Newhouse.

FC027
7/7/67

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LUNAR MODULE SYSTEMS HANDBOOK, VEHICLE LM-1, AS-204/LM-1, REV C

JULY 7, 1967

SPECIAL NOTICE

DO NOT DISCARD REVISION A, DATED MARCH 16, 1967. REVISION A REFLECTS THE MANNED LM CONFIGURATION AND SHOULD BE RETAINED FOR REFERENCE PURPOSES UNTIL THE LM-2 SYSTEMS HANDBOOK IS PUBLISHED.

PREPARED BY

FLIGHT CONTROL DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

APOLLO

LUNAR MODULE SYSTEMS HANDBOOK

VEHICLE LM-1
REV C

PREFACE

This Rev C has been prepared by the Flight Control Division, Manned Spacecraft Center, Houston, Texas, with technical support by Grumman Aircraft Engineering Corporation (GAEC). This document is not a complete revision, but a page change update. Information contained within this document represents the LM-1 configuration as of July 7, 1967.

This document is intended for specialized use by Flight Controllers in real-time and near-real-time operations. Comments concerning the contents should be directed to Mr. James E. Hannigan, Lunar Module Systems Branch, Building 45, Room 438, Phone HU3-4626.

This document is not to be reproduced without the written approval of the Chief, Flight Control Division, Manned Spacecraft Center, Houston, Texas.

Approved by:

James E. Hannigan
Chief, Lunar Module Systems Branch

for David H. Owens
John D. Hodge
Chief, Flight Control Division

APOLLO

LUNAR MODULE SYSTEMS HANDBOOK

VEHICLE LM-1
REV C

REVISION INSTRUCTION SHEET

Update this document in accordance with the following instructions:

Remove and replace the following pages:

vii	6-16	9-3
3-1	6-17	9-4
3-2	6-18	9-5
3-3	7-1	9-6
3-7	7-2	9-7
3-8	7-3	9-8
3-13	7-6	9-11
4-1	7-8	9-15
4-2	7-10	9-16
4-3	7-11	9-17
4-4	7-12	9-18
4-5	8-1	10-4
4-8	8-2	13-2
4-9	8-3	13-8
4-10	8-5	13-10
4-11	8-6	13-11
6-4	8-7	13-15
6-5	8-10	13-16
6-10	8-13	13-49
6-12	8-14	13-50
6-13	8-15	
6-14	9-1	
6-15	9-2	

Add the following new pages:

iia	13-11e
iib	13-11f
3-12a	13-11g
3-13a	13-11h
3-13b	13-11i
3-13c	13-11j
3-13d	13-11k
4-4a	13-11l
13-11a	13-11m
13-11b	13-11n
13-11c	13-11o
13-11d	13-11p

Remove and replace the following drawings.

2.1.1
3.2.1
4.1.1
5.1.1
5.2.1
6.1.1 Sheet 1 of 3
6.1.1 Sheet 2 of 3
6.1.1 Sheet 3 of 3
6.3.1
6.3.2
6.3.3
6.3.4
6.3.5
6.3.6
6.3.7
6.3.8
6.3.9
7.2.1
7.3.1
7.4.1
7.5.1
8.1.1
8.2.1 Sheet 2 of 2
8.2.1 Sheet 1 of 2
8.3.1
8.4.1
9.1.1
9.2.1
9.4.1
9.5.1
13.1.1
15.1.1
16.1.1

Add the following new drawing:

9.3.1

TABLE OF CONTENTS (CONT'D)

* TABLE OF CONTENTS (CONT'D)

TABLE OF CONTENTS (CONCL'D)

LIST OF TABLES

LIST OF TABLES (Concluded)

NOTE: Additional tables are in front of drawings.

*

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE 2-1 CAPABILITIES AND LIMITATIONS

NO.	FUNCTION	COMPONENTS	SYSTEM A INITIATORS	SYSTEM B INITIATORS	
1	STAGING				
	EXPLOSIVE NUTS	FOUR NUTS	0	4	ONE INITIATOR PER NUT OR BOLT
	EXPLOSIVE BOLTS	FOUR BOLTS	4	0	
	ELECTRICAL CIRCUIT INTERRUPTERS	THREE INTERRUPTERS	3	3	TWO INITIATORS PER INTERRUPTER, ONE FROM SYSTEM A AND ONE FROM SYSTEM B, ONE INITIATOR CAN OPERATE THE INTERRUPTER
	CABLE CUTTER	ONE CUTTER	1	1	TWO OPPOSING BLADES, ONE POWERED BY SYSTEM A AND ONE POWERED BY SYSTEM B. TWO TUBES INTERCONNECT THE CHARGES BEHIND EACH BLADE SUCH THAT ONE INITIATOR CAN FIRE THE CHARGE BEHIND BOTH BLADES, ONE BLADE CAN SEVER THE INTERSTAGE UMBILICAL
2	RCS HE. PRESSURIZE				
	RCS SYSTEM A	TWO VALVES IN PARALLEL	1	1	VALVES ARE THE SINGLE INITIATOR TYPE PLACED IN PARALLEL, ONE VALVE WILL PRESSURIZE THE SYSTEM
	RCS SYSTEM B	TWO VALVES IN PARALLEL	1	1	
3	DESCENT ENGINE PRESSURIZE				
	HE. PRESS.	ONE VALVE	1	1	VALVE IS DUAL INITIATOR TYPE, ONE POWERED FROM SYSTEM A AND ONE FROM SYSTEM B, ONE INITIATOR WILL OPERATE THE VALVE
	OX ISOLATION VALVE	ONE VALVE	1	1	
	FUEL ISOLATION VALVE	ONE VALVE	1	1	
4	ASCENT ENGINE PRESSURIZE				
	HE. PRESS. TANK 1	ONE VALVE	1	1	
	HE. PRESS. TANK 2	ONE VALVE	1	1	
	OX ISOLATION VALVES	TWO VALVES IN PARALLEL	1	1	VALVES ARE DUAL INITIATOR TYPE WITH .ME PORT PLUGGED, WITH THE VALVES IN PARALLEL ONE IS POWERED FROM SYSTEM A AND THE OTHER IS POWERED FROM SYSTEM B, ONE VALVE WILL PRESSURIZE THE SYSTEM
	FUEL ISOLATION VALVES	TWO VALVES IN PARALLEL	1	1	

2.2 CAPABILITIES AND LIMITATIONS

A. THE PYRO SYSTEM HAS TWO 30 VOLT BATTERIES RATED AT 0.75 AMP HOURS, ONE FOR SYSTEM A AND ONE FOR SYSTEM B. BOTH PYRO BATTERIES ARE LOCATED IN THE DESCENT STAGE

TABLE 2-2 PRELAUNCH STATUS OF SWITCH/CIRCUIT BREAKER POSITION

NAME	NUMBER	POSITION
LANDING GEAR DEPLOY	251O PNL VIII	SAFE
STAGE	255 PNL VIII	SAFE
RCS PRESSURIZE	252 PNL VIII	SAFE
ASCENT He PRESSURIZE	254 PNL VIII	SAFE
ASCENT He SELECT	253 PNL VIII	BOTH
ABORT STAGE	1514 PNL 1	SAFE
MASTER ARM	257 PNL VIII	OFF
ABORT STAGE	4C82	CLOSED
ABORT STAGE	4C83	CLOSED
LOGIC POWER B	4CB75	CLOSED
LOGIC POWER A	4CB76	CLOSED

2.3 SYSTEM OPERATION

1. AT LEAST ONE PYRO BUS MUST BE ARMED FOR ANY PYRO FUNCTION TO OCCUR
2. THE PROPULSION SYSTEMS (DPS, APS,) WILL OPERATE PROPERLY FOR A SHORT TIME IN A PREPRESSURIZED BLOWDOWN MODE IF BOTH PYRO BUSES FAIL TO ARM., THE APPROXIMATE TIMES ARE:

DPS - 17 SEC
APS - 6 SEC

THE RCS SYSTEM WILL NOT OPERATE IN A PREPRESSURIZED BLOWDOWN MODE

TABLE 2-3 DESCENT STAGE FUNCTIONS LOST AT STAGING

ELECTRICAL CIRCUIT INTERRUPTER #1 (P174)

1. BAT 3 & 4 POWER
*2. ECA 1 & 2 POWER
3. DESCENT ENGINE CONTROL ASSY (DECA)
4. GIMBAL DRIVE ACTUATORS (PITCH & ROLL)
5. DESCENT ENGINE FUNCTIONS
6. OPERATIONAL TELEMETRY

