

MASTER END ITEM DETAIL SPECIFICATION

PART II

PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS

G&N SPACECRAFT EQUIPMENT COMMAND MODULE

BLOCK II

DRAWING NO. 2015000

MEI NO. 2015000

Record of Revisions

Date	Revision Letter	TDRR No.	Pages Revised	Approvals	
				AC	NASA
11/1/66	A	31733	30, 32	MGM EA	WLS
11/15/66	B	31936	2, 4-9, 11-19, 22, 23, 25, 26 29, 31	MGM EA	WLS
3/23/67	C	33360	14-32. Specification was 32 pages, now 33 pages.	MGM EA	WLS
11/2/67	D	34989	18	MGM EA	WLS
11/10/67	E	35034	16	EA	WLS
1/15/68	F	35426	4-6, 9, 11, 14-16, 18, 19, 24-27, 31-33	MGM EA	WLS
3/28/68	G	35986	21-33; was 33 pages, now 35 pages.	MGM EA	WLS
4/11/68	H	36058	17	MGM EA	RJJ
5/3/68	J	36171	7, 11, 31	MGM EA	WLS
7/24/68	K	36577	4, 5	MGM EA	WLS
11/18/68	L	37040	32, 34	MGM EA	WLS

This specification consists of page 1 to 35 inclusive.

APPROVALS	C. METZGER	<i>[Signature]</i>	<i>[Signature]</i>	<i>[Signature]</i>
	NASA/MSC	MIT/IL	AC	OB

1. SCOPE

1.1 PURPOSE. This specification establishes the detail requirements for complete identification and acceptance of the G&N Spacecraft Equipment, Command Module, Block II, Part Number 2015000, hereafter called the system.

1.2 PRODUCT CONFIGURATION BASELINE ACCEPTANCE. The product configuration baseline shall be defined by System Serial No. 203. This unit and all subsequent units, regardless of intended use, shall be accepted to the configuration defined by Serial No. 203 unless formally approved otherwise as required by ANA Bulletin No. 445.

2. APPLICABLE DOCUMENTS

2.1 EFFECTIVE ISSUES. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, Military Standards and Specifications shall be the issue in effect on the date of request for proposal or invitation to bid.

SPECIFICATIONS

APOLLO G&N

ND1002214

General Specification for Preservation, Packaging, Packing and Container Marking of APOLLO Guidance and Navigation Major Assemblies, Assemblies, Subassemblies, Parts and Associated Ground Support Equipment

PS2016005

Procurement Specification, Product Configuration and Acceptance Test Requirements, Command Module Guidance Computer Group

ATP2015497

Assembly Test Procedure for Inertial Subsystem

ATP2015500

Assembly Test Procedure for Optics Subsystem

DRAWINGS

APOLLO G&N

1900030

APOLLO G&N Ground Support Equipment

2015000

G&N Spacecraft Equipment, Command Module, Block II

PUBLICATIONS

Army-Navy-Air Force

Bulletin 445
Dated 12 July '63

Engineering Changes to Weapons, Systems,
Equipments and Facilities

(Copies of specifications, standards, drawings, bulletins, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 CONFLICTING REQUIREMENTS. In event of a conflict between requirements, the following order of precedence shall apply. The contractor shall also notify MIT/IL APOLLO Management of the conflict.

- a. The contract
- b. This specification
- c. Documents listed in this section

3. REQUIREMENTS

3.1 PERFORMANCE

3.1.1 Standby Control

3.1.1.1 Standby Mode. The following requirements shall be met with the IMU in the Standby mode.

3.1.1.1.1 28 VDC IMU Standby. The IMU Standby voltage shall be 28.8 ± 3.0 vdc.

3.1.1.1.2 Inertial Component Temperature. The PIPA temperature after stabilization in Standby shall be within 1.0°F of the temperature recorded in 3.1.3.2. The temperature shall be considered stabilized when the temperature change is less than 0.1°F for 30 minutes.

3.1.1.2 G&N Standby Mode (CGC STBY). The following requirements shall be met with the IMU in the Standby condition and the CGC in the Standby condition.

3.1.1.2.1 3200 CPS Suspension Power. The feedback voltage shall be $28.60 \pm 0.56\text{V}$ rms at a frequency of 3200 ± 1 cps.

3.1.1.2.2 Master Clock. The Master Clock signal shall be present and shall have the following characteristics: (Reference Figure 2).

- a. Amplitude (A): 4 to 14V
- b. Pulse Width (B): 0.50 ± 0.25 μsec
- c. Zero Shift (D): Approximately 50 percent of A
- d. Maximum Risetime (10 to 90 percent of A): 0.2 μsec
- e. Maximum Noise and Ripple: 0.2V
- f. Frequency: 1024 kc ± 2 ppm

3.1.1.3 CGC Operate. The following conditions shall exist with the CGC in the Operate mode (full power state).

3.1.1.3.1 CGC +4 VDC Power Supply. The power supply voltage shall be $+4.00 \pm 0.20$ vdc, with a p-p noise level of 0.4V or less.

3.1.1.3.2 CGC +14 VDC Power Supply. The power supply voltage shall be $+14.00 \pm 0.40$ vdc with a p-p noise level of 0.4V or less.

3.1.1.3.3 CGC +28 VDC. The +28 vdc Computer TP voltage shall be $+28.8 \pm 3.0$ vdc.

3.1.1.3.4 CGC Power Supply Performance

3.1.1.3.4.1 CMC Voltage Fail Alarm Limits

The CMC ALARM CONDITION lamp shall illuminate when either the +4 vdc power supply output is greater than 4.00 vdc or less than 3.50 vdc and/or when the +14 vdc power supply is greater than 16.4 vdc or less than 12.2 vdc.

The CMC ALARM CONDITION lamp shall not illuminate when the +4 vdc power supply output is 3.80 vdc to 4.20 vdc and when the +14 vdc power supply output is 12.80 vdc to 15.60 vdc.

The CMC ALARM CONDITION lamp state is unspecified in voltage regions other than those specified above.

3.1.1.3.4.2 Inhibit Power Fail. The CMC ALARM CONDITION lamp shall not illuminate due to a Voltage Fail Alarm, when the Inhibit Power Fail discrete is present.

3.1.1.3.4.3 Voltage Margin Requirements. No CGC failure indication shall occur under the following conditions with the Inhibit Power Fail discrete present.

- a. The +4 vdc supply shall be varied from a maximum low of 3.4 vdc to a maximum high of 4.6 vdc with the +14 vdc supply held at 12.1 vdc nominally and also at 16.4 vdc nominally.
- b. The +14 vdc supply shall be varied from a maximum low of 12.1 vdc to a maximum high of 16.4 vdc with the +4 vdc supply held at 3.40 vdc nominally and also at 4.6 vdc nominally.

3.1.1.3.5 BMAG Attitude Signals

3.1.1.3.5.1 BMAG Signal Acceptance. BMAG Pitch, Roll, and Yaw attitude information shall be accepted by the CGC with a "1" in bit 8 of Channel 13 of the CGC.

3.1.1.3.5.2 BMAG Signal Verification. The contents of the BMAG counters (locations 42, 43 and 44) in the CGC shall contain the BMAG signal information.

3.1.2 Operate Control. The following conditions shall exist when the 28.8 ± 3.0 vdc IMU Operate voltage is applied to the G&N system interface.

3.1.2.1 Operate Delay Period. The 120 VDC Pulse Torque power supply shall be inhibited and the IMU gimbals shall be driven and held to $0^\circ \pm 5^\circ$ during approximately the first 90 seconds after power application.

3.1.2.2 Operate Delay Complete. The 120 VDC Pulse Torque power supply output shall be 120 ± 6 vdc and the ISS Warning alarm or PROG alarm (Code 00212) shall not be present after approximately 100 seconds.

3.1.3 Inertial Component Temperature. The following requirements shall be met with IMU gimbal angles of $0^\circ \pm 5^\circ$ in Coarse-Align.

3.1.3.1 Standby to Operate Transient. The PIPA temperature during the first 15 minutes after switching from Standby mode to the Operate mode shall be $130.5^{\circ}\text{F} \pm 2.0^{\circ}\text{F}$. The PIPA temperature after 15 minutes in Operate shall be within 0.5°F of the temperature recorded in 3.1.3.2. The IRIG temperature after 30 minutes in Operate shall be within 0.5°F of the temperature recorded in 3.1.3.2.

3.1.3.2 Inertial Temperature Control Point. The PIPA temperature shall be $130.5 (\pm 1.5)^{\circ}\text{F}$ after stabilization in Operate. The IRIG temperature shall be $135 (\pm 2.5)^{\circ}\text{F}$ after stabilization in Operate. The temperatures shall be considered stabilized when the temperature change is less than 0.1°F for 30 minutes.

3.1.3.3 Heater Telemetry Discrete. The Heater Telemetry discrete shall cycle on and off. The ON state shall be 0 ± 5 vdc and the OFF state shall be 28.8 ± 3.0 vdc, at the interface.

3.1.3.4 Blower Telemetry Discrete. The Blower Telemetry discrete shall cycle on and off with a heater duty cycle of approximately 45 percent. The ON state shall be 0 ± 5 V rms and the OFF state shall be 28.0 ± 2.8 V rms, at the interface.

NOTE: With the operating parameters given in this specification, the blowers will always be on.

3.1.3.5 CGC Temperature Monitor. The resistance of the CGC temperature monitor thermistor shall be 1.4K to 13.25K ohms.

3.1.3.6 PSA Temperature Monitor. The resistance of the PSA temperature monitor thermistor shall be 1.715K to 8.37K ohms.

3.1.3.7 PIPA Calibration Module Temperature. The resistance of the PIPA Calibration Module temperature thermistor shall be 2.8K to 13.25K ohms.

3.1.4 System Power Supplies. The System Power supplies shall meet all the requirements specified herein when operated from the 28 vdc system power.

