Table 1. **Recommended GAC *ESD (Electronic Speed Device)***

	Droop
ESD5111	Standard Unit
ESD5111T	Temp Compensated
ESD5131	Soft Coupling Option
ESD5221	Single Element Speed Switch / 10 Amp Relay Output
ESD5335	24 VDC / Speed Ramp / 2 Element Speed Switch w/ Dual Dynamics

Table 2. **Recommended GAC *Feedback-Equipped Actuators***

ATB T2F Series	45-65mm / 12 or 24 VDC / Throttle Body Actuators
ATB T3F Series	75-85mm / 12 or 24 VDC / Throttle Body Actuators
ACE175AF	Bosch 'P' Pump / 12 or 24 VDC / Left Hand Rack / Packard Connector / Feedback Sensor
ADD176AF	Bosch 'A' Pump / 12 or 24 VDC / Left Hand Rack / Packard Connector / Feedback Sensor
ACE275K	Bosch 'P' 3000 - 7000 Fuel Injection Pump / 24 VDC / Heavy Duty Bearing Retention / Packard Connector / Feedback Sensor
ACE295F-24	Bosch 'Z' Pump / 24 VDC / Packard Connector w Mating Connector / Feedback Sensor

INTRODUCTION

The **DFM100** is part of a cost effective, affordable means of turning diesel engines into diesel-gas engines for Bi Fuel applications*. The **DFM100's** function is to drive two **GAC** independent feedback equipped electric actuators in conjunction with one **GAC** ***Electronic Speed Device (ESD)*** *and one* ***GAC Magnetic Pick-Up***.

DESCRIPTION

In Bi Fuel applications, the desire is to operate the engine at a diesel/gas ratio of 30/70%, or better, while maintaining the same power output. The actuators need to be of similar types with similar position sensors and outputs. In order to manipulate both fuel systems the **DFM100** is equipped with a **FUEL BALANCE** adjustment. Some mechanical calibration of the actuator linkage and the fuel rack will be required to assure that the systems are performing correctly. Each actuator driver circuit has its own actuator [**GAS & DIESEL**] **POSITION LOOP GAIN** adjustment to optimize the feedback control loop response.

In most cases while operating in Bi Fuel mode, the diesel function will be limited to a specific percentage level of fuel to START combustion in the engine. The lower the percentage is set on the **DIESEL FUEL LIMIT** adjustment, the higher the amount of gaseous fuel is fed to the engine. Setting the **DIESEL FUEL LIMIT** adjustment lower than the recommended percentage (10-15%), may result in high exhaust temperatures and poor combustion. The LED indicators on the **DFM100** indicate when diesel fuel is being limited as well as when the gas relay is energized and providing gas to the engine.

*GAC defines the term bi fuel as the simultaneous combustion of two fuels. In this case natural gas is utilized in conjunction with diesel fuel to operate the engine.

CONTROL FUNCTION DESCRIPTION

EXHAUST TEMPERATURE MEASUREMENTS

When a **Type K** thermocouple is plugged into **Terminals 23** & **24,** the **DFM100** will detect the exhaust gas temperature. If this feature is not utilized, a jumper should be placed across **Terminals 23** & **24**. An open thermocouple will register as a fault and will automatically remove any fuel limiting from the diesel side. The range of exhaust temperature can be adjusted via the **TEMP** pot. Normal factory setting is 450°C (18-5mV). The thermocouple wire must be used for the entire length of the connection.

DEFEAT DIESEL LIMIT

Closing **Terminals 27 & 28** will shut off the diesel fuel limiter thus causing the diesel fuel to rise to the level necessary to support the engine load.

Governors America Corporation 720 Silver Street Agawam, MA 01001
phone: 413.786.5600 fax: 413.789.7736
www.governors-america.com
info@governors-america.com

INSTALLATION

Refer to **Wiring Diagram 1** for proper connections. It is suggested that the **DFM100** be mounted along side the ***ESD***. When mounting the unit, attach it to a vertical surface to prevent any moisture from collecting on the circuit board. The normal precautions outlined in the ***ESD*** manual should be followed for the **DFM100** as well.

