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CHAPTER 10

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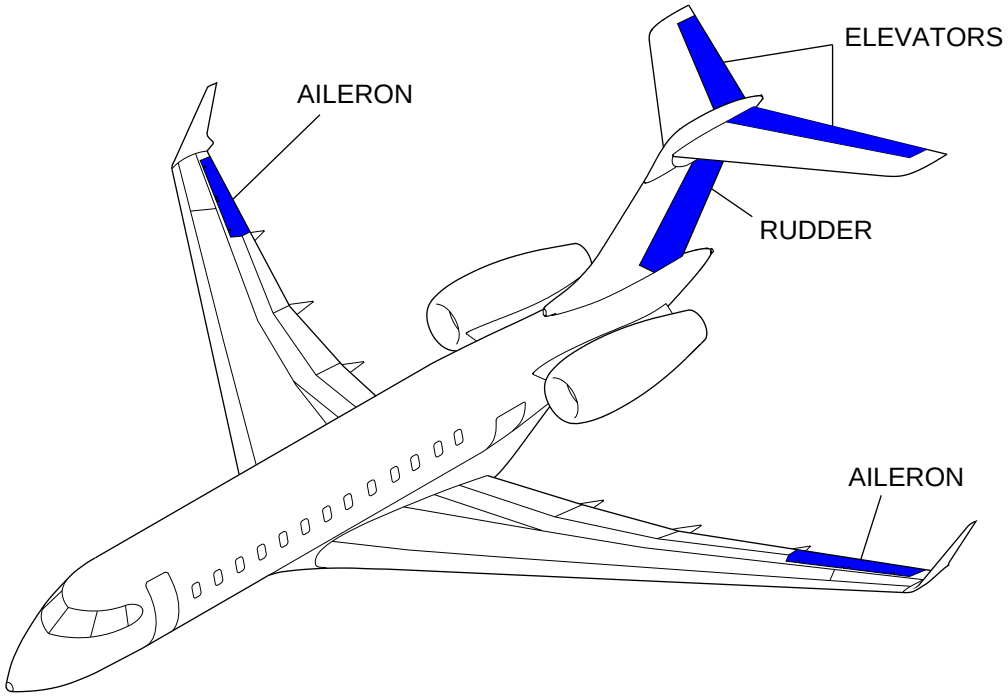
PRIMARY FLIGHT CONTROLS

The primary flight controls consists of two separate elevators, two separate ailerons and a single rudder. The primary flight surfaces are actuated by Power Control Units (PCUs) that are hydraulically powered and mechanically controlled. Artificial control loading (tactile feedback) is provided at the control wheels and rudder pedals. Surface positioning is shown on the EICAS FLIGHT CONTROL synoptic page and trims are shown on the EICAS PRIMARY display.



Each primary control system consists of cable run circuits connected to quadrants. The quadrants receive input from primary control command (flight compartment) using control rod assemblies. The quadrants accept the cable circuit and transmit input to the hydraulically powered primary control surfaces, using control rods and artificial feel assemblies.

Automatic pitch and roll disconnects are provided to allow control of one side of the pitch or roll circuit, in the event of a jam. The roll disconnect mechanism allows the flight crew to isolate the left and right control wheel and cable system from each other. 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 wheel path, with full spoiler control.

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

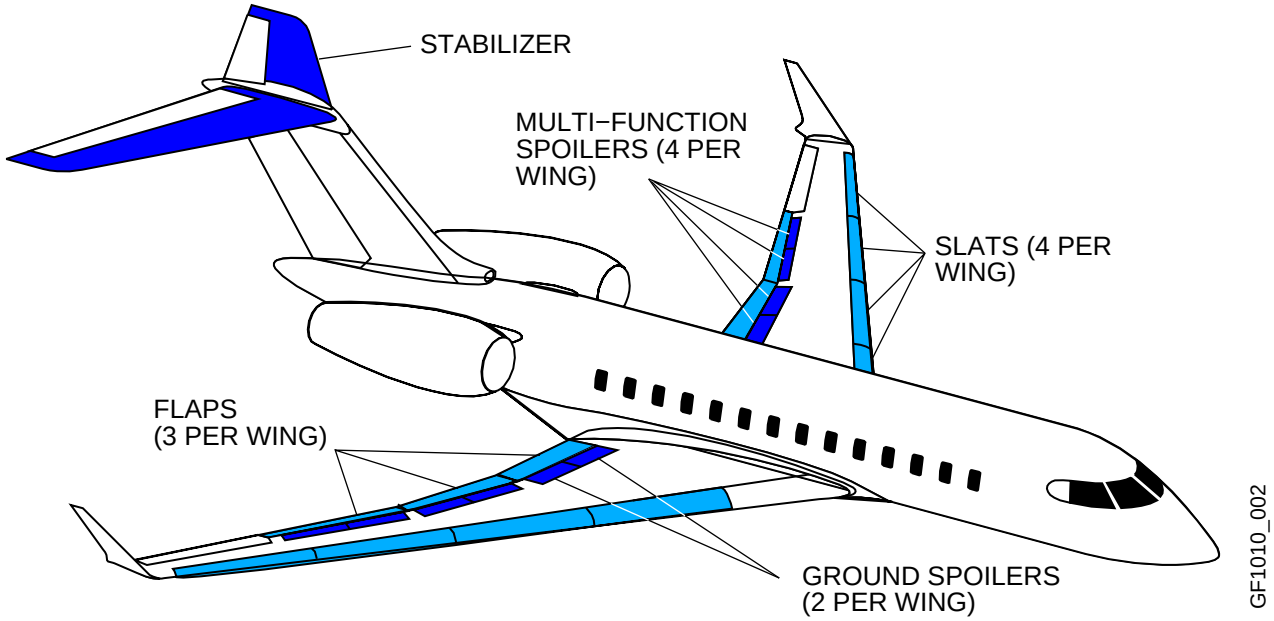
The rudder uses cable split quadrants to dualize the cable paths in the engine turbine burst zone. This method protects the system from loss of pedal commanded rudder control, during a rotor burst event.

Flutter damping for the primary flight controls is provided through the PCUs internal operation. Ground gust damping (gust locks) are provided through PCUs on the elevators, ailerons and rudder. The PCUs provide a hydraulic lock for gust damping, when the hydraulic systems are depressurized.

SECONDARY FLIGHT CONTROLS

The secondary flight controls consist of the flap/slat system, multi-function spoilers, ground spoilers and various trim systems.

The electrical flight control system is built around two identical digital computer units referred to as Flight Control Units (FCUs). The FCUs control and monitor the following systems: multi-functional spoilers, ground spoilers, horizontal stabilizer trim, pitch feel and rudder travel limiting.



SPOILER SYSTEM

Eight multi-functional spoiler panels are electrically controlled and hydraulically actuated by a single PCU on each surface. The multi-function spoilers are used for in flight operation as roll assistance, symmetrically for proportional lift dump and on ground for ground lift dumping.

Four ground spoiler panels are electrically controlled and hydraulically actuated by a single actuator on each surface and are used for ground lift dumping only.

TRIM CONTROL

Lateral trim is accomplished by a dual position switch in the centre pedestal that operates an electric trim actuator at the aft quadrant/aileron artificial feel units. The lateral trim will cause rotation of the control wheel neutral position.

Directional trim is achieved by a single rotary switch in the centre pedestal that operates an electric trim actuator at the summing unit in the vertical fin. Directional trim is summed into the pilot pedal command and no pedal displacement occurs.

Longitudinal trim is achieved by inputs from autopilot, mach trim and switches on the pilot's control wheels. Trim is operated by a dual electric motor and screw jack assembly at the horizontal stabilizer. Mach trim is provided by the two FCUs to correct for inherent airplane trim changes, with changing mach number.

Aileron, elevator and pitch trim indication is shown full time on the EICAS primary display.

HIGH LIFT DEVICES

The high lift devices consist of leading edge slats and trailing edge flaps. The flap/slat systems are mechanically independent. Each system contains ballscrew actuators, linked through a rigid drive line to dual electric motors contained within a central power-drive unit.

An integrated flap/slat selector lever is located in the flight compartment, in the centre pedestal. Electrically, there are two independent channels for both flap and slat systems. Two Slat/Flap Control Units (SFCUs) control the operation of the slats and the flaps.

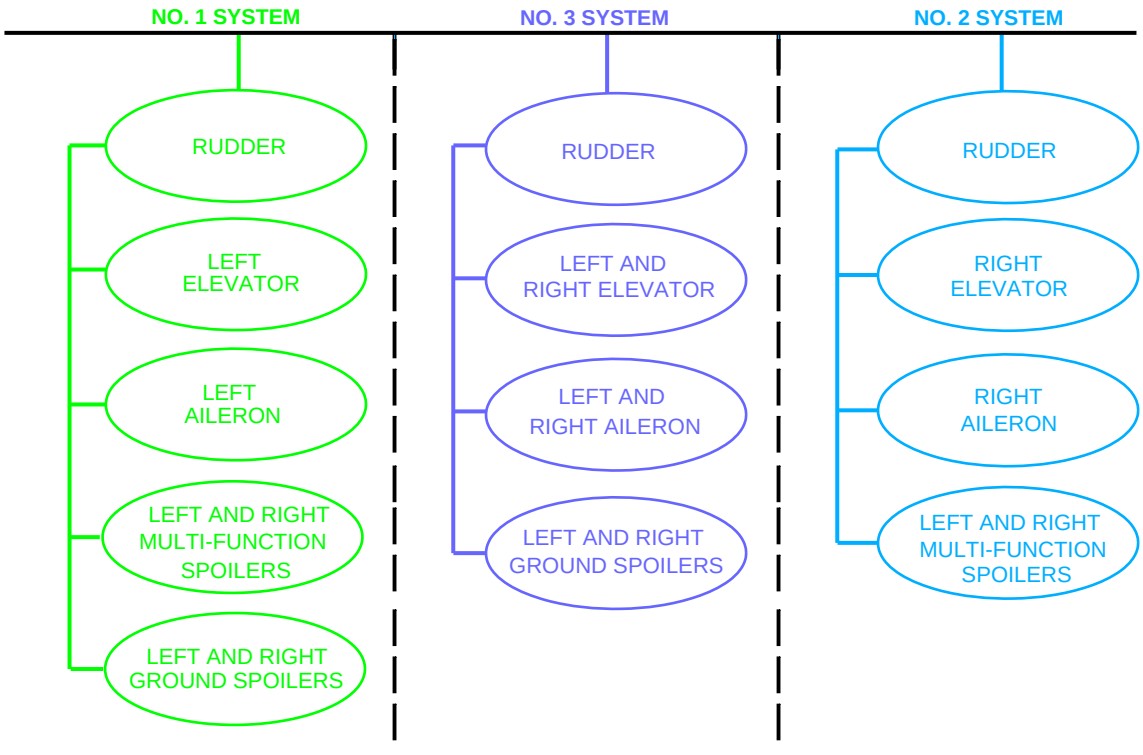
System control provides protection against asymmetry and uncommanded movement. Interface to EICAS and central maintenance are provided for system failure detection and isolation.

STALL PROTECTION

Two subsystems, stall warning and a stick pusher system comprise the stall protection system.

HYDRAULIC POWER DISTRIBUTION

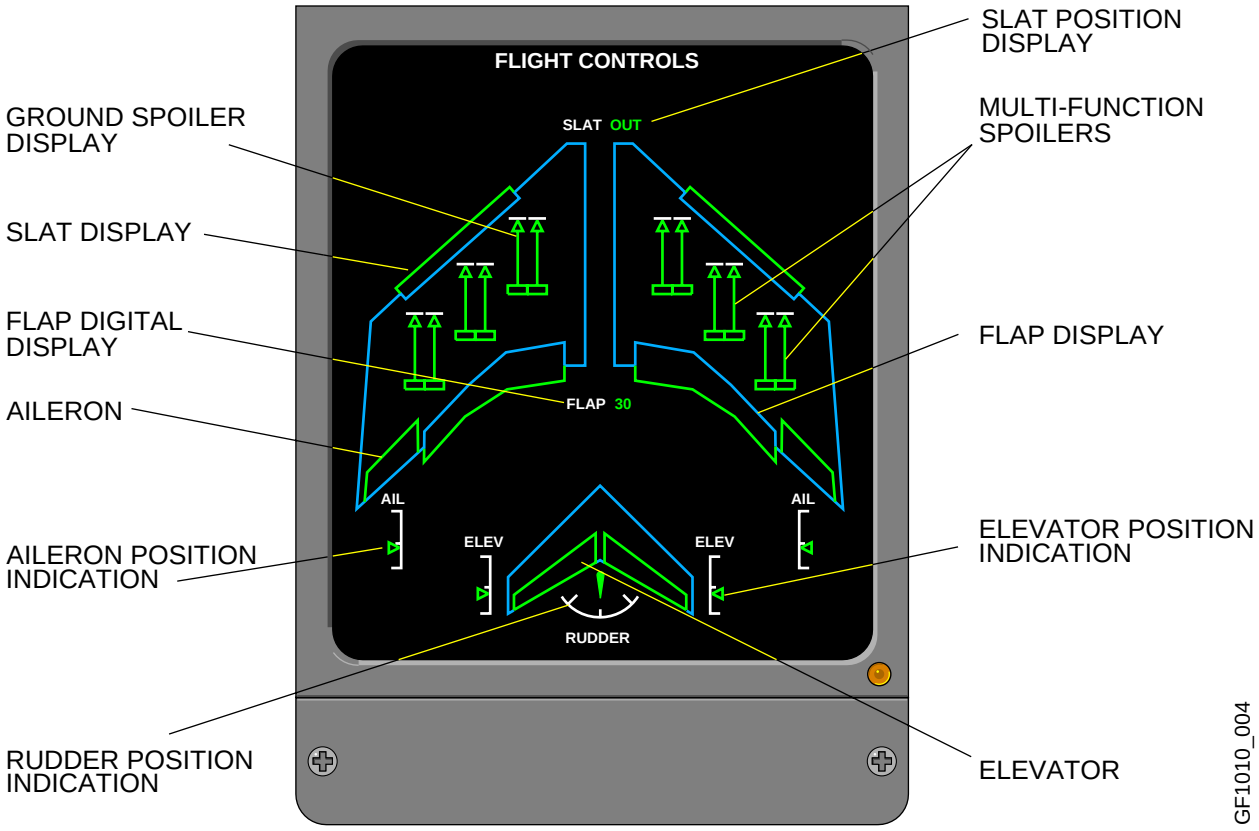
The primary and secondary flight controls are hydraulically powered by the following services:



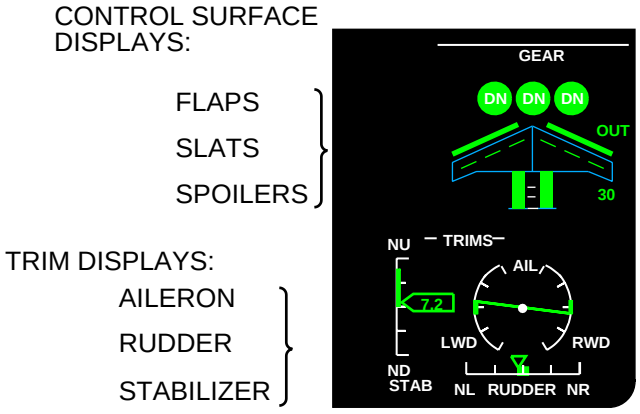
INDICATING SYSTEM

The flight control synoptic page provides position indications of the primary control surface, flap/slats and spoiler system. The roll, pitch and yaw trim indications are displayed on the EICAS primary page.

FLIGHT CONTROL SYNOPTIC PAGE



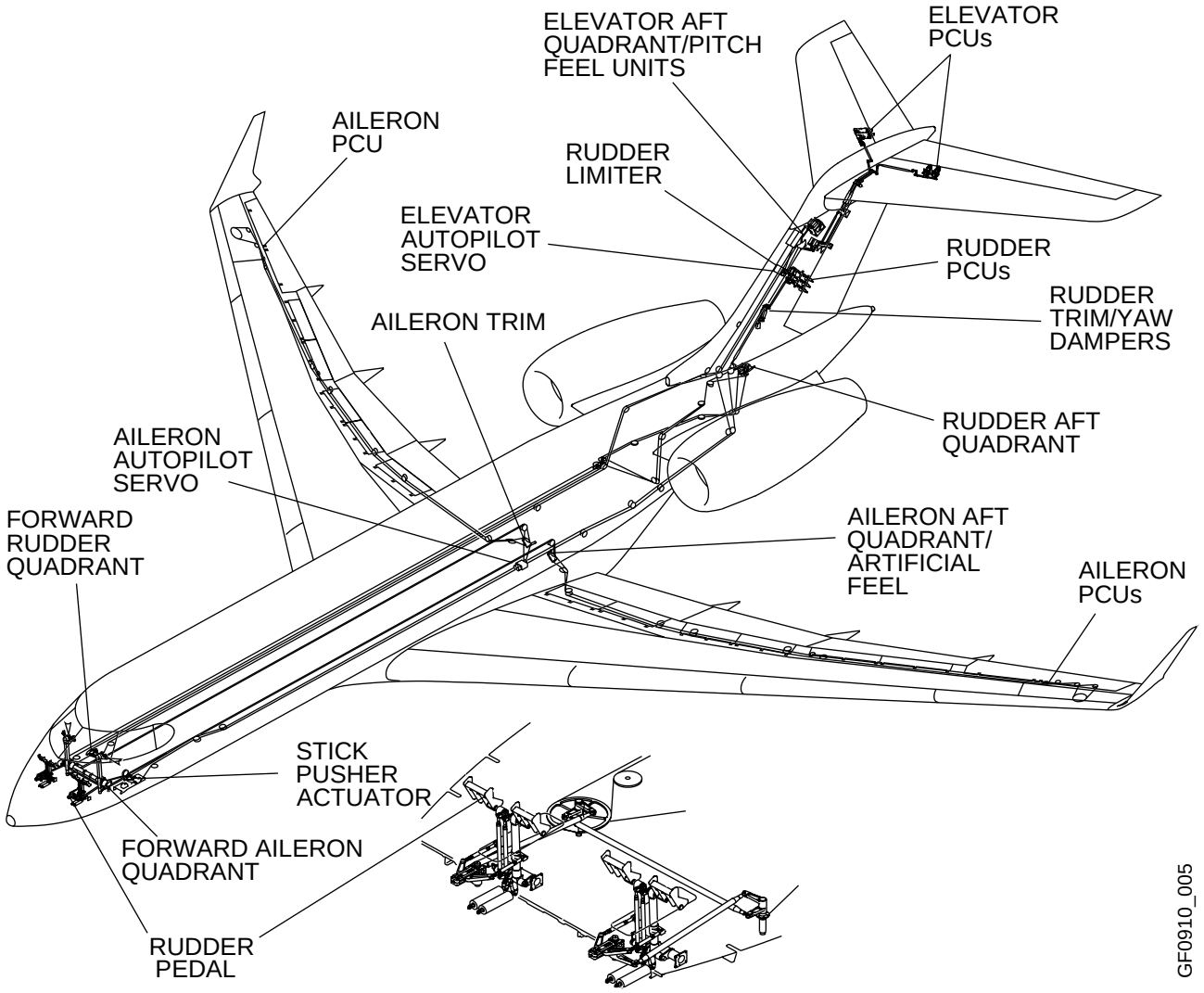
EICAS PRIMARY PAGE



Primary Page

PRIMARY FLIGHT CONTROL SCHEMATIC

Aerodynamic reaction forces at the primary controls are simulated by mechanical artificial feel units.



Lateral control is accomplished by a dual mechanical aileron control system hydraulically powered by two PCUs per aileron. Four multi-function spoilers per wing assist the ailerons in roll control (see SPOILER SYSTEM this Chapter). Aileron disconnect is provided for anti-jam protection. Artificial feel and centering is provided to lighten the load on the aileron control system.

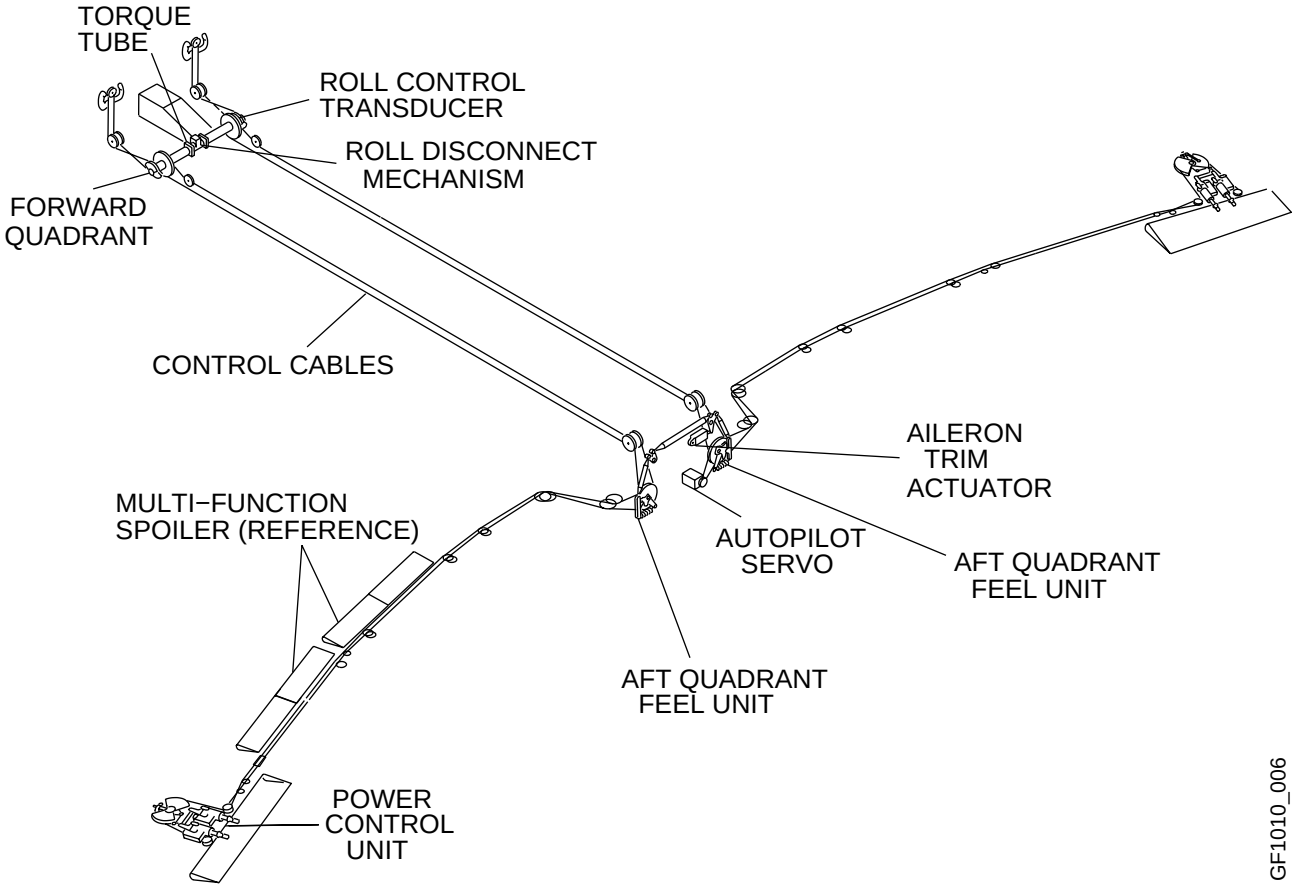
Pitch control is provided by a dual mechanical elevator control system hydraulically powered by two PCUs per elevator. Pitch disconnect is provided for anti-jam protection. Variable pitch artificial feel is provided to vary the load on the elevator control wheel as a function of airspeed and horizontal trim setting.

Yaw control is provided by means of three hydraulic PCUs to power the rudder. Rudder travel limiting as a function of airspeed is provided to limit loads on the structure. The rudder system uses dual cable circuits (aft fuselage) to protect the system from effects of engine rotor burst.

