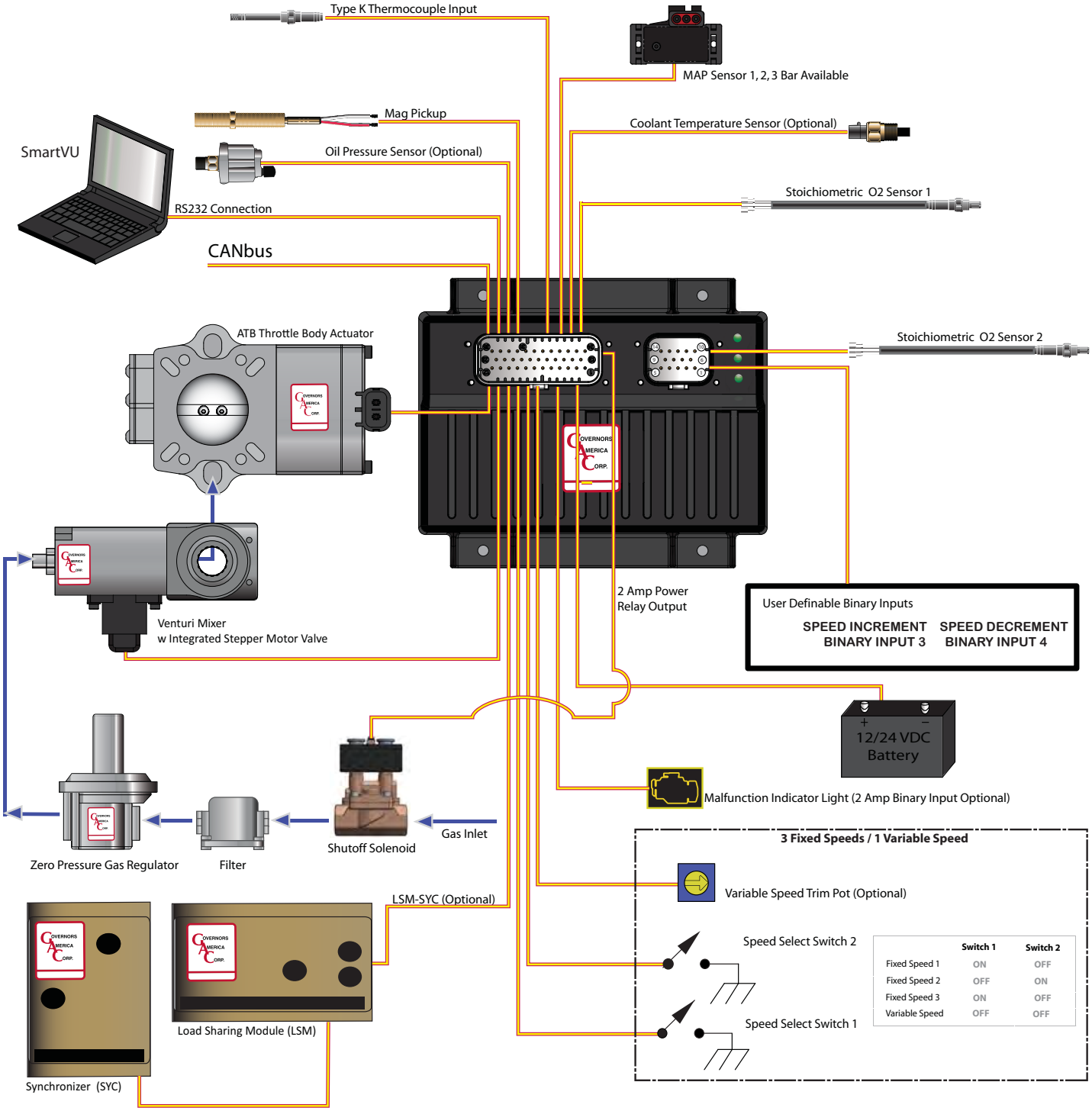
AFR200 Series
Air Fuel Ratio Controller

1 INTRODUCTION

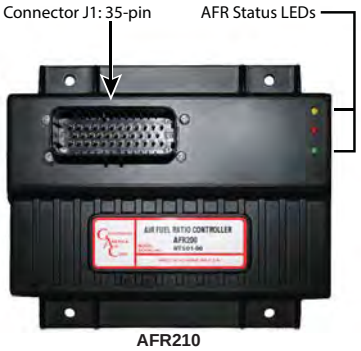
The following sections will cover the selection and installation of AFR components as shown in the diagram below.



2 AFR SELECTION & INSTALLATION

MODEL	DESCRIPTION
AFR210	1 O2 Sensor Input & EGT (Type-K) Input

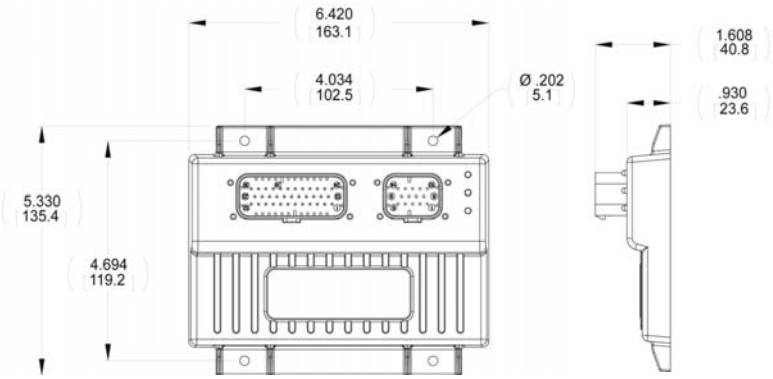
MODEL	DESCRIPTION
AFR201	2 O2 Sensor Input
AFR211	2 O2 Sensor Input (Pre & Post Catalyst) & EGT (Type-K) Input



AFR210

AFR201 & AFR211

NOTE J2 connector used for second O2 sensor



Dimensions:
in. [mm]

Vertical orientation allows for the draining of fluids in moist environments.

Mount in a cabinet, sealed metal box, or directly to the engine.

Avoid Extreme Heat

Do not mount next to turbocharger, exhaust manifold, or high temperatures.

AFR MOUNTING PROCEDURE	
1.	Clean the mounting area from any debris prior to mounting the AFR.
2.	Mount the AFR to the selected location using a bracket or a direct to bulkhead mounting scheme using the dimensions and application information provided. If stand-offs or vibration isolators are required, make sure these are in place prior to proceeding.
3.	Insert the mounting hardware selected into the four holes on the AFR. Pre-drill and tap the locations as required prior to installation.
4.	Using standard values, torque the selected mounting hardware down to a maximum of .25-.50 lb-ft. [0.34-0.68 N•m] without applying excessive force to avoid damaging the mounting tabs or flexing the controller. Ensure that each of the mounting bolts / screws is torqued evenly and gradually.

PERFORMANCE	
Isochronous Operation / Steady-State Stability	± 0.25%
Speed Range / Governor	400-10kHz (Mag Pickup)
Speed Drift with Temperature	< ±1% Max
Idle Adjust	Full Range
Adjustable Droop Range	1-17% Regulation
Speed Trim Range	±5% of Rated Speed
ENVIRONMENTAL	
Temperature Range	-40° to 80°C (-40 to 185°F)
Relative Humidity	up to 95%
INPUT / OUTPUT	
Supply	12-24 VDC Battery Systems (6.5 to 33 VDC)
Polarity	Negative Ground (Case Isolated)
Power Consumption	100mA max. Continuous plus Actuator, Stepper, Heater, and MIL
Speed Sensor Signal	0.5-120 VRMS
Actuator Current	Up to 6 Amps Continuous
Auxiliary (Load Share/Synchronizer) Input	0-10 VDC
Manifold Absolute Pressure (MAP) Sensor Input	0-5 VDC
Coolant Temperature Input	Resistive 0-99 Ohm
Oil Pressure Input	Resistive 10-180 Ohm
Oxygen Sensor	0-1 VDC
Oxygen Sensor Heater, MIL (Malfunction Indicator Lamp)	0-2 Amps High Side Sourced
RELIABILITY	
Vibration	7G @ 20-2000Hz
Shock	20G Peak
Testing	100% Functional Testing
PARAMETERS	
Flywheel Teeth	50-250
Gain/Stability Multiplier	1-100%
Fixed Speed Settings*	0-maxRPM
Variable Speed Settings*	0-maxRPM
Overspeed Settings*	0-maxRPM
Starting Fuel	0-100%
Oxygen Setpoint	0-999mV
Fuel (Gain / Stability Setpoint)	0-100
Full Value Setpoint	0-100%
Manifold Absolute Pressure (MAP) Sensor	1,2 or 3 Bar
COMPLIANCE / STANDARDS	
Agency	CE and RoHS Requirements
Communications	RS-232-C, IEEEE J1939
PHYSICAL	
Dimension	See Section 1 “Installation”
Weight	1.1 lb (0.49 kg)
Mounting	Any position, Vertical Preferred

*Maximum RPM is based on the Flywheel Teeth. RPM = Frequency x 60 / Flywheel Teeth. Maximum Frequency is 10,000 Hz.timing retard/advance.

3 ACTUATOR THROTTLE BODY

The AFR is only capable of driving a universal actuator or a GAC actuator throttle body (ATB). Using engine displacement and operating RPM, the following matrix should be utilized to identify the proper bore size of a GAC actuator throttle body. Since this information is based on ideal situations the bore selection may need to be changed once tested in actual application.

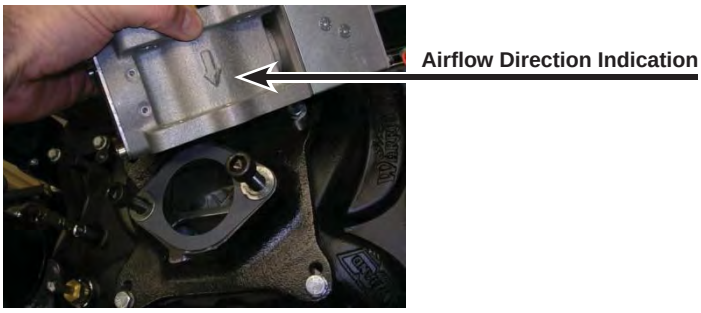
LINK Information about selecting the proper GAC ATB can be found in the Actuator Throttle Body sub-section at **http://www.governors-america.com** under the Actuators product section. Information about dimensions and mounting patterns can be found in the ATB manual located on the website as well.

ATB T1

ATB INSTALLATION PROCEDURE FOR NATURALLY ASPIRATED ENGINES

1. Clean the mounting area to the intake manifold from debris including old gaskets or previously applied sealants.
2. Install the GAC supplied or standard gasket for the throttle body actuator assembly to the intake manifold or use an approved sealant.
3. Place the actuator assembly over the intake manifold with the intake flow indication arrow pointing toward the engine (downward) as shown in the following figure.
4. Torque the mounting bolts down to .74-1.18 lb-ft. [1-1.6 N•m]. Take caution not to over-torque any components based on the selected hardware.

AIRFLOW INDICATION



ATB INSTALLATION PROCEDURE FOR TURBO CHARGED ENGINES

1. Clean the mounting areas on either side of the ATB from debris including old gaskets or previously applied sealants; ideally this location is as close to the intake manifold as possible and after the charge air cooler.
2. Install standard or GAC supplied or gaskets for the throttle body actuator assembly to the intake manifold connecting location or use an approved sealant.
3. When installing the actuator assembly ensure the flow indication arrow is pointing toward the engine intake as indicated in the following figure.
4. Torque the mounting bolts down to .74-1.18 lb-ft. [1-1.6 N•m]. Take caution not to over-torque any components based on the selected hardware.
5. Repeat a similar procedure for the alternate end of the ATB interface with the intercooler output.

4 MIXER AND AIR-FUEL & CONTROL VALVE ASSEMBLY

The information provided in the following tables is the recommended pairings of ATB's and air-fuel mixers with the most common combination emphasized in bold. The actual application may dictate a different pairing. In some cases, there are more than one possible choice of mixer for a given throttle body. **Important:** Contact your GAC representative for confirmation on mixer sizing prior to ordering.

T1 ATB / MIXER COMPATIBILITY MATRIX

MIXER TYPE			T1 ATB SIZE (mm)			
Mixer P/N	Throat Size (in)	Throat Size (mm)	25	30	35	40
MXSB20	0.625	15.88	X			
MXSB22	0.6875	17.46	**X**			
MXSB24	0.75	19.05	X	X		
MXSB26	0.8125	20.64		**X**	X	
MXSB28	0.875	22.23		X	**X**	X
MXSB30	0.9375	23.81			X	**X**

T2 ATB / MIXER COMPATIBILITY MATRIX

MIXER TYPE			T2 ATB SIZE (mm)		
Mixer P/N	Throat Size (in)	Throat Size (mm)	45	55	65
MXMB40	1.25	31.75	**X**		
MXMB42	1.3125	33.33	X	X	
MXMB44	1.375	34.92	X	X	
MXMB46	1.4375	36.51		**X**	X
MXMB48	1.5	38.1		X	X
MXMB50	1.5625	39.68			**X**

NOTE For the MXSB (small-bore) and MXMB (medium-bore) mixers, the ## represents the venturi mixer throat size and is provided in 32nds of an inch. For example, the MXSB20 has a 20/32 in. throat diameter.

