Electronic Fuel Injection System Monitor

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Overview/BackGround

Electronic Fuel Injection System Monitor
(EFI System Monitor)

Perhaps next to flying the aircraft, no function is more fundamental to safe flying than monitoring the fuel status of your aircraft. While there are systems available that do this, most are expensive and have certain limitations. Most required a fuel flow transducer of some sort (two if a return-to-tank system is used) and these alone cost close to $300 each and only provide limited information on fuel factors. For these and other reasons, the EFI System Monitor was developed.

The design objectives were basically to design and fabricate a low-cost, pilot friendly, small footprint system designed for Electronic Fuel Injected aircraft engines. This means a system suitable for alternative engines converted from automobiles to aircraft use. What this EFI System monitor offers is the ability to monitor the crucial fuel factors without using expensive fuel flow transducers, without having to address separate elements to handle the "returned fuel" issue and without any connections to the fuel plumbing. All of this in very small, very light package that fits in a 2 ¼" instrument hole. The display screen is the latest Organic Light Emitting Diode (OLED) display that provides good readability in all light conditions and from all angles.

This system provides the following fuel factor (All Fuel measures are in U.S Gallons) related functions on a series of display screens.

- **Fuel Total**
- **Fuel Loaded**
- **Fuel Used**
- **Flow Rate**
- **Fuel Remaining**
- **Periodic Fuel Alarm (Switch tanks)**
- **Low Fuel Alarm (land and refuel)**
- **Time Remaining (at current flow rate)**
- **Air/Fuel Ratio Indication**

RPM and Calculated Power are also provided.

The screens are divided into two modes. Category 1(Flight). Screens that are principally used while flying such as Air/Fuel ratio indication, fuel flow, fuel used, time remaining, etc.

2(PreFlight). Screens used before engine start functions such as setting fuel status and alarms, calibration, screen attributes (brightness) and status of preflight fuel factors.

The Mode 1 (flight) screens are:

Screen1 (Operations Screen)

- .Provides Air/Fuel ratio indication (Simulated LEDs with Voltage readout of O2 sensor)
- .Fuel Flow (Gallons/hour)
- Fuel Used (Gallons)

Screen2 (Remaining Screen)

- Time Remaining (at the current fuel burn and fuel load).
- Fuel Remaining(U.S. Gallons)

Screen3(Engine)

- Engine RPM
- Engine Power (Estimated - calculated from Fuel burn rate)

Screen4(Fuel) Reserved For Future Changes

- Flow Rate
- Fuel Remaining

Screen5(Status)

- Fuel Remaining
- Fuel Quantity Loaded (Amount last loaded)
- Total Fuel (on board after engine start)
- Fuel Used
- Low Fuel Alarm Setting
- Switch Tank Alarm Setting

Screen 6(EC2)
Additionally, one may access the Fuel Map and Engine Ignition Timing from the Real World Solutions EC2 These EC2 screens are the same as those described below in Category 2 (PreFlight) screens.

The category2 (PreFlight) screens are:

1. **Preface Screen**
2. **Mode Screen.** The mode screen provides the menu for selecting various functions that may require preflight attention. This menu then branches into other sub menus depending on mode selection made:

    - **Status** (Status of Fuel Factors which is the same as Screen5(Status))
    - **Adjustment** - permits adding of fuel, adjusting fuel factors and alarms. Note. Alarm settings are stored in non-violate memory)
    - **Configuration** – 1)Semi automatic calibration of fuel factor accuracy, 2)Change O2 sensor (Air/Fuel Ratio related) scale factor, 3) Screen brightness setting, 4) Initialize variables 5) Cumulative Time/Fuel
    - **EC2** – Permits access to Real World Solution EC2 (if the appropriate wiring connections are made).
    - **Operation** – Activates the
    - Flight-Mode screens.

If you start your engine with power to the EFI System, the unit immediately goes to the Flight screens and starts to log the fuel used.

Sub-menus of **Mode Screen**

- **Status** Menu (no action taken here – just a summary of fuel factors)
- **Adjustment** – this screen permits adjustments to be made to fuel factors
  - Add Fuel
  - Change Fuel Remaining (in case you may have drained a tank)
  - Change Low Fuel Alarm value
  - Change Notification Alarm value (Switch Tank Alarm)

- **Configuration**
  - ***Fuel Factor Calibration***
  - ***Configuration mode***
    - Brightness (Brightness settings for display)
    - Ec2 Monitor Switch
    - 02 Sensor Sensitivity Adjustment
    - Cumulative Time/Fuel Clear
    - Initialization (sets up internal program for Fuel Factor Calibration)
    - Fuel Factor Calibration

This instrument requires the following electrical connections:

1. 12-16 Volts DC power (aircraft power source)
2. Aircraft power ground
3. To injector wiring on EC2 Grounding side (between injector and EC2 connection)
4. Wire to Oxygen Sensor
5. Two wires to EC2 (if EC2 monitoring function is desired)

MONITOR.

The Electronic Fuel Injection System Monitor (henceforth simply called the Monitor) consists of the colored display and control buttons installed in a 2 ¼" standard aircraft instrument case. There are six control buttons labeled **B1** through **B6**. **B1** though **B5** are control buttons and **B6** is the monitor-reset button. Depressing **B6** will restart the software code.

The colored display is one of the newer OLED screens, which overcomes some of the limitations of the more traditional LCD screens. The viewing angle is much broader and the contrast higher making it easier to read in the Sun light and from across the cockpit at an angle.

At the very bottom of the front panel (the clear bulb) is a RED LED which flashes whenever one of the two alarm types are activated. This LED is fairly bright and is designed to attract the pilot's attention very quickly.



Four standard aircraft instrument black brass mounting screws are needed to secure the instrument in the instrument panel.

CAUTION. The OLED display should never be cleaned with any type of liquid, as it will cloud the polarized film. If cleaning in necessary, then see note on next page.

WARNINGS, CAUTIONS, NOTES OF IMPORTANCE

SAFETY WARNING

This device is sold as an aid to assist the pilot is managing his fuel. It is only as accurate as the information provided the unit by the user. In other words, it has no independent method to determine the accuracy of data input by the user. At no time should a user rely on this unit to provide fuel information considered necessary for safety of flight.

The unit can assist the pilot in fuel management by providing indications of fuel usage as well as alarms based on fuel consumption.

EFI Monitor and Real World Solutions EC2

Note: Real World Solution has sole control over the configuration and functions of the EC2 and it is their prerogative to make changes as they deem fit and necessary. In the event any such change should render the Monitor incapable of interacting with the EC2. It is the sole responsibility of Anderson Electronic Enterprises LLC to accommodate any such changes necessary in the Monitor. In other words, the Monitor may need to be returned for modifications, changes and adjustments provided that interaction with the EC2 is desired.

It is possible to damage the EC2 if the three wires (including the grounding wire) connecting the Monitor to the EC2 are:

1 Wired incorrectly
2 Incorrect voltages are applied to those wires
3 Improper connection procedures (such as attempting to connect the two units with power on to either unit)
4 These wires are grounded.

Do not attempt to hook up to the EC2 until the Monitor's other connections are completed (such as to power, ground, O2 sensor and injectors) and the Monitor is operating properly.
Anderson Electronic Enterprises accepts no responsibility for any EC2 damages.

Display Refresh

Note: Because the display manufacture advises that a display can be corrupted by electrical glitches in the environment, a periodic refresh has been implemented for the Flight screens since they are the only ones in which data is periodically (many times a minute) refreshed. You may notice that a screen will blank for a fraction of a second approximately every 2 –3 minutes. This is the screen display data, both the static titles and changing values of fuel factors, being refreshed.

Display Cleaning

DO NOT USE ANY LIQUID for cleaning the screen of the display, as this will cause the polarizing film over the display to go cloudy! If the display must be cleaned, use Scotch Tape Mending Tape No. 810 or an equivalent. (This tape type is one of the most common available in stores so should be easy to find). Lightly apply the tape to the screen front and then gentle pull one end of the tape across the screen such that the angle between the screen and the tape is as small as possible. Do not pull rapidly, but just slowly peel the tape away.

Voltage Indicaton

The display of the monitor is voltage sensitive. The brightness of the display may increases/decreases proportional to the aircraft system voltage. Therefore, if you notice the brightness of the display starting to dim, immediately check the voltage of your aircraft system. This could be an indication of a power problem. The monitor has a voltage regulator that prevents damage to the monitor in the event of voltage over 15 volts. But, should you notice an unusual brighten of the display, this could indicate an over voltage condition. Again, check your system voltage.

PRE-FLIGHT SCREENS

Operations

Provided that the EFI Monitor has been wired to the aircraft systems as required, then the following capability/ functions is provided to the pilot. These functions are a combination of screen displays and push buttons used to select the desired affect.

