CHAPTER 11 – FLIGHT CONTROLS

LIST OF ILLUSTRATIONS

STALL PROTECTION SYSTEM

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1. INTRODUCTION

Flight controls are operated conventionally with control wheels, control columns and rudder pedals for the pilot and copilot. The control surfaces are actuated either hydraulically or electrically. The flight control systems include major control surfaces, components and subsystems that control the attitude of the aircraft during flight. The flight controls are divided into primary and secondary flight controls.

The primary flight controls consist of:

- Ailerons (roll control)
- Spoilerons (roll assist)
- Elevators (pitch control)
- Rudder (yaw control)
- Multifunctional spoilers.

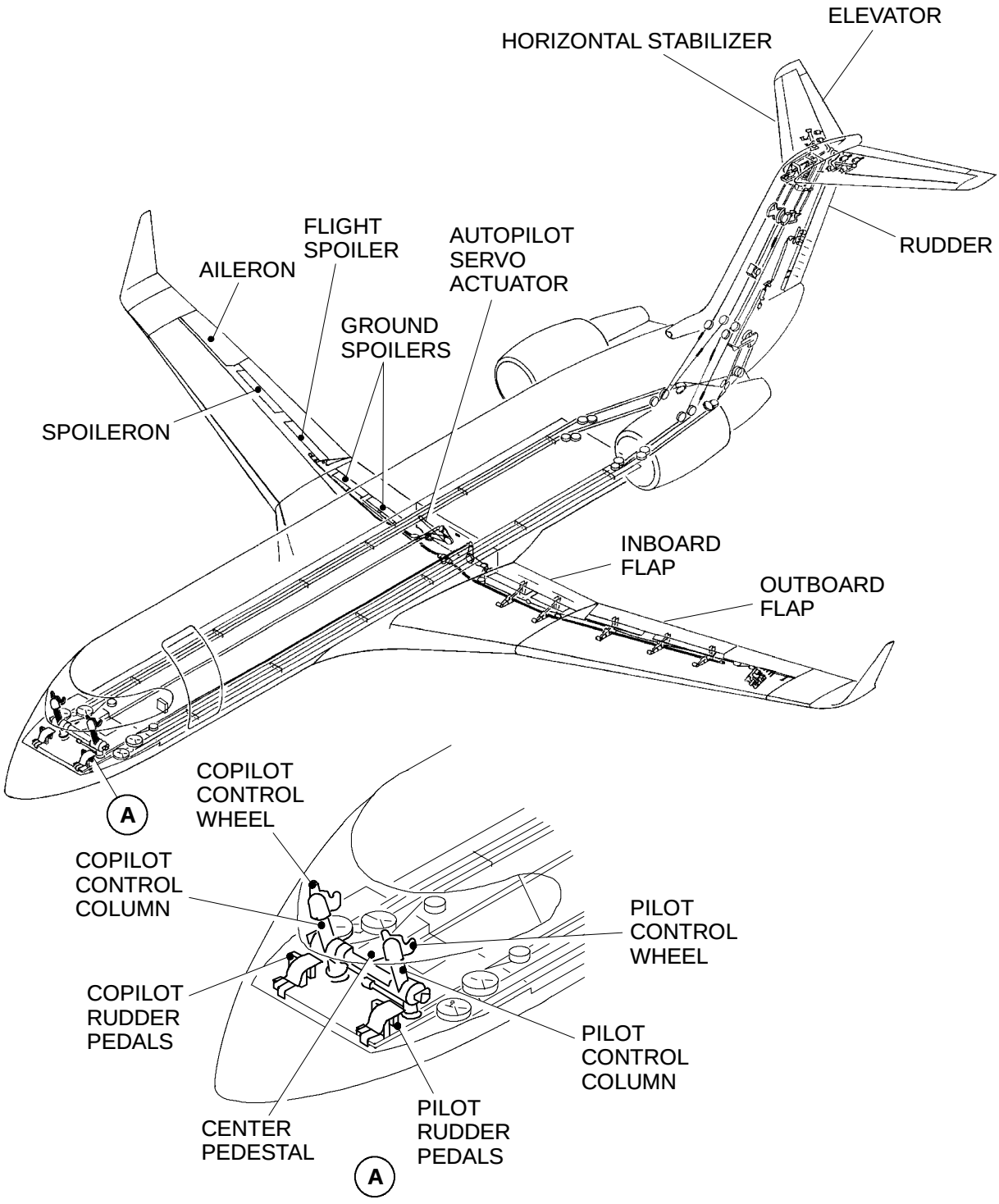
The secondary flight controls consist of:

- Flaps (inboard and outboard)
- Aileron trim
- Rudder trim
- Horizontal stabilizer trim
- Flight spoilers
- Ground spoilers (inboard and outboard).

Lateral (roll) control of the aircraft is provided by the ailerons, assisted by the spoilerons.

Directional (yaw) control of the aircraft is provided by the rudder, assisted by yaw dampers.

Longitudinal (pitch) control of the aircraft is provided by the elevators, assisted by a moveable horizontal stabilizer.



Flight Controls – General Arrangements
Figure 11–10–1

The primary flight controls are controlled by a network of cables, pulleys, push/pull rods and levers that transmit control and pedal inputs to hydraulic power control units. Each aileron and spoileron is powered by two hydraulic systems. The rudder and elevators are power from all three hydraulic systems.

The aileron and elevator controls are equipped with control disconnects which permit the pilot or the copilot to maintain sufficient lateral and longitudinal control in the event of a control jam. The rudder control is equipped with two anti-jam mechanisms that permit both pilots to maintain sufficient directional control, however, additional force is required to obtain surface travel.

In the event of a total electrical power failure, the primary flight controls will remain powered from AC motor pump (ACMP) 3B which will be powered by the ADG in an emergency.

The flight spoilers provides the aircraft with lift dumping and speed control as commanded from the spoiler control lever in the flight compartment.

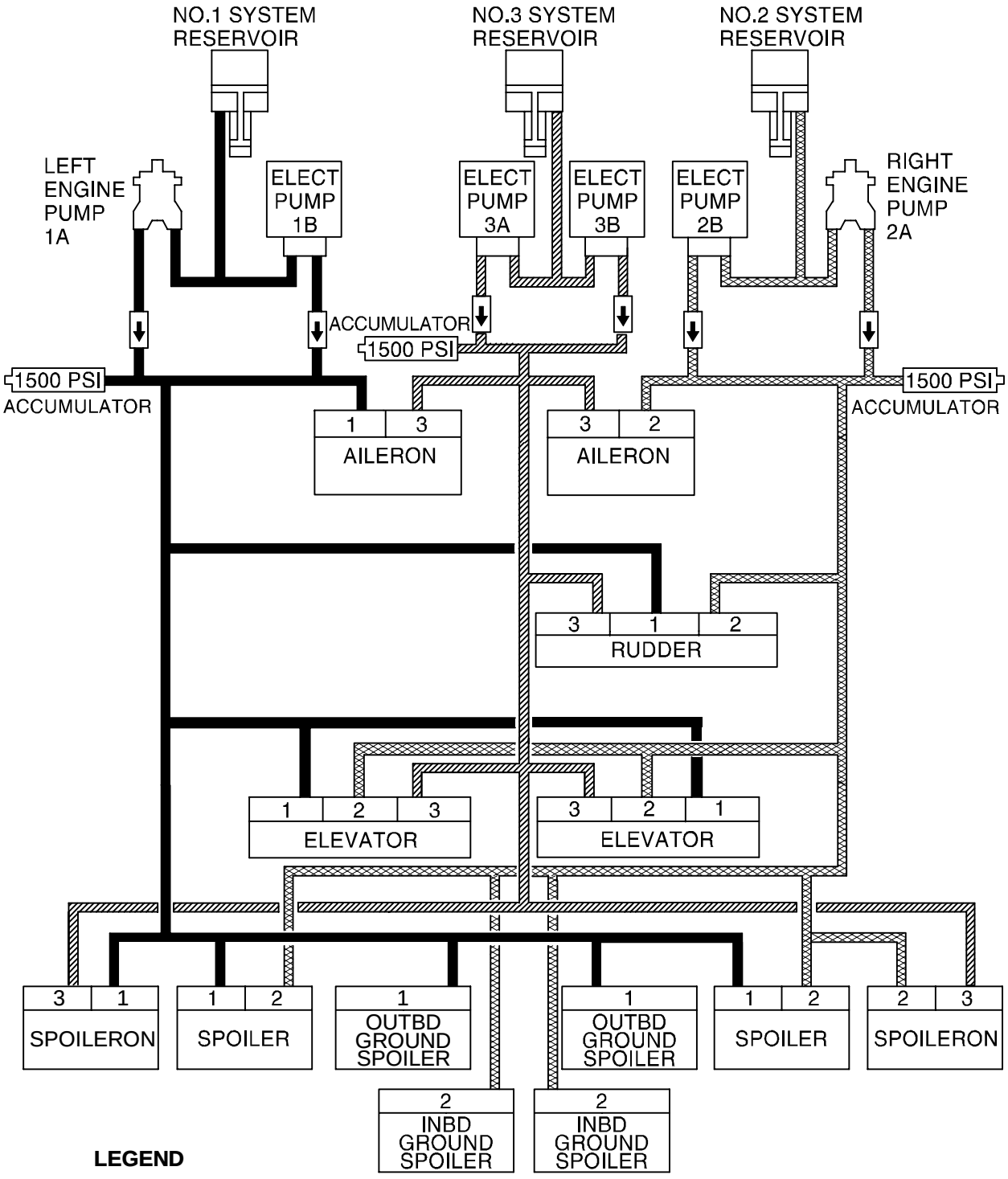
The ground spoilers only deploy on the ground as part of the ground lift dumping function to slow the aircraft during landing. The spoilerons and flight spoilers also deploy on the ground to assist in the ground lift dumping function.

Flight control status and surface positions are displayed on the EICAS primary page, status page and FLT CONTROL synoptic page.

A stall protection system is provided to warn the flight crew of an impending stall when the aircraft attitude approaches a high angle-of-attack (AOA) and to prevent a stall penetration when the aircraft nears the computed stall angle.

Hydraulic power distribution to the flight controls is as follows:

HYDRAULIC SYSTEM 1	HYDRAULIC SYSTEM 3	HYDRAULIC SYSTEM 2
Left Aileron	Left and Right Aileron	Right Aileron
Rudder	Rudder	Rudder
Left Elevator	Left and Right Elevator	Right Elevator
Left and Right Flight Spoilers	Left and Right Spoilerons	Left and Right Flight Spoilers
Left Spoileron		Right Spoileron
Left and Right Outboard Ground Spoilers		Left and Right Inboard Ground Spoilers



Flight Control Systems – Hydraulic Supply
Figure 11–10–2

1. AILERONS

Lateral control of the aircraft is provided by the ailerons with assist from the spoilerons.

The aileron control systems consist of two control circuits and both systems are similar in operation. The pilot operates the left aileron system and the copilot operates the right aileron system. Normally, the two systems are interconnected and there is simultaneous movement of both aileron surfaces. In the event of a jam in either circuit, the system can be separated through a roll disconnect mechanism. The autopilot is connected to the copilots control system only.

Each aileron is hydraulically powered by two power control units (PCUs) and mechanically controlled by rotation of either control wheel. The left aileron PCUs are powered by hydraulic systems 1 and 3 and the right aileron PCUs are powered by hydraulic systems 2 and 3. Control wheel movement also signals the spoiler electronic control unit (SECU) to input the spoileron actuators (on the down-going wing) for roll assist.

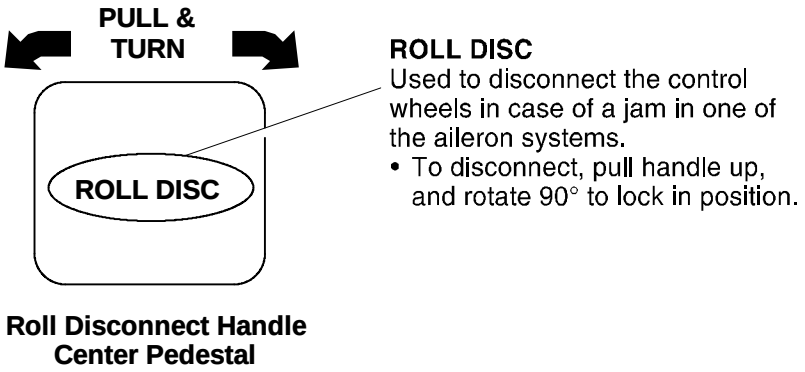
Control wheel centering and artificial feel is provided by mechanical feel units. A flutter damper is attached to each aileron to prevent surface flutter in the event of hydraulic fluid loss at the PCUs during flight. On the ground, the flutter dampers provide gust lock function.

In the event of an aileron control jam, the left and right systems can be mechanically separated by pulling a roll disconnect handle. The roll disconnect allows limited lateral control using the unaffected aileron control system and the opposite side spoileron. Twenty seconds after pulling the roll disconnect handle, the ROLL SEL (amber) switchlights on the left and right glareshield illuminate and a SPOILERON ROLL caution message is displayed on the EICAS primary page. The flight crew then selects the roll priority by pressing the ROLL SEL switchlight on the operable side which allows use of both spoilerons. The ROLL SEL light and PLT/CPLT ROLL light will then turn green and the caution message will be replaced by a PLT/CPLT ROLL CMD advisory message on the EICAS status page.

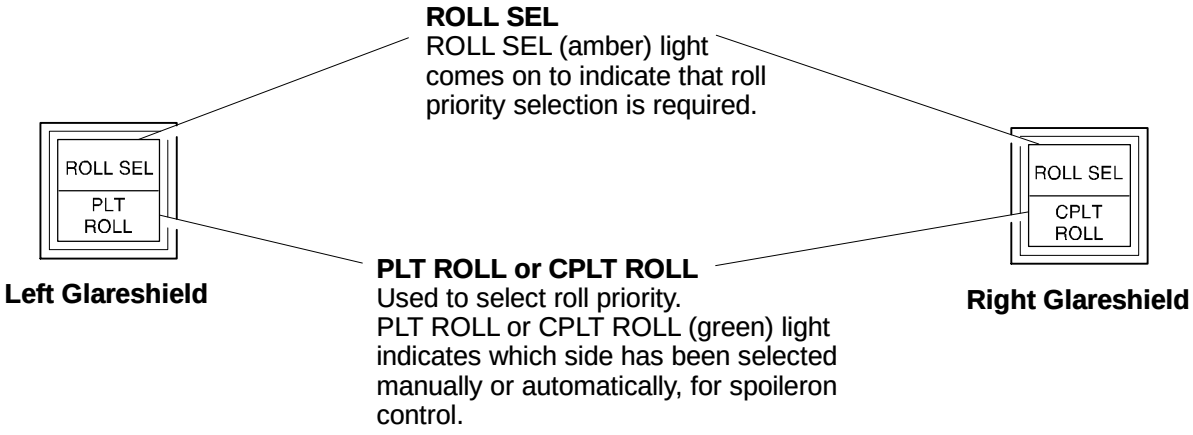
NOTE

It is not recommended to operate the automatic flight control system (AFCS) autopilot, if a jammed aileron control circuit condition exists.