T3/T4 ATB / MIXER COMPATIBILITY MATRIX

MIXER TYPE			T3/T4 ATB SIZE (mm)		
Mixer P/N	Throat Size (in)	Throat Size (mm)	75	85	95
MXLB75	2.141	54.38	**X**	**X**	
MXLB85	2.6	66	**X**	**X**	**X**

NOTE For the MXLB (large-bore) mixers, the ## represents the comparable outer diameter mm size of the ATB unit in which the mixer is compatible. For example, the MLB75 is compatible with the 75mm T3 ATB unit.

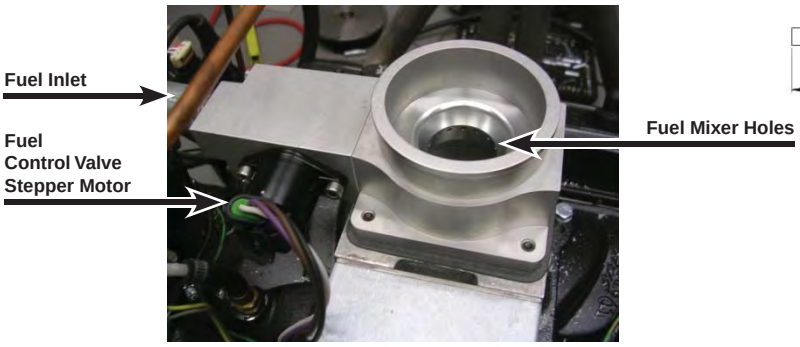
STAND ALONE MIXERS

MIXER TYPE			
Mixer P/N	Air Inlet Hose Fitting	Throat Size	Fuel Inlet Hose Fitting
MX24	2.0in [51mm]	0.95in [24mm]	5/8in [15.88mm]
MX30	2.5in [63.5mm]	1.18in [30mm]	5/8in [15.88mm]
MX32	2.5in [63.5mm]	1.27in [32mm]	5/8in [15.88mm]
MX36	3.0in [77mm]	1.42in [36mm]	3/4in [19.05mm]
MX42	3.0in [77mm]	1.65in [42mm]	3/4in [19.05mm]
MX48	3.5in [90mm]	1.89in [48mm]	1.0in [25.4mm]
MX54	3.5in [90mm]	2.14in [54mm]	1.0in [25.4mm]

NOTE GAC also supplies inline stepper fuel control valve assemblies such as the VFC103, VFC105, and VFC106, which come with 5/8in (15.8mm), 3/4in (19.0mm), and 1in (25.4mm) fittings respectively. Contact GAC for more info.

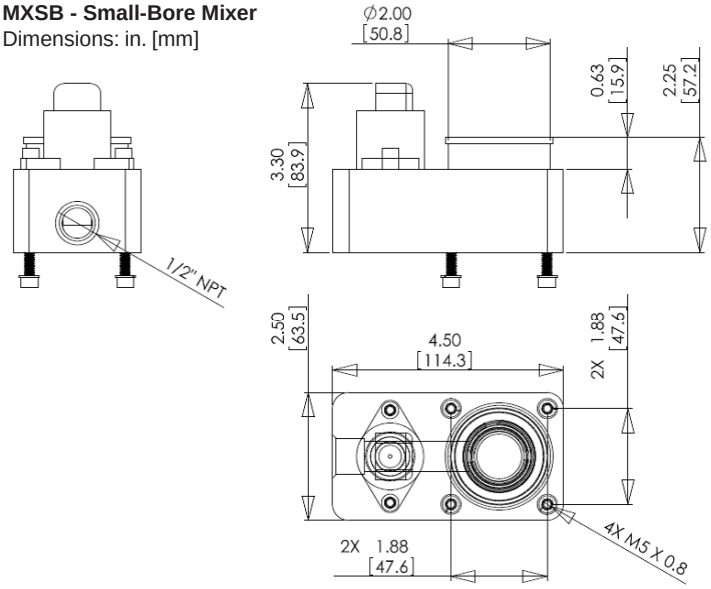
INSTALLATION

The air-fuel mixer and control valve assembly is used to adjust the air to fuel ratio to the engine in order to regulate how lean or rich the engine will run. The mixer and control valve comes as one combined assembly from GAC for a simplified installation. A picture of a mixer / valve assembly mounted on top of an ATB is shown in the following figure.



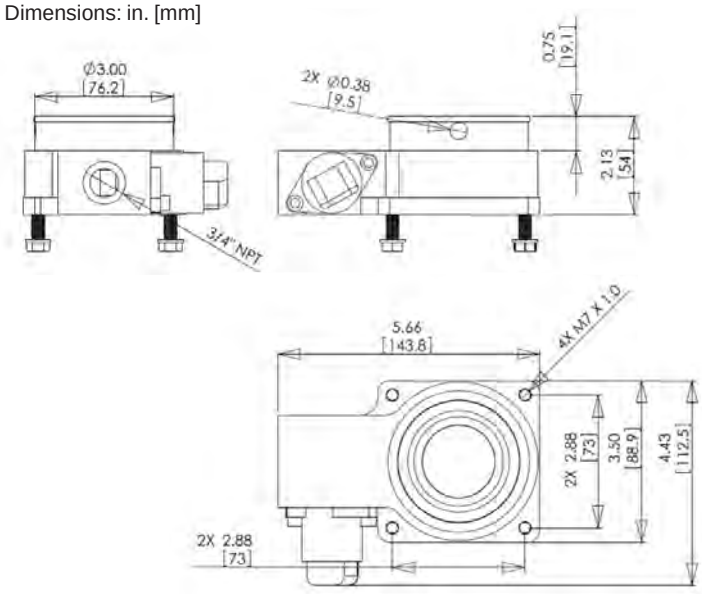
MXSB - Small-Bore Mixer

Dimensions: in. [mm]



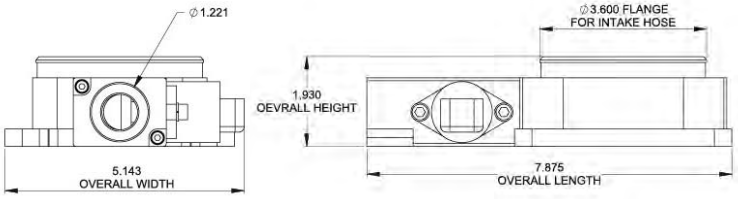
MXMB - Medium-Bore Mixer

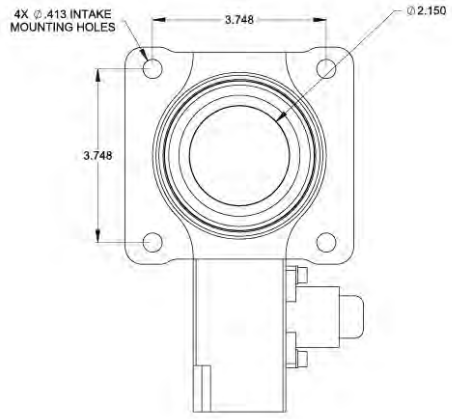
Dimensions: in. [mm]



MXLB - Large-Bore Mixer

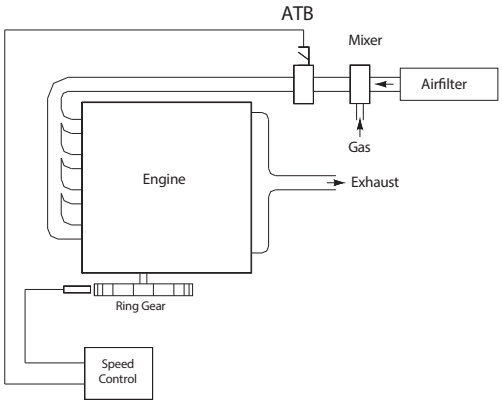
Dimensions: in. [mm]



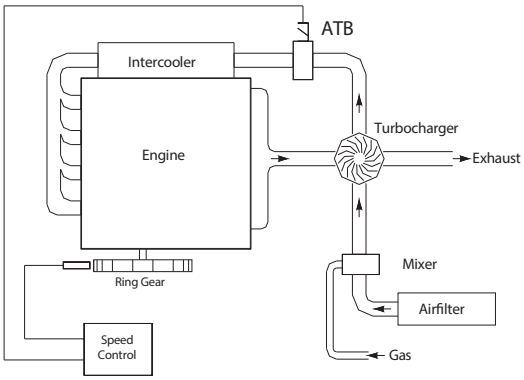


NOTE The mixer must be installed before the ATB unit airflow. Never afterward! See the diagrams below for mixer location.

NATURALLY ASPIRATED ENGINES:



TURBO ENGINES:



INSTALLATION PROCEDURE FOR NATURALLY ASPIRATED ENGINES	
1.	Clean the mounting area to the ATB from debris including old gaskets or previously applied sealants if present.
2.	Install the integral mixer / valve assembly on top of the ATB (with or without adapter plate) using the supplied gasket or an approved sealant. Ensure the mixer assembly is aligned to the desired orientation prior to seating it on top of the ATB.
3.	Insert the four bolts into the mixer / valve assembly, install the nuts, and torque them down to 1-1.8 lb.-ft. [1.36-2.44 N•m]. Ensure the assembly is not over-torqued and that the torque is applied evenly and gradually.
4.	Connection of the fuel supply from the zero pressure gas regulator to the mixer / valve assembly is covered in following sections.

INSTALLATION PROCEDURE FOR TURBO CHARGED ENGINES	
1.	Clean the mounting area to the flange of the turbocharger inlet (or adapter) as well as the air filter connection from debris including old gaskets or previously applied sealants if present.
2.	Install the integral fuel mixer/control valve assembly (with adapter plate) using the supplied gasket or approved sealant. Ensure the mixer assembly is aligned to the desired orientation prior to seating it to the flange and that the fuel inlet is horizontal.
3.	Insert the four bolts into the mixer / valve assembly, install the nuts, and torque them down to 1-1.8 lb.-ft. [1.36-2.44 N•m]. Ensure the assembly is not over-torqued and that the torque is applied evenly and gradually.
4.	Connection of the fuel supply from the zero pressure gas regulator to the mixer / valve assembly is covered in following sections.

5 MIXER AND AIR-FUEL & CONTROL VALVE ASSEMBLY

In most cases you can simply select the correct version of the regulator by choosing the size fitting you prefer and ensuring that the pressure drop is within the allowable range using the provided data.

NOTE GAC carries a full range of regulators so contact us if what you need is not on the list.

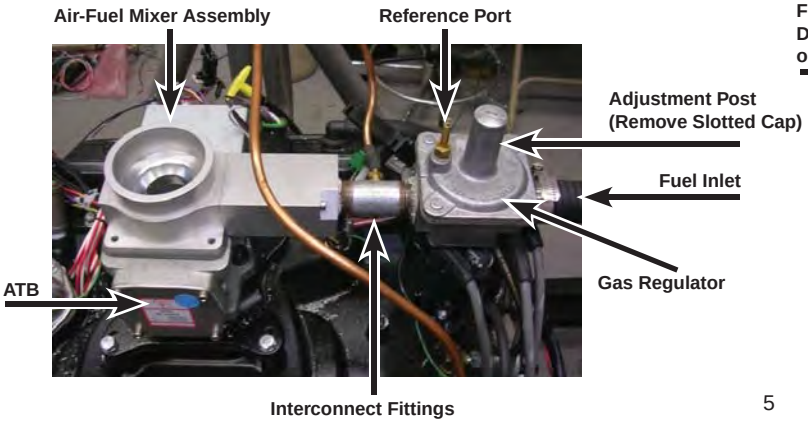
GAS REGULATORS

GAC P/N	REGULATOR P/N	FITTING SIZE	MAXIMUM PRESSURE
RPR102	Maxitrol R500Z	0.75 in	0.5 PSI
RPR103	Maxitrol R600Z	1.0 in	1.0 PSI
RPR104	Maxitrol 210DZ	1.0 in	5.0 PSI
RPR105	Maxitrol 210DZ	1.5 in	5.0 PSI
RPR21EZ	Maxitrol 210EZ	1.5 in	5.0 PSI
RPR-RV61	Maxitrol RV61	1.0 in	1.0 PSI
RPR-RV81	Maxitrol RV81	1.5 in	1.0 PSI

NOTE The venturi mixer & fuel control valve assembly may have a different size fitting, select interconnect plumbing accordingly. See Section 11 for Zero Pressure Gas Regulator Capacities.