CONNECTING TO THE *ESD*

The ***Electronic Speed Device (ESD)*** used with the **DFM100** must be of the actuator voltage driver type with a PWM output and not a current driver type (**see Table 1.**) In normal actuator usage with a **GAC *ESD***, one side of the actuator is typically at near ground level voltage. Connect **Terminal B** on the ***ESD***, (the low side of the actuator drive) to **Terminal 26** on the **DFM100**. Connect **Terminal A** on the ***ESD***, (the high side output of the actuator), to **Terminal 25** on the **DDM100**. Jumpers must be installed between **Terminals 9** and **10** on the **DFM100.**

CONNECTING THE ACTUATORS FOR: No Droop, Droop to Actuator 1, Droop to Actuator 2

Before wiring the actuators to the **DFM100** decide whether droop operation is required in the application.

No Droop

If no droop is required, connect the actuators as shown in **Wiring Diagram 1** directly to the **DFM100**.

Droop to Gas Actuator (Actuator 1)

If droop is required, then the **Gas Actuator** (the actuator used for gaseous fuel control) is best used for the droop signal. To utilize this signal, disconnect **Terminal 26** on the **DFM100** from **Terminal B** on the **Electronic Speed Device (ESD)**. Connect the minus (-) of **Gas Actuator** (connection that would normally go to **Terminals 3** and **4** on the **DFM100**) to **Terminal B** on the **ESD**. Also, connect **Terminals 3** & **4** on the **DFM100** to **Terminal E** of the **ESD**. Droop may be adjusted on the **ESD** and it will be proportional to the current in **Actuator 1**.

Droop to Diesel Actuator (Actuator 2)

If the application requires that droop be proportional to **Actuator 2** (the diesel sides) remove the jumper from **Terminals 9** & **10** and disconnect **Terminal 26** on the **DFM100** from **Terminal B** on the **ESD**. Connect **Terminal 10** on the **DFM100** to **Terminal B** on the **ESD**. Also, connect **Terminal 9** on the **DFM100** to **Terminal E** on the **ESD**.

Other Wiring Issues

It is suggested that each position sensor cable be of a three wire shielded type with the shields connected only to the case on the **DFM100**. The actuator feedback sensor (AB feedback sensor type) is a three, sensor-terminated wire with an AMP connector, refer to **Table 3.**, for accessory parts. For proper connection from the feedback sensor or the cable harness to the **DFM100** refer to **Table 4**. Case ground (right or left corner screw) should be connected to battery minus (**Terminal 7**) with a separate cable for the best EMC ratings. Cables used on the terminals for **Actuator 1** or **2** handle fully actuator current, therefore they must be sized properly to handle the current (see **Table 5.** for recommended wire size).

The terminals labeled **Gas Actuator** and **24V Battery** on the **DFM100** have dual connections. These dual connections are needed because the current rating for the **Gas Actuator** driver is over 20A and the total DC current consumption for both actuators could reach as high as 30A. These values are larger than the rating of a single terminal on the connector. Depending on the choice of actuators, the current consumption will likely be much lower. Refer to actuator publications to determine the total current consumption.

THE EXHAUST TEMPERATURE CAN RUN VERY HOT ON SOME DIESEL ENGINES IN A BI FUEL APPLICATION, WHICH CAN RUIN THE ENGINE WITH EXCESSIVE HEAT. EXHAUST TEMPERATURE VARIES FROM CYLINDER TO CYLINDER SO THEREFORE, MONITORING THE EXHAUST TEMPERATURE IS MANDATORY.

Table 3.

GAC Part Numbers	
Feedback Sensor Mating Connector	EC1515
Feedback Sensor Mating Cable Harness	CH1515

Table 4.

