JOHN DEERE
ENGINE APPLICATION MANUAL

30-5A
ELECTRONIC ENGINE CONTROLS
(ROBERT BOSCH)

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1 - INTRODUCTION

The electronically controlled inline injection system utilizes the same hydraulic pumping mechanism used in current mechanically governed inline pumps. The mechanical governor mechanism is replaced with an actuator which includes a solenoid to move the control rack, a rack position sensor, a speed sensor and a toothed speed wheel. The throttle lever mechanism used on mechanical pumps is removed and its function is implemented by a throttle position sensor input to the Engine Controller.

The Engine Controller controls fuel delivery as a function of engine speed and percent throttle. It also controls the fuel limits for torque curves and the governing for speed regulation. Aneroids are eliminated since for most applications the Engine Controller can control fuel delivery to limit smoke without using additional sensors.

The basic electronically controlled injection system is illustrated in Figure 4 and consists of the following:

- Engine Controller
- Injection Pump
- Injection Pump Rack Actuator With Speed Sensor
- Fuel Shutoff Valve (Pump Mounted)
- Application Dependent Inputs And Outputs
- Engine and Application Wiring Harnesses

The injection pump actuator and fuel inlet assembly consists of the following:

- Actuator Assembly
  - Rack Actuator Solenoid
  - Rack Position Sensor
  - Engine Speed Sensor
  - Housing
- Injection Pump Fuel Inlet Assembly
  - Fuel Shutoff Valve
  - Fuel Temperature Sensor
  - Housing

2 - ELECTRONIC CONTROL APPLICATION FEATURES

2.1 Maximum Fuel Control

The Engine Controller is programmed to limit the maximum fuel delivery as a function of engine speed. These programmed values can be modified during development to obtain nearly any desired torque curve shape within the pump and engine capabilities.

An additional option allows the maximum fuel curve to be switched to any one of three programmed curves without reprogramming. This latter feature is implemented via a

2.1 Maximum Fuel Control (cont'd)

3-state fuel limit switch input. Typically, the normal torque curve is selected by switch position 1. A de-rated torque curve is usually programmed for selection via switch position 2. The third torque curve is typically used for power boosting since operation on this curve can be limited by timers in the controller. This power boost mode is selected by switch position 3. If only one torque curve is required, all three options can be programmed the same.

See Section 9.1 for torque curve selection wiring details.

2.2 Governing

The control system can provide either all-speed governing or min-max governing. The percent speed regulation (droop) can be programmed to provide any desired droop, including zero (isochronous). Isochronous governing at the programmed low idle speed is provided independent of the speed regulation selected for governing over the rest of the operating range. The speed regulation and fast idle speed can also be switched to any one of three programmed values without reprogramming. Governor parameters can be modified to optimize response and stability for each application.

See Section 9.2 for end speed regulation selection wiring details.

2.3 Starting Control

The controller utilizes initial fuel temperature and engine speed to control the rack position during the start mode. This permits use of excess fuel and retarding for cold starting and less fuel and no retard for hot starts. Thus, cold starting is improved and black smoke can be greatly reduced on hot starts. The throttle position is ignored by the controller until the starting routine is exited. An optional feature allows an increased low idle speed to be programmed for a preset time after a cold start.

The start routine is entered when valid engine speed is detected or when the controller receives a start signal. The start signal indicates that power is being supplied to the starting motor to start the engine.

See Section 9.3 for start signal wiring details.

2.4 Throttle Options

There are three throttle options available for use with the electronic control system. These are:

1) An analog throttle which uses a potentiometer and is most commonly used with either all-speed or min-max governing.

2) A 3-state throttle which utilizes a simple switching arrangement to select one of three programmed engine speeds. This is used with all-speed governing when a maximum of three fixed speeds are desired. Typical applications are gen sets where only one fixed speed is desired or combines where a hydrostatic drive is used and only two or three speeds are needed. Air compressors are another example.

2.4 Throttle Options (cont'd)

3) A pulse-width-modulated (PWM) throttle which can be used alone or in conjunction with the analog throttle. It utilizes a pulse width to indicate the desired percent of full throttle. This signal can be provided by a special throttle module or by another control unit such as a transmission controller.

See Section 9.4 for throttle option wiring details.

2.5 Fuel Flow/Throttle Output

The engine controller provides a multiplexed pulse-width-modulated signal output which indicates the percentage of full load rated speed fuel flow and percentage of full throttle. This signal is primarily intended for use by a transmission controller but is also useful for monitoring performance.

See Section 3.3 for fuel flow/throttle output signal specifications.

2.6 Fuel Temperature Compensation

The controller monitors the injection pump inlet fuel temperature and is programmed to provide nearly constant mass fuel flow to the engine over any desired temperature range. This feature maintains consistent engine performance even though fuel temperature may vary due to environment.

2.7 Self-diagnostic and Back-up Features

The controller is programmed to self-diagnose many fuel injection system faults. This includes determining if any of the sensor inputs are too high or too low, if the engine speed signals are valid, and if the control rack is responding properly. In most cases, the controller will output a diagnostic code to indicate the specific condition which has been diagnosed and also flash a fault lamp. The controller will automatically revert to a default mode of operation as a back-up whenever possible or will shut down if control cannot be maintained.

See Section 3.1 for Fault Lamp wiring schematic and Section 3.2 for Diagnostic Code Output signal specifications.

2.8 Buffered Tach Drive Output

The controller provides a buffered output of the magnetic speed sensor. This signal can be monitored by several other systems in the installation without degrading the signal.

See Section 9.5 for wiring details and signal specifications.

2.9 Programmability

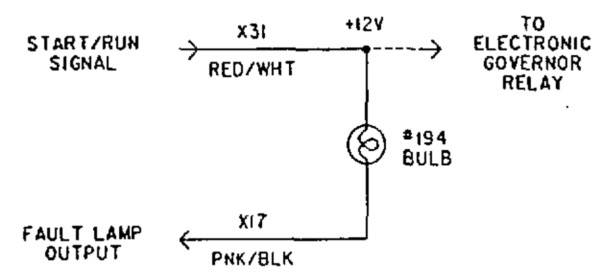
The Engine Controller has the unique capability of being programmed to operate differently for different applications. This feature allows a high degree of flexibility for adapting to specific application requirements.

3 - DIAGNOSTIC FEATURES

3.1 Fault Lamp

Figure 1 shows the wiring for the Fault Lamp. +12 volts must be supplied from switched battery power.

The Fault Lamp will normally flash at a rate of once per second. The Engine Controller output will sink current to ground through the lamp and is short circuit protected. Certain fault conditions will cause the lamp to be ON steady (not flashing) See TM1299. The lamp will be steady on at power on until either a start signal or engine starting speed signal is provided the Engine Controller.



FAULT LAMP WIRING

FIGURE 1

3.2 Diagnostic Codes Output Signal

Diagnostic codes are transmitted on the Diagnostic Code Output signal from the Engine Controller. This interface signal provides an eight-bit numeric value for use by a diagnostic reader such as a machine's digital tachometer or the Electronic Governor Tester service tool (JT05829). Each code represents a specific fault condition which could be caused by one or more problems.

If only one fault condition is present, its code is transmitted once per second, and the reader will display it continuously. If multiple conditions are present, the codes are transmitted one after another, one per second, until all have been transmitted after which the sequence is continuously repeated. A diagnostic code is transmitted only as long as the fault condition exits.

The Engine Controller has the capability to retain (for recall at a later time) the diagnostic codes that have occurred. The retained codes are saved even through power down conditions. This feature allows a service person to check to see if a diagnostic code has occurred in the past even though it is not presently occurring. This is helpful for troubleshooting intermittent failure conditions. When service work has been done which has repaired a problem for which a diagnostic code was stored, the code(s) may be cleared from the controller's memory.

The specifications for the signal output are as follows:

Transmissions shall begin with a logic "1" start bit followed by the LSB and shall end with the MSB. Format is NRZ (non return to zero). Transmission period is 1.0 $\pm$ 0.1 sec. Only a start bit is required if no faults are detected (code zero).

3.2 Diagnostic Codes Output Signal (cont'd)

Output requirements for diagnostic codes:

V(ol) $\leq$ 0.8 V at |I(ol)| $\leq$ 0.5 mA
V(oh) $\leq$ 4.2 V at |I(oh)| $\leq$ 0.5mA

tr $\leq$ 500 μsec
tf $\leq$ 500 μsec

Absolute max voltage levels:
V(ol): 0 Vdc min.
V(oh): 5.7 Vdc max.

where:
V(ol) = low level output voltage (logic "0").
V(oh) = high level output voltage (logic "1").
I(ol) = low level output current (sink).
I(oh) = high level output current (source).

tr = rise time measured between V(ol) and V(oh) with load consisting of 10k ohms and 2500 pF connected to ground.
tf = fall time measured between V(oh) and V(ol) with load consisting of 10k ohms and 2500 pF connected to + 5V.

