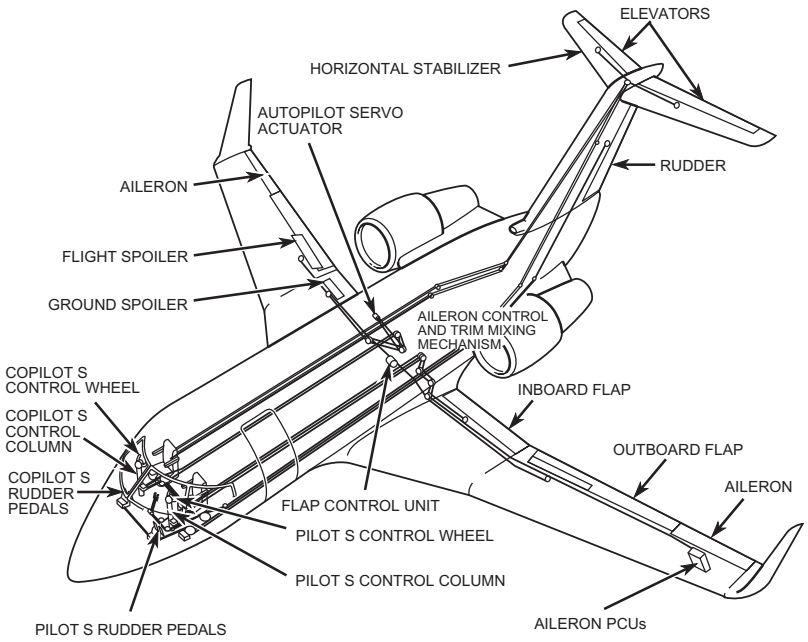
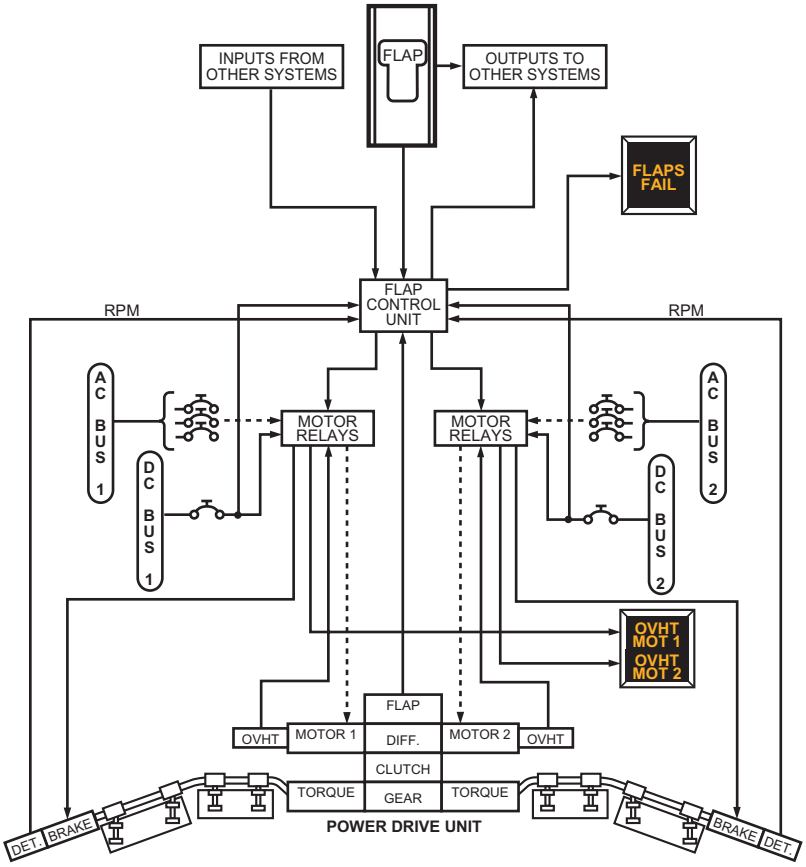
Flight Controls



