through its USB port, or through a MegaSquirt in CAN passthrough mode. Either way, you will need to set it up with the appropriate INI file. If you do not have a copy of this file from TunerStudio and it does not auto-detect the firmware, you may download it here:

CAN-EGT configuration file

Save this file in a convenient folder, such as the TunerStudio Projects folder in My Documents for most Windows installations.

3.1 Connecting to TunerStudio over USB

Click the Other firmware checkbox, select Browse, and specify this file.

There are two project properties settings you may specify. The Temperature Display option lets you display degrees in Fahrenheit or Celsius. The Serial setting allows you to chose whether you are connecting to the CAN-EGT board directly over over CAN. If connecting directly to the CAN-EGT using USB, select Activated.

After you have created the project, go to File -> Project -> Project Properties, and set up the CAN Devices tab. If TunerStudio is talking directly to the CAN-EGT board, you will need to set the Main Controller CAN ID to 1. If the CAN-EGT board will be connected to a MS3, set the Serial Protocol drop down box to “Force - MS3 1.1+”.

3.2 Connecting to TunerStudio through an MS2 or MS3

The MS2 will require setting up Project Properties; with an MS3, this is not required to read data from a CAN-EGT, but will allow you to make changes to the CAN-EGT internal settings from the MS3 project.

3.2.1 Project Properties

When connecting an MS2 to work with the CAN-EGT board, you will need to set this up under the CAN Devices tab under Project Properties from your MegaSquirt project. This is not required on an MS3 unless you wish to change the settings on the CAN-EGT itself in pass through form. Click the “+” button next to the CAN Devices field to add the CAN-EGT. Type in an appropriate description under the Device Identifier and Device Description. The CAN Device ID defaults to 1; you only need to change this if you already have another device with this ID on your network. Click the “...” button under Device Configuration File, and select the CAN-EGT configuration file. The CAN-EGT configuration settings will then appear underneath the Device Configuration File field and you can set these up. Since you are connecting over CAN passthrough, set Serial to Deactivated. You

will have a check box marked Disable Runtime Data.

On an MS3, you should always check this box, as the MS3 will log the EGT readings on its own. For an MS2, you may leave it unchecked if you wish to use the CAN-EGT to log both AFR and EGT readings at the same time, but checking the box will speed up data logging significantly if you only need one or the other. Once you click OK, TunerStudio will refresh its information, and you will now see two new buttons marked “CAN EGT setup” and “Data”. These are used to send settings to the CAN-EGT board.

3.2.2 MS3 settings - 29 bit CAN (1.5.1 and earlier firmware)

Under the CAN bus / Testmode parameters, use the settings below under CAN parameters.\

Under the Advanced Engine menu, you can enable thermocouple input under the EGT / Thermocouple Inputs screen. EGT channels 1 through 8 correspond to CAN ADC01 through CAN ADC08, as shown in the screen below. For Calibration, set Temp at 0V to 32 °F or 0 °C, and Temp at 5V to 2282 °F or 1250 °C.

See the MS3 manual for how to configure the EGT Actions settings.

To enable air/fuel ratio data over CAN, go to the CAN bus / Testmode menu and select the “CAN VSS, gear” screen. Set the Innovate EGO data via CAN section to the settings below:

Under Fuel Settings, select AFR / EGO Control, and enter the number of sensors. Set all EGO ports in use to CAN EGO. You may then assign the EGO sensors to their respective cylinders under AFR / EGO Sensor Mapping.

3.2.3 MS3 settings - 11 bit CAN (requires 1.5.2 firmware or newer)

The 1.5.2 code adds a number of settings to allow running the CAN-EGT in 11 bit CAN mode, which allows using the CAN-EGT even if other devices tie up the 29 bit CAN protocol and prevent using the 29 bit MS-CAN.

Under the Advanced Engine menu, you can enable thermocouple input under the EGT / Thermocouple Inputs screen. Set the number of EGT inputs that correspond to the number of EGT inputs used on the CAN-EGT and set the Input configuration to CANEGT broadcast; the MS3 will automatically assign each input on the CAN-EGT to the same channel on the MS3 and apply the correct calibration. The default Base CAN id is 1680 on the MS3, which is the same as on the CAN-EGT.

See the MS3 manual for how to configure the EGT Actions settings.

