

Sooner or later... you'll fly a rotary...

## REAL WORLD SOLUTIONS, Inc

### EM2 Engine Monitor Installation, Set Up and Operating Guide

Thanks for purchasing the Real World Solutions EM2 engine monitor. We have endeavored to make it the most versatile and cost effective monitor on the market today. Needless to say, the quality of installation is just as important as the quality of the hardware itself. It is not practical to include a course on proper electrical wiring practices in these installation instructions, but it is imperative that proper wiring techniques be employed during the installation of the EM2. Good connections and proper strain relief are crucial to system reliability. If you are not comfortable with reading a wiring schematic or wiring of electrical equipment, find someone to assist you. If you are in doubt about any of the instructions that follow, please contact us here at RWS. I want your project to succeed and your life to be a long and happy one.

#### SUGGESTED MATERIALS & TOOLS REQUIRED

1. Small temperature controlled Soldering iron
2. 63 - 37 or 60 - 40 rosin core electrical solder
3. 22 gauge stranded wire
4. 1/16" ID heat shrink tubing for insulating connector solder connections DigiKey PN VFP116-X-ND X= how many feet you want
5. 5/32" vacuum line to connect EM2 MAP, Airspeed and Altitude sensors.
6. Heat gun for shrinking heat shrink tubing.

The EM2 is shipped with OAT sensor, temperature probes for water and oil and oil pressure sensors. Internal to the EM2 are the manifold pressure, altitude and airspeed sensors. Additional VDO automotive sensors can be purchased on-line from [www.egauges.com](http://www.egauges.com). Choose VDO pressure sensors with a resistance of 10 – 180 OHMs and a 0 – 100 PSI rating for oil & fuel pressure (PN 360 086D) or 0 – 30 PSI for coolant pressure. Additional air temperature sensors are available from us at RWS or you can make your own using National LM34-DZ or LM34-CZ parts available from Digikey and other electronics suppliers. CHT and EGT sensors are standardized and available from many sources such as Aircraft Spruce. O2 sensors for the mixture readout can be purchased at NAPA and other auto parts stores. Use Bosch part number 11027. If you are using other sensors and have trouble setting the EM2 up to work with them, email us with your questions here at [tcrook@rotaryaviation.com](mailto:tcrook@rotaryaviation.com).

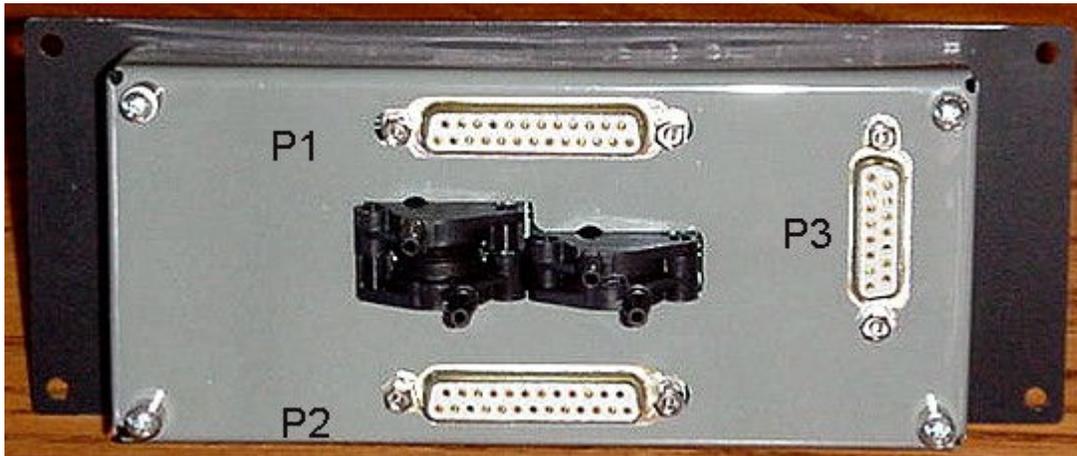
#### INSTALLATION

**CAUTION:** Make sure the positive terminal of the battery is disconnected during installation of the EM2 or any other electrical equipment. Wire all sensors to the connectors prior to plugging the connector into the EM2. Always unplug the sensor connectors prior to replacing sensors or working on sensor wiring. Damage caused by failure to heed this warning or due to incorrect wiring of the EM2 will not be covered under warranty.

#### EC2 SOFTWARE VERSION REQUIREMENTS

If your EC2 was built or last updated before 01-01-04, you will need updated software to be fully compatible with the EM2. This update is free with your purchase of the EM2 but you must furnish the following data on your EC2 in order for us to furnish the properly programmed chips.

1. Serial number of unit
2. Turbo or non turbo version
3. Coils used (Mazda 86 – 91 or GM LS-1 coils)
4. Type of air temp sensor used (2 wire or 3 wire)
5. Engine series (86 – 91 or 93 - 1999 or Renesis 2004 – up)
6. Engine type (13B, 20B, Lycoming, etc)



**Photo 1**  
Rear view of the EM2 showing connector locations

### DISPLAY MODULE

Mount the EM2 on your instrument panel where you can easily see it. (We didn't really need to say that, did we?) Engine instruments are typically installed on the right side of the panel to make room for the primary flight instruments. We suggest not relegating the EM2 to the far corner of the panel. The health of your engine is of prime importance and the engine monitor is your window to its condition. The display window is offset slightly to center the recessed VFD display so that it will appear centered when viewed from the left seat but all the data is visible from any position in the cockpit. The cutout dimensions are 6" x 2.5" for the large display and 3.875" x 2.375" for the small display. The suggested mounting method is to mount the EM2 display behind the panel cutout but it may be mounted in front if you prefer.

### Control switches

Next choose an easily accessible location for the 4 small push-button switches used to control the EM2. This might be near the display, or in a remote switch panel for easier access. You may want to study the operating instructions before making the final decision on where to locate these switches. If desired, you can design and order your own custom engraved switch panel at [www.frontpanelexpress.com](http://www.frontpanelexpress.com). The panel design software is free and extremely easy to use. The EM2 display panel is an example of panels designed and produced by this company.

Wire one lead of each switch to the appropriate pin on P3. Wire the other lead of all four switches to ground.

The switches used most often are "Page-up & Page Down", used to change the functions displayed on the center two lines of the display. These functions might even be assigned to switches on the joystick if you like those elaborate switch festooned stick grips.

The other two switches are "Cancel" and "Ack" (Acknowledge).

'Cancel' is used to return to the home page when you are somewhere in the 8 pages of alternate screens and want to quickly return to Home. It is also used to stop or clear various timers and other functions that will be described later.

'Ack' is used to acknowledge and clear alarms that are triggered anytime a limit is exceeded on any of the critical engine parameters.

Under normal conditions when there are no alarms active, 'Ack' is also used to adjust the brightness of the display. There are 4 brightness levels on the VFD display. The brightness level is stepped down one level on each press of the 'Ack' button until minimum level is reached. Pressing 'Ack' again will return the display to the brightest level.

The LCD version of the EM2 has 3 brightness levels, backlight on full intensity, half intensity and off.

On some of the alternate screens, 'Ack' is also used to start timers and other functions to be described later.

### WIRING THE EM2

Because the placement and configuration of the display and switches will vary greatly depending on installation choices, it is not possible to furnish a pre-wired harness. The required connectors are furnished with the EM2 and the following instructions should enable you to build the harness with a minimum of difficulty. All wiring should be done with 22 gauge wire as indicated on the

“Terminal Assignments and Destinations” sheet at the end of this document. Use wire that meets specification MIL-W-22759/16 or similar high quality wire. This is available from Aircraft Spruce & Specialties and other aircraft suppliers. Remember that the reliability of any electronic device is no better than the wiring and connections used to install it.

You should begin wiring the system only after the display, control switches and all sensors locations have been determined.

I suggest doing all wiring and soldering of the harness connectors at a comfortable workstation with good lighting. The close spacing and small size of the connector terminals require careful work. Doing this work while bent over the control panel in the airplane, will almost certainly result in unsatisfactory results. An adjustable arm magnifier with a built-in florescent light is almost a necessity when doing any fine electrical work. When wiring the connectors, place a 3/8” piece of 1/16” I.D. heat shrink tubing on each wire prior to soldering it to the connector. When you are finished, slide the HS tubing over each terminal and use a heat gun to shrink the tubing.

After all components of the system are in place, use the “Terminal Assignments and Destinations” sheet (at the end of this document) to determine the length of each wire to be soldered to the connectors. Pre-cut all wires and label them about 5 inches from each end with a piece of tape or other suitable means. Take the connectors and the pre-cut wires to your workstation and solder all connections. Note that the connector pins are labeled by numbers molded into the connector body. If you can’t see them, you need the magnifier I mentioned above.

Also note that P1 and P2, the two sensor input connectors, are identical. Be careful not to switch them during final assembly in your aircraft.

**CAUTION! Never wire or replace or work on any of the sensors with the sensor connectors plugged into the EM2. P3 should always be the first connector plugged in before any of the other connectors are installed. Failure to follow this instruction can result in ESD (electrostatic discharge) damage to the sensor input circuits. This type of damage will not be covered under warranty.**

**The connector numbers are not printed on the EM2. See photo on Pg. 2 for connector locations.**

### User Switch connector P3

P3 connects the EM2 to the user controls and +12V power.

