



# CHAPTER 10

## FLIGHT CONTROLS

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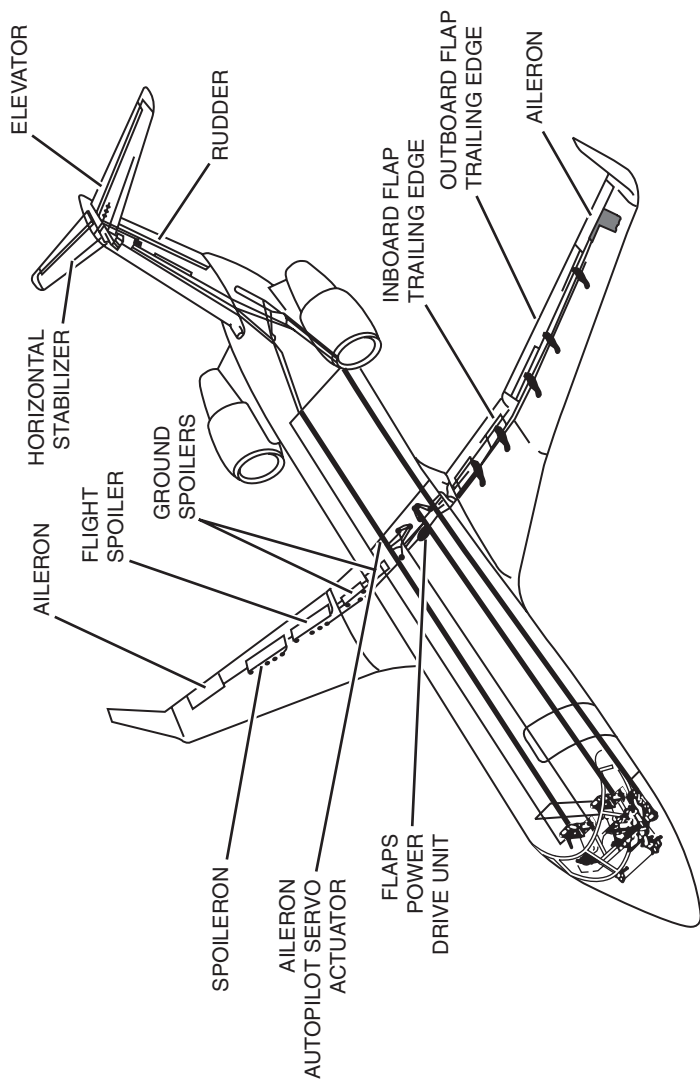


# **CHAPTER 10**

## **FLIGHT CONTROLS**

### **GENERAL**

The primary flight controls are the ailerons, elevators, and rudder (Figure 10-1). The primary flight surfaces are hydraulically actuated from flight crew inputs on a dual network of cables, pulleys, and pushpull rods, which operate hydraulic power control units (PCU). Artificial control loading (tactile feedback) is provided at the control columns, control wheels, and rudder pedals. Aileron and elevator flutter dampers are provided. Ground gust locks are provided on the elevators, ailerons, and rudder. Spoilerons operate with the ailerons to provide roll assistance and are considered part of the primary flight control system.

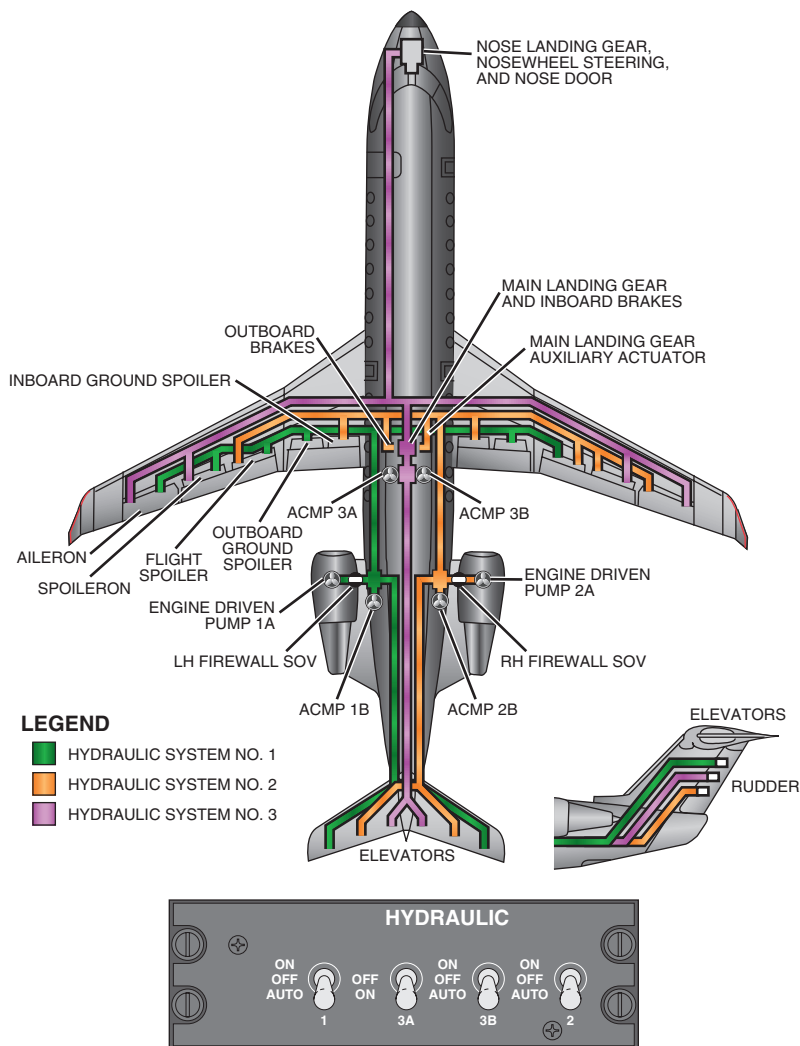


**Figure 10-1 Flight Control System**





Hydraulic power distribution, as indicated on the engine indication and crew alert system (EICAS), to the flight control surfaces is as shown in Figure 10-2 and Table 10-1.



**Figure 10-2 Hydraulic Power Distribution**



**Table 10-1 HYDRAULIC POWER DISTRIBUTION**

| NO. 1 HYDRAULIC SYSTEM                      | NO. 3 HYDRAULIC SYSTEM     | NO. 2 HYDRAULIC SYSTEM                    |
|---------------------------------------------|----------------------------|-------------------------------------------|
| Rudder                                      | Rudder                     | Rudder                                    |
| Elevator (left and right)                   | Elevator (left and right)  | Elevator (left and right)                 |
| Aileron (left)                              | Aileron (left and right)   | Aileron (right)                           |
| Spoileron (left)                            | Spoileron (left and right) | Spoileron (right)                         |
| Flight spoiler (left and right)             |                            | Flight spoiler left and right             |
| Ground spoiler (out-board) (left and right) |                            | Ground spoiler (inboard) (left and right) |

Pitch and roll system disconnects are provided. Pitch disconnect allows the flight crew to isolate the left from the right control column and cable system. Pitch disconnect separates the column interconnect (torque tube) system. Single-side pitch control is then available (either left or right elevator) using the serviceable (operable) control column path.

Roll disconnect allows the flight crew to isolate the left from the right control wheel and cable system. Roll disconnect separates the control wheel interconnect (torque tube) system. Single-side roll control is then available (either left or right aileron) using the operable control wheel path.

Rudder system antijam (spring tension breakout) is provided. Both CA and FO pedals remain operable, however additional force is required to obtain rudder deflection. Flutter dampers are on the aileron and elevator. These double-acting shock absorbers (dampers) prevent aileron or elevator flutter when hydraulic fluid is lost at the aileron or elevator PCUs.



Ground gust damping (gust locks) are provided on the elevators, ailerons, and rudder. Valves in the PCUs provide gust damping when the hydraulic systems are depressurized.

The secondary flight controls consist of the horizontal stabilizer, inboard and outboard flaps, flight spoilers, ground spoilers, and various trim systems. The horizontal stabilizer assists the elevators in providing pitch control. Inputs from the Mach trim, autopilot trim, or control wheel trim reposition the horizontal stabilizer through an electric screw jack.

High lift for takeoff and landing is provided by the trailing edge flaps (inboard and outboard). The flaps are moved by an electric power drive unit, flexible drive shafts, and screw jacks in response to commands from the FLAPS selector. The EICAS provides flap position indicators and readouts (primary page and flight controls page), and aural and visual warnings for takeoff configuration deviation and abnormal flap conditions.

Flight spoilers provide lift dumping in flight. Flight spoiler deployment follows flight crew input at the center pedestal flight spoiler control lever.

Intermediate flight spoiler deploy positions are available between the positions marked. The EICAS indicates flight spoiler cautions, spoiler position readouts (FLIGHT CONTROLS synoptic page), and takeoff configuration aural and visual warnings. The four spoiler panels on the upper surface of each wing function to dump lift and increase drag to assist other braking systems during landing or in the event of a rejected takeoff.

Aileron, horizontal stabilizer, and rudder trim controls are on the center pedestal and control wheel switches (pitch NOSE UP/NOSE DN). The EICAS indicates trim through position indicators and readouts. The EICAS also provides trim system takeoff configuration aural and visual warnings.



