

	FLIGHT CONTROLS DESCRIPTION		1.27.10	P 1
			SEQ 100	REV 15

GENERAL

The fly-by-wire control system was designed and certified to render the new generation of aircraft even more safe, cost effective, and pleasant to fly.

BASIC PRINCIPLE

Flight control surfaces are all :

- Electrically controlled, and
- Hydraulically activated.

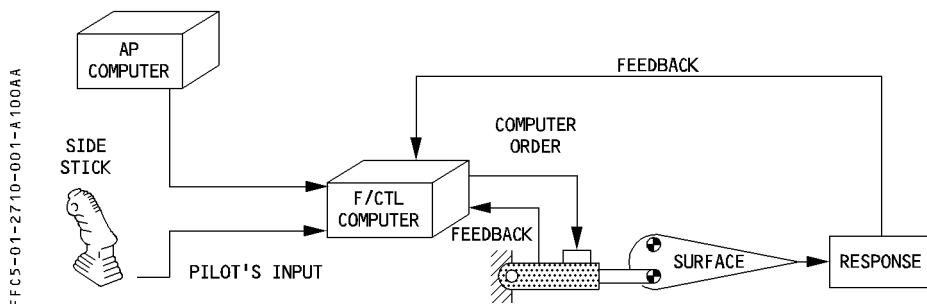
The stabilizer can also be mechanically controlled.

Pilots use sidesticks to fly the aircraft in pitch and roll (and in yaw, indirectly, through turn coordination).

Computers interpret pilot input and move the flight control surfaces, as necessary, to follow their orders.

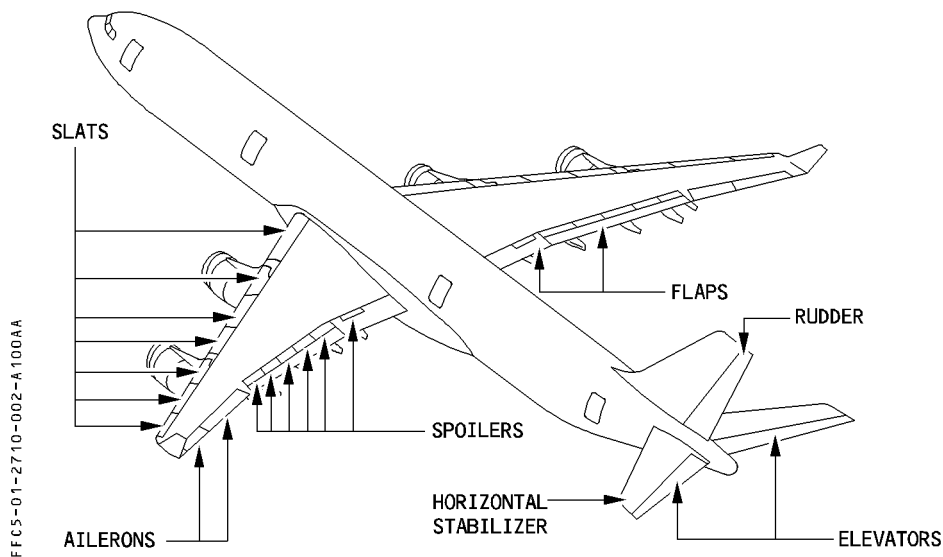
However, regardless of the pilots' input, computers prevent :

- Excessive maneuvers, and
- Flight outside the safe-flight envelope.



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CONTROL SURFACES



The flight controls are electrically or mechanically controlled as follows :

Pitch axis

Elevator control	=	Electrical
Stabilizer control	=	Electrical for normal or alternate control. Mechanical for manual trim control

Roll axis

Aileron control	=	Electrical
Spoiler control	=	Electrical

Yaw axis

Rudder control	=	Electrical
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Other controls

Speed brakes	=	Electrical
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Note : All surfaces are hydraulically actuated.

	FLIGHT CONTROLS DESCRIPTION		1.27.10	P 3
			SEQ 110	REV 15

COCKPIT CONTROLS

- Two sidestick controllers are used for pitch and roll manual control. One is on the CAPT's lateral console, the other is on the FO's lateral console.
The two controllers are springloaded to neutral, and are not mechanically coupled.
Each controller independently sends electrical signals to the flight control computers.
- Two pairs of rigidly interconnected pedals ensure electrical control of the rudder.
- A speedbrake control lever is provided in the center pedestal.
- Two handwheels, on the center pedestal, are used to mechanically control the THS.
- A switch, installed on the center pedestal, ensures the rudder trim control.
- No manual aileron trim switch is provided.

COMPUTERS

Five flight control computers process pilot and autopilot inputs according to normal, alternate, or direct flight control laws.

The computers are :

3 PRIM computers

(Flight Control Primary Computer – FCPC), each of which is used for :

- For autopilot : Normal and alternate control laws.
- For manual flight : Normal, alternate, and direct control laws.
- Speedbrake and ground spoiler control.
- Protection speed computation.
- Rudder travel limit and pedal travel limit.

2 SEC computers

(Flight Control Secondary Computer – FSCS), each of which is used for :

- Direct control laws, including yaw damper function.
- Rudder trim, rudder travel limit, and pedal travel limit.

