NOSE WHEEL STEERING SYSTEM — SYSTEM DESCRIPTION

1. Description

A. General

The Nose Wheel Steering (NWS) is electrically controlled, hydraulically powered and manually actuated. See Figures 1 and 2. The handwheel is located in left side console and controls the hydraulic valve electrically, not mechanically. This handwheel assembly consists of the control wheel, a guarded PWR STEER ON / OFF switch, centering springs, viscous dampener, universal joint and dual potentiometers. Powered steering is limited through the use of stops to 80° ±2° left or right of aircraft centerline using handwheel assembly and pilot or copilot rudder pedals and 7° ±1° using pilot or copilot rudder pedals only. (Dual rudder potentiometers are mounted on a bracket beneath the cockpit and are mechanically connected to the rudder control cable. A linkage causes the rotary shaft to rotate as pilot or copilot moves their respective rudder pedals.) The 80° of nose wheel movements pivots the main wheel, which is permissible when brakes are released. Three taxi lights are mounted on the steering unit. As the steering unit turns, taxi lights will also turn and light the direction of turning providing pilot with increased visibility.

The NWS is utilized for taxi, takeoff and landing and is energized automatically by the nose landing gear nutcracker switch. The nutcracker switch is located on the nose gear. This provides for a smooth transition from aerodynamic directional control to nose wheel steering. Aiding in this transition, the Electronic Control Unit (ECU) or Electronic Control Module (ECM) provides a straight ahead signal to the control valve until nutcracker switch goes into ground mode, at which time the signal is ramped to the rudder input position over a one second interval. This delay prevents sudden steering input once the nose gear contacts the ground during a crosswind landing condition.

The nose steering actuator also incorporates a feedback manifold located on aft side of this actuator assembly. This feedback manifold provides two functions:

- Conduits for hydraulic fluid flow to actuator for left and right steering
- Conversion of mechanical feedback (cam and cam follower) to an electrical feedback signal via a Rotary Variable Transformer (RVT)

The RVT, a nose wheel position sensor, is mounted on the nose wheel outer cylinder. Its input shaft is rotated as the nose wheel actuator rotates.

2. Component Locations

The following components comprise the nose wheel steering system:

UNIT	NO. PER A/C	LOCATION
Nose Wheel Steering / Handwheel Control Assembly	1	Pilot Side Console
Nose Wheel Steering Select Control Panel (Aircraft 1445 and Subsequent and Aircraft having ASC 302A)	1	Pilot Side Console
Rudder Potentiometer Assembly	1	Cockpit, Below Floor (FS 75.00)
Nose Gear Steering Electronic Control Unit (ECU) or Electronic Control Module (ECM)	1	Left Hand Radio Rack

UNIT	NO. PER A/C	LOCATION
Solenoid Selector Valve	2	Nose Wheel Well, Left Side (FS 95.000)
Servo Valve Manifold	1	Nose Wheel Well, Left Side (FS 109.125)
Feedback Manifold	1	Nose Wheel Steering Unit, Aft Side
Rotary Actuator	1	Nose Gear Strut
Position Sensor Rotary Variable Transformer (RVT)	1	Nose Wheel Outer Cylinder

3. Operations

A. Electrical

The electrical feedback signal is transmitted to the ECU / ECM where it is algebraically summed with the input signals from the rudder and / or handwheel. The resulting signal is sent to the Electro Hydraulic Servo Valve (EHSV). As the nose wheel approaches the angular position dictated by the input signal (from handwheel and / or rudder), the summing signal to EHSV nulls the servo valve and holds the nose gear in that position. Any external force that tends to move the nose gear from dictated position by the input signal will create a bias on the servo valve that will counter it.