If uncommanded movement of a PCU occurs, the SECU's command both spoilerons to respond to control wheel inputs. The green ROLL SEL light illuminates and the PLT or CPLT ROLL CMD advisory message is displayed on the EICAS status page. The roll disconnect handle should then be pulled.



Ailerons – Emergency Control
Figure 11–20–1

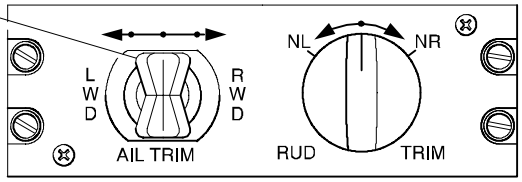


Ailerons – Glareshield Emergency Control
Figure 11–20–2

A. Aileron Trim

Aileron trim is electrically operated and manually controlled using the trim selector on the center pedestal. Operation of the aileron trim will input the aileron trim actuator to reposition the aileron control cables which will cause deflection (rotation) of the control wheels. Aileron trim is displayed on the EICAS Status page and FLT CONTROL synoptic page.

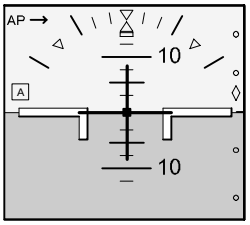
AIL TRIM
Used to control aileron trim.
Spring loaded to center position.
- LWD – Trims left wing down.
- RWD – Trims right wing down.



Aileron / Rudder Trim Panel
Center Pedestal

Ailerons – Trim Control
Figure 11–20–3

Aileron Mistrim Indicator (yellow)
Indicates that the ailerons are in a mistrim condition, when the autopilot is engaged.



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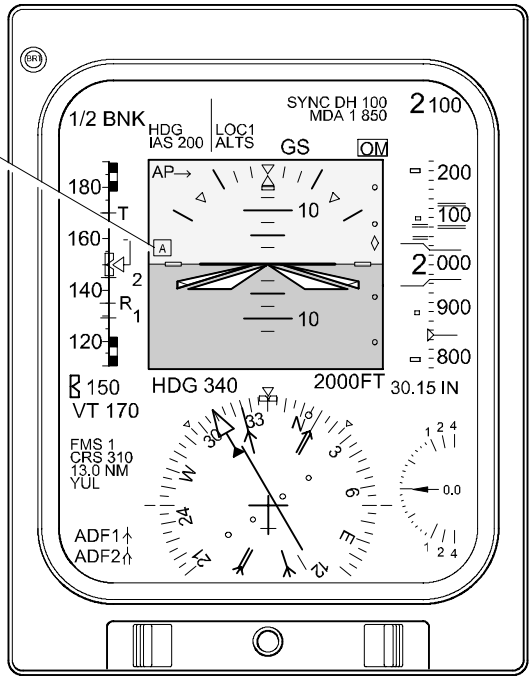
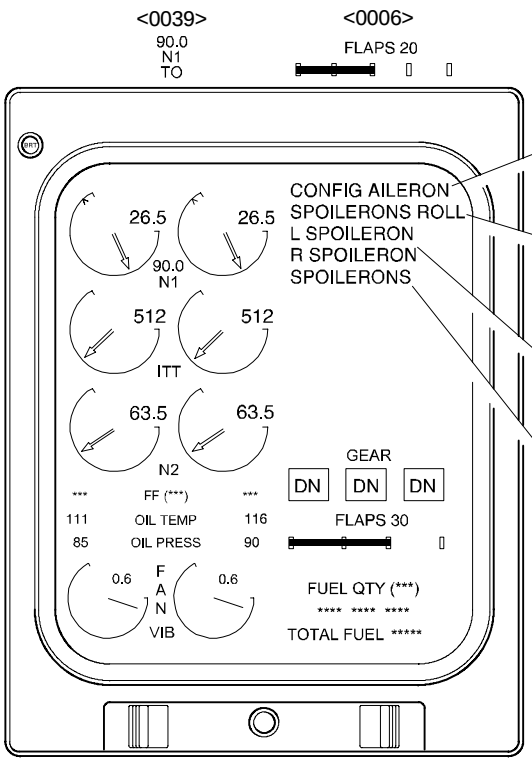


Primary Flight Display
Pilot's and Copilot's Instrument Panels

Aileron Mistrim Flag <MST>
Figure 11–20–4



Primary Page

CONFIG AILERON warning (red)
Comes on when airplane is in the take-off configuration (N1 > 70% RPM with WOW, thrust reversers not deployed) and ailerons are trimmed out of centre (± 1.0 degree).

SPOILERONS ROLL caution (amber)
Comes on to indicate that spoiler control should be transferred to the operative aileron circuit.
- Displayed 20 seconds after the ROLL DISC handle is pulled if a ROLL SEL switch/light has not been pushed.

L, R SPOILERON caution (amber)
Comes on when the respective spoileron is inoperative.

SPOILERONS caution (amber)
Comes on to indicate that the spoilerons are inoperative.

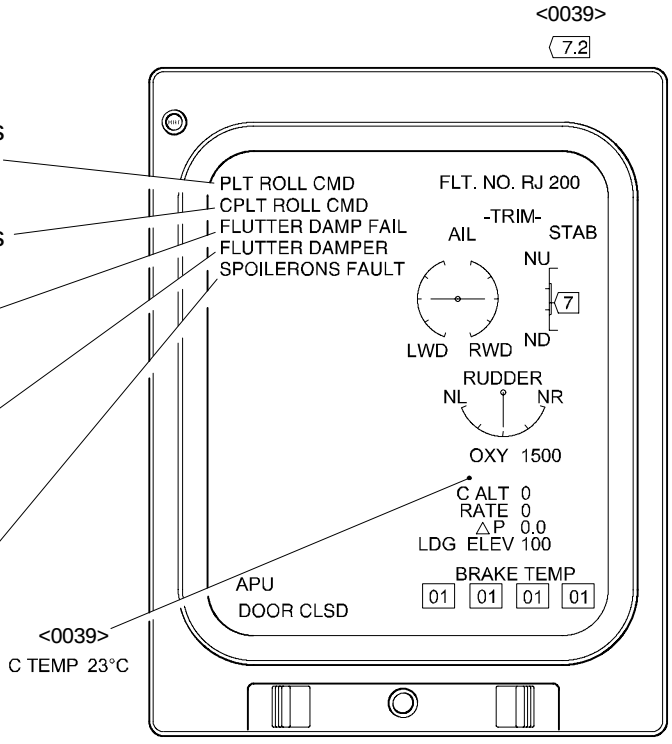
PLT ROLL CMD advisory (green)
Comes on to indicate that spoileron control has been selected to the pilot's aileron circuit.

CPLT ROLL CMD advisory (green)
Comes on to indicate that spoileron control has been selected to the copilot's aileron circuit.

FLUTTER DAMP FAIL status (white)
Comes on to indicate that one or more flutter dampers of the left or right aileron or left or right elevator has failed or has low hydraulic fluid level (<20%).

FLUTTER DAMPER status (white) <0039>
Comes on to indicate that one or more flutter dampers of the left or right aileron or left or right elevator has failed or has low hydraulic fluid level (<20%).

SPOILERONS FAULT status (white)
Comes on to indicate loss of redundancy in the spoileron control.



Status Page

Aileron System – EICAS Messages <MST>
Figure 11–20–5

Spoileron Position Indicator (white)
Indicates relative position of respective spoiler. Indicator is not displayed when respective spoiler is retracted or input data is invalid.

Aileron Position Scale (white)
Top tick mark represents 24 degrees up, center tick mark represents 0 degrees and bottom tick mark represents 20 degres down.

Maximum Spoileron Deployment Mark (white)
Indicates full deployment point of respective spoileron.

<0039>

Aileron Position Indicator (white) <0039>
Indicates relative position of respective aileron.

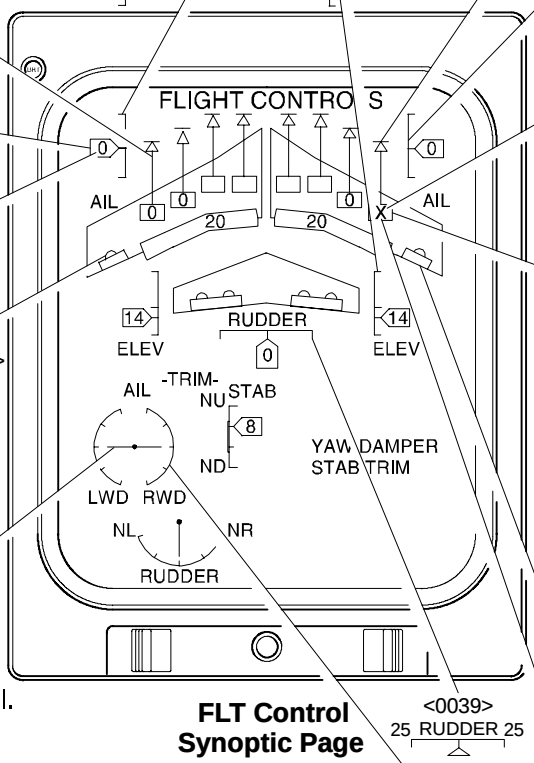
Spoiler Deployment Readout (white)
Indicates angle of deployment, in degrees, of respective spoiler. Two amber dashes are displayed when input data is invalid.

Aileron Position Readout (white)
Numeric value represents position of respective aileron in degrees.

Spoileron Outlines
- Green – Both respective spoiler electronic control units (SECU) and both respective power control units (PCU) are operative.
- White – One of the SECU or one of the PCU is inoperative.
- Amber – Both respective SECUs and/or both respective PCUs are inoperative.
- Half–Intensity Magenta – Input data invalid.

<0039>

Flutter Damper Icons (aileron)
If displayed (white), indicates respective flutter damper(s) has failed, or has low hydraulic fluid level.



FLT Control Synoptic Page

Aileron Outlines (blue)

<0039>
An amber X is displayed when input data is invalid, and position indicator (arrow) is removed.
A spoileron with an amber X indication may still operate normally.

Aileron Trim Pointer
- Green - Aileron trim actuator position is displaced ≤ 0.5 ° from level.
- White - The aileron trim pointer will indicate white during the following conditions:
- Airborne for more than 15 seconds, or
- Airplane previously airborne for more than 15 seconds and airplane on the ground for up to 30 seconds, or
- Aileron trim ± 0.5 ° from level.

Aileron Trim Pointer <0039>
- Green - Aileron trim actuator position is displaced ≤ 1 ° from level.
- White - The aileron trim pointer will indicate white during the following conditions:
- Airborne for more than 15 seconds, or
- Airplane previously airborne for more than 15 seconds and airplane on the ground or up to 30 seconds, or
- Aileron trim ± 1 ° from level.

Aileron Trim Scale (white)
- LWD - Left wing down, bottom left tick mark represents -7.54 °.
- RWD - Right wing down, bottom right tick mark represents 7.54 °.

Flight Control Synoptic Page <MST>
Figure 11–20–6

B. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Ailerons	Trim	AILERON TRIM	DC BUS 2	2	F7	

1. RUDDER

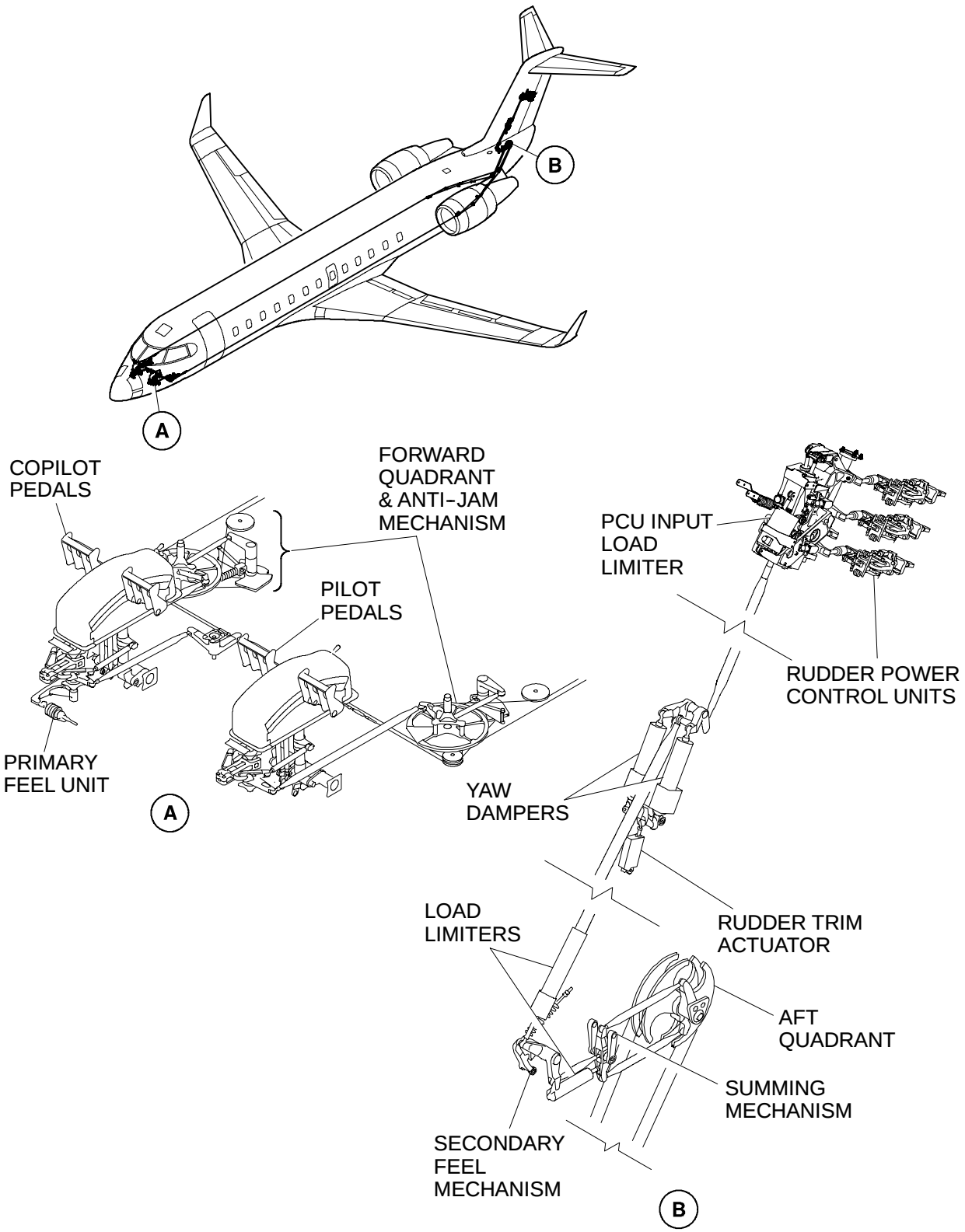
Directional control about the yaw axis is provided by the rudder control system and assisted by yaw dampers.