To enable air/fuel ratio data over CAN, go to the CAN bus / Testmode menu and select the “CAN EGO, GPS” screen. Set the EGO Data Via CAN section to the settings below:

The default value for the Base CAN ID is 1680, which is the same as on the CAN-EGT. The Base CAN ID (2nd box) can be ignored unless you have more than 8 wideband controllers on 2 separate CAN-EGT boxes; in that case the Base CAN ID on the MS3 will need to match the one on that second CAN-EGT. The AFR calibration is done automatically by the MS3 for the LC-2 calibration. Smoothing is not required (or desired) since this is the digital data read directly from the LC-2.

Under Fuel Settings, select AFR / EGO Control, and enter the number of sensors. Set all EGO ports

in use to CAN EGO. You may then assign the EGO sensors to their respective cylinders under AFR / EGO Sensor Mapping.

3.2.4 MS2 settings

These screen shots show MS2/Extra 3.4.4 firmware.

To set the MS2 to talk to the CAN-EGT board, go to Advanced and select CAN Parameters. Enable these settings to allow the MS2 to talk to the CANEGT board.

If you have checked the Disable Realtime Data box in the Project Properties to speed up data logging, you will need to download this special INI file for EGT logging and save it in the ProjectCfg subfolder in your TunerStudio project folder.

If you are using the CAN-EGT's Innovate wideband digital input, you can use one CAN ADC group for the EGT data and one group for the AFR data. Each group is limited to 4 values so if you have more than 4 EGT probes and/or more than 4 wideband controllers, you will need to get the data directly from the CAN-EGT by enabling the Runtime Data (uncheck Disable Runtime Data). To get the AFR data you will need to change the Remote Table Offset for ADC Data number from 2 or 10 to 153.

There aren't any EGT specific settings in MS2/Extra, as MS2/Extra uses the EGT only for logging. To use the air/fuel ratio data from the CAN-EGT board for wideband correction, go to Basic Setup -> EGO Control, and change 1st EGO sensor port from Local to "Remote ADC0" if using the first CAN ADC group or "Remote ADC4" if using the second CAN ADC group. If you wish to use a second LC-1, set 2nd EGO sensor port to "Remote ADC1" if using the first CAN ADC group or "Remote ADC5" if using the second CAN ADC group. You will also need to calibrate the AFR table to use the Innovate calibration.

3.3 CAN-EGT settings

The CAN-EGT firmware v0.1.5 is configured by default to broadcast CAN messages with an 11-bit header containing 8 EGT values and 8 AFR values (4 CAN messages). It is compatible with the 29-bit CAN MegaSquirt protocol and operates at 500kbps. The messages are sent 25 times a second for each message.

The default settings mean that the unit is compatible with all the MS2 and MS3 based ECUs and any CAN devices that can read 11-bit CAN messages. However, certain settings can be changed to improve compatibility with certain setups and to avoid incompatibility and conflicts with some CAN protocols.

3.3.1 ADC settings

ADC resolution changes the accuracy the inputs use. Current MS3 firmware requires setting this to 10 bits. You can set the EGT inputs that are actually connected to Active, and EGT inputs that are not in use to Disabled. The Lag Factor setting allows for software noise reduction. Valid entries are 1 through 100. It multiplies the current sample by the Lag Factor as a percent and the previous setting by 100% minus the Lag Factor to get the reading. 100% Lag Factor means no filtering, while 0% Lag Factor will prevent the EGT readings from updating at all. As EGT inputs are fairly noise sensitive, we recommend using a lag factor from 10 to 30. Our experience is that this lag factor still responds quite well, but filters out noise.

Keeping an unused channel active will not have any impact on the CANEGT operation.

3.3.2 Serial port settings

These settings allow connecting an one or more Innovate wideband control units to the “WB” connection. To communicate with the controller, set Serial port 2 Baud rate to 19200, and set Auxiliary Data Configuration to “Enable LC1 reading from serial port 2”. The Serial port 1 Baud rate can be changed to a lower value if needed but this should not be required when using it with TunerStudio on a PC.

The Default AFR value is used when there is a communication error with the wideband controller.

3.3.3 CAN transfer settings

The CAN-EGT has several different methods of sending messages over CAN.

Transfer modes:

- Polled mode: This one waits for an MS2 or MS3 to send a data request over 29 bit MS-CAN, and replies with a message in the same format.
- Push mode: Uses 29 bit MS-CAN to write data to an MS2 or MS3 without receiving a request from the ECU. Not normally recommended as any configuration error can overwrite the wrong data in the ECU.
- Automatic mode: Similar to push mode, but automatically detects MS2 and MS3 type ECUs and their firmware version.
- Automatic + Offset: A version of the automatic mode that sends data to an offset CAN ADC value. Only recommended if you are very familiar with the MegaSquirt CAN data structure.
- Broadcast standard CAN: Transmits an 11 bit CAN message at regular intervals. Often, this is the most robust communication method, and is easier to configure for non-MegaSquirt ECUs.