P3-1	Backlight	To backlight dimmer switch center contact (LCD version only, N/C all others)
P3-2	Alarm Light *	Alarm light on instrument panel (user provided) *
P3-3	Contrast control	Contrast control pot (LCD version only, N/C all others)
P3-4	Page down	User switch 2 - Note! tie all 4 switch grounds together at panel
P3-5	Ack	User switch 4
P3-6	EFI sense	Primary injector on EFI equipped engines (pin 17 on EC2)
P3-7		No Connection (factory use only)
P3-8	Ground	Ground on panel.
P3-9	+12V power in	+12V from avionics bus
P3-10	+5 V	Connection, (could be used for alarm light power if 5V device used. .15A max)
P3-11	Page up	User switch 1
P3-12	Lyc. Tach Input	Magneto P lead (Lycoming engine) N/C all others
P3-13	Abort	User switch 3
P3-14		No Connection (Factory use only)
P3-15		No Connection (Factory use only)

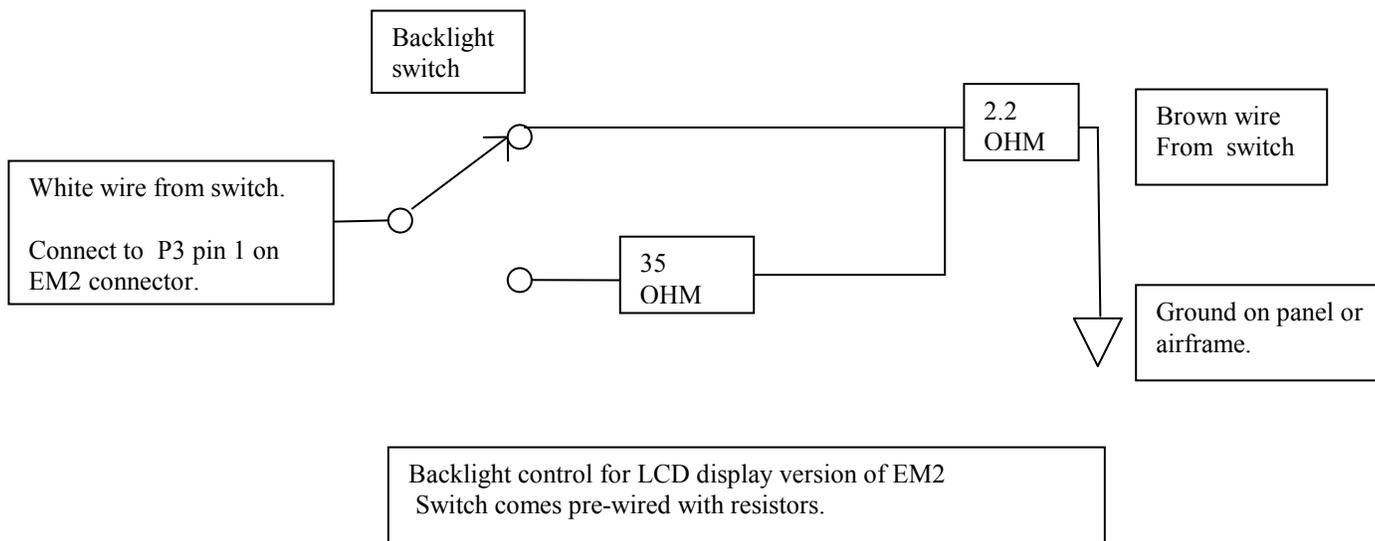
\* Pin 2 is grounded by EM2 when alarm goes active. Connect other end of alarm light to +12. If light used requires voltage other than +12, connect to appropriate voltage. Maximum current for alarm light is .4A.

### LCD DIMMER SWITCH wiring instructions (LCD version only)

The resistors and switch have been preassembled.

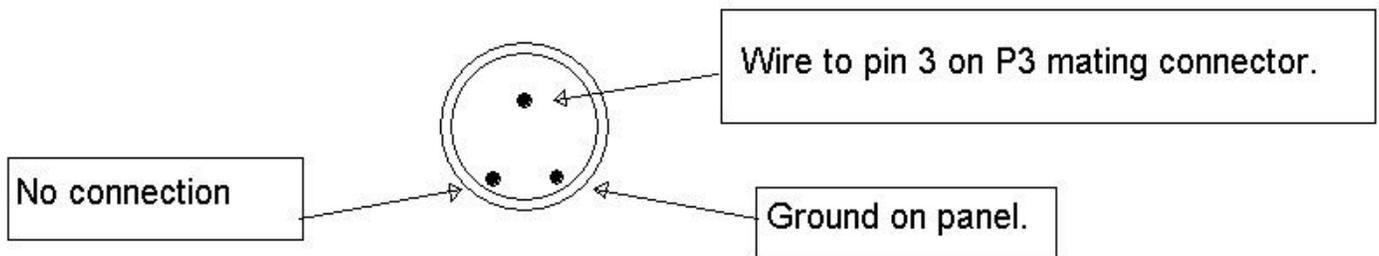
Mount the supplied pre-wired dimmer switch on your instrument panel in any convenient location. It should be mounted with the slot in the threaded barrel pointing up. The bright setting on the display will be active when the switch handle is in the up position.

1. Connect P3 pin 1 to the center contact of the backlight switch (White wire)
2. Connect the brown wire from the switch to ground on your instrument panel.



### LCD CONTRAST CONTROL wiring instructions

Rear view of Contrast control for LCD display.  
Mount on instrument panel in any convenient location.



Normally you will find that the contrast control needs to be set at the most counter-clockwise position and will usually not require any adjustment. Under very hot or cold conditions, adjustments may be required.

## SENSOR CONNECTORS

Sensors are divided into 2 groups on different connectors.

**Group 1 (P2)** is used for resistive and voltage output sensors. These include things like water temperature, oil pressure, and air temperature sensors. Wiring for these sensors is shown on the P2 wiring chart. You may not be using all of the possible sensors. If any of the following sensors are not used, ground the corresponding sensor pins listed below. There are some spare ground pins on P2 for this use.

Oil Pressure	P2-18
Water Pressure	P2-6
Aux 1 air temp	P2-19
Fuel Pressure	P2-20
O2 sensor	P2-8

### Group 2 (P1)

The second sensor group inputs are on the P1 wiring chart. These are for thermocouple type sensors usually used for measuring cylinder head and exhaust gas temperatures (CHT & EGT). The EM2 has 4 of each type. Any "Type J" thermocouple probe may be used for the CHT inputs and type K thermocouples for the EGT inputs.

On Lycoming installations the 4 CHT inputs will most likely be used on the cylinders. If you are not flying a Lycoming, there are other possible uses. They may be assigned as oil or water temperature inputs, for instance, which is sometimes a good option if your engine does not have a convenient place to put a standard sensor. A J type thermocouple intended for placing under a sparkplug for CHT use can be clamped to any convenient spot in the hot water return to the radiator to measure coolant temperature. See the section on "Calibrating the fuel flow & Other functions" for how to select CHT channels for oil & water temp sensing.

### Alternate uses for unused CHT & EGT inputs

Any unused CHT channels can also be used for measuring any other temperatures you might think of. For cooling system analysis, for example, you might want to measure the temperature of the water or oil after passing through the heat exchangers. If you use the extra air temperature inputs in group 1 to measure air temperatures after the heat exchangers, you can determine the exact cause of any cooling problems. Unused EGT inputs can be used the same way.

### Proper termination of CHT & EGT inputs

Thermocouple channels have differential inputs, that is, they measure the difference in voltage between 2 inputs. Thermocouple sensors have color coded wires or terminals and must be connected with the proper polarity. J type thermocouples typically have red and white leads and K types have red and yellow leads. The Group 2 wiring chart shows the matching color for the pins. Some sensor manufacturers color code the terminals differently, so if you don't get the expected reading (a backward sensor will typically give a reading of 32F) try reversing the leads. . Unused CHT & EGT inputs should be grounded.

### Grounded & Ungrounded thermocouple sensors

The EM2 is designed for grounded thermocouple sensors. Most CHT & EGT sensors on the market are of this type. If you want to use an ungrounded sensor, the pin designated for the red sensor wire must be grounded at the EM2 connector in addition to being connected to the sensor wire. Use a spare ground pin on the connector for this purpose.

### DIY thermocouple sensors

You can make your own sensors from raw thermocouple wire or the leads from an old or broken CHT/EGT sensor by stripping some of the wire and twisting or welding the ends together. Connect the other end to the EM2 and voila!, free sensors.

### Extending the leads of thermocouples

In critical applications, use only the proper thermocouple extension wire to extend the length of the sensor. Remember that thermocouple sensors detect the difference in temperature between the junction (at the sensing tip) and the other end of the thermocouple wire. If the end of the wire is at or near the same temperature as the junction, there will be no output. What this means in practical terms is that the thermocouple wire should extend from the point of measurement in the engine compartment, then through the firewall before connecting to an extension wire. If you can tolerate a few degrees inaccuracy in a NON CRITICAL APPLICATION, plain old copper wire can be used once past the firewall, but we recommend that all extensions should use the proper wire in aircraft applications. J and K type thermocouple wire for making thermocouples or extensions is available from McMaster Carr. Find them on the web with any search engine.

**CONNECTOR P2      SENSOR GROUP 1    (Functional Description of pins)**

PIN #	FUNCTION	SENSOR	CHANNEL #	NOTES
P2-14	Coolant TEMP	250degF (VDO)	CH 0 +5V	Main Coolant temp. (Body is gnd)
P2-2	AUX AIR temp 2 sensor	(RWS)	CH 1 +5V	sensor output (white wire)
P2-1	white w/black stripe or Brown			sensor ground (Wh w/ blk stripe or Brown wire)
P2-23	Red or Orange			+5 sensor power (Red or Orange wire) (shared with Aux Air 1 sensor)
P2-15	LIQUID TEMP 2	250deg F (VDO*)	CH 2 +5V	Body of sensor is grounded (SEE NOTE 2 BELOW!)
P2-3	FUEL TANK SENDER RIGHT	(SW)	CH 3 +5V	Used with Vans fuel gauge or 200 ohm Pullup
P2-16	OIL TEMP SENDER	250 degF (VDO)	CH 4 +5V	Body of sensor is grounded
P2-4	FUEL TANK SENDER LEFT	(SW)	CH 5 +5V	Used with Vans fuel gauge or 200 ohm Pullup
P2-17	CARB TEMP SENSOR	(RWS)	CH 6 +5V	sensor also uses +5 & ground
P2-5	LIQUID TEMP 3	250deg F (VDO*)	CH 7 +5V	Body of sensor is grounded (SEE NOTE 2 BELOW!)
P2-18	OIL PRESSURE	0-100 psi (VDO)	CH 8 +2V	Body of sensor is grounded
P2-6	WATER PRESSURE	0-30 PSI (VDO)	CH 9 +2V	(Body of sensor must be grounded if single terminal type)
P2-9	Gnd for two terminal sensor			sensor ground if 2 terminal sensor used
P2-19	AUX AIR 1 TEMP SENDER	(RWS)	CH 10 +2V	sensor output (white wire)
P2-22	White w/black or Brown			sensor ground
P2-23	Red or Orange			+5 sensor power
P2-7	OAT	White wire (RWS)	CH 11 +2V	sensor output (white wire)
P2-21	White w/black stripe or Brown			OAT sensor bias
P2-10	Red or Orange			+5 sensor power
P2-20	FUEL PRESSURE	0-30 PSI (VDO)	CH 12 +2V	(Body of sensor is grounded)
P2-12				sensor ground if 2 terminal sensor used
P2-8	O2 sensor	(NAPA OS700)	CH 13 +2V	Body of sensor is grounded
P2-13 & 25	Spare ground pins. May be used for grounding unused inputs.			
P2-11	Serial data link (input)			Pin 7 on EC2 connector (serial output)
P2-24	Serial data link (output)			Pin 27 on EC2 connector (serial input)

Note: Liquid temp sensors furnished with monitor may be 250 or 300 Deg. F depending on availability at time of shipping. Either will work and the EM2 will come calibrated for the ones included with your unit. If you wish to install additional sensors or replace the sensors with one of a different range, the following calibration values will be useful.