GC0201V	BAT 1 VOLT	GH1301X	DPS ON
GC0202V	BAT 2 VOLT	GH1311V	MAN THRUST CMD
GC0203W	BAT 3 VOLT	GH1313W	PITCH GDA POS
GC0204V	BAT 4 VOLT	GH1314V	ROLL GDA POS
GC1201C	BAT 1 CUR	GH1323V	P TRM FAIL
GC1202C	BAT 2 CUR	GH1330X	R TRM FAIL
GC1203C	BAT 3 CUR	GH1331V	AUTO THRUST CMD
GC1204C	BAT 4 CUR	GH1348X	DPS ARM
GC4361X	BAT 1 HI TAP	GL4026X	CES AC PWR FAIL
GC4362X	BAT 1 LO TAP	GL4027X	CES DC PWR FAIL
GC4363X	BAT 2 HI TAP	GQ3018P	DPS He REG PRESS
GC4364X	BAT 2 LO TAP	GQ3435P	DPS He PRESS
GC4365X	BAT 3 HI TAP	GQ3603Q	DPS FUEL 1 QTY
GC4366X	BAT 3 LO TAP	GQ3604Q	DPS FUEL 2 QTY
GC4367X	BAT 4 HI TAP	GQ3611P	DPS FUEL PRESS
GC4368X	BAT 4 LO TAP	GQ4103Q	DPS OX 1 QTY
GC9961U	BAT 1 MAL	GQ4104Q	DPS OX 2 QTY
GC9962U	BAT 2 MAL	GQ4111P	DPS OX PRESS
GC9963U	BAT 3 MAL	GQ4455Q	DPS PROP LO
GC9964U	BAT 4 MAL	GY0111X	ED ARM A ON
		GY0112X	ED ARM B ON
		GY0121X	STG RLY A FIRE
		GY0122X	STG RLY B FIRE

ELECTRICAL CIRCUIT INTERRUPTER #2 (P173)

1. BAT 1 & 2 POWER
*2. ECA 1 & 2 POWER
3. LUNAR DRILL POWER
4. DESCENT ENGINE FUNCTIONS
5. DFI TELEMETRY
6. OPERATIONAL TELEMETRY

GQ3309X	DPS ME. 1 CLSD
GQ3310X	DPS ME. 2 OPN
GQ3718T	DPS FUEL 1 TEMP
GQ3719T	DPS FUEL 2 TEMP
GQ4218T	DPS OX 1 TEMP
GQ4219T	DPS OX 2 TEMP
GQ6510P	DPS TCP
GQ6806H	VAR INJ ACT POS
GQ7498U, GQ7499U	DPS PROP VLVS Δ POS

ELECTRICAL CIRCUIT INTERRUPTER #3 (L72)

1. DFI TELEMETRY
2. OPERATIONAL TELEMETRY
   GL4222X LM/SLA SEP

* POWER IS IN PARALLEL TO BOTH DESCENT ECAPS THROUGH ECPS 1 AND 2

2.4 COMPARISON OF AS-206 PGNCS AND PRA CONTROLLED ABORT STAGE SEQUENCES

THE SEQUENCE OF EVENTS ASSOCIATED WITH THE NOMINAL LM ABORT STAGE MANEUVER WILL BE FOLLOWED IN THE LM-1 (AS-206) MISSION UNDER PGNCS CONTROL. LM MISSION PROGRAMER (LMP) IMPLEMENTATION REQUIRES THAT THE TIMING OF THIS SEQUENCE BE MODIFIED SLIGHTLY FOR THE ABORT STAGE MANEUVER ACCOMPLISHED UNDER PROGRAM READER ASSEMBLY (PRA) CONTROL. THE TWO AS-206 CONTROL MODE SEQUENCES FOR ABORT STAGE ARE COMPARED IN TABLE 2-4. THE TIMING OF THE ASSOCIATED EVENTS IS BASED UPON THE ACTIVATION OF THE ABORT STAGE COMMAND FOR EACH CASE; HOWEVER, FOR THE PRA CONTROL MODE, THE TAPE FRAME INCREMENTS ARE ALSO INDICATED FOR THOSE FUNCTIONS DISCRETELY COMMANDED BY THE PRA. IT SHOULD BE NOTED THAT THE ONLY VARIATIONS WHICH EXIST BETWEEN THE TWO MODES ARE THE ABSENCE OF LGC ASSOCIATED FUNCTIONS AND A 26 ms LAG IN ARMING THE ASCENT ENGINE AND A.E. THRUST BUILD-UP TO 90 PER CENT IN THE PRA MODE. IN ALL OTHER RESPECTS, THE TWO SEQUENCES ARE IDENTICAL.

TABLE 2-4

COMPARISON OF AS-206 PGNCS AND PRA CONTROLLED ABORT STAGE SEQUENCES

EVENT	PGNCS SEQ TIME	PRA SEQ TIME
ABORT STAGE INITIATED ASCENT ENGINE PRESSURIZATION INITIATED	-1	-1
ASCENT HELIUM PRESSURIZATION TANK VALVES AND ISOLATION VALVES OPENED	-.97	-.97
ABORT STAGE FIRE INITIATED ASCENT ENGINE START DELAY TIMER INITIATED	0 SEC	0 SEC
LGC RECEIVES "ABORT STAGE" DISCRETE AND STARTS ABORT ASCENT PROGRAM LGC CONTINUED "ENGINE ON" COMMAND THRU STAGING	.009	NA
DESCENT ENGINE SHUTDOWN INITIATED BY DECA	.025	.025
DESCENT BATTERIES OFF LINE	.070	.070
LGC RECOGNIZES ABORT STAGE DISCRETE LGC STARTS LM ATTITUDE HOLD LGC STARTS COMPUTATION OF NEW AIMPOINT FOR THRUST VECTOR ASCENT STAGE CONTROL AND STARTS NEW GUIDANCE LAW	.140	NA
PRA INITIATED DESCENT ARM OFF	NA	.250
DESCENT ENGINE THRUST DECAYED 90% (MAXIMUM TIME)	.275	.275
ASCENT ENGINE ARMED	.412	NA
ASCENT ENGINE START INITIATED ASCENT/DESCENT STAGING INITIATED (ASCENT ENGINE ARMED) (ASCENT ENGINE START INITIATED)	NA NA	.412 .438
ASCENT/DESCENT STAGE INTERSTAGE BOLTS PYROTECHNICALLY EXPLODED ASCENT/DESCENT STAGE CONNECTING UMBILICAL DEADFACED ON ASCENT STAGE	.448	.448
ASCENT/DESCENT STAGE UMBILICAL SEVERED BY GUILLOTINE LGC RECEIVES STAGE VERIFIED DISCRETE	.502	.502 NA
ASCENT ENGINE THRUST BUILD UP TO 90% (MINIMUM TIME)	.687	.713
LGC INITIATED DESCENT ENGINE ARM OFF	1.140	NA
LGC TERMINATES LM ATTITUDE HOLD LGC COMMENCES ASCENT STAGE THRUST VECTOR CONTROL	4.140	NA NA

DWG NO. 2.1.1
DETAIL SHEET NO. 1

LTR	ZONE	REVISION	DATE	APPROVAL
G				

ABORT STAGE SW 1-S-14 PNL I

ABORT STAGE RESET

ABORT STAGE RESET

ABORT STAGE FIRE RESET

ABORT STAGE FIRE RESET

4CB3 3A ABORT STAGE PNL XI

V_{28CDR}

SAFE / FIRE

K0205A1

K0254A1

K0257A1

K0206A1

1K19

SH128X ABORT STAGE "1" FIRE / "0" SAFE

1. STARTS ABORT STAGE PROGRAM IN LGC AND AGS
2. SWITCHES TO ASCENT ELECTRICAL POWER
3. ARMS ASCENT ENGINE
4. SETS LOGIC TO ACCEPT ENGINE FIRE COMMAND

8.3.1

4CB3 3A ABORT STAGE PNL XVI

V_{28SE}

K0205A2

K0254A2

K0257A2

K0206A2

1. STARTS ABORT STAGE PROGRAM IN LGC AND AGS
2. SWITCHES TO ASCENT ELECTRICAL POWER
3. SETS LOGIC TO ACCEPT ENGINE FIRE COMMAND
4. SHUTDOWN DESCENT ENGINE