3.1.4.1 IMU and Optics 28V, 1 Percent, 800 CPS Power Supplies. The output voltage of each power supply shall be 28.00 ± 0.56 V rms, 800 ± 1 cps.

3.1.4.2 IMU 28 Volt, 5 Percent, 800 CPS Power Supplies (Phase A and Phase B)

3.1.4.2.1 Voltage. The output voltage of the Phase A supply shall be 28.00 ± 1.4 V rms and the output voltage of the Phase B supply shall be 28.00 ± 2.1 V rms.

3.1.4.2.2 Frequency. The frequency of the power supply outputs shall be 800 ± 1 cps.

3.1.4.2.3 Phase

a. The IMU 28V Phase A power supply output shall be $-90^{\circ} \pm 10^{\circ}$ with respect to the IMU and Optics 28V, 1 percent power supply.

b. The IMU 28V Phase B power supply output shall be $-90^{\circ} \pm 10^{\circ}$ with respect to the IMU 28V Phase A power supply output.

- 3.1.4.3 Optics 28 Volt, 5 Percent, 800 CPS Power Supply. The output voltage of the power supply shall be 28.0 ± 1.48 V rms, 800 ± 1 cps. The output shall be $+270^\circ \pm 10^\circ$ with respect to the Optics 28V, 1 percent power supply output.
- 3.1.4.4 IMU and Optics CDU +4 VDC Supply. The output voltage of the power supply shall be $+4.0 \pm 0.2$ vdc, and the p-p noise shall be less than 200 mv.
- 3.1.4.5 28V, 3200 CPS, 1 Percent Supply. The power supply feedback voltage shall be 28.60 ± 0.56 V rms, 3200 ± 1 cps. The feedback output phase angle shall be $0^\circ \pm 10^\circ$ with respect to the synchronization pulses.
- 3.1.4.6 Minus 28VDC Power Supply. The output of the power supply shall be -27.5 ± 6.0 vdc.
- 3.1.4.7 Pulse Torquing Power Supply. The dc output voltage of the power supply shall be:
- 120 ± 6 vdc
 - 28 vdc (PIPA PVR INPUTS) (3): 28.0 ± 1.4 vdc, with the p-p noise less than 200 mv.
 - $+20.0 \pm 1.2$ vdc
 - -20 ± 2 vdc
 - Gyro PVR Output: 6 ± 0.06 vdc
- 3.1.4.8 CGC +4 VDC Power Supply. The output voltage of the power supply shall be $+4.00 \pm 0.20$ vdc with a p-p noise level of 0.4 volts or less.
- 3.1.4.9 CGC +14.0 VDC Power Supply. The output voltage of the power supply shall be $+14.0 \pm 0.4$ vdc with a p-p noise level of 0.4 volts or less.
- 3.1.4.10 CGC +28 VDC. The +28 vdc Comp TP voltage shall be $+28.4 \pm 3.0$ vdc.
- 3.1.4.11 28 Volt, 800 CPS Reference. The output voltage shall be 28.0 ± 1.4 volts rms at the interface.
- 3.1.4.12 ACE Bias 1. The +4 vdc power supply output shall drop by 0.7 ± 0.3 vdc with the requirements of 4.2.1.4.2.7 met.
- 3.1.4.13 ACE Bias 2. The +14 vdc power supply output shall drop by 3 ± 2 vdc with the requirements of 4.2.1.4.2.7 met.
- 3.1.4.14 PSAAM Power. The PSAAM PWR #1, #2 and #3 output voltages shall be 28.0 ± 3.0 , -3.4 vdc at the interface.
- 3.1.5 Command Guidance Computer (CGC)
- 3.1.5.1 Operational Self-Check. The CGC program shall: sum fixed memory, verify the execution of the machine instructions, control pulses, interrupts and timing, and exercise the erasable, central and special registers. In addition, the program shall verify the proper operation of all electroluminescent displays on the DSKYs.

3.1.5.2 Keyboard Operation. Operation of each listed pushbutton shall result in the described indication or result:

- a. Verb: (Preceding and in conjunction with two numeral pushbuttons) illumination of the same two numerals in the VERB display window.
- b. Noun: (Preceding and in conjunction with two numeral pushbuttons) illumination of the same two numerals in the NOUN display window.
- c. 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, +, -: Illumination of the respective characters on the DSKY display.
- d. CLR: The illuminated characters of Row 1, 2, or 3 of the DSKY display shall extinguish provided the ENTER pushbutton has not been pressed during a DSKY load sequence.
- e. STBY: All DSKY illumination shall extinguish with the exception of the STBY, TEMP, and RESTART lamps. Refer to 3.1.2.1.4 for CGC standby requirements.
- f. RSET: Any or all of the following DSKY display lamps shall extinguish if illuminated initially:
 - (1) PROG
 - (2) RESTART
 - (3) OPR ERR
- g. KEY REL: The KEY REL lamp shall extinguish and the DSKY display control shall return to the monitoring routine commanded by the CGC.
- h. ENTER: Completes a legal entry depending upon the actuation of the proper sequence of VERB or VERB, NOUN, and numeral pushbuttons.

3.1.5.3 Display Operation. Each listed display lamp shall illuminate as a result of the specified stimuli, and its element operation verified through the use of Verb 35.

- a. STBY: Actuation of the STBY pushbutton for at least 3 seconds after entry of Verb 60.
- b. KEY REL (FLASHING): Presence of a "1" in bit 5 of Channel 11 of the CGC.
- c. GIMBAL LOCK: Presence of a "1" in bit 6 of RLY WD 1100 as a result of the middle gimbal CDU indicating angles from +07000 to +29000 as shown by the contents of the CDU counter, address (00034) in the CGC.
- d. TEMP: Presence of a "1" in bit 4 of Channel 11 of the CGC.
- e. PROG: Presence of a "1" in bit 9 of RLY WD 1100 as generated by the CGC program.

- f. RESTART: The result of any or all of the following conditions:
 - (1) Standby
 - (2) TC Trap
 - (3) Rupt Lock
 - (4) Night Watchman
 - (5) Voltage Fail
 - (6) Parity Fail
- g. TRACKER: Presence of a "1" in bit 8 of RLY WD 1100.
- h. OPR ERR (Flashing): Presence of a "1" in bit 7 of Channel 11 of the CGC.
- i. COMP ACTY: Presence of a "1" in bit 2 of Channel 11 of the CGC.
- j. UPLINK ACTY: Presence of a "1" in bit 3 of Channel 11 of the CGC.
- k. NO ATT: Presence of a "1" in bit 4 of RLY WD 1100 as a result of Coarse Align Enable (Bit 4 of Channel 12) being on.
- 1. Electroluminescent Elements. The following numerical displays shall illuminate by program or DSKY stimulation, or both:
 - (1) PROG
 - (2) VERB
 - (3) NOUN
 - (4) Register 1
 - (5) Register 2
 - (6) Register 3

} Flashing, when program simulation causes the presence of a "1" in bit 6 of Channel 11.

3.1.5.4 CGC Commands to Reaction Control System (RCS). A "1" level in the following bit assignments shall result in the presence of 3 to 6 vdc at the interface. A "0" level in the following bit assignments shall result in the presence of 9.6 ± 0.5 vdc.

<u>Signal</u>	<u>Channel 5 Bit No.</u>
+Pitch/+X SOL DR ACT	1
-Pitch/+X SOL DR ACT	4
+Pitch/-X SOL DR ACT	3
-Pitch/-X SOL DR ACT	2
+Yaw/+X SOL DR ACT	5
-Yaw/+X SOL DR ACT	8
+Yaw/-X SOL DR ACT	7
-Yaw/-X SOL DR ACT	6

<u>*Signal</u>	<u>Channel & Bit No.</u>
+Roll/+Z SOL DR ACT	1
-Roll/+Z SOL DR ACT	4
+Roll/-Z SOL DR ACT	3
-Roll/-Z SOL DR ACT	2
+Roll/+Y SOL DR ACT	5
-Roll/+Y SOL DR ACT	8
+Roll/-Y SOL DR ACT	7
-Roll/-Y SOL DR ACT	6

3.1.5.5 CGC DC Discrete Inputs. Each interface specified below, when excited in accordance with the appropriate voltage specified in 4.2.1.4 shall cause the proper bit states as specified in Table I.

TABLE I
CGC DISCRETE INPUTS

DISCRETE	CHANNEL	BIT NO.	ON BIT STATE	OFF BIT STATE
SIVB Separate	30	4	0	1
Service Module Separate	30	2	0	1
LEM Attached	32	11	0	1
S/C Control of Saturn	30	10	0	1
SPS Ready	30	3	0	1
CN & C Autopilot Control	31	15	0	1
Ullage Thrust Present	30	1	0	1
Liftoff	30	5	0	1
Guidance Reference Release	30	6	0	1
Hold Function	31	13	0	1
Free Function	31	14	0	1
+X Trans. Contr.	31	7	0	1
-X Trans. Contr.	31	8	0	1
+Y Trans. Contr.	31	9	0	1
-Y Trans. Contr.	31	10	0	1
+Z Trans. Contr.	31	11	0	1
-Z Trans. Contr.	31	12	0	1
+Pitch Rot. Contr.	31	1	0	1
-Pitch Rot. Contr.	31	2	0	1
+Roll Rot. Contr.	31	5	0	1
-Roll Rot. Contr.	31	6	0	1
+Yaw Rot. Contr.	31	3	0	1
-Yaw Rot. Contr.	31	4	0	1
IMU Cage	30	11	0	1

3.1.5.6 Attitude Impulse Control. The listed positions of the Attitude Impulse Control handle on the G&N Indicator-Control Panel shall result in the associated signals indicated by a "0" level in the bit locations specified.

<u>Handle Position</u>	<u>CGC Channel</u>	<u>Bit No.</u>
a. Up	32	2
b. Down	32	1
c. Left	32	6
d. Right	32	5
e. Clockwise Rotation	32	3
f. Counterclockwise Rotation	32	4

3.1.5.7 Main Engine Signal. A "1" level in bit 13 of Channel 11 of the CGC shall result in a SPS Engine ON/OFF signal of 3 to 6 vdc. A "0" level in bit 13 of Channel 11 shall result in a signal level of 9.6 ± 0.5 vdc at the interface.