Two normally closed Solenoid Shutoff Valves (SOVs) are used to control the hydraulic power to the system. They are in series hydraulically, but are separately electrically controlled. The No. 1 SOV is energized by the pilot control switch (at handwheel) and the NLG DOWN AND LOCKED signal. The No. 2 SOV is energized by the ECU / ECM when the nose landing gear nutcracker switch goes to the GROUND mode. To avoid hydraulically powering the system when the gear is retracted an extra precaution was added by energizing the hydraulic power source through the landing gear down hydraulic circuit.

Systems with the 5250-( ) incorporate a Built-In Test Equipment (BITE) circuit with ten numerical fault codes that appear on a seven segment numerical display on top of the ECU. A push button located on top of the ECU is used to initiate the microprocessor to carry out a system serviceability test. The BITE interrogation cannot be initiated in flight, but if the nose landing gear is down and locked (prelanding BITE check), the BITE circuit will passively check for dormant failures and automatically shut the system down by way of the No. 2 shutoff valve. This supplements the function of the analog comparator circuits which are continuously monitoring for active failures.

Systems with the 15000-01( ) ECM incorporate a BITE circuit with codes that appear on a seven segment numerical display on top of the ECM. A BITE is automatically performed upon application of DC power - Power Up Built In Test (PBIT). Upon detection of a failure, the ECM will automatically shut the system down by way of the No. 2 shutoff valve. This supplements function of the analog comparator which are continuously monitoring for active failures.

Both the ECU and ECM incorporate a watch dog timer with an interval of approximately 220 milliseconds. It is reset at 82 millisecond intervals (providing there are no faults in the system). If malfunctions occur, the watch dog timer will time out in 220 milliseconds and shut down the system through the No. 2 shutoff valve and the STEER BY WIRE FAIL message will display on Engine Instrument and Crew Advisory System (EICAS). If failure is corrected, cycling the system off and on will remove the EICAS message and return system to a full-up status.

This system incorporates two channels to provide a method of checking the condition of system. One channel is required to do the task and the second channel is a mirror image used as a comparator with the first channel. It is a fail passive system. Any component failure in either channel will cause system to shut down and activate STEER BY WIRE FAIL on EICAS. Steering is then done by differential pressure on brake pedals. The STEER BY WIRE FAIL message is inhibited until aircraft landing gear is down and locked.

Test points are also provided on top of ECU for use when rigging of the system. On the ECU, two green LED lights, when on, indicate that unit is receiving the two 28 Vdc power sources from the aircraft.

NOTE: Either system will provide a full-up system and there will be no EICAS message with a failure of either power source.

A 25-pin connector on top of the ECM provides access to test points for rigging system and for initiating rig function. During rig (jumper placed between TP4 and TP10 of the 25 pin connector), the test points display NWS component null values without any ECM offsets applied. Removal of the jumper will allow the ECM to determine and apply the appropriate offset voltages so system nulls are approximately 0. Flashing of decimal point on 7 segment display indicates the ECM processor is functional. A flashing "A" on the 7 segment display verifies the system is in rig mode. A steady "A" on the 7 segment display indicates rig mode is complete (jumper removed between pins TP4 and TP10 of the 25 pin connector) and null values have been stored by the ECM. After an rig has been completed, new null values are not used until power to the ECM is cycled off. When power is reapplied, a "0" on the display confirms that new values have been accepted. A fault code of "7" (rigging fault) on the display after power is cycled indicates that the ECM has rejected the stored values and the rig procedure needs to be redone.

The ECU / ECM described above use a seven segment LED to indicate fault locations. BITE numeric code identifies the Line Replaceable Units (LRU). See Tables 1 and 2.

