



CHAPTER 4

AUTOMATIC FLIGHT CONTROLS

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CHAPTER 4

AUTOMATIC FLIGHT CONTROLS

GENERAL

The automatic flight control system (AFCS) is an integrated autopilot and flight director. The AFCS receives sensor information from the air data, navigation, and attitude heading reference systems (AHRS), as well as the radio altimeter and surface position sensors.

Dependent upon mode selection, the AFCS automatically controls the airplane's flight control surfaces. The AFCS system consists of the following:

- Two interlinked flight control computers (FCC 1 and FCC 2)
- Two-axis autopilot
- Two yaw dampers
- Automatic elevator trim control
- Assorted servos and actuators

The flight director provides pitch and roll commands to the flight crew through the primary flight displays (PFDs). Flight deck controls consist of the following:

- Flight control panel (flight director and autopilot controls)
- Yaw damper panel
- Control wheel switches AP DIS, PTCH TRIM, and SYNC
- Takeoff/go-around (TOGA) switches on the thrust levers

The autopilot (AP) system automatically controls the airplane in pitch, roll, and yaw by actuating the appropriate flight control surfaces. The autopilot responds to commands from the flight director.



Dependent upon the mode selected, the autopilot is capable of the following:

- Capturing and maintaining a desired magnetic heading, desired VOR track, ILS localizer, and glide-slope beam
- Capturing and maintaining a desired pitch attitude
- Maintaining a desired pressure altitude
- Maintaining a selected speed (IAS or Mach)
- Maintaining a selected vertical speed

Whether the autopilot is engaged or not, the flight director system can provide the pitch and roll commands necessary to accomplish the following:

- Hold a desired attitude
- Maintain a pressure altitude
- Hold a vertical speed
- Hold a Mach number or indicated airspeed (IAS)
- Capture and maintain a preselected barometric-corrected altitude
- Capture and track a preselected heading
- Capture and track a preselected radio course (VOR, LOC, and GS)
- Capture and track the localizer and glide slope during Category II procedures
- Maintain a wings-level, fixed, pitch up attitude during go-around
- Provide windshear escape guidance



NOTE

When the autopilot is in IAS or vertical speed mode with the flight director engaged, the flight director may command excursions beyond V_{MO}/M_{MO} .

The flight director provides visual aircraft control guidance using “V” command bars on the attitude director indicator (ADI). The command bars assist the flight crew while flying the airplane manually, and provide a means to visually monitor autopilot responses to the guidance commands. The visual guidance commands (pitch and roll control) are integrated with the AFCS modes of autopilot operation. The AFCS operating modes can be selected with the autopilot disengaged.

Pitch (including speed control) and roll guidance cues for the AFCS display on the ADI portion of the PFDs. The PFDs indicate the following AFCS information:

- Flight director modes and status
- Autopilot modes and status
- Elevator, stabilizer, and aileron trim failures
- Yaw damper disengagement
- Alternate and common source selections (attitude reference, air data reference, and display control panel selection)
- Flight director system monitor status

The flight directors are simultaneously activated by either selecting a vertical or lateral mode or by engaging the autopilot. Flight director selection activates all flight control mode annunciations and presents steering commands for the selected mode(s). Engaging the autopilot activates both flight directors and automatically selects basic pitch and roll modes. Selecting either the vertical or lateral



mode activates both flight directors and automatically selects the basic mode for the other axis.

Transfer mode controls the routing of flight guidance commands to the autopilot and flight directors. When the transfer mode is selected, the First Officer's flight guidance command drives both flight directors. When not transferred, the Captain's flight guidance command drives both flight directors.

SYSTEM DESCRIPTION

LATERAL MODES

Roll Mode

Roll mode holds the heading that exists when the mode is initiated, unless the roll angle upon initiation is over 5°. If the roll angle is over 5°, commands are generated to hold the current roll angle. The roll mode reference is reset to the current heading, or current roll angle, upon AP engagement, FD SYNC, or AP SYNC.

Roll mode is automatically selected when no other lateral mode is active, and the flight director is on. Selection of another lateral mode clears the roll mode.

A green ROLL message in the lateral capture field on the PFD indicates roll mode engagement.

Lateral Takeoff Mode

Lateral takeoff mode generates a wings-level command while on the ground. After takeoff, it generates a heading-hold command with a 5° bank limit, to maintain the heading which existed at takeoff. Selecting a lateral takeoff mode turns on both flight directors, disengages the autopilot, and clears all other lateral modes.

The takeoff/go-around (TOGA) switches are on the thrust levers. Pushing one of the TOGA switches while on the ground selects



lateral takeoff mode. The selection of FD SYNC or another lateral mode clears the lateral takeoff mode.

A green TO message in the lateral capture field on the PFD indicates engagement the lateral takeoff mode.

Heading Select Mode

Heading select mode generates commands to capture and maintain the selected digital heading readout and heading bug on the PFD. Pushing the HDG switch on the FCP selects the heading select mode. Rotating the HDG knob up to 360° changes the selected heading. Pushing the switch in the center of the HDG knob selects the current heading. Pushing the HDG switch again, or selecting another lateral mode, clears the heading select mode.

NOTE

When a pilot selects a HDG change >180°, the aircraft will initiate a roll in the direction of the selected heading change.

Lights on the side of the HDG switch, and a green HDG message in the lateral capture field, annunciate the heading select mode.

Navigation Mode

The navigation mode generates commands to capture and track the selected navigation course displayed on the PFD. The navigation mode arms when selected, but cannot capture if the FCC is not receiving valid navigation data.

The capture point is a function of closure rate, with the capture point moving away from the radial/beam for high closure rates. Capture always occurs if VHF omnidirectional radio range (VOR) deviation is less than 5% of full scale (0.1 dot) or localizer deviation is less than 30% (0.6 dot). Navigation capture clears the heading select mode. A localizer capture clears half-bank and turbulence modes.



Dead reckoning heading information is provided during VOR station passage. When distance measuring equipment (DME) data is available, the dead reckoning region is approximately where the horizontal distance to the station is less than the altitude to the station. Without DME data, dead reckoning is based on a high rate of VOR deviation.

The CRS 1 knob selects the Captain's course; the CRS 2 knob selects the First Officer's course. Both are displayed on the PFDs. Pushing the switch in the center of the course knob selects the course required to fly directly to the station.

Pushing the NAV switch on the FCP selects the navigation mode. Pushing the NAV switch again, selecting another lateral mode, or changing the source of the onside navigation signal clears the navigation mode.

Illumination of the lights on the side of the NAV switch indicate navigation mode selection. Arming is indicated by two messages on the PFD, a green HDG message in the lateral capture field, and a white navigation source identifier (VOR1/2, LOC1/2, or FMS1/2) in the lateral arm field. Capture/tracking is indicated by a green message in the lateral capture field on the PFD which identifies the navigation source (VOR1/2, LOC1/2, or FMS1/2). Dead reckoning operation is indicated by a white DR message on the PFD.

Approach Mode

The approach mode generates flight director commands to capture and track the selected navigation source displayed on the PFD. Tracking performance is more accurate than the navigation mode. Approach mode is armed when selected, but cannot capture if the FCC is not receiving valid navigation data.

The capture point is a function of closure rate, with the capture point moving away from the radial/beam for high closure rates. Capture always occurs if VOR deviation is less than 5% of full scale deflection (0.1 dot) or localizer deviation is less than 30% (0.6 dot). If the



other side does not concurrently capture, it continues to operate on the heading selected until it independently captures.

NOTE

Aircraft limitations prohibit APPR mode VOR approaches (either flight director or autopilot coupled).

Approach mode automatically selects glide-slope mode after localizer capture. An onside localizer capture clears turbulence mode on both sides.

Dead reckoning is provided during VOR station passage. When DME data is available, the dead reckoning region is where DME distance to the station is less than 0.6 nautical mile. Without DME data, dead reckoning is based on a high rate of VOR deviation.

The CRS 1 knob selects the Captain's course; the CRS 2 knob selects the First Officer's course. Both are displayed on the PFDs. Pushing the switch in the center of either course knob selects the course required to fly directly to the station.

Pushing the APPR switch on the FCP selects the approach mode. The approach mode is cleared by pushing the APPR switch again, selecting another lateral mode, or changing the source of the onside navigation signal.

Illumination of the lights on the side of the APPR switch indicate the approach mode engagement. Arming is indicated by two messages on the PFD, a green HDG message in the lateral capture field, and a white navigation source identifier in the lateral arm field. Capture/tracking is annunciated with a green message in the lateral capture field on the PFD identifying the navigation source. The navigation source can be VOR 1 or 2, LOC 1 or 2, or FMS 1 or 2. Dead reckoning operation is indicated by a white DR message on the PFD.

Back Course Mode

The back course mode generates flight director commands to capture and track the selected back course displayed on the PFD. The



back course arms when selected, but cannot capture if the FCC is not receiving valid localizer data.

The capture point is a function of closure rate, with the capture point moving away from the radial/beam for high closure rates. Capture always occurs if localizer deviation is less than 30% of full scale (0.6 dot).

Back course capture clears turbulence, half-bank, and heading modes. The CRS 1 knob selects the Captain's course; the CRS 2 knob selects the First Officer's course. Both are displayed on the PFDs.

Pushing the B/C switch on the FCP selects back course mode. Back course mode is cleared by pushing the B/C switch again, selecting another lateral mode, or changing the source of the navigation signal to something other than a localizer.

Lights on the side of the B/C switch annunciate the back course mode. Arming is annunciated with two messages on the PFD, a green HDG message in the lateral capture field, and a white navigation source identifier in the lateral arm field. Capture/tracking is annunciated with a green message in the lateral capture field on the PFD which identifies B/C 1/2 as the navigation source.

Back course captures are cleared and/or prevented in the flight control computer (FCC) when the flight director on the respective side of the airplane is driven by flight guidance commands from the other FCC. Back course steering information is invalidated when the navigation source is not a localizer.

Half-Bank Mode

Half-bank mode reduces the maximum commanded bank angle to 15°. Automatic transition to the half bank mode occurs when climbing above 31,600 feet (pressure altitude) or if the airplane is above the half-bank transition altitude when the flight director is engaged. Half-bank mode has no effect on roll mode operation.

Half-bank mode is selected by pushing the 1/2 BANK switch on the FCP. Selection is inhibited when in the takeoff mode, go-around



mode, onside approach mode capture, or during any onside localizer capture.

Pushing the 1/2 BANK switch again manually clears the mode. Descending below the half-bank transition altitude automatically clears the half-bank mode.

Illumination of the lights on the side of the 1/2 BANK switch and a white 1/2 BNK message on the PFD indicate half-bank mode operation.