3.1.5.8 Telemetry Uplink

3.1.5.8.1 Accept-Block Uplink. With the UPLINK switch on the G&N Control Panel in the "ACCEPT" position and with an Accept Uplink signal present in accordance with 4.2.1.4, a "1" level shall be present in bit 10 of Channel 33 of the CGC, and continuity shall exist at connector 56P7 between pins 48 and 49. With the UPLINK switch in the "BLOCK" position and with an Accept Uplink signal present at connector 56P6 in accordance with 4.2.1.4, a "0" level shall be present in bit 10 of Channel 33, and continuity shall not exist at connector 56P7 between pins 48 and 49.

3.1.5.8.2 Uplink Too Fast Alarm. An Uplink pulse rate in excess of 6400 pps shall cause a "0" to be present in bit 11 of Channel 33.

3.1.5.8.3 Transmission Verification. Interrogation of the CGC erasable memory shall determine if the known sequence was accepted by the CGC.

3.1.5.9 Telemetry Downlink. With the Dlnk Start, Dlnk End, and Dlnk Sync signals in accordance with the requirements of 4.2.1.4 and with Dlnk Start and Dlnk End pulses occurring at any rate between 10 and 50 pps, a 40-bit word shall be present at a word or burst rate equal to the Dlnk Start and End pulse rate. The data bits shall lag the sync bits by less than $1 \mu\text{sec}$.

3.1.5.9.1 Downlink Data. The Downlink Data signal shall have the following characteristics: (Reference Figure 2)

- a. Amplitude (A): $7 \pm 3V$
- b. Pulse Width at A/2 (B): $2.5 \mu\text{sec}$ to $6 \mu\text{sec}$
- c. Maximum Backswing (C): **6V**
- d. Maximum Droop at a max of $2 \mu\text{sec}$ (D): 15 percent of A

e. Maximum Risetime at 10 to 90 percent of A: 0.2 μ sec

f. Noise

(1) During Pulse Transmission: The signal plus noise shall remain within the envelope of amplitude defined in 3.1.4.9.1. a and b.

(2) During Pulse Absence: +0.4 volts max, -4.0 volts max determined with respect to the amplitude reference.

g. Presence of the pulse shall indicate an "ON" condition. Absence of the pulse shall indicate an "OFF" condition.

3.1.5.9.2 Downlink Too Fast Alarm. Dlnk Start and End pulses occurring at a rate in excess of 100 pps shall cause a "0" to be present in bit 12 of Channel 33.

3.1.5.10 Main Panel DSKY

3.1.5.10.1 SIVB Cutoff. With a CGC command of SIVB Cutoff as indicated by a "1" level in bit 14 of Channel 12, an ON state shall be present at the DSKY interface. A "0" level in bit 14 of Channel 12 shall result in an OFF state at the interface.

3.1.5.10.2 SIVB Injection Sequence Start. With a CGC command of SIVB Injection Sequence Start as indicated by a "1" level in bit 13 of Channel 12, an ON state shall be present at the DSKY interface. A "0" level in bit 13 of Channel 12 shall result in an OFF state at the interface.

3.1.5.10.3 PGNS Caution. The PGNS Caution discrete shall occur as a result of any or all of the following conditions:

- a. Program Caution: A "1" in bit 9 of RLY WD 1100
- b. Temperature: A "1" in bit 4 of Channel 11
- c. Gimbal Lock: A "1" in bit 6 of RLY WD 1100
- d. Tracker: A "1" in bit 8 of RLY WD 1100
- e. Restart

3.1.5.10.4 ISS Warning. The ISS Warning discrete shall occur as a result of a "1" in bit 1 of Channel 11.

3.1.5.10.5 CGC Warning. The CMC ALARM CONDITION lamp shall illuminate and the discrete shall be present at the interface as a result of repeated or prolonged occurrences of the following conditions:

- a. VOLTAGE FAIL (in Standby mode)
- b. ALARM TEST

3.1.6 IMU/CDU Performance

- 3.1.6.1 Command Accuracy. The CGC shall command the IMU gimbals through the CDUs to 45°, 135°, 225° and 315° angles with an accuracy of $\pm 1.5^\circ$.
- 3.1.6.2 Coarse Align Error Signals. The total ac voltage output of the IMU/CDU DAC's subsequent to completion of an associated torquing command shall not exceed 0.30V rms.
- 3.1.6.3 Torquing Rate. The CDU, when stimulated by a maximum CGC torquing command, shall exhibit an average gimbal torquing rate of $14^\circ \pm 2^\circ$ per second over a minimum range of 67.5°.
- 3.1.6.4 Total Attitude Signals. At an Inner, Middle and Outer Gimbal CDU, CGC Register indication of +04500±00001, each gimbal 1X resolver sine and cosine output shall be 18.38±1.84V rms in-phase, with the sine output out of phase at -04500. The voltage phase angle shall be $+6 \pm 5$ arc degrees with respect to the 800 cps reference voltage at +04500.
- 3.1.6.4.1 Null Voltage. The sine and cosine total null voltage shall be less than 150 mv rms at IMU gimbal angles of $0.00^\circ \pm 0.01^\circ$ and $90.00^\circ \pm 0.01^\circ$, respectively.
- 3.1.6.5 Total Attitude Signals (Backup Mode). With the prevailing conditions of 3.1.6.4, the in-phase voltage outputs of the gimbal 1X resolver sine and cosine shall be 17.38±1.74 at a phase angle of $+12 \pm 5$ arc degrees with respect to the 300 cps reference voltage at +04500.
- 3.1.6.6 IMU/CDU Read Repeatability Accuracy. The CGC shall be capable of repeating given IG and OG angles in each quadrant to within ± 3 bits. The same repeating accuracy shall be met for MG angles of less than $+70^\circ$.
- 3.1.6.7 IMU/CDU Read Ambiguity. The IG and OG CDU's shall be capable of repeating an angle of $+225^\circ \pm 2^\circ$ to within ± 3 bits.
- 3.1.6.8 IMU/CDU Fine Error. The total voltage output of each IMU/CDU Fine Error shall not exceed 0.07V rms throughout a range of 22.5° of IMU gimbal rotation.
- 3.1.6.9 IMU/CDU Coarse Error. The total voltage output of each IMU/CDU Coarse Error shall not exceed 0.68V rms throughout an IG and OG rotation of 360° and a MG rotation of 135°.
- 3.1.6.10 IMU/CDU Fail. IMU CDU Fail indicated by a '0' in bit 12 of Channel 30 of the CGC shall occur with a difference of $1.0^\circ \pm 0.1^\circ$ (fine error) or $33.75^\circ \pm 0.30^\circ$ (coarse error) between the CDU read counter and the IMU gimbal resolvers.
- 3.1.6.11 IMU Cage. The IMU gimbals, initially coarse aligned to $2^\circ \pm 1^\circ$, shall drive when the IMU Cage discrete is present, until the resolver 1X sine signals are 0.0 ± 0.5 V rms and the 1X cosine signals are 26.0 ± 2.6 V rms in-phase with respect to the 800 cps reference voltage.

3.1.6.12 Attitude Error Signals. The CGC shall issue the following bit commands to the IMU/CDU DAC's resulting in the specified ac total voltage and phase outputs for the Pitch, Roll and Yaw Attitude Error signals.

<u>Increment From 0 (bits)</u>	<u>Attitude Error (V rms)</u>	<u>Phase *</u>
+385	5.06±0.66	in
+384	5.06±0.66	in
+160	2.11±0.27	in
+135	1.78±0.23	less than ±3°
+90	1.19±0.15	in
+0	0.000±0.056	N/A
-90	1.19±0.15	out
-135	1.78±0.23	out
-160	2.11±0.27	out
-384	5.06±0.66	out
-385	5.06±0.66	out

*Phase is measured with respect to the 800 cps reference voltage.

3.1.6.13 Attitude Error Signals to Saturn Guidance. With the presence of the S/C Control of Saturn discrete at the interface, the CGC shall issue the following bit commands to each of the IMU CDU DAC's resulting in the dc voltage outputs for the Pitch, Roll and Yaw Attitude Error Signals. The noise voltage on the dc level shall be less than 50 mv rms.

<u>Increment From 0 (bits)</u>	<u>Attitude Error (vdc)</u>
+385	+5.06±0.30
+384	+5.06±0.30
+160	+2.11±0.13
+135	+1.78±0.11
+90	+1.19±0.07
0	0±0.01
-90	-1.19±0.07
-135	-1.78±0.11
-160	-2.11±0.13
-384	-5.06±0.30
-385	-5.06±0.30

3.1.7 Accelerometer Loops

3.1.7.1 PIPA Scale Factor. The PIPA scale factor in a 1g field shall not deviate from 5.85 cm/sec/pulse by more than ±1900 parts per million. In addition, the scale factor shall meet the stability requirements of 3.1.7.4.

3.1.7.2 PIPA Bias. The PIPA bias in a 1g field shall not exceed 2.20 cm/sec² and shall conform to the stability requirements of 3.1.7.4.