Actuator Connector		CH1515		DFM100	
Number	Color	Number	Color	Gas Actuator	Diesel Actuator
1	Red	1	Red	15 (+)	22 (+)
2	Black	2	Black	13 (-)	20 (-)
4	White	4	White	14 (⏚)	21 (⏚)

Table 5.
Recommended Wire Size for a GAC Feedback Actuator

Actuator	Recommended Wire Size for Typical Application*
All ATB T2F Series	14 AWG
All ATB T3F Series	14 AWG
ADD176AF - ACE175AF	16 AWG
ACE275K	16 AWG
ACE295F-24	16 AWG

*Compensation for length and temperature affect wire size.

ADJUSTMENTS

Preset the adjustments on the **DFM100** as follows:

FACTORY SETTINGS ON THE DFM100		
Adjustment	**Potentiometer**	**Factory Settings**
ANTICIPATION GAIN	270˚ turn	50%
ANTICIPATION TIME CONSTANT	270˚ turn	50%
GAS POSITION LOOP GAIN	270˚ turn	30%
DIESEL POSITION LOOP GAIN	270˚ turn	30%
GAS LIMITS	270˚ turn	100%
DIESEL LIMITS	270˚ turn	100%
TEMP LIMITS	25 turn	450°c @ 18-5 mV
FUEL BALANCE	270˚ turn	0%
GAS GAIN (GG)	270˚ turn	100%
GAS OFSET (GO)	270˚ turn	0%
DIESEL GAIN (DG)	270˚ turn	100%
DIESEL OFSET (DO)	270˚ turn	0%

For a Bi Fuel application, it's best to first run the system with **100% diesel** to preset the speed control system.

Start the engine and set the speed and performance adjustments as outlined in the **ESD** user guide. It is helpful to record the rack position on an external monitor (via **Terminals 18(+)** & **19(-)**) vs. engine load on the diesel actuator. This will provide information on the quantity of diesel fuel vs. total power produced when in dual fuel operation.

Each actuator driver circuit has its own actuator **POSITION LOOP GAIN** adjustment to optimize the feedback control loop response. Adjust the **GAS & DIESEL POSITION LOOP GAIN** as high as possible without engine or actuator instability.

Note: The **SPEED GAIN** adjustment on the **ESD** and the **ACTUATOR GAIN** adjustment on the **DFM100** can interact some. It is possible to turn one up and the other down and get similar results. The **SPEED LOOP GAIN** must not be turned too low or the speed control performance could suffer. A mid-range setting or higher for both **GAIN** adjustments is preferable.

Once the system is proven to run well on diesel, shut down the system, leave the **DIESEL DEFEAT** switch open, and restart the engine. With no load or a light load on the engine, the engine should run stable.

Apply a greater load to the engine. When the load level is above 40%, adjust the **DIESEL LIMIT CCW** until the diesel fuel level reaches not less than 15% as determined by the data taken above from the position sensors signal when the engine was run on diesel only.

Continue to apply load, noting that the diesel fuel should be holding at a fixed level (**DIESEL ACTUATOR FUEL LIMIT LIMITING LED ON**). As the load increases, the gas valve will incrementally open. The **DIESEL LIMIT** adjustment may need to be adjusted if the exhaust temperature rises too high or the engine does not accept higher amounts of gas. Once the **EXH TEMP LIMIT** is reached, the **DIESEL LIMIT** will be automatically defeated adding more diesel fuel to the engine.

MAXIMUM GAS LIMIT

If it is needed to limit the maximum gas supply (the opening of the gas controlling actuator) to the engine, the **GAS LIMIT** adjustment may be turned **CCW** until the **GAS ACT LIMIT LED** comes **ON**. Once the **GAS LIMIT** has been reached (**GAS ACT LIMIT LED** turns **ON**) the **DIESEL LIMIT** is then defeated and any further load applied to the engine will be supplied via the diesel fuel system up to the maximum of the engine's capacity.

ANTICIPATION ADJUSTMENTS

Two adjustments are provided which affect the load dynamics on the diesel side of the fuel control. The purpose of the anticipation feature is to defeat the **DIESEL LIMIT** when a sudden load change occurs. The magnitude and time constant of the anticipation signal to defeat the limit is adjustable.

