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AUTOFLIGHT, GENERAL

Introduction

The Automatic Flight Control System gives the fail passive automatic control of the airplane and indications for the manual control.

The Automatic Flight Control System (AFCS) does the functions that follow:

- Flight Director (FD)
- Autopilot (AP), pitch and roll axis
- Tactile Control Steering (TCS)
- Automatic pitch trim
- Yaw damping (YD), yaw axis
- Indication of AP disengagement.

Flight Director (FD): The Flight Director (FD) gives lateral and vertical guidance.

Autopilot (AP): The Autopilot (AP) uses data from the FD to move the aircraft control surfaces for automatic flight guidance control.

Tactile Control Steering (TCS): With the AP engaged, the TCS mode lets the pilots adjust Autopilot (AP) without disconnection.

Automatic Pitch Trim: The AFCS has two separate automatic pitch trim functions that follows:

- AP pitch trim
- Flap automatic pitch trim.

Flap: The flap auto pitch trim function decreases the mistrim force on the control columns when the AP is not engaged and the flaps are in transit.

Yaw Damper: The Yaw Damper (YD) stabilizes the aircraft on its yaw axis and is used for turn coordination.

General Description

Refer to Figure 1.

The AFCS has a dual flight director function, a single autopilot, and a single yaw damper.

The AFCS is capable of:

- All weather approach capability that is limited to Category I and II for ILS
- VOR approaches
- Front and back course localizer
- FMS approaches.

The pilots continuously have:

- The indication of the AFCS function engagement, and operational modes
- Priority over the AFCS for override and disengagement.

The AFCS control of the aircraft has limits for residual oscillations as follows:

- 0.6 degrees roll
- 0.6 degrees heading
- 0.02 g lateral acceleration
- 10 ft vertical
- 0.04 g vertical acceleration.

The AFCS Is a dual system that has interfaces with:

- Flight control system
- Flap control system
- Flight Data Processing System (FDPS)
- Electronic Flight Instrument System (EFIS)
- Air Data System (ADS)
- Attitude and Heading Reference System (AHRS)
- VHF navigation
- Radio altimeter
- Distance Measuring Equipment (DME)
- Flight Management System (FMS).

Special Tooling

- Actuator target (steel)
- De–actuator target (copper)
- Air data test set
- Adaptor socket
- Commercially available torque wrench.

The Automatic Flight Control System (AFCS) has the components that follow:

- Modules, Flight Guidance (22–11–01)
- Modules, Autopilot Monitor (22–11–06)
- Panel, Flight Guidance Control (22–11–11)
- Actuator, Roll (22–11–16)
- Capstan, Roll (22–11–21)
- Actuator, Pitch (22–11–26)
- Capstan, Pitch (22–11–31)
- Actuator, Yaw Damper (22–11–36)
- Lights, Autopilot Disconnect Warning (22–11–41).

The Automatic Flight Control System (AFCS) also has the components that are part of other assemblies as follows:

- Go Around (GA) Switches
- Tactile Control Steering (TCS) Switches
- Handwheel disconnect switches.

The two Flight Guidance Modules (FGM1, FGM2) operate independently to make calculations and control the systems that follow:

- FD
- AP and YD

– Automatic pitch trim.

Each FGM can independently calculate the FD commands but two FGMs are necessary to do the AP and YD functions. FGM1 supplies the actual commands to the AP and YD actuators and FGM2 monitors the commands and their operation. If FGM1 or FGM2 malfunctions, the AP disengages and is stopped from engaging.

The FD supplies the aircraft lateral and vertical guidance which is shown on the PFD1 and PFD2 for the manual control of the aircraft or connected to the AP for the automatic control of the aircraft.

FGM1 is energised by the left essential bus and FGM2 is energised by the right main bus.

The FGCP has two channels. The left channel is energised by the left essential bus and the right channel is energised by the right main bus.

The AP pitch and roll actuators and the YD actuator are energised by the left main bus.

The three actuators interface with the flight controls system.

The FGMs are installed in the Integrated Flight Cabinets (IFCs). Electrical power is supplied to the FGMs through a Primary Power Supply Module (PPSM) in the IFCs.

The Flight Guidance Control Panel (FGCP) is used to make mode, target, navigation source, and autopilot and yaw dampener engagement selections.

The Yaw Damper Actuator Unit (YDAU) is an electrical linear actuator. It is summed in series with the manual rudder pedal inputs to control the rudder when the YD is engaged.

The pitch and roll Autopilot Actuator Units (APAUs) have a separate rotary servo motor and capstan. They move the control columns and handwheels through cables when the AP is engaged. The APAU is the same for the pitch and roll axes.

There are two autopilot disconnect switches. One autopilot disconnect pushbutton switch or the other is used to disconnect the AP or to cancel an AP or YD disengage warning. The switches located on the outboard on the pilot's and copilot's handwheels.

There are two Tactile Control Steering (TCS) pushbutton switches. One TCS pushbutton switch or the other is used to momentarily override the AP without disengaging it or to change FD targets in some FD modes.

There are two Go Around (GA) pushbutton switches to disengage the AP and select the GA FD mode (wings level). The GA pushbutton switches are located on the outboard sides of the two power levers.

Two AP disengage warning are used to show an automatic AP disengage caused by a malfunction. The lights are located on the glareshield panel. The Flight Mode Annunciators (FMAs) located on the Primary Flight Displays (PFDs), show other AFCS annunciations.

Detailed Description

Operational Mode: The operational mode has the modes that follow:

– Flight Director (FD)

– Autopilot (AP)

– Tactile Control Steering (TCS)

– Yaw Damper (YD)

– Automatic pitch trim.

The AFCS operates when the conditions that follow are correct:

– Indicated Air Speed is more than 1.2 VSR stall reference and less than 290 KIAS
– Cruise altitude between 0 and 27,000 ft
– Decision height (DH) is 100 ft (Category II approaches)
– Minimum Use Height (MUH) is more than 50 ft (TBC).

The YD cannot be engaged when the aircraft roll attitude is more than ± 45 degrees.

The AP cannot be engaged when the aircraft roll attitude is more than ± 45 degrees, or the aircraft pitch attitude is more than ± 20 degrees.

The YD always engages with an AP selection but the YD can be engaged without the AP.

The AFCS automatically synchronizes FD commands for FD mode transitions to minimize transient inputs to the control surfaces at the moment of the mode transitions. Similarly, before AP engagement, the AFCS automatically synchronizes to the existing aircraft pitch and roll attitude to minimize transient inputs to the control surfaces at the moment of AP engagement.

For aircraft acceleration, the AFCS commands have limits that follows:

– Maximum load factor in pitch, 0.2 g
– Maximum roll angular acceleration, ± 4 degrees/second^2
– Maximum yaw angular acceleration, ± 8 degrees/second^2.

Flight Director: The Flight Director (FD) aircraft lateral and vertical guidance indications are shown on the PFDs for manual control the aircraft. It is coupled to the autopilot for automatic control of the aircraft.

Each FGM can independently control the FD function. They function as a master and slave in the Flight Director (FD) mode. The FGM1 is master and FGM2 is slave. (The FGM2 slaves to the FGM1 FD modes.) If FGM1 malfunctions, FGM2 automatically becomes the master and the FD mode continues to operate. One FGM is necessary for the FD function. If one FGM malfunctions, the autopilot cannot be engaged.

The Flight Guidance Modules have the functions that follow:

– FD mode selections
– FD command calculations
– Sensor selection and monitoring.

Only one FGM is necessary to do the FD function.

The FD has the limits that follow:

– 25 degrees for pitch
– 50 degrees for roll.

The FD armed and active mode annunciations and command bars go out of a view when the aircraft attitude is more than the limits and the AP is not engaged. If the AP is engaged and the aircraft attitude goes more than the limits, the FD modes automatically goes to the lateral basic and pitch hold modes, and armed modes must be cleared. FD mode selections are stopped if the aircraft attitude is more than the limits. FD modes must be re–selected when the aircraft attitude is again less than the limits.

The FD commands are shown in a single cue format (inverted V–bar) or a cross–bar pointer format (double cue) on the PFD. The selection between the two FD indication options are set by the Aircraft Configuration Modules (ACM1 and ACM2) programming.

The FD has active and armed modes. An active FD mode supplies guidance for the indication on the PFD, and for the coupling to the AP. The armed FD mode is waiting for necessary conditions to be satisfied. It will automatically replace the previous active mode if conditions are satisfied.

If FGM1 senses an internal defect that prevents the FD operation, FGM2 becomes the master, the FD modes are cleared, and the FD command bars go out of view.

If FGM1 is correct again, it again becomes the master, the FD modes are cleared, and the FD command bars go out of view. The switching between FGM1 and FGM2 occur automatically.

FGM1 and FGM2 use the data shown on PFD1 or PFD2 for the calculation of FD guidance commands. The HSI SEL pushbutton switch is set to the pilot flying and the light in the arrow adjacent to the HSI SEL push button switch shows the PFD selection. In the dual FD mode FGM1 uses the No. 1 sensors, and FGM2 uses the No. 2 side sensors.

A malfunction of a sensor input necessary for the calculation of an armed or active FD mode causes the FD mode to clear. If the pilots try to make a selection for a mode with data that is not applicable, no mode change occurs and a message is shown on the PFD.

A mismatch between sensors does not clear the FD mode because FGM1 and FGM2 will use the selected side data. But, in the dual FD mode, a mismatch between the two VHF navigation sensors clears the dual FD mode.

Only one AHRS valid or one ADC valid is necessary for the FD command calculations.

The FD is engaged by one of the selections that follow:

- Lateral FD mode on the FGCP (also engages the FD vertical basic mode)
- Vertical FD mode on the FGCP (also engages the FD lateral basic mode)
- Go Around (GA), lateral and vertical FD modes
- Autopilot, lateral and vertical FD modes.

FGM1 and FGM2 supply these parameters to PFD1 and PFD2 for the indication:

- Pitch and roll commands as the FD bars on the attitude direction indicator
- Pitch and roll, active and armed modes messages in the Flight Mode Annunciator (FMA)
- AFCS messages in the FMA.

PFD1 and PFD2 show the FD command bars and messages from the master FGM. FD data from FGM2 is shown on PFD1 and PFD2 only if FGM1 is defective.

In dual FD mode, PFD1 show FD command bars and messages from FGM1, and PFD2 shows FD command bars and messages from FGM2.

Refer to Figure 2.

The Flight Guidance Control Panel and the Go Around mode switches are used to make FD mode selections. The two FGMs receive inputs from the FGCP and the GA switches.

A FD mode or autopilot selection automatically engages the FD.

It uses the shown PFD parameters that follow:

- Air Data Unit (ADU1, ADU2)
- Attitude and Heading Reference System (AHRS1, AHRS2)
- Navigation (NAV1, NAV2, ILS1, ILS2, FMS1, FMS2)
- Course targets
- Heading targets.

Refer to Figure 3.

FGM1 and FGM2 supply these parameters to PFD1 and PFD2 for the indication:

- Pitch and roll commands as the FD bars on the attitude direction indicator
- Pitch and roll, active and armed modes messages in the Flight Mode Annunciator (FMA)
- AFCS messages in the FMA

The two PFDs show the FD command bars and mode annunciations from the master FGM. If both FGMs are serviceable, the FD data from FGM1 is shown on the two PFDs. The FD data from FGM2 is only shown on the two PFD when FGM1 has malfunctioned.

In the dual FD mode, PFD1 shows FD command bars and mode annunciations from FGM1, and PFD2 shows FD command bars and mode annunciations from FGM2.

The FD lateral armed and active modes are shown in the left part of the FMA and the vertical arm and active modes are shown in the right side.

Some modes have the phases that follow:

- Arm
- Capture
- Track.

All FD modes are disengaged by one of the selections that follow:

- HSI SEL (no effect in dual FD mode)
- AHRU reversion selection
- ADU reversion selection
- STBY.

All FD modes are inhibited, disengaged, and disarmed by one of the malfunction of the set AHRU attitude data or ADU airspeed data.

All FD modes are inhibited, disengaged, and disarmed if the aircraft angle for pitch is more than 25 degrees or 50 degrees for roll.

An inhibit condition for all FD modes is set when the Tactile Control Steering (TCS) is active. This condition does not prevent an automatic mode change.

The FD has the modes that follow:

Lateral modes

- Lateral basic mode
- Roll hold sub mode > 6 degrees
- Wings level sub mode< 6 degrees
- Heading hold sub mode
- Heading select mode

- VOR mode
- VOR approach mode
- Localizer mode
- Back course localizer mode
- FMS LNAV mode (optional).

Vertical modes

- Vertical basic (pitch hold) mode
- Altitude select mode
- Altitude hold mode
- Indicated airspeed mode
- Vertical speed mode
- FMS has VNAV (armed) and VNAV
- PATH (active) mode.

Combined lateral and vertical modes

- Go around
- ILS approach mode
- Dual FD sub mode.

Autopilot: The Autopilot (AP) moves the flight control surfaces for automatic control of the aircraft flight path.

The AP pushbutton switch on the FGCP is pushed to engage the autopilot and Yaw Damper (YD) if it is not engaged.

A malfunction condition that prevents the yaw damper from engaging also prevents the autopilot from engaging. A malfunction condition that causes the yaw damper to disengage also cause the autopilot to disengage.

The AP pushbutton switch on the FGCP is pushed to engage the autopilot.

- AHRS1 and AHRS2 are correct
- AHRS1 and AHRS2 parameters do not disagree
- ADC 1 and ADC 2 are correct
- ADC 1 and ADC 2 do parameters not disagree
- The aircraft is airborne
- The aircraft attitude is within the AP engagement limits (45 degrees roll angle and 20 degrees pitch angle)
- The manual pitch trim AP disconnect discrete signal is not set
- No AP disengage switch selection
- TCS mode has not malfunctioned
- TCS mode is not active
- The Stall Warning AP Disconnect discrete signals from SPM1 and SPM2 are not set
- No GA switch selection is not selected
- AP disengagement warnings are not active
- Yaw Damper function is available

– Internal AFCS monitoring is correct.

Refer to Figure 4.

The autopilot has other engagement indications that follow:

– Lights, FGCP
– AD INHIBIT message, PFD
– AP FAIL message, PFD.

Two arrows on each side of the AP pushbutton switch on the FGCP come on and an AP message in green letters is shown in the Flight Mode Annunciators (FMA) of PFD1 and PFD2.

An AP INHIBIT message is shown in white for 5 seconds in the FMA of PFD1 and PFD2 for an autopilot (AP) selection when an external condition prevents autopilot operation as follows:

– An Air Data Computer (ADC) does not supply a correct or the same altitude data to FGM1 and FGM2
– An Attitude and Heading Reference Unit (AHRU) does not supply a correct or the same attitude data to FGM1 and FGM2.

NOTE

The FMA of PFD1 and PFD2 will also show an FD ADC DATA INVLD or FD ATT DATA INVLD message.

NOTE

FD ADC DATA INVLD or FD ATT DATA INVLD messages are inhibited for ADC and AHRS source reversion selections.

The AP INHIBIT message will also come into view for the conditions that are not malfunctions as follows:

– The aircraft is not airborne
– Aircraft attitude is not in the engagement limits
– Manual pitch trim selection
– The AP DISENGAGE message is in view
– The Tactile Control Steering (TCS) mode is active
– The stick shaker or the pusher is in operation.

An AP FAIL message is shown in yellow in the FMA of PFD1 and PFD2 when there is an internal malfunction that prevents autopilot (AP) operation as follows:

– Flight Guidance Module (FGM1 or FGM2)
– Autopilot Actuator Unit – Pitch (APAU–P)
– Autopilot Actuator Unit – Roll (APAU–R).

NOTE

If the AP or Yaw Damper (YD) was engaged, an AP DISENGAGED message is shown until cancelled before this message is shown.

NOTE

The FMA in the PFD can also show the YD NOT CENTERED message.

The AP pushbutton switch on the FGCP is pushed again, or the YD pushbutton switch is pushed to disengage the autopilot.

The autopilot also disengages for a condition that follows:

– A/P DISpushbutton switches a selection on the handwheel
– NOSE UP or DN manual pitch trim selection on the handwheel (TCS is not active)
– GA pushbutton switch selection the power lever

- The manual override of the control column or handwheel
- Electrical power interruption.

Refer to Figure 5.

A yellow AP DISENGAGED or AP/YD DISENGAGED message also comes into view on the PFDs to show an automatic autopilot disengage condition. The AP DISENGAGED or AP/YD DISENGAGED message flashes until the AP pushbutton switch on the FGCP is pushed or an AP disengage pushbutton switch on the handwheel assemblies is pushed.

NOTE

The warning lights and messages go steady for 5 seconds before they go off and the two arrows on each side of the AP pushbutton switch on the FGCP go off.

NOTE

When the manual trim is used to disengage the autopilot, it is an automatic autopilot disengagement.

When the autopilot is manually disengaged, an AP DISENGAGED or AP/YD DISENGAGED message on the PFD comes into view steady for 5 seconds and a 1.5 second aural tone sounds.

NOTE

A manual AP disengage condition does not cause the AP disengage warning lights to come on.

Refer to Figure 6.

Tactile Control Steering (TCS): The TCS mode momentarily overrides the AP (without canceling the AP mode) to manually fly the aircraft to a new FD target.

A Tactile Control Steering (TCS) switch located on the pilot's and copilot's handwheels is pushed and held for TCS operation. If the autopilot mode is engaged, the pitch and roll AP actuators automatically de–clutch and the their monitoring is inhibited. This allows manual control of the pitch and roll flight controls with normal control forces while the autopilot mode engaged.

The FD command bars on PFD go out of view, the numeric values change to dashes, and a TCS message (white letters) is shown on the PFD. If the AP is engaged, the TCS indication replaces the AP message but the lights on the Flight Guidance Control Panel (FGCP) stay on.

When the TCS mode is active, manual selection of a new vertical or lateral FD mode is inhibited but automatic change from armed modes to capture modes, and from capture modes to track modes will occur.

NOTE

The AP is inhibited from engaging when the TCS mode is active.

When the TCS switch is released, the FD maintains the new target for the modes that follow:

- Roll hold submode of the lateral basic mode
- Pitch hold mode
- Altitude hold mode
- Indicated airspeed mode
- Vertical speed mode.

When the wings level submode mode is active and the TCS switch is released, the lateral mode automatically changes to the roll hold submode if the bank angle is more than 6 degrees.

All other FD modes return to their previously calculated targets when the TCS switch is released.

Automatic Pitch Trim: The AFCS automatic pitch trim function does the functions that follow:

- Autopilot pitch trim when the AP is engaged
- Flap auto pitch trim when the AP is not engaged and the flaps are moved.

Autopilot Pitch Trim: When the autopilot mode is engaged, the AFCS commands pitch trim to decrease the mistrim control column force held by the AP pitch servo to make sure that the pitch transient at AP disengagement is minimal.

The AP pitch trim function operates at two speeds:

- High speed trim when the Calibrated Airspeed (CAS) is less than 180 knots (334 km/h)
- Low speed trim when the CAS is more 180 knots (334 km/h).

High Speed Trim: The high speed trim gives the AP sufficient controllability during the conditions that follow:

- Flaps extension or retraction
- Landing gear extension or retraction
- Accelerations and decelerations
- Or, combinations of the above.

Low Speed Trim: The low speed trim gives the AP sufficient precision when a small trim motion has a large effect.

Flap Auto Pitch Trim: The flap auto pitch trim function reduces the mistrim control column force during flap extension or retraction while a pilot is manually flying the aircraft.

The control column force held by the pilot during extension or retraction of the flaps is less than 50 lb (23 kg). The flap auto pitch trim function automatically trims the elevator control system to decrease the control column force the pilot must input to maintain attitude during flap movement.

The flap auto pitch trim function automatically engages when the conditions that follow are correct:

- The aircraft is airborne for two seconds or more
- CAS is less than 180 knots (334 km/h)
- The autopilot is not engaged
- No manual pitch trim selection
- The flaps are moving and between the 15 and 35 degree detents.

The flap auto pitch trim function is automatically disengaged by the one of the conditions that follows:

- The aircraft is on ground
- CAS is more than 180 knots (334 km/h)
- The autopilot is engaged
- A manual pitch trim selection
- The flaps are not in motion
- The flap auto pitch trim function is commanding a pitch trim more than the trim limits.

There is no indication for flap auto pitch trim operation. If the flap auto pitch trim function has malfunctioned because of an input monitor, output monitor, or an AFCS malfunction, an amber AUTO TRIM FAIL message is shown on the PFD.

Yaw Damper: The Yaw Damper (YD) controls of the rudder to dampen Dutch roll and turn coordination.

The YD commands are limited by software as a function of airspeed and it is limited to a maximum of +4.5 degrees of rudder movement by mechanical stops.

The YD can be engaged while the aircraft is on the ground or airborne.

The YD mode is engaged by a YD or AP pushbutton switch selection on the FGCP. The YD pushbutton switch is monitored to sense a stuck condition. If a stuck YD pushbutton switch is sensed, the YD will automatically disengage.

An AP engage selection automatically causes the YD to engage. An AP disengage selection will not cause the YD to disengage but a YD disengage selection will automatically cause the autopilot to disengage.

The YD or AP pushbutton switch on the FGCP is pushed to engage the YD when the conditions that follow are correct:

- AHRS1 and AHRS2 are correct
- AHRS1 and AHRS2 parameters do not disagree
- ADC1 and ADC2 are correct
- ADC1 and ADC2 parameters do not disagree
- The aircraft attitude is within the YD engagement limits (45 degrees roll angle)
- Internal AFCS monitoring is correct
- The YD DISENGAGE message is not active.

The yaw damper function is automatically disengaged by the one of the conditions that follows:

- AHRS1 or AHRS 2 has malfunctioned
- AHRS1 and AHRS2 parameters disagree
- ADC1 or ADC2 has malfunctioned
- A Yaw Damper actuator malfunction is sensed
- The YD pushbutton switch on the FGCP is pushed for manual disengagement
- YD Pushbutton switch is stuck
- Internal AFCS monitoring has malfunctioned
- A long power interruption
- APAU roll position becomes invalid.

The yaw damper has the engagement indications that follow:

- Lights, FGCP
- YD INHIBIT message, PFD
- AP/YD FAIL message, PFD.

A yellow YD DISENGAGED or AP/YD DISENGAGED message comes into view on the PFDs to show an automatic yaw damper disengage condition. The YD DISENGAGED or AP/YD DISENGAGED message flashes until the YD push button switch on the FGCP is pushed or an AP disengage push button switch on the hand wheel assemblies is pushed. The YD messages then stay on stable for five seconds before they go out of a view.

When the yaw damper is manually disengaged, an YD DISENGAGED or AP/YD DISENGAGED message on the PFD comes into view stable for 5 seconds.

The A/P disconnect push button switch on the pilot or copilot hand wheel is pushed to cancel the indication. The two arrows on each side of the AP push button switch on the FGCP go off.

The yaw damper actuator is automatically re–centered after an automatic or manual YD disengagement.

If the YD is not engaged and the yaw damper actuator is not in a centre position, a yellow YD NOT CENTERED message is shown on the PFD.

The FMA in the PFD can also show a message that follows:

- AP FAIL
- AP/YD FAIL.

Maintenance Mode: The Built In Test Equipment (BITE) uses the Central Diagnostic System (CDS) to give the condition of the component. It saves faults in a Non Volatile Memory (NVM) for reporting to the line and shop maintenance.

The Auto Flight Control System (AFCS) has internal and external interfaces.

Internal Interfaces: The AFCS has the internal interfaces that follow:

- Flight Guidance Control Panel to FGM
- FGM to FGM
- FGM to Yaw Damper Actuator Unit
- FGM to Autopilot Actuator Units
- Autopilot Disconnect Switches to FGMs
- TCS Switches to FGMs
- Go Around Switches to FGMs
- FGMs to Autopilot Disengage Warning Lights.

External Interfaces: The AFCS has the external interfaces follow:

- AHRS inputs to the AFCS
- ADU inputs to the AFCS
- VHF NAV inputs to the AFCS
- MLS inputs to the AFCS
- PSEU inputs to the AFCS
- FCS ECU to the AFCS
- SPS to AFCS
- FCU to AFCS
- FGMs to Displays (EIS)
- FDPS to AFCS.

Flight Guidance Control Panel (FGCP)

Refer to Figure 7.

The Flight Guidance Control Panel (FGCP) is installed in the glare shield panel with the screws.

The control panel has a front module and two interface boards. Each board uses an ARINC 429 bus to transmit the data received from the selections (push buttons, rotary switches, optical encoders) on the front face module and the local data from the interface board.

Program pins (PINPROG) at power–up, configure to operate in ARINC 429 high speed mode.

Also, the interface board supplies filtered aircraft 28 VDC for push button legends and 5 VDC dimming voltages for the front face lighting.

The front face of the FGCP has the control knobs that follow:

- HDG, left and right heading selector rotary knobs
- CRS, left and right course selector rotary knobs
- NAV SOURCE, left and right navigation source selector rotary switches
- ALT, altitude selector rotary knob
- NOSE DN and NOSE UP, pitch thumb wheel.

Each knob is clearly labelled to show its function. The course knobs are also etched with bearing pointer symbols and the heading knobs are etched with heading bug symbols to help show their functions. The NOSE DN and NOSE UP label above and below the thumb wheel show its direction of operation.

The front face of the FGCP also has the pushbutton switches that follow:

- IAS, Indicated Airspeed
- VS, Vertical Speed
- VNAV, Vertical Navigation
- ALT, Altitude Hold
- ALT SEL, Altitude Select
- HDG, Heading
- NAV, Navigation
- APPR, Approach
- BC, Back Course Localizer
- STBY, Standby
- AP, Autopilot Engage
- YD, Yaw Damper Engage
- HSI SEL, HSI Select
- Lighting for status indicator.

The Flight Guidance Control Panel (FGCP) weighs 3.75 lb (1.70 kg) and is attached to the centre part of the glareshield panel with four DZUS fasteners.

The FGCP has the functions that follow:

- Engagement of the autopilot and yaw damper
- Set flight targets
- FD modes selection
- Navigation source selection.

Flight Mode Annunciator (FMA): The FMA has five columns and three lines to show:

- Lateral mode armed
- Lateral mode engaged
- Vertical mode armed
- Vertical mode engaged
- Selected IAS numeric value

- Selected VS numeric value
- Mismatch message
- AFCS general messages
- AP / YD status messages
- Flight Director abnormal conditions
- TCS or AP engagement
- HSI SEL message and FD engagement status.

Flight Guidance Module (FGM)

Refer to Figure 8.

The Flight Guidance Modules (FGM1, FGM2) are installed in their related Integrated Flight Cabinet (IFC1, IFC2). Each IFC contains a FGM, Stall Protection Module (SPM), Input Output Module (IOM), Input Output Processor (IOP), and a Primary Power Supply Module (PPSM).

The FGM has the two electronic circuit boards that follow:

- CPU Board (main power supply, processing unit, ARINC and discrete inputs and outputs interfacing)
- Extension Board (AFCS discrete and analogue inputs and output interfaces, AP and YD hardware logic).

The extension board is only necessary for the AP and YD functions. So, the FD functions can be used without the extension board, except for the TCS function. With this construction, it is possible to have a malfunction of the FD and still have AP/YD operation.

The flight guidance module has the modes that follow:

- Initialization
- Power on self test (POST)
- Line operational
- Maintenance
- Teleloading.

The FGM weighs 4.40 lb (2 kg). The IFCs are installed in the Avionics Rack between body stations X20.32 and X31.95. The FGM slides into the IFC using a guide rail, with top and bottom guide pins at the IFC backpanel to ensure precise mating of the FGM to the backpanel. The FGM and the IFC use mechanical keying to ensure that the FGM is inserted into the correct slot of the IFC, and not some other LRM. The FGM is held into place in the IFC using front locking levers that allow easy insertion and extraction of the FGM without requiring any tools.

Yaw Damper Actuator Unit (YDAU)

Refer to Figure 9.

The actuator is installed in the rear of the vertical stabilizer.

One rod end of the yaw damper actuator is attached to the structure and the other to the fork end assembly of the rudder feel and summing unit.

NOTE

The shaft of the actuator needs to be at the electrical middle position when it is installed. During the shutdown sequence, the flight guidance module sends a centring command. This operates the yaw damper actuator to the middle position.

The Yaw Damper Actuator Unit (YDAU) uses electrical commands from the FGMs to give a linear mechanical input to the rudder control system. The YDAU inputs are summed in series with the pilot inputs from the rudder pedals.

The YDAU has the components that follow:

- Housing
- Brushless dc motor
- Reduction gearing
- Mechanical torque limiter
- Irreversible screw and nut mechanism
- Mechanical stops
- Dual potentiometer
- Electronic circuits.

There is no brake or engagement clutch. The output ram is irreversible and cannot be back driven when the YD is disengaged. The mechanical torque limiter protects the motor and gear train when the YDAU is driven into the mechanical travel limit stops.

The stroke of the YDAU relates to 4.5 degrees of rudder movement.

The YDAU supplies a linear movement of the actuator ram.

Roll Autopilot Actuator Unit (APAU)

Refer to Figure 10.

The AFCS uses the same APAUs for the roll and pitch axis.

The roll actuator is installed below the floor of the flight compartment.

NOTE

The actuators and capstans are connected in parallel with the aileron and elevator systems with cables.

The APAU assembly has an APAU actuator connected to an APAU capstan. The APAU actuator supplies the actual rotary motions when commanded by the FGMs and the APAU capstan gives the mechanical interface to the aircraft elevator or roll control system.

The APAU is a rotary output electromechanical actuator.

The APAU actuator has of the components that follow:

- Housing
- Brushless DC Motor
- Electromechanical Engage Clutch
- 2 gearing stages
- Power Electronics Assembly
- Output Shaft
- Dual Potentiometers
- Electronic Board.

The motor drives an output shaft through two stages of reduction gears with an engagement clutch located between the gear stages. When the actuator is disengaged the second stage gears rotate with the capstan while the first stage stays stationary with the motor.

NOTE

The breakout force of an engaged APAU is the same as 40 lb (18.14 kg) at the control column and 17.5 lb (8 kg) at the hand wheel.

The FGM1 engages the APAU by commanding the clutch. FGM2 can prevent the APAU operation by supplying an inhibit discrete signal to remove electrical power from the motor.

The APAU actuator uses current limiting to limit the maximum torque that can be supplied to the APAU to the flight controls. The current limiting value is different for the pitch and roll actuators, as set by a pin programming input from the aircraft wiring. The APAU actuators also measure the actual torque applied and they supply two torque values to the FGMs.

The roll APAU actuator weighs approximately 2.79 lb (1.27 kg). It is attached to the roll capstan with four mounting bolts. The roll capstan is attached to the aileron forward quadrant with four mounting bolts at body station X41.8.

Roll Capstan

Refer to Figure 11.

The AFCS uses the same capstans for the roll and pitch axis.

The capstan for roll is installed below the floor of the flight compartment. It attaches to the forward aileron quadrant with cables and two turnbuckles.

The APAU capstan is a mechanical assembly that takes an input from the output shaft of the APAU actuator and supplies an output to the aileron control system cables. The APAU capstan has an override slip clutch to let the cable drum to turn if a jam or seizure condition exits.

The APAU Capstan has the components that follow:

- Bracket
- Shaft
- Bearing
- Drum
- Override Clutch
- Gasket
- Cable Keeper
- Torque Limiter (mechanical friction device)
- Mounting Plate.

The capstan is a mechanical coupling between the spline output shaft of the autopilot actuator unit and the driving pulley (drum) of the control cable, which is connected to the aircraft flight control system through cables.

NOTE

The peak override torque (breakout) of the capstan is the same as 56 lb (25.40 kg) at the control column and 39 lb (17.69 kg) at the hand wheel.

NOTE

The running torque, after a breakout, is approximately 20% less than the peak override breakout force. There will be a small difference near the neutral position because the mechanical control system is non–linear.

The override clutch is a slip clutch that is adjustable between 62 lbf·in (7 N·m) and 150 lbs·in (16.95 N·m). The nominal override peak torque is set to 135 lbs·in (15.25 N·m) which is the same as 56 lbf (249 N). at the control column. The running torque is approximately 80% of the peak torque.

The roll actuator is attached to the roll capstan with four mounting bolts at body station X41.8.

Pitch Autopilot Actuator Unit (APAU)

Refer to Figure 12.

The AFCS uses the same APAUs for the roll and pitch axis.

The pitch actuator is installed in the vertical stabilizer.

The pitch APAU actuator is attached to the pitch capstan with four mounting bolts at body station X990.7.

Pitch Capstan

Refer to Figure 13.

The AFCS uses the same capstans for the roll and pitch axis, but it is necessary to adjust the cable guard posts (four locations) on the capstan for the pitch location.

The capstan for pitch is installed in the rear of the vertical stabilizer. It attaches to the elevator quadrant with cables and one turnbuckle.

The override clutch is a slip clutch that is adjustable between 62 lbf·in (7 N·m) and 150 lbf·in (16.95 N·m). The nominal override peak torque is set to 135 lbf·in (15.25 N·m) which is the same as 39 lbf (173 N) at the handwheel. The running torque is approximately 80% of the peak torque.

The pitch APAU actuator is attached to the pitch capstan with four mounting bolts at body station X990.7.

AP Disengage Pushbutton Switches

The AP disengage pushbutton switches have the functions that follow:

- To disengaging the autopilot
- Reset the autopilot disengage warnings.

Two red AP disengage pushbutton switches give a remote disengage selection of the AP and YD modes. The switch selection supplies a discrete input to the Flight Guidance Modules (FGM1, FGM2).

The AP disengage pushbutton switch is a device that opens or closes the electrical circuit. It is a usually open and pushed momentarily for close.

TCS Switches

Two black TCS pushbutton switches give a selection of the TCS mode. The switch selection supplies a discrete input to the Flight Guidance Modules (FGM1, FGM2).

The TCS pushbutton switch is a device that opens or closes the electrical circuit. It is a usually open and pushed momentarily for close.

The TCS pushbutton switches are attached to the outboard part of the pilot's and copilot's handwheel assemblies.

Go Around Switches

Two black GA pushbutton switches give a selection of the GA FD mode. The switch selection supplies a discrete input to the Flight Guidance Modules (FGM1, FGM2).

The GA pushbutton switch is a device that opens or closes the electrical circuit. It is a usually open and pushed momentarily for close.

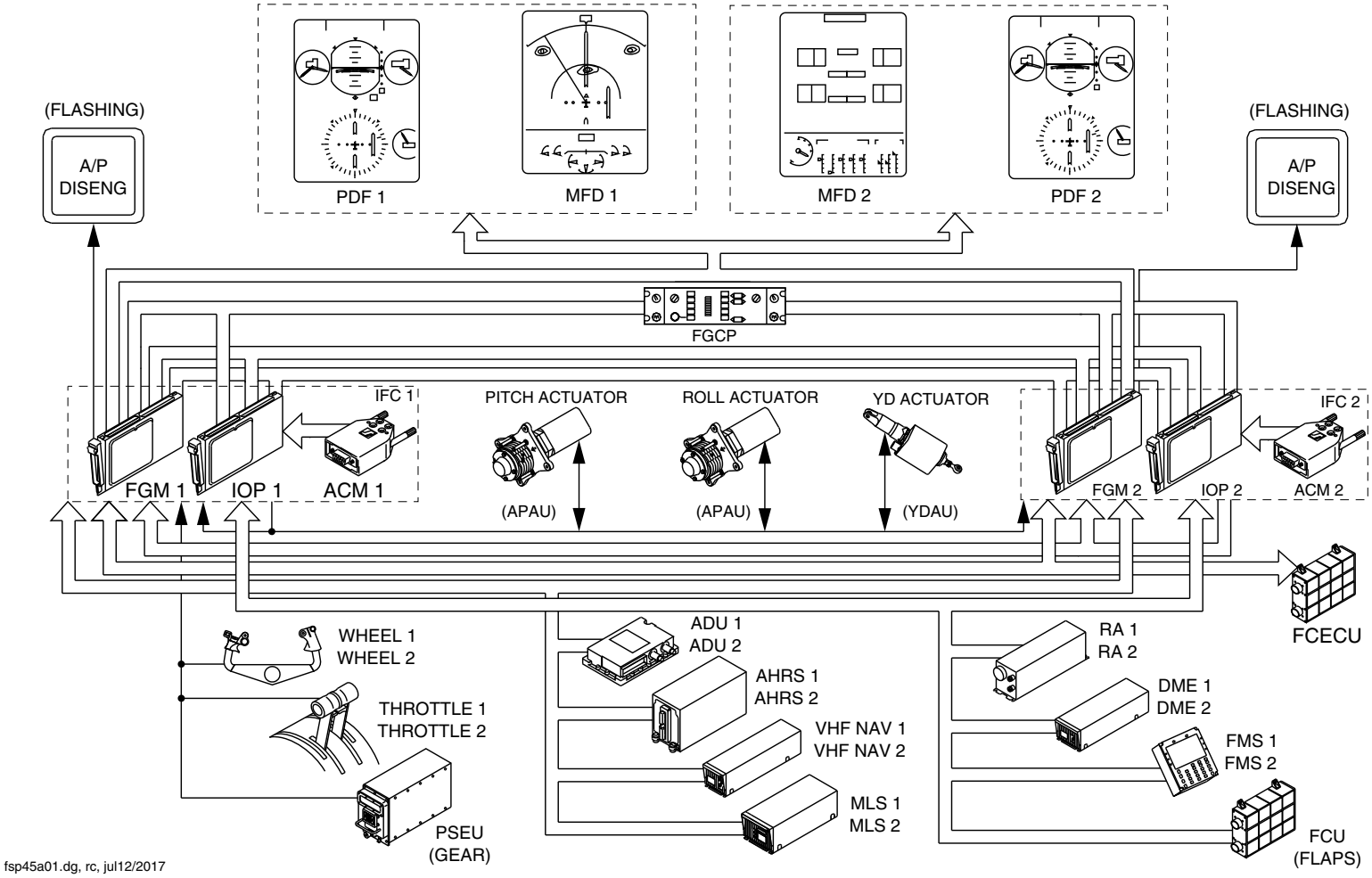
The GA pushbutton switches are attached to the outboard part of the engine power lever.

AP Disengage Warning Lights

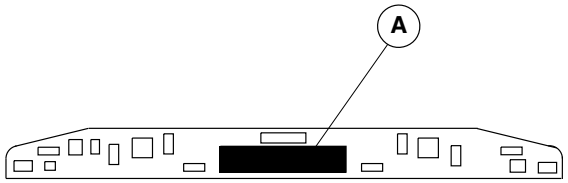
The A/P DISENG warning lights shows an AP disengage condition.

The AP disengage warning lights are attached to the glareshield panel in front of the pilot and copilot in the flight compartment.

The lens is pulled straight out and then tilted down to give access to screws to disengage the clips.



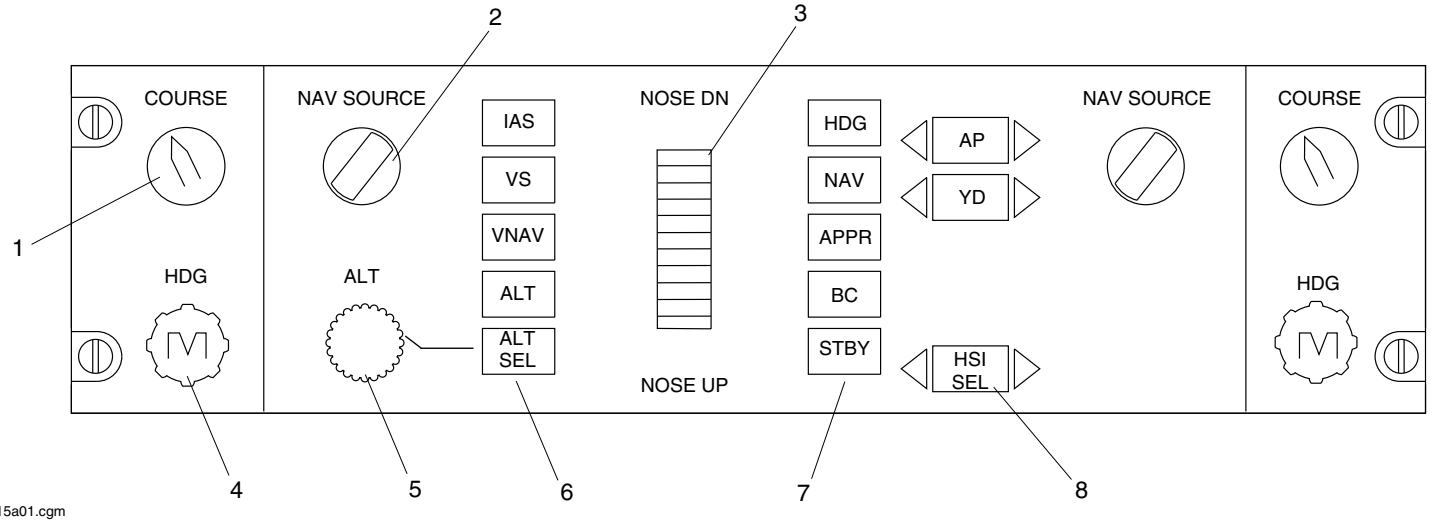
AFCS Block Diagram
Figure 1



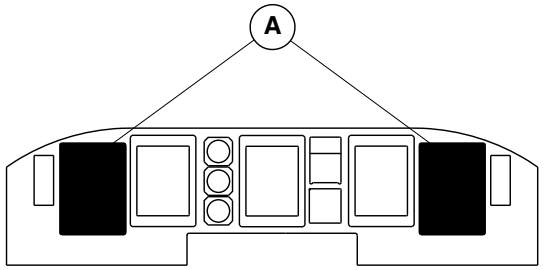
GLARESHIELD PANEL

LEGEND

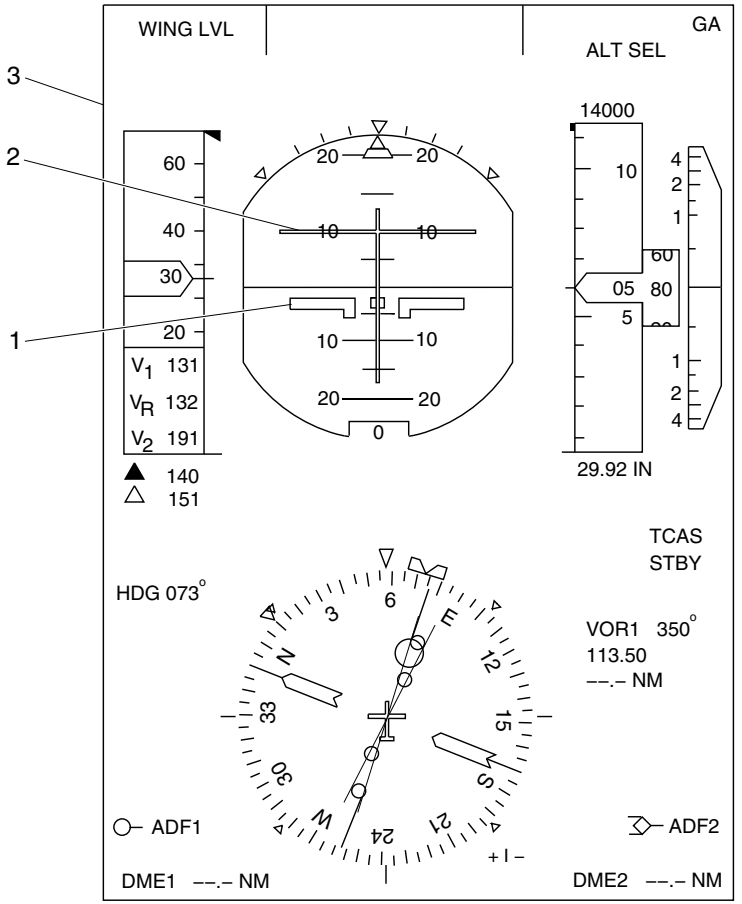
1. COURSE Knob.
2. NAV SOURCE Rotary Switch.
3. NOSE DN/NOSE UP Thumb Switch.
4. HDG Knob.
5. ALT Knob.
6. FD Vertical Mode Pushbutton Switches.
7. FD Lateral Mode Pushbutton Switches.
8. HSI SEL Pushbutton Switch.