Sensor	Scale Factor	Zero offset	Sensor offset	
250F VDO	2.111	100.0	390	(Egauges PN 323 095D)
300F VDO	2.024	100.0	435	PN 323 057D)

**NOTE 2** Liquid temp 2 & 3 are capable of being used with a wide variety of sensors other than the VDO sensors used on coolant and oil temp inputs. The tradeoff for this versatility is that they require external resistors to match them to each individual sensor. To use these inputs with the same VDO sensors used for coolant and oil temp, connect two 200 ohm ¼ watt resistors to the input pin in addition to the sensor wire. Connect one of the resistors to ground and the other to +5 volts. Any of the ground and +5 pins on P2 may be used for these connections.

## EM2 Engine Monitor Connector Assignments and Destinations (Wiring guide)

EM2 CONNECTOR PIN	DESTINATION
<b>P2 connector</b>	
1. Ground for air temp 2	White w/blk stripe or Brown wire on air temp 2 sensor (optional)
2. Air temp 2	Aux air temp sensor White wire on RWS temp sensor (optional)
3. Fuel sender Right Tank	* Stewart Warner 385x-F tank sender 40 – 240 ohm type
4. Fuel sender Left Tank	* Stewart Warner 385x-F tank sender “
5. Liquid temp 3	Liquid Temp sensor, optional (** see note 2 on pg 7 **)
6. Water Pressure (coolant)	VDO 0-30 PSI sensor 10 – 180 Ohm type
7. OAT sensor	RWS temp sensor white wire.
8. Air/Fuel mixture	Sensor output from Bosch 11027 or other oxygen sensor
9. Ground	Air temp 2 sensor ground White w/ Blk stripe or Brown (optional)
10. +5 for OAT sensor	Red or Orange wire on RWS OAT sensor
11. Serial data link (input)	Pin 7 on EC2 connector (serial output)
12. Ground	Spare
13. Ground	Ground on panel.
14. Water Temperature (coolant)	Engine coolant sensor VDO 300 deg F 323 057D
15. Liquid temp 2	Liquid temp sensor (optional) (** see note 2 on pg 7 **)
16. Oil Temperature	Engine oil temp sensor VDO 300 deg F 323 057D
17. Carb Temp (Ice detect)	Carb Ice temp sensor (optional) RWS temp sensor (white wire)
18. Oil Pressure	Engine Oil Pressure sensor VDO 0 – 100 PSI
19. Air Temp 1	Aux air temp sensor (optional) RWS Temp sensor (white wire)
20. Fuel Pressure	Fuel Pressure sensor VDO 0 – 100 PSI
21. OAT Bias voltage	White w/Black stripe or Brown wire on RWS OAT temp sensor
22. Ground	Spare
23. +5	Red or Orange wire on air temp sensor 1 and 2 (if used)
24. Serial data link (output)	Pin 27 on EC2 connector (serial input)
25. Ground	White w/Black stripe or Brown wire on air temp 1 sensor (optional)

\* The Fuel level inputs to the EM2 are intended to be used in parallel with the fuel level meters sold by Vans Aircraft. These are very reasonably priced and give excellent accuracy in an attractive 270 degree sweep meter movement. We highly recommend them and the long life Stewart Warner senders for use in any aircraft. Log on to [www.Vansaircraft.com](http://www.Vansaircraft.com) to see their catalog. They happily sell to builders of any aircraft. Connect the EM2 fuel level inputs and the Van's meter sender terminal (S) to the fuel level sender.

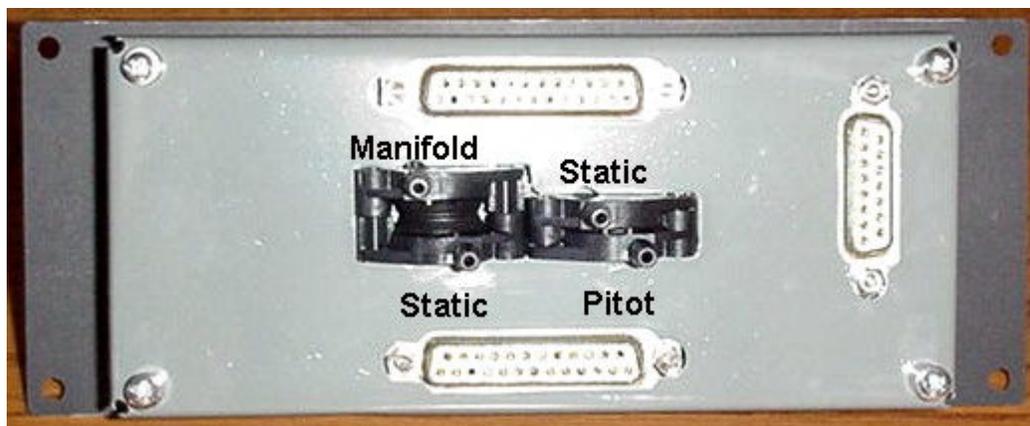
**P1 Connector** (CHT & EGT thermocouple inputs)

CONNECTOR PINS	WIRE COLORS	FUNCTION	Ch #	SENSOR TYPE
P1-9, 12	WHITE, RED *	CHT1	16	J type sensors (CHT)
P1-24, 10	WHITE, RED *	CHT2	17	
P1-23, 22	WHITE, RED *	CHT3	18	
P1-11, 25	WHITE, RED *	CHT4	19	
P1-14, 4	YELLOW, RED *	EGT1	20	K type sensors (EGT)
P1-17, 3	YELLOW, RED *	EGT2	21	
P1-15, 2	YELLOW, RED *	EGT3	22	
P1-16, 5	YELLOW, RED *	EGT4	23	

P1 1,6,7,13,20,21 Spare ground pins. Use for ungrounded type J or K sensors and for grounding unused inputs.  
\* = ground red lead pin at connector if ungrounded sensor used.

Note! Unused CHT & EGT channels should have both input pins tied to ground.

## EM2 PRESSURE SENSOR CONNECTIONS



**Photo 2.** Air pressure ports

There are four air pressure ports of the rear of the EM2.. They are to be connected to ports on the manifold, pitot and static ports on the aircraft as indicated in Photo 2 above. Soft 5/32" ID Silicone, polyurethane or rubber hose should be used. **DO NOT** use hard nylon or plastic hose as the sensors could be damaged when this difficult to remove hose is pulled off the sensor.

### ***Manifold Absolute Pressure (MAP) sensor***

If your engine is equipped with an EC2 engine controller it will receive manifold pressure information from the data link to the controller so a vacuum line to the manifold from the EM2 will not be needed.. If you do not use an EC2, install a 5/32" ID hose connection from the upper left (as shown in photo 2) pressure sensor to a port on your intake manifold. Almost any point downstream of the throttle body or carburetor will do. If your manifold has a plenum chamber, that is an ideal point to take the manifold pressure reading from.

### ***Altitude sensor***

Connect the altitude sensor (lower left port) to the aircraft static system.

### ***Airspeed sensor***

The airspeed sensor (Right side in photo 2) has two ports. The lower port is to be connected to the pitot tube along with your main airspeed indicator (flight instrument). The upper port connects to the aircraft static system.

## EM2 OPERATING PROCEDURE

### **MAIN DISPLAY FEATURES (Top & bottom lines of 4 line display display)**

The main display functions of the EM2 are on the top and bottom lines of the 4 line display. They are labeled with engraved lettering in the panel above or below the area where each parameter is displayed. These parameters are always displayed regardless of what functions are selected for the alternate display pages shown on the two center lines. Most of the main parameters are self explanatory but some explanation will help you to get the most out of your instrument.

#### ***Top Line***

Starting at the upper left is engine **RPM**. This is a high resolution tachometer which will display very small changes in rpm to make engine tuning easier.

Next is manifold absolute pressure (**MP**) in inches of mercury. Manifold pressure is the most commonly used parameter for setting engine power.

Following this is true airspeed (**TAS**). True airspeed is corrected for pressure altitude and temperature. This is not an engine parameter but I found it to be so useful that I included it on the main display.

On the right end is exhaust gas temperature (**EGT**) in degrees Fahrenheit. The highest EGT measured is automatically selected for display. EGT is the best indicator for adjusting mixture under cruise conditions when best economy is the goal.

#### ***Bottom Line***

On the left end is water temperature (**H2O**) shown in degrees F. Again, the number is followed by the degree symbol to remind you this is a temperature. The sensor for this readout should be located in the hottest part of the cooling system, just before the

coolant goes to the radiator. Note that the temperatures & pressures measured by automotive type sensors are not accurate below the ranges they normally measure. Temperature sensors were designed to work between 130 and 300 degrees F. They are reasonably accurate down to 100 F but do not rely on their accuracy below that. Automotive pressure sensors typically start working accurately at around 5 psi and are reasonably accurate up to their maximum rating. The oil pressure sensor supplied with the EM2 is a 100 PSI rated sensor.

Next on the bottom line is a single character height bar graph showing coolant pressure. Top of the scale is 33 PSI. The coolant pressure is displayed in digital form for more exact readings on the Quick Check screen described later. Coolant system pressure is a key parameter as it will usually indicate a system problem long before it shows up on the temperature gauge. You can expect to see a wide range in system pressure depending on what phase of flight you are in. Unlike what you might expect, the rating of the pressure cap on the cooling system does not determine the system pressure most of the time. Study the pattern of how your coolant system pressures change during warm-up, takeoff & climb and cruise and take note of any change in that pattern. Ignore these changes at your own peril as the health of your cooling system is reflected in the pressure readings, if you know how to interpret them.

Following this is oil temperature (**OIL**) in degrees Fahrenheit. The degree symbol at the end of the number will help you remember this is a temperature reading as opposed to pressure. It should be mentioned here that automotive engine temperature sensors are designed for readings in the normal range of operating conditions. They are reasonably accurate down to about 80 degrees F. Below this point they are not particularly accurate so do not expect them to register accurate temperatures on a freezing day before the engine has warmed up. Keep this in mind when calibrating the EM2 and use a low temperature calibration point that is within the normal operating range of an automotive sensor.

Immediately following oil temperature is oil pressure (**OP**) displayed in PSI.

At the right end of the bottom line is system voltage (**VOLT**). This will be the battery voltage before the engines starts and alternator voltage when it is running. It is included on the main display because health of the electrical system is much more vital to alternative engines than with a Lycoming or other standard aircraft engine. Without electrical power for the EFI fuel pumps, engine controller and ignition coils, you are going to be an un-powered glider. When setting the alarm limits on the voltage readout, do not set the lower limit at normal battery voltage levels which can be from 11.8 to 12.6 volts. This voltage level is perfectly adequate for all the above mentioned systems but it also means that the battery is not being charged by the alternator. You want to know the first instant when the alternator quits, not when the battery is discharged. Normal alternator voltage is about 14.2 – 14.4 volts so I would suggest a low voltage alarm limit of around 13.5 volts. Depending on the amp hour rating and condition of your battery and the electrical demands of your aircraft systems, you will have between 30 and 90 minutes to land before running out of battery reserve. Note that the primary electrical power source on the aircraft is the alternator. Think of the battery as the backup power source.