AILERON CONTROL

Lateral (roll) control is provided by ailerons operating in relation to control wheel displacement and controlled via control rods, cable runs and quadrants. The ailerons are assisted by four multi-function spoilers per wing, which are electrically controlled.

Aileron Control General Arrangement



Aileron Control System

Two separate lateral control systems are provided: the pilot's side operates the left-hand aileron and the copilot's side operates the right-hand aileron.

Normally, both control systems are interconnected through the forward torque tube interconnect assembly and there is simultaneous movement of both ailerons.

AILERON CONTROL (CONT'D)

Aileron Control System Operation

The pilot and copilot roll controls are interconnected through a roll disconnect mechanism used to maintain the control wheels connected, until a design torque is developed across the mechanism.

A jammed aileron control circuit can be isolated through automatic activation of the roll disconnect mechanism. This procedure will allow limited lateral control using one aileron and all multi-function spoilers through the operable control circuit.

NOTE

The Automatic Flight Control System (AFCS) should be disconnected if a jammed aileron control circuit condition occurs.

A transducer is mounted at the outboard end of each torque tube assembly (forward quadrant). They provide the roll command inputs to the multi-functional spoilers system for roll assist.

Rotating either control wheel provides an input (via cables and pulleys) to the aileron forward quadrant which directs the control cable to the aft quadrant.

Each aft quadrant has an artificial feel and centering unit. An aileron trim unit is installed with input to each aft quadrant and provides trim input to the aileron control system.

A separate cable circuit is provided for the autopilot servo motor (controlled by the AFCS) assembly which inputs the right aft quadrant.

Disconnecting the autopilot by the pilot overpowering the aileron servo will not cause the auto roll disconnect system to separate the control wheels.

NOTE

Overpowering the aileron servo to disconnect the autopilot is not recommended.

The control cables from the aft quadrant continue outboard to the hydraulically driven PCUs. There are two PCUs for each aileron control surface.

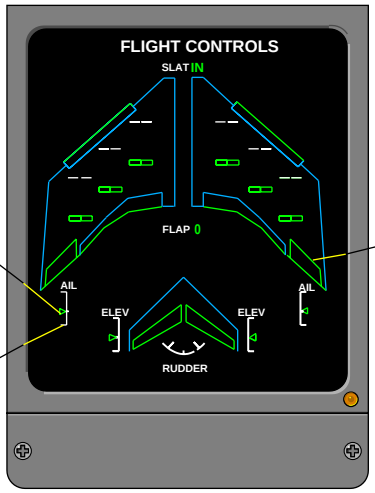
AILERON CONTROL (CONT'D)

Aileron Surface Position Indication

Left and right aileron positions are displayed by a moving pointer on the EICAS flight controls page. Separate pointers indicate the aileron surface position on each wing.

Scale Pointer
Unfilled triangle moves vertically to indicate the range of travel.

The surface position pointer will change color (green or amber) based on hydraulic pressure availability.



Surface Outline
The surface outline has no movement. It will change color, (magenta, green or amber) based on electrical power (ie: battery only or all busses powered) and hydraulic pressure availability.

Scale
Indicates the full range available for aileron up and down travel.

GF1010_007

SCALE		LONG TICK MARKS	SHORT TICK MARKS
Left side	−25° (top) +21.5° (bottom)	at top and bottom	at 0°
Right side	+25° (top) −21.5° (bottom)	at top and bottom	at 0°

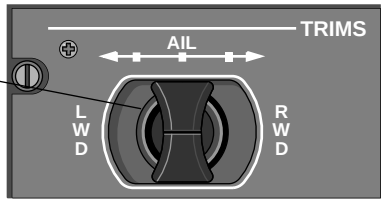
AILERON CONTROL (CONT'D)

Aileron Trim

Aileron trim is accomplished by selecting the AIL TRIM switches on the trim control panel (pedestal) in the desired direction. Actuating both switches provides arming and direction signals to reposition the ailerons through the use of a trim actuator. Hydraulic power is necessary to set aileron trim. Aileron trim position is displayed on PRIMARY page, along with the allowable take-off green band.

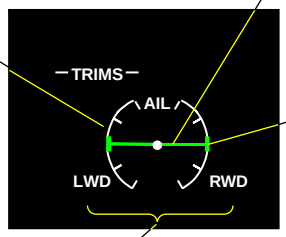
A "**CONFIG AIL TRIM**" red warning message is accompanied by a "NO TAKE-OFF" aural warning. It is displayed during the take-off roll if the aileron trim is set outside the allowable take-off range.

Aileron Trim Switch
Located on the trim control panel (centre pedestal). Spring loaded split switches requires both to be selected in the same direction. Push both switches full left or right to activate the trim.



Trim Scales
Aileron trim range for left wing down, centre and right wing down indications.

Pointer
Pivots about the centre dot and indicates the trim setting.



Green Band (take-off)
Replaces the centre tick mark. White if it is not in the green band.

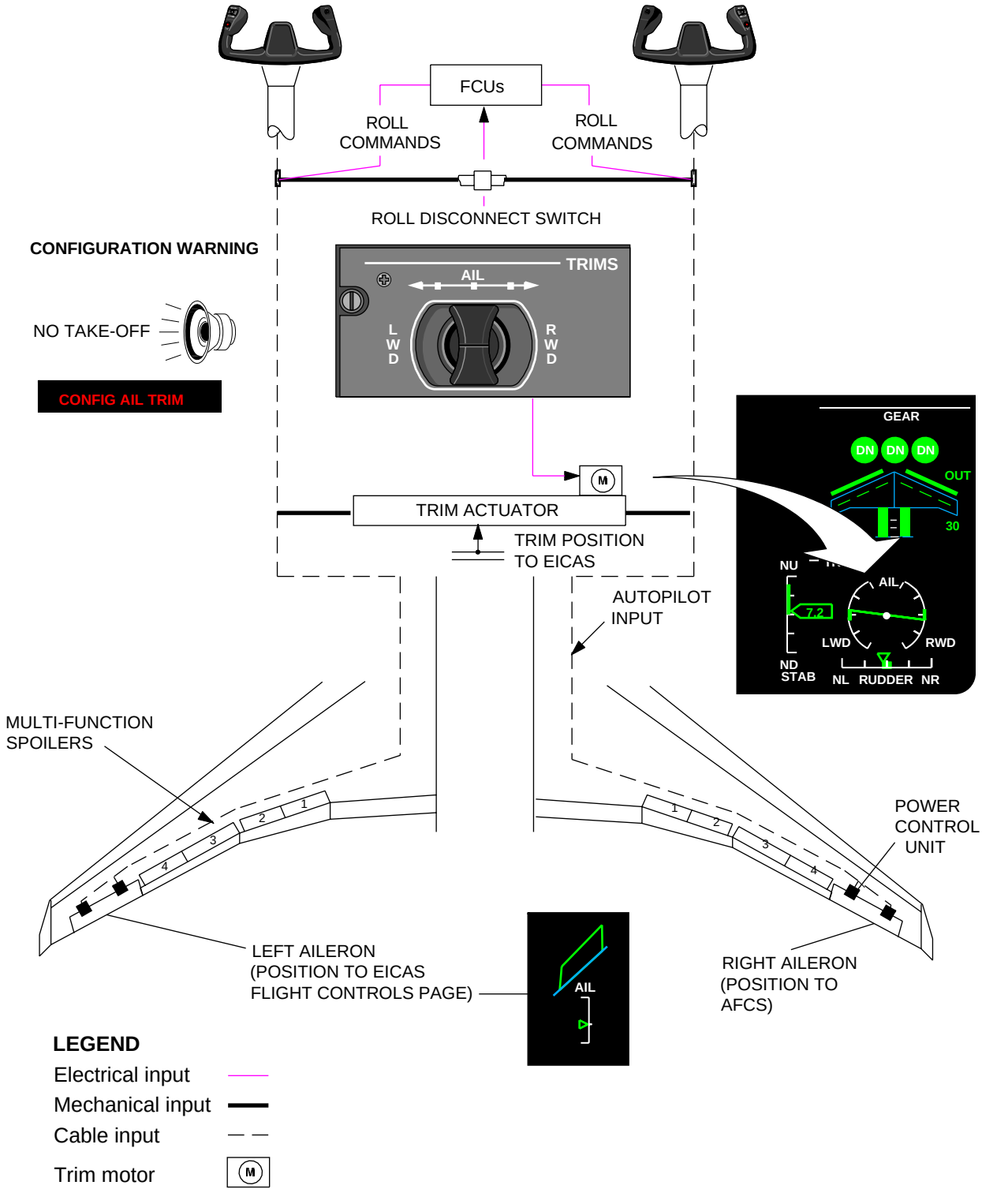
LWD − Left wing down.
RWD − Right wing down.

GF1010_009

SCALE		LONG TICK MARKS	SHORT TICK MARKS
Left side	+ 100% (bottom) − 100% (top)	± 100%	± 50% and 0%
Right side	+ 100% (top) − 100% (bottom)	± 100%	± 50% and 0%
Centre position		−	0%
GREEN BAND		**CENTRE TICK MARK**	
± 14%		Replaced by the green band	−

AILERON CONTROL (CONT'D)

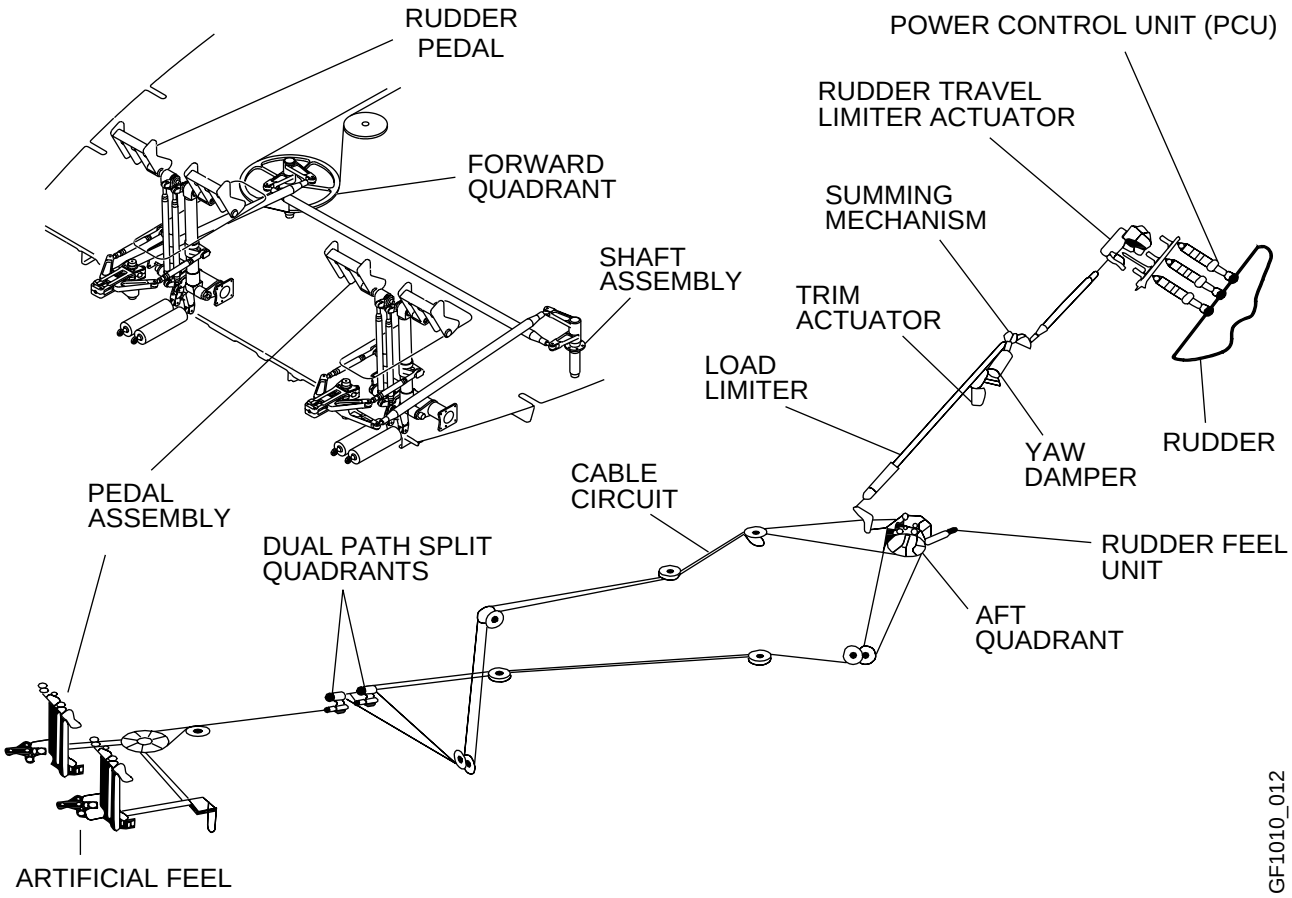
Aileron Control Schematic



RUDDER CONTROL

Directional control about the yaw axis is provided by the rudder control system. The rudder is hydraulically powered through displacement of either pilot's rudder pedals and controlled via control rods, cable runs and quadrants.

Rudder Control General Arrangement



Rudder Control System Operation

Each rudder pedal assembly uses an artificial feel unit and pedal input is transmitted via control rods to the forward quadrant and shaft assembly. The cable system has a single path in the fuselage and dualized in the rotor burst zone. The forward cable quadrant (one in each control circuit) transmits the cable circuit to the aft quadrant. Artificial feel is provided by a linear spring unit (rudder feel unit), connected to the aft quadrant.

Rudder input from the aft quadrant is received by a load limiting bungee (telescopic rod) which protects the system from rapid inputs. The load limiter delivers pilot input to a summing mechanism which adds the trim and yaw damping commands to the pilot commanded rudder input.

Yaw dampers are used to improve the airplane's lateral/directional stability and turn coordination. Dual yaw dampers operate in an active/standby mode to provide continuous yaw damping in the event of one failed yaw damping channel. The active/standby status will be switched each flight leg.

RUDDER CONTROL (CONT'D)

Rudder Control System Operation (Cont'd)

Initial yaw damper engagement is controlled by flight guidance computer at IAC power up. In flight, the pilot must select the YAW switch located on the guidance panel if re-engagement of the yaw damping system is necessary.

The yaw damper authority, given neutral trim, provides a nominal value of 7.5 ° rudder left or right. Yaw damper condition is continuously monitored and any fault detected is displayed on EICAS. To ensure full motor performance in cold conditions, each actuator has a thermofoil heater which is powered, controlled and monitored by the Heater Brake Monitor Unit (HBMU). For the damping control systems characteristics, refer to the AFCS Chapter 4 of this manual.

The summing mechanism output is transmitted to a control rod to the Rudder Travel Limiter (RTL). The RTL limits the rudder surface travel at high speeds and allows full rudder surface travel at low speeds. The RTL output drives a torque tube which is connected (via load limiting bungees) to the input lever of the associated hydraulic PCUs. There are three PCUs powering the rudder system.

Rudder Travel limiter

The RTL limits rudder authority as a function of Calibrated Airspeed (CAS) and flap position to protect the deflection of the rudder surface beyond the structural capability of the vertical stabilizer, while allowing for sufficient authority to control the airplane. The RTL also allows for full rudder authority at high airspeed in the event of total loss of (FCU) control.

The position of the rudder is shown on EICAS Flight Control page (rudder trim position is shown on Primary page). Left and right rudder indication is displayed by a pointer on the synoptic page.

Rudder Surface Position Indication

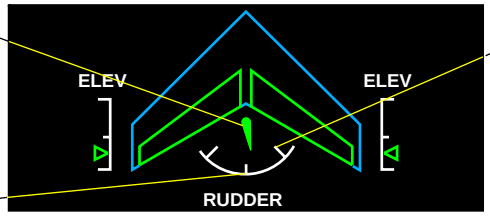
Left and right rudder surface position is displayed by a moving pointer on the EICAS FLIGHT CONTROLS page. A single pointer indicates left and right rudder surface positions.

Scale Pointer

Filled rudder cross−section directed toward the centre of the scale. It will change color, (green or amber) based on hydraulic pressure availability.

Scale

Arc represents the left and right rudder travel paths.



Rudder Limit Bug

Indicates the position and status of the rudder limiter.

- Control active − bug color is white.
- Control inactive − bug color is amber.
- Invalid − bug is removed.

GF1010_013

SCALE		SHORT TICK MARK
Pointer right	+35.5°	at 0°
Pointer left	−35.5°	

Rudder Trim

Rudder trim is available by rotating the RUD TRIM control switch on the trim control panel (centre pedestal), in the desired direction. The control provides signals to a trim actuator that repositions the rudder neutral point.

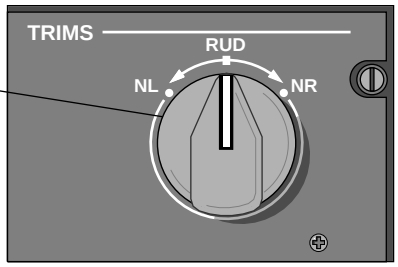
Hydraulic power is necessary to set rudder trim. Rudder trim position is displayed on PRIMARY page, along with the allowable take-off green band.

RUDDER CONTROL (CONT'D)

Rudder Trim (Cont'd)

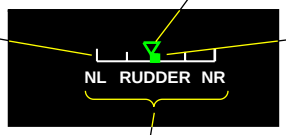
A "**CONFIG RUD TRIM**" red warning message is accompanied by a "NO TAKE-OFF" aural warning. It is displayed during the take-off roll if the rudder trim is set outside the allowable take-off range.

Rudder Trim Switch
Located on the trim control panel (pedestal). Switch must be rotated full left or right to activate the trim. Spring loaded to the centre position.



Pointer
Moves horizontally along the scale to indicate the trim setting.

Trim Scales
Rudder trim range for nose left centre and nose right indications.



Green Band (take-off)
Replaces the centre tick mark. White when not in the green take-off position.

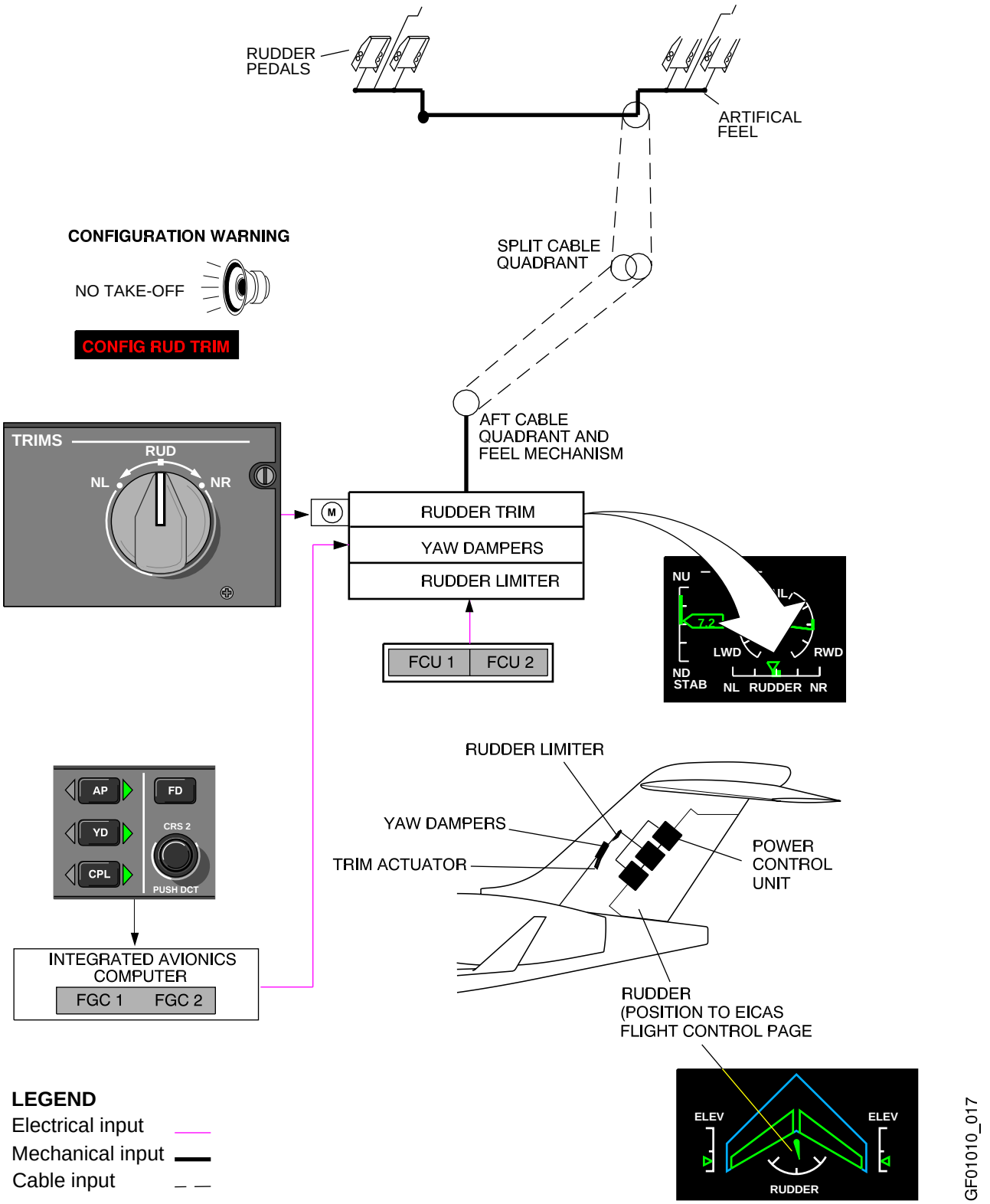
NL − Nose left.
NR − Nose right.

GF1010_015

HORIZONTAL SCALE	LONG TICK MARKS	SHORT TICK MARKS
Between −100% (right), +100% (left)	± 100%	± 50% and 0%
Centre position	−	0%
GREEN BAND	**CENTRE TICK MARK**	
± 7.4%	Replaced by the green band	−

RUDDER CONTROL (CONT'D)

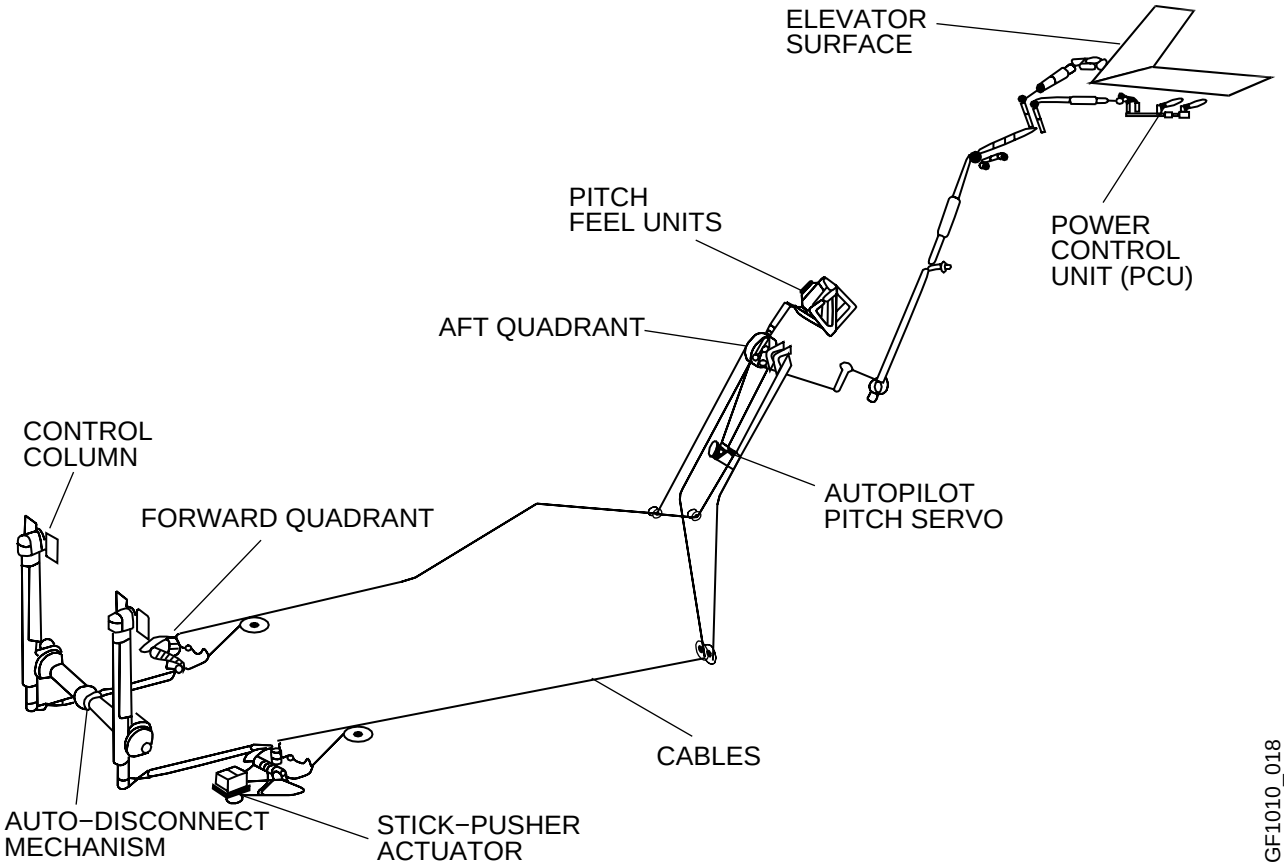
Rudder Control Schematic



ELEVATOR CONTROL

Longitudinal control is provided by elevators operating in relation to control column displacement and supplemented by a moveable horizontal stabilizer for maintaining longitudinal (pitch) trim. Pilot inputs to the elevator circuit are from the dual control columns which are normally connected through an automatic disconnect mechanism.

