

GULFSTREAM G550

OPERATING MANUAL

ENGINE INDICATION

2A-77-10: Engine Indication System

1. General:

A. Description:

Critical engine data is monitored by the Electronic Engine Control (EEC) within each engine Full Authority Digital Electronic Control (FADEC) in the process of matching engine performance to the power levels commanded by the power levers or the autothrottle system. The EEC also monitors engine data to maintain engine operation within defined limits. Engine data used by the EEC is shared with the Modular Avionics Units (MAUs) in order to provide flight crew oversight and control of engine performance using visual graphics shown in selectable windows on the cockpit Display Units (DUs). EEC data is supplemented with information from a separate unit that senses vibration levels within the engine in order to diagnose engine health. The following parameters are the primary means of observing engine performance and are shown on every engine display format:

- Engine Pressure Ratio (EPR)
- Engine Low Pressure (LP) Rotor Speed
- Engine High Pressure (HP) Rotor Speed
- Turbine Gas Temperature (TGT)

NOTE:

HP rotor speed is replaced by a fuel quantity indication if only a single engine display window is selected for viewing.

Supplemental engine data related to engine performance but not directly employed in EEC control of engine operation are included in an optional secondary cockpit display format.

- Oil Pressure
- Oil Temperature
- LP Engine Vibration Monitor (EVM)
- HP Engine Vibration Monitor (EVM)
- Hydraulic Pressure for the Left, Right, and Auxiliary systems and the Power Transfer Unit (PTU)
- Fuel Tank Temperature
- Fuel Quantity

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- Fuel Flow

NOTE:

Although fuel flow may be considered the primary means of engine control since engine power levels are achieved through changes in fuel flow made by the Fuel Metering Unit (FMU), the engine power levers commands to the EEC are set in reference to either EPR or LP rpm with fuel flow considered the result of EEC response to power lever position.

A description of FADEC / EEC sensors and the measurement of other associated engine related data is contained in the appropriate sections of this manual. The Engine Vibration Monitoring (EVM) system is not integrated into EEC engine control and is described in the following paragraphs.

B. Subsystems, Units and Components:

The EVM system provides oversight of the mechanical health of the engines. Since turbofan engines operate at a very high rpm (HP rotor speed is 15,898 rpm at 100%) all rotating components must be very accurately balanced in order that centrifugal effects within the engine do not result in destructive forces. Even small amounts of vibration within the engine could be the precursor of catastrophic damage. The EVM system detects anomalies in engine rotational balance through dual accelerometers mounted side by side on the engine exterior. Only one (primary) accelerometer actively provides signals to the EVM system - the other (secondary) unit provides redundancy and may be selected for signal input in order to confirm abnormal vibration readings. The accelerometers detect vibration as a centripetal force (perpendicular to engine centrifugal force) induced by any out of balance component on the LP or HP rotors. The vibration is measured in inch/pounds per second and reported via low noise cable connections to the Engine Vibration Monitor Unit (EVMU) that is installed in the electronic equipment rack in the baggage compartment.

Since the LP and HP rotors are the only rotating assemblies within the engine and the rpm of each rotor is significantly different (LP rotor speed is 7,341 rpm at 100%) the period or frequency of any vibration can be readily associated one or the other rotors. The EVMU receives signals from the speed probes of each rotor that provide indications to the EEC. The EVMU is programmed to associate vibrational frequencies with rotor speed in order to provide an EVM reading for each rotor. The EVMU supplies readings for each rotor in both engines to the Modular Avionics Units (MAUs) - left engine readings to MAU #1, right engine to MAU #2. The MAUs forward the data to the Monitor and Warning System (MWS) for use in formatting engine displays and for generating Crew Advisory System (CAS) messages. If the vibration level on any of the rotors exceeds zero point eight (0.8) inches per second, the MWS will signal an amber "L-R Engine Exceedance" caution CAS message.