When connecting the CAN-EGT with an MS2 or with an MS3 running firmware 1.5.1 or earlier, we recommend to set the Transfer mode to “Polled mode”, which will disable all the other settings and disable broadcasting of the 11-bit CAN messages. This will optimize the CAN bus traffic and the MS2 or MS3 to read the EGT and AFR values normally with the configuration described in the previous sections.

We do not recommend any methods other than “Polled mode” or “Broadcast standard CAN” at the current time.

The default Transfer mode is “Broadcast standard CAN”, which broadcasts 11-bit CAN messages on the CAN bus. The number of EGT values and the number of AFR values define the number of messages broadcast. Each CAN message contains up to 4 values (16-bit values in a big-endian format), so with 8 EGT values and 8 AFR values the CAN-EGT will send a total of 4 messages.

The Base CAN id is the CAN id of the first message containing EGT values with the second EGT message having a CAN id of Base CAN id + 1, the first AFR message having a CAN id of Base CAN id + 2, and the second AFR message having a CAN id of Base CAN id + 3.

With the default settings, the 4 messages sent have CAN id 1680, 1681, 1682 and 1683. For 4 EGT values or less, the CAN-EGT will not send the second message (1681). If there are zero EGT values and only AFR data, the CAN-EGT will not send the first or second messages (1680 and 1681), and

begins with the AFR data at 1682. If there is no AFR data, the CAN-EGT does not send the third and fourth messages (1682 and 1683), while if there are 1 to 4 AFR values, the CAN-EGT does not send the fourth message (1683).

If using more than one CAN-EGT on the same CAN bus, chanhge the Base CAN id of the second CAN-EGT unit from the default value to another value that will not send messages with the same identifiers as the first unit. If the first CAN-EGT uses the default setting, the easiest option is to set the second CAN-EGT to use 1684 as its base ID. If you are using custom base identifiers, we reconned setting the second to the CAN ID of the first unit plus 4.

You can change the CAN baud rate to accommodate CAN device that operate at different bus speeds. The MegaSquirt protocol default speed is 500kbps, but the CAN-EGT can be set at 250k, 500k or 1Mbps.

If there are CAN devices on the bus that are not running at 500kbps and/or devices that use a CAN protocol using 29-bit messages conflicting with the MegaSquirt-CAN format, you can disable the MegaSquirt-CAN protocol on the CAN-EGT. You cannot change the CAN-EGT settings over CAN with the MegaSquirt-CAN prorocol disabled – use the USB connection instead.

The CAN-EGT allows multiple broadcast rates to send data updates faster or slower. You can set the broadcast rate to 1, 2, 5, 10, 25 or 50 Hz (numbers of values per second). The EGT values are 10-bit values that represent temperatures from 0C to 1250C or 32°F to 2282°F. So the 16-bit values in the 11-bit broadcast CAN messages go from 0 to 1023 for temperatures of 0C (0°F) to 1250C (2282°F). The AFR values are 10-bit values that represent AFR values from 7.35 (0.5 Lambda) to 22.39 (1.523 Lambda). So the 16-bit values in the 11-bit broadcast CAN messages go from 0 to 1023 for AFR values of 7.35 (0.5 Lambda) to 22.39 (1.523 Lambda).

4 Updating firmware

Normally, you will not need to reload the firmware, but reloading the firmware can serve as a “reset button” to erase corrupted settings. It is also possible that we may release future firmware upgrades to provide additional functionality. To reload the firmware to the CAN-EGT, download the CAN-EGT firmware ZIP file and copy its contents to a new folder. You will need to use the JBPerf Port Scanner utility to load firmware, which you can download here. When you load this utility, it checks for available CAN devices, and presents you with this menu:

The button next to the device allows you to change firmware:

Selecting “Upgrade Firmware” will give you a file open dialog you can use to select your firmware. Once you open the file, it will display the firmware upgrade progress, followed by a message about whether it was successfully updated.

You can also change the CAN ID of the device without connecting over serial, using the Change CAN ID command.

This menu lets you change the device CAN ID and at that point you will need to click Confirm. You need to re-scan the ports to see the device on the new CAN ID.