SECTION III
HYDRAULICS & LANDING GEAR

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HYDRAULIC SYSTEM

The aircraft hydraulic system supplies hydraulic pressure for operation of the aircraft landing gear, brake, flap, spoiler/spoileron and thrust reverser systems. Hydraulic fluid flows from the main hydraulic reservoir through two firewall shutoff valves to the main engine-driven hydraulic pumps for distribution to the required systems upon demand.

The hydraulic system has both a main and auxiliary source of hydraulic power. These sources are totally separate up to the source selector valve. An auxiliary dc motor-driven hydraulic pump is installed to provide auxiliary hydraulic pressure to the brake system through the brake source shuttle valve and to the landing gear and flap system through the source selector valve in the event of a malfunction. The auxiliary hydraulic system only provides pressure for the brake system while the aircraft is on the ground.

A 260 cu. in. (4261 cc) reservoir supplies hydraulic fluid to the main and auxiliary hydraulic systems. The reservoir is designed with a separation wall (partition) to contain fluid for either the main or auxiliary system. Reservoir pressure is maintained at approximately 20 psi (138 kPa) by bleed air supplied through a pressure regulator. A bleed-air pressure relief valve releases pressure in excess of 20 psi (138 kPa), and a vacuum relief valve prevents negative pressure in the reservoir. A thermal shutoff valve prevents high energy bleed air (>390° F [199° C]) from entering the reservoir in the event of a hydraulic line failure.

The main and auxiliary hydraulic pumps will each maintain a nominal pressure of 3000 psi (20,685 kPa) for their applicable systems. A precharged (1500 psi [10,343 kPa]) hydraulic accumulator is installed to dampen and absorb pressure surges within the main hydraulic system. A separate brake accumulator, fed by the auxiliary system, maintains pressure for the emergency/parking brakes. Two high-pressure filters and two return filters prevent hydraulic fluid contamination within the main and auxiliary systems. These filters incorporate bypass valves which will open in the event they become clogged. A hydraulic pressure relief valve, installed between the high-pressure and return lines in both the main and auxiliary system filters, will open to relieve pressure in excess of 3700 psi (25,511 kPa).

FIREWALL SHUTOFF VALVES

Two motor-driven firewall shutoff valves can stop hydraulic fluid flow to the main engine-driven hydraulic pumps in the event of an emergency or engine fire. These valves will also shut off fuel supply to the engine and close the engine bleed-air valves. Each shutoff valve is operated by the corresponding FIRE switch on the pedestal (ENGINE panel). (Refer to Engine Fire Extinguishing System, Section II). The valves operate on 28-vdc supplied through the 3-amp L and R FWSOV circuit breakers located on the pilot's and copilot's circuit breaker panels (ENGINE group), respectively. Loss of power causes the shutoff valves to remain in their last position. The firewall shutoff valves are powered from the hot bus.

SOURCE SELECTOR VALVE

A source selector valve controls the source (main or auxiliary) of hydraulic pressure to the landing gear and flap systems. To initiate the hydraulic cross flow function, the auxiliary hydraulic pump must be running. This is achieved by pressing the AUX PUMP switch (GEAR/HYD panel). Manual activation of the valve during flight is accomplished by depressing the alternate-action push button HYD XFLOW switch (GEAR/HYD panel) which connects the landing gear and flap systems to the auxiliary hydraulic system. The switch will illuminate ON to indicate the valve is energized. If the auxiliary fluid level becomes low, the valve will automatically be deactivated in order to conserve fluid for the brake system.

The following CAS illumination is specific to the source selector valve:

CAS	Color	Description
HYD XFLOW ON	White	Hydraulic crossflow function is selected.

AUX HYD PUMP CONTROL

The auxiliary dc motor-driven hydraulic pump is automatically controlled by landing gear position, and manually controlled by the momentary-action push button AUX HYD switch (GEAR/HYD panel). The ON legend will illuminate when the pump is activated either manually or automatically. Normal auxiliary pump operation is based on the following aircraft configurations:

(1) Pump off when aircraft is powered up.
(2) Manual control prior to gear retraction. AUX HYD switch should be ON during normal taxi and takeoff.
(3) Automatically off when gear is transitioned up.
(4) Manual control in flight.
(5) Automatically ON when gear is transitioned down.
(6) Manual control after gear extension.
(7) Automatically off when aircraft is powered down.

