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	ENGINEERING DESIGN INFORMATION EXHIBIT
APOLLO GSE GYRO CAGING PANEL BLOCK II AND LEM SYSTEM DESIGN CRITERIA	By W. Nowak Date Sept. 2, 1965

1. SCOPE

1.1 This document establishes the system requirements for the Apollo GSE Gyro Caging Panel.

2 APPLICABLE DOCUMENTS

ND 1002213 - General Specification for Apollo Ground Support Equipment

2900200 - Diagram, Mechanization Gyro Caging Panel (Block II and LEM)

3. REQUIREMENTS

3.1 General - The function of the Gyro Caging Panel in the Optical Inertial Analyzer (OIA) is to perform a plus or minus gyro selection in order to torque the gyro in the proper direction when gyro torque pulses are received from the GSE Computer Simulator. The Gyro Caging Panel must also perform a caging function when operated in the Inertial Subsystem configuration. If a gyro error signal is received from the Airborne Inertial Measurement Unit (IMU) exceeds 100 arc seconds (assuming 1000 V/Radians) the Gyro Caging Panel performs a plus or minus gyro selection by determining if the error signal is 0 or π phase with respect to the 3200 pps reference signal. After this selection the gyro is torqued until the error signal is decreased to less than 100 arc seconds. This caging function will maintain the gyro float positional accuracy of 100 arc seconds or less.

3.2 CIRCUITS

The circuits required in the Gyro Caging Panel to perform all necessary functions are as follows:

a. Interrogator Circuit
b. A Preferred State Flip-Flop Circuit
c. Selector Driver Circuit
d. Phase A,B and C Flip-Flop Circuit
e. Torque Enable Circuit
f. Torque ON-OFF Circuit

3.2.1 INTERROGATOR CIRCUIT

This circuit shall receive a sinusoidal 3200 CPS Gyro Error signal which is either 0 or π phase. In addition a 3200 pps PIPA Switch pulse which lags the error signal by 135° is an input to the Interrogator circuit. These signals are processed in a phase splitter and the output is a (+T) or (-T), plus or minus Torque. The circuit shall have a (+T) output for π phase error signal and a (-T) output for a 0 phase error signal.

3.2.2 PREFERRED STATE FLIP-FLOP CIRCUIT

The preferred state flip-flop shall operate in a normal set or reset mode with the addition of preferring the set mode of operation. This means that should a set and reset pulse occur simultaneously the flip-flop will prefer the set state of operation.

3.2.3 SELECTOR DRIVER CIRCUIT

This circuit contains logic which will determine a plus or minus gyro torquing coil selection. This signal will occur for only 80 milliseconds duration and be off for 160 milliseconds, and only one selection can be made at one time. This circuit also controls torque "ON" and "OFF" commands that are timed with the plus and minus selection signals which allow only one gyro to be torqued at a time.

3.2.4 PHASE A, B AND C FLIP-FLOP CIRCUIT

This circuit controls the sequence of operation of the caging function. Three flip-flop circuits are operated with X, Y or Z gyro select phase A B or C respectively. Logic incorporated into this circuit will set one flip-flop and reset another flip-flop simultaneously. This means that each flip-flop will be set for 80 milliseconds and reset for 160 milliseconds sequentially. This phase failure logic insures that only one gyro can be caged during any one 80 millisecond period in the event of a circuit failure.

3.2.5 TORQUE ENABLE CIRCUIT

The Torque Enable Circuit will contain a 2 millisecond time delay which will delay the Torque On pulse to insure that gyro plus or minus torquing selection has been made before a torque on condition occurs. This circuit also contains logic which will provide an output only if the phase sequence is proper; if the sequence is not correct an output will provide a torque off command.

3.2.6 TORQUE ON AND TORQUE OFF CIRCUIT

Torque On and Torque Off circuit will provide the Torque On and Torque Off commands through isolation transformers to the Airborne IMU. This circuit also contains a buffered output to the Forward Backward Counter in the OIA. The counter will count the Torque On pulses.