### **Auxiliary Screens (center two lines)**

All control functions of the EM2 are accessed by via the 4 push button switches. Almost all in-flight operations will be with the first two switches which step up or down through the auxiliary display pages on the two center lines of the display. As shipped from the factory, Page 1 is the default page. If you have selected one of the other pages and want to quickly get back to the default page, you can press Abort (switch 3) and the display will go back to Page 1. If the EM2 was powered down with a page other than the default page, it will return to the page last selected when powered up again.

These are subject to minor changes, but the parameters assigned to auxiliary pages are shown below.

### **Page 1 (default page) - GPH fuel flow, GALons used (or remaining), Fuel pressure bar graph, MPG, Mixture bar graph, EGT bar graph.**

Page 1 is the default auxiliary screen that you will probably want selected most of the time. If you are on any of the other auxiliary screens and want to quickly navigate back to this page, pressing ABORT (button 3) will get you there without having to step through any other pages.

**Fuel flow** in gallons per hour (**GPH**) is calculated by measuring the duty cycle of the fuel injectors on EFI equipped engines or by using a Flowsan fuel flow sensor on carbureted engines. The accuracy of this reading depends on how well you calibrate the instrument. As shipped, the EM2 is calibrated for the 13B engine in our test mule aircraft N84TC. How to calibrate this and other gauges is explained later in the section on calibration.

**GAL** This is the total fuel burned (in gallons and tenths) since the last time it was set. It operates in two modes. If the user sets total fuel to zero, it will count up as fuel is burned. If the user puts in a number (typically the gallons of fuel on board), the amount will count down as fuel is burned, which will then reflect gallons remaining. How to set fuel quantity is explained in section “Set Fuel Quantity”.

If you have enabled fuel management alerts, (see Calibrating fuel flow & other functions) the fuel quantity will start to flash every 30 minutes of flight time to remind you to switch tanks, transfer fuel or whatever your aircraft fuel system calls for.

To the right of the Gallons display is a bar graph display of the fuel pressure. **Fuel pressure** is also displayed in digital form on the Quick Check screen. Fuel pressure is a mundane parameter but it can tell you a lot. First, it tells you that your pressure regulator is working but it also can tell you if your fuel filter is getting clogged long before the engine quits, or if the fuel pump is sucking air bubbles in a leaking fuel line. Again, know the pattern of your fuel pressure and pay attention to any changes. Fuel pressure on this screen is presented in bar graph form from 0 to 48 PSI. Each bar segment represents 3 psi. The pressure in most EFI systems will be about 35 PSI so the normal reading will be about 11 – 12 bars. The pressure is presented in digital form on the Page 1A (Quick Check) screen described below.

**MPG** Miles per gallon is calculated based on fuel flow and true airspeed. This does not account for either head or tail winds so it is mainly an indicator of aerodynamic efficiency of the airframe and engine efficiency. If this readout was standard in all aircraft, most pilots would slow down a few knots. Those last few miles per hour cost a lot in terms of fuel flow!

Air/Fuel **Mixture** is measured using a standard automotive oxygen sensor installed in the exhaust system. It is displayed on this page as a vertical bar graph. Low readings indicate leaner and high readings are richer. Stochiometric mixture is mid-scale, best power is about 2/3<sup>rd</sup> scale. Best economy is well below mid-scale but the exact position will depend on your engine type, altitude, engine rpm and other parameters. Some experimentation will be required to find best economy on every installation.

Using leaded aviation fuel slows the response time of oxygen sensors and this ruins them for use on automotive EFI controllers which depend on them to respond almost instantly. This does not matter for our use as a mixture monitor since it does not matter if it takes a half-second to respond. Past experience shows that oxygen sensors will last about 85 hours when run on straight 100LL aviation fuel. Occasional running on unleaded fuel will sometimes make them recover after a diet of 100LL.

**EGT** is shown in bar graph here so that you can quickly compare the balance between EGTs. 13B two rotor engine monitors show 2 bars and 20B three rotors have three. On other engines using the EC2 engine controller, there are 4 EGT bargraphs. In order to show small differences in temperature, the bottom of the scale starts at 1300 F but this can be changed for engines with lower EGTs. (See EGT offset on Pg 17). Top of the scale is 1800 F. This gives a 25 deg F change for each of the 16 bars (14 on small VFD version) in the bar graph. A difference of more than two bars under cruise conditions indicates a mixture imbalance that should be corrected.

In addition to the bars, there is a single digit displayed adjacent to the bars. This indicates which of the EGTs is the highest and is currently being displayed in digital format directly above the bar-graph.

#### **Page 1A (Quick Check Screen) CHT3 , Coolant Pressure, OAT, FP**

This page was added because there are some things you would like to check occasionally without de-selecting the default screen that you want most of the time. Page 1A is displayed when you press and hold the ABORT button (button 3) but returns to the default screen as soon as you release it. Note that since ABORT also resets the selected screen to the default screen (1), the screen will return to the default screen even if you had any of the other screens selected before viewing the Quick Check screen.

These are the items chosen for our factory test plane. CHT3 was used to measure the hot oil temperature into the oil cooler to test cooler effectiveness. Custom quick check screens with the items of your choice can be programmed at extra charge. Contact us to arrange this.

#### **CHT 3**

The 4 CHT inputs are not normally used on water cooled engine installations but I find them useful for checking things like the hot oil temperature (before the cooler) and cool water temperature (after the radiator). You can tell a lot about how the heat exchangers, air inlets and air ducting are performing by studying the temperature delta through them. They could also be used to check the air temperature rise through the heat exchangers by placing the sensors in the airstream behind them.

Once you have gotten your cooling system working well, you might want to switch the quick check screen to display fuel tank levels instead of the CHT inputs. See the section on ‘Calibrating fuel flow & other functions’ for instructions on how to do this.

**WP** Water pressure is shown on the default page (Pg 1) in bar graph form. To get an exact reading, it is shown here on the quick check screen in digital form.

**OAT** Because people like knowing the temperature outside the plane.

**FP, (fuel pressure)** This is a digital display of the fuel pressure shown on the default screen in bar graph form.

**Page 2 Air Data - MPG, Pressure altitude, Vertical speed, OAT (outside air temperature)**

MPG is same as explained for Page 1

Pressure altitude (**ALT**) is used mainly for calculating true airspeed and is not corrected for barometric pressure changes. For this reason it is not intended to be used as the primary altitude instrument in your aircraft. It should only be used as a flight reference in the event of primary altitude instrument failure. Just be aware that the reading is not reliable for judging obstacle clearance near the ground.

Vertical speed indicator (**VSI**) is displayed in feet per minute. Up or down is indicated by an up or down arrow preceding the number on VFD displays. LCD displays use a + or – sign instead of an arrow. The response time of the VSI reading is a bit slower than an analog type instrument so it is mainly for use as a backup rather than a primary flight instrument.

Outside air temperature (**OAT**) is in deg F and measured using the sensor furnished with the EM2. It should be located so that it is not exposed to anything which would heat it higher than ambient temperature. This reading is used in calculating true airspeed, horsepower and other readings so their accuracy depends on OAT being correctly measured.

**Page 3 Fuel Data -**

**Left tank gallons, Right tank gallons, GAL- Total fuel burned since reset or gallons fuel remaining, MPG**

Fuel tank levels are measured by the sending unit installed in your tanks. The unit is shipped calibrated for the standard tank senders currently used by Vans Aircraft in all their kits (Stewart Warner 385B-F). If you are using a different sender, contact us for information on calibrating it for your senders.

Total fuel (**TOT**)- This is the total fuel burned (in gallons and tenths) since the last time it was set. It operates in two modes. If the user sets total fuel to zero, it will count up as fuel is burned. If the user puts in a number (typically the gallons of fuel on board), the amount will count down as fuel is burned, which will then reflect gallons remaining. . How to set is explained in section “Set Fuel Quantity”.

As mentioned earlier, the accuracy of both fuel flow and total fuel burned will depend on how well you calibrate the instrument. When doing this, we suggest that you set total fuel to zero when you top off the tank then log exactly how much fuel you add to the tanks after the initial fill. Do not zero the fuel totalizer but let it accumulate for several tanks of fuel. Then top off the tank and add up all the fuel added since the original top off. You will use this number along with the fuel totalizer reading to calculate the error. See section on **Calibrating Fuel Flow and other functions** for more details.

MPG on page 3 is the same as explained for page 1.

**Page 4 CHT & EGT( digital)    Top line    CHT1, CHT2, CHT3, CHT4  
Bottom line    EGT1, EGT2, EGT3, EGT4**

This is a digital display of all four CHT & EGT channels. It is useful for things like closely balancing the mixture between rotors or cylinders. This page also makes it easy to see the correlation between CHT and EGT on air cooled engines.

**Page 5 Efficiency parameters - Air/Fuel Mixture bar graph (horizontal), Horsepower, MPG**

This is a handy page for efficiency freaks. You can spend a lot of hours playing with various power, mixture settings and altitudes seeing where you get the best fuel economy. This is a great way to pass the time on those long cross countries.

The only new parameter here is Horsepower. This is computed based on fuel flow and brake specific fuel consumption (BSFC). The value of BSFC is adjustable if you don't agree with the value pre-loaded from the factory. (See section on Calibration for details) If your installation has an O2 sensor for reading mixture, the EM2 will adjust the BSFC value it uses depending on current mixture when calculating HP.

### **Page 6 Auxiliary Temperatures - Air temp 1, Air temp 2, OAT, Liquid temp 2, Liquid temp 3**

This one is for experimenters or those trying to figure out why their cooling system isn't working so well. The suggested things to measure with these inputs are:

1. Air temp after radiator
2. Air temp after oil cooler
3. Coolant temp after radiator
4. Oil temp before oil cooler (The main oil temperature sensor for the Mazda rotary engine should be located AFTER the cooler.)

With a basic understanding of cooling systems and these readings you can determine the root cause of most cooling problems.

### **Page 7 Engine Data - Horsepower (HP), Percent of engine power (PWR), CHT & EGT Bar Graphs**

Many pilots are making wild guesses when they quote airspeed at a certain percent of power. This is a good reference page to use when making performance charts for your aircraft. No more guessing at horsepower or percent of power figures. Percent of power is based on fuel flow, BSFC and HP rating of engine.

This is the default page (Page 1) for the Lycoming version of the EM2 so it also has bar-graph displays of all CHT and EGT inputs.

