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**FJO**

**RACING  
PRODUCTS®**



**Wideband Air/Fuel Ratio System  
Series 4000**

**INSTALLATION AND USER MANUAL**

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## 1. System Overview

The purpose of this overview is to provide the user with some basic information regarding the functional operation, installation and configuration of the Air/Fuel Ratio Mini-Controller.

**WARNING! DO NOT plug in the sensor until you have configured the wideband for the correct sensor or you will damage it.**

### 1.1 Wideband AFR Power Input

Connect the controller's white wire to a switched accessory power source that will be ON when the engine is running. Connect the black wire to the chassis ground point that the ECU is grounded to. The controller will add 5 amps to the load so make sure that the fuse rating is sufficient to power both. (The power and ground need to be "clean" in order to obtain the best performance from your wideband AFR so avoid connecting it to the same source as your ignition system).

**Note:** The controller should be on if the engine is running to avoid damage to the sensor.

### 1.2 AFR Analog Output

The GRAY and TAN are AFR voltage signals that can be connected to other FJO products, your ECU, or a datalogger. The GRAY wire outputs the "FJO Legacy" non-linear curve and the TAN wire outputs a user programmable signal for the range of 10~20 AFR (gasoline). For alternate fuels see section 4. **Factory Default setting = 0.5~4.5V linear**

**Note:** when connecting to a non-FJO device, follow the instructions in the "correction factor" section to correctly calibrate the output voltage

### 1.3 Digital Port

This port can be used to connect to the optional digital gauge or the serial port of a PC.

#### 1.3.1 Connecting the DWB4001 Digital Gauge

To install the DWB4001 gauge, connect the white/green wire from the gauge to the white/green wire of the controller. The black wire from the gauge should be connected to a good ground point and the white wire should be connected to a switched 12-volt source. The pink wire from the gauge can be used to dim the display by connecting it to a switched 12-volt source. The display will dim when 12 volts is applied to this wire. The white/red wire from the gauge is not used and should be tied off.

#### 1.3.2 Connecting a PC

This will require that your PC have a serial port or USB/serial adapter. To install the black PC serial cable, connect the red wire from the PC cable to the white/green wire of the controller. Now connect the brown wire from the PC cable to the white/red wire of the controller. Finally, connect the black wire from the PC cable to a good ground point. The PC cable can now be connected to the serial port of your PC.

**Note:** It is possible to connect both the DWB4001 gauge and the PC serial cable to the controller at the same time.

## 1.4 Oxygen Sensor Port

This port connects directly to the FJO-NTK (p/n SO20003) or the FJO-Bosch (p/n SO20004) sensors. The SO20003 sensor comes with a 6-inch harness and the SO20004 comes with a 16-inch harness. Optional sensor extension cables are available if the controller cannot be mounted close enough to the sensor. (4ft = IWS3004, 8ft = IWS3008, 12ft = IWS3012).

### 1.4.1 Setting the Sensor Type

The controller has a short brown wire loop, which sets the sensor type.

LOOP NOT CUT => FJO-NTK (p/n SO20003)  
 LOOP CUT => FJO-Bosch (p/n SO20004)

**WARNING! DO NOT plug in the sensor until you have configured the wideband for the correct sensor or you will damage it.**

### 1.4.2 Oxygen Sensor

*This controller supports the FJO-NTK (p/n SO20003) or the FJO-Bosch (p/n SO20004) sensors only.*

It is recommended that the Oxygen Sensor be installed at least 450 mm [18 inches] downstream from the exhaust valves and before the catalytic converter. In the case of a turbocharged engine, it is recommended that the Oxygen Sensor be installed downstream from the turbo outlet and before the catalytic converter. When installing a single sensor on an engine equipped with individual exhaust runners (headers), the collector area is the preferred mounting location. If the engine was originally equipped with an oxygen sensor, this location may also be used. The sensor requires an M18 X 1.5 threaded boss for installation. A small amount of an anti-seizing compound is recommended on the threads of the sensor, being careful not to get any on the sensor area. Always install the sensor so that the tip (the part in the exhaust stream) is **lower** than the body (the part where the wires exit). The mounting position should be chosen such that the sensor will never become submerged. Tighten the sensor to 45 N-m [33 lbf-ft].

Over tightening or cross threading during installation will cause irreparable damage to the sensor – if the sensor does not thread in easily and smoothly DO NOT FORCE IT – check the threads as they may need to be cleaned or re-tapped. The black sensor harness should be routed away from sources of extreme heat and fastened securely to prevent damage.

**Note: DO NOT run the engine with an unpowered sensor in the exhaust stream. This will cause premature sensor failure.**

## 1.5 RPM Input (KWB4001 only)

The wideband controller is designed to work with most analog Tachometer signals. Alternate sources such as coil triggers can be used if no tachometer signal is available. DO NOT use signals from crank or cam sensors. Connect the green wire included with the controller kit to the TACH source.

**Note:** This wire only needs to be connected if you are using the FJO datalogging and analysis software and want to log the engine RPM.

## 1.6 FJO Digital Data Bus

The FJO Digital Data Bus is a high-speed digital port that allows up to 8 units to be connected and data logged using the software included with the KWB4001 kits.

## 1.7 Status LED

This LED shows the status of the controller.