Bit length: 50.0 $\pm$5 msec

Timing tolerance (beginning of start bit to end of each data bit): $\pm$5.0 msec

A timing diagram for this signal is shown in Figure 2 below with code 130 as an example.

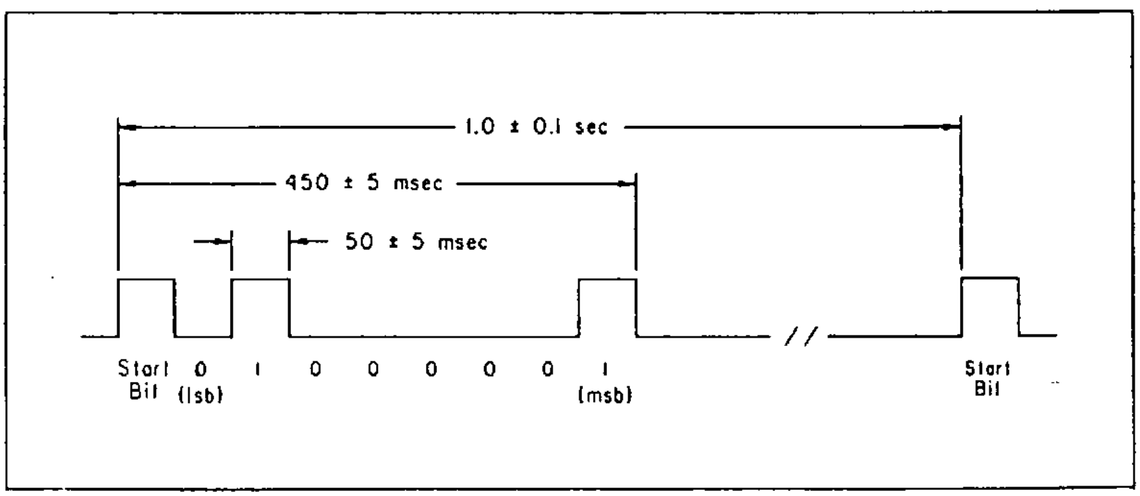


Figure 2 - Diagnostic Output Signal Timing

3.3 Fuel Flow/Throttle Output Signal

This signal is readable only by an electronic device designed to read it, such as the Electronic Governor Tester. Because of the complexity of the signal, a multimeter will not provide any useful information.

The range of percent Fuel Flow is zero percent to 159 percent. During starting, values will normally be greater than 100 percent. During normal operation, values greater than 100 percent indicate that the engine is torque limited.

Zero percent Throttle indicates slow idle, and 100 percent indicates fast idle.

This signal is only accessible in the RE30697 wiring harness at the Diagnostic Reader connector J4 (See Figure 4). It is used by the Electronic Governor Tester (JT05829) for the display of "% Throttle" and "% Fuel." This signal can be monitored during application approval tests to establish engine load factor.

The Fuel/Throttle (FF/T) signal is a dedicated, time multiplexed signal which contains fuel flow delivery and commanded throttle information. The signal contains three pulse types: synchronization; fuel flow; and throttle.

The multiplex waveform shall have a period of 20 msec ±.512 msec noncumulative. The waveform is synchronized by the synchronization (sync) pulse which shall be transmitted once each 20 msec cycle. There shall be one sync pulse, one throttle pulse and two fuel flow pulses each 20 msec cycle. The timing for the FF/T signal is defined in Figure 3 below.

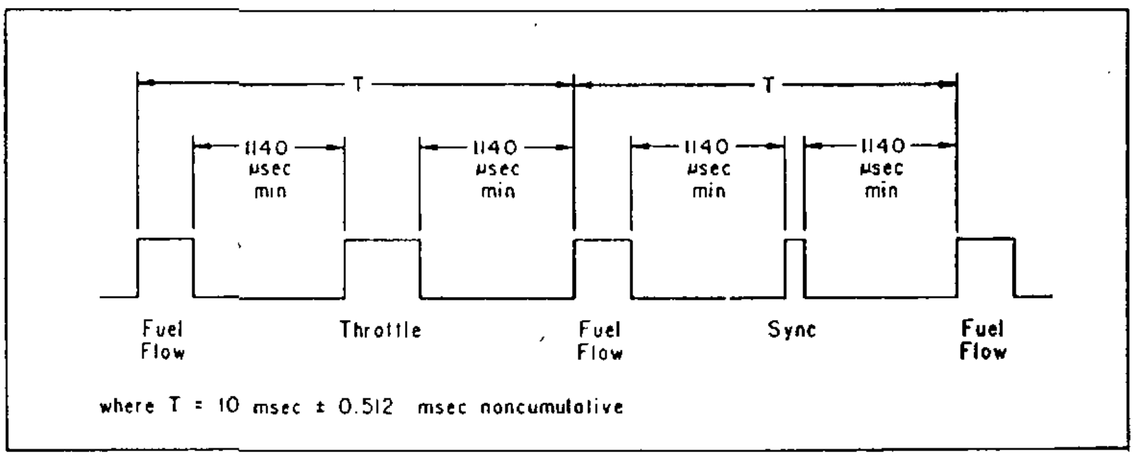


Figure 3 FF/T Signal Timing

3.3 Fuel Flow/Throttle Output Signal (cont'd)

Each pulse is defined as the time duration of the signal at the 50% points of the rising and falling edges. The signal levels are defined as follows:

$V(ol) \leq 0.8$ V at $|I(ol)| \leq 1.0$mA
$V(oh) \geq 4.2$ V at $|I(oh)| \leq 1.0$mA

$tr \leq 10$ μsec
$tf \leq 10$ μsec

Absolute max voltage levels:
V(ol): 0 Vdc min.
V(oh): 5.7 Vdc max.

where:
V(ol) = low level output voltage (logic "0").
V(oh) = high level output voltage (logic "1").
I(ol) = low level output current.
I(oh) = high level output current.

tr = risetime measured between V(ol) and V(oh) with load consisting of 10k ohms and 4500 pF connected to ground.
tf = fall time measured between V(oh) and (V(ol) with load consisting of 10k ohms and 4500 pF connected to +5V.

3.3.1 Sync Pulse - The sync pulse shall have a width of 128 ± 6 μsec. This pulse shall begin at least 1140 μsec after the training edge of the second fuel flow pulse as shown in Figure 3.

3.3.2 Fuel Flow Pulse - The fuel flow pulse shall represent percent of rated flow in pulse-width-modulated form. Rated fuel flow is the temperature compensated fuel delivery at rated speed.

Fuel flow information shall be updated and transmitted every 10 msec in pulse-width-modulated form. This pulse shall begin at least 1140 μsec after the trailing edge of the throttle pulse and at least 1140 μsec after the trailing edge of the sync pulse and with 10 msec $\pm$.512 msec noncumulative between fuel flow pulses as shown in Figure 3. The fuel flow pulse shall be resolved into at least 256 discrete widths. The width of the pulse shall be a linear function of percent fuel flow as defined in Table 1 below.

Table 1
Fuel Flow Pulse Width Scaling

Fuel Quantity (%)	Pulse Width
0%	256 ± 6 μsec
Rated (normal torque curve)	2816 ± 6 μsec
0% $\leq$ %Qty $\leq$ 159.375% of Rated	256 + ((%Qty/100) x 2560) ± 6 μsec
159.375% of Rated	4336 ± 6 μsec

3.3 Fuel Flow/Throttle Output Signal (cont'd)

3.3.3 Throttle Pulse - The throttle pulse shall represent a percent of full throttle as determined by the selected throttle input, either the analog throttle or the three-state throttle. The throttle pulse shall always be transmitted, even if the PWM throttle input is being received by the ECU.

The throttle pulse shall be transmitted once every 20 msec cycle between the two fuel flow pulses and shall be separated from each fuel flow pulse by at least 1140 μsec as shown in Figure 3. The throttle pulse need only be updated every 40 msec.

The throttle pulse shall consist of at least 160 discrete widths. The width of the throttle pulse is defined in Table 2 below.

Table 2
Throttle Pulse Width Scaling

Throttle Command	Pulse Width
Fault (Low Idle)	256 ± 6 μsec
LIZF	2816 ± 6 μsec
LIZF ≤ N(c) ≤ FIZF	256 + ((N(c) - LIZF)/(FIZF - LIZF)) x 2544 ± 6 μsec
FIZF	2800 ± 6 μsec

where: N(c) = commanded engine speed (r/min)
LIZF = Low Idle Zero Fuel speed (r/min)
FIZF = Fast Idle Zero Fuel speed (r/min)

3.4 Electronic Governor Tester

The Electronic Governor Tester is a diagnostic reader which provides a readout of the diagnostic codes and can read the percent full throttle and rated fuel flow signals. The tester is not required for all tests, but is helpful in diagnosing faults or monitoring the system. For instance, if the Fault Lamp is flashing, the tester may be hooked up to read the diagnostic code or a digital readout meter can be installed in the vehicle control panel. The hand-held Electronic Governor Tester (JT05829) may be purchased from John Deere and is described in TM1299.

