M1A1 AECU-J1 Diagnostic Connector Signal Description for use with ABOB and BOB

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Introduction

ABOB is an acronym for Automatic Breakout Box. The ABOB is connected to the AECU's (Analog Electronic Control Unit J1 diagnostic connector. The ABOB very rapidly and accurately measures the diagnostic signals from the AECU J1 connector. These signals, typically voltages, represent various engine operating conditions. ABOB allows you to comprehensively measure and observe a variety of these conditions as they are actually occurring in order to perform a diagnosis.

The signal descriptions and explanations which follow are applicable for use with either the ABOB or BOB. Make sure that when using BOB that the Digital multimeter you use has an input impedance of at least 10 MEG (million) ohms. This is to ensure that the meter does not load down and distort the signal you measuring. This loading effect can cause two problems:

A. The reading appearing on your multimeter will not be accurate.

B. The loading effect can actually change the behavior of the circuit being measured.

Adhering to the above guidance is especially important when you are using more than one multimeter at a time to make your measurements. The requirement of a 10 MEG ohm input impedance will allow you to use more than one multimeter without worrying about signal loading.

AECU signal pin numbers appearing on the ABOB screen correspond exactly to those on the ABOB or BOB (Breakout Box) when Adapter #4 is used to connect either of them to the AECU J1 diagnostic connector. This means that ABOB numbers 1 through 32 correspond exactly to BOB pins 1 through 32.

All parameters referenced in this document are approximate. Common sense and experience will allow you to more easily identify between a good and a bad reading.

WARNING: When using the ABOB or BOB always install two jumper wires to complete the AECU interlock circuits. Install one jumper wire between test jacks 15 and 16 and install another jumper wire between test jacks 17 and 18.

Pin #1 WFFM (Fuel Flow Fault Mode)

WFFM is a discrete signal either 15 VDC (no fault) or 0 VDC (fuel fault). Two types of fuel faults can occur: fuel flow error and fuel flow level.

1. **Fuel Flow Error:** WFFM will transition from 15 VDC to 0 VDC when an error greater than 100 PPH (Pounds Per Hour) exists for time greater than 1/2 second between WFR (Fuel Flow Request) and WFA (Fuel Flow Actual). WFFM will remain low only as long as the fault condition exists and does not latch as does the PM (Protective Mode) caused by the fuel fault.
2. **Fuel Flow Level:** WFFM will transition from 15 VDC to 0 VDC when the indicated fuel flow level (WFA) is less than 10 PPH. WFFM will remain low only as long as the fault condition exists and does not latch as does the PM (Protective Mode) caused by the fuel fault.

A fuel flow fault will cause the AECU to invoke PM 1 during a start attempt (NH speed less than 55%) or PM 3 if the engine has started (NH speed greater than 55%). Fuel flow faults are ignored during the first 7.5 seconds of a start attempt.

Pin #2 NH HZ #1

The NH HZ #1 signal represents the speed of the (HP) High Pressure compressor in HZ (hertz) or cycles per second. 2,164 HZ equals 100% NH compressor speed. 21.64% equals 1% NH speed.

NH HZ #1 is a frequency signal produced by the NH #1 magnetic speed pickup which is mounted on the AGB (Accessory GearBox). There are two magnetic speed pickups mounted on the AGB, NH#1 and NH#2. However, only the frequency of the NH#1 speed pickup is available at the AECU J1 connector.

ABOB does not currently measure this signal. In order to measure this signal you must have a digital multimeter capable of measuring frequency in the range of 0 to 2500 HZ. Make sure you reference pin 2 to pin 3.

Pin #3 NH HZ #2

Explained under Pin 2.

Pin #4 AGND (Analog Ground)

It is not necessary for you to select this pin to make measurements, ABOB has already provided this ground for you.

Bendix Controls Division (manufacturer of the AECU) recommends the use of two distinctive grounds, one for "instrument" measurements and another for "power" measurements. However, Allied Signal and General Dynamics field service representatives have traditionally used analog ground (when using BOB) for all their measurements without any problems. ABOB uses analog ground as its reference point in making its measurements. AGND is the reference point for making "instrument" measurements at the AECU J1 connector. Another ground, PGND (Power Ground) is used as the reference point for the high current, inductive driver circuits as well as the AECU input supply voltages (interlocks 1 & 2). See table #1 for a listing of AECU J1 signals and their respective grounds.

If you are using BOB you can take advantage of these two grounds by referencing an "instrument" measurement to analog ground and referencing a "power" measurement to power ground. This allows you to make two measurements simultaneously.

Pin #5 (-) REF

Pin 5 is the AECU 10.0 VDC internal reference voltage. Typically, this signal reads about 9.8 to 10.2 VDC. If this signal becomes less than 8.5 VDC, for example 8.0 VDC, the AECU will invoke PM 1 during a start attempt (NH speed less than 55%) or PM 3 if the engine is running (NH speed greater than 55%).

Pin #6 (+) REF

Pin 6 is the AECU internal 10.0 VDC reference voltage. Typically, this signal reads about 9.8 to 10.2 VDC. If this signal becomes less positive than 8.5 VDC, for example 8.0 VDC, the AECU will invoke PM 1 during a start attempt (NH speed less than 55%) or PM 3 if the engine is running (NH speed greater than 55%).