FGCP CONTROLS
Figure 2



MAIN INSTRUMENT PANEL

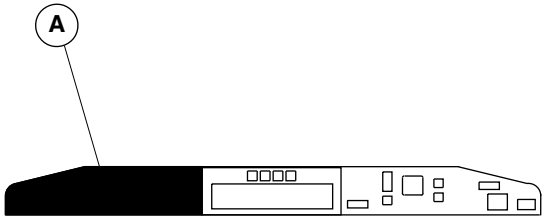


LEGEND

1. Aircraft symbol.
2. Command bars.
3. Flight mode annunciator (FMA).

cg5154a01.dg, rc/vk, jul12/2017

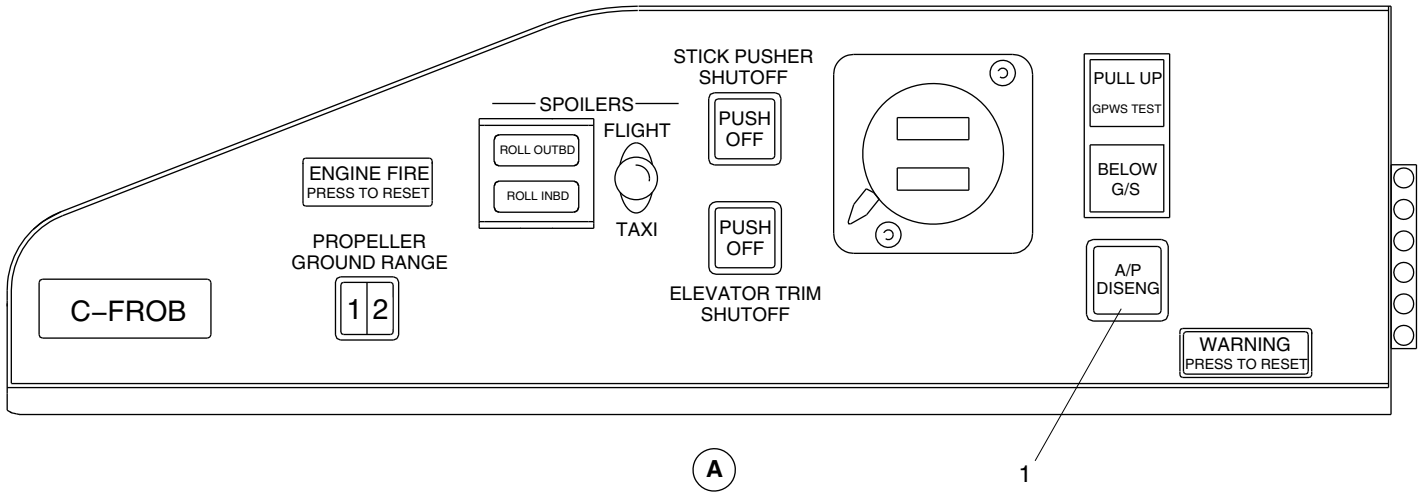
EIS, AFCS Indications
Figure 3



GLARESHIELD PANEL

LEGEND

1. AFCS AP DISENG Warning Light.



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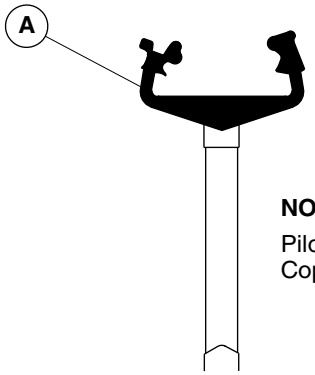
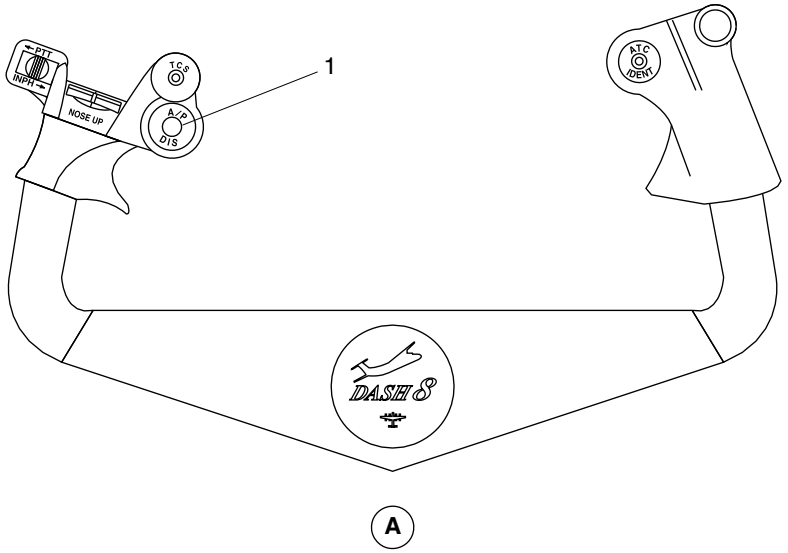
AUTOPILOT DISENGAGE, GLARESHIELD INDICATION
Figure 4



NOTE

Pilot's equipment shown.
Copilot's equipment similar.

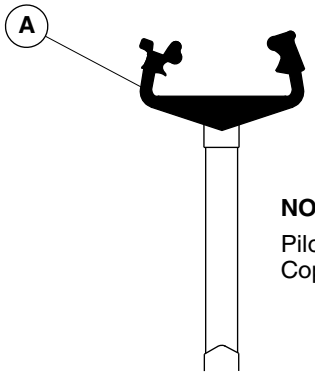


LEGEND

1. Autopilot Disconnect Pushbutton Switch.

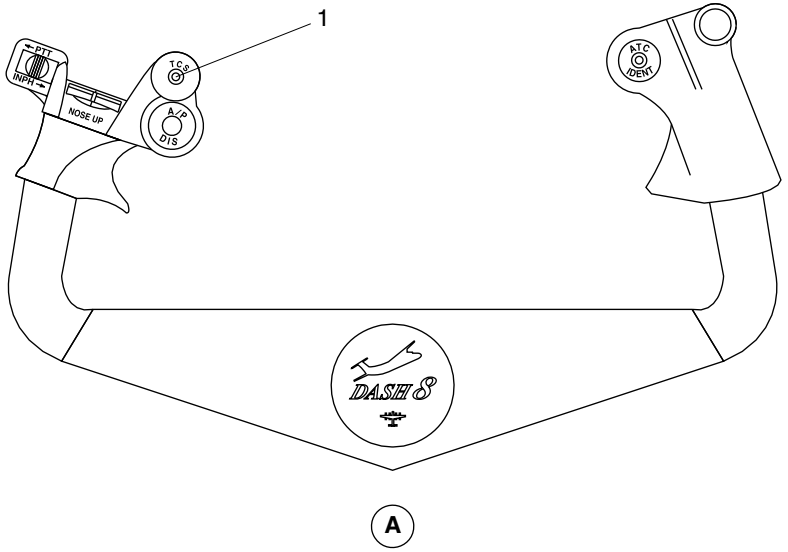
fsp55a01.cgm

AUTOPILOT DISENGAGE CONTROLS
Figure 5



NOTE

Pilot's equipment shown.
Copilot's equipment similar.

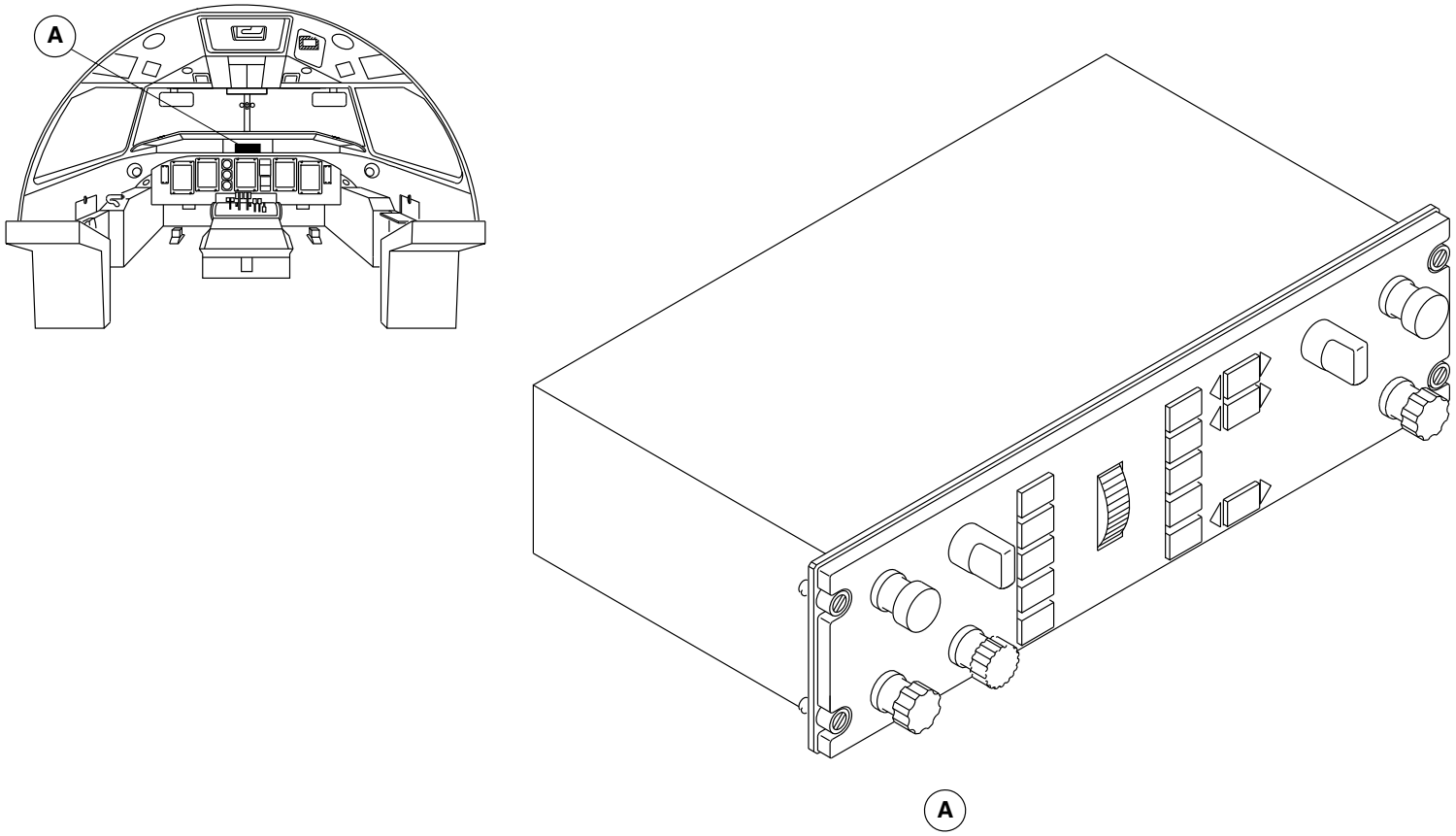


LEGEND

1. TCS Pushbutton Switch.

fsp34a01.cgm

TCS MODE CONTROLS
Figure 6



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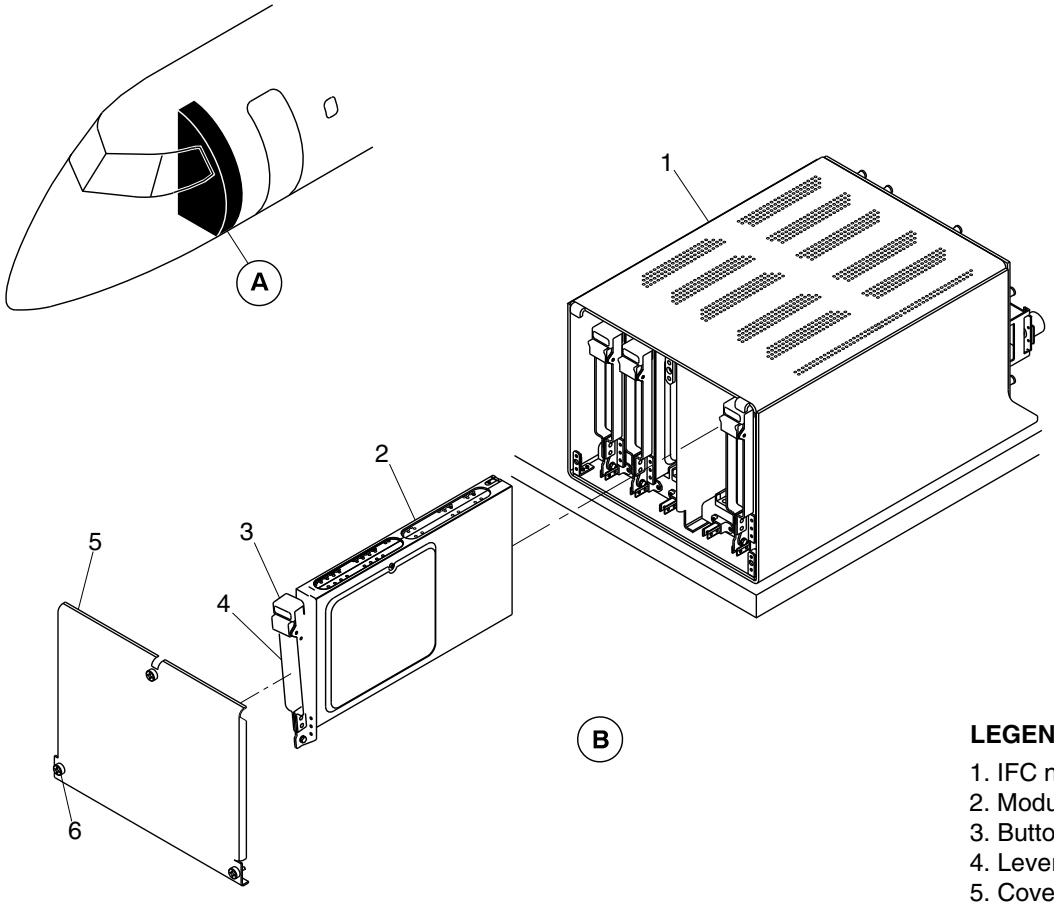
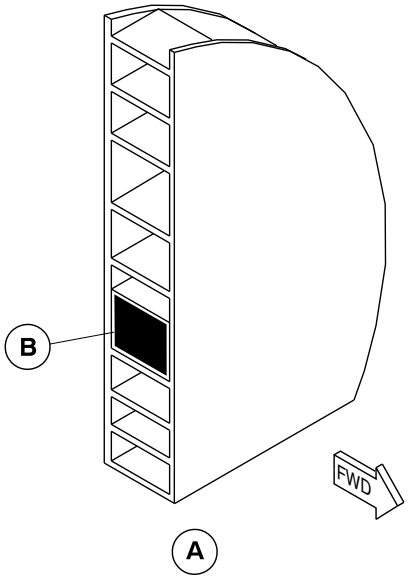
FLIGHT GUIDANCE CONTROL PANEL (FGCP), LOCATOR
Figure 7





AVIONICS RACK ELECTRICAL INSTALLATION

LEGEND

1. IFC no.1 (lower)
2. Module.
3. Button.
4. Lever.
5. Cover.
6. Fastener.

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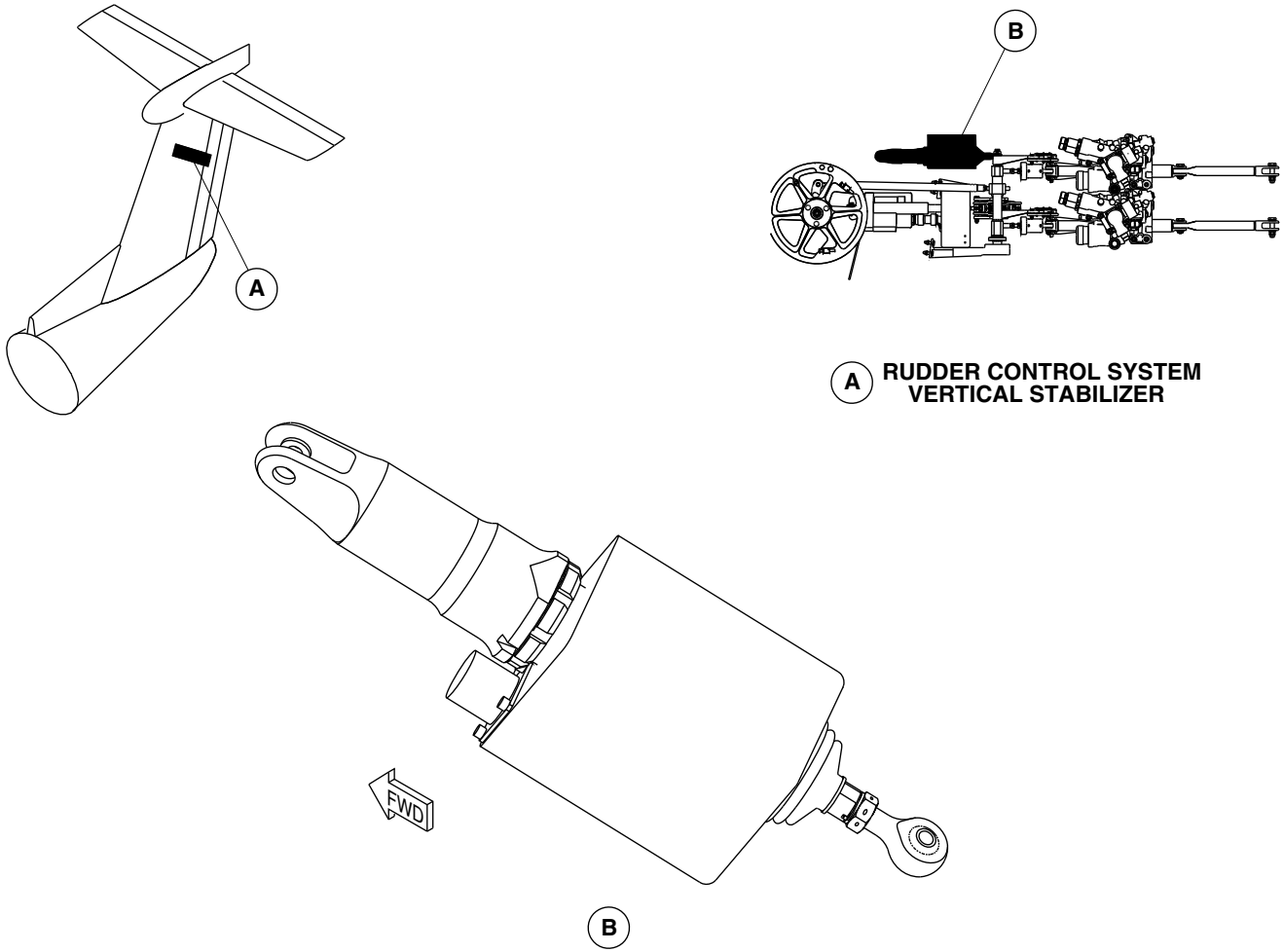
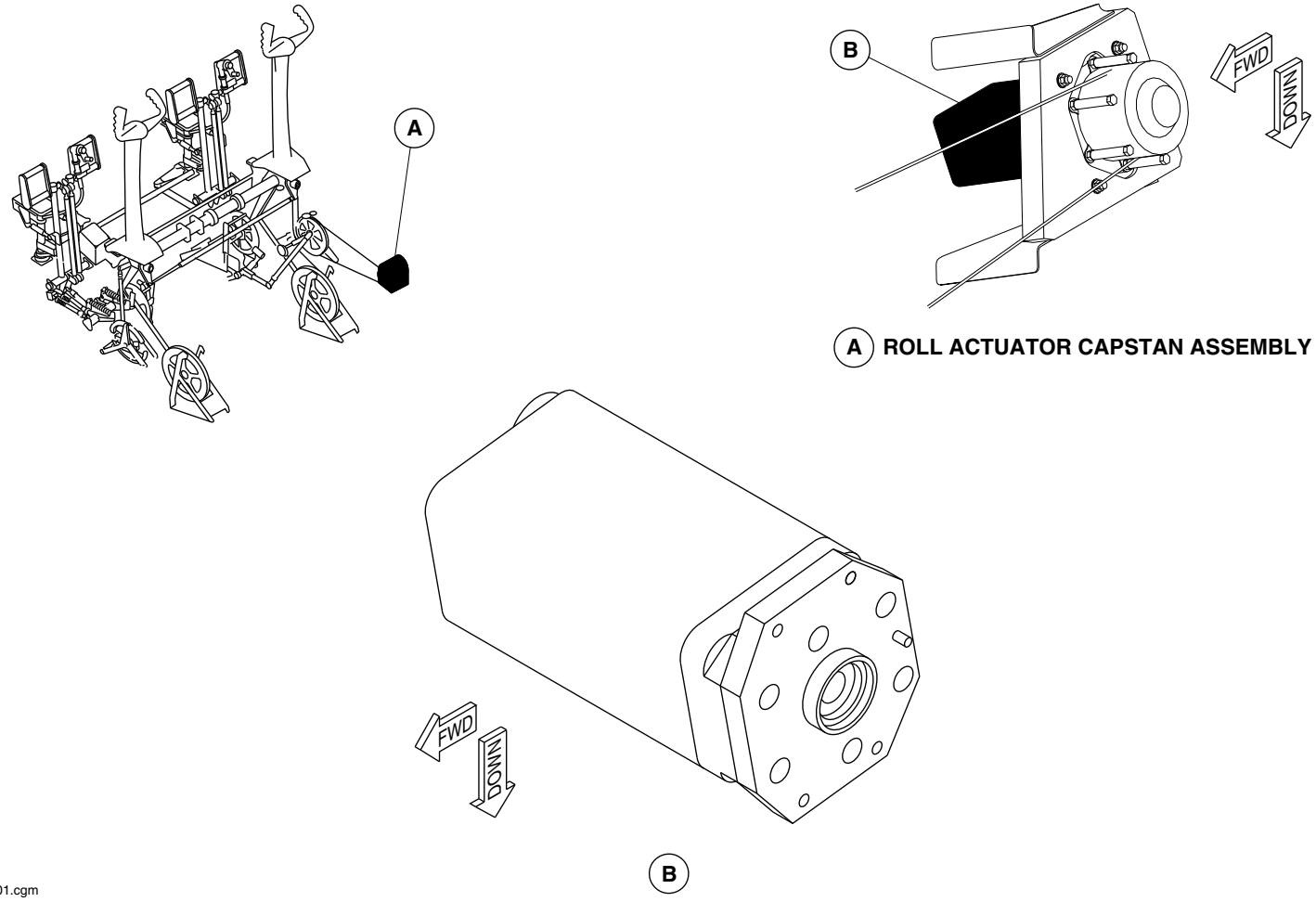
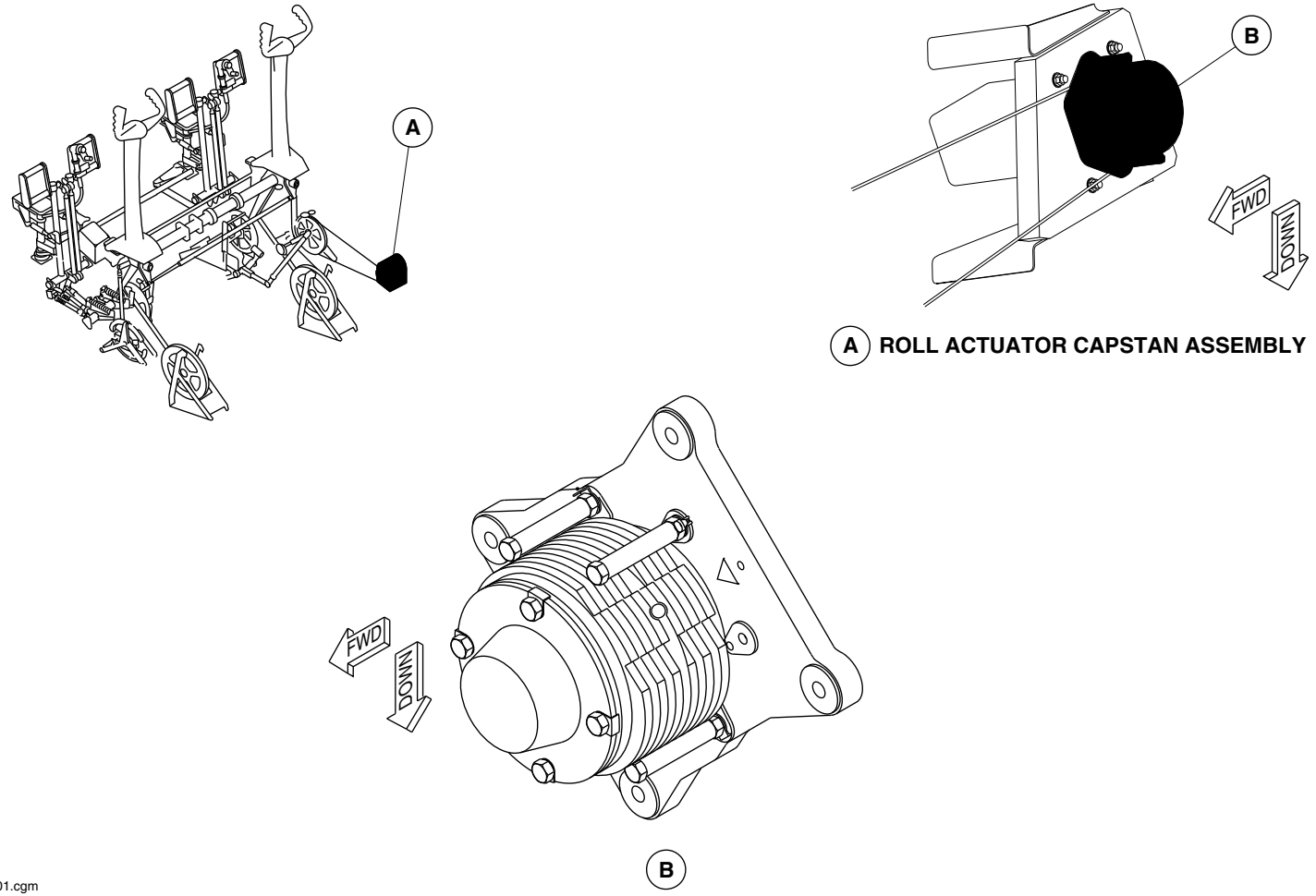
Flight Guidance Module (FGM), Locator
Figure 8



YAW DAMPER ACTUATOR UNIT (YDAU), LOCATOR
Figure 9



ROLL AUTOPILOT ACTUATOR UNIT (APAU), LOCATOR
Figure 10



A ROLL ACTUATOR CAPSTAN ASSEMBLY

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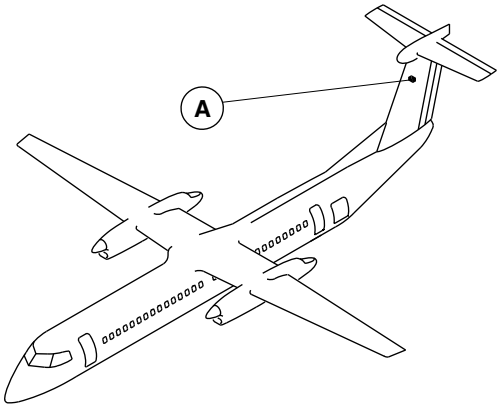
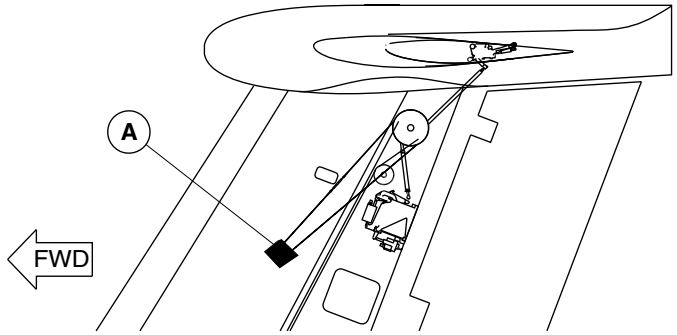
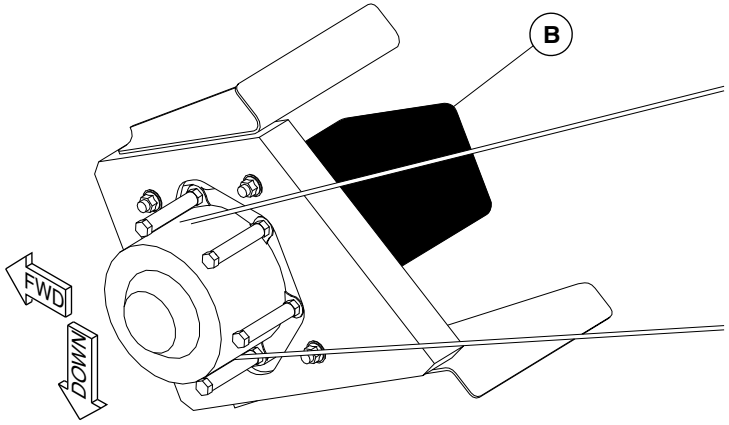
ROLL CAPSTAN, LOCATOR
Figure 11

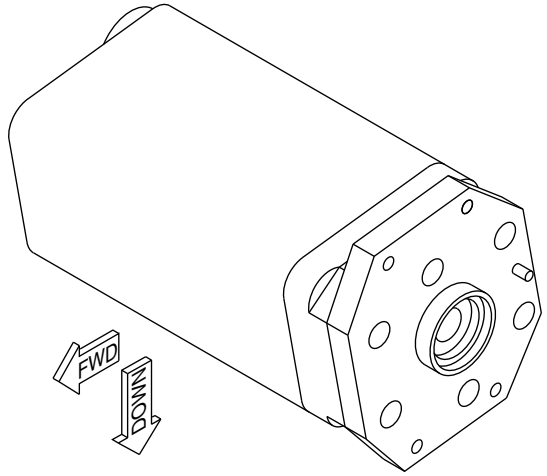




UPPER EMPANNAGE CROSS SECTION



A PITCH ACTUATOR CAPSTAN ASSEMBLY



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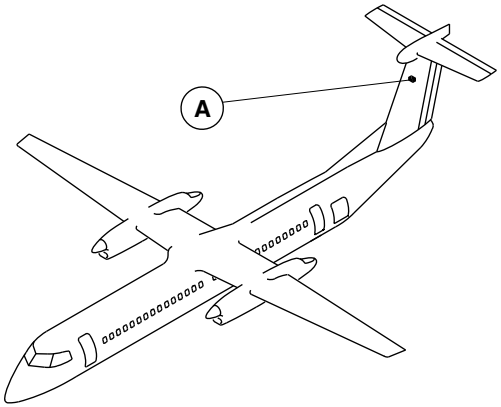
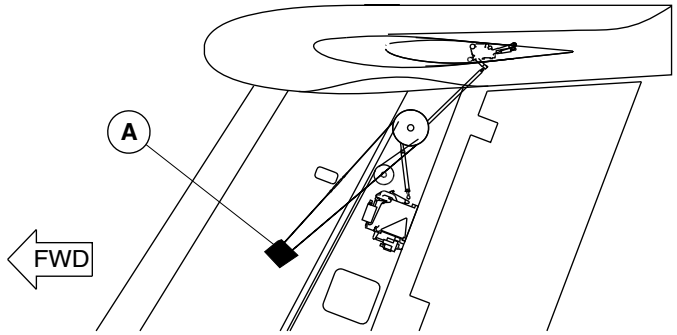
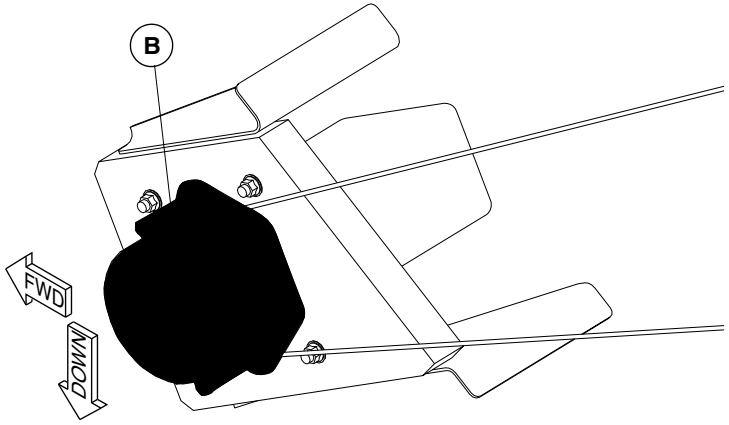
PITCH AUTOPILOT ACTUATOR UNIT (APAU), LOCATOR
Figure 12

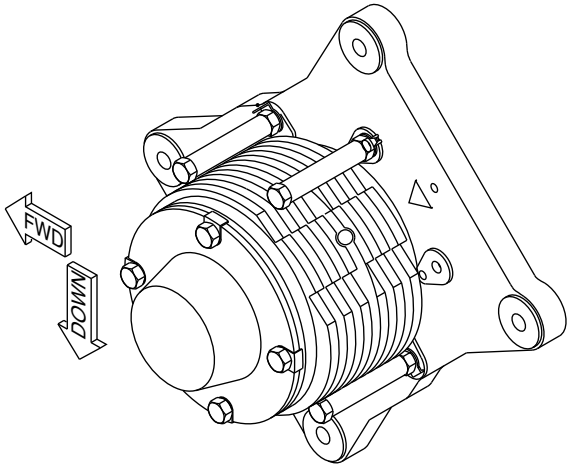




UPPER EMPANNAGE CROSS SECTION



A PITCH ACTUATOR CAPSTAN ASSEMBLY



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PITCH CAPSTAN, LOCATOR
Figure 13

**ON A/C ALL

22–10–00–001

AUTOPILOT

Introduction

The automatic flight control system gives the fail passive automatic control of the airplane and indications for the manual control.

General Description

The automatic flight control system (AFCS) does the functions that follow:

- Flight Director (FD)
- Tactile Control Steering (TCS)
- Autopilot (AP), pitch and roll axis
- Yaw dampening (YD), yaw axis
- AP pitch trim
- Flap automatic pitch trim
- Indication of AP disengagement.

The AFCS has a single autopilot, a single yaw damper and a dual FD capability.

The AFCS is capable of:

- All weather approach operation that is limited to Category I and II for ILS
- VOR approaches
- Front and back course localizer
- FMS approaches.

The pilots continuously have:

- The indication of the AFCS function engagement, and operational modes
- Priority over the AFCS for override and disengagement.

The AFCS control of the aircraft has limits for residual oscillations as follows:

- 0.6 degrees roll
- 0.6 degrees heading
- 0.02 g lateral acceleration
- 10 ft vertical
- 0.04 g vertical acceleration.

The AFCS commands have limits for aircraft acceleration that follows:

- Maximum load factor in pitch, 0.2 g
- Maximum roll angular acceleration, ±4 degrees / second^2
- Maximum yaw angular acceleration, ±8 degrees / second^2.

The AFCS is a dual system that has interfaces with:

- Flight control system
- Flap control system
- Flight Data Processing System (FDPS)

- Electronic Flight Instrument System (EFIS)
- Air Data System (ADS)
- Attitude and Heading Reference System (AHRS)
- VHF navigation
- Radio altimeter
- Distance Measuring Equipment (DME)
- Flight Management System (FMS).

Special Tooling

- Actuator target (steel)
- De–actuator target (copper)
- Air data test set
- Adaptor socket
- Commercially available torque wrench.

Detailed Description

System Description (System Overview):

Refer to Figure 1.

The automatic flight control system has the units that follow:

- Modules, Flight Guidance (22–11–01)
- Modules, Autopilot Monitor (22–11–06)
- Panel, Flight Guidance Control (22–11–11)
- Actuator, Roll (22–11–16)
- Capstan, Roll Actuator (22–11–21)
- Actuator, Pitch (22–11–26)
- Capstan, Pitch Actuator (22–11–31)
- Actuator, Yaw Damper (22–11–36)
- Lights, Autopilot Disconnect Warning (22–11–41).

The flight guidance control panel (FGCP) gives the pilots the selections that follow

- Engagement of the autopilot and yaw damper
- Flight guidance targets
- FD modes
- Navigation source.

The two Flight Guidance Modules (FGM1, FGM2) make independent calculations for operation.

FGM1 and FGM2 calculate the FD commands, the commands to the AP and YD actuators, and the commands to the pitch trim system.

The FD supplies the aircraft lateral and vertical guidance which is shown on the PFD1 and PFD2 for the manual control of the aircraft or coupled to the AP for the automatic control of the aircraft.

In the flight director mode, FGM1 is the master and FGM2 is the slave. If FGM1 malfunctions, FGM2 automatically becomes master and the FD mode continues to operate.

Two FGMs are necessary to do the AP and YD functions. FGM1 commands the actuators and FGM2 monitors the commands and the performance of the AP and YD actuators. If FGM1 or FGM2 malfunctions, the AP disengages and is inhibited from engaging.

FGM1 is energised by the left essential bus and FGM2 is energised by the right main bus.

The FGCP has two channels. The left channel is energised by the left essential bus and the right channel is energised by the right main bus.

The AP pitch and roll actuators and the YD actuator are energised by the left main bus.

The three actuators interface with the flight controls system.

Flight Guidance Module (FGM)

Refer to Figure 2.

The flight guidance modules are installed in the integrated flight cabinets.

Each FGM module has two electronic boards as follows:

- CPU Board (the main power supply, processing unit, ARINC and discrete inputs and outputs interfacing)
- Extension Board (AFCS discrete and analogue inputs and output interfaces, AP and YD hardware logic).

The extension board is only necessary for the AP and YD functions. So, the FD functions can be used without the extension board, except for the TCS function. With this construction, it is possible to have a malfunction of the FD and still have AP/YD operation.

The flight guidance modules has the modes that follow:

- Initialization
- Power On Self Test (POST)
- Line operational
- Maintenance
- Teleloading.

Initialization Mode: The flight guidance module operates in the initialization mode after an electrical power interruption that continues for approximately 75 milliseconds to:

- Initialize the hardware and reset the hardware outputs
- Initialize the software
- Check for corruption of internal data during the power interruption (If internal data was corrupted, the flight guidance module does a POST)
- Restart in the line operational mode
- Restart with the previously engaged FD modes
- Disengage the AP and YD (AP actuator clutches release).

If the aircraft is on the ground and there is a long power interruption (approximately 200 milliseconds), the flight guidance module does a POST before it goes to the operational mode. But, it starts the teleloading mode if the teleloading discrete is set. If it is airborne, it goes directly to the operational mode.

POST: The POST checks:

- Internal FGM integrity
- ARINC 429 inputs outputs
- Analogue and discrete inputs and outputs (For example; AP and YD engage/disengage switches)
- Output integrity (AP and YD engagement)

– Actuator interface monitoring.

The POST continues for 60 seconds. If not all tests are successfully completed, the FGM will do the POST a second time before a fault is logged.

When the POST is successfully completed, the FGM re–initializes and then transit on to the line operational mode.

Maintenance: The maintenance mode gives Central Diagnostic System (CDS) indications of malfunctions. Internal malfunctions are saved in the Non Volatile Memory (NVM) of the flight guidance module. External malfunctions of the Automatic Flight Control System (AFCS) are saved only when the aircraft speed is more than 80 knots. All malfunctions are supplied to the Central Diagnostic System (CDS).

Teleloading Mode: The FGM operational software and data base is downloaded from a Portable Maintenance Access Terminal (PMAT) through an RS422 serial connection to the flight guidance module. The complete teleloading time is not more than 5 minutes.

Line operational: The line operational mode of the flight guidance module has the functions that follow:

– Flight Director mode engagement and guidance processing
– AP and YD engagement and actuator commands
– Pitch trim commands
– Continuous built in test (BIT) monitoring.

Flight Guidance Control Panel (FGCP)

Refer to Figure 3.

The flight guidance control panel (FGCP) is installed in the glareshield panel with the screws.

The control panel has a front module and two interface boards. Each board uses an ARINC 429 bus to transmit the data received from the selections (pushbuttons, rotary switches, optical encoders) on the front face module and the local data from the interface board. Program pins (PINPROG) at power–up, configure to operate in ARINC 429 high speed mode.

Also, the interface board supplies filtered aircraft 28 VDC for pushbutton legends and 5 VDC dimming voltages for the front face lighting.

The front face has rotary encoders for:

– Course
– Heading
– Navigation Source Selection
– ALT
– PITCH.

Pushbuttons for:

– IAS (Indicated Air Speed)
– VS (Vertical Speed)
– VNAV (Vertical Navigation)
– ALT (Altitude Hold)

- ALT SEL (Altitude Select)
- HDG (Heading Select)
- NAV (Navigation)
- APPR (Approach)
- BC (Back Course)
- STBY (Standby)
- HSI SEL (HSI select)
- YD (Yaw Damper)
- AP (Autopilot)
- Lighting for status indicator.

The FGCP has the functions that follow:

- Engagement of the autopilot and yaw damper
- Set flight targets
- FD modes selection
- Navigation source selection.

Roll and Pitch Actuator Units

Refer to Figures 4 and 5.

The roll and pitch APAU are the same and attach to capstan with bolts. The roll actuator is installed below the floor of the flight compartment and the pitch actuator is installed in the vertical stabilizer.

NOTE

The actuators and capstans are connected in parallel with the aileron and elevator systems with cables.

The APAU has:

- Electronic board
- Motor
- Clutch
- Reduction gears
- Dual potentiometer driven externally by the capstan through a coupling device for feedback.

The motor drives an output shaft through two stages of reduction gears with an engagement clutch located between the gear stages. When the actuator is disengaged the second stage gears rotate with the capstan while the first stage stays stationary with the motor.

NOTE

The breakout force of an engaged APAU is the same as 40 lb (18.14 kg) at the control column and 17.5 lb (7.94 kg) at the handwheel.

Roll and Pitch Actuator Capstan

Refer to Figures 6 and 7.

The roll and pitch actuator capstans are the same, but it is necessary to adjust the cable guard posts (four locations) on the capstan for the pitch location.

The capstan for roll is installed below the floor of the flight compartment. It attaches to the forward aileron quadrant with cables and two turnbuckles.

The capstan for pitch is installed in the rear of the vertical stabilizer. It attaches to the elevator quadrant with cables and one turnbuckle.

The Capstan has:

- Capstan cable drum
- Torque Limiter (mechanical friction device)
- Mounting Plate.

The capstan is a mechanical coupling between the splined output shaft of the autopilot actuator unit and the driving pulley (drum) of the control cable, which is connected to the aircraft flight control system through cables.

NOTE

The peak override torque (breakout) of the capstan is the same as 56 lb (25.40 kg) at the control column and 39 lb (17.69 kg) at the handwheel.

NOTE

The running torque, after a breakout, is approximately 20% less than the peak override breakout force. There will be a small difference near the neutral position because the mechanical control system is non–linear.

Yaw Damper Actuator

Refer to Figure 8.

The actuator is installed in the rear of the vertical stabilizer.

One rod end of the yaw damper actuator is attached to the structure and the other to the fork end assembly of the rudder feel and summing unit.

NOTE

The shaft of the actuator needs to be at the electrical middle position when it is installed. During the shutdown sequence, the flight guidance module sends a centring command. This operates the yaw damper actuator to the middle position.

The YDAU has:

- DC motor
- Reduction gearing
- Mechanical torque limiter
- Irreversible screw and nut mechanism
- Mechanical stops
- Dual potentiometer
- Electronic circuitry.

There is no brake or engagement clutch. The output ram is irreversible and cannot be back driven when the YD is disengaged. The mechanical torque limiter protects the motor and gear train when the YDAU is driven into the mechanical travel limit stops.

The stroke of the YDAU relates to 4.5 degrees of Rudder movement.

The YDAU supplies a linear movement of the actuator ram.

Autopilot Disconnect Warning Light

Refer to Figure 9.