## **SYSTEM DESCRIPTION**

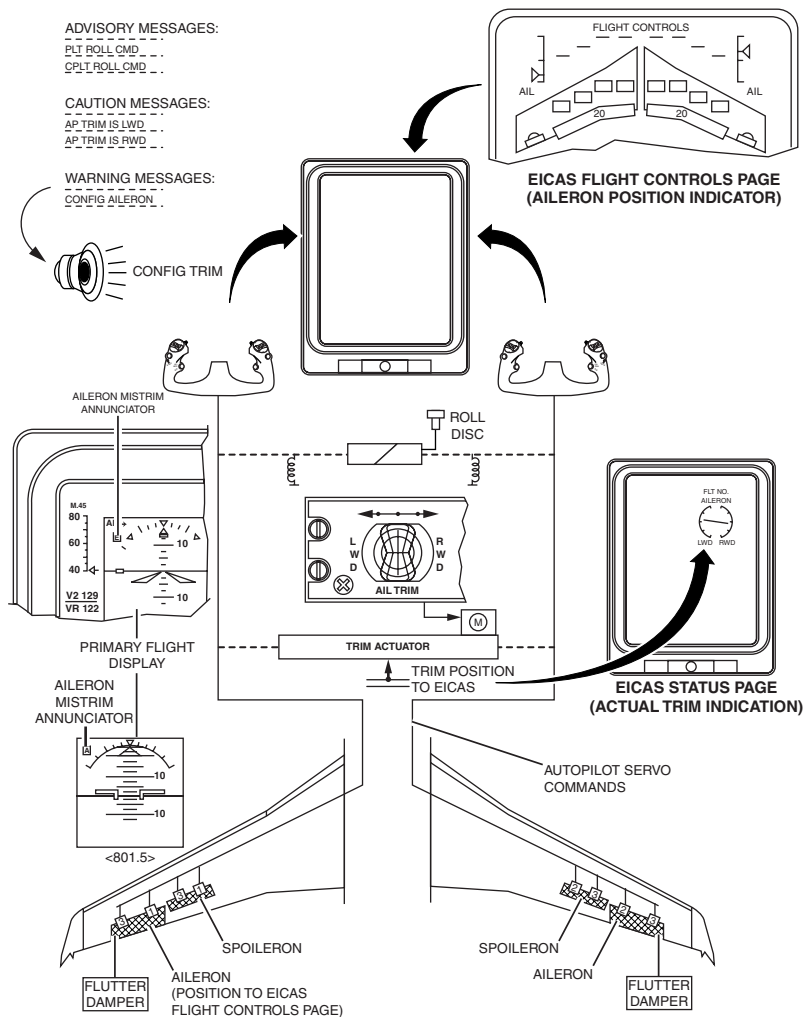
### **LATERAL CONTROL**

Lateral (roll) control is provided by ailerons supplemented by spoilers operating in relation to control wheel displacement (Figure 10-3). Two separate lateral control systems are provided: the CA's side operates the left aileron and the FO's side operates the right aileron. Normally, both control systems interconnect producing simultaneous movement of both ailerons.

A jammed aileron control circuit can be isolated (by operating the ROLL DISC handle), thereby allowing limited lateral control (one aileron only) through the operable circuit. Pressing the ROLL SEL switch on the side with the unjammed aileron ensures that the left and right spoilers are controlled by the operable circuit. With an aileron PCU runaway, a bungee breakout switch provides automatic spoileron control transfer to the operable circuit. The automatic flight control system (AFCS) (autopilot) should be disconnected if a jammed aileron control circuit condition occurs (operates with FO's aileron system only).

Rotating either control wheel sends a signal (via cables and pulleys) to the aileron and spoileron PCUs. Two PCUs are used for each aileron and two for each spoileron. The spoileron PCUs operate on the down-going wing only and assist the ailerons in roll control.

Aileron positions are shown on the FLIGHT CONTROLS synoptic page of the EICAS display. Separate pointers and readouts indicate the aileron positions on each wing. A full scale deflection of the position indicator corresponds to maximum aileron travel (24° up and 20° down). Spoileron position indications and readouts and hydraulic actuator status information are also shown.



**Figure 10-3 Aileron and Spoileron System**



Aileron trim is accomplished by pushing the AIL TRIM switches. Actuating both switches provides arming and direction signals to reposition the ailerons. Hydraulic power from one of the three hydraulic power systems is necessary to set aileron trim. An aileron trim position indicator display is shown on the EICAS display (status and flight controls pages). Aileron and aileron trim position and condition is continuously monitored and any fault detected appears on the EICAS display.

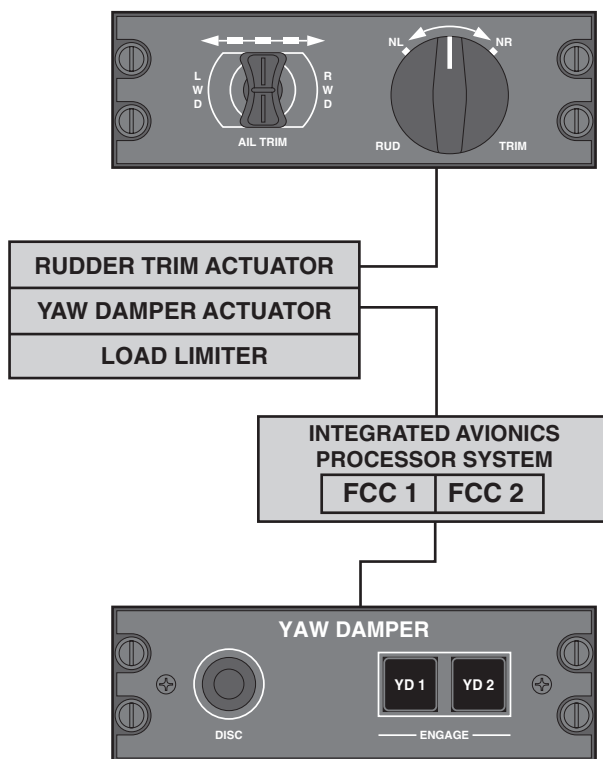
## **DIRECTIONAL CONTROL**

Directional control about the yaw axis is provided by the rudder control system (Figure 10-4). The rudder is hydraulically powered and controlled via cable runs and quadrants through displacement of either pilot's rudder pedals. Two yaw dampers operate through the flight control computers to improve lateral directional stability (alleviate Dutch roll).

Two separate cable run systems with antijam/breakout are provided. Displacement of either set of pedals sends a signal to the three rudder hydraulic actuators. The position of the rudder is shown on the EICAS secondary display (FLIGHT CONTROLS synoptic page) with pointers. Pushing a rudder pedal to its stop causes a full scale deflection of the pointer from the neutral mark and the pointers indicate a 25° deflection.

Rudder trim is available by rotating the RUD TRIM control in the desired NL/NR (nose left/nose right) direction. Actuation of the rudder trim does not cause rudder pedal deflection, due to the position of the trim actuator input, located after the AFT quadrant. The rudder trim indication on the EICAS display shows the selected units of trim.

Two independent yaw damper systems operate continuously in flight to improve the airplane's lateral directional stability and turn coordination. Each flight control computer (FCC) has a yaw damper controller. The controller provides signals to operate the yaw damper actuators. The yaw dampers are engaged by pushing the YD 1 and YD 2 switchlights on the YAW DAMPER panel. Should a yaw damper failure occur, the yaw damper disconnects from the FCCs.



**Figure 10-4 Rudder Control System**

Rudder and rudder trim position and condition is continuously monitored and any detected fault appears on the EICAS display.

## LONGITUDINAL CONTROL

Longitudinal control is provided by the elevators and supplemented by a moveable horizontal stabilizer for maintaining longitudinal

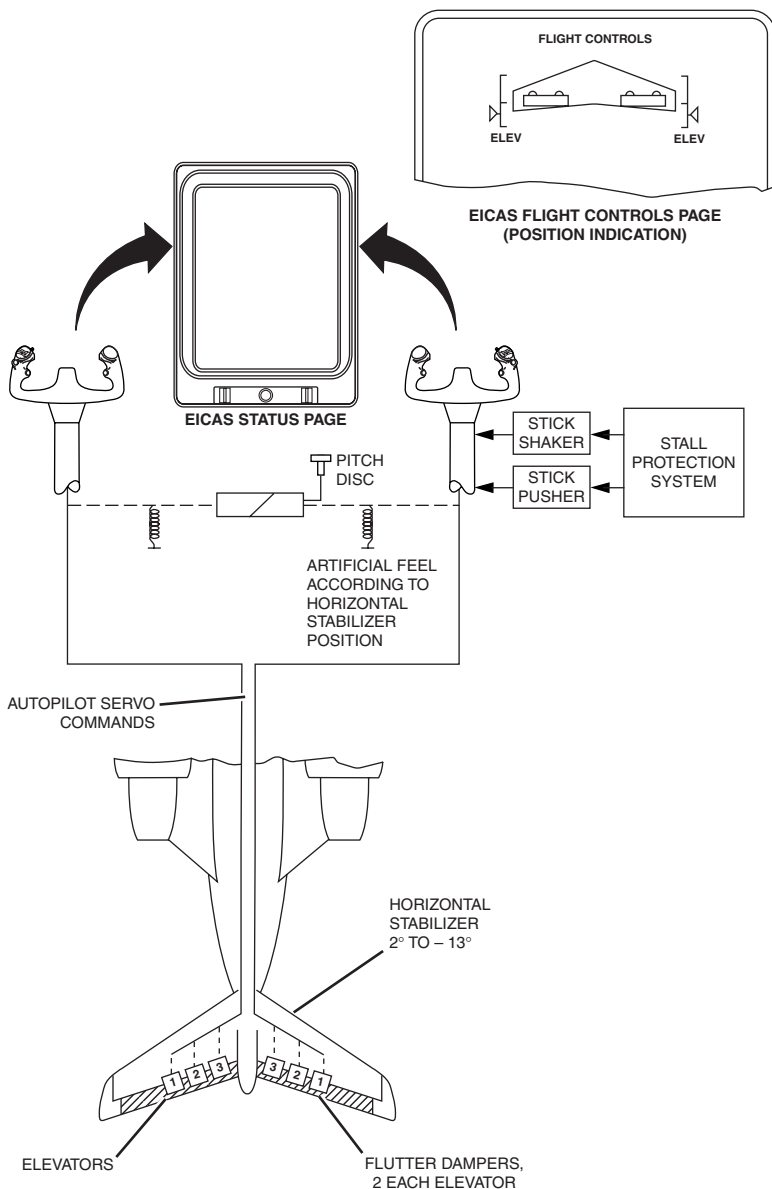


(pitch) trim (Figure 10-5). Two pitch control systems are provided: the CA's side operates the left elevator and the FO's side operates the right elevator. Normally, both control systems interconnect and produce simultaneous movement of both elevators. Fore or aft movement of either control column sends signals (via cables and pulleys) to the elevator PCUs. Three actuators are used for each elevator.