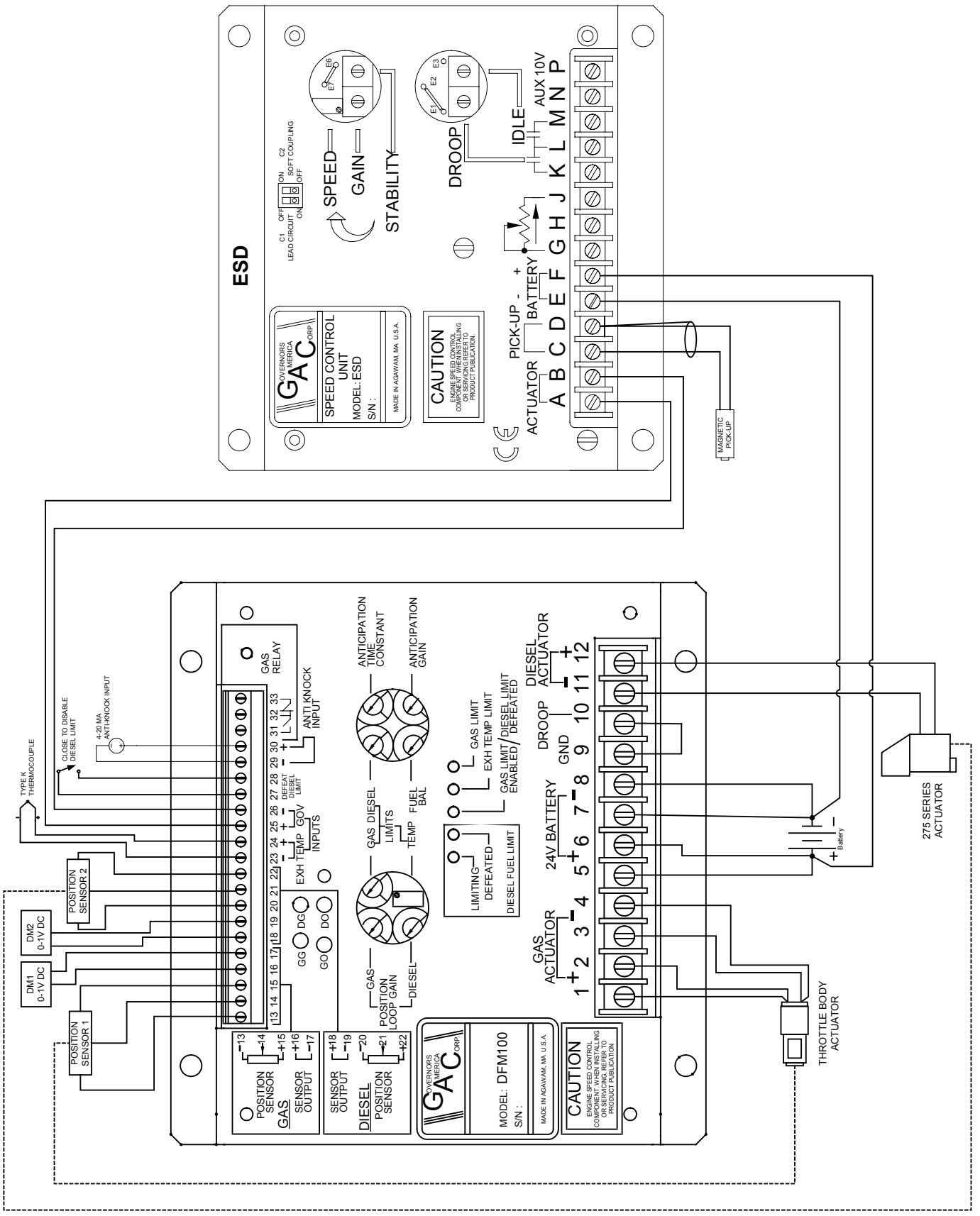
Apply a step load of at least 50%. Adjust the **ANTICIPATION GAIN** adjustment **CW** so that the diesel fuel increases during the transient. The higher setting the greater the ff-speed load transient. Next, adjust the **ANTICIPATION TIME CONSTANT** so that the off-speed transient has the shortest time off-speed. Adjusting these two controls, will make it possible to provide near optimum transient response with the diesel fuel or operation that approaches diesel fuel performance alone.