Two light assemblies, one on each side of the glareshield panel flash to show automatic autopilot disengagement.

The lens is pulled straight out and then tilted down to give access to screws to disengage the clips.

Controls and Indications

Refer to Figure 10.

Flight Director (FD): The FD lets the pilots set lateral and vertical guidance modes.

The flight guidance modules have the FD functions that follow:

- FD mode selections
- FD command calculations
- Sensor selection and monitoring.

Only one FGM is necessary to do the FD function.

The FD has the limits that follow

- 25 degrees for pitch
- 50 degrees fo roll.

The FD armed and active mode annunciations and command bars go out of a view when the aircraft attitude is more than the limits and the AP is not engaged. If the AP is engaged and the aircraft attitude goes more than the limits, the FD modes automatically goes to the lateral basic and pitch hold modes, and any armed modes must be cleared. FD mode selections are stopped if the aircraft attitude is more than the limits. FD modes must be re–selected when the aircraft attitude is again less than the limits.

The FD commands are shown in a single cue format (inverted V–bar) or a cross–bar pointer format (double cue) on the PFD. The selection between the two FD indication options are set by the Aircraft Configuration Modules (ACM1 and ACM2) programming.

The FD has active and armed modes. An active FD mode supplies guidance for indication on the PFD, and for coupling to the AP. The armed FD mode is waiting for necessary conditions to be satisfied. It will automatically replace the previous active mode conditions are satisfied.

If FGM1 senses an internal defect that prevents the FD operation, FGM2 becomes the master, the FD modes are cleared, and the FD command bars go out of the view.

If FGM1 is correct again, it again becomes the master, the FD modes are cleared, and the FD command bars go out of view. The switching between FGM1 and FGM2 occur automatically.

FGM1 and FGM2 use the data shown on PFD1 or PFD2 for calculation of FD guidance commands. The HSI SEL pushbutton switch is set to the pilot flying and the light in the arrow adjacent to the HSI SEL pushbutton switch shows the PFD selection. In the dual FD mode FGM1 uses the No. 1 sensors, and FGM2 uses the No. 2 side sensors.

A malfunction of a sensor input necessary for the calculation of an armed or active FD mode causes the FD mode to clear. If the pilots attempt to make a selection for a mode with data that is not valid, no mode change occurs and a message is shown on the PFD.

A mismatch between sensors does not clear the FD mode because FGM1 and FGM2 will use the selected side data. But, in dual FD mode, a mismatch between the two VHF navigation sensors clears the dual FD mode.

Only one AHRS valid or one ADC valid is necessary for the FD command calculations.

The FD is engaged by one of the selections that follow:

- Lateral FD mode on the FGCP (also engages the FD vertical basic mode)
- Vertical FD mode on the FGCP (also engages the FD lateral basic mode)
- Go Around (GA), lateral and vertical FD modes
- Autopilot, lateral and vertical FD modes.

FGM1 and FGM2 supply these parameters to PFD1 and PFD2 for the indication

- Pitch and roll commands as the FD bars on the attitude direction indicator
- Pitch and roll, active and armed modes messages in the Flight Mode Annunciator (FMA)
- AFCS messages in the FMA.

PFD1 and PFD2 show the FD command bars and messages from the master FGM. FD data from FGM2 is shown on PFD1 and PFD2 only if FGM1 is defective.

In dual FD mode, PFD1 show FD command bars and messages from FGM1, and PFD2 shows FD command bars and messages from FGM2.

The FD lateral armed and active modes are shown in the left part of the FMA and the vertical arm and active modes are shown in the right side.

Some modes have the phases that follow:

- Arm
- Capture
- Track.

All FD modes are disengaged by one of the selections that follow:

- HSI SEL (no effect in dual FD mode)
- AHRU reversion selection
- ADU reversion selection
- STBY.

All FD modes are inhibited, disengaged, and disarmed by one of the malfunction of the set AHRU attitude data or ADU airspeed data.

All FD modes are inhibited, disengaged, and disarmed if the aircraft angle for pitch is more than 25 degrees or 50 degrees for roll.

An inhibit condition for all FD modes is set when the Tactile Control Steering (TCS) is active. This condition does not inhibit an automatic mode transition.

The FD has the modes that follow:

Lateral modes

- Lateral basic mode
- Roll hold sub mode> 6 degrees
- Wings level sub mode< 6 degrees

- Heading hold sub mode
- Heading select mode
- VOR mode
- VOR approach mode
- Localizer mode
- Back course localizer mode
- FMS LNAV mode (optional).

Vertical modes

- Vertical basic (pitch hold) mode
- Altitude select mode
- Altitude hold mode
- Indicated airspeed mode
- Vertical speed mode
- FMS has VNAV (armed) and VNAV
- PATH (active) modes.

Combined lateral and vertical modes

- Go around
- ILS approach mode
- Dual FD sub mode.

Refer to Figures 11 and 12.

Lateral Basic: Valid CAS and TAS data from the set ADC and attitude data from the set AHRS is necessary for the lateral basic FD mode.

The lateral basic FD mode is set when no lateral FD mode is active and the AP is engaged, or a vertical FD mode is set.

The lateral basic mode has three sub modes that follow:

- Roll hold (the current roll angle is more than 6 degrees)
- Wings level (the roll angle is less than 6 degrees)
- Heading hold.

The wings level lateral basic sub mode automatically changes to the heading hold sub mode when all the conditions are as follows:

- The wings level is the lateral active basic sub mode
- The Bbank angle is less than 3 degrees for more than 10 seconds
- Heading data from the set AHRS is valid.

The heading hold FD sub mode is deactivated by:

- The selection of any lateral FD mode. (Then HDG SEL or the LNAV mode is active)
- Restarting the lateral basic mode logic with TCS (Then the wings level or roll hold sub mode is active)
- A malfunction of heading data from the set AHRS (Then the Wings Level Sub mode is active).

When the lateral basic FD mode is activated with a GA mode selection, the wings level FD sub mode is activated and does not change to the heading hold sub mode regardless of the bank angle.

The wings level FD mode is deactivated by:

- The selection of any lateral FD mode. (Then HDG SEL or the LNAV mode is active)
- TCS operation (at the TCS switch release, the lateral basic FD mode is restarted).

The active lateral basic FD mode has indications on the PFD.

In the roll hold or wings level, heading hold FD sub modes, the AP/FD commands to hold the target roll attitude. This is the bank angle that existed at a mode engagement, or when the TCS switch was released. The roll attitude target is limited to 45 degrees for the roll hold and 0 degrees for the wings level, the heading hold.

The AP commands are rate limited to 4 degree/second of the roll rate in lateral basic FD modes.

Refer to Figures 13 and 14.

Heading Select: The heading select FD mode is used to hold a heading target.

The heading select FD mode needs the valid parameters that follow:

- CAS or TAS data from the set ADC
- Attitude or heading data from the set AHRS
- Set the heading target from the FGCP.

The heading select FD mode is set with the FGCP selections that follow:

- HDG
- NAV (arms VOR or LOC)
- APPR (arms VOR approach, LOC, and GS)
- BC (arms back course LOC).

The heading select mode is deactivated by:

- HDG selection again
- Change to the VOR capture, the VOR approach capture, the localizer capture, or the back course localizer capture mode
- GA FD mode selection
- LNAV FD mode selection
- STBY selection
- HSI SEL selection
- ADC or the AHRS reversion selection
- The malfunction of CAS or TAS data from the set ADC (disengages the FD)
- The malfunction of attitude data from the selected AHRS (disengages the FD)
- Heading data from the set AHRS is not valid
- The Selected heading target from the FGCP is not valid
- The Malfunction of the FGCP (then no upper lateral mode is active).

The FGCP has two Heading (HDG) knobs to let the pilots set the heading target. The FD uses the left or right heading target set by the HSI SEL pushbutton switch selection.

In the heading select mode, the AP/FD commands to capture and hold the set heading target.

The AP/FD commands are limited to 24 degrees of roll attitude in the heading select FD mode. The AP commands are rate limited to 4 degree/second of the roll rate.

Refer to Figures 15 and 16.

VOR Mode: The VOR FD mode acquires and holds a VOR radial.

The VOR mode has sub modes that follow:

- VOR arm
- VOR capture
- VOR track
- VOR over station.

The transitions between these sub modes are done automatically by the FD.

The VOR FD mode needs the valid parameters that follow:

- CAS or TAS data from the set ADC
- Attitude and heading data from the set AHRS
- A VOR frequency
- VOR data from the set VHF navigation receiver
- Selected course.

To arm the VOR mode:

- VHF navigation receiver 1 or VHF navigation receiver 2 is set as the navigation source
- The VOR frequency is tuned
- A course is set to the desired VOR radial
- The intercept heading target is set
- The NAV pushbutton switch on the FGCP is pushed.

The arming of the VOR mode automatically sets the heading select mode.

The FD mode automatically changes to the VOR capture mode from the VOR arm when the aircraft intercepts the desired VOR radial and the intercept angle is less 90 degrees.

The FD mode automatically changes to the VOR track mode from the VOR capture when the aircraft has turned on to the desired VOR radial.

As the aircraft approaches a VOR station, it enters a zone of confusion where the VOR deviation signal is very noisy. When this occurs, the VOR FD mode automatically changes to the VOR over station mode. In the VOR over station mode commands the aircraft to a heading that is same as the selected course. When the aircraft departs the zone of confusion, the VOR deviation signal will again become clear of noise, and the FD mode automatically changes to the VOR capture mode.

The VOR arm mode is disarmed by:

- NAV selection again
- APPR selection (VOR approach mode is armed, HDG SEL mode is active)

- GA FD mode selection
- STBY selection
- HSI SEL selection
- ADC or the AHRS reversion selection
- Change to the VOR capture mode
- The malfunction of CAS or TAS data from the set ADC
- The malfunction of attitude data from the set AHRS
- The navigation source is changed
- The frequency of the set VHF navigation receiver is changed to a localizer frequency
- VOR data from the set navigation receiver is not valid for 30 seconds
- The selected course is not valid
- Heading data from the set AHRS is not valid
- The malfunction of the FGCP.

The VOR capture modes are deactivated by:

- NAV selection again
- APPR selection (VOR Approach mode is armed, HDG SEL mode is active)
- HDG selection
- GA FD mode selection
- HSI SEL selection
- Change to the VOR track or the VOR over station mode
- The ADC or AHRS reversion selection
- The malfunction CAS or TAS data from the set ADC
- The malfunction of attitude data from the set AHRS
- The navigation source is changed
- The frequency of the VHF navigation receiver is changed to a localizer frequency
- VOR data from the set navigation receiver is not valid for 30 seconds
- The selected course is not valid
- Heading data from the set AHRS is not valid
- The malfunction of the FGCP.

The FGCP has two COURSE knobs to let the pilots set the course. The FD uses the left or right course and left or right VOR bearing set by the HSI SEL pushbutton switch selection.

The intercept should be less than 45 degrees at capture.

The distance from the station is supplied by the DME.

The AP/FD commands are limited to 24 degrees roll attitude in VOR capture, track and over station modes and are rate limited to 4 degrees/second of roll rate.

Refer to Figure 17.

VOR Approach Mode: The VOR approach FD mode acquires and holds a VOR radial (usually to a runway) similar to the VOR FD mode, but is intended to be used in the approach flight phase.

The VOR approach FD mode has the sub modes that follow:

- VOR approach arm

- VOR approach capture
- VOR approach track
- VOR approach over station.

The VOR APPR FD mode requires the same conditions as the VOR FD mode. But, a co–located DME is also necessary for the VOR approach.

NOTE

The same conditions arm, disarm, activate, and deactivate the VOR approach FD mode as the VOR mode.

The APPR pushbutton switch on the FGCP is pushed to arm the mode, not NAV.

The AP/FD commands are limited to 24 degrees of roll attitude in VOR approach capture and 10 degrees of roll attitude in VOR approach track and VOR approach over station. The AP commands are rate limited to 4 degrees/second of roll.

Refer to Figures 18 and 19.

Localizer Mode: The localizer FD mode acquires and tracks an ILS localizer beam.

The localizer FD mode has the sub modes that follow:

- Localizer arm
- Localizer capture
- Localizer track.

The LOC FD mode needs the conditions that follow:

- The active lateral FD mode is not a BC Capture or a track
- The active vertical FD mode is not GA
- CAS and TAS data from the set ADC are valid
- Attitude and heading data from the set AHRS is valid
- A localizer frequency is set
- Localizer data from the set VHF navigation receiver is valid or NCD
- The selected course is valid.

To arm the localizer mode when a VHF navigation receiver is the navigation source:

- VHF navigation receiver 1 or VHF navigation receiver 2 is set as the navigation source
- The localizer frequency is tuned
- A course is set to the desired runway
- An intercept heading target is set
- The NAV pushbutton switch on the FGCP is pushed.

To arm the ILS mode when an FMS is the navigation source:

- FMS is set as the navigation source, with an ILS approach entered in the flight plan and the approach is armed on the FMS
- The Localizer frequency is tuned
- The APPR pushbutton switch on the FGCP is pushed.

The arming of the LOC mode automatically sets the heading select mode if LNAV is not previously set.

The FD mode automatically changes to the LOC capture mode from the LOC arm when the aircraft intercepts the desired ILS localizer beam.

The FD mode automatically changes to the LOC track mode from the LOC capture when the aircraft has turned on to the localizer beam.

The LOC arm mode is disarmed by:

- NAV selection again (no lateral mode is armed)
- An APPR selection again after the GS FD mode is armed (no lateral mode is armed)
- BC selection (BC is armed)
- GA mode selection
- HSI SEL selection
- Change to the localizer capture mode
- ADC or the AHRS reversion selection
- The malfunction of CAS or TAS data from the set ADC
- Attitude or heading data from the set AHRS
- The navigation source is changed
- The frequency of the set VHF navigation source is changed to a VOR frequency
- ILS1 tuned or ILS2 tuned discrete from the set VHF navigation source is reset
- Localizer data from the set VHF navigation receiver is not valid for 5 seconds
- The selected course is not valid
- A malfunction of the FGCP.

The localizer capture mode is deactivated by:

- NAV selection again (lateral mode is active or armed)
- APPR again when the GS FD mode is armed or active (no upper lateral mode is active or armed)
- BC selection (no FD lateral mode is active or armed)
- HDG selection
- GA selection
- STBY selection
- HSI selection
- Change to the localizer track mode
- ADC or the AHRS reversion selection
- CAS or TAS data from the set ADC is not valid
- Attitude or heading data from the set AHRS is not valid
- The navigation source is changed
- The frequency of the set VHF navigation source is changed
- Localizer data from the set VHF navigation receiver is not valid for 5 seconds
- The selected course is not valid
- The malfunction of the FGCP.

The FGCP has two COURSE knobs to let the pilots set the course. The FD uses the left or right course and left or right LOC deviation set by the HSI SEL pushbutton switch selection, but not during the DUAL FD mode.

The intercept should be less than 90 degrees at capture.

The AP/FD commands are limited to 30 degrees roll attitude in LOC capture and 24 degrees in LOC track modes when the radio altitude (above ground level altitude) is more than 800 ft. The command for LOC track changes to 10 degrees roll attitude when the radio altitude is less than 800 ft, or the radio altitude is invalid. The AP commands are rate limited to 7 degree/second of roll rate in LOC capture and 5.5 in LOC track.

Refer to Figure 20.

Back Course Localizer Mode: Localizer FD mode acquires and tracks an ILS back course localizer beam.

The back course localizer mode is similar to the localizer mode. It has the sub modes that follow:

- Back course localizer arm
- Back course localizer capture
- Back course localizer track.

The BC FD mode needs the same conditions as the LOC FD mode.

NOTE

The same conditions arm, disarm, activate, and deactivate the BC FD mode as the LOC mode.

The BC pushbutton switch on the FGCP is pushed to arm the mode, not NAV or APPR.

The AP/FD commands are the same as the LOC mode. The back course localizer mode shall not be used below 250 ft of the runway threshold.

Refer to Figures 21 and 22.

FMS LNAV Mode (Optional): The LNAV mode acquires and hold a lateral flight path calculated by the FMS.

The LNAV FD mode is an active mode that has no arm or capture sub modes.

The LNAV FD mode needs the conditions that follow:

- CAS and TAS data from the set ADC are valid
- Attitude data from the set AHRS is valid
- The navigation source is set to FMS1 or FMS2
- The roll steering command is valid.

To activate the LNAV mode:

- FMS is set as the navigation source
- The lateral flight plan on the MCDU is activated
- The NAV push button switch on the FGCP is pushed.

The LNAV is deactivated by:

- NAV selection again
- HDG selection
- HSI SEL selection
- Change to the localizer capture mode
- ADC or the AHRS reversion selection
- CAS or TAS data from the set ADC is not valid
- Attitude data from the set AHRS is not valid
- The navigation source is changed

- The roll steering command from the set FMS is not valid
- The malfunction of the FGCP.

The AP/FD commands are limited to 30 degrees roll attitude in the LNAV mode and 4 degree/second of roll rate.

Refer to Figure 23.

Pitch Hold Mode: The FD commands to hold a pitch attitude target.

The vertical basic FD mode needs the valid CAS and TAS data from the set ADC and attitude data from the set AHRS.

The pitch attitude target is initially set to the aircraft pitch attitude that exists when the pitch hold mode is activated. The pitch attitude target can then be changed by a pitch thumbwheel selection on the FGCP. The pitch attitude target can also be changed by a Tactile Control Steering (TCS) selection. The pitch attitude target is set to the aircraft pitch attitude when the TCS switch is released.

The pitch hold commands are limited to less than 20 degrees and to a maximum aircraft acceleration of 0.2 g. The FD bars are not shown if the current aircraft attitude is more than 20 degrees.

Refer to Figures 24 and 25.

Altitude Select Mode: The altitude select mode commands to acquire and hold a selected altitude target from the FGCP.

The altitude select mode has the sub modes that follow:

- Altitude select arm
- Altitude capture.

The ALTSEL (arm) mode needs the conditions that follow:

- Active vertical FD mode is not GS capture or track mode
- Barometric corrected altitude, standard altitude, CAS and TAS data from the set ADC are valid
- Vertical speed, inertial altitude and attitude data from the set AHRS is valid
- The selected altitude target from the FGCP is valid.

The altitude select mode is armed manually by an ALT SEL push button switch selection on the FGCP. Subsequent short pushes do not disengage the FD mode but let a new altitude to be set. A long push disengages the ALTSEL mode. The altitude select mode is also armed when the selected altitude is changed during the altitude capture mode.

AHRS and ADC altitudes are used by the AFCS to calculate its own altitude. This corrected barometric inertial altitude is the inertial altitude from the set AHRS corrected by the difference between barometric corrected altitude and standard altitude from the set ADC.

When the corrected barometric inertial altitude is near the selected altitude target, the FD mode automatically changes to the altitude capture mode. When the selected altitude target is captured, the FD mode automatically changes to the altitude hold.

The change to the altitude capture mode is inhibited when the altitude hold mode is engaged.

The altitude select is disarmed by:

- ALT SEL selection again
- Change to the altitude capture
- Change to the GS capture
- GA selection
- HSI SEL selection

- The ADC or AHRS reversion selection
- Standard altitude barometric corrected altitude, CAS, or TAS data from the set ADC are not valid
- Vertical speed, inertial altitude or attitude data from the set AHRS is not valid
- The selected altitude target is not valid
- The malfunction of the FGCP.

The altitude capture mode is deactivated by:

- ALT SEL again
- The change to the altitude hold
- Change GS capture
- VS selection
- IAS selection
- GA selection
- Selected altitude selection
- Pitch thumbwheel selection
- HSI SEL selection
- ADC or the AHRS reversion selection
- Standard altitude, barometric corrected altitude, CAS or TAS data from the set ADC are not valid
- Vertical speed, inertial altitude, or attitude data from the set AHRS is not valid
- Selected altitude from the FGCP is not valid
- The malfunction of the FGCP.

The limit of the selected altitude is 0 to 27,000 ft.

In the altitude select FD mode, the AP/FD commands to hold the target pitch attitude to less than 20 degrees. The altitude capture mode is limited to 0.1 g.

Refer to Figure 26.

Vertical Navigation: Vertical navigation mode calculations are done by the flight management system (FMS), not the AFCS. See the description of FMS for the vertical navigation mode.

Refer to Figures 27 and 28.

Altitude Hold: In the altitude hold mode, the FD commands to hold an altitude target.

The altitude hold mode needs the conditions that follow:

- Standard altitude, barometric corrected altitude, CAS, and TAS data from the set ADC are valid
- Vertical speed, inertial altitude, and attitude data from the set AHRS are valid
- Corrected barometric inertial altitude is between 0 and 27,000 ft.

Then, the ALT HOLD mode is activated automatically, by the altitude select mode, or when the ALT push button switch on the FGCP is pushed. The altitude target is initially set to the aircraft altitude that exists when the altitude hold mode is activated.

The altitude target can be changed by a TCS selection. The altitude hold target is set to the aircraft barometric corrected altitude that exists when the switch is released.

If the barometric correction is changed during the altitude capture or hold mode, the altitude captured and held will be the barometric corrected altitude (same as the selected altitude), adjusted for the barometric correction.

NOTE

A thumbwheel selection when the ALT HOLD mode is engaged and the ALT SEL mode is armed with a selected altitude the same as the held altitude, the ALT hold mode is disengaged and replaced by the PITCH HOLD mode and an ALT OFF message is shown. ALT SEL stays armed and ALT capture is inhibited.

NOTE

When the ALT SEL mode is armed and the ALT target changed, then the ALT SEL stays armed and the ALT capture is inhibited.

The altitude hold mode is deactivated by:

- ALT selection again
- Change to the GS capture
- GA selection
- VS selection
- IAS selection
- Pitch thumbwheel selection
- STBY selection
- HSI SEL selection
- ADC or the AHRS reversion selection
- Standard altitude, barometric corrected altitude, CAS, or TAS data from the set ADC is not valid
- Vertical speed, inertial altitude, attitude data from the set AHRS is not valid
- The malfunction of the FGCP.

The limit of the altitude hold mode is from 0 to 27,000 ft.

The altitude hold target pitch attitude is limited to less than 20 degrees and he altitude capture mode is limited to 0.1 g.

Refer to Figures 29 and 30.

Indicated Airspeed Mode: The FD commands to hold an IAS target.

The IAS FD mode needs the conditions that follow:

- VMO, CAS, and TAS data from the set ADC are valid
- Attitude data from the set AHRS is valid
- FGCP is valid
- CAS is between 95 knots (175.94 km/h) and 290 knots (km/h).

The IAS mode is activated when the IAS push button switch on the FGCP is pushed. The IAS target is initially set to the aircraft indicated airspeed that exists when the IAS mode is activated.

The IAS target can then be changed by a pitch thumbwheel selection on the FGCP. The IAS target can also be changed by a TCS selection. The IAS target is set to the aircraft indicated airspeed that exists when the TCS switch is released.

The IAS mode is deactivated by:

- IAS selection again

- Change to the ALT capture
- Change to the GS capture
- ALT selection
- GA selection
- VS selection
- STBY selection
- HSI SEL selection
- ADC or the AHRS reversion selection
- The malfunction of VMO, CAS, or TAS data from the set ADC
- The malfunction of attitude data from the set AHRS
- The malfunction of the FGCP.

The IAS mode is shown on the PFD with the target speed.

In the IAS FD mode, the AP/FD commands to hold the target pitch attitude to less than 20 degrees and 0.1 g.

Refer to Figures 31 and 32.

Vertical Speed Mode: The FD commands to hold a vertical speed target.

The vertical speed mode needs the conditions that follow:

- CAS and TAS data from the set ADC are valid
- Inertial vertical speed and attitude data from the set AHRS is valid
- FGCP is valid
- Inertial vertical speed is between –6,000 and 6,000 ft per minute.

The VS mode is activated when the VS push button switch on the FGCP is pushed. The VS target is initially set to the aircraft vertical speed that exists when the VS mode is activated. The VS target can then be changed by a pitch thumbwheel selection on the FGCP. The VS target can also be changed by a TCS selection. The VS target is set to the aircraft vertical speed that exists when the TCS switch is released.

The vertical speed mode is deactivated by:

- VS selection again
- Change to the altitude capture
- GS capture
- ALT selection
- GA selection
- IAS selection
- STBY selection
- HSI SEL selection
- ADC or the AHRS reversion selection
- The malfunction of CAS or TAS data from the set ADC
- The malfunction of inertial vertical speed or attitude data from the set AHRS
- The malfunction of the FGCP.

The AP/FD commands to hold the target pitch attitude to less than 20 degrees and 0.1 g.

Refer to Figures 33 and 34.

Go Around, Wings Level Mode: The Go Around (GA) mode is usually used to the transition from an approach to a climb out for a missed approach, but can be set at any time. If the LNAV mode is previously engaged, LNAV stays active after the go around selection for the missed approach flight plan with LNAV coupled to FD.

The go around mode needs correct CAS and TAS data from the set ADC and attitude data from the set AHRS.

The GA mode is activated when one of the two go around switches on the power levers is pushed.

When the GA mode is set:

- AP disengages
- FD vertical mode transitions to the GA mode
- FD lateral mode transitions to wings level mode if the LNAV mode is not previously active
- All FD armed modes are disarmed.

The GA mode is deactivated by:

- Change to the altitude capture
- VS selection
- IAS selection
- VNAV selection
- AP selection (vertical and lateral basic modes are activated)
- STBY selection
- HSI SEL selection
- ADC or the AHRS reversion selection
- The malfunction of CAS or TAS data from the set ADC
- The malfunction of the FGCP.

NOTE

A lateral basic mode is activated by a VS, IAS, or VNAV selection.

The wings level mode is deactivated by:

- Deactivating GA
- HDG SEL selection
- LNAV Selection
- Transitioning to the VOR Capture.

NOTE

A lateral FD mode selection other than the wings level does not deactivate GA.

A TCS selection in the GA mode does not change the GA pitch target, and does not deactivate the mode. When the TCS switch is released by the pilot, the FD lateral mode transitions from the wings level mode to a basic lateral mode roll hold or the wings level.

The FD commands to hold the target pitch attitude to +10 degrees for all flap positions zero roll attitude.

Refer to Figures 35 and 36.

ILS Approach Mode: The ILS approach mode is a mixture of the lateral and vertical mode used to do precision Category I and Category II ILS approaches. The ILS approach mode captures and tracks ILS localizer and glideslope beams.

The ILS approach mode has the sub modes that follow:

Lateral

- Localizer arm
- Localizer capture
- Localizer track.

Vertical

- Glideslope arm
- Glideslope capture
- Glideslope track.

The transitions between these sub modes are done automatically by the FD. The transition from the glideslope arm to the glideslope capture is inhibited until the lateral mode has transitioned to the localizer capture or the localizer track.

The ILS approach mode needs the conditions that follow:

- All conditions to arm the localizer mode are satisfactory or the localizer mode is armed or active
- Glideslope data from the set VHF navigation receiver is valid
- Vertical speed from the set AHRS is valid.

To arm the ILS mode without the FMS, the pilots make the selections that follow:

- VHF navigation receiver 1 or VHF navigation receiver 2 is set as the navigation source
- Localizer frequency is tuned (GS frequency is automatically tuned)
- A course is set to the desired runway
- Intercept heading target is set
- APPR pushbutton switch on the FGCP is pushed.

To arm the ILS mode with the FMS, the pilots make the selections that follow:

- FMS is set as the navigation source, with an ILS approach entered in the flight plan and approach is armed on the FMS
- The localizer frequency is tuned (The GS frequency is automatically tuned)
- The APPR pushbutton switch on the FGCP is pushed.

The localizer mode can also be armed with the NAV switch on the FGCP.

If the flight crew first select NAV to arm the localizer mode, then a subsequent selection of APPR is necessary to arm the glideslope mode.

For the Description of the localizer arm, the localizer capture, and the localizer track, see the localizer mode.

The FD shall transition from the GS arm to the GS capture mode when the aircraft intercepts the desired ILS glideslope beam and the lateral mode has transitioned to localizer capture or localizer track.

The GS mode is disarmed by:

- The localizer mode is not armed or active
- The transition to the GS capture

- GS data from the set VHF navigation receiver is not valid for 5 seconds
- Vertical speed from the set AHRS is not valid.

NOTE

The Altitude select mode stays armed, if it was previously armed, and if GS capture mode is not activated.

NOTE

The Altitude select mode is disarmed, if it was previously armed, after the transition to the GS capture mode.

NOTE

The GS modes cannot be disarmed by a pilot selection without disarming the localizer.

The GS capture and track modes are deactivated by:

- The localizer mode is not active
- VS selection
- IAS selection
- ALT HLD selection
- GA selection
- Pitch thumbwheel selection
- GS data from the set VHF navigation receiver is not valid for 5 seconds
- Vertical speed from the set AHRS is not valid.

NOTE

The conditions to disengage the GS track mode are different for the dual FD mode. See the Description for the dual FD mode.

The AP/FD commands are limited to +10 and −15 degrees pitch attitude in the GS capture and track. The AP/FD commands are load factor limited to 0.2 g in GS capture and 0.1 g in GS track.

Refer to Figure 37.

Dual FD Mode: The dual FD mode is a sub mode of the ILS approach mode shows the pilots that the AFCS is in a configuration applicable for category II ILS approaches. In the dual FD sub mode, FGM1 independently supplies FD commands to PFD1, and FGM2 independently supplies FD commands to PFD2.

During the ILS approach mode, the dual FD sub mode is activated if:

- FGM1 and FGM2 are valid
- EFIS ADC and ATT/HDG source selection switches are set to the NORM position
- FGM1 and FGM2 sense that ADC1 and ADC2 are valid
- FGM1 and FGM2 sense that AHRS1 and AHRS2 are valid
- VHF navigation receiver 1 is set as the left navigation source and VHF navigation receiver 2 is set as the right navigation source
- VHF navigation receiver 1 and VHF navigation receiver 2 are tuned to the same localizer frequency
- FGM1 and FGM2 sense ILS data from VHF navigation receiver 1 and VHF navigation receiver 2 are correct and the same
- Left and right course selections are the same
- The localizer track and glideslope track FD modes are active

- One radio altimeter is correct and the radio altitude is less than 1200 ft
- The left and right FD commands are the same
- TCS is not active.

When the dual FD sub mode is active, a DUAL FD message is shown in the FMA of PFD1 and PFD2 and the lights in the two arrows adjacent to the HSISEL push button switch on the FGCP come on.

During the dual FD sub mode:

FGM1 Inputs

- ADC1
- AHRS1
- VHF navigation receiver 1
- The left course from the FGCP.

FGM2 Inputs

- ADC2
- AHRS2
- VHF navigation receiver 2
- The right course from the FGCP.

If the dual FD sub mode is cancelled, a CAT II FAIL message is shown if one of the two decision height selections is less than 200 ft (for CAT II approaches), or if the two decision height selections are invalid. If not, a DUAL OFF message is shown.

NOTE

The dual FD sub mode is deactivated if the EFIS ADC or ATT/HDG source selection switch is set to the 1 or 2 position. The CAT2 FAIL message will come on and then go off and the vertical and lateral basic FD modes are set.

NOTE

An HSI switch selection has no effect during the dual FD mode.

Tactile control steering (TCS): The TCS pushbutton switch on the handwheel is pushed to let the pilots change the FD targets and to override the AP momentarily without disengaging it.

The FD command bars on PFD go out of view, the numeric values change to dashes, and a TCS message (white letters) is shown on the PFD. If the AP is engaged, the TCS indication replaces the AP message but the lights on the flight guidance control panel (FGCP) stay on.

When the TCS mode is active, manual selection of a new vertical or lateral FD mode is inhibited but automatic transitions from armed modes to capture modes, and from capture modes to track modes will occur.

NOTE

The AP is inhibited from engaging when the TCS mode is active.

When the pilot releases the TCS switch, the FD modes update their targets for the modes that follow:

- Roll hold sub mode of the lateral basic mode
- Pitch hold

- Altitude hold
- Indicated airspeed
- Vertical speed

NOTE

When the wings level sub mode is active and the pilot releases the TCS switch, the lateral mode automatically goes to the roll hold sub mode if the bank angle is more than 6 degrees.

Flight Mode Annunciator (FMA): The FMA has five columns and three lines to show:

- Lateral mode armed
- Lateral mode engaged
- Vertical mode armed
- Vertical mode engaged
- Selected IAS numeric value
- Selected VS numeric value
- Mismatch message
- AFCS general messages
- AP / YD status messages
- Flight Director abnormal conditions
- TCS or AP engagement
- HSI SEL message and FD engagement status.

The flight director mode status messages are summarized in the table that follows:

Table 1: FD Mode Status Messages

FD MODE	COLOUR	MESSAGES
Lateral mode armed	White	VOR, LOC, VOR APP, BC
Lateral mode active	Green	ROLL HOLD, HDG HOLD, WING LVL, HDG SEL, VOR*, VOR, VOR OS, VOR APP*, VOR APP, VOR APP OS, LOC*, LOC, BC*, BC, LNAV
Vertical mode armed	White	ALT SEL (on the left side of the column), GS (on the right side of the column), VNAV (on the right side of the column)
Vertical mode active	Green	PITCH HOLD, IAS xxx, VS +xxxx, VS –xxxx, ALT*, ALT, GA, GS*, GS, VNAV PATH, VNAV FLC, VNAV ALT, VNAV ALT*

NOTE

Vertical Mode Armed (white): ALT SEL may be armed at the same time as GS and VNAV.

NOTE

Vertical Mode Engaged (green): PATH, FLC, ALT and ALT* are shown in green in inverse video for 5 seconds and then normal.

Selected Targets: The selected targets messages are summarized in the table that follows:

Table 2: Selected Targets Messages

MODE	COLOUR	DESCRIPTION
IAS	Green	When IAS mode is active, a numeric value between 0 to 999 knots is shown. The numbers are replaced by 3 white dashes if IAS is invalid. The selected IAS numeric value also changes to dashes when the TCS is active.
VS	Green	When the VS mode is active, a numeric value between –9900 to +9900 is shown in 100 ft per minute increments. The numbers are replaced by 4 white dashes if the selected VS is invalid. The selected VS numeric value also changes to dashes when the TCS is active.

Mismatch Messages: The messages (yellow) have a priority that follows:

Table 3: Mismatch Messages

PRIORITY	MESSAGE	DESCRIPTION
1	[CHECK PFD1] or [CHECK PFD2] (flashing for 5 seconds then steady)	A difference of critical parameters are shown by the PFD. The message is calculated by the DUs
2	EXCESS DEV (flashing)	Senses an ILS LOC or GS excessive deviation during an AFCS dual FD mode approach mode
3	PITCH MISMATCH	A difference between the pilot's and copilots parameters are shown on the PFDs.
4	ROLL MISMATCH	A difference between the pilot's and copilots parameters are shown on the PFDs.
5	IAS MISMATCH	A difference between the pilot's and copilots parameters are shown on the PFDs.
6	ALT MISMATCH	A difference between the pilot's and copilots parameters are shown on the PFDs.
7	HDG MISMATCH	A difference between the pilot's and copilots parameters are shown on the PFDs.
8	RAD ALT MISMATCH	A difference between the pilot's and copilots parameters are shown on the PFDs.

PRIORITY	MESSAGE	DESCRIPTION
9	GS MISMATCH	A difference between the pilot's and copilots parameters are shown on the PFDs.
10	LOC MISMATCH	A difference between the pilot's and copilots parameters are shown on the PFDs.

NOTE

The excess deviation message is set when the glideslope signal is more than 75 micro–amps or when the localizer signal is more than 25 micro–amps.
The radio altitude is between 50 ft and 500 ft, or invalid for the indication for the localizer and 100 ft and 500 ft, or invalid for the indication for the glideslope.

NOTE

The flashing of the FMA message is synchronised with the GS scale and pointer or with the LOC scale and pointer.

NOTE

The MISMATCH messages come on flashing for 5 seconds and then go steady.

AFCS General Failure Messages: The AFCS general failure messages (flashing for 5 seconds then steady) have a priority that follows:

Table 4: AFCS General Failure Messages

PRIORITY	MESSAGE	DESCRIPTION
1	AFCS FAIL	DU does not receive data from the two FGMs
2	AP PITCH TRIM FAIL	AFCS is unable to command pitch trim while the AP is engaged
3	AUTO TRIM FAIL	AFCS is unable to do the flap auto trim function pitch trim while the AP is not engaged. It is out of the view when elevator trim shutoff is set to OFF.
4	YD NOT CENTER	Yaw Damper actuator is not centred and not engaged
5	AFCS CONTROL–LER INOP	A stuck pushbutton switch on the FGCP or a FGCP data bus malfunction
6	L or R FD FAIL	DU does not receive data from the left or right FGM

AP/YD Status Messages: The AP/YD status messages have yellow letters. They come into view flashing for five seconds, then go to steady.

The AP/YD status messages are summarized in the table that follows:

Table 5: AP/YD Status Messages

PRIORITY	MESSAGE	DESCRIPTION
1	AP/YD DISENGAGED	An automatic or manual AP/YD disconnect
2	AP DISENGAGED	An automatic or manual AP disconnect
3	YD DISENGAGED	An automatic or manual YD disconnect AFCS internal malfunction inhibits the AP/YD engagement
4	AP/YD FAIL	AFCS internal malfunction inhibits the AP/YD engagement
5	AP FAIL	AFCS internal malfunction inhibits the AP engagement
6	MISTRIM [TRIM NOSE UP] or MISTRIM [TRIM NOSE DN]	The control columns will move forward when the AP disengages or the control columns will move aft when the AP disengages
7	MISTRIM [TRIM L WING DN] or [TRIM R WING DN]	The handwheel will move counterclockwise when the AP disengages or the handwheel will move clockwise when the AP disengages

NOTE

The DISENGAGED messages come on flashing for an automatic disconnect and the flashing is stopped by an AP DISC pushbutton switch selection on a handwheel. Then, after 5 seconds, the message goes out of view.

NOTE

The DISENGAGED messages come on steady for 5 seconds for a manual disconnect and then go out of view.

NOTE

The FAIL and MISTRIM messages do not reset unless the defect is no longer sensed.

NOTE

The MISTRIM status message also comes into view if APAU torque feedback malfunctions.

Flight Director (FD) Abnormal Messages: The Flight Director (FD) abnormal messages (yellow or white) have a priority that follows:

Table 6: Flight Director (FD) Abnormal Messages

PRIORITY	MESSAGE	DESCRIPTION
1	FD MODE CHANGE (yellow, flashing for 5 seconds then steady)	FD mode cancelled by a defective ADC or AHRS, HDG SEL or HDG HOLD cancelled by a malfunction of heading data, FD navigation armed or active mode cancelled by a malfunction of the navigation source, FD VOR approach capture or track mode cancelled by a selected course change, FD VPATH armed or active mode cancelled by preselected target altitude selection above the current aircraft altitude, FD VPATH active mode is cancelled when the aircraft crosses the preselected altitude while ATLSEL is not armed, FD VPATH active mode is cancelled by a preselected target altitude change
2	FD ATT DATA INVLD (white for 5 seconds)	Tried to engage a FD mode when the AHRS is defective
3	FD ADC DATA INVLD (white for 5 seconds)	Tried to engage a FD mode when the ADC is defective
4	FD HDG DATA INVLD (white for 5 seconds)	Tried to engage the HDG SEL mode when the heading data is defective
5	FD NAV DATA INVLD (white for 5 seconds)	Tried to engage the LNAV mode when the FMS is defective
6	FD MODE INHIBIT (white for 5 seconds)	Tried to engage ALT SEL while the GS capture or the track mode is active, Tied to engage FMS VNAV while FMS is defective
7	CHECK NAV SOURCE (white for 5 seconds)	Loss of the VOR or LOC mode caused by the navigation source selection
8	ALT OFF (yellow)	The Thumbwheel is used in the altitude capture or hold modes
9	VNAV PATH OFF (flashing for 5 seconds then steady)	The FMS has caused an over speed condition

Tactile Control Steering (TCS) or Autopilot (AP) Engagement Messages: The TCS or AP engagement messages (white or green) have a priority that follows:

Table 7: TCS or AP Engagement Messages

PRIORITY	MESSAGE	DESCRIPTION
1	TCS	White message shows TCS and AP is active
2	AP	Green message shows AP is engaged
3	AP INHIBIT	A White message for 5 seconds show AP malfunction or a condition inhibits the engagement
4	YD INHIBIT	A White message for 5 seconds show YD malfunction or a condition inhibits the engagement

HSI SEL Message or FD Engagement Status: The HSI SEL message or FD engagement status have a priority that follows:

Table 8: HSI SEL Message or FD Engagement Status

PRIORITY	MESSAGE	DESCRIPTION
1	CAT2 FAIL (yellow, flashing for 5 seconds then steady)	The message logic is armed during the dual FD mode when the radio altitude is more than 50 ft, or invalid for indication and one decision height is set less than 200 ft, or the two DH selections are invalid. The logic is disarmed when the GS mode is disengaged or when the radio altitude is less than 50 ft, or the two DH are set more than 200 ft. The CAT2 FAIL message is shown when a condition is as follows: FGM1 or FGM2 is defective (internal monitoring of FGM), Pitch, Roll, IAS, ILS LOC, ILS GS, or radio altitude mismatch, ILS LOC, ILS GS or radio altitude essential display monitoring defect sensed by the FDPS, Essential display monitoring is defective, [CHECK PFD1] or [CHECK PFD2] condition, PFD does not receive valid pitch, roll, heading, IAS, ILS LOC, ILS GS, radio altitude, or IOP1 or IOP2, Opposite PFD is invalid or sends a Cat2 Fail flag through the feedback bus
2	DUAL OFF (yellow, flashing for 5 seconds then steady)	The DUAL FD mode is cancelled while the two DH are set more than 200 ft

PRIORITY	MESSAGE	DESCRIPTION
3	DUAL FD (green)	The Dual FD mode is engaged
4	HSI and caret (green)	Show opposite HSI selection for navigation and is only shown on the PFD opposite side of the set HIS
5	Four white dashes	No data is available or the HSI select status is set invalid by the IOP

Refer to Figures 38 and 39.

Autopilot (AP): The AP pushbutton switch on the FGCP is pushed to engage the autopilot and yaw damper actuator units for automatic control of the aircraft flight path.

NOTE

The yaw damper automatically engages with the autopilot.

The AP mode needs the conditions that follow:

- ADC 1 and ADC 2 are valid and do not disagree
- AHRS1 and AHRS2 are valid and do not disagree
- The aircraft is airborne
- The aircraft attitude is within the AP engagement limits (45 degrees roll angle and 20 degrees pitch angle)
- No manual pitch trim selection
- No AP disengage switch selection
- The TCS function is not defective or is not active
- No stall condition sensed
- No GA pushbutton switch selection the power lever
- The AP disengagement indication are not shown
- Yaw Damper function is serviceable
- Internal AFCS monitoring is valid.

Two arrows on each side of the AP pushbutton switch on the FGCP come on and an AP message in green letters is shown in the Flight Mode Annunciators (FMA) of PFD1 and PFD2.

An AP INHIBIT message is shown in white for 5 seconds in the FMA of PFD1 and PFD2 for an Autopilot (AP) selection when an external condition prevents autopilot operation as follows:

- An Air Data Computer (ADC) does not supply valid or the same altitude data to FGM1 and FGM2
- An Attitude and Heading Reference Unit (AHRU) does not supply valid or the same attitude data to FGM1 and FGM2.

NOTE

The FMA of PFD1 and PFD2 will also show an FD ADC DATA INVLD or FD ATT DATA INVLD message.

NOTE

FD ADC DATA INVLD or FD ATT DATA INVLD messages are inhibited for ADC and AHRS source reversion selections.

The AP INHIBIT message will also come into view for the conditions that are not malfunctions as follows:

- The aircraft is not airborne
- Aircraft attitude is not in the engagement limits
- Manual pitch trim selection

– The AP DISENGAGE message is in view
– The Tactile Control Steering (TCS) mode is active
– The stick shaker or the pusher is in operation.