A jammed elevator control circuit can be isolated by operating the PITCH DISC handle, thereby allowing limited longitudinal control (one elevator only) through the operable circuit. The AFCS should be disconnected if a jammed elevator control circuit condition occurs (operates with CA's elevator system only).

Elevator positions are shown on the FLIGHT CONTROLS synoptic page on the EICAS display. Separate pointers and readouts indicate elevator position. A full scale deflection of the position indicator corresponds to maximum elevator travel (23° up and 18° down). Hydraulic actuator status information and pitch disconnect messages are also shown.





**Figure 10-5 Elevator Control System**



## **HORIZONTAL STABILIZER**

The stabilizer trim control system provides pitch trim by varying the angle of incidence of the horizontal stabilizer (Figure 10-6). The stabilizer is positioned by a jack screw driven by electric trim motors. Stabilizer position is shown on the STATUS and FLIGHT CONTROLS synoptic pages on the EICAS display. The STAB position indicator uses pointers to show the stabilizer position as an amount of surface deflection. The display's green band indicates the normal trim settings for takeoff.

Manual trim switches, on the control wheels, send signals to the horizontal stabilizer trim control unit (HSTCU), which controls the trim motors in the stabilizer screw jack (horizontal stabilizer actuator). The control unit has two channels (CH 1 and CH 2), which are engaged by the CH1/CH2 switchlights on the STAB TRIM control panel on the center pedestal. With manual trim, the stabilizer moves at 0.5° per second. Each motor has a brake to prevent trim runaway. Emergency trim disconnect switches (PITCH TRIM DISC) are on each control wheel. Stabilizer trim can be reengaged by operating the switchlights on the STAB TRIM control panel.

The Mach trim system provides longitudinal stability at airspeeds above Mach 0.4. The Mach trim system, using Mach speed information from the air data computer (ADC), varies the angle of incidence of the horizontal stabilizer by commanding the horizontal stabilizer actuator. Computer controlled stabilizer trim is available from the AFCS and Mach trim. During AFCS operation, trim rate is determined by flap movement. Stabilizer trim control precedence is as follows:

- Captain trim
- First officer trim
- Autotrim function of AFCS trim
- Mach trim

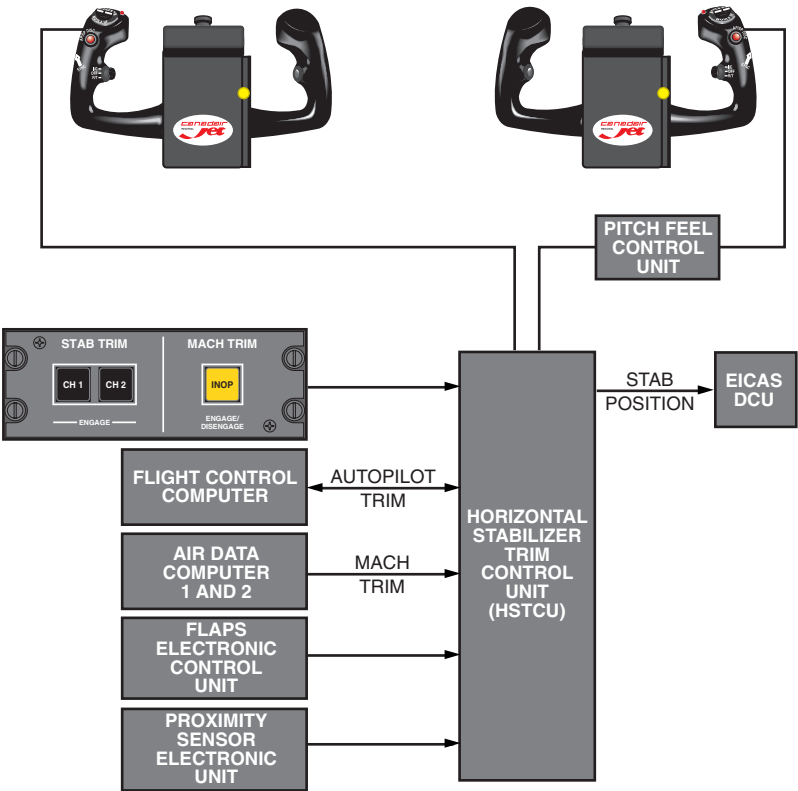


Figure 10-6 Horizontal Stabilizer Trim Control System



Automatic trim rates are as follows:

- Autopilot:
  - High rate,  $0.5^{\circ}$  per second (flaps extending or retracting)
  - Low rate,  $0.1^{\circ}$  per second (flaps stationary)
- Mach trim: Stabilizer movement of  $0.03$  to  $0.06^{\circ}$  per second

Horizontal stabilizer trim position and condition is continuously monitored and any detected fault appears on the EICAS display.

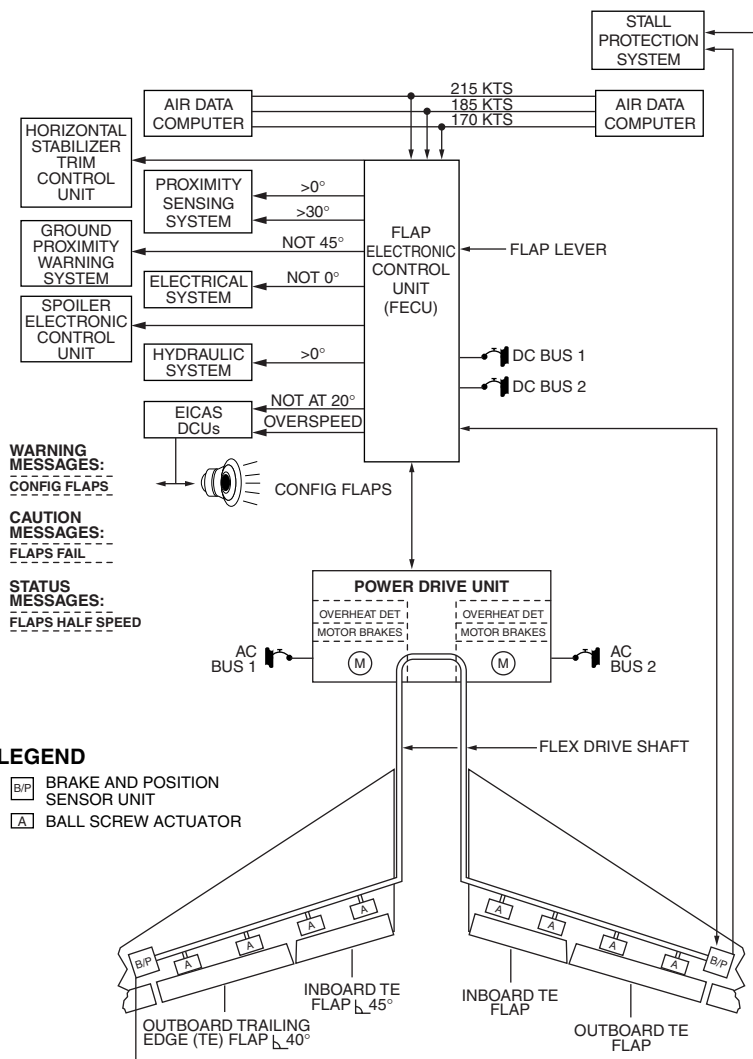
## FLAPS

The flaps are a double-slotted type and move aft and down when extending (Figure 10-7). The outboard flaps have fixed leading edge vanes and cams to operate the built-up trailing edge (BUTE) doors (used to direct airflow over the leading edge vane). The inboard flaps have spring-loaded leading edge vanes that automatically extend when the flaps deploy.

Each inboard and outboard flap segment moves in response to FLAP lever commands, by two AC motors rotating a drive shaft and two ballscrew actuators. The flaps continue to operate at a reduced speed with a single motor operating. All flap segments are mechanically connected on each side for simultaneous extension and retraction.

Flaps may be set to any of four or five positions, depending on aircraft configuration, in a  $0$  to  $45^{\circ}$  range by movement of the FLAP lever into preset feel detents. Two flap gates are in the flap lever quadrant. The forward gate, prevents inadvertent flap selection to  $0^{\circ}$  during a missed approach, and the rearward gate, precludes  $V_{FE}$  (flaps  $30^{\circ}$ ) from being exceeded.

The EICAS primary page shows flap positions and landing gear position when either landing gear or flaps are extended. At all other times, the gear and flap information is removed from the EICAS primary display. Flap position readouts are always shown on the FLIGHT CONTROLS synoptic page. Flaps position and condition



**Figure 10-7 Flap Control System**



is continuously monitored and any detected fault appears on the EICAS display.

