DDM101
Dual Driver Module

1 INTRODUCTION

The DDM101 is an accessory module whose function is to drive two independent, feed-back-equipped GAC electronic actuators (see TABLE 1) from one GAC *ESD Electronic Speed Device* (see TABLE 2) This module is primarily installed where two actuators are required for a single engine i.e., two independent diesel fuel pumps or two gaseous throttle body actuators (ATBs).

2 SPECIFICATIONS

POWER INPUT	
DC Input Voltage	18 - 32 VDC(Nominal 24V DC) Transient protected to +/-250 VDC
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
ENVIRONMENTAL	
Operating Temperature	40° to +85°C
Humidity	up to 100%
RELIABILITY	
Vibration	1G, 20-100 Hz
Shock	10 G (11ms)
EMC	PER CE EN55011, EN50081-2, and EN50082-2

3 INSTALLATION

In the described applications, the desire is to drive two feedback-equipped, electric actuators equally so that either banks or cylinder groups receive equal fuel levels. The actuators should be of similar types with similar position sensors with equal outputs. To equalize the fuel to each cylinder bank the DDM101 has two advanced features, fuel and exhaust temperature balance. The fuel balance feature will correct any unbalances in the fuel systems by equalizing the fuel being delivered by each actuator. Any differences noted by the accurate actuator position sensors will be nulled out by the electronics so that the position sensors will track equally throughout the range, unless compensated with the FUEL BALANCE.

Engine power should be balanced by measuring the exhaust gas temperature readings at each bank. Some mechanical calibration of the actuator linkage and the fuel rack will be required to assure that the systems are nearly alike at one fuel delivery point. This can be either idle fuel or any midpoint of load control. The FUEL BALANCE adjustment is then used to set equal engine cylinder power at near 100% of engine load. In order to achieve minimum difference at any load point, the mechanical linkage adjustments should be set equal at 20% power with the electrical adjustments set equal at 80% power.

Each actuator driver circuit has its own GAIN [ACT 1 and ACT 2] adjustment to optimize the feedback control loop response. (See TABLE 6)

Refer to (WIRING DIAGRAM 4.) for proper connections. It is suggested that the DDM101 be mounted along side the *Electronic Speed Device (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 DDM101 as well.