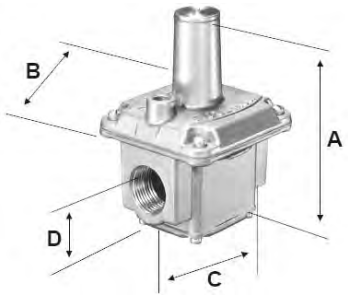
INSTALLATION

A Zero Pressure Gas Regulator is attached to the fuel inlet port on the mixer / fuel control valve assembly to regulate the pressure / flow to the assembly. The regulator has a reference / feedback port on top of the unit in order to regulate pressure. A representation of a regulator connected to the mixer / control valve on top of an ATB for a naturally aspirated engine is shown in the following figure.



NOTE The regulator must be installed as close as possible to the mixer and never greater than 2m (6 ft).

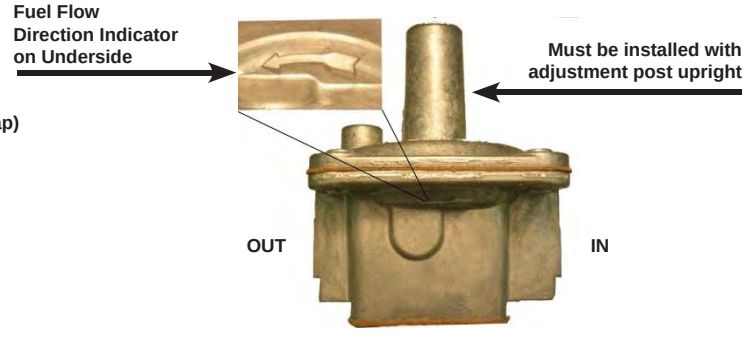
The following figure shows the dimensions of the gas pressure regulator for the purpose of determining a suitable mounting or placement location. Refer to the component selection section to determine the regulator choice if you purchased one from GAC.



Model	Pipe Size	Vent Connection	Swing Radius	DIMENSIONS			
				A	B	C	D
RPR102	.75in	1/8in NPT	3.6in (90mm)	4.7in 119mm	3.1in 79mm	3in 79mm	1.2in 30mm
RPR103	1.0in	1/8in NPT	4.3in (109mm)	5.7in 144mm	3.9in 98mm	4in 102mm	1.5in 37mm
RPR104	1.0in	1/2in NPT	5.4in (138mm)	9in 229mm	7in 178mm	6in 152mm	2.4in 60mm
RPR105	1.5in	1/2in NPT	5.4in (138mm)	9in 229mm	7in 178mm	6in 152mm	2.4in 60mm
RPR21EZ	1.5in	3/4in NPT	8.3in (211mm)	11.3in 286mm	9.1in 232mm	8in 203mm	2.9in 75mm
RPR-RV61	1.0in	1/8in NPT	4.8in (122mm)	6.4in 164mm	4.4in 111mm	5.4in 138mm	1.6in 41mm
RPR-RV81	1.5in	3/8in NPT	6.4in (213mm)	8.4in 213mm	6in 152mm	7in 178mm	2in 51mm

INSTALLATION PROCEDURE	
1.	Ensure that the fuel supply is shutoff or disconnected whenever working fuel system plumbing.
2.	Install the selected interconnect between the mixer assembly and the pressure regulator using pipe unions or barbed fittings into the fuel inlet port for the air-fuel mixer assembly. Use an approved pipe thread sealant to ensure the connection is leak proof. If barbed fittings are used, ensure that properly-sized, high-quality, hose clamps are installed in pairs.
3.	The zero pressure gas regulator is directional. Refer to the following figure for identification of the fuel flow direction indicator and ensure the fuel flow direction is toward the mixer / air-fuel control valve assembly during installation.
4.	Install the zero pressure gas regulator outlet port to the interconnect from the air-fuel control and mixer assembly in Step 1 using the appropriate pipe unions or barbed fittings. Ensure the pressure regulator is installed in the correct orientation as detailed in the following figure and the application considerations section. An approved pipe thread sealant can be used to ensure the connection is leak proof. If using barbed fittings use properly sized, high-quality hose clamps in pairs.

Continue Reading



5. Connect a hose (or equivalent) to the feedback port that is long enough to reach the air cleaner or air filtration system connection point. This information is covered in greater detail in the section labeled 'Air Filtration. The reference pressure is taken between the air filtration system and the venturi inlet.
6. Once all the plumbing is complete, enable the fuel supply, and ensure the inlet pressure to the regulator is positive but within the guidelines shown in the application considerations.
7. Remove the slotted cap on the regulator adjustment post to reveal the pressure adjustment screw.
8. Ensure the outlet pressure is slightly positive at full output.

NOTE The outlet pressure needs to be adjusted once the fuel has been turned on and is the most common reason why an engine will not start or will not run correctly on initial key up. After the SmartVU configuration procedure is complete, the fuel system needs to be enabled. If the engine is being under-fueled at startup, then increase fuel regulator flow. If the engine is over-fueled at startup, then decrease flow. In most cases it is best to decrease the flow of the regulator to its minimum and increase the flow while cranking until the engine starts.

6 ELECTRONIC GAS LOCKOUT VALVE

GAC has many different offerings from partner companies. Contact GAC if a lockout valve is needed as part of your kit.


SOS100


SOS102


SOS103

MODEL	DESCRIPTION
SOS100-12	12VDC / .75in [19.05mm] / Direct-Acting / Pressure Diff 0-3PSI [0-0.2Bar] Min-Max
SOS100-24	24VDC / .75in [19.05mm] / Direct-Acting / Pressure Diff 0-3PSI [0-0.2Bar] Min-Max
SOS101-12	12VDC / 1.0in [25.4mm] / NPT Fittings / Pilot-Operated Quick Open / Pressure Diff .015-3PSI [0.001-0.2Bar] Min-Max
SOS101-24	24VDC / 1.0in [25.4mm] / NPT Fittings / Pilot-Operated Quick Open / Pressure Diff .015-3PSI [0.001-0.2Bar] Min-Max
SOS102-12	12VDC / 1.0in [25.4mm] / NPT Fittings / Direct-Acting / Pressure Diff 0-0.75PSI [0-0.5Bar] Min-Max
SOS102-24	24VDC / 1.0in [25.4mm] / NPT Fittings / Direct-Acting / Pressure Diff 0-0.75PSI [0-0.5Bar] Min-Max
SOS103-12	12VDC / 1.5in [38.1mm] / NPT Fittings / Pilot-Operated Quick Open / Pressure Diff .015-3PSI [0.001-0.2Bar] Min-Max
SOS103-24	24VDC / 1.5in [38.1mm] / NPT Fittings / Pilot-Operated Quick Open / Pressure Diff .015-3PSI [0.001-0.2Bar] Min-Max

This electronic gas lockout valve gives the fuel control system electronic authority of gas flow into the regulator increasing over-all safety and performance. Generally when the control system is disabled the gas lockout valve prohibits gas flow. Refer to the manufacturer's manual for installation.

NOTE If the desire is for the AFR controller and electronic gas lockout valve to wake / shutdown at the same time, wiring information can be found in later sections.

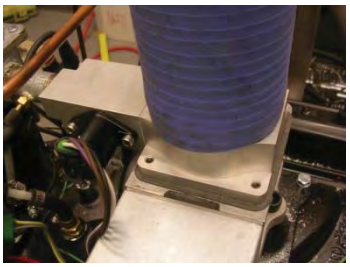
7 GAS FILTERS

MODEL	DESCRIPTION
GF6066	3/4in. NPT Fittings / 15 PSI (1 bar) Maximum Inlet Pressure
GF6088	1in. NPT Fittings / 15 PSI (1 bar) Maximum Inlet Pressure
GF80121	1.5in. NPT Fittings / 15 PSI (1 bar) Maximum Inlet Pressure
KTGF60	Filter Kit - Replacement Filter and Hardware / 6066 & 6088
KTGF80	Filter Kit - Replacement Filter and Hardware / 801212

LINK GAC's offerings change occasionally. See our website for a complete listing: http://www.governors-america.com/gaseous

The air filtration is used to avoid accidental or unintentional pollutants and debris into the air intake system. The available configurations for plumbing the air filtration range from a simple hose connection at the inlet of the fuel valve assembly or a direct connection of the air filter unit to the mixer assembly. Refer to the manufacturer's guidelines for installation and application information.

Hose Connection to Mixer



Direct Filter Connection to Mixer Intake

NOTE Running an engine without an air filter is not recommended due to contamination of the mixture or / and engine back fire.

8 MAGNETIC SPEED PICKUPS

LINK GAC's offerings change occasionally. See our website for a complete listing: http://www.governors-america.com/magnetic-pick-ups

Available Thread Sizes

3/8 - 24 UNF | **5/8 - 18 UNF** | **3/4 - 16 UNF** | **M16x1.5 UNF** | **M18x1.5 UNF**

Available Connectors


Automotive


Military Style

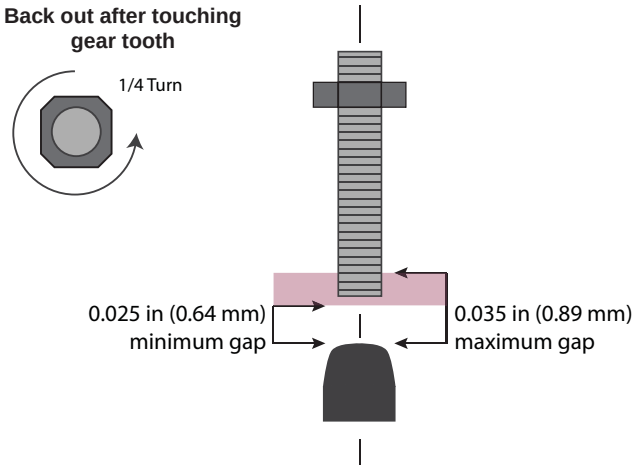

Packard


Dual Packard


Screw-On Terminals

The Magnetic Speed Sensor detects when ring gear teeth, or other ferrous projections, pass the tip of the sensor. The output signal is an AC sine wave whose frequency is converted to crankshaft revolutions per minute (RPM) via the input flywheel teeth value within the AFR.

INSTALLATION PROCEDURE	
1.	Ensure the engine is not running and the ignition switch is turned to the OFF position.
2.	Install the magnetic pickup in the engine bell housing, ring gear case, or fabricated bracket.
3.	Screw the speed sensor in until it touches a gear tooth and then back it out 1/4 of a turn. Adjust the pickup such that there is a nominal .025 in.[0.64mm]-.035in.[0.89mm] gap clearance between the teeth and sensor.
4.	Secure the speed sensor using the supplied locknut.
5.	An AC voltage meter can be used to verify proper magnetic pickup installation. During cranking, sensor output should be greater than 1.0 VAC.

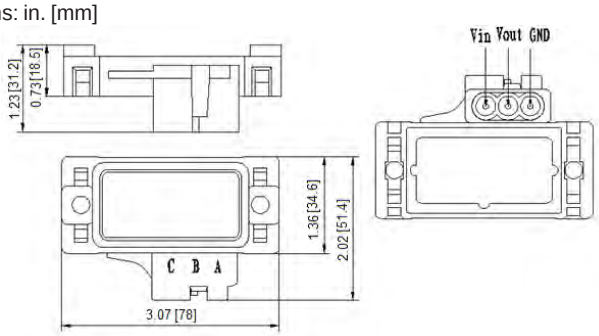


9 MANIFOLD ABSOLUTE PRESSURE SENSOR

The Manifold Absolute Pressure sensor from GAC is available in three different pressure ranges (1, 2, or 3 Bar; 14.5, 29, or 43.5 PSI) supporting up to 30 psig of boost as detailed in the parts list section. Typically, naturally aspirated engines use the 1 bar model. All three variations have the same mounting footprint and instructions. A representation of the Manifold Absolute Pressure sensor (MAP) is shown in the following figure.

MAP - Manifold Absolute Pressure

Dimensions: in. [mm]



INSTALLATION PROCEDURE	
1.	Lubricate the o-ring seal on the MAP sensor to ensure it is not damaged during installation.
2.	Thread the MAP sensor into the appropriate location on or near the intake manifold using the 5mm thru-holes and the selected mounting hardware. Do not over torque the assembly down and ensure that the barb fitting is not damaged during installation and is free from obstruction.
3.	If the sensor is remote mounted, install the barb fitting on the intake manifold which should be a 6.4mm [0.25 in] barb fitting. Install a section of hose from the intake manifold to the MAP sensor. Ensure the vacuum hose is positioned and cut to the appropriate length to avoid kinks or low points in the line. Avoid routing the vacuum hose next to high temperature components such as turbochargers and exhaust systems.