Operation of the EVM system may be tested by the flight crew prior to engine start using the ENG VIB MON TEST pushbutton on the SYSTEM TEST panel on the cockpit overhead, shown in Figure 6. When the pushbutton is depressed, the blue TEST legend within the button will

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illuminate, an EVM reading of 2.0 ± 0.2 is displayed on all selected Engine windows, and the amber "L-R Engine Exceedance" caution message will appear on the CAS window accompanied by the aural caution alert and illumination of the glareshield "C" caution indicator. The pushbutton immediately to the right of the TEST pushbutton is labeled PRI/SEC and when depressed will select the secondary accelerometer on the engine in order to confirm abnormal vibration readings. When selected, the blue legend SEC will illuminate within the pushbutton.

2. Engine Displays:

The G550 PlaneView™ display system incorporates four (4) Accelerated Graphics Modules (AGMs) capable of generating a large amount of graphic information at a rapid refresh rate for the cockpit displays. Because of the number of variables available on the display formats and the importance of color cues in graphic instrumentation, the primary reference for engine data display is Section 2B-07-00 of this manual. The following paragraphs document only the essential features of the engine displays.

NOTE:

The illustrations accompanying the following text are highly generalized and are shown only to indicate the areas where information is displayed on the appropriate 1/6 windows. No attempt has been made to depict actual engine operating conditions.

A. Default Display Format:

The normal configuration of formats shown on the four (4) cockpit Display Units (DUs) at initial application of full electrical power places the primary Engine 1/6 window in the top right section of DU #2 with the secondary Engine 1/6 window directly below in the bottom right of DU #2. In this configuration, the primary Engine window contains analog dial representations for EPR, TGT and LP rpm and digital indications for HP rpm and fuel flow (FF) with a split arrow icon showing differences in engine FF. See Figure 1. The secondary Engine 1/6 window will display only digital indications for the following engine parameters: oil pressure, oil temperature, LP and HP EVM, hydraulic pressures, fuel tank temperature and fuel quantity (a split arrow icon representing differences in tank quantities is also shown). See Figure 2.

B. Alternate Display Formats:

If for any reason the flight crew chooses to rearrange the default display format, the following options are available:

- (1) If the secondary Engine 1/6 window is eliminated from display, the primary Engine 1/6 window format will change to an Alternate Primary Engine 1/6 window display where the digital indications of HP rpm and fuel flow (and split arrow difference icon) are replaced with digital readings of fuel quantity including a total fuel indication and a split arrow tank difference icon. See Figure 3.

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- (2) A Compacted Engine 1/6 window may be elected for display - the window is automatically shown if only battery power is available for the aircraft electrical system. The compacted window contains digital indications for EPR, TGT, LP and HP rpm, FF, oil pressure, oil temperature and fuel quantity. See Figure 4.

C. Multi-function Control and Display Unit (MCDU) Engine Display:

In the event that a malfunction or failure prevents viewing engine readings on any of the Display Units, a standby engine instrumentation presentation is available on MCDU #1 only. The display is available with only battery power and consists of digital readings of EPR, TGT, LP and HP rpm, Fuel Flow (FF) and Fuel Quantity (FQ). The MCDU presentation is shown in Figure 5. The display is accessible by selecting the menu function key on MCDU #1, then choosing Standby Engine from the displayed menu with the Line Select Key (LSK),

D. Engine Associated Display Items:

The Primary Flight Display (PFD) will contain an indication of the current operating mode when the autothrottle system is engaged. The indication will appear in abbreviated text format at top center of the PFD window.

3. Controls and Indications:

(See Figure 6.)

A. Circuit Breakers (CBs):

The following CB powers an element of the engine indicating system:

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
ENG VIB MONITOR	REER	C-13	R MAIN DC Bus

B. Crew Alerting System (CAS) Messages:

CAS messages associated with the engine indication are:

Area Monitored:	CAS Message:	Message Color:
EEC	L-R Engine Exceedance	Red
EEC or EVMU	L-R Engine Exceedance	Amber

C.