Lateral Go-Around Mode

Lateral go-around mode generates heading hold flight director commands with a 5°-bank limit. Selection of the lateral go-around mode activates both flight directors, disengages the autopilot, and clears all other lateral modes. Lateral and vertical go-around mode selections are coincident. When lateral go-around causes autopilot disengagement, the resultant autopilot disengagement warning is canceled by a second push of a TOGA switch, or by pushing the AP disconnect switch.

Pushing one of the thrust lever-mounted TOGA switches while airborne selects lateral go-around mode. The mode is cleared by selecting FD SYNC or another lateral mode. The green GA message in the lateral capture field of the PFD indicates a lateral go-around mode engagement.

VERTICAL MODES

Pitch Mode

When the pitch mode is selected, the pitch reference (pitch command on the PFD) is set to the current pitch angle. The pitch mode generates flight director commands to maintain the pitch reference value.

Rotation of the VS/pitch wheel changes the pitch reference value by 1/2° per click. The pitch reference is reset to the current pitch attitude upon either AP engagement, transferring to the pitch mode, or



pushing the FD SYNC switch. When the preselected altitude is captured, rotating the VS/pitch wheel also rearms the altitude preselect mode.

When capturing or tracking a preselected altitude, a new preselected altitude must be chosen prior to the selection of the pitch mode to avoid an immediate recapture of the existing preselected altitude.

The pitch mode is automatically selected when no other vertical mode is active and the flight director is on. Rotating the VS/pitch wheel on the FCP manually selects the pitch mode when the flight director is on, unless in glide-slope capture or the VS mode. Selection of a vertical hold mode or a vertical mode capture clears the pitch mode. A green PITCH message in the vertical capture field on the PFD annunciates pitch mode.

Vertical Takeoff Mode

The vertical takeoff mode generates a 15° pitchup flight director command. Loss of an engine limits the pitchup command to 10°.

Selecting the vertical takeoff mode turns on both flight directors, disengages the autopilot, clears all other vertical modes, and switches the flight guidance commands to a dual independent configuration. Lateral and vertical takeoff mode selections are coincident.

When takeoff causes autopilot disengagement, the resultant warning is canceled by a second push of a TOGA switch, or by pushing the AP disconnect switch.

Pushing one of the TOGA switches while on the ground selects the vertical takeoff mode. Engaging the autopilot, selecting FD SYNC, or the selection or capture of another active mode, will clear the vertical takeoff mode.

A green TO message in the vertical capture field of the PFD indicates vertical takeoff mode engagement.



Altitude Preselect Mode

The altitude preselect mode generates flight director commands to capture and track a preselected altitude. The barometric preselected altitude displays on the PFD and is controlled via the ALT knob on the FCP. Pushing the switch in the ALT knob cancels the aural and visual alerts associated with the preselected altitude.

The altitude preselect mode arms upon selection. The capture point is a function of closure rate, with the capture point moving away from the preselected altitude for high closure rates. Capture does not occur if the preselected altitude is slewed through the current altitude. At capture, any previously active vertical mode clears.

If the preselect altitude changes, or if the VS/pitch wheel is rotated during altitude capture, the autopilot/flight director continues to capture the original preselect or altitude. If a new preselect altitude is not set, then selection of IAS, MACH, PTCH, or VS mode results in the current altitude being captured. If the preselect altitude changes after capture (altitude track), altitude hold automatically engages and altitude preselect rearms.

Altitude preselect mode is automatically selected upon selection of any vertical mode, except glide-slope capture or overspeed. Glide-slope capture or overspeed clears the altitude preselect mode.

Altitude preselect is annunciated on the PFD with a white ALTS message in the vertical arm field for arm, a green ALTS CAP message in the vertical capture field for capture, and a green ALTS message in the vertical capture field for track. Altitude captures cleared without a subsequent selection of altitude track or arm, are indicated by an amber ALTS message on the PFD. The message remains on for 10 seconds, or until the altitude preselect rearms, whichever is shorter.

Altitude Hold Mode

The altitude hold mode generates flight director commands to capture and maintain the altitude reference. When altitude hold mode is selected, the altitude reference is set to the current pressure altitude.



When the altitude hold mode is selected by the FMS, the altitude reference is a barometric value from the VNAV, which the FCS converts to pressure altitude after capture.

Selection of FD SYNC resets the altitude reference to the current pressure altitude. There is no display of the altitude reference value.

Pushing the ALT switch on the FCP, or changing the altitude preselect setting while in altitude preselected track, selects the altitude hold mode. In VNAV mode, the FMS can select altitude hold. Selection is inhibited by glide-slope capture or overspeed. Pushing the ALT switch again, selection of a vertical hold mode, or vertical mode capture clears the altitude hold mode.

Altitude hold mode is annunciated with lights on the side of ALT switch on the FCP, a green ALT CAP message for capture, and a green ALT message for track in the vertical capture field on the PFD.

Speed Mode

The speed mode generates flight director commands to maintain the airspeed reference value. When the Speed Mode is selected, the IAS reference on the PFD is the airspeed at the time of selection.

The first push of the Speed Mode button on the FCP initiates a climb (CLB) or descent (DES), respectively, if the altitude preselect has been changed to a higher or lower altitude. In CLB, the aircraft will pitch up to maintain the airspeed indicated on the airspeed tape at the time of speed mode selection. While in the climb, a higher speed can be selected by turning the SPEED knob on the FCP. The aircraft will lower the pitch attitude to acquire the higher speed, but will maintain at a minimum a climb rate of at least +50 feet per minute. In DES, the aircraft will pitch down to maintain the airspeed indicated on the airspeed tape at the time of mode selection. If a slower speed is selected using the SPEED knob on the FCP, the aircraft will pitch up to acquire the slower speed but will maintain at a minimum a descent rate of at least -50 fpm.

A second push of the Speed Mode button on the FCP will replace CLB or DES with IAS Mode. IAS Mode works similarly to CLB



and DES, except that the aircraft may exchange altitude for airspeed. There are no plus or minus 50 fpm protections to prevent the aircraft from reversing vertical direction in an attempt to acquire a changed speed.

The airspeed reference is manually set with the speed knob. FD SYNC selection or AP engagement resets the airspeed reference to the current airspeed. Altitude capture (selected altitude) disables the speed mode.

Speed mode is annunciated with lights at the side of the SPEED switch on the FCP and can be displayed in either IAS or MACH. Pushing the switch in the center of the SPEED knob on the FCP selects the speed readout (IAS or MACH).

NOTE

Use of IAS mode or DES mode (flight director or autopilot coupled) during approach is not permitted.

Vertical Speed Mode

The vertical speed mode generates flight director commands to maintain the VS reference value. When vertical speed mode is selected, the VS reference on the PFD is the VS at the time of selection.

Throughout a $\pm 12,000$ feet/minute range, the VS reference value can be changed using the VS/pitch wheel on the FCP. FD SYNC selection or AP engagement resets the VS reference to the current vertical speed.

When capturing or tracking a preselected altitude, a new preselected altitude must be chosen prior to selection of vertical speed mode. This precludes an immediate recapture of the existing preselected altitude.

Pushing the VS switch on the FCP manually selects the vertical speed mode. Selection is inhibited by glide-slope capture or over-speed. Pushing the VS switch again, selecting a vertical hold mode, or a vertical mode capture clears the vertical speed mode.



The vertical speed mode is annunciated with lights at the side of the VS switch on the FCP and with a green VS ## ↑ or VS ## ↓ in the vertical capture field on the PFD. The ## is the VS reference value, in thousands of feet/minute (values over 10,000 feet/minute are displayed without a decimal point). The up arrow indicates a climb rate reference, and the down arrow a descent rate reference.

Lights at the side of the VS switch on the FCP annunciate the vertical speed mode. Moving the VS/pitch wheel on the FCP determines the climb or descent rate.

Glide-Slope Mode

Glide-slope mode generates flight director commands to capture and track the glide slope. Captures can be performed from above or below the glide-slope beam.

Glide-slope capture does not occur if the localizer is not captured, or if the FCC is not receiving valid glide-slope data. Upon glide-slope capture, other vertical modes are automatically cleared on the captured side. If the other side does not concurrently capture the glide slope, it continues to operate in the current active vertical mode, or ensuing vertical mode until it independently captures the glide slope.

The capture point is a function of closure rate, with the capture point moving away from the beam for high closure rates. Capture always occurs if deviation is less than 10% of the full scale (under 0.2 dot).

The glide-slope mode automatically engages when in the approach mode, with a valid localizer as the lateral navigation source. Glide-slope mode automatically clears if approach mode is lost. When armed, glide-slope mode is also cleared by turning outbound, or by the loss of a valid localizer signal. Once the glide-slope is captured, the glide-slope mode clears if the source of the lateral navigation signal changes to an invalid localizer signal.

A white GS message in the vertical arm field on the PFD annunciates glide-slope arming. A green GS message in the vertical capture field on the PFD annunciates glide-slope capture.



Vertical Go-Around Mode

Pushing either one of the TOGA switches while airborne selects the vertical go-around mode. Go-around mode is cleared by engaging the autopilot by selection FD SYNC or by the selecting or capture of another active mode. Go-around mode generates a 10° pitch up command.

Selection of vertical go-around mode turns on both flight directors, disengages the autopilot, clears all other vertical modes, and switches the flight guidance commands to a dual-independent configuration.

When a go-around causes the autopilot to disengage, pushing the TOGA switch again, or pushing the AP disconnect switch, cancels the autopilot warning.

A green GA message in the vertical capture field on the PFD announces go-around mode.

AUTOPILOT OPERATION

Pushing the AP ENG switch on the FCP engages the autopilot. Upon engagement, the autopilot follows flight director commands existing prior to engagement of capture modes.

Engagement occurs if one yaw damper is engaged, the AP DISC switchbar is in the UP position, the continuous self-monitoring in the FCC is detecting no failure, and there is no significant instability of the airplane. Significant instability of the airplane exists during the following conditions:

- Pitch rate over 5° per second
- Normal acceleration less than -0.4g or over 0.6g
- Roll rate is over 21° per second
- Bank angle over 45°



- Pitch angle below 15° nose down or above 25° nose up
- Yaw rate exceeds 9° per second

Autopilot engagement clears vertical takeoff and go-around modes and turns on both flight directors. Autopilot disengagement clears the turbulence mode.

Lights at the side of the AP ENG switch on the FCP illuminate, and a green AP message on the PFD indicate autopilot engagement. During autopilot synchronization, the AP annunciation changes to amber.

A warning of autopilot engagement during takeoff is indicated by a red CONFIG AP message on the EICAS and a “config autopilot” aural alert.