Elevator Control General Arrangement



Elevator Control System

Two separate pitch control systems are provided: the pilot's side operates the left-hand elevator and the copilot's side operates the right-hand elevator. Normally, both control systems are interconnected through a torque tube assembly and there is simultaneous movement of both elevators.

Elevator Control System Operation

The pilot and copilot pitch controls are interconnected through a pitch disconnect mechanism used to maintain the control wheels connected, until a design torque is developed across the mechanism.

NOTE

The AFCS (autopilot) should be disconnected if a jammed elevator control circuit condition occurs.

ELEVATOR CONTROL (CONT'D)

Elevator Control System Operation (Cont'd)

A jammed elevator control circuit can be isolated through automatic activation of the pitch disconnect mechanism. This procedure will allow limited pitch control using one elevator through the operable control circuit.

A control rod located at the base of each column transmits pilot command to the left and right forward quadrants. The left forward quadrant includes a cable interface with the stick pusher servo of the stall protection system.

The cable circuits travel independently from the forward quadrant to the aft quadrant located in the vertical stabilizer. A separate cable circuit is provided for the autopilot servo motor assembly which inputs the right aft quadrant.

Disconnecting the autopilot by the pilot overpowering the pitch servo will not cause the auto pitch disconnect system to separate the control columns.

NOTE

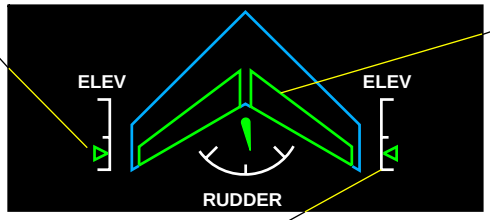
Overpowering the servo to disconnect the autopilot is not recommended.

Two electrical actuators positioned at the pitch feel simulator provides input to the aft quadrant for force feel requirements. The actuators receive command input from the FCUs based on airspeed and horizontal trim position.

The aft quadrants drive a series of control rods and levers which input a torque tube assembly to positions the hydraulic PCUs. Two PCUs are used for each elevator.

Elevator Surface Position Indication

Left and right elevator positions are displayed by a moving pointer on the FLIGHT CONTROLS page on EICAS. Separate pointers indicate the left and right elevator surface positions.



Scale Pointer
Unfilled triangle moves vertically to indicate the range of travel.
The surface position pointer will change color (green or amber) based on hydraulic pressure availability.

Surface Outline
The surface outline has no movement. It will change color (magenta, green or amber) based on electrical power (ie: battery only or all busses powered), and hydraulic pressure availability.

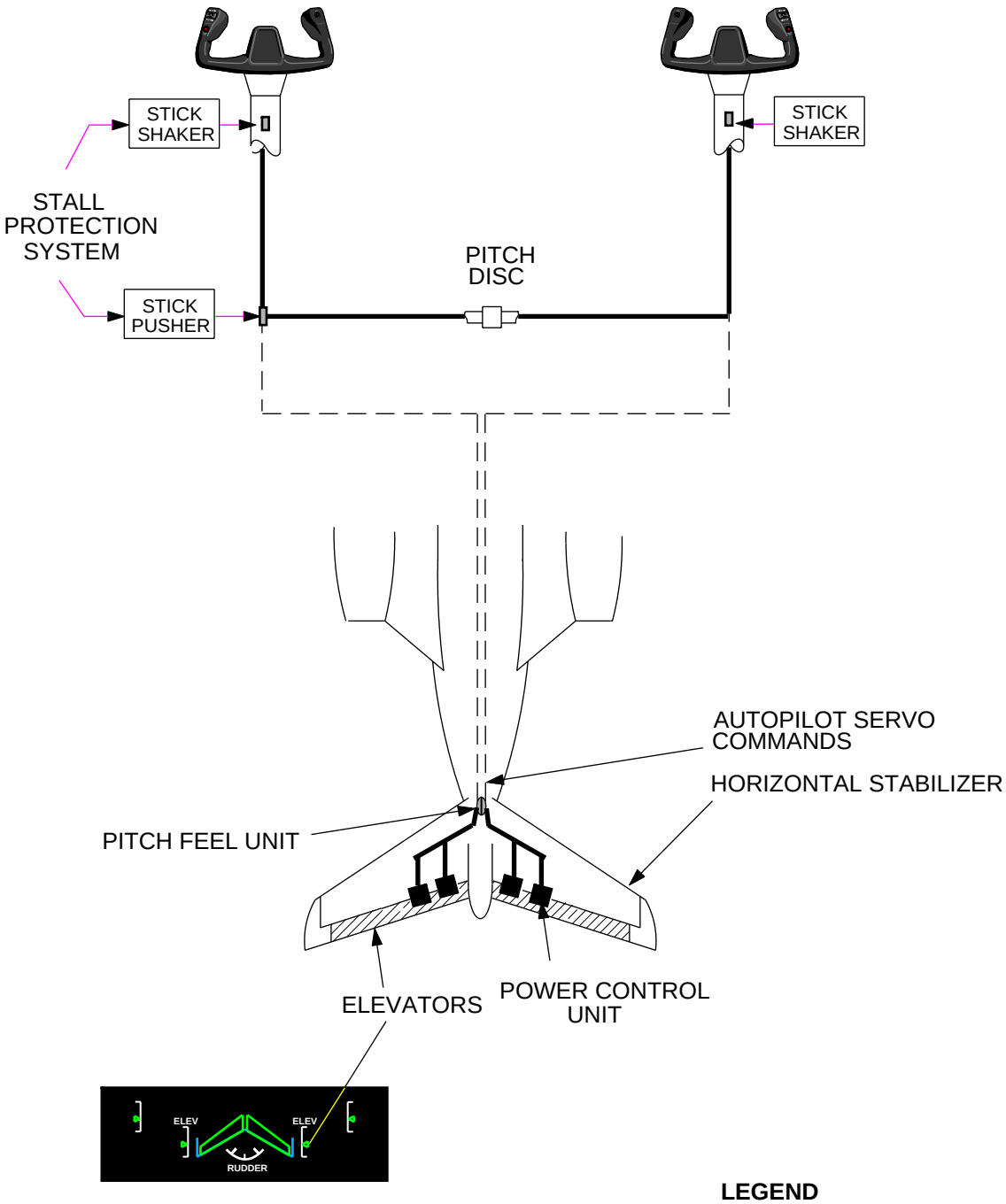
Scale
Indicates the full range available for elevator up and down travel.

GF1010_019

SCALE		LONG TICK MARKS	SHORT TICK MARKS
Left side	−22.5° (top) +17.5° (bottom)	at top and bottom	at 0°
Right side	−22.5° (top) +17.5° (bottom)	at top and bottom	at 0°

ELEVATOR CONTROL (CONT'D)

Elevator Control Schematic



FLIGHT CONTROL SYNOPTIC PAGE

STABILIZER TRIM

The stabilizer trim control system provides pitch trim by varying the angle of incidence of the horizontal stabilizer. The system consists of two Flight Control Units (FCUs), dual channel Motor Drive Unit (MDU) and a dual electric channel trim actuator which drives a screw jack assembly to position the horizontal stabilizer.

The pilot controls consist of switches on each control column and one horizontal stabilizer trim panel. Pilot trim commands have priority and will override copilot trim command inputs. The horizontal stabilizer can be trimmed from 2 degrees airplane nose down to 12 degrees nose up.

The FCUs are responsible for the monitoring of the trim system. They have their own dedicated interfaces with other airplane systems and with pilot/copilot controls to perform trim control and monitoring. The horizontal stabilizer system provides two redundant channels in an active/standby basis such that full performance requirements can be met with either channel.

Pitch Trim Input

The FCUs receive inputs from the following systems:

- Integrated Avionic Computer (IACs).
- Air Data Computer (ADCs).
- Automatic Flight Control System (AFCS).
- STAB switches.
- Pitch trim and disconnect switches.

For manual stabilizer trim control, the FCUs receive commands from the pilot and copilot trim switches. To perform the Mach trim function, the FCUs receive the airplane mach number from three ADCs. Two IACs which comprise the AFCS function provide stabilizer trim command when the autopilot is engaged. The ADCs provide mach data used for mach trim and rate scheduling.

The FCUs in turn command the MDUs to drive the motors of the horizontal stabilizer trim actuators. The FCUs monitor the results of the command inputs to ensure correct control trim rate and direction is achieved.

The Stab trim switches on the STAB control panel send signals to the FCUs for engagement and disconnect. These switches also send a signal direct to the MDU to ensure disconnect of the applicable trim actuator.

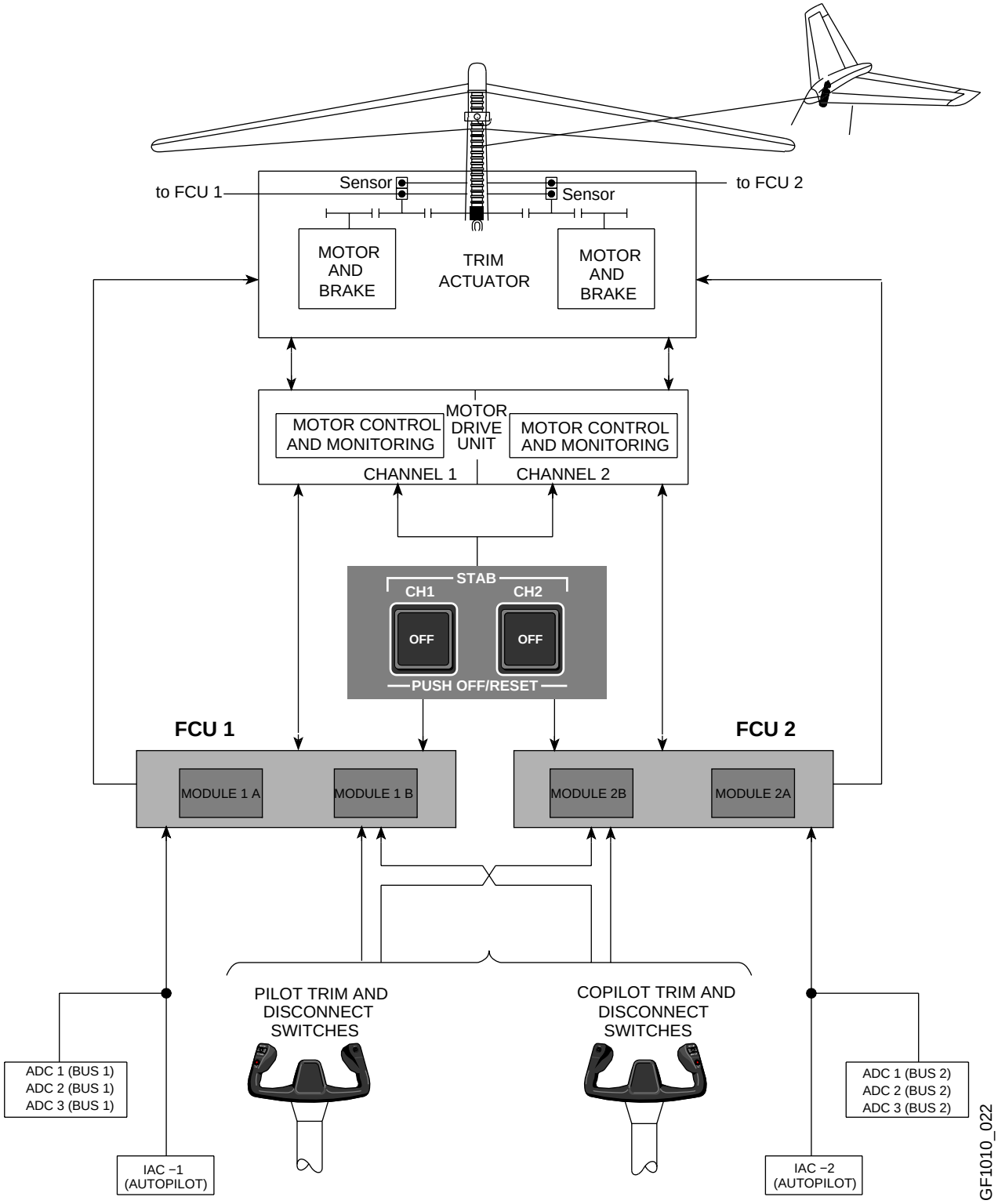
Stabilizer Actuator Assembly

Refer to Pitch Trim Schematic

The actuator assembly positions the surface in response to electrical signals from the MDU. The stabilizer is positioned by a jack screw driven by electric trim motors within the actuator assembly. The actuator assembly has brakes which provide a secondary means of preventing creeping in flight under aerodynamic loads. A sensor mounted on each motor sends signals to the MDU to determine each motor position.

STABILIZER TRIM (CONT'D)

Pitch Trim Schematic

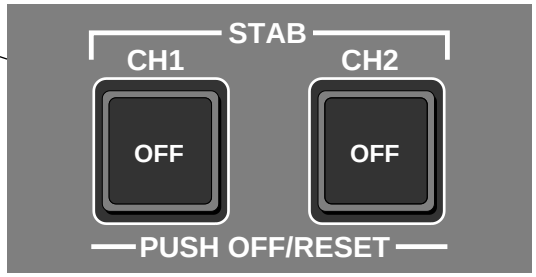


STABILIZER TRIM (CONT'D)

Stabilizer Trim Control Switches

The STAB trim control switches are located on the flight control trim panel (centre pedestal). For normal operations, both switches are normally released (not pushed in) and remain dark. A white “OFF” legend is displayed only when the switch is selected. This action will disconnect the channel from the trim system and will remain disconnected as long as the switch has been selected.

STAB Switches
Used to disconnect each channel of the trim system or reset certain latched transient faults.
Selecting the switch will disengage the pitch trim channel and the "OFF" light will illuminate.

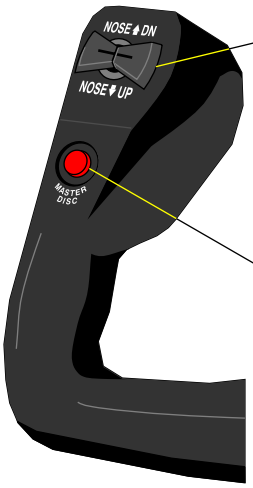


GF1010_023

Failure monitoring within the FCU provides automatic failure detection and transfer to the opposite channel, along with disabling of the channel detected as failed.

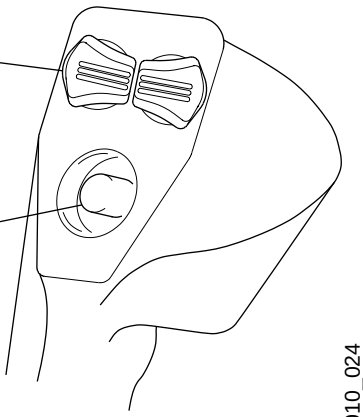
Manual Pitch Trim

The horizontal stabilizer trim is commanded through trim switches located on the pilot and copilot control columns. The switches command airplane nose up or nose down movement of the actuator with a controlled trim rate dependent on the airplane Mach number.



Stabilizer Trim Lever Switches
Enables pilot to vary stabilizer trim according to flight requirement. Both levers must be pushed fully up or fully down to activate the pitch trim.

Master Disconnect Switch
Provides a disconnect command to the AFCS and disconnects the pitch trim function and stall pusher while the switch is held.



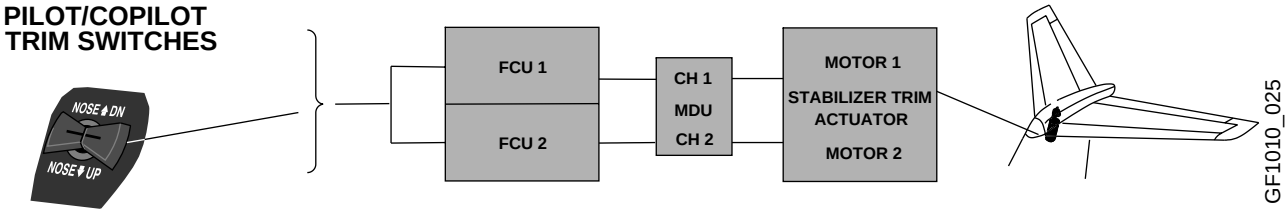
NOTE
The pilot control column is shown: copilot’s is similar.

GF1010_024

STABILIZER TRIM (CONT'D)

Manual Pitch Trim (Cont'd)

The manual trim rate is 0.5 degree per second at low Mach number and decreases gradually to 0.25 degree per second as the Mach number increases above 0.5M.

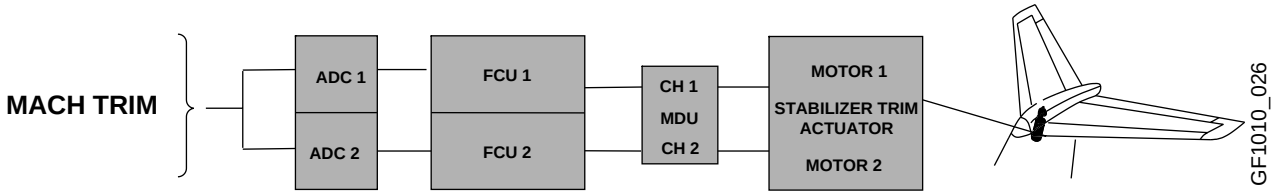


Mach Trim

The Mach trim system provides longitudinal stability using Mach speed information from the ADCs and varies the angle of incidence of the horizontal stabilizer by commanding the horizontal stabilizer actuator. Mach trim provides automatic compensation of airplane pitching with changes of Mach number. The trim rate follows a schedule dependent on Mach number. The Mach number is transmitted to the FCUs from the airplane ADCs which pass command signals to the MDU.

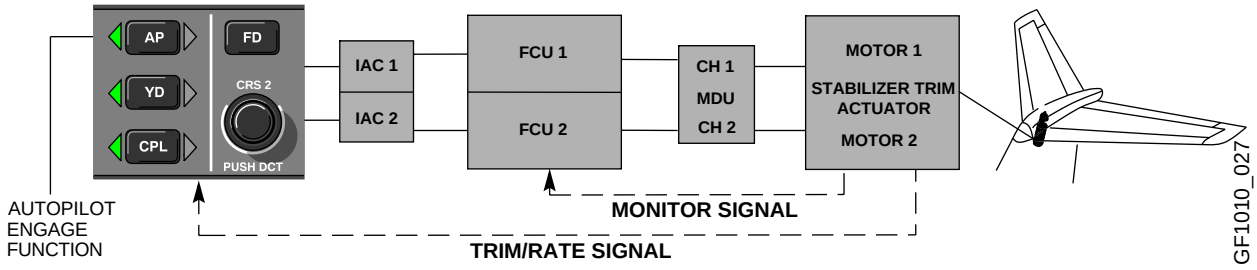
The Mach trim authority is limited to 2 degrees of horizontal stabilizer movement and the trim rate varies between 0.03 and 0.06 degree per second.

Mach trim is disabled when the Automatic Flight Control System(AFCS) is engaged.



Automatic Pitch Trim

When automatic flight is engaged, the trim system will take its commands from the AFCS. The AFCS function is performed by the Integrated Avionics Computers (IACs). The FCUs receive motor commands from the AFCS through the IACs, then pass the command signals to the MDU. Trim rate and motion is received by the AFCS and monitoring is also performed in the FCU.



Manual trim has priority over autopilot pitch trim and mach trim. If the pilot or copilot trim switches are activated with the AFCS engaged, the FCU will generate a signal causing the AFCS to disengage. The automatic pitch trim rate operation is from 0.5 to 0.015 degree per second.

STABILIZER TRIM (CONT'D)

Stabilizer Trim Display

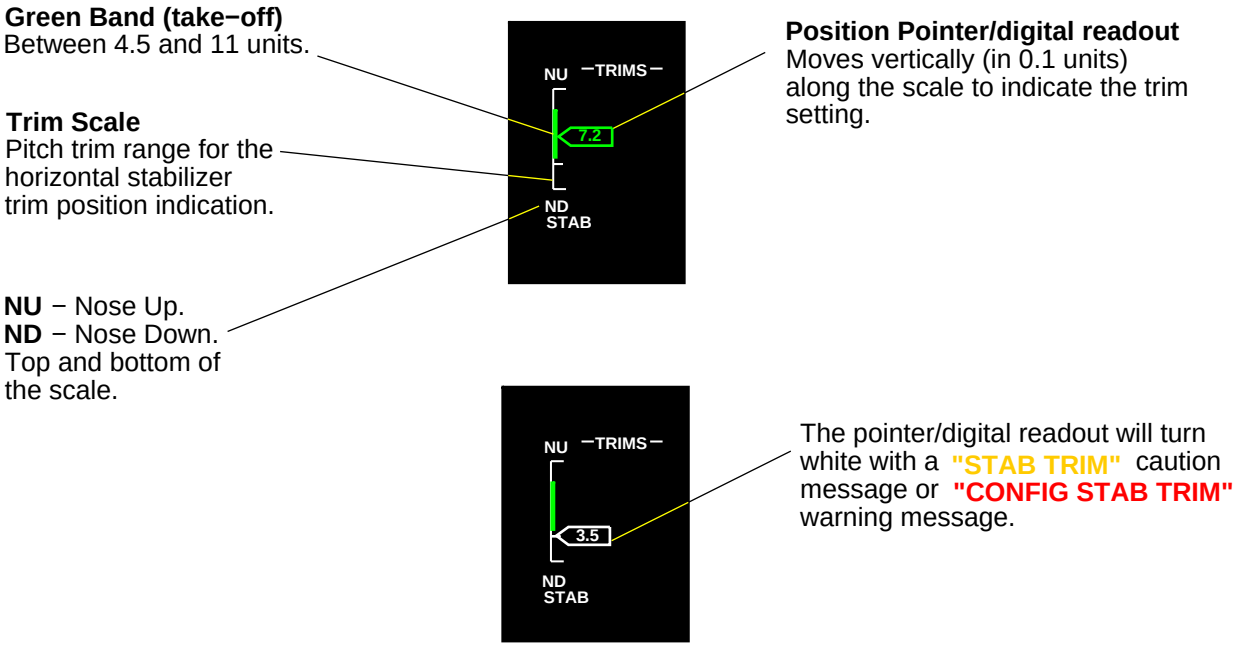
The EICAS primary page provides a full time display of the horizontal stabilizer trim position and system status. The display is grouped with the display for the aileron and rudder trims. The horizontal stabilizer trim position is represented by a pointer moving on a vertical linear scale. The pointer includes a digital readout of the trim value. The range of stabilizer movement in degrees is converted to units from 0 to 14 for the purpose of position display.