## **SPOILERS**

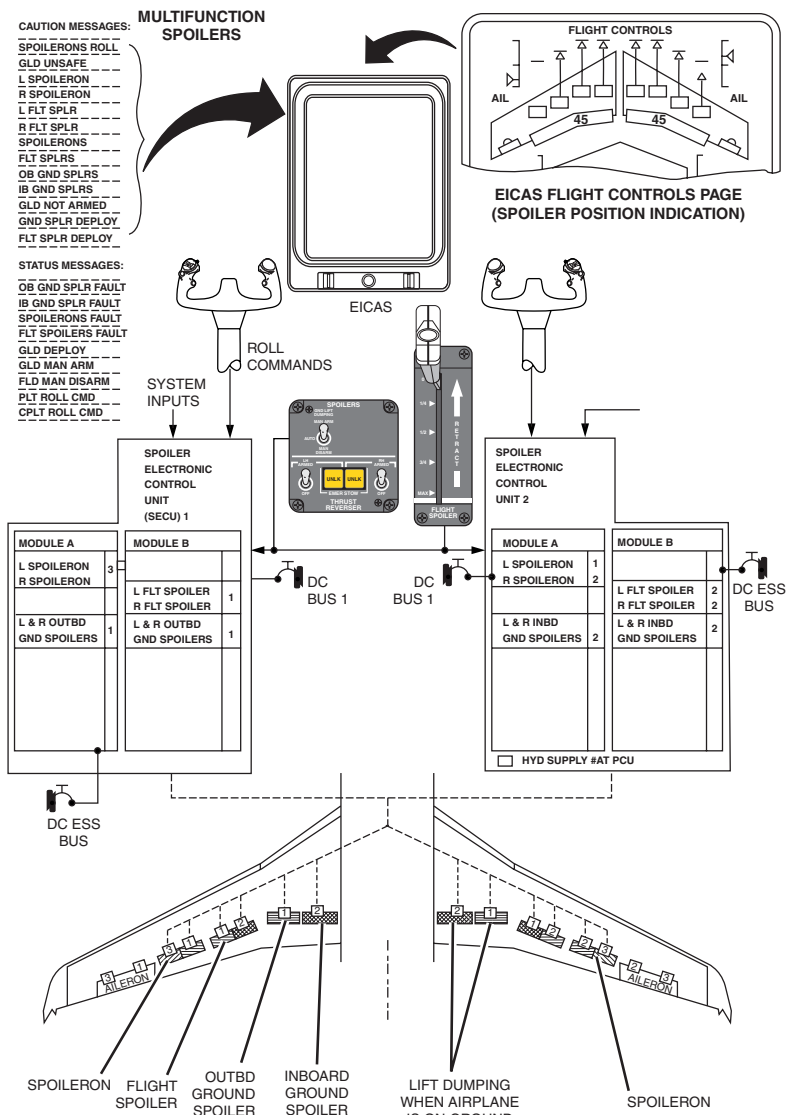
There are four spoiler panels on the upper surface of each wing, just forward of the flaps (Figure 10-8). The spoileron panel on each wing operates with the ailerons to provide roll control. The flight spoiler panels provide lift dumping and speed control as commanded by the spoiler control lever. The inboard and outboard ground spoilers, together with the spoileron and flight spoiler panels, function to dump lift and increase drag to assist other braking system on landing or in the event of a rejected takeoff.

The control wheels and the flight spoiler control lever send signals to the spoiler electronic control unit (SECU): SECU 1 and SECU 2. Dual redundant modules, within each SECU, control extension and retraction of each spoiler panel. The SECUs combine the control wheel signals with airspeed information, from the ADC, and flap position information, from the flap electronic control unit (FECU), to determine the required spoileron panel deflection for a given airplane configuration.

The ground lift dumping system is fully automated. Arming, deploying, and retracting is automatically controlled by the SECUs, which monitor inputs from the following:

- Engine  $N_1$  signals
- Thrust lever positions switches
- Proximity sensor electronic unit (weight-on-wheels)
- Antiskid control unit (wheel speed)
- Radio altimeter

In the event of a malfunction or failure of the automatic arming and disarming (automatic retraction), the ground lift dumping system



**Figure 10-8 Spoiler and Spoileron Control System**



may be manually armed or disarmed through the SPOILERS, GND LIFT DUMPING panel on the center pedestal.

The flight spoilers may be extended to any position, between 0 and 50°, as required for the intended flight path. The ground spoilers have only two positions: fully retracted during flight or fully deployed at 45° after landing.

The position of all spoilers is shown on the EICAS secondary display FLIGHT CONTROLS synoptic page. Symbology at each spoiler panel displays the following:

- Spoiler panel status
- Deployed or retracted indications
- Pointers to show position

Spoiler position and condition is continuously monitored and any detected fault appears on the EICAS display. The spoiler circuit must be armed before deployment can take place. The spoiler system can be armed automatically or manually as follows:

- Automatic:
  - Spoiler control switch in the AUTO positions and
  - L and R thrust  $\geq$  MIN TAKEOFF setting
- Manual: Spoiler control switch in the MAN ARM position

The ground and flight spoiler deploy logic requires the system to be armed and the following (Table 10-2):

1. Left and right thrust levers at IDLE and (2 of the following 3):
2. Left or right main landing gear weight-on-wheels (WOW)
3. Rad alt < 5 feet
4. Wheel speed > 16 knots





The spoileron deploy logic requires the system to be armed and the following:

1. Left and right thrust levers at IDLE
2. Left and right main landing gear WOW, and one of the following:
  - Rad alt < 5 feet, or
  - Wheel speed > 16 knots

**Table 10-2 SPOILER DEPLOY LOGIC**

| <b>AUTOMATIC RETRACT<br/>(ON GROUND FOLLOWING<br/>DEPLOYMENT)</b>           | <b>MANUAL RETRACT</b>  |
|-----------------------------------------------------------------------------|------------------------|
| L or R thrust < Minimum required<br>for takeoff                             | DISARM—Switch position |
| and                                                                         |                        |
| Inboard and outboard wheel<br>speed < 45 knots (for at least<br>10 seconds) |                        |
| Deploy logic (airplane on the<br>ground for at least 40 seconds)            |                        |

The proximity sensing system consists of proximity sensors on various airplane components (spoilers, doors, landing gear, etc.) and a proximity sensor electronics unit (PSEU). The PSEU receives inputs from the sensors together with airplane systems and configuration information (flap > 0, thrust lever position, and landing gear commands). It also controls the sequencing of the landing gear and gear doors, takeoff configuration warnings and automatic ground spoiler deployment through the SECU.



The PSEU provides WOW signals to the following systems:

- Stall warning system—Stick shaker and stick pusher are disabled on the ground and at rotation
- HSTCU—Disables built-in test equipment (BITE) during flight
- Flap electronic control unit—Prevents reset of flap asymmetry during flight and enables preflight test on the ground
- SECU—Automatic ground spoiler deployment at airplane touchdown with wheel spin-up and radio altitude at < 5 feet

Failures of the proximity sensing system are indicated on the EICAS display (see to Chapter 15, “Landing Gear” for details).

## STALL PROTECTION

The stall protection system provides the flight crew with aural, visual, and feel (stick shaker, stick pusher) indications of an impending stall. If no corrective action is taken, the system activates the stick pusher mechanism, preventing the airplane from entering the stall.

A dual-channel stall protection computer monitors the following inputs:

- Left and right angle-of-attack (AOA) transducers—AOA
- #1 and #2 attitude and heading systems—Lateral acceleration
- Left and right flap position transmitters—Flap position
- #1 and #2 WOW—Weight on wheels
- #1 and #2 ADC and Mach transducer—Mach



The stall protection computer uses the above inputs to calculate the AOA trip points. As a high AOA is approached, continuous ignition is activated. If the AOA continues to increase, the stick shakers are activated and the autopilot is disengaged. If the AOA still continues to increase, the stick pusher mechanism is activated, STALL lights on the glareshield panel flash red, and the warbler sounds. In the event of an AOA increase greater than  $1^{\circ}$  per second, the stall protection computer lowers the AOA trip points. This prevents the airplane's pitching momentum from carrying it through the stall warning and stick pusher sequence into the stall.

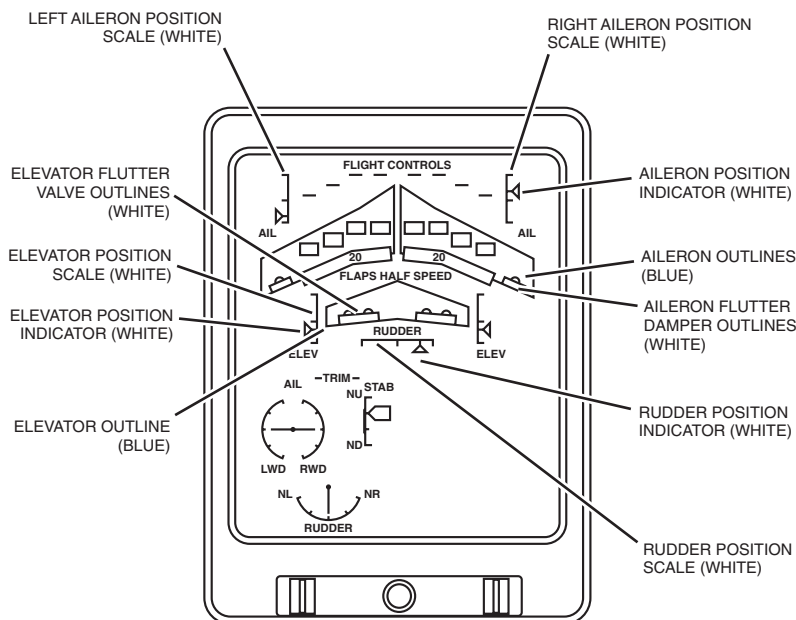
An acceleration switch disconnects the stick pusher mechanism if less than 0.5 g's is reached during the stick pusher activation. The stick pusher may be stopped by pressing and holding the autopilot stick pusher disconnect switch (AP/SP DISC), on the CA's or FO's control wheel. The stick pusher is capable of operating immediately once the autopilot/stick pusher disconnect switch is released. In the event of a malfunction, the stick pusher may be disconnected by selecting the PUSHER switch to OFF on the CA's or FO's stall protection panel. Both switches must be ON for stick pusher activation.

Testing the stall protection system is carried out on the ground by momentarily pressing one of the STALL switchlight on the CA's or FO's glareshield panel. The stall protection computer continuously monitors the stall protection system, and any detected fault is sent to the EICAS for aural and visual annunciation.