One computer of any type is capable of controlling the aircraft and of assuming safe flight and landing. In normal operation, one PRIM computer is declared to be the master (P1). It processes the orders and sends them to the other computers (P1 / P2 / P3 / S1 / S2), which will then execute them on their related servo-control.

If one computer is unable to execute the orders sent by the master, another computer executes the task of the affected computer (except for spoiler control).

If the master computer (P1) cannot be the master, then P2 (or P3, if P2 is not available) becomes the master.

Note : *When the green hydraulic system is lost, P2 replaces P1 as the master computer.*

In case all PRIM computers are lost, each SEC is its own master and controls its associated servoloop in direct law.

A single SEC can provide complete aircraft control in direct law.

	FLIGHT CONTROLS DESCRIPTION		1.27.10	P 4
			SEQ 100	REV 16

2 Flight Control Data Concentrators (FCDC) computers

The FCDCs acquire data from the PRIMs and SECs and send this data to the EIS and CMC.

1 Backup Control Module (BCM) computer :

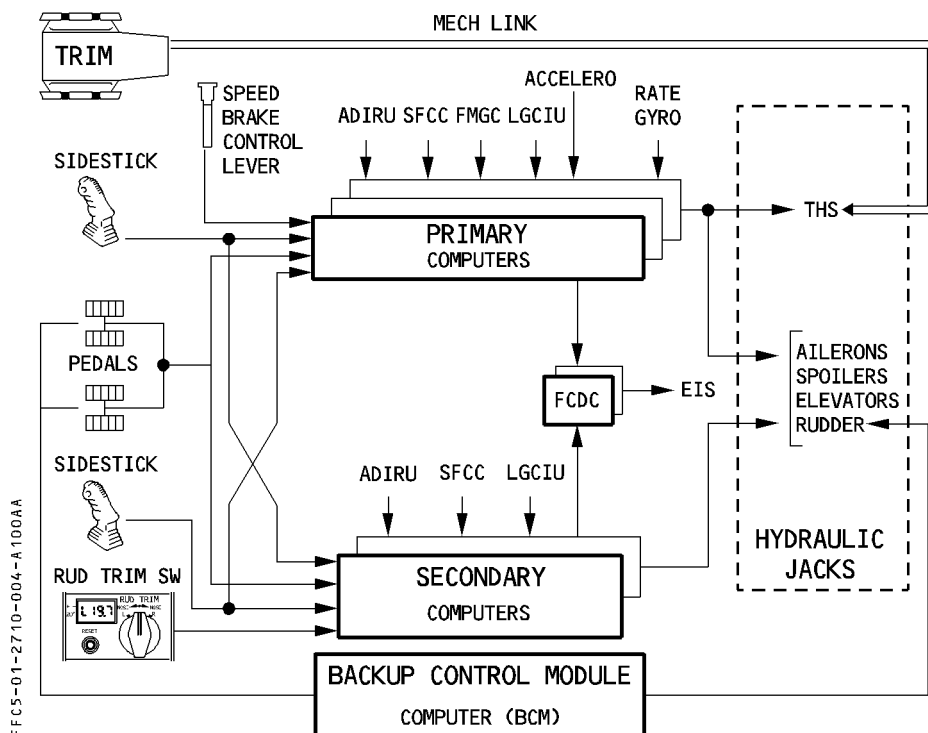
The BCM computer provides yaw damping, and direct rudder command with pedals, via an independent unit, in cases of :

- Total electrical failure, or
- Loss of rudder control due to a Flight Control Computer (PRIM and SEC) failure.

It includes :

- Its own electrical generator, referred to as the Backup Power Supply (BPS), which is supplied by the B or Y hydraulic system ;
- Its own sensors (gyrometers and pedals deflection) ;
- Control of the B and Y hydraulic actuators.