A "**CONFIG STAB TRIM**" red warning message is accompanied by a "NO TAKE-OFF" aural warning and is displayed during the take-off roll if the stabilizer trim is set outside the allowable take-off range.

The color of the pointer and digital readout is dependent on system status:

- WHITE − On ground or during take-off if the horizontal stabilizer trim is trimmed outside the take-off range (green band).
- GREEN − Operative and when on the ground or during take-off, trimmed within the take-off range.

When the airplane is on the ground or during take-off, the trim take-off range is displayed as a green band within the white scale. In flight, the complete scale reverts to green.



VERTICAL SCALE	LONG TICK MARKS	SHORT TICK MARKS
Between 0 units (bottom) and 14 units (top)	0 and 14 unit positions	3.5, 7 and 10.5 units
GREEN BAND	**TAKE-OFF GREEN BAND**	−
Between 4.5 and 11 units	Replaces the 7 and 10.5 marks	

STABILIZER TRIM (CONT'D)

Stabilizer In Motion Aural Warning

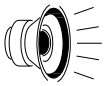
The stabilizer in motion aural clacker signals operation of the horizontal stabilizer under the following conditions:

- Operation of more than 3 seconds at a rate used for manual trim (0.2 degrees per second or greater).

  OR

- More than 6 seconds at a low rate above the mach trim rate (.08 degrees per second or greater).

CONFIGURATION WARNING



CLACKER

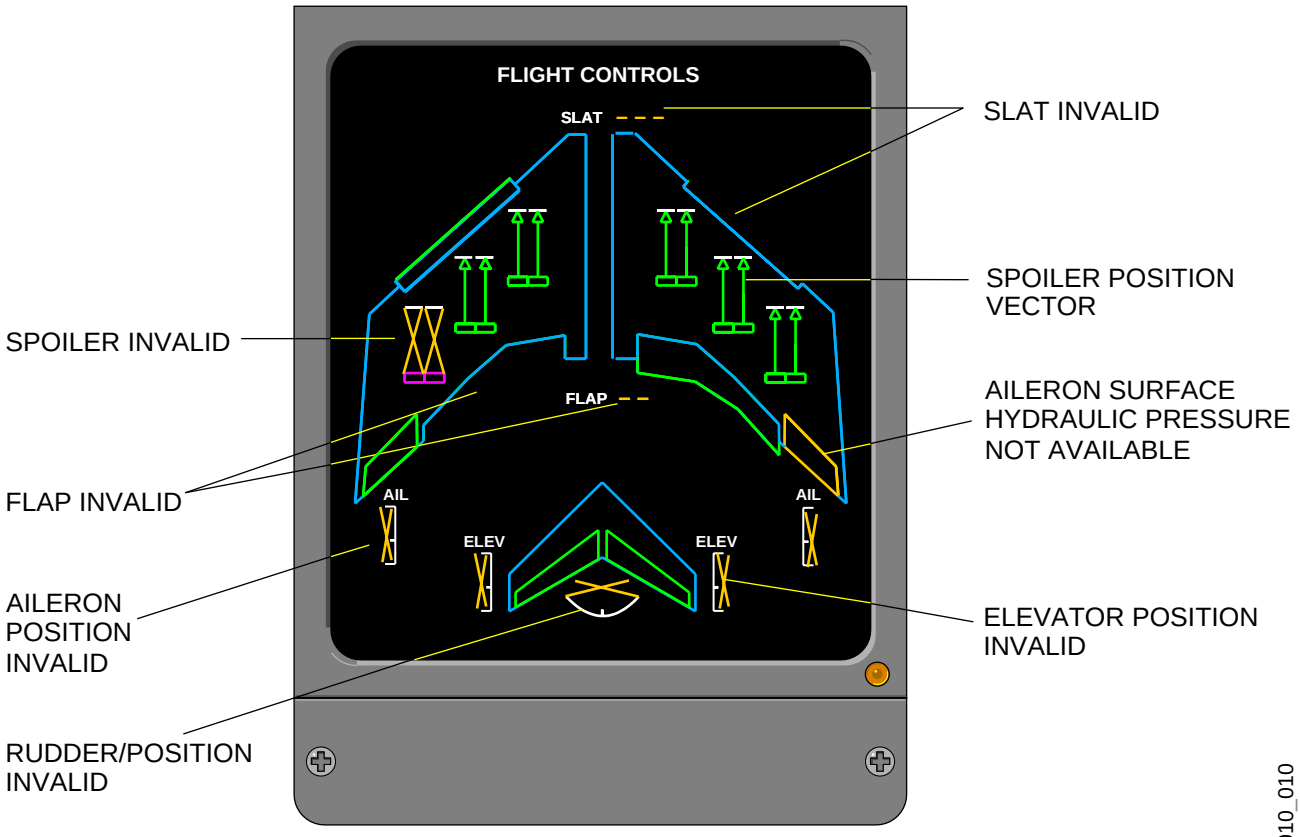
Horizontal stabilizer trim position and condition is continuously monitored and any fault detected is displayed on EICAS.

SPLRS/STAB In Test

An advisory message "**SPLRS/STAB IN TEST**" will be displayed when the spoilers and stab trim systems are performing self-test once hydraulics are applied. The horizontal stabilizer system is inoperative through the duration (approximately 20 seconds) of the test. Refer to the EICAS MESSAGES in the spoiler section of flight controls for the message display.

FLIGHT CONTROL INVALID DATA DISPLAYS

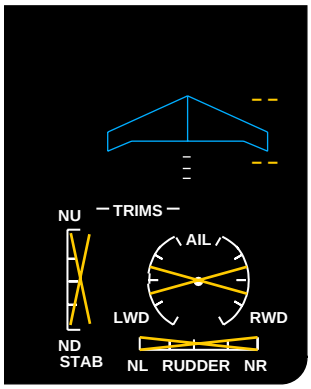
Flight Control Synoptic Page



GF1010_010

Invalid data

Flight Control Primary Page



CONTROL SURFACE DISPLAYS:

- FLAPS
- SLATS
- SPOILERS

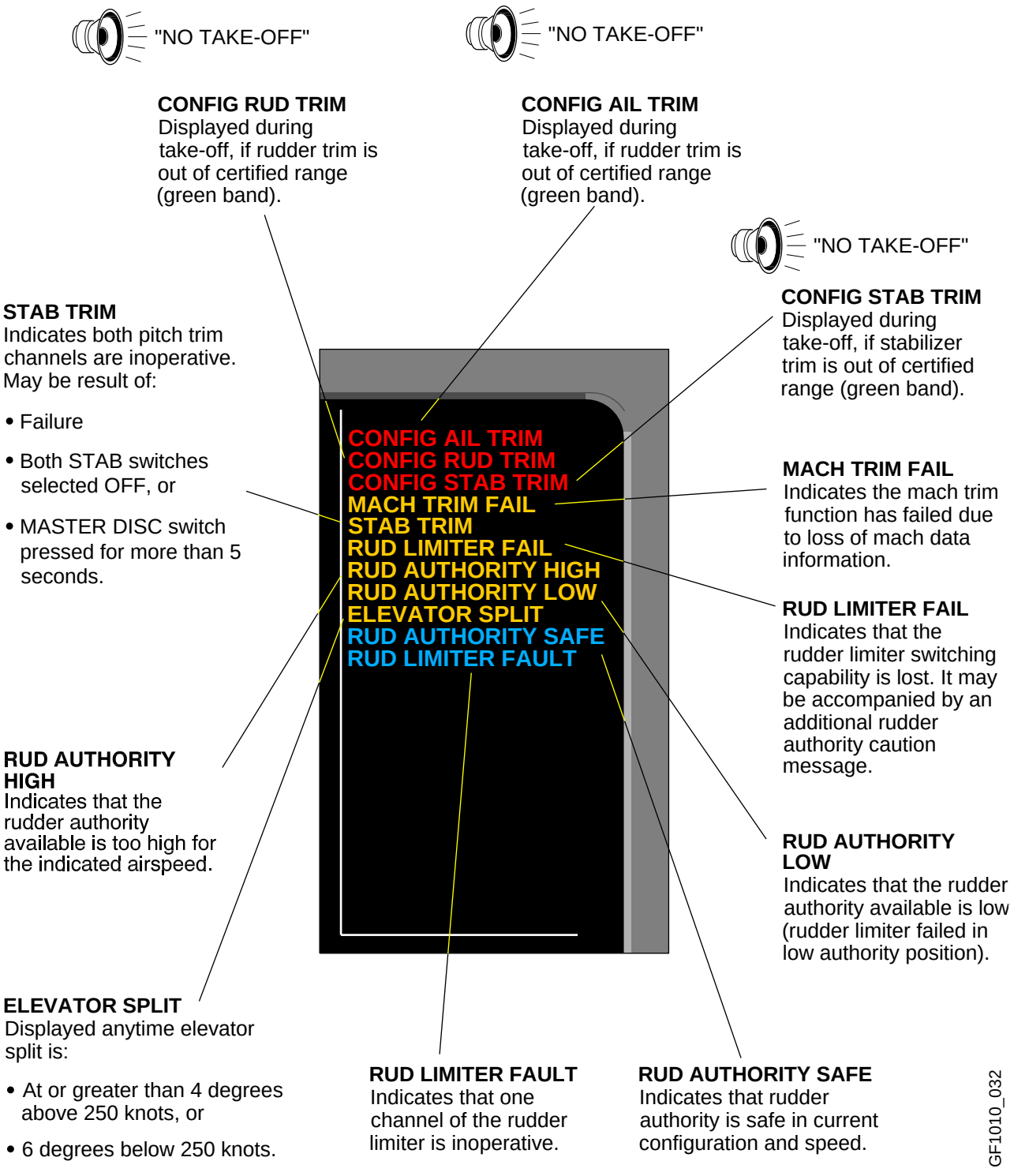
TRIM DISPLAYS:

- AILERON
- RUDDER
- STABILIZER

GF1010_031

Invalid data

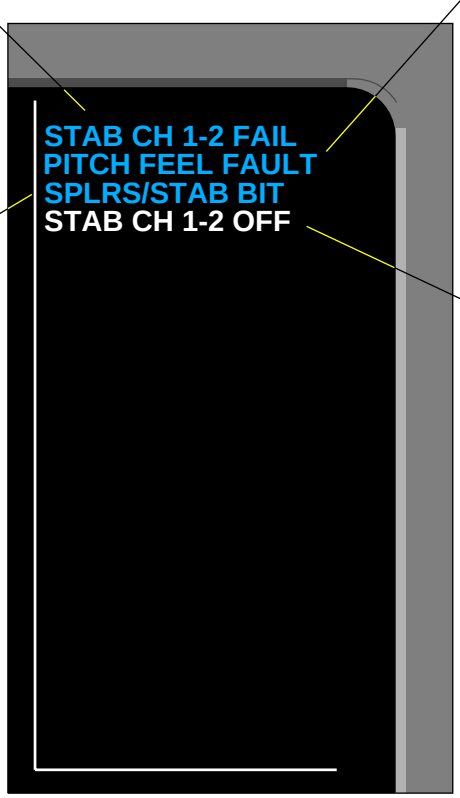
PRIMARY/SECONDARY FLIGHT CONTROL EICAS MESSAGES



PRIMARY/SECONDARY FLIGHT CONTROL EICAS MESSAGES (CONT'D)

STAB CH 1-2 FAIL
Indicates that channel 1 or 2 failed.

PITCH FEEL FAULT
Indicates that either pitch feel is inoperative or degraded (force gradient not nominal) on one or both channels.



SPLRS/STAB BIT
Indicates that a fault has been recognized by the flight control unit (maintenance action before the next scheduled check). This message appears only on the ground.

STAB CH 1-2 OFF
Indicates that the affected pitch trim off switch (centre pedestal) has been selected to the OFF position.

GF1010_033

SLAT/FLAP CONTROL SYSTEM

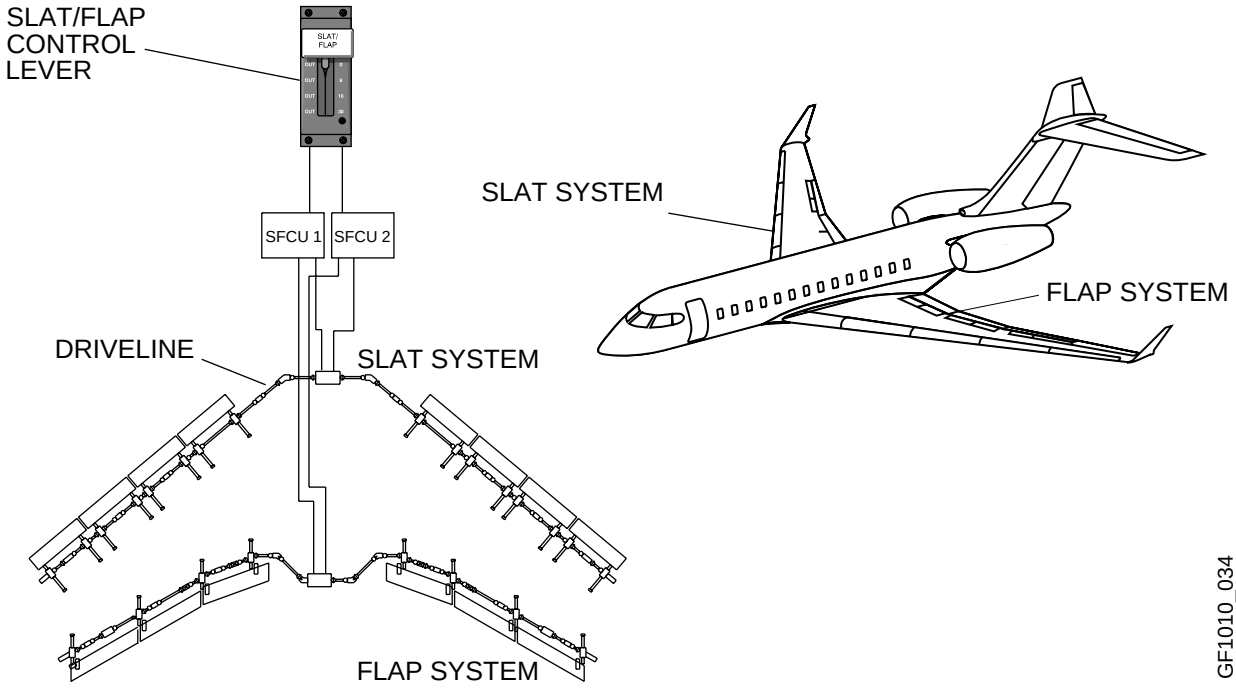
The slat and flap control system is an integrated electro-mechanical system which operates both slats and flaps from a single flight compartment control lever. The flap and slat control systems are mechanically independent. Each system is comprised of actuators, linked through a rigid driveline, to a central Power Drive Unit (PDU). Each PDU incorporates dual electric motor/brake assemblies. The slats and flaps will continue to operate at half speed with a single motor operating.

Asymmetry brakes for both flaps and slats are installed to provided driveline braking in the event of shaft failures. Dual sensors are located at the outboard-most ends of the driveline. They are used by the control units for system positioning and fault monitoring. Position sensors are located next to each flap actuator to provide position feedback to the control units.

The slats are extended first if both slat and flap extension is required. The flaps are retracted first if both slat and flap retraction is required.

Two Slat/Flap Control Units (SFCUs) control the operation of the slats and flaps. Electrically there are two independent channels for slats and two independent channels for flaps. Each SFCU controls and monitors the flaps and slats independently of the other unit. Each SFCU controls one slat PDU motor and asymmetry brake and one flap PDU motor and asymmetry brake. System control provides protection against asymmetry and uncommanded movement.

Slat/Flap System Schematic

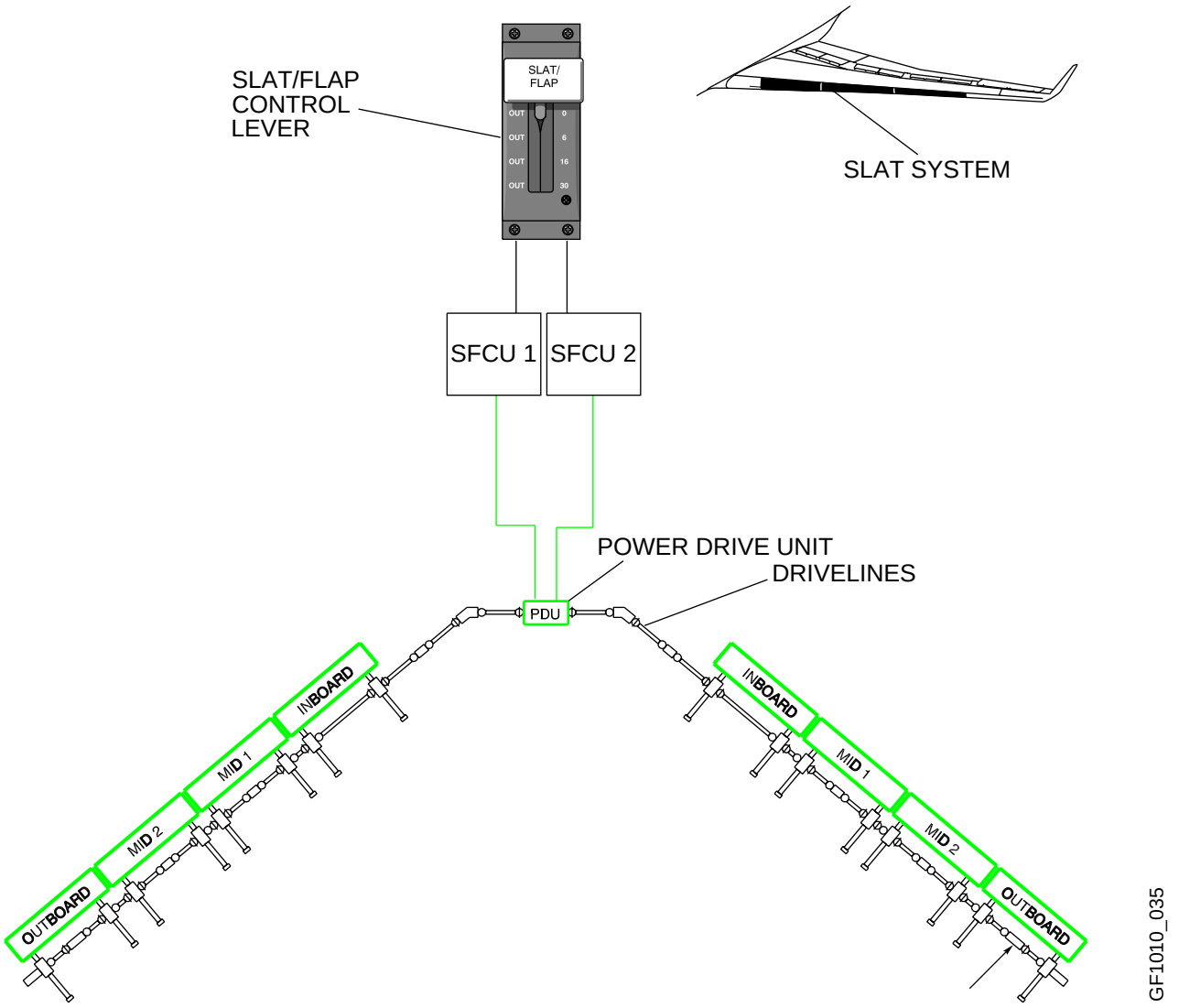


SLAT CONTROL SYSTEM

The slat system has four leading edge slat panels with two actuators per slat panel connected to a slats Power Drive Unit (PDU), linked through a rigid driveline (torque tubes/bearings) and controlled by the slat/flap handle position. The PDU is driven by two DC motors connected together in a speed sum configuration. Each motor is controlled by a single channel SFCU. There is a brake on each slat motor that is also controlled by the SFCU. The PDU provides protection against an overload and jam condition. To protect against asymmetry, there are dual coil brakes and position sensors located on each outboard station, left and right, that interface with both SFCUs.

The slats are anti-iced and automatically controlled by the ice detection system. Telescopic ducting is installed between the inboard fixed leading edge and the outboard slats for anti-icing. Refer to Chapter 14 for additional information on the anti-icing/bleed system.

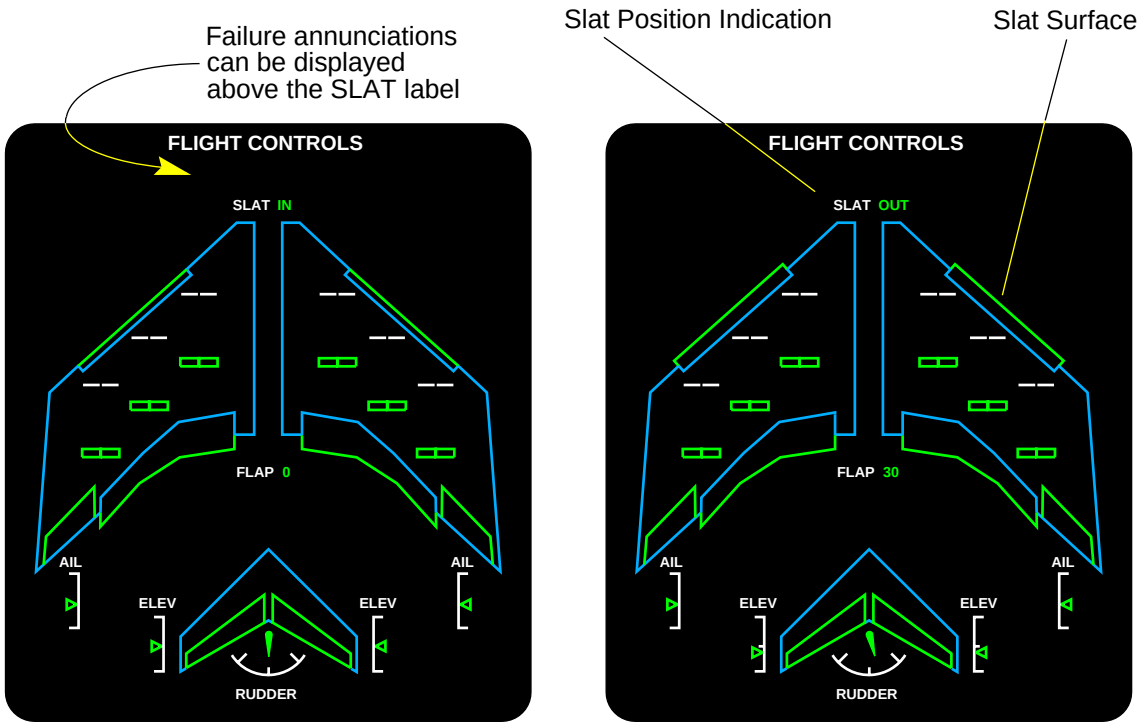
Slat System Schematic



The slat position and surface position is displayed on the EICAS FLIGHT CONTROL synoptic page. Slat indication is also shown on the EICAS PRIMARY PAGE.