**ON** – the controller has power and has a sensor connected.

**STEADY FLASH** – the controller has power but has a sensor fault

**DOUBLE FLASH** – one of the other controllers connected on the Digital Data Bus is reporting a sensor fault

## 1.8 Status Messages on the Gauge

When the unit is first activated, the gauge will run through a “self-test” which lasts approximately 2 seconds. It will, in sequence, display “8.8.8.”, “FJO”. At this point it will begin to display status messages from the controller. While the sensor is warming, the display will show “bH#” or “nH#” depending on the sensor type configured. Once the sensor is ready, the gauge will begin to display the air/fuel ratio numbers.

### Status messages

8.8.8.	Gauge Self-test
bH#	Sensor warming – configured for Bosch sensor
nH#	Sensor warming – configured for NTK sensor
Slo	Sensor slow to reach operating temperature
Err	Sensor error
Hot	Sensor too hot
Cld	Sensor too cold
- - -	No data from controller
Exy	Number of controllers detected (y) is less than the number of controllers expected/configured (x)

## 2. Operation with Advanced Analysis Software

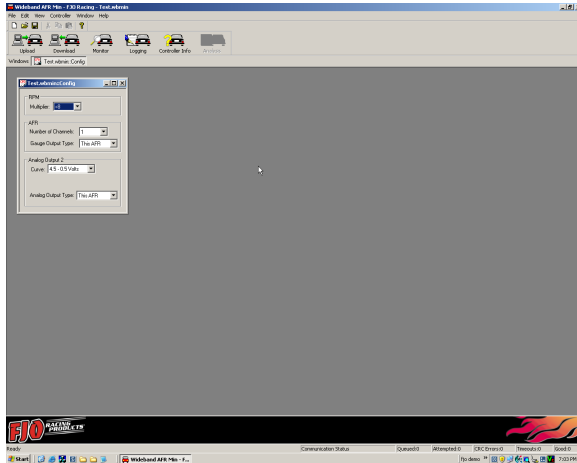
Updates and manuals are available from [www.fjoracing.com](http://www.fjoracing.com). To install the Advanced Analysis Software click the Wideband AFR link on the CDROM startup menu included with the kit. There you will find information on installing and using the datalogging software.

Your PC will require a serial port to connect to the WBAFR. Some newer laptops do not have an integrated serial port and will require an optional USB-Serial adapter or a PCMCIA serial adapter. Please contact your computer equipment supplier to purchase this adapter.

**Note:** Due to the wide variety of adapters available, FJO cannot guarantee the functionality of a specific adapter.



## 2.1 Main Screen



The main screen allows you to:

- Upload your saved configurations to the unit and to download your configurations from the unit to your PC.
- Enter the monitor window.
- Configure RPM, AFR, and Analog output #2

## 2.2 Configuration Menu

To begin the configuration process, click on “File” and then “New Config” from the menu in the upper left corner of the window.

### 2.2.1 RPM

Multiplier selects the correct pulse count for the RPM counter. Use the following as a guide to determine the correct setting:

a) **Using a TACH signal** – TACH signals will typically have 1 pulse per cylinder during 2 revolutions of the crankshaft (1 full cycle) and therefore the correct setting would be

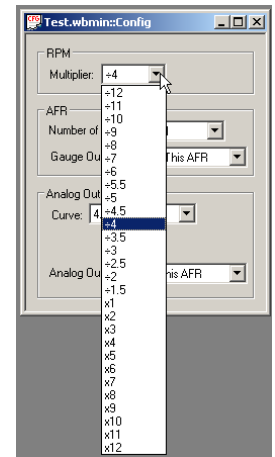
$$\div (\frac{1}{2} \text{ the number of cylinders})$$

*Example: When using a TACH signal*

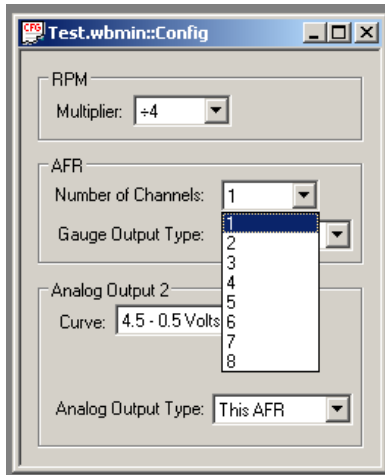
- 4 cylinder setting would be  $\div 2$
- 6 cylinder setting would be  $\div 3$
- 8 cylinder setting would be  $\div 4$

b) **Using a trigger signal from a coil** – first determine how often it fires per revolution of the crankshaft. The correct setting would be:

- **x1** for a waste-spark since it fires each revolution of the crankshaft
- **x2** for a full-sequential since it fires every other revolution.

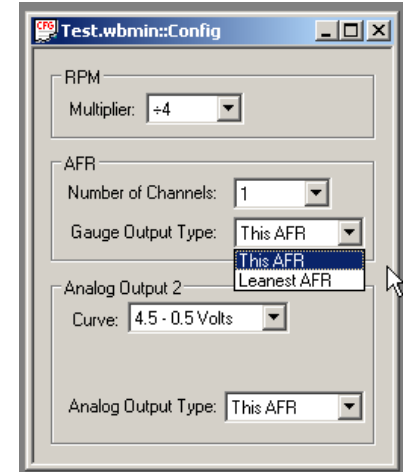


## 2.2.2 AFR Configuration

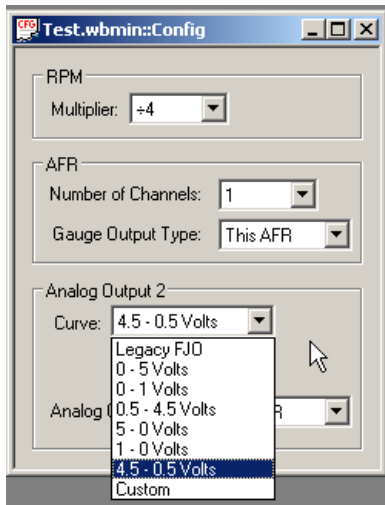


**Number of Channels** tells the wideband how many channels (including itself) must be detected before it will go online. If there are fewer units detected, the wideband will report an error. If there are more units, they will be adopted by the primary controller, however it will not report a configuration error until there are fewer than specified by this parameter.