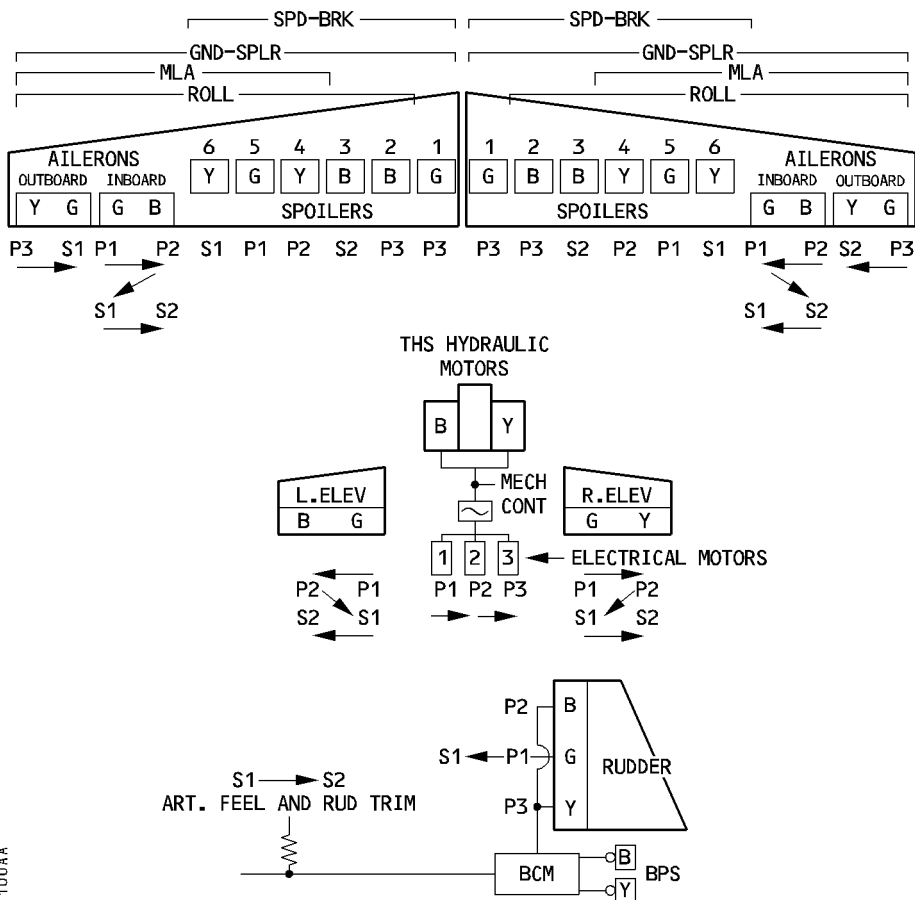
When activated, as in yaw alternate law, there is no turn coordination.



ARCHITECTURE

GENERAL ARCHITECTURE

FOR INFO



P= PRIM COMPUTERS S= SEC COMPUTERS

ARROWS INDICATE THE CONTROL RECONFIGURATION PRIORITIES

G B Y INDICATE THE HYDRAULIC POWER SOURCE FOR EACH SERVO CONTROL

MLA = MANEUVER LOAD ALLEVIATION

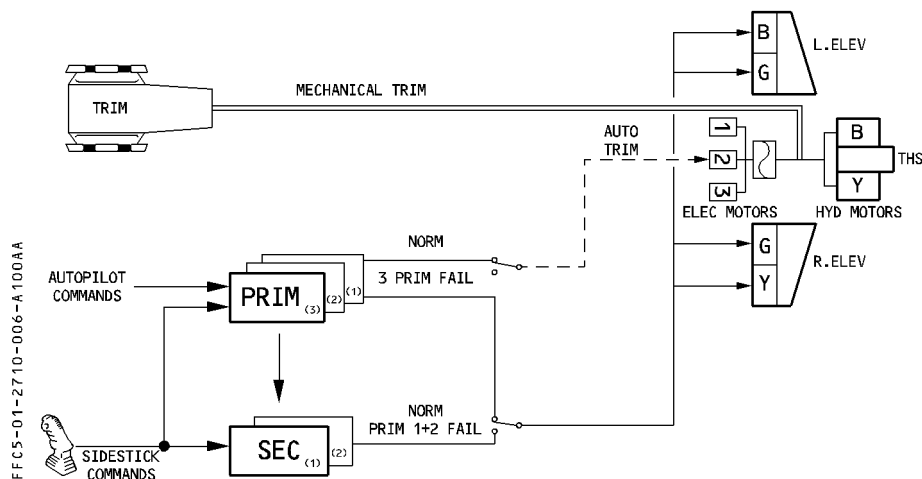
BCM = BACKUP CONTROL MODULE

BPS = BACKUP POWER SUPPLY

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	DESCRIPTION		SEQ 100	REV 15

PITCH CONTROL



Two elevators and the trimmable horizontal stabilizer (THS) control the aircraft in pitch. The maximum elevator deflection is 30° nose up and 17° nose down. The maximum THS deflection is 14° nose up and 2° nose down.

ELECTRICAL CONTROL

- In normal operations, the PRIM 1 controls the elevators and the horizontal stabilizer, and the green hydraulic jacks drive the left and right elevator surfaces.
The THS is driven by N° 1 of three electric motors.
- If a failure occurs in PRIM 1 or the associated hydraulic systems or hydraulic jacks, the system shifts pitch control to PRIM 2. PRIM 2 then controls the elevators via the blue and yellow hydraulic jacks and controls the THS via the N° 2 electric motor.
- If neither PRIM 1 nor PRIM 2 are available, the system shifts pitch control to SEC 1 for elevator control, and to PRIM 3 for THS control via the N° 3 electric motor.

In case of 3 PRIM failure, SEC 1 controls the elevator.

Electrical control of THS is lost. THS actuation is still available through manual pitch trim wheel control.

MECHANICAL CONTROL

Mechanical control of the THS is available from the pitch trim wheel, at any time, if either the blue or the yellow hydraulic system is functioning.

Mechanical control from the pitch trim wheel has priority over electrical control.