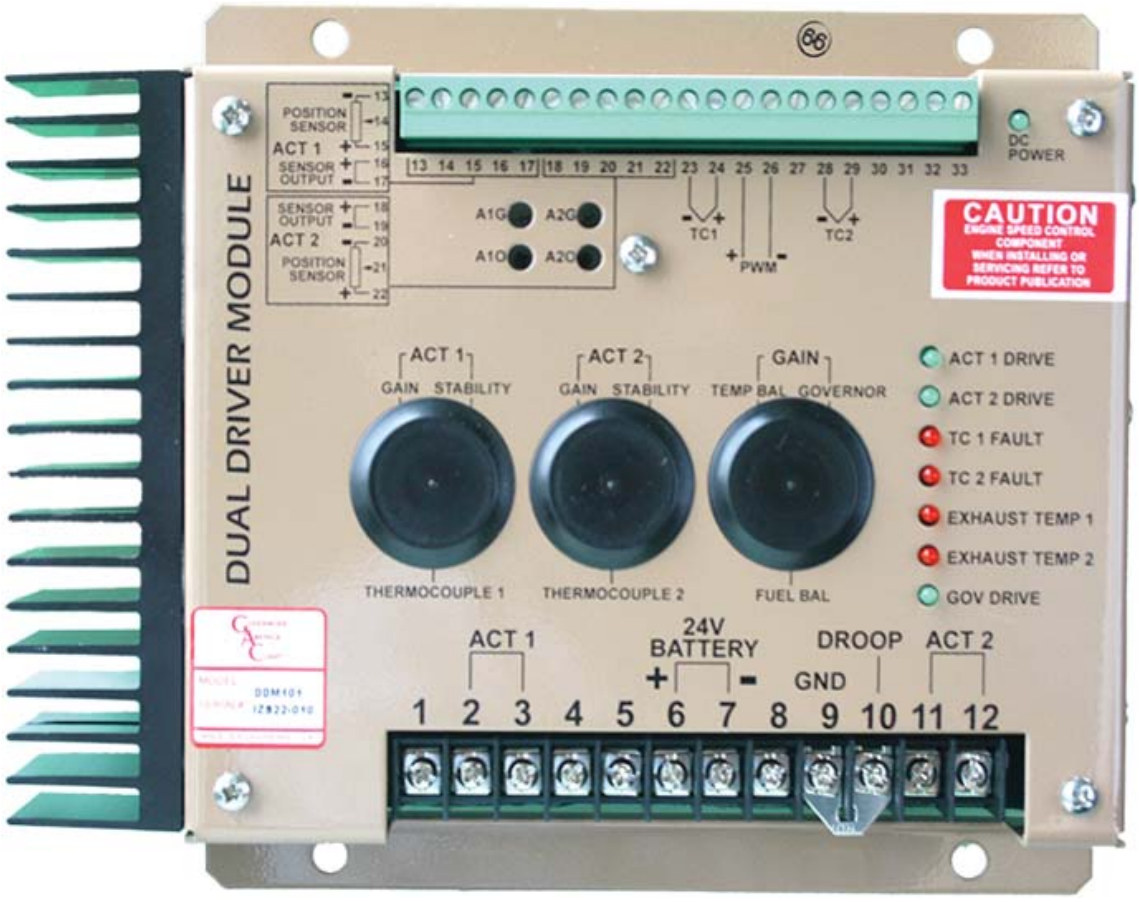


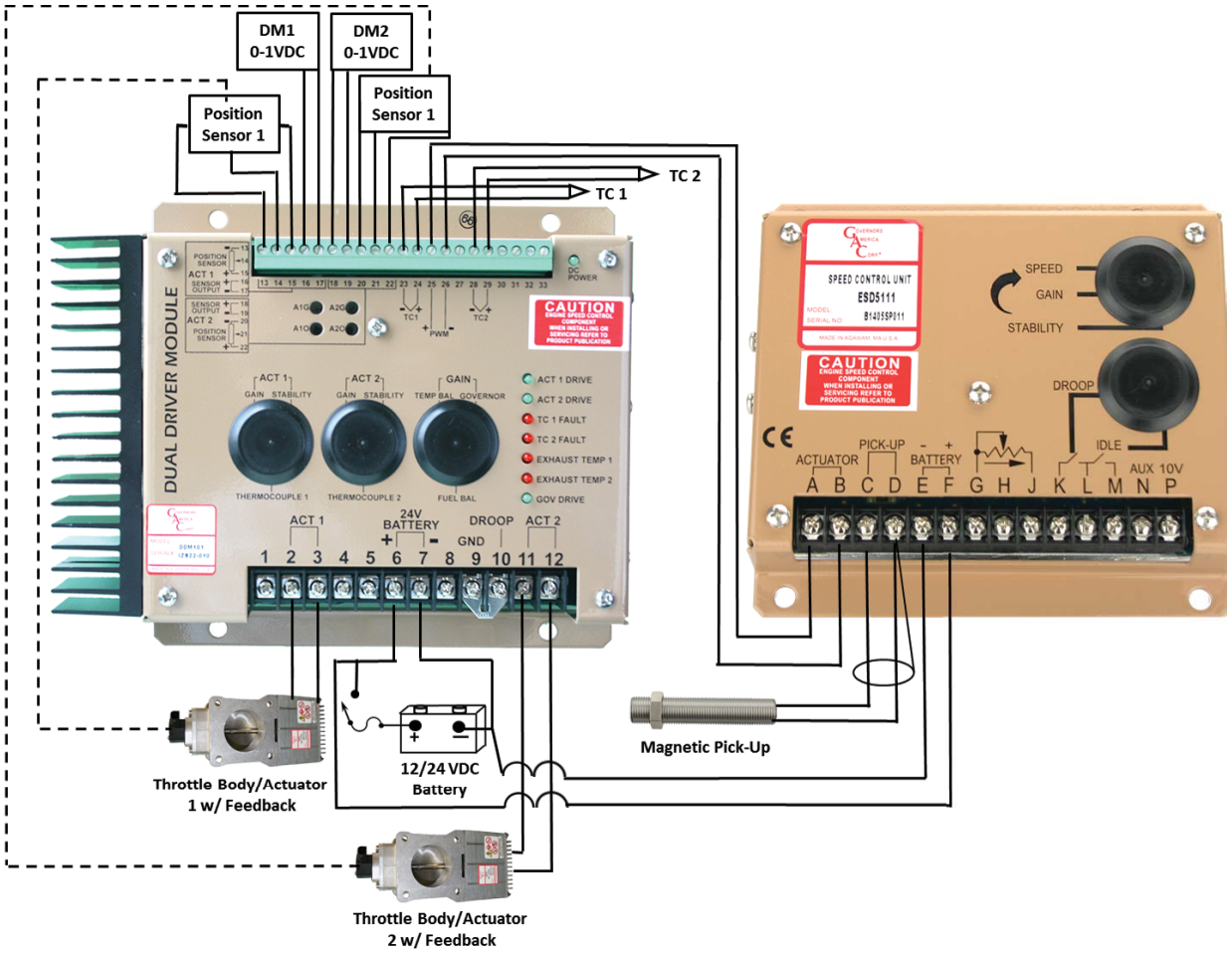
TABLE 1: Recommended GAC Feedback Sensor Equipped Actuators