**Gauge Output Type** determines if the data sent to the gauge is from the unit it is physically connected to (this AFR) or if it is the leanest reading from the cluster. The cluster is defined as all the wideband controllers that are connected via the Digital Data Bus. This mode allows you to connect up to 8 units together and have only 1 gauge to monitor all 8. **Factory Default setting = Leanest AFR**



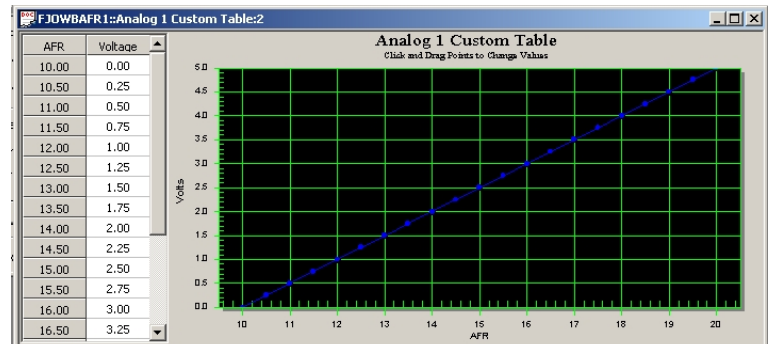
## 2.2.3 Analog #2 Output Configuration

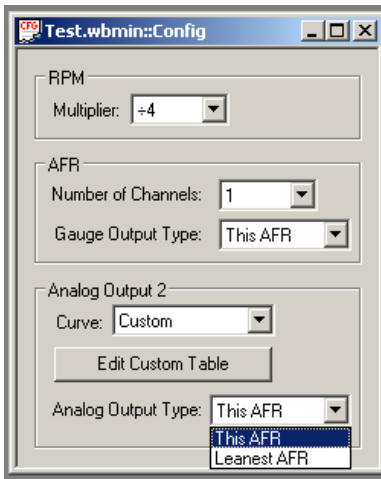


**Curve** allows you to set the type of voltage curve used by output #2. Select a curve type from the menu that is displayed by tapping on the down arrow. **Factory Default setting = 0.5~4.5V linear**

**Note:** All options except Custom and Legacy FJO are linear curves. Legacy FJO is the standard curve from our original CWC0002 and CWC0001 controllers.

**Edit Custom Table** allows you to create a custom output curve. To edit the curve, type the voltage values next to the applicable AFR, or using the cursor, drag the blue dots up/down the scale to the desired value. (curve type must be set to "custom" for the *Edit Custom Table* button to appear.





Analog Output Type determines if the AFR output voltage is determined by the AFR from the unit it is physically connected to (this AFR) or if it is determined by the leanest reading from the cluster. The cluster is defined as all the wideband controllers that are connected via the Digital Data Bus. This mode allows you to connect up to 8 units together and have an ECU with only 1 input able to monitor all 8 channels.

**Factory Default setting = Leanest AFR**

## 2.3 Software Preferences

To configure the software preferences select View on the top menu bar and then options from the pull-down menu. This window allows you to configure the General, Monitoring, Channel 1, and RPM preferences.

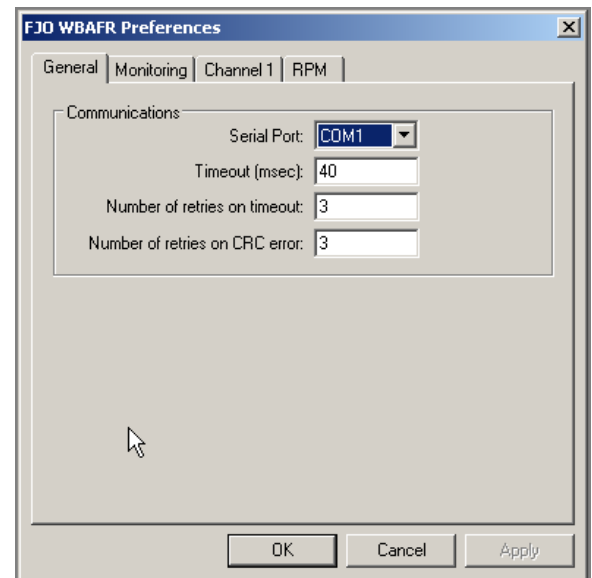
### 2.3.1 General TAB

Serial Port allows you to select which COM port the software will use on your PC. Select the correct port from the drop-down menu.

Timeout sets the time that the software waits before resending a command if there was a communication error. For most PC's this should be set to **40**.

Number of retries on timeout sets the maximum retry count before the software displays a timeout error. For most PC's this should be set to **3**.

Number of retries on CRC error sets the maximum retry count before the software displays a CRC error. For most PC's this should be set to **3**.



**Note:** Some PC's using USB-serial converters will experience a higher error rate due to the performance characteristics of the converter. In these cases we recommend that you increase the Timeout value to 2000 to determine if this corrects the problem. Doing so will reduce the update frequency and slow down the display or logging rate.