An AP FAIL message is shown in yellow in the FMA of PFD1 and PFD2 when there is an internal malfunction that prevents Autopilot (AP) operation as follows:

– Flight Guidance Module (FGM1 or FGM2)
– Autopilot Actuator Unit – Pitch (APAU–P)
– Autopilot Actuator Unit – Roll (APAU–R).

NOTE

If the AP or Yaw Damper (YD) was engaged, an AP DISENGAGED message is shown until cancelled before this message is shown.

NOTE

The FMA in the PFD can also show the YD NOT CENTERED message.

The AP pushbutton switch on the FGCP is pushed again, or the YD pushbutton switch is pushed to disengage the autopilot.

The autopilot also disengages for a condition that follows:

– The A/P DIS pushbutton switches selection on the handwheel
– NOSE UP or DN manual pitch trim selection on the handwheel (TCS is not active)
– GA pushbutton switch selection the power lever
– The manual override of the control column or handwheel
– Electrical power interruption.

Refer to Figure 40.

The Manual Autopilot Disengagement: An AP DISENGAGED or AP/YD DISENGAGED message is shown in yellow for 5 seconds and an aural tone sounds for 1.5 seconds for the manual autopilot disengagement.

NOTE

The AP DISENG warning lights do not come on for a manual AP disengagement.

The Automatic Autopilot Disengagement: The two AP DISENG warning lights on the glare shield panel come on flashing and an aural tone sounds continuously for an automatic autopilot disengagement indication. An AP DISENGAGED or AP/YD DISENGAGED message is also shown in yellow and flashing in the FMA of PFD1 and PFD2. The A/P DIS pushbutton switch on the pilot or copilots handwheel is pushed to cancel the indication.

NOTE

The warning lights and messages go steady for 5 seconds before they go off and the two arrows on each side of the AP pushbutton switch on the FGCP go off.

NOTE

When the manual trim is used to disengage the autopilot, it is an automatic autopilot disengagement.

Refer to Figure 41.

Yaw Damper: The YD or the AP pushbutton switch on the FGCP is pushed to engage the yaw damper actuator unit for Dutch roll damping and turn coordination. AP engagement automatically engages the yaw damper. AP disengagement does not disengage the yaw damper, unless the AP disengagement was caused by a

malfunction of the yaw damper. A yaw damper disengagement automatically disengages the Autopilot.

The yaw damper operation is limited to 4.5 degrees of rudder movement by mechanical stops.

The YD mode needs the conditions that follow:

- AHRS1 and AHRS2 are valid and do not disagree
- ADC1 and ADC2 are valid and do not disagree
- The aircraft attitude is within the YD engagement limits (45 degrees roll angle)
- Internal AFCS monitoring is valid
- The YD DISENGAGE message is not active.

Two arrows on each side of the YD pushbutton switch on the FGCP come on.

A YD INHIBIT message is shown in white for 5 seconds in the FMA of PFD1 and PFD2 for an yaw damper (YD) selection when an external condition prevents yaw damper operation as follows:

- An air data computer (ADC) does not supply valid or the same altitude data to FGM1 and FGM2
- An attitude and heading reference unit (AHRU) does not supply valid or the same attitude data to FGM1 and FGM2
- Aircraft attitude is not in the engagement limits
- YD DISENGAGED message is in view.

The yaw damper disengages for a condition that follows:

- A defect of the yaw damper actuator unit
- The YD pushbutton switch is stuck
- Electrical power interruption.

Refer to Figure 42.

The Manual Yaw Disengagement: A YD DISENGAGED or AP/YD DISENGAGED message is shown in yellow for 5 seconds for the manual autopilot disengagement.

The Automatic Yaw Disengagement: A YD DISENGAGED or AP/YD DISENGAGED is shown in yellow and flashing in the FMA of PFD1 and PFD2.

The A/P DIS pushbutton switch on the pilot or copilot handwheel is pushed to cancel the indication. The two arrows on each side of the AP pushbutton switch on the FGCP go off.

A YD NOT CENTERED message in shown in the FMA of PFD1 and PFD2 when the yaw damper actuator unit (YDAU) is not engaged and not in the centre position.

The FMA in the PFD can also show a message that follows:

- AP FAIL
- AP/YD FAIL.

AP Pitch Trim: The AFCS commands the pitch trim to decrease the control column pitch transient when the AP is disengaged

The AP pitch trim function operates at two speeds:

- High speed for Calibrated Airspeed (CAS) more than 180 knots (334 km/h)
- Low speed for CAS less than 180 knots (334 km/h).

Each FGM monitors the AP actuator unit (APAU) torque when the AP is engaged. If the torque is more than the threshold, a MISTRIM

[TRIM NOSE UP] or MISTRIM [TRIM NOSE DN] is shown on PFD1 and PFD2 because there can be a significant control column force and pitch transient when the AP disengages.

The AP does not automatically disengage when a pitch mistrim occurs. But, the AP will automatically disengage when the AP pitch servo torque is more than 10.9 Nm.

An AP PITCH TRIM FAIL message is shown on PFD1 and PFD2 if the AP pitch trim malfunctions.

Flap Automatic Pitch Trim: The AFCS also commands the pitch trim to decrease the control column force during flap operation when the pilot is manually flying the aircraft.

The flap automatic pitch trim commands different speeds for two degrees of pitch trim.

The flap auto pitch trim function automatically functions when the conditions are as follows:

- The aircraft is airborne for two seconds
- CAS is less than 180 knots (334 km/h)
- The autopilot is not engaged
- The flight crew are not operating manual pitch trim
- The AFCS senses that the flaps are moving between Flaps 15 and Flaps 35.

There is no indication for flap auto pitch trim engaged or disengaged, but an AUTO TRIM FAIL message is shown on PFD1 and PFD2 if the flap automatic trim malfunctions.

NOTE

The control column force held by the pilot during extension or retraction of the flaps should be less than 50 pounds.

Refer to Figures 43 , 44 and 45.

BITE Retrieval:

The AVIONICS STATUS page of the Central Diagnostic System (CDS) gives the list of currently failed avionics subsystems.

If no failure is detected, the page NO FAULT DETECTED is shown.

MEL/CDL:

A/P DISENG annunciators on the glareshield panel may be inoperative. Any autopilot mode functioning normally may be used.

Autopilot pitch trim system (AP PITCH TRIM FAIL) may be inoperative provided manual pitch trim is operative, autopilot is considered inoperative and not used, and flap Auto Pitch Trim (AUTO TRIM FAIL) is considered inoperative and not used.

Two tactile control steering (TCS) switches may be inoperative.

Individual modes of operation of the flight guidance control panel (FGCP) may be inoperative provided that heading bugs, navigation source selectors and course selection functions are operative.

Flight guidance control panel indicators (AP, HSI SEL only) may be inoperative.

Yaw damper system may be inoperative and autopilot will not be available.

Two A/P DIS switches may be inoperative provided the autopilot is considered inoperative and not used.

One A/P DIS switch may be inoperative provided the autopilot is not used below 1,000 ft. AGL.

Operation:

Critical ARINC 429 signals such as pitch changes and discrete signals such AP or YD pushbutton selections are supplied from the FGCP directly to FGM1 and FGM2.

ARINC 429 signals are also supplied directly to FGM1 and FGM2 from the navigation sources that follow:

- The Attitude and Heading Reference System No. 1 and 2 (AHRS1 and AHRS2)
- The Air Data System No. 1 and 2 (ADS1 and ADS2)
- The VHF navigation No. 1 and 2 (VHF/NAV1 and VHF/NAV2).

Critical discrete signals are also supplied from other sources that follow:

- The Flight Control System Electronic Control Unit left and right (FCS ECU) for AP disengage and trim position
- The Stall Protection System No. 1 and 2 (SPS1 and SPS2) for AP disengage
- The pilot and copilot handwheels for the AP disengage and TCS
- The power lever No. 1 and 2 for the Go Around mode (GA)
- The Proximity Sensor Electronic Unit (PSEU) for Weight On Wheels (WOW1 and WOW2).

A discrete signal such as AP engage light signal is supplied from FGM1 directly to the FGCP to make the light in the panel come on.

ARINC 429 signals such as FD pitch command can be supplied directly to the display units (PFD1, PFD2, MFD1 and MFD2) or signals such as vertical NAV arm through the FDPS to the FMS.

Analogue signals such as AP and YD actuator commands are supplied from FGM1 to the actuators and discrete signals are supplied to inhibit the actuators.

Analogue signals such as the actuator servo position and torque is supplied from the AP actuators to FGM1 and FGM2.

Discrete signals such as inhibit feedback are supplied from the AP actuators to FGM2.

Some ARINC 429 signals are supplied through the FDPS to FGM1 and FGM2.

From the navigation sources:

- The Radio Altimeter No. 1 and 2 (RA1 and RA2)
- The Distance Measuring Equipment No. 1 and 2 (DME1 and DME2)
- Flight Management System No.1 and 2 (FMS1 and FMS2).

Other sources that follow:

- The Engine and System Integrated Display Control Panel (ESCP)
- Proximity Sensor Electronic Unit (PSEU)
- Flap Position Indicator Unit (FPIU).

Not critical ARINC 429 signals such as the HDG target is supplied from the FGCP through the Flight Data Processing System (FDPS) to FGM1 and FGM2.

ARINC 429 signals such as the AP pitch command are supplied from FGM1 and FGM2 to the opposite FGM for monitoring.

Discrete signals such as the AP engage are supplied from a FGM back to the same FGM and to the opposite FGM. But, some discrete signals such as FGM healthy are only supplied to the opposite FGM.

Analogue signals such as the APAU pitch command is supplied from FGM1 back to FGM1 and to FGM2 for monitoring.

Flight Guidance Module Inputs:

SOURCE	SIGNAL	TYPE	RECEIVED BY	DIRECT OR THROUGH FDPS	COMMENTS
AHRU1 and AHRU2	Pitch angle	ARINC 429	FGM1 and FGM2	Direct	–
	Roll angle	ARINC 429	FGM1 and FGM2	Direct	–
	Body longitu–nal accelera–tion	ARINC 429	FGM1 and FGM2	Direct	–
	Body lateral accelera–tion	ARINC 429	FGM1 and FGM2	Direct	–
	Body normal accelera–tion	ARINC 429	FGM1 and FGM2	Direct	For flight envelope monitor–ing
	Body pitch rate	ARINC 429	FGM1 and FGM2	Direct	–
	Body roll rate	ARINC 429	FGM1 and FGM2	Direct	–
	Body yaw rate	ARINC 429	FGM1 and FGM2	Direct	–

SOURCE	SIGNAL	TYPE	RECEIVED BY	DIRECT OR THROUGH FDPS	COMMENTS
	Magnetic heading	ARINC 429	FGM1 and FGM2	Direct	–
	Vertical speed	ARINC 429	FGM1 and FGM2	Direct	–
	Baro–metric inertial altitude	ARINC 429	FGM1 and FGM2	Direct	–
ADC1 and ADC2	Standard altitude	ARINC 429	FGM1 and FGM2	Direct	–
	Baro–metric corrected altitude	ARINC 429	FGM1 and FGM2	Direct	–
	Compu–ted airspeed	ARINC 429	FGM1 and FGM2	Direct	–
	True Airspeed	ARINC 429	FGM1 and FGM2	Direct	–
	VMO	ARINC 429	FGM1 and FGM2	Direct	–
VHF NAV1 and VHF NAV2	ILS LOC deviation	ARINC 429	FGM1 and FGM2	Direct	–
	ILS Glide deviation	ARINC 429	FGM1 and FGM2	Direct	–
	VOR bearing	ARINC 429	FGM1 and FGM2	Direct	–
	VOR/ ILS frequency	ARINC 429	FGM1 and FGM2	Direct	–
	VOR/ ILS selection	ARINC 429 Discrete	FGM1 and FGM2	Direct	–
RA1 and RA2	Radio altitude	ARINC 429	FGM1 and FGM2	FDPS	–

SOURCE	SIGNAL	TYPE	RECEIVED BY	DIRECT OR THROUGH FDPS	COMMENTS
DME1 and DME2	Distance channel 1	ARINC 429	FGM1 and FGM2	FDPS	–
	Distance channel 2	ARINC 429	FGM1 and FGM2	FDPS	–
	Freque–ncy channel 1	ARINC 429	FGM1 and FGM2	FDPS	–
	Freque–Frequency channel 2	ARINC 429	FGM1 and FGM2	FDPS	–
	Tuning channel 1	ARINC 429	FGM1 and FGM2	FDPS	–
	Tuning channel 2	ARINC 429	FGM1 and FGM2	FDPS	–
FGCP1 and FGCP2	PITCH increment	ARINC 429	FGM1 and FGM2	FDPS	Pitch, VS, IAS target
	FD mode PB	ARINC 429	FGM1 and FGM2	FDPS	–
	HDG left side target	ARINC 429	FGM1 and FGM2	FDPS	–
	HDG right side target	ARINC 429	FGM1 and FGM2	FDPS	–
	CRS left side target	ARINC 429	FGM1 and FGM2	FDPS	–
	CRS right side target	ARINC 429	FGM1 and FGM2	FDPS	–
	ALT target	ARINC 429	FGM1 and FGM2	FDPS	–
	HSISEL	ARINC 429	FGM1 and FGM2	FDPS	Side reference source selection

SOURCE	SIGNAL	TYPE	RECEIVED BY	DIRECT OR THROUGH FDPS	COMMENTS
	Naviga–tion source 1	ARINC 429 Discrete	FGM1 and FGM2	FDPS	–
	Naviga–tion source 2	ARINC 429 Discrete	FGM1 and FGM2	FDPS	–
	AP PB pressed	Discrete	Related FGM	Direct	–
	YD PB pressed	Discrete	Related FGM	Direct	–
ESCP	ADU reversion 1	ARINC 429 Discrete	FGM1 and FGM2	FDPS	–
	ADC reversion 2	ARINC 429 Discrete	FGM1 and FGM2	FDPS	–
	ATT reversion 1	ARINC 429 Discrete	FGM1 and FGM2	FDPS	–
	ATT reversion 2	ARINC 429 Discrete	FGM1 and FGM2	FDPS	–
FPIU	Flap position	ARINC 429	FGM1 and FGM2	FDPS	–
	Flap HLTHY	ARINC 429 Discrete	FGM1 and FGM2	FDPS	–
FCS ECU R and L	ECU AP DISENG–AGE	Discrete	FGM1 and FGM2	Direct	Manual pitch trim diseng–age
	Left pitch trim position	ARINC 429	FGM1 and FGM2	Direct	–
	Right pitch trim position	ARINC 429	FGM1 and FGM2	Direct	–
SPM1	SPS 1 AP DISC	Discrete	FGM1 and FGM2	Direct	AP disconn–ect
SPM2	SPS 2 AP DISC	Discrete	FGM1 and FGM2	Direct	AP disconn–ect

SOURCE	SIGNAL	TYPE	RECEIVED BY	DIRECT OR THROUGH FDPS	COMMENTS
Hand–wheel 1	INST AP DISC 1	Discrete	FGM1 and FGM2	Direct	AP disconn–ect
	TCS 1	Discrete	FGM1 and FGM2	Direct	–
Hand–wheel 2	INST AP DISC 2	Discrete	FGM1 and FGM2	Direct	AP disconn–ect
	TCS 2	Discrete	FGM1 and FGM2	Direct	–
Power Lever 1	GO AROUND 1	Discrete	FGM1 and FGM2	Direct	–
Power Lever 2	GO AROUND 2	Discrete	FGM1 and FGM2	Direct	–
PSEU	POST IFC 1 NG WOW 1	Discrete	FGM1	Direct	–
	POST IFC1 NG WOW 2	Discrete	FGM1	Direct	–
	POST IFC2 NG WOW 1	Discrete	FGM2	Direct	–
	POST IFC2 NG WOW 2	Discrete	FGM2	Direct	–

SOURCE	SIGNAL	TYPE	RECEIVED BY	DIRECT OR THROUGH FDPS	COMMENTS
FGM1 and FGM2	AP pitch command	ARINC 429	Opposite FGM	Direct	–
	AP roll command	ARINC 429	Opposite FGM	Direct	–
	Yaw damper command	ARINC 429	Opposite FGM	Direct	–
	AP Pitch unpassi–vated command	ARINC 429	Opposite FGM	Direct	–
	AP Roll unpassi–vated command	ARINC 429	Opposite FGM	Direct	–
	YD unpassi–vated command	ARINC 429	Opposite FGM	Direct	–
	FD pitch command	ARINC 429	Opposite FGM	Direct	–
	FD roll command	ARINC 429	Opposite FGM	Direct	–
	Pitch outer loop command	ARINC 429	FGM2	Direct	–
	Pitch outer loop target	ARINC 429	FGM2	Direct	–
	Roll outer loop command	ARINC 429	FGM2	Direct	–
	Roll accuracy input	ARINC 429	FGM2	Direct	–
	FD modes engage–ments	ARINC 429 Discrete	FGM2	Direct	–
	Dual mode	ARINC 429 Discrete	Opposite FGM	Direct	–
	TCS active	ARINC 429 Discrete	Opposite FGM	Direct	–
	Flap pitch trim own side conditions	ARINC 429 Discrete	Opposite FGM	Direct	–
	Monitor–ing FGM	ARINC 429 Discrete	Opposite FGM	Direct	–

SOURCE	SIGNAL	TYPE	RECEIVED BY	DIRECT OR THROUGH FDPS	COMMENTS
	AP ENG	Discrete	FGM1 and FGM2	Direct	–
	YD ENG	Discrete	FGM1 and FGM2	Direct	–
	FGM HEAL–THY	Discrete	Opposite FGM	Direct	–
	FGM exchange 1	Discrete	Opposite FGM	Direct	Used for POST synchro–nization
FGM 1	APAU pitch command	Analogue	FGM1 and FGM2	Direct	–
	APAU roll command	Analogue	FGM1 and FGM2	Direct	–
	YDAU command	Analogue	FGM1 and FGM2	Direct	–
Pitch APAU	Pitch servo position 1	Analogue	FGM1 and FGM2	Direct	–
	Pitch servo position 2	Analogue	FGM1 and FGM2	Direct	–
	Pitch servo torque 1	Analogue	FGM1 and FGM2	Direct	–
	Pitch servo torque 2	Analogue	FGM1 and FGM2	Direct	–
	APAU pitch inhibit feedback	Discrete	FGM2	Direct	–

SOURCE	SIGNAL	TYPE	RECEIVED BY	DIRECT OR THROUGH FDPS	COMMENTS
Roll APAU	Roll servo position 1	Analogue	FGM1 and FGM2	Direct	–
	Roll servo position 2	Analogue	FGM1 and FGM2	Direct	–
	Pitch servo torque 1	Analogue	FGM1 and FGM2	Direct	–
	Roll servo torque 2	Analogue	FGM1 and FGM2	Direct	–
	APAU roll inhibit feedback	Discrete	FGM2	Direct	–
YAW Damper Actuator	Yaw servo position 1	Analogue	FGM1 and FGM2	Direct	–
	Yaw servo position 2	Analogue	FGM1 and FGM2	Direct	–
	YDAU inhibit feedback	Discrete	FGM2	Direct	–
FGM Connec–tor	PPROG SIDE CPU 1	Discrete	Own FGM	Direct	–
	PPROG SIDE CPU 2	Discrete	Own FGM	Direct	–
	PPROG SIDE EXT	Discrete	Own FGM	Direct	–

SOURCE	SIGNAL	TYPE	RECEIVED BY	DIRECT OR THROUGH FDPS	COMMENTS
FMS1 and FMS2	FMS Roll target	ARINC 429	FGM1 and FGM2	FDPS	–
	FMS Pitch target	ARINC 429	FGM1 and FGM2	FDPS	–
	VPATH arm enable	ARINC 429	FGM1 and FGM2	FDPS	Used with FMS UNS 1E pre V803
	Reques–ted VNAV mode	ARINC 429 Discrete	FGM1 and FGM2	FDPS	–
	VASEL mode arm able	ARINC 429 Discrete	FGM1 and FGM2	FDPS	–
	Activation discrete	ARINC 429 Discrete	FGM1 and FGM2	FDPS	–
	FMS VFLC target	ARINC 429	FGM1 and FGM2	FDPS	–
	FMS altitude target	ARINC 429	FGM1 and FGM2	FDPS	–
	LOC inbound course	ARINC 429	FGM1 and FGM2	FDPS	–
	ILS tune status	ARINC 429 Discrete	FGM1 and FGM2	FDPS	–

Flight Guidance Module Outputs:

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
AP Pitch command	ARINC 429	FGM1 and FGM2	Opposite FGM	–
AP Roll command	ARINC 429	FGM1 and FGM2	Opposite FGM	–
Yaw damper command	ARINC 429	FGM1 and FGM2	Opposite FGM	–
AP Pitch unpassi–vated command	ARINC 429	FGM1 and FGM2	Opposite FGM	–
AP Roll unpassi–vated command	ARINC 429	FGM1 and FGM2	Opposite FGM	–

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
Yaw unpassi–vated command	ARINC 429	FGM1 and FGM2	Opposite FGM	–
Pitch outer loop command	ARINC 429	FGM1 and FGM2	Opposite FGM	–
Roll outer loop command	ARINC 429	FGM1 and FGM2	Opposite FGM	–
Pitch outer loop target	ARINC 429	FGM1 and FGM2	Opposite FGM	–
Roll accuracy command	ARINC 429	FGM1 and FGM2	Opposite FGM	–
FD Pitch command	ARINC 429	FGM1 and FGM2	Display units, PFD and MFD	Flight Director commands
FD Roll command	ARINC 429	FGM1 and FGM2	Display units, PFD and MFD	

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
IAS Target	ARINC 429	FGM1 and FGM2	Display units, PFD and MFD	Flight targets (IAS target and VS target are also received by FMS1 and FMS2 through FDPS)
VS Target	ARINC 429	FGM1 and FGM2	Display units, PFD and MFD	
Pitch Target	ARINC 429	FGM1 and FGM2	Display units, PFD and MFD	
Heading hold	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	Lateral basic mode
Wings level	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
Roll hold	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
Heading select	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	Lateral cruise mode
VOR Navigation arm	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
VOR Navigation capture	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
VOR Navigation track	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
VOR OS	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
VOR Approach arm	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	Lateral approach mode
VOR Approach capture	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
VOR Approach track	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
VOR Approach OS	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
Lateral NAV	ARINC 429 Discrete	FGM1 and FGM2	FMS1 and FMS2 through FDPS and EIS	–
Vertical NAV arm	ARINC 429 Discrete	FGM1 and FGM2	FMS1 and FMS2 through FDPS and EIS	–
Vertical NAV active	ARINC 429 Discrete	FGM1 and FGM2	FMS1 and FMS2 through FDPS and EIS	–
VASEL armed	ARINC 429 Discrete	FGM1 and FGM2	FMS1 and FMS2 through FDPS and EIS	–
VALT capture	ARINC 429 Discrete	FGM1 and FGM2	FMS1 and FMS2 through FDPS and EIS	–
VALT track	ARINC 429 Discrete	FGM1 and FGM2	FMS1 and FMS2 through FDPS and EIS	–

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
VPATH active	ARINC 429 Discrete	FGM1 and FGM2	FMS1 and FMS2 through FDPS and EIS	–
VAPP active	ARINC 429 Discrete	FGM1 and FGM2	FMS1 and FMS2 through FDPS and EIS	–
VFLC active	ARINC 429 Discrete	FGM1 and FGM2	FMS1 and FMS2 through FDPS and EIS	–
Altitude target	ARINC 429 Discrete	FGM1 and FGM2	FMS1 and FMS2 through FDPS	–

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
LOC arm	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	Lateral ILS approach mode
LOC capture	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
LOC track	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
LOC back course arm	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
LOC back course capture	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
LOC back course track	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
Pitch Hold	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	Longitudinal basic mode

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
ALT Hold	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	Longitudinal cruise mode
ALT Select arm	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
ALT Select capture	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
IAS mode	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
V/S mode	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
GS arm	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	Longitudinal approach mode
GS capture	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
GS track	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
Pitch go around	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
Dual mode	ARINC 429 Discrete	FGM1 and FGM2	Opposite FGM, FDPS, Display Units	–
Flap auto pitch trim own side conditions	ARINC 429 Discrete	FGM1 and FGM2	Opposite FGM	–
HSISEL_L forced	ARINC 429 Discrete	FGM1 and FGM2	FDPS	Force HSISEL reconfigu–ration after dual loss
HSISEL_R forced	ARINC 429 Discrete	FGM1 and FGM2	FDPS	

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
Mistrim roll L Wing DN	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	Pitch and roll mistrim warning messages
Mistrim roll R Wing DN	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
Mistrim pitch nose DN	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
Mistrim pitch nose UP	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
AP pitchtrim fail	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
Flap pitch trim fail	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	–
AFCS CP inoperative	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	–

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
AP engaged	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	AP/YD engage–ments messages
YD engaged	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
TCS active	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
AP disengaged	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
YD disengaged	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
AP/YD disengaged	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
AP inhibit	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
YD inhibit	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
AP fail	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
AP/YD fail	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
YD not centered	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
AP aural warning disengage	ARINC 429 Discrete	FGM1 and FGM2	FDPS	Warning tone generator
FD ATT data invalid	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	FD modes abnormal messages
FD ADC data invalid	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
FD HDG data invalid	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
FD NAV data invalid	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
FD mode inhibit	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
Check NAV source	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
ALT off	ARINC 429 Discrete	FGM1 and FGM2	Display units, PFD and MFD	
BITE messages	ARINC 429	FGM1 and FGM2	Display units, PFD and MFD	–

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
FGM part number	ARINC 429 group of N Discrete Data	FGM1 and FGM2	Display units, PFD and MFD	4 labels are emitted
Flight test bus	ARINC 429	FGM1 and FGM2	–	–
AP engage LT	Discrete	FGM1	FGCP	AP/ YD status indicator engage–ments
YD engage LT	Discrete	FGM1	FGCP	
AP ENG	Discrete	FGM1 and FGM2	FGM1 and FGM2	opposite side and feedbacks
YD ENG	Discrete	FGM1 and FGM2	FGM1 and FGM2	
FGM exchange 1	Discrete	FGM1 and FGM2	FGM1 and FGM2	–
FGM exchange 2	Discrete	FGM1 and FGM2	FGM1 and FGM2	–
HEALTHY FGM	Discrete	FGM1 and FGM2	FGM1 and FGM2	Module validity status

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
AP pitch actuator command	Analogue	FGM1 and FGM2	Pitch actuator and FGM1 and FGM2	To actuators, opposite FGM, and feedbacks
AP roll actuator command	Analogue	FGM1 and FGM2	Roll actuator and FGM1 and FGM2	
YD actuator command	Analogue	FGM1 and FGM2	Yaw actuator and FGM1 and FGM2	
AP pitch clutch	Discrete	FGM1	PITCH actuator	–
AP pitch inhibit	Discrete	FGM2	PITCH actuator	–
AP roll clutch	Discrete	FGM1	ROLL actuator	–
AP roll inhibit	Discrete	FGM2	ROLL actuator	–
Yaw damper inhibit	Discrete	FGM2	YAW actuator	–
Nose UP command	Discrete	FGM1	FCS ECU	–

SIGNAL	TYPE	TRANSMITTED BY	RECEIVED BY	COMMENT
Nose DOWN command	Discrete	FGM1	FCS ECU	–
ECU HI/LO speed select	Discrete	FGM1	FCS ECU	–
Pitch trim enable	Discrete	FGM1 and FGM2	FCS ECU	–
AP warning	Discrete	FGM1 and FGM2	AP disengage light	Visual warning

FGCP Inputs

SOURCE	TYPE	SIGNAL	COMMENTS
FGM1	Discrete	AP engage LT	AP/YD engagements status indicator
FGM1	Discrete	YD engage LT	

FGCP Outputs

SIGNAL	TYPE	RECEIVED BY	COMMENTS
Pitch Increment	ARINC 429	FGM1 and FGM2	–
Mode PB Pressed actions	ARINC 429	FGM1 and FGM2	–
HDG Left side Target	ARINC 429	FGM1 and FGM2 through FDPS	–
HDG Right side Target	ARINC 429	FGM1 and FGM2 through FDPS	–
CRS Left side Target	ARINC 429	FGM1 and FGM2 through FDPS	–
CRS Right side Target	ARINC 429	FGM1 and FGM2 through FDPS	–
ALT Target	ARINC 429	FGM1 and FGM2 through FDPS	–
HSISEL	ARINC 429 Discrete	FGM1 and FGM2 through FDPS	–
Navigation sources 1	ARINC 429 Discrete	FGM1 and FGM2 through FDPS	–

SIGNAL	TYPE	RECEIVED BY	COMMENTS
Navigation sources 2	ARINC 429 Discrete	FGM1 and FGM2 through FDPS	–
AP PB pressed FGM 1	Discrete	FGM1	–
YD PB pressed FGM 1	Discrete	FGM1	–
AP PB pressed FGM 2	Discrete	FGM2	–
YD PB pressed FGM 2	Discrete	FGM2	–

AP Pitch Actuator Inputs

SOURCE	TYPE	SIGNAL	COMMENTS
FGM1	Discrete	AP pitch clutch	–
FGM2	Discrete	AP pitch inhibit	–
FGM1	Analogue	AP pitch command	–

AP Pitch Actuator Outputs

TRANSMITTED BY	TYPE	SIGNAL	RECEIVED BY	COMM-ENTS
AP pitch actuator	Analogue	PITCH servo position 1	FGM1 and FGM2 through FDPS	–
AP pitch actuator	Analogue	PITCH servo position 2	FGM1 and FGM2 through FDPS	–
AP pitch actuator	Analogue	PITCH servo torque 1	FGM1 and FGM2 through FDPS	–
AP pitch actuator	Analogue	PITCH servo torque 2	FGM1 and FGM2 through FDPS	–
AP pitch actuator	Discrete	APAU Pitch inhibit FBK	FGM2	–

AP Roll Actuator Inputs

SOURCE	TYPE	SIGNAL	COMMENTS
FGM1	Discrete	AP roll clutch	–
FGM2	Discrete	AP roll inhibit	–
FGM1	Analogue	AP roll command	–

AP Roll Actuator Outputs

TRANSMITTED BY	TYPE	SIGNAL	RECEIVED BY	COMM-ENTS
AP roll actuator	Analogue	ROLL servo position 1	FGM1 and FGM2 through FDPS	–
AP roll actuator	Analogue	ROLL servo position 2	FGM1 and FGM2 through FDPS	–
AP roll actuator	Analogue	ROLL servo torque 1	FGM1 and FGM2 through FDPS	–
AP roll actuator	Analogue	ROLL servo torque 2	FGM1 and FGM2 through FDPS	–
AP roll actuator	Discrete	APAU Roll inhibit FBK	FGM2	–

Yaw Damper Actuator Inputs

SOURCE	TYPE	SIGNAL	COMMENTS
FGM1	Analogue	Yaw damper command	–
FGM2	Discrete	Yaw damper inhibit	–

Yaw Damper Actuator Outputs

TRANSMITTED BY	TYPE	SIGNAL	RECEIVED BY	COMM-ENTS
Yaw damper actuator	Analogue	YAW servo position 1	FGM1 and FGM2	–
Yaw damper actuator	Analogue	YAW servo position 2	FGM1 and FGM2	–
Yaw damper actuator	Discrete	YDAU inhibit FBK	FGM2	–

Refer to Figure 46.

The AFCS has the internal interfaces that follow:

- Flight Guidance Control Panel to FGM
- FGM to FGM
- FGM to Yaw Damper Actuator Unit
- FGM to Autopilot Actuator Units
- Autopilot Disconnect Switches to FGM
- TCS Switches to FGM
- Go Around Switches to FGM
- FGM to Autopilot Disengage Warning Lights.

FGCP to FGM: Each FGM receives two ground or open input discrete signals from the FGCP, one from the YD engage pushbutton switch and the other one from the AP engage. Also FGM1 supplies

two ground or open discrete signals back to each channel of the FGCP for indication of YD and AP engagement.

Each FGM receives an ARINC 429 data bus input from the FGCP, FD pushbutton switch selections. The left FGCP channel supplies FGM1 and the right channel supplies FGM2.

FGM to FGM: Each FGM transmits on an ARINC 429 data bus to the other FGM for internal AFCS communication between the two channels for cross–monitoring. Each FGM also transmits healthy and engagement discrete signals to the other FGM for internal AFCS communication between the two channels.

FGM to Yaw Damper Actuator Unit (YDAU): Each FGM is connected to the YDAU. The FGM1 supplies an analog DC command to the YDAU, and receives back two analog DC position feedback signals. FGM2 supplies a 28 V dc oprn discrete to inhibit the YDAU (28 VDC is not inhibited). A ground or open feedback discrete is supplied from the YDAU to FGM2 for the status of the YDAU (ground is not inhibited).

FGM to Autopilot Actuator Unit: Each FGM is connected to the pitch and roll APAUs. FGM1 provides an analogue DC command to the APAU, and receives back two analogue DC position feedback signals. FGM2 also receives the two analogue DC position feedback signals. Each FGM also receives two analogue DC voltages from each APAU relating to actuator torque.

The FGM1 supplies 28 Vdc or open discrete signal to engage the APAU clutches, where 28 Vdc is engaged. In addition, FGM2 supplies a 28 Vdc or open discrete signal to inhibit the actuators, where 28 Vdc is not inhibited.

The APAU also supplies a ground or open status discrete signal (ground is not inhibited) back to FGM2 to prevent dormant malfunctions.

Go–Around Switches to FGM1 and FGM2: The two go–around switches supply a ground discrete input to each FGM to disengage the autopilot and activate the FD go–around and wings level modes.

Autopilot Disconnect Switches to FGM1 and FGM2: The two autopilot disconnect switches supply a ground discrete input to each FGM to disengage the autopilot and cancel aural and visual warnings when the autopilot or yaw damper is disengaged automatically because of a malfunction

TCS Switches to FGM1 and FGM2: The two TCS switches supply a ground discrete input to each FGM to command the FGM1 and FGM2 to declutch the pitch and roll APAUs if the AP is engaged, and to change the FD targets when the switch is released.

FGM1 and FGM2 to Autopilot Disengage Warning Lights: Each FGM can command both Autopilot Disengage Warning Lights by grounding an output discrete for indication of automatic disengage caused by a malfunction.

The AFCS has the external interfaces that follow:

- AHRS inputs to the AFCS
- ADU inputs to the AFCS
- VHF NAV inputs to the AFCS
- PSEU inputs to the AFCS
- FCS ECU to the AFCS
- SPS to AFCS
- FCU to AFCS

- FGM1 and FGM2 to Displays units
- FDPS to AFCS.

AHRS Inputs to AFCS: Each FGM receives an ARINC 429 data bus from AHRS1 and AHRS2 for FD, AP, and YD control laws.

ADC Inputs to the AFCS: Each FGM receives an ARINC 429 data bus from ADC1 and ADC2 for FD, AP, and YD control laws and automatic pitch trim logic.

VHF NAV Inputs to the AFCS: Each FGM receives an ARINC 429 data bus from VHF NAV1 and VHF NAV2 for the FD outer loop control laws.

PSEU Inputs to the AFCS: Each FGM receives a WOW1 and WOW2 discrete signal from the PSEU for the airborne or on ground condition of the airplane to inhibit:

- The POST in flight
- Flap automatic pitch trim function when the aircraft is on the ground
- AP engagement when the aircraft is on the ground

FCS ECU to AFCS: Each FGM receives a ground or open discrete signal from the left FCS ECU channel to disengage the AP when the manual pitch trim is operated by the pilots. The left and right FCS ECU channels transmit the pitch trim position through an ARINC 429 bus to the FGM1 and FGM2 to monitor the pitch trim motion.

Each FGM supplies discrete commands to the FCS ECU to command pitch trim as follows:

- 28 VDC or open discrete for the trim enable 1 or trim enable 2 command
- A ground or open discrete nose up command
- A ground or open discrete nose down command
- A ground or open discrete pitch trim speed selection command.

SPM1 and SPM2 to AFCS: Each SPM sets a ground or open discrete to FGM1 and FGM2 to disengage the autopilot when the SPS calculates the aircraft angle of attack has reached the stick shake condition to prevent the autopilot from commanding the aircraft into a stall.

FGM1 and FGM2 to Displays Units (EIS): Each FGM supplies the FD mode, the FD commands, AP and YD engagement status, TCS engagement status, pitch and roll mistrim messages, FD abnormal conditions messages, AFCS general failure messages through an ARINC 429 data bus to PFD1, PFD2, MFD1, and MFD2 for indication.

FDPS to AFCS: Each FGM receives an ARINC 429 data bus from each of the FDPS IOP data concentrators. These buses transmit data received from other aircraft avionics, including the ACM, ESCP, ICP, FGCP, FMS, DME, radio altimeter, FPIU, and CDS. Also, each FGM supplies FMS and CDS data through and ARINC 429 data bus to each IOP.

ACM Inputs to AFCS: Each FGM receives data relating to the aircraft version and serial number, the FD display type, the FMS options, and if the radio altimeter is installed, through the FDPS from the ACM1 and ACM2.

ESCP Inputs to AFCS: FGM1 and FGM2 receive through the FDPS the selections of the EFIS ATT/HDG SOURCE and EFIS ADC SOURCE switches on the ESCP for the FD source selection logic.

ICP Inputs to AFCS: FGM1 and FGM2 receive the decision height selection through the FDPS from ICP1 and ICP2 to calculate a CAT II approach condition.

FGCP Inputs to AFCS: FGM1 and FGM2 receive left and right HDG, CRS, and NAV SOURCE knobs, the altitude target from the ALT knob, and the HSI SEL selection through the FDPS for the FD.

FMS Interface to AFCS: FGM1 and FGM2 receive FMS pitch target, roll target, and mode through the FDPS from the FMS. FGM1 and FGM2 transmit LNAV and VNAV data through the FDPS to the FMS.

DME Inputs to AFCS: FGM1 and FGM2 receive DME distance to station data through the FDPS the for use in the FD VOR modes.

Radio Altimeter Inputs to AFCS: FGM1 and FGM2 receive radio altitude data through the FDPS for DUAL FD ILS approach condition, and to change gains in an ILS approach.

FPIU Inputs to AFCS: FGM1 and FGM2 receive flap position and flap position validity discrete from the left and right FPIU channels through the FDPS for flap automatic pitch trim.

FGM1 and FGM2 to CDS Interface: The automatic flight control system communicates with the centralized diagnostic system (CDS) through IOP1. When the FGM1 or FGM2 sense a defect, they each transmit the malfunction through and ARINC 429 bus to the CDS (IOP1). When the aircraft is on the ground, the CDS can also command to reset and enter a maintenance state through IOP1.

The automatic flight control system monitoring has:

- FGM external input monitoring
- FGM internal monitoring
- Yaw damper monitoring
- Autopilot monitoring
- Pitch trim monitoring

FGM External Input Monitoring: FGM1 and FGM2 each monitor the following external inputs:

- FGCP
- AHRS
- ADC
- VHF NAV
- FCS ECU
- FPIU Flap Position
- Radio Altimeter
- DME
- FMS.

For a critical parameter of the AP and YD inner loops, a malfunction of one sensor, or a mismatch between two sensors, disengages the AP or AP and YD.

For a parameter shown on the PFD which is used by the active FD mode outer loop control laws, a malfunction causes the FD mode to fail.

If a defect is sensed that causes the AP/YD or FD to fail, the AFCS shows the malfunction with a message on the PFD.

The AFCS records a maintenance messages for all sensor malfunctions.

FGCP Data Monitoring: The FGM1 and FGM2 monitor the labels received directly from the FGCP ARINC 429 data buses, or through the FDPS, for SSM validity and update rate.

Each FGM also monitor the all FGCP for the stuck pushbutton switches (pushed for more than 10 seconds) but the HSI SEL pushbutton switch is monitored by the FDPS.

A stuck switch does not affect other FGCP functions.

An AFCS CONTROLLER INOP message is shown in FMA of the PFD.

AHRS Data Monitoring: Roll angle, roll rate, pitch angle, pitch rate, yaw rate, lateral acceleration, longitudinal acceleration, and normal acceleration) are monitored for discrepancies between AHRS1 and AHRS2.

ADC Data Monitoring: Calibrated airspeed and true airspeed are monitored for discrepancies between ADC1 and ADC2.

VHF NAV Data Monitoring: During a dual FD ILS approach, FGM1 and FGM2 do comparison monitoring of the localizer and glideslope data from VHF NAV1 and VHF NAV2. A mismatch or malfunction of the localizer or glideslope data from the not–selected VHF NAV causes a loss of the dual FD mode, but does not disengage the FD, or cause a reversion to the basic lateral or vertical modes.

FCS ECU Data Monitoring: The range of the pitch trim position value is monitored. FGM1 usually uses the pitch trim position from the left FCS ECU channel and FGM2 usually uses the pitch trim position from the right FCS ECU channel. A malfunction of one pitch trim position causes the FGM, using the label, to use the pitch trim position from the other FCS ECU channel.

A malfunction of the left and right FCS ECU pitch trim position labels fails the AP pitch trim and flap automatic pitch trim, but has no other effect on the AP/YD or FD.

FPIU Flap Position Data Monitoring: FGM1 and FGM2 use the FLAP HEALTHY discrete signal for validity of the flap positions from the FPIU through the FDPS. The flap position data is critical for the flap automatic pitch trim function.

For the flap auto pitch trim function, the FGM1 and FGM2 must receive valid left and right flap positions, and the comparison monitor (difference of the left and right flap positions) must be valid.

Radio Altimeter Data Monitoring: A malfunction of the radio altitude data inhibits the dual FD mode.

DME Data Monitoring: A malfunction of selected DME data from the FDPS used in a VOR mode does not disengage the mode, but degrades the performance of the FD.

FMS Data Monitoring: Failure of the selected FMS data from the FDPS disengages and inhibits the FD LNAV and VNAV modes.

FGM Internal Monitoring: The FGM internal monitoring consists of:

- Power on self tests (POST)
- Continuous self monitoring
- FGM1/FGM2 cross monitoring.

Power On Self Tests: The power on self tests (POST) senses AFCS hardware defects that are not sensed by continuous monitoring or apparent to the pilots for maintenance purposes. Each FGM does a POST independently of the other FGM. The flight guidance modules exchange discrete signals to make sure that they do not do the POST at the same time, which could cause the YD or AP actuator unit to move. The FGM does the POST two times before it set an

unhealthy condition to make the test less sensitive to external transients.

The POST tests:

- Program Memory
- Data Memory
- Watch Dog
- Power Supplies HW Monitoring
- Discrete Inputs
- Discrete Outputs
- Module Validity HW logic
- ARINC 429 Inputs
- ARINC 429 Outputs
- Memory Partitioning HW Monitoring
- Time Partitioning HW Monitoring
- I/O Sequencer
- Analog Reference Voltages
- Analog Inputs
- AP and YD Engage/Disengage HW Logic.

The results of the POST are stored in memory. If the FGM subsequently powers up in flight, the FGM will use the POST results stored in memory for its healthy status.

Continuous Self Monitoring: Each FGM continuously does self monitoring to make sure that it is can do the AFCS functions.

The continuous self monitoring tests:

- Secondary power supplies
- Watch dog
- Memory partitioning
- Stack overflow
- Job overflow
- Bus error
- I/O sequencer validity
- CPU Board/EXT board ARINC 429 dialogue.

FGM1/FGM2 Cross Monitoring: Each FGM monitors the healthy status of the opposite FGM using a discrete signal from the opposite FGM. Each FGM will inhibit the AP and YD for a malfunction of the opposite FGM, but not the FD.

FGM1 and FGM2 also supply a YD and AP engagement status discrete signal to the opposite FGM. If a FGM senses that the signals are different, the FGM will immediately disengage the YD and AP.

Refer to Figures 47 and 48.

Yaw Damper Monitoring: Each FGM independently calculates the YD commands with data from AHRS1 and AHRS2 and ADC1 and ADC2. FGM1 and FGM2 supply their commands to the opposite FGM for comparison monitoring (C1) and for passivating together. The passivated commands in each FGM are then supplied again to the opposite FGM for more comparison monitoring (C2).