Pin #7 Triwave

The triwave signal is currently not measured by ABOB. Triwave is a 20 PP (peak to peak), 5.77 VRMS (Voltage, Root Mean Square) or 5.55 VAVG (Voltage Average), 3500 HZ, triangular wave form signal. Triwave can be measured with a digital multimeter using its AC volts function. To get an accurate reading the multimeter must be capable of measuring true RMS (Root Mean Square) voltages. Triwave provides the following functions:

1. Excitation to the primary winding of the fuel flow main metering valve LVDT (Linear Voltage Differential Transformer). This excitation causes a voltage to be produced in the LVDT's secondary winding. The output voltage of the LVDT secondary winding produces a signal that represents the mechanical position of the main metering valve. The voltage produced by the secondary winding is AC and is converted to DC once inside the AECU.
2. Excitation to the primary winding of the PLA (Power Level Angle) or throttle RVDT (Rotary Variable Differential Transformer). This excitation causes a voltage to be produced in the RVDT's secondary winding. The output voltage of the RVDT secondary winding produces a signal that represents the mechanical position of the throttle. The voltage produced by the secondary winding is AC and converted to DC once inside the AECU.
3. Excitation to the primary winding of the IGV (Inlet Guide Vane) RVDT. This excitation causes a voltage to be produced in the RVDT's secondary winding. The output voltage of the RVDT secondary winding produces a signal that represents the mechanical position of the inlet guide vanes. The voltage produced by the secondary winding is AC and is converted to DC once inside the AECU.
4. Excitation to the primary winding of the PTS (Power Turbine Stator) RVDT. This excitation causes a voltage to be produced in the RVDT's secondary winding. The output voltage of the RVDT secondary winding produces a signal that represents the mechanical position of the power turbine stators. The voltage produced by the secondary winding is AC and is converted to DC once inside the AECU.
5. As a reference time base (3500 Hertz) for the pulse width modulated driver circuits of the WF,IGV, and PTS solenoids.

Pin #8 WFR (Fuel Flow Request)

WFR is the AECU's request for fuel flow. The signal range is 0 to 8.0 VDC. Convert WFR voltages to fuel flow in accordance with the following formula: **Voltage x 100.**

During a start attempt when NH speed is less than 55%, fuel flow scheduling is automatic and the AECU does not respond to PLA (throttle control) input or other commands such as tach idle or pivot steer. However, once the engine has started (NH speed equal to 55%) the AECU will respond to these commands which will result in an increase in fuel flow.

WFR starts at 40 PPH during a start attempt and ramps upward at 5 PPH per second. For NH speed 0 to 35%, maximum fuel flow is limited to 75 PPH. For NH speed greater than 35% but less than 55%, maximum fuel flow is limited to 165 PPH. Once NH speed reaches 55%, the start sequence is completed and fuel flow is scheduled in accordance with throttle position and engine operating schedules and parameters.

Pin #9 Backup S Low (Backup Solenoid negative side of circuit)

The backup solenoid signal indicates whether or not the backup solenoid is open or closed. A closed backup solenoid is indicated by approximately 0-1.5 VDC. An open backup solenoid is indicated by the presence of system voltage, typically in the range of 18-28 VDC.

The positive side of the backup solenoid is powered directly by AECU supply voltage. The negative side of the solenoid is grounded by the backup solenoid driver circuit. THE AECU backup solenoid test point is located on the negative side of the circuit at a point before the transistor driver which is turned on to close the solenoid and turned off to open the solenoid. This is why a low voltage indicates a closed backup solenoid and a high voltage indicates an open backup solenoid.

During normal engine operation the backup solenoid is powered closed. During a PM III condition the backup solenoid is de-energized and moves to the open position. However, if the cause of the PM III condition was loss of AECU supply voltage, there would be no voltage at this pin to measure.

The backup solenoid is used to provide a fixed fuel flow to the engine under a PM III condition. When the AECU invokes PM III, power is removed from the WF and backup solenoids. The fuel flow main metering valve is hydraulically driven to its minimum position (40 PPH) and the backup solenoid opens providing an additional 80 PPH of fuel flow.

Total fuel flow to the engine under a PM III condition is approximately 120 PPH. You will not be able to measure 120 PPH at pin 22 (WFA-Fuel Flow Actual) because fuel passing through the backup solenoid does not flow through the main metering valve.During a PM III condition the WFA signal will indicate the minimum fuel flow position of the main metering valve, approximately 40 PPH.

Pin #10 Pilot Relay (Starter Pilot Relay)

The starter pilot relay signal indicates that the AECU has received either a start or starter only command and has applied power to the starter pilot relay. The starter pilot relay signal is typically 12-24 VDC.

The function of the starter pilot relay is to complete the circuit between the batteries and the starter solenoid. The starter solenoid engages the starter's splined drive and provides power to the starter motor in order to crank the engine or more specifically rotate the AGB (Accessory Gearbox).

The starter pilot relay circuit functions as follows:

1. **Normal Start** If NH speed is less than 5% and the start button is pressed and released, the AECU will issue a start command and energize the starter pilot relay. When NH speed reaches 55% the AECU turns off power to the starter pilot relay and the starter is disengaged from the AGB. If NH speed is less than 55% for time greater than 60 seconds the AECU will abort the start (PM I).
2. **Cold Weather Start** If NH speed is less than 5% and the start button is pressed and held, the AECU will issue a start command and energize the starter pilot relay until the start button is released.
3. **Starter Only** If NH speed is less than 5% and the starter only switch is activated, the AECU will issue a purge command and energize the starter pilot relay. The starter will crank the engine until the starter only switch is released.