The auxiliary pump operates on 28-vdc supplied from the L ESS bus. Power for the auxiliary pump is provided by the 1-amp PWR circuit breaker located on the pilot's circuit breaker panel (GEAR/HYDRAULICS group [AUX HYD PUMP]). Power for the auxiliary pump control circuit is provided by 2-amp CTRL circuit breaker located on the pilot's circuit breaker panel (GEAR/HYDRAULICS group [AUX HYD PUMP]). Refer to Airplane Flight Manual for hydraulic pump limitations.

The following CAS illumination is specific to the auxiliary hydraulic pump:

CAS	Color	Description
AUX HYD PMP LO	Amber	Auxiliary hydraulic pump is on and pressure is less than 1900 psi.

MAIN/AUXILIARY SYSTEM PRESSURE

The HYD system page on EICAS contains a schematic display of fluid flow in the main and auxiliary hydraulic systems. Main system pressure is sensed by a pressure transducer which provides an analog signal to the EICAS. Pressure is displayed as a digital readout on the HYD system page with a range of 0 to 4000 psi (27,580 kPa) and a display resolution of 10 psi (69 kPa). Low-pressure switches relay information to CAS for low-pressure indications for the left or right side of the main hydraulic system, or in the auxiliary system.

The following CAS illuminations are specific to hydraulic system pressure:

CAS	Color	Description
AUX HYD PMP LO	Amber	Auxiliary hydraulic pump is on and pressure is less than 1900 psi.
MAIN HYD PRESS	Amber	Hydraulic pressure (main system) is not within the acceptable range (either too high or too low).
HYD PUMP LOW	White	Pressure from the associated (L or R) engine-driven hydraulic pump is low.

BRAKE ACCUMULATOR PRESSURE

The brake accumulator provides reserve hydraulic pressure of 3000 psi (20,685 kPa) for emergency brake operation and for parking brake operation. The accumulator is designed to provide at least six emergency brake applications or parking brake pressure for approximately 48 hours. The brake accumulator incorporates a pressure transducer which provides a signal to CAS. The following CAS illumination is specific to the brake accumulator:

CAS	Color	Description
BRK ACUM PRESS	Amber	Emergency brake accumulator pressure is not within the acceptable range (either too high or too low).

HYDRAULIC GROUND SERVICE

The hydraulic system is serviced through a ground service access located below the right engine pylon. A ground service panel within this access monitors hydraulic system condition for the auxiliary dc motor brushes, main/auxiliary system filters, status of the ground service valve, and main/auxiliary reservoir fluid levels. If the BRUSH indicator illuminates, the dc motor brushes are 90% worn (refer to Chapter 29 in the Airplane Maintenance Manual for corrective actions). A ground service switch allows system pressurization by either main or auxiliary pumps. The ground service access also includes quick-disconnect ports for pressure, return and fill lines, and an air bleed valve for the reservoir.

The following CAS illuminations are specific to the hydraulic system:

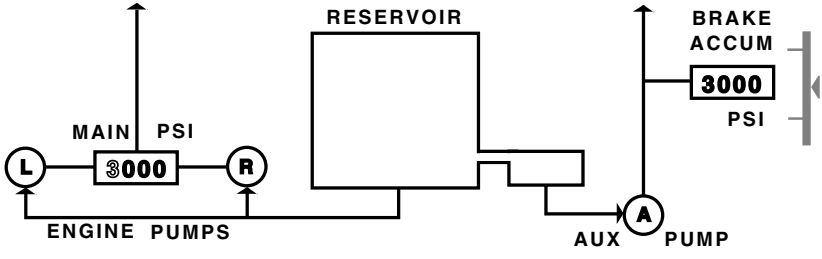
CAS	Color	Description
AUX HYD QTY LO	Amber	Auxiliary hydraulic reservoir quantity is low. Auxiliary hydraulic pressure is not available to operate the landing gear and flaps. Auxiliary hydraulic pressure is still available to the brakes and brake accumulator.
MAIN HYDQTY LO	White	- The fluid level in the hydraulic reservoir (main system) is either low or overfull. or - One or more of the hydraulic system (main or auxiliary) filters is becoming clogged.