4 - CONTROLLER ENVIRONMENTAL RESTRICTIONS

Operating Temperature Range :	-40F to +150F
Storage Temperature Range :	-58 F to +212F
Operating Vibration Range :	30 m/sec2 max from 0-2500 hz
Moisture :	Protect engine controller from rain and pressure wash by mounting in cab or control cabinet. Do not immerse in water.

5 - MOUNTING REQUIREMENTS

The Engine Controller shall be mounted securely with the 4 corner mounting holes in a vertical plane with the connector on the side of the controller so that the wires which exit the mating connector are directed downward. This orientation provides maximum moisture resistance. The application wiring harness should be routed to provide access to the J3 and J4 diagnostic connectors (See Figure 4) for service diagnostic work. An operational test must be performed to verify vibrational amplitudes are acceptable.

The RE30711 Transient Voltage Protection module (or equivalent) should be mounted vertically with the pigtail wires exiting from the bottom of the module. The mounting location should be vehicle chassis, cab or control cabinet, away from battery fumes, engine heat and vibration. Mounting ears of the module may not withstand overtightening of mounting bolts.

6 - SUPPLY VOLTAGE REQUIREMENTS

Nominal Supply Voltage :	12 V
Operating Supply Voltage :	9 to 16 V
Starting Supply Voltage Range :	6 to 16 V
Max. Allowable Supply Voltage:	26.5 V for less than 5 min.
Current Capacity (including rack actuator coil and fuel shutoff valve):	17 A maximum 7 A nominal

External protection against transient voltages (such as alternator load dump) greater than 40 V and excessive current (greater than 20 A) must be provided. RE30711 provides this protection and is included with the John Deere application wiring harness (RE30697).

7 - MINIMUM USER APPLICATION INPUT

The John Deere Electronically Controlled Fuel Injection System interfaces with the end application wiring harness through the unterminated wires of the Electronic Control Application Harness. The unterminated wires are also used to select the factory programmed application features desired for the end application. The following application inputs/interfaces are minimum requirements for Electronic Control Fuel System operation:

- Throttle
- Start/Run signal - keyswitch on and start position
- *Diagnostic interface (fault lamp and/or diagnostic reader)*
- Power (12V)
- Ground
- Basic end application wiring harness (See Figure 6)
- Basic wiring hook-up (See Figures 4, 5, 6)
- Application feature wiring (See Figures 5 and 6 and Section 9)
- Analog throttle adjustment for Analog Throttle Applications (See Section 8.4)
- Installation checkout (See Section 8.5)

8 - WIRING HARNESSES

The Bosch electronic fuel injection system consists of two main harnesses: a short engine harness; and a long application harness.

Engine Harness:	Installed on engine at factory. Figure 4
Application Harness:	RE30697 (R.B..) Figures 4 and 5
Connectors:	Standard electrical connectors used in industrial applications such as crimp type ring terminals and screw terminals recommended
Diagnostic Ports:	Reference TM-1299 Technical Manual

IMPORTANT : Careful consideration should be given to the choice of wiring to minimize leadwire resistance and provide adequate input voltage especially during starting conditions. Low voltage starting capability is directly affected by the magnitude of the source voltage and the resistance of the governor system supply voltage circuit. See Table 3 for unterminated wire sizes and insulation colors.

8.1 Engine Harness

The engine harness will be the same for most applications, and comes pre-installed on the engine by the factory. This harness has two Packard Electric Weather Pack connectors at the rear of the engine and four connectors installed on the pump and Auxiliary Speed Sensor. The Weather Pack connectors mate with the application harness which includes the Engine Controller connector, the service connectors, and terminations to machine wiring.

NOTE: Because of the importance of maintaining a good connection at connector J12 *(7-pin pump connector), the engine harness should not be removed from the* pump except when required by diagnostic procedures in the technical manual for troubleshooting or pump replacement. Technical manual TM-1299 has specific instructions for assembly, torquing and the recommended tool for handling connector J12.

8.2 Application Harness

All application harnesses should have the basic features of the John Deere OEM harness (RE30697). The drawing for this harness defines the Engine Controller connector part number, the contacts for that connector, wire sizes, service connectors, and the connectors to mate with the engine harness. These items should be the same for all application harnesses because of the basic system configuration, current requirements, and diagnostic procedures. Drawings can be obtained from Sales Engineering for use by customers designing their own application harness.

An application would also include whatever wiring is required to hook up various options, sensors, power and ground. Refer to Section 9 Application Feature Wiring for details concerning optional feature wiring.

The following list describes the features of the OEM wiring harness. (See Figure 4):

1. J1 - 35-pin Engine Controller connector.
2. J3 - Diagnostic Voltages Connector. Used for troubleshooting and system checkout. Keep protected with cap when not in use. Water or dirt in this connector may cause erratic engine operation.
3. J4 - Diagnostic Reader Connector. Mates with Electronic Governor Tester (JT05829). See technical manual TM-1299 for instructions on using the Tester. Keep protected with cap when not in use.
4. J5, J6 - These connectors would be used by service personnel with factory authorization to service the Engine Controller. Keep protected with caps when not in use.
5. J7, J8 - These connectors mate with the engine harness which comes from the factory already installed on the engine. These connectors are for controlling the injection pump and for receiving signals from certain sensors on the pump and engine.
6. Transient Voltage Protection (TVP) Connector - This connector mates with the TVP Module. If the TVP Module is missing, or not working, the engine will not start.
7. Unterminated wires - This wiring is provided for electronic governor interface with customer machine wiring harness and for wiring application features. (See Figures 5 and 6 and Section 9.)

8.3 Installation of RE30697 Application Wiring Harness

Mount the Engine Controller according to Section 5 (Mounting Requirements) and Section 4 (Environmental Restrictions). Make sure the location is close enough to the engine so that the application harness will reach.

DO NOT connect J1 to the Engine Controller until the following initial checks are made:

Connect J8 with the mating connector on the engine harness located toward the rear of the engine. Make sure that the harness is routed and fixed into place to prevent accidental damage. DO NOT connect J7 until after installation checkout steps have been completed. (See Section 8.5.)

8.3 Installation of RE30697 Application Wiring Harness (cont'd)

Make sure the Transient Voltage Protection Module is mounted according to Section 5 (Mounting Requirements) and plugged into the harness.

Make sure that service connectors J3, J4, J5 and J6 are accessible for convenient servicing of the fuel injection system.

The unterminated wires of the harness may be cut as short as desired for convenient wiring to the machine electrical system. The wire covering protecting the unterminated wires may also be shortened if necessary to accommodate shortened wire length.

Determine the wiring required to implement your fuel injection system options (See Section 9) with the unterminated wires of the OEM harness. Cut and terminate the needed wires using Table 3 (Description of Unterminated Wires) and Figure 5 as a reference. Use the proper size solderless terminal for the wire size to ensure a reliable crimp. Tape the ends of the unneeded wires, but do not shorten until engine operation has been completely checked. If an analog throttle is used, adjust mounting and/or linkage per Section 8.4.

8.4 Analog Throttle Adjustment Procedure

Use the Diagnostic Voltages connector (J3) to access the throttle voltage signals during adjustment. Use a digital multimeter to measure the voltages, with the black (common) probe on the signal marked "(-)" and the red probe on the signal marked "(+)". Measurements are made as follows:

Analog Throttle +5V: Measure from J3 socket D(-) to J3 socket A(+).

Throttle Input voltage: Measure from J3 socket D(-) to J3 socket B(+).

NOTE: Wiring Harness (RE30697) Connector Sockets are labeled.

The Throttle Input voltage must be corrected for the variation of the Analog Throttle +5V value from exactly +5.00 volts. The calculation to do this requires a multiplication and a division:

$$\text{Corrected throttle voltage} = \frac{5 \times \text{Voltage measured at socket B}}{\text{Voltage measured at socket A}}$$

IMPORTANT: If the sensor and linkage being used do not allow for adjustment according to this procedure. contact the factory for assistance.

The adjustment procedure is as follows:

1. Locate Diagnostic Voltages Connector (J3) and remove dustcap.
2. Connect Electronic Governor Tester (service tool JT05829) to Diagnostic Reader Connector (J4).
3. Turn on ignition but do not start engine.
4. Measure and make note of voltage at socket A (Analog Throttle +5V).