8.4.1

8.3.1

ABORT STAGE FIRE

ABORT STAGE FIRE

4CB75 5A LOGIC POWER B PNL XVI

V_{28SE}

PYROTECHNIC SYSTEM B

4CB76 5A LOGIC POWER A PNL XI

V_{28CDR}

MASTER ARM SW 2-S-7 PNL VIII

OFF / ON

K0205B1

K0254B2

K0201A1

K0251A1

K0201A2

W0251A2

MASTER ARM OFF

MASTER ARM OFF

MASTER ARM ON

MASTER ARM ON

PYRO BAT A .75 AH

PYRO A

STAGE SW 2-S-5 PNL VIII

SAFE / FIRE

ABORT STAGE ARM

ABORT STAGE ARM

K1

K2

MASTER ARM

GSE

SY0112 SB ARM B ON

SY0111 SB ARM A ON

SY0122 STG RLY B FIRE

SY0121 STG RLY A FIRE

"1" = SAFE "0" = FIRE

V_{28} PYRO A

ASCENT ENG ON

8.4.1

K2

STAGE

GSE INST

2.1.1

V_{28PA}

F13

SQ16

PYRO A

TIME DELAY (50 MS)

STAGE SEQUENCE

K3

CABLE CUTTER

K4

F3

F2

SQ8

SQ9

QUAD 1

QUAD 3

STAGING BOLTS

K5

F1

F4

SQ10

SQ7

QUAD 2

QUAD 4

STAGING BOLTS

K5A

F5

F6

F19

SQ6

SQ5

SQ17

ELECTRICAL CIRCUIT INTERRUPTERS

K6

GV0102 EED CONT SYS B

GV0101 EED CONT SYS A

GV0103 STAGING RELAY CLOSED

SYS A

GV0104 STAGING RELAY CLOSED

SYS B

V_{28PA}

F10

F22

F23

SQ11

SQ20

SQ21

He PRESS

RCS ISOLATION VALVE

FUEL ISOLATION VALVE

PYRO A

GSE

DESCENT ENGINE ON

TO K1 K2 K3 K4

K9

DESCENT ENGINE

8.3.1

RCS PRESS RESET

RCS PRESS RESET

RCS PRESS SW 2-S-2 PNL VIII

SAFE / FIRE

K0208A1

K0252A1

RCS PRESS FIRE

RCS PRESS FIRE

V_{28PA}

F9

F10

SQ2

SQ1

He SUP A

He SUP B

PYRO A

K7

RCS He PRESS

ASC He PRESS SW 2-S-4 PNL VIII

SAFE / FIRE

ASC He SEL SW 2-S-3 PNL VIII

BOTH / TANK 1 / TANK 2

K0255A1

APS He 1 INHIBIT

APS He 2 INHIBIT

K0256A1

GSE

V_{28PA}

F7

F8

SQ4

SQ3

PYRO A

TANK 1 ASCENT ENG He PRES

TANK 2 ASCENT ENG He PRESS

K10

K11

GSE

V_{28PA}

F20

F21

SQ18

SQ19

OX ISOLATION VALVE

FUEL ISOLATION VALVE

PYRO A

ASCENT ENGINE

K12

GSE

GY 0201X EED RELAY SYS A

GSE

GY 0202 EED RELAY SYS B

GSE

NOTE: PYROTECHNIC SYSTEM B IS IDENTICAL TO PYROTECHNIC SYSTEM A. ALL PRIME AND RTC RELAYS IN SYS A HAVE COUNTERPARTS IN SYS B WHICH ARE ACTUATED BY THE SAME COMMAND. ALL SWITCHES SHOWN HAVE ONE SET OF CONTACTS FOR SYS A AND ONE SET FOR SYS B. ALL PYRO BATTERIES ARE LOCATED IN THE DESCENT STAGE.

PYRO

SIGNATURES	DATE
DR	
ENG	11/14/67
CH	11/14/67
APP	
AUTH	11/14/67

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER - HOUSTON, TEXAS

PYROTECHNIC SYSTEM SCHEMATIC

LM / LM-T

SIZE E

DWG NO. 2.1.1

SCALE

SHEET 1 OF 1

3.1 SYSTEM DESCRIPTION

3.1.1 LM DC Electrical System

A. The LM dc electrical system consists of six silver zinc primary batteries, four Electrical Control Assemblies (ECA), and two dc buses (commander's and system engineer's).

B. Four of the primary batteries and two ECA's are located in the descent stage. A low voltage tap is provided at the 17 cell point of each 20 cell descent battery, but is disconnected. The high voltage battery tap is wired to the low voltage terminal on each ECA such that the LV contactors are used to connect the batteries to the buses. To avoid over voltage conditions due to using all 20 cells, the descent batteries will be installed predischarged from the nominal 400 amp-hr rating to 350 amp-hrs. Battery No. 1 is tied to the SE bus and Batteries 2, 3, and 4 are tied to the CDR bus. R-C

C. Two of the LM primary batteries and two ECA's are located in the ascent stage. To avoid overvoltage conditions and to supress transients, the ascent batteries may be installed predischarged from the nominal 300 amp-hr rating to 250 amp-hrs. R-C

3.1.2 LM AC Electrical System

The LM ac electrical system consists of two single phase ac inverters and one ac bus, and is located in the ascent stage. Only one of the ac inverters will supply power to the ac bus at any given time.

*

TABLE 3-1 LM-1 LOAD ANALYSIS

SYSTEM	WATTS	DC AMPS AT 30 VDC	ON AT ALL TIMES
ELECTRICAL			
ELECTRICAL CONTROL ASSEMBLY (DESCENT)	20.0	0.67	NO
ELECTRICAL CONTROL ASSEMBLY (ASCENT)	10.0	0.33	YES
METERS & FLAGS (DESCENT AND ASCENT)	4.5	0.15	NO
METERS & FLAGS (ASCENT)	3.5	0.11	NO
INVERTER LOSSES (EFF = 65%) (BURN)	45	1.5	NO
(COAST)	40	1.33	NO
ENVIRONMENTAL			
GLYCOL PUMPS (2)	61.0	2.02	YES
COMMUNICATIONS			
S-BAND XMTR/RCVR	36	1.20	NO
S-BAND PWR AMP	72	2.4	NO
SIG PROC ASSY	15.5	0.52	R-C
INSTRUMENTATION			
PCMTE	11	0.37	YES
C&WEA	13.6	0.45	YES
SIG COND UNITS	30.7	1.02	YES
SENSORS (DESCENT AND ASCENT)	14.5	0.48	NO
SENSORS (ASCENT)	10.5	0.35	YES
C-BAND BEACON (2)	56.0	1.87	YES
VHF XMTRS (5)	280	9.3	YES
DFI (EXCEPT XMTRS)	311	10.4	YES
DUAL FEED COUPLER	1.5	0.05	YES
PROGRAMER			
PRA	23	.71	NO
DCA	15.0	0.50	YES
PCA	14	0.47	NO
GUIDANCE			
IMU	300.0	10.0	YES
LGC	110.0	3.67	YES

*

TABLE 3-1 LM-1 LOAD ANALYSIS (CONCLUDED)

SYSTEM	WATTS	DC AMPS AT 30 VDC	ON AT ALL TIMES
CONTROL			
DECA	10.5	0.35	YES
DECA (AC)	6.3	0.11	YES
GIMBAL DRIVE ACTUATORS (AC)	80	2.67	NO
ATCA	42	1.4	YES
S&C CONT ASSY	5.2	0.17	YES
PROPULSION			
ASCENT ENG PROP VALVE	200.0	6.67	NO
ASCENT ENG ISOL REG SOL VALVE	56.0	1.87	NO
ASCENT ENG GAGING	1.0	0.03	NO
DESCENT ENG ISOL REG SOL VALVE	56.0	1.87	NO
DESCENT ENG GAGING	12.7	0.42	NO
THROTTLE ACT AMP	90	3.0	NO

DESCENT ENG S/O VALVE	60	2.0	NO
DESCENT ENG PRE-VALVE	85	2.8	NO
RCS			
THRUST CHAMBER ASSY	112 PER TCA	3.74 PER TCA	NO
ASCENT INTERCONNECT VALVE	70 PER VLV	2.33 PER VLV	NO
MAIN PROP SOV	70 PER VLV	2.33 PER VLV	NO
CLUSTER SOL VALVE	70 PER VLV	2.33 PER VLV	NO
CROSSFEED VALVE	70 PER VLV	2.33 PER VLV	NO
THUSTER PRESS. TRANSDUCER	4.5	0.15	NO
PROP QTY GAGING	1.0	0.03	YES
THRUSTER HEATERS (MAX)	764	25.5	NO
(AVG)	190	6.3	NO
TYPICAL POWER LOADS			
COAST	55.1 AMPS		
DPS BURN	70.1 AMPS		
APS BURN	61.8 AMPS		

R-C

*

TABLE 3-2 COMMANDER'S BUS CIRCUIT BREAKER TABULATIONS (PANEL XI)