HYDRAULIC SYSTEM PAGE

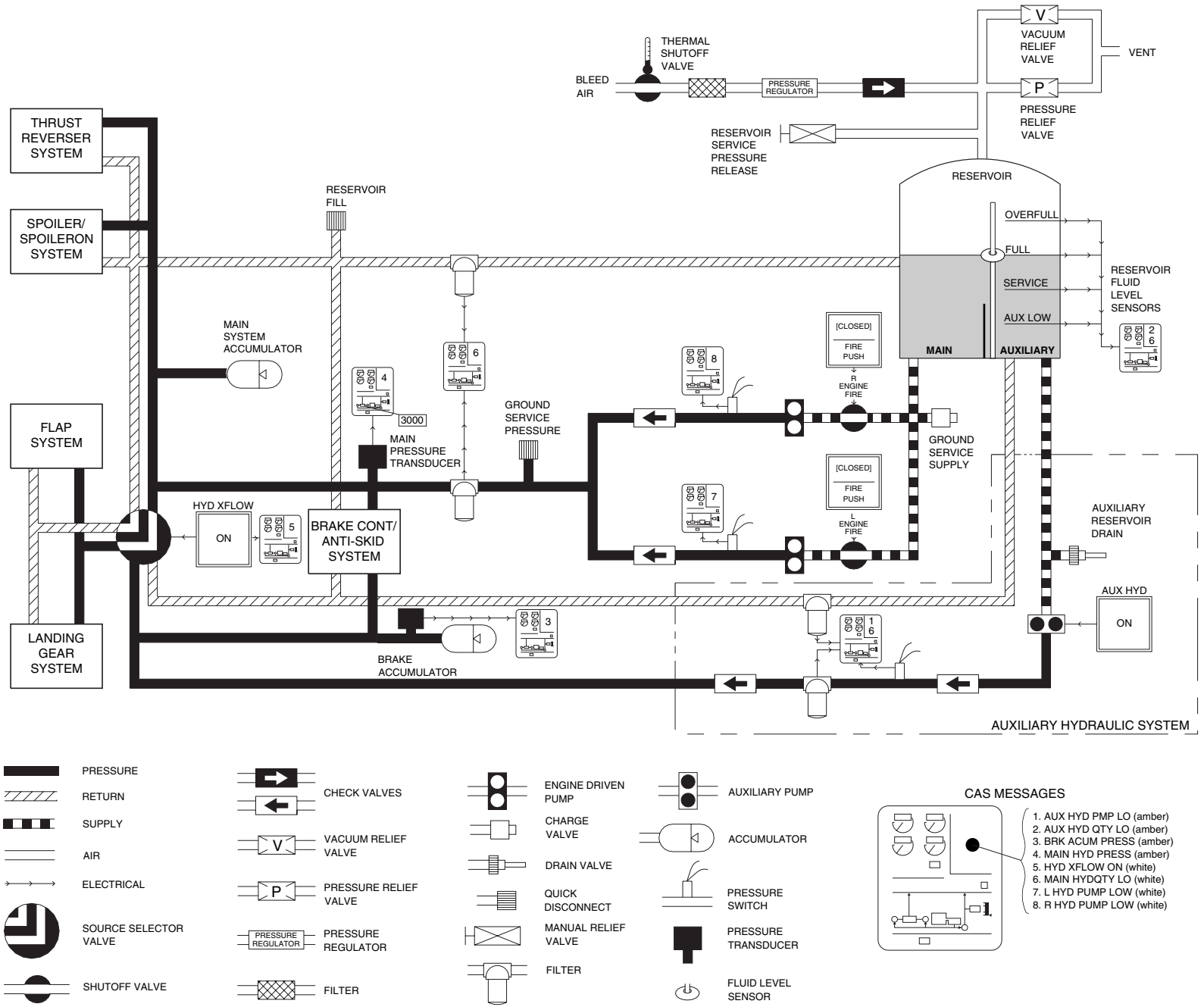
The HYD system page can be selected for display from the System Page Menu. This page includes a system schematic that presents both a graphic and a digital display of system pressures, quantities and faults.

These indications include a digital readout of main hydraulic system pressure, a digital and analog indication of brake accumulator pressure, and a LOW indication for the auxiliary reservoir fluid level. These indications will change color when operating limits are exceeded.

A circled L, R, and A on the HYD page schematic represent the three hydraulic pumps. These pump symbols will turn amber if the corresponding pump output pressure switch in the hydraulic manifold does not detect normal output pressure.