Pin #11 Cutoff-S (Fuel Cutoff Solenoid)

The fuel cutoff solenoid signal indicates whether or not the fuel cutoff solenoid is energized. Typically, a reading of 18 - 24 VDC indicates that the AECU has applied power to the solenoid to close it. The cutoff solenoid is open during engine start attempts and normal engine operation. The cutoff solenoid is powered closed during engine shutdown.

The fuel cutoff solenoid circuit functions as follows:

Start When the start button is pressed, the AECU issues a start command and powers the fuel cutoff solenoid closed thus preventing fuel from reaching the fuel nozzle. At 5% NH speed the AECU removes power from the cutoff solenoid causing it to open which allows fuel to flow to the fuel nozzle.

Starter Only When the starter only switch is activated, the AECU issues a purge command and powers the fuel cutoff solenoid closed. During the time the engine is cranking the cutoff solenoid remains closed. When the starter only switch is released, the engine coasts to a stop. The cutoff solenoid will remain energized for approximately 45 seconds after NH speed falls below 5%.

Shutdown When the engine shutoff switch is activated the AECU issues an engine stop command and powers the fuel cutoff solenoid closed. The fuel supply is cut off to the fuel nozzle and the engine coasts to a stop. The cutoff solenoid will remain energized for approximately 45 seconds after NH speed falls below 5%.

Continuity The AECU contains circuitry to detect an open or shorted fuel cutoff solenoid circuit. When the start button is pressed but before the AECU issues a start command, the AECU checks the continuity level or resistance of the fuel cutoff solenoid circuit. If this value is from 5 to 500 ohms, the AECU will issue a start command. If the value is less than 5 ohms or greater than 500 ohms the AECU will not issue a start command. The word continuity means continuous; without a break. Since the normal resistance of the fuel cutoff solenoid is approximately 20 to 50 ohms, a value less than 5 ohms would indicate a short circuit and a value greater than 500 ohms would indicate an open circuit.

The main purpose of the fuel cutoff solenoid circuitry is to prevent the AECU from issuing a start command with the EMFS (ElectroMechanical Fuel System) electrically disconnected from the AECU. This condition would cause the engine to be over fueled because the EMFS is no longer under the control of the AECU.

Without any control from the AECU, the EMFS will deliver 120 PPH (40 PPH - minimum position of the main metering valve and 80 PPH - backup solenoid) of fuel flow to the engine. This over fueling condition will cause catastrophic thermal damage to the engine.

However, during a starter only request the AECU will crank the engine even if an open or short circuit exists in the fuel cutoff solenoid circuit.

Pin #12 IGN EXC (Ignition Exciter)

The ignition excitor signal indicates that the AECU has issued a start command and has applied power to the ignition excitor. The ignition excitor signal is typically 12 to 24 VDC.

The function of the ignition excitor is to produce a pulsating high voltage in order to create a spark that will "jump" the gap between the center and ground electrodes of the ignitor. The spark ignites the air-fuel mixture in the combustor.

The ignition excitor circuit functions as follows:

1. **Normal Start** If NH speed is less than 5% and the start button is pressed and released, the AECU will issue a start command and apply power to the ignition excitor. When NH speed reaches 55%, the AECU turns off power to the ignition excitor. If NH speed is less than 55% for time greater than 60 seconds the AECU will abort the start (PM-I).
2. **Cold Weather Start** If NH speed is less than 5% and the start button is pressed and held, the AECU sill issue a start command and apply power to the ignition excitor until the start button is released.
3. **Starter Only** The ignition excitor is not powered during a starter only (purge) command.

Pin #13 WF-S (Fuel Flow Solenoid)

The WF solenoid positions the main metering valve in response to WFR (Fuel Flow Request) and feedback from WFA (Fuel Flow Actual). WF-S is a 3500 HZ, constant amplitude, rectangular, pulse width modulated signal. The width of the pulse represents the amount of current required to move the main metering valve to a new position or maintain its current position. You would only be able to see the shape of the pulse if you measured WF-S with an oscilloscope.

WF-S operates at a frequency of 3500 hz which is much faster than the ABOB or a digital multimeter makes measurements. This has the effect of causing the voltage appearing at this pin to change amplitude as the pulse width and therefore the current changes in response to WFR and feedback from

WFA.

The amplitude of the voltage measured at this pin is an "average" voltage representing the width of the pulse. Wider pulses produce higher voltage readings and narrower pulses produce lower voltage readings.

WF-S voltage can be used successfully to identify large fuel flow errors. This is because under these conditions the pulse width will become very small or very large in an attempt to correct the error. Since the amplitude of the voltage is dependent on pulse width an increase or decrease in voltage from the null voltage will be obvious.

When WFR and WFA are equal to one another there is no error and the width of the pulse is equal to some null value, typically 275 ma (milliamps). When an error exists between WFR and WFA the pulse width either shortens or lengthens, depending on the direction of the error.

WFA is less than WFR the width of the pulse will lengthen from its null value increasing current to the WF solenoid. This causes the main metering valve to move to the requested position. When WFA and WFR are equal again the width of the pulse will return to its null value.