8.5 Installation Checkout (cont'd)

Put Start/Run switch in the RUN position. Make sure there is battery voltage at the Diagnostic Reader service connector (J4), and also at J7 (4-way Weather Pack which connects to engine harness). At J4, measure from J4 socket F(-) to J4 socket A(+). At J7, measure from battery ground (-) to J7 pin A(+).

NOTE: Wiring Harness (RE30697) Connector Sockets are labeled.

Turn Start/Run control to OFF. Connect J7 to engine harness.

Connect J1 to the Engine Controller by first inserting the toe of the harness connector into the keyed locking lip on the ECU housing with the harness connector at a 30 degree angle from the controller connector.

NOTE: Do not force the connector if interference is felt.

Pivot the wire end of the harness connector toward the controller until the spring latch on the controller locks the connector into place.

If machine uses the Fault Lamp, make sure lamp comes on during the following step:

Turn Start/Run control to RUN or ON without cranking the engine. Leave ON for the following steps.

Make sure there is +5 volts at the Diagnostic Voltages Connector (J3). Measure from J3 socket D(-) to J3 socket A(+).

Make sure the rack position feedback circuit is operational. Measure from J3 socket (D(-) to J3 socket C(+). The measured voltage should be 0.4 - 0.6 volts.

Make sure the throttle input voltage is correct. Measure from J3 socket D(-) to J3 socket B(+).

For systems with 3-state throttle (including engine option 1650):
- Speed 1 - approx. +5 volts
- Speed 2 - approx. 0 volts
- Speed 3 - approx. +2.5 volts

For systems with analog throttle:
- Slow Idle setting - approx. +0.4 volts
- Fast Idle setting - approx. +4.6 volts

Make sure all connectors (except service connectors) are properly connected and locked in place.

Clear any stored diagnostic codes by using the Electronic Governor Tester or by shorting J4 sockets B and C to J4 socket F (Power Ground) for at least two seconds (power should still be on).

Turn Start/Run control to OFF.

Make sure all caps are now in place on service connectors.

8.4 Analog Throttle Adjustment Procedure (cont'd)

5. Measure and make note of voltage at socket B (Analog Input voltage).
6. Adjust to obtain the following end point voltages:

   NOTE: If the throttle sensor mounting screws are used to provide end-of-range adjustment for either the slow idle or the high idle position, then this adjustment *should be made first.*

   Slow idle: Corrected throttle voltage = 0.4 ±0.05 volts

   Fast idle: Corrected throttle voltage = 4.6 ±0.05 volts
7. Move lever from end stop to end stop noting the voltages at each end and verify that they are within the above adjustment. If not, repeat step 6.
8. Additional checks can be made with the Electronic Governor Tester. If the sensor and linkage are adjusted properly, %Throttle should be 0 and Diagnostic Code 12 should not appear at the slow idle position. At the fast idle position, %Throttle should be 100 and Diagnostic code 11 should not appear.
9. Put Tester into the Display Codes mode. Read and make note of the stored codes by pressing the Recall Codes key on the Electronic Governor Tester. (The stored codes may indicate other problems which the Engine Controller detected during installation. This is not unusual if power is applied to the controller before installation is complete.)
10. Clear the stored codes by pressing both the Recall Codes and Clear Codes keys at the same time until zero appears (one or two seconds).

8.5 Installation Checkout

The following steps may be used to perform some checks to make sure the wiring is correct before an engine start is attempted:

Before the harness is connected to the Engine Controller (Connector J1), some simple voltage and resistance measurements can be made to check the wiring. A digital multimeter is recommended for these checks. Make sure the meter is set for voltage or resistance measurement as required. For voltage measurements, use the black (common) probe on the signal marked "(-)" and the red probe on the signal marked "(+)".

With the wiring complete and the Engine Controller NOT connected, make the following checks:

> **NOTE:** See Table 3 and Figure 5 for application harness unterminated wire details.

Make sure there is battery voltage where the harness is wired into the machine electrical system. Measure from Power Ground(-) to +12V Input (+).

> **CAUTION:** Avoid possible injury. Wear tight fitting clothing. Keep clear of moving parts and hot surfaces while making adjustments or taking measurements.

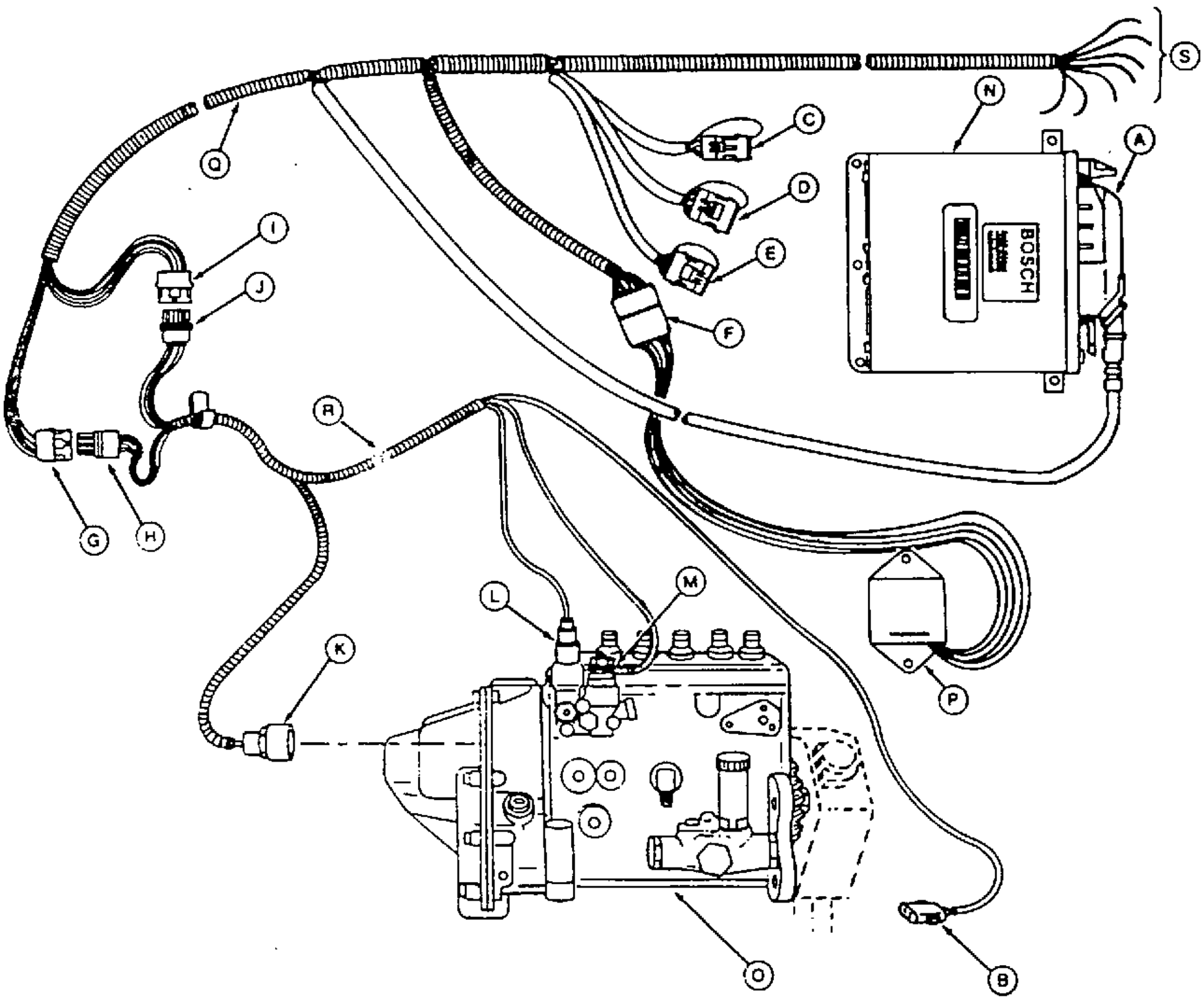
Make sure there is battery voltage (greater than 7 volts during cranking) at the START/RUN signal where the harness is wired into the machine electrical system when the control is in the START and RUN positions. The engine should crank but not start because the Engine Controller is disconnected. Measure from Power Ground(-) to Start/Run(+).

8.5 Installation Checkout (cont'd)

The electrical portion of the fuel injection system should now be operational. If diagnostic codes are present or if the Fault Lamp flashes after an engine start is made or attempted, refer to technical manual TM-1299 for further information and troubleshooting procedures.

After engine checkout is complete, unterminated and unused wires in the OEM harness may be shortened (be sure to tape ends) as desired.

