TM1

operational & installation manual

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VR Avionics
www.vravionics.com

Contents

Introduction

Thank you for choosing the TM1 turbine engine monitor for your aircraft / project. This manual describes the preparation, operation, installation, configuration, and maintenance of the TM1 line-replaceable unit(s).

Should anything explained in here be unclear feel free to ask us about it.

Recommended Steps

We recommended the following sequence of actions:

1. Decide on what parameters you need to monitor and how they should be displayed. This will determine whether you'll need one TM1 or more as well as what additional equipment to get. Use this manual starting with the chapter on operation to help you with these decisions.
2. Order the TM1(s) and other parts and perform the installation.
3. Update the TM1's firmware to the latest version (or at least version 1.1).
4. Adjust the TM1 configuration settings to your application requirements. To do so you will need an LSI unit and adjust its configuration settings also. To help with this consult our **LSI User Guide** which you can download from our Support web-page. If unsure about something, feel free to email us your configuration file and we'll help you get it set up.
5. If you are using the RealDash dashboard app it needs to be setup. To help with this you can consult the **LRU RealDash Helper Guide** which you can download from our **Support** web-page.
6. Perform various operations to verify correct functioning of your engine monitoring system. If possible log operations to an LSI's SD card, analyze the results yourself through our SetView app, and should you need our help simply email the log files to us.
7. Based on the log files (graphs) if required make new adjustments to configuration settings and repeat the previous step until satisfied with all aspects of operation.

Operation

The TM1 connects to sensors inside, on and near a turbine engine to acquire and pass along operational parameters via CAN bus to HMI (human-machine interface) equipment for display as operator instruments on DX1 displays, commercial off-the-shelf dashboard devices, or both.

Parameters Acquisition

The TM1 acquires different operational parameters from reading sensors as follows:

Temperatures (T1 thru T3)

A single TM1 unit allows for up to three temperature measurements. The most important one is core turbine temperature, usually named either ITT or EGT. The T1 channel on the TM1 is reserved for this measurement as it is designed to measure 0 to 1200° Celsius.

Another important temperature is oil temperature for which we recommend you use channel T2. On channel T3 any other temperature such as outside air temperature can measured. These two latter channels are designed to measure -100 and 411° Celsius.

All temperature measurements are performed through k-type thermocouples. For ITT (or EGT) the sensor comes with (inside) the engine. For other temperatures these may have to be sourced separately.

The TM1 communicates temperatures in Celsius. Except for the factory calibration settings, there are no other user setting related to them. Should Fahrenheit be preferred, this conversion needs to happen at the HMI (human-machine interface) end.

For exact instructions on temperature sensor installation see the section on temperature sensing. Any unconnected temperature channel (or those where the sensor or one of the sensor wires failed) will read their respective maximum (1200°C for T1 and 411°C for T2 and T3).

Pressures (P1 thru P3)

A single TM1 unit allows for up to three pressure measurements. Engine torque is an important parameter typically derived from one of these. For conformity we recommend you use P1 for torque. Other important turbine parameters are oil pressure and fuel pressure for which we recommend P2 and P3 respectively.

All pressure measurements must be performed through ratiometric pressure sensors. These are the most commonly available and cost-effective commercial of-the-shelf pressure sensor type and does not typically come with an engine.

To work correctly the full-scale value (or rating) of the sensor need to be equal to or higher than the maximum operational value expected to be applied to it. It should not be orders of magnitude higher though as this could impact measurement accuracy.

The parameters derived from different pressure sensors can be communicated in various measurement units. This can be %, PSI, BAR, KPA, etc. To configure these parameters for particular measurement units as well as particular full-scale values, see the section on P1, P2 & P3 Pressure Sensor Full-Scale Value.

Though conversions can be done at the HMI (human-machine interface) end, these settings allow them to be done by the TM1.

For exact instructions on pressure sensor installation see the section on pressure sensing. Any unconnected pressure channels (or those where the sensor or one of the sensor wires broke) will report as zero.