The rudder is hydraulically powered by three power control units (PCU's) located in the vertical stabilizer. The PCUs receive mechanical inputs from the rudder pedals via cable runs and quadrants. Each hydraulic system powers one of the three PCU's. Both sets of pedals move simultaneously when operated from either the pilot or the copilot station. Two yaw dampers (controlled by the flight control computers) are connected to the rudder control system and are used to improve the aircraft lateral stability.

Rudder pedal centering and artificial feel is provided by a primary feel unit, located on the copilots rudder pedal pivot assembly. A secondary feel unit, located in the aft fuselage, ensures that the rudder remains centered in the event of a control disconnect.

In the event of a control jam, the pilots and copilot's pedals will remain operable through anti-jam mechanisms, however additional pedal force will be required to obtain rudder deflection.

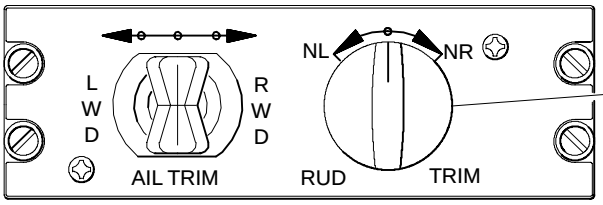
Two rudder load limiter assemblies, installed in the vertical stabilizer, give overload (stress) protection to the rudder control system mechanical components. A rudder load limiter, installed in the PCU input assembly, allows continued control input movement to the remaining PCU's if one PCU becomes jammed.



Rudder System
Figure 11–30–1

The rudder trim is electrically operated and manually controlled using the trim selector on the center pedestal. Operating the trim selector to the NL/NR (nose left/nose right) repositions the rudder control cables to move the rudder. Hydraulic pressure from at least one of the hydraulic system is required to move the rudder. Actuation of the rudder trim will not cause rudder pedal deflection.

Rudder trim indications are displayed on the EICAS Status page and FLT CONTROL synoptic page. On the ground, with the rudder trim in the neutral position, the trim indication is green. In flight, the indication is white regardless of trim position.



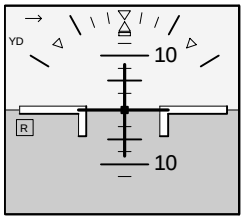
Aileron/ Rudder Trim Control Panel
Center Perdestal

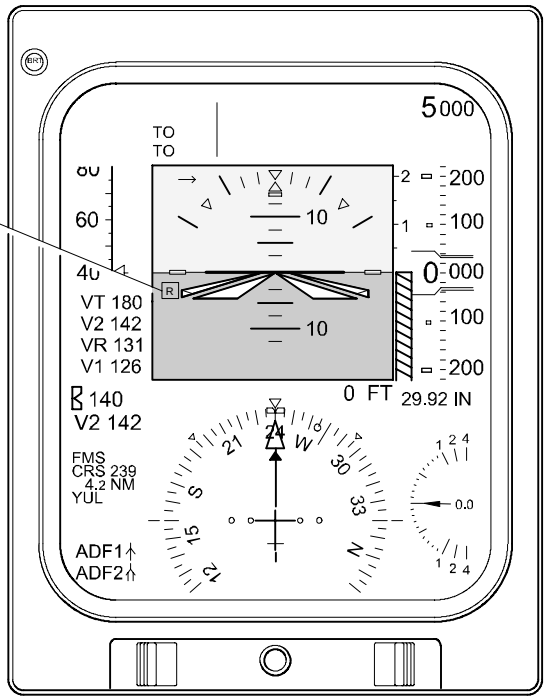
RUD TRIM
Used to control rudder trim.
Spring loaded to centre position.
- NL – Increases rudder trim to nose left.
- NR – Increases rudder trim to nose right.

NOTE
Switch must be rotated fully left or fully right to activate trim.

Rudder Mistrim Indicator (yellow)
Indicates that the rudder is in a mistrim condition, when the autopilot is engaged.

<0015>





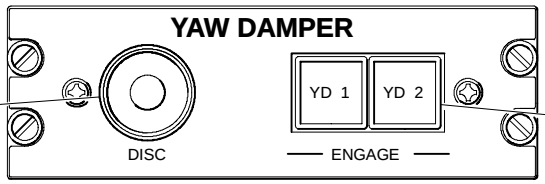
Primary Flight Display
Pilot's and Copilot's Instrument Panels

Rudder Trim Control Panel and Rudder Mistrim Indicator <MST>
Figure 11–30–2

Two independent yaw damper systems operate continuously in flight to improve the aircraft directional stability and turn coordination by damping out oscillations in yaw. The yaw dampers are engaged by pushing the YD1 and YD2 switchlights on the YAW DAMPER panel. Each yaw damper actuator automatically respond to inputs received from one flight control computer (FCC). If a yaw damper failure occurs, it will be disconnected from the FCC's control. One yaw damper system must be engaged to engage the autopilot.

NOTE

During ground operations, power switching of the APU generator to IDG 2, and vice versa, will cause a momentary power loss on DC Bus 2, which will disengage Yaw Damper #2. To re-engage Yaw Damper #2, wait 30 seconds (with the aircraft stationary) before pressing the YD 2 switchlight.



DISC
Used to disengage yaw dampers

ENGAGE
Used to engage respective yaw damper channel.

Yaw Damper Panel
Center Pedestal

YD (amber)
Indicates that both yaw dampers have been disengaged.

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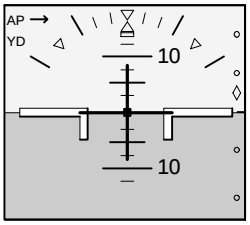
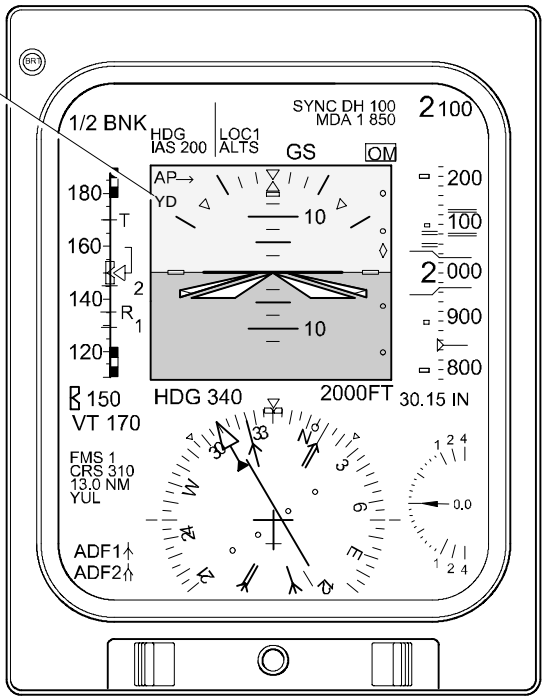
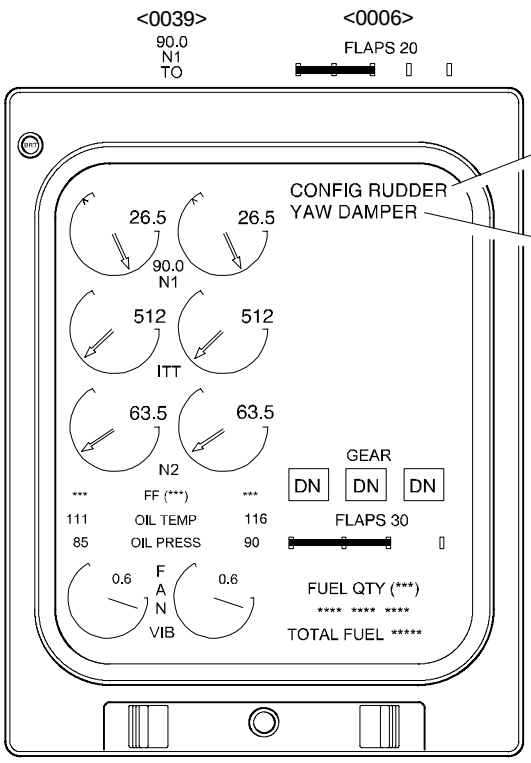




Primary Flight Display
Pilot's and Copilot's Instrument Panels

Yaw Damper Controls and PFD Flag <MST>
Figure 11–30–3



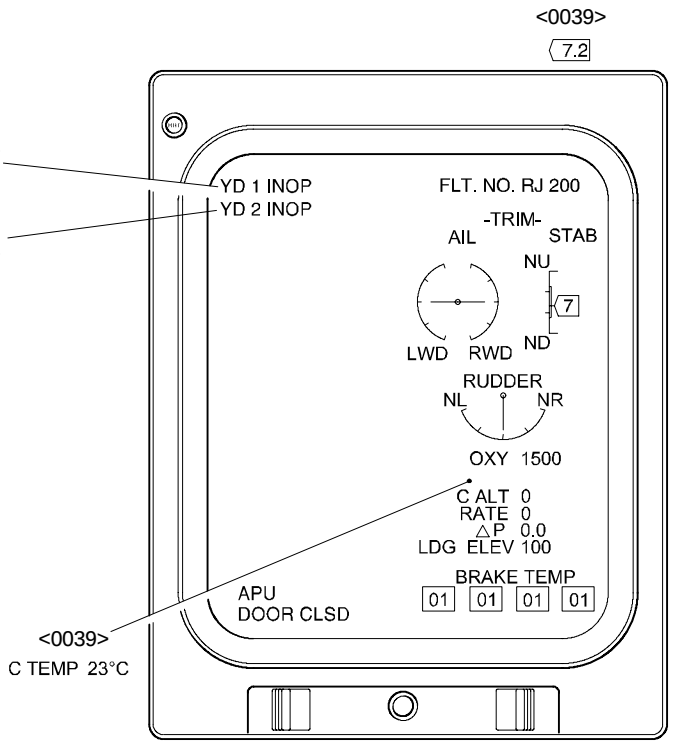
Primary Page

CONFIG RUDDER warning (red)
Comes on when airplane is in the take-off configuration (N1 > 70% RPM with WOW, thrust reversers not deployed) and rudder is trimmed out of centre (± 1.0 degree).

YAW DAMPER caution (amber)
Comes on to indicate that channel YD 1 and channel YD 2 are disengaged.

YD 1 INOP status (white)
Comes on to indicate that channel YD 1 is disengaged with channel YD 2 engaged.

YD 2 INOP status (white)
Comes on to indicate that channel YD 2 is disengaged with channel YD 1 engaged.



Status Page

Rudder System – EICAS Messages <MST>
Figure 11–30–4

Rudder Position Scale (white) <0005><0073>
Left tick mark represents 25 degrees, center tick mark represents 0 degrees and right tick mark represents 25 degrees.

Rudder Position Scale (white)
Left tick mark represents 33 degrees, center tick mark represents 0 degrees and right tick mark represents 33 degrees.

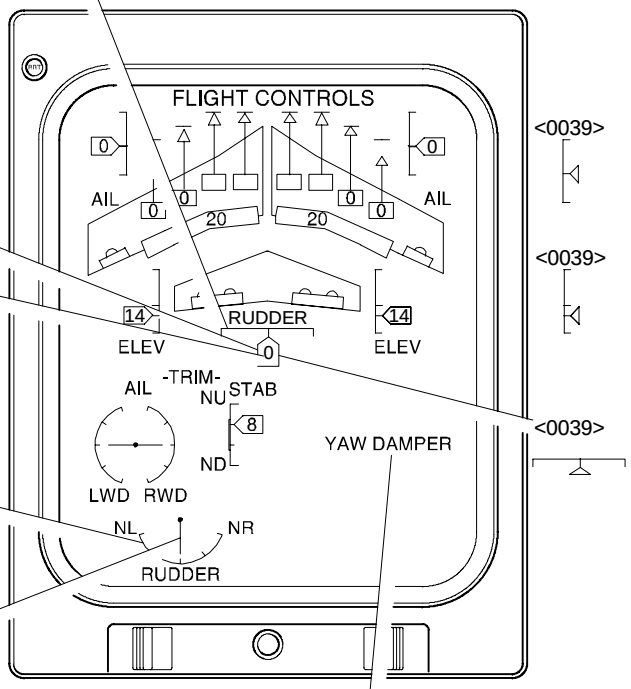
Rudder Position Indicator (white) <0039>
Indicates relative position of rudder.

Rudder Position Readout (white)
Numeric value represents position of rudder in degrees.

Rudder Trim Scale (white)
- NL - Nose left, far left tick mark represents 8.56 °.
- NR - Nose right, far right tick mark represents -8.56 °.

Rudder Trim Pointer (white)
- Green - Rudder trim actuator position is displaced ≥ 0.5 ° from centre.
- White - The rudder trim pointer will indicate white during the following conditions:
- Airborne for more than 15 seconds, or
- Airplane previously airborne for more than 15 seconds and airplane on the ground for up to 30 seconds, or
- Rudder trim ± 0.5 ° from centre.

Rudder Trim Pointer (white) <0039>
- Green - Rudder trim actuator position is displaced ≤ 1 ° from centre.
- White - The rudder trim pointer will indicate white during the following conditions:
- Airborne for more than 15 seconds, or
- Airplane previously airborne for more than 15 seconds and airplane on the ground for up to 30 seconds, or
- Rudder trim ± 1 ° from centre.



FLT Control Synoptic Page

YAW DAMPER caution (amber)
Comes on to indicate that both yaw dampers have failed.

YAW DAMPER 1/2 INOP status (white)
Comes on to indicate that the respective yaw damper has failed.

Rudder System – Synoptic Page Indications <MST>
Figure 11–30–5

A. System Circuit Breakers

SYSTEM	SUB–SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Rudder	Trim	RUDDER TRIM	DC BUS 2	2	F6	

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1. ELEVATORS

Longitudinal (pitch) control is provided by the elevators and supplemented by a moveable horizontal stabilizer (see section 50 of this chapter).

Two separate elevator control systems are provided. The left elevator system is controlled by the pilot and the right system is controlled by the copilot. Under normal conditions, the two systems are interconnected through a pitch disconnect mechanism. Forward and aft movement of either control column inputs simultaneous movement of both elevator surfaces. Both systems are similar, with the exceptions that the autopilot servo is connected to the left elevator system and the stall protection stick pusher system is connected to the right elevator system. A pitch feel simulator unit provides artificial feel to the control columns.

Each elevator system is hydraulically powered by three power control units (PCU's) located in the left and right horizontal stabilizers. The PCU's receive mechanical inputs from the control columns via cable runs and quadrants. Each hydraulic system powers one of the three PCU's of each elevator.