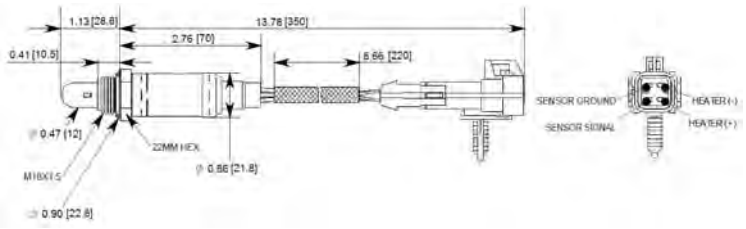
10 EXHAUST OXYGEN SENSOR

The engine exhaust oxygen level sensor is used to determine whether or not the engine is running lean or rich and to facilitate the closed loop feedback from the control system. A stoichiometric oxygen sensor (narrow-band) with an output signal of 0 to 1V is used with the AFR. An internal heater element (12V only) allows the sensor to reach its activation temperature quickly for accurate measurements. The SOX103 (12 or 24V) is heated by the exhaust stream. Depending on the configuration selected you will have one (pre-catalytic converter) or two (pre- and post-catalytic converter) sensors. A representation of the GAC narrow-band oxygen sensors are shown in the following figure.

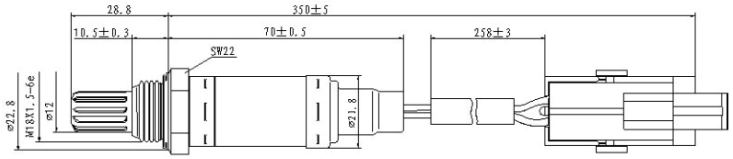
Oxygen Sensor

Dimensions: in. [mm]

SOX102



SOX103



IMPORTANT NOTE If using a lean burn kit, refer to the included lean burn kit PIB for details. No SOX is required since they are included with the kit.

http://www.governors-america.com/documents/PIB3002_A_EAM212.pdf

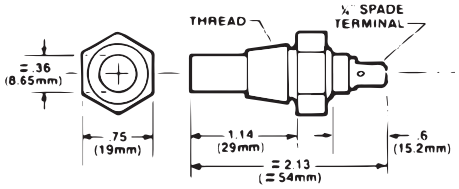
INSTALLATION PROCEDURE	
1.	Install the oxygen sensor into the appropriate location by threading into the location determined from the application considerations section finger tight. Both oxygen sensors have a M18x1.5 thread.

NOTE

- For the primary oxygen sensor, the sensor should be located in the engine exhaust outlet as close to the merge of all cylinders as possible but prior to the catalytic converter (if equipped).
- For the post-catalytic oxygen level sensor ensure the selected mounting location is mounted near the catalytic converter in order to provide accurate data.
- In turbo-charged applications the sensor must be installed no closer than 18 in. [457 mm] away after the turbocharger outlet
- Ensure the threads are not galled during this operation. Use a 22mm wrench to tighten the oxygen sensor into place by 1/2 to 3/4 of a turn max. Take caution not to over-torque the sensor and damage it.

11 ENGINE COOLANT TEMPERATURE SENSOR (OPTIONAL)

The engine coolant temperature sensor is an optional sensor provided from GAC. The coolant temperature sensor is monitored by the AFR for engine protection in the event of an engine over temperature situation. These limits can be calibrated within the AFR controller using SmartVU. A representation of the engine coolant temperature sensor is shown in the following figure.



3/8-18 NPT fitting.

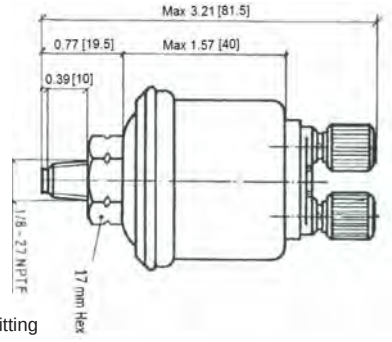
CAUTION The sensor is easily damaged so take caution when installing the sensor.

ECT SENSOR INSTALLATION PROCEDURE	
1.	Apply thread sealant to the tee-fittings if applicable but not the sensor threads.
2.	Thread the sensor finger tight into the drilled/tapped location from the application considerations.
3.	Using the appropriate wrench, torque the sensor to 30 N•m into the designated location. Take care not to over-torque since the sensor can be damaged.
4.	If the sensor is installed by teeing in to a coolant line ensure that the fittings are all torqued down correctly and the coolant temperature is securely mounted.
5.	The required electrical connections to the sensor are a pair of 1/4" female insulated quick connect terminals. Connect the signal and ground terminals accordingly.
6.	Refill the engine cooling system for any lost coolant. Once the engine is started make sure to top off the cooling system and check for any coolant leaks.

The coolant temperature sensor should be located in the engine cooling water jacket prior to the thermostat. The sensor is ideally installed in a coolant passage on the engine block since this location represents engine temperature most accurately.

12 ENGINE OIL PRESSURE SENSOR (OPTIONAL)

The engine oil pressure sensor is an optional sensor available from GAC. The engine oil pressure sensor is monitored by the AFR for engine protection in the event of a low oil pressure condition during operation. These limits can be calibrated within the AFR controller using SmartVU. A representation of the engine oil pressure sensor is shown in the following figure.



1/8-27 NPTF Fitting

CAUTION The sensor is easily damaged so take caution when installing the sensor.

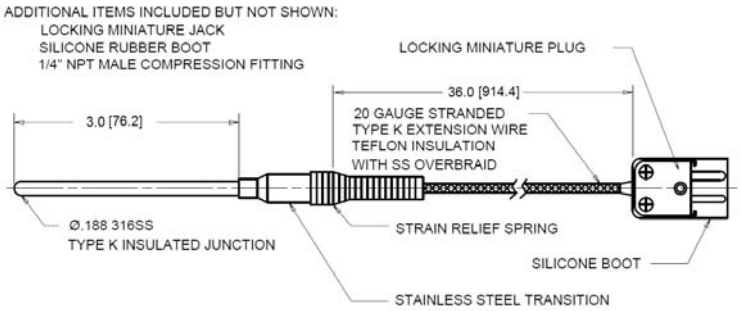
OIL PRESSURE SENSOR INSTALLATION PROCEDURE	
1.	Apply thread sealant to the sensor.
2.	Thread the sensor finger tight into the location from the application considerations.
3.	Once complete, torque the sensor to a maximum of 30 N•m using a 17mm wrench.
4.	The electrical connection points are M4 knurled nuts and the electrical connectors required are #10 insulated ring terminals.

The oil pressure sensor should be located in a pressurized oil galley or a location representative of the actual engine oil pressure (not conditioned or restricted by some device). The sensor is mounted via a 1/8-27 NPTF fitting as shown in the following figure.

NOTE The oil pressure sensor should be located in a pressurized oil galley or a location representative of the actual engine oil pressure (not conditioned or restricted by some device).

13 EXHAUST GAS TEMPERATURE SENSOR

The exhaust gas temperature sensor is an optional sensor available from GAC. The engine exhaust temperature sensor is monitored by the AFR for engine protection in the event of a high exhaust temperature condition during operation. This threshold will cause a de-rate in throttle % and will allow the system to recover once the temperature has returned to the normal operating region. If the temperature does not decrease over a set time interval the AFR will shut the engine down. These limits and thresholds can be calibrated within the AFR controller using SmartVU. A representation of a typical thermocouple is shown in the following figure.



CAUTION The sensor is easily damaged so take caution when installing the sensor. Use Type-K wire and connectors only. Do not mix dissimilar metals.

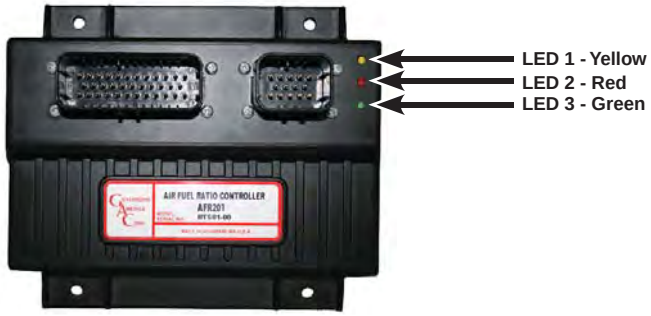
NOTE The sensor includes a weld bung. Drill and weld, then insert sensor using below procedure.

EGT TEMPERATURE SENSOR INSTALLATION PROCEDURE	
1.	Apply thread sealant to the sensor.
2.	Thread the sensor finger tight into the location from the application considerations.
3.	Once complete, turn the sensor 2 full turns past finger tight.

NOTE The exhaust temperature probe is located in the engine exhaust outlet as near as possible to the point where all of the cylinders merge. Alternatively, the sensor can be placed in the manifold outlet pipe. A weld bung or tapped hole must be used and care should be taken such that the tip of the probe is well within the outlet exhaust flow. The sensor is mounted via a 1/8 in. NPT fitting. Drill and tap the determined mounting location using the provided dimensions.

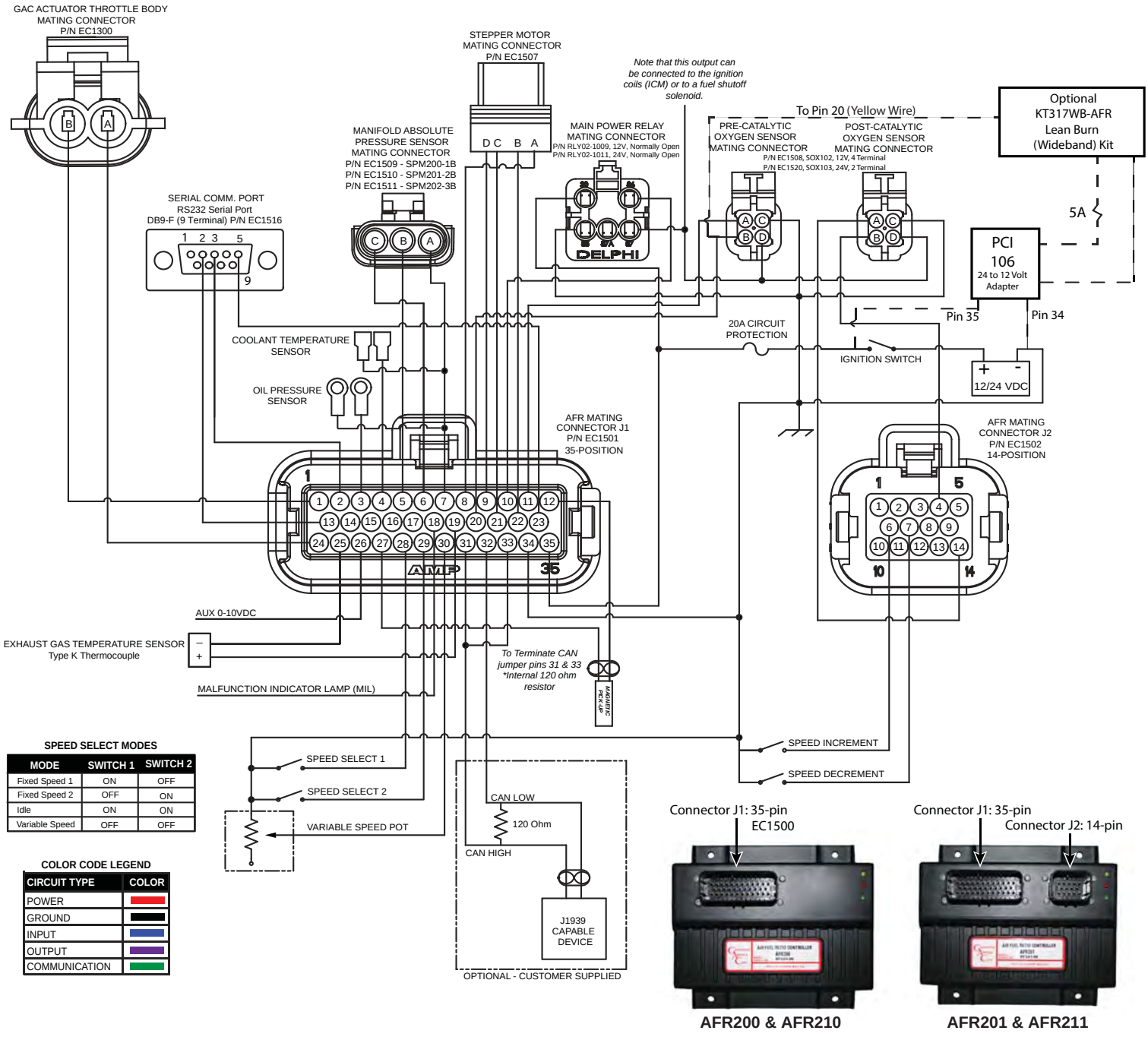
14 LED DEFINITIONS

LED	COLOR	LED STATE	DEFINITION
1	Yellow	OFF	While engine is running, this indicates there are no new entries in the alarm / warning history.
		BLINKING	A warning or shutdown is active. The light will turn off when the condition goes away and the unit has been power cycled.
2	Red	OFF	Unit is operating in closed loop mode.
		ON	Unit is operating in open loop mode.
		BLINKING	Unit is changing the position of the fuel valve.
3	Green	OFF	Unit is not powered on.
		ON	Unit is powered on.