D. Text Cues on Primary and Compacted Engine Windows:

Whenever engine sub-systems or engine related systems are operating, an abbreviated text icon is displayed on the Primary or Compacted Engine 1/6 window to alert the flight crew of a change that effects engine performance. The following table summarizes the text cues, however a full description is contained in Section 2B-07-00.

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System:	Indication:	Display Color:	Notes:
Anti-icing	A/I icon displayed between TGT and LP indications.	Green	Wing or cowl anti-icing is selected on.
Engine Alternate Control Mode	ALT icon displayed by LP indication.	Amber	EEC has reverted to alternate (LP rpm) control mode.
		Blue	Flight crew has selected alternate control mode.
Ignition	IGN icon displayed by HP indication.	Green	Ignition on during normal engine start. OR: Continuous ignition selected by flight crew. OR: EEC auto-relight function is active. OR: EEC inclement weather protection is active.
Starter Air Valve	SAV icon displayed by HP indication.	Blue	Starter air valve is open during engine start.
		Amber	Starter air valve has failed to close during engine start
Thrust Reverser	REV icon displayed by LP indication.	Blank	Thrust reverser stowed.
		White	Thrust reverser in transit.
		Green	Thrust reverser deployed (ground).
		Amber	Uncommanded thrust reverser deployment on ground.
		Red	Uncommanded thrust reverser deployment in flight. NOTE The EEC will automatically reduce power to idle on the engine with the deployed reverser.

4. Limitations:

A. Flight Manual Limitations:

- (1) General Engine Instrument Range Marking Colors
 - Normal Range Values: Green or White
 - Caution Range Values: Amber
 - Warning Range Values: Red

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(2) Powerplant Indications:

- ENGINE PRESSURE RATION (EPR):
No Limitation Markings
0.60 to 2.0: Pilot Selectable Command Marker
- TGT°C:
900°C and above: Red Arc
860°C to 900°C: Amber Arc
0 to 860°C: White Arc
- %LP RPM (LP):
101.1% and above: Red Arc
101.0% to 101.1%: Amber Arc
0 to 101.0%; White Arc
- %HP RPM (HP):
99.6% and above: Red Arc
98.9% to 99.6%: Amber Arc
0 to 98.9%; White Arc
- FUEL FLOW (FF):
No Limitation Markings
- OIL TEMPERATURE (OIL TEMP):
160°C and above: Red Digits
+20°C to 160°C: White Digits
-30°C to +19°C: Amber Digits
-31°C and below: Red Digits
- OIL PRESSURE (OIL PRESS):
35 psi and above: White Digits
26 to 34 psi: Amber Digits
0 to 25 psi: Red Digits
- ENGINE ANTI-ICE PRESSURE:
33 psi and above: Amber Digits

5. Operational Notes:

A. Criteria for Engine Shutdown:

High EVM indications should not be the sole criteria for engine shutdown. If EVM indications exceed 0.8 for LP and/or HP rotors, first confirm the reading by selecting the secondary accelerometer. If EVM remains excessive, retard the engine power lever to reduce EVM to an acceptable value. If high EVM readings are accompanied by other abnormal engine indications, the engine should be shut down.

When operating in icing conditions, high EVM readings may be expected as the engine sheds accumulations of frozen precipitation.

B. EVM Indications During Engine Start:

If the engine has been shut down for more than twenty (20) minutes but less than five (5) hours, temperatures at different areas within the engine

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will not be uniform and high EVM values during starting are not uncommon. The engine should be cranked at maximum HP rpm for thirty (30) seconds before selecting the FUEL CONTROL switch to ON. Cranking the engine distributes temperatures evenly throughout the engine.