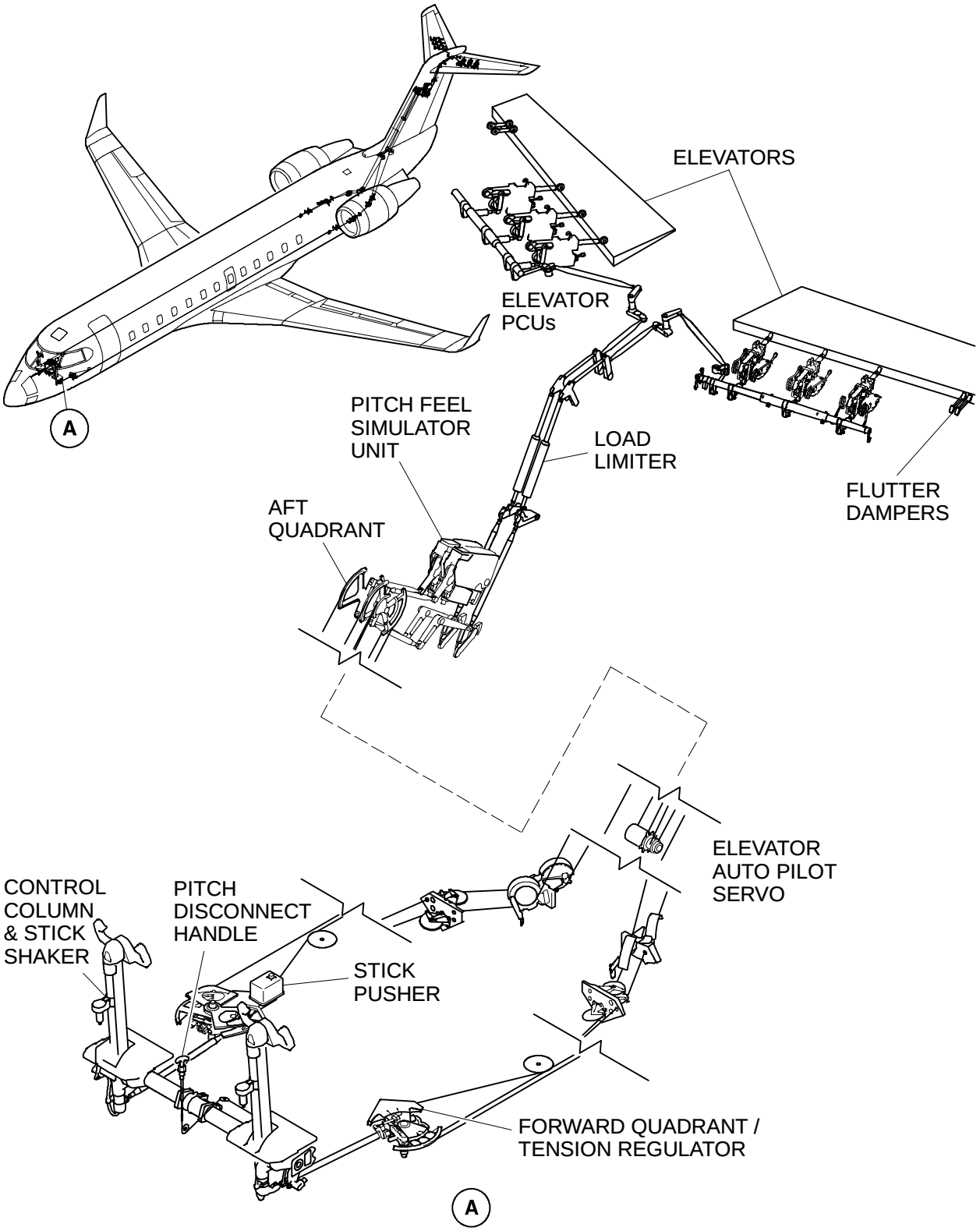
Two flutter dampers are installed outboard of the PCU's on each elevator. The flutter dampers are double acting shock absorbers which prevent elevator control surface flutter in flight if all hydraulic pressure is lost to the PCU's. On the ground, the flutter dampers provide a gust lock function.

In the event of an elevator control jam, the left and right elevator systems can be mechanically separated by pulling a PITCH DISC handle and turning it 90° to lock the handle in place. The operable side can then be used to maintain pitch control.

Elevator position indications are displayed on the EICAS FLT CONTROL synoptic page.

NOTE

A difference of up to 3 degrees between the left and right elevator indications on the FLT CONTROL synoptic page is allowed. When the elevator is in the neutral position (0° ± 0.5°), a tolerance of ± 1.0° in the indication is allowed.



Elevator System
Figure 11–40–1

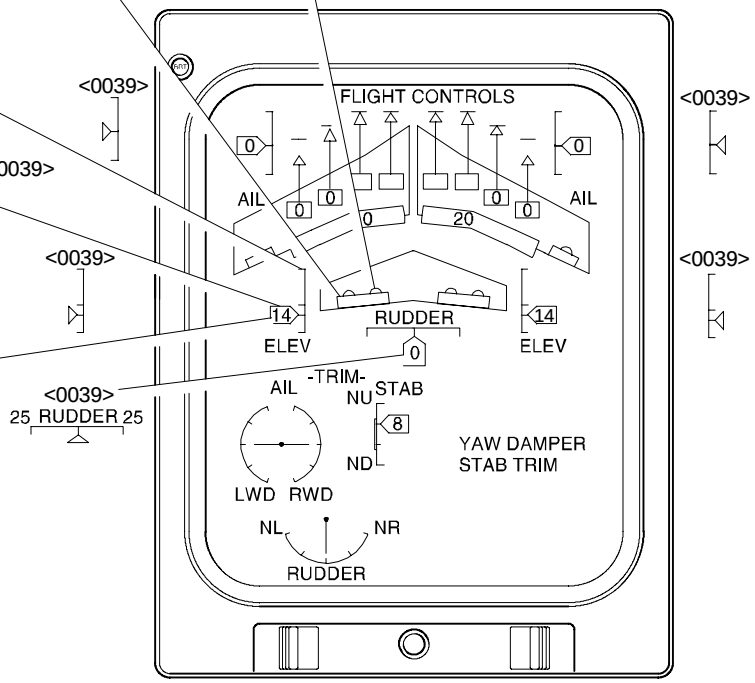
Elevator Flutter Damper Outlines (white)
Comes on to indicate that respective elevator flutter damper has failed.

Elevator Outlines (blue)

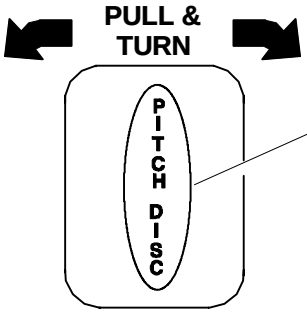
Elevator Position Scale (white)
Top tick mark represents 23.6 degrees, center tick mark represents 0 degrees and bottom tick mark represents –18.4 degrees.

Elevator Position Indicator (white) <0039>
Indicates relative position of respective elevator.

Elevator Position Readout (white)
Numeric value represents position of respective elevator in degrees.



FLT Control Synoptic Page



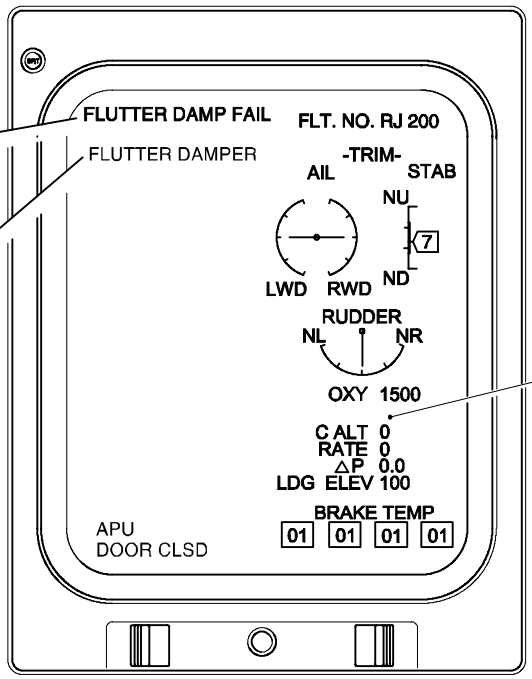
PITCH DISC
Used to disconnect the control columns in case of a jam in one of the elevator systems.
- To disconnect, pull handle up, and rotate 90 º to lock in position.

Pitch Disconnect Handle
Center Pedestal

Elevator System – Synoptic Page Indications and Pitch Disconnect Handle <MST>
Figure 11–40–2

FLUTTER DAMP FAIL status (white)
Comes on to indicate that one or more flutter dampers of the left or right aileron or left or right elevator has failed or has low hydraulic fluid level (≤ 20 %).

FLUTTER DAMPER status (white) <0039>
Comes on to indicate that one or more flutter dampers of the left or right aileron or left or right elevator has failed or has low hydraulic fluid level (≤ 20 %).



<0039>
7.2

<0039>

Status Page

Elevator System – EICAS Messages <MST>
Figure 11–40–3

1. HORIZONTAL STABILIZER TRIM

The horizontal stabilizer trim system supplements the elevators in providing pitch control.

The horizontal stabilizer trim system provides pitch trim by varying the angle of incidence of the horizontal stabilizer. The horizontal stabilizer is positioned by a screw jack driven by two electric motors controlled by the horizontal stabilizer trim control unit (HSTCU) through a motor control unit (MCU). Each motor has a magnetic brake to prevent trim runaway. Trim range is from +2° (leading edge up) to −13° (leading edge down).

The HSTCU has two channels that are engaged by selection of the STAB TRIM, CH1 and CH2 engage switches on the center pedestal. The horizontal stabilizer is positioned, by manual operation of the control wheel trim switches or automatically by the autopilot trim or Mach trim systems. During AFCS operation, the trim rate is influenced by flap movement.

Trim disconnect switches are provided on each control wheel to disengage the stabilizer trim.

The Mach trim system is selected by engaging the Mach TRIM switchlight on the center pedestal. The Mach trim function of the HSTCU repositions the horizontal stabilizer to make allowances for the rearward shift of the aerodynamic center of pressure as the airspeed increases above Mach 0.4. At least one STAB channel must be engaged for the Mach trim to function.

The HSTCU operates in one of four modes in the following order of priority:

- Manual trim – Nose-up or nose-down trim commands (from the control wheel switches) are sent to the HSTCU which moves the screw jack at a rate that is dependent on Mach airspeed.

- Autopilot – When the AP is engaged, the horizontal stabilizer is trimmed at two rates. High rate (0.5° per second) occurs when the flaps are extending and retracting and low rate (0.1° per second) occurs when the flap are stationary.

- AUTO trim – Auto trim occurs when the flaps are moving between 0 – 20° in either direction. In this condition the horizontal stabilizer is automatically trimmed to compensate for aircraft pitching caused by flap configuration changes.

- Mach trim – When the Mach trim is engaged, the horizontal stabilizer trim is adjusted (at a rate of 0.03° to 0.06°per second) to compensate for the aircraft tendency to pitch down at increasing Mach numbers. The Mach TRIM function is disabled when the autopilot is engaged.

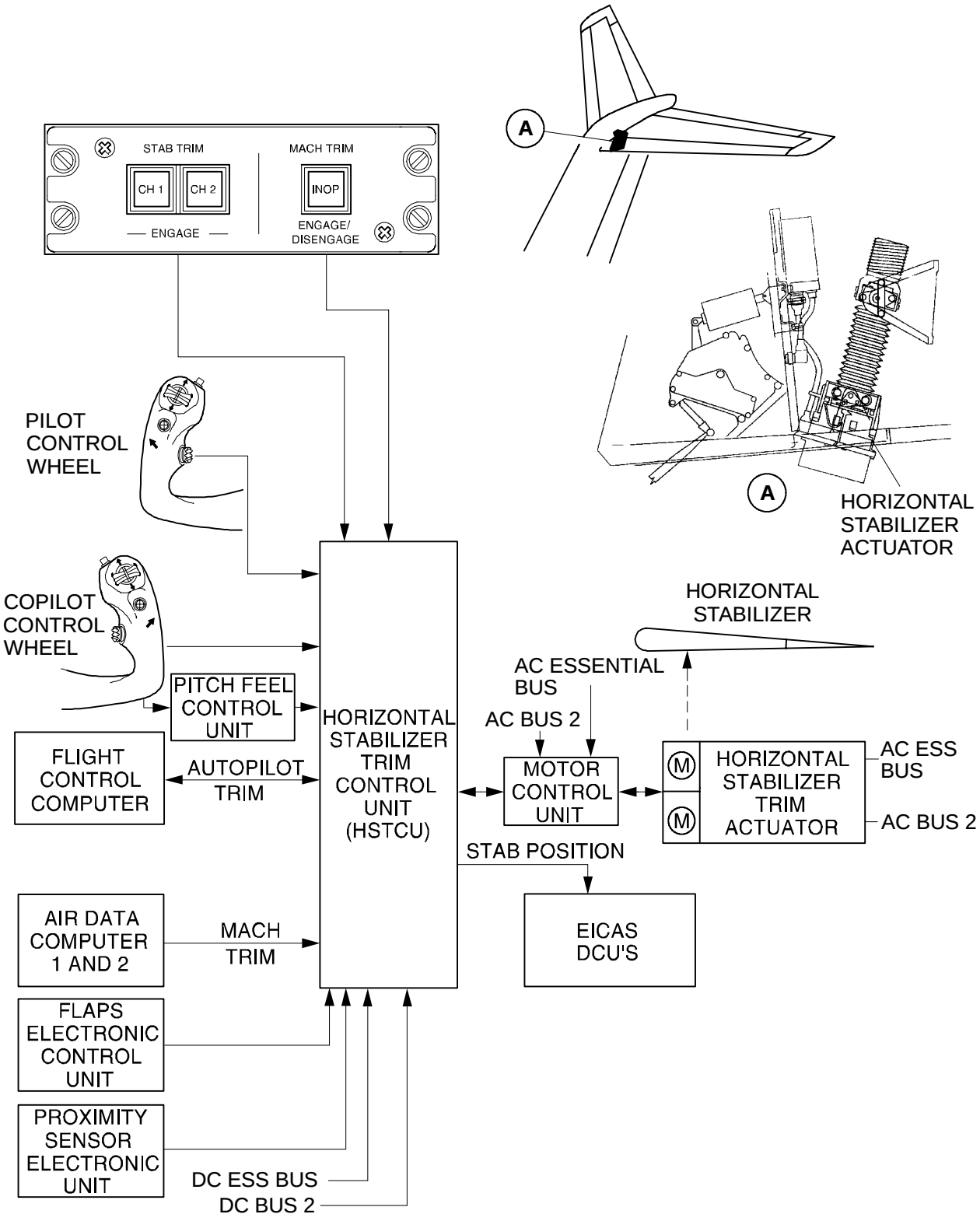
NOTE

If the horizontal stabilizer is in motion at the high or slow rate for more than 3 seconds, a clacker is activated to alert the crew of a possible horizontal stabilizer trim runaway condition.

Horizontal stabilizer trim position indication is displayed on the EICAS Status page and on the FLT CONTROL synoptic page.