SYSTEM	CIRCUIT BREAKER	RATING	NOMENCLATURE	
PYROTECHNICS	4CB76	3A	LOGIC PWR A	
	4CB149	3A	LDG GEAR FLAG	
ELECTRICAL	4CB129	3A	DOCK WINDOW (HEATER)	
	4CB6	3A	ASC ECA CONT	
	4CB8	3A	DES ECA CONT	
	4CB10	3A	DES ECA	
	4CB15	3A	ASC ECA	
	4CB12	25A	INV 1	
	4CB4	50A	X LUNAR BUS TIE	R-B
	4CB184	25A	BAL LOAD CROSS TIE	
	4CB20	100A	BUS CROSS TIE	
	4CB18	100A	BAT FEED TIE	R-B
	4CB26	100A	BAT FEED TIE	
ENVIRONMENTAL	4CB107	5A	CABIN FAN 1	
	4CB138	20A	SUIT FAN 1	
	4CB117	3A	GLYCOL PUMP 1	
	4CB141	3A	GLYCOL PUMP 2	
COMMUNICATIONS	4CB137	5A	SEC S-BND XMTR/RCVR	R-B
	4CB136	5A	SEC S-BND PWR AMPL	
	4CB86	3A	CDR AUDIO	
	4CB87	3A	VHF A RCVR	
	4CB162	3A	VHF B XMTR	
INSTRUMENTATION	4CB131	3A	SIG CONDR 1	
	4CB22	3A	DC BUS VOLT	
	4CB181	50A	R/D INST	
PROGRAMER	4CB179	50A	LMP FEED	R-B
GUIDANCE	4CB122	7.5A	LGC/DSKY	
(PRIMARY)	4CB105	10A	LDG RDR	
	4CB157	3A	LDG RDR (HEATER)	
	4CB124	20A	IMU OPR	
	4CB155	5A	RDR OPR (HEATER)	R-B
	4CB156	5A	RNDZ STBY (HEATER)	
	4CB29	15A	RNDZ RDR	
	4CB213	3A	AOT (HEATER)	
	4CB154	3A	SIG STR DISP	
	4CB161	3A	IMU STBY	

R-B

TABLE 3-3 SYSTEMS ENGINEERS BUS CIRCUIT BREAKER TABULATIONS (PANEL SVI) (Concluded) R-B

SYSTEM	CIRCUIT BREAKER	RATING	NOMENCLATURE	
CONTROL	4CB37	3A	ENGINE ARM	
	4CB41	7.5A	AELD	R-B
	4CB82	7.5A	ATCA	
	4CB2	3A	ABORT STAGE	
PROPULSION	4CB50	3A	TEMP/PRESS/DISP FLAGS	
	4CB49	5A	ISOL VLV-B	
	4CB45	15A	QUAD 1 TCA-B	
	4CB44	15A	QUAD 2 TCA-B	R-B
	4CB43	15A	QUAD 3 TCA-B	
	4CB42	15A	QUAD 4 TCA-B	
	4CB54	5A	CROSSFEED	
	4CB73	5A	MAIN SOV-B	
	4CB52	5A	ASC FEED	
	4CB121	3A	PQGS (RCS)	R-C
	4CB68	3A	DISPLAY (HEATER)	R-B
	4CB53	5A	ASC HE. REG	
	4CB103	3A	TEMP/PRESS. DISPLAY	
	4CB32	3A	PQGS (DES)	R-C
(HEATERS)	4CB222	7.5A	QUAD 1 RCS SYS A/B-2	
	4CB223	7.5A	QUAD 2 RCS SYS A/B-2	R-B
	4CB224	7.5A	QUAD 3 RCS SYS A/B-2	
	4CB225	7.5A	QUAD 4 RCS SYS A/B-2	
MISC	4CB126	3A	FDAI	
(FLIGHT DISPLAYS)	4CB134	3A	X-POINTER	
LIGHTING	4CB128	5A	FLOOD	
	4CB147	5A	MASTER ALARM	R-B
	4CB160	15A	TRACK	R-C
	4CB148	3A	ANUN/DOCK/COMPNT	
CREW PROVISIONS	4CB33	3A	CAMERA SEQUENCE	

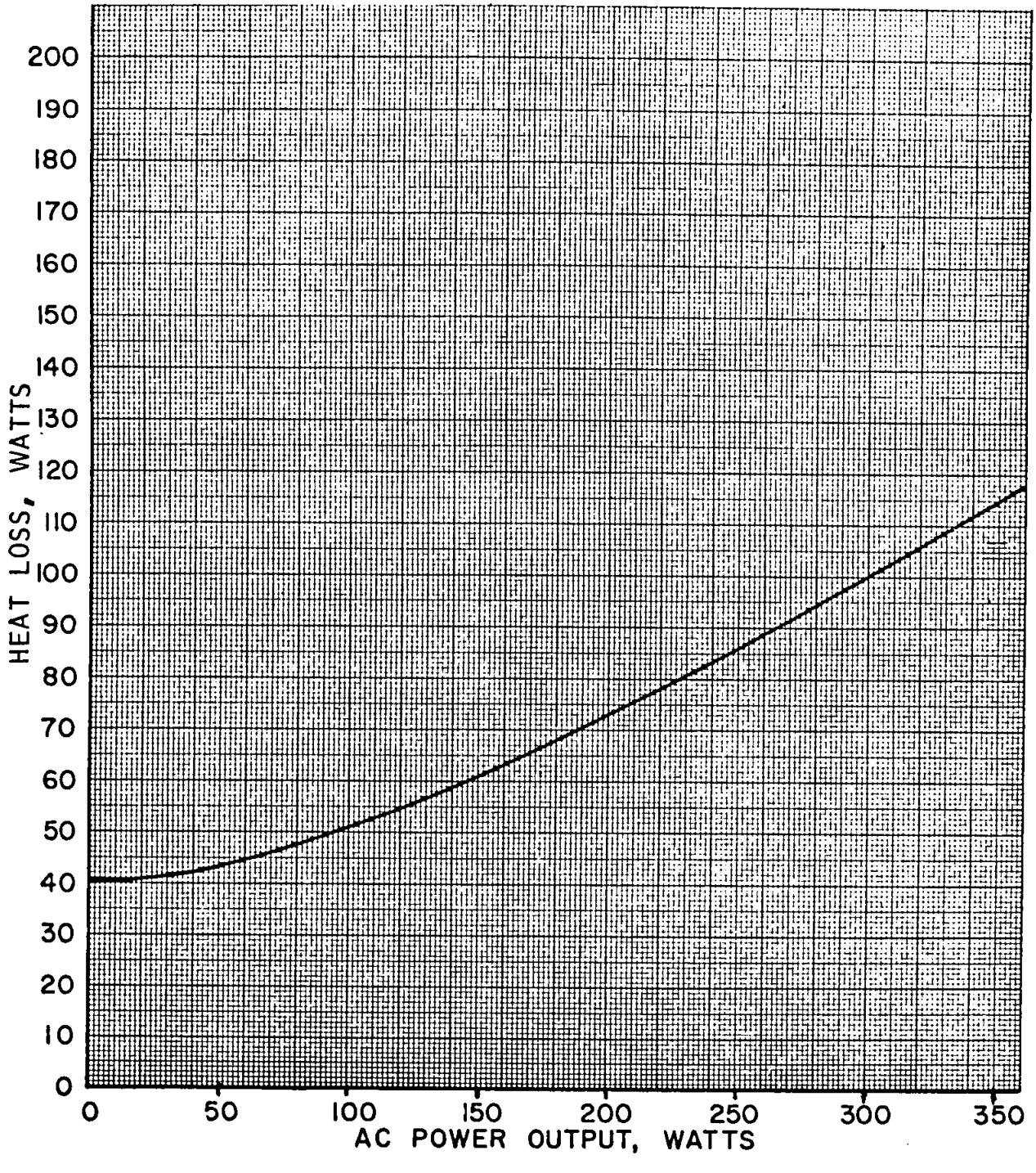
*

TABLE 3-4 AC BUS CIRCUIT BREAKER TABULATIONS (PANEL XI) R-B

SYSTEM	CIRCUIT BREAKER	RATING	NOMENCLATURE	
ELECTRICAL	4CB144	3A	CDR WINDOW (HEATER)	R-B
	4CB152	3A	S.E. WINDOW (HEATER)	
	4CB23	5A	AC BUS FEED TIE	
	4CB24	5A	AC BUS FEED TIE	
COMMUNICATIONS	4CB34	1A	S-BAND ANT	
INSTRUMENTATION	4CB202	3A	TAPE RCDR	
	4CB27	1A	AC BUS VOLT	
GUIDANCE	4CB203	3A	AGS	
	4CB212	3A	AOT LAMP	
	4CB206	3A	RNDZ RDR	
CONTROL	4CB207	3A	DECA GIMBAL	
PROPULSION	4CB169	3A	HE/PQGS DISP	R-C
MISC	4CB201	3A	GASTA	
(FLIGHT DISPLAY'S)	4CB209	1A	CDR FDAI	
	4CB204	3A	RNG/RNG RT ALT/ALT RT	
	4CB210	1A	SE FDAI	
LIGHTING	4CB211	3A	INTGL	
	4CB200	3A	NUM	