SLAT CONTROL SYSTEM (CONT'D)

Slat Position and Surface Indications



Slat/Flap surfaces retracted **Slat/Flap surfaces extended**

Slat Position Indication and Surface color	
If the slats are at commanded position, the slat position indication and slat surface will turn green.	
If the slats are in motion, the slat position indication and slat surface will turn white.	
If the "SLAT FAIL" or "SLAT FAULT" message is displayed, the slat position indication and slat surface will turn amber.	
Synoptic Failure Annunciations	**Logic**
"HALFSPEED"	If "SLAT HALFSPD" message is on.
"DRIVE OVERHEAT 1"	Overheat detected by channel 1.
"DRIVE OVERHEAT 2"	Overheat detected by channel 2.
"DRIVE OVERHEAT 1−2"	Overheat detected by channel 1 and 2.

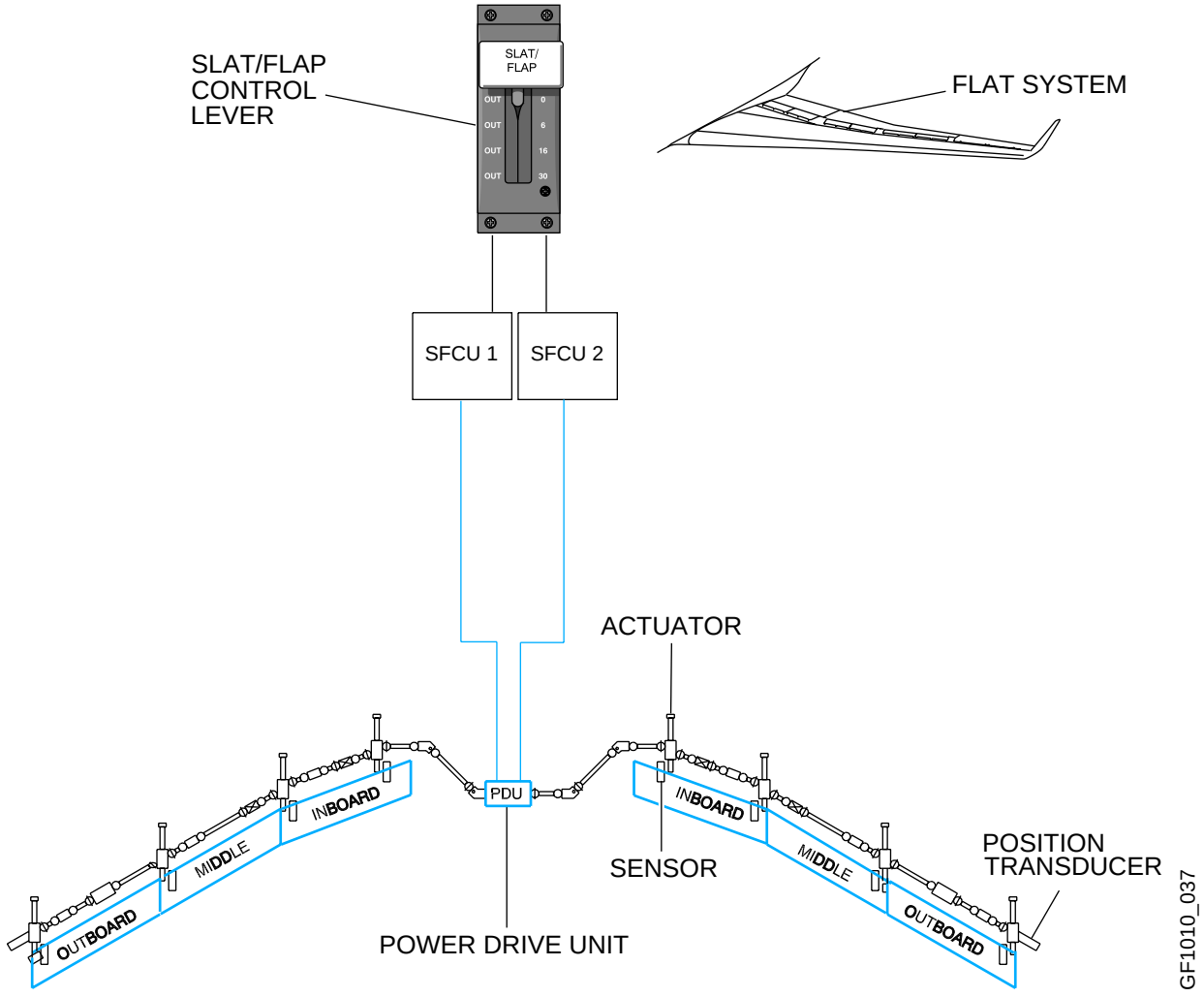
GF1010_036

FLAP CONTROL SYSTEM

The flap system has three flap panels with four actuators per wing connected to a flaps Power Drive Unit (PDU), linked through a rigid driveline (torque tubes/bearings) and controlled by the slat/flap handle position. The PDU is driven by two DC motors connected together in a speed sum configuration. Each motor is controlled by a single channel SFCU. There is a brake on each flap motor that is also controlled by the SFCU. The PDU provides protection against an overload and jam condition.

To protect against asymmetry, there are dual coil brakes and position sensors located on each outboard station, left and right, that interface with both SFCUs. There are also direction sensors on the flap system used to detect actuator disconnects. The sensors on the left wing report to SFCU 1 and the sensors on the right wing report to SFCU 2.

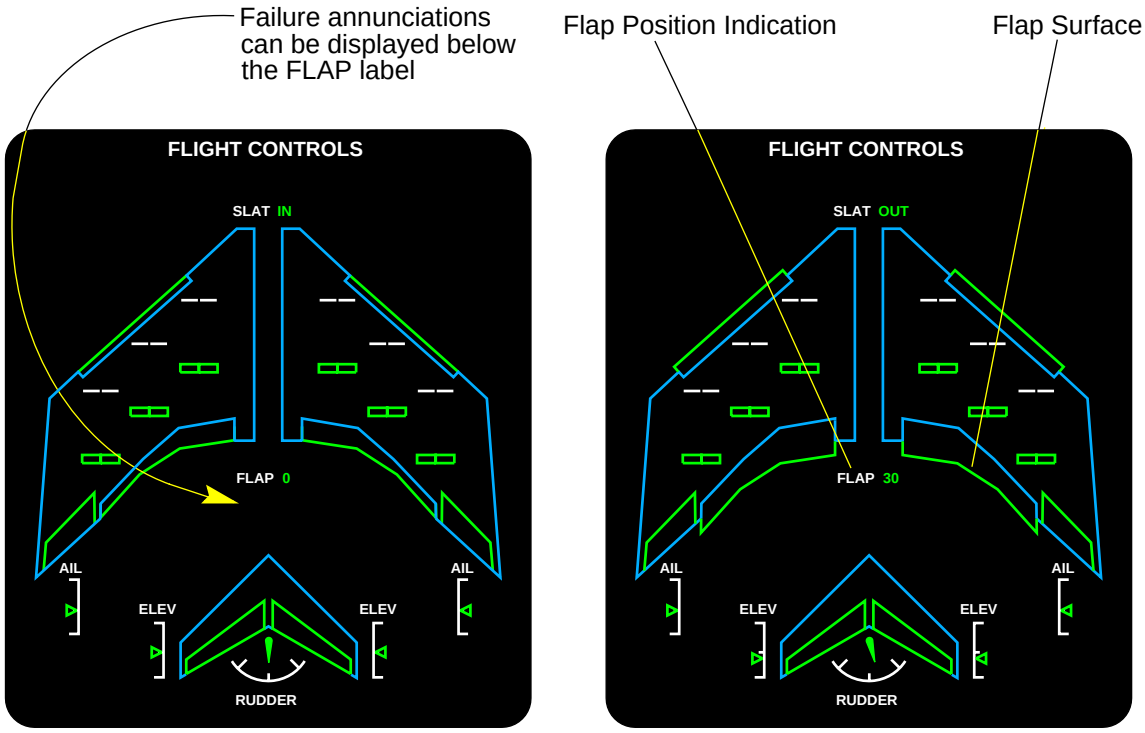
Flap System Schematic



The flap position and surface position is displayed on the EICAS FLIGHT CONTROL synoptic page. Flap indication is also shown on the EICAS PRIMARY PAGE.

FLAP CONTROL SYSTEM (CONT'D)

Flap Position and Surface Indications



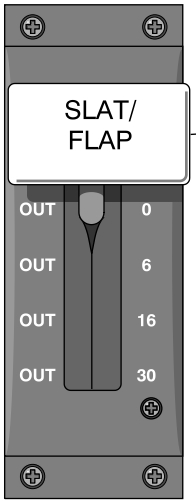
Slat/Flap surfaces retracted **Slat/Flap surfaces extended**

Flap Position Indication and Surface color	
If the flaps are at commanded position, the flap position indication and flap surface will turn green.	
If the flaps are in motion, the flap position indication and flap surface will turn white.	
If the "FLAP FAIL" or "FLAP FAULT" message is displayed, the flap position indication and flap surface will turn amber.	
Synoptic Failure Annunciations	**Logic**
"HALFSPEED"	If "FLAP HALFSPD" message is on.
"DRIVE OVERHEAT 1"	Overheat detected by channel 1.
"DRIVE OVERHEAT 2"	Overheat detected by channel 2.
"DRIVE OVERHEAT 1–2"	Overheat detected by channel 1 and 2.

GF1010_038

SLAT/FLAP CONTROL LEVER

An integrated slat/flap control lever located in the flight compartment (centre pedestal) will command position of the slat/flap system operation.



Slat/Flap Control Lever
To deploy slat/flap: move the slat/flap control lever aft to the position that corresponds to the required slat/flap angle.

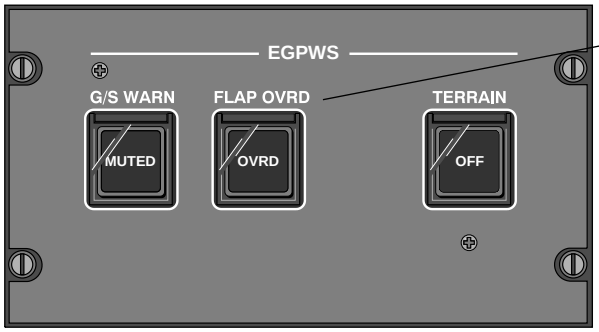
GF1010_039

The slat/flap configuration is as follows:

SLAT POSITION	FLAP POSITION	PLACARD SPEED	PROTECTION
IN	0	N/A	LATCH
OUT	0	225 kts	GATE
OUT	6	210 kts	GATE
OUT	16	210 kts	DETENT
OUT	30	185 kts	LATCH

FLAP OVERRIDE SWITCH

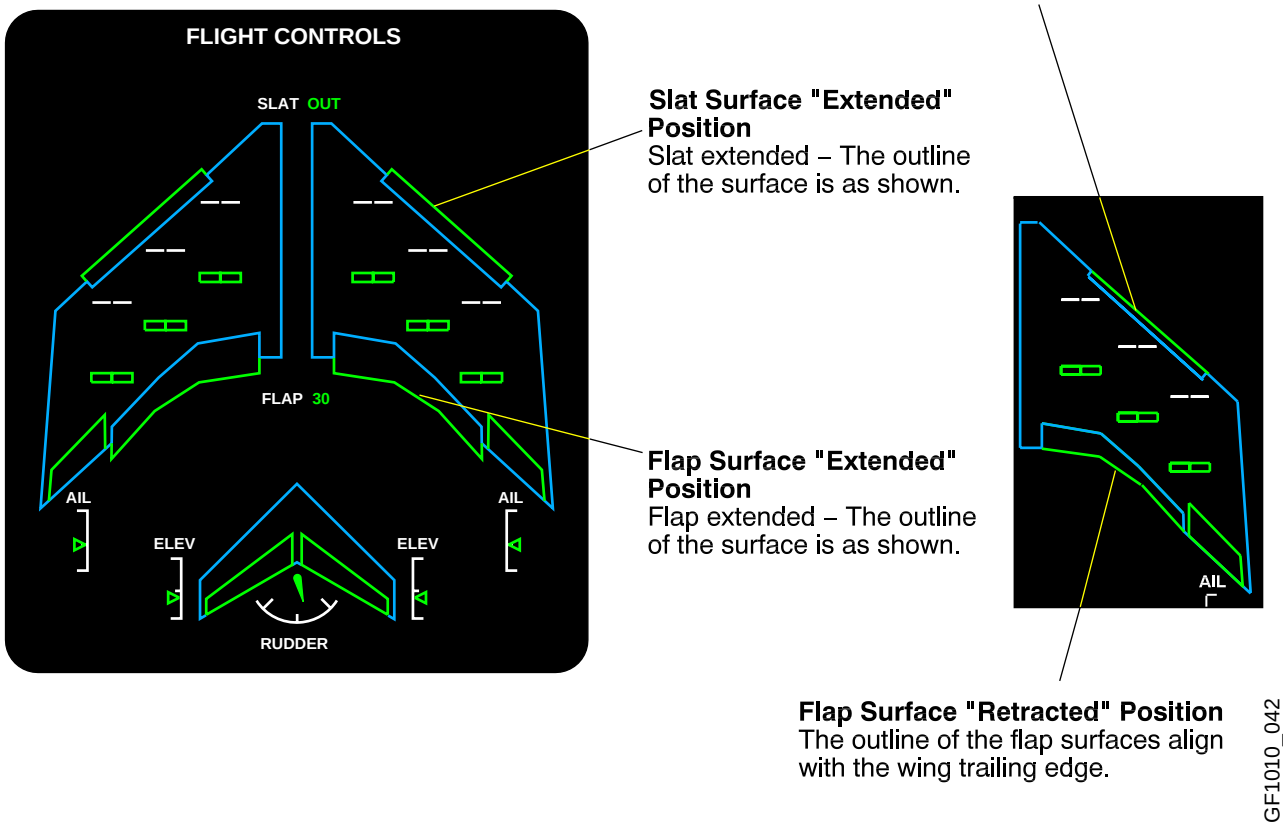
A flap override switch is located on the centre pedestal in the flight compartment. The switch is used to cancel the flap aural warning if the flaps cannot be correct configured for OUT/30 landing.



EGPWS FLAP OVRD (safe guarded) Switch
FLAP OVRD − When selected, mutes the flap aural warning with the flaps not in the correct landing configuration.

GF1010_041

FLIGHT CONTROL SYNOPTIC DISPLAY



Slat Surface "Retracted" Position
The outline of the slat surfaces align with the wing leading edge.

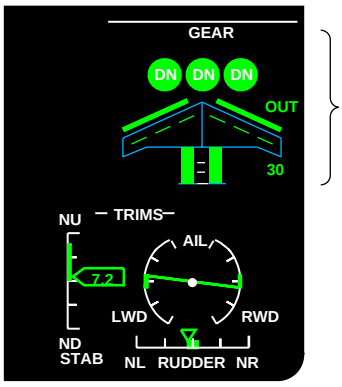
Slat Surface "Extended" Position
Slat extended – The outline of the surface is as shown.

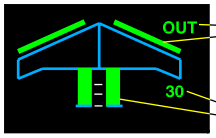
Flap Surface "Extended" Position
Flap extended – The outline of the surface is as shown.

Flap Surface "Retracted" Position
The outline of the flap surfaces align with the wing trailing edge.

GF1010_042

SLAT/FLAP PRIMARY EICAS DISPLAY





Slat Position Indication
Displays symbol and numerical value.

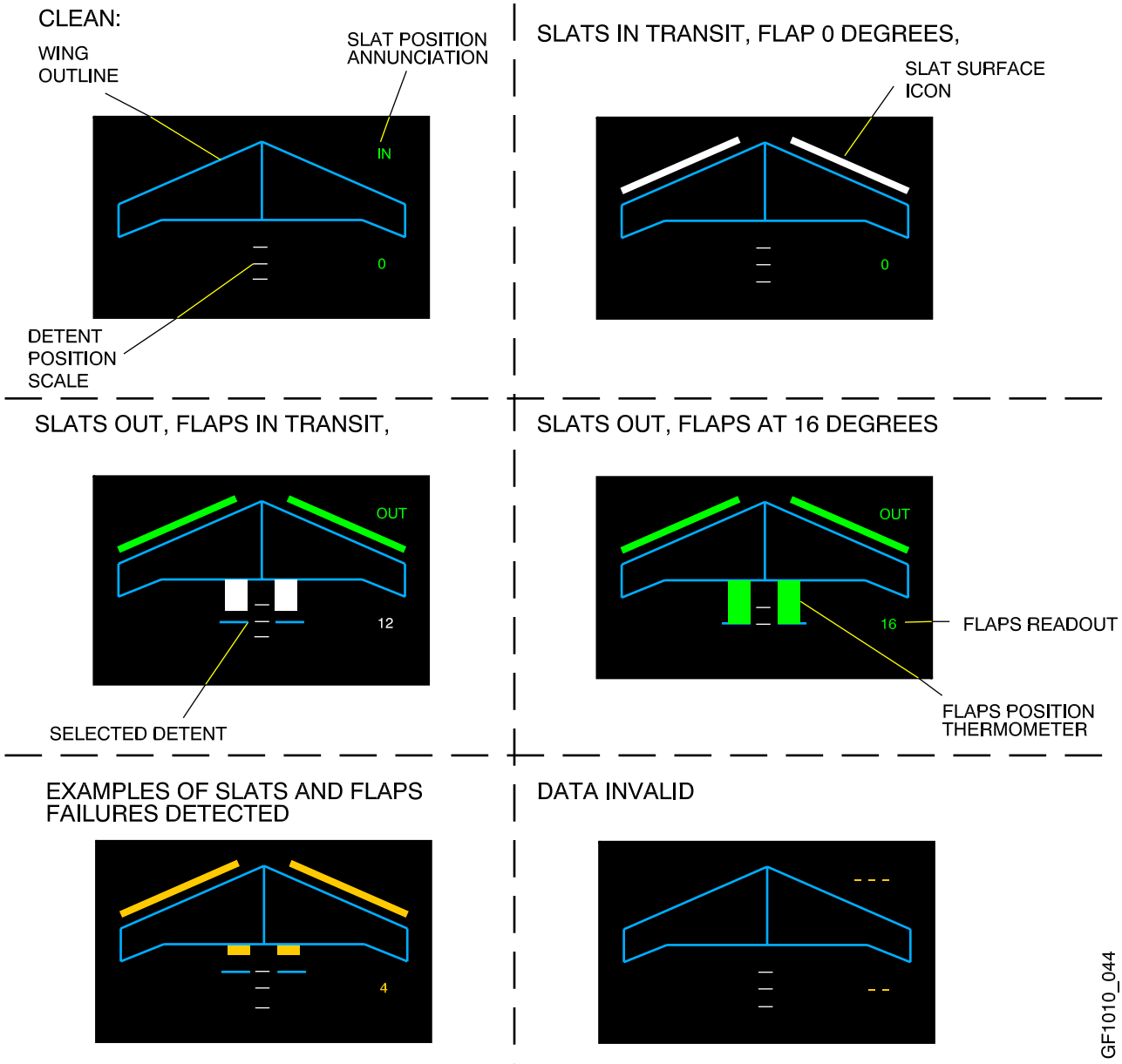
Flap Position Indication
Displays symbol and numerical value.

Slats/Flaps, Spoilers and Gear Position Pop–Up
The pop–up display will be removed from the primary page (in flight only), 30 seconds after the gear and flaps indicate up and no predetermined malfunctions exist.
The pop–up display will appear with flap selection greater than zero degrees, gear selected down, flight spoiler extended, and/or if any predetermined malfunctions exist.

GF1010_043

SLAT/FLAP PRIMARY EICAS DISPLAY (CONT'D)

The following represents slat and flap configurations in both serviceable and failure conditions.

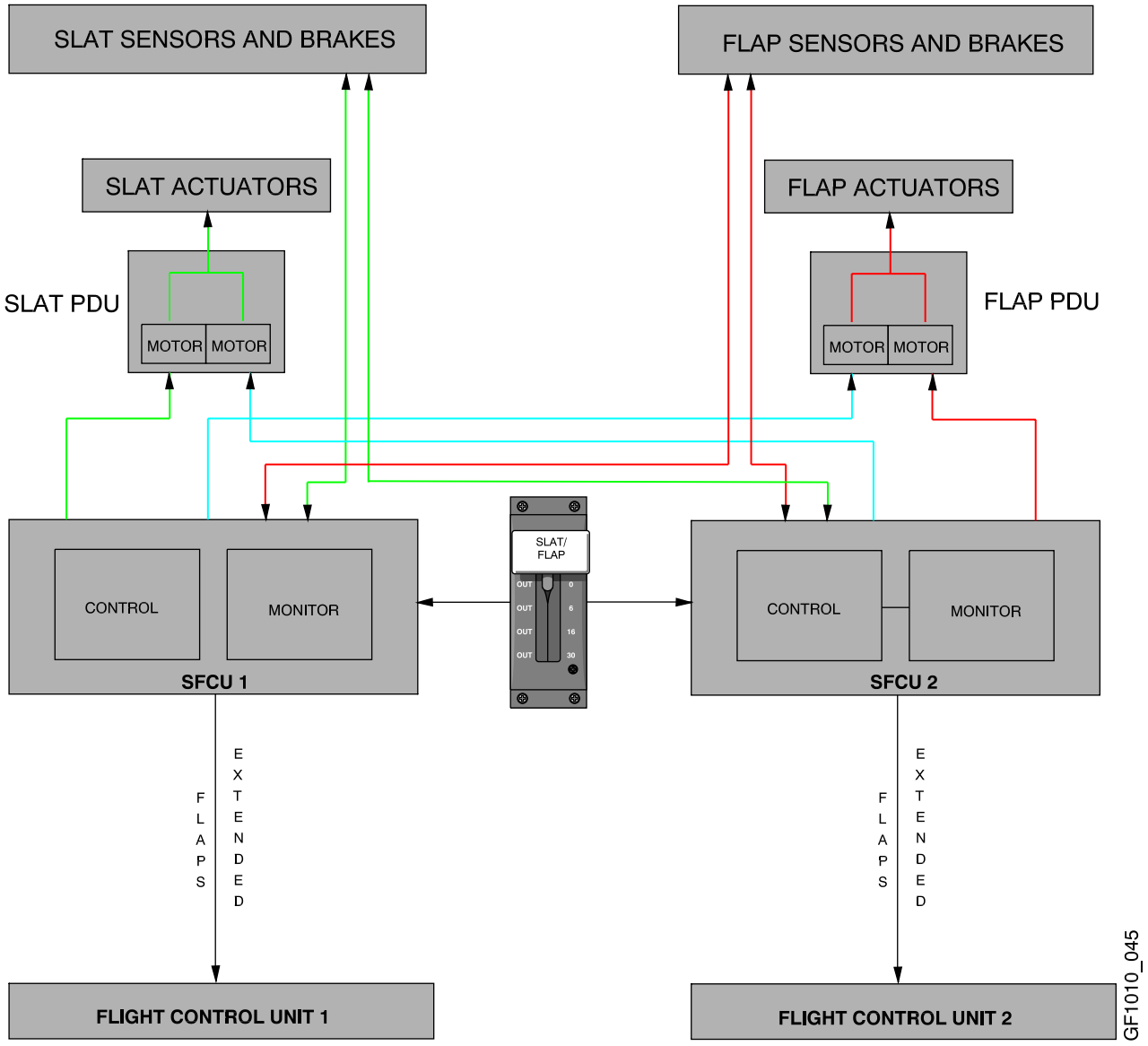


SLAT/FLAP OPERATION

Both SFCU 1 and 2 receive input signals from the slat/flap control lever. The SFCUs then release the brakes from the motor drive units of the PDUs and asymmetry brake detectors. The PDU powers the driveline and actuators to achieve slat/flap travel.

The position sensors return signals to the SFCUs to confirm correct operation of speed, rotation and position. Each SFCU sends signals to FCUs 1 and 2 which process this logic for system(s) operation.

SLAT/FLAPS SCHEMATIC



FLAP/SLAT/GEAR EXTENSION SPEED BUGS

The flap/slat/gear extension speed bugs are displayed as a sideways letter “T”, ⊣ as illustrated below.