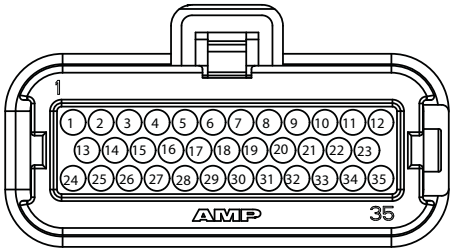


15 WIRING DIAGRAM

WIRING DIAGRAM



AFR 35 PIN MATING CONNECTOR

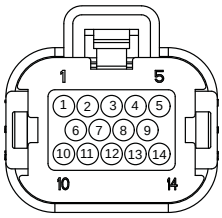


AFR 35-PIN J1 CONNECTOR DEFINITION & WIRING TABLE				
PIN	**DESCRIPTION**	**COMMENT**	**WIRE**	**TWISTED PAIRS**
1	GAC ATB - A	Low Side of the GAC ATB PWM Output	16 AWG	
2	RS232 Receive	RS232 Communication Port	20 AWG	A
3	Oil Pressure	Oil Pressure Resistive Analog Input	20 AWG	
4	Coolant Temperature	Coolant Temperature Resistive Analog Input	20 AWG	
5	MAP Signal	Manifold Absolute Pressure 0-5V Analog Input	20 AWG	
6	MAP Power	Manifold Absolute Pressure Sensor +5V Power	20 AWG	
7	MAP Ground	Manifold Absolute Pressure Sensor Ground	20 AWG	
8	Stepper Motor 1	Stepper Motor Control Output 1	20 AWG	
9	Stepper Motor 2	Stepper Motor Control Output 2	20 AWG	
10	Main Power Relay	Main Power Relay Enable Signal	20 AWG	
11	O2 Sensor 1 Ground	Oxygen Sensor 1 Ground	16 AWG	
12	Mag Pickup Ground	Magnetic Speed Pickup Sensor Ground	20 AWG	B
13	RS232 Transmit	RS232 Communication Port	20 AWG	A
14				
15				
16				
17				
18	MIL	Malfunction Indicator Lamp Output - 2A	16 AWG	
19	EGT +	Exhaust Gas Temperature Input +	20 AWG	
20	O2 Sensor 1	Oxygen Sensor 1, 0-1V Analog Input	20 AWG	
21	Stepper Motor 3	Stepper Motor Control Output 3	20 AWG	
22	Stepper Motor 4	Stepper Motor Control Output 4	20 AWG	
23	RS232 Ground	RS232 Communication Port Ground	16 AWG	A
24	GAC ATB - B	High Side of the GAC ATB PWM Output - B	20 AWG	
25	EGT -	Exhaust Gas Temperature Input -	20 AWG	
26	Auxiliary Speed Trim	Auxiliary Speed Trim	20 AWG	
27	Mag Pickup	Magnetic Speed Pickup Input	20 AWG	B
28	Speed Select 1	Speed Select Switch 1 Input	20 AWG	
29	Speed Select 2	Speed Select Switch 2 Input	20 AWG	
30	Variable Speed	Variable Speed Resistive Input	20 AWG	
31	CAN High	CAN High Signal	20 AWG	C
32	CAN Low	CAN Low Signal	20 AWG	C
33	CAN Termination	CAN Termination Resistor (when tied to CAN Low)	20 AWG	
34	Battery Ground	Battery Ground	16 AWG	
35	Battery	12/24 Volt DC Battery Power	16 AWG	

NOTE Unpopulated table entries represent unused connector pins. Twisted pair groupings are represented by letters.

RECOMMENDATIONS
1. The AFR should be wired through a switched (On / Off Switch) DC power source of 5 to 32VDC and circuit protected with a 20 Amp fuse or circuit breaker. 2. Not all of the circuits will apply to your particular application.

AFR 14 PIN MATING CONNECTOR



AFR 14-PIN J2 CONNECTOR DEFINITION & WIRING TABLE			
PIN	**DESCRIPTION**	**COMMENT**	**WIRE**
1			
2			
3			
4	O2 Sensor 2	Oxygen Sensor 2, 0-1V Analog Input	18 AWG
5			
6	Speed Increment	Speed Increment +10RPM	18 AWG
7	Speed Decrement	Speed Increment -10RPM	18 AWG
8			
9			
10			
11			
12			
13			
14	O2 Sensor 2 Ground	Oxygen Sensor 2 Ground	18 AWG

NOTE

The AFR has the ability to control a power relay when the system is enabled and use this for controlled shutdowns of the engine. The output of this relay is tied to the ignition coil outputs (if an ICM is installed), the oxygen sensor heater circuits, and the fuel shut-off solenoid (if applicable). This allows the AFR to control the air/fuel, ignition, and fuel shut-off solenoids in the event of a controlled shutdown due to a high-temperature, low oil pressure, overspeed, or due to an emergency shutdown using SmartVU.

PIN: 8 9 21 22 — **STEPPER MOTOR**

The fuel valve used by the AFR is a high-resolution bipolar stepper motor. The following table provides the stepper motor specifications.

STEPPER MOTOR SPECIFICATIONS	
PARAMETER	**VALUE**
Rated Operating Voltage	12V
Resistance, Inductance, Current per Phase	53Ω +/- 10%, 33.5mH, 200mA
Total Steps	240
Travel per Step	0.0164 in. [0.0417mm]
Maximum Travel	0.4 in. [10mm]
Operating Temperature	-40° to 257°F [-40° to 125°C]

The stepper motor has two separate coils (A & B) which when provided the correct signal in the correct orientation will modulate the stepper motor clockwise (extend) or counter-clockwise (retract). The following table details the stepper motor input combinations for operation.

STEPPER MOTOR CONTROL LOGIC					
	PHASE	**A PIN A**	**/A PIN B**	**B PIN C**	**/B PIN D**
EXTEND ↓	1	+	-	+	-
	2	+	-	-	+
	3	-	+	-	+
	4	-	+	+	-
↑ **RETRACT**					

PIN: 26 — **AUXILIARY INPUTS**

Pin 26 is used for load sharing and synchronizing with a 0-10 VDC signal, nominal 5V.

PIN: 28 29 30 — **SPEED SELECT INPUTS**

The AFR has two inputs which in various combinations allow the user to select between the 3 fixed speed settings or the variable speed setting. This is accomplished by tying the inputs to ground or leaving them open. The variable speed setting requires an additional potentiometer which can be OEM supplied or purchased from GAC using the information provided previously.

There is a potentiometer calibration within SmartVU that characterizes the selected potentiometer. The following table details the speed selector input combinations and the associated settings.

SPEED SELECTION TABLE		
DESIRED SELECTION	**SPEED SELECT SWITCH INPUT 1**	**SPEED SELECT SWITCH INPUT 2**
Variable Speed	Open	Open
Fixed Speed Setting #1	Ground	Open
Fixed Speed Setting #2	Open	Ground
Fixed Speed Setting #3 (Idle)	Ground	Ground

NOTE

The “variable speed” can be used as a fixed speed without any switch inputs connected by setting speed min and speed max to the same value. None of these selections are required and the default setting (both open) is variable speed. The variable speed setpoint can be set identically (i.e. same RPM) to act as an additional (or primary) fixed speed setting.

PIN: 31 32 33 — **CAN / J1939**

The CAN output supports J1939 protocol for basic engine sensor information and Diagnostic Trouble Codes (DTCs). For J1939 data readers, the current implementation provides engine speed, oil pressure, and coolant temperature information. Information regarding the Diagnostic Trouble Codes (DTCs) is covered under the System Diagnostics section.

NOTE

The AFR is not designed to be the end of line device on the CANbus. If the AFR is located at the end of the CANbus trunk ensure that a 120Ω termination resistor is placed across CAN H and CAN L (pins 18 and 19). As with all CANbus applications there needs to be a matching 120Ω resistor at the other end of the trunk for a total parallel resistance of 60Ω.

16 SMARTVU - CONNECTION SETUP

Computer

Internet Connection

Smart VU Software

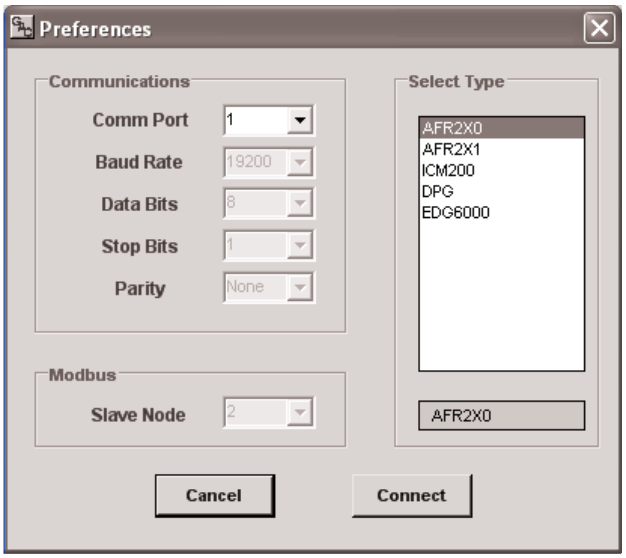
A computer and an Internet connection will be required to download and then run GAC's SmartVU software. The SmartVU installation file and instructions can be found at: http://www.governors-america.com/Downloads/SmartVU

WARNING Ensure the fuel supply is disconnected from the engine prior to performing any of the following configuration procedures. The engine can be shut off by pressing the Stop Engine button within the SmartVU interface.

The AFR is programmed using GAC's SmartVU software. Once SmartVU has been installed, start SmartVU with the RS232 Communications port properly connected to the computer and AFR200.

NOTE The SmartVU software requires a serial port (or USB to serial adapter) and a pass-through DB9 F/M cable.

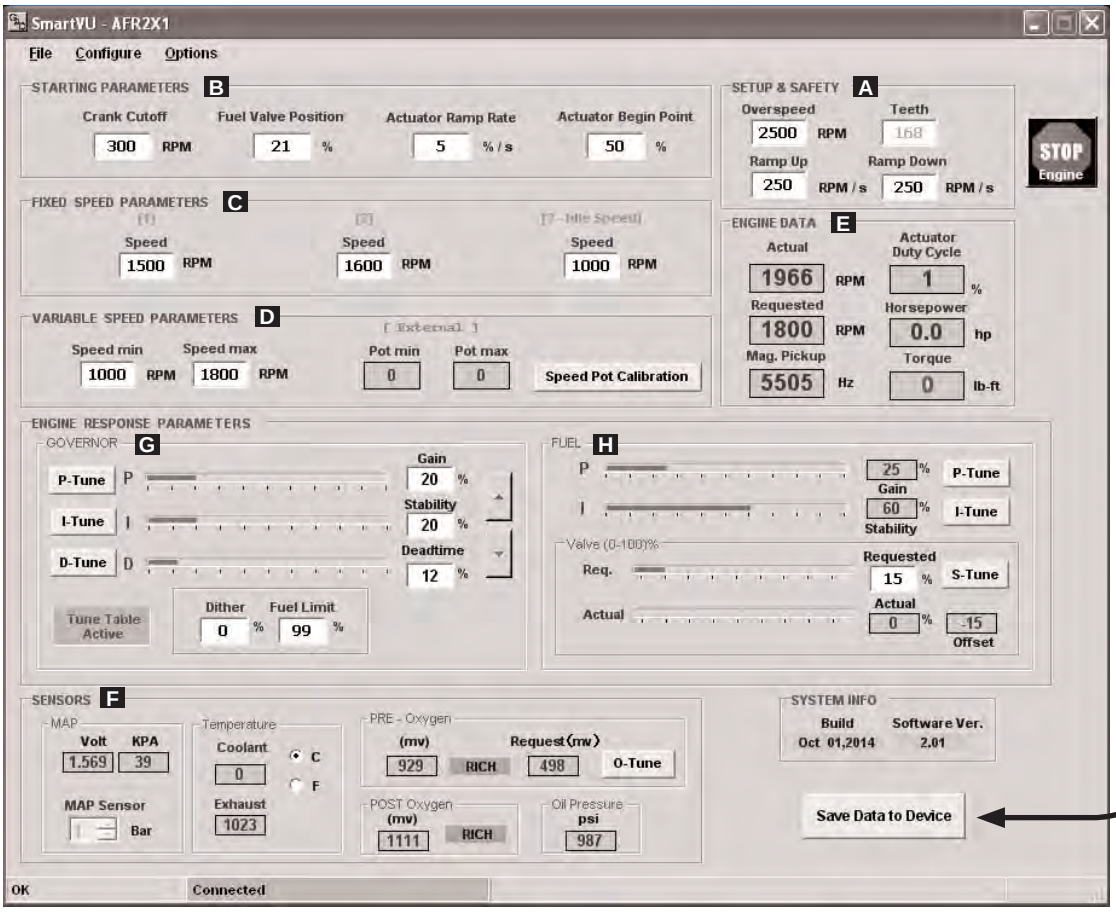
Connection Setup Menu:



After the AFR2X0/2X1 has been properly selected from the Setup Connection Sub menu (found under the "Configure" pull-down menu) and SmartVU recognizes the device, parameters can then be adjusted using the Main Menu and the Governor Advanced Settings Menu.