## 2.3.2 Monitoring TAB

This menu lets you set the default operational settings for the monitor and logging functions.

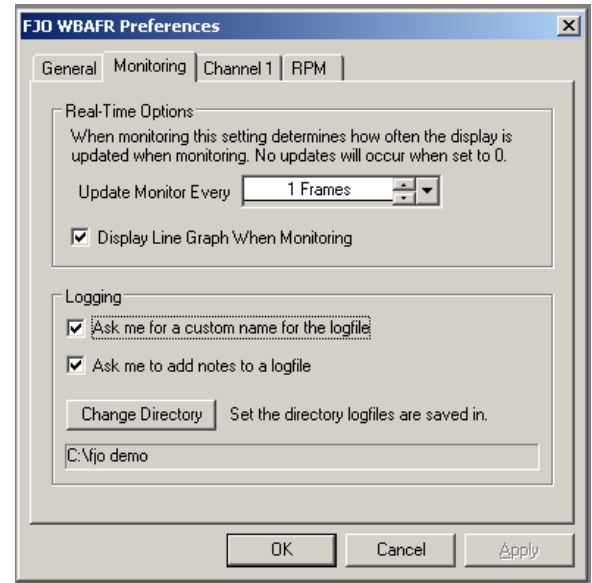
Update Monitor Every determines how fast the monitor window is updated. The lower the number the faster the update rate, however this will slow down the datalogging with the monitor window open.

Display Line Graph When Monitoring allows you to turn off the strip chart display. This will improve performance if you are using an older computer with limited resources.

Ask me for a custom name for the logfile will force the program to prompt for a custom name when saving the logfile. See data logging for more details.

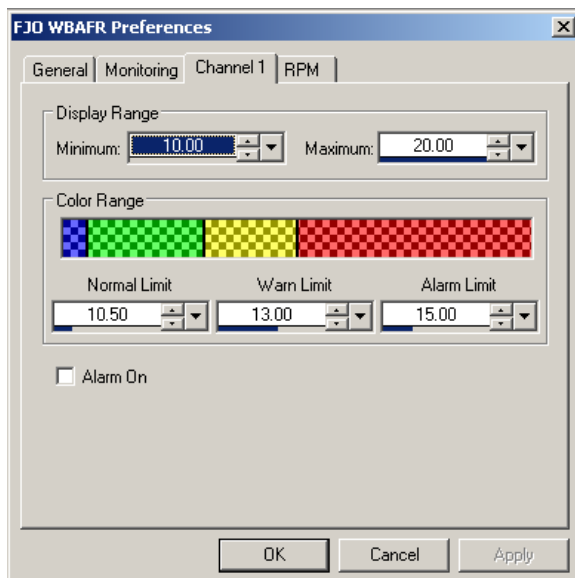
Ask me to add notes to a logfile will have the program prompt you if you want to add a note to the logfile. See data logging for more details.

Change Directory allows you to set the default directory where log files and configuration files are saved to and opened from.



## 2.3.3 Channel 1

This menu allows you to customize the way that the software monitor displays the AFR data.



Display Range (Minimum / Maximum) allows you to set the AFR display range in the Monitor screen.

Normal Limit sets the AFR point where the monitor screen display color changes from blue to green.

Warn Limit sets the AFR point where the monitor screen display color changes from green to yellow.

Alarm Limit sets the AFR point where the monitor screen display color changes from yellow to red. It also sets the trigger for the audible alarm.

Alarm sets the lean trigger point above which the software will beep. To enable this feature click the box until a checkmark appears.

### 2.3.4 RPM TAB

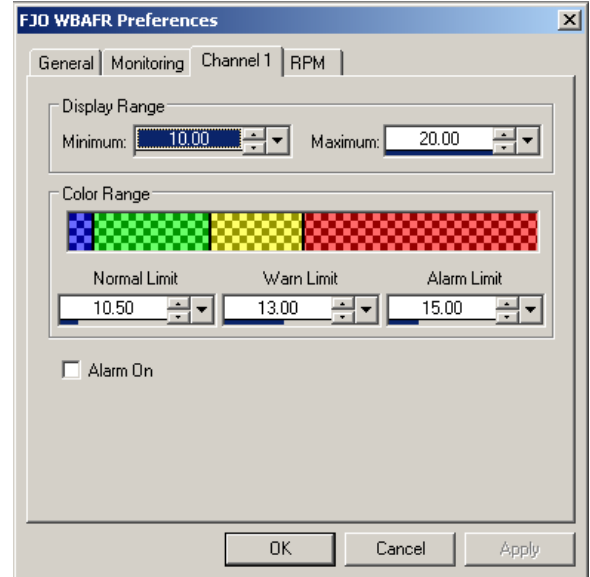
This menu allows you to customize the way that the software monitor displays the RPM data.

Display Range (Minimum / Maximum) allows you to set the RPM display range in the Monitor screen.

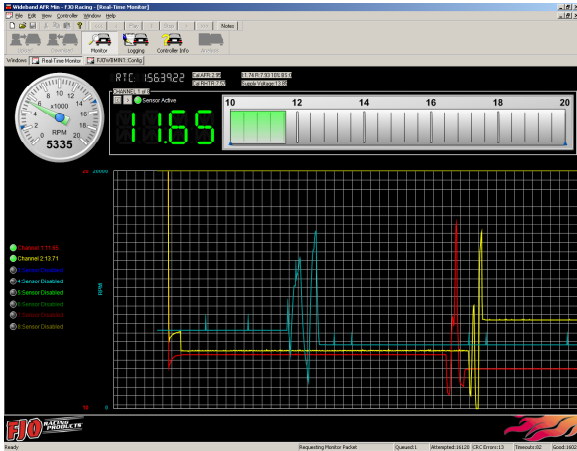
Warn Limit sets the RPM point where the monitor screen display color changes from green to yellow.