General

The EFI Monitor determines values of all its fuel factors from signals from the Electronic Fuel Injectors and the Oxygen Sensor. It has no way of monitoring fuel quantity in the tanks; therefore it is crucially important that this information be manually entered into the monitor accurately. The monitor for each aircraft type does have a maximum fuel load quantity that it checks and presents a WARNING if you enter more than that amount.

Alarms

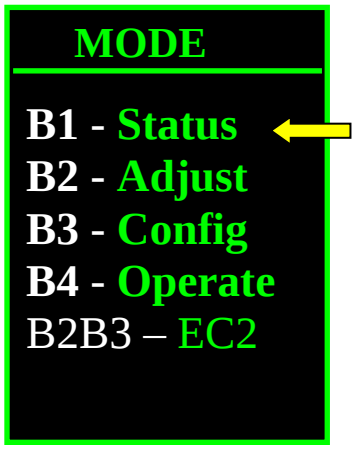
The system has two types of alarms, which are triggered by fuel quantity used. There is the periodic "**Switch Tank**" alarm and the "**Low Fuel**" alarm. Each alarm can be set to trigger by manually entering the desired fuel quantity value.

Automatic Turn-on

The monitor (if wired as directed) will power up to the logo screen when the aircraft power switch is turned on. As soon as the engine is started the monitor will immediately go into its operational mode recording fuel usage. This precludes the pilot forgetting to turn the system on at engine start and perhaps only later realize the error after an unknown number of gallons have already been consumed.

Initial set-up

Once power is applied, but before engine start, the user can enter any of the "pre-flight" screens. These are screens from which the user can enter information and select configurations. If the engine is started, the monitor will immediately go to the Operations Flight Screen and begin recording fuel usage. The user can force the monitor to return to the "Pre-Flight" screens after engine start, but then it must be manually reset to operations mode.



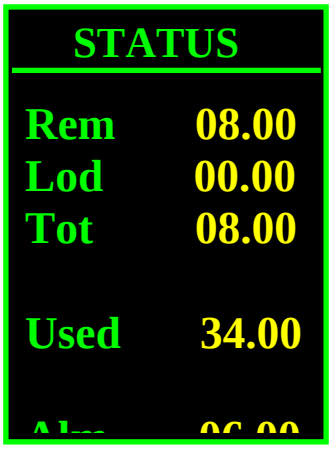
Pre_Flight Screen Description

MODE Screen

The Pre-Flight **MODE Screen** provides several sub menus to select from.

B1 – Status

Pressing button **B1** brings up the **Status** Screen. This is a display-only screen providing a summary of the fuel factors (all values in US gallons) including:

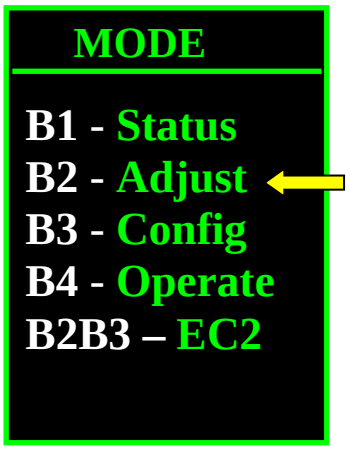


Rem 08.00 (8 Gallons Fuel Remaining)
Lod 00.00 (0 Gallons Fuel loaded)
Tot 08.00 (8 Gallons Fuel Total)
Used 34.00 (34 Gallons Fuel Used)
Alm 06.00 (6 Gallons Low Fuel Alarm)
Not 21.00 (21 Gallons Fuel Notification Alarm)

Note: Any of these values may be changed, except Fuel-Used, by going to the adjustment screen (selected by button B2 of the MODE screen).

Pressing button **B5** will take you back to the previous **MODE** screen. This button will normally return you to the previous screen or continue to the next appropriate screen depending on which mode/function you are current in.

The STATUS screen is available both as a Pre-Flight and Flight Screen and is intended to provide a one page summary of Fuel factors.



B2 - Adjust

B2 – Adjust Pressing button **B2** of the **MODE** screen brings up the **ADJUST** (adjustment) Screen. This screen permits the user to change/ adjust fuel factors such as the following:

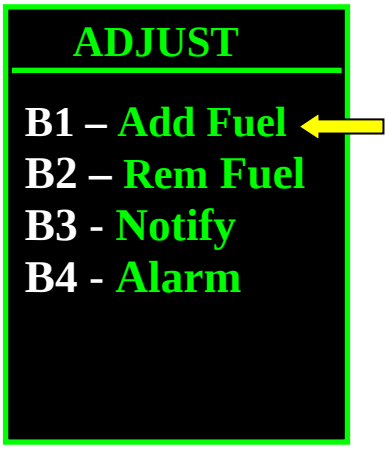
B1 – Add Fuel Pressing **B1** will now permit the user to enter additional fuel quantity into the monitor. Pressing **B1** will display the **ADD FUEL** screen.

At the top of the screen the amount of fuel remaining (**09.00**). Any fuel added will be added to this figure for a total fuel on-board amount.



The second line with the value [01.50] enclosed in green brackets is where the amount of new fuel loaded is input. Then the fuel loaded (1.50 gallons) and fuel remaining (09.00 gallons) are added for a fuel total (in this example **10.50** gallons).

You enter fuel by using the **B1**, **B2**, and **B3** buttons while in this screen. **B1** controls the stepping of the tens digit within the green brackets, **B2** controls the units digit and **B3** controls the tenths of a gallon digit. There is no provision for entering 1/100 th of a gallon so you may only enter to the nearest 1/10th of a gallon.



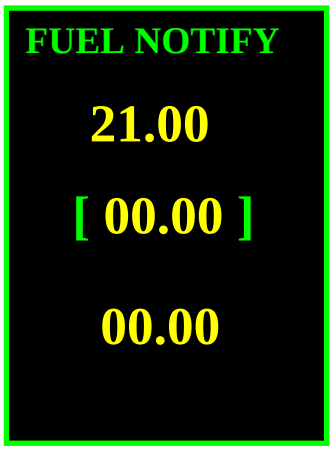
As you add fuel, you will notice the total fuel sum at the bottom will change to reflect the newest total.

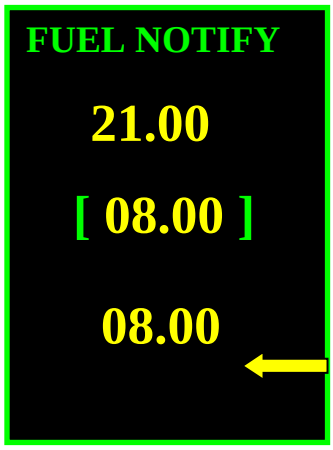
When you have completed entering the fuel amount, then press the **B5** button. This will display a screen entitled **Fuel Added**, which will display only the amount of fuel added **01.50**.

This provides the user with a visual check. If this value is correct then again press button **B5**, if incorrect Press **B4**. If **B4** is pressed the amount entered is voided and it takes you back to the **ADJUST** Screen where you can select **B1** again to enter the ADD FUEL mode. Then enter the correct amount. If the amount originally entered needs no correction, then pressing **B5** takes you back to the **MODE** screen.



If you need to change any of the other fuel factors such as **B2 – Rem** (Fuel remaining), B3 - Notify (Notification alarm) or **B4 – Alarm** (low fuel alarm), then you select the appropriate button. For these screens there is an important difference than the **B1** mode. In screens **B2** through **B4** the amount entered becomes the new amount; it is not added to the current amount, as was done when adding fuel loaded to the remaining fuel.





So for example, if you select **B3 –Notify** you see an old value of **21.00** this being the number of gallons used before the **SWITCH TANK** alarm would activate and start flashing along with the red alarm LED. However, the user may decide they instead want to switch tanks every 8 gallons and wish to change the notification alarm.

Here again using the same buttons to change digits as described in the ADD FUEL section, we can change the notification amount to 8.00 gallons. Notice that there is no totalizing of the current amount and new entered amount. The new amount entered simply replaces the old amount.

Once you have entered the desired amount you press **B5** brings you to the confirmation screen.



If the confirmation screen shows the desired value then press button **B5** to accept else press to re-enter the Adjust screen where you would again press **B3– Notify** and go through the process again entering the correct amount and then pressing **B5**, confirming that amount and again pressing **B5** to accept it.

Important: Once you have completed all desired changes to the fuel factors and are back to the MODE screen, you must press **B4 - Ops**, the Operations button to store these value in non-volatile memory. If you fail to do so then the entered values are lost and must be re-entered.

The same process is used for the
B2 – Rem (Fuel remaining)
B3 - Notify (Notification alarm) or
B4 – Alarm (Low Fuel Alarm).
Now is a good time to mention the two alarms.