### **Page 8 Timers -**

#### **Engine hours (HOBBS), Flight time (FLT), Hours since oil change (OIL), General purpose timer (GP)**

The Hobbs meter starts running when the oil pressure reaches 30 psi or more and shows total running time of engine in hours and tenths of hour. The flight timer (FLT) starts automatically when true airspeed reaches 30 MPH or more and reads in hours and minutes. The oil timer (OIL) shows hours of engine time since last oil change. The user must reset this timer at each oil change. General purpose timer (GP) shows minutes and seconds and can be used for whatever the pilot chooses. Possible uses might be time between check points, time to switch fuel tanks, etc. It is stopped when the EM2 is powered up. When the timer page is displayed, pressing switch 4 (ACK) starts the timer counting and pressing switch 3 (ABORT) stops it. If the ABORT switch is pressed again, the GP timer will be cleared to zero.

#### **Fuel Transfer Timer**

Rather than a fuel tank selector valve, the fuel system in N84TC uses a Facit fuel pump to transfer fuel from the right tank to the left when needed. This eliminated the need for a complex and expensive dual fuel selector valve that would switch the return fuel from one tank to the other and also greatly simplified the fuel system. The only down side to this system is that if the fuel transfer pump is left on too long, the left tank could overflow and fuel will be lost from the tank vent. If the fuel transfer timer has been enabled (see Calibration of fuel flow & other functions), starting the GP timer also starts the fuel transfer timer. When seven minutes have elapsed after starting the timer, the alarm light will flash to remind you to turn off the fuel transfer pump. The Facit fuel pump most often used for this application pumps about 30 GPH so 7 minutes represents about 3.5 gallons of transferred fuel

#### **ALARMS**

All of the main engine parameters have adjustable upper and lower alarm points. The procedure to set these limits will be covered in the calibration procedure. When a parameter exceeds its preset limit, two things happen. An (optional – user provided) alarm light will start flashing to alert you to the problem. Any panel light rated at 12V at .5 amp or less is acceptable.

To determine which parameter is threatening to ruin your day, look at the display to see which one is blinking on & off. The flashing alarm light should be big and bright enough to get your attention, but after it has served that purpose, it is a distraction while you are trying to deal with a possible emergency. Pressing the ACK button will stop it. The offending parameter will continue to blink on the display until it is within limits.

How you deal with an in-flight engine alarm will depend on the situation, your aircraft characteristics and your own experience. Unless I am climbing out after takeoff and need to clear obstacles, my first reaction to any sign of engine trouble is to reduce power to the minimum required for level flight. Opinions on this will vary greatly but in my experience, this will maximize the amount of time you have to deal with the problem in the event that the alarm is warning of something you can't fix while in-flight.

#### **CALIBRATION & ALARM LIMITS**

This is a section usually not found in engine monitor instruction manuals. Because the EM2 was designed with the 'bleeding edge' of experimental aircraft builders in mind, field calibration capability was added. The EM2 comes from the factory pre-loaded with calibration constants suitable for the recommended VDO engine sensors so if you are using these, you may never have to worry about calibration. But the EM2 can also be re-calibrated for use with a wide range of other sensors if your engine happens to be equipped with others. Another advantage is the ability to calibrate it more accurately since automotive sensors are often not as

consistent as instrument grade sensors. Another reason for not skipping this section is that the upper & lower alarm limit settings are in the calibration table.

Calibration is mainly intended for matching the EM2 with alternate automotive sensors used for water and oil temperature or pressure. Other sensors such as the RWS air temp sensors, CHT & EGT thermocouple sensors virtually never need calibration because they are industry standardized and very consistent.

### ***Other possible uses for calibration***

You may have an aircraft that has different fuel tank sensors than the standard Stewart Warner sensor the EM2 is calibrated for. Or you may have a third fuel tank that you want to monitor. It may be possible to use one of the auxiliary air or liquid temp inputs for this if you calibrate that channel appropriately. In addition to recalibration, it may be necessary to add an external pull-up or pull-down resistor to the input in order to get it working right. It isn't practical to include directions for setting up the EM2 for every conceivable sensor out there but if you will email us a request for help in setting up a particular sensor, we will be glad to assist you.

### **Custom display screens**

As in the additional fuel tank example above, it would be nice if the on-screen label matched the new function. It is not possible to change this in the field but if you want customized screen labels (or entirely new screens), we can offer this at a reasonable price. Contact us via email for more details if needed.

Before we get into the details of calibration, it should be pointed out that you will need a reasonably accurate reference instrument in order to compare it to what the EM2 is reading. For temperature functions, the easiest reference is a non-contact IR (infrared) thermometer. These instruments read the temperature of any surface simply by pointing it at the surface in question. This eliminates the need to swap (or add) a sensor for a reference instrument into the point of interest. These are now available for very reasonable prices (around \$50.00) and have many uses. Be aware that the color of the surface to be measured can affect the accuracy of the reading. The ideal color is flat black so I would suggest painting a small flat black spot on the places you expect to be measuring. We use a model IR201 EXTECH brand IR thermometer here at RWS which are available at several sources. A web search should turn up one handy to you.

### ***The "GUTS" of Calibration***

Calibration constants are stored in a non-volatile memory table containing 26 groups of 4 parameters, one group for each of the 26 sensor channels. The first two parameters in each group are the ones that match the EM2 with the sensor. The second two parameters are the low and high alarm limits.

The best way to learn and understand this sort of thing is to go through an example of calibration. The main calibration mode is activated by holding down the ABORT button then press UP. The display will switch to calibration mode. The top line will display instructions on what to do next. At this point it should read "SELECT CHANNEL" followed by the current channel number "0". To help you navigate through this rather tedious procedure, the description of the current channel is displayed on the bottom line, in this case it will read "COOLANT TEMPERATURE".

If this was not the parameter you wanted to calibrate you would press the up or down buttons to step through the channels. The number on the top line will change along with the description below.

For this example, let's say we want to calibrate the coolant temperature channel. To select the currently displayed channel, press the EXECUTE button (button 4). The top line will now change to read "SELECT PARAMETER" followed by a parameter number 0 – 3. Each channel has four (4) parameters (0,1,2 &3) that may be adjusted. They are:

- 0 SCALE FACTOR
- 1 LOW END OFFSET
- 2 SENSOR OFFSET (Channels 0 – 15 only, not used on all channels)
- 2 LOW ALARM LIMIT
- 3 HIGH ALARM LIMIT

When you are at this stage in the calibration screen (selecting the parameter to adjust), the description of the parameter being displayed is shown on the bottom line of the display.

### **SCALE FACTOR, LOW END OFFSET and SENSOR OFFSET explained**

The first three are non obvious and will require some explanation. The computer in the EM2 reads all sensor channels as a voltage which is converted to a number between 0 and 1023. This is called the raw sensor data. Since we want to display the sensor data in a form that is meaningful to humans, the raw data must be converted to familiar units such as degrees Fahrenheit, PSI, miles per hour, etc.

For example, if our oil pressure sensor gives us full scale voltage output at 100 PSI, the computer would read this as the number 1023. To scale this down to the value we want (100 PSI) we divide (or multiply in some cases) the raw sensor reading by the proper factor which we would calculate as  $1023 / 100 = 10.23$  which we call the scale factor. So, when the computer reads the oil pressure channel and gets the raw number 1023, it divides it by the scale factor 10.23 and Voila!, gets 100, our oil pressure in psi.

### **If only life were that simple**

If things were that simple our job would be done but, as in most of life, it isn't. Many sensors, especially automotive ones, do not give zero output at zero pressure or temperature. So, another calibration factor, SENSOR OFFSET, is used to correct for this offset at a defined point, usually near the bottom of the sensor's range. For example, if the sensor gives a raw data value of 50 at zero psi of oil pressure, the SENSOR OFFSET would be subtracted from the raw sensor data before being scaled with the SCALE FACTOR.

In the case of automotive temperature senders, their minimum usable temperature is well above zero so a higher reference point is used for the sensor offset, typically, 130 deg F. After subtracting the sensor offset and scaling, The remaining factor LOW END OFFSET is then added to the final result to give the actual reading. Note that not all sensors require the sensor offset factor. If not used, the sensor offset is loaded with zero.

If you use the recommended sensors, you probably don't need to worry about this because the proper values have already been installed but if you are using different sensors, this information will come in handy. As mentioned earlier, automotive sensors are not as consistent as laboratory grade sensors. If you have an accurate reference and want to calibrate the EM2 to the individual sensors on your engine, this information will help.

### **HOW TO ADJUST PARAMETERS**

Now that you understand the way that the scale factor and low end offset affect the result, lets continue on with the mechanics of how to adjust these parameters. We left off in our example of calibrating the coolant temperature screen at the point where we had the SELECT PARAMETER prompt displayed on the top line followed by the number of the parameter (0 – 4). The bottom line has a description of the selected item to help you navigate through the procedure. Also note that the current value of the parameter is displayed on line2. Input the amount of change (displayed on line 1) to the selected parameter by pushing the up or down button.

Lets say we want to adjust the first parameter (0) which is the scale factor. With this parameter displayed, push the ACK (button 4) and the top line of the display will prompt you with a request to INPUT CHANGE followed by a flashing cursor. Since we do not have a keyboard to enter numeric data, changes are made to floating point numbers (numbers with a decimal point) like the scale factor by selecting a percentage amount. To input the desired change, press the up or down buttons to display the desired percentage of change. Each press of the up or down button increments the displayed change amount by about .5%. (1/2%). Normally, .5% is as small a change as is ever necessary. If you want to change a parameter by less than .5%, you can do this by changing it in the direction you want to go by 1 or more percent then changing it back in the other direction by the same amount. You will not be back at the same number because the value of the second change will differ (by a small amount) than the first change.

Once you have selected the amount of change you want, press the execute button (button 4) to execute the change. The new value of the parameter will appear at the left end of line 2 to show the result. On line 3, the new reading on the channel being calibrated will be displayed. Note that some functions will not have this feature and it will be necessary to exit the calibration screen (Abort) and check the new reading on the normal EM2 display. Assuming that you have the input being calibrated hooked to a known pressure or temperature (or whatever you happen to be calibrating), you can decide if it needs further adjustment. If it does, the blinking cursor is now back at the top line urging you to try again.

### **I'm finished calibrating (or I'm hopelessly lost)**

If the reading you are calibrating is now satisfactory, you can press ABORT (button 3) and the EM2 will go back to normal operation. Or, if you are totally confused and want out of the calibration mode without making any change (assuming that you haven't already made a change by pressing the ACK button, you can push ABORT at any time and the EM2 will return to normal operation.

### **Want to calibrate more accurately or Using Different Sensors?**

Automotive sensors are not as consistent as lab grade sensors so there will be some variation between sensors of the same rating. If you wish to calibrate the EM2 to give more accurate readings with the sensor in use on your engine, use the following guide to make the necessary changes. When doing this, you should use an instrument of known accuracy to verify your calibration accuracy. On temperature channels, you can use one of the air sensor input channels on the EM2 to compare with the channel you wish to calibrate. The RWS air temperature sensors are inherently accurate over their operational range and generally require no calibration. Note that Aux air temp 2 channel is usable up to 270 degrees F and that the OAT and Aux air temp 1 are only usable up to 140 and 190 degrees F respectively.