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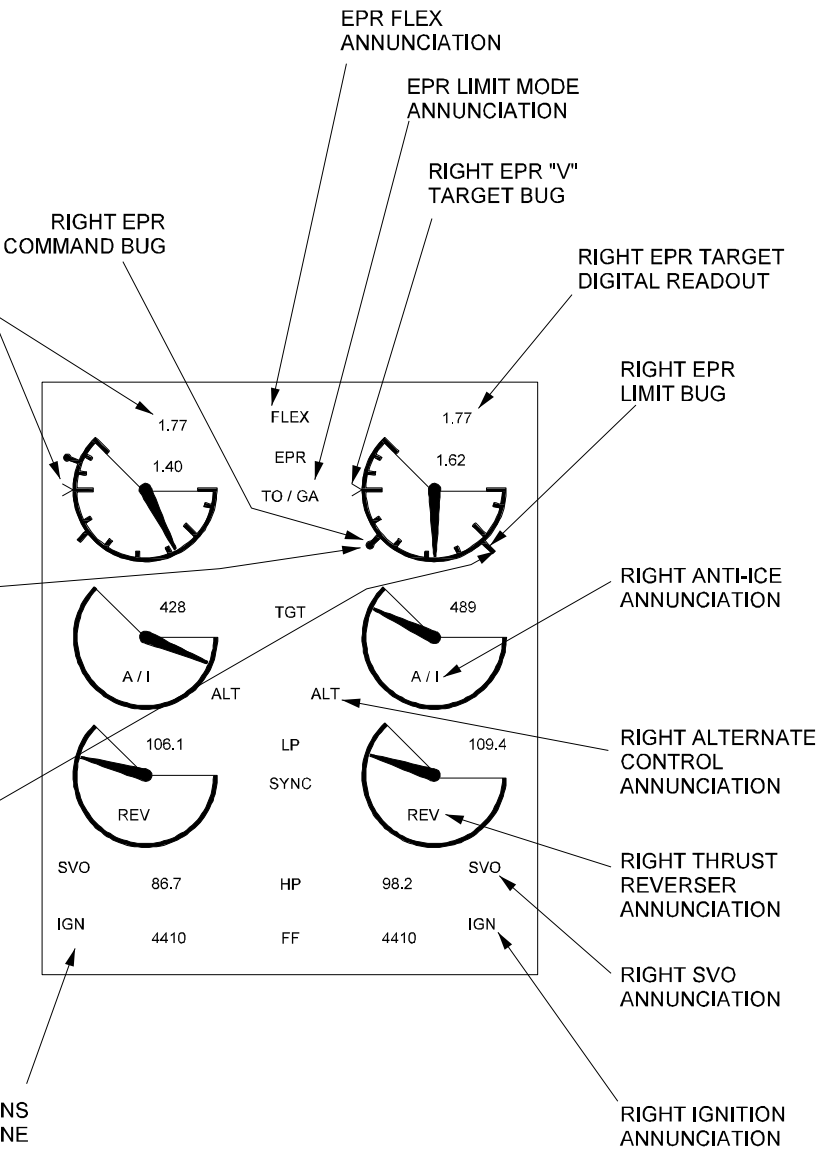
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EPR Target Bug and Digital Readout - The EPR target bug (V) is displayed on the outside of the EPR scale and its digital readout is displayed above the boxed EPR digital readout. The target bug value is the EPR required to operate the selected mode. This value is determined by the autothrottle system. When FLEX EPR mode is not selected, the bug (V) and digital readout are magenta. The magenta target bug and digital readout are not displayed if the aircraft is on the ground, or if AT is engaged, or if the autothrottle system does not have enough information to determine a target value. When FLEX EPR mode is selected, the bug (V) and digital readout are green. When AT is engaged in FLEX EPR mode, the V bug changes to I bug. The FLEX EPR target bug and digital readout are removed when FLEX mode is deselected or when either gear or flap is moved.

EPR Limit Bug - The white EPR limit bug (I) is displayed on the outside of the EPR scale. The limit bug value corresponds to the EPR limit for the given flight mode as selected from the thrust reference system menu on the display controller.