Speeds (N1 and N2)

A single TM1 unit allows for up to two speed measurements. For conformity we recommend you use N1 for N1, and N2 for N2, propeller or rotor speed should you have a split-shaft engine.

All speed measurements are performed through tachometer-generator sensors, which typically are supplied with an engine. They can be communicated in different measurement units - %, RPM, etc.

To work as intended the full-scale value (or rating) of the sensor and the frequency from the tachometer-generator must be known, and entered into the operational settings for these measurements.

For exact instructions on speed sensor wiring see the installation section on speed sensing. Any unconnected speed channels (or those where the sensor or its sensor wire broke) will read as zero.

Fuel Flow and Count (FF1 and FC1)

A single TM1 unit allows one fuel flow measurement (FF1) accompanied by its fuel counter parameter (FC1).

Fuel flow is measured through a pulse-based fuel flow sensor, which will have to be sourced separately. Fuel flow can be communicated in different measurement units - GPH, LPH, PPH, etc.

To work properly the k-factor of the sensor as well as the expected full-scale flow-rate in terms of the desired fuel quantity units (gallons, liters, pounds, etc) must be known, and correctly configured into the operational settings.

For exact instructions on speed sensor wiring see the installation section on fuel flow sensing. If unconnected (or the sensor or its wiring fails) then FF1 will read as zero, and FC1 will no longer count the fuel used.

Voltage and Amps (V1 and A1)

A single TM1 unit allows for one voltage and one amps (electrical current) measurement.

The amps measurement is performed through a current measurement shunt. These are commonly available commercial of-the-shelf sensors and will have to be sourced separately.

The voltage measurement simply senses one side of the shunt to report a voltage between 0 and 50V to the nearest 0.1 volt resolution.

For the amps measurement to work properly the rating or full-scale value of the shunt/sensor need to be equal to or higher than the maximum operational value expected to be applied to it. Do not make it too much higher though, since this can impact measurement accuracy.

The amps parameter is communicated in the desired amps resolution. Except for the factory calibration settings, there are operational settings for it. Though conversions can be done at the HMI (human-machine interface) end, these settings allow them to be done by the TM1.

For exact instructions on shunt/sensor wiring see installation section on voltage and amps sensing. If unconnected (or the sensor or its wiring fails) then one or both parameters may read as zero.

Discrete Inputs (D1 thru D5)

A single TM1 unit allows up to five discrete measurements on inputs D1 to D5.

Each discrete parameter reports one of three states – FLOAT, HIGH, or LOW. It reports FLOAT when its input is open circuit, HIGH if a voltage above 2.5V is applied to it, and LOW if the applied voltage is below 1V.

For instructions on discrete input wiring see installation section on discrete input sensing.

Parameters Communication

The TM1 communicates acquired parameters (described in the previous section) via Standard Frame messages via its CAN bus interface as described in this section.

CAN Bus Interface Basics

Nominal bit time / rate	Determined by the setting "CAN Bus Interface Speed"
Frame format / identifier bit length	Base frame format / 11 identifier bits

Information Message #1

Information message #1 identifier	CAN Bus Base ID + 0
Information message #1 length	8 (bytes)
Information message #1 send rate	10 messages per second

Parameter	*Size (bits)*	*Index (bits)*	*Value Offset*	*Details*
N1	12	0	0	N1 speed parameter.
N2	12	12	0	N2 speed parameter.
T1	11	24	0	T1 temperature parameter in degrees Celsius from 0 to 1200.
T2	9	35	-100	T2 temperature parameter in degrees Celsius from -100 to 411.
P1	10	44	0	P1 pressure parameter.
P2	10	54	0	P2 pressure parameter.