If WFA is greater than WFR the width of the pulse will shorten from its null value decreasing current to the WF solenoid. This causes main metering valve to move to the requested position. When WFA and WFR are equal again the width of the pulse will return to its null value.

When the error between WFA and WFR is zero or small, WF-S voltage is typically some value between 2.5 and 3.5 VDC (representative of the null current and pulse width). For reference purposes the 2.5 and 3.5 voltage reading can be considered a null voltage because WFR and WFA are equal or close to one another.

When WFA is less than WFR, WF-S voltage will increase from the null voltage towards a higher voltage. When WFA and WFR are equal again WF-S voltage will return to the null value.

When WFA is greater than WFR, WF-S voltage will decrease from the null voltage towards a lower voltage. When WFA and WFR are equal again, WF-S voltage will return to the null value.

The WF solenoid is powered at the initiation of a start or starter only command. Since the fuel flow computation circuit is active during a starter only command and the cutoff solenoid is energized closed, you can troubleshoot some fuel flow errors without starting the engine. NH speed during a starter only command will be less than 35% so normally scheduled fuel flow will not exceed 75 PPH.

During a PM III condition, the AECU removes power from the WF and backup solenoids. The main metering valve is hydraulically driven to its minimum position of 40 PPH and the backup solenoid opens providing an additional 80 PPH of fuel flow. Total fuel flow to the engine under a PM III condition is approximately 120 PPH.

Pin #14 T7 PTS (T7 Power Turbine Stator Request)

Although this signal is available to be measured, it is not used for troubleshooting.

Pin #15 Interlock

With a set of well charged batteries Pin 15 will read approximately 24 VDC with master power on and 18 to 24 VDC during engine cranking. If the engine is running and the charging system is functioning you should read approximately 27 -30 VDC.

Interlock 1 consists of a jumper wire between pins 15 and 16, and interlock 2 consists of a jumper wire between pins 17 and 18. Interlocks 1 and 2 are in parallel and supply power to the AECU. Pin 15 represents system supply voltage to the AECU before the jumper wire that connects pin 15 and 16.

If voltage on pins 15 and 17 and/or the voltage on pins 16 and 18 drop below approximately 10.75 VDC, the AECU will abort a start attempt (PM I). If the voltage drops below approximately 10.75 VDC while the engine is running, PM III will be in effect.

Pin #16 Interlock 1

With a set of well charged batteries, Pin 16 will read approximately 24 VDC with master power on and 18 to 24 VDC during engine cranking. If the engine is running and the charging system is functioning, you should read approximately 27 - 30 VDC.

Interlock 1 consists of a jumper wire between pins 15 and 16 and Interlock 2 consists of a jumper wire between pins 17 and 18. Interlocks 1 and 2 are in parallel and supply power to the AECU. Pin 16 represents system supply voltage to the AECU after the jumper wire that connects pin 15 to pin 16.

If voltage on pins 15 and 17 and/or the voltage on pins 16 and 18 drop below approximately 10.75 VDC, the AECU will abort a start attempt (PM I) If the voltage drops below approximately 10.75 VDC while the engine is running, PM III will be in effect.

Pin #17 Interlock 2

With a set of well charged batteries Pin 17 will read approximately 24 VDC with master power on and 18 -24 VDC during engine cranking. If the engine is running and the charging system is functioning, you should read approximately 27 - 30 VDC.

If the voltage on pins 15 and 15 and/or the voltage on pins 16 and 18 drop below approximately 10.75 VDC the AECU will abort a start attempt (PM I). If the voltage drops below approximately 10.75 VDC while the engine is running PM III will be in effect.

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Pin #18 Interlock 2

With a set of well charged batteries, pin 18 will read approximately 24 VDC with master power on and 18 to 24 VDC during engine cranking. If the engine is running and the charging system is functioning, you should read approximately 27 - 30 VDC.

Interlock 2 consists of a jumper wire between pins 17 and 18 and Interlock 1 consists of a jumper wire between pins 15 and 16. Interlocks 1 and 2 are in parallel and supply power to the AECU. Pin 17 represents system supply voltage to the AECU before the jumper wire that connects pin 17 to pin 18. If the voltage on pins 15 and 17 and/or the voltage on pins 16 and 18 drop below approximately 10.75 VDC, the AECU will abort a start attempt (PM I). If the voltage drops below approximately 10.75 VDC while the engine is running PM III will be in effect.

Pin #19 NPT SPD (Power Turbine Speed)

The NPT SPD signal represents the speed of the power turbine. The range of the NPT SPD signal is 0 to 5 VDC. To convert voltage to RPM (Revolutions Per Minute) or percentage (%) NPT speed use the following formulas:

1. Voltage to RPM: Voltage x 720 = RPM.
2. Voltage to % NPT speed: Voltage x 24 = % NPT speed.

Two magnetic speed pickups are mounted to the RGB (Reduction GearBox). Each speed pickup produces an AC signal whose frequency is proportional to RGB rotation. Once the signals reach the AECU they are converted to DC.

The powershaft connects the power turbines to the RGB. The RGB reduces the speed of the power turbines by a factor of 7.5 to 1 through a planetary gearset. The output of the RGB is coupled to the input of the transmission.