## CONTROLS AND INDICATIONS

The EICAS displays warnings, cautions, advisories, and status indications for the primary and secondary flight controls. Figure 10-9 illustrates the indications for the primary flight controls.



**Figure 10-9 EICAS Primary Flight Control Indications**

## PRIMARY FLIGHT CONTROLS

### Ailerons

#### Aileron Position Indicators

The aileron position indicator shows the relative position of the ailerons in relation to each other.



## **Aileron Position Readout**

The indicators show the position of the respective aileron.

## **Aileron Flutter Damper Outlines**

The flutter damper outlines illuminate if the respective aileron flutter damper fails or has a low hydraulic fluid level.

## **Rudder**

### **Rudder Position Indicator**

The rudder position indicator shows the relative position of the rudder.

### **Rudder Position Scale**

The left and right tick marks represent 25°, the center tick mark 0°.

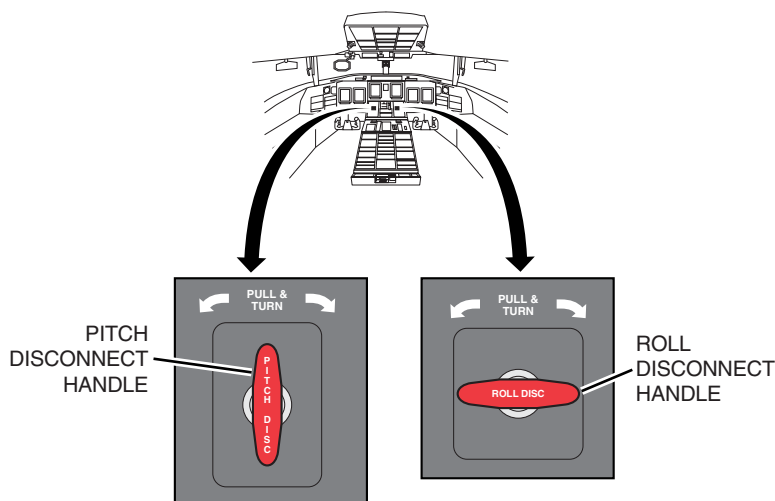
### **Trim Readouts**

The trim readouts are the same as on the status page.



## Pitch and Roll Disconnects

Figure 10-10 shows the pitch and roll disconnect handles.



**Figure 10-10 Pitch and Roll Disconnect Controls**

### PITCH DISCONNECT Handle

When the PITCH DISC handle is pulled and turned, it disconnects the control columns from each other. It is used when one of the elevators jams. Pulling the PITCH DISC handle gives control of the left elevator to the CA, and control of the right elevator to the FO.

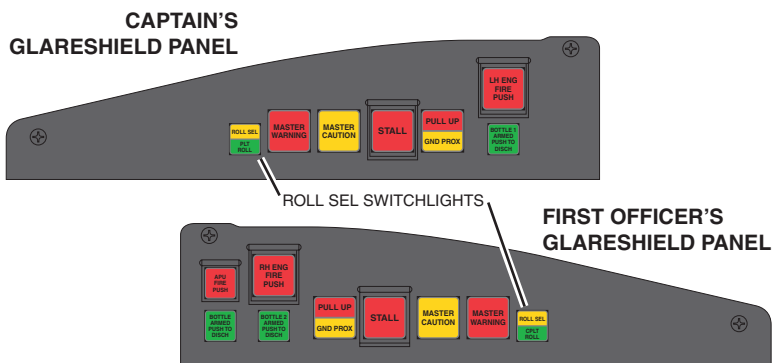


## ROLL DISCONNECT Handle

When the ROLL DISC handle is pulled and turned, it disconnects the control wheels from each other. It is used when one of the ailerons jams. Pulling the ROLL DISC handle gives control of the left aileron to the CA, and control of the right aileron to the FO.

## ROLL SEL Switchlights

Illumination of the amber portion of both ROLL SEL switchlights (Figure 10-11) indicates that the roll disconnect handle has been pulled. The ROLL SEL switchlight on the unjammed side must be pushed to transfer spoileron control to the operable side.



**Figure 10-11 Roll Disconnect Indications**

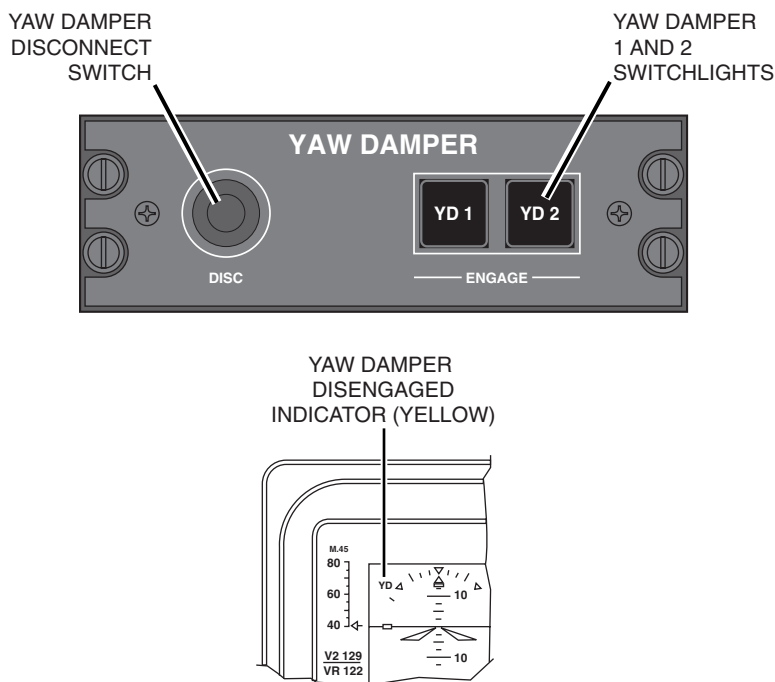


## Yaw Damper

Figure 10-12 shows the yaw damper controls and indications.

### Yaw Damper DISC Switch

The yaw damper DISC switch disengages channel YD 1 and/or channel YD 2, if engaged.



**Figure 10-12 Yaw Damper Control PFD Indication**





## **YD 1 and YD 2 Switchlights**

The YD 1 and YD 2 switchlights on the yaw damper panel engage channel YD 1 and channel YD 2 respectively.

The white YD 2 INOP status message on the EICAS indicates that channel YD 2 is not engaged and that YD 1 is engaged.

### **NOTE**

Switching power between the APU and the No. 2 engine generator during ground operations causes a momentary power loss to DC bus 2, which disengages yaw damper No. 2.

To reengage yaw damper No. 2, wait 30 seconds with the airplane parked before pressing the YD 2 switchlight.

## **Yaw Damper Disengaged Indicator**

The yellow yaw damper disengaged indicator on the PFD appears when the yaw damper system disengages.

## **Elevator**

### **Elevator Flutter Valve Outlines**

A flutter damper white outline on the EICAS primary flight control page displays if the respective elevator flutter damper fails or has a low hydraulic fluid level.

### **Elevator Position Indicator**

The elevator position indicator shows the position of the elevators.



## **SECONDARY FLIGHT CONTROLS**

### **Spoilers**

#### **Flight Spoiler Lever**

Moving the flight spoiler lever aft deploys the spoilers. The flight spoiler lever has the following five labeled and detented positions (Figure 10-13).

Four additional detented position are available between the labeled positions on the spoiler lever panel.

#### **Maximum Spoiler Deployment Mark**

The white maximum deployment mark indicates that the respective spoiler is fully deployed.

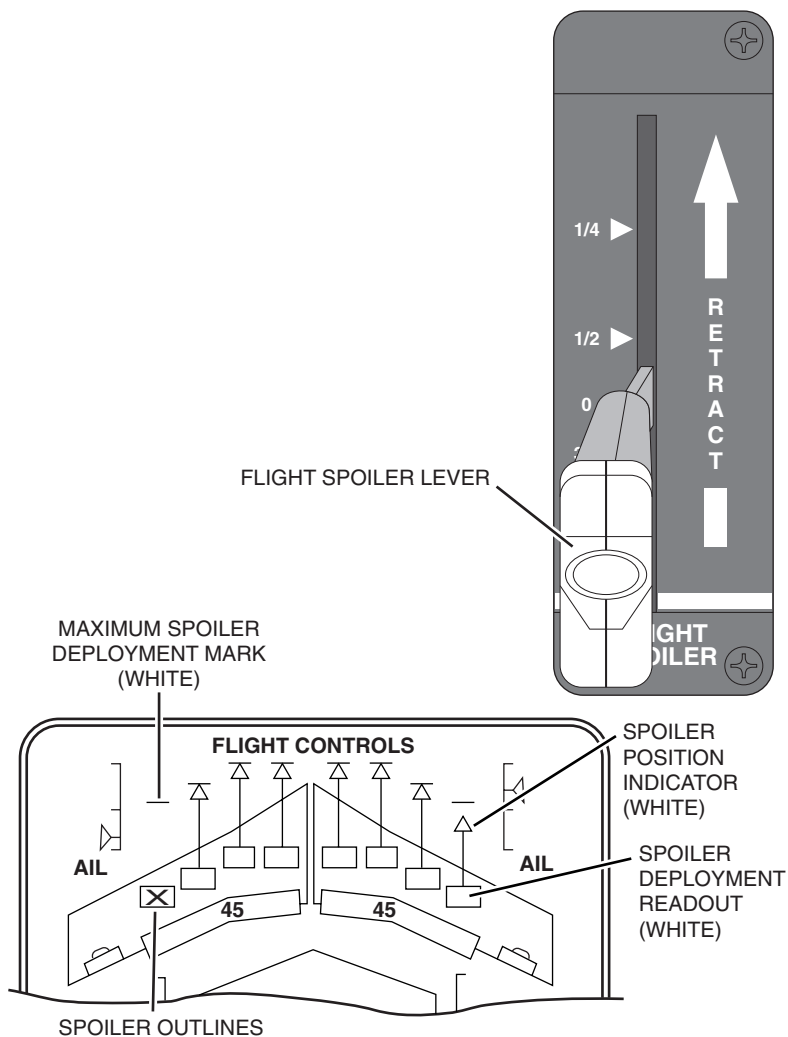
#### **Spoiler Outlines**

The possible four different colors of the spoiler outline box indicate the following conditions:

- Green—Both the respective spoiler electronic control units (SECUs) and power control unit (PCUs) are operational
- White—One of the respective SECUs or PCUs is inoperative
- Amber—Both of the respective SECUs and/or both of the respective PCUs are inoperative
- Half intensity magenta—Invalid input data

#### **Spoiler Position Indicator**

The indicator shows the relative position of the respective spoiler. The indicator is not displayed when the respective spoiler is retracted or the input data is invalid.