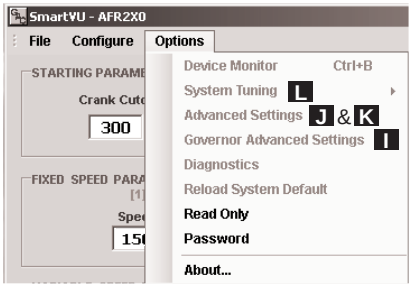
NOTE If the setup goes straight to the main page and you need to configure your device, then go to the top menu bar -> Configure -> Setup Connection

17 SMARTVU - MENUS & PARAMETERS



Parameter Adjustment Order:

A	Setup & Safety
B	Starting Parameters
C	Fixed Speed Parameters
D	Variable Speed Parameters
E	Engine Data
F	Sensors
G	Engine Response Parameters - Governor
H	Engine Response Parameters - Fuel
I	Governor Advanced Settings
J	Advanced Settings - Fuel Control Settings
K	Advanced Settings-Sensors
L	System Tuning

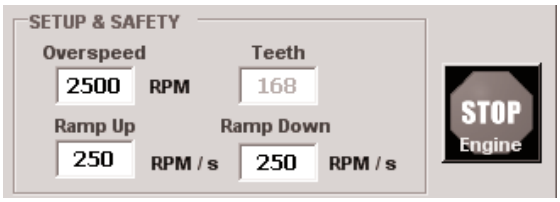


NOTE It is important to press the "Save Data to Device" button in order to store any changes made to the calibration. Otherwise, the controller will lose any changes since the previous save in the event the power is cycled to the controller. It is good practice to save often and after any changes which are final.

A

SETUP & SAFETY

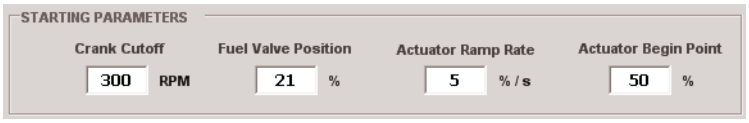
Name	Range	Default	Definition
Overspeed	Application Dependent	2220	Set this value to an engine RPM under the speed where damage may occur. The controllers use this value to de-energize the power relay and close the throttle body as an additional safety measure. This value should be set low enough to prevent mechanical damage but high enough to allow realistic load rejection speeds without stopping the engine. As a starting point this should be set to no more than 25% above rated speed.
Teeth	50-250	120	Number of teeth on flywheel. The governor functionally uses this information to calculate engine speed. You cannot edit this parameter while the engine is running. freq(Hz) = (RPM/60) x (# of gear teeth)
Ramp Up	0 - 9999	300	Restricts the rate of acceleration in engine speed. A smaller value allows for a gradual increase in response to engine speed demands while a large valve causes a faster response. Ideally, this value will be set with little overshoot during engine start and acceleration. (RPM/sec)
Ramp Down	0 - 9999	300	Restricts the rate of deceleration in engine speed. A small value allows for gradual decrease in response to engine speed demands while a large value causes a faster response. Ideally this value will be set at the minimum value that allows for rapid engine speed response with little undershoot or stumbling during deceleration. (RPM/sec)



B

STARTING PARAMETERS

Name	Range	Default	Definition
Crank Cutoff	100 - 500	420	Set the RPM point which tells the control when the engine has started and is above crank speed. Once the engine has surpassed the crank cut off value, the governor will enter closed loop and will transition from start fuel control.
Fuel Valve Position	0 - 100	50	Set the commanded start position of the fuel valve in %. The valve will move itself to this position after the unit has been powered up and the valve has calibrated itself. Once the engine speed passes crank cutoff, the fuel valve will move to the intended open loop position dictated by the fuel table and the load/speed index.
Actuator Ramp Rate	0 - 100	2	Set this value (%/sec) to the rate of change desired in the throttle position from the actuator begin point to 100% during the start/crank cycle. 100% is the fastest actuator response and 1% is the slowest. Start with 50% and modify from there for optimal response.
Actuator Begin Point	0 -100	100	Set this value (%) as the starting position of the actuator during the crank cycle. The value of 100% is fully open and 0% is fully closed. The actuator will start the actuator begin point once the engine begins cranking and the ramp based on actuator ramp rate.



C

FIXED SPEED PARAMETERS

Name	Range	Default	Definition
Speed 1,2,3	0 - 9999	1500, 1800, 900	AFR selects one of three fixed speeds. Fixed Speed 3 is Idle Speed (RPM)

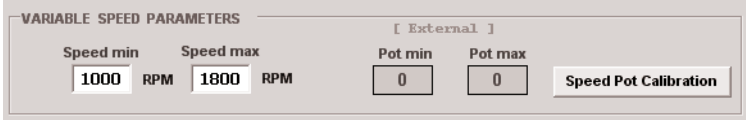
IMPORTANT Fixed speed 3 must be set below operation speed but above crank cutoff (600-1200) even if it is not being used

D

VARIABLE SPEED PARAMETERS

Name	Range	Default	Definition
Speed Min	0 - 9999	50	Set the minimum allowed speed desired while in variable speed mode. If the speed pot is not installed, this value must be set to the operating speed of the engine. (RPM)
Speed Max	0 - 9999	1800	Set the maximum allowed speed desired while in variable speed mode. If the speed pot is not installed, this value must be set to the operating speed of the engine. (RPM)
Speed Pot Calibration	Run the Speed Pot Calibration, which will prompt you through the procedure for setting the Pot Min and Pot Max values. Once complete, these values will directly correlate to the Speed Min and Max values.		

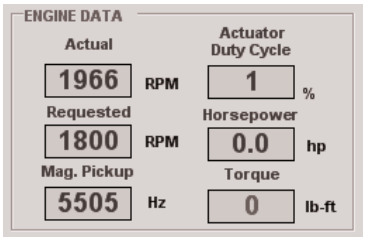
NOTE If you do not install a speed potentiometer, you can set the speed min and max to the same value to act as a fixed speed setting without wiring the speed select switched. This is good practice to do regardless.



E

ENGINE DATA

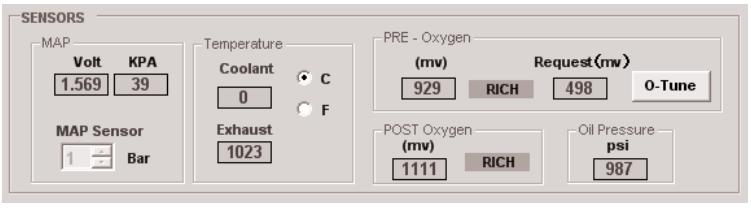
This area shows the actual vs. requested speed based on the number of teeth and frequency (Hz) read by the magnetic speed pickup sensor. There is also a readout of the HP / torque as needed from the Horsepower Readout table covered in the **System Tuning** tables section.



F

SENSORS

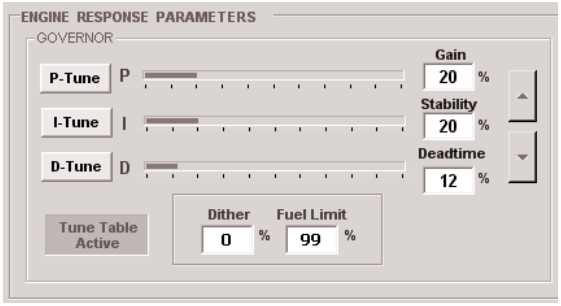
Name	Units	Definition
MAP	V, kPa	Displays voltage reported by Manifold Absolute Pressure sensor and corresponding pressure reading. Value is required when editing any System Tuning tables.
MAP Sensor	# bars	Indicates the type of MAP sensor (1, 2, or 3 bar) - Set immediately, drop down box, and PRESS ENTER with 1, 2, or 3 bar selected
Temperature	°F / °C	Displays measured engine coolant and exhaust temperature
PRE-Oxygen	mV/State	Displays reading from pre-catalyst oxygen sensor. High values indicate rich fuel mixture, low value indicates lean mixture. State of fuel mixture (Lean, Rich, Stoic) also indicated.
Request	mV	Displays value AFR is trying to attain with the feedback control loop
POST-Oxygen	mV, State	Displays reading from post-catalyst oxygen sensor. Shown only when controller with post-catalytic sensor enabled is selected. Also indicates state of fuel mixture.
		NOTE Only available on AFR201 and AFR211.
Oil Pressure	PSI	Displays engine oil pressure



G

ENGINE RESPONSE PARAMETERS - GOVERNOR

Name	Range	Default	Definition
P	0 - 100, 100 = Max Gain	20	Proportional (P) set point of the PID control. This parameter changes the general response of the engine. Increasing the gain makes the engine more responsive to load changes. Avoid instability due to high gain when adjusting this parameter.
I	0 - 100, 100 = Longest Time	20	Integral (I) set point of the PID control. This parameter changes the steady state response of the engine. Increasing the stability allows the system to come to steady state speed faster.
D	0 - 100	10	Derivative (D) set point of the PID control. This parameter changes the transient response of the engine and affects the stability parameter during transient load changes. Increasing the deadtime decreases both the percent overshoot and settling time during a transient load change. Adjusting the value too high can cause random speed instability at steady state since any small speed errors are picked up and amplified by this function.
Dither	0 - 100 0 = No Dither	0	Adds a high-frequency, low amplitude signal to the actuator to prevent the butterfly valve from sticking in harsh environments. Increase or decrease this value for the desired action, but take caution to avoid engine surging. A value of 0% is no dithering action, and maximum value should be selected based on engine stability. (%)
Fuel Limit	0 - 100	99	Maximum allowable throttle % the system can command. It is used to prevent overfueling after the engine has started. During normal starting cycles and short step loads, the function will not engage since there is a 1-second delay. Adjust this parameter accordingly.



BASIC TUNING PROCEDURE

1. Increase the Gain (P) parameter until instability develops.
2. Gradually decrease the Gain (P) until stability returns.
3. Decrease the adjustment one count further to ensure stable performance.
4. Increase the Stability (I) parameter until instability develops.
5. Gradually decrease the Stability (I) until stability returns.
6. Decrease the parameter by one count to ensure it is stable. If there is no instability, leave the value set at 25.
7. Increase the Deadtime (D) compensation parameter until instability develops.
8. Gradually decrease the Deadtime (D) until stability returns.
9. Decrease the parameter by one count to ensure it is stable.
10. Gain, Stability, and Deadtime parameters may require minor changes after engine load is applied. Normally, adjustments made at no load achieve satisfactory performance, but a strip chart recorder can be used to further optimize adjustments.

H

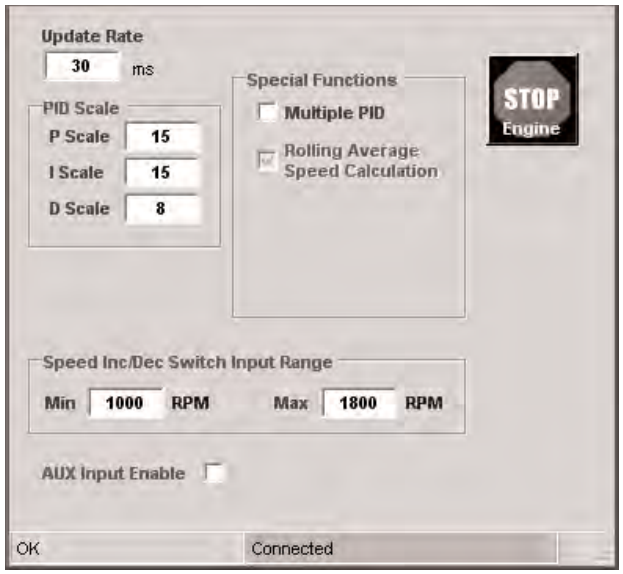
ENGINE RESPONSE PARAMETERS - FUEL			
Name	**Range**	**Default**	**Definition**
P	0 - 100	30	This changes fuel response of the engine. Increasing gain makes the engine more responsive to demand changes. Avoid instability due to high gain. Ideally, set the value to allow for effective and quick switching of the O2 sensor reading between states. Default is usually sufficient.
I	0 - 100	15,15,8	This changes steady state fuel response. Increasing it allows the system to compensate for fuel demands faster. Default is usually sufficient.
PTune	0 - 100	Off	Fuel gain can be adjusted across the range of speed and loads. This button loads the System Tuning window. See Section L.
ITune	0 - 100	1000	Fuel stability can be adjusted across the range of speed and loads. This button loads the System Tuning window. See Section L.
STune	0 - 100	1800	Fuel valve position can be adjusted over the engine speed and load range. This button loads the System Tuning window. See Section L.
Requested		Off	Here you can edit the S-Tune value for a single cell (load vs. speed), does not affect adjacent cell on table.
Actual			This shows actual fuel value.
Offset			This is the difference between the requested value versus what the controller is setting it to, based on O2 sensors.