3.3 PERFORMANCE REQUIREMENTS

The circuits of paragraph 3.2 shall provide torquing and caging functions for controlling the gyros of the IMU in the ISS Configuration. This shall be accomplished by the following input and output signals

3.3.1 INPUT SIGNALS

The input signals shall be received from the following components: Airborne IMU, GSE Computer Simulator, Test Control Panel, Electronic Power Supply and the Monitor Panel. The GSE components are located in the OIA. The input signals shall have the following characteristics.

3.3.1.1 X, Y, Z GYRO ERROR SIGNAL

The Gyro Error Signal originating in the gyro is received by the Gyro Caging Panel (GCP) from a buffer amplifier in the GSE Distribution Box. The signal is sinusoidal 3200 CPS, 0 or π phase and amplitude from 0 to 10 volts. The buffer amplifier shall have an output impedance of less than 75 ohms.

3.3.1.2 X, Y, Z GYRO CAGE COMMAND

This signal from the Test Control Panel is the 27 volt DC High of Relay Lamp Power and is used to command Caging function.

3.3.1.3 PLUS AND MINUS X, Y AND Z IRIG SET SIGNALS

These signals are received from the Computer Simulator to torque the gyros at a specific rate. The signal is 3200 PPS and when terminated into a 200 ± 10% ohm load shall have an amplitude of 5.0± .5 V p-p, pulse width (50%) of 3.0± .5 μ seconds, rise time (40-90%) of 0.2 μ seconds and droop of 0.6 volts maximum.

3.3.1.4 X IRIG SELECT (PHASE A) SIGNAL

This signal is received from the Computer Simulator and is a resultant of the following signals (1) Phase A 3200 pps signal 80 milliseconds wide, (2) 12.5 pps signal 10 microseconds wide and (3) Strobe 0-102.4 K pps signal that is three microseconds wide. The resultant is a signal pulse three microseconds wide in phase with 3200 pps Phase A, the frequency rate is 102.4 K pps for 80 milliseconds duration.

The Y IRIG Select and Z IRIG Select will meet the same requirements as X IRIG Select, however they shall be in phase with 3200 pps Phase B and Phase C respectively. These signals are timed to be on 80 milliseconds and off 160 milliseconds sequentially with Phase A, B and C.

3.3.1.5 PIPA SWITCHING SIGNAL

This signal is received from the Computer Simulator and is a 3200 pps and is strobed by Strobe I, it is a 3 microsecond pulse width that lags the Gyro Error Signal by 135 degrees. This signal is processed in the interrogator with the gyro error signal to determine a plus torque or minus torque by position of the interrogate pulse at either the peak or the trough of the error signal. This position will determine either a 0 or a π phase error.

3.3.1.6 PHASE A, B, C RESET COMMAND SIGNAL

This signal of +30 VDC originates in the Electronic Power Supply and is received from the Test Control Panel. The signal will reset the A, B, C Flip-Flops and stop torquing and caging functions.

3.3.1.7 GYRO TORQUE DISCRETE

This is a 102.4 KPPS generated in the Computer Simulator. It is strobed with Strobe II and will have the following characteristics when terminated into a 200 $\pm$ 10% ohm load, Amplitude of 6 $\pm$ 0.6 V p-p, rise time (10-90%) 0.2 microseconds and pulse width of 3.0 $\pm$ 0.5 microseconds.

3.3.1.8 BLOCK II-LEM STATUS

This signal is a 27 VDC Relay Lamp Power High which originates in the Test Control Panel and is routed to the Gyro Caging Panel when the OIA is in the Block II or LEM Configuration.

3.3.1.9 ENABLE GYRO TORQUING

This is a 27 VDC Relay Lamp Power Lo (ground) which is closed by a switch on the Test Control Panel. Without this ground the Gyro Caging Panel will not operate.

3.3.1.10 -30 VDC

The power used for the A, B and C Flip-Flops is supplied by the Negative Power Supply (NPS) located in the OIA.

3.3.1.11 + 30 VDC

The power used for the X, Y and Z Select and Torque On driver circuits is supplied by the Positive Power Supply (PPS) located in the OIA. Both 3.3.1.10 and .11 shall be properly fused to protect the energized circuitry.

3.3.1.12 The Gyro Caging Panel shall contain two ground points for termination of shielded lead grounds and common chassis ground.