- Figure 4 -
Robert Bosch Electronic Fuel Injection System
Components and Wiring Harnesses



A—J1 Engine Controller Connector
B—J2 Auxiliary Speed Sensor Connector
C—J3 Diagnostic Voltages Connector
D—J4 Diagnostic Reader Connector
E—J5 Service Connector
F—TVP Connector
G—J7 In-Line Connector
H—J8 In-Line Connector
I—J9 In-Line Connector
J—J10 In-Line Connector
K—J12 Actuator Connector
L—J13 Fuel Temperature Sensor Connector
M—J11 Fuel Shutoff Solenoid
N—Engine Controller
O—Fuel Injection Pump
P—TVP Module
Q—Application Wiring Harness
R—Engine Wiring Harness
S—Unterminated Wires

NOTE: Connectors J2, J8, J10, J11, J12, J13 are located on the Engine Wiring Harness (R) (short harness). Connectors J1, J3, J4, J5, J7, J9, are located on the Application Wiring Harness (Q) (long harness). On some applications, J6 (not illustrated) is also located on the same pigtail as the J3, J4, and J5 connectors. J6 is a service connector only.

Table 3

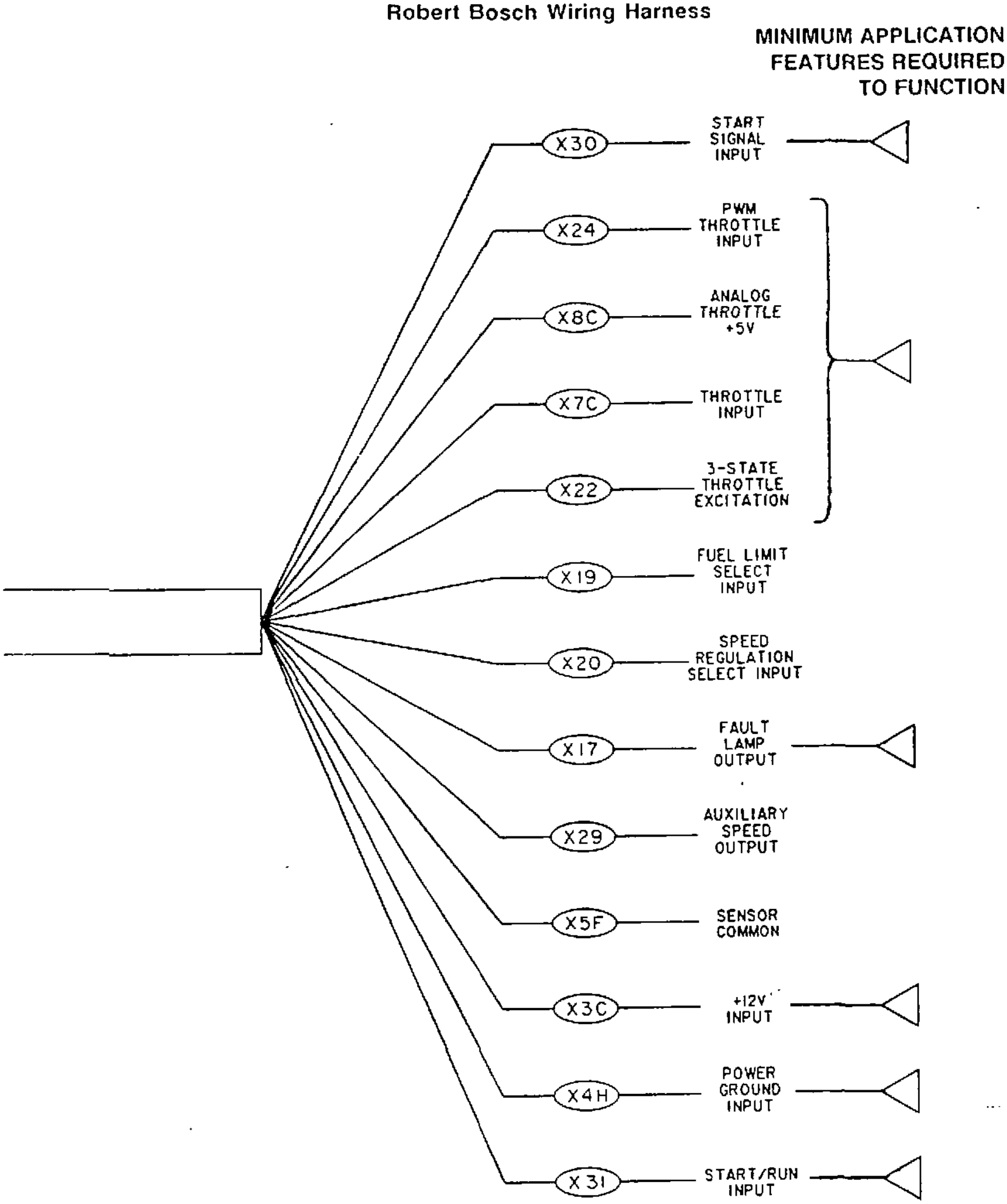
DESCRIPTION OF UNTERMINATED WIRES (Robert Bosch Harness).

The unterminated wires of the RE30697 wiring harness can be cut to a length appropriate for the application. Terminations should be made using crimped solderless terminals which are proper for the wire size and termination style (for example, screw terminals).

CKT. NO.	WIRE COLOR	GAUGE*	SIGNAL NAME/DESCRIPTION
X3C	RED	12	+12V Input - Provides power to the Engine Controller directly from battery. This line is switched on and off in the Transient Voltage Protection (TVP) Module using the Start/Run signal.
X4H	BLACK	12	Power Ground Input - High current ground connection to the Engine Controller from Battery (-).
X5F	PUR/BLK	16	Sensor Common - Used to provide a reference voltage for sensors and for voltage measurements. (Must not be connected to machine ground.)
X7C	WHITE	18	Throttle Input - 0 to 5 volt analog voltage input used by an analog throttle sensor or a 3-state throttle input for throttle command.
X8C	BROWN	18	Analog Throttle +5V - Supply voltage for an analog throttle sensor (potentiometer type).
X17	PNK/BLK	18	Fault Lamp Output - Drives low side of indicator lamp during system fault condition.
X19	LT BLUE	18	Fuel Limit Select Input - 3-state input which selects between three optional torque curves.
X20	ORG/BLK	18	Speed Regulation Select Input - 3-state input which selects between three optional end speed regulation curves.
X22	LT GREEN	18	3-State Throttle Excitation - Output which supplies +5 volts through a 2000 ohm resistor (located inside the Engine Controller) for 3-state throttle applications.
X24	ORG/WHT	18	PMW Throttle Input - Optional throttle command which has a priority over Throttle Input signal when present.
X29	YEL/WHT	18	Auxiliary Speed Output - Provides buffered output of the Auxiliary Speed input for use by tachometers.
X30	BRN/WHT	16	Start Signal Input - A high voltage (greater than 3 volts) which indicates that an engine start is being attempted (starter motor running). Usually comes from keyswitch or other engine start control. Connected to Battery (+) voltage when on.
X31	RED/WHT	16	Start/Run - Battery (+) voltage from keyswitch or other engine control when desired operation is starting or running. This signal turns on relay in TVP Module to supply electrical power to the electronic governor system.