**NOTE:**

AN AMBER X IS DISPLAYED WHEN DATA IS INVALID, AND POSITION INDICATOR (ARROW) IS REMOVED. A SPOILER WITH AN AMBER X INDICATION MAY STILL OPERATE NORMALLY.

**Figure 10-13 Flight Spoilers Controls and Indications**

Figure 10-14 shows the horizontal stabilizer trim controls and indications.

There is a STAB TRIM DISC switch on the top of the outside horn of each control wheel which disconnects the pitch trim when pushed.



### Figure 10-14 Stabilizer Trim Lever Control and PFD Indications



## Stabilizer Trim Lever Switches

The dual lever stabilizer trim switches vary stabilizer trim as required. Both levers must be pushed fully to the NOSE UP or NOSE DOWN position to activate the pitch trim.

## Stabilizer Trim Pointer

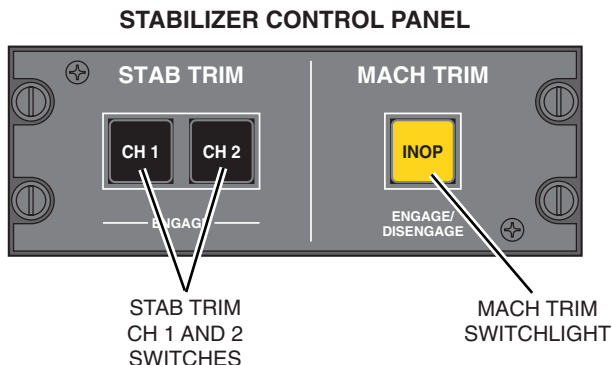
The stabilizer trim pointer on the EICAS secondary status page indicates the position of the stabilizer in units. On the ground, the pointer is green if the stabilizer is within the takeoff trim range (three to nine units).

## STAB TRIM CH 1 and STAB TRIM CH 2 Switchlights

Pressing the CH 1 or CH 2 switchlight on the stabilizer control panel engages the associated horizontal stabilizer trim control unit (HSTCU) (Figure 10-15). Pressing the STAB TRIM DISC switch on the CA's or FO's control wheel disengages the system.

## MACH TRIM Switchlight

To engage Mach trim, both HSTCU channels must be powered and one of them engaged. Pressing the MACH TRIM switchlight engages Mach trim and extinguishes the INOP light.

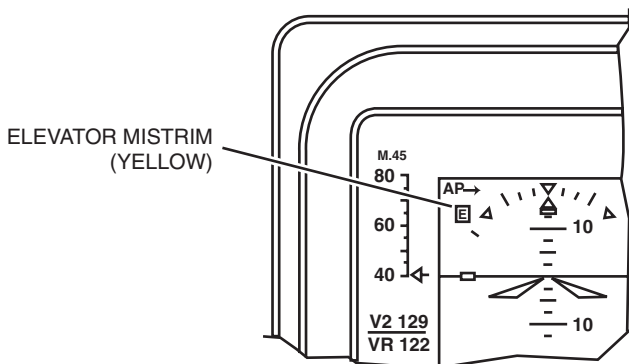


**Figure 10-15 STAB TRIM and MACH TRIM Controls**



## Elevator Mistrim Indicator

During a horizontal stabilizer mistrim condition with the autopilot engaged, the yellow elevator mistrim indicator appears on the CA and FO primary flight displays (Figure 10-16).



**CAPT AND F/O PRIMARY FLIGHT DISPLAYS**

**Figure 10-16 Elevator Mistrim Indications**

## AIL TRIM Lever Switches

The dual lever AIL TRIM switches are spring loaded to the center position. Both levers must be pushed fully left or fully right to activate the aileron trim (Figure 10-17).

## RUD TRIM Rotary Switch

The RUD TRIM switch is spring loaded to the center (off) position and must be rotated fully left or fully right to activate the rudder trim.



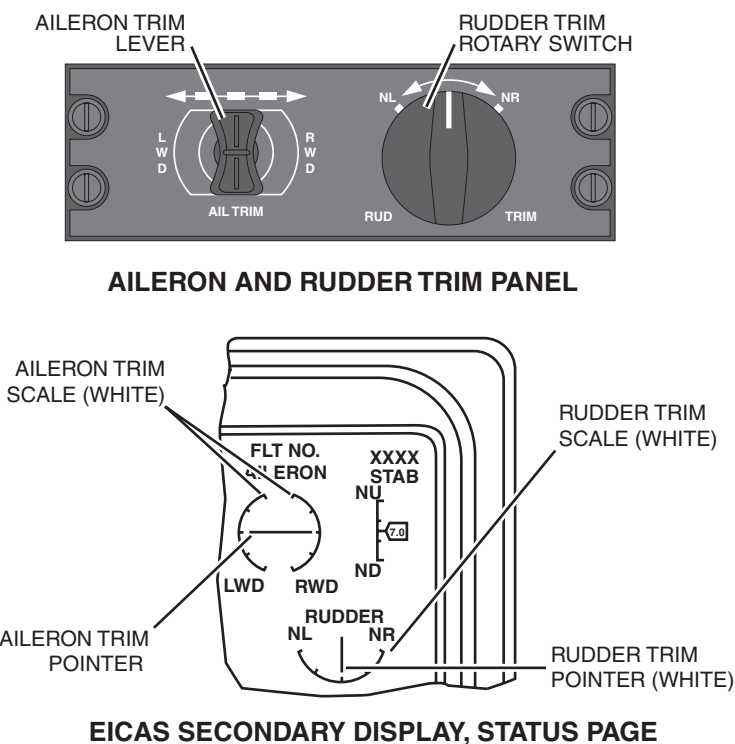
## Rudder Trim Pointer

On the ground, the pointer appears as follows:

Green—Indicates that the rudder trim actuator is displaced  $\leq 1^\circ$ .

White—Indicates that the rudder trim actuator is displaced  $\pm 1^\circ$ .

In flight, the indicators appear white.



**Figure 10-17 Aileron and Rudder Trim Controls and PFD Indications**

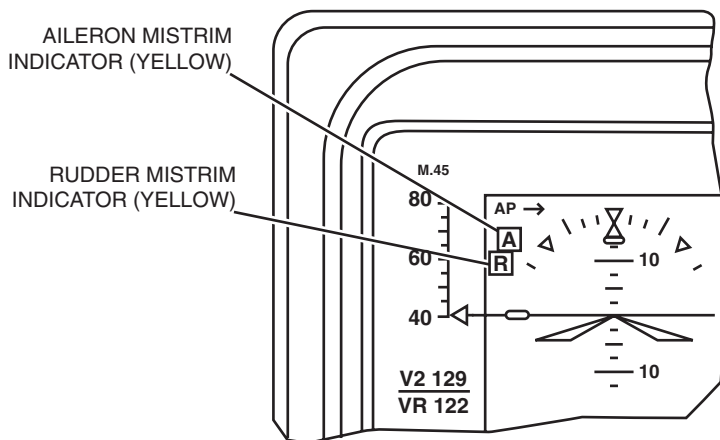


## Aileron Mistrim Indicator

During an aileron mistrim condition, and with the autopilot engaged, the yellow aileron mistrim indicator appears on the PFDs (Figure 10-18).

## Rudder Mistrim Indicator

During a rudder mistrim condition, and with the autopilot engaged, the yellow rudder mistrim indicator appears on the PFDs.



PILOT'S AND COPILOT'S PRIMARY FLIGHT DISPLAY

Figure 10-18 Aileron and Rudder PDF Mistrim Indications





## Flaps

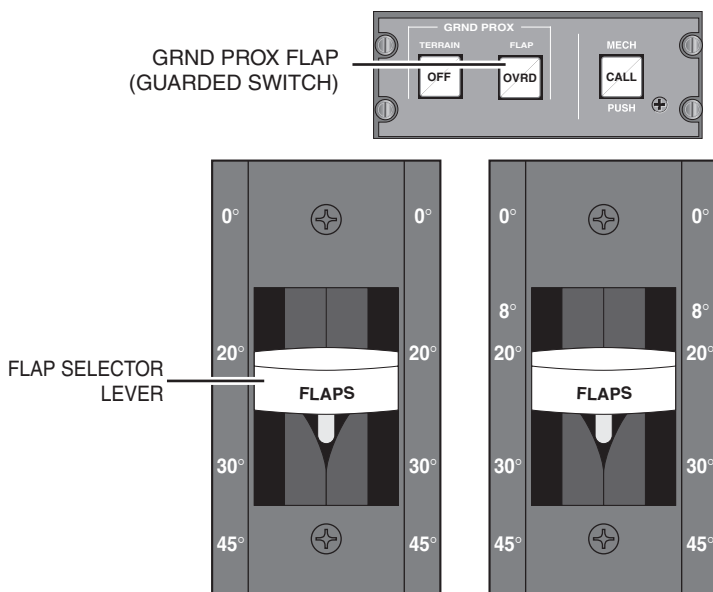
### Flap Selector

Moving the flap selector aft to a detent position moves the flaps to the selected flap angle (Figure 10-19).