3.3.1.13 CONTINUOUS TORQUE COMMAND

This signal is a 27VDC High sent from the Test Control Panel which will provide the Gyro Caging Panel the capability to continuously torque a gyro which has been selected by the Computer Simulator. This capability is required to conduct the Friction Test.

3.3.2 OUTPUTS

The Gyro Caging Panel shall have outputs to the Airborne IMU, the GSE Test Control Panel, Monitor Panel and the Forward Backward Counter located in the OIA. The Output signals shall have the following characteristics.

3.3.2.1 PLUS AND MINUS X, Y AND Z SELECT SIGNALS

The signal pulses are 102.r KPPS with a duration of 80 milliseconds, pulse width 3.5 $\pm$ 1 microsecond, rise time of less than 1 microsecond, amplitude of 5 to 10 volts. The output impedance of the signal shall be less than 100 ohms transformer coupled and the load is 100k shunted with 1500 pf capacitor. These signals are used to select both the gyro and the direction to torque.

3.3.2.2 TORQUE ON AND TORQUE OFF COMMAND SIGNALS

These torque signals shall have the following characteristics. They are 3200 per second pulses with amplitude of 5 to 10 volts, pulse width of 3.5 $\pm$ 1 microsecond, rise time of less than 1 microsecond and a load of 2.2 $\overline{K}$ ohms shunted with a 1500 pf capacitor. The output impedance of the signal is less than 100 ohms transformer coupled. These signals shall be positive going pulses.

3.3.2.3 PHASE A, B, C RESET ENABLE

This signal is +30 volts DC originating in the OIA Electronic Power Supply and is routed out of the Gyro Caging Panel to the Test Control Panel.

3.3.2.4 GYRO CAGING PANEL FUNCTIONS NORMAL

This ground completes a circuit of the Torque Enable Relay which will turn on of power to operate the Gyro Caging Panel. The Torque Enable Relay Low circuit will connect the Relay Lamp Power Low only when the inputs Gyro Select Phase A, B and C timing from the Computer Simulator is operating properly. This is a fail safe feature to assure that no malfunction has occurred prior to turning the power on to the Gyro Caging Panel.

3.3.2.5 RELAY LAMP POWER LOW

This ground functions as a part of the interlock scheme described in paragraph 3.3.2.4.

3.3.2.6 X, Y, Z GYRO CAGE INDICATION

This is the connection of the Relay Lamp Power Low when a gyro error signal and a cage command signal is present. This ground is used to complete an indicator light circuit in the Test Control Panel.

3.3.2.7 TORQUE SET SIGNAL PULSE

This signal is buffered Torque On signal and will occur for every Torque On output pulse. The Torque On pulses can be counted on the Forward Backward Counter. The repetition rate is 3200 pps, with minimum amplitude of 1.0 volt, and pulse width of 3.5 $\pm$ 1 microsecond. The input impedance of the Forward Backward Counter is 1 megohm shunted with approximately 75 pf. The spurious input spikes shall be less than 100 mv rms. The output impedance of the Buffer Amplifier is less than 2.2 K ohms.

3.3.2.8 BLOCK I SERIES 100 INDICATION

This signal is a Relay Lamp Power Low that is switched to the Monitor Panel to operate in a status interlock scheme used to verify that the proper relays are energized for the Block I Series 100 configuration.

3.3.2.9 NOT BLOCK I SERIES 100 INDICATION

This signal is a Relay Lamp Power Low that is switched to the Monitor Panel to operate in a status interlock scheme to verify that the proper relays are energized for the Block II-LEM configuration.

3.3.2.10 PLUS AND MINUS X, Y AND Z IRIG SET

These output signals shall have identical characteristics as the Plus or Minus X, Y and Z IRIG Set Signals that are received from the Computer Simulator (paragraph 3.3.1.3) with the exception of the phasing. The input to the Gyro Caging Panel are positive going pulses, whereas the outputs of the Gyro Caging Panel are negative going pulses. The inputs to the Gyro Caging Panel shall be switched when the OIA is in the Block I Series 100 to be used for operation of the Caging Electronics in the Primary Signal Select.