Alarm Limit sets the RPM point where the monitor screen display color changes from yellow to red. It also sets the trigger for the audible alarm.

Alarm sets the lean trigger point above which the software will beep. To enable this feature click the box until a checkmark appears.



## 2.4 Monitor Window



This screen allows you to graphically view the data from the wideband controller in a real-time. To access this screen, simply click the Monitor button on the Main Screen.

The screen will display the current RPM (as shown in the circle), Oxygen sensor status and AFR, and a strip chart display of each.

To exit this screen click on the X in the upper right hand corner of the screen.

## 2.5 Data Logging

To start logging click on the Logging button while the monitor window is open. To stop logging, click on the button again. When logging is turned on, the PC creates a file using the following name format:

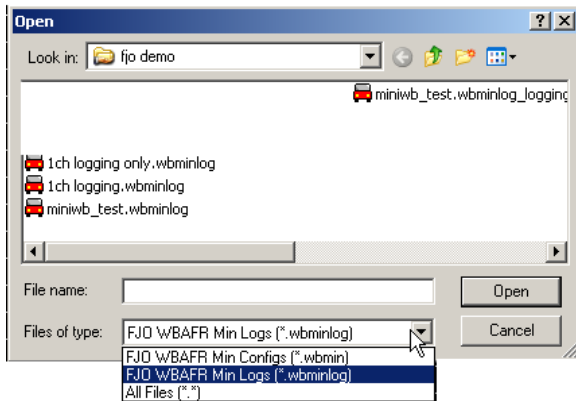
“FJO WBAFR YYYYMMDD-HHMMSS.wbminlog”

where:

YYYY = year  
MM = month  
DD = date  
HH = hours  
MM = minutes  
SS = seconds

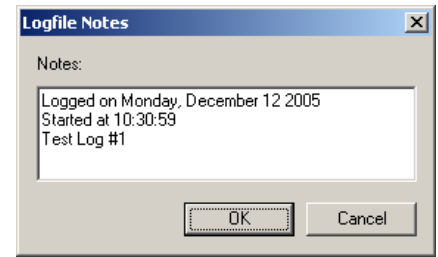
If you enabled the Ask me for a custom name for the logfile option in the Monitoring TAB, the program will prompt you for a name to save the file as. This will replace the default format listed above. The

program will also prompt you to add a note to the log file if you enabled the Ask me to add notes to a logfile option. You can manually edit the logfile's note by clicking on the Notes button that appears when you open the logfile.



You can playback your log files by opening the file using the standard windows method. Select File, then Open, then select the type of file you wish to open (*wbmin - config / wbminlog - log*). Once a log file is open, the monitor screen appears and the playback buttons at the top of the screen become accessible.

To delete logfiles, highlight the file you want to remove and hit the delete key on the keyboard.



## 2.6 Data Analysis

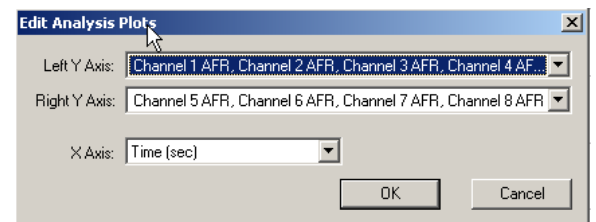
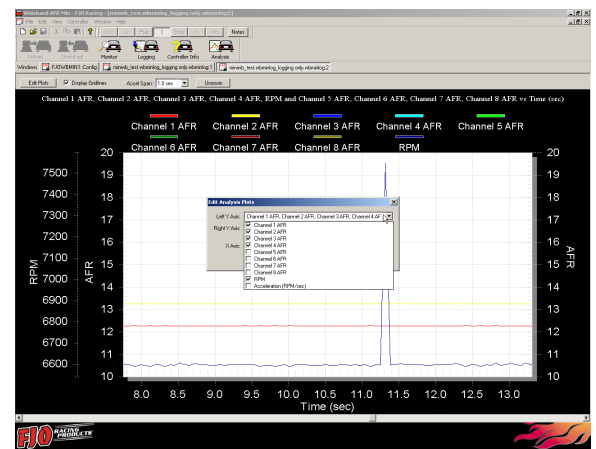
This feature allows you to display data from a previously saved logfile in a graphical format for advanced analysis. This is a very unique and powerful tool for tuning. To begin, open the log file and then click the Analysis Plots button on the upper task bar.

Gridlines enables or disables the gridlines on the graph.

Accel Span sets the time window used to smooth the displayed acceleration curve.

The X and Y axes can be customized to display any combination of items. This is done by clicking the "Edit Plots" button.

- Channel x are the AFR channels
- RPM is the TACH signal
- Acceleration is the rate of change of the RPM



To **ZOOM in** on any section of the graph simply click and hold the left mouse button, and then drag the cursor. A box will appear which indicates the area to be zoomed. To **ZOOM out**, click on the Unzoom button that appears in the upper right when you zoom in.