The NPT minimum governor will attempt to maintain NPT speed at 30.9% (927 RPM) during idle with PLA (throttle) at its minimum position. NPT minimum governor has the authority to schedule up to 350 PPH of fuel flow in order to maintain minimum governor speed.

When the transmission is in neutral NPT speed is limited to a maximum of 80% (2400 RPM). When the transmission is in range, NPT speed is limited to a maximum of 103.3% (3100 RPM); 3,000 RPM equals 100% NPT speed.

An overspeed condition exists when NPT speed reaches 106% (3,180 RPM). The action of the AECU is to reduce fuel flow and latch the overspeed light on. When NPT speed falls to 95% (2,850 rpm) normal fuel flow scheduling is resumed. To extinguish the overspeed light the AECU must receive a fault reset command by pressing the reset button.

If the tactical idle switch is selected by NPT tactical idle governor will attempt to maintain a minimum NPT speed of 43.6% (1308 rpm) with PLA (throttle) at its minimum position. However, if you rotate the throttle you can increase NPT speed above 43.6% (1308 rpm).

If Pivot/Neutral is selected (not available on GHSS) the minimum NPT speed limit is 43.6% (1308 rpm) and the maximum NPT speed limit is 80% (2400 rpm).

If the engine is running (NH speed 55% or greater) and NPT speed is less than 1%, the AECU will invoke PM III if the transmission is in neutral and PM II if the transmission is in range. The AECU does not abort the start attempt (PM I) if NPT speed less than 1%.

In order for NPT speed to be less than 1% both NPT speed circuits would have to be faulty. If only one speed circuit is faulty, the AECU will obtain NPT speed input from the other circuit. When only one NPT circuit is faulty, PM IV is invoked by the AECU.

Pin #20 NH SPD (High Pressure Compressor Speed)

The NH SPD signal represents the speed of the HP compressor. The range of this signal is 0 to 10 VDC.

To convert voltage to percent (%) NH compressor speed, use the following formula: Volts 10, move decimal point two places to the right and add zeros as necessary. Place % sign next to right most digit.

Two magnetic speed pickups are mounted to the AGB (Accessory GearBox). Each speed pickup produces an AC signal whose frequency is proportional to the speed of the slotted disk rotating underneath the speed pickups. The slotted disk is attached to the top of the oil pump drive gear and is driven by the HP compressor/turbine assembly through a gear train.

The minimum governor will attempt to maintain NH speed at 59% during idle with PLA (throttle) at its minimum position. NH minimum governor has the authority to schedule up to 175 PPH of fuel flow in order to maintain NH minimum governor speed.

If the tactical idle switch is selected, the NH tactical idle governor will attempt to maintain a minimum NH speed of 66%. This is to ensure that sufficient power is developed by the HP turbine to drive the hydraulic pump without creating an over temperature condition. The hydraulic pump is mounted to the AGB and is driven through a gear train by the HP turbine.

In order for NH speed to be less than 1%, both NH speed circuits would have to be faulty. If only one speed circuit is faulty, the AECU would obtain NH speed input from the other circuit. When only one NH speed circuit is faulty, PM IV is invoked by the AECU.

Pin #21 T7I (Temperature, Power Turbine Inlet, Instantaneous)

The T7I signal represents the instantaneous inlet temperature to the power turbines. The range of this signal is -10 VDC to 10 VDC. T7I scaling is follows: 1 VDC per 100 deg. F.

Convert voltage to temperature in accordance with the following formulas:

1. Multiply voltage by 100. If your answer is positive subtract it from 1000. This is your T7I temperature.
2. Multiply voltage by 100. If your answer is negative, drop the negative sign and add your answer to 1000. This is your T7I temperature.
3. -10 VDC equals 2000 deg.F. 0 VDC equals 1000 deg.F. 10 VDC equals 0 deg.F.

A thermocouple is a device constructed of two dissimilar metals joined together to form a junction. When the junction is heated, a voltage proportional to temperature is produced. The output voltage of a thermocouple is very small and must be amplified for practical use. Thermocouples can be connected in parallel to average the temperature of the item being measured.

The AGT 1500 uses 12 type K thermocouples in parallel at the power turbine inlet. A type K thermocouple is constructed of two alloys: Nickel-Chromium (Chromel) and Nickel-Aluminum (Alumel). The Chromel side of the thermocouple junction is positive (+) and the Alumel side of the junction is negative (-). The maximum temperature range of a type K thermocouple is -328 to 2282 deg.F.

T7 (not T7I) temperature signal is the amplified thermocouple voltage and is used as input to circuitry that detects temperature limits and faults, triggers protective modes, and reduces fuel flow during an over temperature condition.

A thermocouple does not react instantly to a change in temperature, but instead requires a finite amount of time to stabilize in response to a change. Variables that effect accurate T7 temperature measurement include thermocouple probe mass and the rate of gas flow past the probe which in turn depends on engine speed.

T7I (T7 Instantaneous) is the T7 temperature signal with variable compensation to correct for the time response characteristics of the thermocouple probes. T7I is used for critical computations within the AECU. During acceleration and deceleration, T7I leads T7. During steady state operation T7I equals T7.

During a start attempt if T7 temperature exceeds 1360 deg.F. for NH speed greater than 5% but less than 55%, the AECU will abort the start (PM I).

Occasionally a starter will produce EMI (ElectroMagnetic Interference) great enough that it will cause the AECU to abort the start. The EMI produces a voltage spike that appears to the AECU as a rapid increase in temperature.