Information Message #2

Information message #1 identifier	CAN Bus Base ID + 1
Information message #1 length	8 (bytes)
Information message #1 send rate	10 messages per second

Parameter	*Size (bits)*	*Address (bits)*	*Value Offset*	*Details*
FF1	12	0	0	Fuel Flow (rate) parameter.
A1	12	12	0	Amps parameter.
T3	9	24	-100	Temperature 3 parameter in degrees Celsius from -100 to 411.
P3	10	33	0	P3 parameter.
V1	9	43	0	Voltage parameter in 0.1 volts resolution from 0 to 50 volts.
Unused	2	52	-	Blank bits = 0
D1	2	54	0	0 = Open, 1 = High, 2 = Low
D2	2	56	0	0 = Open, 1 = High, 2 = Low
D3	2	58	0	0 = Open, 1 = High, 2 = Low
D4	2	60	0	0 = Open, 1 = High, 2 = Low
D5	2	62	0	0 = Open, 1 = High, 2 = Low

Information Message #3

Information message #1 identifier	CAN Bus Base ID + 2
Information message #1 length	8 (bytes)
Information message #1 send rate	1 message per second

Parameter	*Size (bits)*	*Address (bits)*	*Value Offset*	*Details*
SN1	14	0	0	Serial number of particular TM1 unit.
FC1	14	14	0	Fuel Counter parameter. Starts at zero after power-up.

Human-Machine Interfaces

Dashboard Devices

Parameters measured by TM1 units can be displayed on dashboard devices using vehicle companion or dashboard apps like **RealDash** (realdash.net). These apps run on various commercial off-the-shelf devices on top of all the main operating systems. Below is an example of a custom dash panel you can construct.

To transfer the parameters from CAN bus to the dashboard device you can use an LSI unit from us or any similar device from another vendor that is supported by the dashboard app. Since the CAN bus messages can be shared with multiple devices simultaneously, this allows the use of multiple different devices.

Note that at least one LSI is required to perform support tasks through our SetView app. This LSI can however also be used to transfer data to a dashboard device as support tasks only require temporary access to this LSI. After such tasks, the dashboard device can be plugged back into the LSI for normal operation.

For more on the LSI, how it works and how to configure it, consult the LSI User Guide which you can download from our website.

To get you started quickly with the TM1 and RealDash, see the **LRU RealDash Helper Guide** which you can download from our **Support** web-page.

DX1 Displays

The TM1 units can also work with one or more of our DX1 displays to provide operator instrumentation as shown to the right which can mount onto an instrument panel.

It has a persistent annunciation bar at the top across all pages and these can be linked to TM1 discrete parameters.

On the engine page (shown) it has space for 4 primary needle gauges on the left, as well as up to 6 secondary slider gauges to the right, which can be scrolled through or set to automatically scan through every 10 seconds.

Maintenance Support

The TM1 works with an LSI to allow maintenance and support tasks to be performed. These tasks are a must to configure the TM1, update its firmware, and helps to validate operation.

The LSI connects via USB cable to a laptop PC that runs our SetView app.

For instructions to install maintenance support see installation of basic power & communication.

The SetView App

SetView is a free Windows application that you can download from our website. It comes bundled with the latest firmware for all VR Avionics LRUs, including the TM1, SGC, TSLM, PDC, FSM, and LSI.

Through SetView all maintenance support tasks can be performed on any LRU including:

- Viewing system parameters in real-time (and recording them to file),
- Performing diagnostic tests to troubleshoot the system,
- Adjusting configuration settings, and
- Updating system firmware.
- Viewing log files recorded on an LSI's SD card.

Download it by the following direct link:

http://www.vravionics.com/support/how-to/#sv-install

You can learn how to perform the various tasks SetView offers you from our **Support** web-page.

Installation

Mounting and Wiring

The TM1 unit should be physically mounted close to the engine compartment without exposing it to excessive heat. Wires that could be subjected to noise will thus be shorter rather than longer.