HYD SYSTEM PAGE
Figure 3-1



HYDRAULIC SYSTEM SCHEMATIC
Figure 3-2

LANDING GEAR SYSTEM

The landing gear is hydraulically retractable, tricycle gear with air-hydraulic shock strut-type nose and main gear. The main gear struts are of a trailing-link design. The main gear has dual wheels and brakes on each strut. Each main gear wheel is equipped with three fusible plugs which will melt and release tire pressure in the event wheel temperature reaches 390° F (199° C). The brake system incorporates four hydraulically-actuated multi-disc carbon brakes with an integral anti-skid system. The nose gear utilizes a chined tire to prevent splashing into the engine inlet. Nose wheel steering is electrically powered and controlled by the nose wheel steering controller. Hydraulic pressure for gear retraction and extension is transmitted by a system of tubing, hoses, and actuating cylinders, and is electrically controlled by switches, relays, and solenoid valves. Emergency extension can be accomplished by mechanical landing gear "free-fall" in case of hydraulic or electrical system failure. Two doors enclose each main gear after retraction. The inboard doors are hydraulically operated, and the outboard doors are mechanically operated by linkage connected to the main gear struts. The nose gear doors operate mechanically with linkage attached to the nose gear shock strut.

LANDING GEAR CONTROL SWITCH

The Landing Gear Control switch (GEAR/HYD panel) is a lever-lock type switch and must be pulled aft before selecting the UP or DN position. The switch controls the position of the gear selector valve and the door selector valve through gear and door position-sensing switches. Electrical power for the control circuits is 28-vdc supplied through the 3-amp GEAR circuit breaker on the pilot's circuit breaker panel (GEAR/HAYDRAULICS group). The landing gear control circuits are powered from the EMER BATT.

Landing gear retraction cycle: When the Landing Gear Control switch is placed in the UP position and the main gear weight-on-wheels switches are in the air mode, the following sequence of events will occur:

1. 28-vdc will be applied to the "open" solenoid of the door selector valve and hydraulic pressure will be applied to both inboard main gear door actuators and the inboard door uplocks.
2. When the inboard main gear doors open, door open switches will complete a circuit from the Landing Gear Control switch to the "up" solenoid of the gear selector valve. Hydraulic pressure will be applied to the main and nose gear actuators and the gear will retract.

3. When the main gear retract, gear up switches will complete a circuit from the Landing Gear Control switch to the "close" solenoid of the door selector valves. Hydraulic pressure will be applied to the inboard main gear door actuators to raise the gear doors. Pressure will remain on the main gear actuators until the doors are in the locked position.

4. The gear doors are locked into position by a hook/roller locking mechanism.

The normal retraction cycle takes approximately 11 seconds to complete with one or two main pumps. The auxiliary pump cycle will take about 18 seconds to complete.

Landing gear extension cycle: When the Landing Gear Control switch is placed in the DN position the following sequence of events will occur:

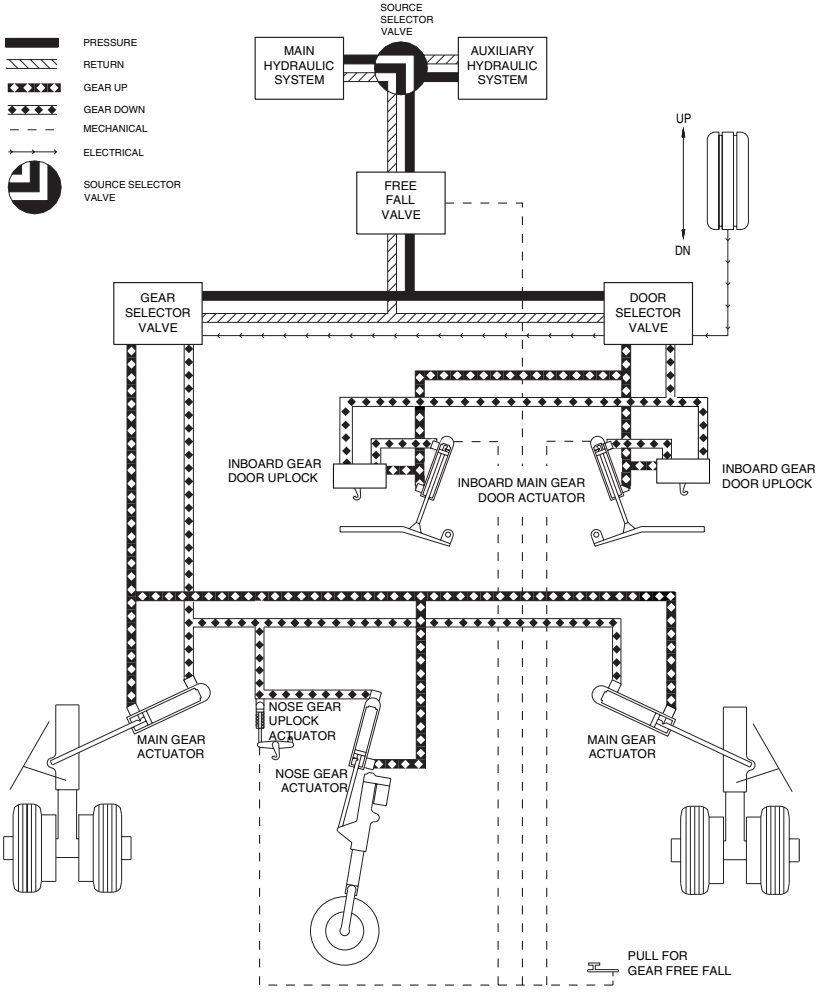
1. 28-vdc will be applied to the "open" solenoid of the door selector valve and hydraulic pressure will be applied to both inboard main gear door uplock actuators. Simultaneously, pressure is applied to the gear up actuator to hold gear in up position while main landing gear inboard doors open.