Autopilot Disconnect

Pushing either of the AP disconnect switches on the outboard side of the control wheels manually disengages the autopilot. The autopilot also manually disengages by pushing the AP ENG switch, selecting takeoff or go-around mode, operating the manual pitch trim, or lowering the AP DISC switchbar.

Automatic disengagement occurs if both yaw dampers disengage, a failure condition is detected by FCC monitoring, the stick shaker activates, or an excessive attitude occurs. An excessive attitude is a roll beyond 45° or a pitch beyond 25° nose up or 17° nose down. The autopilot automatically disengages two seconds after a windshear warning (if the autopilot has not already been manually disengaged). During those two seconds, the autopilot follows windshear commands.

The autopilot disengage warning is annunciated with a red AP message on the PFD and an aural cavalry charge. When a disengagement is induced, the autopilot disengage warning does not automatically cancel, but must be manually canceled by pushing the AP disconnect switch or either TOGA switch. The annunciator changes to a white AP arrow. Re-engaging the autopilot cancels any disengage warnings.



Synchronization

When the autopilot is not engaged, the flight director AP/FD SYNC switch synchronizes (sets) the vertical and/or lateral reference to the current flight value. Pushing the switch has no effect if the autopilot is engaged.

The vertical references synchronized and their respective modes are CLB, DES, IAS, MACH, VS, altitude hold memory, and pitch angle memory. Overspeed and vertical capture modes are not affected by the switch operation. The only lateral references that can be synchronized are the bank and heading memories of roll mode.

Synchronization is engaged by pushing the AP/FD SYNC switch, on the side of each control wheel, while the autopilot is not engaged. The off-side flight director synchronization switch is not functional when the off-side flight director is off.

An amber SYNC on the PFD annunciates synchronization. The message remains visible for three seconds or until the synchronization switch is released, whichever is longer.

Automatic Pitch Trim

Automatic pitch trim drives the aircraft trim system, alleviating any non-trivial pitch mistrim condition. A pitch trim failure does not cause autopilot disengagement.

Autopilot engagement enables automatic pitch trim. Automatic pitch trim is disabled by autopilot disengagement, or by pitch trim failure while the autopilot is engaged.

Mistrims annunciate only when the autopilot is engaged. Significant elevator, rudder, and aileron mistrims are annunciated with amber boxed E, R, or A symbols on the PFD. The EICAS annunciates significant elevator mistrims with an amber AP TRIM IS NU (nose up) or AP TRIM IS ND (nose down) message. Significant aileron mistrims annunciate with an amber AP TRIM IS LWD (left wing down) or AP TRIM IS RWD (right wing down) message.



Protracted automatic trim operation signals the trim clacker aural alert. Pitch trim failure annunciates with an amber AP PITCH TRIM message on EICAS when the autopilot is engaged.

Turbulence Mode

The turbulence mode adapts autopilot gains to turbulent flight conditions. Pushing the TURB switch on the FCP selects the turbulence mode but it cannot be selected if the onside localizer is captured or if the autopilot is disengaged. The turbulence mode is manually cleared by pushing the TURB switch again, by an onside localizer capture, or by autopilot disengagement. Lights at the side of the TURB switch on the FCP indicate turbulence mode engagement.

Monitoring Overview

The FCC performs extensive system monitoring. When the FCC detects a relevant failure or excessive attitudes, it disengages the autopilot and/or yaw damper. Monitoring is selected automatically at all times and cannot be deselected.

Pitch trim failure inhibits automatic pitch trim operation, but the autopilot remains engaged. An amber AP PITCH TRIM message on the EICAS annunciates pitch trim failure.

When the airplane exceeds pre-determined limits of altitude, rate, and/or acceleration, and the autopilot is not generating corrective commands, one or more servos cut out.

A red FD failure flag on the PFD annunciates invalid steering.

When the Captain's flight director fails, a white FD 1 FAIL message illuminates on the EICAS. When the First Officer's flight director fails, a white FD 2 FAIL message illuminates on the EICAS. When both flight directors fail, a red AFCS MSGS FAIL message illuminates on the EICAS.

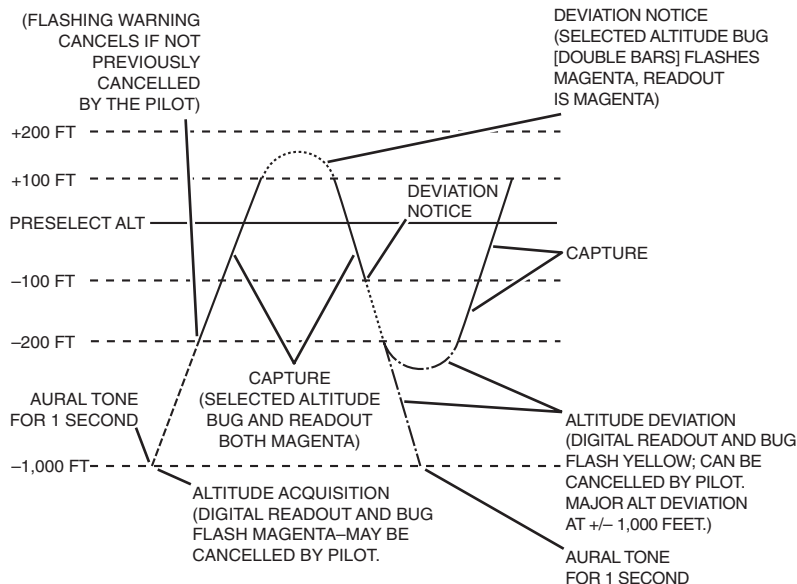


Figure 4-1 Altitude Alert System

Altitude Alert System

The PFDs alert the pilots when the airplane is approaching the preselected altitude or if the airplane is deviating from a previously selected and acquired altitude (Figure 4-1). Altitude advisories display on the altimeter portion of the PFDs at the preselect altitude digital readout, above the barometric tape, at the preselect bugs, and by double bars across fine and coarse tapes.

The altitude alert system processes data from the air data computers and is independent of autopilot or flight director modes. The altitude (ALT) knob on the flight control panel sets the desired altitude.

The preselect digital readout and bugs change state and color as follows:



- At the altitude alert threshold, the readout and bugs flash magenta, and a one-second aural tone sounds. The threshold is approximately 1,000 feet from the selected altitude.
- When within 200 feet from the selected altitude, the readout and bugs illuminate steady. This indicates altitude capture.
- If the airplane subsequently deviates more than 100 feet from the selected altitude, the altitude bug (double bars) flash, and a series of tones are broadcast.
- When the airplane is 100 feet below selected altitude, the flashing magenta bugs and readout cancel.
- If the airplane subsequently continues to deviate more than 200 feet from the selected altitude, the altitude bugs and the digital readout flash amber and audible tones sound.
- When the airplane is again within 200 feet of the selected altitude, the readout and bugs illuminate steady, and the audible tones and messages reset.

Pushing the ALT switch or selecting a different altitude cancels the altitude alerts. Altitude alerts are inhibited if the glide slope is captured.

Integrated Avionics Processor System

The integrated avionics processor system (IAPS) is the central data processor and concentrator for the airplane avionics system. Avionics sensor data routes through the IAPS for processing and distribution (Figure 4-2). The left and right sides of the IAPS have two channels each. Each side has redundant data concentrators, power supplies, and data buses.

Fan failure status messages and overheat caution messages on the EICAS indicate malfunctions within the IAPS. Within the IAPS, the Captain's side FCC 1 and both channels of the input/output concentrators are disabled during a left-side overheat shutdown.

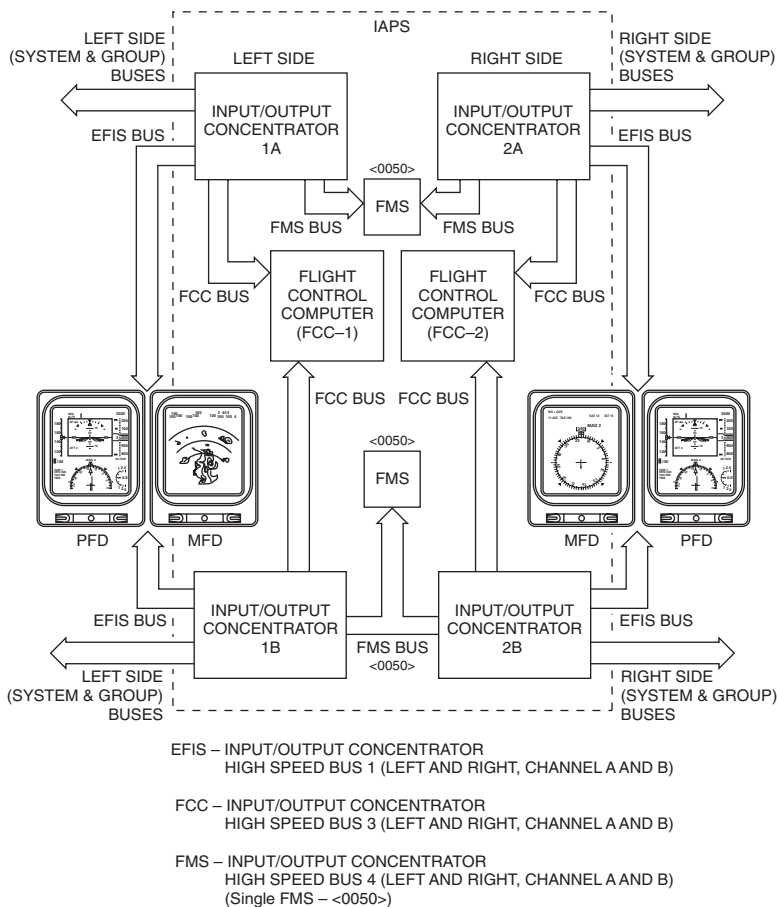


Figure 4-2 IAPS Diagram



Within the IAPS, the First Officer's side FCC 2 and both channels of the input/output concentrators are disabled during a right-side over-heat shutdown.

CONTROLS AND INDICATIONS

FLIGHT CONTROL PANEL

The flight control panel, in the center of the glareshield, controls the two independent flight directors and the autopilot.