Alarms

B3 – Notify

The Notification Alarm uses the value entered to periodically trigger the SWITCH TANK alarm which together with a red flashing LED will activate each time the fuel used reaches a multiple of the notification amount. For example, having entered 8.00 gallons, the alarm will trigger immediately upon entering the Flight-mode to show it has activated. So if the alarm was set after 12 gallons were used the alarm would initially flash to signify it was beginning the sequence. It would then trigger when 8 more gallons (12 + 8 = 20 gallons total) has been used, when 16 more gallons (12 + 2*8 = 28 gallons total) fuel used. This will continue at multiples of the notify amount until the Low fuel alarm value is encountered.

The Switch Tank alarm flashing display may be turned off by pressing simultaneously buttons **B1** and **B2** until the alarm ceases. The Alarm is still active and will again flash when the next multiple of the notify value is reached by the Fuel Used factor.

B4 – Alarm

The **LOW FUEL** alarm is set independently of the switch tank alarm. When the fuel used reaches this level a flashing text message "**Low Fuel**" and the LED are activated.

The low fuel alarm will activate at the set quantity and will reactivate each 2 gallons of fuel usage thereafter, until there is less than 4 gallons remaining. After 4 gallons is reached the alarm will display every 1 gallon. Also when the fuel remaining reaches ½ of the value of the alarm quantity set, the color of the Fuel Used (ops screen) and both the Time Remaining and Fuel Remaining values on that screen will turn color from the normal yellow to **Red**. This is another indicator of a fuel situation that bears immediate attention.

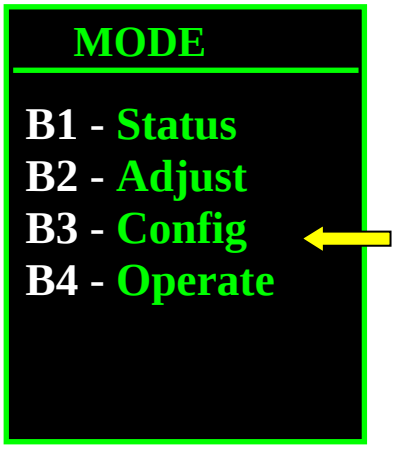
IMPORTANT. The Low Fuel activation can not be turned off. However, the alarm display can be temporarily deactivated each time it flashes. It will trigger again under the above conditions until fuel exhaustion

The Low Fuel warning should be set to a value that is truly an emergency fuel level value.

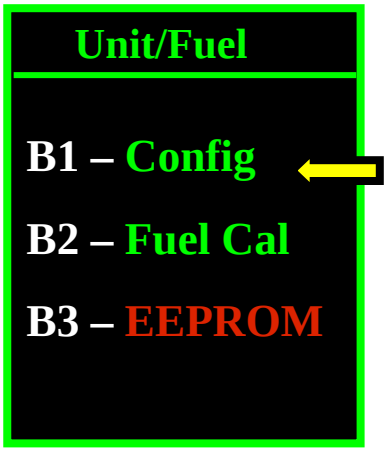
So do not set it unrealistically high, I would recommend initially setting it at FAA recommended VFR 45 minutes worth of your cruise fuel burn. In my case, I set it at 06.00 gallons which at my normal 8 GPH fuel burn would give me 45 minutes before fuel exhaustion.

Yes, the flashing LED and Text could become annoying, but running out of fuel even more so.

Before addressing further screens, recall that button B5 can be used to escape a screen to the previous screen or next appropriate screen.

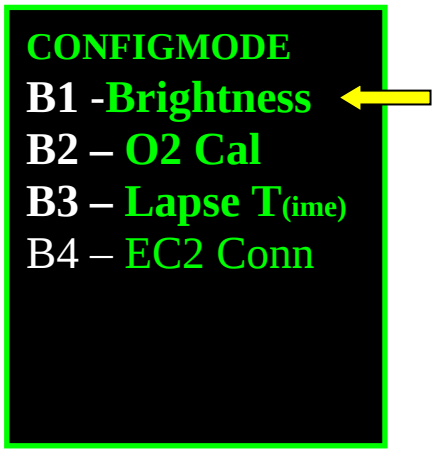


B3 - Config
The next function to be reached from the MODE screen is the **B3 – Config**. This function permits the configuration of several parameters and preferences that are stored in permanent memory – such as alarm levels – so that they do not need to be re-entered each flight.



Pressing B3 presents a screen with three choices, **B1Config**(Configuraton) and **B2 – Fuel Cal** (Calibration). **B3**– EEPROM (ReSet Defaults).

We will address the Semi-Automatic fuel calibration process later. So pressing **B1** takes us to the **CONFIG MODE** screen. Each of the four displayed functions set parameters that are stored in non-volatile memory so do not need to be repeated.

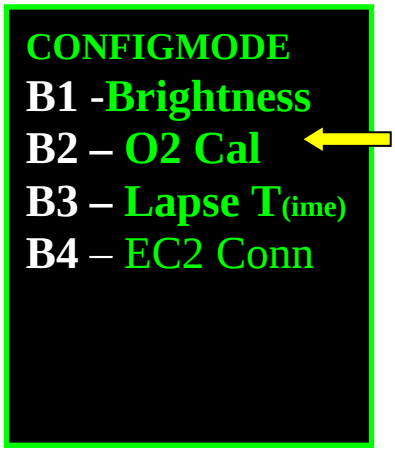


B1 – Brightness
This function controls the display screen brightness, which can be adjusted to best match ambient light conditions. Depressing **B1** brings up this screen. As the descriptions implies, you choose a desired brightness level by pressing the button that gives you the desired level of brightness. The selected state of screen brightness will occur immediately, so you can then decide if that choice is appropriate. You depart this screen back to the previous screen by pressing button **B5**.



Button **B2** selects the **O2 Cal** (Air/fuel Ratio) function. This can be used to adjust a division variable that will adjust the limits of the Air/Fuel Ratio Indicator display Bar in the Operation Screen. This button and the other buttons are addressed in more detail on the next page.

B3 – Lapse T(ime)
Resets Lapse Time counter back to zero.

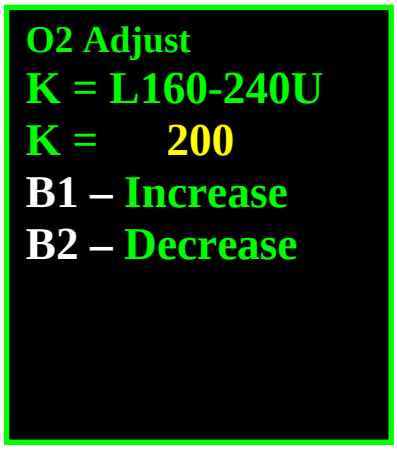


B3 – EC Com
Note: If your Ec2/Ec3 does not use the staging function then there is no benefit/need in this monitoring for the "staging " information from the EC and it is therefore removed from the screen.

The EC2 provides a "staging" byte which indicates whether only the primary injectors are firing or whether all injectors (primary + Secondary) are firing. If below the staging point the calculated fuel flow is divided in half so that the EFISM only shows ½ the fuel flow of all injectors operating. The only way the EFISM can track whether the EC2 has staged or not is for a communication link be maintained.

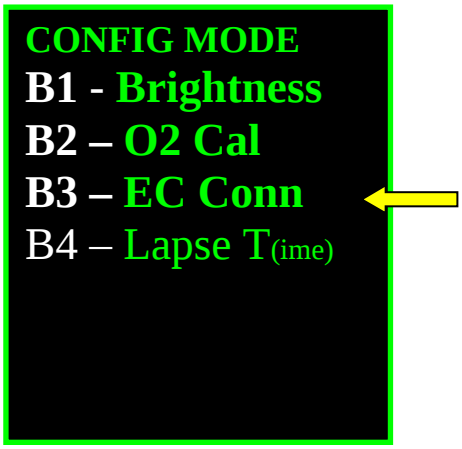
This function is described further on the next page

After changing the K factor using the B1 or B2 buttons, you initialize and store the changed K by pressing B5 until a message shows the changed K value momentarily at the bottom of the screen.



You are then returned to the CONFIG MODE screen.

The last configuration function is B4 – EC2 Conn. This function determines whether or not the EC2 will be periodically sent a command requesting data. You will be always be able to access the EC2 manually by depressing a button sequence (assuming it is hooked up and functioning), however, this configuration function will do it periodically.



This function will only automatically request the Engine Frame Data of the EC2 and not the Fuel Map data.



EC2 Access.

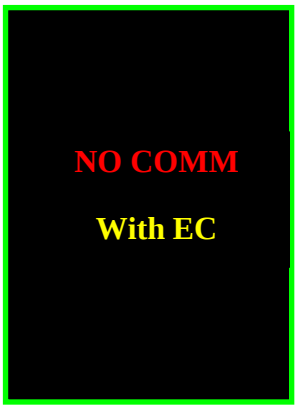
Fuel Map data can only be accessed by using the manual access function by depressing buttons B2 and B3 simultaneously. Manual access to the EC2 data is shown on the MODE screen as the button sequence B2B3 – EC2.