If you are using a different brand sensor than the one recommended, there is a good chance you can calibrate the EM2 to work with it. This assumes that the sensor in question is of the same basic type. For instance, you can't substitute a capacitive fuel tank sender for a variable resistance type and get it to work. Most any sensor that varies a resistance or puts out a variable voltage can be made to work on the EM2. Some builders have reported that there are converters available to give a voltage output from capacitive fuel level sensors.

### **CALIBRATING FOR A NEW SENSOR**

Setting the calibration parameters for a new sensor is done in the reverse order that they appear in the list, sensor offset first (if used), low end offset, then scale factor.

#### **Editing the SENSOR OFFSET.**

Sensor offsets are integer numbers which are edited in the same way as high and low alarm limits (explained below). You will note that when the sensor offset parameter is displayed, the current raw sensor reading is also displayed directly underneath the offset. To set sensor offset, have the temperature or pressure at a known point at the lower end of the scale that you want to measure. Now set the sensor offset to the same value as the raw sensor data. Raw sensor data is displayed on the line reading "CH ADC = xxx". For example, adjust the airspeed sensor offset to exactly the same value as the current sensor reading when your airspeed is zero.

#### **Editing the LOWEND OFFSET.**

After setting the sensor offset, set the low end offset to the same temperature or pressure that you used for the sensor offset point. Low end offset is a floating point number so it is edited in the same way as Scale Factor described above. Note that the low end offset should be the same temperature or pressure that was chosen for the sensor offset point.

#### **Editing the SCALE FACTOR**

After you have the reading correct at the low end calibration point, get the temperature or pressure set at a known point near the high end of the desired range. Now adjust the SCALE FACTOR to get the readout at the current known value.

#### **VDO temperature sensor calibration values.**

We have shipped two different temperature range VDO sensors at various times. Both work equally well but they require different calibration values. You may wish to install additional sensors which may be of the other range so the following calibration values may be useful.

Sensor	Scale Factor	Zero offset	Sensor offset
250F/120C VDO	2.111	100.0	390
300F/150C VDO	2.024	100.0	435

### **EDITING LOW AND HIGH ALARM LIMITS**

Most EM2 users will not find it necessary to use the calibration screen for calibrating sensors but most everyone will need it to set the alarm limits. This is done in the same way but when selecting the parameter to edit, select the low or high alarm limits (parameter 3 or 4) at the SELECT PARAMETER prompt and then press ACK. All will be the same as when editing the scale factor and low end offset except that the numbers will be fixed point (no decimal point) rather than floating point. When the INPUT CHANGE prompt is displayed, the up and down buttons (1 & 2) will step the change value up or down by units of 1 instead of a percentage value. The change must be in the range of + or - 127. If you need to make a larger change than this, do it in two or more steps.

Note that there are a few quirks on some of the limit settings. The Voltage limits are entered as the value you want the limit set at multiplied times 10. For example, if you want the lower limit set to 13.5 (thirteen and ½) volts, you would enter 135.

Note that when in calibration mode, if the up or down buttons are held down more than 1 second, the change value or parameter will step up or down at a rate of 10 counts per second. This makes it easier to set large values. After you have set the change

value you want, press ACK (button 4) to execute the change to the selected parameter which (shown on the bottom line to remind you). The new value will be displayed on the left side of the second line to confirm the change. The blinking cursor will return to the top row to prompt you for another change if needed. If you are happy with this setting, press ABORT (button 3) to return to normal operation.

**Manifold Pressure alarm limit.**

Setting this parameter is different than the other alarm limits. This one is set in the calibration constants described below.

### Calibrating Fuel Flow and other functions

Calibration data for fuel flow and various other readouts are accessed on a different screen. These have only a single calibration variable so they are stored in a separate list and accessed on a different screen. This screen accessed by holding down cancel/abort button (3) and pressing button 2 (Down).

The following is a list of these variables and their functions.

Table #	Name	Default value	Description
0.	BSFC	.55	Pounds of fuel per hour burned per horsepower produced.
1.	WTSOURCE	0	Source channel used for coolant temperature 0 = VDO sensor, 1 – 4 = CHT 1 – 4
2.	MAX HP	1.869	Horsepower rating of engine divided by 100 (engine rating in N84TC is default)
3.	OTSOURCE	0	Source channel used for oil temperature 0 = VDO sensor, 1 – 4 = CHT 1-4
4.	STAGE COMP	.85	Staged injection fuel flow compensation
5.	FF CONSTANT	1800	Constant used in calculating fuel flow (do not edit)
6.	FF CAL	151	Constant for calibrating Fuel flow (calibration value for N84TC)
7.	O2 sensor	1	0 if not installed. Set to 1 if O2 sensor connected to EM2.
8.	CHT OFFSET	300	Base of CHT Bar graph displays
9.	EGT OFFSET	1300	Base of EGT Bar graph displays
10.	Display in use	0	Set to 0 for large VFD, 1 for small VFD, 2 for LCD
11.	Turbo	0	0 = normally aspirated engines. Set this parameter to 1 if your engine is turbocharged
12.	MAP high alarm	50.0"	High alarm limit for manifold pressure
13.	Quick Check screen	0	1 = L & R fuel levels instead of CHT 3 & Coolant pres. on Quick Check screen
14.	Fuel Alert Enable	0	0 = disabled Set to 1 to enable alert every 30 minutes as a fuel management reminder.
15.	Fuel Transfer timer	0	0 = disabled. Set to 1 to enable. See section "Page 8 Timers" for details.
16.	Tach Calibration	572	Preset at factory, do not adjust.

Selection and editing is similar to the calibration procedure. Select the table address you want with the Up & Down buttons. The table address is shown on the bottom line and the current value on line 2. Press Execute (4) to select the displayed table entry number. You will then be prompted to INPUT CHANGE on the top line using the Up & Down buttons. Floating point numbers are edited by selecting the percentage of change (up or down) that you want to make to the entry. Fixed point numbers are edited by inputting the number you want to add or subtract from the current value. When you have set the change you want to make, press Execute (4) to execute the change.

Note that there is no description shown for the table address during this procedure so you will want to make a written list of the table entries shown above. Make sure you have selected the address you want before editing. It gets really confusing when you have changed the wrong address. It's also a good idea to keep a written record of your table address values so you can restore the data should the worst happen anyway.

### Table Address Descriptions

#### 0 - BSFC

Break Specific Fuel Consumption This variable defines the average efficiency of the engine and is used to calculate things like HP output and percentage of power. All internal combustion gasoline engines have an average BSFC of around .55. It is a bit lower when running lean mixtures and a bit higher when running at best power mixtures which are much richer. The EM2 uses this entry as the average BSFC and either adds or subtracts a bit when it calculates horsepower depending on fuel mixture being measured by the O2 sensor (if installed). It uses the default value as-is if no sensor is installed.

#### 1. WTSOURCE

This variable defines what input channel the EM2 uses for the main engine coolant temperature. The default setting for this is zero, which selects the VDO water temperature sensor channel. This is what most users will use since most engine installations will have a convenient place for a threaded automotive type sensor. You may also select any of the 4 CHT channels by setting this variable to 1 – 4 if a thermocouple type sensor is more suited to your installation. For example, the engine installation on N84TC uses a CHT sensor bolted to the waterpump housing to sense water temperature.

#### 2. MAXHP

This is simply the maximum HP rating of the engine you are using divided by 100 (1% of engine rating) The EM2 uses this variable when calculating percentage of power output. It's up to you to set this at a realistic number for your particular

installation. It comes from the factory set with the rating of the 13B installed in N84TC, our beloved company test mule aircraft (and winner of the 2003 SUN 100 air race, category 8).

### 3. OTSOURCE

This variable defines where the EM2 gets the main engine oil temperature reading from. It works just like #1 WTSOURCE described above except that 0 selects the VDO oil temp sensor channel.

### 4. STAGE COMP

This variable is used by the EM2 when calculating fuel flow when the EC2 it is connected to is staging. Staging means that only two of the 4 injectors are being used. When this happens, there is a non linearity in the fuel flow that creates an error in the flow calculation. In the case of N84TC, the fuel flow reading would read about 15% too high when staged so this variable was set to .85 to correct for that error. You may have different results depending on the injectors used and many other factors. If you note a sudden change in fuel flow when very slowly moving the throttle at the staging point, you may have to adjust this variable to suit your engine. When properly set, the fuel flow should have a linearly reducing value as the throttle is slowly increased or decreased around the staging point. The default staging point on the EC2 engine controller is 15.5" Hg manifold pressure but be aware that this parameter is user programmable in the EC2 and may have been changed.

### 5. FFCONSTANT

Way too much to explain and it is not meant to be changed, so don't. If you accidentally do, set it back to 1800.000

### 6. FF CAL

This one is used to calibrate the fuel flow and fuel totalizer functions. It may need changing depending on what fuel injectors you use, fuel pressure regulator, etc, etc.

Recommended method of setting this is to clear the fuel total on EM2 and top off your tanks. Then fly off at least two tanks of gas while keeping track of all fuel added to tanks. Then top off tanks and compute the total amount of fuel used. Now compare this to the fuel total on the EM2 and calculate the percentage of error. If the EM2 total is higher than actual fuel used, increase FF CAL value by the percentage of difference. If it is lower, reduce the value of FF CAL by this percentage. If you do this several times, you can achieve accuracies of better than 1 %.

**7. Mixture Monitor**      **0 = O2 sensor not installed, 1 = installed**      Set to 1 if you installed one of these in your exhaust system. I highly recommend that you do.

**8. CHT OFFSET**              **Sets base of CHT bar graphs**

**9. EGT OFFSET**              **Sets base of EGT bar graphs**

These variables are used for the bar graph displays of CHT & EGT. The offset defines the starting temperature at the bottom of the bar graph. CHT temperatures below 300 are usually of no interest. There is normally no need to change any of these settings.

**10. DIU (display in use**    **0= large VFD, 1 = small VFD, 2 = LCD**    Don't change this unless you are retrofitting the EM2 with a different display.

**11. Turbo**              **0 = normally aspirated engine, 1 = turbo engine**

10 & 11 are set at factory and no change is necessary

**12. Manifold Pressure high pressure alarm limit.** Turbo or supercharged engine operators will want to enter an appropriate value for this level. The units used are inches of mercury. It comes preset to 50.0" Hg. Normally aspirated engines will normally not need an alarm limit set since they normally never exceed atmospheric pressure (30.0" Hg at sea level).

### FUEL & TIMER SETTINGS

This is where you will set fuel status, oil timer and HOBBS meter. Enter this screen by holding down button 1 (Up) and pressing Abort. The procedure is again similar to the other user setting screens. Select the function you want to adjust by pressing Up or Down. The description on the bottom line will remind you of the function.