3.1.7.4 PIPA and IRIG Stability Requirements

3.1.7.4.1 Calculation of PIPA and IRIG Stability Terms. The coefficient stability terms (D_1 , D_2 , and D_3) shall be calculated after each data point to determine if they exceed the maximum values. The coefficient stability terms shall be calculated as follows:

Equations for Calculating Stability Terms

- a. $D_1 = |X_{i-1} - X_i|$
- b. $D_2 = |X_{i-1} - X_i| + |X_{i-2} - X_{i-1}|$
- c. $D_3 = |X_{i-1} - X_i| + |X_{i-2} - X_{i-1}| + |X_{i-3} - X_{i-2}|$

Where: X_i is last data point,

X_{i-1} is last previous data point (ISS or G and N),

X_{i-2} is last data point before X_{i-1} (ISS or G and N), and

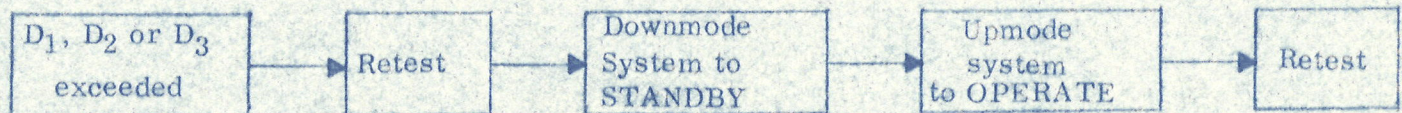
X_{i-3} is last data point before X_{i-2} (ISS or G and N).

Maximum Values for Coefficient Stability Terms

COEFFICIENT	UNITS	D_1	D_2	D_3
a. PIPA Bias (A_b)	cm/sec ²	0.50	0.70	0.90
b. PIPA Scale Factor	ppm	400	500	600
c. IRIG Bias Drift (NBD)	meru	6.0	9.0	11.0
d. IRIG IA Acceleration Drift (ADIA)	meru/g	17.0	33.0	40.0
e. IRIG SRA Acceleration Drift (ADSRA)	meru/g	14.0	21.0	25.0

3.1.7.4.2 Retest. If the D_1 , D_2 , or D_3 value for any PIPA or IRIG exceeds the maximum value given in 3.1.7.4.1, that PIPA or IRIG shall be retested in the sequence shown below. The coefficient stability terms shall then be recalculated. If the maximum value for D_1 , D_2 , or D_3 is exceeded after the retest sequence has been completed, the criteria of 3.1.7.4.3 shall apply.

Retest Sequence



3.1.7.4.3 Stability Requirements. Failure to be within the maximum values given for D_1 , D_2 , or D_3 in 3.1.7.4.1 after the retest sequence of 3.1.7.4.2 has been completed shall constitute failure of the assembly.

3.1.7.4.4 PIPA Degaussing. If a PIPA is degaussed, it shall be retested in the same sequence as indicated in 3.1.7.4.2. The requirements of 3.1.7.4.2 shall then apply. Data taken prior to the degaussing shall not be used in calculating stability terms.

3.1.8 Stabilization Loops

3.1.8.1 Step Response. The IRIG floats shall be initially displaced from electrical null by the application of 10, 5, and 5 vdc $\pm 5\%$ to the test inputs of the respective Inner, Middle, and Outer Gimbal dc amplifiers and shall return to null upon removal of this voltage. The time interval between the removal of this disturbance and the settling to within $\pm 5\%$ of steady state value shall not exceed 0.1 second. The inner and middle gimbal error signals shall have a maximum of 3 oscillation peaks outside the 5% tolerance band. The outer gimbal error signal shall have a maximum of 5 oscillation peaks outside the 5% tolerance band.

3.1.8.2 Gimbal Torque Level. The friction level of each gimbal, when torqued by its IRIG, shall not exceed 26.5 in-oz, as demonstrated by a peak torque motor current not to exceed 0.125 amp.

3.1.9 IRIG Drift Coefficients

3.1.9.1 NBD. The IRIG bias drift (NBD) shall not exceed 15.0 meru maximum limit and shall conform to the stability requirements of 3.1.7.4.

3.1.9.2 ADIA. The IRIG drift due to acceleration along the input axis (ADIA) shall not exceed 100 meru/g maximum limit and shall conform to the stability requirements of 3.1.7.4.

3.1.9.3 ADSRA. The IRIG drift due to acceleration along the spin reference axis (ADSRA) shall not exceed 40 meru/g maximum limit and shall conform to the stability requirements of 3.1.7.4.

3.1.10 IRIG Scale Factor. The IRIG pulse torque scale factor shall be 2π radians/ 2^{21} pulses ± 1750 ppm.

3.1.11 Gyrocompassing. The following requirements shall be met following a settling period of 120 minutes. The outer gimbal axis of the system shall be aligned to within 00.0 ± 0.5 arc degrees of local vertical initially with X_{SM} along the desired azimuth and Z_{SM} down.

3.1.11.1 Gyrocompass Accuracy. After 4 hours, the accuracy of the gyrocompass shall be determined using optical targets. The Z_{SM} axis shall be within 0.045° degrees of the desired vertical reference position excluding the error due to previously measured accelerometer bias. The X_{SM} axis shall be within 10.0 milliradians of the desired azimuth reference position excluding the error due to previously measured gyro drift.

3.1.11.2 Gyrocompass Stability. After 2 hours of settling, the stability of the gyrocompass shall be determined by monitoring gimbal angles. From 2 hours to 4 hours, with the system at nominal bus voltage, the peak to peak spread of the outer gimbal angle shall not exceed 0.12° and the peak to peak spread of the inner and middle gimbal angles shall not exceed 0.06° . The system shall then be operated for 1 hour with the bus voltage at the lower limit. The peak to peak spread of the outer gimbal angle during this period shall not exceed 0.3° and the peak to peak spread of the inner and middle gimbal angles shall not exceed 0.09° . The system shall then be operated for one hour with the bus voltage at the upper limit. The peak to peak spread of the outer gimbal angle during this period shall not exceed 0.6° and the peak to peak spread of the inner and middle gimbal angles shall not exceed 0.18° .

3.1.12 System Fine Alignment Accuracy. The Stable Member (SM) as defined by the X, Y, and Z PIPA input axes shall be aligned to a known orientation with respect to the SXT St LOS with a maximum error of 150 arc seconds about any PIPA input axis. This shall be accomplished by an AGC alignment test program in conjunction with the Fine Alignment procedure. The maximum error shall not include the PIPA bias terms.

3.1.13 Optics Control

3.1.13.1 Zero Optics

3.1.13.1.1 CGC Mode Indication. The contents of Channel 33 bit 4 of the CGC shall be a "0".

3.1.13.1.2 CGC Angle Counters. The Trunnion and Shaft CDU Counters in the CGC shall indicate $0.000^\circ \pm 0.006^\circ$, -0.007° and $0.00^\circ \pm 0.02^\circ$, -0.03° after 30 seconds.

3.1.13.2 Manual Mode

3.1.13.2.1 Reticle Brightness Control Operation. The RETICLE BRIGHTNESS control shall vary the illumination of the optical reticles and the SCT TPAC readouts.

3.1.13.2.2 Optics Coordinate Transformation Control. The system shall meet the following requirements while in the Resolved mode at an SCT shaft angle of 225.000 arc degrees and an SCT trunnion angle of 10 arc degrees LOS.

3.1.13.2.2.1 Phasing. With the control stick positioned 45 ± 10 arc degrees in the upper right quadrant, the target shall appear to move toward the upper right field of view of the SCT at 45 ± 10 arc degrees. The SHAFT CDU indication shall change no more than 10 arc degrees before the image leaves the SCT field of view.

3.1.13.2.2.2 Image Rate. With the CONTROLLER SPEED selector switch in the "MED" position, the image rate of travel as measured from control-stick-on to control-stick-off shall be 1.25 arc degree/sec ± 25 percent.

3.1.13.2.3 Optics Slew Rate. With the St LOS slewed about the trunnion or shaft axis in both directions and the TELESCOPE TRUNNION switch in the "SLAVE TO SXT" position, and the Direct mode selected, the following requirements shall be met.

3.1.13.2.3.1 Maximum Rate. With the CONTROLLER SPEED selector switch in the "HI" position and the Control Stick at maximum, the SXT TRUNNION and SHAFT tachometer outputs shall be $3.3 \pm 1.3V$ rms and $3.3 \pm 1.3V$ rms, respectively. The SCT TRUNNION and SHAFT tachometer outputs shall be $0.85 \pm 0.35V$ rms and $3.3 \pm 1.3V$ rms, respectively.

3.1.13.2.3.2 Medium Rate. With the CONTROLLER SPEED selector switch in the "MED" position and the Control Stick at maximum, the SXT TRUNNION tachometer output shall be

0.33±0.13V rms and the SXT SHAFT tachometer output shall be 0.33±0.13V rms. The SCT TRUNNION tachometer output shall be 0.085±0.035V rms and the SCT SHAFT tachometer output shall be 0.33±0.13V rms.

3.1.13.2.3.3 Low Rate. With the CONTROLLER SPEED selector switch in the "LOW" position and the Control Stick at maximum, the SXT TRUNNION tachometer output shall be 0.033±0.013V rms and the SXT SHAFT tachometer output shall be 0.033±0.013V rms. The SCT TRUNNION tachometer output shall be 0.009±0.004V rms and the SCT SHAFT tachometer output shall be 0.033±0.013V rms. With the control stick in its detent position, the St LOS drift rates shall not exceed the following:

Shaft drift	.2 $\overbrace{\text{min}}^{\text{arc}}/\text{sec}$
Trunnion drift	1 $\overbrace{\text{min}}^{\text{arc}}/\text{sec}$

3.1.13.3 Optics Computer Mode

3.1.13.3.1 CGC Mode Indication. The contents of Channel 33, bit 5, shall be a "0" indicating the OPTICS MODE switch is in the "COMPUTER" position.

3.1.14 Optics Alignment Accuracy

3.1.14.1 Scanning Telescope

3.1.14.1.1 Scanning Telescope Slaved to SXT. The Scanning telescope shall meet the following requirements.

3.1.14.1.1.1 Star LOS. The SCT LOS shall be parallel with the SXT St LOS within 0.2 arc degree for 0° and 25° when the TELESCOPE TRUNNION switch is in the "SLAVE TO SXT" position.

3.1.14.1.1.2 Offset 25°. The SCT trunnion angle shall be automatically offset to a position which places the target reticle center within a circle bounded by the SCT reticle 25 arc degree discontinuity when the TELESCOPE TRUNNION switch is in the "OFFSET 25" position.