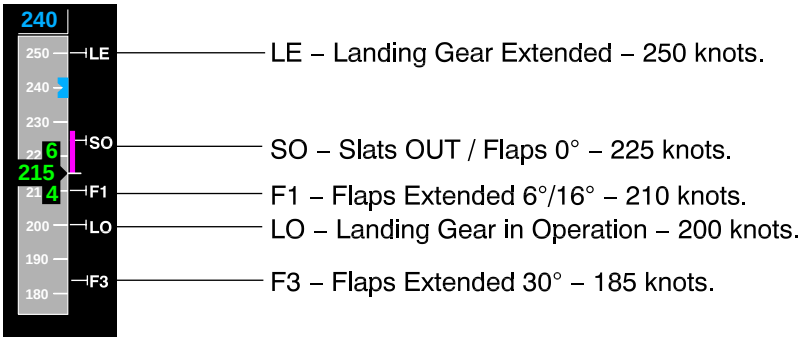
The flap/slat/gear extension speed bugs are displayed in a fixed position on the airspeed tape and will go out of view beyond the ends of the airspeed tape.

NOTE

Speed bugs are displayed at 18,000 feet and below or with Flap/Slat/Gear out.

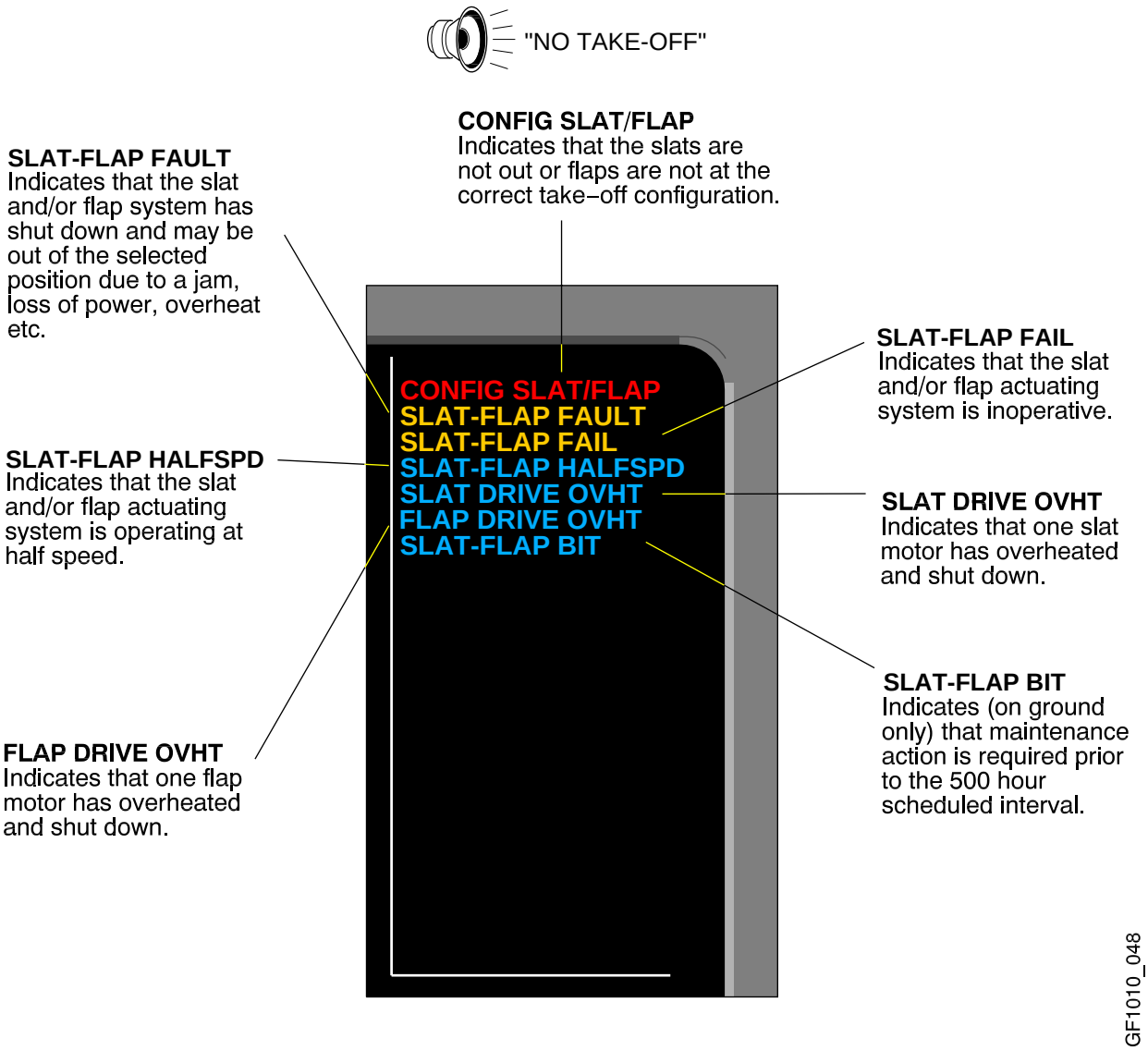
The flap/slat/gear extension speed symbols are as follows:

PFD



GF1010_047

SLAT/FLAP EICAS MESSAGES

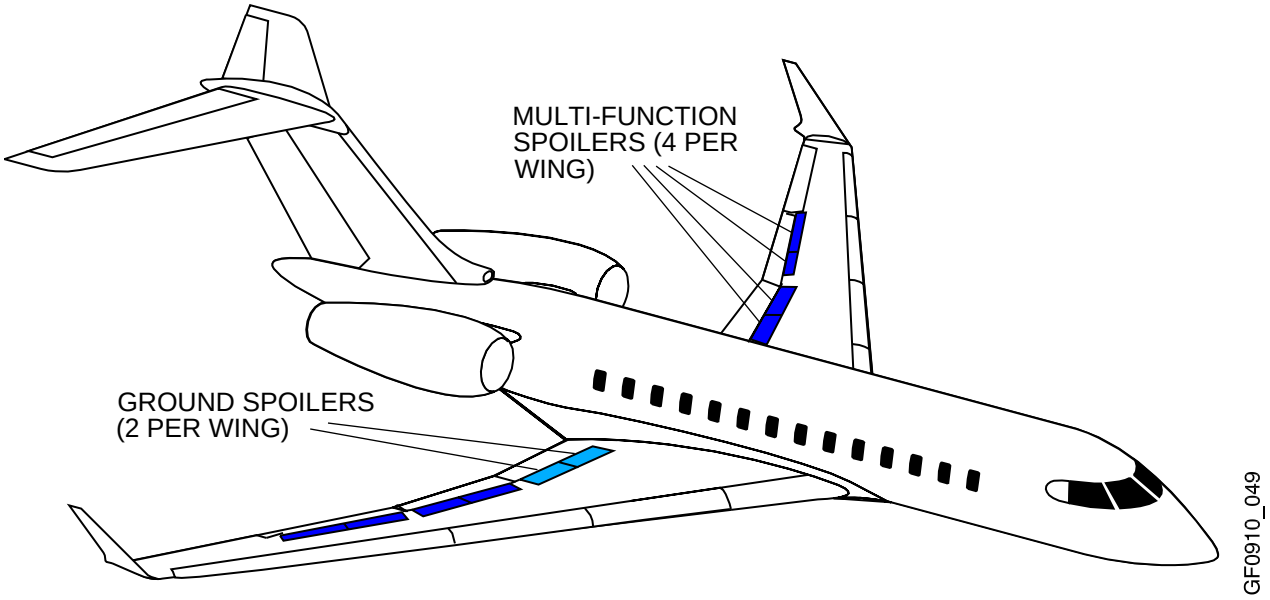


SPOILER SYSTEM

There are four Multi-Functional Spoiler (MFS) panels and two Ground Spoiler (GS) panels located on the upper surface of each wing, just forward of the flaps. MFS and GS position is shown on the EICAS primary and flight control synoptic pages.

A Flight Spoiler Control Lever (FSCL) in the flight compartment is used to control the MFS symmetrically for in flight dumping and provides input to the two FCUs to control the extension/retraction of each MFS panel. Deployment angle is proportional to the position of the FSCL. When the flaps are retracted, all four pairs of MFS are available for lift dumping: with the flaps extended, only the two inboard pairs are used.

The MFS panels provide roll assistance, in flight lift dumping (speed brakes) and ground lift dumping. They are also used as a back-up to the ailerons, in the event of an aileron failure. The MFSs are electrically controlled by the FCUs which actuate hydraulic PCUs, one per surface. The MFSs are hydraulically powered by # 1 and 2 systems. To prevent lift asymmetry, a failed panel will automatically disable the corresponding symmetric panel on the opposite wing.



The GS (most inboard spoilers) deploy on ground only as part of the ground lift dumping function. The GS are controlled symmetrically to either the full extended or full retracted position through hydraulically powered PCUs, one per surface. The GS are hydraulically powered by #1 and 3 systems. Hydraulic supply for PCU operation is provided by an electrically controlled selector valve. Extension of a pair of GS is controlled by energizing two solenoid valves in the selector valve. Retraction occurs as soon as electrical power is removed from one (or both) solenoids which control valve movement.

The GS together with the MFS are used to dump lift and increase drag to assist other braking systems on landing or in the event of a rejected take-off. Each spoiler surface is equipped with one proximity sensor to detect when the surface is retracted. When a proximity sensor indicates a non-retracted surface and no deployment has been commanded, an EICAS message will be displayed on the primary page.

SPOILER SYNOPTIC DISPLAY

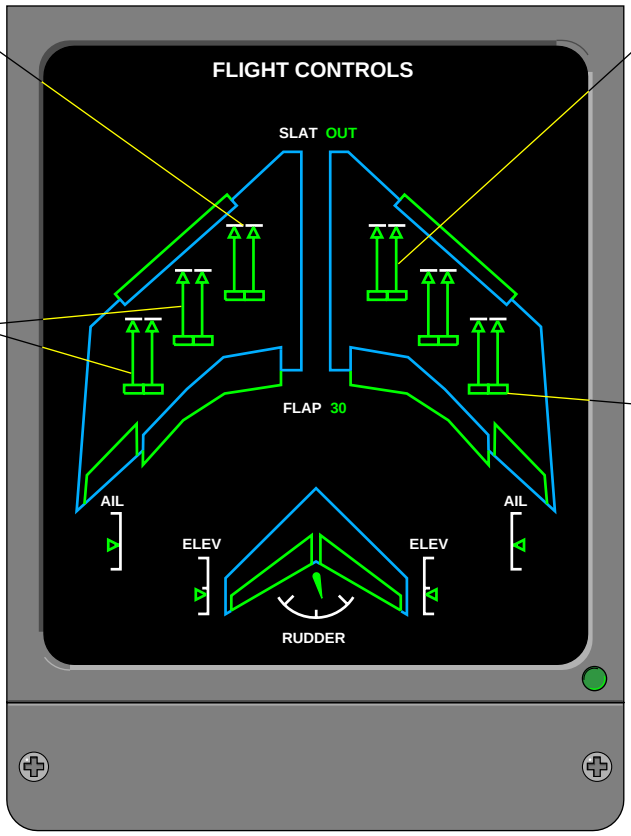
The deployment position of all spoilers is shown on the EICAS primary page and flight controls page. When there is no spoiler deployment, all EICAS spoiler icons disappear. Symbology at each spoiler panel display:

- Spoiler panel status.
- Deployed or retracted position.

Spoilers position and condition is continuously monitored and any fault detected is displayed on EICAS.

Spoiler Scale
The horizontal line represents the maximum spoiler travel and remains as full time display.

MFS Position Vectors (line and arrow)
The MFS position vectors move linearly to the top of the scale.



Ground Spoiler Position Vectors (line and arrow)
The ground spoiler position vectors will be fully extended or not displayed. They will not move linearly.

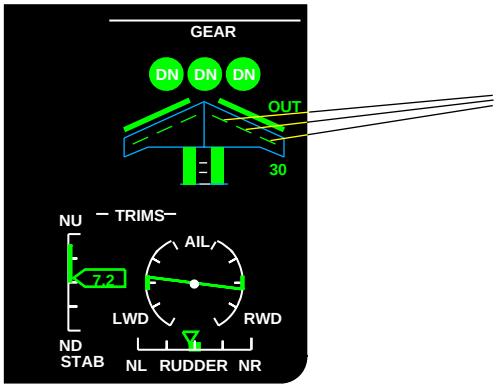
Spoiler Surface Panel
All spoiler panel surfaces are full time display.

MFS and GS Position Vectors And Scale Colors	
Item	**Color**
Position Vector	Green if surface is green.
Position Vector	Amber if surface is amber.
Position Scales (upper tick mark)	Remain white.

GF1010_050

SPOILER PRIMARY EICAS DISPLAY

Spoiler operation can be monitored when the pop-up window is displayed on the primary EICAS page.

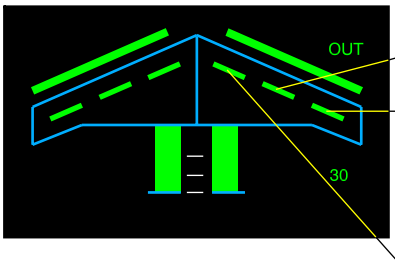


Spoilers Display
Multi-function and ground spoilers are shown in the deployed position.

GF1010_051

The following are examples of spoiler configurations displayed on the primary EICAS page:

ALL SPOILERS EXTENDED (ON GROUND)

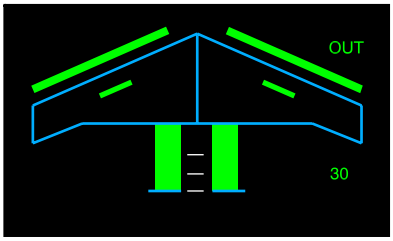


MFS 1 AND 2 ICON

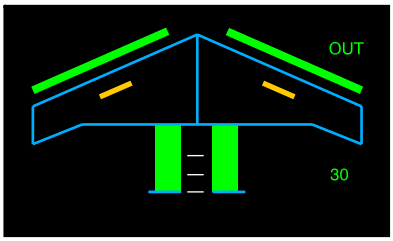
MFS 3 AND 4 ICON

GROUND SPOILERS ICON

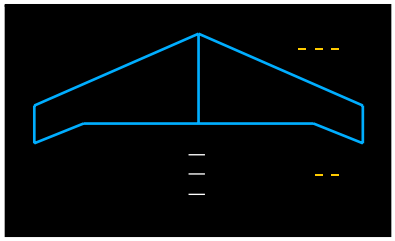
MFS EXTENDED (IN FLIGHT)



MFS FAILURE DETECTED



DATA INVALID



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FLIGHT SPOILER CONTROL LEVER

The flight spoiler control lever (FSCL) located in the centre pedestal (flight compartment) is the input handle which controls the MFS surfaces for lift dumping in flight. Markings on the mounting plate are illuminated by integral lighting located in the lever. The FSCL includes four sensors to transmit input lever command to the FCUs.

The MFS may be extended to any position, between 0 and FULL, as required for the intended flight path. The MAX position is used for emergency descent whereby all MFS deploy if flaps are retracted to zero degrees. The FSCL unlatch selector located on top of the FSCL must be pressed to release the lever from the zero position and from the FULL to MAX position. If the flaps are not retracted, only the inboard MFS are available for lift dump and the MAX selection will have no effect.

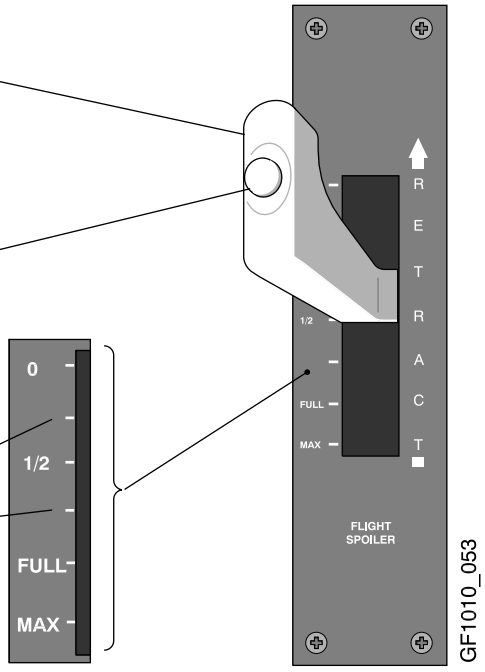
FSCL Lever Assembly

- 0 – Retracted position.
- 1/2 and FULL position.
- MAX – Maximum extended position.

To deploy the flight spoilers, move the flight spoiler lever aft to any of the detent positions.

FSCL Unlatch Selector

- The unlatch selector located on top of the lever must be pressed to release and operate the lever from the zero position and from the FULL to MAX position.
- There are soft detents (with friction force) at the following positions: between 0 and 1/2, 1/2 and FULL.
- Whenever the lever is returned to the zero position (spoilers fully retracted), the lever will be latched again.

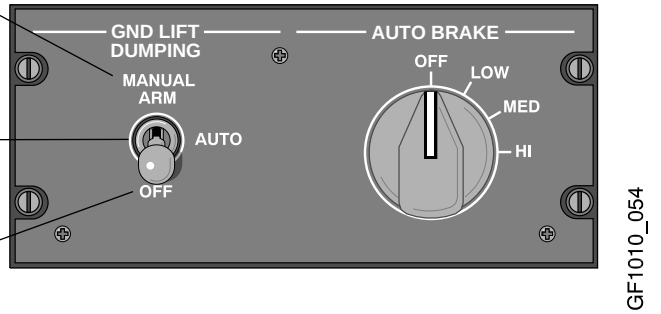


GND LIFT DUMPING/AUTOBRAKE CONTROL PANEL

The panel is located in the centre pedestal (flight compartment) and is used to manually arm or disarm the spoiler system.

GND LIFT DUMPING Switches

- **MANUAL ARM –** Manually arms the ground lift dumping system such that when the airplane is on ground, all spoilers will be commanded to deploy. A status message will be displayed when the switch is selected to manual arm.
- **AUTO –** Arms the ground lift dumping.
- **OFF –** Selecting the switch " OFF " will disarm the ground lift dumping system in the event of an inadvertent deployment or failure of the automatic system. A status message will be displayed when the switch is selected to off.



SPOILER FUNCTIONS

The spoiler system performs the following:

- ROLL ASSIST − by asymmetric deployment of up to four pairs of MFS to augment the ailerons control. The surface deflection is a function of the handwheel roll angle (derived from the average of two sensors) compensated with airspeed and flaps position. Right wing down command deploys the right spoilers, left remain stowed. Left wing down deploys the left spoilers, right spoilers remain stowed.
- PROPORTIONAL LIFT DUMPING − by symmetric deployment of up to four pairs of MFS commanded by the FSCL. Four pairs of MFS may be deployed when the flaps are fully retracted. Two pairs (inboard) of MFS will deploy when the flaps are in any of their extended position detents. Under this condition, the outboard MFS will be available for roll assistance only.
- GROUND LIFT DUMPING − through the symmetric full extension of all spoilers upon landing or rejected take-off condition. At initial touchdown with at least one left or right main landing gear indicating on-ground (wheels spinning up), the two pairs of GS deploy first. The deployment of the two pairs of MFS is delayed (until weight on wheels) slightly to prolong roll control.
- COMBINATION ROLL ASSIST AND PROPORTIONAL LIFT DUMPING − MFS control mixes the roll command and proportional lift dumping command. To command a handwheel command and a FSCL command, spoiler deployment of one wing decreases and increases on the other. The roll effect is obtained by the differential deployment of left and right spoilers.

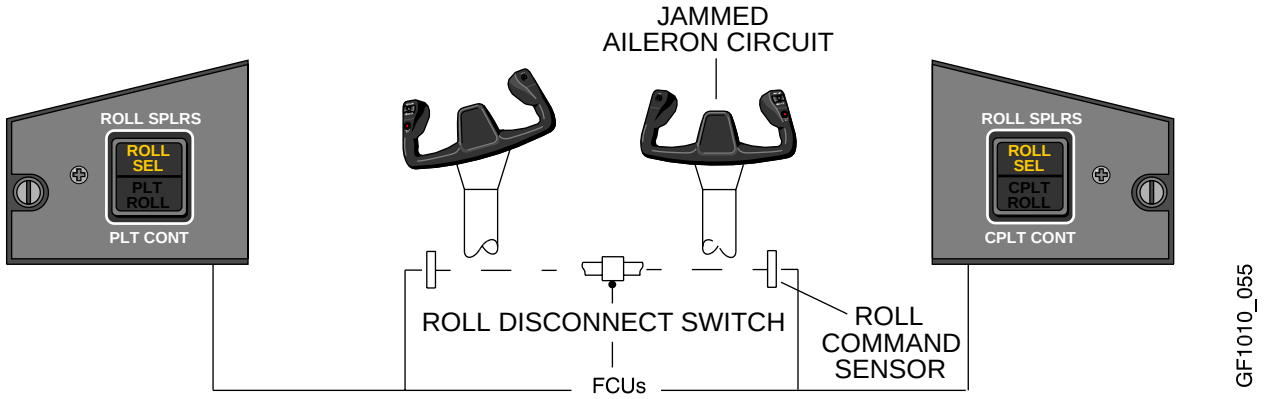
For roll assist and proportional lift dumping, the spoiler scheduling depends on handwheel roll sensors and FSCL sensors. Corrections to the scheduling is a function of the airplane airspeed provided by the three air data computers and flap position under control of the SFCUs.

SPLRS/STAB IN TEST

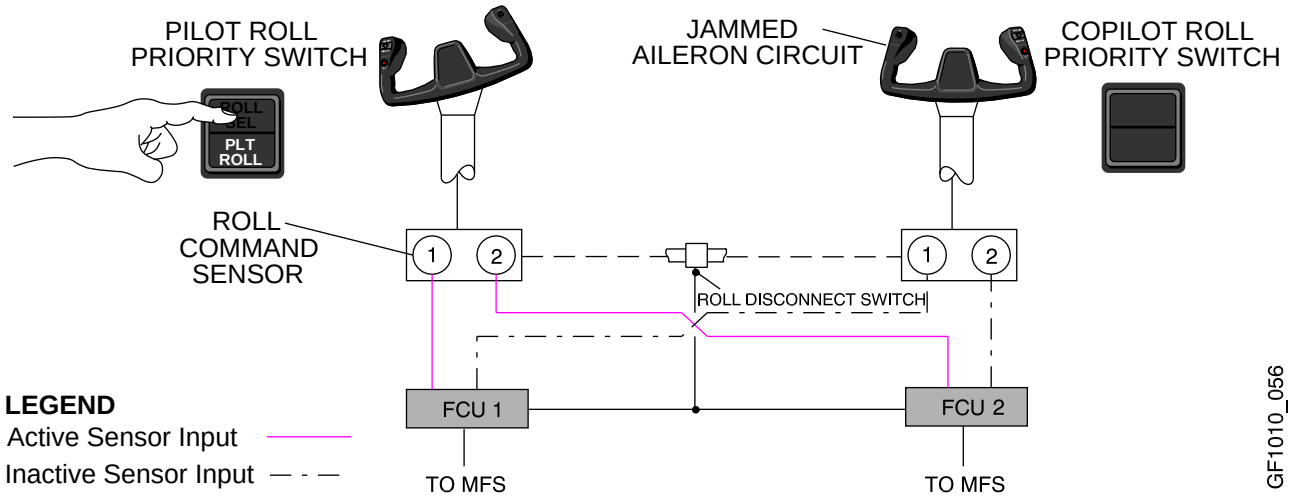
An advisory message “**SPLRS/STAB IN TEST**” will be displayed when the spoilers and stab trim systems are performing self-test when hydraulics are first applied. The spoiler system is inoperative throughout the duration (approximately 20 seconds) of the test.