The passivated command from FGM1 is changed from software to an analogue voltage and supplied to the YDAU. Each FGM receives

back the analogue YDAU command for comparison with the passivated command from FGM1 (C3).

Each FGM has a software model of the YDAU. The position of the YDAU is supplied back to each FGM for comparison with the expected position of the model (C4). Also, the YDAU supplies two position feedback signals to each FGM and are compared (C5).

The YD is disengaged if any of the comparison monitors in one of the two FGM senses a defect.

FGM1 disengages and re–centres the YDAU by setting its output command to 0 volts. FGM2 disengages the YDAU by applying a YD Inhibit discrete to the YDAU. The YDAU supplies back the status of this discrete to FGM2 for monitoring to prevent dormant malfunctions.

Refer to Figures 49 and 50.

Autopilot Monitoring (Same for both the pitch and roll APAU): The FD commands and modes are transmitted from FGM1 to FGM2. Each FGM independently calculates the control law using the FD command calculated in FGM1 and inputs from AHRS1 and AHRS2 and ADC1 and ADC2. Synchronization in FGM2 prevents FGM2 from being different from FGM1 because of biases. The FGM1 and FGM2 supply their inner loop commands to the opposite FGM for comparison monitoring (C1) and for passivating together. The passivated commands in each FGM are then supplied again to the opposite FGM for more comparison monitoring (C2).

The passivated command from FGM1 is changed from software to an analogue voltage and supplied to the APAU.

Each FGM receives back the analogue APAU command for comparison with the passivated command from FGM1 (C3).

Each FGM has a software model of the APAU. The position of the APAU is supplied back to each FGM for comparison with the expected position of the model (C4). Also, the APAU supplies two position feedback signals to each FGM and are compared (C5).

The AP is disengaged if any of the comparison monitors in one of the two FGM senses a defect.

The FGM1 supplies analogue commands to the APAU. The APAU feeds back two position signals to each FGM.

The reference voltage for the POS1 feedback is from the electrical power source of the APAU. The reference voltage for POS2 feedback is from FGM2.

FGM1 engages and disengages the APAU by commanding the APAU to engage the clutch. FGM2 disengages the APAU by supplying an AP inhibit discrete to the APAU.

The APAU supplies back the status of this discrete to FGM2 for monitoring to prevent dormant malfunctions.

The APAU also supplies two torque values to each FGM. FGM1 and FGM2 use the pitch APAU torque for the AP pitch trim function and for the PITCH MISTRIM messages. FGM1 and FGM2 use the roll APAU torque for the ROLL MISTRIM messages.

Pitch Trim Monitors: The AFCS automatic pitch trim has the functions that follow:

- Autopilot pitch trim when the AP is engaged
- Flap automatic pitch trim when the AP is not engaged and the flaps move.

The AFCS commands the flight control system electronic control unit (FCS ECU) to control the pitch trim actuator.

FGM1 and FGM2 monitor the autopilot pitch trim and the flap auto pitch trim functions.

NOTE

The monitoring is described separately for each function although some of the monitors are the same for both functions.

Refer to Figure 51.

Autopilot Pitch Trim Monitoring: The pitch APAU supplies two torque inputs to each FGM to calculate speed, nose up and nose down trim commands, and for comparison monitoring.

These commands and a speed selection discrete signals are transmitted from FGM1 to the FCS ECU, but the FCS ECU only starts the pitch trim if it receives the trim enable 1 discrete from FGM1 and a trim enable 2 discrete from FGM2.

FGM1 and FGM2 fail the AP pitch trim function if the torque values are not the same (AP PITCH TRIM FAIL message is shown on PFD1 and PFD2).

The pitch trim position from the FCS ECU is also used to sense the malfunction of the left and right channels of the FCS ECU as follows:

- No pitch trim motion when commanded by the AFCS
- Pitch trim motion in the opposite direction of the AFCS command.

The FCS ECU transmits the pitch trim position through an ARINC 429 data bus to each FGM. If the rate of change of the pitch trim position is not consistent with the AFCS speed selection, a maintenance message is recorded, but the AP pitch trim function continues to operate.

NOTE

The FCS ECU does not starts the pitch trim if it receives both nose up and nose down trim commands at the same time.

NOTE

If the pitch trim is near the mechanical limits, the AFCS stops commanding pitch trim, but no fault message is shown.

The FCS ECU also supplies a manual AP trim disconnect discrete signal to FGM1 and FGM2 to disengage the autopilot (TCS is not active).

Refer to Figure 52.

Flap Automatic Pitch Trim Monitoring: Left and right flap positions are supplied from the flap position indicator unit (FPIU) through the flight data processing system (FDPS) to FGM1 and FGM2 to calculate speed, nose up and nose down trim commands, for comparison monitoring, and for valid. FGM1 and FGM2 average the left and right flap positions, and use the rate of change to calculate when to command the pitch trim.

Like the AP pitch trim function, these commands and a speed selection discrete signals are transmitted from FGM1 to the FCS ECU, but the FCS ECU only starts the pitch trim if it receives the trim enable 1 discrete from FGM1 and a trim enable 2 discrete from FGM2.

FGM1 and FGM2 use the pitch trim position from the FCS ECU to sense the malfunctions that follow:

- Left and right flap position signals are incorrect
- The two positions are different

– Pitch trim motion from the FCS ECU is in the opposite direction of the AFCS command.

NOTE

The AUTO TRIM FAIL message is shown on PFD1 and PFD2.

NOTE

Like the AP pitch trim function, if the pitch trim is near the mechanical limits, the AFCS stops commanding pitch trim, but no fault message is shown.

Like the AP pitch trim, the flap automatic pitch trim function uses the FCS ECU pitch trim position to sense the pitch trim malfunction. FGM and FGM2 fail the flap auto pitch trim function if the left and right channels of the FCS ECU have malfunctioned.

The flap automatic pitch trim function is inhibited by FGM1 and FGM2 when the calibrated airspeed is more than 180 knots, but do not inhibit the function if the calibrated airspeed from ADC1 and ADC2 is not valid.

FGM1 and FGM2 do not monitor the pitch trim speed when the flap automatic pitch trim function is engaged.

LIMITATIONS:

The automatic flight guidance control system automatic flight guidance control system has the adjustment and tests that follow:

– operational test of the pitch and roll actuators

– functional test of the automatic flight guidance control system

– Functional check of the pitch and roll capstans (MRB#221100 201)

– Functional test for the return–to–service of the autopilot

– Functional test of the automatic pitch trim system.

DIAGNOSTICS:

Possible malfunctions of the automatic flight control system are described.

FD input malfunctions: A malfunction of an input sensor not used in an active FD mode outer loop control law has no effect on the FD. If it used, it will cause a reversion to the lateral or vertical FD basic mode or a disengagement of the FD. A NAV SOURCE, EFIS ATT/HDG SOURCE, or EFIS ADC SOURCE reversion is made to re–engage the FD mode.

AP and YD input malfunctions: A malfunction of any input data used in the AP or YD inner loops (pitch attitude, pitch rate, roll attitude, roll rate, yaw rate, lateral acceleration, longitudinal acceleration, normal acceleration, calibrated airspeed, and true airspeed), or a difference between left and right side data, causes in immediate disengagement of the AP and YD. Malfunctions of input data not used in the AP or YD inner loops does not cause the AP or YD to disengage. A malfunction of one SPS AP disengage discrete input to the FGM1 and FGM2 could cause the AP to disengage, but would have no effect on the other AFCS functions.

Automatic pitch trim: A malfunction of the two pitch trim position inputs from the left and right FCS ECU channels fails the AP pitch trim function and the flap automatic pitch trim function. A malfunction of the flap position input from the left and right FPIU channels will fail the flap automatic pitch function. Two different messages are shown.

Weight On Wheels (WOW): A malfunction of the PSEU to the on ground condition will prevent AP and automatic pitch trim operation, but would have no effect on the FD or YD. A failure to the airborne condition would prevent the FGM1 and FGM from doing a power on self test (POST), and would prevent use of the CDS maintenance

mode. This will also prevent engagement of the YD on ground when the aircraft is parked with the airspeed less than 30 knots.

Go–around switches: A malfunction of one switch to the set position would immediately disengage the AP, if engaged, and would set the go–around and wings level FD modes. The AP cannot be re–engaged while this condition existed. A malfunction to the open (not–set) position will prevent the pilots from using the switch to set the go–around mode. The pilots use the other go–around switch or an AP disengage switch to disengage the AP (but not to set go–around mode) if this occurs.

Tactile control steering switches: A malfunction of one switch to the set position will immediately de–clutch the AP, if engaged, and give an indication on PFD1 and PFD2. If the TCS input to only one FGM is set (wiring fault), the AP will disengage. The AP cannot be re–engaged while the defect is sensed.

A malfunction to the not–set position will prevent the pilots from using the switch to set the TCS mode. The pilots use the other TCS switch or the AP disengage switches to disengage the AP (but not to select TCS mode) if this occurs.

AP disengage switches: A malfunction of one switch to the set position will immediately disengage the AP, if engaged. The AP cannot be re–engaged while the malfunction condition is sensed.

A malfunction to the not–set position will prevent the pilots from using the switch to disengage the AP. The pilots can use the other AP disengage switch or the AP pushbutton switch on the FGCP to disengage the AP if this occurs.

FGCP defects: A malfunction of a FD mode pushbutton switch to the not–set position will prevent operation of the mode. A malfunction of a FD mode pushbutton switch to the set position is sensed by the stuck pushbutton monitoring, and inhibit the FD mode. There is no effect on the AP or YD.

A malfunction of the AP or YD engage pushbutton to the not–set position will prevent the AP or YD from being engaged, and prevent the YD from being disengaged (if the malfunction occurs while the YD is engaged). The AP can be disengaged by other switches. A malfunction of the AP or YD pushbutton switch to the set position is sensed by the stuck pushbutton monitoring, and inhibit the AP and YD. It does not affect the FD.

A malfunction of a control knob or the HSI SEL pushbutton switch (which are received by FGM1 and FGM2 through the FDPS) affects the related FD functions only.

YDAU malfunctions: The YDAU can have one of the malfunctions that follow:

- Does not engage
- Does not inhibit
- Jams
- Hardover or oscillatory.

One malfunction in the AFCS cannot cause an unlimited hardover or oscillatory malfunction of the YDAU because FGM1 and FGM2 are necessary for operation of the YD. FGM1 centres the command to the YDAU and lets FGM2 to inhibit the motor of the YDAU.

If FGM1 has malfunctioned and does not command the YDAU, or FGM2 has malfunctioned and continuously inhibits the YDAU motor, the YD immediately disengages.

If the YDAU does not inhibit, then the FGM1 continues to command the YDAU to the centre position (no motion).

If the FGM1 command to the YDAU malfunctions, then the FGM2 inhibit command makes sure that the motor does not drive the rudder.

A message is shown on PFD1 and PFD2.

The YDAU can supply an offset to the rudder if it jams. The rudder trim can be used to the offset this input.

A hardover or oscillatory malfunction of the YDAU is sensed by the FGM monitoring and will inhibit the YD.

The amount is also limited by the mechanical stroke and the rate of the YDAU motor.

APAU malfunctions: The APAU can have one of the malfunctions that follow:

- Does not engage
- Does not inhibit or declutch
- Jams
- Hardover or oscillatory
- Torque feedback.

One malfunction in the AFCS cannot cause an unlimited hardover or oscillatory malfunction of the APAU because FGM1 and FGM2 are necessary for operation of the YD. FGM1 de–clutches the APAU and lets FGM2 to inhibit the motor of the APAU.

The APAU uses current limiting to limit the amount of torque the APAU can supply to the control systems. Two position and torque feedback signals are used for monitoring the APAU.

The APAU capstan has a mechanical override slip clutch that lets the pilots overpower the AP at the control column and wheel.

The APAU can fail to engage if the clutch fails, or FGM2 continuously inhibits the APAU motor. Then the AP will disengage.

The APAU clutch will still disengage if the APAU does not inhibit by removing the APAU motor outputs. The inhibit signal will make sure that the motor does not supply torque if the APAU does not declutch.

The APAU cannot be disengaged from the flight controls if the APAU jams. Then, the clutch of the APAU capstan lets the pilots override the AP at the control column or handwheel.

The flight control system also has pitch and roll disconnect handles to let the pilots isolate the jam to one side of the flight controls, and control the other side with normal force levels (but with reduced control).

A hardover or oscillatory malfunction of the APAU is sensed by the FGM monitoring and will disengage the AP. The amount is also limited by the torque and the rate of the APAU motor.

A mistrim message is shown in the FMA of PFD1 and PFD2 is a malfunction of the APAU torque feedback signal sensed by FGM1 and FGM2.

The AP pitch trim function also malfunctions if the torque feedback for the pitch APAU malfunctions.

AP disengage warning light: An AP disengage warning light not coming on when it should would be sensed by a advisory lights test. A light coming on when it should not would be seen by the pilots.

Training Information Points

Refer to Figure 53.

The AUTO TRIM FAIL message on the PFD can also come on while the flaps continue to operate correctly.

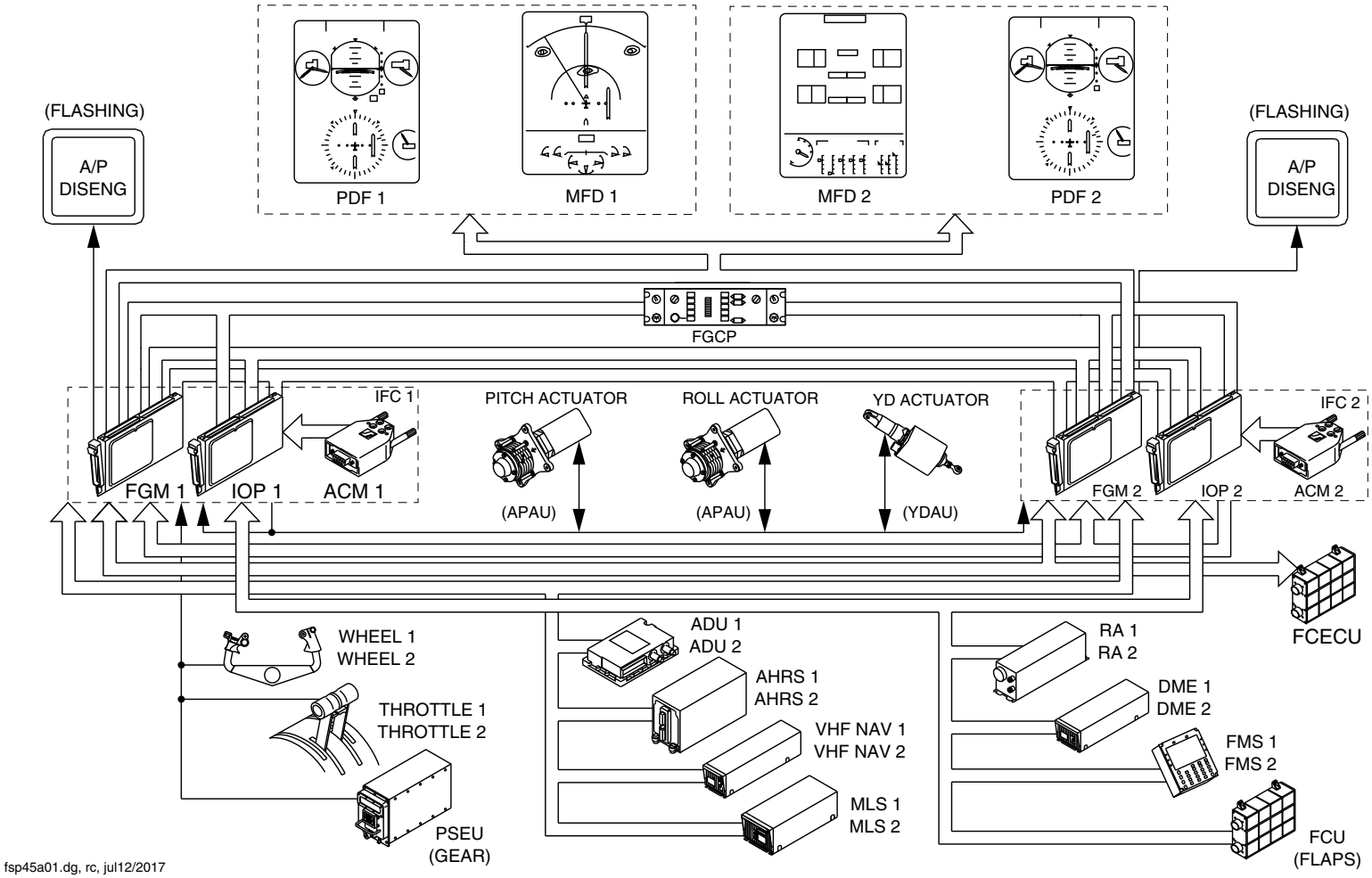
The FMA in the PFDs show an AUTO TRIM FAIL message when an FGM does not receive valid data from the two FPIU channels.

The flap position is supplied by the outboard part of the left and right Rotary Variable Displacement Transducer (RVDT), FPIU, FDPS1 and FDPS2 to FGM1 and FGM2 for the flap automatic pitch–trim. There is no indication if the flap automatic pitch–trim is engaged or disengaged, but an AUTO TRIM FAIL message is shown on PFD1 and PFD2, if the flap automatic pitch–trim fails. The AP PITCH TRIM FAIL message is shown, if the AP pitch trim fails.

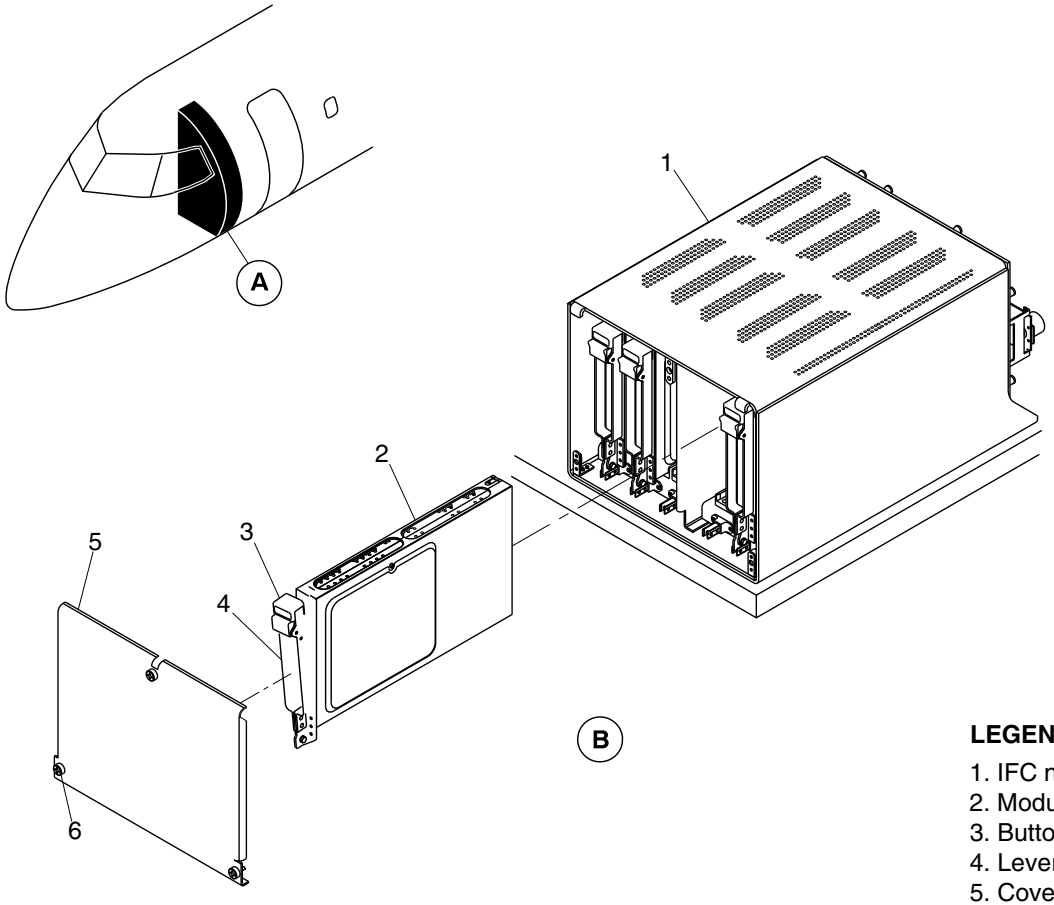
The flap position pointer is usually shown on MFD1 and goes out of the view when the parameter is no longer valid. The data is also supplied by the outboard part of left and right RVDTs, through the FPIU, FDPS1 and FDPS2. The right RVDT data is used for the indication, if it is valid and automatically switches to the left side, if it is not invalid.

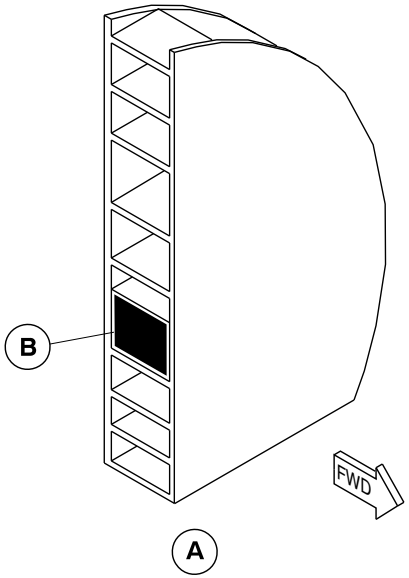
The FCU receives signals from the inboard part of the left and right flap RVDT to control flap movement. The position of the transducer used for control is shown in the CDS on the SYSTEM CALIBRATION 3/3 page of the FLAP DRIVE SYSTEM page.

So, it is possible that the flaps continue to operate with a defective RVDT, because the value on the SYSTEM CALIBRATION page is for control and not for the flap position indication on the MFD and flap automatic pitch trim.



AFCS Block Diagram
Figure 1





AVIONICS RACK ELECTRICAL INSTALLATION

LEGEND

1. IFC no.1 (lower)
2. Module.
3. Button.
4. Lever.
5. Cover.
6. Fastener.

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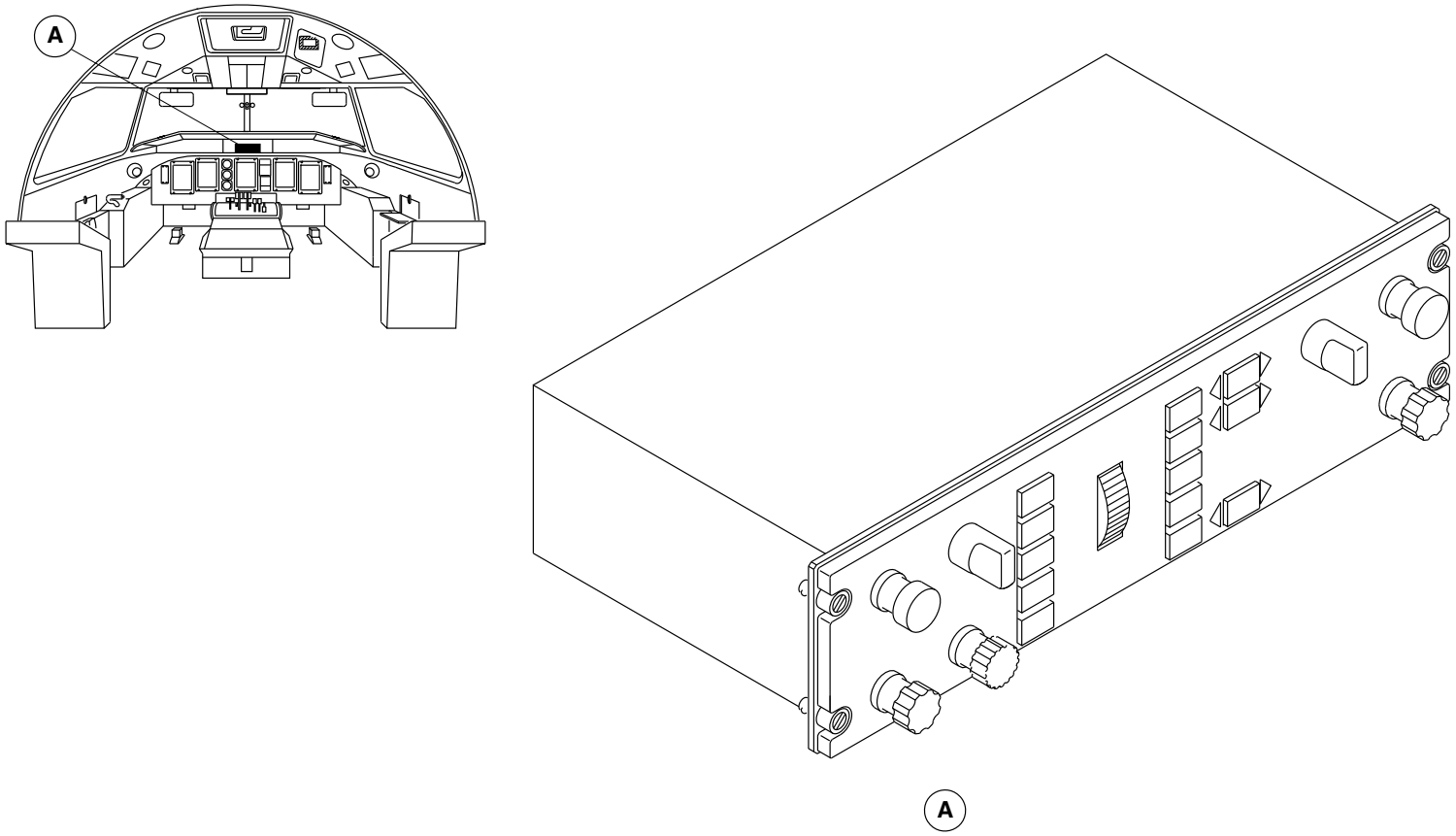
Flight Guidance Module (FGM), Locator
Figure 2



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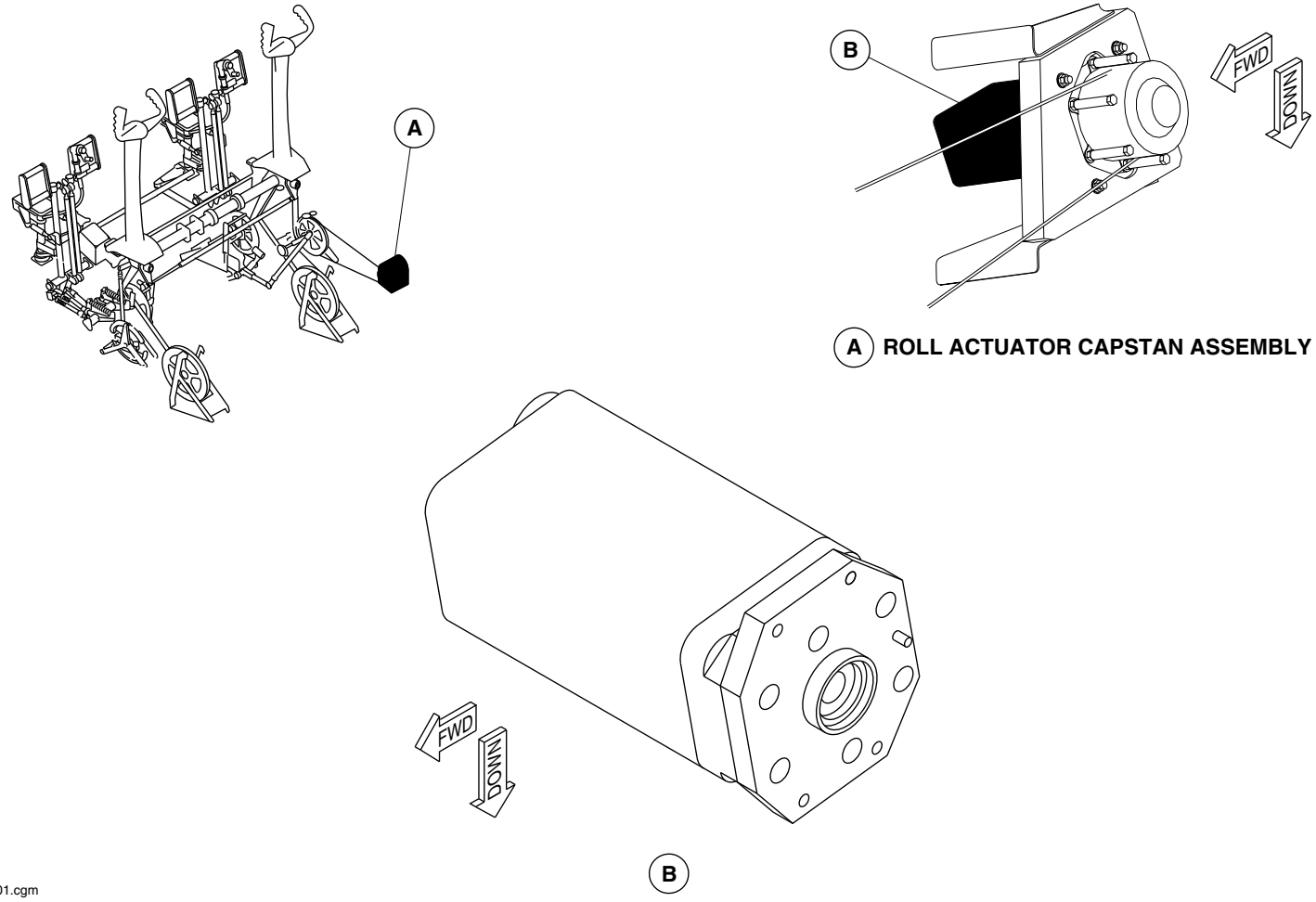
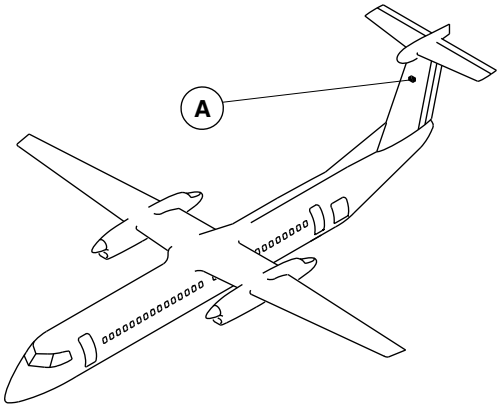
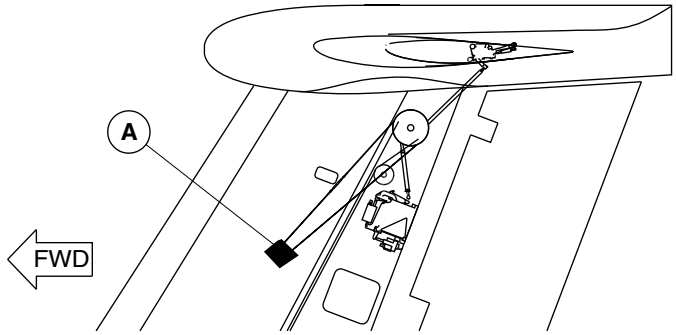
FLIGHT GUIDANCE CONTROL PANEL (FGCP) LOCATOR
Figure 3

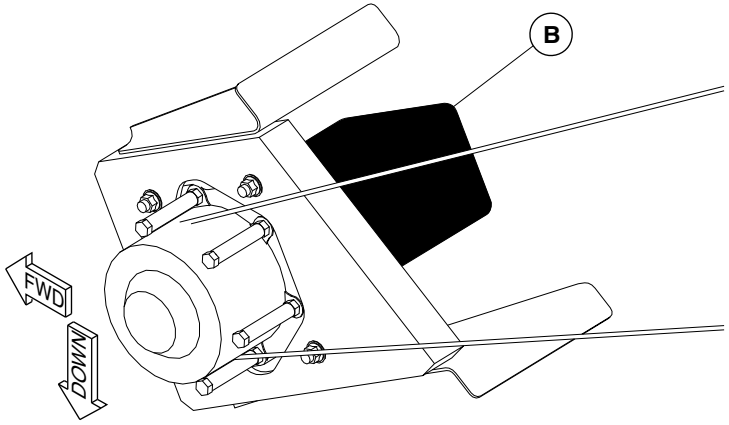


ROLL AUTOPILOT ACTUATOR UNIT (APAU), LOCATOR
Figure 4

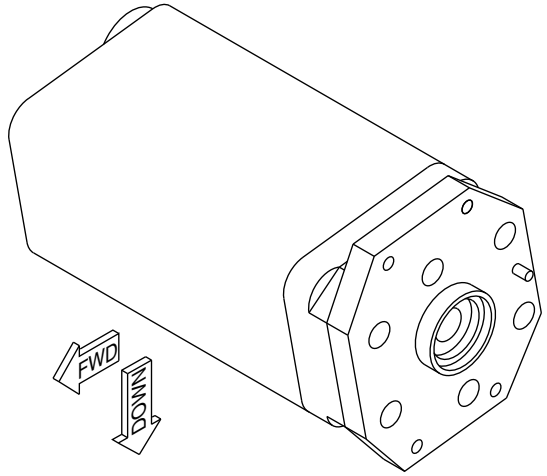




UPPER EMPANNAGE CROSS SECTION



A PITCH ACTUATOR CAPSTAN ASSEMBLY



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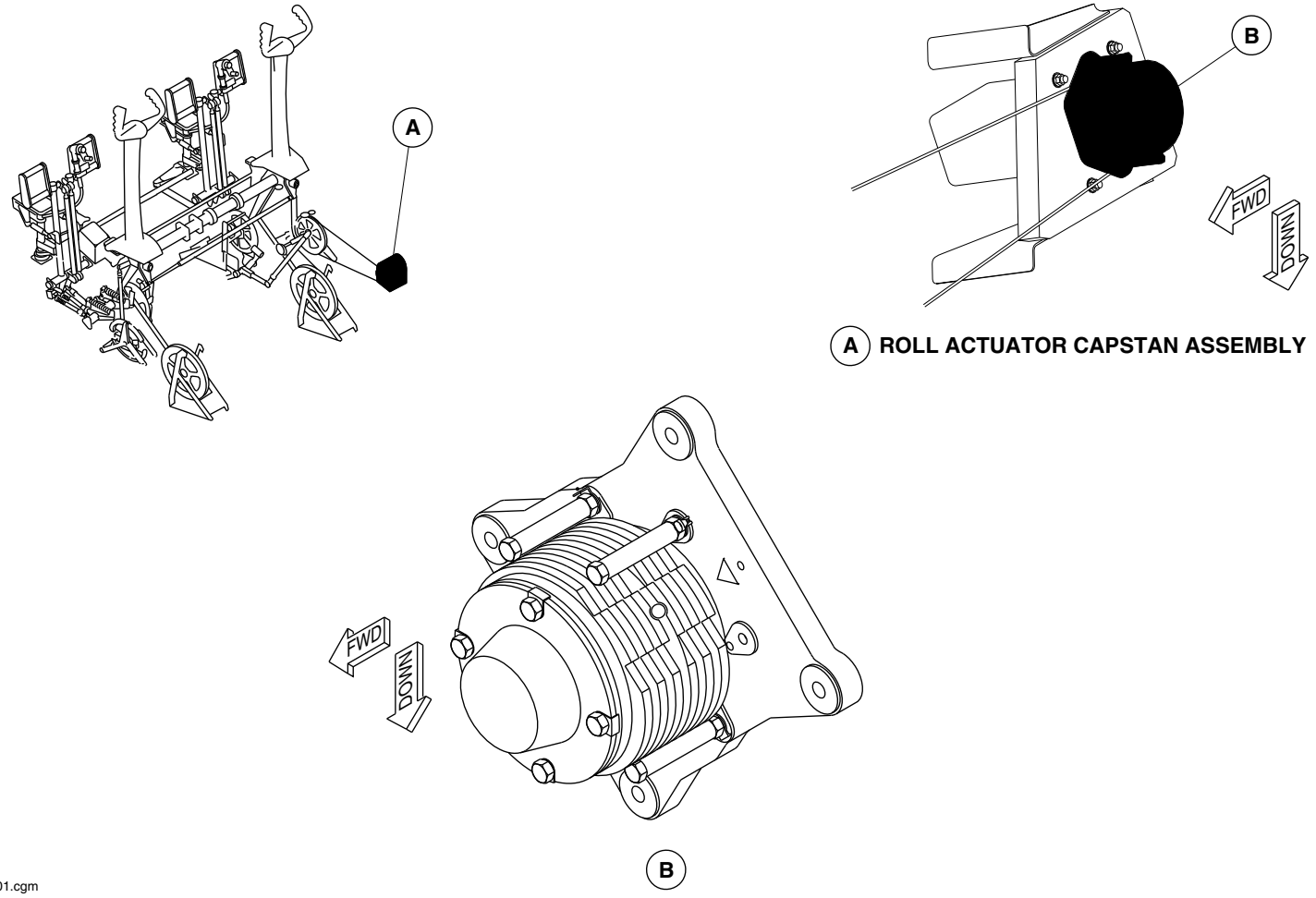
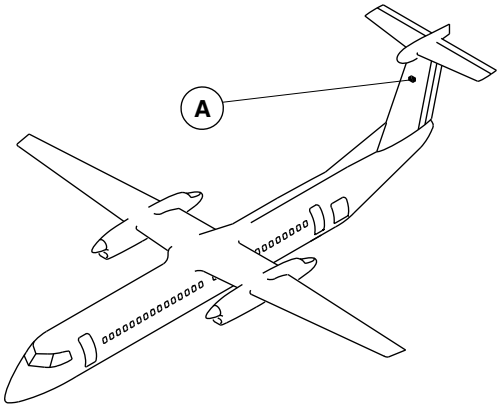
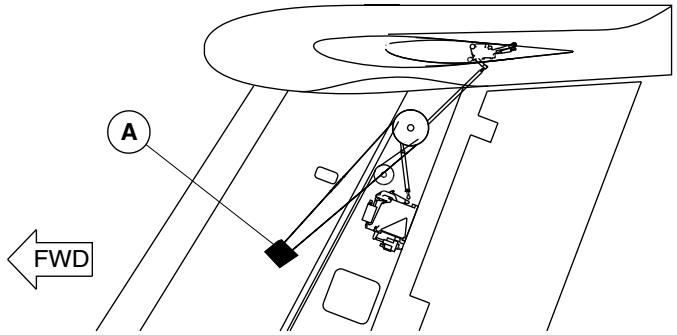
PITCH AUTOPILOT ACTUATOR UNIT, LOCATOR
Figure 5



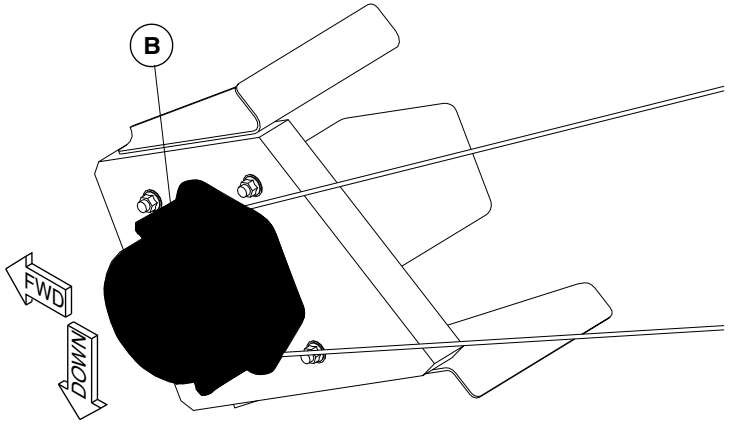
A **ROLL ACTUATOR CAPSTAN ASSEMBLY**

ROLL CAPSTAN, LOCATOR
Figure 6

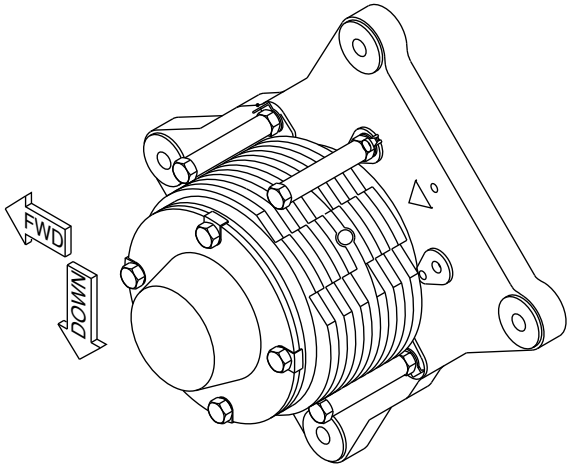




UPPER EMPANNAGE CROSS SECTION



A PITCH ACTUATOR CAPSTAN ASSEMBLY



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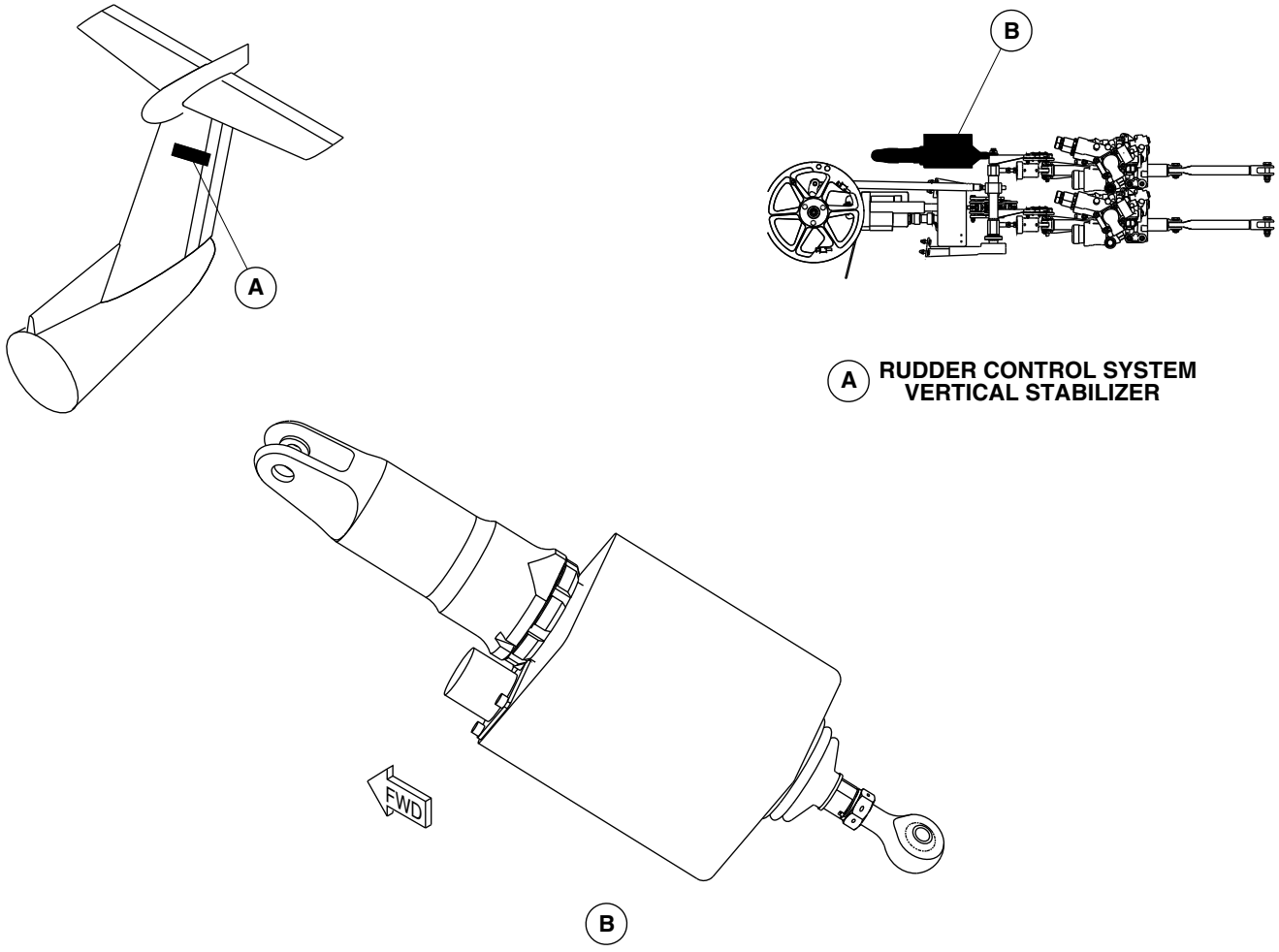
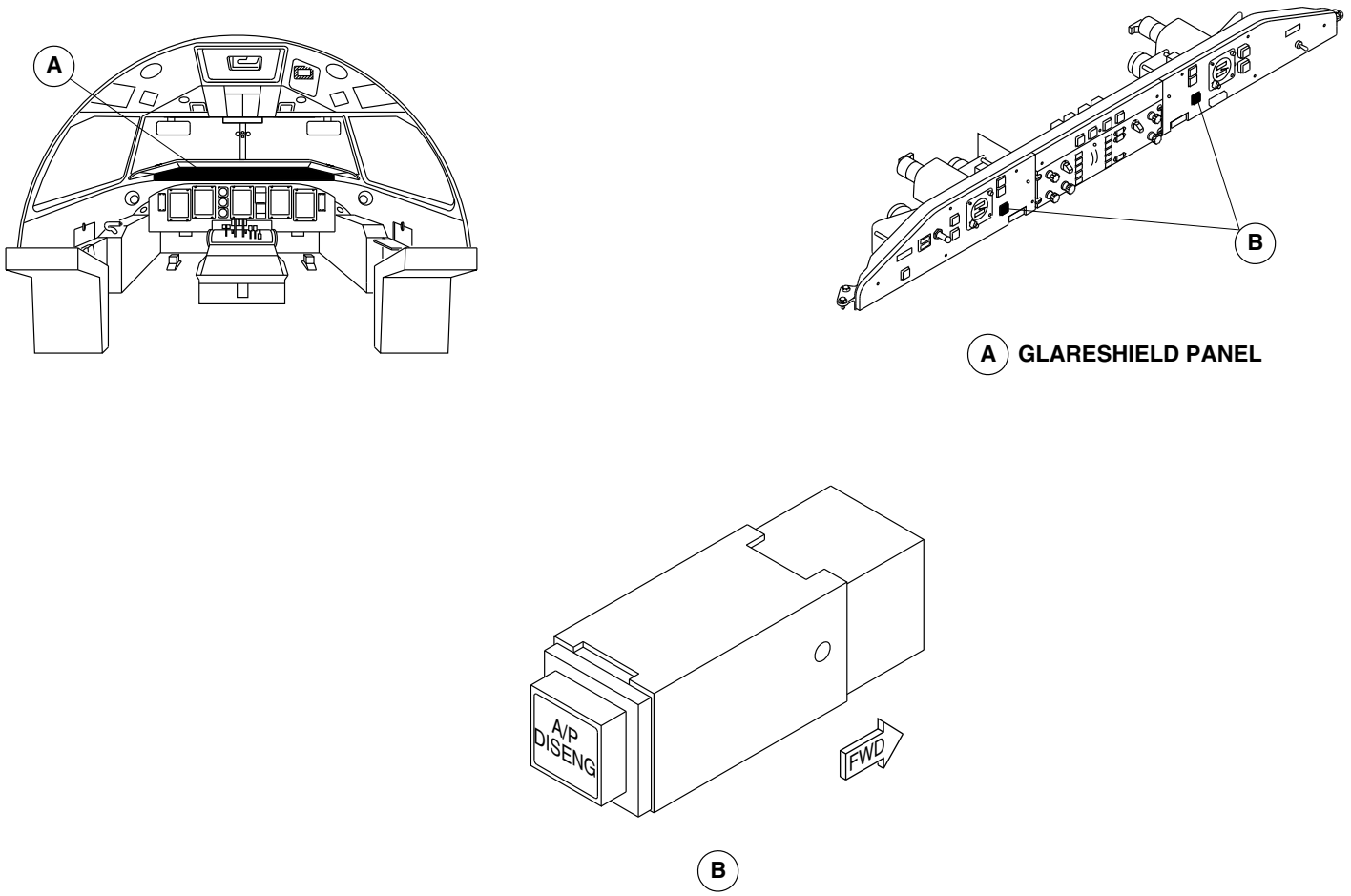
PITCH CAPSTAN, LOCATOR
Figure 7