	FLIGHT CONTROLS		1.27.10	P 7
	DESCRIPTION		SEQ 001	REV 10

ACTUATION

Elevators

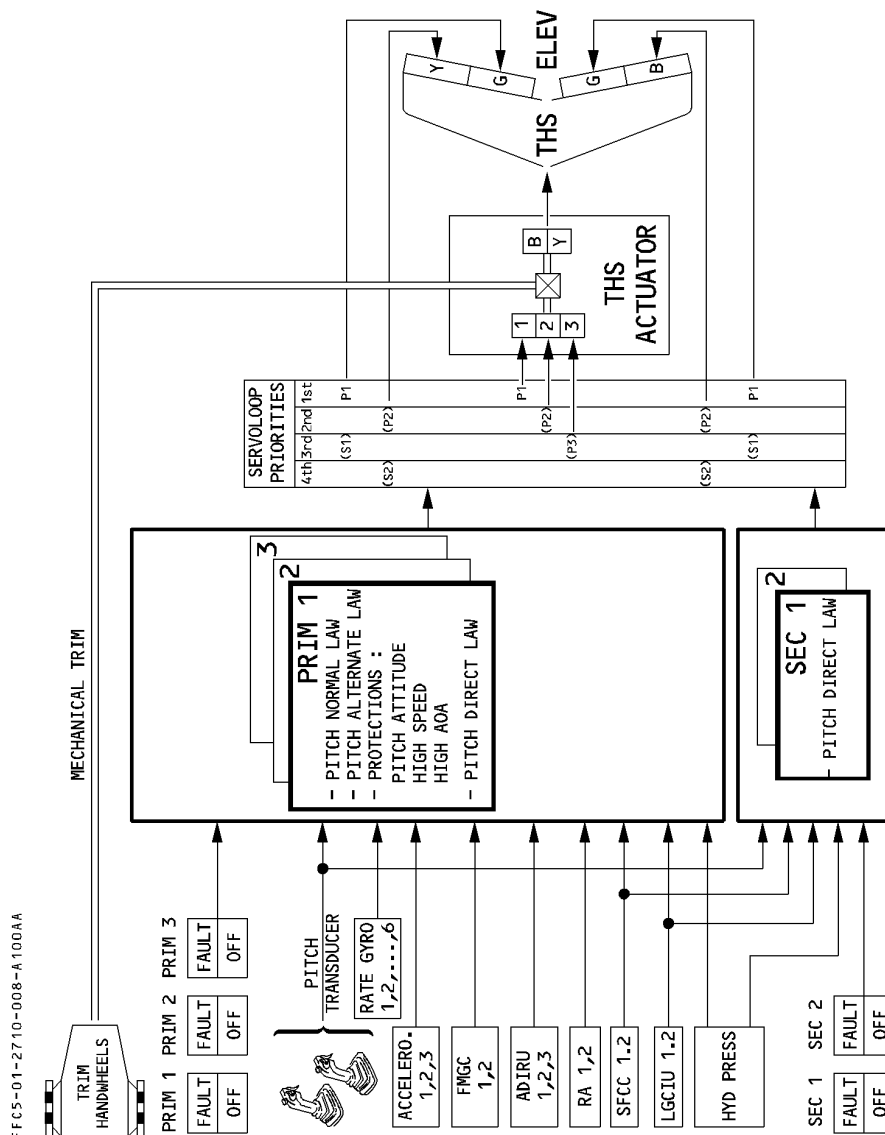
- Two electrically controlled hydraulic servojacks drive each elevator.
Each servojack has three control modes :
 - . Active : Jack position is electrically controlled.
 - . Damping : Jack follows surface movement.
 - . Centering : Jack is hydraulically maintained in neutral position.
- In normal operation:
 - One jack is in active mode.
 - The other jack is in damping mode.
 - Some maneuvers cause the second jack to become active.
- If the active servojack fails, the damped one becomes active and the failed jack is automatically switched to the damping mode.
If neither jack is being controlled electrically nor hydraulically, both are automatically switched to the damping mode.
If neither of the four jacks is being controlled electrically, the four jacks are automatically switched to the centering mode.

Stabilizer

- A screwjack driven by two hydraulic motors drives the stabilizer.
- The two hydraulic motors are controlled by :
 - one of three electric motors, or
 - the mechanical trim wheel.

PITCH CONTROL – SCHEMATIC

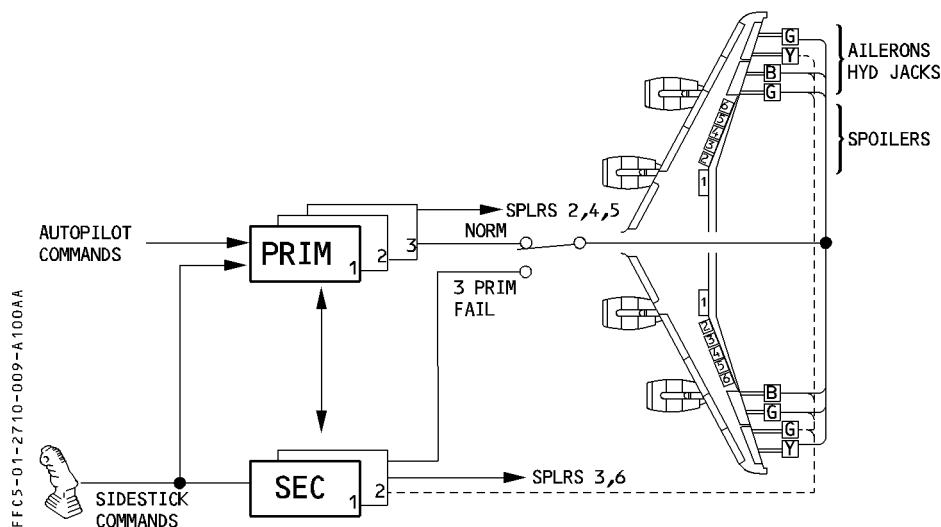
FOR INFO



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	DESCRIPTION		SEQ 100	REV 15