### EGPWS FLAP OVRD Switchlight

The guarded switchlight has two positions, GRND PROX FLAP OVRD (pushed in) and NORM (selected out).

EGPWS FLAP OVRD—Mutes the flap aural warning when the airplane enters the landing configuration with the flaps not in the landing configuration.



**Figure 10-19 EGPWS Override/Flap Selector Lever**



## NOTE

When positioning the flaps for a go-around, ensure that the back face of the flap lever is pushed without any downward pressure. This ensures that the correct flap position is selected for go-around.

## NOTE

There is a forward gate at flaps 8° or 20°, depending on aircraft configuration, and a rearward gate at the 20° position. Push the flap lever down to pass through the gate.

## Flap Position Readout

The readout on the EICAS secondary display, flight controls page indicates the position of the left and right flaps in degrees (Figure 10-20). Amber dashes are displayed if the inputs are invalid. A green display indicates that the left and right flap positions do not differ by more than five degrees. A white display indicates that they differ by more than five degrees.

## Flaps Outlines

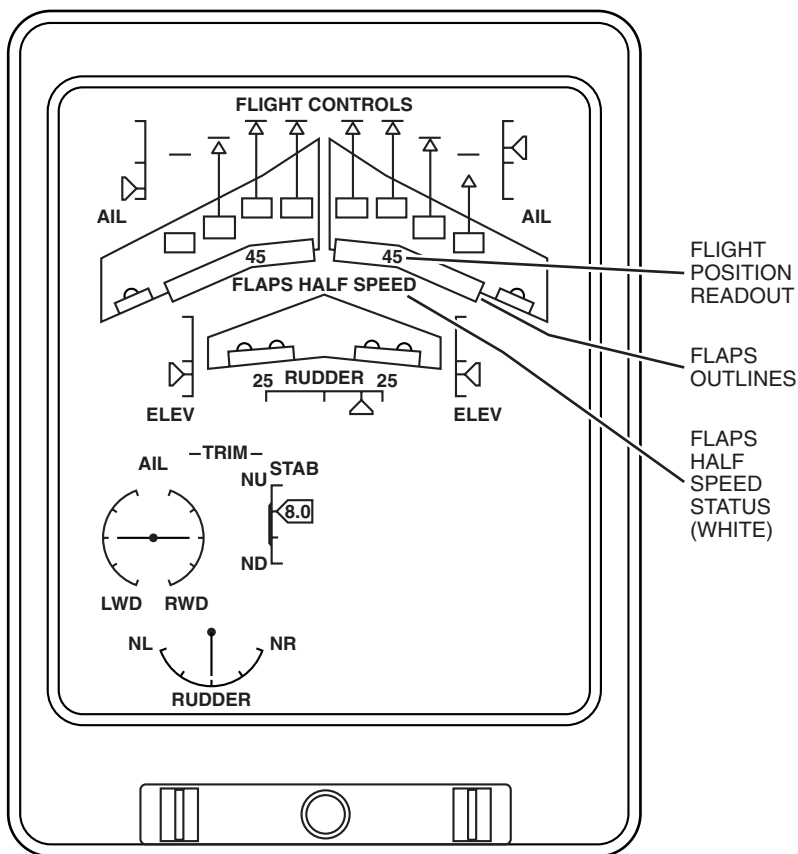
The flap outline provides information in one of four color codes.

**Green**—Indicates that both channels of the flaps electronic control unit (FECU) are operative.

**White**—Indicates that one of the channels of the FECU is inoperative.

**Half-intensity magenta**—Indicates that the input value is invalid.

**Amber**—Indicates that both channels of the FECU are inoperative.



**Figure 10-20 Flaps Position Readout**



## FLAP HALF SPEED Status

The white FLAPS HALF SPEED status message appears on the EICAS secondary display status page when one of the FECU channels fail. The flaps continue to operate but at a reduced rate.

## Flaps Position Bar

The green flaps position bar (Figure 10-21) appears when the flaps are deployed and the input data is valid. A white bar is displayed if the EICAS detects a miscompare with a difference between the left and right flap positions of  $> 5^\circ$ .

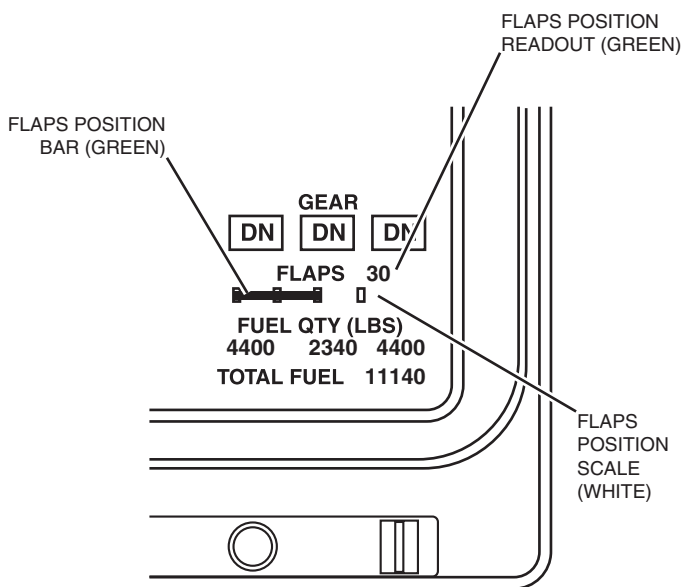


Figure 10-21 Flap PFD Indications



## **Flaps Position Readout**

The green flaps position readout indicates the angle of flap deployment. It is displayed when the flaps are deployed and/or the gear is not up and locked. Amber dashes are displayed if the input value is invalid.

## **Flaps Position Scale**

The white flaps position scale displays when the flaps position readout is displayed. The tick marks, from left to right, represent 0, (8 on select aircraft), 20, 30, and 45°.



## **Ground Spoilers**

The ground spoiler controls and indications are shown in Figure 10-22.

### **GND LIFT DUMPING Toggle Switch**

The three position GND LIFT DUMPING switch controls arming and disarming of the ground lift dump system.

**AUTO**—Automatically arms the ground lift dumping system when the airplane is configured for landing

**MAN ARM**—Manually arms the system should automatic arming fail

**MAN DISARM**—Disarms the system in the event of inadvertent deployment or automatic system failure

### **Ground Spoiler Position Indicator**

The white ground spoiler position indicators extend to the full travel tick mark when the respective ground spoiler is fully deployed. The indicators are not visible when the ground spoilers are not fully deployed or retracted.

### **Ground Spoiler Outline**

The ground spoiler outline provides information in one of four color codes.

**Green**—The respective hydraulic manifold and SECU are operational.

**White**—A loss of redundancy exists in the respective ground spoiler.

**Amber**—The respective hydraulic manifold or SECU is inoperative.

**Half-intensity magenta**—The input data is invalid.

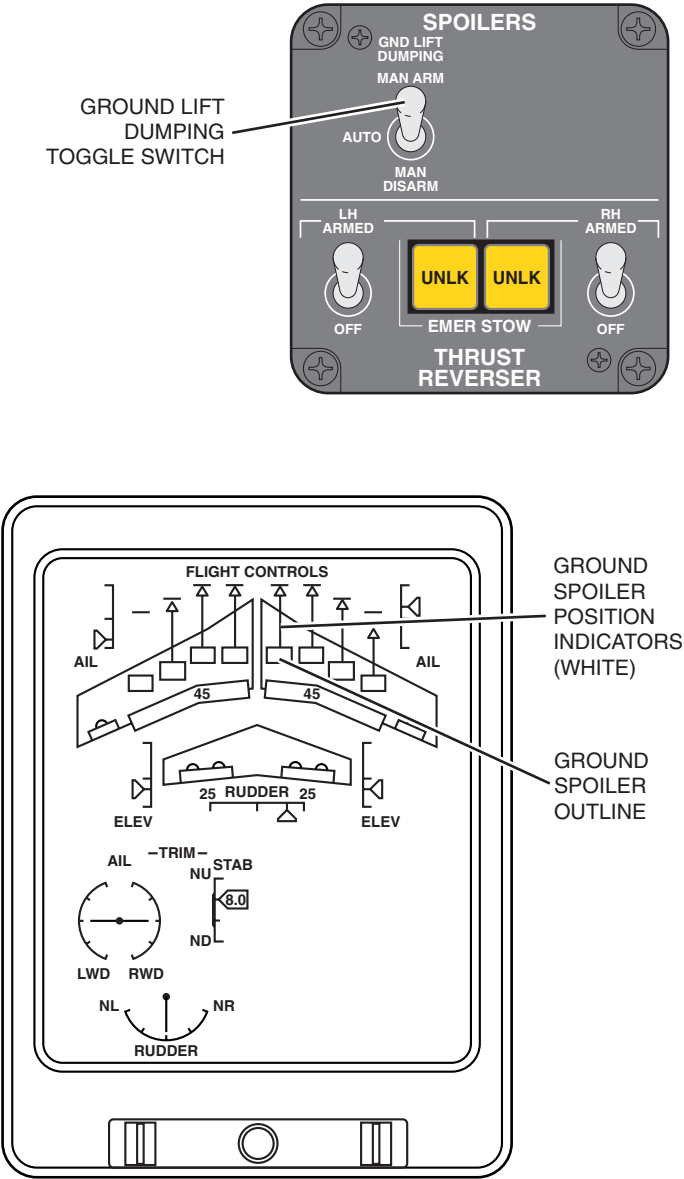


Figure 10-22 Ground Spoiler Controls and Indications



## Stall Protection

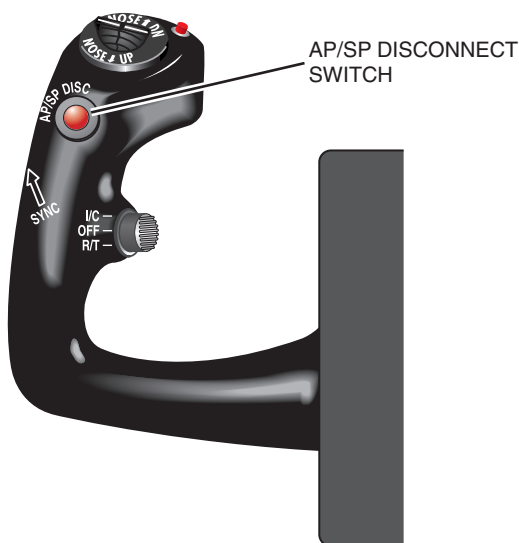
### AP/SP DISC Switch

Pushing the red AP/SP switch on either control wheel disengages the autopilot and momentarily disables the stick pusher (Figure 10-23).