2. When the main gear doors open, door open switches will complete a circuit from the Landing Gear Control switch to the "down" solenoid of the gear selector valve. Hydraulic pressure will simultaneously be applied to release the nose gear uplock, apply pressure to the main and nose gear actuators, and extend all three landing gear.

3. When the main gear are full down, gear down switches will complete a circuit from the Landing Gear Control switch to the "close" solenoid of the door selector valve. Hydraulic pressure will be applied to the inboard main gear door actuators to raise the gear doors.

4. The main gear doors are locked into the retracted position by a hook/roller locking mechanism.

The normal extension cycle takes approximately 11 seconds to complete with one or two main pumps. The auxiliary pump cycle will take about 35 seconds to complete.



LANDING GEAR EXTENSION/RETRACTION SCHEMATIC
Figure 3-3

LANDING GEAR POSITION LIGHTS

The landing gear position lights, consisting of three Advisory/DOWN lights arranged in a triangular pattern, are located on the panel GEAR/HYD panel. The Advisory portion of each light is white in color with a black hash background and equipped with dual bulbs. The DOWN portion of each light is green in color and is also equipped with dual bulbs.

The location of each light in the triangular arrangement corresponds to the location of the gear on the aircraft. A white/hash (advisory) indication signifies that the corresponding gear position does not agree with the position of the Landing Gear Control switch, or that the inboard door is not up and locked. A DOWN (green) indication signifies the corresponding gear is down and locked.

During the gear retraction sequence, the three Advisory lights will illuminate when the sequence is initiated, remain illuminated throughout the retraction cycle, and then extinguish when the nose gear is up and locked, and the main gear inboard doors close.

During the gear extension sequence, the three Advisory lights will illuminate when the sequence is initiated, remain illuminated throughout the extension cycle, and then extinguish when the nose gear is down and locked and the main gear inboard doors close.

The lights are operated by the same switches that control the landing gear extension and retraction cycles. The lights are dimmed when the navigation lights are on, and may be tested at any time by setting the SYSTEM TEST switch to the GEAR position and depressing.

The landing gear position indicator lights operate on 5-vdc provided by the lighting control unit. The position indicator lights are powered by the EMER BATT. In the event of a complete dc electrical failure, the landing gear position lights will be powered by the emergency power system when the EMER BATT switch is in the ON position.

LANDING GEAR WARNING SYSTEM

Landing gear indications are installed to alert the operator of potentially unsafe flight conditions with the landing gear retracted or in transition. The system provides outputs to the CAS and CWP which activate aural and visual annunciation during such conditions. Depending upon the flight condition encountered, a distinct warning or caution will be indicated.

Gear Warning Indications

- **Master Warning Light Illuminated**
- **Aural Warning Master Warning Tone and Voice Message, "GEAR . . . GEAR . . . GEAR"**
- **GEAR red CWP**
- **GEAR red CAS**

The aforementioned warning indications will be activated by either of the following conditions:

- One or more landing gear are not down and locked, and flaps lowered beyond 25°.
- One or more landing gear are not down and locked, both thrust levers are set less than MCR, and radio altimeter (valid) is less than 500 feet.

The "GEAR" warning function cannot be muted.