R-B

LM-1
REV C
NEW PAGE



DC POWER INPUT = AC POWER OUTPUT + HEAT LOSS

Figure 3-2 Inverter Heat Loss

TABLE 3-8

LM-1 CIRCUIT BREAKER TABULATION

CIRCUIT BREAKER (WCB)	RATING (AMP)	NOMENCLATURE	SYSTEM				BUS				PRELAUNCH
			ELEC/COMM	ENVIR	GUID & CONT	PROP	X_L[a]	CDR	SE	AC	
1	3	SIG CONDR 2	INST						X		C
2	3	ABORT STAGE			CONTROL				X		C
3	3	ABORT STAGE			CONTROL			X			C
4	50	X-LUNAR BUS TIE	EPS				X	X			C
5	50	X-LUNAR BUS TIE	EPS				X		X		C
6	3	ASC ECA CONT	EPS					X			C
7	3	ASC ECA CONT	EPS						X		C
8	3	DES ECA CONT	EPS					X			C
9	3	DES ECA CONT	EPS						X		C
10	3	DES ECA	EPS				X	X			C
11	3	DES ECA	EPS				X		X		C
12	25	INV 1	EPS					X			O
13	25	INV 2	EPS						X		O
14	3	ASC ECA	EPS						X		C
15	3	ASC ECA	EPS					X			C
16	3	DISPLAY	EPS						X		O
17[xx]	100	BAT. FEED TIE	EPS						X		C
18[xx]	100	BAT. FEED TIE	EPS					X			C
19	100	BUS CROSS TIE	EPS						X		O
20	100	BUS CROSS TIE	EPS					X			O
21	3	DC BUS VOLT	INST						X		C
22	3	DC BUS VOLT	INST					X			C
23	5	AC BUS FEED TIE	EPS							X	C
24	5	AC BUS FEED TIE	EPS							X	C
25[xx]	100	BAT. FEED TIE	EPS						X		C
26[xx]	100	BAT. FEED TIE	EPS					X			C
27	1	AC BUS VOLT	INST							X	C
28	10	AEA			GUID (ABORT)				X		O
29	15	RNDZ RDR			GUID (PRI)			X			O
30	5	PRIM S-BAND PWR AMPL	COMM						X		C
31	3	S-BAND ANT (HEATER)	COMM				X		X		O
32	3	PQGS				PROP			X		C
33	3	CAMERA SEQUENCE		CREW PROV					X		O
34	1	S-BAND ANT	COMM							X	O
35	3	ANT TRNFR A	EPS					X			C
36	3	ANT TRNFR B	EPS					X			C
37	3	ENG ARM			CONTROL				X		C
40	7.5	AELD			CONTROL			X			C
41	7.5	AELD			CONTROL				X		C
42	35	QUAD 4 TCA -B				PROP			X		C
43	15	QUAD 3 TCA -B				PROP			X		C
44	15	QUAD 2 TCA -B				PROP			X		C
45	15	QUAD 1 TCA -B				PROP			X		C
49	5	ISOL VLV -B				PROP			X		C
50	3	TEMP/PRESS./DISP FLAG				PROP			X		O
51	5	ASC FEED				PROP		X			C
52	5	ASC FEED				PROP			X		C
53	5	ASC HE. REG				PROP			X		C
54	5	CROSS FEED				PROP			X		C
59	15	ATT DIR CONT			CONTROL			X			O

CIRCUIT BREAKER (WCB)	RATING (AMP)	NOMENCLATURE	SYSTEM				BUS				PRELAUNCH
			ELEC/COMM	ENVIR	GUID & CONT	PROP	X_L[a]	CDR	SE	AC	
60	15	QUAD 4 TCA -A				PROP		X			C
61	15	QUAD 3 TCA -A				PROP		X			C
62	15	QUAD 2 TCA -A				PROP		X			C
63	15	QUAD 1 TCA -A				PROP		X			C
67	5	ISOL VLV -A				PROP		X			C
68	3	DISPLAY (HEATER)				PROP			X		O
69	20	DECA PWR			CONTROL			X			C
72	5	MAIN SOL -A				PROP		X			C
73	5	MAIN SOL -B				PROP			X		C
74	5	DES HE. REG				PROP		X			C
75	3	LOGIC PWR B	PYRO						X		C
76	3	LOGIC PWR A	PYRO					X			C
79	20	ASA			GUID (ABORT)		X		X		O
80	3	DES ENG CONT ASSY			CONTROL			X			C
81	3	ATCA (PNGS)			CONTROL			X			C
82	7.5	ATCA			CONTROL				X		C
84	3	CO_2 SENSOR		ECS					X		O
85	3	SE AUDIO	COMM						X		O
86	3	CDR AUDIO	COMM					X			O
87	3	VHF A RCVR	COMM					X			O
88	3	GASTA		FLT DISP				X			O
96	3	GLYCOL PUMP SEC		ECS					X		C
97	3	FDAI		FLT DISP				X			C
98	5	PRI GLYCOL EVAP FLOW		ECS					X		O
99	3	CWEA	INST						X		C
102	3	PMP	COMM						X		C
103	5	TEMP/PRESS. DISPLAY				PROP			X		O
104	3	TV	COMM						X		O
105	10	LDG RDR			GUID (PRI)			X			O
106	3	ENG FIRE OVRD			CONTROL			X			C
107	5	CABIN FAN 1		ECS				X			O
108	5	CABIN FAN 2		ECS					X		O
109	3	CABIN FAN CONT		ECS					X		O
110	3	S-BAND ANT	COMM						X		O
111	5	PRIM S-BAND XMTR/RCVR	COMM						X		C
112	3	DIVERT VLV		ECS					X		O
113	3	CABIN REPRESS.		ECS					X		O
114	3	VHF B RCVR	COMM						X		O
115	3	VHF A XMTR	COMM						X		O
117	3	GLYCOL PUMP 1		ECS				X			C
119	20	SUIT FAN 2		ECS					X		O
120	3	SUIT FAN CONT		ECS					X		O
121	3	PQGS (RCS)				PROP			X		O
122	7.5	LGC/DSKY			GUID (PRI)			X			C
123	3	RNG/RNG RT-ALT/ALT RT		FLT DISP				X			O
124	20	IMU OPR			GUID (PRI)		X	X			C
125	3	PCMTE	INST						X		C
126	3	FDAI		FLT DISP					X		O
128	5	FLOOD		LIGHTING			X		X		O
129	3	DOCK WINDOW (HEATER)	EPS					X			O
131	3	SIG CONDR 1	INST					X			C