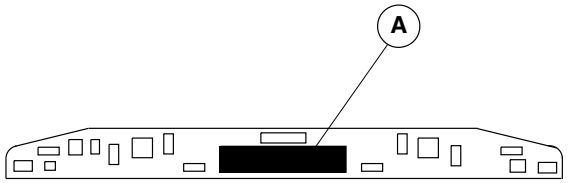


A **RUDDER CONTROL SYSTEM VERTICAL STABILIZER**

YAW DAMPER ACTUATOR UNIT (YDAU), LOCATOR
Figure 8



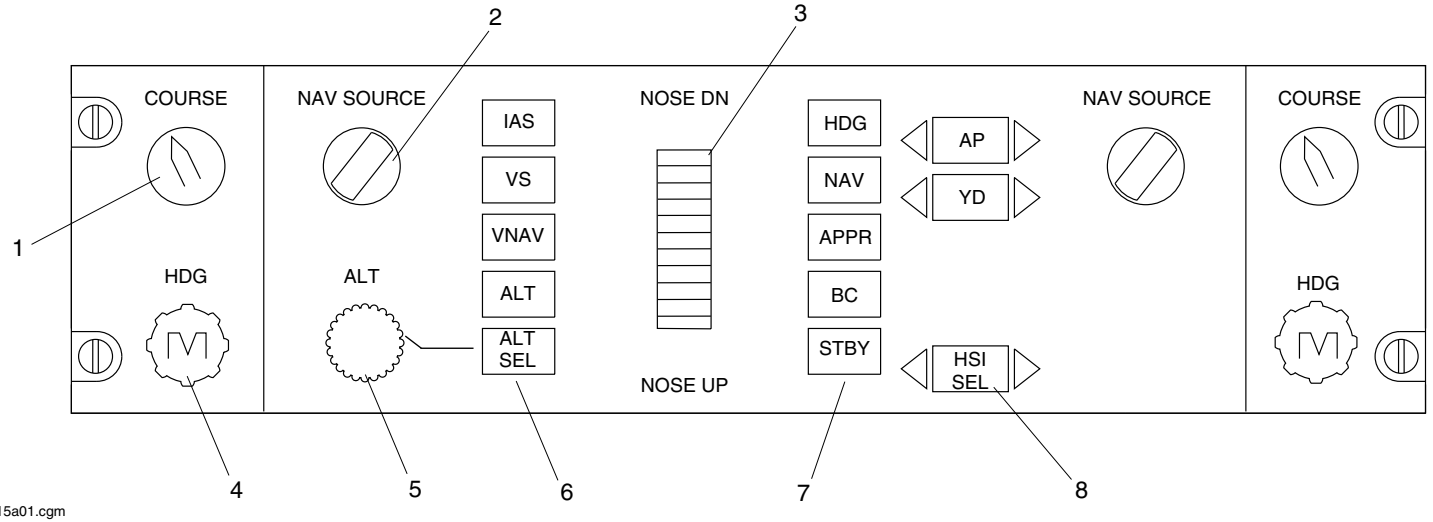
AP DISENGAGE WARNING LIGHTS, LOCATOR
Figure 9



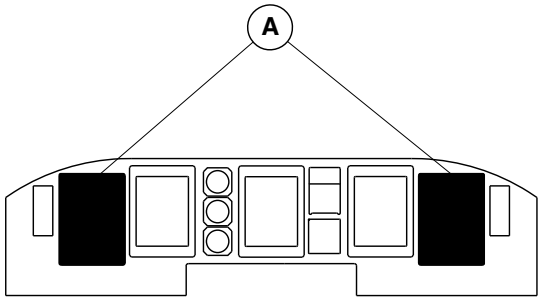
GLARESHIELD PANEL

LEGEND

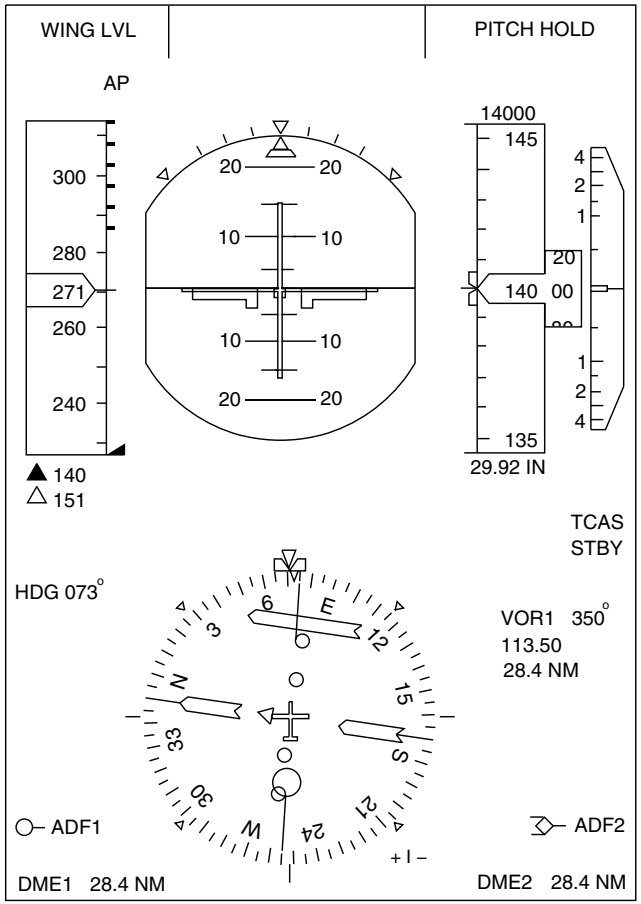
1. COURSE Knob.
2. NAV SOURCE Rotary Switch.
3. NOSE DN/NOSE UP Thumb Switch.
4. HDG Knob.
5. ALT Knob.
6. FD Vertical Mode Pushbutton Switches.
7. FD Lateral Mode Pushbutton Switches.
8. HSI SEL Pushbutton Switch.



FGCP CONTROLS
Figure 10

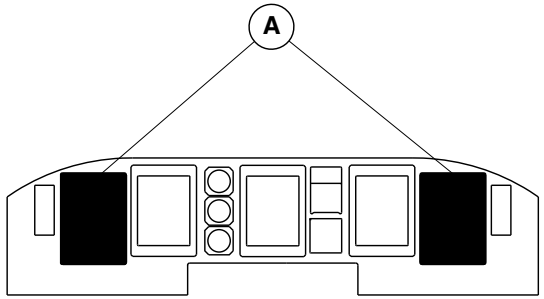


MAIN INSTRUMENT PANEL

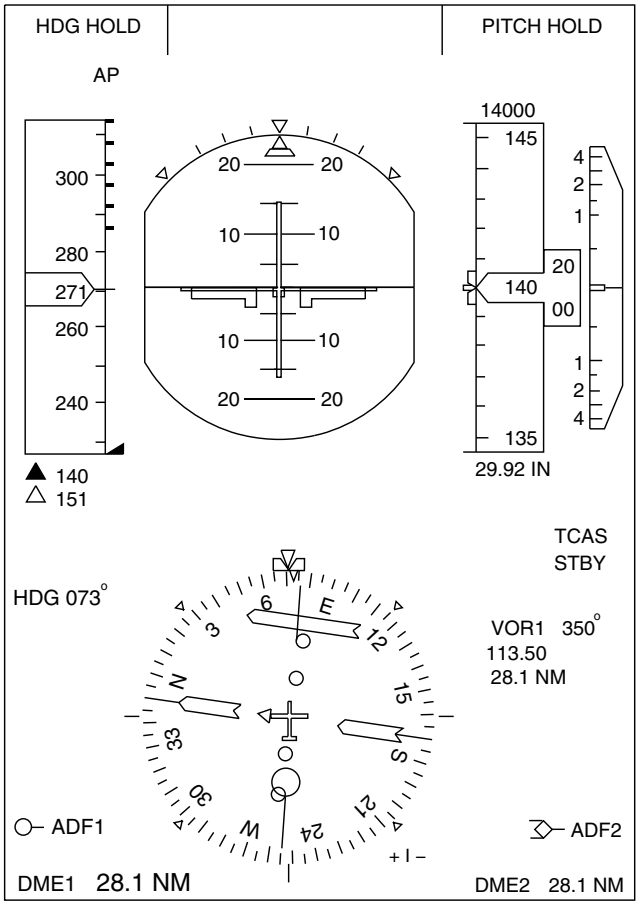


cg4754a01.dg, rc, jul12/2017

FD Wings Level Mode, PFD Indications
Figure 11

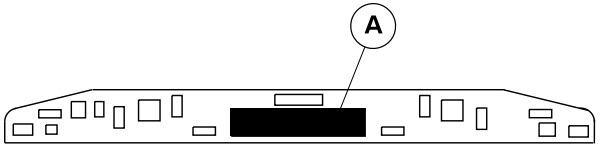


MAIN INSTRUMENT PANEL



cg4755a01.dg, rc, jul12/2017

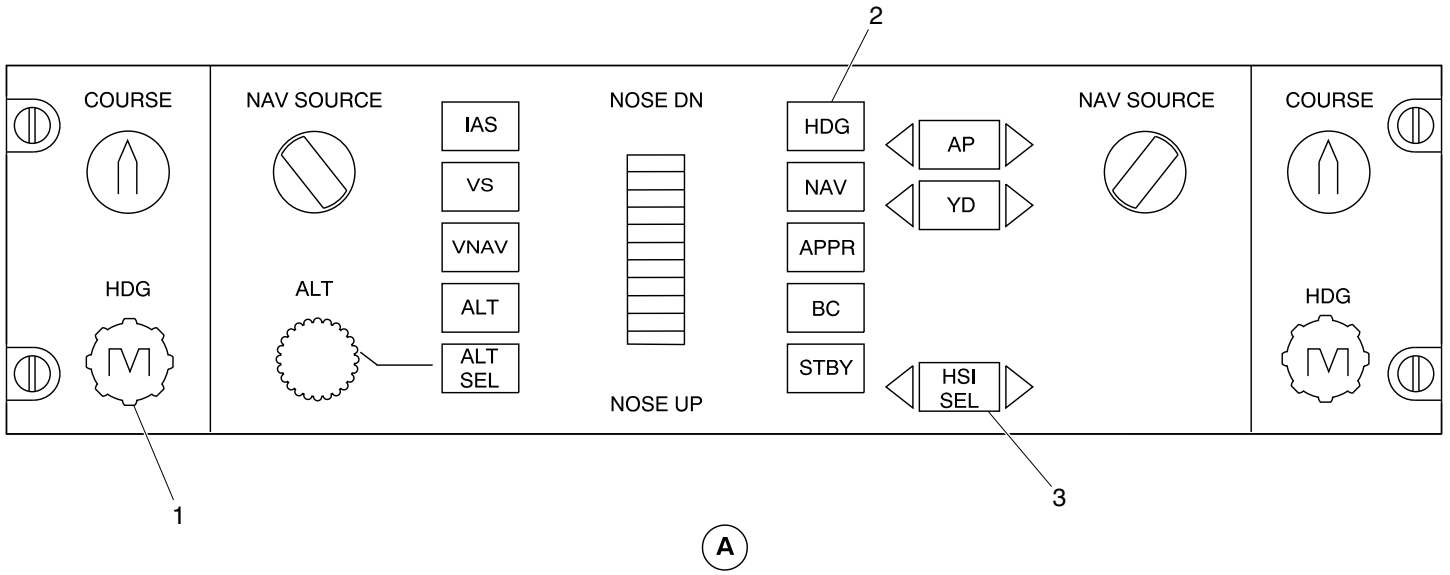
FD Heading Hold Mode, PFD Indications
Figure 12



GLARESHIELD PANEL

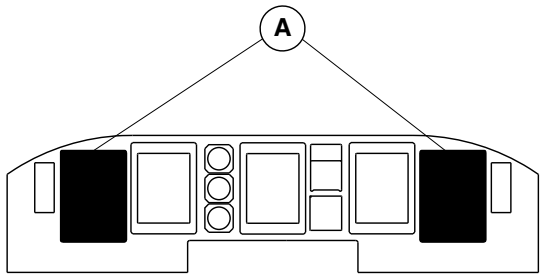
LEGEND

1. HDG knob.
2. HDG pushbutton switch.
3. HSI SEL pushbutton switch.

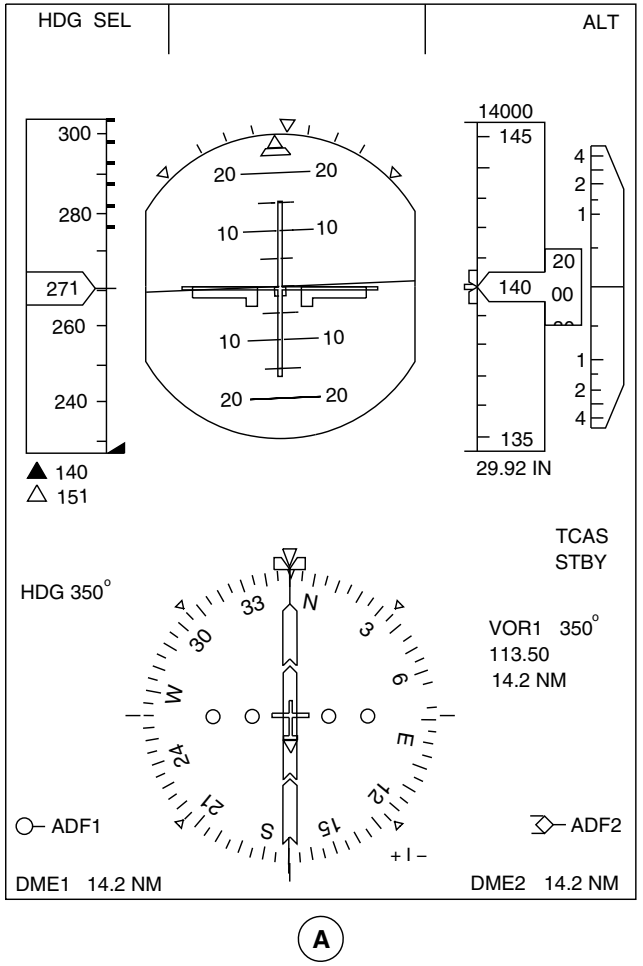


fsp28a01.dg, nn, aug21/2018

FD, FGCP Heading Select Mode Controls
Figure 13

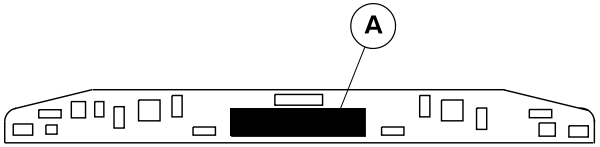


MAIN INSTRUMENT PANEL



cg4756a01.dg, rc, jul12/2017

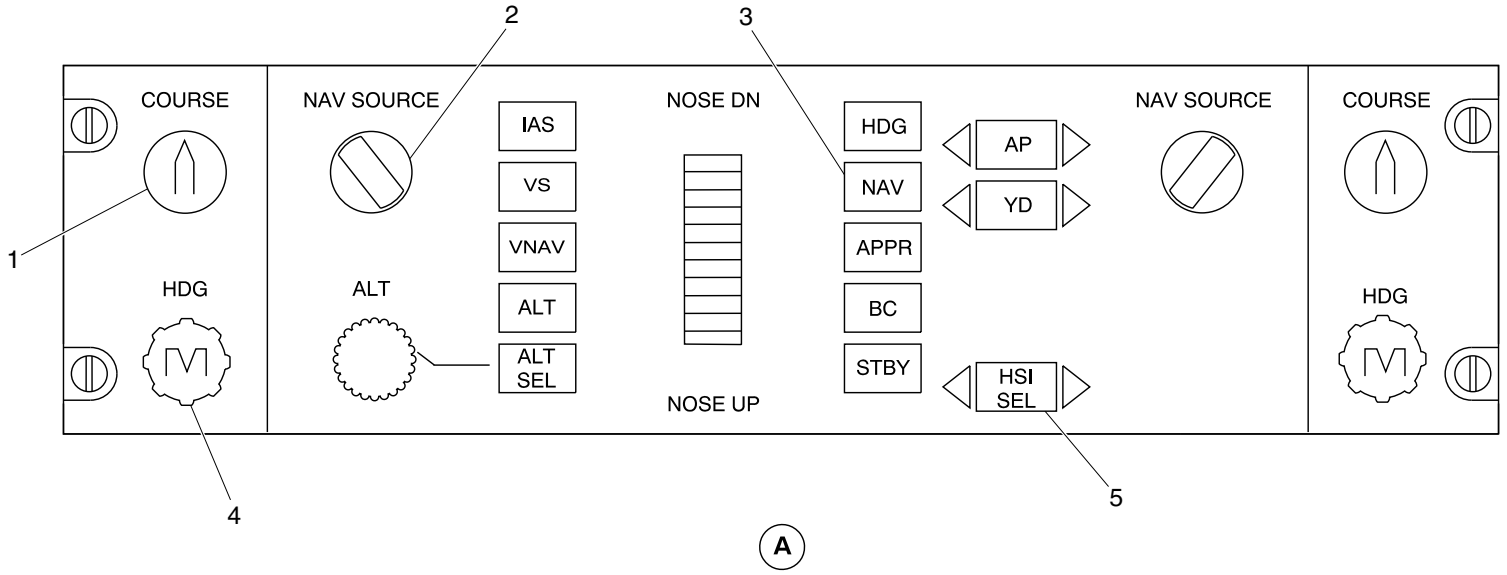
FD Heading Select Mode, PFD Indications
Figure 14



GLARESHIELD PANEL

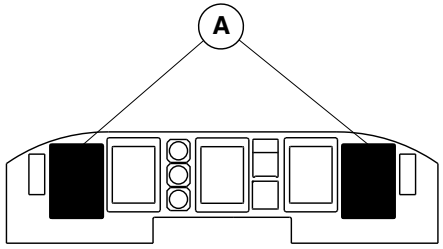
LEGEND

1. COURSE knob.
2. NAV SOURCE rotary switch.
3. NAV pushbutton switch.
4. HDG knob.
5. HSI SEL pushbutton switch.

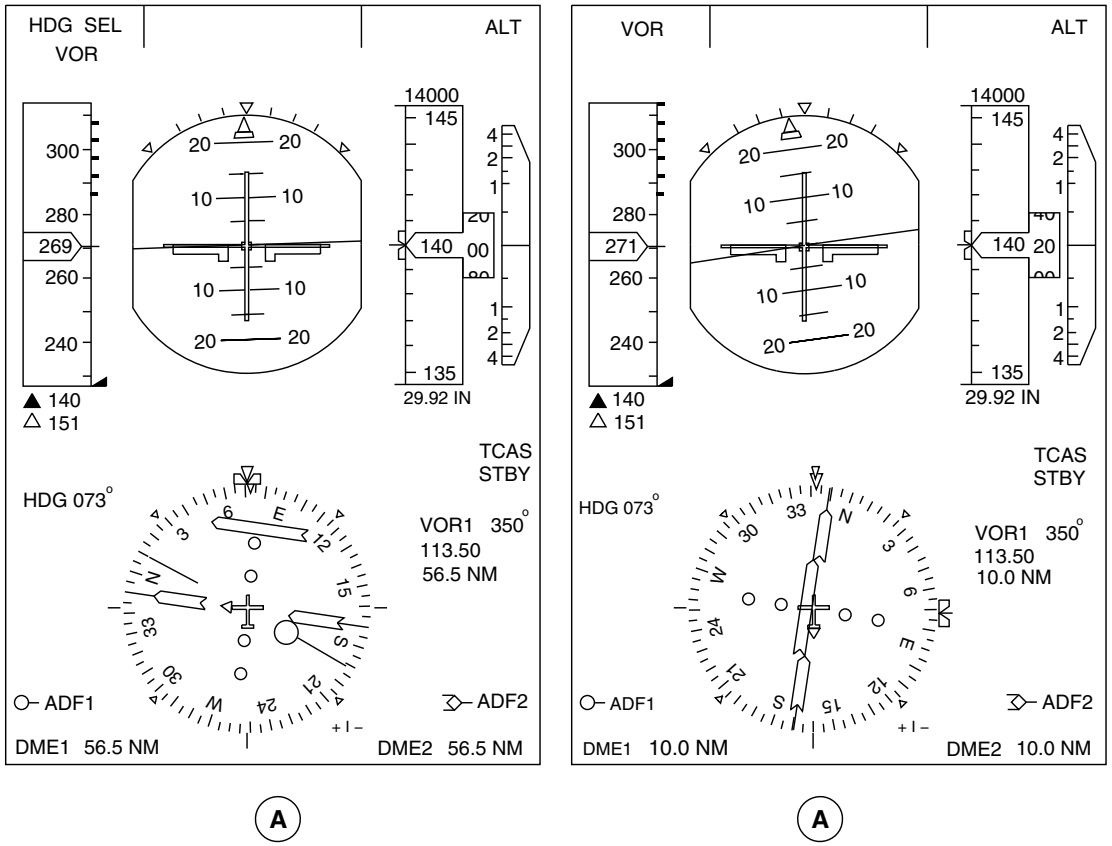


cg5408a01.dg, nn, aug21/2018

FD, FGCP VOR Mode Controls
Figure 15

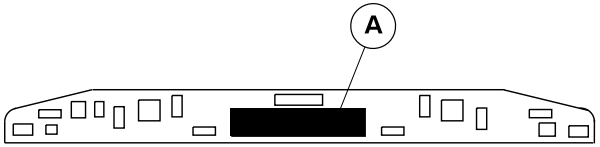


MAIN INSTRUMENT PANEL



cg4757a01.dg, rc, jul12/2017

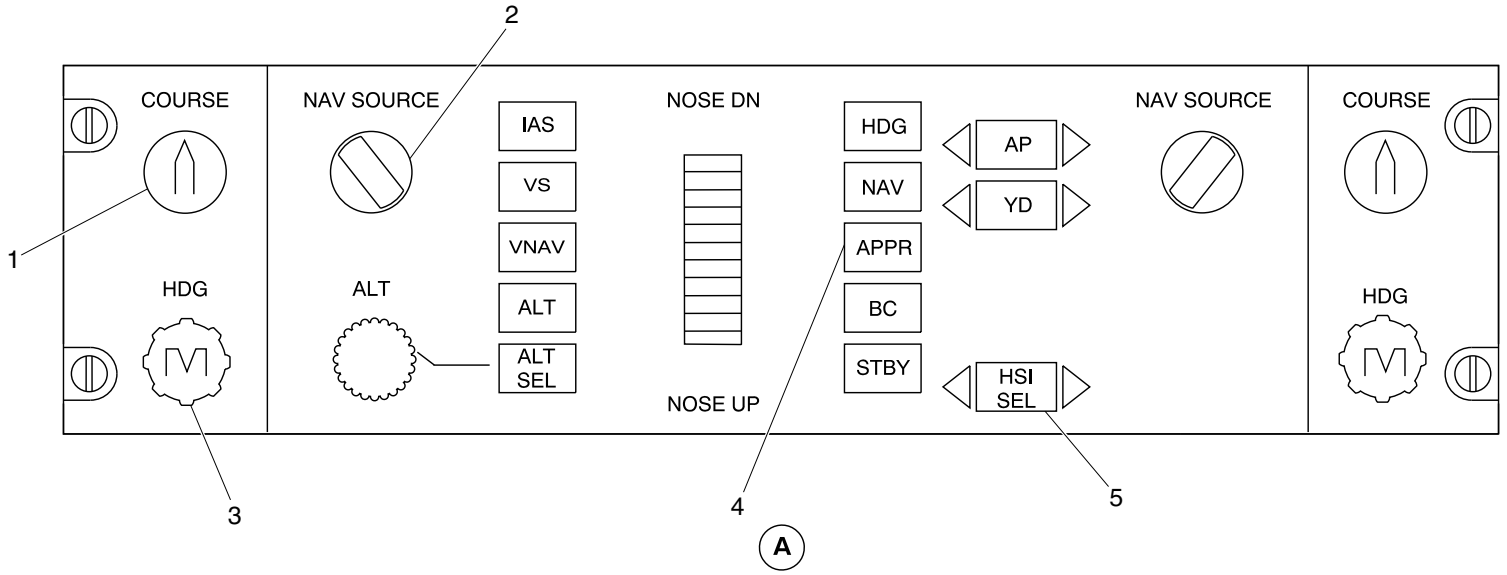
FD VOR Mode, PFD Indications
Figure 16



GLARESHIELD PANEL

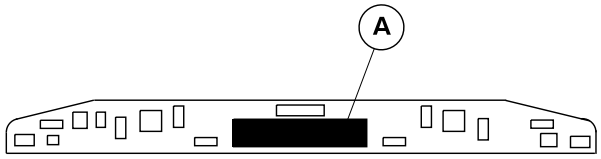
LEGEND

1. COURSE knob.
2. NAV SOURCE rotary switch.
3. HDG knob.
4. APPR pushbutton switch.
5. HSI SEL pushbutton switch.



cg5409a01.dg, nn, aug21/2018

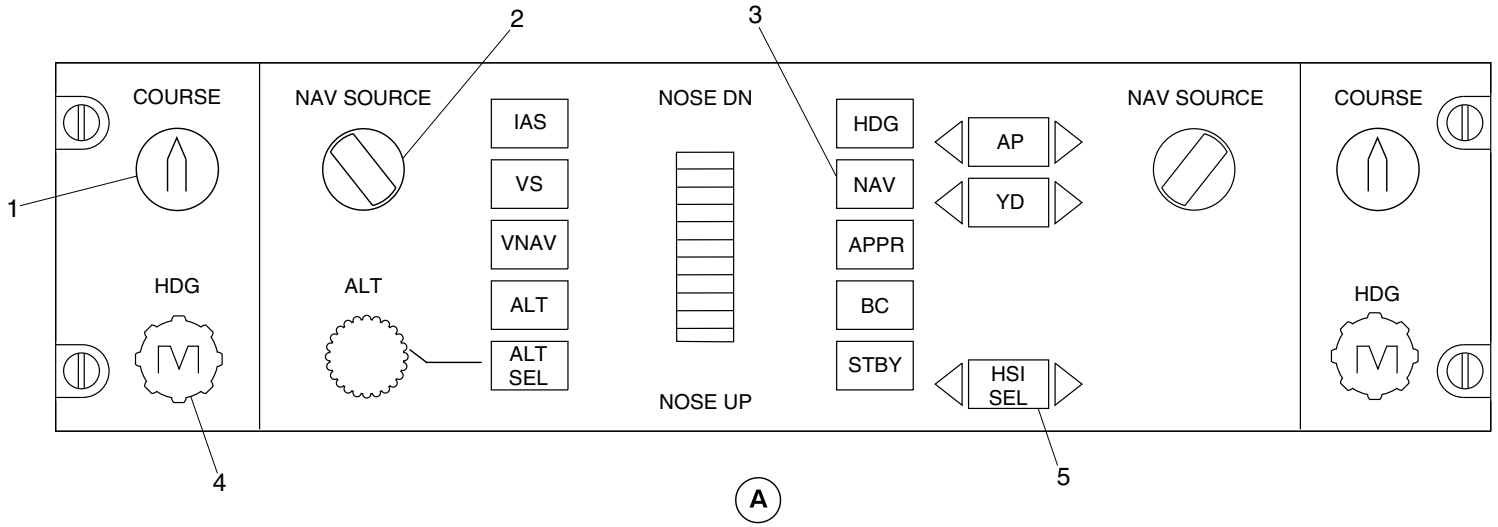
FD, FGCP VOR Approach Mode Controls
Figure 17



GLARESHIELD PANEL

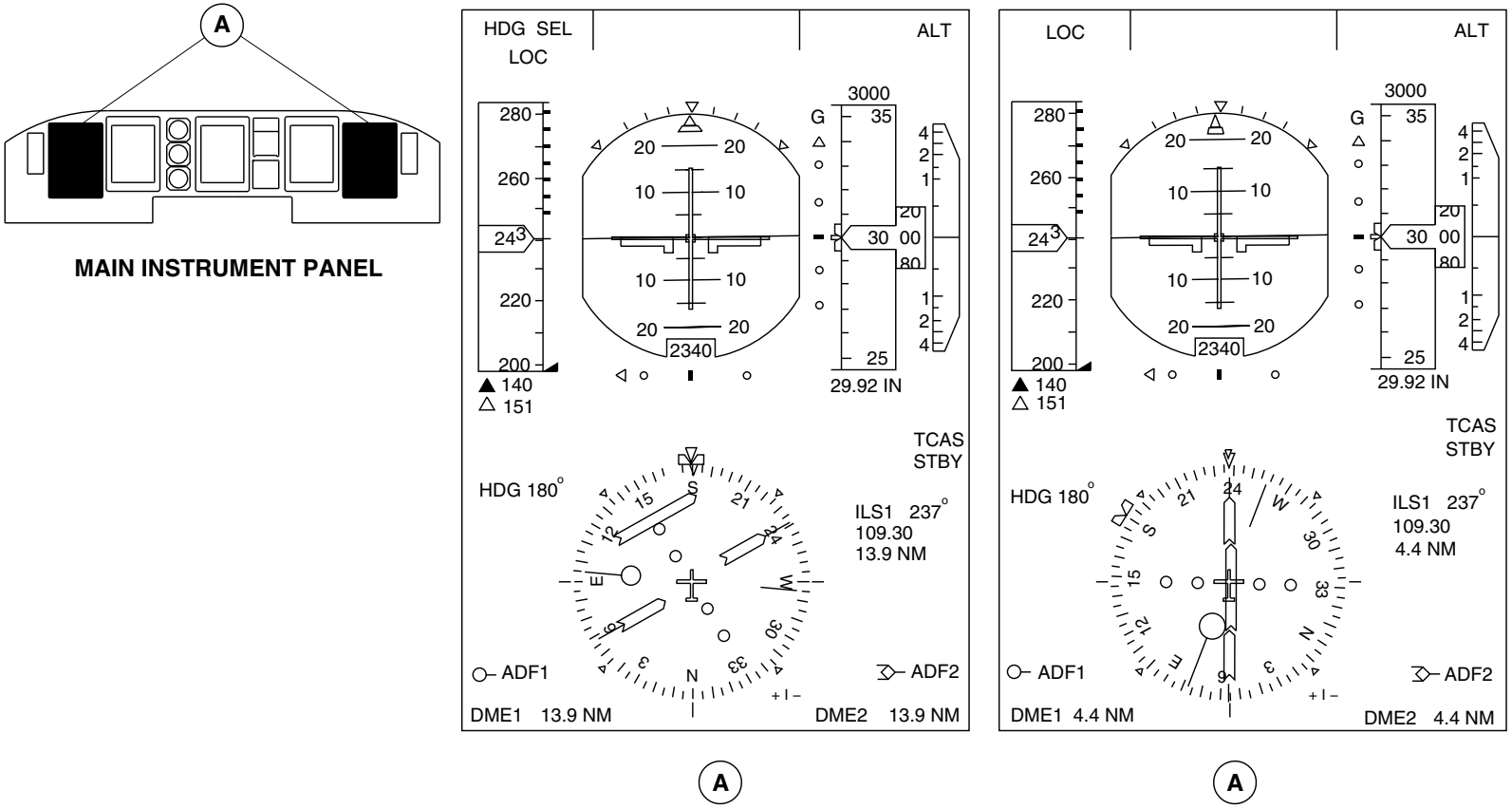
LEGEND

1. COURSE knob.
2. NAV SOURCE rotary switch.
3. NAV pushbutton switch.
4. HDG knob.
5. HSI SEL pushbutton switch.



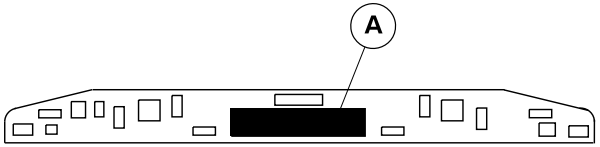
cg4807a01.dg, rc, aug21/2018

FD, FGCP Localizer Mode Controls
Figure 18



cg4758a01.dg, rc, jul12/2017

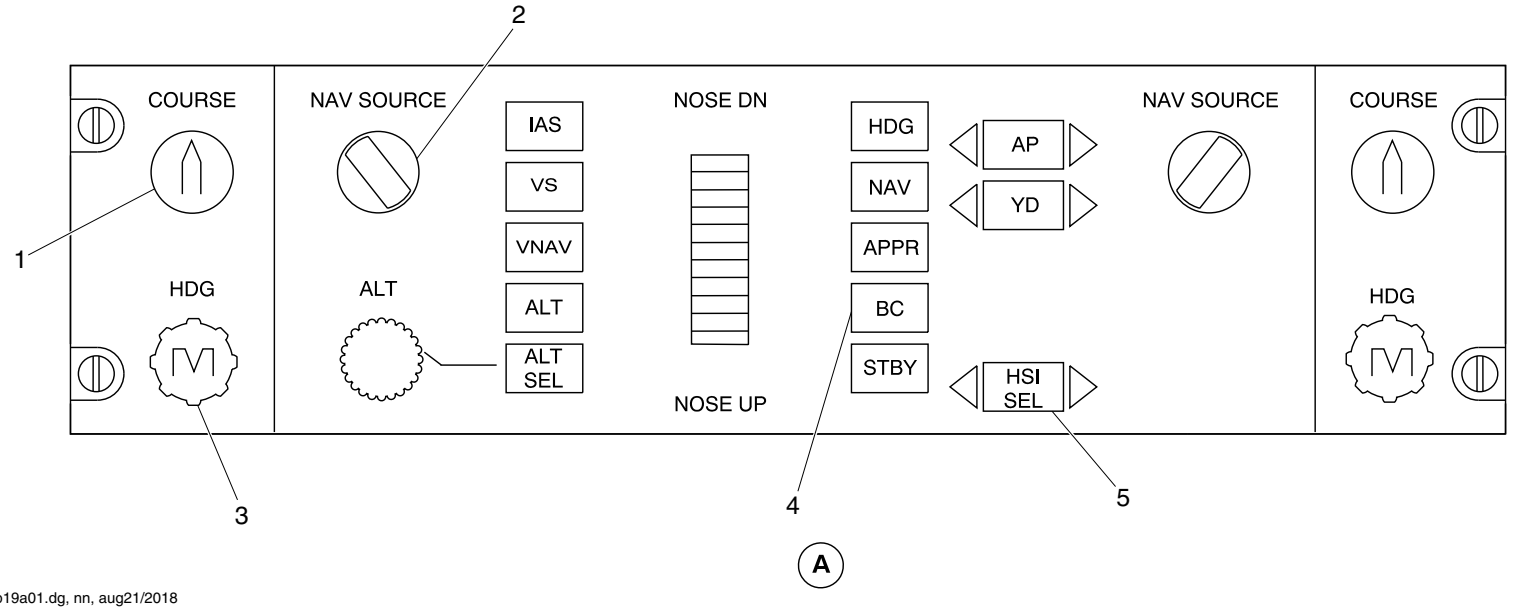
FD Localizer Mode, PFD Indications
Figure 19



GLARESHIELD PANEL

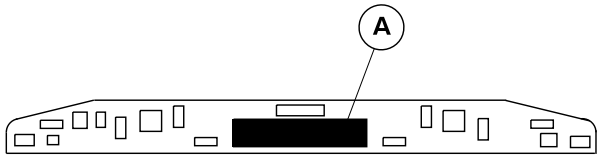
LEGEND

1. COURSE knob.
2. NAV SOURCE rotary switch.
3. HDG knob.
4. BC pushbutton switch.
5. HSI SEL pushbutton switch.



fsp19a01.dg, nn, aug21/2018

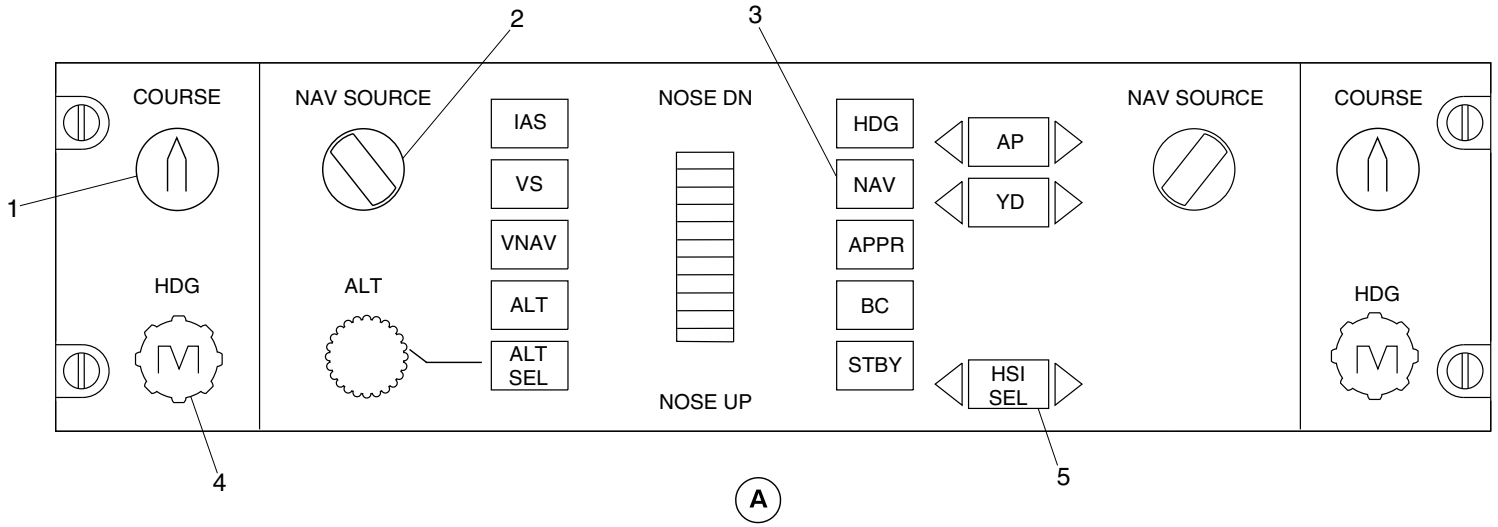
FD, FGCP Back Course Localizer Mode Controls
Figure 20