ROLL CONTROL



Two ailerons and five spoilers on each wing control the aircraft about the roll axis.
The maximum deflection of the outer ailerons is $-25^\circ/+25^\circ$; and of inner ailerons is $-30^\circ/+20^\circ$.
Ailerons partially extend when the flaps are extended (aileron droop).
The maximum spoiler deflection is 35° .

ELECTRICAL CONTROL

- Inner ailerons are normally controlled by PRIM 1 (LH) and 2 (RH) with each of these computers being capable of controlling both sides. SEC 1 and 2 provide backup control in case of PRIM 1 and 2 failure.
- The outer ailerons are normally controlled by PRIM 3. SEC 1 and 2 provide backup control in case of PRIM 3 failure.
- The SECs control the N° 3 and 6 spoilers; the PRIMs control the N° 2, 4 and 5 spoilers.

	FLIGHT CONTROLS		1.27.10	P 10
	DESCRIPTION		SEQ 100	REV 16

ACTUATION

– Outer Ailerons

Two electrically-controlled hydraulic servojacks drive each outer aileron.

Each servojack has two control modes :

- Active : Jack position is electrically-controlled.
- Damping : Jack follows surface movement.

The system automatically selects damping mode, in the event of green and yellow low pressure, or if the respective computer fails.

At high speed (above 190 knots, in CONF 0), the outer ailerons are controlled to zero deflection.

In some failure cases, the outer ailerons are used up to 300 knots.

When the emergency generator is only supplied by the RAT, the outer ailerons are controlled in damping mode to reduce hydraulic power consumption.

– Inner Ailerons

- Two electrically-controlled hydraulic servojacks drive each inner aileron.

Each servojack has three control modes :

- . Active : Jack position is electrically-controlled.
- . Damping : Jack follows surface movement.
- . Centering : Jack is hydraulically maintained in the neutral position.

- In normal operation :

- One jack is in active mode.
- The other jack is in damping mode.
- Some maneuvers cause the second jack to become active.

- If the active servojack fails, the damped one becomes active and the failed jack is automatically switched to the damping mode.

If neither jack is hydraulically controlled, both are automatically switched to the damping mode.

If neither jack is electrically controlled, both are automatically switched to the centering mode.

– Spoilers

A servojack positions each spoiler. Each servojack receives hydraulic power from either the green, yellow, or blue hydraulic system, controlled by the PRIM or SEC (as shown in the diagram on Page 13).

The system automatically retracts the spoilers to their zero position, if it detects a fault or loses electrical control.

If the system loses hydraulic pressure, the spoiler retains the deflection it had at the time of the loss, or a lesser deflection if aerodynamic forces push it down.

When a spoiler surface on one wing fails, the symmetric one on the other wing is inhibited (except for spoilers 4 and 6).

	FLIGHT CONTROLS		1.27.10	P 11
	DESCRIPTION		SEQ 110	REV 16

SPEEDBRAKE AND GROUND SPOILER CONTROL

SPEEDBRAKE CONTROL

The pilot controls the speedbrakes with the speedbrake lever. The speedbrakes involve spoilers 1 to 6. Speedbrake extension is inhibited, if :

- Maneuver Load Alleviation (MLA) is activated.
- Angle-of-attack protection is active.
- Low speed stability is active.
- Flaps are in Configuration FULL.
- At least one thrust lever is above MCT.
- Alpha floor activation.

If an inhibition occurs when the speedbrakes are extended, they automatically retract and stay retracted until the inhibition condition disappears, and the pilots reset the lever. (The speedbrakes can be extended again, 5 seconds after the lever is reset.) When a speedbrake surface on one wing fails, the symmetric one on the other wing is inhibited.

FOR INFO

Maximum deflection : 25° for spoiler 1
30° for spoilers 2 to 6
Reduced in Conf 2 and 3

At high altitude close to MAX ALT, this maximum deflection is reduced. For surfaces 2 to 6 (which perform roll and speedbrake functions), the roll function has priority: When the sum of a roll order and a simultaneous speedbrake order on one surface is greater than the maximum deflection achievable in flight, the symmetrical one is retracted until the difference between the two surfaces is equal to the roll order.

GROUND SPOILER CONTROL

The ground spoiler function involves all spoilers and ailerons. When a ground spoiler surface on one wing fails, the symmetric one on the other wing is inhibited.

Arming :

The pilot arms the ground spoiler function by pulling the speedbrake control lever up into the armed position.

Extension :

– Full extension

The ground spoilers and ailerons automatically extend during rejected takeoff (at a speed greater than 72 kt) or at landing, when both main landing gear have touched down and:

- All thrust levers are set to idle, provided they are armed, or
- Reverse is selected on at least two symmetrical engines (remaining engines at idle).