ACTUATOR MODEL NO.	DESCRIPTION
ATB T1F Series	25mm to 40mm Bore Size / 12 or 24 VDC / Packard Connector / Sealed to 5.0 Bar
ATB T2F Series	45mm to 65mm Bore Size / 12 or 24 VDC / Packard Connector / Sealed to 5.0 Bar
ATB T3F Series	75mm Bore Size / 12 or 24 VDC /Packard Connector / Sealed to 5.0 Bar (Also listed Under T4)
ATB T4F Series	75mm to 95mm Bore Size / 12 or 24 VDC / Packard Connector / Sealed to 5.0 Bar
ADD175F	Bosch 'P' 3000 - 7000 Fuel Injection Pump/ 12 or 24 VDC/ Right hand Rack/ Packard Connector
ADD176AF	Bosch 'A' Size Fuel Injection Pump/ 12 or 24 VDC/ Left Hand Rack/ Packard Connector
ACE275K	Bosch 'P' 3000 - 7000 Fuel Injection Pump/ 24 VDC/ Heavy Duty Bearing Retention/ Packard Connector
ACE295F-24	Bosch 'P' 9000 - 10,000 Fuel Injection Pump/ 24 VDC/ Packad Connector with Mating Connector

TABLE 2: Recommended GAC Governor Controllers

GOVERNOR MODEL NO.	MULTI VOLT UNITS/ ISOCHRONOUS, VARIABLE & DROOP OPERATION/ ADJUSTABLE PID/ IDLE SPEED ADJUSTMENT/ AUXILLARY ACCESSORY INPUT
ESD5111	Standard Unit
ESD5131	Switchable Soft Coupling and Lead Circuit
ESD5221	Single Element Speed Switch / 10 Amp Relay Output

4 WIRING DIAGRAM



5 WIRING

CONNECTING TO THE ESD

The *Electronic Speed Device (ESD)* used with the DDM101 must be of the actuator voltage driver type with a PWM output and not a current driver type (see Table 2). 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 DDM101. Connect Terminal A on the *ESD*, (the high side output of the actuator), to Terminal 25 on the DDM101. A jumper must be installed between Terminals 9 and 10 on the DDM101.

CONNECTING TO THE ACTUATORS

Before wiring the actuators to the DDM101 decide whether droop operation is required in the application.

NO DROOP

If droop is not required then connect the actuators as shown in (WIRING DIAGRAM 4) directly to the DDM101. A jumper must be installed between Terminals 9 and 10 on the DDM101.

DROOP TO ACTUATOR 1

If your application requires droop, then the current in Actuator 1 is best suited for the droop signal. To utilize this signal, disconnect Terminal 26 on the DDM101 from Terminal B on the *ESD*. Connect Terminal 3 [the minus (-) of Actuator 1 on the DDM101] to Terminal B on the *ESD*. Connect Terminal 3 on the DDM101 to Terminal E on the *ESD*. Droop may be adjusted, proportional to the current in Actuator 1, on the *ESD*. See the *ESD* Manual for droop adjustment details.

DROOP TO ACTUATOR 2

If the application requires that droop be proportional to Actuator 2, remove the jumper from Terminals 9 and 10 and disconnect Terminal 26 on the DDM101 from Terminal B on the *ESD*. Connect Terminal 10 on the DDM101 to Terminal B on the *ESD*. Connect Terminal 9 of the DDM101 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 DDM101. 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 DDM101 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 full actuator current, therefore they must be sized properly to handle the current. (see TABLE 5)

TABLE 3: Accessory Parts

ACTUATOR	POSITION SENSOR MATING CONNECTOR	POSITION SENSOR MATING HARNESS
ADD175F-12/24	EC1523	CH1243
ADD176AF-12/24	EC1515	CH1515
ACE275K	EC1515	CH1515
ACE295F-24	EC1515	CH1515
ATB T1 Series	EC1523	CH1243
ATB T2 Series	EC1515	CH1515
ATB T3 Series	EC1515	CH1515
ATB T4 Series	EC1523	CH1243

TABLE 4: Connection - Feedback Sensor / Cable

	CONNECTION							
	Position Sensor Connector		Harness CH1515		Harness CH1243		DDM101	
Signal	Number	Color	Number	Color	Pin	Color	Act 1	Act 2
+5V	1	Red	1	Red	A	Red	15 (+)	22 (+)
GND	2	Black	2	Black	B	Black	13 (-)	20 (-)
Out	4	White	4	White	C	White	14 (‹)	21 (‹)

TABLE 5:

RECOMMENDED WIRE SIZE	
Actuator	Recommended Wire Size for Typical Application*
ATB T1F/T2F/T3F/T4F Series	14 AWG
ADD175F	16 AWG
ADD176AF	16 AWG
ACE275K	16 AWG
ACE295F-24	16 AWG

*Compensation for length and temperature affects wire size.