During a start attempt if T7 temperature is less than 250 deg.F. for NH speed greater than 35%, the AECU will abort the start (PM I).

If T7 temperature exceeds 1800 deg.F. for NH speed greater than 55% (engine running) the AECU will invoke PM III if the transmission is in range. During a start attempt (NH speed less than 55%) the AECU imposes a T7 limit of 1200 deg.F. for all ambient temperatures. To keep T7 from exceeding this limit the AECU will reduce fuel flow. If T7 temperature continues to rise and exceeds 1360 deg.F. the AECU will turn on the Gas Overtemp light and abort the start (PM I).

During a start attempt (NH speed less than 55%) the AECU will activate a T7 flag signal. The T7 flag signal turns on the Gas Overtemp light when T7 temperature reaches 1182 deg.F. and turns off the light when T7 temperature decreases to 1162 deg.F. For NH speeds 5% to 78% activation of the T7 flag depends on T1 temperature. Above 78% NH speed the T7 flag is inactive.

During a full power steady state condition (NH rate of change less than 3.7% per second) with the transmission in drive, if the PTS are fully open and T7 has reached 1430 deg.F, the AECU will modulate fuel flow to control T7 temperature. If T7 were to reach 1800 deg.F the AECU would invoke PM II.

T7 temperature is controlled by PTS position and fuel flow. Proper PTS mechanical and electrical adjustment are important as a misrigged PTS will cause a low power condition.

A short or low resistance in the T7 measurement circuit will make the T7 temperature appear colder to AECU. An open or high resistance in the T7 measurement circuit will make the T7 temperature appear hotter to the AECU. If the T7 cable becomes disconnected, the T7 signal will read approximately -10 VDC (2000 deg.F) to -12 (2200 deg.F).

Pin #22 WFA (Fuel Flow Actual)

The normal range of this signal is 0.4 VDC to 8.0 VDC which equals 40 to 800 PPH (Pounds Per Hour). The WFA signal represents the mechanical position of the fuel main metering valve and therefore fuel flow. Under normal conditions WFA tracks WFR.

Convert voltage to fuel flow in PPH in accordance with the following formula: Voltage x 100.

WFA is the position of the main metering valve and is reported to the AECU through an LVDT (Linear Voltage Differential transformer mounted inside the EMFS (ElectroMechanical Fuel System). The LVDT is connected to the bottom of the main metering valve.

Movement of the main metering valve causes the AECU invoke PM I or PM III: fuel flow error and fuel flow level.

Movement of the main metering valve causes a corresponding movement (up or down) in the LVDT. The LVDT produces a voltage which is proportional to the position of the main metering valve. The voltage produced by the LVDT is AC and is converted to DC once inside the AECU.

Two types of fuel faults can occur that will cause the AECU to invoke PM I or PM III: fuel flow error and fuel flow level.

1. Fuel flow error: Typically, there is always some small steady state error or difference between WFR (Fuel Flow Request) and WFA (Fuel Flow Actual). A fuel flow error condition occurs when a difference greater than 100 PPH exists for a time greater than 1/2 second between WFR and WFA; 100 PPH equals 1 VDC.
2. Fuel flow Level: This condition occurs when the indicated fuel flow level (WFA) is less than 10 PPH; 10 PPH equals 0.1 VDC.

During a fuel fault condition the WFFM signal will transition from 15 VDC (no fault) to 0 VDC (fuel fault). WFFM will remain low only as long as the fault condition exists and does not latch as does the PM (Protective Mode) caused by the fuel fault.

A fuel flow fault will cause the AECU to invoke PM I during a start attempt (NH speed less than 55%) or PM III if the engine is running (NH speed greater than 55%). Fuel flow faults are ignored during the first 7.5 seconds of a start attempt. However, WFFM will transition from 15 VDC to 0 VDC whenever a fuel fault is present independent of time.

During a PM III condition the AECU removes power from the WF and backup solenoids. The fuel flow main metering valve is hydraulically driven to its minimum position of 40 PPH and the backup solenoid opens providing an additional 80 PPH of fuel flow.

Total fuel flow to the engine under a PM III condition is approximately 120 PPH. You will not be able to measure 120 PPH at pin 22 (WFA) because fuel passing through the backup solenoid does not flow through the main metering valve. During a PM III condition, the WFA signal will indicate the minimum fuel flow position of the main metering valve, approximately 40 PPH.

Pin #23 T7 WF (T7 Fuel Flow Request)

Although this signal is available to be measured, it is currently not used for troubleshooting.

Pin #24 T1 (Ambient Inlet Air Temperature)

The T1 signal represents the ambient air temperature in deg.F entering the front of the engine as sensed by the T1 temperature sensor. The T1 sensor is mounted to the engine air inlet or bellmouth. The range of this signal is 0 to 8 VDC. To convert voltage to temperature use the following formula: (Volts - .03) - 75 = Ambient temperature.

The T1 sensor is a platinum RTD (Resistance Temperature Detector) that changes resistance in proportion to temperature. An increase in temperature produces an increase in resistance, a decrease in temperature produces a decrease in resistance. The resistance value of the T1 sensor is converted to a DC voltage in the AECU.

If the T1 circuit fails, the AECU will invoke PM IV and substitute a 125 deg.F (6 VDC) temperature into all schedules biased with T1. T1 circuit failures are detected when the T1 indication is less than -100 deg.F or greater than 200 deg.F.