Lamps, adjacent to each mode switch, indicate flight control computer responses to mode selection (Figure 4-3):

- Left lamp—Indicates that the Captain's side (FCC No. 1) is processing mode selection
- Right lamp—Indicates that the First Officer's side (FCC No. 2) is processing mode selection

Using the flight control panel, the crew can accomplish the following:

- Remove flight director cues from the PFD (FD OFF) and revert to basic pitch and roll displays
- Set course and fly to the active navigation source
- Engage, disengage, and transfer control of the autopilot
- Reduce autopilot gains
- Set and maintain airspeed, vertical speed, and altitude
- Set navigation, heading select, and approach modes

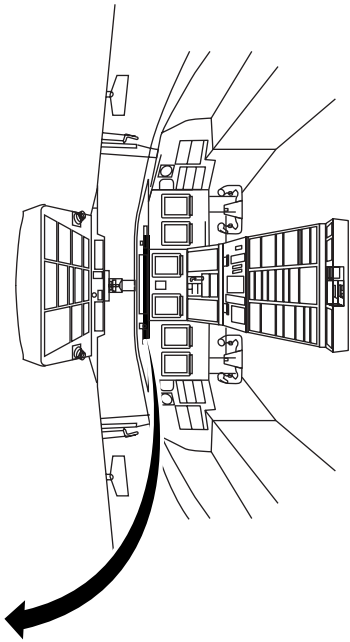
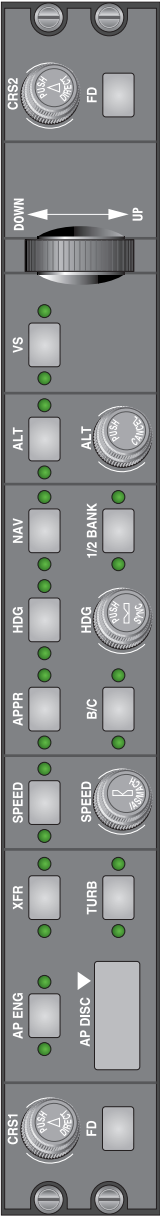


Figure 4-3 Flight Control Panel



CRS 1 and CRS 2 Knobs

Rotating the CRS 1 and CRS 2 knobs (Figure 4-4) changes the selected course reference values. CRS 1 changes the Captain's side course, and CRS 2 changes the First Officer's side course. The PFD course setting is indicated by the course arrow and readout as selected by the NAV SOURCE on the display control panel. Clockwise rotation of the knob increases the selected course angle.

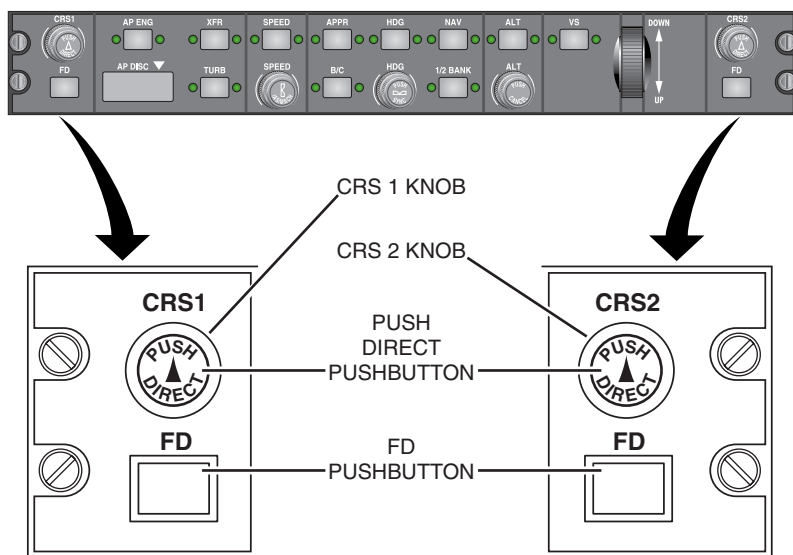


Figure 4-4 Flight Control Panel—Flight Director Controls



PUSH DIRECT Pushbutton

The PUSH/DIRECT pushbutton selects a present position—direct course. When pressed, the course pointer and readout indicate the direct course to the tuned VOR station. This course is the theoretical no wind heading to the selected station.

FD Pushbutton

The FD pushbutton removes the flight-director guidance commands from the PFD on the uncoupled side. Operation of this pushbutton does not disengage the autopilot. When the autopilot is coupled, the FD pushbutton is inoperative.

When the autopilot is not coupled, pushing the FD button removes steering and mode information from the pilot's PFD. It also selects basic pitch and roll modes.

When a mode switch is pressed, a mode request is sent to the onside flight control computer (FCC 1 or FCC 2).



AP ENG Pushbutton

The AP ENGAGE pushbutton (Figure 4-5) engages or disengages the autopilot. Pushing the AP ENGAGE pushbutton engages the autopilot and illuminates the channel indicators beside the pushbutton. The lights indicate which FCC has acknowledged autopilot engagement. The PFD indicates a green AP → (coupled to the right side) or AP ← (coupled to the left side). When engaged, the autopilot flies flight director commands from the coupled side.

NOTE

The airplane must be trimmed prior to engaging the autopilot.

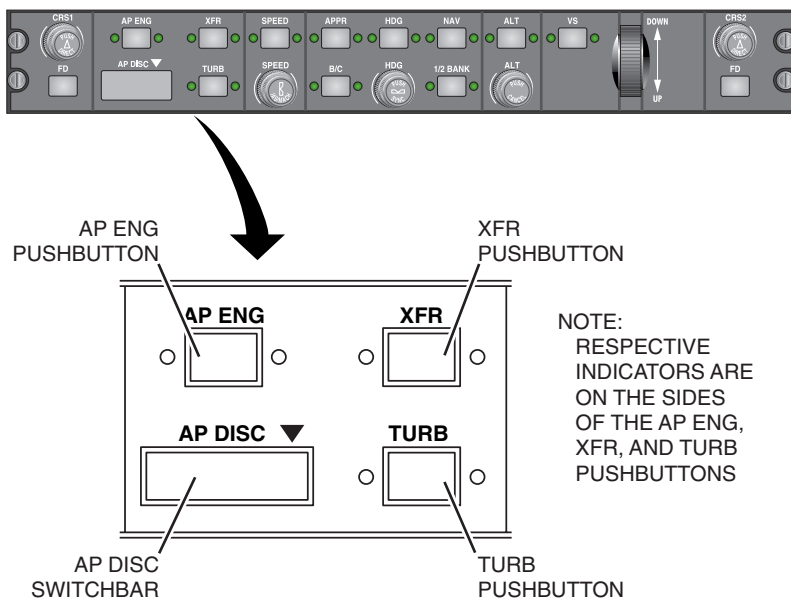


Figure 4-5 Flight Control Panel—Autopilot Controls



XFR Pushbutton

The XFR pushbutton changes the flight guidance commands from the Captain's to the First Officer's side. Normally, the autopilot flies flight guidance commands from the Captain's FCC. When the autopilot transfer mode is selected, the autopilot uses the First Officer's FCC. If transfer mode is selected before autopilot engagement, the white AP → displays.

AP DISC Switchbar

The AP DISC switchbar disengages the autopilot. The go-around switches on the thrust levers, and AP/SP DISC switches on the control wheels also disengage the autopilot. The yaw damper remains engaged.

The autopilot automatically disengages if the FCC detects an AP failure. During failure, the PFD indicates a flashing red AP → or AP ← after automatic disengagement. The AP/SP disconnect switch (or go-around or AP engage switches) cancels the flashing indications and silences the aural warnings.

NOTE

The pilot must hold the control wheel when disengaging the autopilot.

TURB Pushbutton

The TURB pushbutton selects or deselects the turbulence mode. When selected, indicators illuminate beside the TURB pushbutton and autopilot gains are reduced providing smoother flight during turbulent conditions. The mode is cleared when the localizer is captured or when the autopilot is disengaged.



SPEED Pushbutton

The SPEED pushbutton (Figure 4-6) alternately selects IAS or Mach speed modes. When selected, indicators illuminate beside the SPEED pushbutton. Automatic switchover from IAS to Mach occurs when climbing through 31,600 feet.

SPEED IAS/MACH Knob

The SPEED IAS/MACH knob enters the desired IAS or Mach reference value. When rotated, the knob changes the selected speed value, designating the speed to maintain. The setting is indicated on the PFD by the magenta speed bug symbol and speed bug readout. When the IAS or Mach mode is selected, the speed bug symbol and readout synchronize to the current airspeed. The SPEED knob operates at all times and does not depend upon autopilot engagement/disengagement nor flight director vertical mode states.

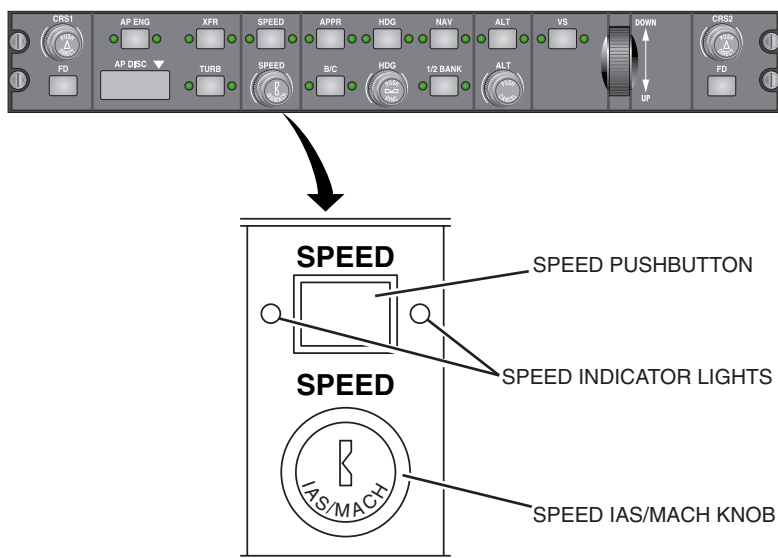


Figure 4-6 Flight Control Panel—Speed Controls



APPR Pushbutton

The APPR pushbutton selects or deselects the approach mode (Figure 4-7). Indicators, adjacent to the pushbutton, illuminate or extinguish, respectively. The type of approach is determined by the active navigation signal selected on the NAV SOURCE knob of the display control panel and radio tuning unit. The navigation source is displayed on the PFD (VOR 1, LOC 1, etc.)

The approach mode arms when the APPR pushbutton is pressed. Prior to capture, the system operates in the currently active lateral mode (heading select or roll). Capture occurs when the capture conditions are met.

