ENGINE
GOVERNING
SYSTEM

AFR200 Series
Air Fuel Ratio Controller

GOVERNORS AMERICA CORP.®

- Optimal Closed Loop Air-Fuel Ratio and Delivery Control
  - -Proprietary, Fast Responding, Non-Linear, Air / Fuel Ratio Control
  - -Actuator Throttle Body or Universal Actuator Control
  - -Variable O2 Lambda Control Strategy
  - -Fail-safe Open Loop Control
  - -Industrial, Highly Accurate High Resolution Stepper Motor with Programmable Start Position
  - -Integrated Venturi Mixer / Valve Assembly
- A Built-in Engine Speed Governor
  - -Multi PID Governing EDG Technology Designed to Control Engine Speed with Precise Response to Transient Load Changes
  - -Three Fixed Speeds & Variable Speed Governing with Droop Capability
  - -Overspeed Shutdown Protection
  - -Speed Ramping Functionality
  - -Starting Fuel Control Adjustment
  - -Full PID Adjustment Capability
- Engine Sensor, Data Monitoring and Diagnostic Capability
  - -Pre- and Post- Catalytic Converter O2 Sensors
  - -Manifold Absolute Pressure (MAP) Sensor
  - -Magnetic Speed Pick-Up
  - -Exhaust Gas Temperature Sensor; Type-K Thermocouple
  - -Engine Oil Pressure Sensor
  - -Engine Coolant Temperature Sensor
- Inputs and Outputs
  - -Power Relay Output (2A)
  - -Malfunction Indicator Lamp (MIL) Output
  - -Variable Speed Increment / Decrement
  - -Load Sense / Synchronizing Speed Trim Input
- 12 and 24VDC Compatible
- CAN / Serial Communication
- Easy Configuration and Customization using GAC SmartVU Software
- High Reliability & Durability

INTRODUCTION

The Air Fuel Ratio (AFR) 200 series controller is part of the GAC comprehensive fuel management system for gaseous-fueled, spark-ignited engines ranging from 1L to 13L+. The AFR200 series controllers when used in conjunction with the ICM200 (Ignition Control Module) offers a complete Fuel and Ignition Management System (FIMS) referred to as the FIMS500 system. Each of these controllers has the ability to work independently of the other in the event of a failure.

The AFR system is capable of supporting the strict emission regulations of both the US and Europe as well as the rest of the world. Once a system has been calibrated for optimal emissions results, the firmware file can be loaded into subsequent systems using GAC's configuration software available on *www.governors-america.com.*

The AFR200 series controller is ruggedly designed to be used in a wide variety of engine environments. The connector, harness and cast aluminum case are all environmentally sealed to IP-67. The AFR is designed to be highly reliable and includes protection against reverse battery voltage, transient voltages, short circuits and a loss of engine speed sensor signal or battery supply.

DESCRIPTION

The AFR's fuel control algorithm maintains a stoichiometric air-fuel ratio for optimized emissions and engine performance. Engine speed can be governed in either isochronous or droop modes using GAC's proprietary Electronic Digital Governor (EDG) algorithm. The AFR control operates the closed loop fuel system with five major components:

- Digital precise stepper motor fuel control valve to adjust the flow of fuel into the system.
- Static venturi mixer to combine fuel and air with the appropriate mixture.
- Electrically controlled throttle body valve or universal actuator to control the amount of the air that enters the engines' intake manifold based on engine speed input.
- Oxygen sensor to monitor exhaust to determine whether the engine is running lean or rich.
- Manifold Absolute Pressure (MAP) sensor to determine engine load.

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Depending on the AFR version selected, the following sensor inputs are supported for added control and engine protection:

- Second (post-catalytic) oxygen sensor
- Engine Oil Pressure (EOP) sensor
- Engine Coolant Temperature (ECT) sensor
- Exhaust Gas Temperature (EGT) sensor; Type K thermocouple

The AFR uses a narrow-band oxygen sensor with an output between 0 and 1V based on the oxygen concentration in the exhaust gas. The closed loop feedback is accomplished by varying fueling based on engine speed and load in addition to the oxygen sensor signal.

When no signal is received from the O2 sensor, the sensor fails, or the sensor is not at operating temperature, the AFR orders a fixed (unchanging) rich fuel mixture for open-loop operation.