It is important to remember that the T1 signal can represent an actual temperature greater than 125 deg.F. During engine operation in very hot climates, T1 can easily approach 130 deg.F. or higher. Even though the indicated T1 is greater than 125 deg.F, the AECU will internally substitute a 125 deg.F temperature into all schedules biased with T1.

Pin #25 PLA (Power Lever Angle)

The PLA signal represents the mechanical position of the throttle which is used to control the speed of the engine. The range of this signal for the minimum throttle position is 500 to 600 millivolts (0.5 to 0.6 VDC). The range of this signal for maximum throttle position is 6.5 to 6.7 VDC.

PLA or throttle position is reported back to the AECU by a RVDT (Rotary Variable Differential Transformer). Movement of the throttle causes the RVDT to rotate which produces a voltage proportional to throttle position. The voltage produced by the RVDT is AC and is converted to DC once inside the AECU.

If the PLA signal is missing, the AECU will allow the engine to start and run but will not be able to respond to a throttle request. However, the AECU will still schedule fuel flow in order to maintain the NH and NPT minimum speed governors.

During a PM II condition, fuel flow is limited to a range of 90 to 292 PPH and is scheduled proportionally to throttle rotation. When PLA is equal to 64 degrees fuel flow will be equal to 292 PPH.

During a PM III condition, fuel flow is fixed at 120 PPH and the rotation of the throttle will have no effect on engine speed. The throttle is not affected by a PM IV condition.

Pin #26 PTS-S (Power Turbine Stator Solenoid)

The PTS solenoid positions the PTS servo valve in response to PTSR (Power Turbine Stator Request) and feedback from PTSA (Power Turbine Stator Actual). The PTS servo valve meters fuel to the PTS actuator which positions the power turbine stator vanes.

PTS-S is a 3500 HZ, constant amplitude, rectangular, pulse width modulated signal. The width of the pulse represents the current required to move the PTS actuator to a new position or maintain its present position. You would only be able to see the shape of the pulse if you measured PTS-S with an oscilloscope.

PTS-S operates at a frequency of 3500 HZ, which is much faster than the ABOB or a digital multimeter makes measurements. This has the effect of causing the voltage appearing at this pin to change amplitude as pulse width and therefore the current changes in response to PTSR and feedback from PTSA.

Under normal conditions, PTSR and PTSA should equal -6.2 VDC. When PTSR is 0.3 VDC (open PTS) and PTSA indicates an open position of -6.5 VDC, the summation of these two voltages will equal -6.2 VDC. When PTSR is -5.7 VDC (closed PTS) and PTSA indicates a closed position of -0.5 VDC, the summation of these two voltages will equal -6.2 VDC.

When PTSR and PTSA equal -6.2 VDC, the PTS circuit is in a null condition and the width of the pulse represents the amount of current required to position the PTS actuator at the requested position. The voltage appearing at PTS-S is an "average" voltage representing this condition.

When the summation of PTSR and PTSA does not equal -6.2 VDC, an error condition exists. The following example demonstrates the change in amplitude of PTS-S voltage in reaction to an error condition. When a PTS error causes the summation of PTSR and PTSA to be more than negative -6.5 volts, there will be a large increase in PTS-S voltage in comparison to the value observed when PTSR and PTSA were equal to -6.2 VDC. When a PTS error causes the summation of PTSR and PTSA to be less negative than -6.5 volts, There will be a large decrease in PTS-S voltage in comparison to the value observed when PTSR and PTSA were equal to -6.2 VDC.

It is important to remember that there is no protective mode for a PTS error, only for a PTS level fault (PTSA less than -0.1 VDC).

The AECU powers the PTS at 35% NH speed during a start attempt. If a PTS level fault (PTSA less than -0.1 VDC) is detected during a start attempt, the engine will continue to start successfully. However, once the engine has started and NH speed is greater than 55%, the AECU will invoke PM III if the transmission is in neutral or PM II if the transmission is in range.

During a PM II or PM III condition the AECU removes power from the PTS solenoid which causes the PTS actuator to move the power turbine stators to the open position.

Pin #27 PGND (Power Ground)

See the discussion under pin 4, (analog ground). Power ground is used as a reference for "power" measurements such as the backup solenoid, starter relay pilot, fuel cutoff solenoid, ignition excitor, WF solenoid, and interlocks 1 and 2, PTS solenoid, and the IGV solenoid.

Pin #28 IGV-S (Inlet Guide Vane Solenoid)

The IGV solenoid positions the IGV servo valve in response to IGVR (Inlet Guide Vane Request) and feedback from IGVA (Inlet Guide Vane Actual). The IGV servo meters fuel to the IGV actuator which in turn positions the inlet guide vanes through a linkage.

IGV-S is a 3500 HZ, constant amplitude, rectangular, pulse width modulated signal. The width of the pulse represents the current required to move the IGV actuator to a new position or maintain its present position. You would only be able to see the shape of the pulse if you measured IGV-S with an oscilloscope.

IGV-S operates at a frequency of 3500 HZ, which is much faster than the ABOB or a digital multimeter makes measurements. This has the effect of causing the voltage appearing at this pin to change amplitude as the pulse width and therefore the current changes in response to IGVR and feedback from IGVA.