Flap System


INPUTS FROM OTHER SYSTEMS
FLAP
OUTPUTS TO OTHER SYSTEMS
FLAPS FAIL
FLAP CONTROL UNIT
RPM
RPM
AC BUS 1
DC BUS 1
MOTOR RELAYS
MOTOR RELAYS
AC BUS 2
DC BUS 2
OVHT MOT 1
OVHT MOT 2
FLAP
OVHT
MOTOR 1
DIFF.
MOTOR 2
OVHT
CLUTCH
TORQUE
GEAR
TORQUE
DET.
BRAKE
BRAKE
DET.
POWER DRIVE UNIT

Primary Flight Controls

The mechanically actuated primary flight controls receive crew inputs through control wheels, control columns, and rudder pedals that operate hydraulic power control units (PCUs) to move the control surface. The No. 3 hydraulic system is the only hydraulic system to operate all primary flight controls (**see Table 4-E**).

Hydraulic System		
No. 1	**No. 3**	**No. 2**
Left Aileron Left Elevator Rudder	Left & Right Ailerons Left & Right Elevators Rudder	Right Aileron Right Elevator Rudder

Table 4-E; Hydraulic Power – Primary Flight Controls

Ailerons

Moving a control wheel left or right from neutral transmits control inputs by separate cable runs to the aileron power control unit (PCU) input quadrants. Although each aileron's control cables are independent from its opposite, a mechanical interconnection between the forward quadrant assemblies synchronizes control wheel movement.

Movement of the input quadrants drive the PCU's control valve and hydraulic cylinder in the desired direction for aileron deflection. The control valve then directs hydraulic pressure to the cylinder's extend or retract port while connecting the opposite port to return. Under pressure, the cylinder moves to deflect the aileron. When the aileron reaches the desired deflection, a feedback mechanism moves the control valve to the null position; the aileron stops moving. As the ailerons move, two position transmitters drive their respective AILERON indicators.

If an aileron control mechanism jams, pulling the ROLL DISC handle out and then rotating 90° actuates the roll disconnect mechanism. This separates the interconnection between left and right aileron control mechanism so the control wheels can independently control their aileron.

Rotating the ROLL DISC handle 90° from the locked position and pushing it in reconnects the left and right aileron control mechanisms. Both aileron and/or elevator cockpit controls should be in the same position prior to unlocking or stowing the respective disconnect handle.

Roll Trim

Moving both AIL TRIM switches in the desired direction supplies 28V DC from DC BUS 1 to the aileron trim actuator. The actuator then extends or retracts to move the ailerons through the artificial feel unit of the aileron rear quadrant assembly. As the roll trim actuator moves, the AIL TRIM indicator shows roll trim in units left (LWD) or right (RWD) wing down. Since the trim causes both the left and right aft quadrants to move, both handwheels also move when trim is applied.

Elevators

Moving the control column forward or aft from neutral transmits inputs through separate cable runs, push-pull rods, quadrants, and levers to the left and right elevator rear quadrants. This moves the elevators via their PCUs in the desired direction. As the elevators move, two position transmitters drive the cockpit ELEVATOR indicators. A pitch artificial feel unit provides the control column with the required “stick” force relative to the horizontal stabilizer position.

If an elevator operating mechanism jams, pulling the PITCH DISC handle out and then rotating 90° to lock separates the two halves of the control column cross-coupling shaft. Movement of either control column then independently moves the associated elevator.

After rotating the PITCH DISC handle 90° to unlock it, push the handle in so the two halves of the cross-coupling shaft can reconnect. Both aileron and/or elevator cockpit controls should be in the same position prior to unlocking or stowing the respective disconnect handle.

Pitch Trim

Pushing both sides of one of the split pitch trim control switches toward the NOSE ↑ UP or NOSE ↓ DN position generates a pitch trim command for the two channel horizontal stabilizer trim control unit. The control unit interprets these commands and generates the necessary electrical signal to drive the two-motor (primary and backup) horizontal stabilizer actuator. As the horizontal stabilizer moves, its position is transmitted to the STAB indicator.