Once the signal is registered, adaptation is further carried out by a feedback / predictive algorithm which uses customizable PIDs. The predefined table values are changed real-time to ensure the desired oxygen sensor voltage set point (lambda value) is maintained. The air-fuel mixture is constantly adjusted which results in a switching between lean/rich in order to operate at peak efficiency and minimize emissions. Voltages near 0.9V indicate that the fuel mixture is rich and there is little unburned oxygen in the exhaust whereas voltages closer to 0.1V indicate the mixture is lean. At 0.5V the engine is operating at stoichiometry.

An additional oxygen sensor can be mounted in or behind the catalytic converter to monitor converter efficiency. These are referred to as downstream O2 sensors. If the converter is doing its job and is reducing the pollutants in the exhaust, the downstream oxygen sensor should show little activity. If the signal from the downstream oxygen sensor starts to mirror that from the upstream oxygen sensor, it means converter efficiency has dropped off.

The AFR uses the Manifold Absolute Pressure (MAP) sensor to determine engine load. The engine oil pressure sensor is used by the AFR in order to diagnose a low oil pressure condition during engine operation. The engine coolant temperature sensor is used by the AFR to monitor engine temperature. The AFR will shutdown the engine for low oil pressure or high temperature conditions.

The type K thermocouple input is used by the AFR to monitor exhaust gas temperature. In the event the temperature exceeds a calibrated threshold, the AFR will impose a derate in throttle %. If the temperature returns to the normal operating region within a set time interval, the AFR will reallow throttle. Otherwise, the AFR will shut down the engine to protect it. All engine protection limits and thresholds can be calibrated within the AFR controller using SmartVU.

The AFR also includes a 2A low-side binary output for control of the power relay. The power relay is used to provide power to the oxygen sensor heaters as well as control the shutdown of the engine if the ignition coils or a fuel shutoff solenoid are connected to it.

The proprietary multiple PID governor control system provides fast and accurate control (+/- 0.25%) of the engines speed to any dynamic load changes in isochronous or droop operation. When connected to a throttle body actuator and supplied with a magnetic speed sensor signal the governor will direct the engine to the desired speed setting.

The three fixed governed speeds and one variable governed speed are all selectable through two discrete inputs. The AFR also has two binary low inputs, when tied to ground momentarily, will either increment or decrement engine speed by 10 RPM while in variable speed mode. In addition, the AFR supports an Aux Load Sharing / Synchronizing signal which is intended to provide a speed trim input for the engine to synchronize with another power source / generator.

During the engine cranking cycle, starting fuel can be adjusted from an almost closed, to a nearly full fuel position. Once the engine has started, and passed the crank termination set point, the speed control point is determined by the idle speed set point and the speed ramping algorithm. The speed ramping functions adjust the engines speed acceleration and deceleration and is fully customizable using SmartVU.

When at the desired governed engine speed, the actuator will be energized with sufficient current to maintain the desired engine speed in a closed loop speed control, independent of engine load (isochronous operation) if selected.

The controller has both RS-232 and CANbus communication capability. Communication with SmartVU is done over RS-232 using a serial connection. The SmartVU interface allows the user the ability to customize engine performance real-time, monitor data, view diagnostic information, and store configurations. The CANbus is typically used to communicate with other devices such as J1939 capable display devices, and data readers.