ROLL SPOILER PRIORITY

The “ROLL SPLRS” priority switches are located on the glareshield at each pilot position. They are released/pressed switches with a split legend, an amber “ROLL SEL” and a white “PLT ROLL” (“CPLT ROLL”). During normal operation, the switches are not selected and remain dark. The MFSs receive roll commands from the FCUs through sensor inputs from movement of each control column. The roll commands are averaged from the sensor inputs to the FCUs for MFS operation, with the disconnect system in the normal configuration.



In the event of a jammed aileron system, the pilots free the non-jammed system by forcing the disconnect mechanism. If no ROLL SPLRS switch selection is made within 30 seconds following disconnect, the roll disconnect switch sends a signal to the FCUs which command both “ROLL SEL” captions and a “**ROLL SELECT**” message to appear. Both “ROLL SEL” captions illuminate to indicate to the pilot that a priority is required by switch selection, for MFS operation due to disconnect. The 30 second time delay for illumination of the “ROLL SEL” captions is to avoid increasing pilot workload in the instant following an aileron system failure.



Selecting the appropriate priority switch prior to or following a “ROLL SEL” indication, commands the valid side to be used by the FCUs. Example above: if pilot side is selected, both pilot and copilot “ROLL SEL” captions extinguish and the “PLT ROLL” caption illuminates and vice versa for a copilot action. Until one side is selected, the FCUs continue to average pilot and copilot roll commands. After switch selection, both FCUs will use the corresponding roll input (unjammed side). This will enable the MFS to operate through their full range of operation with a single control column input.

SPOILER SYSTEM OPERATION

The spoiler system modes of operations are as follows:

Ground Lift Dumping

Ground lift dumping function commands extension of the spoilers when engines are equal to or below idle and the ground condition is recognized. Engine throttle lever position is provided by sensors in the throttle lever assembly.

Ground condition is determined from the airplane height provided by:

- Radio Altimeters (RA).
- Wheel speed, through the Brake Control Unit (BCU).
- Weight-On-Wheels(WOW), through the Landing Gear Electronic Control Unit (LGECU).

The ground lift dumping system is fully automated or can be operated manually. Arming, deployment and retraction is controlled by the FCUs.

In the event of a malfunction, failure of the automatic arming or disarming (automatic retraction), the ground lift dumping system may be manually armed or manually disarmed through the GND LIFT DUMP/AUTOBRAKE panel.

Arming

The system is automatically armed when the throttle levers are at the minimum take-off position. The flight compartment ground lift dumping “MANUAL ARM” switch is provided in case of auto arming failure and to test the system during pre-flight.

Deployment

All spoilers deploy simultaneously during a rejected take-off.

The GS deploy first in order to dump the airplane lift; therefore, the logic is split for GS and MFS operations.

To deploy ground spoilers the system must be armed, engine throttles at idle position (or below) and two of the three following conditions:

- Radio Altimeter (RA) below 7 feet.
- Left or right main landing gear WOW indication.
- Left or right wheel speed greater than 16 knots.

Radio altimeter and wheel spin will normally be the first conditions satisfied. Deployment of the MFS is delayed until the airplane is more firmly on the ground to prolong maximum roll control, through the spoilers roll assist function.

To deploy multi-functional spoilers the ground lift dumping must be armed, both the left and right throttles at idle (or below) and:

- Both main landing gear have WOW.

  AND
- Left or right wheel speed indication above 16 knots, OR radio altimeter below 7 ft.

When the MFS are commanded for ground lift dumping, roll assist is available for partial multi-function spoiler operation.

SPOILER SYSTEM OPERATION (CONT'D)

Disarm

The logic automatically disarms after the airplane has been on the ground for 40 seconds following touchdown and the wheel speed has decreased below 45 knots for 30 seconds. Automatic disarming prevents the spoilers from deploying during taxiing. The system can also be manually disarmed (turned off) to override the automatic arm/disarm circuits, through the ground lift dumping “OFF” switch on the “GND LIFT DUMP/AUTOBRAKE” panel located in the centre pedestal.

SPOILER SYSTEM/FCU INTERFACE

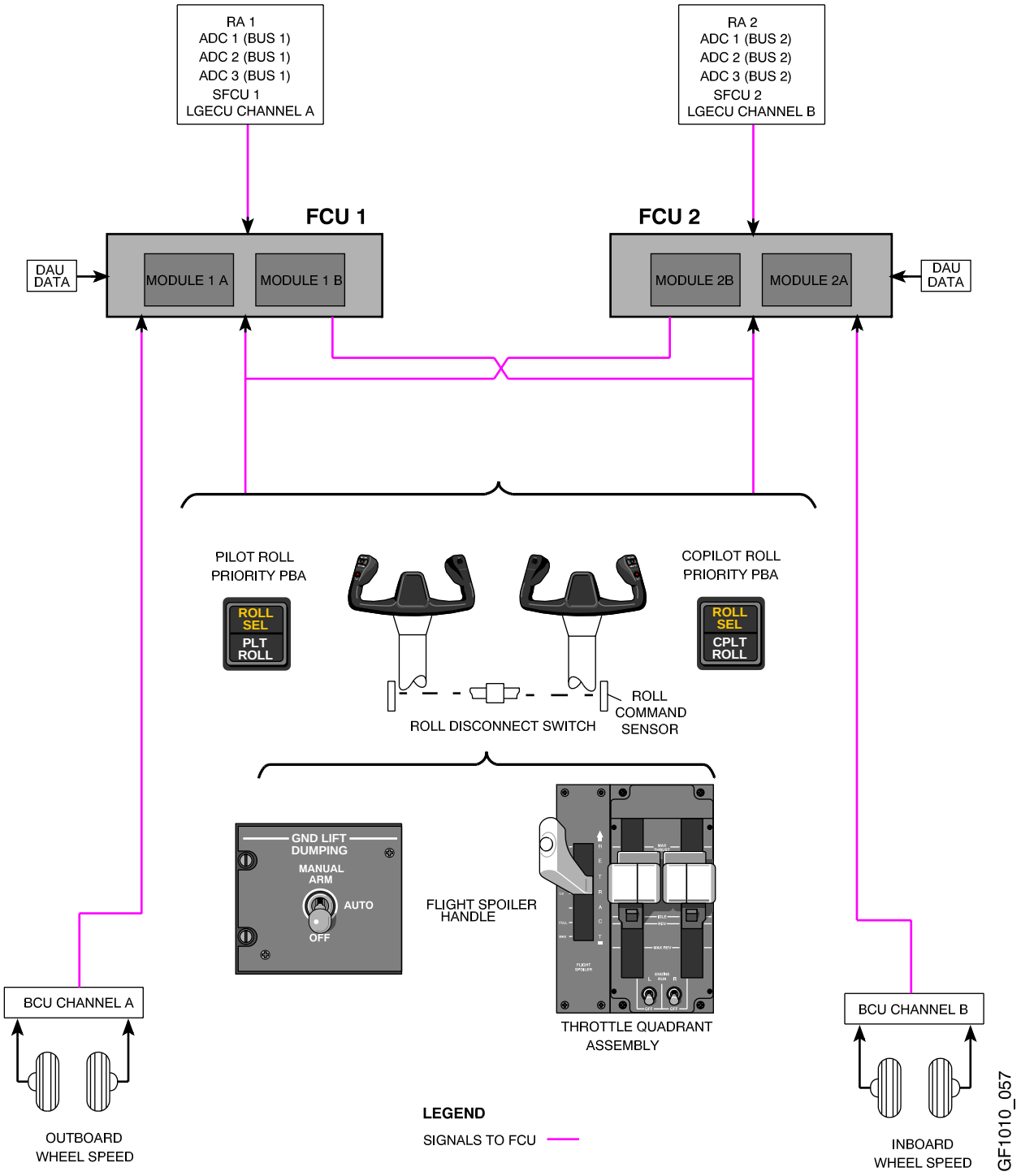
The spoiler system operation is under control of two FCUs which have dual modules to control and monitor the spoiler surfaces in pairs. The FCUs receive input from various airplane systems and schedule the MFSs either symmetrically or proportionally depending on airplane configuration. The FCUs also control and monitor the operation of the GS through valves within the ground spoiler selector valves. Refer to the SPOILER CONTROL AND MONITORING this Chapter.

The FCUs control the priority of spoiler operations for flight and ground phases of operation and spoiler system malfunctions are reported on the EICAS system.

The FCUs interface with the following systems for spoiler control and monitoring:

- BCU − Brake Control Unit provides wheel speed for Ground Lift Dumping (GLD) logic.
- LGECU − Landing Gear Electronic Control Unit provides Weight-On-Wheels (WOW) for GLD logic.
- DAUs − Data Acquisition Units provide hydraulic pressure data.
- ADCs − Air Data Computers provide airspeed data.
- RA − Radio Altimeter provides height for GLD.
- TQ − Throttle Quadrant assembly provides left and right throttle lever position sensors for GLD logic.
- SFCU − Slat/Flap Control Unit provides flap position for Proportional Lift Dumping (PLD).

SPOILER FCU INPUT SCHEMATIC



SPOILER CONTROL AND MONITORING

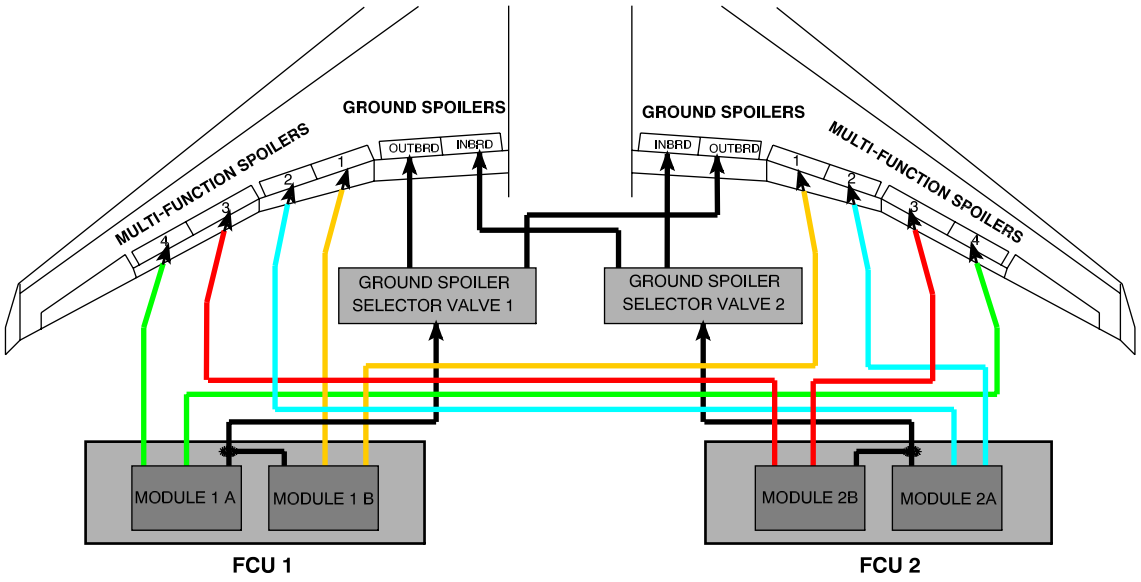
Spoiler control and monitoring of the MFS and ground spoilers are as follows:

Multi-Functional Spoilers

The MFS PCUs are hydraulically powered and electrically controlled. The FCU controls each PCU servo valve and uses an integral sensor to determine their position. The PCUs incorporate a hydraulic lock to prevent upfloat in the event of a hydraulic failure. The MFS surfaces use a proximity sensor to detect that the surface is retracted.

The FCU provides monitoring of the PCU command, PCU response to the command, spoiler surface through the proximity sensor and detection of interface electrical failures.

When a MFS panel failure is detected, the opposite panel will automatically be disabled, in order to ensure lift dumping remains symmetrical.



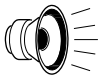
Ground Spoilers

An electrically controlled ground spoiler selector valve is used to provide hydraulic pressure to single actuators (at each panel), to either retract or extend a left or right pair of ground spoilers.

The FCU must energize two valves within the ground spoiler selector valve for a pair of ground spoilers to deploy. Proximity sensors are used for monitoring and indication and to detect whether a ground spoiler panel is retracted or not.

The actuators at each ground spoiler panel incorporates a hydraulic lock to prevent upfloat in the event of a hydraulic failure. Each of the two FCUs controls and monitors one of the two pairs of ground spoilers.

SPOILER EICAS MESSAGES

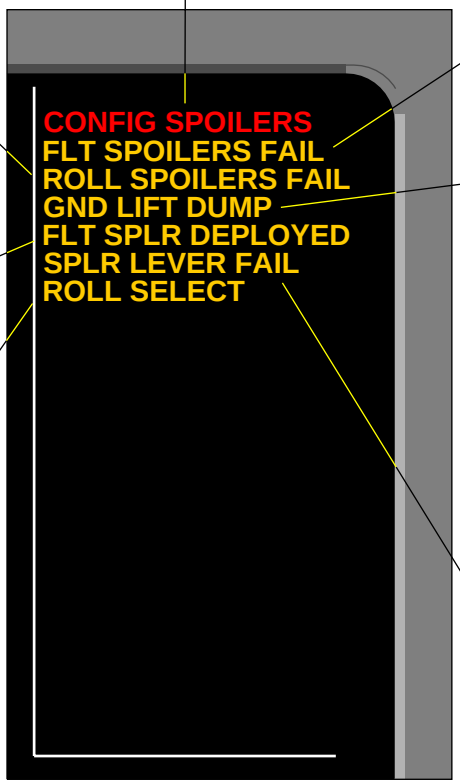


"NO TAKE-OFF"

CONFIG SPOILERS
Displayed during take-off, if a spoiler is deployed for other than roll assistance.

ROLL SPOILERS FAIL
Indicates that roll function for at least two pairs of MFS is inoperative.

FLIGHT SPOILERS FAIL
Indicates two or more flight spoilers have failed.



GND LIFT DUMP
Indicates when at least two pairs of spoilers (MFS or GS) are not available or degraded for ground lift dumping, or

- Ground lift dumping is not available.

OR

- Ground lift dumping switch has been selected off.

FLT SPLR DEPLOYED
Indicates flight spoilers deployed at low altitude, (below 300 ft. AGL or when the throttle quadrant angle is at high power).

ROLL SELECT
Indicates roll disconnect and no roll priority has been selected within 30 seconds.

SPLR LEVER FAIL
Indicates that the MFS function for at least two pairs of MFS is inoperative. Ground lift dump and roll assist are not affected.

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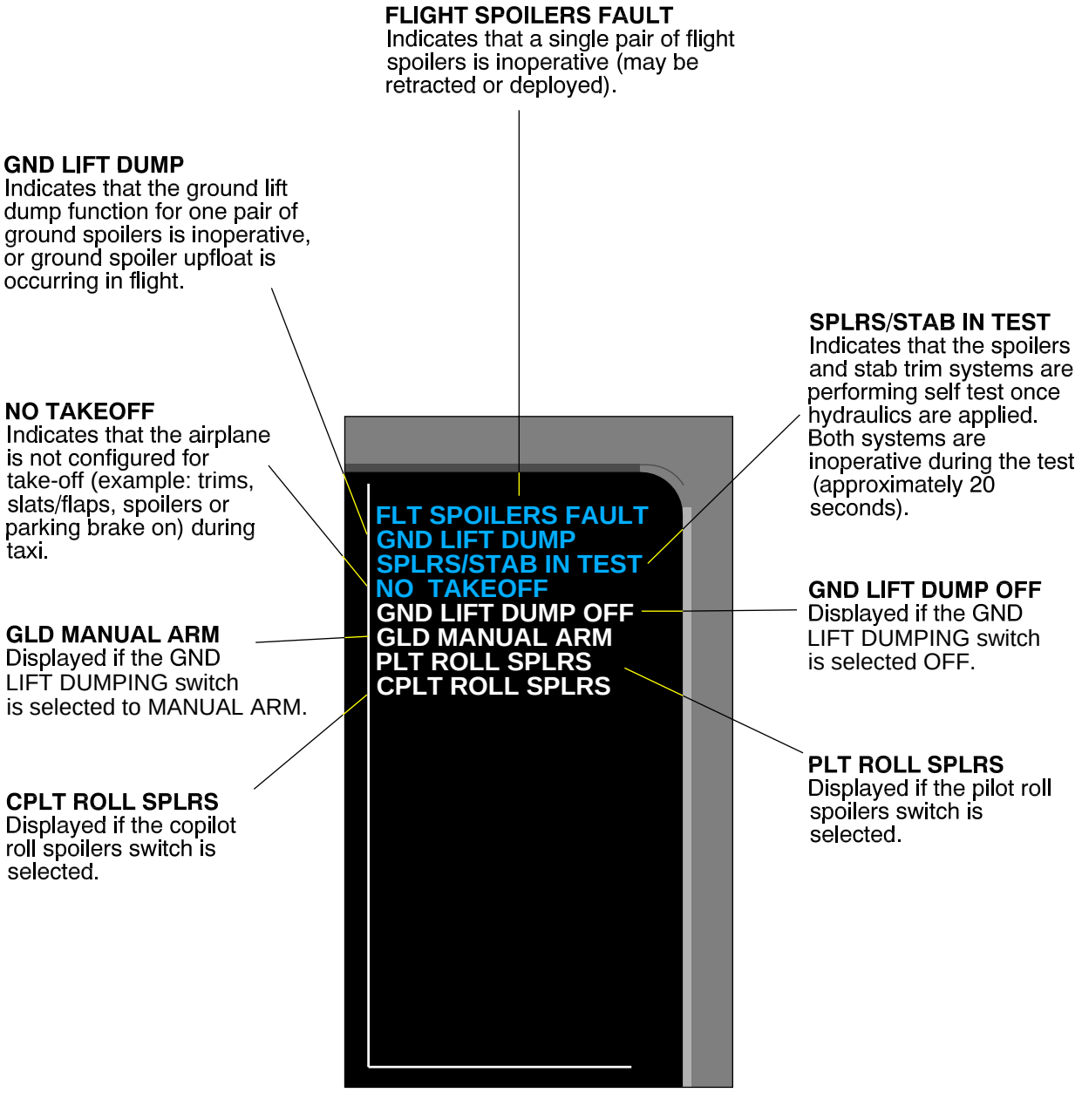
SPOILER EICAS MESSAGES (CONT'D)



STALL PROTECTION

The Stall Protection System (SPS) provides the flight crew with aural, visual and feel (stick shaker) indications of an impending stall. Following these events and no corrective action is taken, the system activates the stick pusher mechanism, preventing the airplane from entering the stall.

The stall protection system consists of two (electrically anti-iced) angle of attack sensors, a dual channel computer, two stick shakers, a stick pusher system and mach sensing to back up the air data computers. Each channel of the computer controls a stick shaker. The computer provides two independent signals to the pusher system logic. Both channels of the computer must agree to activate the stick pusher system based on similar system inputs.

The stall protection function is inhibited when both weight-on-wheels inputs indicate on ground or calibrated airspeed is recognized to be less than 70 kts.

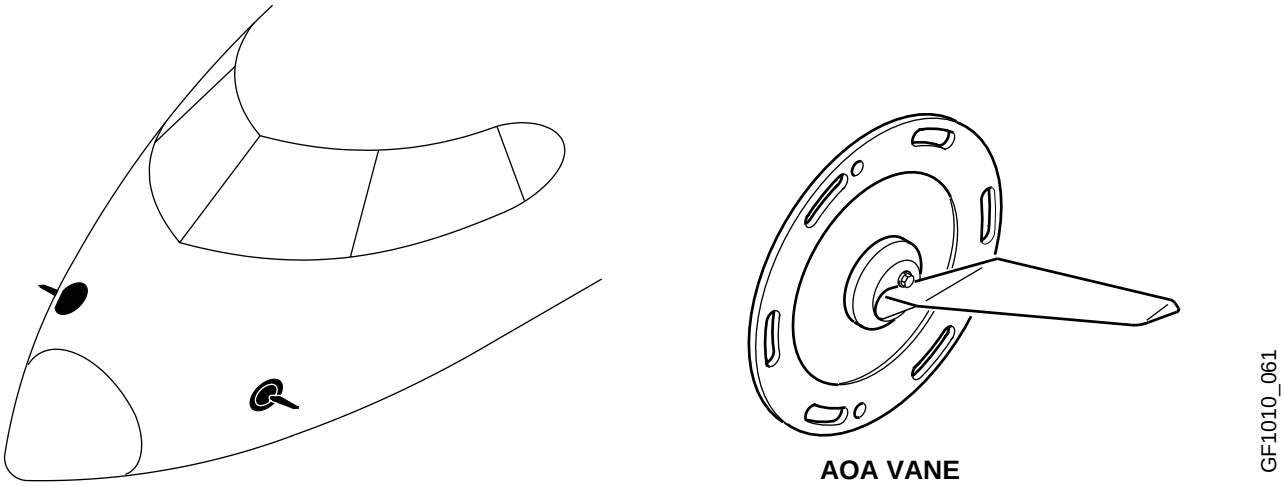
The stall protection computer continuously monitors the SPS and faults detected are sent to EICAS for aural and/or visual annunciation.

STALL PROTECTION COMPONENTS

The stall protection system consists of the following components:

Angle-Of-Attack (AOA) Vane

Two AOA vanes are mounted on the forward fuselage (left and right) of the airplane. They rotate to align with the prevailing airflow to measure the direction of the airflow relative to the fuselage.



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AOA VANE

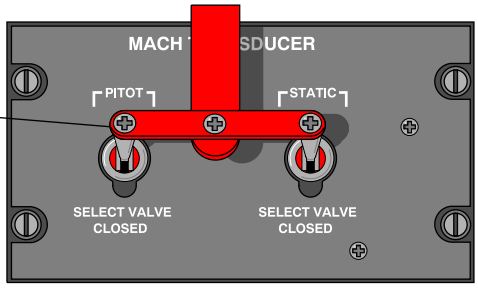
The vanes provide information to both channels of the stall protection computer. There are self-regulating heaters controlled and monitored by the Heater and Brake temperature Monitor Unit (HBMU) located in the vanes. The heaters provide the sensors with de-icing and anti-icing capability in icing conditions.

STALL PROTECTION COMPONENTS (CONT'D)

Mach Transducer

The mach transducer control is installed on the right side of the flight compartment, below the copilot's side console. It is connected to the pitot-static system through a selector/isolator switch. The mach transducer receives electrical input and pressure through connectors and supplies secondary mach information to the channels of the Stall Protection Computer (SPC). The ADCs supply primary mach data to the channels of the (SPC).

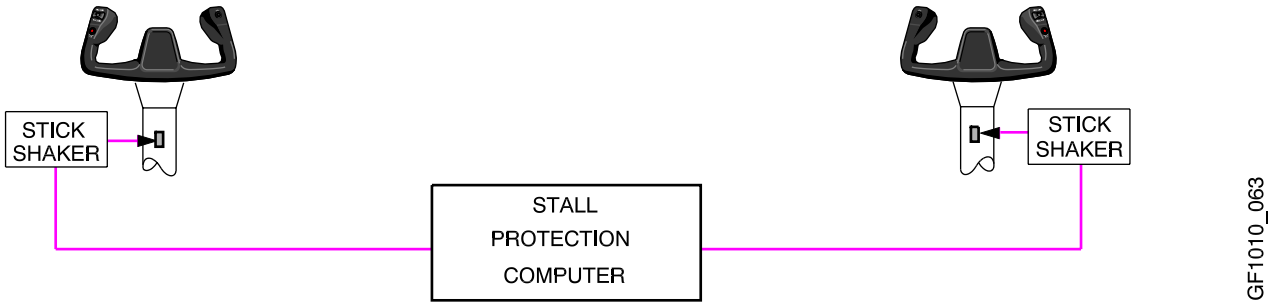
Mach Transducer Selector
Normal operation is selection in the pitot/static position.



The mach transducer is operated in the pitot-static position and is used to cross check for errors from the micro air data computer system. This is accomplished by providing dissimilar source for mach number, airspeed and altitude inputs.

Stick Shaker Actuator

A stick shaker (mechanical vibratory device) actuator is located on each control column and provides tactile sensing, simulating airplane buffeting.