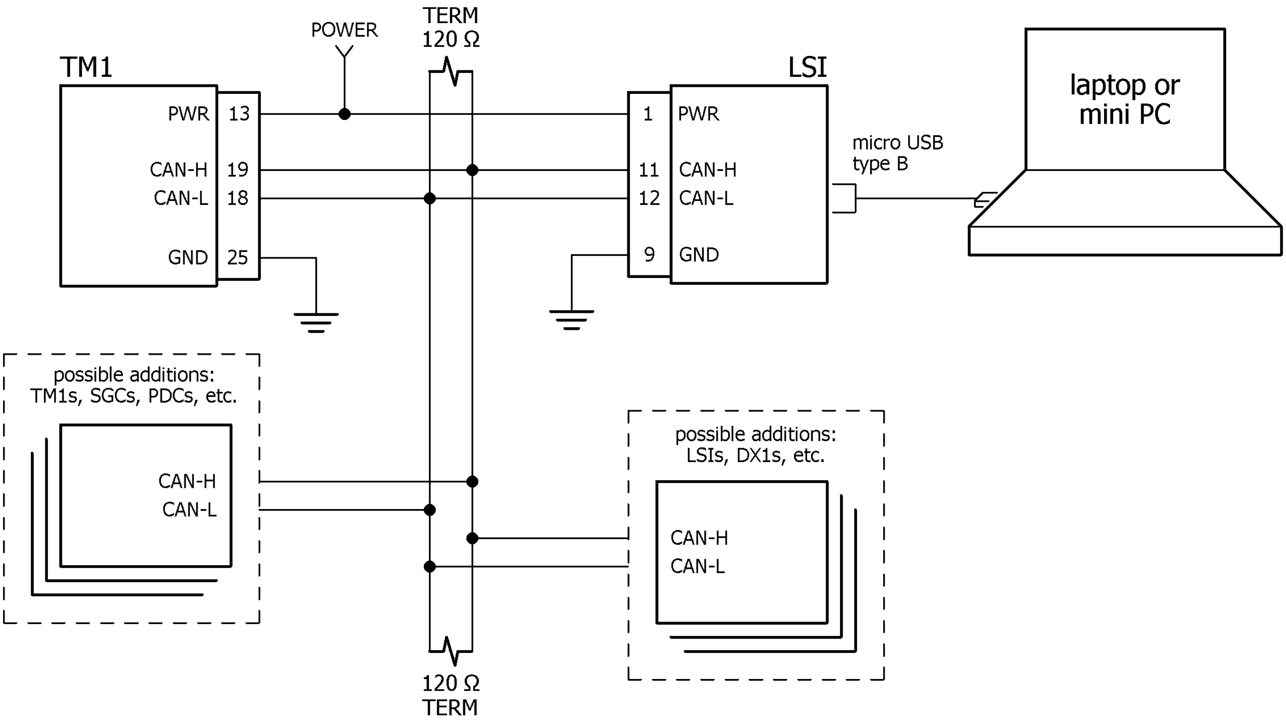
We recommend in general the use of 20-24 gauge aircraft grade Teflon or Tefzel insulated wire for all wiring to and from the TM1 unit. We also recommend you use machined contacts (such as 205090-1) with a crimp connector housing (such as 5205207-1) and a connector hood (such as 5207908-7).

To crimp these machined contacts, you can use the AFM8 crimp tool and K13-1 positioner from DMC, alternatively, the PA1440 crimp tool from Paladin, or similar tools.

Ensure you use the correct splicing techniques to properly insulate any exposed wire, route and strain-relieve all wires so they will not chafe against any other object, and secure all connections. Since improper wiring may cause damage to the TM1 or aircraft, we recommend you confirm all wire connections are correct before turning on any power.

Basic Power & Communication

The diagram below shows how to connect the TM1 to power (10 – 30VDC) and a CAN bus communication network with other devices including at least one LSI.



The Windows laptop or PC shown only needs to be connected when you are configuring settings or updating firmware. Afterwards it can be unplugged (if it is not also doubling as your dashboard device) and the USB cable to the LSI can then be reattached to your normal dashboard device.

The 120 Ohm termination resistors should be positioned at opposite ends of the CAN bus cable. The devices that share the CAN bus must be grounded at a common grounding point.