The aileron roll function is inhibited when the ailerons are used for the ground spoiler function.

	FLIGHT CONTROLS DESCRIPTION	1.27.10	P 12
		SEQ 100	REV 15

– Partial extension

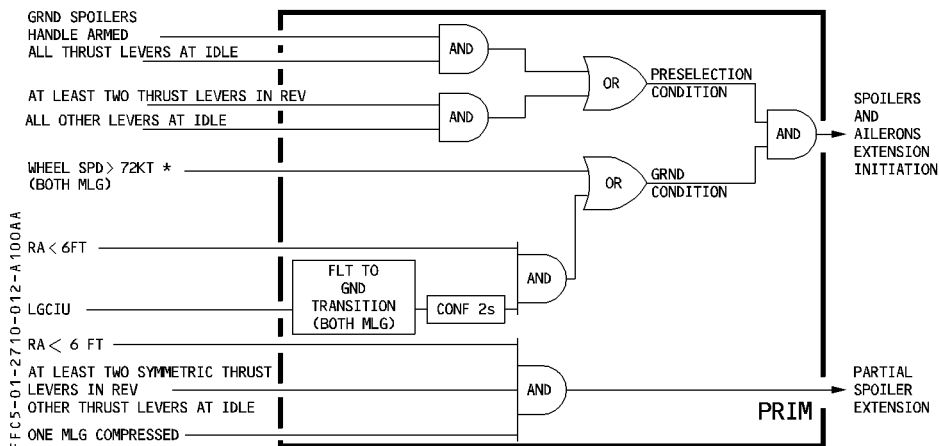
The ground spoilers (not the ailerons) partially extend, when reverse is selected on at least two symmetric engines (remaining engines at idle) and one main landing gear is compressed. This partial extension, by decreasing the lift, will ease the compression of the second main landing gear and will consequently, lead to normal ground spoiler extension.

Retraction :

The ground spoilers and ailerons retract when :

- One thrust lever is above idle, or
- All thrust levers are at forward idle and the speedbrakes control lever is pushed down.

FOR INFO



* Condition on wheel speed is inhibited after GND/FLT transition.

This condition is rearmed, if wheel rotation stops.

Consequently, after an aircraft bounce (aircraft airborne), if the spoilers are extended :

- They remain extended with the thrust lever at idle ;
- They retract, if thrust is increased above idle (go-around), and extend again after the next touchdown.

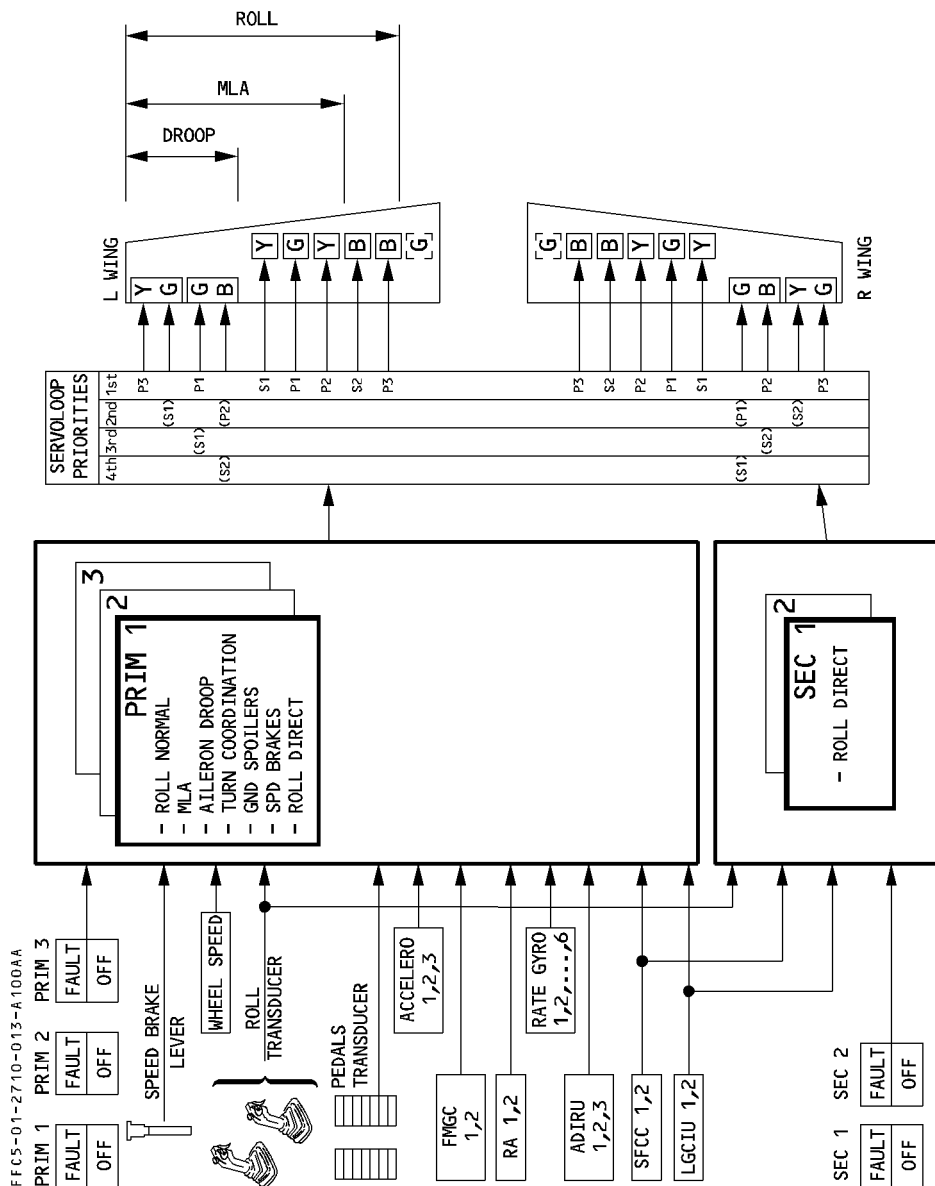
The thrust levers are considered at idle when they are :