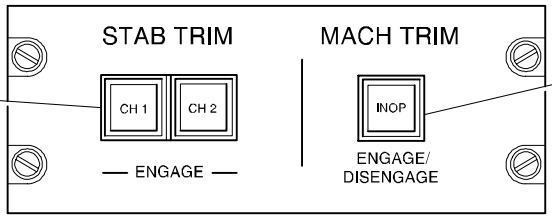
NOTE

The T/O CONFIG OK advisory message will come on when the horizontal stabilizer trim indication is within the green band on the stabilizer trim scale. <0039>



Horizontal Stabilizer System
Figure 11–50–1

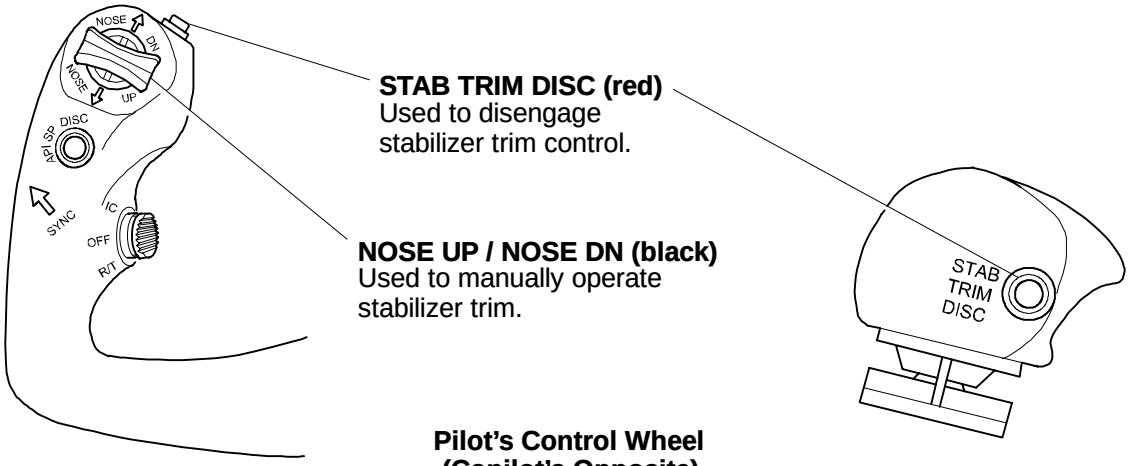
STAB TRIM
Used to engage respective stabilizer trim channel.



MACH TRIM
Used to engage Mach trim function.
- To disengage the Mach trim function, press the MACH TRIM switch/light; INOP light (amber) comes on.

Stabilizer/ Mach Trim Panel
Center Pedestal

Stabilizer/ Mach Trim Control Panel
Figure 11–50–2



STAB TRIM DISC (red)
Used to disengage stabilizer trim control.

NOSE UP / NOSE DN (black)
Used to manually operate stabilizer trim.

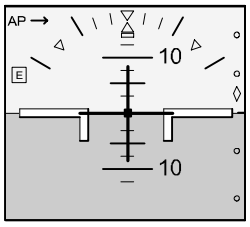
Pilot's Control Wheel
(Copilot's Opposite)

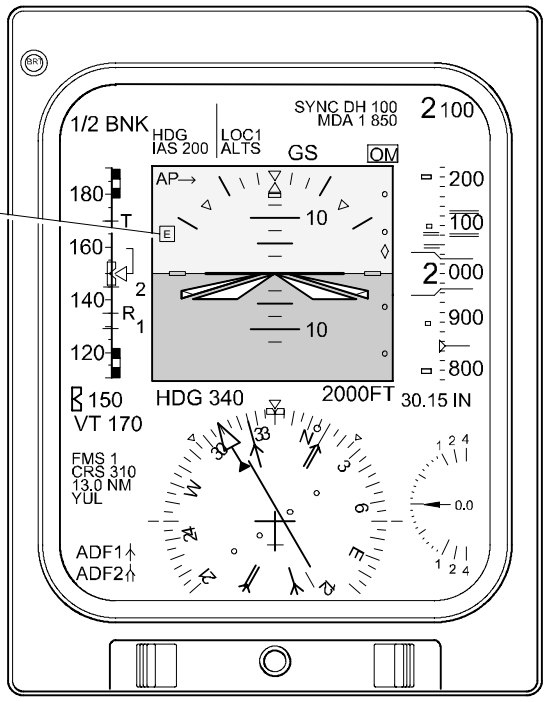
TOP VIEW

Stabilizer Trim – Pilot's Control Wheel
Figure 11–50–3

Elevator Mistrim Indicator (yellow)
Indicates that the horizontal stabilizer is in a mistrim condition, when the autopilot is engaged.

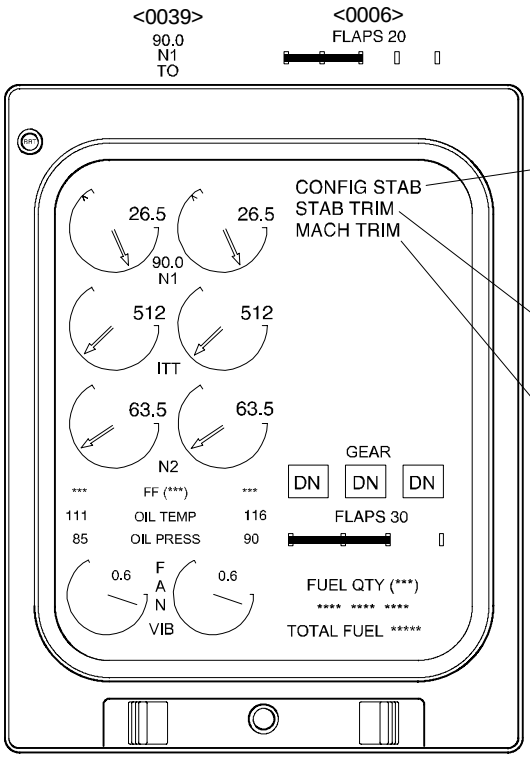
<0015>





Primary Flight Display
Pilot's and Copilot's Instrument Panels

Elevator Mistrim Flag – PFD <MST>
Figure 11–50–4



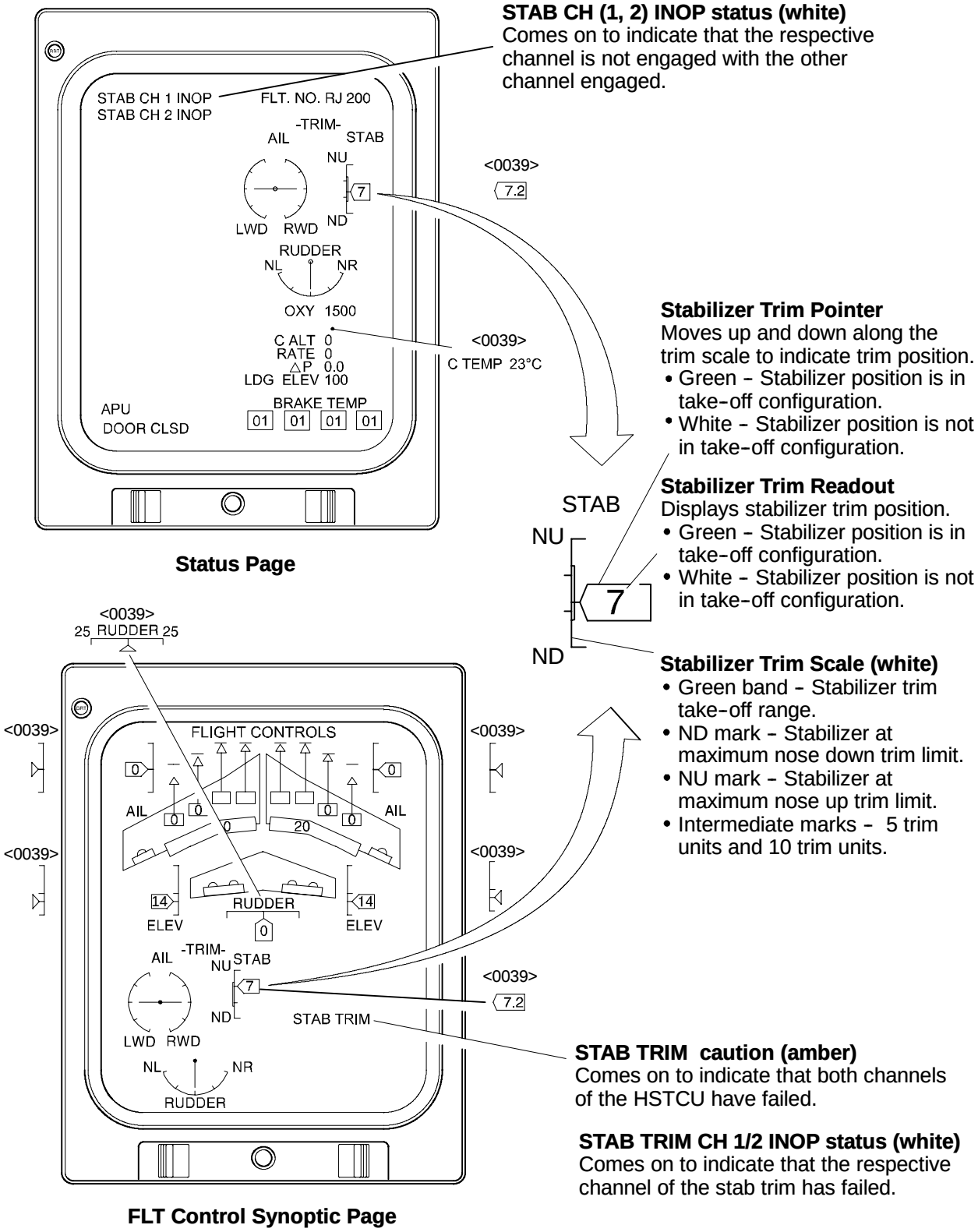
Primary Page

CONFIG STAB warning (red)
Comes on when airplane is in the take-off configuration (N1 > 70% RPM with WOW, thrust reversers not deployed) and stabilizer is not in the take-off trim range (3 to 9 units).

STAB TRIM caution (amber)
Comes on to indicate that both channels of the HSTCU have failed or are disengaged.

MACH TRIM caution (amber)
Comes on to indicate that the Mach trim function has failed or is disengaged.

Horizontal Stabilizer Trim – EICAS Messages <MST>
Figure 11–50–5



STAB CH (1, 2) INOP status (white)
Comes on to indicate that the respective channel is not engaged with the other channel engaged.

Stabilizer Trim Pointer
Moves up and down along the trim scale to indicate trim position.
- Green – Stabilizer position is in take–off configuration.
- White – Stabilizer position is not in take–off configuration.

Stabilizer Trim Readout
Displays stabilizer trim position.
- Green – Stabilizer position is in take–off configuration.
- White – Stabilizer position is not in take–off configuration.

Stabilizer Trim Scale (white)
- Green band – Stabilizer trim take–off range.
- ND mark – Stabilizer at maximum nose down trim limit.
- NU mark – Stabilizer at maximum nose up trim limit.
- Intermediate marks – 5 trim units and 10 trim units.

STAB TRIM caution (amber)
Comes on to indicate that both channels of the HSTCU have failed.

STAB TRIM CH 1/2 INOP status (white)
Comes on to indicate that the respective channel of the stab trim has failed.

Status Page

FLT Control Synoptic Page

Horizontal Stabilizer Trim – EICAS Indications <MST>
Figure 11–50–6

A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Horizontal Stabilizer Trim	Horizontal Stabilizer Trim Control Unit	STAB CH 1 HSTCU	DC BUS 2	2	F5	
		STAB CH 2 HSTCU	DC ESS	4	A1	
	Horizontal Stabilizer Trim Actuator	STAB CH 1 HSTA	AC BUS 2	2	B8	
		STAB CH 2 HSTA	AC ESS	3	A5	

1. FLAPS

The flap system provides lift augmentation during take-off and landing. The flap system consists of externally hinged inboard and outboard flap panels mounted on the trailing edge of each wing. Flap settings (to a maximum of 45 degrees) are selected from a single flap control lever, located on the center pedestal. The flap system is controlled and monitored by a flap electronic control unit (FECU). During extension, the flaps move slightly aft and down around hinge pivots.

The flap system is driven by a dual motor power drive unit. The power drive unit drives the flaps through a series of drive shafts, gearboxes and actuators. Brake and position sensor units, mounted at the outboard ends of each drive system, provide braking for asymmetric protection and provide surface position feedback to the FECU.

The flap selector has the following selectable flap detent positions:

- 0 degrees, 20 degrees, 30 degrees, and 45 degrees.
- 0 degrees, 8 degrees, 20 degrees, 30 degrees, and 45 degrees. <0006>

The lever quadrant feature a gate at the 20 degree setting. The gate prevents inadvertent flap selection to 0 degrees during a missed approach and precludes V_{FE} (flaps 30) from being exceeded. To move the lever through the gate, it must be pushed down (against a spring) an then moved forward or aft.