GAS AND DIESEL RACK POSITION MONITORING CALIBRATION

With power applied to the **DFM100** and before starting the engine, the voltage at the **Terminals 16(+) & 17(-)** should be adjusted to zero Volts by the **Gas Offset (GO)** for the Gas rack position and at **Terminals 18(+) & 19(-)** by the **Diesel Offset (DO)**. At maximum Gas and Diesel rack positions the voltage at the above-mentioned terminals should be 1 Volt and can be adjusted by **Gas Gain (GG)** and **Diesel Gain (DG)** respectively.

THE EXHAUST TEMPERATURE CAN RUN VERY HOT ON SOME DIESEL ENGINES IN A BI FUEL APPLICATION, WHICH CAN RUIN THE ENGINE WITH EXCESSIVE HEAT. EXHAUST TEMPERATURE VARIES FROM CYLINDER TO CYLINDER SO THEREFORE, MONITORING THE EXHAUST TEMPERATURE IS MANDATORY.

Wiring Diagram 1.



DECLARATION OF CONFORMITY TO EC DIRECTIVES

Application to Council Directives	Heavy & Light Industrial Applications
Standard to which Conformity is Declared	EN55011, EN50081-2, and EN50082-2
Manufacturer's Name	GOVERNORS AMERICA CORPORATION
Manufacturer's Address	Agawam, MA 01001 USA
Importer's Name	
Importer's Address	
Type of Equipment	Bi Fuel Module
Model Number	DFM100
Serial Number	Above J7000
Year of Manufacture	2007 and later

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directives & Standards.

Place: Agawam, MA USA

Date: 08-28-07

Signature:

Full Name: Mr. William Ferry

Position: President

In order to be compliance with the above directives, the installer is obligated to install the equipment in strict accordance with the following guidelines.

1. The device must be mounted against a metal ground plate with four bolts which make positive electrical connections between the case and the back plane must be installed.

2. All cable shields on connections to the device must be connected to the case at the screw on the case as shown on **Wiring Diagram 1**.

3. Battery minus connections must be jumper wired to the case as shown in the **Wiring Diagram 1**.

4. The installer must refer to **Wiring Diagram 1** provided in the literature for proper electrical connections.

SPECIFICATIONS

PERFORMANCE

DC Input Voltage ..... 18 - 32 Volts DC (Nominal 24V DC)
Transient protected to +/-250V DC
Actuator 1 Current .....up to 15 Amps, Short Circuit protected
Actuator 2 Current .....up to 15 Amps, Short Circuit protected
PWM Drive from Governors .....550 Hz Min from 12-32 V DCMax amplitude
Actuator Position Sensors .....5V DC excitation 1 to 4V DC output
Thermocouple…….....TypeK(1.0mV=25°C,22.3mV=540°C(1000°F))
Cold junction compensated above 0°C

ENVIRONMENTAL

Operating Temperature .....40° to +85to°C
Humidity .....up to 100%
Vibration.....1G@20-100Hz
Shock.....10 G (11ms)

AGENCY COMPLIANCE

EMC .....PER CE EN55011, EN50081-2, and EN50082-2

PHYSICAL

Dimensions ..... See Outline (Wiring Diagram 1.)
Weight..... 2.0 lbs.
Mounting ..... Any Position, Vertical Preferred

Governors America Corporation 720 Silver Street Agawam, MA 01001
phone: 413.786.5600 fax: 413.789.7736
www.governors-america.com
info@governors-america.com