**1. SET FUEL QUANTITY.** This is usually done whenever you add fuel to your tanks. There are two ways to use the fuel totalizer function. If you clear the fuel quantity to 0, the totalizer will count up as fuel is consumed to show total fuel used since reset. This is what you will want to do when calibrating the fuel flow function. To clear the total to 0, press button 3 (Abort). Unlike other situations, pressing Abort at this time will not return to normal EM2 operation, it only clears the fuel added to zero.

If you want to return to normal operation from this point, press Execute to confirm that you want to clear fuel total to zero, then press Abort to return to normal operation.

The second way to use the totalizer is to set the number of gallons of fuel on board. Do this by pressing Up to increment the amount you want to add to the fuel total (displayed on line two). To make this easier, remember that it will rapidly count up (in tenths of gallons) if you hold down the Up button. If you overshoot the number you wanted, press Down to decrement it to the proper value. Then press Execute to add the fuel to total. Now press Abort to return to normal operation.

If you set a fuel quantity rather than resetting to zero, the fuel total will count down to reflect gallons to empty. This assumes, of course, that you set the total to accurately reflect the actual number of gallons aboard and that you have accurately calibrated the EM2 to your engines fuel consumption. The total in all tanks is shown so it is still up to you to do proper fuel management by switching tanks at the appropriate time.

## 2. CLEAR OIL TIME

Select this item whenever you change the engine oil. Pressing Execute will immediately clear the oil hour timer so don't select this item unless you really want to clear it. After clearing, press Abort to return to normal operation.

## 3. SET HOBBS TIME

After selecting this item, press Up or Down to enter the appropriate number of hours on the HOBBS meter. Press Execute to record the number. Abort gets you back home again.

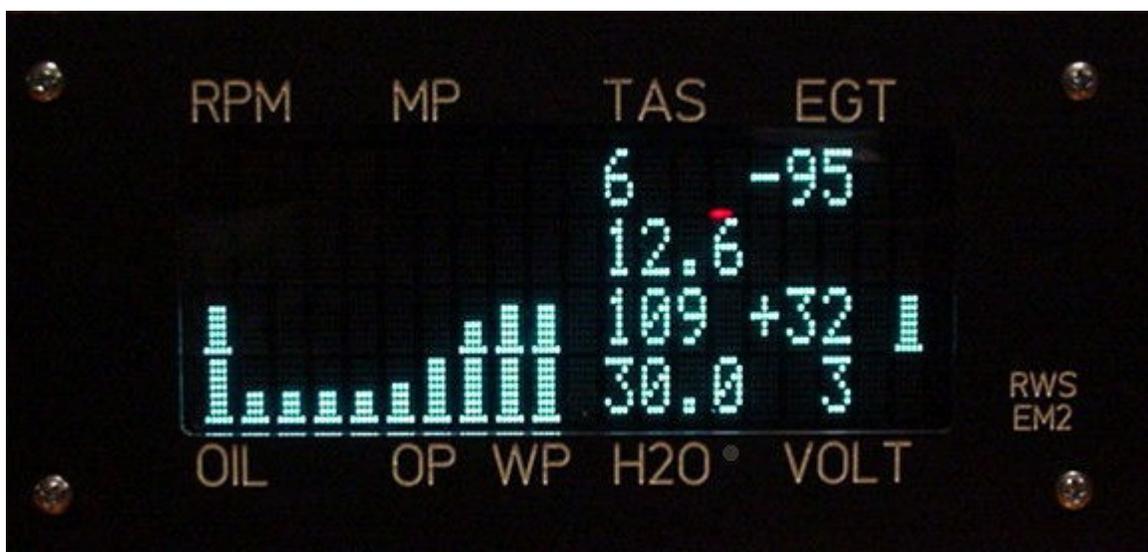
## EC2 Manifold Absolute Pressure (MAP) TABLE SCREEN

This screen applies only to EM2s used with an EC2 engine controller. Note that in order to use this screen that the EC2 must be updated with a software version dated 01-10-04 or later. Email or call us about updating your EC2 software if necessary.

The main purpose of this screen is to let you see how the MAP tables are setup and to make any corrections that might be needed. Note that using the EM2 also allows you to make adjustments to the EC2 MAP table without having the engine running, something that is not possible with the EC2 alone.

In the EFI world it is common to refer to the procedure of tuning the engine controller as "Mapping the engine". This does have some relationship to the MAP table referred to in this guide but it is not synonymous. Always remember that MAP in this discussion refers to Manifold Absolute Pressure, which is the key parameter which determines which number in the table of mixture correction values (hereafter called MAP table) is used to correct the mixture. Review the EC2 guide for a fuller explanation of how the engine controller works.

To enter this mode on the EM2, hold down Abort (3) and press Execute (4). You should see something like the following display.



## Understanding the MAP table screen

The display will show 10 vertical bar graphs on the left and 8 numeric values on the right. The bar graphs represent 10 of the 128 values stored in the EC2 MAP tables.

### **The Editing area**

The top two lines on the right show the selected MAP table information. The upper left number is the MAP table address that is selected for editing by the EM2. Note that the MAP table address starts at 0, not 1. Computers always start counting at 0. To the right of the address is the data contained in that address. Just below the address is the manifold pressure in inches Hg that corresponds to the MAP table address. Although not shown in this photo, to the right of the manifold pressure on line 2, the current static ignition timing adjustment for the EC2 is displayed. This value can be adjusted from the EC2 in mode 8. See Mode 8 in the EC2 setup guide for details.

Note on the left side of the screen that one of the bar graph columns is blinking. This corresponds to the MAP table entry selected for editing. We'll get back to how to edit the MAP table data in a moment but first let's complete our tour of the data presented on the right side of the display

### **The EC2 data area**

The lower two lines on the right side of the display show a MAP table address and data in exactly the same format as described in the editing area. The big difference is that these values are the ones currently being used by the EC2 to control the engine. This is real time data so if the engine is running, you will see the MAP table address and manifold pressure change when the throttle is changed. You can't edit the data displayed here but you can use it to identify where you need to set the editing address on the upper two lines in order to correct a mixture problem.

To the right of the manifold pressure on line 4 the current staging status of the EC2 is displayed (just above the "V" in VOLT). If the EC2 is staging (only 2 primary injectors being used) an asterisk (\*) will be displayed. It will be blank if not staging. This can be useful when tuning the EC2 near the staging point to determine where the staging point is and which side of the staging point needs to be adjusted.

To the right of the staging indicator, the current setting of the EC2 Injector Flow Rate value is displayed. This will be a number between 67 and 255. This is the parameter which is adjusted using Mode 3 on the EC2. It displayed for information purposes only and cannot be adjusted from the EM2.

### **Mixture Display**

The final item on the screen is a single bar graph on the far right side of the display. This is a real time display of the mixture. It is the same as the mixture bar shown on the main instrument display. This allows you to see whether the mixture is too rich or too lean in a problem spot. The mixture display is valid only when the engine is running because it depends on the gases sensed by the O2 sensor in the exhaust system. O2 sensors only work when heated to around 800 deg. F or higher.

### **Editing the MAP table**

To select a MAP table address other than the one currently selected, push the UP button to increment it. The new selection will now blink on the bar graph and the address and data fields will now show the new selection. To decrement the MAP table address, push the DOWN button. If you want to rapidly increment or decrement the address, press and hold the UP or DOWN button. After a second, the address will rapidly step at a 10 step per second rate. The display is updated every 1/2 second so you will not necessarily see every address as it is incremented. If you step past the address you want, just single step back until you get the desired address.

The EM2 display only shows 10 of the 128 MAP addresses on the bar graph display. The selected address is usually shown in the center of the bar graph area. As you change the MAP address, the bar graph will scroll left or right to keep the selected address in the center. The bar graph display is useful because it allows you to see the relative values around the target which can often give you a clue as to where a problem may lie.

Values in the MAP table are in the range of -127 to +127 with a value of 0 being the center of the range. On the bar graph display, -127 would be shown as single line at the bottom of a bar graph. +127 would be a solid bar 4 rows high. Zero would be at half scale (2 character high bar). Remember from your EC2 guide that 0 represents no MAP table correction to the mixture. A negative value adjusts the mixture lean and a positive number adjusts the mixture richer.

### **Dual MAP table**

As already stated, there are 128 addresses in the MAP table. The lowest address (0) corresponds to the lowest manifold pressure and the highest address corresponds to the highest manifold pressure. Since engines do not run at zero manifold pressure (perfect

vacuum) the MAP table address zero starts at about 10" Hg, which is the lowest manifold pressure that engines will normally run at.

You also need to be aware that the MAP table is actually split into two separate tables. Addresses 0 to 63 are called the low RPM MAP table (used at engine rpms between 0 and 2800) and addresses 64 – 127 are called the high RPM MAP table, used at engine speeds above 2800 rpm. Here is a brief explanation of why 2 are needed.

It is possible for the engine to see a low manifold pressure under two very different conditions. The first is when idling. At idle, the manifold pressure is in the range of 11 – 13" Hg. When on the ground with a propeller load, the manifold pressure will always be considerably higher when the engine is running at a higher rpm than idle (typically 1000 – 1700 RPM) The low RPM MAP table will cover this operating condition and is easily adjusted on the ground.

When in-flight, the engine can see a very different condition. If the aircraft is cruising at high altitude or is descending at low throttle, the engine will now be able to run well above 2400 rpm even at low manifold pressures. The mixture correction for this condition may be significantly different than what was called for at low rpm. The selection of which MAP table the EC2 uses is automatic and requires no action from the pilot.

### Using the MAP table screen

There are several ways the MAP table display can be used to make tuning the EC2 easier. One way is to view the map table screen during operation of the engine and note the MAP table address where any mixture anomaly occurs. You may not be in a position to make adjustments to the EC2 at that time but you can go back later (while safely on the ground) and make appropriate adjustments to the MAP table. If you are in a situation where you can make adjustments while in-flight, using Mode 9 on the EC2 while watching the mixture monitor on the EM2 is probably the best way.

Making adjustments to the MAP table using the EM2 is similar to using Mode 9 on the EC2 so you should refresh your memory by reviewing that section of the EC2 guide. Let's say that during flight you noticed the engine was running too rich when the manifold pressure was at 20.4" Hg. Later, you can set the manifold pressure in editing field to this reading and see the MAP address and data at that location and visually compare it with surrounding MAP addresses. Remember that there are two addresses that correspond to 20.4" Hg manifold pressure, one in the low rpm map table (0 – 63) and one in the high rpm map table (64 – 127). Be sure you are selecting the right one to edit. If it was a setting you noticed while in-flight, it is likely to be in the high rpm table.