3.1.14.1.1.3 Landmark LOS 0 Arc Degrees. The SCT trunnion angle shall automatically zero to a position which places the target reticle center within a circle bounded by SCT reticle 0 arc degree discontinuity when the TELESCOPE TRUNNION switch is in the "0" position.

3.1.14.1.2 SCT LOS Positional Accuracy

3.1.14.1.2.1 SCT Trunnion TPAC Accuracy. The trunnion TPAC shall indicate the SCT trunnion line of sight angle within ±0.22°.

3.1.14.1.2.2 SCT shaft TPAC Accuracy. The shaft TPAC shall indicate the SCT shaft angle within ±0.11°.

3.1.14.1.3 Image Resolution. The Scanning Telescope shall have an image resolution of 3 arc minutes.

3.1.14.2 Sextant

3.1.14.2.1 SXT LOS Positional Accuracy. The measurement accuracy of an included angle between the St LOS and LLOS of 45.000° shall be ± 2 bits using the CGC MARK routine. Subsequent measurement accuracy of $45.000^\circ \pm 30, 60, \text{ and } 90$ arc second angles shall be ± 2 bits.

3.1.14.2.2 SCT LOS Parallelism. The optics in the Zero mode shall have an included angle between the St LOS and LLOS of less than 10 arc seconds in the measurement plane.

3.1.14.2.3 Image Resolution. The Sextant shall have an image resolution of 10 arc seconds at the center field of view.

3.1.15 Optics/CDU Performance

3.1.15.1 Command Rate and Positional Accuracy. The St LOS shall be positioned to a trunnion angle of $45^\circ \pm 5$ bits and a shaft angle of $270^\circ \pm 5$ bits with a maximum CGC rate command issued to the CDU DAC's. The CDU shall exhibit an average torquing rate of $1.83^\circ \pm 0.45^\circ$ per second for the trunnion rate command and $7.32^\circ \pm 1.83^\circ$ per second for the shaft rate command.

3.1.15.2 Thrust Vector Control Command. With the presence of the GN&C Autopilot Control and SPS Ready discrettes at the interface, the CGC shall be enabled to issue the following bit commands to each of the Optics CDU DAC's resulting in the specified dc voltage outputs of the Pitch and Yaw SPS Engine Steering signals.

<u>Increment From 0 (bits)</u>	<u>SPS Engine Steering Signal (vdc)</u>
+385	$+5.06 \pm 0.30$
+384	$+5.06 \pm 0.30$
+160	$+2.11 \pm 0.13$
+135	$+1.78 \pm 0.11$
+90	$+1.19 \pm 0.07$
0	0 ± 0.01
-90	-1.19 ± 0.07
-135	-1.78 ± 0.11
-160	-2.11 ± 0.13
-384	-5.06 ± 0.30
-385	-5.06 ± 0.30

3.1.15.2.1 Noise. The noise voltage on the dc level shall be less than 50 mv rms sinusoidal. The nonsinusoidal noise shall be less than that specified in Figure 1.

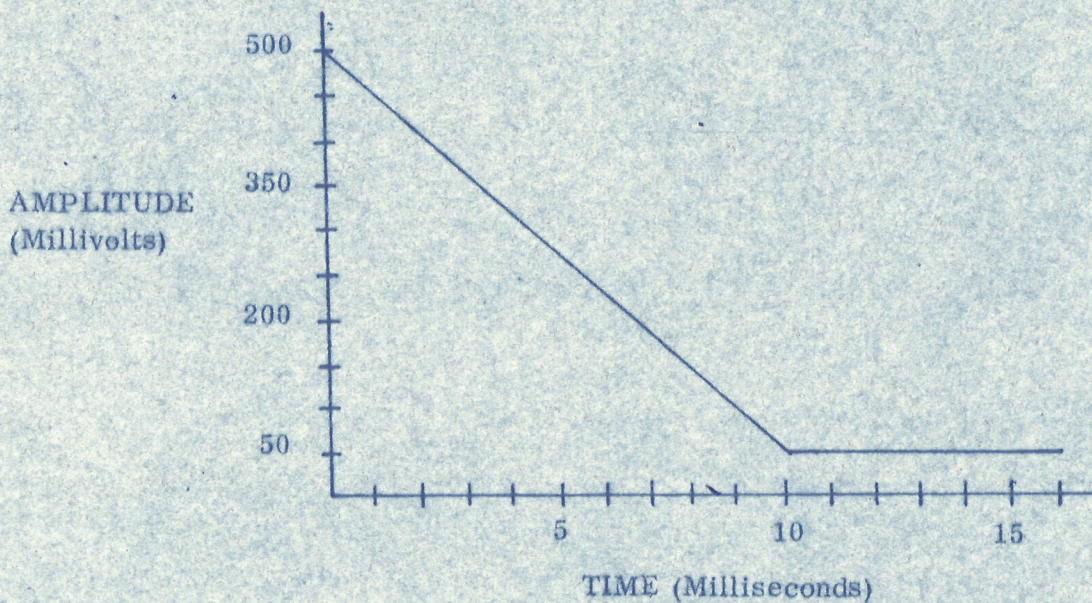
3.1.15.3 OCDU fail indicated by lighting of the tracker alarm shall occur with a difference between OCDU read counter output and optic resolver output of greater than 1.45° for shaft and/or greater than 0.72° for trunnion.

3.1.16 Astronaut Interface

3.1.16.1 Master Alarm Interface. The MASTER ALARM lamp on the G&N Control panel shall illuminate when 0 ± 2 vdc is present at the interface. With the MASTER ALARM RESET switch set to "RESET", +28 vdc signal shall appear at the interface. With the CONDITION LAMP control switch in the "TEST" position, a +28 vdc signal shall appear at the interface.

3.1.16.2 LEB Condition Annunciator. The PGNS, CMC, ISS condition lamps shall be controlled by the CONDITION LAMP control switch. With the switch in the ON position, the lamps can be activated; in the OFF position, the lamps cannot be activated; in the TEST position, the STAR ACQ lamp shall be illuminated.

3.1.16.3 MARK, MARK REJECT Function. Activation of the MARK and MARK REJECT switches shall result in a "1" in bits 6 and 7 respectively of Channel 16.



NONSINUSOIDAL NOISE LIMITS

FIGURE 1

3.1.17 Flight Qualification and Operational Signal Conditioner Assemblies

3.1.17.1 Signal List

3.1.17.1.1 Common Signals. The following signals shall be measured on both Flight Qualification and Operational Signal Conditioner Assemblies:

- a. 1X Resolver Sin and Cos Low Gain
- b. Servo Errors
- c. 3200 CPS Power Supply
- d. PIPA G/S
- e. CMC Warning
- f. Optics Operate Discrete (800 cps)
- g. Shaft and Trunnion DAC
- h. 800 CPS 1% IMU Power Supply
- i. 28 VDC CGC Operate
- j. 28 VDC Standby
- k. PIPA Temperature
- m. 2.5 VDC Bias
- n. 120 VDC Power Supply

3.1.17.1.2 Additional Flight Qualification Signal Conditioner Signals. The following additional signals shall be measured on Flight Qualification Signal Conditioner Assemblies:

- a. Pitch, Roll, and Yaw Attitude Errors
- b. 1X Resolver Sin High Gain
- c. Torque Motor Currents
- d. Shaft and Trunnion CDU Fine Errors
- e. Heater Current Discrete
- f. Blower Current Discrete
- g. SXT Shaft and Trunnion Tachometer
- h. SCT Shaft and Trunnion Tachometer
- i. IRIG Temperature
- j. 800 CPS 1% Optics Power Supply

3.1.17.2 +28 VDC Amplifiers. With the G&N 28 vdc bus adjusted to 28.80 ± 0.25 vdc, the SCA output for the CGC Operate bus, IMU Standby bus, and Heater Current discrete shall be 4.4 ± 0.5 vdc.

3.1.17.3 Power Supplies, Blower Discrete, and TM Bias Amplifiers. The SCA amplifier outputs for the G&N Power Supplies, Blower Current discrete, and TM Bias amplifier shall exhibit the following DC outputs:

<u>Input Signal</u>	<u>SCA Output</u>
120V DC Power Supply	3.5 ± 1.2 vdc
28V, 3200 CPS Power Supply	4.4 ± 0.5 vdc
28V, 800 CPS IMU Power Supply	4.5 ± 0.4 vdc
28V, 800 CPS Optics Power Supply	4.5 ± 0.4 vdc

<u>Input Signal</u>	<u>SCA Output</u>
Blower Discrete (800 cps)	4.3±0.4 vdc
Optics Operate Discrete (800 cps)	4.3±0.4 vdc
2.5VDC TM Bias	2.5±0.06 vdc
CMC Warning	4.3±0.6 vdc

3.1.17.4 PIP and IRIG Temperature Indication Amplifiers. With the system in the Operate mode for a minimum of 15 minutes, the SCA amplifier outputs for the IRIG and PIPA temperature shall be 2.75±0.80 vdc and 2.63±0.40 vdc, respectively.

3.1.17.5 Servo Error and Torque Motor Current Amplifiers. The gain of the SCA Servo Error amplifiers and the TM Current amplifiers shall be determined by applying a test input into the PSA Gimbal Servo amplifier and comparing the change in the SCA Servo Error input signal to the change in the SCA output signal. The gain of the SCA Servo Error amplifiers shall be 0.91±15% vdc/vrms, the gain of the SCA IG and MG TM Current amplifiers shall be 5.0±1.0 v/v, and the gain of the OG TM Current amplifier shall be 2.8±1.0 v/v. With no test input applied, the SCA TM Current amplifier outputs shall be 2.5±0.1 vdc.

3.1.17.6 PIPA G/S Amplifiers. The SCA PIPA G/S amplifier shall be evaluated by monitoring the recorded SCA PIPA G/S output for a PIPA loop closure from the -45° limit and the 135° limit. The SCA output shall respond accordingly, and after loop closure, the SCA output shall be 2.5±0.5 vdc.