6 ADJUSTMENTS

Before starting the engine, check and/or restore POT values to the factory settings. (see TABLE 6.)

TABLE 6: Factory Settings

FACTORY SETTING OF THE POTENTIOMETERS			
	Potentiometer	Type	Setting
ACT 1	Gain	270˚ Turn	30˚
	Stability	270˚ Turn	50˚
	Thermocouple	270˚ Turn	50˚
ACT 2	Gain	270˚ Turn	30˚
	Stability	270˚ Turn	50˚
	Thermocouple	270˚ Turn	50˚
GAIN	Temp Balance	270˚ Turn	50˚
	Governor	270˚ Turn	30°
	Fuel Balance	25 Turn	12 Turns CW

Start the engine and follow the setup procedure outlined in the *ESD* Manual that is being used.

With the engine running, stable operation should be achieved by properly adjusting the *ESD* and the following:

POSITION LOOP GAINS ADJUSTMENT

Each actuator driver circuit has its own actuator GAIN [ACT 1 and ACT 2] adjustment on the DDM101 to optimize the feedback control loop response. Adjust ACT 1 and ACT 2 as high as possible without developing engine or actuator instability.

Adjust Actuator 1 first by rotating the ACT 1 GAIN potentiometer CW until instability in the engine develops. Gradually move the adjustment CCW until stability returns. Move the adjustment 1/8 of a turn CCW to ensure stable performance. Next, adjust the ACT 2 GAIN potentiometer following the above described method.

Poke or disturb the actuator to try to induce instability. Adjust the GAIN and STABILITY adjustments for best response from the actuators.

The SPEED and GAIN adjustment on the *ESD* and the GAIN [ACT 1 and ACT 2] adjustments on the DDM101 can have some interaction. It is possible to turn one up and the other down and get similar results. The GAIN adjustments on the DDM101 must not be turned to low or speed control performance may suffer. A mid-range setting or higher for all of the GAIN adjustments is recommended.

NOTE

ACTUATOR STABILITY ADJUSTMENT

Each actuator has its own actuator STABILITY [ACT 1 and ACT 2] adjustment to optimize system stability. Adjust both [ACT 1 and ACT 2 STABILITY] adjustments as high as possible without engine or actuator instability.

Adjust Actuator 1 first by rotating the ACT 1 STABILITY adjustment CCW until instability in the engine develops. Gradually move the adjustment CW until stability returns. Move the adjustment 1/8 of a turn CW to ensure stable performance. Next, adjust Actuator 2 via the ACT 2 STABILITY adjustment following the above described method.

Poke or disturb the actuator to try to induce instability. Adjust the GAIN and STABILITY for best response of the actuator.

FUEL BALANCE ADJUSTMENTS

The FUEL BALANCE adjustment allows for equalization of the fuel being delivered by each actuator. With the engine running at no load, measure the DC voltage output of the feedback sensors from each actuator. Voltage measurement for Actuator 1 is taken across Terminals 13 and 14. Voltage measurement for Actuator 2 is taken across Terminals 20 and 21. Both voltage measurements should have an operational range of 1 to 4 VDC. If the voltage readings are not equal, adjust the FUEL BALANCE potentiometer on the DDM101 until the voltage readings are equalized and the exhaust temperatures are balanced.

GOVERNOR GAIN ADJUSTMENT

With the engine running at rated speed, the PID system in the ESD can be adjusted for optimum performance (see the ESD's manual).

For best performance, the ESD's GAIN adjustment should be set between 40-60% of range. If the ESD's GAIN adjustment is below 25% the DDM101's GOVERNOR GAIN adjustment should be rotated CCW to a lower setting. The ESD's PID settings will have to be readjusted for optimum transient performance (refer to the ESD's manual).