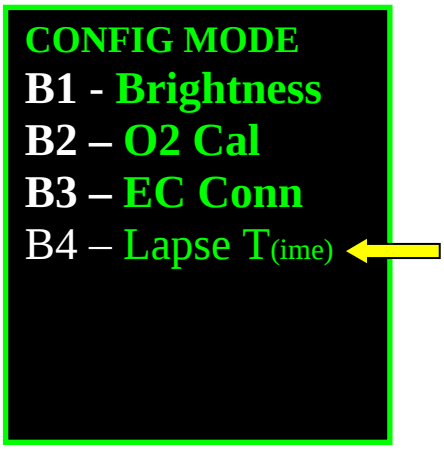
The manual mode is available in Pre-Flight MODE screen and all Flight screens.

Pressing B4 gives you the Monitor EC2 screen. Pressing B1- YES will result in the Engine Data Frame (with Ignition timing) and Injector Staging information to be periodically (approx every two seconds) to be automatically monitored.

CAUTION!. If you select "yes" for monitoring and you either do not have an EC2 properly connected or if the EC2 is off, then you will get a repeated error message.

The error message will appear on any of the Flight screens once the monitor is actively operating with the engine running. This repeating message can become annoying, therefore, if you do not have an EC2 wired to the Monitor set the Monitor EC2 function to B2-NO to preclude this message. Be advised that whenever this message is seen it signifies there is no communication with the EC2 and therefore no data to or from the EC2.





The B4-Lapse Time button provides a screen which presents lapse time and cumulative fuel burned. It is cleared back to zero only by pressing B1-Clear. It records lapse time and fuel used while the engine is running up to 10 hours or 99 gallons whichever comes

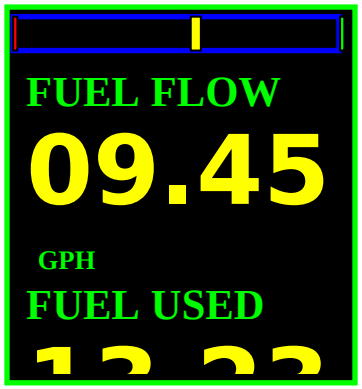


first. This can be useful on long trips with several refueling stops.

This concludes the section on the configuration mode of the EC2 with the exception of further explanation of the Fuel Calibration and O2 Calibration modes further described in Appendix **A.**

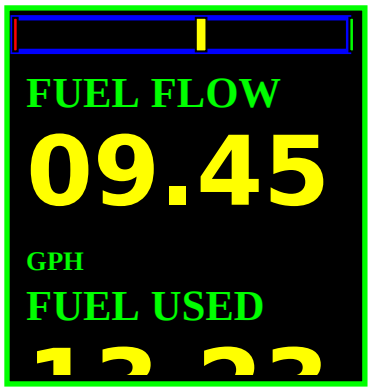
FLIGHT SCREENS

Once the engine is started, the Monitor will automatically enter into the **Flight Mode**. In the flight mode, the Monitor performs all the fuel factor functions. These factors can be displayed on several screens selectable by the user. These screens include the following:



This is considered the primary in-flight screen as it provides the crucial real-time information about the fuel factors including Air Fuel Ratio, Fuel Flow and Fuel Used. This is the default flight screen and when ever a message or alarm activates, the monitor returns to this screen. This is also the screen that automatically comes up once the engine is started. Button **B1** can be used to display this screen at anytime while in the operations mode.

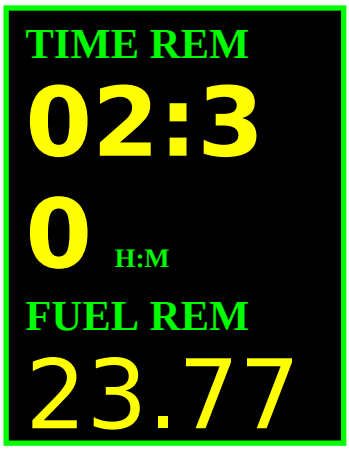
Air/Fuel Ratio Window. There is a blue rectangular box at the top of the screen with a red (lean) side on the left and a green (rich) side on the right. A small rectangular moving bar within this window provides Air/Fuel Ratio Indication. This indicator bar will move left for leaner Air/Fuel Ratio conditions and right for richer conditions. The bar will also change color going from yellow to red at the leanest condition and from yellow to green for the richest conditions.



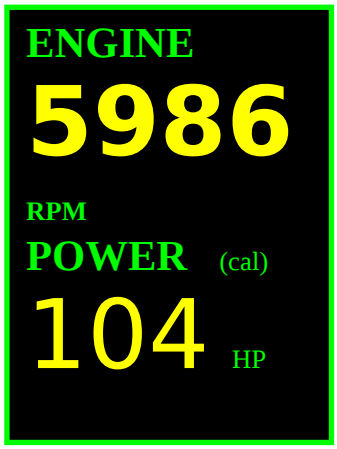
There is a hidden function available on the operations screen. If buttons **B3** and **B4** are pressed simultaneously the voltage (between 0 and 1000 millivolts) of the O2 sensor will be momentarily displayed in the Air/Fuel Ratio indication window.

The duration screen is accessed by pressing button **B2** during operations. This screen presents the time remaining before fuel exhaustion at the current flow rate (burn rate) shown on the Operations Screen. Based on that flow rate and the fuel remaining a time remaining is calculated and displayed on this screen.

The Engine Screen is accessed by pressing button **B3**. This screen displays the engine RPM and the calculated power of the engine based solely on the fuel flow rate of the engine. The BSFC figure used for this calculation for the rotary engine is 0.55. The fuel mass for 100LL used is 6.25 pounds/gallon. Note: This power is not a dynamometer-derived figure but is a simple calculated value.



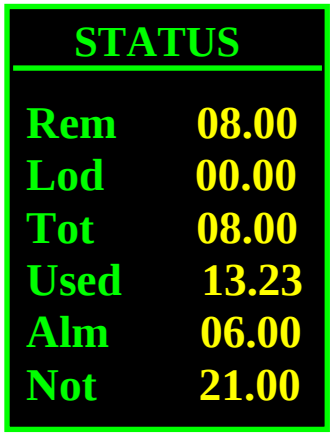
Display by pressing button **B4** This screen is reserved for a future functions providing data. Currently it provides fuel flow and fuel remaining data together on the same screen for those who prefer that to fuel used. However, as mentioned, while the monitor is very accurate regarding fuel used, it is no more accurate than the user who keys in the fuel quantity loaded on board. For this reason, the Operation Screen with Fuel_Used factor is to be preferred for accurate fuel data.



The last flight screen is the Lapse time and cumulative fuel used screen. This retains the run time and fuel used until cleared in the configuration mode preflight screen. Up to 10 hours and/or 99 gallons of fuel used can be displayed.



Also available as a Flight screen is the same **STATUS** screen found as a Pre-Flight screen. This display is accessed during operations by pressing button **B5**.



Note: Because the display manufacture advises that the display can be corrupted by electrical glitches in the environment, a periodic refresh of operational screens will occur. Since Flight mode screens are the only ones in which data is periodically (many times a minute) refreshed. You may notice that a screen will blank for a fraction of a second approximately every 2 –3 minutes. This is the screen display, both the static titles and changing values of fuel factors, being refreshed.

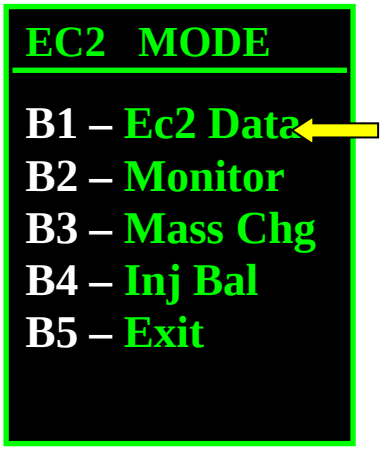
EC2 INTERFACE SCREENS

The Monitor can interface with the Real World Solutions ™ EC2 if connected and the link is functioning.

Note: Real World Solution has sole control over the configuration and functions of the EC2 and it is their prerogative to make changes, as they deem fit and necessary. In the event any such change should render the Monitor incapable of interacting with it. It is the sole responsibility of Anderson Electronic Enterprises LLC to accommodate any such changes in the Monitor. In other words, the Monitor may need to be returned for modifications, changes and adjustments provided that interaction with the EC2 are desired.

The EC2 interface function is not essential for operation of the EFI System Monitor. The functionality provided is to be able to view the ignition timing currently being used by the engine and the Fuel Map. The Monitor may be used to change the ignition timing as well as the fuel map one value at a time. In other words, for safety reason, you can not make a massive change to the entire fuel MAP.

Ec2 Mode



The EC2 Mode Screen is activated from either the pre-flight or Flight screens by **simultaneously** pressing B2 and B3 from any screen.