The FCC arms for a glide-slope capture (on a valid ILS approach only) after localizer capture. The glide slope is displayed on the PFD. At capture, commands display to maintain flight on the

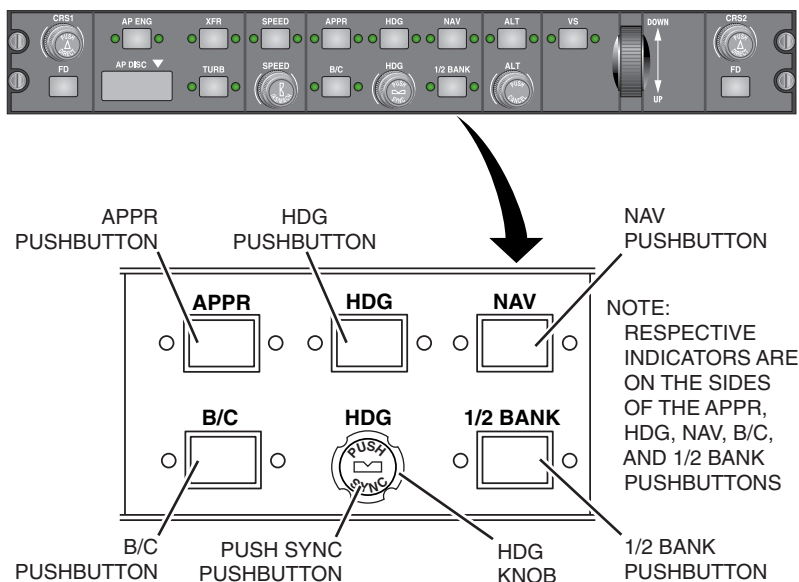


Figure 4-7 Flight Control Panel—Approach Controls



glidepath. The approach (capture) mode is cleared by selection of another lateral mode or changing the source of the navigation signal.

Lateral approach capture clears the 1/2 bank mode and any other previously active lateral mode. Localizer capture clears the turbulence mode. Approach (armed) is cleared by selecting NAV, go-around, or changing the source of the navigation signal.

HDG Pushbutton

The HDG pushbutton selects or deselects the heading mode. Indicators, adjacent to the pushbutton, illuminate or extinguish, respectively. HDG is displayed on the lateral mode indicator of the PFD. The flight director commands generated to capture and maintain the selected heading are indicated by the heading bug and readout on the HSI portion of the PFD. Selecting another lateral mode clears the heading select mode.

NAV Pushbutton

The NAV pushbutton selects or deselects the navigation mode. Indicators, adjacent to the pushbutton, illuminate or extinguish, respectively. The FCC generates lateral commands to track the active navigation signal selected on the NAV SOURCE knob of the display control panel and radio tuning unit. The signal source is displayed on the PFD (VOR 1, LOC 1, etc.). Navigation mode arms when the NAV switch is pressed and capture conditions are met. Prior to capture, the system operates in the currently active lateral mode. After capture, commands are generated to maintain the selected course.



B/C Pushbutton

The B/C pushbutton selects or deselects the back-course mode. Indicators, adjacent to the pushbutton, illuminate or extinguish respectively. Back course capture clears all lateral modes. Back course mode arming is indicated on the PFD by the green HDG indication in the lateral capture field, and as the white B/C1 in the navigation source indicator field. Back-course mode capture is indicated on the PFD in green as B/C1 in the lateral capture field.

HDG Knob

Rotating the HDG outer knob changes the selected heading (indicated by the heading bugs and readouts on both PFDs). Clockwise rotation increases the selected heading.

PUSH SYNC Pushbutton

The PUSH/SYNC pushbutton synchronizes the heading indications on the PFD to the current aircraft heading (indicated by the lubber line on the PFD). Operation of the pushbutton synchronizes the heading bugs on both PFDs.

1/2 BANK Pushbutton

Used during heading select mode, the 1/2 BANK pushbutton alternately selects or clears the half-bank mode. Indicators, adjacent to the pushbutton, illuminate or extinguish respectively. At power on, the AFCS sets the high-bank limit (31.5°). Pressing the button sets the low-bank limit (15°). When pressed, 1/2 BANK displays on the PFD. Half-bank mode is automatically selected above 31,600 feet. Approach mode capture or any localizer capture clears the half-bank mode.



ALT Pushbutton

The ALT pushbutton (Figure 4-8) selects or clears the altitude hold mode. Indicators, adjacent to the pushbutton, illuminate or extinguish, respectively. When pressed, the vertical mode indicator on the PFD indicates ALT (altitude hold). Commands generate to maintain the pressure altitude existing at the time of selection.

When not coupled, the altitude reference is resynchronized to the current pressure altitude whenever the control wheel SYNC switch is pressed. Altitude hold mode is selected if the altitude preselector (ALT knob) setting is changed while in the altitude preset track.

Selection or capture of another vertical mode clears the altitude hold mode.

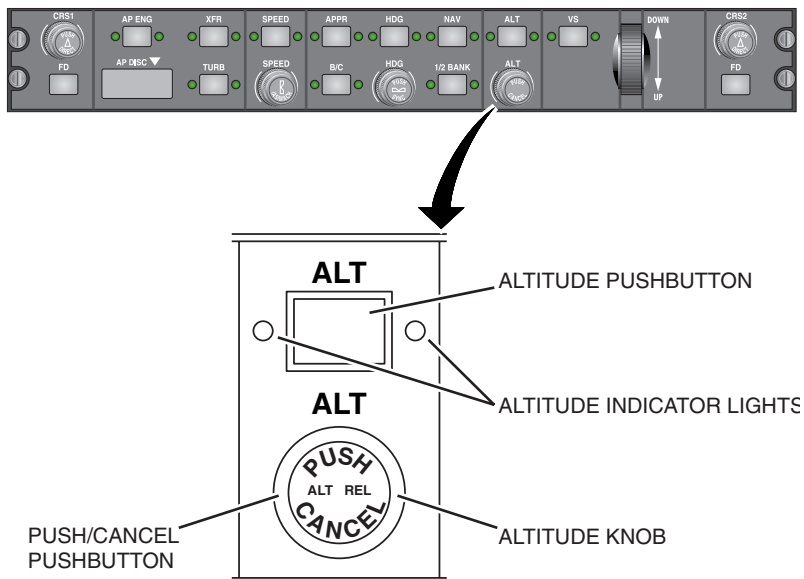


Figure 4-8 Flight Control Panel—Altitude Controls



ALT Knob

The ALT outer knob changes the preselected altitude reference value. When rotated, the knob changes the preselect altitude. Clockwise rotation increases the preselected altitude. The setting is indicated on the barometric tape and readout on the PFD. The range is from -1,000 to 50,000 feet.

PUSH CANCEL Pushbutton

When pushed, the PUSH CANCEL button cancels the flashing display and audible warning altitude alerts. If pressed when no alert exists, the pushbutton tests the preselect aural warning system.

VS Pushbutton

The VS pushbutton (Figure 4-9) selects or clears the vertical-speed mode. Indicators, adjacent to the pushbutton, illuminate or extinguish respectively. When pressed, the vertical speed reference

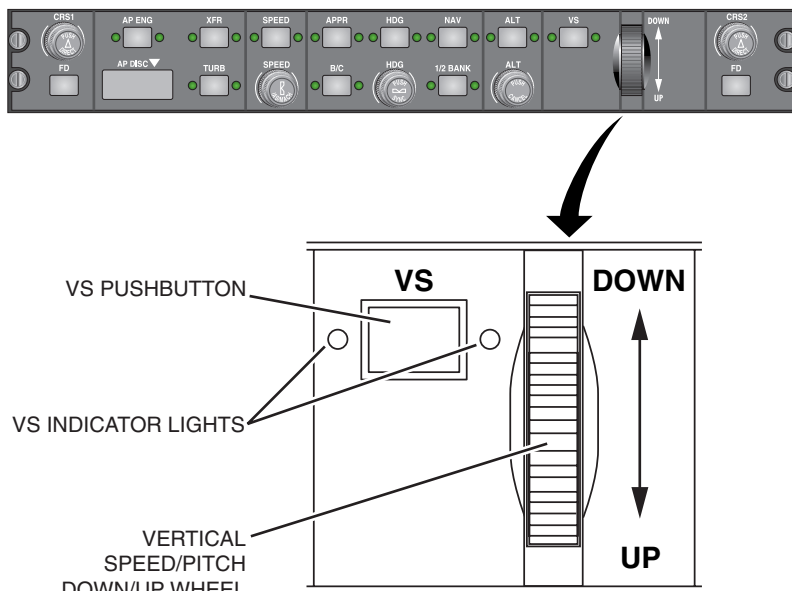


Figure 4-9 Flight Control Panel—Vertical Speed Controls



(displayed on the PFD) is synchronized with the current vertical speed. Commands generate to maintain the referenced vertical speed. The referenced vertical speed can be changed using the VS/pitch wheel.

Pushing either control wheel SYNC switch (when not coupled) synchronizes the VS reference to the current vertical speed. Selection or capture of another vertical mode clears the vertical speed mode.

Speed/Pitch DOWN/UP Wheel

When rotated, the VS/pitch wheel changes the current vertical-speed reference value. The current vertical reference value is indicated on the top left portion of the PFD.

Rotating the wheel upward decreases the vertical speed value and downward increases the vertical speed value. The wheel functions as a pitch mode selector for the autopilot and flight director. When rotated, the wheel applies a pitch “take command” signal to the autopilot. Rotating the wheel upward commands pitch down, rotating it downward commands pitch up. The rate is proportional to displacement from the center detent. At the detent, the current set pitch angle is maintained.

The pitch wheel functions only when the autopilot is engaged or with the flight director active. When rotated, any active vertical mode clears, except glide-slope capture and pitch hold engages. The PFD indicates PTCH (pitch hold) on the vertical mode display.



YAW DAMPER PANEL

DISC Button

The DISC button (Figure 4-10), on the center pedestal yaw damper panel, disengages both yaw damper channels.

YD 1 and YD 2 ENGAGE Pushbuttons

The YD 1 and YD 2 ENGAGE pushbuttons engage the yaw damper channels No. 1 and No. 2, respectively.

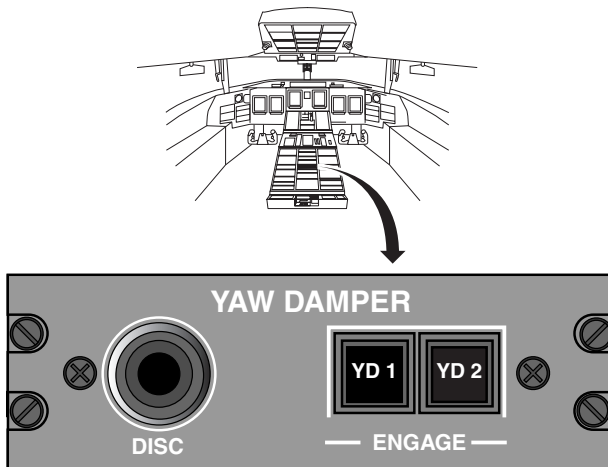


Figure 4-10 Yaw Damper Panel



CONTROL WHEELS AND THRUST LEVERS

Autopilot Disconnect Switches

The autopilot disconnect switches, on each of the control columns (Figure 4-11), disengage the autopilot.