Normally, control unit channel 1 controls the pitch trim system while channel 2 monitors system operation. If a fault occurs, the system automatically switches to the other channel and illuminates the respective CHAN 1 INOP/CHAN 2 INOP switchlight. If an overspeed fault occurs, the system disconnects the overspeeding channel and illuminates the OVSP light. The other channel must be manually selected.

Pressing the control wheel PITCH DISC disconnects the pitch trim system and brakes the horizontal stabilizer actuator. Pressing the CHAN 1 INOP/CHAN 2 INOP switchlight followed by the OVSP/CHNG CHAN switchlight re-engages the system.

Commands from the stability augmentation system and the autopilot can also control the pitch trim system.

Rudder

Deflecting the rudder pedals transmits control inputs by cables, push-pull rods, quadrants, and levers to the three rudder PCUs. The PCUs then move the rudder in the desired direction. As the rudder moves, a position transmitter drives the RUDDER indicator.

If part of the rudder control mechanism jams, two anti-jam mechanisms isolate the offending system for continued rudder control. Additional pedal force on the unjammed rudder operate the anti-jam mechanism allowing the pilot with unjammed controls to operate the rudder.

Rudder Trim

Rotating the RUD TRIM knob left or right from neutral moves the rudder through the rudder trim actuator in the desired direction. The actuator then moves the rudder through the yaw damper actuator. A trim position transmitter drives the RUD indicator.

Artificial Feel Systems

Hydraulically boosted flight controls offer none of the feedback normally generated by a control surface as it extends into the airstream. To counter this, mechanical artificial feel mechanisms generate control forces proportional to control surface deflection.

Flight Control Monitoring System

A flight control monitoring system provides visual warnings of aileron, elevator, and rudder power control unit (PCU) jamming or insufficient hydraulic system pressure to operate the flight control. The system consists of a 12-channel monitoring unit that receives power control unit position from proximity sensors.

If an aileron, elevator, or rudder PCU jams, the corresponding proximity sensor de-actuates. The control unit, in turn, illuminates the associated amber ROLL, PITCH, or YAW light. Low hydraulic pressure to the aileron or rudder PCUs also illuminates the respective ROLL or YAW light.

With the hydraulic systems unpressurized, the ROLL, YAW, and MON SAFE lights illuminate. The MON SAFE light illuminates when the aileron and rudder PCUs are unpressurized and the elevator PCUs are unjammed.

Stall Protection System

With the PUSHER switches in the ON position, a transducer on each side of the forward fuselage provides AOA data to the two channel stall protection system (SPS) computer. Supplied with AOA data, flap position, lateral acceleration, and aircraft altitude, the SPS computer responds to an increasing AOA by triggering auto ignition, stick shaker, or stick pusher operation.

The SPS computer first responds to an increasing AOA by initiating auto-ignition operation. The IGN A/ON and IGN B/ON lights illuminate as both ignition systems operate continuously.

As AOA continues to increase toward a potential stall condition, the SPS computer triggers the stick shaker and disconnects the autopilot.

If AOA increases to a point short of a stall, the SPS computer first sounds the stall protection warning horn and then flashes the STALL PUSH lights. When both SPS computer channels indicate stick pusher operation, the SPS computer triggers the stick pusher actuator. The actuator pushes the control columns forward to prevent the aircraft from entering a stall. When the aircraft reaches 1/2 G during recovery, the pusher deactivates. This prevents negative G flight.

The STALL PROTECT FAIL lights flash if:

- SPS computer loses power
- SPS computer stick shaker or pusher circuits fail
- one or both AOA transducers fail
- a difference in excess of 3.5° occurs between compensated AOA signals
- a difference in excess of 0.03G occurs between the lateral accelerometers
- simultaneous weight-on-wheels (WOW) and WOW O/P FAIL signals to SPS computer
- stick shaker electrical system fails.