Note that you can't set the manifold pressure in the editing area directly, but you can select the map address that corresponds to that manifold pressure. In this case we find that 20.5" Hg correlates to MAP table address 88 (in the high rpm table). You should also note that each MAP table address is used over a range of about .45" Hg of manifold pressure. The manifold pressure displayed in the editing field is about the center of the range so it may not exactly match the manifold pressure you recorded earlier but it will be within about .2" of it. Select the MAP table address that most closely matches the target manifold pressure.

### What should the data look like?

Many times it will be obvious from the visual bar graph display that the address in question is out of whack. A properly set up MAP table will show a smooth curve, a linear ramp, or a straight line, depending on the area being looked at. If the bar graph shows a large step on either side of the suspect address, it is probably set improperly. For this example, if MAP table address 87 was -58 (bar graph about 25% high), our target address 88 was +35 (about 65% high) and address 89 was -60 (down to 25% high), this, along with your observation that the engine was a bit rich at address 88, would leave little doubt that 88 was too high. In a situation like this, you would probably want to adjust 88 to a value around halfway between address 87 and 89's value, i.e. something around -67.

### Exceptions to the rule

Even though most of the MAP data will look like the description above, don't automatically assume that a large step in the data is bad and change it. There are a few areas where this may be normal. One is around idle, where the mixture requirements of an engine can change rapidly. The other is around the staging point where the engine switches from running on only 2 injectors to running on all 4. The EC2 is usually set to stage around 15.5" Hg. This of course only applies to engines like the 13B & 20B rotary which have more than one injector per rotor. In general, if the engine runs well and the mixture stays fairly stable in the area where you notice a large step, it's probably the way it should be.

### Making the adjustment

Let's say that you have determined that an adjustment is definitely needed at our target address of 88. To make this adjustment, first select MAP address 88 on the EM2 then set the program knob on the EC2 for a small negative adjustment (between 9:00 and 11:00 O'clock). It is not necessary to select any particular program mode on the EC2 mode switch. In fact, it is a good idea to

leave it on mode 0 which locks out any direct programming on the EC2. Press execute (button 4) on the EM2 (not the program button on the EC2) and address 88 will be adjusted down by an amount proportional to how far left of 12:00 you set the EC2 program knob. If it wasn't far enough, push execute again and address 88's data will be reduced again. If you overshoot the point you wanted to set, set the EC2 program knob for a small positive adjustment (1:00 – 2:00 O'clock) and push execute. With a little practice this will become intuitive and automatic.

Note that you could in fact make changes to the MAP table by using the EC2 in program mode 1 or 9, even while the EM2 is monitoring the MAP table. Just be aware that it will edit the MAP address shown in the real time display area (lower two lines) and not the address in the editing data area on the upper two lines. The real time data will change to reflect the programming done on the EC2. If the editing table address is close to the real time EC2 table address you will also see the change reflected on the bar graph display. There may be occasions when this might be handy.

### **Track Mode**

Sometimes it can be useful to display the MAP table address and surrounding addresses associated with the real time data used by the engine as it is running. Track Mode allows you to do just this. Track mode can be entered only after you have already selected the MAP table display screen. Once there, you can enter track mode by holding down the Up button (1) and pressing Down (button 2). The editing fields on the top two lines will now change to read the same values shown on the real time engine data fields on the bottom 2 lines. The main difference is that the bar graph display now shows the MAP table address in use by the engine at the blinking bar, in other words, the selected MAP address at the blinking bar “tracks” with the EC2 selected MAP address. As you change the throttle, the bar graph display will scroll up or down to keep the operating MAP table address in the center under the blinking bar. The data on the right side of the screen will also change to reflect this. Now that the EC2 selected MAP table is in the editing field, you can edit it just as you did when the EM2 was in control of the editing field. Just keep in mind that the throttle position now selects the MAP table address, not the EM2. Pressing the UP or Down buttons while in track mode will have no effect on the selected MAP table address.

To exit track mode, again hold down the UP button (1) and press DOWN (2). The EM2 will now return to the normal MAP table display screen and you can again control the MAP table address edit field with the UP and DOWN buttons.

Once you are finished displaying or editing the MAP table, press ABORT (3) to return to normal EM2 operation.

If you spend some time viewing the MAP table in Track mode while the engine runs, you will soon gain an intuitive understanding of how this screen works and the effect that the MAP table has on mixture. Just to refresh your memory of the EC2 installation guide, the object of MAP table tuning is to have the mixture (as shown on the mixture monitor) remain the same at all throttle settings. Turbo charged engines are an exception. When under boost, the mixture should be richer in order to avoid detonation. Keep in mind that it is a normal characteristic of all engines to require a richer mixture at idle than at mid or high throttle settings. At high RPM the engine can be run at mixtures so lean that they are off the bottom of the mixture display but the engine will stop abruptly if you attempt to run this lean at idle.

### **Auto Program Mode** (applies only to engines equipped with an EC2 engine controller)

A newly added feature of the EM2 is Auto Program mode. Auto program is intended to take most of the work out of fine tuning the MAP table in the EC2 engine controller. In order to work, the EM2 must be connected to an O2 sensor installed in the engine's exhaust system. It also works only with the engine running.

It is absolutely mandatory that you try this on ground and verify that everything is working properly. Enable auto program in flight only after you are sure it is working properly on the ground. It is also suggested that you have the EC2 tuned well enough for the engine to run reasonably smooth over the full range of throttle settings.

To use Auto Program Mode, follow the steps below.

1. Make SURE your mixture monitor is functioning normally before invoking auto program mode.
2. Set Mode 0 on EC2
3. Select EC2 MAP table mode on EM2. (Hold Abort button (3) and press Ack (4))
4. Select Track mode (Hold UP button (1), press DOWN button (2))
5. Verify that EM2 MAP display is tracking engine.

6. Set mixture control on EC2 to midpoint (12:00) or as close to this as possible with engine running smoothly at a mid to low throttle setting (about 19" MAP). Keep the manifold pressure constant during the initial test.
7. Set the Program knob on EC2 to 12:00. In Auto Program mode, this sets the target mixture point that auto program attempts to adjust the mixture to.
8. Select Mode 9 on EC2. This is the final step which enables Auto Program mode.
9. Watch EM2 display and verify that MAP table is being adjusted to bring mixture bar near mid point. In Auto Program mode, the Program knob on the EC2 panel sets the mixture target that the EM2 will attempt to adjust the mixture to. When the Program knob is at 12:00, the target mixture will be about mid point on the mixture monitor which is about 14.7 to 1 mixture ratio (stoichiometric). If Auto program is working correctly, the mixture should go to this point. Programming occurs slowly in small steps so don't expect the mixture to instantly change to the target point.

On turbocharged engines, you will want to increase the setting of the Program knob when Auto Programming above 32" Hg. The higher the manifold pressure, the higher you should set the Program knob. Prior to starting Auto Program mode, you may want to preset the high end of the MAP table to a richer setting to avoid detonation.

We cannot advise you on the proper mixture for all possible engines. The normally aspirated rotary engine can be safely operated at full throttle at stoichiometric mixture but this may not be true of all other engines.

Note: Only the currently selected MAP table entry is adjusted. Adjustment occurs slowly and gradually. Observe the MAP table data field to see that it is being adjusted. The setting is adjusted at around once per second and each step is + or - 2. Once the mixture is at the target point, Auto Program stops adjusting the MAP table.

10. When current MAP table address is adjusted to the target point, change throttle position slightly to move the edit point to a new MAP table address. Wait until the new address is adjusted properly before moving on to the next MAP table address with throttle position. Continue this procedure until the full range of throttle settings has been adjusted. Be sure the airplane is tied down before starting. It may take about 10 minutes to go through the full range depending on how far out of adjustment the MAP table was. If the engine reaches maximum temperature before this procedure is complete, stop auto program mode and let the engine cool down. Note the point at which you stopped auto programming and resume Auto Programming where you left off when you restart the engine.

11. Auto Program is disabled when any of the enabling factors are removed (EC2 Mode 9, Map table display on EM2, Track Mode enabled, engine running)

If much of the MAP table tends to be adjusted toward the Lean end (bottom) or the MAP table is adjusted at full lean and the mixture is still too rich, this indicates that the injector flow rate needs to be reduced. (See Mode 3 instructions on EC2) The inverse is true if you run out of range on the rich end of MAP table.

After Auto Program mode has done it's best to optimize the MAP table on the ground and you are confident that everything is working as expected, you can then run Auto Program while in-flight. I would not recommend enabling Auto Program mode until you have leveled off at a safe altitude and can pay close attention to the procedure.

### **Turbo charged engine considerations**

Turbo charged engines require a richer mixture when on boost in order to avoid detonation. On turbo engines, Auto Program the MAP table up to about 32" of manifold pressure with the Program knob set at 12:00. Above this point, I would suggest adjusting each MAP table address above the last one programmed with a successively richer setting by turning the Program knob clockwise until the entire table is filled. The MAP table will look like an up-sloping ramp after 30" MAP on the EM2 display. This is only a general guideline. The exact mixture required at various boost pressures depends on many factors and is a far more complicated subject than can be covered here.

**Summary of Calibration and Setup screens and how to select them:**

OPERATION MODE	HOLD DOWN	then	PRESS & release	DESCRIPTION
MAIN CALIBRATION	Button 3 (Abort)		Button 1 (UP)	calibration of temp, pres, limits etc.
EDIT CONSTANTS	Button 3		Button 2 (DOWN)	BSFC, calibrate fuel flow, etc.
SET FUEL & TIMERS	Button 1		Button 3	Enter fuel added, clear oil timer
EC2 MAP	Button 3		Button 4 (ACK)	Inspect & change EC2 MAP table
TRACK MODE	Button 1		Button 2	Makes MAP display track engine map

**Parts Included with the EM2**

1. EM2 instrument.
2. Four SPST pushbutton switches.
3. Two DB-25 male connectors for wiring to sensors
4. One DB-15 male connector for wiring to user switches, and power.
5. Backshells for connectors.
6. Two 300 or 250 degree F range VDO temp sensors for water and oil temperature.
7. One 0 – 100 PSI VDO pressure sensor for oil pressure.
8. One RWS air temp sensor for use as OAT sensor.
9. Altitude, Airspeed and Manifold pressure sensors (mounted internally in the EM2)

**WARRANTY**

The RWS EC2 comes with a 1 year warranty. Note that we will repair, free of charge except for shipping costs, any defect in parts or manufacture. Warranty does not cover damage due to wiring error, over voltage or other builder errors. Owner will be responsible for returning the unit to us, packed in a manner that prevents further damage. Please ship via an insured method – we cannot be liable for units lost in shipping. Enclose payment for return shipping costs.

**Product Support**

If you have installation or operational questions, please email us at [tcrook@rotaryaviation.com](mailto:tcrook@rotaryaviation.com)  
We can probably help you with questions about setting up the EM2 with other sensors as well.

Repair service is available by sending the unit back to RWS.

Happy flying from all (three) of us here at Real World Solutions.

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