Adjusting the DDM101 can also be accomplished by analyzing the ESD's PWM voltage input to Terminals 25 and 26 on the DDM101. The desirable voltage reading between Terminals 25 and 26 should measure 7 VDC at no load and 14 VDC at full load. If the measured voltage is lower than the desired range, the DDM101's GOVERNOR GAIN adjustment is set too high and should be rotated CCW to a lower setting. The voltage across Terminals 25 and 26 on the DDM101 should increase. If the measured voltage is lower than the desired range, the DDM101's GOVERNOR GAIN adjustment is set too low and should be rotated CW to a higher setting. The voltage across Terminals 25 and 26 on the DDM101 should decrease.

RACK POSITION-MONITORING

With power applied to the DDM101 and before starting the engine, measure the voltage at the Terminals 16(+) & 17(-). It should be adjusted to zero Volts by the Actuator 1 Offset (A1 O) for Actuator 1 (closed position) and at Terminals 18(+) & 19(-) by the Actuator 2 Offset (A2 O). At maximum positions the voltage at the above-mentioned terminals should be 1 Volt and can be adjusted by Actuator 1 Gain (A1 G) and Actuator 2 Gain (A2 G) respectively. To manually open the actuator, remove the wire from Terminal A on the *ESD* and connect the wire to Terminal F on the *ESD*. Adjust A1 G and A2 G for 1 Volt output at Terminal 16 and Terminal 18. Reconnect the wire back to Terminal A on the *ESD.*

TABLE 7:

LED	FUNCTION
ACT 1	Actuator drive circuit 1 is receiving a drive signal from the control.
ACT 2	Actuator drive circuit 2 is receiving a drive signal from the control.
TC 1 FAULT	Thermocouple 1 has a fault or open circuit.
TC 2 FAULT	Thermocouple 2 has a fault or open circuit.
EXHAUST TEMP 1	Unbalances in exhaust temperatures; control is actively trimming fuel to actuator 1 to rebalance the system.
EXHAUST TEMP 2	Unbalances in exhaust temperatures; control is actively trimming fuel to actuator 2 to rebalance the system.
GOV DRIVE	Drive signal from external governor is being removed to open up the throttle.

EXHAUST TEMP DIFFERENCE MONITORING AND CONTROL

The DDM101 requires the use of exhaust temperature thermocouples to balance the load precisely with the dynamic balancing function.

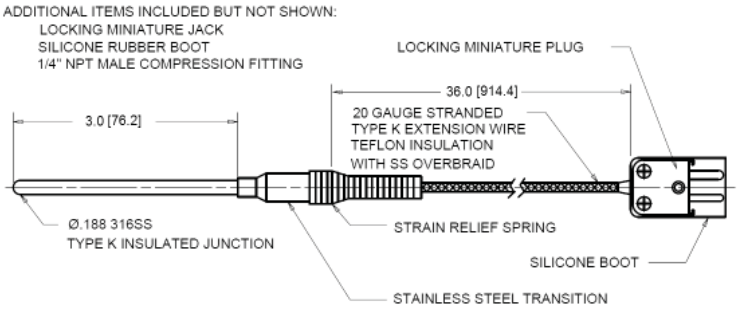
CAUTION Placement of thermocouples in the exhaust gas stream does not guarantee that equal measurements provide equal power from each bank. Exhaust temperature is, however, a good indication of balance and the exhaust temperature control loop will actively trim the system.

With the installation of two industrial rated Type K type thermocouples in the exhaust pipe of each bank, the DDM101 can measure and track two exhaust temperatures. The thermocouple adjustments (THERMOCOUPLE 1 & THERMOCOUPLE 2) are calibrated at the factory to receive equal input signals from the thermocouples. If a difference in either bank's exhaust temperature is measured by the DDM101, the control loop will readjust the fuel balance automatically to minimize the difference. If a measured difference is still found, the operator can manually reduce the unbalance and increase the temp control loop authority by a CW rotation of the TEMP. BAL GAIN adjustment.

If at any time, one or both of the thermocouples signals are lost (open circuit detected) the TC 1 or TC 2 fault LED will light and the balancing function will shut off. (see TABLE 7)

WARNING Do not alter the factory settings of THERMOCOUPLE 1 or THERMOCOUPLE 2 adjustments unless a significant unbalance exists. If a balance does occur, first try to correct the issue using the standard mechanical and electronic balancing methods described above. If a problem persists, determine which exhaust channel is higher in temperature and adjust the bank's THERMOCOUPLE adjustment CCW to equalize the exhaust temperature. Adjusting the cooler banks THERMOCOUPLE adjustment CW will equalize the exhaust temperature as well.

Exhaust Gas Temperature Sensors, part number STE101: Type K Thermocouple with 1200°F (650°C) Maximum. Mating Connector Included.



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.