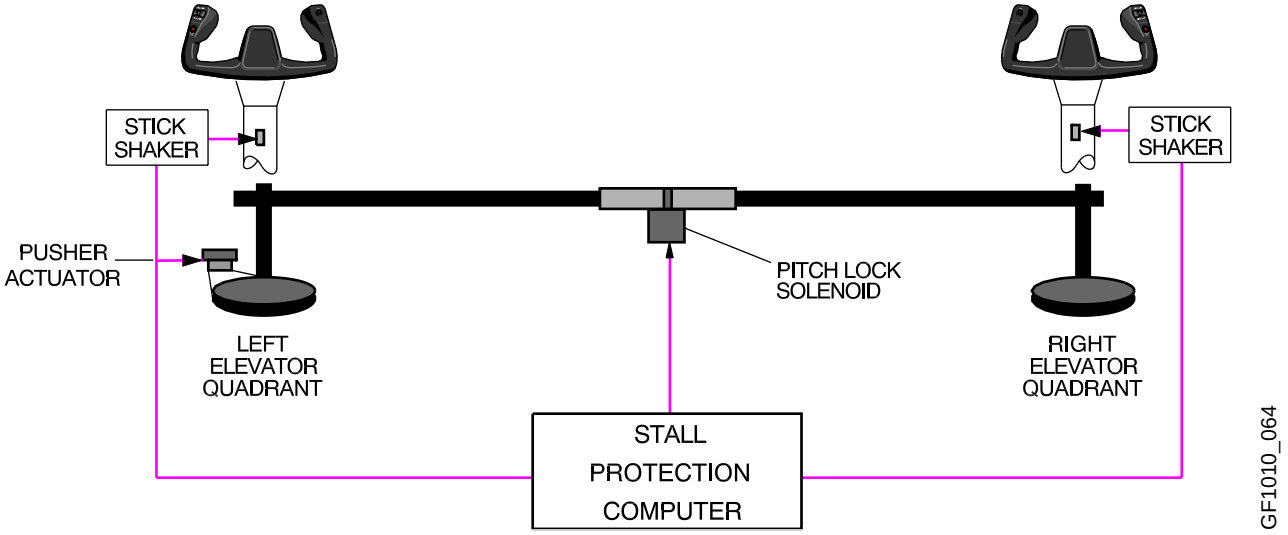
The stick shakers consist of a high speed motor and the actuators are controlled from the SPC channels.

STALL PROTECTION COMPONENTS (CONT'D)

Stall Pusher

If the angle of attack increases to a point where the airplane's stall margin is too small, the SPC will command a push of both control wheels. This is accomplished using a motor assembly which will drive the forward left elevator quadrant. The right control wheel will receive its input to push through the coupled automatic pitch disconnect mechanism.

The pitch disconnect mechanism has a function to engage a solenoid piston to prevent elevator split during push.



The pitch disconnect solenoid is controlled by the SPC and when operated, prevents the automatic pitch disconnect mechanism from activating when push is commanded by the SPC.

When the AOA approaches pusher firing angle (1½ degrees before push occurs) the pitch disconnect locking mechanism is activated. When the push is cancelled, the solenoid for the pitch disconnect locking mechanism is deactivated.

STALL PROTECTION COMPONENTS (CONT'D)

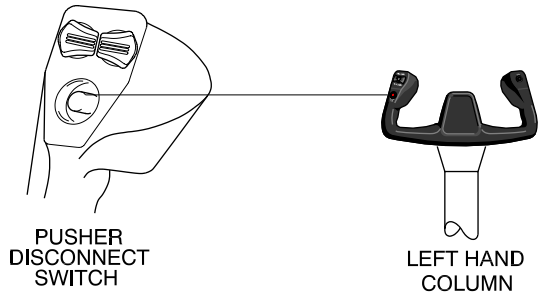
Stall Protection Disconnect Buttons

The stall protection disconnect buttons are located on the pilot and co-pilot control column. These switches also provide a disconnect command to the autopilot and pitch trim functions.

NOTE

A “STALL PROTECT FAIL” caution message will be displayed if the disconnect button is held for longer than 2 to 3 seconds.

The stick pusher will not be stopped by pressing and holding the autopilot/stick pusher disconnect (AP/SP DISC) switch.



NOTE
The pilot control column is shown, copilot control column is similar.

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The remaining stall warning functions are available with the disconnect button held. All other SPS functions operate normally.

- *Airplanes 9002 thru 9999* ***not incorporating*** *Service Bulletin:*
  - *SB 700−27−025, Stall Protection − Disable Stick Pusher Cancel Function from Autopilot Master Disconnect Switch for JAA Aircraft.*

The stick pusher may be stopped by pressing and holding the autopilot/stick pusher disconnect (AP/SP DISC) switch.

The SPC will remove power to the actuator as long as either switch is activated and the push will be cancelled. The stick pusher is capable of operating immediately once the AP/SP DISC switch is released and a stall push is requested by the computer.

The remaining stall warning functions are available with the disconnect button held. Only the pusher function is disabled with either switch held. All other SPS functions operate normally.

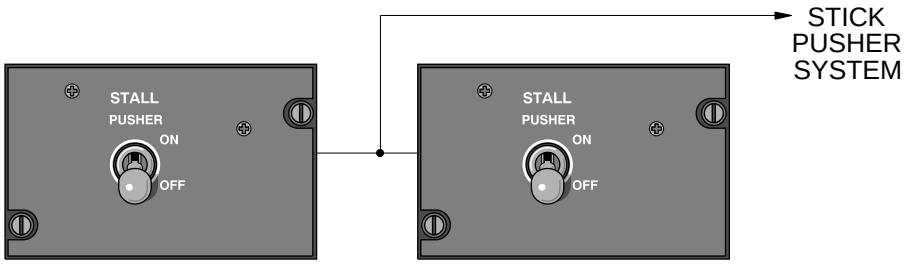
STALL PROTECTION COMPONENTS (CONT'D)

Stall Pusher On/Off Switches

The stall pusher “ON/OFF” switches are used for long term disabling of the pusher system. The switches are located on the pilot and copilot side panels.

NOTE

Selecting either stall pusher switch to “OFF” will cause a “STALL PROTECT FAIL” caution message to be displayed.



PILOT’S SIDE PANEL **COPILOT’S SIDE PANEL**

In the event of a malfunction, the stick pusher may be disabled by selecting the PUSHER switch to the “OFF” position on the pilot or copilot’s stall protection panel. When either or both switches are selected to “OFF” the SPC cannot command a push.

STALL PROTECTION OPERATION

In flight the stall protection computer uses numerous system inputs to calculate the angle of attack trip points. As a high angle of attack is approached:

- Ignition is activated.

If the angle of attack continues to increase:

- The stick shakers are activated.
- Autopilot disengages.
-  " STALL "
- Voice advisory sounds.

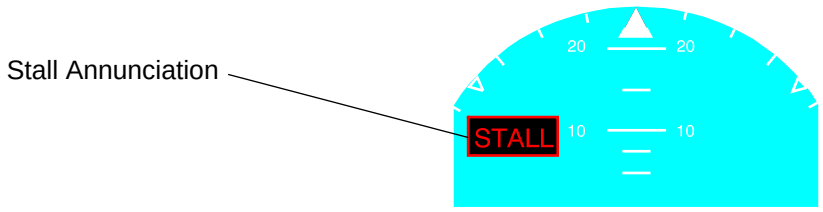
If the angle of attack continues to increase:

- The pitch disconnect system will lock.
- The stick pusher mechanism is activated.

STALL PROTECTION OPERATION (CONT'D)

This results in both control columns advancing to the full forward limit to correct the stall condition.

- The word "**STALL**" appears in a red box on the attitude sphere during the push phase.



Primary Flight Display

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The stall annunciation shall initially blink at a rate of 1 second on and ½ seconds off for 5 seconds and then shall remain steady.

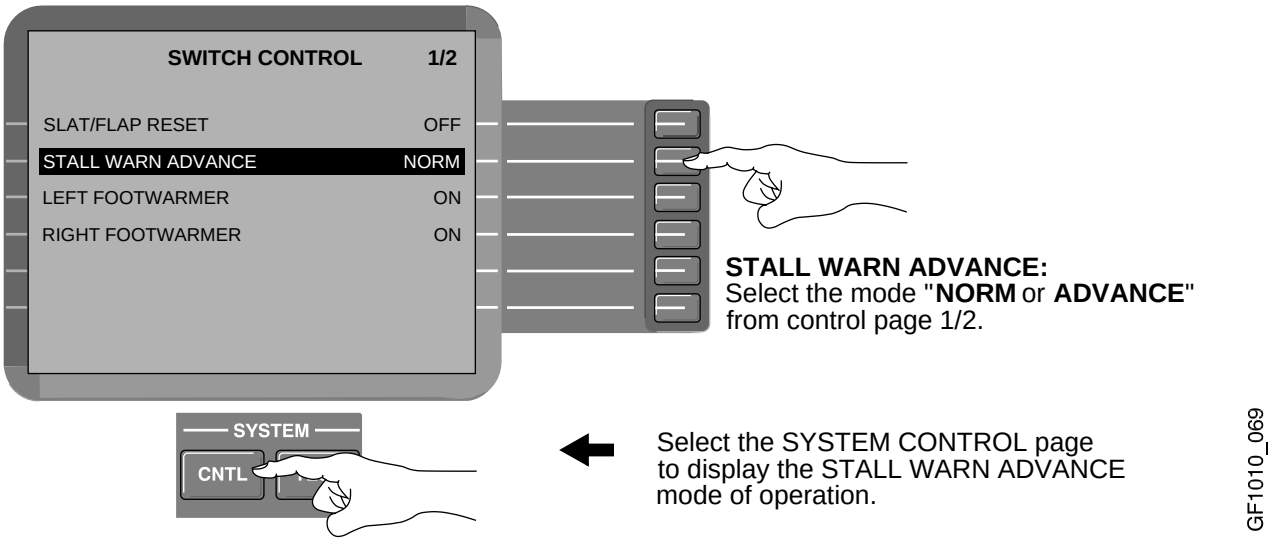
When stall has been corrected the SPC will cancel:

- The push and pitch disconnect locking mechanism.
- "**STALL**" on the attitude sphere.
- Voice advisory.
- Stick shakers.
- Ignition.

STALL WARNING ADVANCE

In specific conditions the SPC will cause warnings to occur sooner than normal. The stall warning advance system will advance the stick shaker firing angles through the SPC when these conditions are sensed. Events which may lead to a stall warning advance are icing conditions during anti-ice fail (indicated from the bleed management controller), slats failed in or stall protection system failure cases.

The pilot has an interface through the Electrical Management System (EMS)/Control Display Unit (CDU) to select the stall warning advance for undetected failures (example: damage of slat panel due to bird strike). Either pilot's EMS/CDU can command mode changes from the control page 1/2. Once selected it can only be canceled by pilot input. The two modes of operation selectable on the EMS/CDU are "NORM or ADVANCE".



NOTE

Only pilot action can return the SPS from advance mode to normal mode.

Pilot command interface on EMS/CDU:

- Command mode change from the control page.
- Either pilot's EMS/CDU can command mode changes.

NOTE

The pilot cannot override advanced mode for detected failures.

Advanced mode indication on EICAS and EMS/CDU:

- "STALL WARN ADVANCE" EICAS advisory message.
- "ADVANCE" on EMS/CDU.

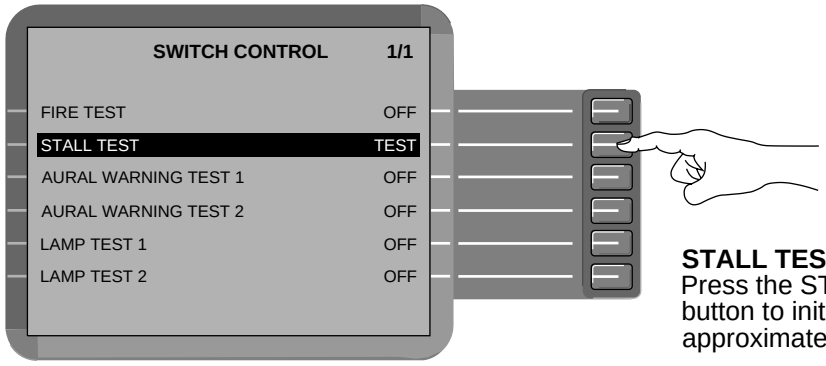
STALL SYSTEM PILOT ACTIVATED TEST (ON GROUND ONLY)

Effectivity:

- *Airplanes 9002 thru 9122* ***not incorporating*** *Service Bulletin:*
  - *SB 700−24−045, AC and DC Power Distribution − Unit Change and Activation of Build 4 Electrical System.*

STALL SYSTEM PILOT ACTIVATED TEST

The pilot activated test is initiated by the pilot during pre-flight. It takes approximately 20 seconds to complete the test. The test is initiated through the EMS/CDU. Refer to Chapter 7 ELECTRICAL SYSTEM for the pilot activated testing procedure.



STALL TEST:
Press the STALL TEST activation button to initiate test. Test duration approximately 20 seconds.

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The pilot activated test will accomplish the following:

- Checks each shaker individually.
- Checks audio and visual warnings.
- Activates and monitors pitch disconnect lock for proper operation.
- Checks pusher for activation only under correct conditions (computer logic).
- Simulates a stall event and verifies AOA serviceability electronically (no AOA movement).
- Pushes both columns forward at the end of test.

STALL SYSTEM PILOT ACTIVATED TEST (ON GROUND ONLY) (CONT'D)

Stall Protection Computer

A dual-channel stall protection computer (avionics bay) monitors the following inputs:

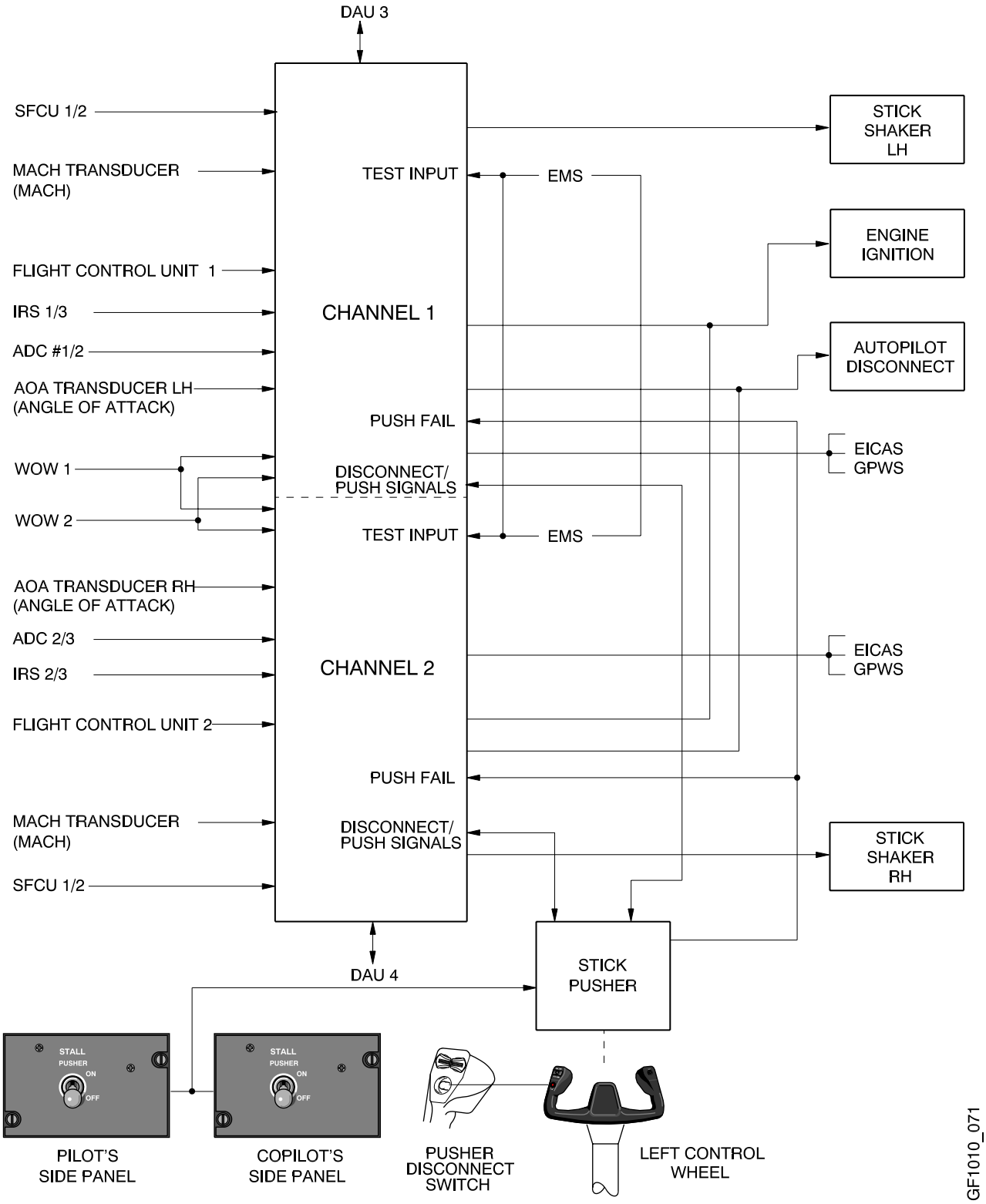
- LH, RH Angle-of-attack (AOA) transducers − Angle of attack
- LH, RH Lateral accelerometers − Lateral acceleration
- LH, RH Flap/slat − Flap/slat position
- #1, #2 weight on wheels (WOW) − WOW and SPS inhibit
- #1, #2 and #3 ADC, MACH Transducer − Airspeed, altitude and Mach
- Inertial Reference Unit (IRU) − Normal and lateral acceleration
- WOW Fail − Weight on wheels

The SPC receives data input from the bleed management controller, landing gear electronic control unit, heater brake monitor unit and EMS CDU through the data acquisition units. The EGPWS uses the AOA for windshear requirements.

Low speed awareness output is a function of the SPC to the Electronic Flight Instrument System (EFIS).

- Red line − Shaker or stall warning speed.

STALL PROTECTION COMPUTER SCHEMATIC

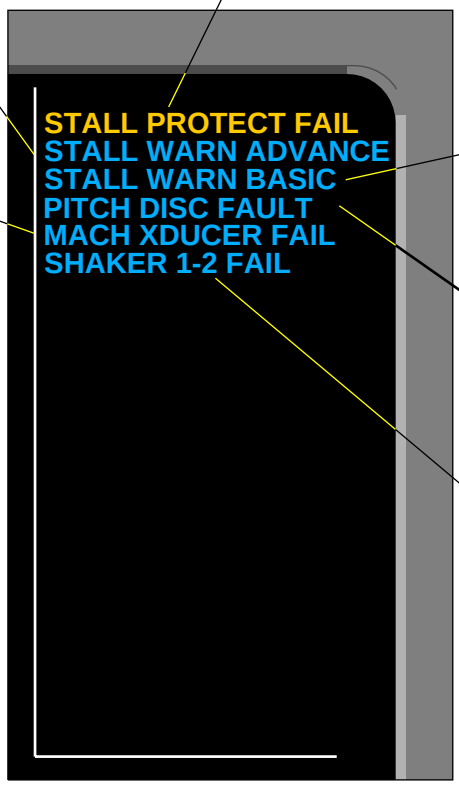


STALL PROTECTION EICAS MESSAGES

STALL WARN ADVANCE
Indicates that the stall warning advance mode has been activated. Can occur automatically based on airplane condition or manually through the EMS CDU.

STALL PROTECT FAIL
Indicates either the pusher is manually deactivated, pusher switch is disabled or one of the following have failed:

- SPC channel.
- AOA sensor.
- Pusher.



MACH XDUCER FAIL
Indicates that the mach transducer has failed.

STALL WARN BASIC
Indicates that the system is incorrectly operating in a single engine configuration (Basic mode).

PITCH DISC FAULT
Indicates that the pitch disconnect solenoid has failed in the locked or unlocked position.

SHAKER 1-2 FAIL
Indicates pilot or copilot's shaker has failed (actual motor) or the commanding SPC channel has failed.

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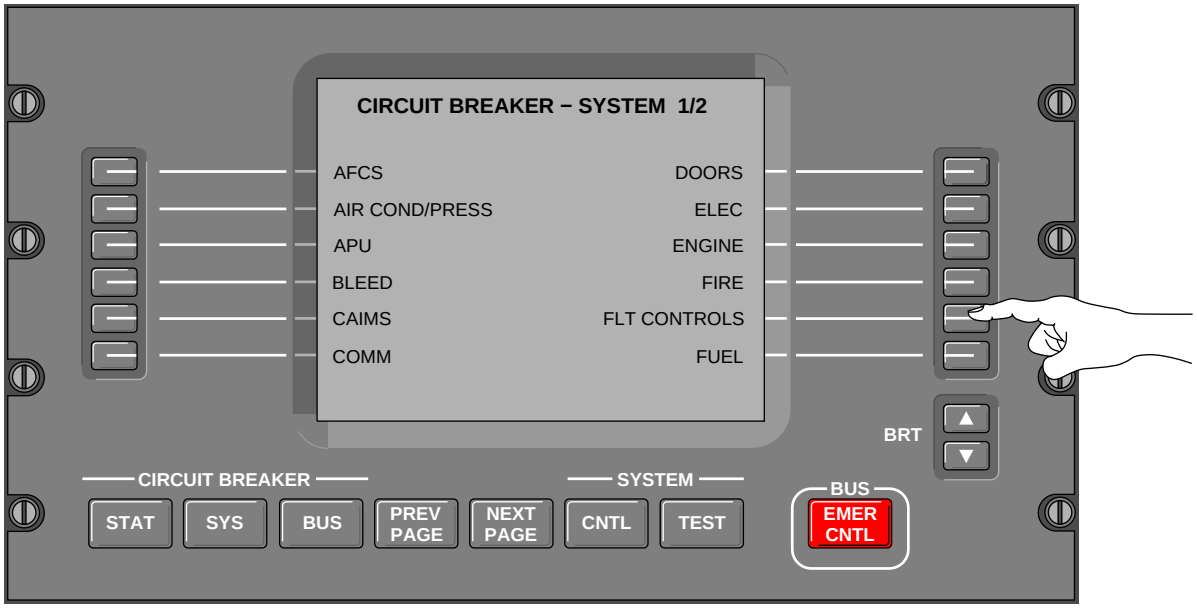
CB - FLT CONTROLS SYSTEM



CB – FLT CONTROLS SYSTEM 1/4		
AILERON TRIM	DC 2	IN
FLT CTL 1 CH A	DC 1	IN
FLT CTL 1 CH B	DC 2	IN
FLT CTL 2 CH A	DC ESS	IN
FLT CTL 2 CH B	DC ESS	IN
MACH TRANSDUCER	BATT	IN

CB – FLT CONTROLS SYSTEM 2/4		
P FEEL/RUD LIM 1	DC 1	IN
P FEEL/RUD LIM 2	DC ESS	IN
PUSHER LOCK CH A	BATT	IN
PUSHER LOCK CH B	DC ESS	IN
RUDDER TRIM	DC ESS	IN
SLAT/FLAP CTLR 1	BATT	IN

CB – FLT CONTROLS SYSTEM 3/4			
SLAT/FLAP CTLR 2	DC ESS		IN
SLAT/FLAP PWR 1	AC 1	CCBP	IN
SLAT/FLAP PWR 2	AC ESS	CCBP	IN
SPC CH A	BATT		IN
SPC CH B	DC ESS		IN
STAB TRIM CH 1	AC 1	ACPC	IN

CB – FLT CONTROLS SYSTEM 4/4			
STAB TRIM CH 2	AC ESS	CCBP	IN
STICK PUSHER PWR	BATT		IN
STICK SHAKER 1	BATT		IN
STICK SHAKER 2	DC ESS		IN

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