The lever quadrant features two gates, one at the 8 degree setting and one at the 20 degree setting. The gate at the 8 degree setting prevents inadvertent flap selection to 0 degrees during a missed approach (go-around) and the gate at 20 degrees, precludes V_{FE} (flaps 30) from being exceeded. To move the lever through a gate, it must be pushed down (against a spring) an then moved forward or aft. <0006>

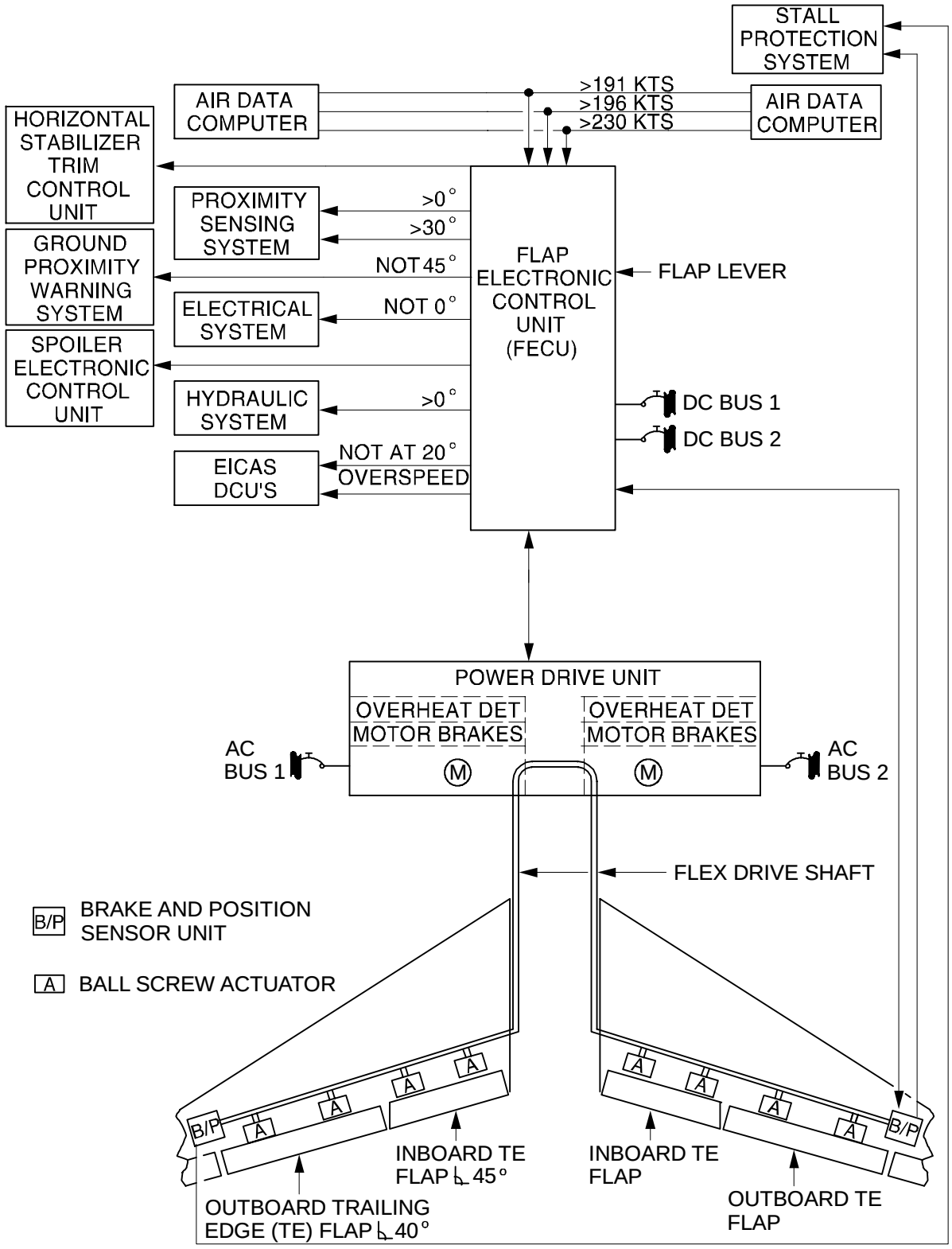
When a flap selection is made, the FECU releases the system brakes and commands the power drive unit to deploy or retract the flaps to the selected position.

NOTE

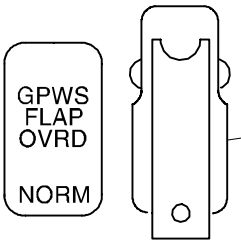
1. An overspeed clacker will sound if the airspeed is too high for the selected flap setting.
2. To ensure that the correct flap position is selected for go-around, make sure that the back face of the flap lever is pushed without any downward pressure.

If one of the two power drive unit motors fails, the system will remain functional, but will operate at half speed and a FLAPS HALF SPEED status message will be displayed on the EICAS status page and on the FLT CONTROLS synoptic page.

The EICAS primary page will display flap position in relation to landing gear position when either the landing gear or flaps are extended. At all other times, the gear and flap information is removed from the primary page, but flap position is always displayed on the FLT CONTROLS synoptic page.

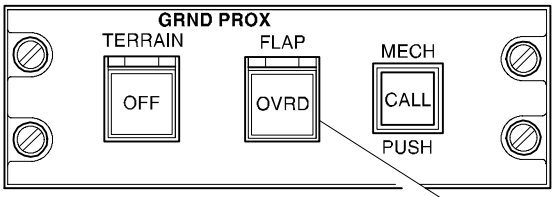


Flap System
Figure 11–60–1

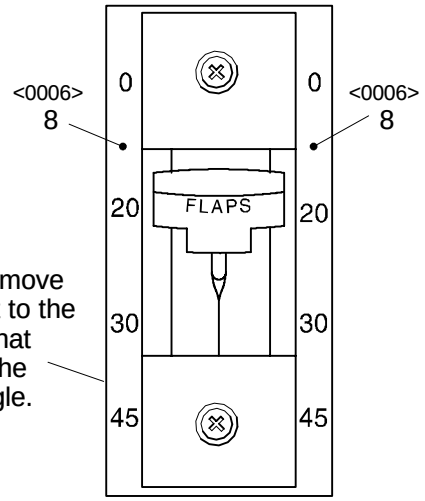


GPWS FLAP OVRD Guarded Toggle Switch

- GPWS FLAP OVRD – Mutes flap aural warning when entering the landing configuration with flaps not in the landing configuration.
- NORM (guarded) – Normal operation.



GPWS / Mechanic Call Panel
Centre Pedestal



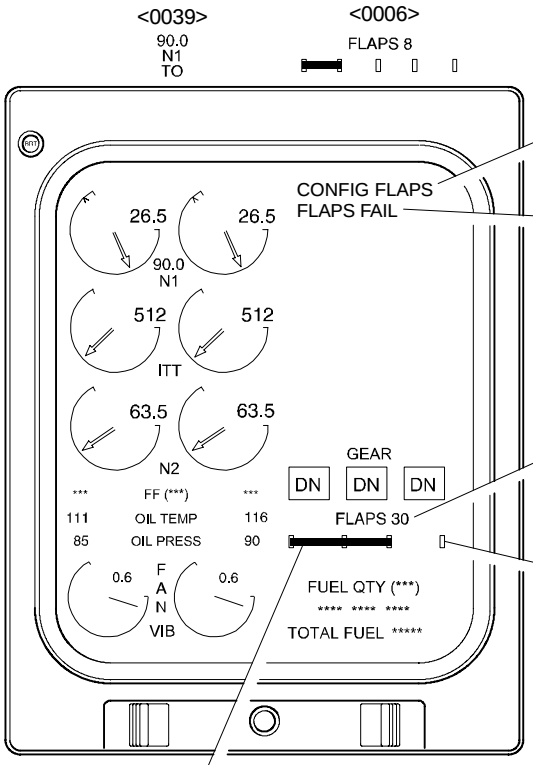
Flaps Selector
To deploy flaps, move flaps selector aft to the detent position that corresponds to the required flap angle.

Flap Selection Lever
Centre Pedestal

GRND PROX FLAP (guarded Switch) <0040>
When pressed:

- Mutes TOO LOW FLAPS or TOO LOW TERRAIN under certain conditions.
- OVRD (white) comes on.

Flap Controls <MST>
Figure 11–60–2



Primary Page

CONFIG FLAPS warning (red)
Comes on when airplane is in the take-off configuration, N1 > 70% RPM with WOW, and flaps are not in the take-off setting.

FLAPS FAIL caution (amber)
Comes on to indicate that both channels of the flap electronic control unit (FECU) have failed, or an asymmetric condition exists.

Flaps Position Readout (green)
Indicates angle of flaps deployment and is displayed when flaps are deployed and/or landing gear is not up and locked (+30 seconds). White readout will be displayed if input value is < 0 degrees or > 46.5 degrees, or if a flap miscompare is detected by EICAS (difference between left and right flap position > 5 degrees).

Flaps Position Scale (white)
Displayed when flaps position readout is displayed. Tick marks, from left to right, represent 0, 20, 30 and 45 degrees for the 4 positions.

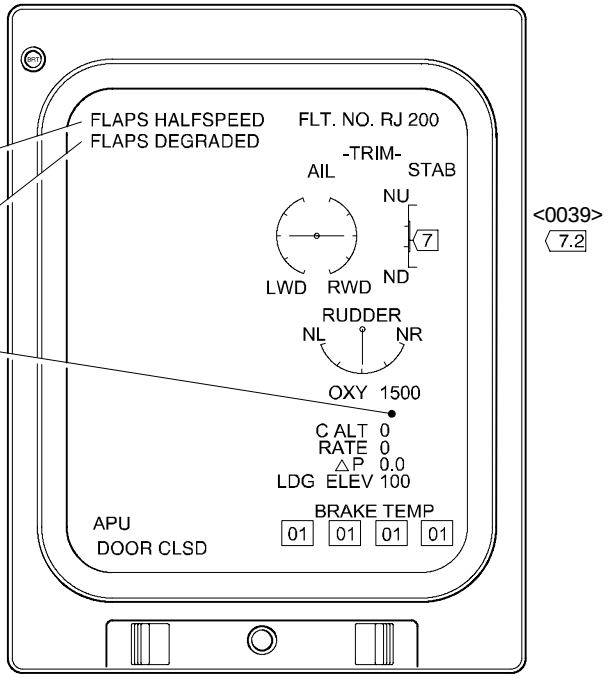
Flaps Position Scale (white) <0006>
Displayed when flaps position readout is displayed. Tick marks, from left to right, represent 0, 8, 20, 30 and 45 degrees for the 5 positions.

Flaps Position Bar (green)
Displayed when flaps are deployed (≥ 0 degrees to ≤ 46.5 degrees) and input data is valid. White bar is displayed if a flap miscompare is detected by EICAS (difference between left and right flap position > 5 degrees).

FLAPS HALFSPEED status (white)
Comes on to indicate that channel 1 or 2 of the FECU is inoperative resulting in a reduced flaps deployment and retraction rate.

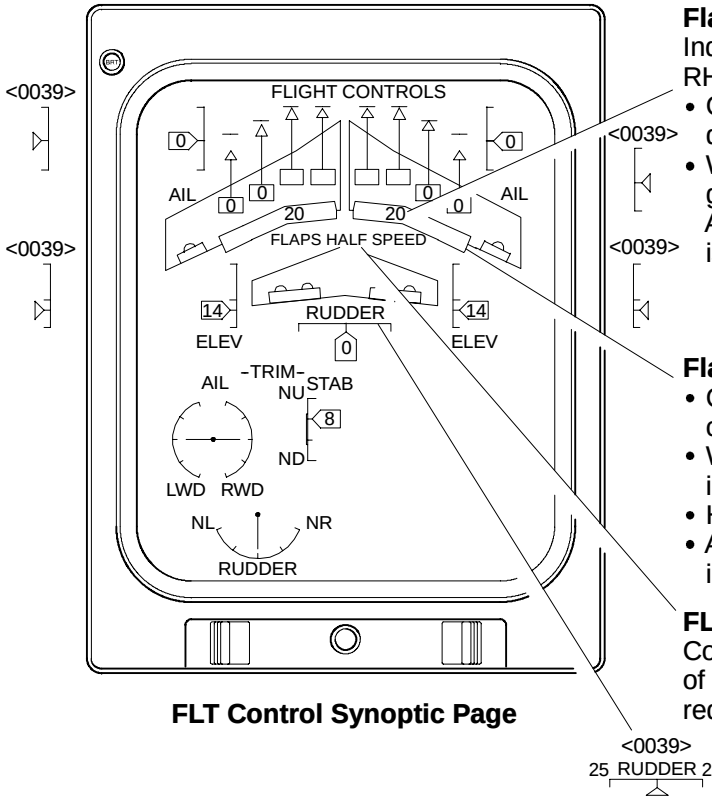
Effectivity:
Airplanes 7800 and subsequent.

FLAPS DEGRADED status (whlte)
Displayed for all skew detection sensor faults. With the exception of DC power supply faults. (DC power supply faults force the system into halfspeed mode with the FLAP HALFSPEED status message being displayed).



Status Page

Flap System – EICAS Messages <MST>
Figure 11–60–3



FLT Control Synoptic Page

Flaps Position Readout
Indicates, in degrees, the position of LH and RH flaps.
- Green – LH and RH flaps positions do not differ by 5 degrees.
- White – LH and RH flaps positions differ by greater than 5 degrees.
  Amber dashes will be displayed if input value is invalid.

Flaps Outlines
- Green – Both channels of the flap electronic control unit (FECU) are operative.
- White – One of the channels of the FECU is inoperative.
- Half-Intensity Magenta – Input value is invalid.
- Amber – Both channels of the FECU are inoperative.

FLAPS HALF SPEED status (white)
Comes on to indicate that one of the channels of the FECU is inoperative, resulting in a reduced flaps deployment and retraction rate.

Flight Controls Synoptic Page – Flap Indications <MST>
Figure 11–60–4

A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Flaps	Power Drive 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	

1. SPOILERS

There are four spoiler panels located on the upper surface of each wing consisting of:

- One spoileron (outer panel)
- One flight spoiler
- Two ground spoilers (inner two panels).

Each spoiler is actuated by a single electro-hydraulic power control unit and provides roll assist and proportional lift dumping functions. Spoiler operation is controlled by two, dual module, spoiler electronic control units (SECUs).

Roll assist is provided by asymmetric deployment of the spoilerons. Deployment is relative to control wheel inputs, Mach number and flap position. Roll assist is used to improve lateral control of the aircraft at low airspeeds.

Proportional lift dumping is provided in flight by symmetric deployment of the flight spoilers. Deployment is relative to the position of the flight spoiler control lever. Proportional lift dumping is used for speed control and to stabilize the aircraft on the glide path or during rapid descents.

The ground spoilers provide ground lift dumping function only. Ground lift dumping is used to assist in aircraft braking on the ground by full deployment of the spoilerons, flight spoilers and the ground spoilers Ground lift dumping is normally automatic but can be manually controlled by the GND/LIFT DUMPING switch on the center pedestal. Automatic deployment is triggered on the basis of:

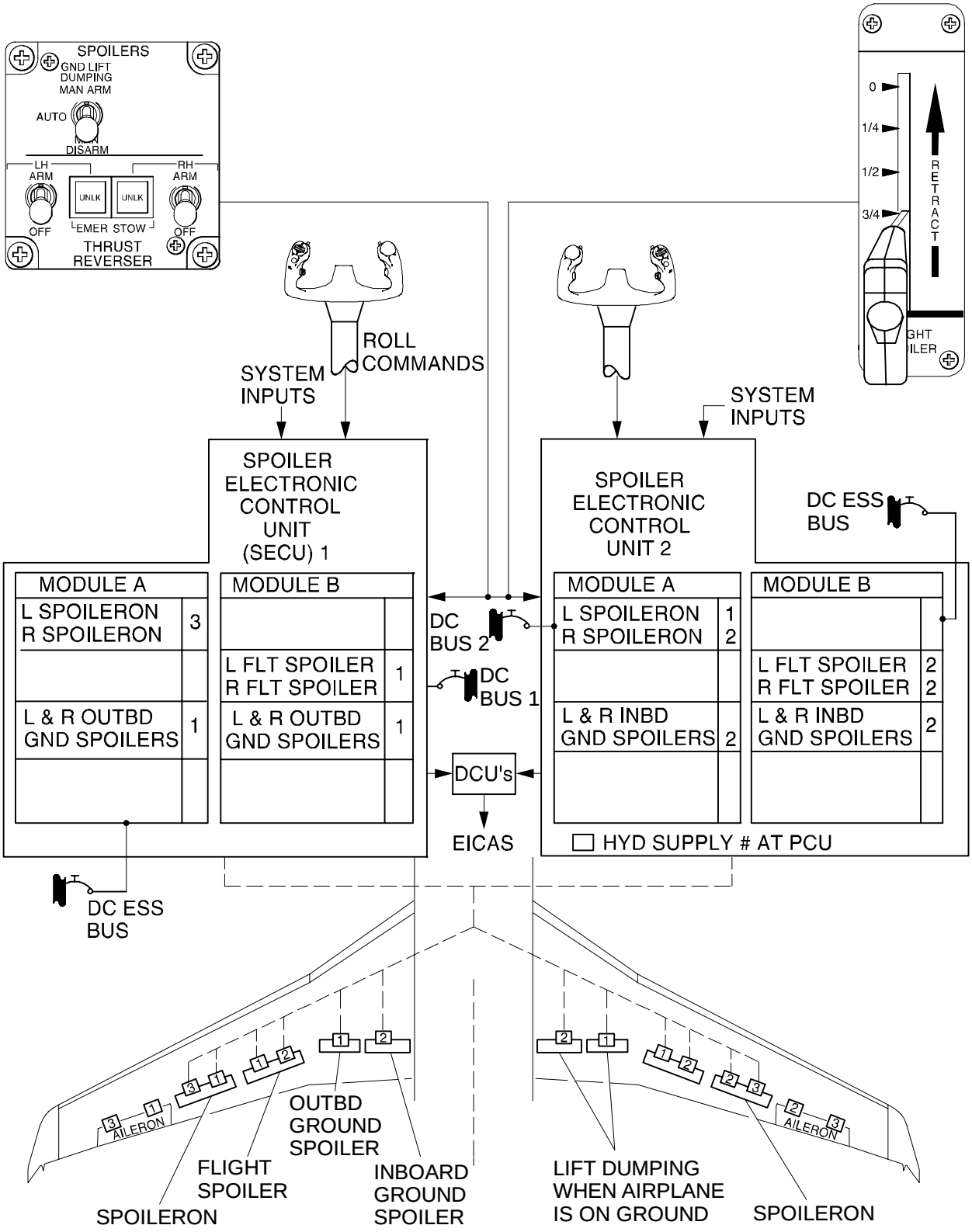
- Thrust lever position
- Engine N1 signals
- Radio altitude
- Wheel speed from the anti-skid control unit (ASCU)
- PSEU weight-on-wheels conditions.