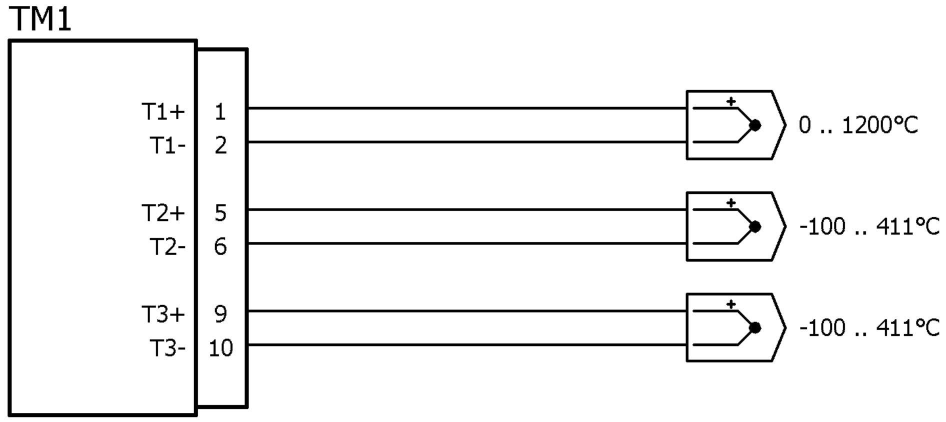
We recommend using two core cable, one for CAN-H and one for CAN-L.

Temperature Sensing

Install k-type thermocouple sensors as may be required by your application as shown in the diagram below to acquire the temperature parameter measurements T1, T2, and T3. If a particular measurement is not required you can leave their input pins open (unconnected).

K-type thermocouple cable must be used to connect the sensors to the TM1. They usually come within yellow sheaths enclosing two metal wires, one Chromel (positive) and the other Alumel (negative). The typical color coding of the two wires are as follows:

Conductive Material	Polarity	Color Code
Chromel	+ Positive	Yellow
Alumel	- Negative	Red



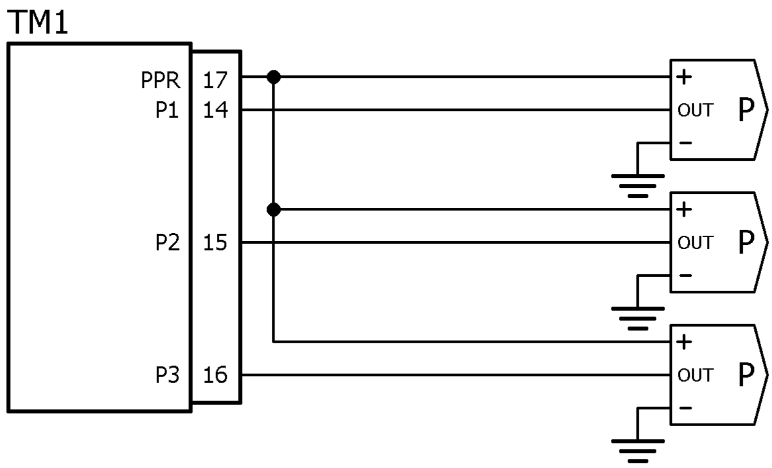
We recommend the use of steel braided thermocouple cables in front of the engine firewall.

Pressure Sensing

Install ratiometric (0.5-4.5VDC) pressure sensors as may be required by your application as shown in the diagram below to acquire the pressure parameter measurements P1, P2, and P3. If a particular measurement is not required you can leave their respective input pin(s) open (unconnected).

There are hundreds of

The PPR pin provides 5VDC nominal power and reference to all three sensors. We recommend doing the necessary splice as close to the TM1 unit as possible and then running separate wires to each sensor along with their respective signal wires as shown. To further improve accuracy we recommend running separate ground wires from each sensor to the common grounding point shared by the TM1 unit.

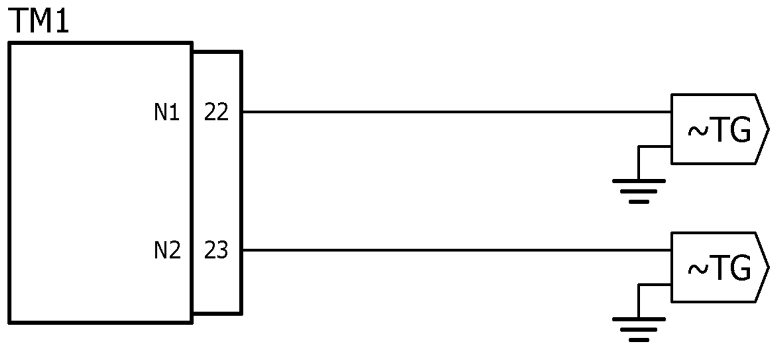


We recommend the use of shielded cabling particularly in applications subject to significant noise (EMI).