3.1.17.7 Gimbal Resolver Low Gain Amplifiers. The gain of the SCA 1X Resolver Sine and Cosine amplifiers shall be evaluated by comparing the change in the SCA resolver amplifier input voltage to the change in the SCA resolver amplifier output voltage for gimbal displacements of 45° and 225°. The gain of the SCA 1X resolver amplifiers shall be 0.123±12% vdc/vrms.

3.1.17.8 Resolver 1X Sine High Gain Amplifiers. The gain of the SCA resolver 1X sine amplifiers shall be evaluated by comparing the change in the SCA resolver 1X sine amplifier input voltage to the change in the SCA resolver 1X sine amplifier output voltage for a plus and minus 7° gimbal displacement. The gain of the SCA resolver 1X sine amplifiers shall be 0.5±12% vdc/vrms.

3.1.17.9 CDU Fine Error Amplifiers. With the CONTROLLER SPEED selector switch in the "HI" position and the Control Stick displaced as specified below until the corresponding SCA CDU fine error input is obtained, the SCA CDU fine error output shall be as specified:

<u>Control Stick Displacement</u>	<u>SCA CDU Fine Error Input</u>	<u>SCA CDU Fine Error Output</u>
Left - Shaft, in-phase	1.0 vrms	4.6±0.3 vdc
Right - Shaft, π-phase	1.0 vrms	0.4±0.3 vdc
Down - Trunnion, in-phase	0.64 vrms	4.6±0.4 vdc
Up-Trunnion, π-phase	0.64 vrms	0.4±0.4 vdc

- 3.1.17.10 CDU Shaft and Trunnion DAC Amplifiers. The SCA SXT Trunnion and Shaft DAC amplifiers shall be evaluated by activating the CDU Error Counter through CMC control to provide an in-phase and a π -phase of 10.2 ± 1.0 vrms. The output of the SCA CDU DAC amplifier shall be 4.5 ± 0.5 vdc for the in-phase input and 0.5 ± 0.5 vdc for the π -phase input.
- 3.1.17.11 SXT and SCT Shaft and Trunnion Tachometer Amplifiers. The SXT and SCT Shaft and Trunnion SCA Tachometer amplifiers shall be evaluated by manually slewing the Shaft and Trunnion gimbals with the Control Stick in the plus and minus directions and comparing the change in the SCA tachometer amplifier input to the change in the SCA tachometer amplifier output. The gain of the SCA SXT Shaft and Trunnion amplifiers shall be 5.0 ± 1.0 vdc/vrms, and the gain of the SCA SCT Shaft and Trunnion tachometer amplifiers shall be 0.50 ± 0.10 vdc/vrms. With no gimbal movement, the SCA tachometer amplifier outputs shall be 2.5 ± 0.1 vdc.
- 3.1.17.12 Attitude Error Amplifiers. The Roll, Pitch, and Yaw CDU DAC's shall be commanded, through CMC control, to indicate a plus and minus 16° error indication. The change in the SCA Attitude Error amplifier input voltage shall be compared to the change in the SCA Attitude Error amplifier output voltage for the plus and minus 16° error signals. The gain of the SCA Attitude Error amplifiers shall be $0.41 \pm 12\%$ vdc/vrms.

3.2 PRODUCT CONFIGURATION

- 3.2.1 Drawings. The configuration of the system shall be in accordance with Drawing 2015000 and all drawings and engineering data referenced thereon.
- 3.2.2 Maximum Weight
- 3.2.3 Standards of Manufacturing, Manufacturing Process and Production

4. QUALITY ASSURANCE PROVISIONS

4.1 PRODUCT PERFORMANCE AND CONFIGURATION REQUIREMENTS/QUALITY VERIFICATION CROSS REFERENCE INDEX

<u>Test/Examination</u>	<u>Requirement</u>	<u>JDC</u>
G&N System Visual Inspection	3.2.1	12200
Standby Control Tests	3.1.1	12205
System Operational Tests	3.1.5 through 3.1.5.3	12206
Operate Control Tests	3.1.2, 3.1.3, and 3.1.16	12207
System Power Supply Tests	3.1.4	12208
CGC Output Test	3.1.5.4, 3.1.5.7, 3.1.5.9, and 3.1.5.10	12209
CGC Input Test	3.1.5.5, 3.1.5.6, and 3.1.5.8	12210
Optics Coordinate Transformation Control Test	3.1.13.2.1 and 3.1.13.2.2	12211
Zero Optics Test	3.1.13.1	12212
Optics Slew Rate Tests	3.1.13.2.3	12213
Optics Positional Accuracy Tests	3.1.14	12214
Semi Automatic Mode Test	3.1.6.1 through 3.1.6.12, 3.1.13.3, and 3.1.15.1	12216
IMU Performance Test	3.1.7	12217
G&N Fine Alignment Test	3.1.12	12218
IRIG Scale Factor Test	3.1.9 and 3.1.10	12219
Gimbal Response Test	3.1.8	12220
Space Craft Control and Displays Interface Test	3.1.6.12, 3.1.6.13, and 3.1.15.2	12221
Gyro Compassing Test	3.1.11	12222
Signal Conditioner Functional Checkout	3.1.17	12224

4.2 GENERAL. The contractor responsible for the manufacture of the system shall be responsible for the accomplishment of each test required herein.

4.2.1 Test Conditions

4.2.1.1 Test Environment

- a. Particle Size and Count Adjacent to Optical Unit: Particle count shall not exceed a total of 100,000 particles per cubic foot, 0.5 microns and larger; or 700 particles per cubic foot, 5.0 microns and larger.

NOTE: This requirement applies only to periods when Sextant and Scanning Telescope Optics heads are uncovered.

- b. Room Particle Size and Count: Particle count shall not exceed a total of 200,000 particles per cubic foot, 0.5 microns and larger; or 1400 particles per cubic foot, 10 microns and larger.
- c. Temperature: $75^{\circ} \pm 4^{\circ}F$
- d. Relative Humidity: 50% or less
- e. Cover Garments: Caps, gowns, and boots

4.2.1.2 Prior Compliance. Prior to system testing, assembly level testing, subsystem testing, and inspection shall have been accomplished in accordance with ATP2015497, ATP2015500, and PS2016005.

4.2.1.3 Output Loading. The output loading required during testing shall be as specified in Table II.

TABLE II
OUTPUT LOADING

SIGNAL	LOAD (Ohms)
Master Clock	500 (approx)
DLNK Data	500 (approx)
CGC Warning	lamp
PGNS Caution	lamp
ISS Warning	lamp
INJ SEQ START (SIVB)	lamp
Cut Off CMD (SIVB)	lamp
Engine Gimbal Angle (Pitch)	20.1K $\pm 2\%$
Engine Gimbal Angle (Yaw)	20.1K $\pm 2\%$
Master Alarm Reset	switch
Sin A_{ig} Cos A_{ig} Sin A_{mg} Cos A_{mg} Sin A_{og} Cos A_{og}	Refer to 4.2.1.3.1 and 4.2.1.3.2
Pitch Attitude Error (AC)	40K $\pm 5\%$ / $0^{\circ} \pm 5^{\circ}$
Roll Attitude Error (AC)	40K $\pm 5\%$ / $0^{\circ} \pm 5^{\circ}$
Yaw Attitude Error (AC)	40K $\pm 5\%$ / $0^{\circ} \pm 5^{\circ}$
800 cps Reference Voltage	<3 watts, power factor >0.9
Pitch Attitude Error (DC)	20.1K $\pm 2\%$ +j 250 max, ohms, at 800 cps
Roll Attitude Error (DC)	20.1K $\pm 2\%$ +j 250 max, ohms, at 800 cps
Yaw Attitude Error (DC)	20.1K $\pm 2\%$ +j 250 max, ohms, at 800 cps
Nav DSKY Dimmer Control	10K $\pm 5\%$ pot.
Main DSKY Dimmer Control	Linear taper

4.2.1.3.1 Normal Resolver Loads. The loads for the applicable signals specified in Table II shall correspond to a resolver having the following characteristics during modes of operation other than backup:

- a. $Z_{po} = (310 \pm 15 \text{ percent} + j 1970 \pm 10 \text{ percent})$ ohms
- b. $Z_{so} = (375 \pm 15 \text{ percent} + j 2160 \pm 10 \text{ percent})$ ohms
- c. Phase Shift = $6.5^\circ \pm 1.0^\circ$
- d. Transformation ratio = $1 \pm 3 \text{ percent}$
- e. Total null voltage versus rotation = 35 mv rms max
- f. Impedance unbalance ≤ 200 arc sec
- g. Secondary loading = 51.1K ohms (resistive on both secondary windings)

4.2.1.3.2 Backup Resolver Load. During the backup mode, the loads for the applicable signals specified in Table II shall consist of the load specified in 4.2.1.3.1 in parallel with a load corresponding to a resolver having the following characteristics:

- a. $Z_{po} = (300 \pm 20 \text{ percent} + j 1820 \pm 20 \text{ percent})$ ohms
- b. $Z_{so} = (1225 \pm 20 \text{ percent} + j 7350 \pm 20 \text{ percent})$ ohms
- c. Phase Shift = $4.5^\circ \pm 1.0^\circ$
- d. Transformation ratio = 1.907 ± 0.057 (secondary to primary)
- e. Total null voltage vs rotation = 35 mv rms max
- f. Impedance unbalance ≤ 200 arc sec
- g. Secondary loading = 50K ohms minimum

4.2.1.3.3 Attitude Error (DC) Load

- a. ICD MHO1-01386-216

Pitch Attitude Error 20.1K $\pm 2\%$ + j 250 max ohms at 800 cps
Roll Attitude Error 20.1K $\pm 2\%$ + j 250 max ohms at 800 cps
Yaw Attitude Error 20.1K $\pm 2\%$ + j 250 max ohms at 800 cps

- b. GSE Mechanization Load

Pitch Attitude Error 40.2K
Roll Attitude Error 40.2K
Yaw Attitude Error 40.2K

- c. Scale Factor for 3.1.6.13

The output voltage specified in this paragraph must be multiplied by $\frac{13.78}{13.18}$ to accommodate for the differences in loading between the ICD and GSE.