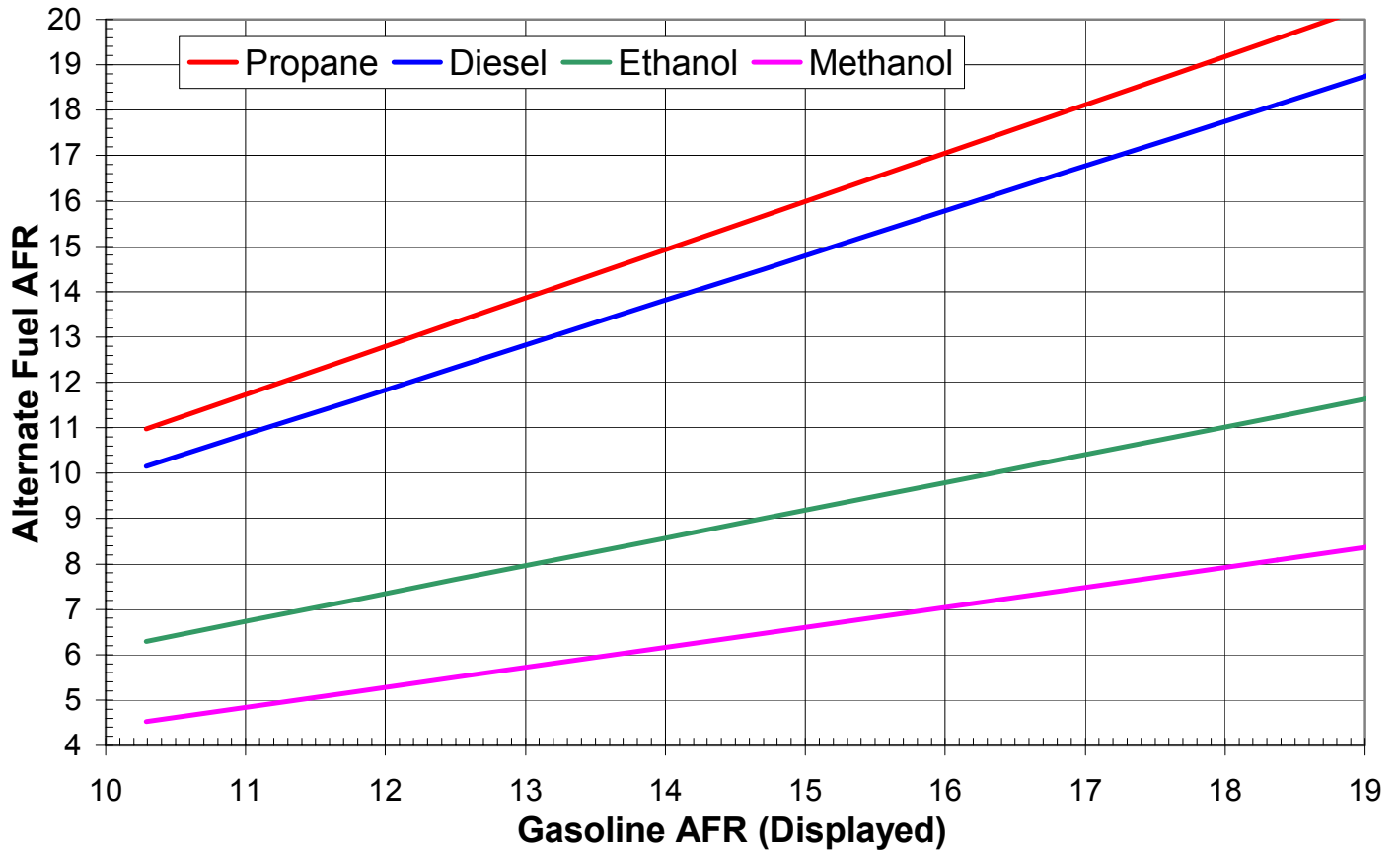
Additional features are available to customize the graph view as well as export the screen to a file or printer. This menu is selected by clicking the right mouse button while the cursor is over the graph.

To print or save graphs select Export Dialog. The utility will prompt your for printer information if you are printing or will open a standard file save window if you are trying to save the graph.

### 3. Alternate Fuels

While the FJO Wideband Analysis System has been designed for use with unleaded gasoline, it may be used with alternate fuels using the following conversion table.

Air/Fuel Ratio					
Gasoline	Lambda	Propane	Methanol	Ethanol	Diesel
10.3	0.70	11.0	4.5	6.3	10.2
11.0	0.75	11.8	4.9	6.8	10.9
11.8	0.80	12.5	5.2	7.2	11.6
12.5	0.85	13.3	5.5	7.7	12.3
13.2	0.90	14.1	5.8	8.1	13.1
14.0	0.95	14.9	6.1	8.6	13.8
14.7	1.00	15.7	6.5	9.0	14.5
15.4	1.05	16.5	6.8	9.5	15.2
16.2	1.10	17.2	7.1	9.9	16.0
16.9	1.15	18.0	7.4	10.4	16.7
17.6	1.20	18.8	7.8	10.8	17.4
18.4	1.25	19.6	8.1	11.3	18.1
19.1	1.30	20.4	8.4	11.7	18.9



## 4. AFR Output Voltage Curves

The controller's analog outputs come pre-configured from the factory as follows:

Analog #1 (Gray wire) = FJO LEGACY curve

Analog #2 (Tan wire) = 0.5v~4.5v curve

Analog output #1 is hard coded and cannot be changed, however output #2 can be changed using the datalogging software.