- Below 4.7°, when the RA is above 6 feet, and
- Below 32°, when the RA is below 6 feet.

Surfaces partially/fully extend to :

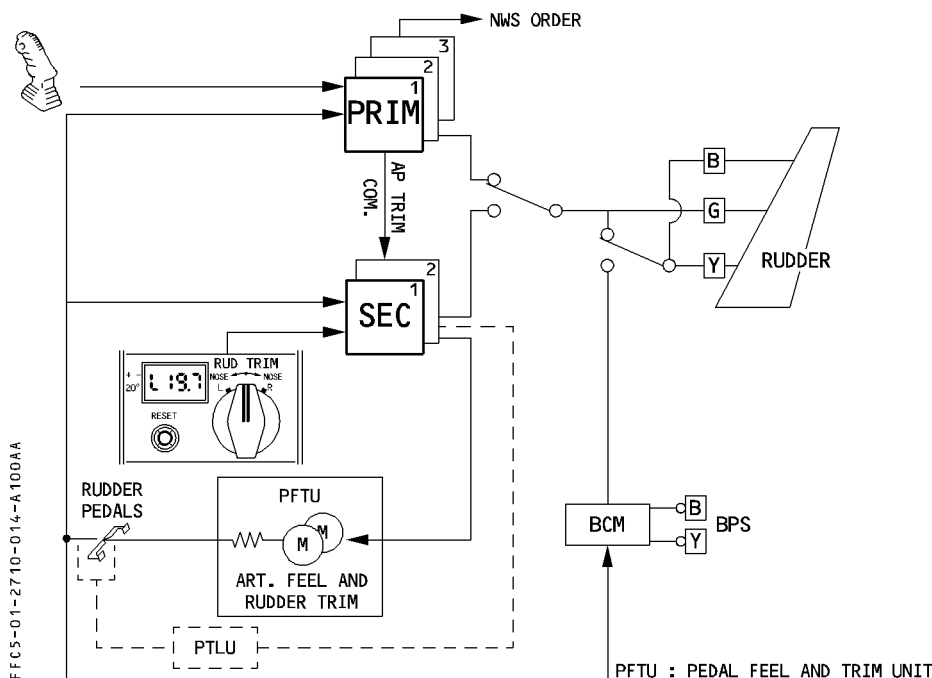
- 14°/35° for spoiler 1 ;
- 20°/50° for spoilers 2 to 6 ;
- 25° for outer ailerons, and
- 20° for inner ailerons.

ROLL CONTROL - SCHEMATIC



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	DESCRIPTION		SEQ 100	REV 15

YAW CONTROL



Yaw control is achieved by one rudder surface (rudder deflection $\pm 35^\circ$).

ELECTRICAL RUDDER CONTROL

- In normal operation, PRIM 1 controls the green hydraulic jack, PRIM 2 controls the blue hydraulic jack, and PRIM 3 controls the yellow hydraulic jack.
- If PRIM 1 fails, SEC 1 controls the green hydraulic jack.
- In case of a total electrical failure or loss of rudder control due to flight control computers failure, the Backup Control Module (BCM) controls the yellow hydraulic jack, or the blue hydraulic jack, if the yellow hydraulic jack is not available.

ACTUATION

The rudder is actuated by 3 independent hydraulic jacks operating in parallel.

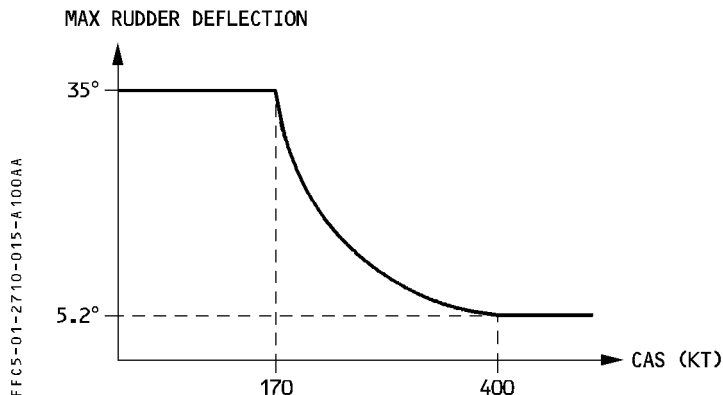
- In normal operation, the 3 jacks are simultaneously in active mode.
- In case of an electrical or hydraulic failure, the corresponding jack is in damping mode.