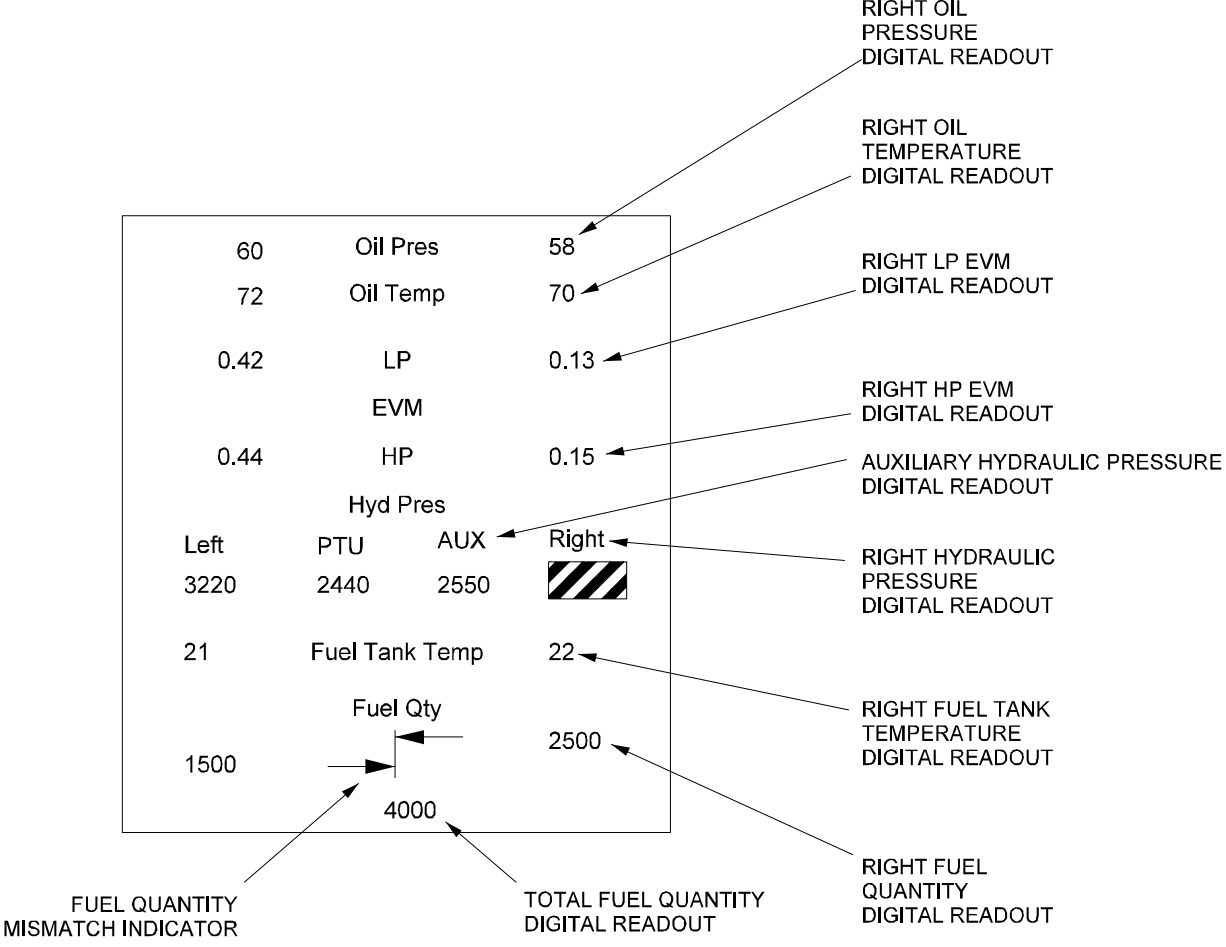
EPR Command Bug - The EPR command information is displayed as a white command bug (lollipop shaped) on the outside of the EPR scale. its value corresponds to the position of the throttle levers and it indicates the EPR that will be established after the engines have responded to a change in throttle position. Its position can range from the bottom of the scale (0.85) to the top of the scale (1.8). When the EPR command values are greater than 1.8, the bug parks at the top of the scale. When the EPR command values are less than 0.85, the bug parks at the bottom of the scale.