### 4.1 Analog Output Voltage

AFR	Lambda	Analog Output Curve						
		Legacy FJO	0 - 5 Volts	0 - 1 Volts	0.5 - 4.5 Volts	5 - 0 Volts	1 - 0 Volts	4.5 - 0.5 Volts
10.00	0.68	0.81	0.00	0.00	0.50	5.00	1.00	4.50
10.25	0.70	0.91	0.13	0.03	0.60	4.88	0.98	4.40
10.50	0.71	1.01	0.25	0.05	0.70	4.75	0.95	4.30
10.75	0.73	1.11	0.38	0.08	0.80	4.63	0.93	4.20
11.00	0.75	1.21	0.50	0.10	0.90	4.50	0.90	4.10
11.25	0.77	1.31	0.63	0.13	1.00	4.38	0.88	4.00
11.50	0.78	1.42	0.75	0.15	1.10	4.25	0.85	3.90
11.75	0.80	1.52	0.88	0.18	1.20	4.13	0.83	3.80
12.00	0.82	1.61	1.00	0.20	1.30	4.00	0.80	3.70
12.25	0.83	1.71	1.13	0.23	1.40	3.88	0.78	3.60
12.50	0.85	1.80	1.25	0.25	1.50	3.75	0.75	3.50
12.75	0.87	1.88	1.38	0.28	1.60	3.63	0.73	3.40
13.00	0.88	1.97	1.50	0.30	1.70	3.50	0.70	3.30
13.25	0.90	2.06	1.63	0.33	1.80	3.38	0.68	3.20
13.50	0.92	2.14	1.75	0.35	1.90	3.25	0.65	3.10
13.75	0.94	2.22	1.88	0.38	2.00	3.13	0.63	3.00
14.00	0.95	2.30	2.00	0.40	2.10	3.00	0.60	2.90
14.25	0.97	2.38	2.13	0.43	2.20	2.88	0.58	2.80
14.50	0.99	2.45	2.25	0.45	2.30	2.75	0.55	2.70
15.00	1.02	2.54	2.50	0.50	2.50	2.50	0.50	2.50
16.00	1.09	2.68	3.00	0.60	2.90	2.00	0.40	2.10
17.00	1.16	2.80	3.50	0.70	3.30	1.50	0.30	1.70
18.00	1.22	2.91	4.00	0.80	3.70	1.00	0.20	1.30
19.00	1.29	3.00	4.50	0.90	4.10	0.50	0.10	0.90
20.00	1.36	3.10	5.00	1.00	4.50	0.00	0.00	0.50

## 4.2 Determining Correction Factor

Some devices which have a 5 volt input may have too low of an input impedance and will load down the FJO's analog output signal. To correct this, the published AFR vs. Voltage data will need to be adjusted. The following instructions explain how to do this using a digital voltmeter (DVM).

**Note:** The FJO digital displays are not affected by this and therefore are accurate regardless of what devices you connect to the analog output.

1. Remove the sensor from the exhaust pipe, but leave it connected to the FJO controller.
2. Make sure that the analog output wire of the FJO is disconnected from your device's 5v input.
3. Power up the FJO for 1 minute and measure the analog output voltage. Connect your DVM's + (positive) lead to the FJO analog signal and the – (negative) lead to the ground point of your device and record the voltage **V1= \_\_\_\_\_** (to be accurate you must measure all voltages to at least 2 decimal places).
4. Leave the FJO powered on with the DVM connected and power on your device.
5. Once it is ready, connect the FJO to your device and record the voltage **V2= \_\_\_\_\_**.
6. The correction factor is obtained by dividing “V2” by “V1”, or  $C = V2 / V1$ .

**Note:** The “corrected” voltage table data is obtained by multiplying “C” times the "published voltage" for a given AFR, or  $\text{Corrected\_Voltage} = C \times \text{Published\_Voltage}$ .

Example:

If the voltages you measured were  $V1 = 4.723\text{v}$  and  $V2 = 4.597$

Then the correction factor is  $4.597/4.723 = 0.9733$ .

AFR	Published Voltage	Corrected Voltage
11.009	1.217	=> 1.185
11.875	1.564	=> 1.522
12.605	1.833	=> 1.784

**Note:** An electronic version of the above information (in spreadsheet form called “*Calibration data for analog output*”) may be downloaded from [www.fjoracing.com/products/WBAFR/downloads.php](http://www.fjoracing.com/products/WBAFR/downloads.php)

## 5. Accessories



**IWS3004** : WIDEBAND AFR SENSOR CABLE - 4 FOOT  
**IWS3008** : WIDEBAND AFR SENSOR CABLE - 8 FOOT  
**IWS3012** : WIDEBAND AFR SENSOR CABLE - 12 FOOT

**DWB4001** : Wideband AFR display, 2 1/16<sup>th</sup> inch GAUGE



**HSB0001** : O2 SENSOR BUNG & PLUG

**SO20003** : WIDEBAND AFR SENSOR, NTK



**SO20004** : WIDEBAND AFR SENSOR, BOSCH

## 6. Disclaimer

FJO Racing Electronics may not be held responsible for any damages, how so ever caused, to any persons or equipment during the installation or operation of its products. FJO Racing Electronics products are meant for off-road use only, and make no claims as to the units' ability to meet local safety or emissions laws.

## 7. Warranty

FJO Enterprises Inc. (FJO) warrants the material and workmanship of the equipment, components and parts manufactured by FJO against defects under normal use and service. This warranty shall extend for 180 days from the date of manufacture provided that the customer first returns the defective part or component through an authorized distributor, shipping costs prepaid. Prior to returning a product for warranty inspection, the customer must contact FJO's service department with the product serial number to receive a WARRANTY CLAIM NUMBER. Units returned without this number will be refused.