GLARESHIELD PANEL

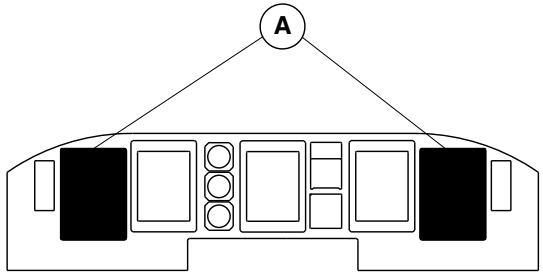
LEGEND

1. COURSE knob.
2. NAV SOURCE rotary switch.
3. NAV pushbutton switch.
4. HDG knob.
5. HSI SEL pushbutton switch.

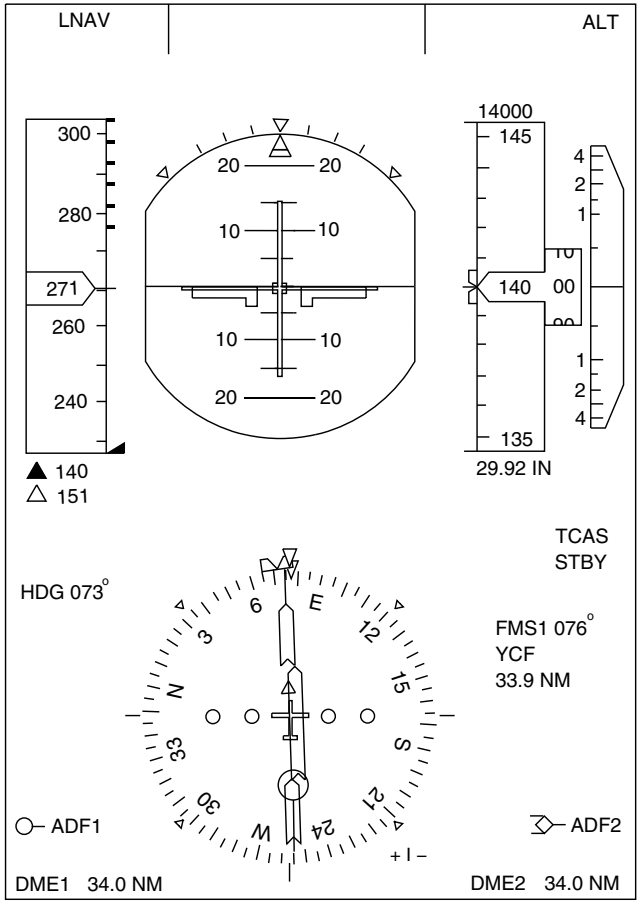


cg4806a01.dg, rc, aug21/2018

FD, FGCP FMS LNAV Mode Controls
Figure 21

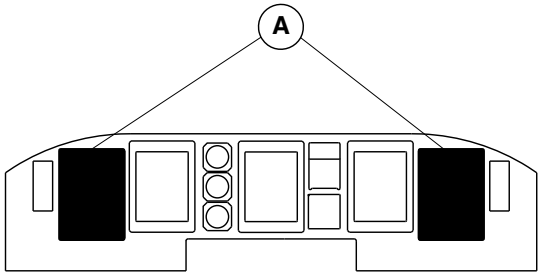


MAIN INSTRUMENT PANEL

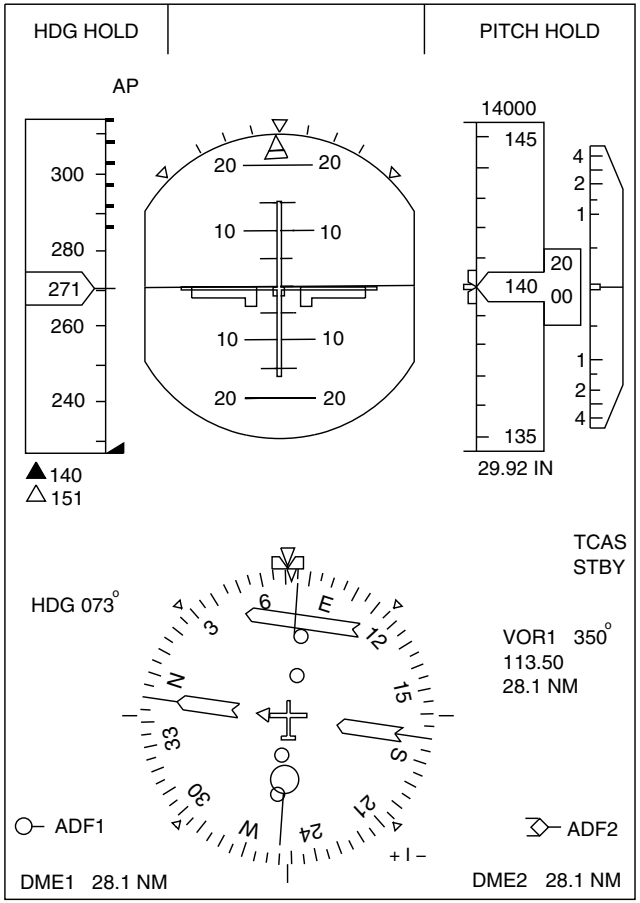


cg4759a01.dg, rc, jul12/2017

FD LNAV Mode, PFD Indications
Figure 22

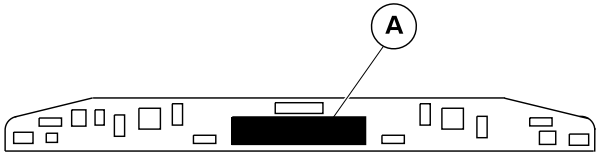


MAIN INSTRUMENT PANEL



cg4760a01.dg, rc, jul12/2017

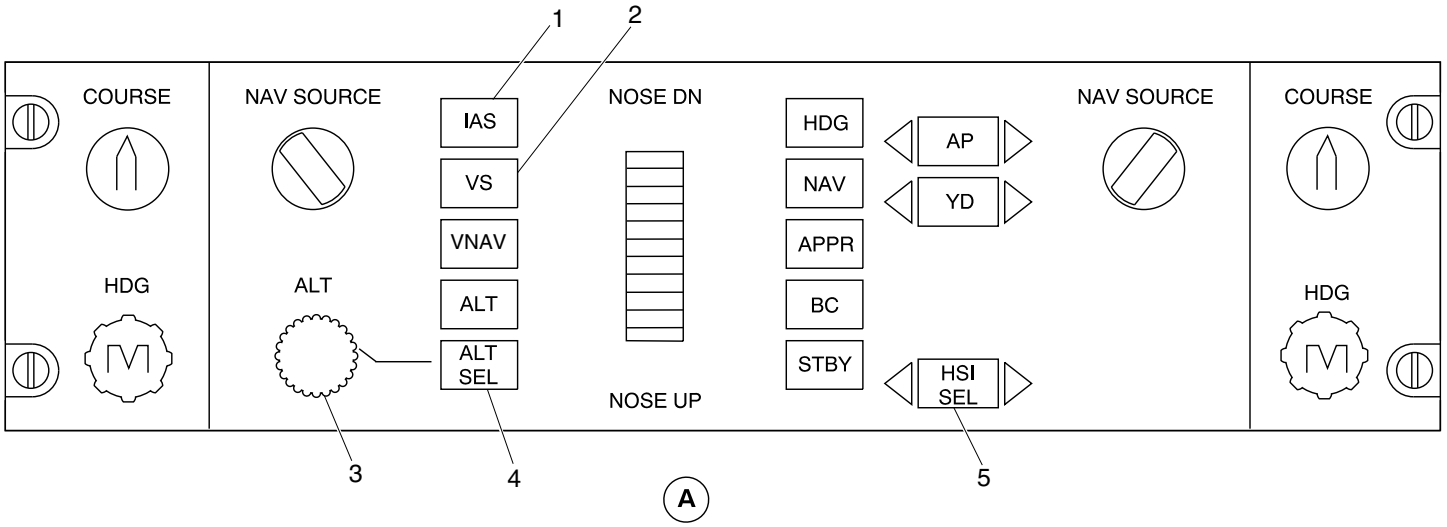
FD Pitch Hold Mode, PFD Indications
Figure 23



GLARESHIELD PANEL

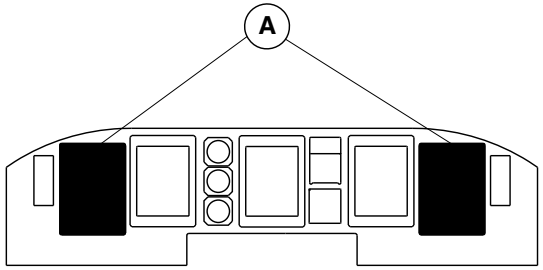
LEGEND

1. IAS pushbutton switch.
2. VS pushbutton switch.
3. ALT knob.
4. ALT SEL pushbutton switch.
5. HSI SEL pushbutton switch.

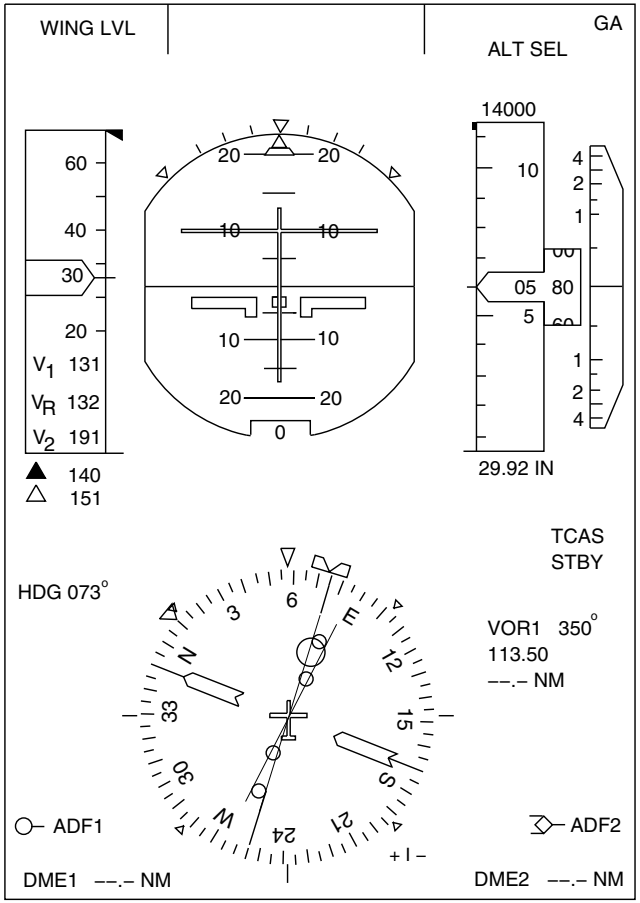


fsp21a01.dg, kb, aug21/2018

FD, FGCP Altitude Select Mode Controls
Figure 24

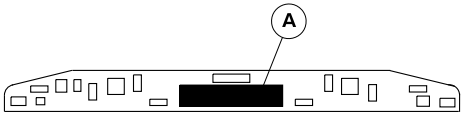


MAIN INSTRUMENT PANEL



cg4761a01.dg, rc, jul12/2017

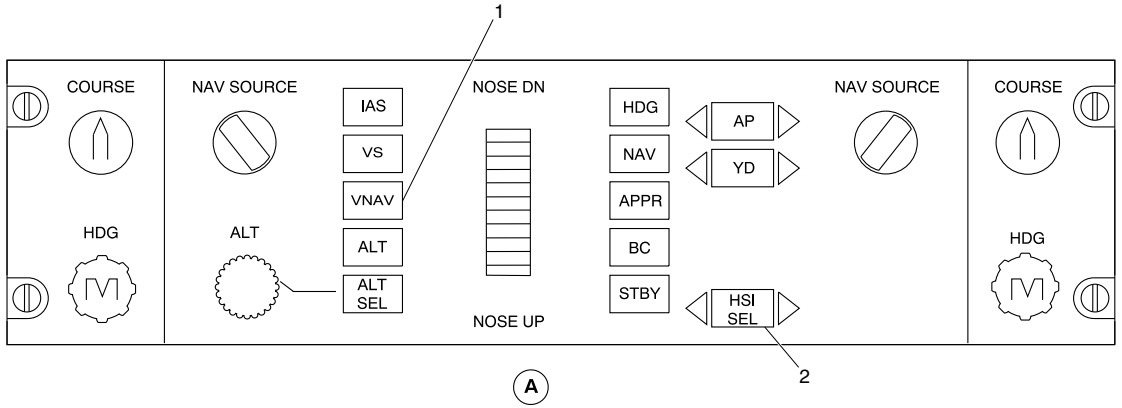
FD Altitude Select Mode, PFD Indications
Figure 25



GLARESHIELD PANEL

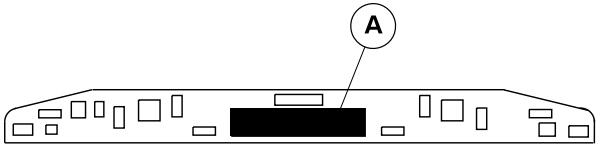
LEGEND

1. VNAV push button switch.
2. HSI SEL push button switch.



fsp23a01.dg, kb, aug21/2018

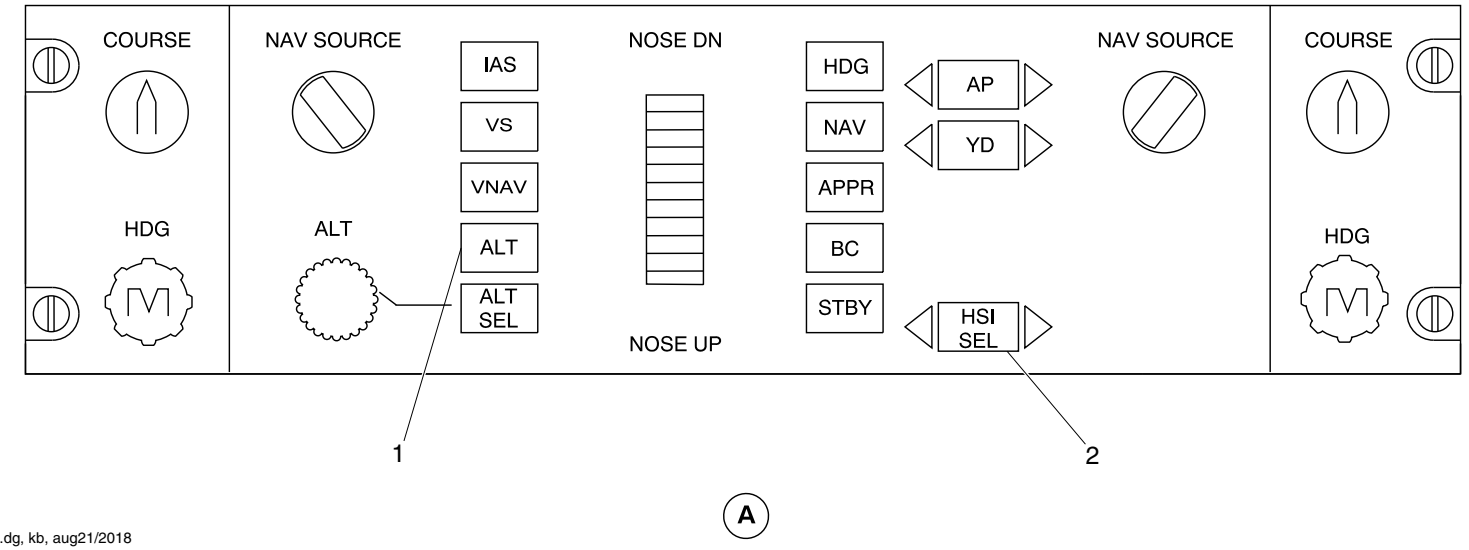
FD, FGCP FMS Vertical Navigation Mode Controls
Figure 26



GLARESHIELD PANEL

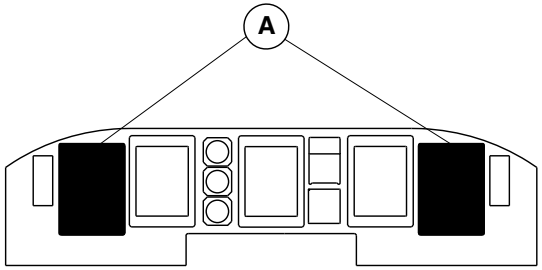
LEGEND

1. ALT pushbutton switch.
2. HSI SEL pushbutton switch.

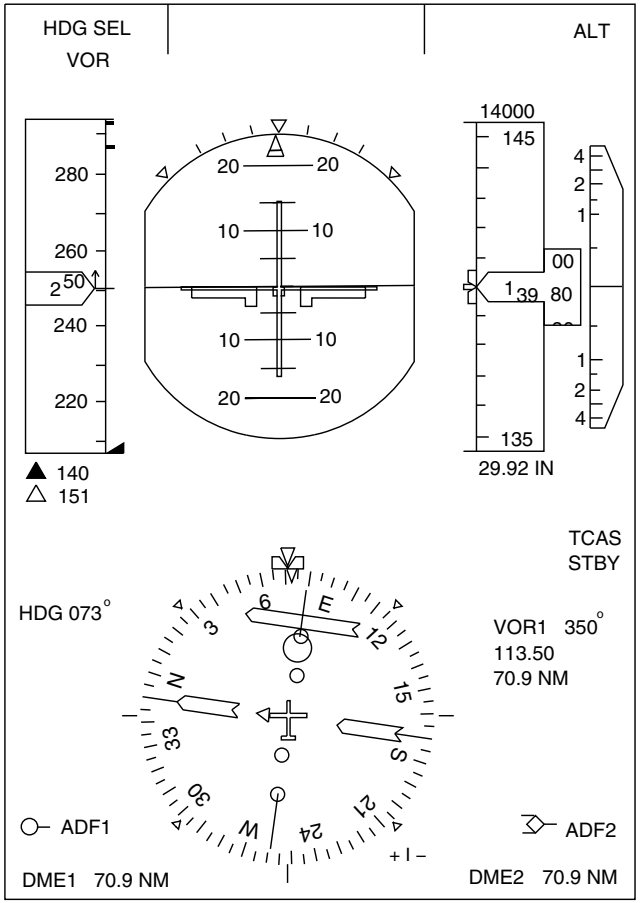


fsp26a01.dg, kb, aug21/2018

FD, FGCP Altitude Hold Mode Controls
Figure 27

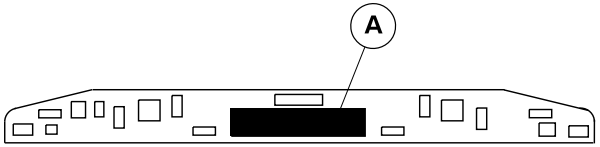


MAIN INSTRUMENT PANEL



cg4762a01.dg, rc, jul12/2017

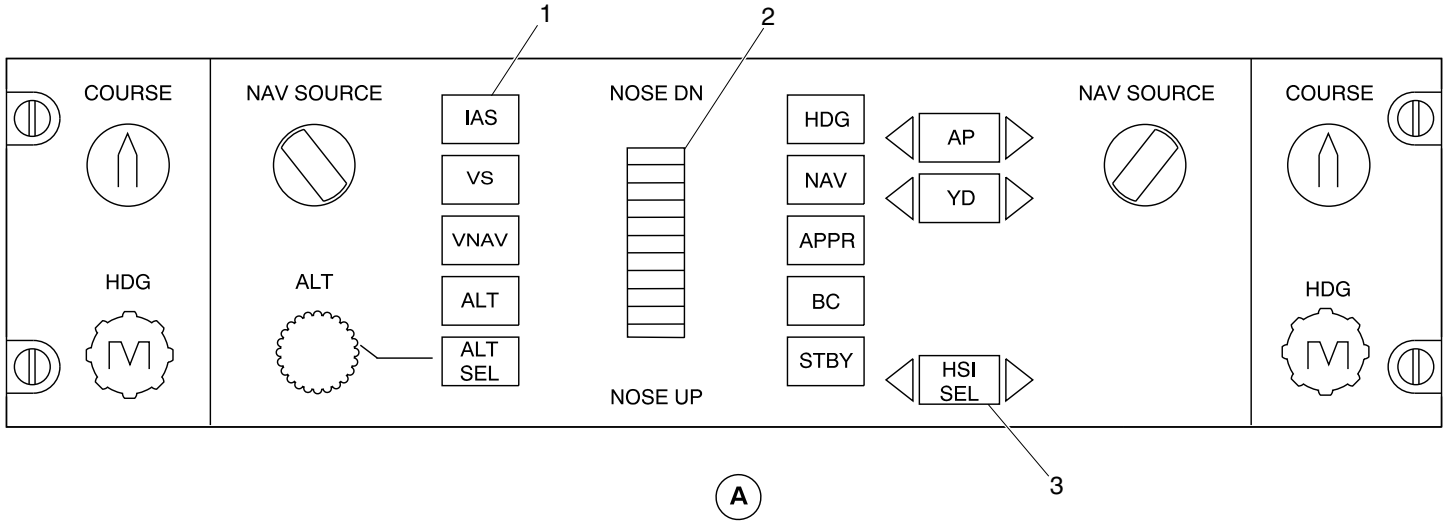
FD Altitude Hold Mode, PFD Indications
Figure 28



GLARESHIELD PANEL

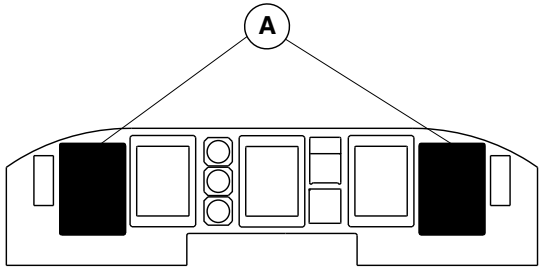
LEGEND

1. IAS push button switch.
2. NOSE DN/NOSE UP thumb switch.
3. HSI SEL pushbutton switch.

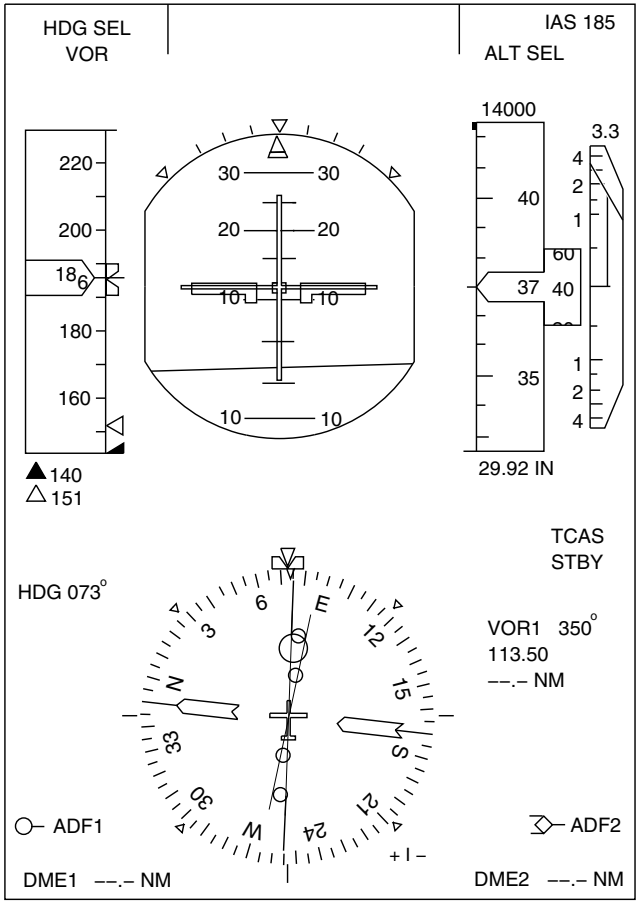


fsp22a01.dg, kb, aug21/2018

FD, FGCP Indicated Airspeed Mode Controls
Figure 29

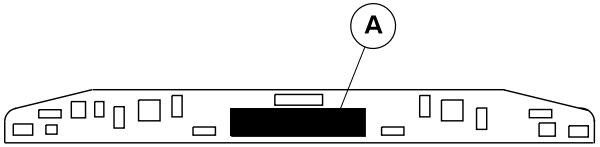


MAIN INSTRUMENT PANEL



cg4763a01.dg, rc, jul12/2017

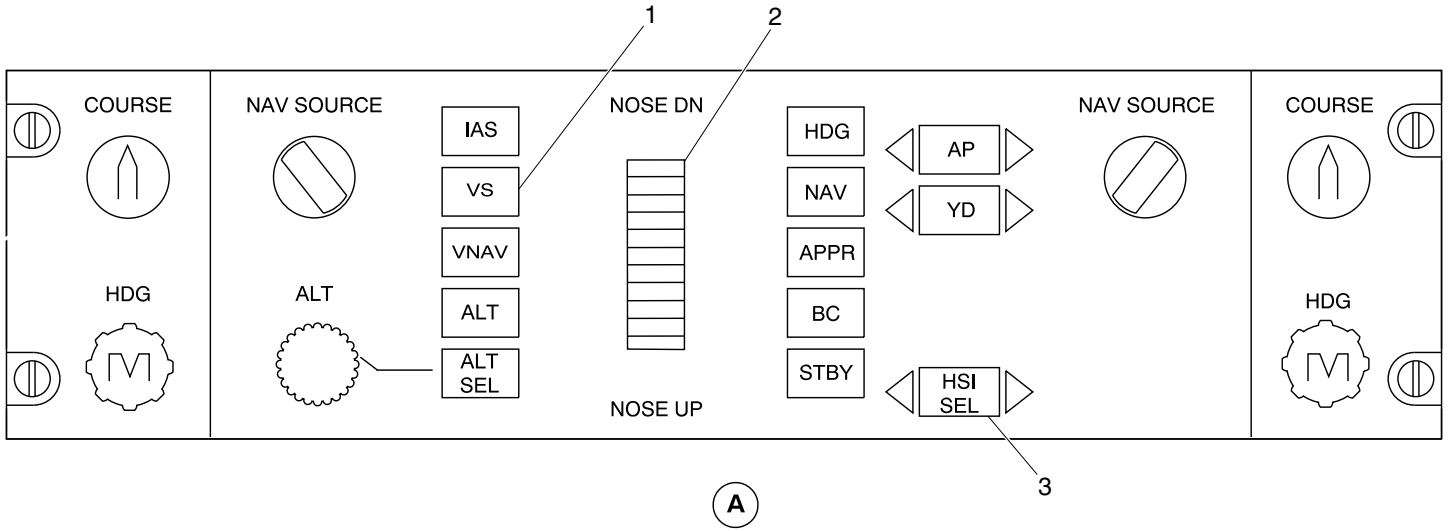
FD Indicated Airspeed Mode, PFD Indications
Figure 30



GLARESHIELD PANEL

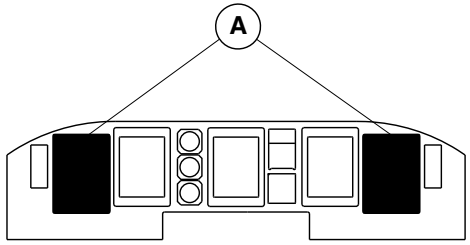
LEGEND

1. VS pushbutton switch.
2. NOSE DN/NOSE UP thumb switch.
3. HSI SEL pushbutton switch.

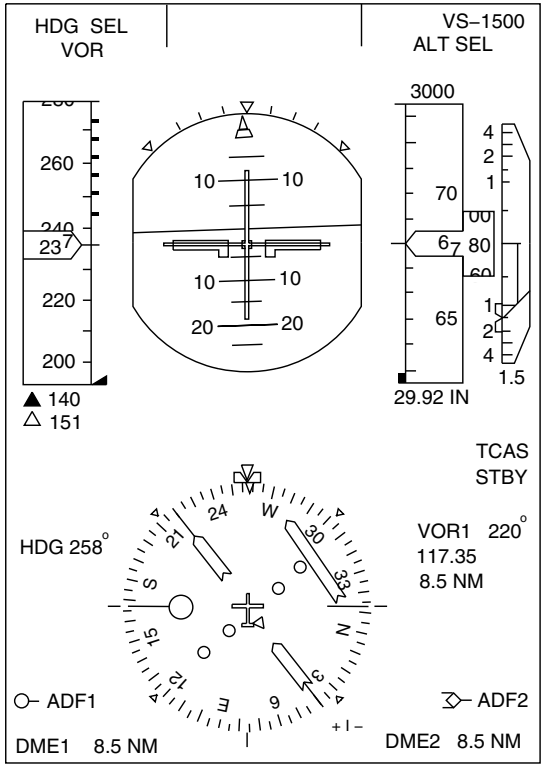


fsp25a01.dg, kb, aug21/2018

FD, FGCP Vertical Speed Mode Controls
Figure 31

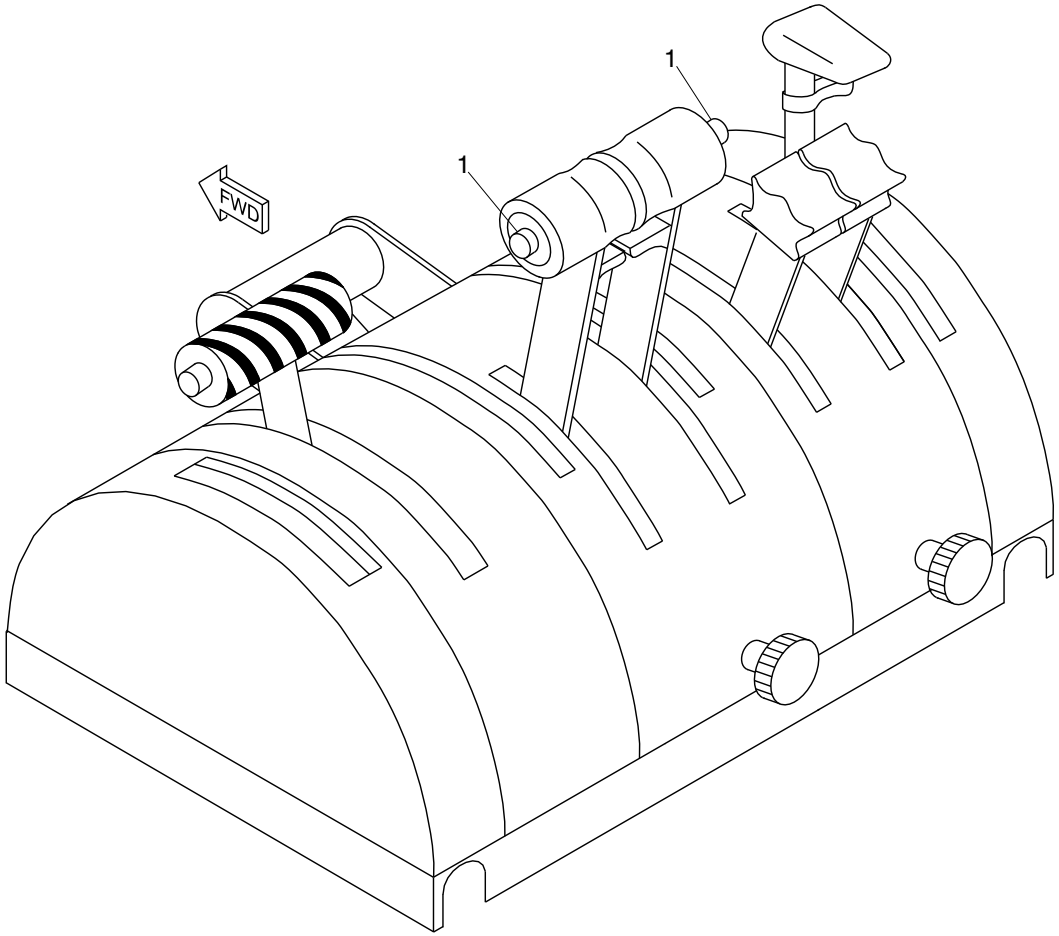


MAIN INSTRUMENT PANEL



cg4799a01.dg, rc, jul12/2017

FD Vertical Speed Mode, PFD Indications
Figure 32

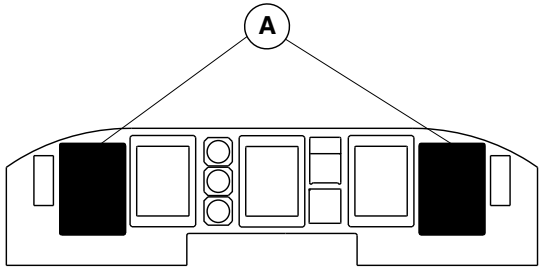


LEGEND

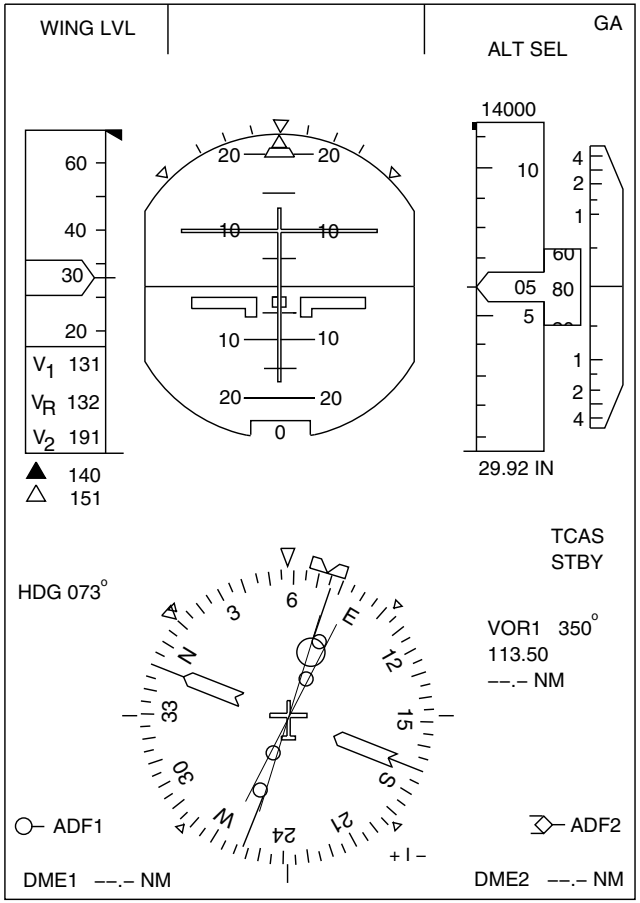
1. GA push button switch.

fsp31a01.dg, rc, sep22/2011

FD, GA Mode Controls
Figure 33

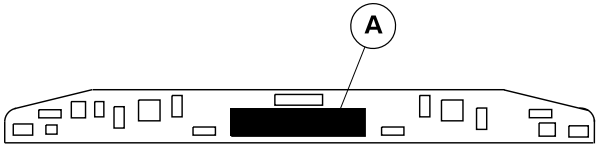


MAIN INSTRUMENT PANEL



cg4764a01.dg, rc, jul12/2017

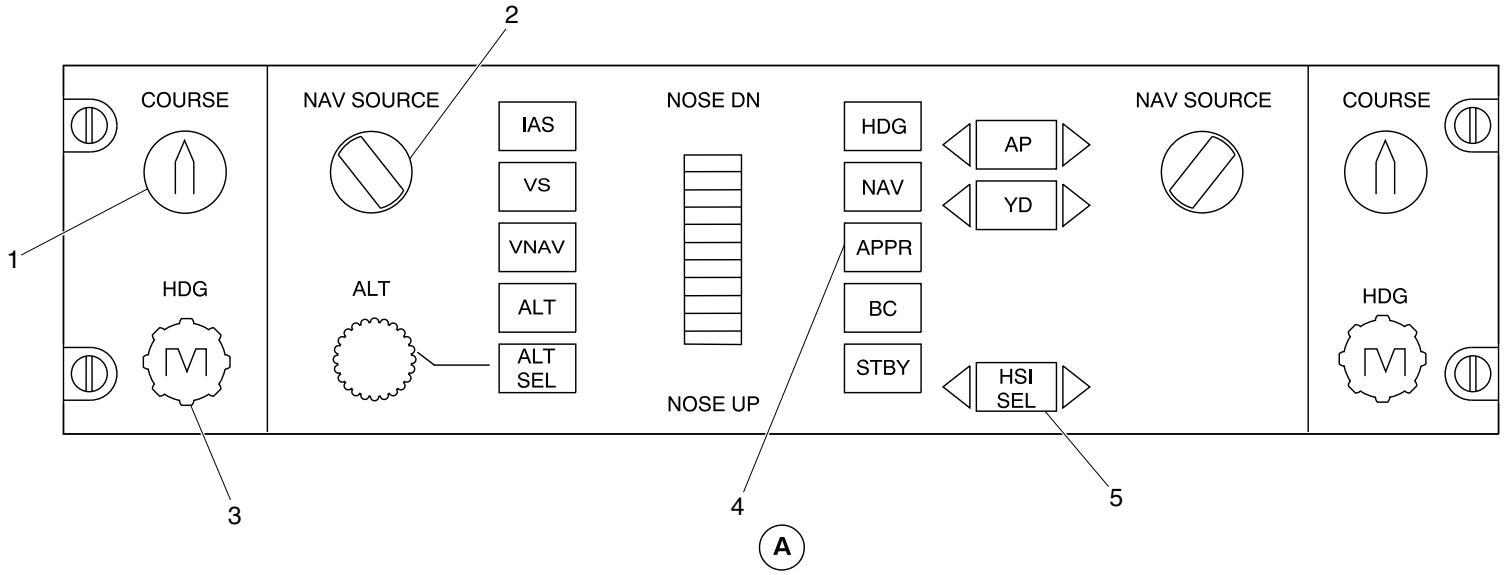
FD Go Around, Wings Level Mode, PFD Indications
Figure 34