4.2.1.4 Inputs. The system shall perform as specified herein with the following inputs.

4.2.1.4.1 Prime Power. The system prime power shall be as specified in Table III.

TABLE III
 SYSTEM PRIME INPUT POWER

VOLTAGE	IDENTIFICATION
+28.8±3.0 vdc	+28 vdc IMU Standby Bus A
+28.8±3.0 vdc	+28 vdc IMU Standby Bus B
+28.8±3.0 vdc	+28 vdc IMU Operate Bus A
+28.8±3.0 vdc	+28 vdc IMU Operate Bus B
+28.8±3.0 vdc	+28 vdc CGC Bus A
+28.8±3.0 vdc	+28 vdc CGC Bus B
+28.8±3.0 vdc	+28 vdc Optics Bus A
+28.8±3.0 vdc	+28 vdc Optics Bus B
115±4V, 400±7 cps III	AC lighting
115.0±4.3V, 400±7 cps	(Controlled 0-115 vac) Nav DSKY Key Illumination
115.0±4.3V, 400±7 cps	(Controlled 0-115 vac) Main DSKY Key Illumination
5V, 400 cps	(Controlled 0-5 vac) Nav DSKY Caution & Status Lights
5V, 400 cps	(Controlled 0-5 vac) Main DSKY Caution Lights
5V, 400 cps	(Controlled 0-5 vac) Main DSKY Status Lights

4.2.1.4.2 Signals. The system input signals shall be as specified in Table IV.

TABLE IV
 SYSTEM INPUT SIGNALS

SIGNAL	CHARACTERISTICS
SPS Ready	
LEM Attached	
Hold Function	
Free Function	
Accept Uplink	
Service Module Separate	+17.5±0.5 vdc for a "1" level and
SIV B Separate	0±2 vdc for a "0" level
Lift Off	
Guidance Reference Release	
Ullage Thrust Present	
IMU Cage	
S/C Control of Saturn	
GN&C Autopilot Control	
Downlink Start	
Downlink End	
Downlink Sync	Refer to 4.2.1.4.2.1
Uplink 0	
Uplink 1	

TABLE IV (Continued)

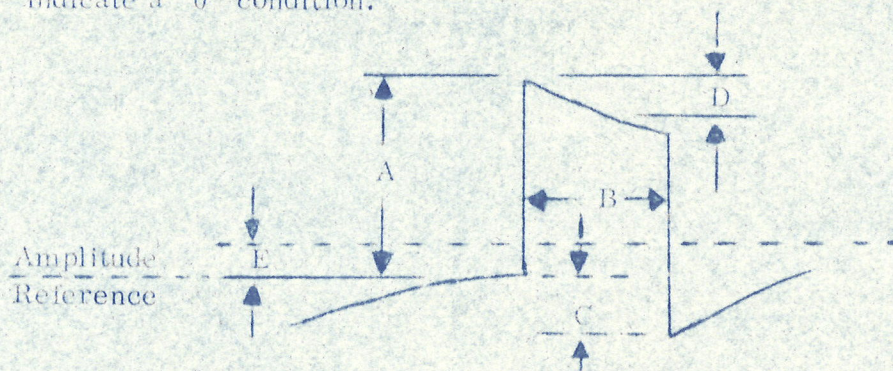
SIGNAL	CHARACTERISTICS
Translational Controller +x Command Translational Controller -x Command Translational Controller +y Command Translational Controller -y Command Translational Controller +z Command Translational Controller -z Command Rotational Controller + Pitch Command Rotational Controller - Pitch Command Rotational Controller + Roll Command Rotational Controller - Roll Command Rotational Controller + Yaw Command Rotational Controller - Yaw Command	Refer to 4.2.1.4.2.2
CGC Warning Lamp Circuit ISS Warning Lamp Circuit PGNS Warning Lamp Circuit	+28 S/C with warning lamps in series at 120 ma steady state, 1 amp peak for 10 msec allowed.
Warning Lamp Return	0 vdc S/C
-Yaw BMAG +Yaw BMAG -Pitch BMAG +Pitch BMAG -Roll BMAG +Roll BMAG	Refer to 4.2.1.4.2.3
Master Alarm +28 VDC Master Alarm Signal	+28.8±3.0 vdc 0±2 vdc
+Pitch/+x Sol DR Act -Pitch/+x Sol DR Act +Pitch/-x Sol DR Act -Pitch/-x Sol DR Act +Yaw/+x Sol DR Act -Yaw/+x Sol DR Act +Yaw/-x Sol DR Act -Yaw/-x Sol DR Act -Roll/+z Sol DR Act -Roll/+z Sol DR Act +Roll/-z Sol DR Act -Roll/-z Sol DR Act +Roll/+y Sol DR Act -Roll/+y Sol DR Act +Roll/-y Sol DR Act -Roll/-y Sol DR Act SPS Eng On/Off	10±0.5 vdc with 2K ohms in series

TABLE IV (Continued)

SIGNAL	CHARACTERISTICS
SIV B 28V	Refer to 4.2.1.4.2.4
SIV B 28V	Refer to 4.2.1.4.2.4
Control 1 (ACE)	Refer to 4.2.1.4.2.5
Control 2 (ACE)	Refer to 4.2.1.4.2.5
Inhibit Power Fail	28.8±3.0 vdc

4.2.1.4.2.1 Telemetry Signals. The signal characteristics shall be as follows:
 (Reference Figure 2)

- a. Amplitude (A): $4.5 \pm 1.0V$
- b. Pulse Width (B): $4.5 \pm 1.5 \mu\text{sec}$ at $A/2$
- c. Maximum Droop (D): 15 percent of A at $2 \mu\text{sec}$
- d. Maximum Risetime (10 to 99 percent of A): $0.2 \mu\text{sec}$
- e. Noise:
 - (1) During pulse transmission the signal plus noise shall remain within the envelope defined in a and b.
 - (2) During pulse absence the noise shall be between $+0.4V$ max and $-4.0V$ max with respect to the amplitude reference (See Figure 2).
- f. Presence of the pulse shall indicate a "1" condition. Absence of the pulse shall indicate a "0" condition.



PULSE DIAGRAM
 FIGURE 2

4.2.1.4.2.2 Controller Signals. The signal characteristics shall be as follows:

- a. "ON" Signal
 - (1) Voltage: $28 \pm 1V$ vdc
 - (2) Source Impedance: 3.9K ohms nominal - Rotational Controller
 1.95K ohms nominal - Translational Controller

b. "OFF" Signal

- (1) Voltage: +2, -5 vdc
- (2) Source Impedance: 100K ohms (minimum)

4.2.1.4.2.3 BMAG Signals. The signal characteristics shall be as follows: (Reference Figure 2)

- a. Amplitude (A): $7 \pm 3V$
- b. Pulse Width (B): 2 to 6 μsec at $A/2$
- c. Maximum Backswing (C): 4V
- d. Droop (D): 20 percent of A at 2 μsec
- e. Maximum Risetime (10 to 90 percent of A): 0.5 μsec
- f. Delta Angle: Each pulse appearing on the line shall represent $0.1^\circ \pm 8$ percent. The maximum pulse repetition rate shall be 640 pps.
- g. Noise:
 - (1) During pulse transmission the signal plus noise shall remain within the envelope defined in a and b.
 - (2) During pulse absence the noise shall be +0.4V max to -4.0V max with respect to the amplitude reference (See Figure 2).
- h. Presence of the pulse shall indicate a "1" condition. Absence of the pulse shall indicate a "0" condition.

4.2.1.4.2.4 SIVB Signals. An input of 28.8 ± 3.0 simultaneously supplied with the S/C Control of Saturn Signal.

4.2.1.4.2.5 ACE Bias Signals. A switchable ground shall be supplied to each input.

4.2.1.5 Test Equipment. The test equipment utilized or required by the respective JDC's shall be in accordance with Drawing 1900030.

4.2.1.5.1 Test Facility Alignment. The following alignment requirements shall be verified prior to subjecting the system to the operational test procedures. All requirements are given for the fixture in the X-axis vertical position.

4.2.1.5.1.1 Target No. 1

- a. The optical centerline of Target No. 1 shall be aligned to an azimuth of true north ± 1 arc minute.

- b. The optical centerline of Target No. 1 shall be aligned to be perpendicular to local vertical within ± 3 arc seconds.
- c. Target No. 1 shall be positioned laterally so that the target optical centerline is 1.20 ± 0.10 inches to the west of the mechanical axis of the sextant shaft measured horizontally in the plane of the fixture navigation base mounting pads.
- d. Target No. 1 shall be positioned in elevation so that the target optical centerline is within ± 0.10 inches to the mechanical axis of the sextant shaft measured vertically in the plane of the fixture navigation base mounting pads.

4.2.1.5.1.2 Target No. 2

- a. The optical centerline of Target No. 2 shall be aligned in azimuth to the optical centerline of Target No. 1 within ± 10 arc seconds.
- b. The optical centerline of Target No. 2 shall be aligned to be perpendicular to local vertical within ± 10 arc seconds.
- c. Target No. 2 shall be positioned laterally so that the target optical centerline is 7.05 ± 0.05 inches to the west of the optical centerline of Target No. 1 measured horizontally in the plane of the fixture navigation base mounting pads.
- d. Target No. 2 shall be positioned in elevation so that the target optical centerline is within ± 0.10 inches of the optical centerline of Target No. 1 measured vertically in the plane of the fixture navigation base mounting pads.