LEFT ENGINE INDICATIONS
IDENTICAL TO RIGHT ENGINE



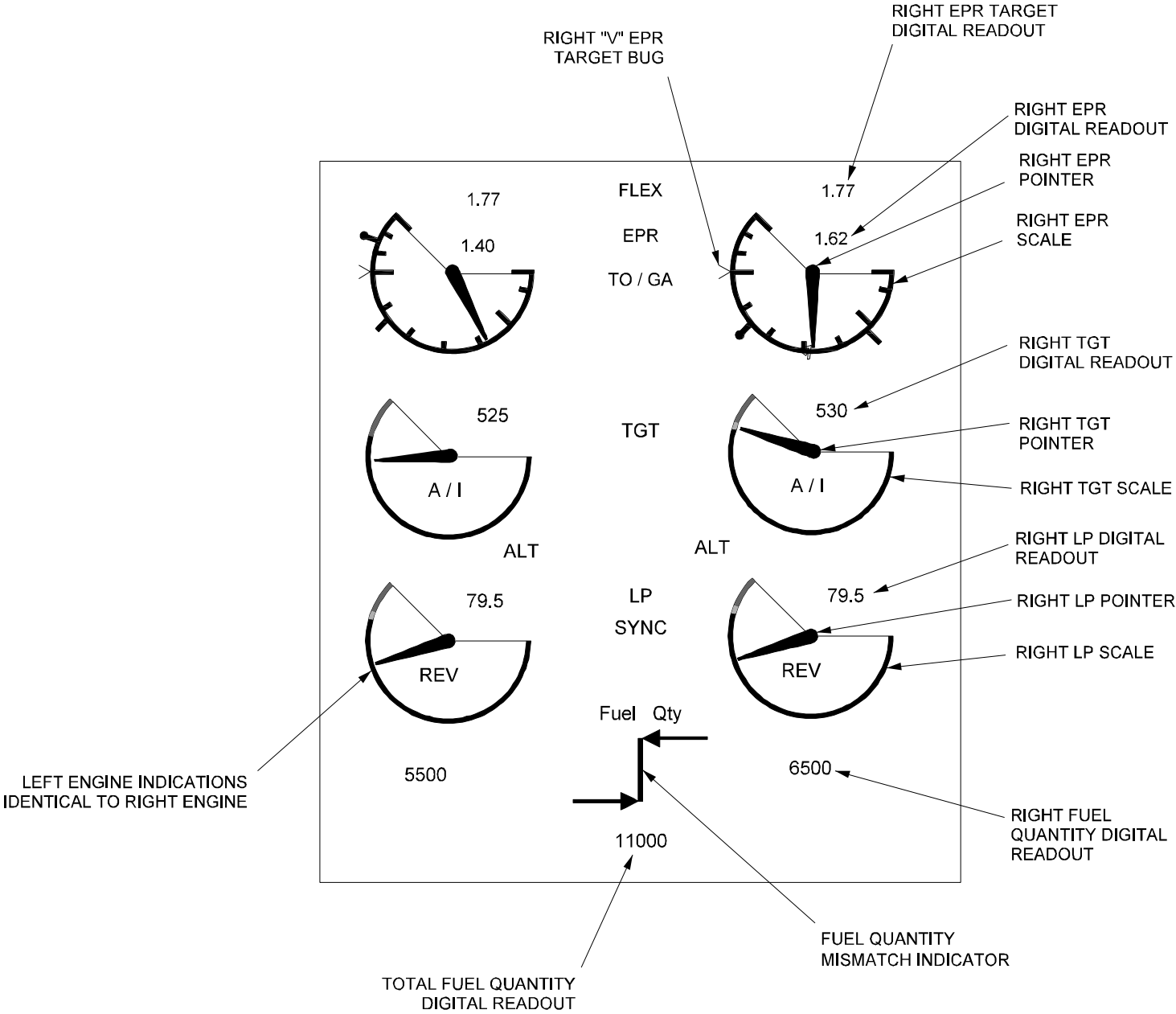
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Primary Engine Display
1/6 Window
Figure 1