Gear Caution Indications

- **Master Caution Light Illuminated**
- **Aural Caution Master Caution Tone and Voice Message, "GEAR . . . GEAR . . . GEAR"**
- **GEAR amber CAS**

The aforementioned caution indications will be activated by either of the following conditions:

- One or more landing gear are not down and locked, both thrust levers are set less than 70%, airspeed is below approximately 170 KIAS, altitude is below approximately 14,500 feet, and radio altimeter is invalid.
- One or more landing gear are in transition, or either main gear door is not up and locked, and airspeed is 210 KIAS or above.

The "GEAR" caution function can be muted by depressing either the Master Caution light on the glareshield or the Mute switch on the right thrust lever handle.

The following CAS illuminations are specific to the landing gear warning system:

CAS	Color	Description
GEAR	Red	The landing gear is not down and locked and other conditions indicate a landing is imminent.
GEAR	Amber	• The landing gear is not down and locked and other conditions indicate the flight is transitioning into the landing phase. or • The landing gear is being operated with an airspeed in excess of the maximum landing gear operating speed.

LANDING GEAR FREE FALL

In the event of a main/auxiliary hydraulic system failure or an electrical system malfunction, the landing gear can be extended using gravity to allow the gear to "free fall". Whenever free fall gear extension is to be accomplished, the Landing Gear Control switch should be placed in the DN position and the GEAR circuit breaker on the copilot's circuit breaker panel should be pulled after gear extension. This will prevent inadvertent gear retraction in the event electrical power to the system is regained.

Landing gear free fall extension is activated by the GEAR FREE FALL lever located on the copilot side of the forward pedestal. Pushing this lever mechanically unlocks the uplock actuators of the nose gear and main gear doors. This action also actuates an emergency valve allowing the hydraulic pressure and return lines of the door selector and gear selector valves to connect; thus, isolating them from the main and auxiliary hydraulic systems. Hydraulic resistance is minimized and the landing gear "free fall" to the extended and locked position. All three Advisory lights illuminate when gear control switches are placed in the down position. Each gear down light illuminates as the respective gear is down and locked. The main gear door Advisory lights will remain illuminated since the inboard doors are still extended.

NOSE WHEEL STEERING SYSTEM

The nose wheel steering system is controlled by the nose wheel steering computer. This steer-by-wire system receives pilot and copilot inputs through two rudder pedal position sensors and two dual pedal force sensors. A steering command based upon pedal position and force, nose strut position, and aircraft speed is calculated by the computer. This command is relayed to a dc motor which positions the nose wheel via a nose wheel strut gearbox.

The nose wheel steering system is powered by 28-vdc through the 25-amp MOTOR and 2-amp CMPTR circuit breakers located on the pilot's circuit breaker panel (GEAR/HYDRAULICS group [NOSE STEER]). Arming of the system is initiated by depressing the momentary-action NOSE STEER switch (GEAR/HYD panel). The NOSE STEER switch will illuminate ON when the following conditions occur:

- Both system dc power sources are on and available to the computer.
- The nose gear is down and locked.
- No system faults or failures are detected.
- Main gear and nose gear weight-on-wheels switches are in the ground mode.

Once the system is armed, computer steering commands will be transmitted to the nose wheel during ground operation.

For low speed ground operations, 60° of steering authority either side of center is available. At low speed and large rudder pedal deflection, the nose wheel displacement will be large for high maneuverability. Once a rudder pedal has reached its stop, further nose wheel displacement is generated by additional force being applied to that rudder pedal. As ground speed increases, the maximum wheel deflection is reduced to zero. The nose wheel steering system remains active through liftoff.

The NOSE STEER switch will illuminate ON when the system is armed. When the nose gear is no longer in the down and locked position, the ON annunciator on the NOSE STEER switch will extinguish; however, the computer is still powered and system monitor circuitry remains active.

For landing, the nose wheel steering system becomes active only after all weight-on-wheels switches are in the ground mode. The ON annunciator on the NOSE STEER switch will illuminate provided no faults have been detected. The nose wheel steering system has a fade-in feature that allows several seconds to transition from rudder steering to nose wheel steering, to avoid an initial oversteer condition.

The nose wheel steering system can be disarmed at anytime by depressing the NOSE STEER switch, or either Control Wheel Master (MSW) switch during ground operations.

NOSE STEER SWITCH

The NOSE STEER switch is used to activate nose steering circuits for taxi operations. Momentarily depressing the NOSE STEER switch will activate the system and the ON annunciator will illuminate. When nose steering has been activated, the system can be disengaged by depressing either the pilot's or copilot's MSW or by depressing the NOSE STEER switch a second time. A disconnect tone will sound.