CIRCUIT BREAKER (WCB)	RATING (AMP)	NOMENCLATURE	SYSTEM				BUS				PRELAUNCH
			ELEC/COMM	ENVIR	GUID & CONT	PROP	X_L[a]	CDR	SE	AC	
132	3	SIG SENSOR	INST						X		C
133	3	X-PNTR		FLT DISP				X			O
134	3	X-PNTR		FLT DISP					X		O
136	5	SEC S-BAND PWR AMPL	COMM					X			C
137	5	SEC S-BAND XMTR/RCVR	COMM					X			C
138	20	SUIT FAN 1		ECS				X			O
140	3	DISP		ECS					X		O
141	3	GLYCOL PUMP 2		ECS				X			C
144	3	CDR WINDOW (HEATER)	EPS							X	O
146	3	AMVN DOCK/COMPNT		LIGHTING			X	X			O
147	5	MASTER ALARM		LIGHTING					X		O
148	3	AMVN/DOCK/COMPNT		LIGHTING					X		O
149	3	LDG GEAR FLAG	PYRO					X			O
152	3	SE WINDOW (HEATER)	EPS							X	O
153	3	DISPLAY	COMM						X		O
154	3	SIG STR DISP			GUID (PRI)			X			O
155	5	RDR OPR (HEATER)			GUID (PRI)		X	X			O
156	5	RNDZ STBY (HEATER)			GUID (PRI)			X			O
157	3	LDG RDR (HEATER)			GUID (PRI)		X	X			C
159	3	EVENT TIMER		FLT DISP				X			O
160	25	TRACK		LIGHTING					X		O
161	3	IMU STBY			GUID (PRI)		X	X			C
162	3	VHF B XMTR	COMM					X			O
168	3	THRUST DISP		FLT DISP				X			O
169	3	HE./PQGS DISP				PROP				X	O
179[xx]	50	LMP FEED				PROP		X			C
181	50	R/O INST	INST					X			C
182	50	SCIENTIFIC EQUIP (DESC)	EPS						X		O
183	25	BAL LOAD CROSS TIE	EPS						X		C
184	25	BAL LOAD CROSS TIE	EPS					X			C
200	3	NUM		LIGHTING						X	O
201	3	GASTA		FLT DISP						X	O
202	3	TAPE RCDR	INST							X	O
203	3	AGS			GUID					X	O
204	3	CDR FDAI		FLT DISP						X	O
206	3	RNDZ RDR			GUID					X	O
207	3	DECA GIMBAL			CONTROL					X	C
209	1	CDR FDAI		FLT DISP						X	O
210	1	SE FDAI		FLT DISP						X	O
211	3	INTGL		LIGHTING						X	O
212	3	AGS			GUID					X	O
213	3	AOT (HEATER)			GUID (PRI)						O
218	7.5	QUAD 1 RCS SYS A/B-1				PROP		X			C
219	7.5	QUAD 2 RCS SYS A/B-1				PROP		X			C
220	7.5	QUAD 3 RCS SYS A/B-1				PROP		X			C
221	7.5	QUAD 4 RCS SYS A/B-1				PROP		X			C
222	7.5	QUAD 1 RCS SYS A/B-2				PROP			X		C
223	7.5	QUAD 2 RCS SYS A/B-2				PROP			X		C
224	7.5	QUAD 3 RCS SYS A/B-2				PROP			X		C
225	7.5	QUAD 4 RCS SYS A/B-2				PROP			X		C

R-C

R-C

R-C

R-C

R-C

[a] X_L - TRANSLUNAR BUS (THE EPS RETURNS ASSOCIATED WITH THE FOLLOWING CB ARE CONNECTED TO THE X_L)

[xx] CIRCUIT BREAKERS ARE SLUGGED.

TABLE 3-9- LM-1 SWITCH TABULATION

SYSTEM	SWITCH/ CONTROL	SW/CONT NOMENCLATURE	PANEL											PRELAUNCH CONDITION	POSITIONS	
			I	II	III	IV	V	VI	VIII	X	XII	XIV	ECS CONT		TYPE & POS. TITLES	TYPE OF CLOSURE
ENGINE THRUST CONTROL	1-S-1	ENGINE ARM	X											OFF	3-POS. TOGGLE ASC/OFF/DES	LOCK/LOCK/LOCK
	1-S-2	ENGINE START					X							OUT	PUSH BUTTON IN: START	MAIN
	1-S-3	ENGINE STOP (CDR)					X							OUT	PUSH BUTTON IN: STOP	MAIN
	1-S-4	ENGINE STOP (SE)						X						OUT	PUSH BUTTON IN: STOP	MAIN
	1-S-5	DESCENT RATE					X							CENTER	3-POS. TOGGLE	MOM/MAIN/MOM
	1-S-6	X-TRANSLATION	X											4 JET	2-POS. TOGGLE 4/2 JET	MAIN/MAIN
	1-S-8	ENGINE GIMBAL			X									ENABLE	2-POS. TOGGLE ENABLE/OFF	LOCK/LOCK
	1-S-9	BALANCED COUPLES	X											ON	2-POS. TOGGLE ON/OFF	LOCK/LOCK
	1-S-10	MANUAL THROTTLE	X											SE	2-POS. TOGGLE CDR/SE	LOCK/LOCK
	1-S-11	THRUST CONTROL	X											AUTO	2-POS. TOGGLE AUTO MAN	LOCK/LOCK
	1-S-12	+X TRANSLATION					X							OFF	PUSH BUTTON IN: TRANSL	MOM
	1-S-13	ABORT	X											OFF	PUSH BUTTON IN: ABORT	MAIN
	1-S-14	ABORT STAGE	X											OFF	PUSH BUTTON IN: ABORT STAGE	MAIN
EXPLOSIVE DEVICES	2-S-1	DESC. PRESS.							X					SAFE	2-POS. TOGGLE FIRE/SAFE	MOM/LOCK
	2-S-2	RCS PRESS.							X					SAFE	2-POS. TOGGLE FIRE/SAFE	MOM/LOCK
	2-S-3	ASC. HE. SELECT							X					BOTH	3-POS. TOGGLE TANK 1/BOTH/TANK 2	LOCK/LOCK/LOCK
	2-S-4	ASC. HE. PRESS.							X					SAFE	2-POS. TOGGLE FIRE/SAFE	MOM/LOCK
	2-S-5	STAGE							X					SAFE	2-POS. TOGGLE FIRE/SAFE	LOCK/LOCK
	2-S-7	MASTER ARM							X					OFF	2-POS. TOGGLE ON/OFF	LOCK/LOCK
	2-S-10	LDG GEAR DEPLOY							X					OFF	2-POS. TOGGLE ON/OFF	MOM/LOCK
IMU	3-S-1	IMU CAGE				X								OFF	2-POS. TOGGLE ON/OFF	MOM/MAIN
ELECTRICAL POWER SYSTEM	4-S-1	HI VOLT BAT 1										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-2	HI VOLT BAT 2										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-3	HI VOLT BAT 3										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-4	HI VOLT BAT 4										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-5	LO VOLT BAT 1										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-6	LO VOLT BAT 2										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-7	LO VOLT BAT 3										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-8	LO VOLT BAT 4										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-9	DESC BATS										X		* CONNECT	3-POS. TOGGLE CONNECT/CTR/DLADFACE	MOM/LOCK/MOM
	4-S-10	NORM FEED BAT 5										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-11	NORM FEED BAT 6										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-12	BC FEED BAT 5										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-13	BC FEED BAT 6										X		*OFF/RST	3-POS. TOGGLE ON/CENTER/OFF RST	MOM/MAIN/MOM
	4-S-14	AC PWR										X		OFF	3-POS. TOGGLE INV 1/OFF/INV 2	LOCK/LOCK/LOCK
	4-S-15	P.P/TEMP MON										X		OFF	10-POS. ROTARY OFF/1 THRU 6/CDR/SE/AC	
	4-S-16	AUTO TRANSFER										X		ENABLE	2-POS. LOCK TOGGLE ENABLE/INHIBIT	LOCK/LOCK
C&W	6-S-2	MASTER ALARM	X											OFF	PUSH BUTTON IN: RST ALARM	MOM
	6-S-3	MASTER ALARM			X									OFF	PUSH BUTTON IN: RST ALARM	MOM
ENVIRONMENTAL CONTROL SYSTEM	7-H-6	CDR SUIT FLOW											X	N/A	3-POS. COLLAR CONT. TORSO/SUIT DISCONNECT/HELMET	
	7-H-7	SE SUIT FLOW											X	N/A	3-POS. COLLAR CONT. TORSO/SUIT DISCONNECT/HELMET	
	7-H-8	SUIT GAS DIVERTER											X	N/A	2-POS. "T" HANDLE PUSH-CABIN/PULL-EGRESS	