If you fail to press both buttons simultaneously then you will either get the B2 or B3 screen or an error message. I find that if you make a "Y" of your index and middle finger and spread them to touch both buttons that by pushing your arm gentle forward both buttons will activate simultaneously. Practice it a few times and it will be come natural.

Once the EC2 MODE screen appears there are three choices. Pressing B1 – EC2 Data will cause the monitor to send a request to the EC2 for both Engine Frame data and Fuel MAP data. There are only three data items used out of the 30 Engine Frame items. The three are the engine ignition timing information, the manifold pressure information for the Fuel Map pointer position and the staging information for modifying fuel flow. The only Engine Frame item that can be changed through the EFI System Monitor is the ignition timing. The fuel MAP values can also be changed.

All parameters of the EC2 that are changeable by its own control panel remain that way.

B2 – Erase
is used to erase the EFI System Monitor's copy of EC2 data in its own memory. It DOES NOT erase any of the EC2's own memory or in any way communicate with the EC2. It will only blank the monitor s graphic display of the Fuel Map. You may replenish the EC2 data copied to the EFI System Monitor by again pressing B1 – Ec2 Data.



After you have pressed B1 – EC2 Data button, the monitor will acquire data from the EC2. If you see an error message of " No Comm with EC2" then that tells you either the EC2 is not turned on or there is a connectivity problem between the EC2 and the monitor.

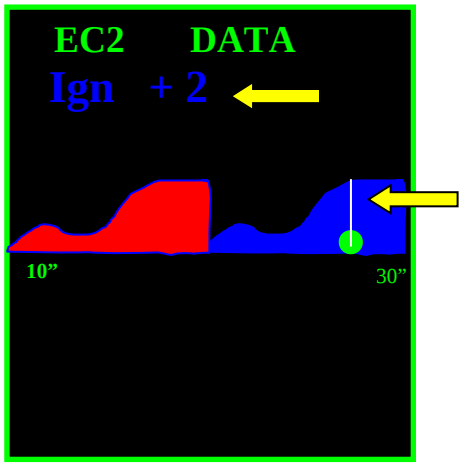
If there is a problem, you will see the error message twice, once when the monitor attempts to acquire engine frame data and the second time when it attempts to acquire Fuel Map data. Both of these separate commands are sent when B1 – Ec2 Data is pressed.

Assuming no problems in communicating with the EC2, the monitor will (after receiving and conditioning the EC2 data) display it on the EC2 Data Screen.

The EC2 Data Screen first comes up displaying both the Ec2 Ignition Timing and the two EC2 Fuel Maps (red low rpm MAP and blue high rpm MAP).

In this screen the top yellow arrow points to the ignition timing data display. In this example the color **blue** and the plus (+) sign both indicate the timing is advanced 2 degrees from the EC2 default of 25 deg Before Top Dead Center (BTDC) or the timing is at 25 +2 = 27 degrees BTDC. Note: This assumes the static timing has been set per RWS EC2 instruction. If the timing were retarded then the color would change to **red** and the sign would change from + to a – (negative sign).

The second yellow arrow points to the two EC2 Fuel Map display graphs. The color denotes whether it is the Low rpm fuel map (Red) or the high rpm fuel map (Blue). There are 64 fuel map bins in each section for a total of 128. On the display screen each of the 128 bins are displayed as a tiny line or bar graph. The height of the graph indicates relative fuel quantity that would be dispensed by the injectors if operating at that bin position. The horizontal or "bin" position is a reflection of relative manifold pressure. The green ball represents the manifold pressure the engine was operating at when the data was acquired.

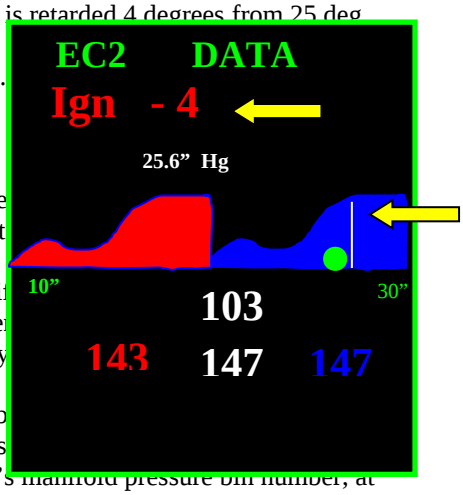


In other words, the display is NOT real time but only a snap shot in time when the B1- Ec2 Data button was pushed. However, if the engine operating parameters were in steady state, it should be reasonably close to the engine state at that time. The longer period of time since the B1 – Ec2 Data button was pushed, the more outdated the display is likely to become.

The white vertical line through the green ball is a movable cursor that is initially positioned where the operating manifold pressure bin (the green ball) is located. This cursor can be manually moved to any bin position to obtained a value of the bar and the bin location of that bar.

The screen will remain as shown until a button is depressed. The top two buttons, B1 and B2, are used to move the cursor left or right respectively. The bottom two buttons B3 and B4 are used to adjust the value of the selected bin position the cursor is positioned to. When any of these four buttons are pressed, the screen will now reflect additional data shown in the following screen.

Notice that in this example, the ignition timing data is shown in red as – 4. That indicates the timing is retarded 4 degrees from 25 deg BTDC BTDC.



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cursor's manifold pressure bin number, at that position the bar graph value is 147 also in white. To each side of the cursor is shown the lower bin in Red (143) and the upper bin in Blue (147). These values to either side of the cursor position at 103 are displayed so the viewer can visually see how their relative values of the three bin locations correlate.

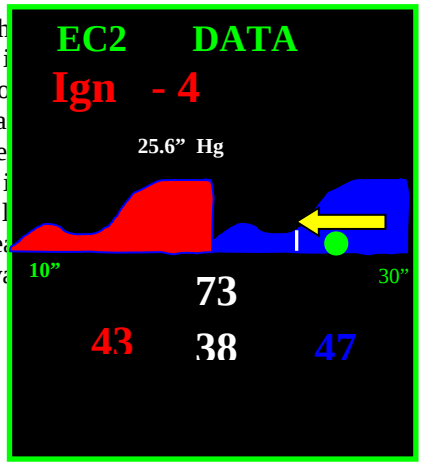
Again by depressing B1 or B2 the white cursor can be moved to the left or to the right respectively. Holding either button will cause a continuous movement where pushing and releasing the button will cause a step motion. As the cursor moves the cursor position location in white will change to reflect the current position and the three bar values at and to each side of the cursor position.

The fuel map displayed is the actual representation of the fuel map your engine is using with the EC2 Controller A selected. Controller B data can not be accessed by the monitor.

This is the basic EC2 Data screen by which all data, ignition and Fuel Map are displayed. The bar graph makes it easy to see radical change in values from one bin to the next. Holes or peaks out of line with their surrounding bins are the ones to examine as to whether changes are needed to

Again, the only Ec2 parameters, which the monitor is capable of changing, are the ignition timing and the value of the individual fuel map bar.

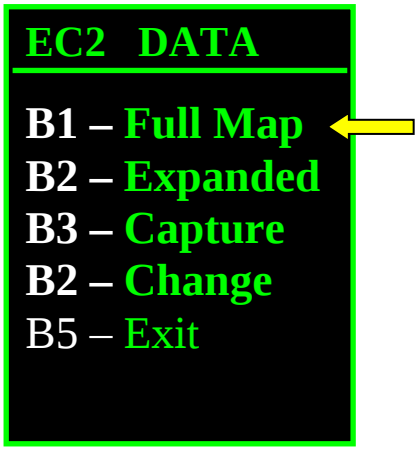
We will first address changing a fuel map bin – the height of its bar.



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With the cursor remaining at position 73, the bottom right button B4 is depressed to increase the value of the bar at position 73. B3 would decrease its value. The maximum value permitted is 255 and the lowest is zero. You would normally not see either of these extremes. Hold button B4 until the bar value at bin 73 has increased from 38 to 45, then release the button.

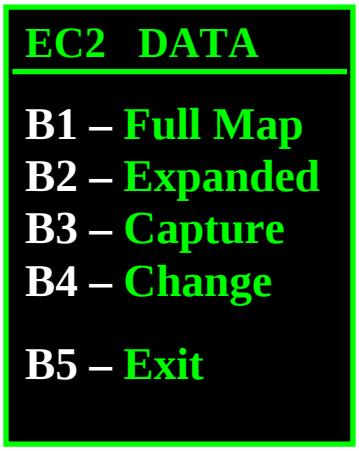
What you have done is set up a change to the Ec2's fuel map position 73. However, this change has not yet been transmitted to the EC2 to replace the current value of 38. To implement this change, you must first press button B5 (the universal exit) to take you to the update screen.