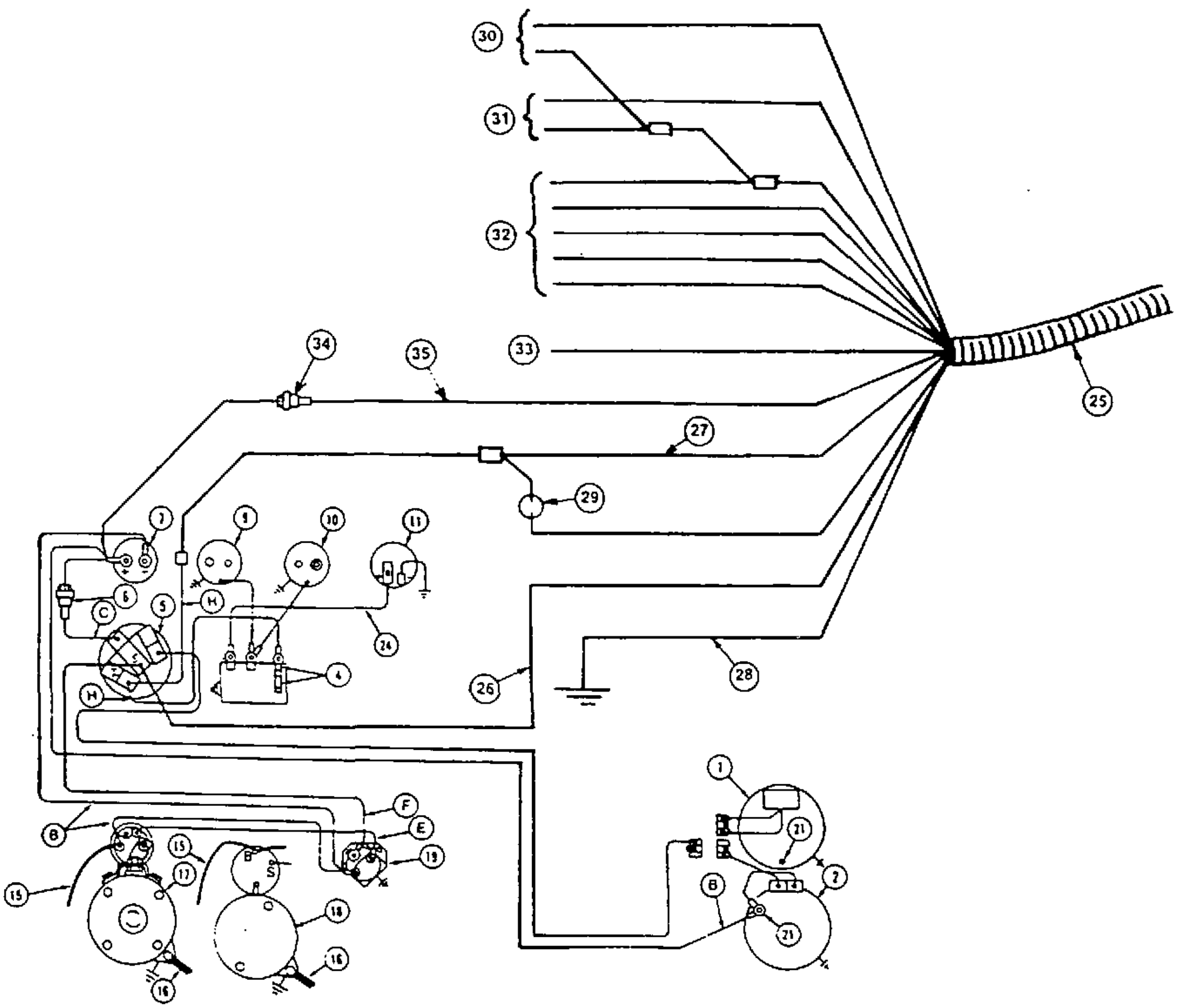
*See Table 6 on page 30 for metric wire size equivalents for AWG wire gauge.

- Figure 5 -
RE30697
Robert Bosch Wiring Harness



UNTERMINATED WIRES

- Figure 6 -
WIRING DIAGRAM - 12 VOLT ROBERT BOSCH SYSTEM



1-Motorola Alternator
2-Delco-Remy Alternator
3-
4-Safety Switch with SFE 14-AMP Fuse
5-Key Switch
6-Fuseholder with MDL 25-Amp Fuse
7-Ammeter
8-
9-Oil Pressure Gauge
10-Water Temperature Gauge
11-Hour Meter
12-
13-
14-
15-Positive Battery Cable
16-Negative Battery Cable
17-Delco-Remy Starting Motor
18-John Deere Starting Motor
19-Starter Circuit Relay
20-Magnetic Speed Sensor
21-Output Terminal
22-
23-
24-
25-RE30697 Application Wiring Harness
26-Controller Start Signal
27-Controller Start/Run Signal
28-Controller Power Ground
29-Fault Lamp
30-Torque Curve Select Wires*
31-Rated Speed/Droop Select Wires*
32-Throttle Option Wires*
33-Controller Tach Drive Output*
34-Fuseholder with MDL 20-Amp Fuse
35-Controller +12V Power

A-
B-8 Gauge-Red or Brown **
C-12 Gauge-Red or Brown
D-
E-10 Gauge-White
F-14 Gauge-White
G-
H-16 Gauge-Purple
I-
J-

* See Section 9 for wiring details
** NOTE Brown wiring leads not used at starter circuit relay (Key 19).

9 - APPLICATION FEATURE WIRING

9.1 Maximum Fuel Control

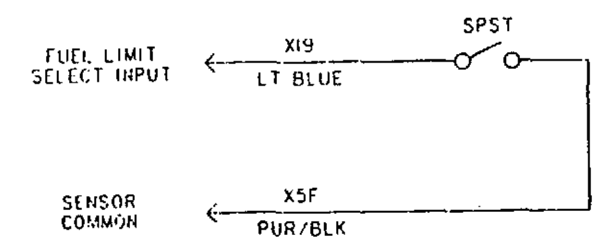
The wiring required for each of the three torque curves is defined as follows:

Torque Curve 1:	Fuel Limit Select Input is open Circuit.
Torque Curve 2:	Fuel Limit Select Input is shorted to Sensor Common.
Torque Curve 3:	Fuel Limit Select Input is connected to Sensor Common through a 2000 ohm ±10% resistor (at least 1/4 watt rating).

If only one torque curve is desired, no switch is required. To obtain the desired torque curve, the *Fuel Limit Select Input must be wired for Torque Curve* 1, 2 or 3 as described above.

If more than one torque curve are desired, two or three of the programmed torque curves can be obtained by using a simple switching arrangement. (The engine option for Group 1600 defines what torque curves are available for a specific engine application.) Figures 7, 8 or 9 show different methods of obtaining more than one torque curve.

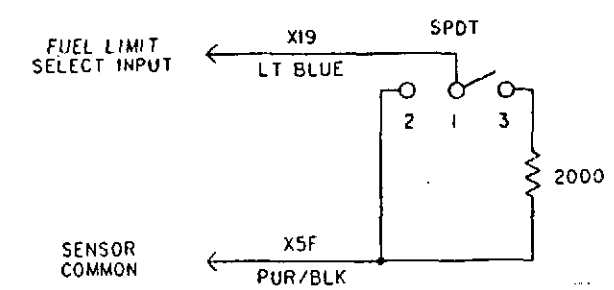
Figure 7 shows a Single Pole, Single Throw (SPST) switch used to select either Torque Curve 1 or Torque Curve 2. When the switch is open, Torque Curve 1 is selected. When the switch is closed, Torque Curve 2 is selected.



FUEL LIMIT SELECT WIRING
FOR 2 TORQUE CURVES

FIGURE 7

Figure 8 is a method for obtaining each of the three torque curves by using one Single Pole, Double Throw switch with the center position open circuit (SPDT, Center off). When the switch is in the center position, the *signal is disconnected and* Torque Curve 1 is selected. When the switch is thrown to the left, the signal is shorted to Sensor Common and Torque Curve 2 selected. Torque Curve 3 is selected when the switch is thrown to the resistor side.

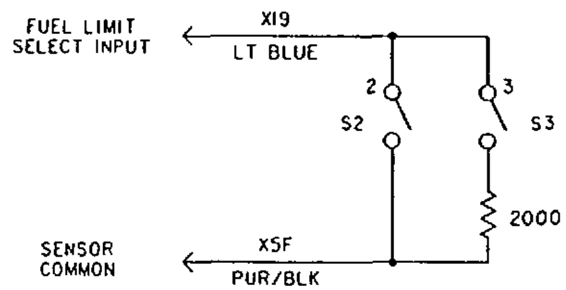


FUEL LIMIT SELECT WIRING
FOR 3 TORQUE CURVES
USING ONE SWITCH

FIGURE 8

9.1 Maximum Fuel Control (cont'd)

Figure 9 shows another method of obtaining each of the three torque curves. This method uses two switches instead of one. In this configuration both switches have to be OFF to select Torque Curve 1. Turn on only Switch S3 to select Torque Curve 3. If Switch S2 is ON, Torque Curve 2 will be selected regardless of the state of Switch S3.



FUEL LIMIT SELECT WIRING
FOR 3 TORQUE CURVES
USING TWO SWITCHES

FIGURE 9

9.2 Governing

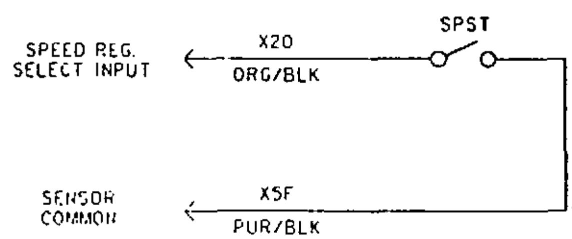
The speed regulation and fast idle speed can be switched to any one of the three pre-programmed values while the engine is stopped OR while the engine is running. The wiring required for each of the three speed regulation combinations is defined as follows:

Droop 1: Speed Regulation Select Input is open Circuit.
Droop 2: Speed Regulation Select Input is shorted to Sensor Common.
Droop 3: Speed Regulation Select Input is connected to Sensor Common through a 2000 ohm $\pm 10\%$ resistor (at least 1/4 watt rating).

If only one Fast Idle/Rated Speed combination (droop) is desired, no switch is required. To obtain the desired droop, the Speed Regulation Select Input must be wired for Droop 1, 2 or 3 as described above.

If more than one droop is desired, two or three of the programmed droops can be obtained by using the same switching arrangement as for the Fuel Limit Select Input. (The engine option for Group 1600 defines what speed regulation values are available for a specific application.) Figures 10, 11 and 12 show different methods of selecting a different droop option.