Effectivity:

- Airplanes 7002, 7003 to 7066 and subsequent.

NOTE

On the ground, the IB, OB GND SPLR FAULT status message(s) can be cleared by deploying/retracting the ground spoilers with all hydraulic systems powered.

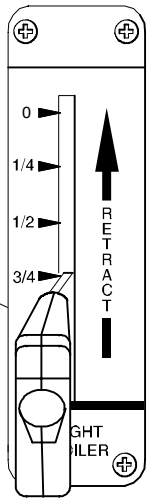


Spoiler System
Figure 11–70–1

Flight Spoiler Lever

- 0 - Retracted
- 1/4 deployment - 8 degree
- 1/2 deployment - 19 degree
- 3/4 deployment - 33 degree
- MAX deployment- 50 degree (fully extended)

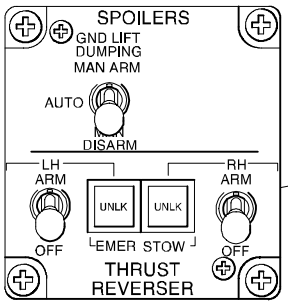
To deploy flight spoilers, move flight spoiler lever aft to any one of eight detent positions. (Four additional detent positions are possible between the above indicated positions.)



Flight Spoiler Lever
Centre Pedestal

Ground Lift Dumping Toggle Switch

- AUTO – Arms the ground lift dumping system automatically when airplane is in the landing configuration.
- MAN ARM – Manually arms the ground lift dumping system if automatic arming fails.
- MAN DISARM – Disarms the ground lift dumping system in the event of an inadvertent deployment or failure of automatic system.



Ground Lift Dumping Panel
Centre Pedestal

Spoiler System Controls
Figure 11–70–2

The spoiler ground lift dumping (GLD) circuits must be armed before deployment can take place. The GLD system is armed either automatically or manually. After landing or a rejected takeoff, the GLD spoilers automatically retract. During a touch-and-go, the GLD spoilers will deploy when all deployment parameters are met. Advancing the thrust levers for takeoff retracts the spoilers and rearms the system.

A. GLD Arming

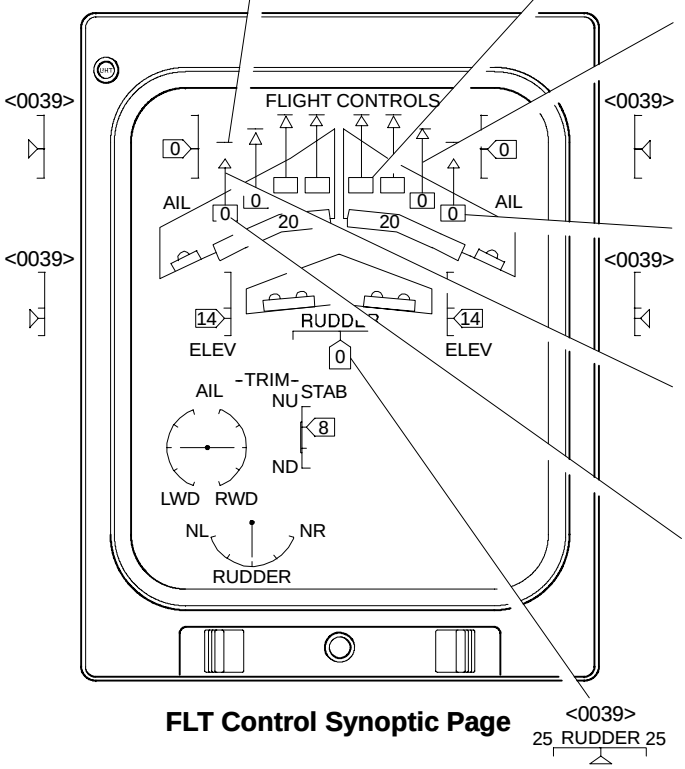
(1) Automatic arming

- Spoiler control switch in the AUTO position, and
- L or R engine > 79% N1 or thrust levers > takeoff power, and
- Wheel speed >45 kts.

(2) Manual arming

- Spoiler control switch in the MAN ARM position.

Maximum Spoiler Deployment Mark (white)
Indicates full deployment point of respective spoiler.



FLT Control Synoptic Page

Ground Spoiler Outline
- Green – Respective hydraulic manifold and respective SECU are operative.
- White – Loss of redundancy in respective ground spoiler.
- Amber – Respective hydraulic manifold or respective SECU is inoperative.
- Half–Intensity Magenta – Input data invalid.

Ground Spoiler Position Indicators (white)
Are either shown fully extended to the full travel mark, when ground spoilers are deployed, or not shown at all, when ground spoilers are retracted.

Spoiler Outlines
- Green – Both respective spoiler electronic control units (SECU) and both respective power control units (PCU) are operative.
- White – One of the SECU or one of the PCU is inoperative.
- Amber – Both respective SECUs and/or both respective PCUs are inoperative.
- Half–Intensity Magenta – Input data invalid.

Spoiler Position Indicator (white)
Indicates relative position of respective spoiler. Indicator is not displayed when respective spoiler is retracted or input data is invalid.

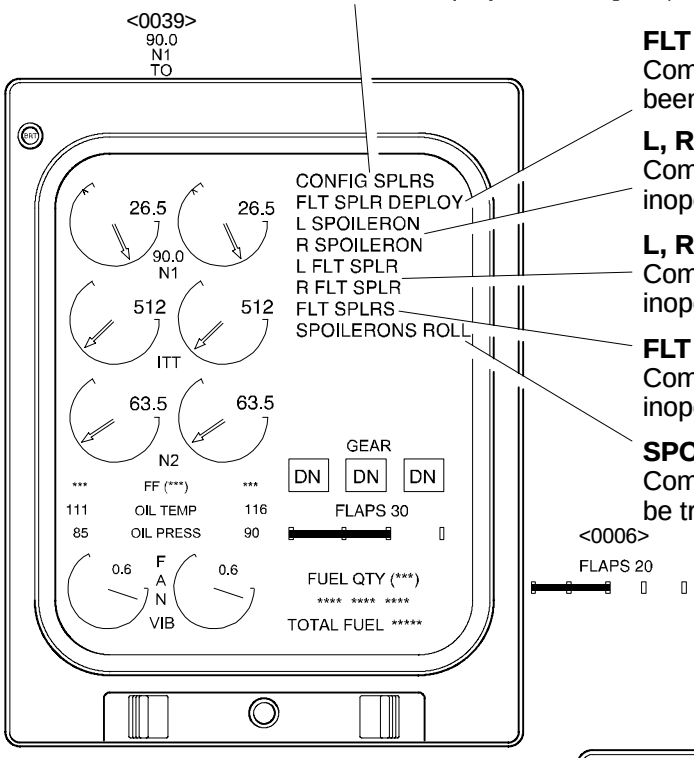
Spoiler Deployment Readout (white)
Indicates angle of deployment, in degrees, of respective spoiler. Two amber dashes are displayed when input data is invalid.

NOTE <0039>

An amber X is displayed when input data is invalid, and position indicator (arrow) is removed.
A spoiler with an amber X indication may still operate normally.

Spoiler System Synoptic Page Indications <MST>
Figure 11–70–3

CONFIG SPLRS warning (red)
Comes on when airplane is in the takeoff configuration, N1 > 70% RPM with WOW, thrust reversers not deployed and flight spoilers are not retracted.



FLT SPLR DEPLOY caution (amber)
Comes on to indicate that the flight spoilers have been deployed at an unsafe altitude.

L, R SPOILERON caution (amber)
Comes on when the respective spoileron is inoperative.

L, R FLT SPLR caution (amber)
Comes on when the respective flight spoiler is inoperative.

FLT SPLRS caution (amber)
Comes on to indicate that flight spoilers are inoperative.

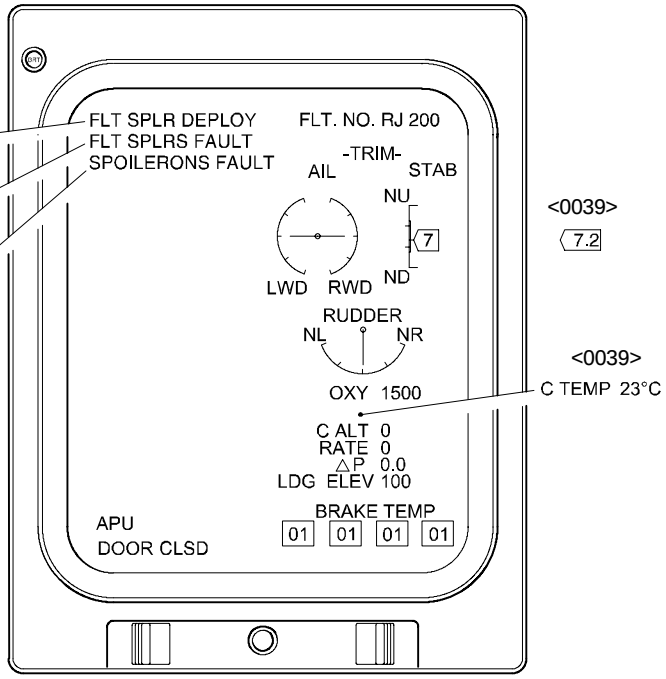
SPOILERONS ROLL caution (amber)
Comes on to indicate that spoiler control should be transferred to the operative aileron circuit.

Primary Page

FLT SPLR DEPLOY advisory (green)
Comes on to indicate that the left and/or right flight spoilers are extended in air at a RAD ALT of > 800 ft AGL and both N1 < 79% or, with the RAD ALT invalid, the landing gear not extended.

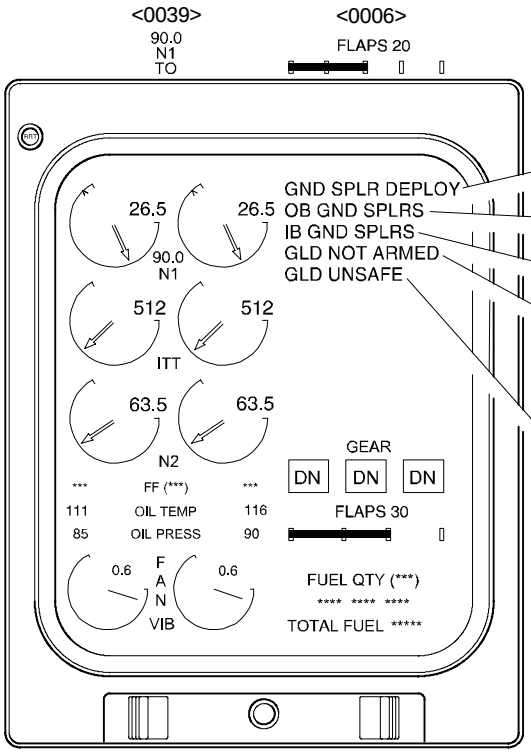
FLT SPLRS FAULT status (white)
Comes on to indicate loss of redundancy in the flight spoilers control.

SPOILERONS FAULT status (white)
Comes on to indicate loss of redundancy in the spoileron control.



Status Page

Spoileron and Flight Spoiler – EICAS Messages <MST>
Figure 11–70–4



Primary Page

GND SPLR DEPLOY caution (amber)
Comes on to indicate that any one of the ground spoilers have extended in the air (RAD ALT > 10 feet AGL).

OB GND SPLRS caution (amber)
Comes on to indicate that the outboard ground spoilers are inoperative.

IB GND SPLRS caution (amber)
Comes on to indicate that the inboard ground spoilers are inoperative.

GLD NOT ARMED caution (amber)
Comes on to indicate that airplane is in the landing configuration (landing gear extended or flaps 30 degrees) or in the takeoff configuration (left and right N1 greater than 70% and WOW) and spoilers not armed for ground lift dumping.

GLD UNSAFE caution (amber)
Comes on to indicate that the ground lift dumping system is in an unsafe condition, which may lead to an inadvertent deployment (upon subsequent failure), with manual disarm not selected.

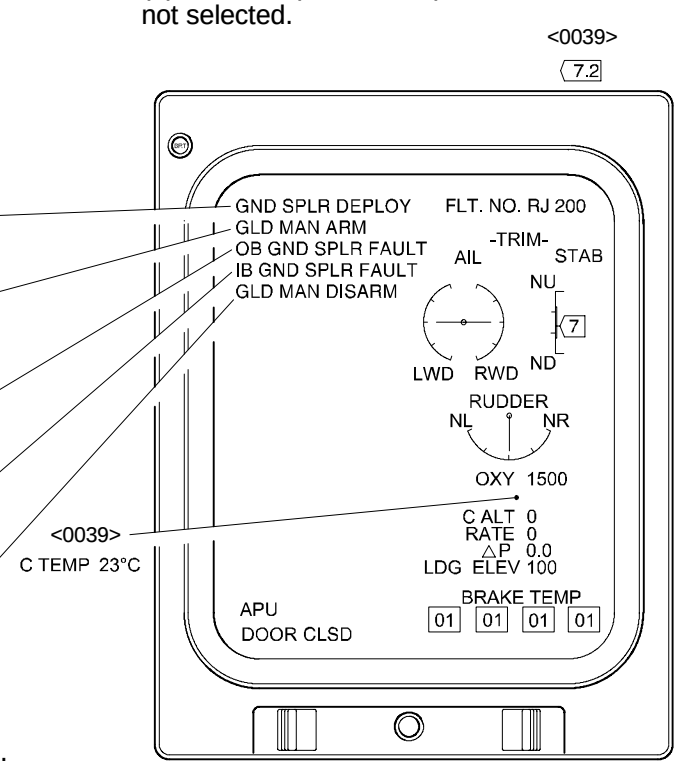
GND SPLR DEPLOY advisory (green)
Comes on to indicate that ground spoilers have deployed:
- Either on the ground, or
- when RAD ALT < 10 feet AGL.