The amplitude of the voltage measured at this pin is an "average" voltage representing the width of the pulse. Wider pulses produce higher voltage readings and narrower pulses produce lower voltage readings.

The IGV circuit is designed with a 0.67 VDC rigging offset in the circuit. The offset is obtained through the use of shims which mechanically positions the IGV feedback cable. Throughout the range of IGVR and IGVA, there should always be 0.67 VDC difference between IGVR and IGVA. This differs from the fuel flow circuit where WF request and WF actual should always be equal to one another.

The following example demonstrates the change in amplitude of IGV-S voltage in reaction to an error condition. When IGVR is 10 VDC (closed IGV) and IGVA indicates a closed position of -10.67 VDC, the IGV solenoid voltage for this condition becomes the reference point for comparison purposes. For the same IGVR request (10 VDC), if IGVA were to become more negative, for example -11.5 VDC, there would be a large increase IGV solenoid voltage as compared to the previous reference. If IGVA were to become less negative, for example -9.95 VDC, there would be a large decrease in IGV solenoid voltage as compared to the previous reference.

The AECU powers the IGV solenoid during a start attempt at 35% NH speed. If an IGV error occurs during the start attempt, the engine will continue to start successfully. However, once the engine has started and NH speed is greater than 55%, the AECU will invoke PM III if the transmission is in neutral or PM II if the transmission is in range.

During a PM II or PM III condition the AECU removes power from the IGV solenoid which causes the IGV actuator to move the inlet guide vanes to the closed position.

Pin #29 PTSR (Power Turbine Stator Request)

This signal represents the AECU's PTS request schedule to position the power turbine stator vanes. A voltage of approximately 0.3 VDC, indicates a requested open PTS position. A voltage of approximately -.57 VDC indicates a requested closed PTS position.

The PTS vanes are modulated between an open and closed position to control T7 temperature. With NH speed increasing from below 75%, the PTS vanes shall remain fully open until 78% NH speed. Modulation shall then occur to control T7 temperatures at all NH speeds from 78% and upwards. If NH speed decreases below 75%, the PTS vanes shall return to the fully open position.

During acceleration (NH speed rate of change greater than 3.7%) the PTS vanes are positioned open. During steady state conditions the PTS vanes shall remain fully open until 78% NH speed. Modulation shall then occur to control T7 temperature at all NH speeds from 78% upward. If NH speed decreases below 75%, the PTS vanes shall return to the fully open position.

During acceleration (NH speed rate of change greater than 3.7%) the PTS vanes are positioned open. During steady state conditions the PTS vane position is modulated to maintain a scheduled T7 temperature as a function of NH speed and T1 ambient temperature.

Pin #30 PTSA (Power Turbine Stator Actual)

The PTSA signal represents the mechanical position of the power turbine stator vanes.

A reading of approximately -6.5 VDC indicates an open PTS and a reading of approximately -0.5 VDC indicates a closed PTS. PTSA should track PTSR.

PTS position is reported to the AECU through an RVDT mounted to the EMFS (ElectroMechanical Fuel System). The RVDT is connected by cable to the PTS actuator and arm. Movement of the PTS actuator will cause the RVDT to rotate and produce a voltage proportional to PTS position. The voltage produced by the RVDT is AC and is converted to DC once inside the AECU.

If the engine is running (NH speed 55% or greater) and PTSA voltage is less than -0.1 VDC, the AECU invoke PM III if the transmission is in range. During a PM II or III condition power is removed from the PTS solenoid and the PTS moves to the open position.

Pin #31 IGVR (Inlet Guide Vane Request)

This signal represents the AECU's request schedule to position the inlet guide vanes. A voltage of approximately 10 VDC indicates a requested closed IGV position. A voltage of approximately 0 volts indicates a requested open IGV position.

The IGV are coupled to a bleed valve through linkage. When the IGV are fully closed, the bleed valve will reach its fully closed position prior to the IGV reaching its fully open position.

The function of the IGV and bleed valve arrangement is to prevent the compressors from stalling. The IGV are scheduled in accordance with NH speed and T1 ambient temperature. Using a 59 deg.F. day as a reference, the IGV will open sooner for temperatures colder than 59 deg.F and open later for temperatures hotter than 59 deg.F.

Pin #32 IGVA (Inlet Guide Vane Actual)

The IGVA signal represents the mechanical position of the IGV. A reading of approximately -10.67 VDC indicates a closed IGV and a reading of approximately -0.67 VDC indicates an open IGV.

IGV position is reported back to the AECU through an RVDT mounted to the EMFS. The RVDT is connected by cable to the IGV linkage. Movement of the IGV linkage by the IGV actuator will cause the RVDT to rotate and produce a voltage proportional to IGV position. The voltage produced by the RVDT is AC and is converted to DC once inside the AECU.

If the engine is running (NH speed 55% or greater) and the difference between IGVR and IGVA is more positive than .33 VDC or more negative than -1.67 VDC for a time greater than 1/2 second, the AECU will invoke PM III if the transmission is in neutral or PM II if the transmission is in range.

Another way to express IGV error is plus or minus 1 volt from the IGV requested position, assuming a -0.67 VDC offset due to IGV rigging.

During a PM II or III condition, power is removed from the IGV solenoid and the IGV moves to the closed position. An IGV error condition will not cause the AECU to abort the start attempt (PM I).

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