Figure 10 shows a Single Pole, Single Throw (SPST) switch used to select either Droop option 1 or Droop option 2. When the switch is open, Droop 1 is selected. When the switch is closed, Droop 2 is selected.

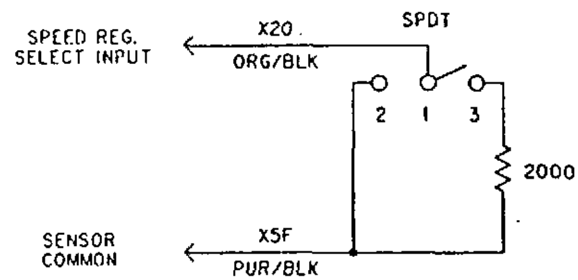


SPEED REGULATION SELECT WIRING
FOR 2 FAST IDLE/RATED SPEED OPTIONS

FIGURE 10

9.2 Governing (cont'd)

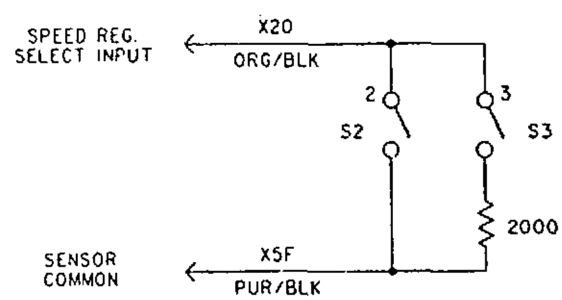
Figure 11 is a method for obtaining each of the three droop options by using one Single Pole, Double Throw switch with the center position open circuit (SPDT, Center Off). When the switch is in the center position, the signal is disconnected and Droop 1 is selected. When the switch is thrown to the left side, the signal is shorted to Sensor Common and Droop 2 is selected. Droop 3 is selected when the switch is thrown to the resistor side.



SPEED REGULATION SELECT WIRING
FOR 3 FAST IDLE/RATED SPEED OPTIONS
USING ONE SWITCH

FIGURE 11

Figure 12 shows another method of selecting each of the three droop options. This method uses two switches instead of one. In this configuration both switches have to be OFF to select Droop 1. Turn on only Switch S3 to select Droop 3. If Switch S2 is ON, Droop 2 will be selected regardless of the state of Switch S3.

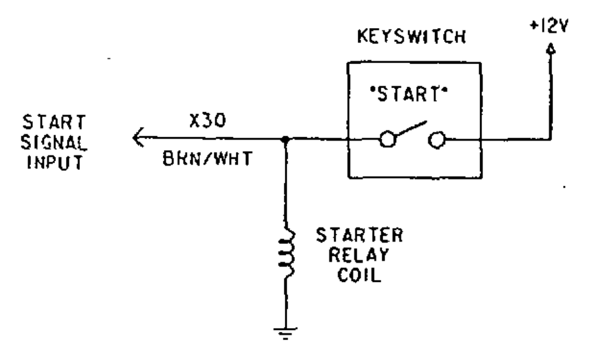


SPEED REGULATION SELECT WIRING
FOR 3 FAST IDLE/RATED SPEED OPTIONS
USING TWO SWITCHES

FIGURE 12

9.3 Starting Control

The Start Signal comes from a keyswitch or remote engine starting controls. This signal is used to energize the starter relay and is also used to tell the Engine Controller that an engine start is being attempted. The controller will position the control rack to the starting fuel position when the Start Signal goes from a low to a high voltage. Figure 13 is a schematic showing the relationship between the Start Signal, the starter relay and the keyswitch.



START SIGNAL WIRING

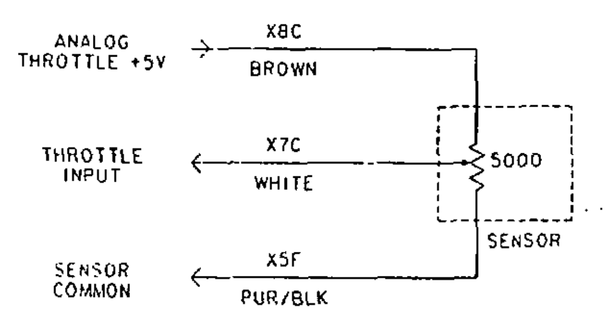
FIGURE 13

9.4 Throttle Options

9.4.1 Analog Throttle - The sensor should be a potentiometer with an end-to-end value of 5000 ohms +/-1000 ohms. If the sensor is spring loaded to one end, the "at rest" position of the sensor should give an output voltage that is close to 0 volts and not close to 5 volts. In order for the analog throttle to correctly command the total desired range of slow idle to fast idle speeds, the throttle sensor must be properly adjusted (refer to Section 8.4 for throttle adjustment procedure). If the sensor is not adjusted correctly, the following problems are possible:

- Diagnostic Code 11 generated because throttle signal goes too high. (This results in slow idle being commanded.)
- Diagnostic Code 12 generated because throttle signal goes too low.
- Slow idle speed too high.
- Fast idle speed too low.

Figure 14 shows the analog throttle configuration. A higher sensor output voltage will command a higher engine speed.



ANALOG THROTTLE WIRING

FIGURE 14

9.4.2 3-State Throttle - The 3-state throttle is used with all-speed governing and when a maximum of three fixed speeds are desired. Typical applications are gen sets where only one fixed speed is desired or combines where a hydrostatic drive is used and only two or three engine speeds are needed. Air compressors are another example.

NOTE: Gen set option 1650 requires the user to select one of three rated speeds (1800, 1500 or 2000 rpm).

The wiring required for each of the three fixed engine speeds is defined as follows:

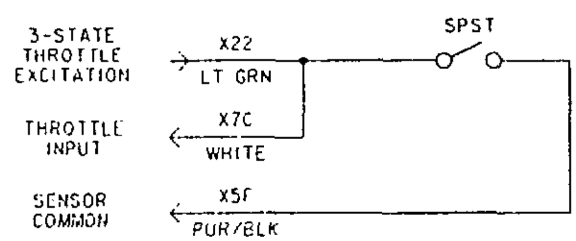
IMPORTANT: In ALL cases, the 3-State Throttle Excitation must be connected to the Throttle Input when using the 3-state throttle mode.

Speed 1: Open circuit (no additional wiring).
Speed 2: 3-State Throttle Excitation shorted to Sensor Common.
Speed 3: 3-State Throttle Excitation connected to Sensor Common through a 2000 ohm ±10% resistor (at least 1/4 watt rating).

If only one fixed speed is desired, no switch is required. To obtain the desired operating speed, the 3-State Throttle Excitation must be connected to the Throttle Input and then wired for Speed 1, Speed 2 or Speed 3 as described in the previous paragraph.

If more than one fixed speed are desired, two or three of the programmed speeds can be obtained by using a simple switching arrangement. (The engine option for Group 1600 defines what speeds are available for a specific engine option.) Figures 15, 16 and 17 show different methods of obtaining more than one engine speed with an Engine Controller factory-programmed for 3-state throttle operation.

Figure 15 shows an SPST (Single Pole, Single Throw) switch used to switch between Speed 1 and Speed 2. When the switch is open, Speed 1 is selected. When the switch is closed, Speed 2 is selected.

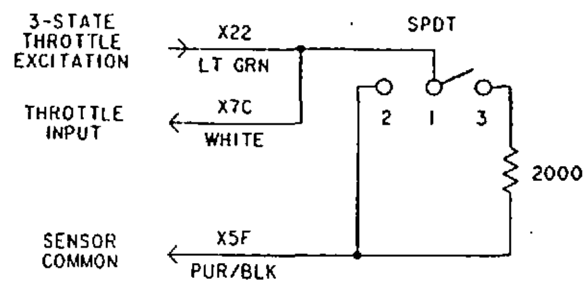


3-STATE THROTTLE WIRING FOR 2 SPEEDS

FIGURE 15

9.4.2 3-State Throttle (cont'd) -

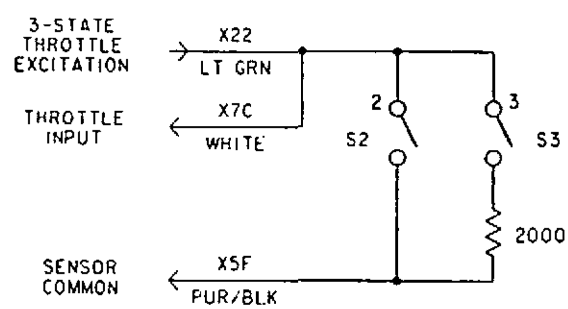
Figure 16 is a method for obtaining each of the three fixed speeds by using one Single Pole, Double Throw switch with the center position open circuit (SPDT, Center Off). When the switch is in the center position, the signal is disconnected and Speed 1 is selected. When the switch is thrown to the left side, the signal is shorted to Sensor Common and Speed 2 is selected. Speed 3 is selected when the switch is thrown to the resistor side.