The following CAS illuminations are specific to the nose steering system:

CAS	Color	Description
NWS FAIL	Amber	The nose wheel steering system has failed.
NWS FAULT	White	A fault is detected in the nose wheel steering system. The system will operate in degraded mode.

WHEEL BRAKE CONTROL /ANTI-SKID SYSTEM

The wheel brake control/anti-skid system is a brake-by-wire system that electronically controls hydraulic brake pressure. The system is designed to maximize braking efficiency and reduce tire wear by modulating brake pressure to each of the four wheels at the time of an impending skid. Major components of the system include: a brake control unit, four wheel-speed transducers, two hydraulic shutoff valves, four two-channel pedal transducers, five hydraulic fuses, a pressure switch, an emergency/parking brake valve assembly, an emergency/parking brake accumulator, four brake control valves, four brake pressure transducers, four brake shuttle valves, a source shuttle valve, and four brake assemblies.

The brake control unit is divided into two independent channels for the inboard and outboard wheels. Each channel applies brake pressure commands to the respective left or right brake control valves. The brake control valves regulate actual brake pressure to each corresponding brake. Brake pressure commands from the brake control unit are determined from the combination of pilot/copilot pedal commands, and anti-skid, locked-wheel protection and touchdown protection functions. Hydraulic fuses, located in the main gear wheel wells, will close to prevent pressure loss if fluid flow exceeds normal brake actuation rate.

Power is supplied by 28-vdc provided through the 3-amp INBD BRAKES circuit breaker located on the pilot's circuit breaker panel (GEAR/HYDRAULICS group) and the 3-amp OUTBD BRAKES circuit breaker located on the copilot's circuit breaker panel (GEAR/HYD group). The wheel brake control/anti-skid system is active whenever power is present on the right essential bus and the emergency battery bus, the circuit breakers are engaged, and hydraulic pressure is present at the source shuttle valve.

TOUCHDOWN PROTECTION

Braking is enabled after touchdown when wheel spin-up is achieved (≥50 knots) or after the main gear weight-on-wheels switches are in the ground mode and time-out has elapsed. This prevents landing with the brakes engaged and allows spin-up time for traction to be established. The time-out function is a safety feature in the event of a wheel-speed transducer failure. Locked-wheel protection is provided by the brake control unit so that brake pressure is removed from a wheel if that wheel's velocity is less than or equal to 30% of the velocity of the fastest wheel. Removal of brake pressure from the slow wheel allows traction to be re-established.

The following CAS illuminations are specific to the brake system:

CAS	Color	Description
NORM BRK FAIL	Red	All four brakes (normal system) have failed.
CPLT BRK FAULT	Amber	One or more of the copilot's brake LVDTs has failed.
INBD BRK FAIL	Amber	The associated (L and/or R) inboard brake (normal system) has failed.
OUTBD BRK FAIL	Amber	The associated (L and/or R) outboard brake (normal system) has failed.
PLT BRK FAULT	Amber	One or more of the pilot's brake LVDTs has failed.
BRAKE FAULT	White	A minor brake system fault is detected. Minor faults will not significantly degrade brake performance. Reduced performance may be experienced during maximum braking.

EMERGENCY/PARKING BRAKE

The emergency/parking brake component of the brake system utilizes the emergency/parking brake valve assembly, emergency/parking brake accumulator. An EMERGENCY/PARKING BRAKE handle and cable system is used to apply emergency braking or to set the parking brakes. Emergency braking works independently of the main braking system and the brake accumulator is charged from the auxiliary hydraulic system. The EMERGENCY/PARKING BRAKE handle is located on the pedestal below the thrust levers. The handle is mechanically connected to the emergency/parking brake valve assembly. A switch within this assembly senses on/off condition and provides the signal for illumination of the EMER/PARK BRK red and white CAS. The parking brake is engaged by pulling the EMERGENCY/PARKING BRAKE handle and rotating clockwise or counterclockwise to the locking position. Rotating back to center position and releasing park brake handle disengages the parking brake. Emergency braking is controlled by pulling the EMERGENCY/PARKING BRAKE handle with a force proportional to the amount of emergency braking desired. Releasing the handle to the off position will disengage the emergency brake.