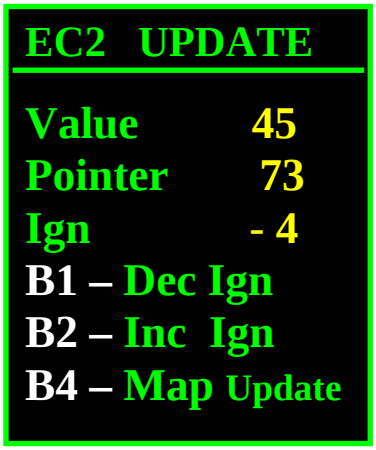
The update screen is the screen from which the desired changes to EC2 parameters are actually sent to the Ec2. This is also the screen where you actually select and transmit changes to the ignition timing.

B1- Full Map brings up the screen first shown with both the low and high rpm fuel maps. Pressing B2-Expanded will expand ½ of the range to fill the entire screen giving a larger display of the selected fuel map. You can make the same changes to fuel bar values as described for the full screen. The bars are somewhat more visually discrete making it a bit easier to see.

Once you have viewed the data screens you arrive back at this menu screen by pressing B5. Once back at this screen, you then decide whether there are any changes you want sent to the EC2. If yes, then press B4-Change, if no changes, then press B5 to exit back to the EC2 Data access screen.



However, if there is a change to the ignition timing or you have made one to a bin of the fuel map and you want to update the EC2 with this new settings, you press B4- Change. This will take you to the EC2 UPDATE screen.



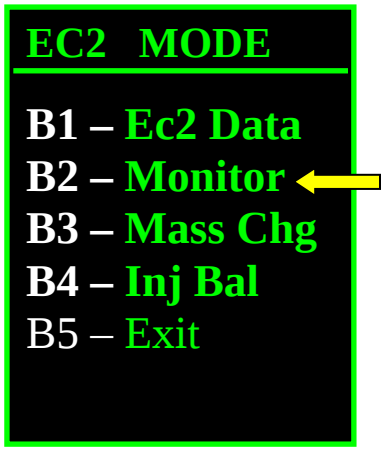
Here we see the proposed value of the Map update (45) at bin position 73. Also we see the ignition data. If we press B4-Map Update, the value of 45 for position 73 is sent to the EC2. If you decide not to make that change at this point, you simply press B5 to exit this screen. Lets assume you also wanted to change the ignition timing. Here you press B1-Dec Ign to decrease (Retard) the timing one deg or B2-Inc Ign to increase (advance) the timing one deg.

You can only change the timing one deg at a time. When you press either B1 or B2, the unit sends the update of ignition timing only (not the map data) and returns to the EC2 Data access screen where you must press B1-Ec2 Data in order to refresh the monitors information and display it on the data screen. Since this involves 3 steps, you may prefer to change ignition using the EC2 Mode 8 and just retrieve the data on the change by pressing B1-EC2 Data in order to verify and track the changes to ignition timing.

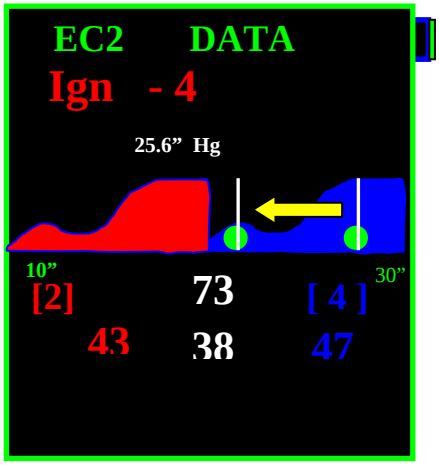
That is about it, just a few practice runs with the EC2 on but the engine not running and you can become proficient at stepping between these screens. Remember that with this unit, you can change the ignition timing without the engine running, so remember to set it back to zero or close to it before attempting to start the engine or fly.

You do not want to attempt to run the engine with 10 deg retarded timing (or advance for that matter).

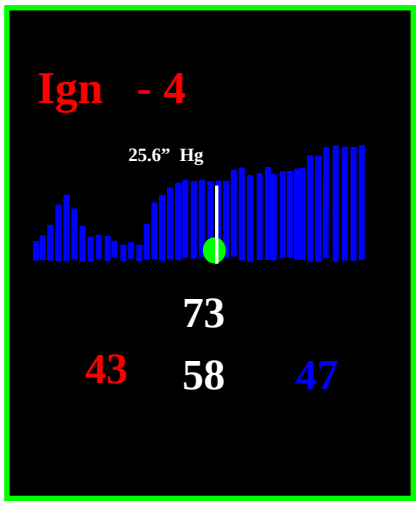
Monitor Screen



The monitor screen may be activated after obtaining data from the EC2. If you press **B2 – Monitor** without first loading EC2 data, you will get an error message.



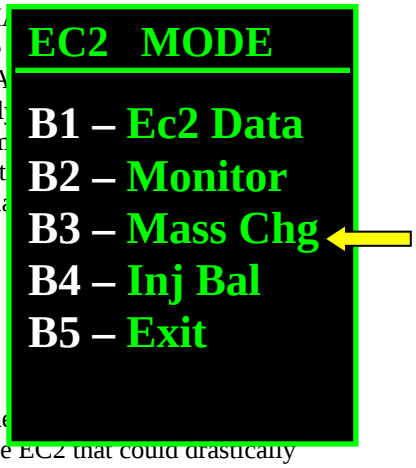
The monitor screen does nothing but display both MAPs (low and high) and a green ball which represents the current manifold bin the engine is operating at and the Air Fuel Ratio indicator bar.



The monitor mode quries the EC2 approx once per second to get the latest manifold pressure pointer. So very rapid changes in throttle position can cause the data displayed to temporarily lag. Here you can **not** make a change to the fuel map, this screen/mode only permits you to monitor where the engine is currently operating. This can be useful in determining regions of the fuel MAP where engine operation may require attention. If you exit this screen and immediately press B1-EC2 Data, the location of the pointer on this new screen will be at the same MAP location (assuming you have not made a throttle change) which can aid when making changes to the MAP.

The red brackets with the numeral 2 **[2]** indicates the number of injectors in operation at idle. The blue brackets with a 4 indicates **[4]** when all 4 injectors are operating. Only one or the other will be present at any one time.

Mass MAP Change



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change to the EC2 that could drastically and adversly change engine operation indicates that care should be used. In other words, if you used this to change the MAP values to zero or some other extreme value and then used this mode to update the EC2 the engine may not be able to operate with those settings. In other words, the engine could STOP running.

To prevent this, the MASS MAP CHANGE mode is only available in Pre-Flight Mode. Anytime you go to Flight mode or anytime the engine is running, this menu choice is disabled and does not even appear as a choice on the EC2 Mode screen. So you may only make mass changes to the EC2 fuel MAP while on the ground and with the engine NOT running.

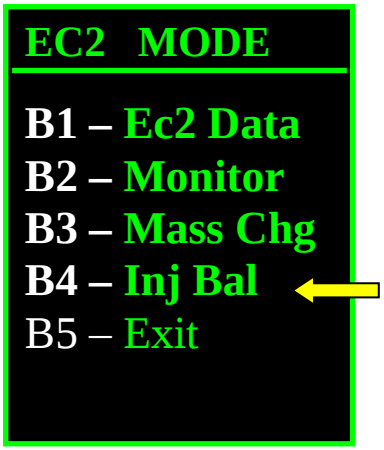
You must first load the EC2 MAP data by using **B1-EC2 Data** . Then you may make as many changes as desired to the fuel MAP by changing the manual pointer indicator to the appropriate bin and then changing its value as indicated in **B1-EC2 Data** description. Once you have finished with the desired changes press B5 twice to exit the screen and return to the EC2 Mode screen. Then press **B3-Mass Chg** to load the changes to the EC2.

If you change the MAP to the point to where the engine will not operate properly, check the EC2 Operating Manual provided by Real World Solutions for instructions how to reset the EC2 fuel MAP back to a default state.

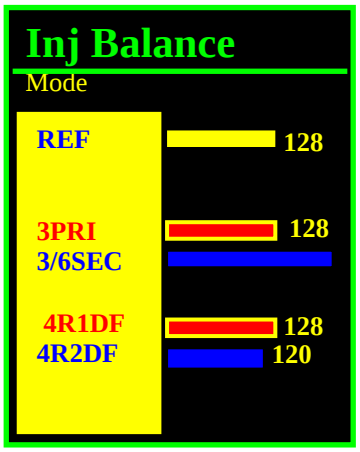
Injector/Rotor Balance

The last screen is **B4-Inj Bal** only permits the user to observe the balance of injector settings between primary and secondary and the fuel balance of the two rotors.

You must use the various modes of the EC2 itself to affect any change. The monitor does not have any capablity to make changes in these parameters of the EC2. However, this screen does provide a means of visually observing the relative values of these parameters and the effects of any changes made.