Speed Sensing

Install wires from tachometer-generator sensors to the TM1 as shown in the diagram below to acquire the speed parameter measurements N1 and N2. If a particular measurement is not required you can leave their input pin(s) open (unconnected).

Tachometer-generator sensors are typically specific to your engine make and model. As such you need to consult its manual for electrical connector specifics, for example which pin to ground.

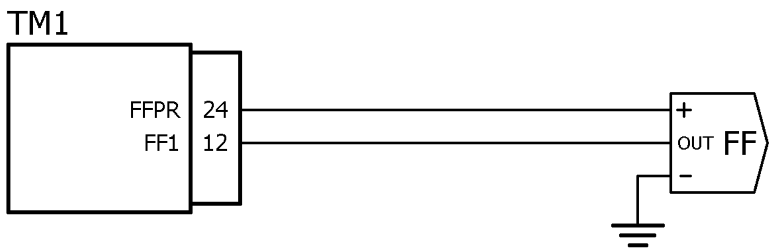


Fuel Flow Sensing

Install a fuel flow sensor as may be required by your application as shown in the diagram below to acquire the fuel flow (rate) and fuel count (fuel used) parameters FF1 and FC1. If these are not required you can leave the pins shown below open (unconnected).

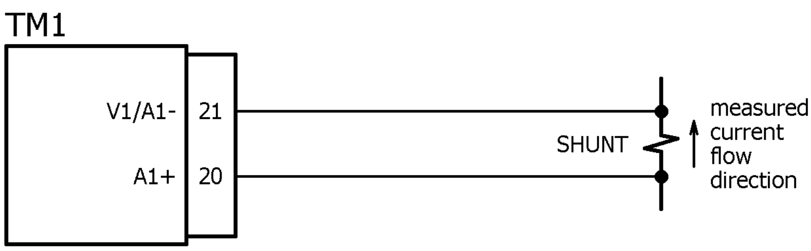
The FFPR pin provides 12VDC nominal power to the sensor. The TM1 also has a 4.7K ohm pull-up resistor on its FF1 pin that will accept any compatible pulse-based flow sensor.

Follow the sensor manufacturer's instructions on mechanical mounting and integration into your fuel system as well as any electrical recommendations.



Voltage and Amps Sensing

Install a current measurement shunt/sensor as may be required by your application as shown in the diagram below to acquire the amps and voltage parameters A1 and V1. If none of these are required you can leave all the pins shown below open (unconnected). If only voltage is required then no shunt is necessary, and only the V1/A1- pin has to be connected to the node that must be measured.

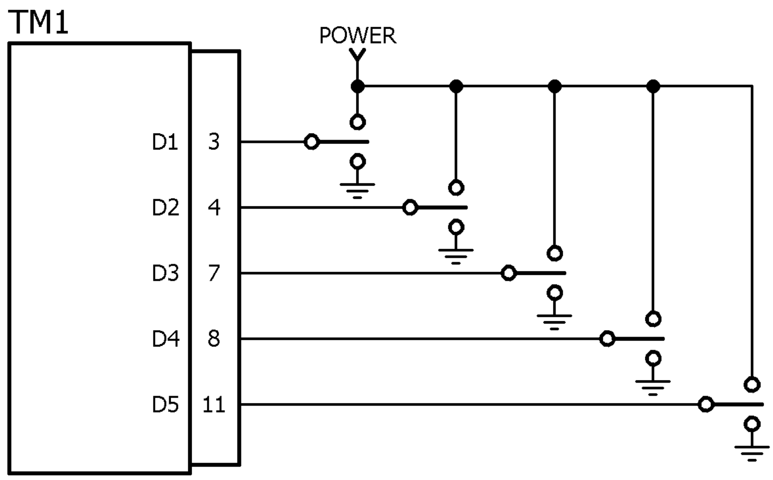


We recommend the use of shielded cabling particularly in applications subject to significant noise (EMI).