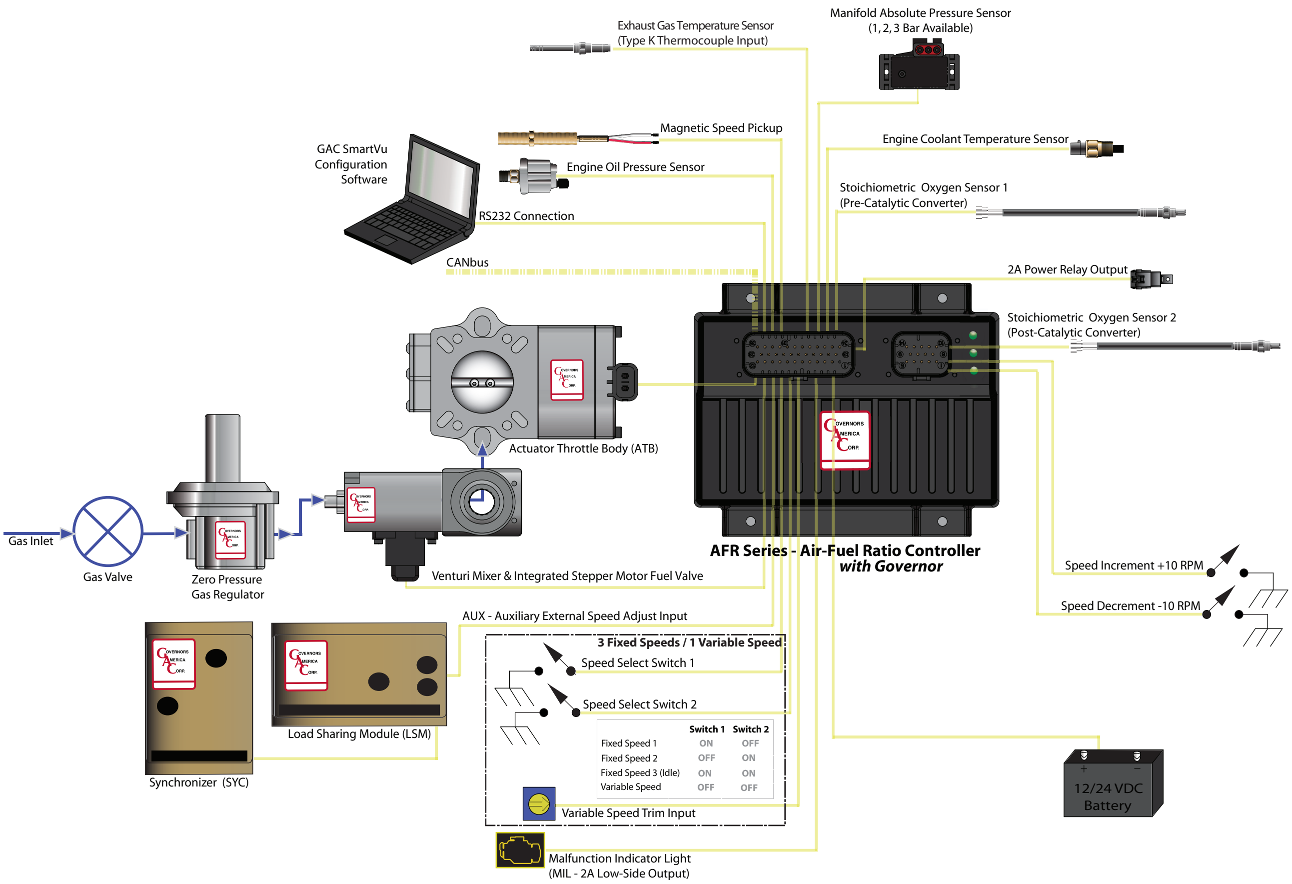
The AFR has the ability to diagnose and indicate numerous fail modes, as well as, store an extensive fault history. This information is indicated by the available Malfunction Indicator Lamp (MIL) output or by the status indication LEDs on the AFR itself. For more detailed troubleshooting the SmartVU diagnostic interface provides engine data, and OBDII P-codes and GAC G-codes.

SELECTION TABLE

Model	Unique Features
AFR200	1 Oxygen Sensor Input
AFR201	2 Oxygen Sensor Inputs
AFR210	1 Oxygen Sensor Input 1 Exhaust Gas Temperature Input (Type K Thermocouple)
AFR211	2 Oxygen Sensor Inputs 1 Exhaust Gas Temperature Input (Type K Thermocouple)

Note: This table does not include the standard features that are applicable to all models.

DIAGRAM 1 SYSTEM WIRING / OUTLINE



SPECIFICATIONS

PERFORMANCE

Isochronous Operation / Steady State Stability............................ +/- 0.25%
Speed Range / Governor...400-10kHz(Mag Pickup)
Speed Drift w/ 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 85°C (-40° to 180° 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..100 mA Max Continuous
Plus Actuator, Stepper, O2 Heater, and MIL
Speed Sensor Signal...0.5 - 120 VRMS
Actuator Current..Up to 6 Amps Continuous
Aux (Load Share / Synchronizer)Input...0-10 VDC
Manifold Absolute Pressure Input..0-5 VDC
Coolant Temperature Input...Resistive 0-450 Ohm
Oil Pressure Input...Resistive 0-250 Ohm
Oxygen Sensor..0-1 VDC
Oxygen Sensor Heater, MIL.........................0-2 Amps High Side Sourced

RELIABILITY

Vibration...7G@20-2000Hz
Functional Test (Full Verification)...100%

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-maxFuel
Oxygen Setpoint...0-999mV
Fuel (Gain / Stability multiplier)..0-100
Fuel Value Setpoint..0-235 Steps (0-100%)
Manifold Absolute Pressure Sensor...1,2 or 3 Bar

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