NOTE This map is not an indication of the actual engine horsepower and is merely used as a supplement to dynamometer data so that the user can acknowledge an approximate engine horsepower while using SmartVU for test purposes only.

I

The Governor Advanced Settings window is primarily used for PID adjustments, load sharing / synchronizing, and droop limitation. It can be accessed by going to the top menu and selecting Options -> Governor Advanced Settings.

GOVERNOR ADVANCED SETTINGS			
Name	**Range**	**Default**	**Definition**
Update Rate		30	This changes the rate at which the PID routine is called (in msec), thus changing the time constant of the overall system. Increasing time will increase stability but decrease response. P, I, and D values may need to be returned when tuning Update.
PID Scale		15,15,8	This sets multiplier values based on desired engine operational characteristics. This is generally used if the PID values are near the limits and need additional adjustment. The scale will only work when engine is running. Higher values give greater response. Changing multipliers results in normalization of the corresponding value.
Multiple PID		Off	This enables or disables multi-PID tables.
Speed Inc / Dec Min		1000	This dictates the minimum allowable RPM available for the speed decrement input to the AFR (201, 211 only). Ensure that the value is above the idle speed setpoint. The AFR can increase/decrease in 1-10 RPM increments if this option is used.
Speed Inc / Dec Max		1800	This sets the maximum allowable RPM for the speed increment input to the AFR (201, 211 only), and must be below the overspeed setpoint or shutdown will occur.
AUX Input		Off	This enables or disables the load sync input, which requires a reverse polarity 0-10V input signal. Above 5V to decrease speed and below 5V to increase speed.

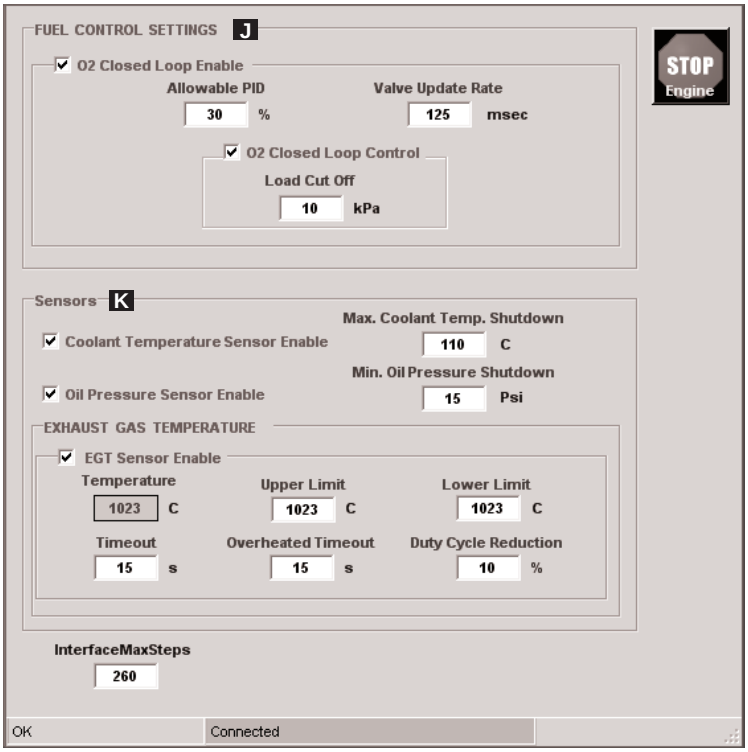


NOTE PID Scale changes can make drastic changes in parameters. If the multiplier is decreased by 1, the corresponding value will double, and if the multiplier is increased by 1, the parameter value will be halved.

J

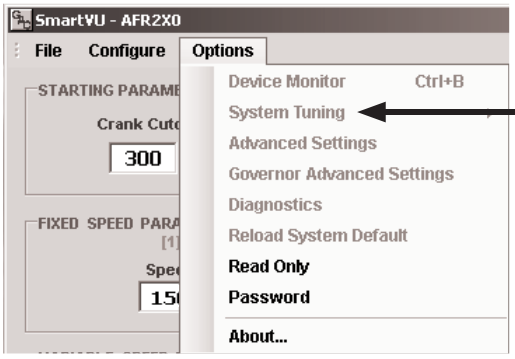
K

Advanced Settings - Fuel Control Settings			
Name	**Range**	**Default**	**Definition**
Allowable PID		50	This represents the total allowable % offset for the control system from the commanded starting position of the stepper motor. The default allows 50% of travel from the store table and is typically sufficient.
Valve Update Rate		125	This represents the rate at which the control system will register updated position information from the fuel valve, measured in msec. Typically the default is sufficient. (msec)
O2 Closed Loop Control		ON	This enables or disables the closed loop control system, which will only apply when the engine is operating above all cutoffs. (OFF/ON) When enabled, this will automatically go into open loop mode when operating below the cutoff. When disabled, the oxygen sensor is operating in closed loop no matter what load.
Load Cut Off		20	This is the value of intake manifold pressure (kPa) after which the control system will implement the closed loop fuel control algorithm,and the default is typically acceptable.



Advanced Settings - Sensors			
Name	**Range**	**Default**	**Definition**
Coolant Temp. Sensor Enable		Off	Checking this box indicates that the coolant temperature sensor is installed and being used.
Max. Collant Temp. Shutdown		110	Threshold for engine shutoff should be set in degrees Celsius.
Oil Pressure Sensor Enable		Off	Checking this box indicates that the engine oil pressure sensor is installed and in use.
Min. Oil Pressure Shutdown		15	Threshold should be set in PSI.
EGT Sensor Enable		AFR200/201 Off AFR210/211 On	This box should be checked if the exhaust gas temperature sensor is installed and in use. This input must be disabled if the sensor is not installed or the engine will shut down inadvertently.
Temperature		-	This displays the temperature as read from the EGT sensor.
Upper Limit		650	This is the upper limit threshold at which engine duty cycle will be reduced to lower exhaust gas temperature.
Lower Limit		645	This is the lower limit threshold after which the AFR will re-allow full duty cycle to the engine if the temperature remains below the limit for the timeout duration.
Timeout		5	This value (sec) is the duration after which the AFR will re-allow full duty cycle the engine if the EGT remains below the lower limit.
Overheated Timeout		5	This value (sec) is the duration after which the AFR will shut down the engine if the EGT remains above the upper limit.
Duty Cycle Reduction		10	This value is the percent reduction in engine duty cycle imposed by the AFR of the exhaust gas temperature rises above the specified upper limit.

L ADVANCED GOVERNOR & FUEL TUNING



SYSTEM TUNING

Governor gain(P), stability(I), and deadtime(D) as well as Fuel gain(P) and stability(I) can be adjusted across the range of speed and loads by selecting Options -> System Tuning -> Governing from top of the main menu.

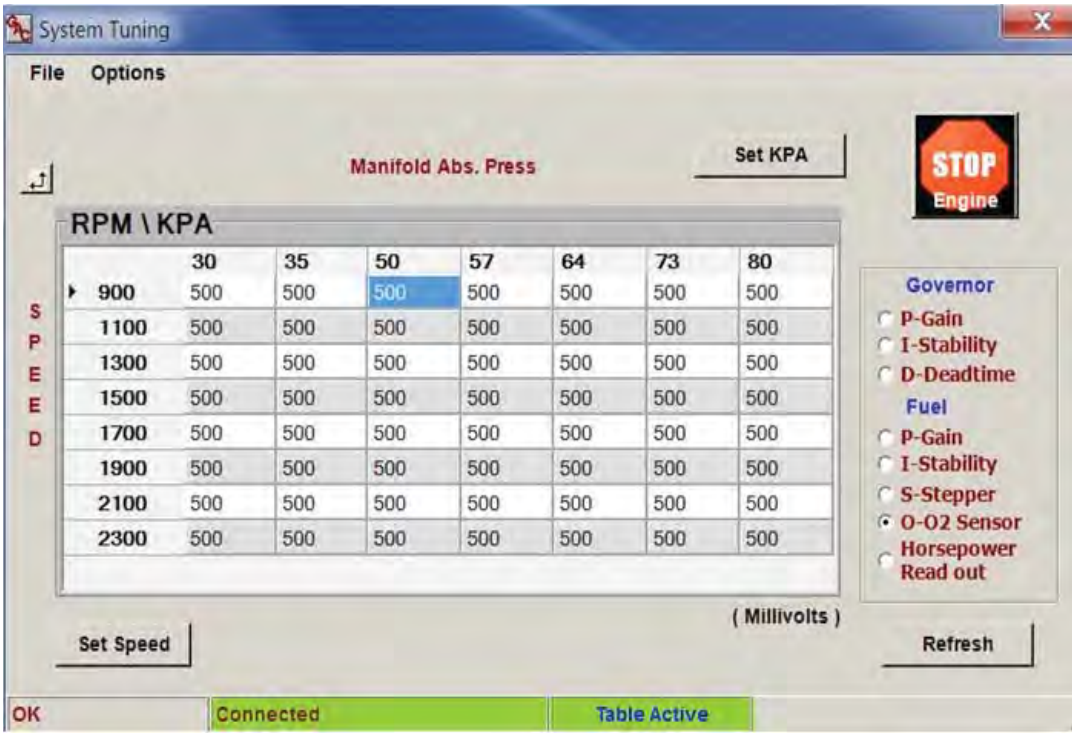
Before You Tune:

L1
- Use the axis button to change the axis before modifying any parameters. Modify the axes in reverse order. Start at the highest pressure, located in the far right of the top axis, and work to the left. When changing the RPM values on the side axis, start at the bottom with the highest value and work up to the lowest value. Remember to hit the "Save Data " button on the main menu when done.

L2
- Select each parameter to be altered from the side bar.

L3
- Once axis has been set and a parameter to alter has been selected, the table itself can be modified. The in the table will correspond with the axis set in step 1.

NOTE A green box indicates the current load vs. speed cell.



BUTTONS and INTERFACE

- **Set Speed** or **Set Load** - Speed and load axis values can be edited to adjust range and resolution of the table.
- **Radio buttons on the side panel** allow you to switch between tables.
- **Refresh** - will update the maps real time; this should be done after making any changes to ensure the values have been entered correctly.
- **Highlighted Cell** - indicates the engine's current speed and load value.
- **Return to Main Screen -** Ctrl+B or select Options -> Back to Main Screen, or close the window to return to the main screen.
- **Stop Engine** - icon can be used to shut down the engine at any time.

ADVANCED FUEL TUNING PROCEDURE

1.	Go to Options -> Advanced settings in the menu bar to enter the "Advanced Settings" window.
2.	Enable the O2 Closed Loop Enable by unchecking the box. This will enable the closed-loop feedback on the primary O2 sensor.
3.	Return to the STune window and allow the map to update to the current process or settings.
4.	Adjust the speed and load scales by selecting the "Set Load" or "Set Speed" buttons and entering the required linear values. Press Save and Close when complete.
5.	Enter 50% as a baseline value for all speed and load settings.
6.	Refresh the map to assure that all values have been accepted by the controller.
7.	Go back to the main page and document the "actual" stepper position at each speed and load. Allow a short pause at each point for the stepper to settle.
8.	Update the table to reflect the values documented
9.	Adjust the values as needed for optimal stepper position in open-loop mode
10.	Once preliminary tuning is complete, enable the O2 Closed Loop Enable function by re-checking the box. Remember to hit the "Save" button when done. The goal is to minimize offset.

NOTE Advanced fuel tuning can significantly improve load transient response if edited correctly. Consult GAC if needed.

ADVANCED GOVERNOR TUNING PROCEDURE

1.	Open the system tuning window and select the radio button for the Governor P, I, or D table and allow the map to update.
2.	Adjust the speed and load scales by selecting the "Set Load" or "Set Speed" buttons and entering the required linear values. Press Save and Close when complete
3.	Enter values for P, I, and D as determined from the Governor PID tuning guidelines as a baseline value.
4.	Refresh the map by pressing the Refresh button to assure that all values have been accepted by the controller.
5.	Once complete with preliminary tuning, recheck the response from the system to ensure optimal operation and readjust as necessary.
6.	Adjust each of the values as needed across the speed and load range. Remember to hit the "Save" button on the main page when done.

OXYGEN SENSOR SYSTEM

The oxygen sensor request can be adjusted over the engine speed and load range.

NOTE If using lean burn system, refer to manual provided with KT317WB.