4.2.1.5.1.3 Target No. 3

- a. The optical centerline of Target No. 3 shall be aligned to an azimuth of $315^\circ \pm 1$ arc minute. The angle formed with the optical centerline of Target No. 1 shall be known within ± 4 arc seconds.
- b. The optical centerline of Target No. 3 shall be aligned to be perpendicular to local vertical within ± 10 arc seconds.
- c. Target No. 3 shall be positioned laterally so that the target optical centerline intersects the mechanical axis of the sextant shaft at a point 2.617 ± 0.10 inches south of the sextant trunnion.
- d. Target No. 3 shall be positioned in elevation so that the target optical centerline is within ± 0.10 inches of the optical centerline of Target No. 1 measured vertically in the plane of the fixture navigation base mounting pads.

4.2.1.5.1.4 Target No. 4

- a. The optical centerline of Target No. 4 shall be aligned to an azimuth of $315^\circ \pm 1$ arc minute. The angle formed with the optical centerline of Target No. 1 shall be known within ± 4 arc seconds.

- b. The optical centerline of Target No. 4 shall be aligned to be perpendicular to local vertical within ± 3 arc seconds.
- c. Target No. 4 shall be positioned laterally so that the target optical centerline intersects a vertical line perpendicular to and passing through the mechanical axis of the sextant shaft at a point 10.280 ± 0.100 inches north of the sextant trunnion axis.
- d. Target No. 4 shall be positioned in elevation so that the target optical centerline is 0.724 ± 0.100 inches below the optical centerline of Target No. 1 measured vertically in the plane of the fixture navigation base mounting pads.

4.2.1.5.2 Fixture. The G&N System Holding Fixture tilt axis shall be aligned in an east-west direction within ± 1 minute of arc.

4.2.1.5.3 Alignment Procedures

4.2.1.5.3.1 Optical Targets. The Optical Target alignment shall be in accordance with JDC 12223.

4.2.1.6 Test Data. All system test data shall be recorded on suitable reproducible forms and stored at the contractor's facility.

4.2.1.7 Test Values. Test values given in Section 3 of this specification may reflect allowances for instrumentation error, loads, or variation in supply voltages and frequencies.

4.2.1.8 Safety Precautions. Normal safety precautions required during testing of precision electromechanical equipment shall be followed.

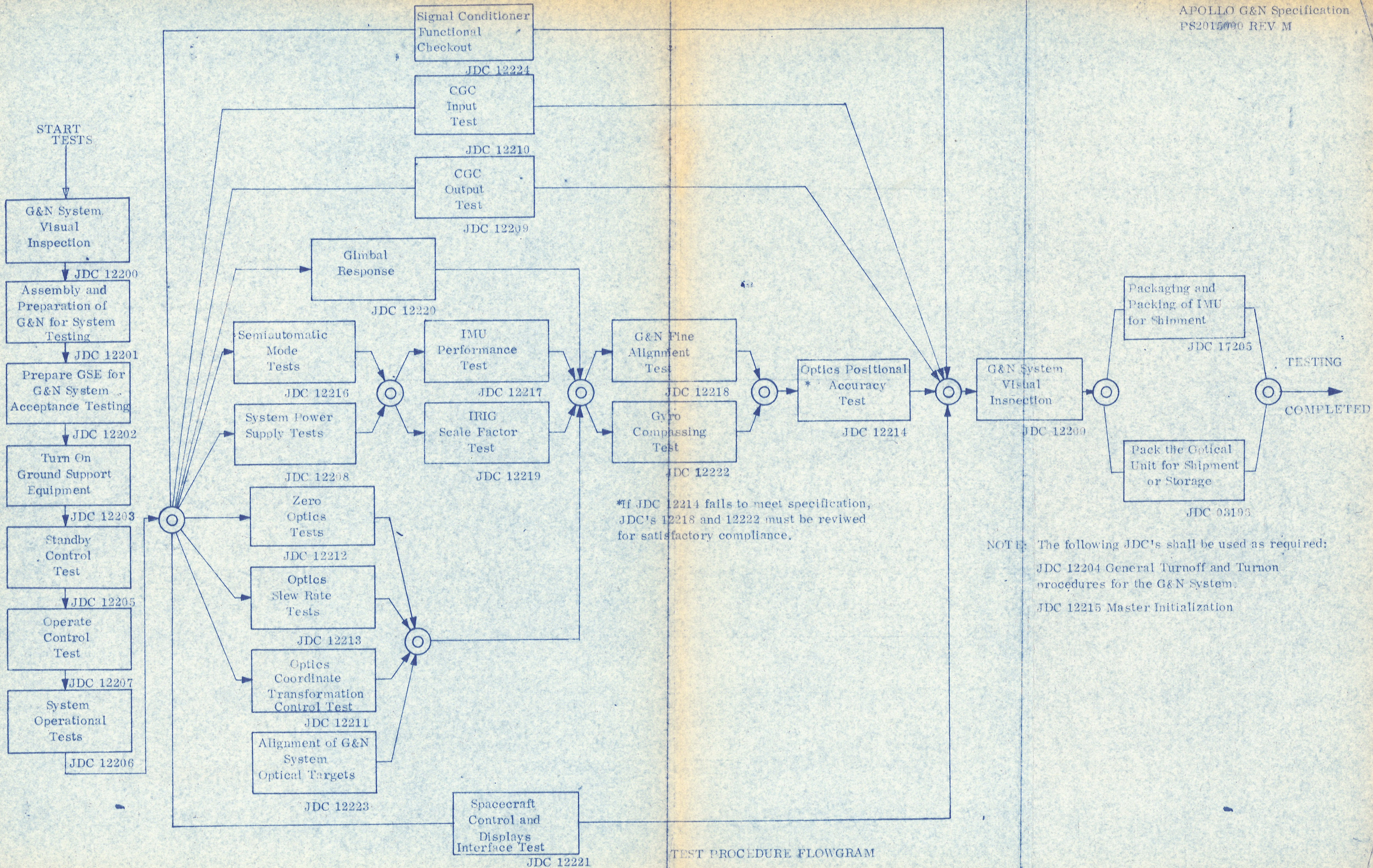
4.2.1.9 Operational Precautions

4.2.1.9.1 G&N System Turn-On. The following conditions shall be met prior to IMU power application.

4.2.1.9.1.1 Initial Turn-On. If the IMU has just been installed in the test fixture, CGC power shall be applied with the IMU Standby power for a minimum of two hours.

4.2.1.9.1.2 General Turn-On. If the IMU Operate power has been applied to the G&N System through normal JDC procedures specified in Figure 3 and the IMU gimbals have been positioned such that the PIPA and IRIG output axes are horizontal $\pm 1^\circ$ not in excess of twelve days or the IMU gimbals have been positioned such that the output axes are horizontal $\pm 5^\circ$ not in excess of five days, and the IMU gimbals have not been moved since parking, CGC power shall be applied with the IMU Standby power for a minimum of fifteen minutes.

4.2.1.9.2 G&N System Turn-Off. The following conditions shall be strictly adhered to prior to removal of G&N System power at the interface.



TEST PROCEDURE FLOWGRAM

FIGURE 3

4.2.1.9.2.1 Deleted.

4.2.1.9.2.2 Power Turn-Off Sequence. Upon G&N System power removal, the IMU Operate power shall be turned off first. The IMU Standby, Optics, and CGC power may then be turned off, in that order.

4.2.1.9.3 IMU Coolant Requirements. The IMU shall be provided with water-glycol coolant at a temperature of $45^{\circ} \pm 3^{\circ}\text{F}$ and a flow rate of 33 ± 3 lbs per hour.

4.2.1.9.4 PSA, CDU, PEA Header Temperatures. The headers shall be provided with coolant sufficient to maintain the header temperatures as follows:

- a. PSA: 54° to 72°F
- b. CDU: 52° to 83°F
- c. PEA: 40° to 60°F

4.2.1.9.5 Inertial Component Temperatures. Temperature of inertial components shall be maintained between the limits specified below. Noncompliance shall result in recalibration of the components.

- a. IRIG: 120°F and 150°F
- b. PIPA: 115°F and 145°F

4.2.1.9.6 Suspension Power. The CGC power and ISS Standby power shall not be off while torquing of the inertial components is taking place. Noncompliance shall result in degaussing and recalibration of the components.

4.2.1.9.7 Gimbal Lock. A Verb 36 shall not be entered into the DSKY unless the IMU Middle Gimbal is within the gimbal lock limits of $\pm 70^{\circ}$.

4.2.1.9.8 Inertial Component Performance Tests. The IMU Operate power must be applied for a minimum of one hour prior to performing JDC 12217, JDC 12218, JDC 12219 and JDC 12222.

4.2.1.10 Test Setup. Master Initialization, as required by the applicable JDC's, shall be accomplished in accordance with JDC 12215. The system assembly and the interconnection for testing shall be accomplished in accordance with the following procedures:

- JDC 12201
- JDC 12202
- JDC 12203

4.2.1.11 Test Limits. The initials of the individual performing the inspection shall be inserted in the space provided. If limits are not stated the individual performing the test shall place his initials in the space provided indicating that the requirements were met satisfactorily. Where a range of values is specified in this specification, the actual value at which the desired response occurs or the actual value which is obtained as an output will be recorded on the data sheet.

4.2.1.12 Test Sequence. The sequence of operations shall be as specified in Figure 3.

4.2.2 Nonconforming Units. Failure of the system to pass any examination or test of this specification shall automatically classify the unit as nonconforming. Each nonconforming unit corrected shall be reinspected. Reinspection may be limited to the test or examination which defined the nonconformance, or, when directed by the cognizant inspector, a complete retest and re-examination may be required. Nonconforming units which have not been corrected will be considered for acceptance only upon formal application by the contractor to the cognizant NASA representative.

4.3 TESTS

4.3.1 Applicable JDC's. The JDC's and their respective data sheets specified in the index of 4.1 form the acceptance test procedures of this specification.

5. PREPARATION FOR DELIVERY

5.1 GENERAL. Preparation for delivery shall be in accordance with Specification ND1002214, JDC 17205 (Packaging and Packing of IMU for Shipment), and JDC 03196 (Pack the Optical Unit for Shipment or Storage).

6. NOTES

6.1 DEFINITIONS AND ABBREVIATIONS