TABLE 3 3 LM-1 SWITCH TABULATION

SYSTEM	SWITCH/ CONTROL	SW./CONT. NOMENCLATURE	PANEL											PRELAUNCH CONDITION	POSITIONS	
			I	II	III	IV	V	VI	VIII	X	XII	XIV	ECS CONT.		TYPE & POSITION TITLES	TYPE OF CLOSURE
ENVIRONMENTAL CONTROL SYSTEM (CONTINUED)	7-H-9	SUIT CKT RELIEF											X	N/A	3 POS. FAUCET OPEN/AUTO/CLOSE	
	7-H-10	WATER SEPARATOR RELIEF											X	N/A	2 POS. "T" HANDLE PUSH-SEP 1/PULL SEP-2	
	7-H-11	CABIN RELIEF & DUMP VLV (FWD)											X	AUTO	3 POS. BAR LEVER CLOSE/AUTO/DUMP	
	7-H-12	CABIN TEMP CONT.											X	MAX COOL	MODULATING FAUCET MAX HEAT/NORM/MAX COOL	
	7-H-13	PLSS DRINK											X	CLOSE	2-POS. FAUCET OPEN/CLOSE	
	7-H-14	WATER TANK SELECT											X	ASC.	3-POS. FOLDOUT HAND CRANK DESC/ASC./EMER	
	7-H-17	CABIN GAS RETURN VLV											X	N/A	3-POS. FAUCET OPEN/AUTO/EGRESS	
	7-H-18	SEC GLYCOL											X	CLOSED	2-POS. AND MODULATING FAUCET OPEN/CLOSE	
	7-H-19	CO_2 CANISTER SEL.											X	N/A	2-POS. BAR LEVER PRIMARY/SECONDARY	
	7-H-20	CABIN RELIEF & DUMP VLV (U/H)											X	AUTO	3-POS. BAR LEVER CLOSE/AUTO/DUMP	
	7-H-22	SUIT TEMP											X	COLD	MODULATING FAUCET HOT/INCR/DECR/COLD	
	7-H-23	PRIM CANISTER VENT											X	N/A	MOM. PUSH BUTTON VENT PUSH	
	7-H-24	SEC CANISTER VENT											X	N/A	MOM. PUSH BUTTON VENT PUSH	
	7-S-1	SUIT FAN		X										1	2-POS. ROTARY 1/2	
	7-S-2	O_2/H_2O QTY MON		X										ASC 1	4-POS. ROTARY C&W RST/DES/ASC1/ASC2	
	7-S-3	GLYCOL PUMP		X										1	3-POS. ROTARY EMER/1/2	
	7-S-4	PRIM EVAP FLOW											X	CENTER OFF	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/LOCK/MOM
REACTION CONTROL	8-S-7	MAIN SOV (SYS A)		X										*CLOSE/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/LOCK/MOM
	8-S-8	ASC FEED (SYS A)		X										*CLOSE/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/LOCK/MOM
	8-S-9	MAIN SOV (SYS B)		X										*CLOSE/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/LOCK/MOM
	8-S-10	ASC FEED (SYS B)		X										*CLOSE/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/LOCK/MOM
	8-S-11	QUAD 1 (SYS A)		X										*OPEN/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	8-S-12	QUAD 2 (SYS A)		X										*OPEN/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	8-S-13	QUAD 1 (SYS B)		X										*OPEN/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	8-S-14	QUAD 2 (SYS B)		X										*OPEN/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	8-S-15	QUAD 3 (SYS A)		X										*OPEN/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	8-S-16	QUAD 4 (SYS A)		X										*OPEN/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	8-S-17	QUAD 3 (SYS B)		X										*OPEN/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	8-S-18	QUAD 4 (SYS B)		X										*OPEN/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	8-S-19	TEMP/PRESS MON.		X										HE.	4-POS. ROTARY HE/PRPLNT/FUEL MANF/OXID MANF	
	8-S-20	CROSS FEED		X										*CLOSE/	3-POS. TOGGLE OPEN/CENTER/CLOSE	MOM/LOCK/MOM
FLIGHT CONTROLS	9-S-2	RATE/ERR MON (CDR)	X											LDG RDR/CMPTR	2-POS. TOGGLE RNDZ RADAR/LDG RDR-CMPTR	MAIN/MAIN
	9-S-3	ATTITUDE MON (CDR)	X											PGNS	2-POS. TOGGLE PGNS/AGS	MAIN/MAIN
	9-S-4	RNG/ALT MON	X											RNG/RNG RT	2-POS. TOGGLE RNG-RNG RT/ALT-AL+RT	MAIN/MAIN
	9-S-6	GUID CONT	X											PGNS	2-POS. TOGGLE PGNS/AGS	LOCK/LOCK
	9-S-7	RATE ERROR MON (SE)		X										LDG RDR/CMPTR	2-POS. TOGGLE RNDZ RADER/LDG RDR-CMPTR	MAIN/MAIN
	9-S-8	SHFT/TRUN ANGLE	X											+/-50°	2-POS. TOGGLE ±50°/±5°	MAIN/MAIN
	9-S-9	MODE SELECT	X											PGNS	3-POS. TOGGLE LDG RADAR/PGNS/AGS	MAIN/MAIN/MAIN
	9-S-10	ATTITUDE MON (SE)		X										PGNS	2-POS. TOGGLE PGNS/AGS	MAIN/MAIN
	9-S-11	RESET/COUNT					X							UP	3-POS. TOGGLE RST/UP/DOWN	MOM/MAIN/MAIN
	9-S-12	TIMER COUNT					X							CENTER	3-POS. TOGGLE START/CENTER/STOP	MOM/MAIN/MOM
	9-S-13	MIN SLEW CONT.					X							CENTER	3-POS. TOGGLE TENS/CENTER/UNITS	MOM/MAIN/MOM
	9-S-14	SEC SLEW CONT.					X							CENTER	3-POS. TOGGLE TENS/CENTER/UNITS	MOM/MAIN/MOM

TABLE 3-9 LM-1 SWITCH TABULATION

SYSTEM	SWITCH/ CONTROL	SW./CONT NOMENCLATURE	PANEL											PRELAUNCH CONDITION	POSITIONS	
			I	II	III	IV	V	VI	VII	X	XII	XIV	ECS CONT		TYPE & POS. TITLES	TYPE OF CLOSURE
FLIGHT CONTROLS	9-S-17	X-POINTER SCALE (CDR)			X									HI MULT	2 POS TOGGLE HI MULT/LO MULT	MAIN/MAIN
	9-S-18	X-POINTER SCALE (SE)			X									HI MULT	2 POS TOGGLE HI MULT/LO MULT	MAIN/MAIN
MAIN PROP (CONTINUED)	10-S-1	PROPELLANT TEMP/PRESS MON	X											DES 1	3 POS TOGGLE ASC/DES 1/DES 2	MAIN/MAIN/MAIN
	10-S-3	ASC HE. REG 1	X											*OPEN/	3 POS TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	10-S-4	ASC HE. REG 2	X											*OPEN/	3 POS TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	10-S-5	DES HE. REG 1	X											*OPEN/	3 POS TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	10-S-6	HELIUM MON	X											OFF	DESC: SUPCRIT PRESS ASC: TEMP 1/TEMP 2/PRESS 1/PRESS 2	
	10-S-7	DES HE. REG 2	X											*CLOSE/	3 POS TOGGLE OPEN/CENTER/CLOSE	MOM/MAIN/MOM
	10-S-8	PRPLNT QTY MON	X											OFF	3 POS TOGGLE DES 1/DES 2/OFF	MAIN/MAIN/MAIN
STABILIZATION AND CONTROL	11-S-1	GYRO TEST			X									OFF	3 POS TOGGLE POSRT/OFF/NEGRT	MOM/LOCK/MOM
	11-S-2	DEADBAND			X									MIN	2 POS TOGGLE MAX/MIN	MAIN/MAIN
	11-S-3	PITCH ATT. CONT.			X									MODE CONT.	3 POS TOGGLE DIR/PULSE/MODE CONT	MAIN/MAIN/MAIN
	11-S-4	ROLL ATT. CONT.			X									MODE CONT.	3 POS TOGGLE DIR/PULSE/MODE CONT	MAIN/MAIN/MAIN
	11-S-5	YAW ATT. CONT			X									MODE CONT.	3 POS TOGGLE DIR/PULSE/MODE CONT	MAIN/MAIN/MAIN
	11-S-6	MODE CONTROL			X									AUTO	3 POS TOGGLE OFF/ATT HOLD/AUTO	MAIN/MAIN/MAIN
	11-S-7	GYRO TEST			X									PITCH	3 POS TOGGLE ROLL/PITCH/YAW	MAIN/MAIN/MAIN
AGS	12-S-17	AGS STATUS						X						OFF	3 POS TOGGLE OPERATE/STANDBY/OFF	LOCK/LOCK/LOCK
COMM	13-R-10	SQUELCH: VHF A									X			FULL DECR	THUMBWHEEL	
	13-R-15	SQUELCH: VHF B									X			FULL DECR	THUMBWHEEL	
	13-S-1	RANGE/TV									X			OFF	3 POS TOGGLE RANGE/OFF/TV	MAIN/MAIN/MAIN
	13-S-2	PWR AMPL									X			OFF	3 POS TOGGLE PRIM/OFF/SEC	MAIN/MAIN/MAIN
	13-S-3	BIOMED									X			OFF	3 POS TOGGLE LEFT/OFF/RT	MAIN/MAIN/MAIN
	13-S-4	PCM/KEY									X			PCM	3 POS TOGGLE PCM/OFF/KEY	MAIN/MAIN/MAIN
	13-S-5	MODULATE									X			PM	2 POS TOGGLE PM/FM	MAIN/MAIN
	13-S-6	VOICE/VOICE BU									X			OFF	3 POS TOGGLE VOICE/OFF/VOICE BU	MAIN/MAIN/MAIN
	13-S-7	VHF A: XMTR									X			OFF	2 POS TOGGLE ON/OFF	MAIN/MAIN
	13-S-8	XMTR/RCVR									X			OFF	3 POS TOGGLE PRIM/OFF/SEC	MAIN/MAIN/MAIN
	13-S-10	VHF A: RCVR									X			OFF	2 POS TOGGLE ON/OFF	MAIN/MAIN
	13-S-11	RECORDER									X			OFF	2 POS TOGGLE ON/OFF	MAIN/MAIN
	13-S-12	VHF B: XMTR									X			OFF	3 POS TOGGLE VOICE/OFF/DATA	MAIN/MAIN/MAIN
	13-S-13	PCM									X			HI	3 POS TOGGLE HI/LO	MAIN/MAIN
	13-S-15	VHF B: RCVR									X			OFF	2 POS TOGGLE ON/OFF	MAIN/MAIN
COMM ANT.	14-B-1	PITCH									X			+255°	ROTARY -75° TO +255°	
	14-B-2	YAW									X			-30 DEG	ROTARY -75° TO +75°	
	14-S-3	TRACK MODE									X			OFF	3 POS TOGGLE AUTO/OFF/SLEW	MAIN/MAIN/MAIN
	14-S-5	S-BAND									X			2	4 POS TOGGLE 1/2/SLEW/LUNAR STAY	
	14-S-6	VHF									X			1	4 POS TOGGLE PLSS TEST/1/2/EVA	
COMM (AUDIO CONT)	15A-R-7	ICS PCV VOL							X					FULL DECR	THUMBWHEEL	
	15A-R-8	VOX SENS							X					FULL DECR	THUMBWHEEL	
	15A-R-12	VHF B VOL							X					FULL DECR	THUMBWHEEL	
	15A-R-13	VHF A VOL							X					FULL DECR	THUMBWHEEL	
	15A-R-14	S-BAND RCV VOL							X					FULL DECR	THUMBWHEEL	
	15A-R-15	MASTER VOL							X					FULL DECR	THUMBWHEEL	