#### NOTE

The stick pusher will re-engage once the AP/SP DISC switch is released.

When the autopilot disconnect switch is pressed and held for more than four seconds, the STALL FAIL caution message appears. The STALL FAIL messages goes out approximately one second after the switch is released.



**Figure 10-23 AP/SP DISC Switch**





## STALL PTCT PUSHER Switch

The two-position STAL PTCT PUSHER switch controls operation of the stick pusher (Figure 10-24).

ON—Arms the stick pusher only if both the CA's and FO's STAL PTCT PUSHER switches are ON

OFF—Disables the stick pusher

## EICAS PRIMARY DISPLAY

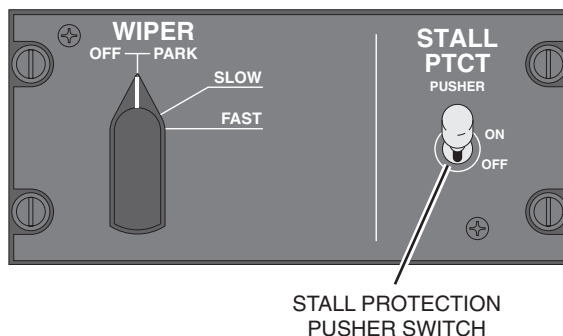
The EICAS primary display presents warning, caution, status, and advisory messages as they apply to flight control operation.

## Warning Messages

The following EICAS warning messages display in red:

CONFIG SPLRS—This warning appears when the airplane is in the takeoff configuration,  $N_1 > 70\%$  RPM, weight-on-wheels indication, thrust reversers stowed, and the flight spoilers deployed.

CONFIG STAB—This warning illuminates when the airplane is in takeoff configuration and the stabilizer is not in the takeoff range.



**Figure 10-24 STALL PTCT PUSHER Switch**



**CONFIG RUDDER**—Indicates the airplane is in the takeoff configuration and the rudder is out of center  $\pm 1^\circ$ .

**CONFIG AILERON**—Appears when the airplane is in the takeoff configuration and the ailerons are out of center  $\pm 1^\circ$ .

**CONFIG FLAPS**—Appears when the flaps are not in the takeoff setting with the rest of the airplane in takeoff configuration.

## Caution Messages

The following EICAS Caution messages display in amber:

**SPOILERONS ROLL**—Spoiler control should be transferred to the operative aileron circuit. This caution displays 20 seconds after the ROLL DISC handle is pulled if a ROLL SEL switchlight has not yet been pushed.

**YAW DAMPER**—Indicates that both channel YD 1 and channel YD 2 are not engaged.

**FLT SPLR DEPLOY**—Appears when the flight spoilers are deployed at an unsafe altitude lower than 300 feet AGL.

**L and R SPOILERON**—Appears when the associated spoileron is inoperative.

**L and R FLT SPLR Caution**—Appears when the associated flight spoiler is inoperative.

**FLT SPLRS**—Appears when the flight spoilers are inoperative.

**SPOILERONS**—Appears when the spoilerons are inoperative.

**STAB TRIM**—Indicates that both channels of the HSTCU are inoperative or not engaged.

**MACH TRIM**—Indicates that MACH trim is inoperative or disengaged.

**FLAPS FAIL**—Appears when both channels of the FECU fail.



**GND SPLR DEPLOY**—Indicates that a ground spoiler has extended while airborne (radar altitude > 10 feet AGL)

**OB GND SPLR**—Indicates that the outboard spoilers are inoperative

**IB GND SPLRS**—Indicates that the inboard spoilers are inoperative

**GLD NOT ARMED**—Indicates that the airplane is in either the takeoff or landing configuration and the ground spoilers are not armed

**GLD UNSAFE**—Indicates that the ground lift dumping system is in an unsafe condition—Inadvertent deployment may occur if the spoilers are not manually disarmed.

**STALL FAIL**—Indicates failure of one or both channels of the stall protection system which renders the stick pusher system inoperative—The white WINDSHEAR FAIL status message also appears indicating that windshear guidance is also inoperative on both sides.

**YAW DAMPER**—Indicates that both YD 1 and YD 2 channels are not engaged

## Advisory Messages

The following EICAS advisory messages appear in green:

**PLT or CPLT ROLL CMD**—Indicates which aileron circuit has spoileron control

**FLT SPLR DEPLOY Advisory (green)**—Indicates that the left or right flight spoilers are extended, the radar altitude is greater than 800 feet AGL, and both  $N_1$  RPMs < 79%, or that the radar altitude is invalid and the landing gear is not extended



**GND SPLR DEPLOY**—Indicates that the ground spoilers have deployed (radar altitude < 10 feet AGL)

**GLD MAN ARM**—Indicates the ground lift dump system has been manually armed

## Status Messages

The following EICAS status messages appear in white:

**SPOILERON FAULT** Status—Indicates a loss of redundancy in the spoileron control system

**FLT SPLRS FAULT** Status—Indicates a loss of redundancy in the flight spoiler control system

**STAB CH 1 or 2 INOP**—Indicates that the displayed channel is not engaged and that the other channel is engaged.

**OB GND SPLR FAULT**—Indicates a loss of redundancy or ground spoiler test inhibit in the outboard spoiler control

**IB GND SPLR FAULT**—Indicates a loss of redundancy or ground spoiler test inhibit in the inboard spoiler control

**GLD MAN DISARM**—Indicates that the ground lift dumping system has been manually disarmed

**WINDSHEAR FAIL**—Indicates that windshear guidance is inoperative on both sides

**YD 1 or YD 2 INOP**—The illuminated channel indicates that it is not engaged and that the other channel is engaged.

**FLAPS HALFSPEED** Status—Comes on to indicate that channel 1 or 2 of the FECU is inoperative resulting in a reduced flaps deployment and retraction rate.

**FLAPS DEGRADED** Status—Displayed for all skew detection sensors faults with the exception of DC power supply faults (DC power supply faults force system into the “halfspeed” mode when FLAPS HALFSPEED status message is displayed).



## POWER SUPPLY AND CIRCUIT-BREAKER SUMMARY

Table 10-3 shows the circuit breaker and electrical bus associated with each flight control system and subsystem.

**Table 10-3 POWER SUPPLY AND CIRCUIT-BREAKER  
SUMMARY**

| SYSTEM           | SUB-SYSTEM         | CB NOMEN-CLATURE        | BUS BAR          | CB PANEL NUMBER | CB LOCATION |
|------------------|--------------------|-------------------------|------------------|-----------------|-------------|
| Flaps            | Power Driver Units | FLAPS PDU 1             | AC Bus 1         | 1               | B5          |
|                  |                    | FLAPS PDU 2             | AC Bus 2         | 2               | B5          |
|                  | Flap Controllers   | FLAPS CONT CH 1         | DC Bus 1         | 1               | F4          |
|                  |                    | FLAPS CONT CH 2         | DC Bus 2         | 2               | F4          |
| Trims            | Rudder             | RUDDER TRIM             |                  |                 | F6          |
|                  | Aileron            | AILERON TRIM            |                  |                 | F7          |
| Stall Protection |                    | STALL PROT/R CH         | DC Essential Bus | 4               | C7          |
|                  |                    | STALL PROT/L CH         | DC Battery Bus   | 1               | Q2          |
|                  |                    | STALL PROT STICK PUSHER |                  |                 | Q1          |



**Table 10-3 POWER SUPPLY AND CIRCUIT-BREAKER SUMMARY (Cont)**

| SYSTEM           | SUB-SYSTEM                                | CB NOMEN-CLATURE | BUS BAR             | CB PANEL NUMBER | CB LOCATION |
|------------------|-------------------------------------------|------------------|---------------------|-----------------|-------------|
| Stabi-lizer Trim | Horizon-tal Stabi-lizer Trim Control Unit | STAB CH 1 HSTCU  | DC Bus 2            | 2               | F5          |
|                  |                                           | STAB CH 2 HSTCU  | DC Essen-tial Bus   | 4               | A1          |
|                  | Horizon-tal Stabi-lizer Trim Actuator     | STAB CH 2 HSTCU  | AC Bus 2            | 2               | B8          |
|                  |                                           | CH 2             | AC Essen-tial Bus   | 3               | A5          |
| Spoilers         | Spoiler ECU                               | SECU 1A          | DC Essen-tial Bus 1 | 4               | A2          |
|                  |                                           | SECU 1A and 1B   | DC Battery Bus      | 1               | N8          |
|                  |                                           | SECU 2A and 2B   | DC Battery Bus      | 2               | N8          |
|                  |                                           | SECU 2B          | DC Essen-tial Bus   | 4               | A3          |
|                  |                                           | SECS PWR 1       | DC Bus 1            | 1               | F3          |
|                  |                                           | SECS PWR 2       | DC Bus 2            | 2               | F3          |
|                  |                                           | SECS 1 PWR 3     | DC Essen-tial Bus   | 4               | A4          |
|                  |                                           | SECS 2 PWR 3     |                     |                 | A5          |