3.3.2.11 CONTINUOUS TORQUE INDICATION

This signal is a 27VDC RLP Low which shall be sent to the Test Control Panel to complete a circuit to light the Continuous Torque Indicator.

3.4 DETAIL REQUIREMENTS

3.4.1 TIME DELAY (2 MILLISECOND)

The two millisecond delay is used to delay the Torque On signal to insure that the IRIG selection has started before the torquing has begun. It also insures that Torque ON and Torque OFF do not occur simultaneously. The delay shall have a tolerance of ± 10%.

3.4.2 TIME DELAY-TURN OFF (468 MICROSECONDS)

This delay is located in each of the plus and minus selection outputs to delay the selection turn off time, this selection time will be at least 80.3 milliseconds. This adjusts the timing to assure that the reset pulse will occur one clock pulse (312microseconds) before the end of selection. The delay shall be 468 microseconds ± 156 microseconds.

3.4.3 BUFFER AMPLIFIER

This amplifier shall buffer the Torque On signals to the Forward-Backward Counter. The characteristics of the signal, load and impedances are the same as specified in paragraph 3.3.2.6.

3.4.4 TIME DELAY TURN ON (1.0 MILLISECONDS)

A 1.0 millisecond time delay shall be located in each ± X, Y Z Gyro Select circuit. It is used to delay the turn on of the gyro selection in order to eliminate the possibility of selecting two gyros simultaneously. The delay shall have a tolerance of 1 millisecond ± 10%.

3.4.5 SCALE FACTOR TEST

The GCP shall provide the capability to perform an IRIG Scale Factor Test. This test requires that two gyros are caged and the third gyro shall be torqued by signals from the Computer Simulator. The Torque Set output signals to the Counter in the Primary Signal Selector shall only be the torque set signals from the Computer Simulator and not the Gyro Caging Torque Set Signals. The ability to count these pulses shall be used to determine the Scale Factor of the gyro.

GYRO CAGING PANEL INTERFACE

Cross Reference Number	Connector/ Pin	Nomenclature	Signal Description
1	J1-A	Chassis Ground	
1613	J1-P	Block II/LEM Status	27VDC RLP High
1570	J1-R	Y IRIG Cage Command	27VDC RLP High
1569	J1-S	Y IRIG Cage Indication	27VDC RLP Low
121	J1-U	Y Gyro Error High	Sinusoidal 3200 (0 or phase)
122	J1-T	Y Gyro Error Low	0 - 10 V(amplitude)
1568	J1-V	X IRIG Cage Command	27 VDC RLP High
1567	J1-W	X IRIG Cage Indication	RLP Low
119	J1-Y	X Gyro Error High	Sinusoidal 3200 CPS
120	J1-X	X Gyro Error Low	0 or π phase 0 - 10 V(amplitude)
1574	J1-M*	GCP Functions Normal	RLP Low
1575	J1-P*	Phase ABC Reset Enable	+ 30 VDC
1576	J1-Q*	Phase ABC Reset Command	+ 30 VDC
1572	J1-R*	Z IRIG Cage Command	27 VDC RLP High
1571	J1-S*	Z IRIG Cage Indication	RLP Low
129	J1-U*	Z Gyro Error High	3200 CPS 0 or π phase
130	J1-T*	Z Gyro Error Low	Amplitude 0 - 10V
1	J1-CC	27 VDC RLP Low	
1573	J1-DD	Enable Gyro Torquing	27 VDC RLP Low