The screen shows six parameters related to the balance of fuel flow rates between the two sets of injectors (primary and secondary) and also balance between the front (Rotor 1) and the rear (Rotor 2) in both low rpm (primary injectors only operating) and high rpm (all four injectors operating).



This screen accesses the EC2 Engine Data to provide information on parameters related to fuel flow between injector pairs and between rotors.

The Front Rotor (Rotor1) is the rotor next to the water pump and pulley end of the engine. The Rear Rotor (Rotor 2) is the rotor next to the PSRU.

Read the EC2 Instruction Manual for a description and how to change these parameters.

The first bar is simply a reference bar with a value of 128. This value represents a default positon to which the other bars values may be compared. The first parameter pair shown is the balance between the primary and secondary injector pairs fuel flow rate. The flow rate of each pair are adjusted by **EC2 Mode 3**. The difference (if any) between primary and secondary injector flow rates are shown by the relative difference between **3PRI** and **3/6SEC.** While mode 3 controls the relative flow rate of both pairs (primary and secondary), mode 6 is used to differentiate between primary and secondary flow rates.

If for example you had larger secondary injectors than primary you may need to use mode 6 to adjust the secondary injector flow rates.

The second parameter pair **4R1DF** and 4R2DFshown is the balance of fuel flow between the front rotor (Rotor 1) and the rear rotor (Rotor 2) at low rpm (Primary injectors only firing). There may be a need to adjust the flow rate between the two rotors. This is done use Mode 4.

By keep this screen displayed as you made those changes using the various modes of the EC2, you should will be able to see the relative difference those changes make.

Appendix A Calibration

The EFI System Monitor comes set up for your particular installation. However, since the flow of injectors can change with age and wear, pump pressure, etc., this Monitor comes with a fuel flow calibration procedure.

The fuel flow calibration procedure is set up with your injector's nominal fuel flow as the default. If there are no errors or differences, then the fuel you would need to fill the tanks at the end of a flight would be your maximum fuel load minus your fuel remaining in the tanks. This is called the **Predicted Fuel Load** or **PFL**.

If the amount of fuel you actually loaded –**Actual Fuel Load (AFL)** is equal to the **PFL** then there is no difference, or error, and therefore nothing to change.

However, if there is a consistent difference between the **AFL** and **PFL** then this difference can be minimized and eliminated by the semi-automatic calibration procedure.

You should (if needed) perform this operation when you are prepared to fill up and top off your tanks – in other words do not attempt to calibrate with a partial fuel load. The "ground truth" for fuel calibration is a full load of fuel which should equal your maximum fuel load set in the EFISM.

After carefully filling you tanks on level ground and with attention to removing or minimizing air bubbles, accurately record the amount of fuel to the nearest 10^{th} of a gallon that filling the tanks required. This is your **AFL**.

Turn on the monitor with the engine off. Go to the MODE screen and press B3-Config.

This will bring up the UNIT/FUEL Configure Screen with the B1-Configure (for EFISM) and B2-Fuel Cal(ibrate) choices. Select B-2 for Calibration.

This will bring up a screen with three choices. B1- Fuel Cal, B2- Initial and B3-Inj K. The very first time you are performing this calibration procedure, press B2-Initial. . For the first time and this **one time only**, press B2-Initialize. The screen will blank for a moment and then return with "Initialized" on the screen for a moment before returning to the Fuel Cal screen.

What you have done is **initialize** a running average algorithm used in the Fuel Calibration process. It keeps track and averages the last four corrections to the fuel flow constant. So you do not want to initialize again or it will erase the four calibration efforts and you will have to start over. But, if in case you committed an error in entering fuel for the calibration process and later realized it, you may want to re-initialize and start over.

After initialization, you will be returned to the MODE screen.

There press B2- Adjust in order to enter the amount of fuel you just filled the tanks with, this is your **AFL** quantity.

Press B1-Add fuel and enter in the amount of fuel required to fill the tanks. Then pressing B5, twice return to the MODE screen. Press B3-Config and B2-Fuel_Cal again. This time when the choices, B1-Fuel Cal and B2-Initial Calibration appear, press B1-Fuel Calibration.

NOTE: If you forgot to enter fuel before your press the B2- Fuel Calibrate button, an error message will appear. Simply return to B2-Adjust and add the correct fuel. Repeat the previous steps.

Upon pressing B2-Fuel Calibrate the algorithm will calculate the difference between **AFL** and **PFL** and taking a percentage of that difference adjust the fuel flow constant to move the **PFL** closer to the **AFL**. This will take a moment and two Values ("K" and "Limit") will appear on the screen. If you failed to enter fuel, a message of **No Fuel Loaded** will be displayed. You must enter a fuel load (at full tanks) for the calibration procedure to work.

K will be a four digit number, record this value for future reference. Limit will be a 7 digit number, also record this value. These numbers will now be used by the monitor to derive new fuel flow and fuel usage constants. Press B5 and you will return to the MODE screen. These values will be stored in memory.

Final step is to ensure your total fuel is equal to your max fuel load. I recommend adjust the value of your Fuel Remaining variable such that the total of fuel remaining and fuel added is equal to your max fuel load (which is what you should have in your tanks to do the calibration).

This adjustment will ensure that when you start your engines the next time that your injector constant has been has been adjusted to more accurate reflect reality and the fuel load is starting off equal to your maximum load.

Important! After adjusting your total fuel to equal Max fuel load, check one last time by pressing B1-Status Once that is done then make certain you press B4-Ops to ensure all your fuel loaded data and adjustments are saved to memory.

B3-Inj K will simply display the current constants for K and Limit on the screen when ever pressed. You might

for instance press B3 first to get your current constants before starting the calibration process and then check it against the constants after calibration to ensure that a change has taken place.

If the difference between your **AFL** and **PFL** is a ½ gallon or less, I personally would not recalibrate although you may do so.

EXAMPLE

Here is an example: Using an RV-6A max fuel load of 38 gallons.

Using the B2-Adjust button, enter that mode and using B3-Fuel Rem button set the fuel remaining quantity to 8 gallons. Press B5 twice to get back to the Mode screen and press B1-Status. The Rem(aining) displayed should = 8 gallons and the Tot(al) should = 8 gallons. The fuel alarm values do not play any part in the calibration process and can be ignored. So we have EFISM fuel remaining **EFISM Fuel Remaining = 8** Gallons.

Now the **Predicted Fuel Load(PFL)** that would be expected (assuming the default K factors were perfect) would be
PFL = Max_Load – EFISM Fuel Remaining = 38 – 8 = 30 gallons. However, lets assume when you loaded the additional fuel the actually amount it took to achieve **Max_load** (38 gallon) was 32 gallons instead of the 30 gallons predicted. This implies that the fuel Remaining calculated during the flight by the EFISM is off by 2 gallons and instead of 8 gallons, the actual fuel remaining (**AFR**) is 6 gallons
Max_Load -AFL = AFR.

Or taking our example values **Max_Load-AFL = 38 –32 = 6** gallons **AFR**.

If the quantity difference generates a remainder fuel value with a negative sign, simply ignore the sign and only enter the quantity - the calculation algorithm will take care of the sign.

Note: If your aircraft type has a different **Max_Load** quantity than this example, then use that value to calculate **PFL**. For example if your **Max_load** value was 40 gallons, then **PFL = Max_Load – EFISM Fuel Remaining** = 40 – 8 = 32 gallons and if you loaded say 33 gallons then the actual fuel remainder would be **Max_Load -AFL = AFR** = 40 – 33 = 7 gallons instead of 8 gallons. So you would change your fuel remainder in the EFISM to the actual 7 gallons and then add fuel of 33 gallons to bring you to a **Max_load** of 40 gallons.

If this is the FIRST attempt at calibration then the B2-Initialize button should be pressed on the Fuel Calibration screen. However, if after you start a calibration sequence (of up to four flights) , you do not want to Initialize again – unless, you decide there has been a mistake in your calibration and you wish to initialize and start all over.

The next step would be to adjust the EFISM units Fuel Remaining value to reflect what we know to be "Ground Truth" or change if from the calculated 8 gallons to the actual 6 gallons that you found to be remaining in the tanks.

You enter the B2-Adjust mode and then select B2-Rem Fuel and change the fuel remaining to the "ground truth" value, 6 gallons in this example. After entering 6 gallons press B5 twice to get back to the MODE screen. Press B2-Adjust and then B1-Add. Add 32 gallons of fuel which should bring the total amount incremented to 38 gallons (Max_Load). Press B5 twice to get back to the Mode screen.

Then press B3-Config button followed by B2-Fuel Cal button on the subsequent screen. This will bring to the Fuel Ks screen where you would select B1-Fuel Cal which would then perform the calcuations and display a new K and Limit values on a screen titled Fuel Factor.