Discrete Input Sensing

Install wires from various electrical switches and nodes to the TM1 as may be required by your application as shown in the diagram below to acquire discrete input parameters D1 to D5. If any of these are not required you can leave their pin(s) shown below open (unconnected).

Each TM1 pin will differentiate between being floating (open), powered high, and grounded. Employ them accordingly.



Sensors / Transducers / Senders / Probes

The TM1 allows for literally hundreds if not thousands of possible sensors from a variety of manufacturers, suppliers, mounting methods, and other specifications. In this manual they are referred to as sensors, but they are also sometimes referred to as transducers, senders, and probes.

If you are new to sourcing such sensors, we recommend starting with online part supply stores such as:

- Aircraft Spruce & Specialty Co. (aircraftspruce.com)
- UMA Instruments (umainstruments.com)
- Electronics International (iflyei.com)
- Auber Instruments (auberins.com)
- Mouser (mouser.com)
- Digikey (digikey.com)

Configuration

To set the TM1 up for your application, we recommend the following:

- ✔ Get to know and understand all the configuration settings described in this chapter.
- ✔ Before doing an engine cycle, if you know any setting's value or can determine it as described here, do so, else leave it at its factory default as provided here.
- ✔ Do a recorded engine cycle, analyze the recording, make adjustments, and repeat until satisfied.
- ✔ Feel free to contact us for advice, suggestions or only for confirmation.

You can view and alter TM1 configuration settings by connecting a Windows laptop or PC for support tasks and using our free SetView app.

Operational Settings

Configuration Setting	Minimum	Maximum	Factory
CAN Bus Base ID	0	2047	1536
CAN Bus Interface Speed	125K	1000K	142.8K
N1 Speed Sensor Full-Scale Frequency (Hz)	50.00	10000.00	70.00
N1 Speed Sensor Full-Scale Value	1	4000	1000
N2 Speed Sensor Full-Scale Frequency (Hz)	50.00	10000.00	70.00
N2 Speed Sensor Full-Scale Value	1	4000	1000
FF Fuel Flow Sensor K-Factor (pulses per liter/gallon/pound)	10.00	10000.00	1200.00
FF Fuel Flow Sensor Full-Scale Value (liter/gallon/pound per hour)	1	400	100
A1 Current Sensor/Shunt Full-Scale Value	0	8000	500
A1 Current Zero Deadband Value	0	100	0
P1 Pressure Sensor Full-Scale Value	1	2000	1000
P2 Pressure Sensor Full-Scale Value	1	2000	1000
P3 Pressure Sensor Full-Scale Value	1	2000	1000

CAN Bus Base ID

This setting sets the base ID for the standard frame (11 bit) messages the TM1 send via its CAN bus interface. To communicate and work with an LSI or DX1 the base ID needs to be set as follows:

First Unit	1536
Second Unit	1540

Note you are free to select any other base ID should you need it to communicate with other device(s).

CAN Bus Interface Speed

This sets the speed in bits per second (bps) of the TM1's CAN bus interface. Options are as follows:

Setting	CAN Bus Speed (bps)
0	142.8K (default)
1	125K
2	250K
3	500K
4	1000K

You must configure all devices on the CAN bus to the same speed to allow them to communicate with each other.

N1 & N2 Speed Sensor Full-Scale Frequency (Hz)

These settings determine the frequency (in Hertz) on the N1 and N2 inputs respectively that would constitute full-scale speed. It allows for fine adjustment to the nearest 0.01Hz. In most applications tachometer-generators run at around 70Hz at their respective full-scale speeds. See also N1 & N2 Speed Sensor Full-Scale Value discussed next as they are related.