	FLIGHT CONTROLS		1.27.10	P 15
	DESCRIPTION		SEQ 100	REV 15

RUDDER AND PEDAL TRAVEL LIMIT

The rudder and pedal deflection is limited as a function of the speed and mach.

In case of three ADR or three FCPC failure, the maximum rudder deflection remains at the value reached before the failure. Then, maximum deflection is available when the slats are extended.



Note : Depending on the Mach, this Max rudder deflection value may decrease slightly (by less than 1°).

	FLIGHT CONTROLS		1.27.10	P 16
	DESCRIPTION		SEQ 100	REV 15

RUDDER TRIM

Inside the PFTU, artificial feel and rudder trim are achieved by two electric motors which position the artificial feel unit. In normal operation, SEC 1/MOTOR 1 are driving, and the SEC 2/MOTOR 2 remain synchronized as a backup.

In manual flight, the pilot can apply rudder trim from the RUD TRIM rotary switch, located on the pedestal.

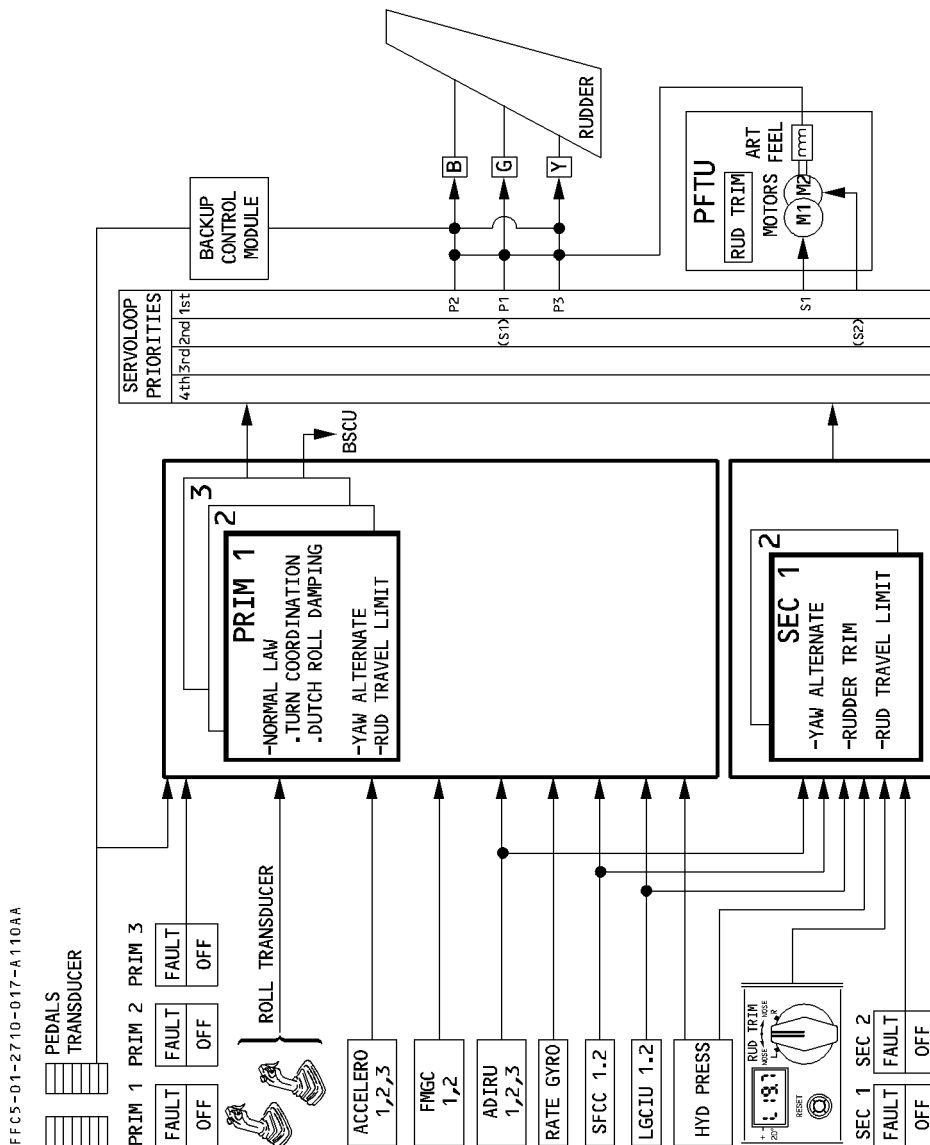
- Authority : 85 % of max rudder deflection (limited to 29°).
- Rudder trim speed :
 - In clean configuration : 1°/second
 - With flaps/slats extended :
 - For input up to 1.5 seconds : 1°/second.
 - After 1.5 seconds : 3°/second.

A button is provided on the RUD TRIM panel to reset the rudder trim to zero.

Note : *With the autopilot engaged, rudder trim orders are computed by the PRIM and transmitted to the SEC for actuation. The rudder trim rotary switch is not active.*

YAW CONTROL – SCHEMATIC

FOR INFO



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