Flight Director SYNC Switches

A black flight director sync switch is on the rear side of each control wheel. When the autopilot is not coupled, the flight director sync switch synchronizes the vertical and lateral references to those currently in use. The vertical references include IAS, Mach speed, vertical speed, altitude hold, and pitch angle. The synchronized lateral references include the bank and heading values used in the roll mode. SYNC appears in amber on the PFD when the sync switch is pushed. The sync switch has no function when the autopilot is engaged.

Stabilizer Trim Switches

The black stabilizer trim switches on the control wheel enable the pilot to vary the stabilizer trim position according to flight requirements.

NOTE

Operating the stabilizer trim switches disconnects the autopilot, if engaged.

STAB TRIM DISC Switch

When pressed, the red stabilizer trim disconnect switch on the control wheel removes power from the system and stops the stabilizer actuator. The system is reactivated with the CH 1/CH 2 switches.

AP/SP DISC Switch

When pressed, the red autopilot/stick pusher disconnect switch on the control wheel disengages the autopilot and deactivates the stick pusher. When released, the stick pusher system is immediately reactivated, but the autopilot remains disengaged.

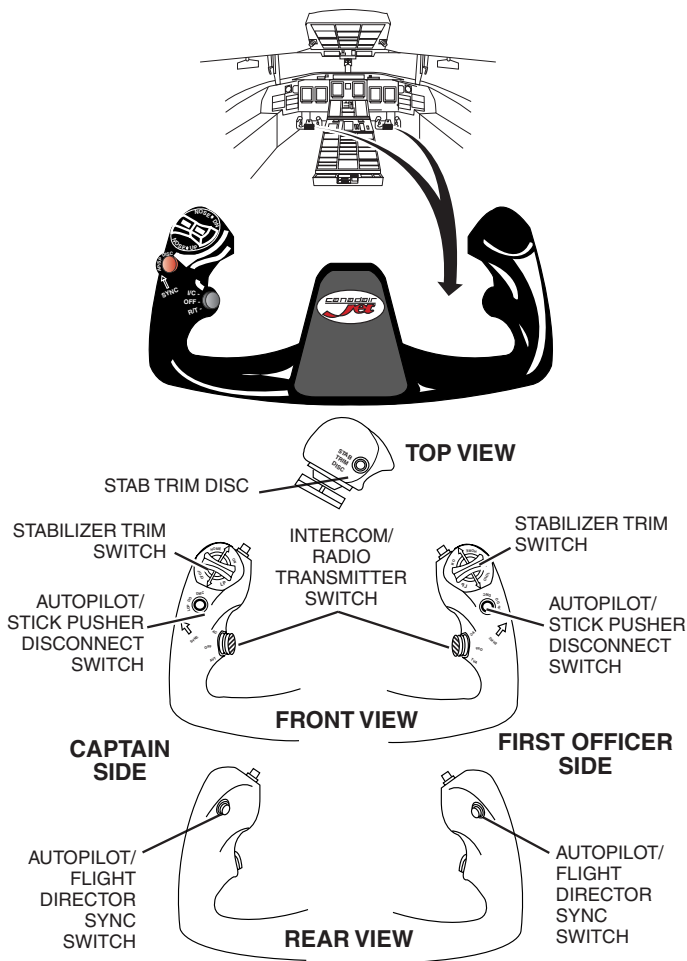


Figure 4-11 Control Wheels

NOTE

When the autopilot disconnect switch is pressed for four seconds or longer, the STALL FAIL caution message illuminates. The STALL FAIL caution message extinguishes approximately one second after the switch is released.



Intercom/Radio Transmitter Switch

The black three-position intercom/radio transmitter switch is on the inner side, outer handle of the control wheel. The three positions are intercom (I/C), OFF, and radio transmitter (R/T).

Takeoff/Go-Around Switches

A takeoff/go-around (TOGA) switch (Figure 4-12) is on each thrust lever handle. They supply a fixed pitch-up command for both on-the-ground or airborne usage. When the switch is pushed in flight, the FCC commands the lateral mode to hold the heading at the moment of go-around selection. When the switch is pushed on the ground, the FCC commands wings-level until takeoff. After takeoff, the FCC supplies heading-hold steering commands.

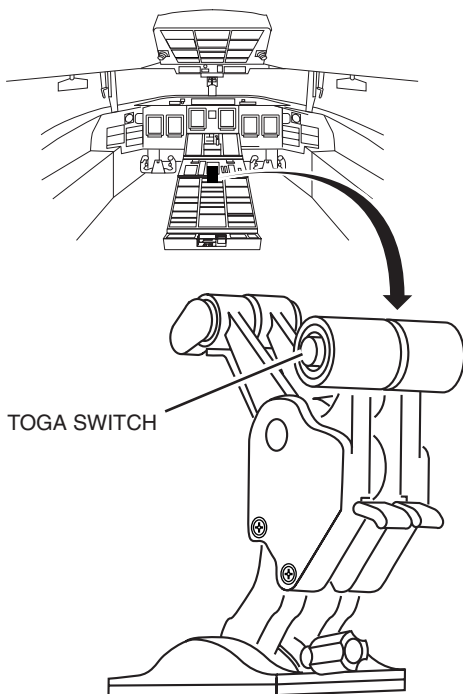


Figure 4-12 Thrust Levers



When go-around is selected, the autopilot disengages and all other flight director modes clear. The yaw damper function is not changed.

A lateral mode go-around disengages when the autopilot is engaged or if a different lateral mode is selected. A vertical mode go-around disengages when the autopilot is engaged or if there is an automatic capture of a different vertical mode.

The go-around switch also initiates windshear escape guidance during takeoff or go-around if the windshear warning occurs.

During takeoff mode, when either TOGA switch is pressed:

- TO displays on both PFDs.
- The flight director guidance cue displays 15° pitch up (10° pitch up if an engine fails).
- During subsequent windshear alerts, TO displays.
- During subsequent windshear warnings, TO/WS displays.
- If a vertical or lateral mode is selected, the takeoff mode clears, and the selected mode is displayed.

During go-around mode, when either TOGA switch is pressed:

- GA displays on both PFDs.
- The flight director guidance cue displays 10° pitch up.
- During subsequent windshear alerts, GA displays.
- During subsequent windshear warnings, GA/WS displays.
- If a vertical or lateral mode is selected, the go-around mode clears, and the selected mode is displayed.



PRIMARY FLIGHT DISPLAY

Figure 4-13 shows the primary flight display.

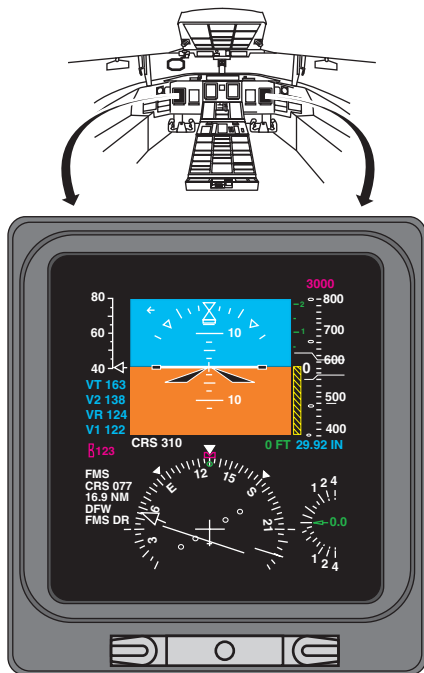


Figure 4-13 Primary Flight Display



The PFD indications are shown in Table 4-1.

Table 4-1 PFD INDICATIONS

INDICATION	COLOR	DESCRIPTION
A	Amber	Significant aileron mistrim
ALT	Green	Altitude hold mode—tracking
ALT CAP	Green	Altitude hold mode—capturing
ALTS	White	Altitude preselect—armed
	Green	Altitude preselect mode—tracking
	Amber	Altitude preselect mode—aborted capture
ALTS CAP	Green	Altitude preselect mode—capturing
AP→	Green	Autopilot engaged and transferred
	Red	Autopilot disengage warning and transferred
	Amber	Autopilot engaged and transferred (aileron and elevator servo clutches released)
→	White	Autopilot disengaged and transferred
AP←	Green	Autopilot engaged and not transferred
	Red	Autopilot disengage warning and not transferred
	Amber	Autopilot engaged and not transferred (aileron and elevator servo clutches released)
←	White	Autopilot disengaged and not transferred
B/C1	White	Back course mode—armed (annunciated, in lateral arm field, identifying navigation source)
B/C2	Green	Back course mode—capture/tracking (annunciated, in the lateral capture field, identifying navigation source)



Table 4-1 PFD INDICATIONS (Cont)

INDICATION	COLOR	DESCRIPTION
CLB	Green	XXX
DES	Green	XXX
GS	Green	Glide slope mode—captured (annunciated in vertical capture field)
HDG	Green	Heading select mode
PTCH	Green	Pitch mode
ROLL	Green	Roll mode
SYNC	Amber	Flight director synchronization in progress
TEST	Amber	Diagnostics
TO	Green	Lateral takeoff mode (annunciated in lateral capture field)
		Vertical takeoff mode (annunciated in vertical capture field)
TO/WS		Takeoff/windshear display after initial windshear alert
DR	White	Dead reckoning operation
E	Amber	Significant elevator mistrim
FD	Red	Flight director flag
FD1	Green	Flight director computations being performed by FD1 (annunciated on copilot's PFD)
FD2	Green	Flight director computations being performed by FD2 (annunciated on pilot's PFD)



Table 4-1 PFD INDICATIONS (Cont)

INDICATION	COLOR	DESCRIPTION
IAS or MACH	Green	Speed mode (annunciated in vertical capture field)
	Flashing amber	Overspeed mode (annunciated in vertical capture field)
FMS1 FMS2 LOC1 LOC2 VOR1 VOR2	White	Navigation or approach mode—armed (annunciated, in the lateral arm field, identifying navigation source)
	Green	Navigation or approach mode—capture/tracking (annunciated, in the lateral capture field, identifying navigation source)
GA	Green	Lateral go-around mode (annunciated in lateral capture field)
		Vertical go-around mode (annunciated in vertical capture field)
GA/WS		Go-around display after initial windshear warning
GS	White	Glide slope mode—armed (annunciated in vertical capture field)
VS #.#↑	Green	Vertical speed mode, (current vertical speed reference is — — — fpm up)
VS #.#↓	Green	Vertical speed mode, (current vertical speed reference is — — — fpm down)
YD	Amber	Both yaw dampers disengaged
1/2 BNK	White	Half bank mode (illuminates when airplane altitude is ≥31,600 feet or when 1/2 BANK pushbutton selected)
V-bars	Magenta	Integrated lateral and vertical flight guidance commands (not present if either command is invalid)



EFIS AUTOPILOT MESSAGES

The flight director autopilot mode annunciator, called the flight mode annunciator or FMA, is comprised of vertical and lateral mode visual indications (Figure 4-14), which are displayed on the electronic flight instrument system (EFIS) primary flight display. The modes appear above the attitude display indicator on each PFD. The modes appear above the attitude display indicator on each PFD. The lateral modes display above the vertical modes. The green active (capture) modes display to the left of a divider line, the white (armed) modes to the right of the line. Flashing green modes (5 seconds) indicates capture mode transition. Flashing modes (10 seconds) and then blank indicates flight control computer failure.