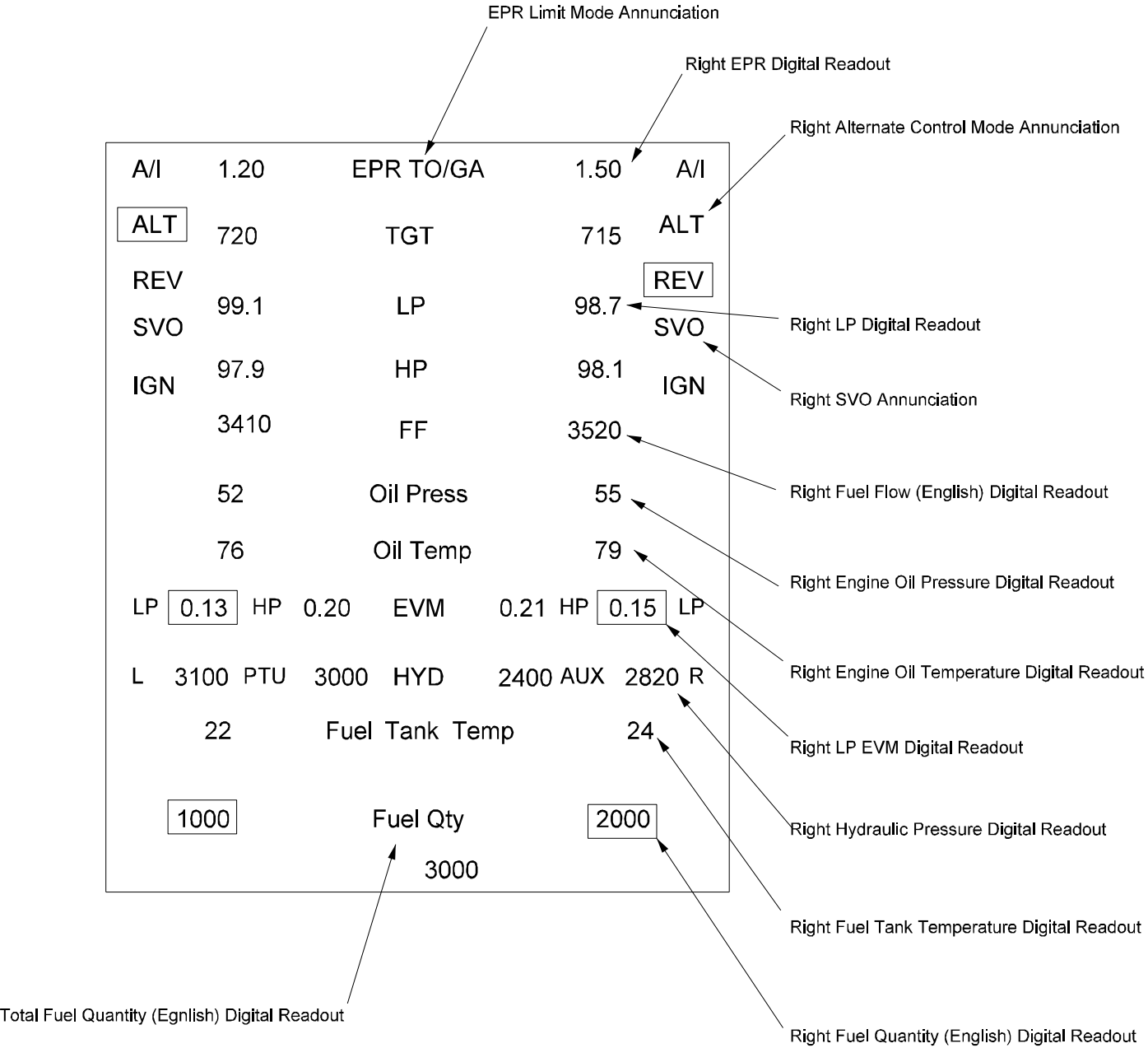
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Secondary Engine Display
1/6 Window
Figure 2