If the SPS computer loses DC Essential and Battery bus power, the STALL PROTECT FAIL lights illuminate steady.

If an SPS altitude transducer fails or a 2,000 ft difference exists between the two transducers, the SPS computer illuminates the ALT COMP FAIL lights. The reference point for operation then becomes 15,000 ft altitude.

Gust Locks

A bypass, damping, or relief valve in the primary flight control PCUs effectively lock the control surfaces in the neutral position when all three hydraulic systems are unpressurized. Each valve essentially connects the PCU's extend and retract ports to restrict control surface movement. This does, however, allow some movement in response to external forces.

Secondary Flight Controls

Secondary flight controls include the electrically operated and powered flaps and the mechanically controlled and hydraulically operated flight and ground spoilers.

Flaps

Moving the FLAPS control lever from the 0° (retracted) position to the 20, 30, or 45° position moves the control lever rotary switch to the associated position. The flap control unit (FCU) then generates the necessary command to operate the flap power drive unit (PDU). Once the flap extend relays energize, 220V AC from AC Bus No. 1 and 2 supply the two PDU motors. The PDU motors rotate and, through a clutch and gearbox, extend the flaps through flexible shaft assemblies. As the flaps extend, the PDU's potentiometer provides a feedback signal to the flap control unit consistent with flap position. When the flaps reach the desired position, the FCU de-energizes the extend relays; the flaps stop moving.

Moving the FLAPS control lever to retract the flaps essentially reverses the flap extension sequence. The FCU energizes the flaps retract relays and the PDU retracts the flaps through their flexible shaft assemblies. When the flaps reach the selected position, the flap control unit de-energizes the flap retract relays so the PDU stops.

An asymmetry/overspeed detector and brake assembly between each aileron and outboard flap monitor provides flap movement signals to the flap control unit. If a system fault occurs (i.e., flap asymmetry, overspeed, underspeed, no movement, or uncommanded movement), the flap control unit applies the PDU brakes and asymmetry detector/brake units to stop flap movement. The FLAPS FAIL light illuminates.

If a PDU motor overheats, the overheat relay opens to stop flap motor operation and illuminate the associated OVHT MOT 1 or OVHT MOT 2 light. The other motor continues to drive the PDU at approximately one-half normal speed.

Flight Spoilers

Moving the FLIGHT SPOILER handle out of the 0° detent to extend the flight spoilers mechanically operates each spoiler's two power control units (PCUs) through push-pull rods, quadrants, and cables. The PCUs' control valves shift to the extend position to route No. 1 and 2 hydraulic system pressure to the PCU cylinder. The PCU cylinders extend and drive the flight spoiler panels to the extended position. When the spoiler panels are out of the closed position, the amber LH and RH FLT SPLR lights illuminate. Extending the flight spoilers past 20° also illuminates the green LEFT and RIGHT flight spoiler lights.

When spoiler panel position matches the selected handle position, summing mechanisms shift the control valves to the neutral position so they trap hydraulic pressure within the PCU cylinder. The flight spoilers stop moving.

Moving the FLIGHT SPOILER handle toward the RETRACT position shifts the summing mechanism that moves the control valve to the retract position. The control valve then directs hydraulic pressure to the retract side of the PCU cylinder; the flight spoiler panel retracts. The green LEFT and RIGHT flight spoiler lights extinguish when the spoilers retract below the 20° position. The amber LH and RH FLT SPLR lights extinguish when the panels are completely retracted.

As the flight spoilers extend and retract, a position transmitter on each inboard flight spoiler PCU drives the FLT SPLR indicator.

Ground Spoilers

On S/Ns 3060 and subsequent, S/Ns 3001 to 3059 with SB 601-0113 and S/Ns 5001 and subsequent: with the GROUND SPOILERS switch in the ON position and a weight-on-wheels or wheel spin-up signal, the ground spoilers automatically deploy with either of the following conditions.