The following CAS illuminations are specific to the EMERGENCY/ PARKING BRAKE system:

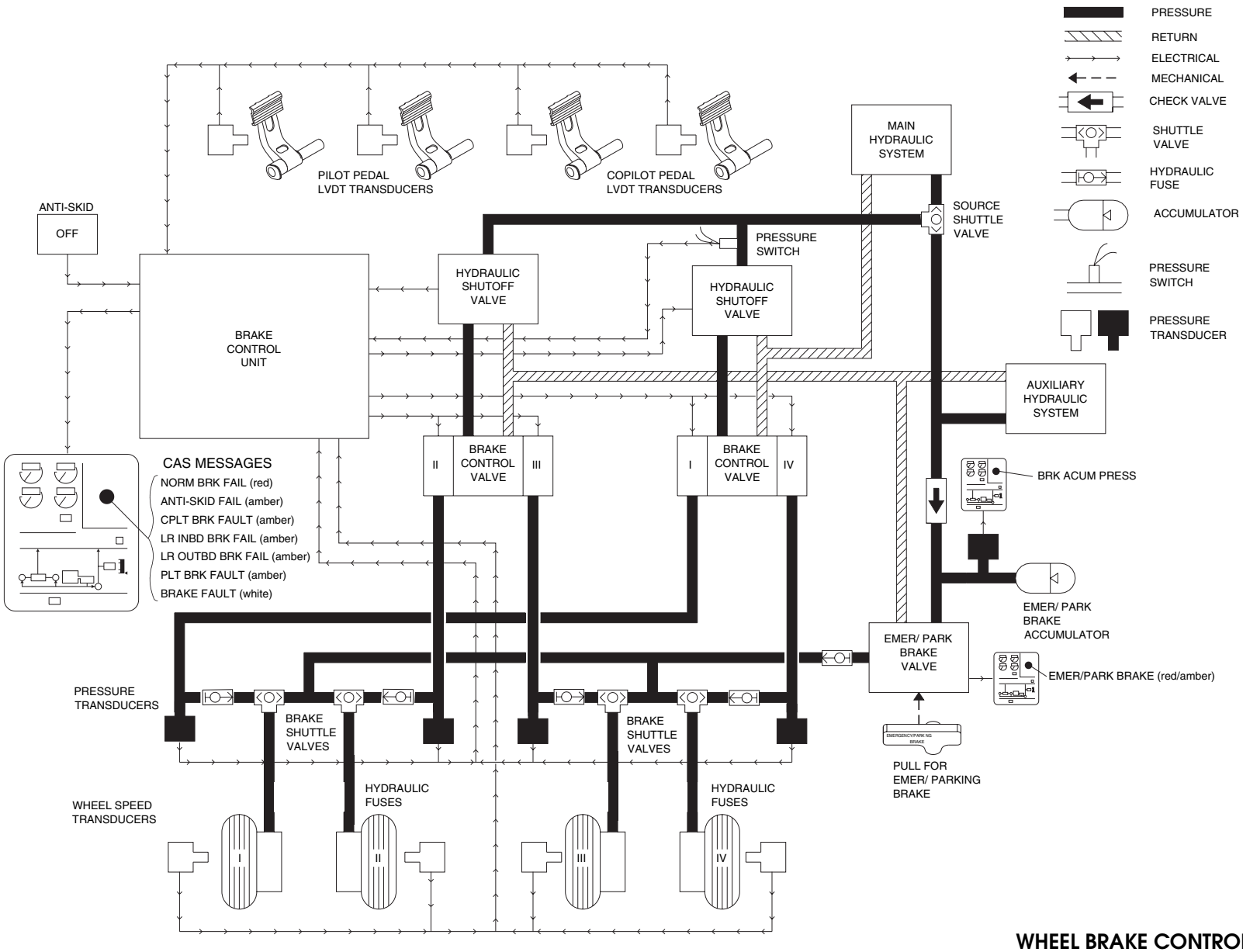
CAS	Color	Description
EMER/PARK BRK	Red	Parking brake valve (lever) is not fully released and thrust levers are advanced to MCR or above.
EMER/PARK BRK	White	Parking brake valve (lever) is not fully released.

ANTI-SKID SWITCH

The anti-skid function can be disabled by depressing the ANTI-SKID switch (GEAR/HYD panel). This alternate-action switch will illuminate OFF to indicate the anti-skid function is disabled. The switch indicator lamps can be tested by placing the SYSTEM TEST switch in the LTS position and depressing.

The following CAS illumination is specific to the anti-skid system:

CAS	Color	Description
ANTI-SKID FAIL	Amber	Failure of anti-skid function to one or more brakes, or ANTI-SKID switch is OFF.



WHEEL BRAKE CONTROL/ANTI-SKID SYSTEM SCHEMATIC
Figure 3-4