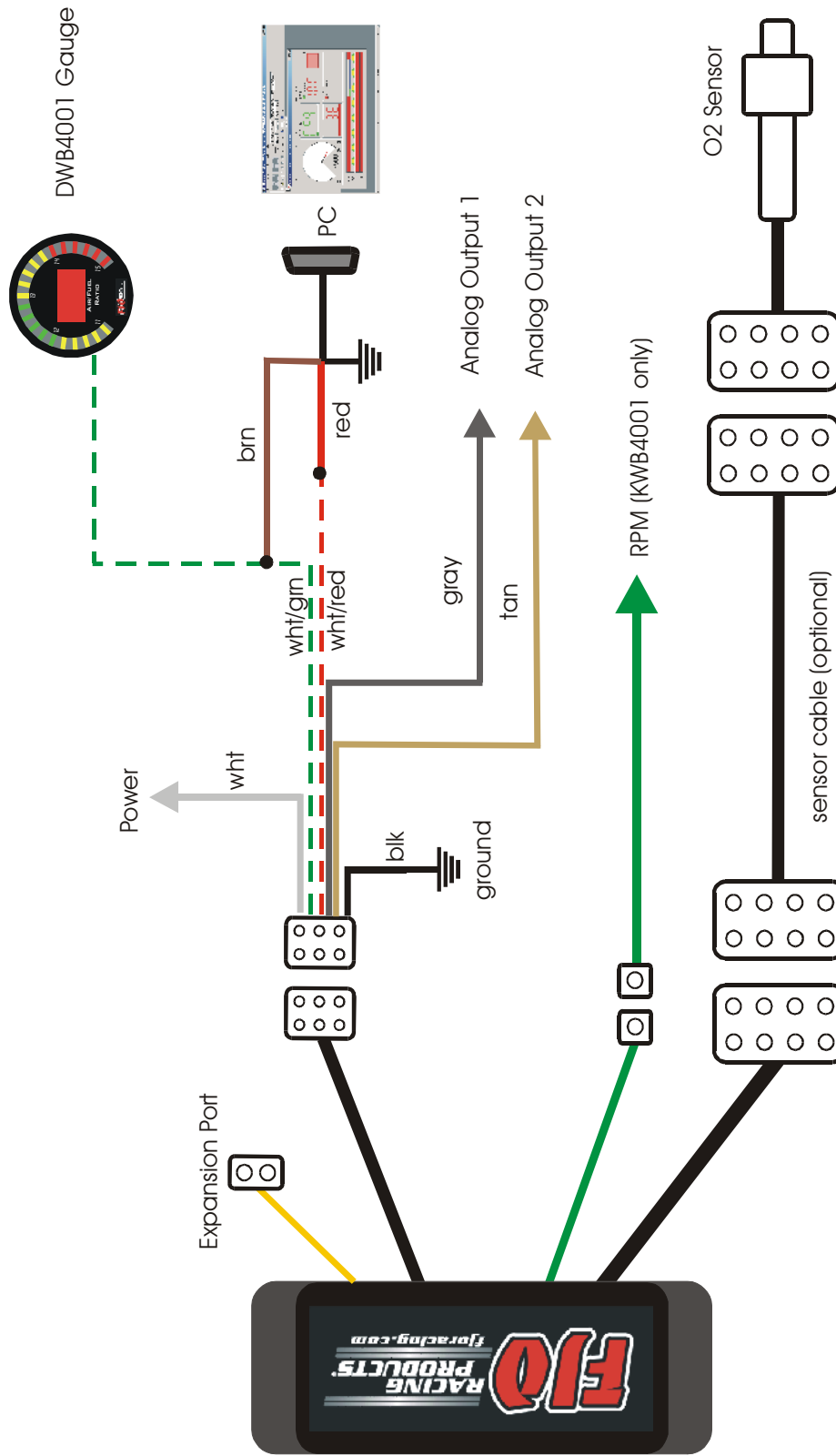
FJO may at its option, repair or replace without cost for parts and labour, the defective product. This warranty does not cover finishes, normal wear and tear, nor does it cover damage resulting from accident, misuse, dirt, tampering, unreasonable use, service attempted or performed by unauthorized service agencies, failure to provide reasonable maintenance, or FJO products that have been modified or used for commercial reasons.

FJO specifically does not warrant equipment, parts or components purchased by FJO or the customer from any third party manufacturers or suppliers. Rather, for any defect in respect of equipment, parts and components purchased from third party manufacturers and suppliers, the customer shall have recourse only to the terms of the warranty of that particular manufacturer or supplier. Any recommendations made by the third party manufacturer or suppliers concerning the use or application of their products are those of the manufacturer or supplier, and FJO extends no warranty with respect to the results obtained for their use. FJO does not warranty those products in any way beyond the term of the warranty extended by the manufacturer or supplier.

The warranty provided above, FJO's obligations and liabilities hereafter, and the rights and remedies of the customer are exclusive and in substitution for, and the customer waives all other warranties, guarantees, obligations, liabilities, rights and remedies, expressed or implied, arising by law or otherwise, including (without limitation) the implied warranties of merchantability or fitness of purpose, and any obligations or liability of FJO arising from tort, or loss of use, revenue or profit, or for incidental or consequential damage.



## 8. Wiring Diagram



## 8.1 Digital Data Bus Wiring