Press B5 to exit to the Mode screen and then **IMPORTANT!** Press B4-Ops to store the fuel data in memory. This will take you to the Flight Screen (Fuel Flow). Press B5 to observe the fuel status screen to verify that the Fuel Remaining and fuel total = 38 gal. You should also see that the Lod (Loaded) fuel = 32 gal.

You have completed the calibration process. This may need to be repeated for 4 flights if the EFISM monitor disagrees with the actual fuel usage by more than ½ gallon or whatever you feel comfortable with.

Note: After doing this example calibration procedure, I strongly suggest that you got back to the Fuel Calibration screen and press B2-Initial to put the system back to your default injector constants.

Note: Even small inaccuracies in measurement of fuel for calibration can produce calibration errors. For example, in my RV-6A it is possible to trap a half to a full gallon of air in each tank during refueling which will throw the calibration off. So try to ensure you refuel on level ground and shake the wings to remove air bubbles.

With adjusted injector constants and the fuel load accurately reflecting the Fuel State, you are now ready for your next flight.

Injector Size Changes

Normally, the injector size information you provided when ordering the unit should provide accuracy to within 2% or better. So give the unit a chance over several flights before deciding to calibrate.

IF you should change the size of your injectors significantly – say going from 460 cc/min (information initially supplied on you injectors) to 550 cc/min then re-calibration will be required. Either re-calibration – or returning the EFSIM unit to have the injector constants re-calculated and reprogrammed into the unit. Otherwise, if you ever initialize, it would put you back using the initial 460 cc/min value initially programmed into the unit.

Summary of Steps for actual recalibration of Fuel Injector Constants

1. Calculate Actual Fuel Remaining, **AFR = Max_Load – Actual Fuel Loaded** (to achieve Max_Load – i.e full tanks)

2. Initialize Fuel Calibration algorithm (if this is the first time to perform the Fuel Calibration process, otherwise skip these items under step 2 and got to Step 3).
   Mode Screen, Press B3-Config
   Unit/Fuel Screen, Press B2-Fuel Cal
   Fuel Ks Screen, Press B2-Initial

3. Adjust Fuel Remaining in EFISM to Actual Fuel Remaining value from step 1.
   Mode Screen, Press B2-Adjust
   Adjust Screen, Press B2-Rem Fuel
   Fuel Rem Screen, Press buttons to change value to actual fuel remaining
   Press B5 when finished entering quantity
   Rem Set Screen (should show value entered)
   Press B5 to return to MODE Screen.

4. Increase Fuel in EFISM to Actual Fuel Loaded value from step 1.
   Mode Screen, Press B2-Adjust
   Adjust Screen, Press B1-Add Fuel
   ADD FUEL Screen, Press buttons to change value in brackets on screen to actual fuel loaded
   Press B5 when finished entering quantity
   Fuel Added Screen (should show value entered)
   Press B5 to return to MODE Screen

5. To activate Fuel Calibration algorithm
   Mode Screen, Press B3-Config
   Unit/Fuel Screen, Press B2-Fuel Cal
   Fuel Ks Screen, Press B1-Fuel Cal
   Within a second the Fuel Factor Screen will appear with the new K and Limit values
   Push B5 to return to MODE screen.

6. Push B4-Ops button to store data by entering Flight Mode Screens.

7. Push B5-Status to verify that the Rem (fuel remaining) value and the Tot (Total) are equal to your Max_Load values.

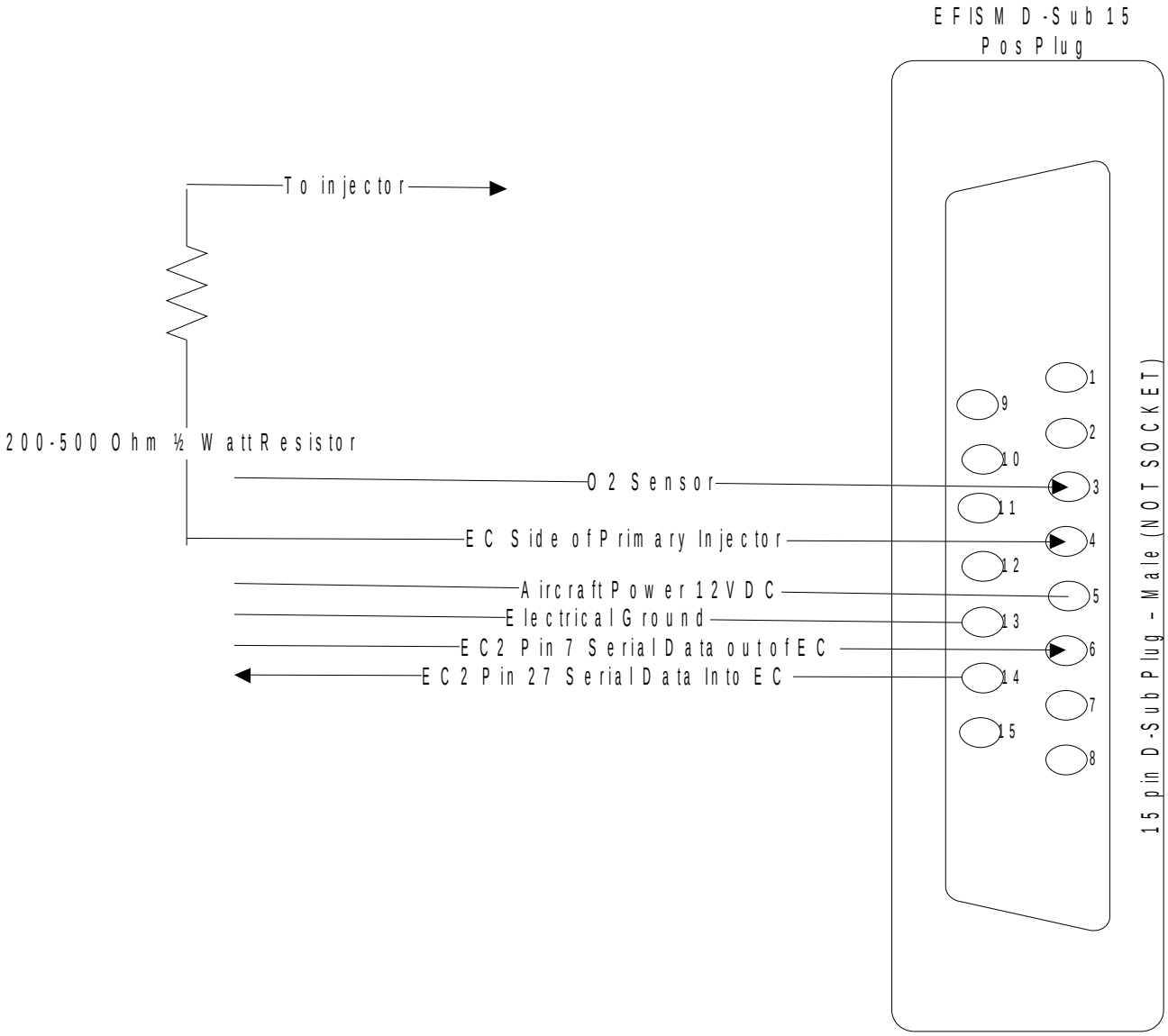
Insert Proper Wiring Diagram for Type RWS Controller used – EC2 or EC3

EC2 Wiring Diagram

D-sub 15 Pos Plug
Pin
3 Narrow Band Oxygen Sensor Signal Output (Note. Take care to identify O2 sensor output Lead)
4 Connection to one of the primary fuel injectors (Note. MUST be between injector and EC)
5 Connection to aircraft Power (9 – 18 Volts)
13 Connection to aircraft electrical ground
6 Connection to EC2 Pin 7 (Seria Data l output pin from EC2 provides input to EFISM pin 6)
14 Connection to EC2 Pin 27 (Serial Data input pin to EC2, from EFISM pin 14)

Do not make any connection to other pins on D-sub 15 plug

Resistor – Should the wire between injector and EFISM become grounded, it is possible that could cause the injector to operate in the full open position. This resistor would prevent sufficient current flow to preclude a grounding from causing the injector to open should a grounding happen.



EC3 Wiring Diagram

D-sub 15 Pos Plug
Pin
3 Narrow Band Oxygen Sensor Signal Output (Note. Take care to identify O2 sensor output Lead)
4 Connection to one of the primary fuel injectors (Note. MUST be between injector and EC)
5 Connection to aircraft Power (9 – 18 Volts)
13 Connection to aircraft electrical ground
6 Connection to EC 3 Pin 13 (Seria Data loutput pin from EC 3 provides input to EFISM pin 6)
14 Connection to EC 3 Pin 12 (Serial Data input pin to EC 3, from EFISM pin 14)

Do not make any connection to other pins on D-sub 15 plug

Resistor – Should the wire between injector and EFISM become grounded, it is possible that could cause the injector to operate in the full open position. This resistor would prevent sufficient current flow to preclude a grounding from causing the injector to open should a grounding happen.