- The spoiler control lever is less than 1/4 and both throttles have been advanced above IDLE and then returned to the IDLE position or lower
- The spoiler control lever is between 1/4 and MAX positions, and both throttle levers are at the IDLE position or lower.

On S/Ns 3001 to 3059 without SB 601-0113: with the GROUND SPOILERS switch in the ON position, the ground spoilers will deploy only if ALL the following conditions are met.

- The button on top of the spoiler control lever is depressed, and the spoiler control lever is moved up and rearward through the stop gate to the EXTEND position
- The left throttle lever is in IDLE position or lower
- A weight-on-wheels or wheel spin-up signal is present.

The spoiler control unit energizes the ground spoiler manifold solenoids. The two solenoids then shift to direct No. 1 hydraulic system pressure to the ground spoiler actuators. Under pressure, the ground spoiler panels extend; the LH and RH GND SPLR lights illuminate.

De-energizing the ground spoiler manifold solenoids directs hydraulic pressure to the retract side of the actuators so the panels retract. Any of the following can de-energize the solenoids:

- loss of weight-on-wheels signal with loss of wheel spin-up signal
- advancing a throttle lever above the IDLE position
- placing the GROUND SPOILER switch in the OFF position.

The solenoids then shift to direct hydraulic pressure to the retract side of the actuators. The ground spoiler panels retract and the LH and RH GND SPLR lights extinguish.

Primary Flight Controls

Power Source	No. 1, 2, and 3 hydraulic systems DC Essential bus (monitoring) DC Bus 2 (monitoring) 26V AC bus (position) 26V AC Essential bus (position)
Control	Control wheels Control columns Rudder pedals Power control units PITCH DISC handle ROLL DISC handle
Monitor	SURFACE indicators Flight control monitoring system PITCH, ROLL, YAW, and MON SAFE light
Protection	Pitch disconnect mechanism Roll disconnect mechanism Rudder anti-jam mechanism Flutter dampeners

Trim Systems

Power Source	AC Essential bus (pitch) AC Bus 1 (pitch) DC Bus 1 (rudder) DC Bus 2 (aileron)
Control	Pitch trim switches AIL TRIM switch RUD TRIM knob
Monitor	TRIM indicators CHAN 1 INOP/CHAN 2 INOP lights (pitch trim) OVSP/CHNG CHAN light (pitch trim)
Protection	Circuit breakers

Stall Protection System

Power Source	DC Essential bus Battery bus
Distribution	Stick shaker Stick pusher
Control	AP/SP DISC switches PUSHER switch TEST switch G SWITCH TEST switch
Monitor	STALL PROTECT FAIL lights STALL/PUSH lights ALT COMP FAIL lights SPS TEST INDICATOR
Protection	Circuit breakers SPS computer monitoring circuits

Flaps

Power Source	Battery bus (indication) DC Bus 1 and DC Bus 2 (flap control unit) AC Bus 1 and AC Bus 2 (flap motors)
Control	FLAPS control lever Flap control unit
Monitor	Flap position indicator FLAPS FAIL light OVHT MOT 1/OVHT MOT 2 light
Protection	Asymmetry/overspeed detector brake assembly Flap control unit Thermal switches and flap overheat relay Circuit breakers

Flight Spoilers

Power Source	26VAC Bus (indication) No. 1 and No. 2 hydraulic systems
Control	FLIGHT SPOILER handle Power control units (PCUs)
Monitor	LH/RH FLT SPLR lights LEFT/RIGHT FLIGHT SPOILERS lights FLT SPLR indicator
Protection	Load limiters Circuit breakers

Ground Spoilers

Power Source	DC Bus 1 and DC Bus 2 No. 1 hydraulic system
Control	FLIGHT SPOILER handle GROUND SPOILERS switch Throttle lever switches Weight-on-wheels system Wheel spin-up Spoiler control unit
Monitor	LH/RH GND SPLR lights SPLRS INOP light
Protection	Spoiler control unit Circuit breakers