3-STATE THROTTLE WIRING FOR 3 SPEEDS USING ONE SWITCH

FIGURE 16

Figure 17 shows another method of obtaining each of the three fixed speeds. This method uses two switches instead of one. In this configuration both switches have to be OFF to select Speed 1. Turn on only Switch S3 to select Speed 3. If Switch S2 is ON, Speed 2 will be selected regardless of the state of Switch S3.



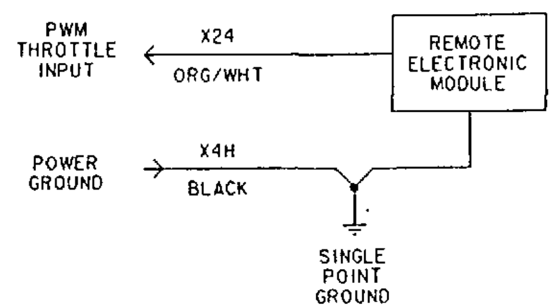
3-STATE THROTTLE WIRING FOR 3 SPEEDS USING TWO SWITCHES

FIGURE 17

9.4.3 PWM Throttle - The PWM Throttle uses a pulse width to indicate the desired percent of full throttle. This signal can be provided by a special throttle module or by another control unit such as a transmission controller. A PWM Throttle signal may be used in the same application with an analog throttle input, but not with a 3-state throttle. If the PWM Throttle signal is OFF or disconnected, the Engine Controller will use the analog throttle for the throttle command. If the PWM Throttle signal is turned ON, then the Engine Controller will automatically start using the PWM throttle signal for the throttle command instead of the analog throttle input. If the PWM Throttle signal is turned OFF again, the controller will switch back to using the analog throttle input.

Figure 18 shows that only one wire is required to hook-up Throttle signal.

NOTE: The module which generates the PWM Throttle signal must be grounded to Single Point Ground. Single Point Ground is the point where all electronic modules are grounded at one place near the battery to minimize ground offset voltages between modules.



PWM THROTTLE WIRING

FIGURE 18

The signal specification for the PWM Throttle Input is provided in Section 9.4.4.

9.4.4 Pulse-Width-Modulated Throttle Signal Specification - The pulse-width-modulated (PWM) throttle input shall represent percent of full throttle position as defined in Table 4 below. The signal shall be a pulse width having a resolution of at least 256 discrete widths. The period of the waveform shall be 10 msec $\pm 32\ \mu$ sec. The position of the pulse in any cycle may vary ± 1 msec, nonaccumulative, referenced to an absolute time frame. The pulse width shall be defined as the time duration of the signal between the 50% points of the rising and falling edges.

9.4.4 Pulse-Width-Modulated Throttle Signal Specification (cont'd) -

Table 4
PWM Throttle Scaling

Pulse Width (t)	Commanded Speed
256 +6 µsec/-20 µsec	N(c)=LIZF
256 + (N(c)-LIZF)/(FIZF-LIZF) x 4080 ±6 µsec	N(c)=LIZF + (FIZF-LIZF)x((t-256)/4080)
4336 +20 µsec/-6 µsec	N(c)=FIZF

where: N(c) = commanded engine speed (r/min)
LIZF = Low Idle Zero Fuel speed (r/min)
FIZF = Fast Idle Zero Fuel speed (r/min)
t = signal pulse width (µsec)

The PWM Throttle signal levels are specified as follows:

V(il) ≤ 1.5 V at |I(il)| ≤ 300 µA
V(ih) ≥ 3.5 V at |I(ih)| ≤ 300 µA

tr ≤ 10 µsec
tf ≤ 10 µsec

Absolute max voltages levels:
V(ol): 0 Vdc min.
V(oh): 5.7 Vdc max.

where:
V(il) = low level input voltage (logic "0").
V(ih) = high level input voltage (logic "1").
V(ol) = low level output voltage of signal source.
V(oh) = high level output voltage of signal source.
I(il) = low level input current.
I(ih) = high level input current.
tr = rise time measured between V(ol) and V(oh) with load consisting of 10k ohms and 4500 pF connected to ground.
tf = fall time measured between V(ol) and V(oh) with load consisting of 10k ohms and 4500 pF connected to +5V.

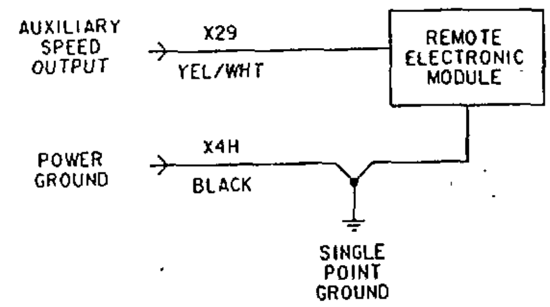
Input impedance:

R > 40k ohms
C (to ground) < 1000 pF

If this throttle input signal is present, it shall take priority as throttle input. If this signal is missing, throttle command shall revert back to analog throttle input. Engine controller may consider the PWM Throttle input missing if the signal is not valid within 40 ±5 msec.

9.5 Auxiliary Speed (Tach) Output Signal Specifications

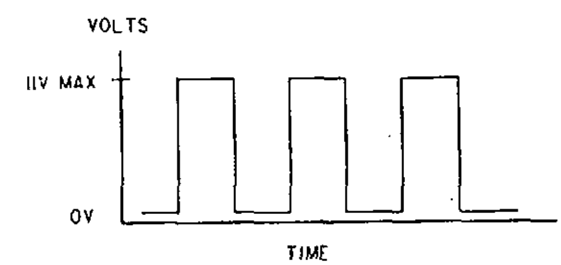
The Engine Controller provides a buffered output of the auxiliary speed sensor signal which can be used to monitor engine speed. This signal is the Auxiliary Speed Output signal. The wiring shown in Figure 19 is similar to that of the PWM Throttle Input, with the receiving electronic module grounded to Single Point Ground to minimize voltage offsets in the ground circuit.



AUXILIARY SPEED OUTPUT WIRING

FIGURE 19

Figure 20 shows that the Auxiliary Speed Output is a digital signal which switches between 0V and 11V (no load). The frequency is the same as the Auxiliary Speed Input signal which comes directly from the sensor.

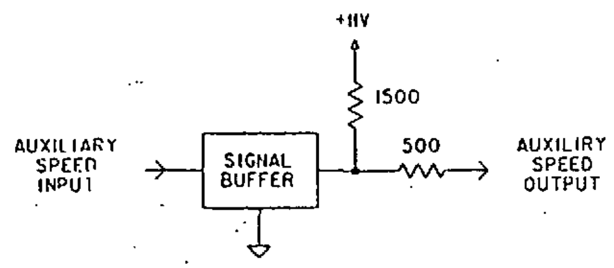


AUXILIARY SPEED OUTPUT SIGNAL WAVEFORM

FIGURE 20

9.5 Auxiliary Speed (Tach) Output Signal Specifications (cont'd)

The actual voltage levels seen by the receiving electronic module are dependent on the input impedance of the receiving circuit. Figure 21 shows the source resistance of the output circuit within the Engine Controller. The 500 ohm resistance protects the controller against short circuits, but will cause a voltage drop between the signal buffer and the receiver in both the high and low states. There will be a voltage drop across both the 1.5K and 500 ohm resistances in the high state. The waveform and the voltage drops need to be considered when interfacing this signal with an electronic tachometer.



AUXILIARY SPEED OUTPUT SOURCE RESISTANCE

FIGURE 21

Table 5
Definition of Terms

Analog	Voltage which has a continuous range of possible voltages. Usually represents a continuously variable physical value such as rack position, fuel temperature or throttle lever position.
Electronic Governor	The computer program within the Engine Controller which determines the commanded fuel delivery based on throttle command, engine speed and fuel temperature. Replaces the function of a mechanical governor. The entire electronic fuel injection system is sometimes referred to as the "electronic governor."
PWM	Pulse-width-modulated. A digital electronic signal (not analog) which consists of a pulse generated at a fixed frequency. The information transmitted by the signal is contained in the width of the pulse. The width of the pulse is changed (modulated) to *indicate a corresponding* change *in* the information being transmitted, such as throttle command.
TVP Module	Transient Voltage Protection Module. A device which protects the Engine Controller electronics against high energy voltage transients such as alternator load dumps.
3-state	*An input signal* which only has three possible states (voltages). These voltages are typically 0 volts, +2.5 volts, and +5 volts. An application may only require one or two of the three possible input states.

Table 6
Metric Wire Size Conversion

AWG WIRE SIZE	METRIC WIRE SIZE
0.5	20
0.8	18
1.0	16
2.0	14
3.0	12