GLD MAN ARM advisory (green)
Comes on to indicate that the ground lift dumping system has been armed manually.

OB GND SPLR FAULT status (white)
Comes on to indicate loss of redundancy in the outboard ground spoiler control, or ground spoiler test inhibit.

IB GND SPLR FAULT status (white)
Comes on to indicate loss of redundancy in the inboard ground spoiler control, or ground spoiler test inhibit.

GLD MAN DISARM status (white)
Comes on to indicate that the ground lift dumping system has been manually disarmed.



Status Page

Ground Spoilers – EICAS Messages <MST>
Figure 11–70–5

B. GLD Deploy

(1) For the ground and flight spoilers:

- L and R thrust levers at idle or L and R N1 <40%, and with 2 of the following 3 parameters:

- L or R MLG WOW
- Wheel speed >16 kts
- Rad Alt < 5 ft.

NOTE

1. The FLT SPLR DEPLOY caution message comes on when the flight spoilers have been deployed at an unsafe altitude, lower than 800 feet AGL. <JAA>
2. The FLT SPLR DEPLOY caution message comes on when the flight spoilers have been deployed at an unsafe altitude, lower than 300 feet AGL. <FAA><TC>

(2) For the spoilerons:

- L and R thrust levers at idle or L and R N1 <40%, and
- L or R MLG WOW, and with 1 of the following 2 parameters:

- Wheel speed >16 kts
- Rad Alt < 5 ft.

C. GLD Deployment Disarming

(1) Automatic Retract for Go-around

- L or R thrust setting IDLE.

(2) Automatic Retract

- L or R engine < MIN TAKEOFF setting, and
- INBD and OUTBD wheel speed < 45 kts (for at least 10 seconds), and
- Aircraft on the ground for at least 40 seconds.

(3) Manual Retract

- MAN DISARM switch position selected.

D. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Spoilers	Spoiler Electronic Control Unit	SECU 1A	DC ESS	4	A2	
		SECU 1A & 1B	DC BAT	1	N8	
		SECU 2A & 2B		2	N8	
		SECU 2B	DC ESS	4	A3	
		SECS PWR 1	DC BUS 1	1	F3	
		SECS PWR 2	DC BUS 2	2	F3	
		SECS 1 PWR 3	DC ESS	4	A4	
		SECS 2 PWR 3			A5	

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1. STALL PROTECTION SYSTEM

The purpose of the stall protection system is to provide warning of an impending stall when the aircraft attitude approaches a high angle–of–attack (AOA) and to prevent stall penetration when the aircraft nears the computed stall angle. The system alerts the flight crew by means of visual, aural, and feel (stick shaker) indications. If no corrective action is taken, the system activates the stick pusher mechanism to prevent the aircraft from entering a stall.

The stick pusher mechanism is armed by selecting the pilot's and copilot's STALL PTCT pusher switches.

NOTE

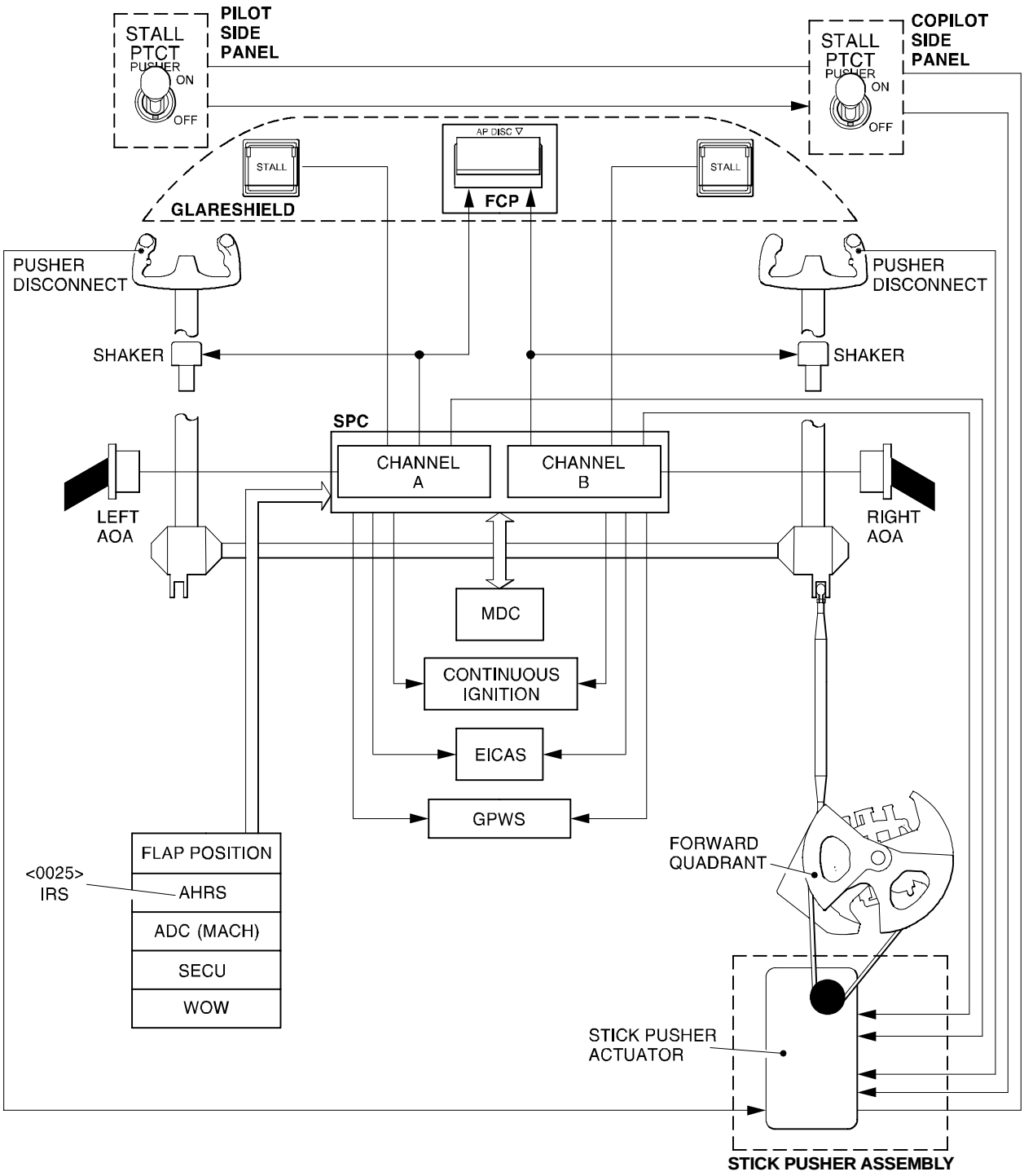
Both the pilot and copilot STALL PTCT switches must be selected ON to arm the stick pusher system. Selecting either switch OFF disables the system.

Angle of attack vanes located on each side of the forward fuselage measure the aircraft attitude in relation to the ambient airstream. The stall protection computer (SPC) uses the AOA information and airspeed to compute the stall angle trip points.

When the aircraft approaches a high AOA, the stall protection computer will activate the engines auto-ignition system. If the AOA continues to increase, the stick shaker is activated and the autopilot is disengaged.

If the angle of attack still continues to approach the critical stall point, the stick pusher is activated, the STALL switchlights flash red, and the warbler sounds. The stick pusher then pushes the control column forward to give the aircraft a pitch down attitude. In the event of an AOA rate increase greater than 1 degree per second, the SPC lowers the AOA trip point to prevent the aircraft pitching momentum from carrying it through the stall warning/stick pusher sequence into the stall.

The stick pusher can be stopped by pressing and holding the AP/SP DISC switch on the pilot's and copilot's control wheel.



Stall Protection System Schematic <MST>
Figure 11–80–1

Testing of the stall protection system is initiated by momentarily pressing one of the STALL switchlights, and verifying that:

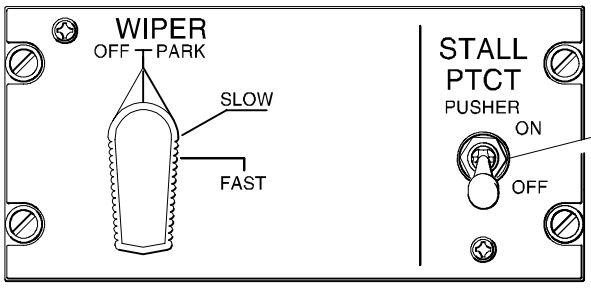
- Auto-ignition is activated (CONT ON and CONT IGNITION status messages come on)
- Pilot's and copilot's stick shakers activate
- STALL switchlights flash
- Stick pusher is activated.

While in stick pusher mode:

- Pilots control column bounces back to neutral position when the AP/SP DISC button is momentarily pressed
- Pilot's control column will take several seconds to go back to the neutral position. Copilot should pull (override) the control column and note diminished feel force loads while momentarily pressing AP/SP DISC button
- Stick pusher is de-activated
- STALL switchlights go out
- Pilot's and copilot's stick shakers stop
- CONT ON and CONT IGNITION status messages go out.

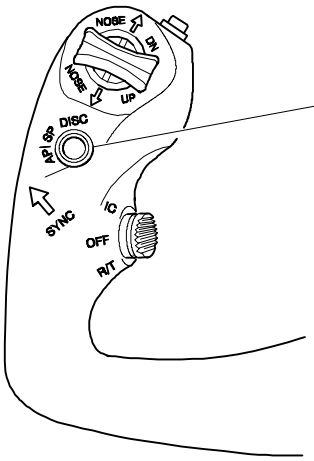
NOTE

Pressing the pilot's or copilot's STALL switchlight a second time during the test, will interrupt the test sequence.



Stall Protection Panel
Pilot and Copilot Side Panels

STALL PROTECTION PUSHER
Lever Switch (locked at ON) (2)
- ON – Stick pusher is armed (both pilot's and copilot's PUSHER switches must be at ON position).
- OFF – Stick pusher is disabled.



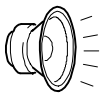
Pilot and Copilot Control Wheels

AP/SP DISC (red)
Used to disengage autopilot and momentarily de-activate stall protection system.
- Press to disengage autopilot and momentarily disable stick pusher.
- Release to re-activate stick pusher.

NOTE
When pressed for 4 seconds or longer, STALL FAIL caution message will come on. Caution message will go out approximately 1 second after switch is released.

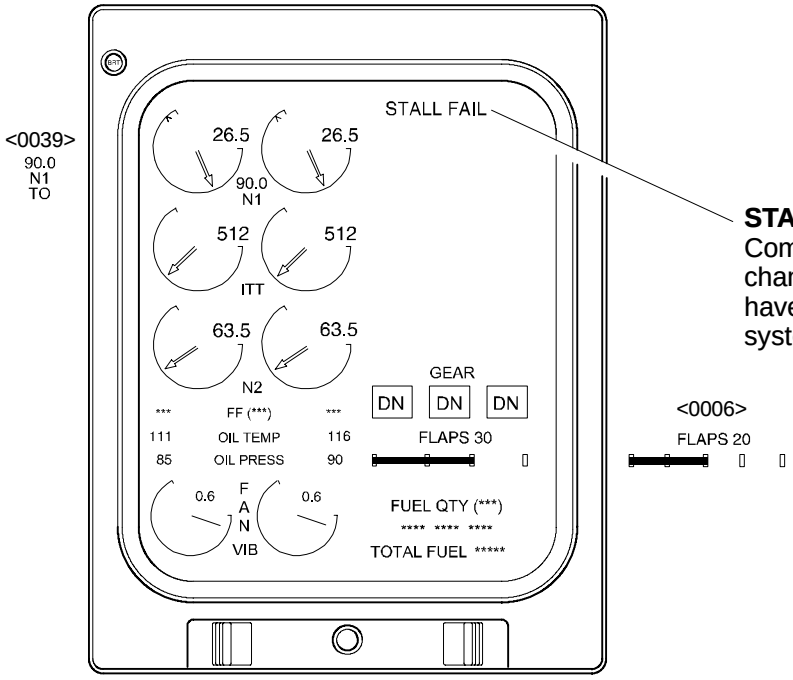
Pllot's Glareshleld Panel
(Copilot's, Opposite)

STALL Switch/Lights (2)
Flash red when:
- AOA reaches stick pusher trip point.
- Stick pusher is disabled.



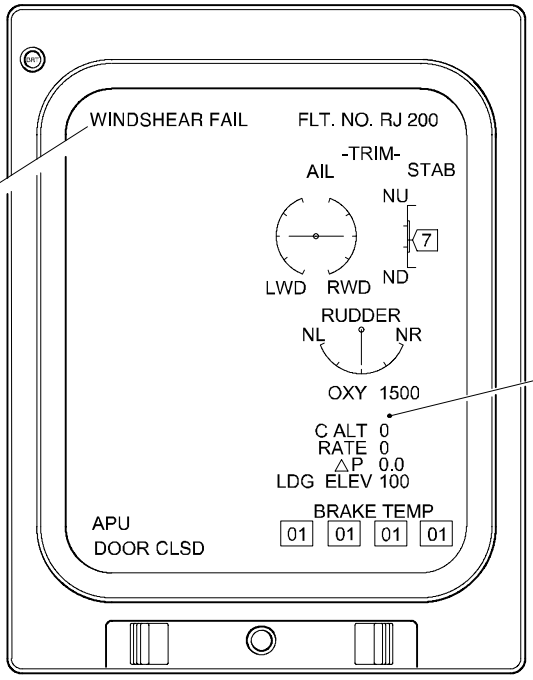
Warbler comes on to indicate a stall condition.

Stall Protection Controls
Figure 11–80–2



STALL FAIL caution (amber)
Comes on to indicate that one or both channels of the stall protection system have failed resulting with stick pusher system inoperative.

Primary Page



WINDSHEAR FAIL status (white)
Comes on to indicate that windshear guidance is inoperative on both sides.

Status Page

Stall Protection System EICAS Messages <MST>
Figure 11–80–3

A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Stall Protection System	Computer	STALL PROT R CH	DC ESS	4	C7	
		STALL PROT L CH	DC BAT	1	Q2	
	Stick Pusher	STALL PROT STICK PUSHER			Q1	