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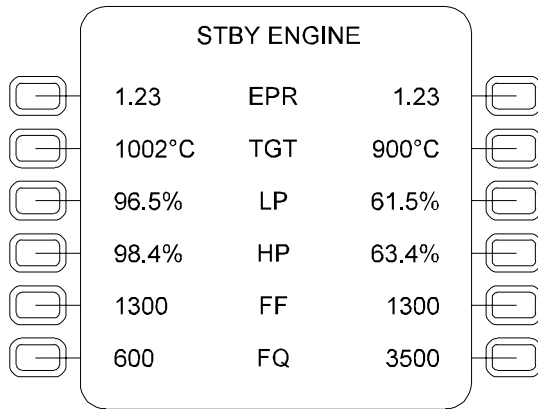
Alternate Primary Engine
Display 1/6 Window
Figure 3



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Compacted Engine
Display 1/6 Window
Figure 4

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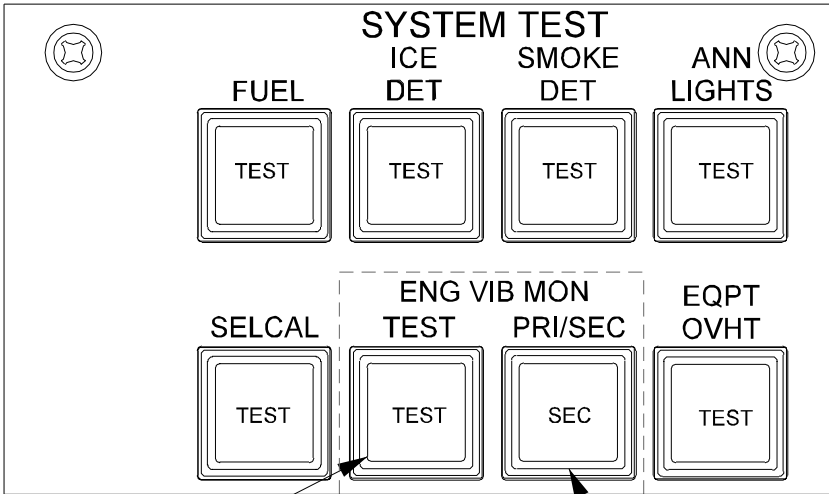
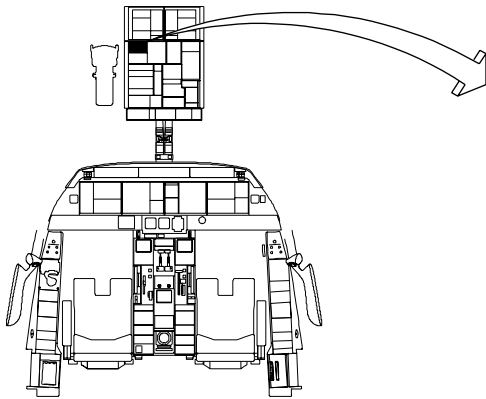


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MCDU Engine Display
Figure 5

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TEST

Momentary action switch used to test Primary (PRI) and Secondary (SEC) portions of EVM system.

When depressed:

- TEST legend illuminates blue.
- EVM indication on EICAS increases to 1.8 to 2.2 and color changes to amber.
- Amber L-R ENG EXCEEDANCE caution message is displayed on CAS. Associated aural tone sounds and caution reset switch on MASTER WARN panel on glareshield is illuminated.

When released:

- TEST legend extinguishes.
- EVM indication on EICAS decreases to original value and color changes to white when below 0.80.
- Amber L-R ENG EXCEEDANCE caution CAS message is extinguished. Associated annunciations cease.

PRI / SEC

Alternate action switch used to select Primary (PRI) or Secondary (SEC) EVM sensing system for testing or active use.

When extended (normal position):

- SEC legend extinguished.
- Primary EVM sensing system is active.

When depressed:

- SEC legend illuminated.
- Secondary EVM sensing system is active.

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Engine Vibration
Monitoring System
Controls
Figure 6

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