Cross Reference Number	Connector/ Pin	Nomenclature	Signal Description
273	J1-EE	- 30 VDC High	
274	J1-GG	+ 30 VDC High	
2	J1-FF	± 30 VDC Low	
1644	J1-MM	Block I, Series 100 Indication	27VDC RLP Low
1645	J1-NN	Not Block I Series 100 Indic.	27 VDC RLP Low
1732	J1-HH	Continuous Gyro Torque Cmd.	27 VDC RLP High
1733	J1-PP	Continuous Gyro Torque Ind.	27 VDC RLP Low
1611	J2-1 I	PIPA Switching High	3200 pps 3 u sec pulse width
1612	0	PIPA Switching Ret	Lags Error Sig. by 135°
1601 TL	J2-3 I	Torque ON Command High	3200pps ampl. 56 10V, pos. going
1602 TL	0	Torque ON Command Low	P/W 3.5 usec Buffered
1626 TL	J2-4 I	Torque Set High	3200 min amp. 1.0V
1627 TL	0	Torque Set Low	P/W 3.5 usec Buffered
1603 TL	J2-9 I	Torque OFF Command High	3200 pps amp 56 10V
1604 TL	0	Torque OFF Command Low	P/W 3.5 ± lusec positive going
865	J2-11 I	-Y IRIG Set High	3200 pps amp 5.0 ± .5V
864	0	-Y IRIG Set Low	P/W 3usec ± .5
860	J2-12 I	-X IRIG Set High	3200 pps A.M. 5.0 ± .5V
861	0	-X IRIG Set Low	P/W- 3usec ± .5
1591	J2-14 I	-X Gyro Select Hi	102.4 KPPS 80mil sec. duration
1592	0	-X Gyro Select Low	3usec pulse width
866	J2-10 I	-Z IRIG Set High	Same as -X IRIG Set
867	0	-Z IRIG Set Ret	
1625	J2-21 0	-Z IRIG Set High	Same as -X IRIG Set
1624	I	-Z IRIG Set Ret	

CROSS REFERENCE	CONNECTOR/ PIN	NOMENCLATURE	DESCRIPTION
1617	J2-22 O	-X IRIG Set High	3200 pps P/W 3.0 ± 5usec
1616	I	-X IRIG Set Ret	Amp 5.0 ± .5V neg going
1615	J2-23 O	+X IRIG Set High	Same as above
1614	I	+X IRIG Set Ret	
863	J2-24 I	+Z IRIG Set High	Same as above but positive
862	O	+Z IRIG Set Ret	but positive going pulses
857	J2-25 I	+Y IRIG Set High	Same as above
856	O	+Y IRIG Set Ret	
858	J2-26 I	+X IRIG Set High	Same as above
859	O	+X IRIG Set Ret	
1593 TL	J2-28 I	+Y Gyro Select High	102.4 KPPS amp 5 to 10V
1594 TL	O	+Y Gyro Select Low	P/W - 3.5 ± 1 usec
1589 TL	J2-29 I	+X Gyro Select High	Same as above
1590 TL	O	+X Gyro Select Low	
1595 TL	J2-30 I	-Y Gyro Select High	Same as above
1596 TL	O	-Y Gyro Select Low	
1623	J2-38 O	+Z IRIG Set High	3200 pps P/W 3.0 ± .5usec
1622	I	+Z IRIG Set High	Amp. 5 ± .5V neg. going.
1621 W	J2-39 O	-Y IRIG Set High	Same as above
1620 W	I	-Y IRIG Set Ret	Neg. going.
1617 W	J2-40 O	+Y IRIG Set HI	Same as above
1618 W	I	+Y IRIG Set Ret	Neg. going.
1605	J2-41 I	X IRIG Select (Phase A) HI	3usec pulse width, in phase
1606	O	X IRIG Select (Phase A) Ret	3200, Freq. Rate 102.4 KPPS
1607	J2-42 I	Y IRIG Select (Phase B) HI	Same as above
1608	O	Y IRIG Select (Phase B) Ret	

CROSS REFERENCE	CONNECTOR/ PIN		NOMENCLATURE	DESCRIPTION
1609	J2-43	I	Z IRIG Select (Phase C)HI	Same as preceding page.
1610		O	Z IRIG Select (Phase C)Low	
1597	J2-46	I	+Z Gyro Select HI	102.4 KPPS amp 5 to 10V
1598		O	+Z GYro Select Low	P/W 3.5 ± lusec
1658	J2-47	I	Gyro Torque Discrete HI	102.4 KPPS AM 6 ± .6V
1659		O	Gyro Torque Discrete Ret	P/W 3.0 ± 0.5usec
1599	J2-48	I	-Z Gyro Select HI	102.4 KPPS amp 5 to 10V
1600		O	-Z Gyro Select LO	P/W 3.5 ± lusec

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