GLARESHIELD PANEL

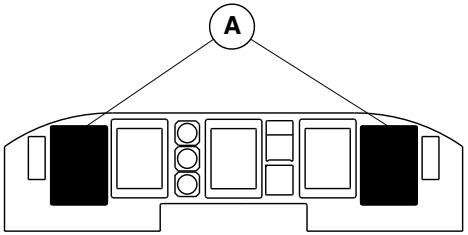
LEGEND

1. COURSE knob.
2. NAV SOURCE rotary switch.
3. HDG knob.
4. APPR pushbutton switch.
5. HSI SEL pushbutton switch.

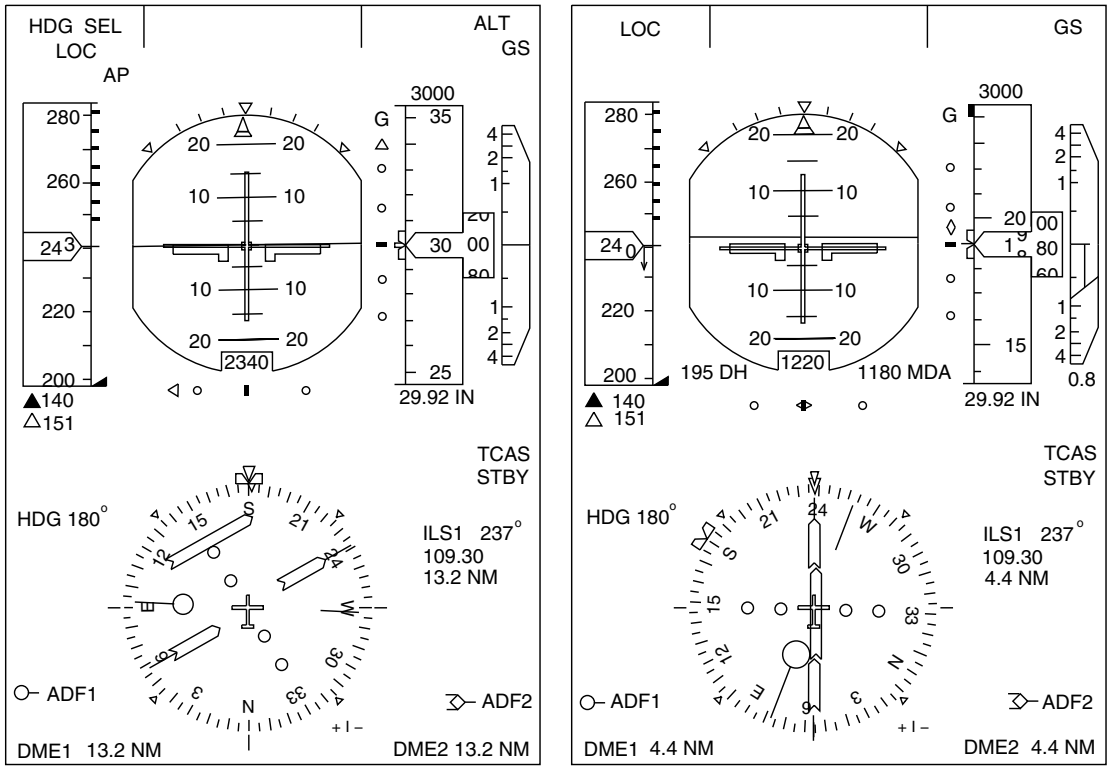


cg5410a01.dg, nn, aug21/2018

FD, FGCP ILS Approach Mode Controls
Figure 35

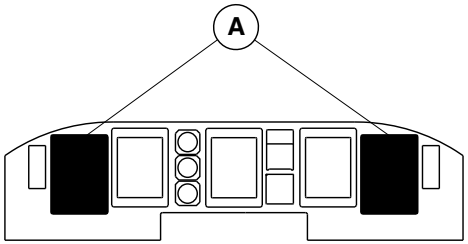


MAIN INSTRUMENT PANEL

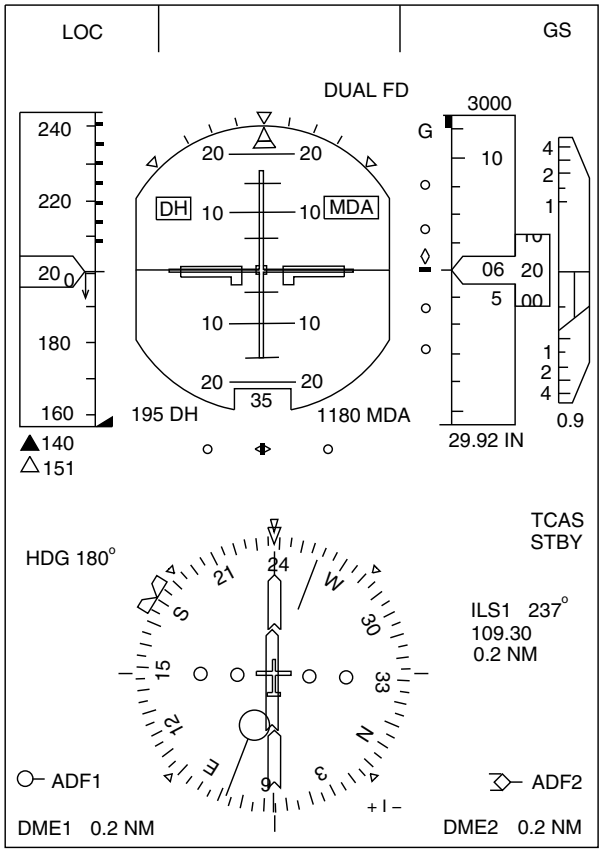


cg4765a01.dg, rc, jul12/2017

FD ILS Approach Mode, PFD Indications
Figure 36

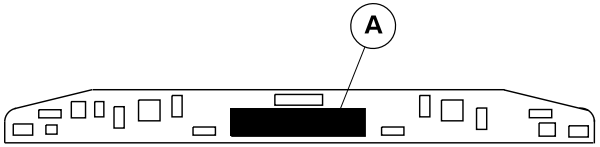


MAIN INSTRUMENT PANEL



cg4766a01.dg, rc, jul12/2017

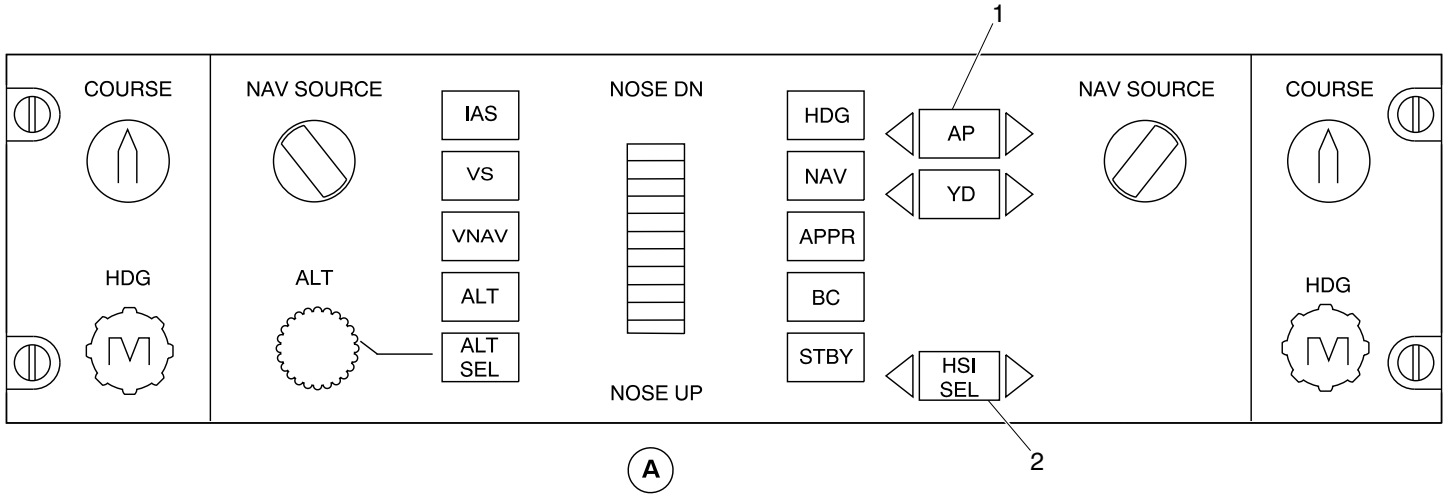
Dual FD Mode, PFD Indications
Figure 37



GLARESHIELD PANEL

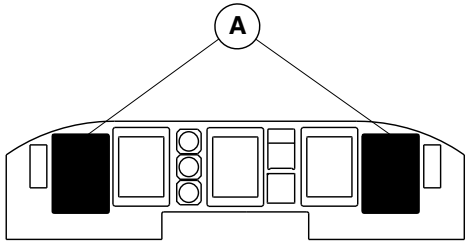
LEGEND

1. AP pushbutton switch.
2. HSI SEL pushbutton switch.

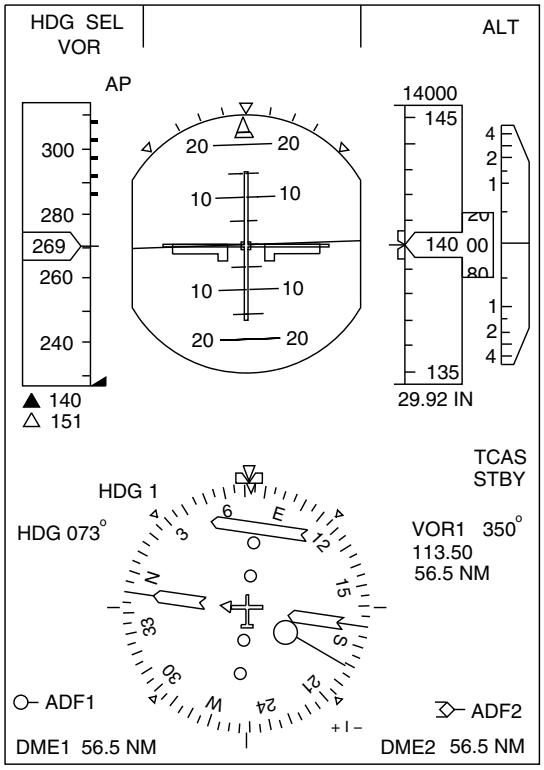


fsp32a01.dg, kb, aug21/2018

Autopilot Mode Controls
Figure 38

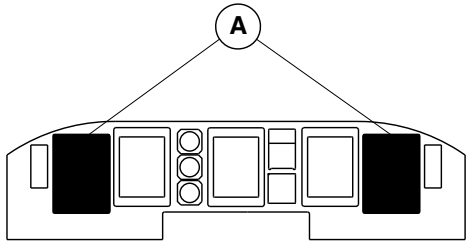


MAIN INSTRUMENT PANEL

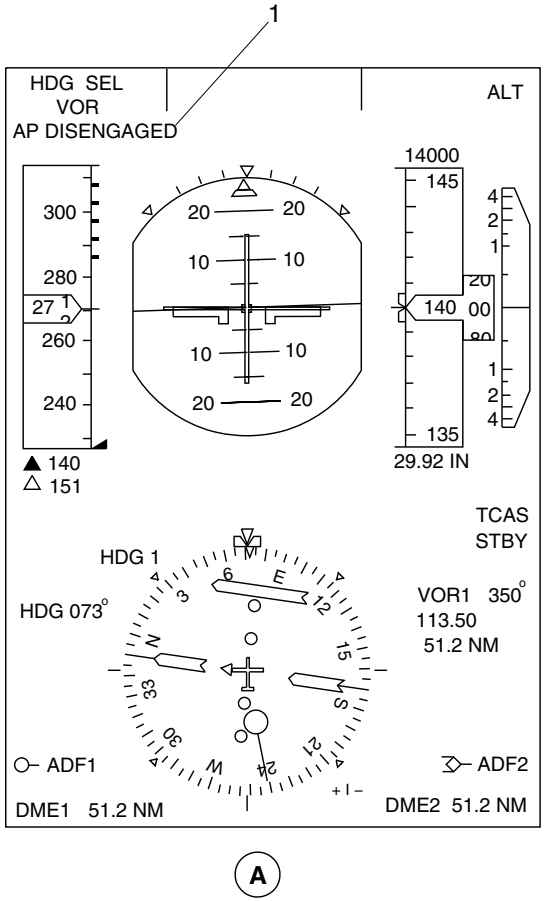


cg4767a01.dg, rc, jul12/2017

FD Autopilot Mode, PFD Indications
Figure 39



MAIN INSTRUMENT PANEL

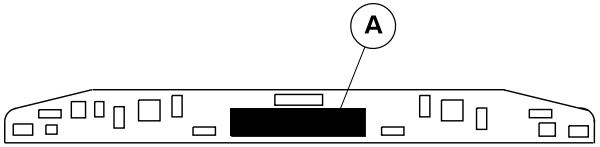


LEGEND

1. AP status message.

cg4798a01.dg, rc, jul12/2017

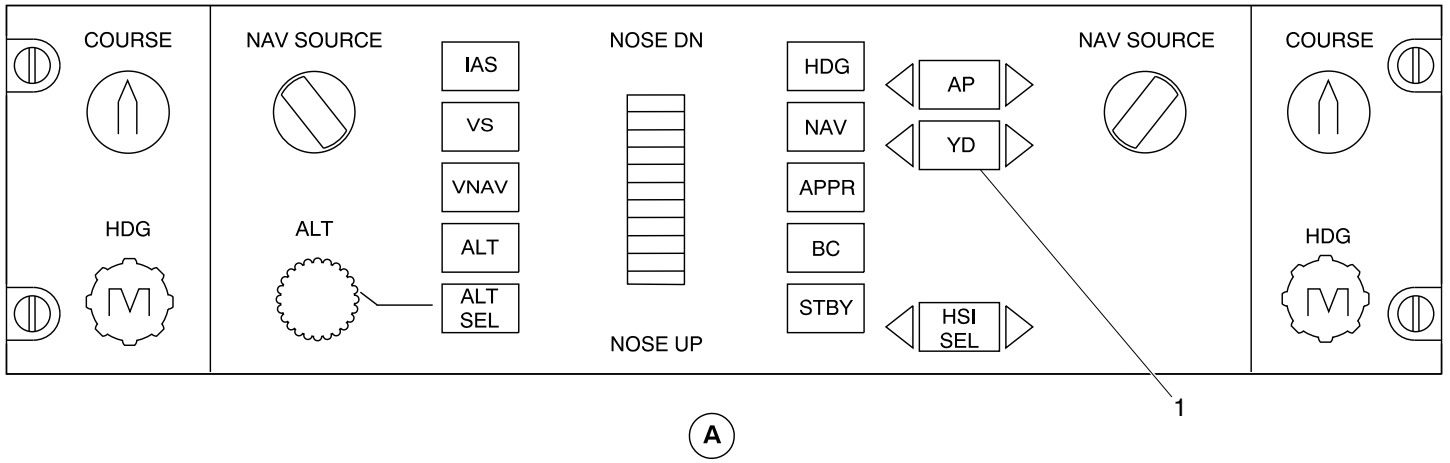
FD Mode, AP Disengaged Message
Figure 40



GLARESHIELD PANEL

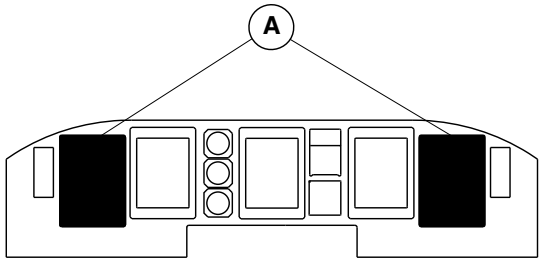
LEGEND

1. YD pushbutton switch.

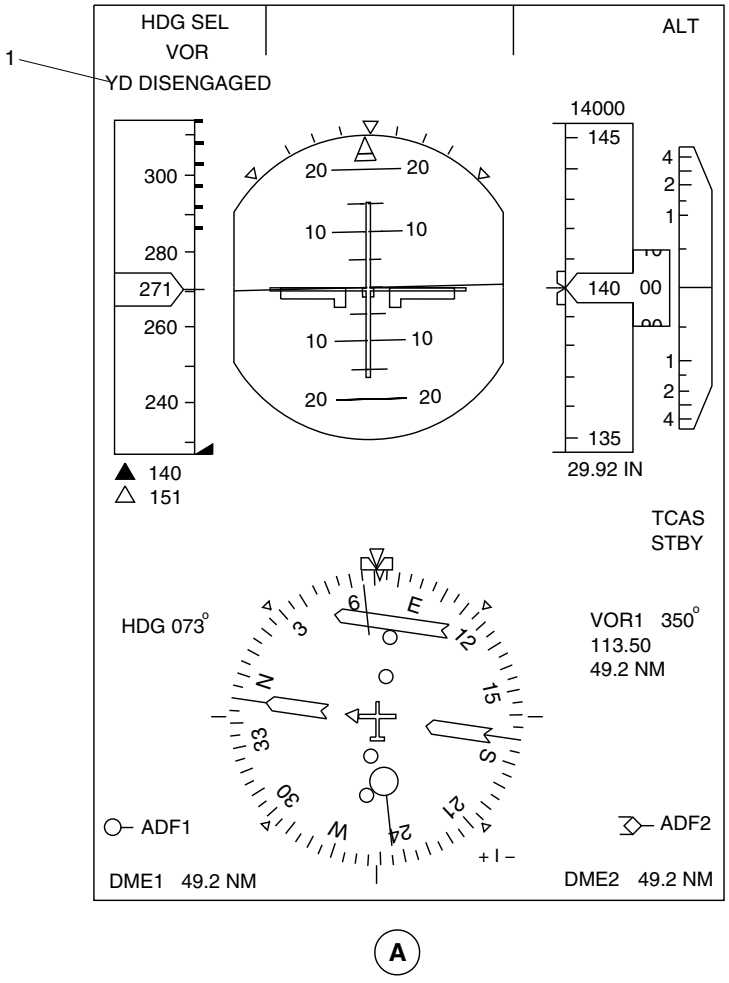


fsp67a01.dg, kb, aug21/2018

Yaw Damper Mode Control
Figure 41



MAIN INSTRUMENT PANEL

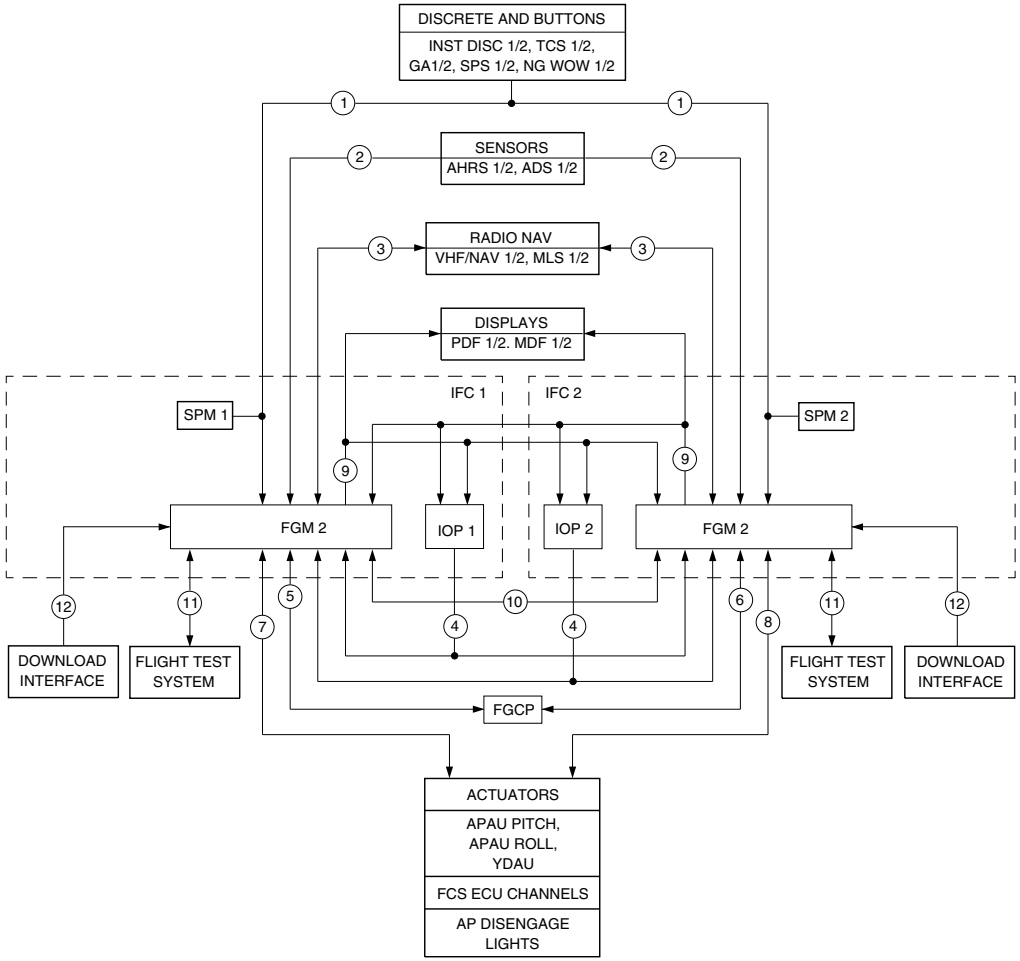


LEGEND

1. YD status message.

cg4768a01.dg, rc, jul12/2017

FD Mode, YD Disengaged Message
Figure 42

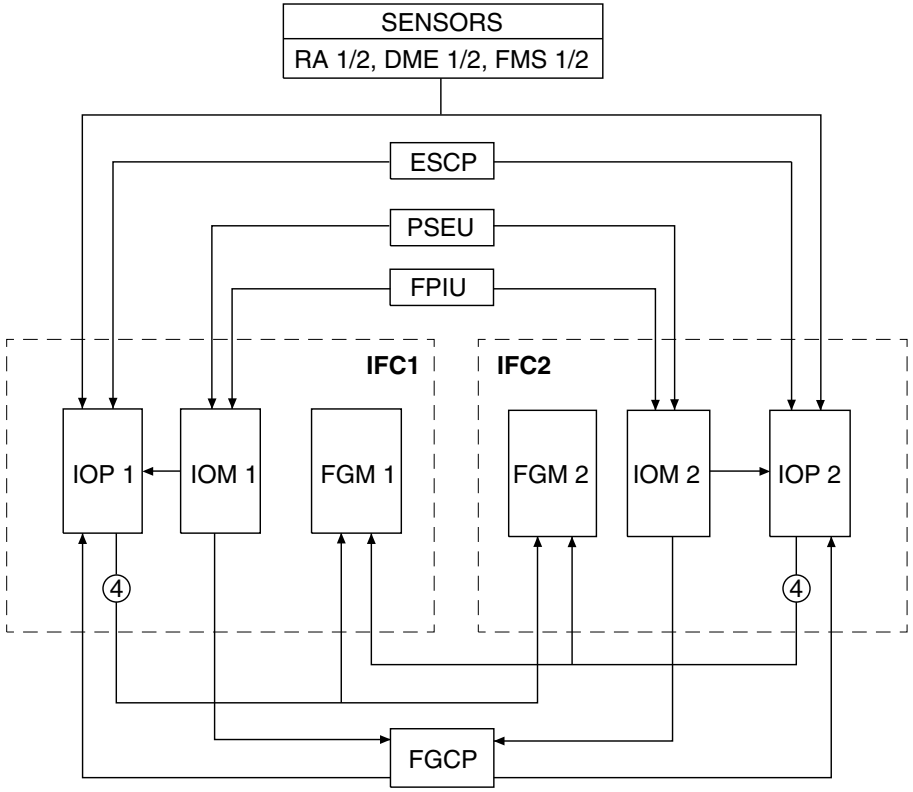


INTERFACE DEFINITION:

1 : 10 DSI.
2 : 4 DGI.
3 : 4 DGI.
4 : 1 DGI (see decomposition figure 3–2).
5 : 1 DGI + 2 DSI + 2 DSO.
6 : 1 DGI + 2 DSI.
7 : 2 DGI + 10 ANI + 3 ANO + 1 DSI + 6 DSO.
8 : 2 DGI + 10 ANI + 4 DSI + 5 DSO.
9 : 1 DGO.
10 : DSIO + ANIO (see decomposition figure 2–3).
11 : 1 DGI + 1 DGO + 2 DSI.
12 : 1 DSI + 1 RS4221.

cg4769a01.dg, rc, jul12/2017

AFCS Architecture
Figure 43

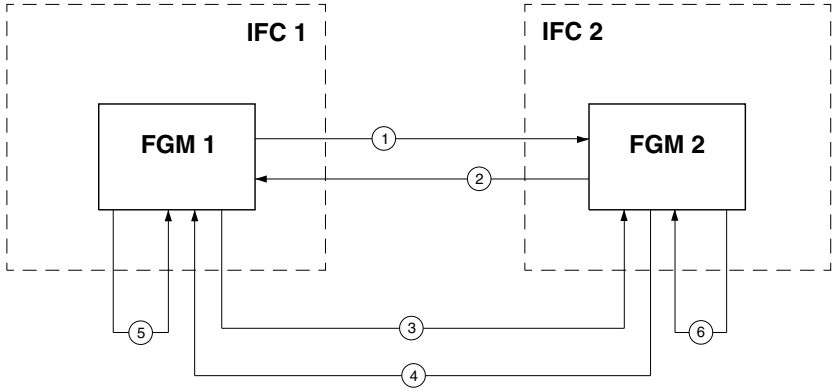


INTERFACE DEFINITION VIA FDPS:

IOP 1/2 TRANSMIT DATA THROUGH A ARINC 429 BUS TO FGM 1/2 (BUS 4).
IOM 1/2 TRANSMIT 2 DISCRETE TO FGCP.

cg4770a01.dg, rc, jul12/2017

Flight Guidance Module Architecture (FGM–FDPS)
Figure 44

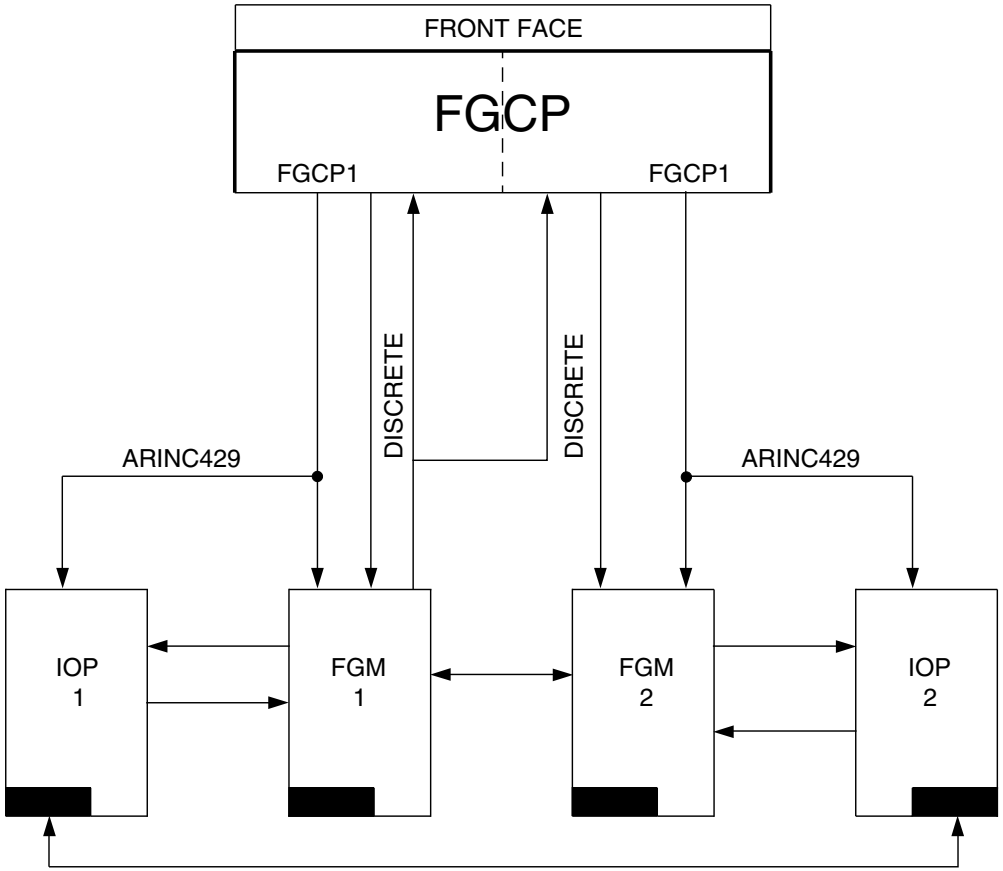


INTERFACE DEFINITION:

(1) : 1 A429.
(2) : 1 A429.
(3) : 5 DIS : AP ENG 1.
YD ENG 1.
FGM 1 HEALTY.
FGM 1 EXCHANGE 1.
FGM 1 EXCHANGE 2.
+3 ANA : APAU PITCH CMD.
APAU ROLL CMD.
YDAU CMD.
(4) : 5 DIS : AP ENG 2.
YD ENG 2.
FGM 2 HEALTY.
FGM 2 EXCHANGE 1.
FGM 2 EXCHANGE 2.
(5) : 2 DIS : AP ENG 1 FBK.
YD ENG 1 FBK.
+3 ANA : APAU PITCH CMD FBK.
APAU ROLL CMD FBK.
YDAU CMD FBK.
(6) : 2 DIS : AP ENG 2 FBK.
YD ENG 2 FBK.

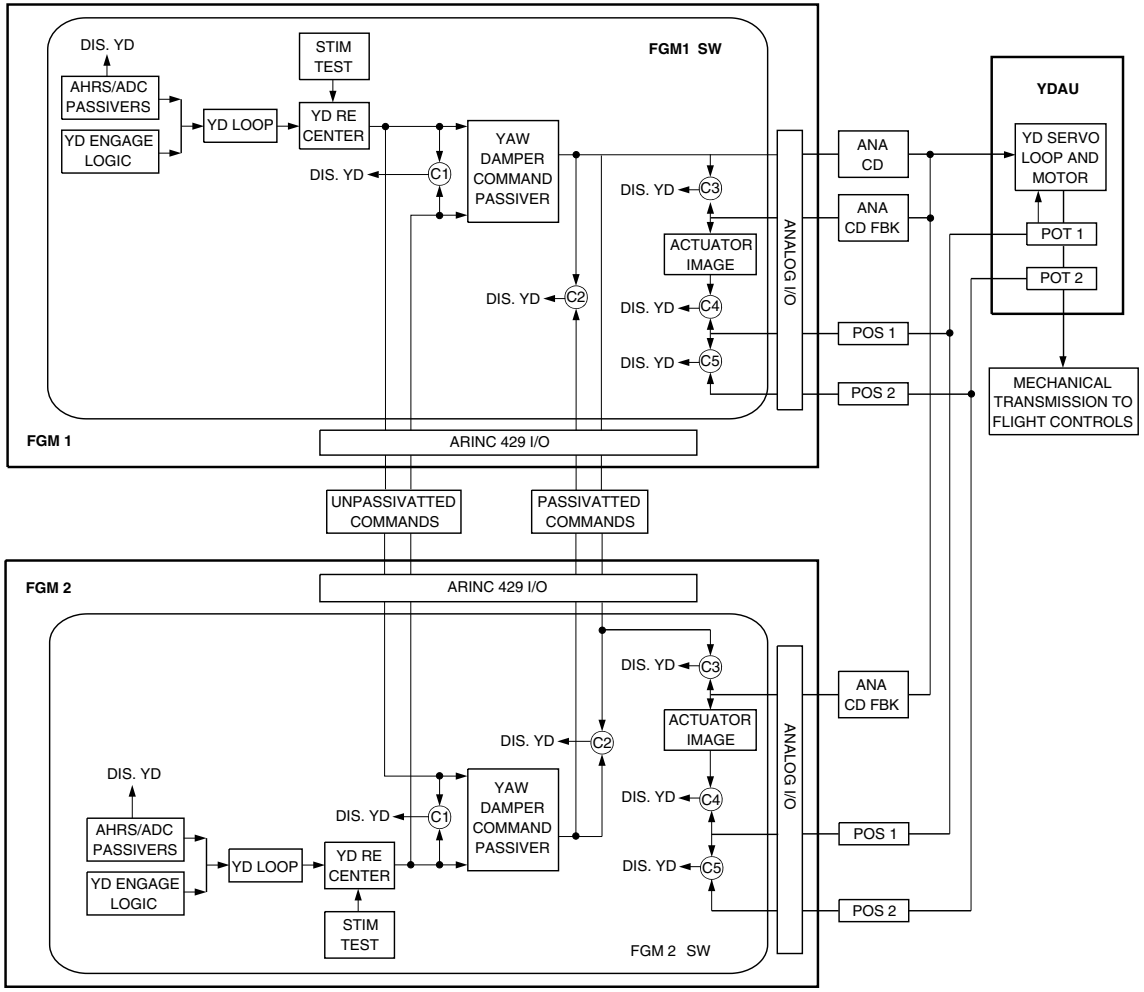
cg4771a01.dg, rc, jul12/2017

Flight Guidance Module functional Diagram
Figure 45



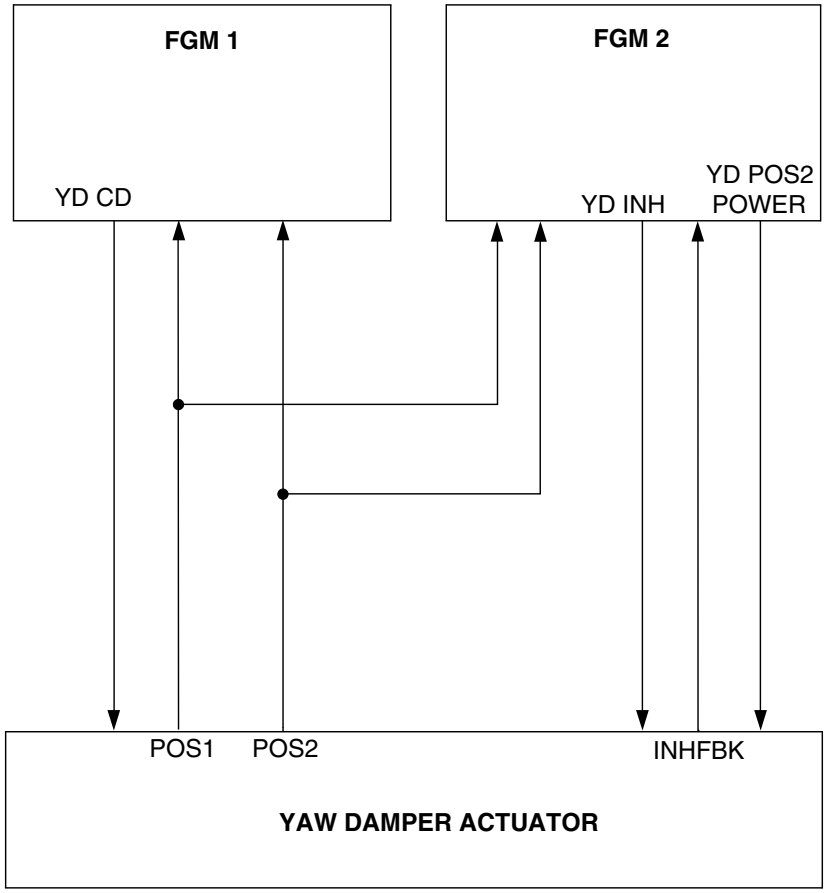
cg4772a01.dg, rc, jul12/2017

FGCP Architecture
Figure 46



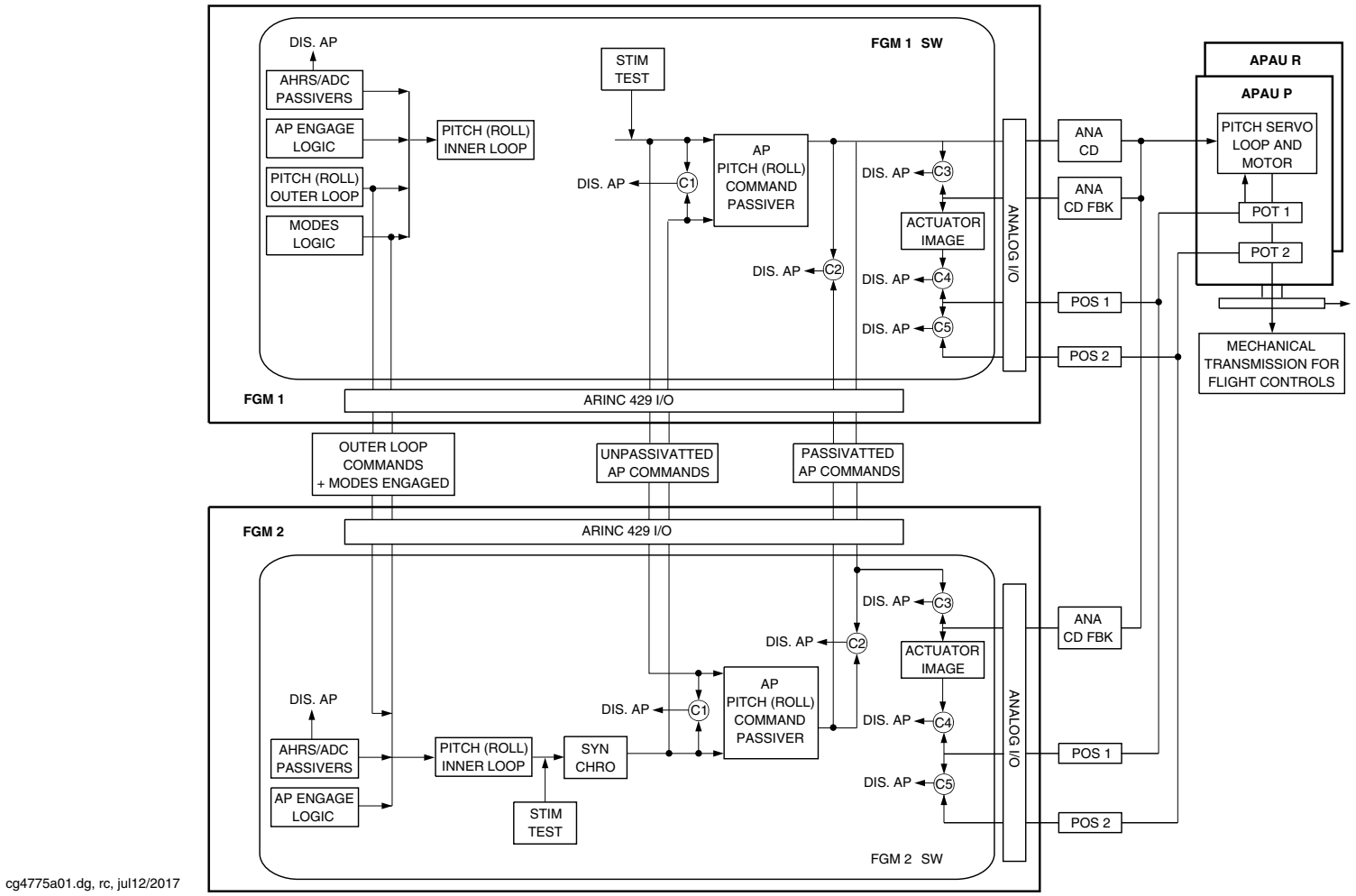
cg4773a01.dg, rc, jul12/2017

Yaw Damper Architecture
Figure 47



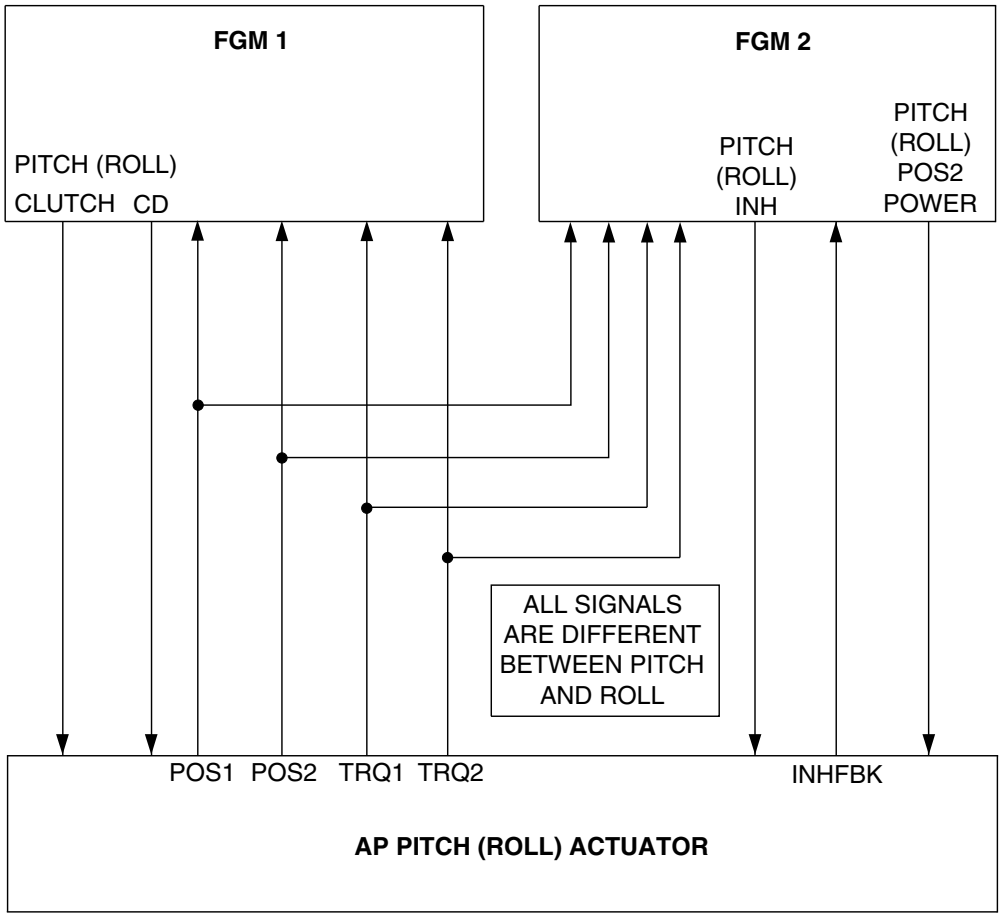
cg4774a01.dg, rc, jul12/2017

FGM/YDAU Interface
Figure 48



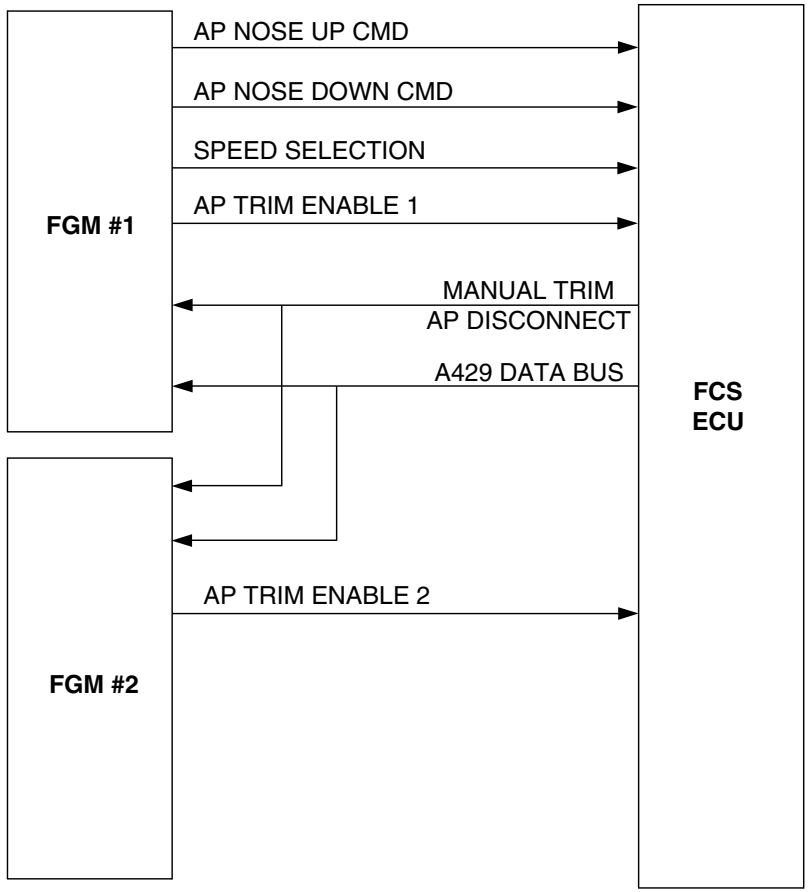
cg4775a01.dg, rc, jul12/2017

Autopilot Architecture
Figure 49



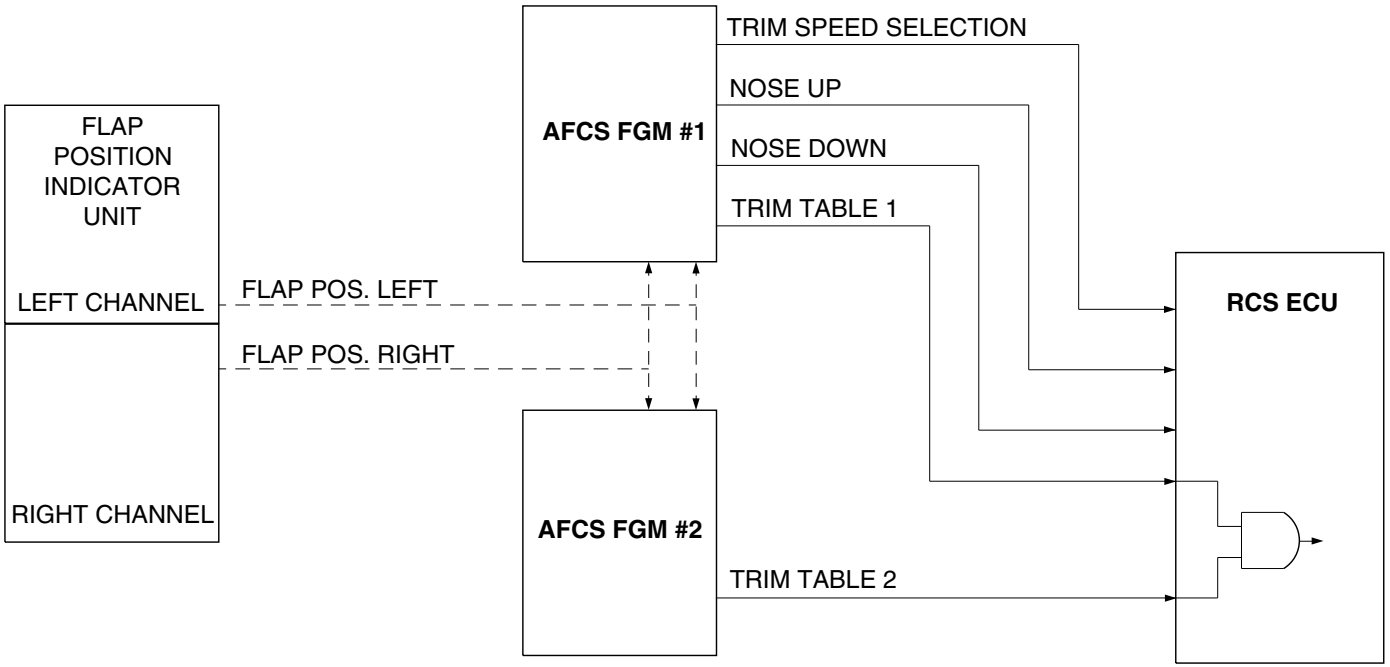
cg4776a01.dg, rc, jul12/2017

FGM/APAU Interface
Figure 50



cg4777a01.dg, rc, jul12/2017

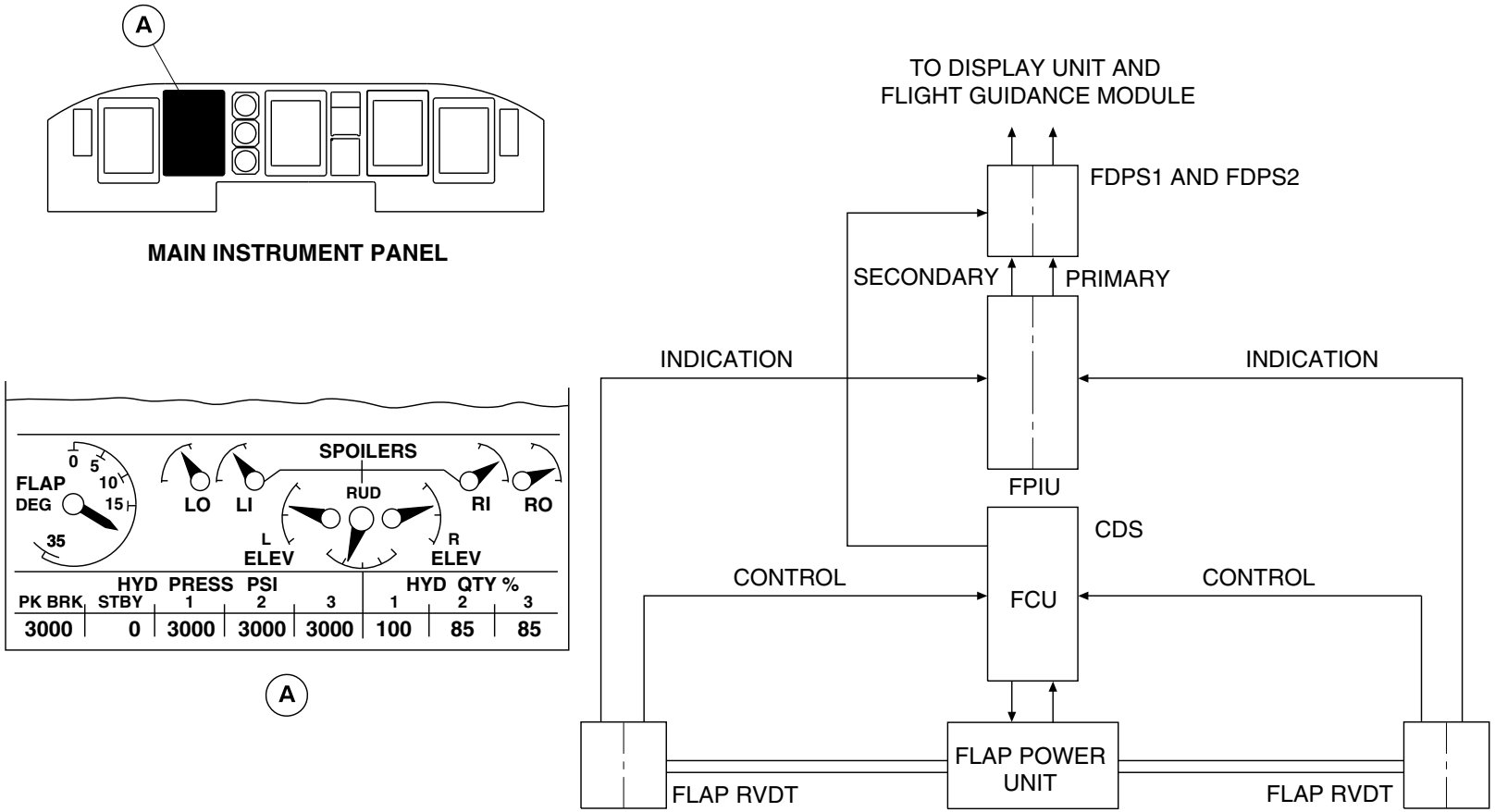
Autopilot Pitch Trim Architect
Figure 51



TRIM ENABLE FCS ECU = (TRIM ENABLE 1 AND TRIM ENABLE 2)

cg4778a01.dg, rc, jul12/2017

Flap Auto Pitch Trim Architecture
Figure 52



cg4718a01.dg, nn, jul13/2017

Auto Trim Fail Message
Figure 53