Lateral Modes

GA/WS—(Green) Escape guidance during windshear

GA—(Green) Go-around

HDG—(Green) Heading select

LOC 1 or 2—(Green or white) Localizer system 1 (Captain's side) and 2 (First Officer's side)

ROLL—(Green) Roll hold

VOR 1 or 2—(Green or white) VOR system 1 (Captain's side) and 2 (First Officer's side)

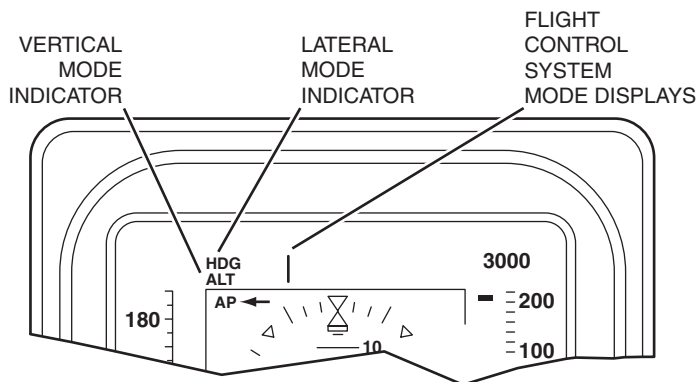


Figure 4-14 PFD—EFIS Autopilot Messages



FMS Vertical Modes

ALT—(Green) Altitude hold

ALTS—(Green) Track selected altitudes, (amber) abort selected altitudes, (white) arm selected altitudes

CLB—(Green) XXX

DES—(Green) XXX

GA/WS—(Green) Escape guidance during windshear

GA—(Green) Go-around

GS—(Green or white) ILS glide slope

IAS XXX—(Green) IAS hold, XXX—captured airspeed

MACH .XX—(Green) Mach mode, .XX—Selected Mach

PTCH—(Green) Pitch hold

VS XX↑↓—Vertical speed, XX—selected vertical speed, ↑↓—up or down

NOTE

Intermittent failure of the flight control computers (FCCs) may occur, resulting in erratic speed bug operation (fluctuates/jumps) and/or uncommanded FCC vertical mode changes or abnormal FCC operation.

No further use should be made of the failed FCC channel. The flight director and autopilot may still be used but must be transferred to the operative FCC channel.



Course Arrow and Course Readout

The course arrow and course readout (Figure 4-15) indicate the course as set on the course select knob on the flight control panel. The color matches the navigation source.

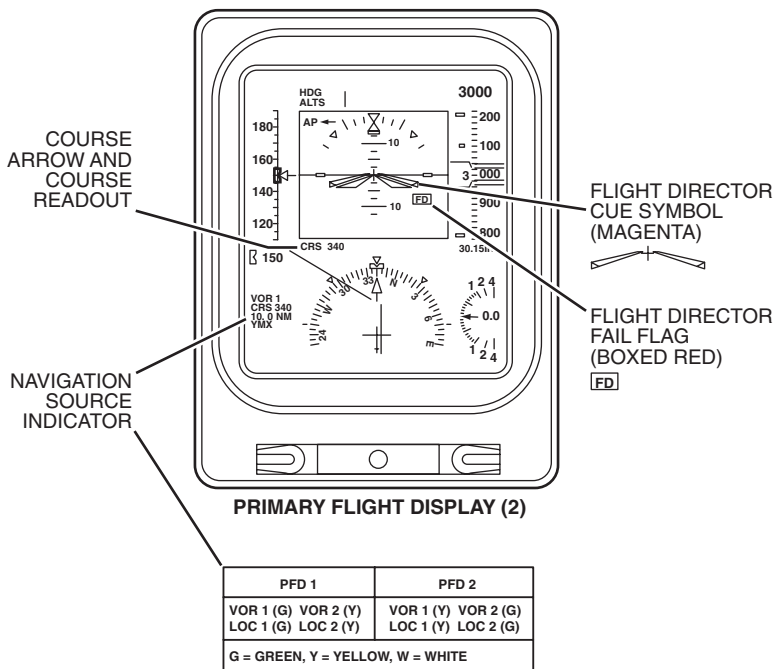


Figure 4-15 PFD—Navigation and Flight Director Indications

Navigation Source Indicator

The navigation source indicator shows the navigation source setting of the NAV SOURCE knob on the display control panel.



Autopilot Mode Annunciators

The autopilot mode annunciator (Figure 4-16) indicates the following autopilot modes:

- 1/2 BNK—White message indicates half-bank selected
- DR—White message indicates dead reckoning
- TEST—Amber message denotes diagnostics
- SYNC—Amber message denotes synchronize

Half-Bank Mode Annunciator

The half-bank (1/2 BNK) annunciator automatically illuminates when the airplane altitude is at 31,600 feet or greater or when selected.

Autopilot Engagement Annunciator

The autopilot engagement annunciator indicates engagement/disengagement/side transfer:

- AP ← → —Green arrows indicate autopilot engagement and the horizontal arrow points to the coupled side.
- AP ← → —Red arrows indicate the autopilot has disengaged. The arrows remain flashing until acknowledged by pressing disengage (AP DIS) switch.

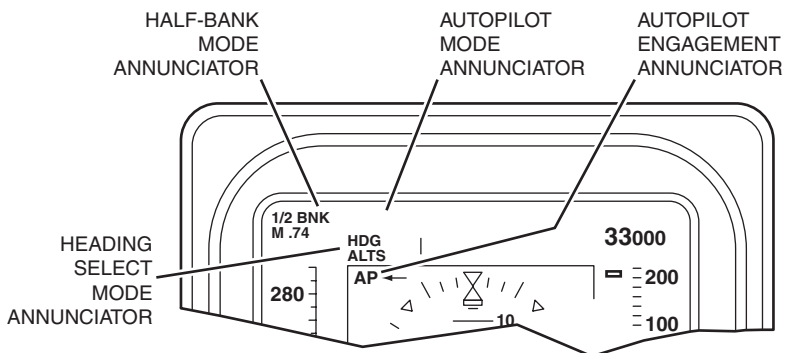


Figure 4-16 PFD—Autopilot Mode Annunciations



- → —White arrow indicates the autopilot is not engaged and control has been transferred to the copilot side. (← —control is on the Captain's side.)
- Blank—This indicates the autopilot is not selected.

Pitch Tape

White pitch tape (Figure 4-17) tick marks appear at 2-1/2° increments on the primary flight display. Minor marks indicate 5° increments; major marks indicate 10° increments.

NOTE

At extreme pitchup attitudes, red down-pointing chevrons display between 30 and 50°, 50 and 65°, and 65 and 90°. At extreme pitchdown attitudes, red up-pointing chevrons display between -20 and -40°, -40 and -55°, -55 and -70°, and -70 and -90°. During unusual attitudes (pitch at +30 or -20°, roll at ±65°) primary flight display declutters. Only attitude, airspeed, altitude, vertical speed, basic compass, and autopilot engage/disengage status display.

Vertical Mode Indicator

The green vertical mode indicator displays the selected vertical speed (VS) and either an up arrow (↑) or a down arrow (↓) when in the vertical speed mode. The indicator displays pitch hold (PTCH) when in pitch mode.

Vertical Speed Fail Flag

The red vertical speed fail flag (a boxed VS) illuminates instead of the vertical speed scale, pointer, and indicator when the vertical speed fails.

Vertical Speed Pointer

The green vertical speed pointer indicates the present vertical speed.



Vertical Speed Indicator

The green vertical speed indicator shows present vertical speed. Values are rounded to the nearest 100 feet per minute. Values are the numerical equivalent of the vertical speed pointer indicator.

Vertical Speed Scale

The white vertical speed scale indicates vertical speed between $\pm 4,000$ feet per minute (non-linear).

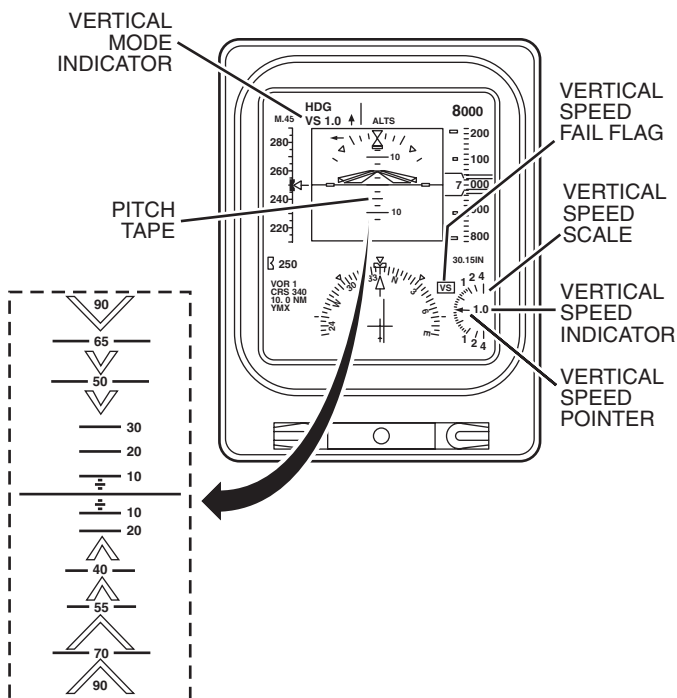


Figure 4-17 PFD—Pitch and Vertical Speed Indications



Barometric Altitude Fail Flag

When in view, the red barometric altitude fail flag (Figure 4-18) indicates altitude data from the selected source failed. In this situation, the following are removed from the PFD:

- Barometric altitude tape
- Altitude readout
- Preselect altitude reference bug
- Preselect altitude readout

Preselect Altitude Readout

The magenta preselect altitude readout indicates the preselect altitude. The range is from -1,000 to 50,000 feet and resolution is in 100 foot increments.

MDA Readout

The cyan readout indicates the minimum descent altitude.