N1 & N2 Speed Sensor Full-Scale Value

These settings set the value the respective N1 and N2 parameters will indicate should the full-scale frequency (set by N1 & N2 Speed Sensor Full-Scale Frequency) be sensed on the N1 and N2 inputs. Any received frequency above or below will be scaled accordingly. This setting also determines the resolution (or decimals) of the respective parameter. For example set this to 1000 to indicate in percentage with a resolution of 0.1% (as typically used for N1).

FF Fuel Flow Sensor K-Factor

This setting sets the k-factor the TM1 will use to calculate the FF1 and FC1 parameters from the fuel flow sensor signal it gets on its FF1 input. For precision it allows for fractional adjustment to the nearest 0.01.

Sensor manufacturers usually supply a k-factor in terms of pulses per US gallon. This value can be used directly, or can be adjusted through a simple calculation for other units such as liters, pounds, etc.

This setting can also adjust the resolution or decimals of these parameters - full gallons, tenths of a gallon, etc. This simply involves multiplying the setting value by 10 or dividing it by 10.

Note that both the FF1 and FC1 parameters will report in the same decimal resolution and fuel quantity measurement units set by this setting.

FF Fuel Flow Sensor Full-Scale Value

This setting adjusts the fuel flow parameter's accuracy and responsiveness to be optimal for your application. Set this to the full-scale (or maximum operational) reading you would see for FF1. This setting can be a rough estimate of what you expect the maximum flow rate your engine will experience.

A1 Current Sensor/Shunt Full-Scale Value

This setting sets the particulars of the current sensing shunt connected to the A1+ and V1/A1- inputs so that the TM1 will correctly calculate the A1 parameter from the differential voltage between these pins. It sets the amps value for a 50mV differential voltage. Any voltage above (up to 75mV) or below will be scaled accordingly. Shunt are commonly rated at 50mV. For those that are rated different such as for 60mV, this value can easily be adapted after a simple calculation. Note that the resolution or decimals for the amps reading is also determined by this setting.

A1 Current Zero Deadband Value

This setting sets the minimum value the A1 parameter will report according to the differential voltage on the A1+ and V1/A1- inputs described under A1 Current Sensor/Shunt Full-Scale Value. Should the parameter fall short of the deadband, the TM1 will hold the A1 parameter at zero.

P1, P2 & P3 Pressure Sensor Full-Scale Value

These settings set the full-scale value the TM1 should report should it sense full-scale signal on its P1, P2, and P3 inputs.

Each pressure sensor has a rated pressure. This is the pressure where the sensor will output full-scale signal. This pressure rating can be in different units of pressure (PSI, Bar, KPa, etc.) as provided by the manufacturer. If this is what you want the TM1 to report in, simply enter this for this setting. If you want it reported in something else including percentage (for engine torque maybe), you can calculate the setting from the rated pressure value.

For example, if you want P1 to report in 0.1 percentage counts where 128 PSI on a 200 PSI sensor should equate to 100%, you can calculate **P1 Pressure Sensor Full-Scale Value** as follows:

$$\frac{1000 \times 200}{128} = 1562$$

Factory Calibration Settings

Factory Calibration settings are particular to a specific TM1 unit and were originally configured at the factory. As such they will seldom if ever need adjustment. They are however accessible should re-calibration be needed and the necessary equipment and time is at hand.

Configuration Setting	Minimum	Maximum	Factory
Factory Calibration: T1 Span	0	255	Unit specific
Factory Calibration: T1 Zero	0	255	
Factory Calibration: T2 Span	0	255	
Factory Calibration: T2 Zero	0	255	
Factory Calibration: T3 Span	0	255	
Factory Calibration: T3 Zero	0	255	
Factory Calibration: P1 Span	0	255	
Factory Calibration: P1 Zero	0	255	
Factory Calibration: P2 Span	0	255	
Factory Calibration: P2 Zero	0	255	
Factory Calibration: P3 Span	0	255	
Factory Calibration: P3 Zero	0	255	
Factory Calibration: V1 Span	0	255	
Factory Calibration: V1 Zero	0	255	
Factory Calibration: A1 Span	0	255	
Factory Calibration: A1 Zero	0	255	