On Aircraft 1000 - 1242 having ASC 176 and Aircraft 1243 and subsequent, a nose wheel steering pressure switch and electrical circuitry are provided to alert the crew of a problem in the nose wheel steering system prior to takeoff and or landing. See Figure 2. The pressure switch and the additional circuitry allow additional parameters to be monitored. When one of the following conditions exists on aircraft having this modification, a STEER BY WIRE FAIL message will be displayed on EICAS:

- Nose wheel nutcracker switch stuck in ground position while in flight
- Nose wheel steering shutoff valves stuck in open position while in flight
- Nose wheel steering system inoperative due to loss of power while on the ground
- Improperly installed steer by wire ECU / ECM or ECU / ECM connectors

Aircraft having ASC 302A allows pilot to select normal steering (handwheel and rudder pedals) or handwheel only which permits only the handwheel to control steering.

See Figure 1 for Nose Wheel Steering – System Schematic.

See Figure 2 for Nose Wheel Steering – Electrical Schematic.

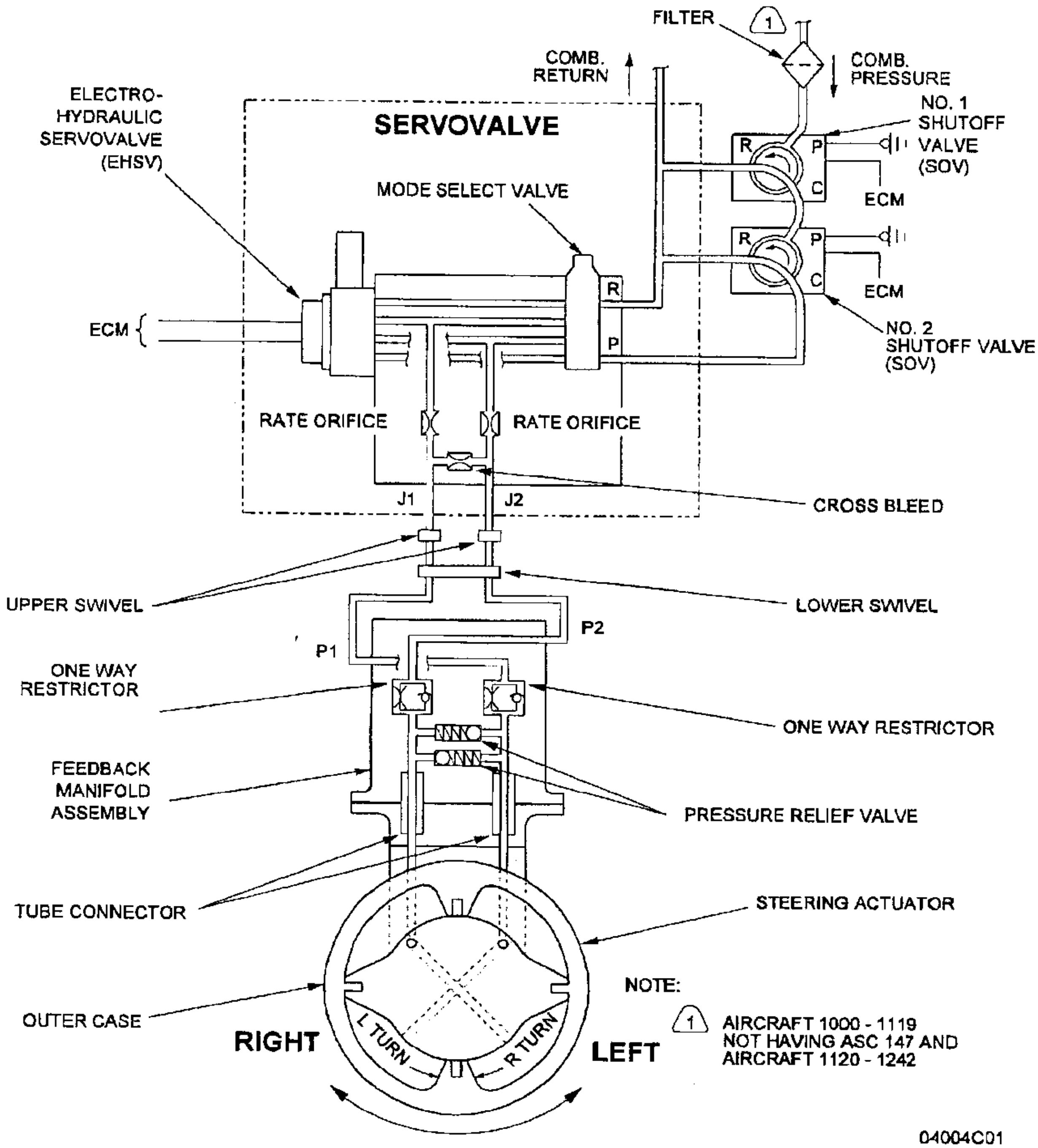
Table 1: ECU 5250-( )