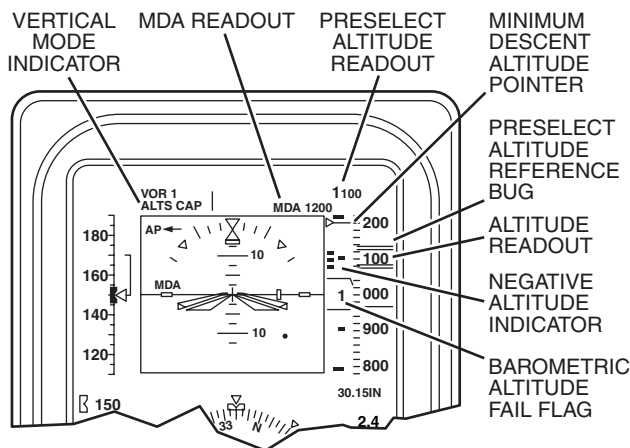


Figure 4-18 PFD—Altitude Indications



MDA Pointer

The cyan minimum descent altitude (MDA) pointer is controlled by the MDA knob on the air-data reference panel.

Preselect Altitude Reference Bug

The magenta double bars indicate the preselected altitude set with the ALT knob on the flight control panel. If the measurement is off the scale, half of the bug is displayed to indicate direction for altitude capture.

Amber double bars indicate a major deviation in the preselected altitude.

Altitude Readout

A white measurement indicates the altitude.

NEG Indicator

An amber negative indicator (NEG) displays on the coarse barometric tape when the airplane enters a negative altitude (−1,000 to −1 foot).

Indicated Mach Number Readout

The white readout shows the Mach value to the nearest hundredth beginning at 0.45 Mach (inhibited below 0.40 Mach).



Vertical Mode Indicator

The vertical mode indicator (Figure 4-19) displays the following during autopilot hold:

- IAS XXX—IAS hold
- MACH XX—Mach hold

Auto Changeover

Changeover between speed and mach occurs automatically as the aircraft ascends or descends through 31,600 feet. A climb in IAS mode is shown as IAS ###. At 31,600 feet, the reference is automatically switched to MACH .##.

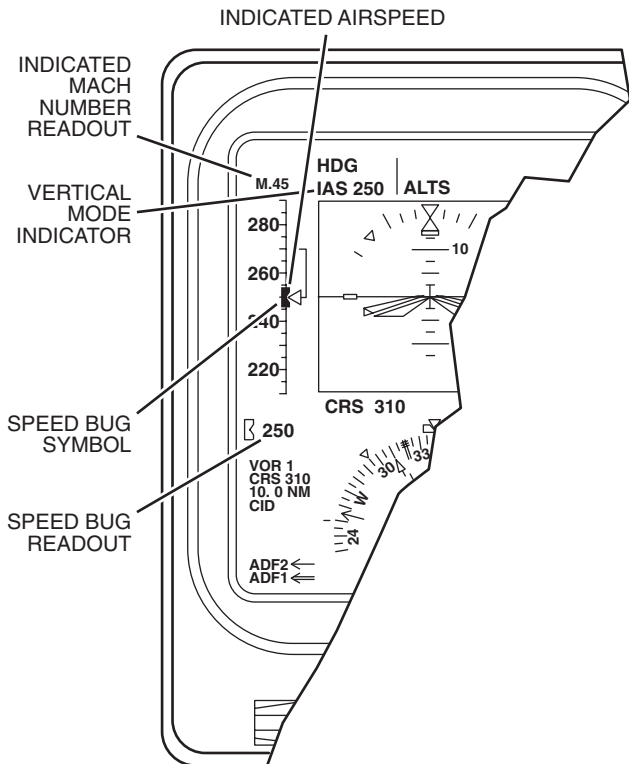


Figure 4-19 PFD—Vertical Mode Indications



Speed Bug Readout

The magenta speed bug readout indicates the setting of the speed bug in either IAS or Mach modes (.XX Mach or XXX IAS).

NOTE

Intermittent failure of the flight control computers (FCCs) may occur, resulting in erratic speed bug operation (fluctuations/jumps), and/or uncommanded FCC vertical mode changes or abnormal FCC operation.

No further use should be made of the failed FCC channel. The flight director and autopilot may still be used, but must be transferred to the operative FCC channel.

Indicated Airspeed Scale

The indicated airspeed (IAS) scale shows a moving white tape, a fixed white pointer, and readouts and symbols indicating airspeed range from 30 to 400 knots. The pilot may select autopilot speed reference or one of the V_1 , V_2 , V_R , or V_T speed bugs.

The magenta autopilot speed reference is shown as a box pointer symbol on the left of the scale, controlled by the SPEED knob on the flight control panel. The cyan V-speeds are controlled by the SPEED REFS knob and SEL switch on the air-data reference panel. The V-speeds are shown on both PFDs.

The following are calculated references:

- 1.27 VS green indicators show as a line across the airspeed scale. They are blanked out if the angle-of-attack (AOA) data fails.
- Red and black checkerboard low-speed cues descend from an impending stall speed to the bottom of the scale. The cues are inhibited on the ground and until three seconds after takeoff.



If the AOA data fails, an amber bar brackets the lowest and highest stall speeds.

- Red and black checkerboard VMO and MMO overspeed cues move up and down the scale, indicating the maximum speed allowable for current airplane configuration.
- A red IAS fail flag displays when the airspeed data fails. The flag replaces scale and airspeed references.

Vertical and Lateral Mode Indicators

The vertical and lateral mode indicators (Figure 4-20) show TO or GA in green when takeoff or go-around are selected as the active mode. Vertical go-around is cleared by coupling the autopilot (by operating the SYNC switch in pitch mode), manual selection, or capture of another vertical mode. Lateral go-around is cleared by coupling the autopilot (by operating the SYNC switch in roll mode) or selecting another lateral mode.

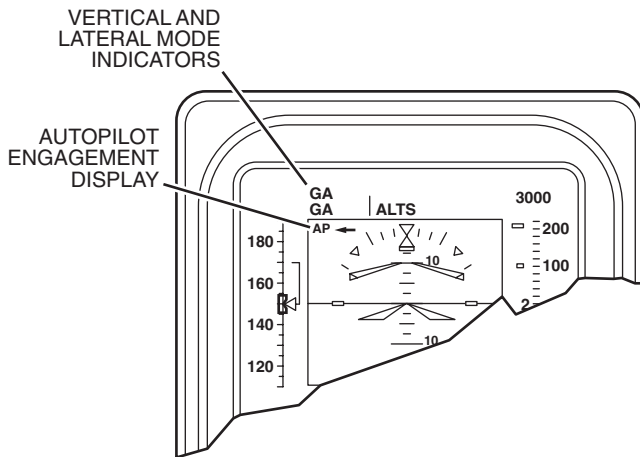


Figure 4-20 PFD—Takeoff and Go-Around Indications



Autopilot Engagement Display

The autopilot engagement display indicates engagement, disengagement, or side transfer (see Table 4-1). After autopilot disengagement, the takeoff/go-around (TOGA) switches cancel the autopilot caution and audible warnings.

Mistrim Indicators

The mistrim indicators (Figure 4-21) display when the autopilot monitoring system detects failure in the trim systems.

YD—The yellow indication shows the yaw damper is disengaged.

E—The boxed yellow indication shows a mistrimmed elevator.

A—The boxed yellow indication shows a mistrimmed aileron.

R—The boxed yellow indication shows a mistrimmed rudder.

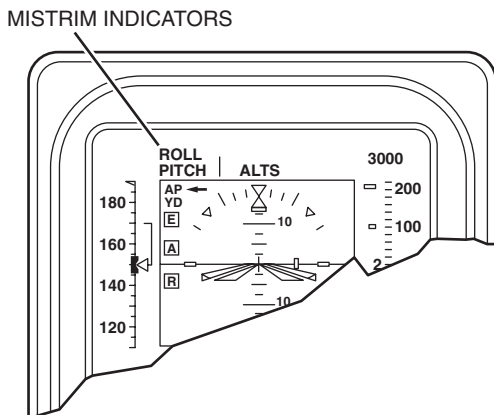


Figure 4-21 PFD—Yaw Damper and Mistrim Indications



EICAS MESSAGES

Primary Page Warning Messages

AFCS MSG FAIL—This red message indicates an invalid flight control system message. When this warning occurs, AFCS-related messages and aural warnings are no longer available from the EICAS.

CONFIG AP—This red message indicates the potential to attempt a takeoff with the autopilot engaged on the ground. (both engines >70% N_1 and no thrust reverser deploy command). This message is accompanied by the “config autopilot” aural warning.

Primary Page Caution Messages

AP TRIM IS LWD—This amber message indicates the autopilot is counteracting a significant left wing down mistrim.

AP TRIM IS ND—This amber message indicates the autopilot is counteracting a significant nose down mistrim.

AP TRIM IS NU—This amber message indicates the autopilot is counteracting a significant nose up mistrim.

AP TRIM IS RWD—This amber message indicates the autopilot is counteracting a significant right wing down mistrim.

AP PITCH TRIM—This amber message indicates the autopilot pitch trim failure.

YAW DAMPER—This amber message indicates both yaw dampers are disengaged or all IAPS input buses are invalid.



Secondary Page Status Messages

FD 1 or FD 2 FAIL—These white messages indicate failure of either the Captain's or First Officer's flight director, respectively.

IAPS OVERTEMP—This white message indicates an overtemperature condition in any IAPS power supply.

IAPS DEGRADED—This white message indicates a failure in any of the IAPS buses.

SPEED REFS INDEP—This white message indicates that the Captain's and First Officer's V-speed selections are not synchronized.

YD 1 INOP—This white message indicates that yaw damper No. 1 is disengaged and yaw damper No. 2 is engaged.

YD 2 INOP—This white message indicates that yaw damper No. 2 is disengaged and yaw damper No. 1 is engaged.

AURAL MESSAGES

“Config Autopilot”

This voice message sounds during a takeoff if the autopilot is engaged. EICAS visual warnings appear and the glareshield MASTER WARNING lights illuminate.

Cavalry Charge

This tone sounds when the autopilot is disengaged.

Trim Clacker

This tone sounds when there is protracted automatic pitch trim operation.



CIRCUIT BREAKERS

The circuit-breaker/power supply summary is shown in Table 4-2.

**Table 4-2 POWER SUPPLY AND
CIRCUIT-BREAKER SUMMARY**

SYSTEM	UNIT NUMBER	POWER SUPPLY	BUS BAR	CB PANEL NUMBER	CB NUMBER
Integrated Avionics Processor System	Left AFCS	IAPS LEFT AFCS	DC BAT	2	P7
	Right AFCS	IAPS RIGHT AFCS	DC BUS 2	2	H3