ADVANCED FUEL TUNING PROCEDURE

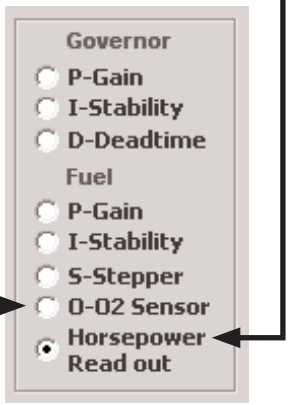
1. Enter the “Advanced Setting” window by going to Options -> Advanced Settings in the top menu bar. Make sure “O-O2 Sensor “ is selected.
2. Adjust the speed and load scales by selecting the “Set Load” or “Set Speed” buttons and entering the required linear values. Press Save and Close when complete.
3. Enter 500 as a baseline value for all speed and load setting and refresh the map to ensure that all values have been accepted to the O2 voltage request map.
4. Under the Configuration dropdown menu, select “Save Data to Device”. Allow some time for the map to be flashed to the device memory. This can also be done using the Save Data to Device button in the main screen. Return to the main screen.
5. Start the engine and allow the oxygen sensor to reach operating temperature. If the engine does not start, refer to the Symptom Troubleshooting section in the AFR Product User Guide.
6. In the sensors section of the main screen, verify that the PRE-oxygen voltage is switching between Lean-Stoic-Rich. If the voltage is static at Lean or Rich, increase or decrease the regulator output until switching is achieved.
7. Mixture can be richened at various speeds and loads by setting the O-Tune request voltage up to a max of 600 mV and lean the mixture by setting the O-Tune request to a min of 400 mV as long as the majority of the values are set to 500 mV.
8. Once preliminary tuning is complete, enable the O2 Closed Loop Enable function by re-checking the box. The AFR will resume control and adjust the fuel flow based on the O2 sensor and O-Tune request voltage.

HORSEPOWER READOUT

The horsepower readout table is used to cross-reference the engine speed and manifold absolute pressure (indication of engine load) with an equivalent horsepower reading on the main page of the AFR interface.

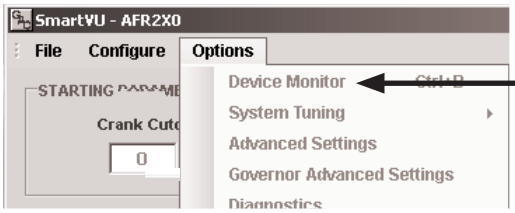
TUNING HORSEPOWER READOUT

Follow steps for tuning Fuel System, but at steps 3 and 4, instead enter values determined by engine speed and manifold absolute pressure as determined by a correctly calibrated dynamometer.



DEVICE MONITOR

The device monitor is a visual interface which helps you monitor key outputs of the control system. To display the device monitor, select Options -> Device Monitor from the dropdown menu, or press Ctrl + B.



SPEED

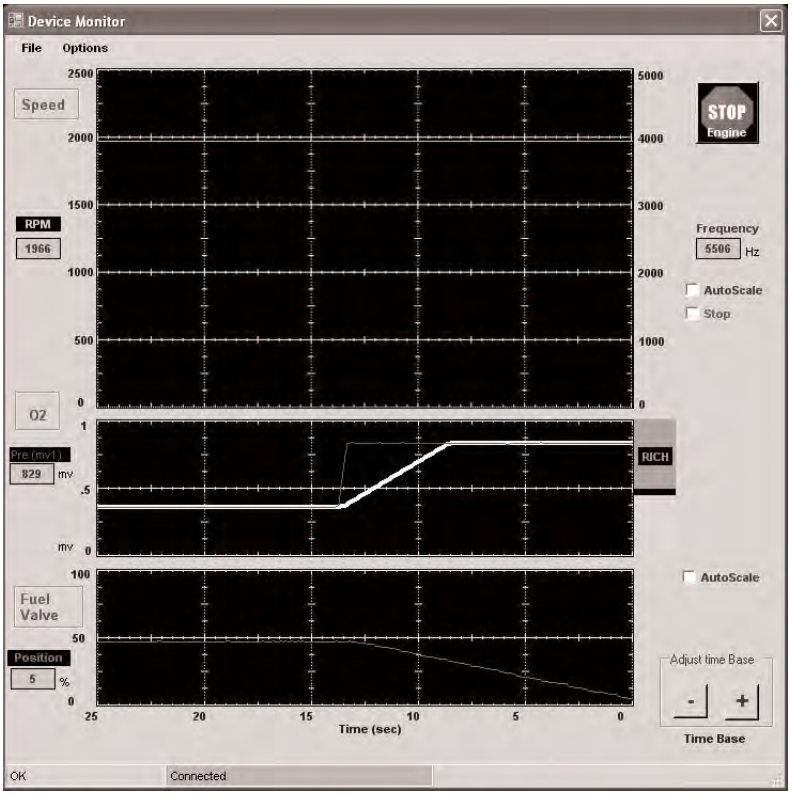
The speed monitor displays engine speed based on the measured magnetic pickup frequency. It also features formatting options for the graphic interface, including Auto Scale time base adjustment, refresh,and display freezing. Make the time scales smaller by pressing the zoom in “+” button and larger by pressing the zoom out “-” button. The engine can be stopped at any time by pressing the Stop engine button.

O2

The O2 monitor displays both pre- and post-catalyst oxygen sensor voltages as well as a rich/lean indication and average value. The post-catalyst O2 sensor will have a separate trace. You can select which O2 trace to view by selecting Options -> Display O2.

FUEL VALVE

The fuel valve window displays the commanded fuel valve position from 0-100% and allows an adjustable time base for all real-time monitor graphs.



18 FAULT / WARNING BLINK CODES

The AFR has a simplified blink code system in the event a computer is not available.

DISPLAYING BLINK CODE HISTORY	
1.	Power OFF the AFR
2.	Power ON the AFR, without the engine running
3.	The fault LED (LED 1) will blink through the entire fault history in reverse chronological order (newest code first, oldest last).
4.	Once the AFR has reached the end of the list, it will stop flashing the fault codes.

AFR FAULT INDICATION BLINK CODES	
COUNT	**ALARM/WARNING**
1	O2 Sensor Circuit No Activity Detected
2	Engine Speed Input Circuit No Signal
3	Engine Overspeed Condition
4	Engine High Temperature Condition
5	Engine Oil Pressure Too Low
6	Not Used
7	Post O2 Circuit or Sensor Failure
8	MAP Circuit Low Input
9	Not Used
10	Exhaust Gas Temperature Too High

19 SUPPORTED FAULT LIST

P-CODE	DESCRIPTION	POTENTIAL FAILURE CAUSE
P0108	MAP Circuit Failure	Open or short circuit in wiring or connector / Poor connection / Defective sensor
P0118	Coolant Temperature Sensor Failure	Open or short circuit in wiring or connector / Poor connection / Defective sensor
P0133	Pre-O2 Sensor Circuit Slow Response (Bank 1, Sensor 1)	Short circuit in wiring or connector / Poor connection / defective heater circuit or sensor / Sensor beying maintenance interval replacement period
P0134	Pre-O2 Sensor Circuit No Activity (Bank 1, Sensor 1)	Open or short circuit in wiring or connector / Poor connection / Defective sensor
P0153	Post-O2 Sensor Circuit Slow Response (Bank 2, Sensor1)	Short circuit in wiring or connector / Poor connection / defective heater circuit or sensor / Sensor beyond maintenance interval replacement period
P0154	Post-O2 Sensor Circuit No Activity (Bank 2, Sensor 1)	Open or short circuit in wiring or connector / Poor connection / Defective sensor
P0171	System too Lean (Bank 1)	Low gas pressure, poor fuel quality / Pressure regulator misadjustment / Fuel valve assembly not responding or sticking closed
P0172	System too Rich (Bank 1)	High gas pressure / Pressure regulator misadjustment / Fuel valve assembly not responding or sticking open
P0217	High Coolant Temperature	Engine coolant temperature has exceeded operational limit defined in calibration / Defective sensor
P0219	Engine Overspeed	Engine magnetic speed pickup signal has exceeded operational limit defined in calibration / Defective sensor
P0521	Low Oil Pressure	Engine oil pressure has fallen below minimum operational limit defined in calibration while engine was running / Defective sensor
P0523	Engine Oil Pressure Sensor Failure	Engine exhaust gas temperature has exceeded the operational limit defined in calibration / Defective sensor
P0725	Engine Speed Input Circuit Failure	Open or short circuit in wiring or connector / Poor connection / Defective sensor

G-CODE	DEFINITION	REASON
G9002	User Emergency Shutdown	User has commanded shutdown in SmartVu (Stop button)
G9004	Reload System Defaults	User has reloaded the calibration / configuration defaults in SmartVu
G9005	Diagnostic Timer Reset	User has reset the diagnostic timer in SmartVu
G9006	Diagnostic Logging Has Been Cleared	User has reset / cleared the diagnostic fault code log
G9021	EGT Maximum Temperature Shutdown	The exhaust gas temperature maximum limit has been reached and the engine was commanded to shut down
G9022	EGT Maximum Value Reached	The exhaust gas temperature operational limit was reached and the engine was derated to reduce temperature
G9023	Reset Shutdown	The engine speed input was inaccurate, erratic, or lost / For 24 V applications, the “Rolling Average Speed Calculation” should always be enabled in the governor advanced settings menu

JDR TEXT	SPN	FMI	FAULT	ACTION	POTENTIAL FAILURE CAUSE
Engine Oil Pressure	100	2	Open circuit		Open circuit on harness or connector / Failed sensor
Engine Oil Pressure	100	4	Short to Ground		Short circuit to ground in harness or connector / Failed sensor
Engine Oil Pressure	100	1	Low Reading	Shutdown	Engine oil pressure has fallen below minimum operational limit defined in calibration while the engine was running / Defective sensor
Engine Intake Manifold 1 Pressure	102	4	Short to Ground		Short circuit to ground in harness or connector / Failed sensor
Engine Coolant Temperature	110	7	Short to Ground		Short circuit in harness or connector / Failed sensor
Engine Coolant Temperature	110	0	High Reading	Shutdown	Engine coolant temperature has exceeded operational limit defined in calibration / Defective sensor
Engine Exhaust Gas Temperature	173	2	Open Circuit		Open circuit on harness or connector / Failed sensor
Engine Exhaust Gas Temperature	173	4	Short to Ground		Short circuit to ground in harness or connector / Failed sensor
Engine Exhaust Gas Temperature	173	3	Short to Power		Short circuit to battery or sensor supply in harness or connector / Failed sensor
Engine Exhaust Gas Temperature	173	10	Data Erratic		Exhaust gas temperature sensor data erratic / Intermittent or incorrect poor connection / Defective sensor
Engine Exhaust Gas Temperature	173	16	High Reading	De-rate	Engine exhaust gas temperature has exceeded the operational limit defined in calibration / Defective Sensor
Engine Exhaust Gas Temperature	173	0	Severe High	Shutdown	Engine exhaust gas temperature has exceeded the critical maximum limit defined in calibration and the engine was shut down / Defective Sensor
Engine Speed	190	2	Open Circuit	Shutdown	Open circuit on harness or connector / Failed sensor
Engine Speed	190	0	Over Speed	Shutdown	Engine magnetic speed pickup signal has exceeded operational limit defined in calibration / Defective Sensor
3217	3217	4	O2-1 Short to Ground		Short circuit to ground in harness or connector / Failed sensor
3217	3217	10	O2-1 Insufficient Activity		Open circuit on harness or connector / Failed sensor
3227	3227	4	O2-2 Short to Ground		Short circuit to ground in harness or connector / Failed sensor
3227	3227	10	O2-2 Insufficient Activity		Open circuit on harness or connector / Failed sensor

When not using the JDR for fault codes, use the following parameter group names

PGN	DEFINITION	NOTES
61444	Engine Speed	Speed which is calculated over a minimum crankshaft angle of 720 degrees divided by number of cylinders.
65263	Oil Pressure	Gage pressure of oil in engine lubrication system as provided by oil pump.
65262	Coolant Temperature	Temperature of liquid found in engine cooling system.
65270	MAP Pressure	The gage pressure measurement of the air intake manifold. If there are multiple air pressure sensors in the intake stream, this is the last one in flow direction before entering the combustion chamber. This should be the pressure used to drive gauges and displays.
59904	Diagnostic	Used to request a Parameter Group from a network device or devices.

20 J1939 CAN INFO

AFR CAN ID = 25

21 SYSTEM TROUBLESHOOTING

NOTE Disable fuel supply before troubleshooting.

PROBLEM	ACTIONS / POSSIBLE SOLUTIONS
Engine does not start	1. Verify power to the AFR controller: a. Check for green power LED indicator b. Check for adequate battery voltage c. Check power cable and supply 2. Verify engine speed is reporting a. Verify proper settings in SmartVU b. Check magnetic pickup clearance c. Check wiring to magnetic pickup 3. Verify proper actuator operation: a. Verify proper settings in SmartVU b. Verify actuator duty cycle in SmartVU c. Measure voltage to actuator d. Check connections and wiring to actuator 4. Verify proper fuel valve operation: a. Verify proper settings in SmartVU b. Cycle unit power and verify fuel valve calibration c. Check wiring to fuel valve 5. Verify the ignition system is accurately providing spark to cylinders 6. Important: The stepper goes through a calibration at key/power-on from 0 - 100V which takes several seconds. If you attempt to crank during this time, you may have difficulty starting. Key on, wait, then try to crank.