CODES	LRU
0	No Fault
1	ECM Fault
2	Solenoid Valve Fault

CODES	LRU
3	EHSV Fault
4	Handwheel Potentiometer Fault
5	Feedback RVT Fault
6	Rudder Potentiometer Fault
7	Short Circuit
8	LED Check
9	Test Incomplete

Table 2: ECM 1500-01(A)

CODES	LRU
0	No Fault
1	ECM Fault
2	Solenoid Valve Fault
3	EHSV Fault
4	Handwheel Potentiometer Fault
5	Feedback RVT Fault
6	Rudder Potentiometer Fault
7	Rigging Fault
8	Power Up Sequence in Progress
Blank	ECM Fault
Flashing "A"	ECM is in Rig Mode
Steady "A"	Rig Mode is Complete

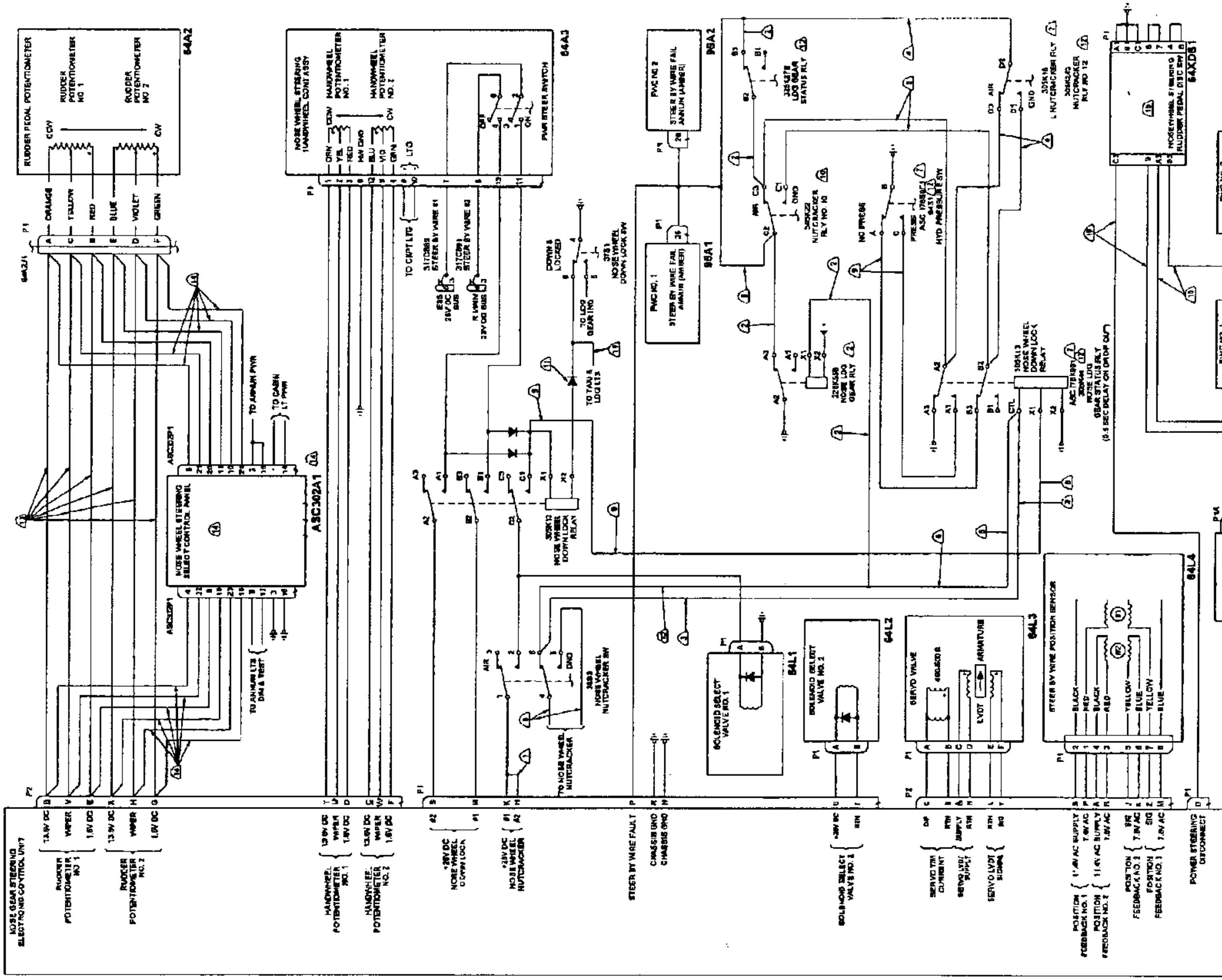


Nose Wheel Steering – System Schematic
Figure 1

Gulfstream IV
MSG-3 MAINTENANCE MANUAL

CALLOUT(S):

1. AIRCRAFT 1000, 1002 - 1005
2. AIRCRAFT 1034, 1144 - 1242 NOT HAVING ASC 176 AND AIRCRAFT 1243 AND SUBSEQUENT
3. AIRCRAFT 1000 - 1143 EXCLUDING 1034 HAVING ASC 176
4. AIRCRAFT 1000 - 1143 EXCLUDING 1034 HAVING ASC 176 AND AIRCRAFT 1243 AND SUBSEQUENT
5. AIRCRAFT 1034, 1144 - 1242 HAVING ASC 176
6. AIRCRAFT 1034, 1144 - 1242 HAVING ASC 176 AND AIRCRAFT 1243 AND SUBSEQUENT
7. AIRCRAFT 1000 - 1242 EXCLUDING 1034 HAVING ASC 176
8. AIRCRAFT 1000 - 1143 EXCLUDING 1034 HAVING ASC 176 AND AIRCRAFT 1034, 1144 AND SUBSEQUENT
9. AIRCRAFT 1000 - 1242 EXCLUDING 1034 HAVING ASC 176 AND AIRCRAFT 1243 AND SUBSEQUENT
10. AIRCRAFT 1034, 1144 AND SUBSEQUENT
11. AIRCRAFT 1163 AND SUBSEQUENT
12. AIRCRAFT 1243 AND SUBSEQUENT
13. AIRCRAFT NOT HAVING ASC 302A
14. AIRCRAFT HAVING ASC 302A
15. AIRCRAFT 1445 AND SUBSEQUENT



Nose Wheel Steering – Electrical Schematic
Figure 2

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Engineering Analysis of Differential Braking

- The braking time used corresponds to the slight rise in left brake pressure on the FDR data, so corresponds to the actual reaction times in the incident. It was assumed that the brakes take 0.5 seconds to reach maximum braking.
- 2) The braking coefficient of 0.5 corresponds to a nominal maximum braking value
- 3) 6 degree steering failure causes maximum lateral deviation, which is more conservative than the angles seen in the lab.

Positive lateral deviation is to the right. Note that the aircraft started slightly right of center.

With maximum differential braking, the nosewheel ends up just off the edge of the runway, but still on the paved shoulder. The right main gear would still be on the shoulder as well.