TABLE 3-9 LM-1 SWITCH TABULATION

SYSTEM	SWITCH/ CONTROL	SW./CONT. NOMENCLATURE	PANEL											PRELAUNCH CONDITION	POSITIONS	
			I	II	III	IV	V	VI	VII	X	XII	XIV	ECS CONT		TYPE & POS TITLES	TYPE OF CLOSURE
COMM (AUDIO CONT.) CONTINUED	15A-S-1	S-BAND T/R/RCV							X					OFF	3 POS TOGGLE S-BAND TR/OFF/S-BAND RCV	MAIN/MAIN/MAIN
	15A-S-2	VHF A							X					OFF	3 POS TOGGLE TR/OFF/RCV	MAIN/MAIN/MAIN
	15A-S-3	ICS T/R/RCV							X					OFF	3 POS TOGGLE ICS TR/OFF/ICS RCV	MAIN/MAIN/MAIN
	15A-S-4	RELAY							X					RELAY OFF	2 POS TOGGLE RELAY ON/RELAY OFF	LOCK/LOCK
	15A-S-5	AUDIO CONT							X					NORM	2 POS TOGGLE NORM/BU	MAIN/MAIN
	15A-S-6	VOX							X					PTT	3 POS TOGGLE ICS XMTR/ICS/PTT	MAIN/MAIN/MAIN
	15A-S-9	VHF B							X					OFF	3 POS TOGGLE TR/OFF/RCV	MAIN/MAIN/MAIN
	15B-R-7	ICS VOL									X			FULL DECR	THUMBWHEEL	
	15B-R-8	VOX SENS									X			FULL DECR	THUMBWHEEL	
	15B-R-12	VHF A VOL									X			FULL DECR	THUMBWHEEL	
	15B-R-13	VHF B VOL									X			FULL DECR	THUMBWHEEL	
	15B-R-14	S-BAND VOL									X			FULL DECR	THUMBWHEEL	
	15B-R-15	MASTER VOL									X			FULL DECR	THUMBWHEEL	
	15B-S-1	S-BAND T/R/RCV									X			OFF	3 POS TOGGLE S-BAND TR/OFF/S-BAND RCV	MAIN/MAIN/MAIN
	15B-S-2	VHF A									X			OFF	3 POS TOGGLE TR/OFF/RCV	MAIN/MAIN/MAIN
	15B-S-3	ICS T/R/RCV									X			OFF	3 POS TOGGLE ICS TR/OFF/ICS RCV	MAIN/MAIN/MAIN
	15B-S-4	RELAY									X			RELAY OFF	2 POS TOGGLE RELAY ON/RELAY OFF	LOCK/LOCK
	15B-S-5	AUDIO CONTROL									X			NORM	2 POS TOGGLE NORM/BU	LOCK/LOCK
	15B-S-6	VOX									X			PTT	3 POS TOGGLE ICS XMTR/ICS/PTT	MAIN/MAIN/MAIN
	15B-S-9	VHF B									X			OFF	3 POS TOGGLE TR/OFF/RCV	MAIN/MAIN/MAIN
LIGHTING	16-R-2	ANUN/NUM					X							FULL DECR	CONTINUOUS ROTARY DIM⟶BRT	
	16-R-3	INTEGRAL					X							FULL DECR	CONTINUOUS ROTARY DIM⟶BRT	
	16-S-1	SIDE PANELS					X							OFF	2 POSITION TOGGLE ON/OFF	MAIN/MAIN
	16-S-2	EXTERIOR LTS			X									OFF	5 POS. ROTARY DOCK/OFF/DIM/OFF/BRIGHT	
	16-S-3	INTEGRAL					X							OFF	2 POS TOGGLE ON/OFF	MAIN/MAIN
	16-S-4	ANUM					X							OFF	2 POS TOGGLE ON/OFF	MAIN/MAIN
	16-S-5	NUM					X							OFF	2 POS TOGGLE ON/OFF	MAIN/MAIN
	16-S-6	FLOOD			X									OFF	3 POS TOGGLE ON/OFF/PARTIAL	MAIN/MAIN/MAIN
	16-S-9	LIGHTING SIDE PANELS			X									OFF	2 POS TOGGLE ON/OFF	MAIN/MAIN
	16-S-10	LAMP/TONE TEST			X									OFF	8 POS ROTARY:OFF/ALARM TONE/CW 1/ ENG PB-CW 2/CW 3/CW 4/COMPNT/OFF	
RADAR	17-S-1	SLEW			X									CENTER	SPRING LOADED 4-WAY CENTER OFF TOGGLE:UP/RIGHT/DOWN/LEFT	
	17-S-2	SLEW RATE			X									LO	2 POS TOGGLE HI/LO	MAIN/MAIN
	17-S-3	RNDZ RDR MODE			X									SLEW	3 POS ROTARY AUTO TRACK/SLEW/LGC	
	17-S-5	LDG ANT			X									DES	3 POS TOGGLE AUTO/DES/HOVER	LOCK/LOCK/LOCK
	17-S-6	RADAR TEST			X									OFF	3 POS TOGGLE RNDZ/OFF/LDG	MAIN/LOCK/MAIN
	17-S-8	TEST MONITOR			X									AGC	6 POS ROTARY:ALT XMTR/VEL XMTR/AGC XMTR PWR/SHFT ERR/TRUN ERR	
HEAT. CONT	18-S-10	HEATER CONT TEMP MON			X									RADAR:RNDZ	7 POS ROTARY:RNDZ/LDG/QUAD 1/ QUAD 2/QUAD 3/QUAD 4/S-BAND	
DFI	19-S-1	C-BAND PWR								X				ON	2 POS TOGGLE OFF/ON	MAIN/MAIN
	19-S-2	R/D TM CAL								X				OFF	2 POS TOGGLE OFF/ON	MAIN/MAIN
	19-S-3	LMP-TCA-ISOL		X										ENABLE	2 POS TOGGLE ENABLE/OFF	MAIN/MAIN

*THE PRELAUNCH CONDITION VOLUMN FOR THESE SWITCHES IS THE LAST PRELAUNCH MOMENTARY ACTUATION OF THIS SWITCH.

*

THIS PAGE INTENTIONALLY LEFT BLANK

3.2 SYSTEM DATA

3.2.1 PREDISCHARGED DESCENT BATTERY

CAPACITY	350 AMP-HRS
TERMINAL VOLTAGE	28.0 TO 32.5VDC

3.2.2 ASCENT BATTERY

CAPACITY	250 AMP-HRS
TERMINAL VOLTAGE	28.0 TO 32.5VDC

3.2.3 AC BUS

VOLTAGE	115 ± 2.5VAC
FREQUENCY	400 ± 10CPS

3.2.4 MALFUNCTION INDICATION

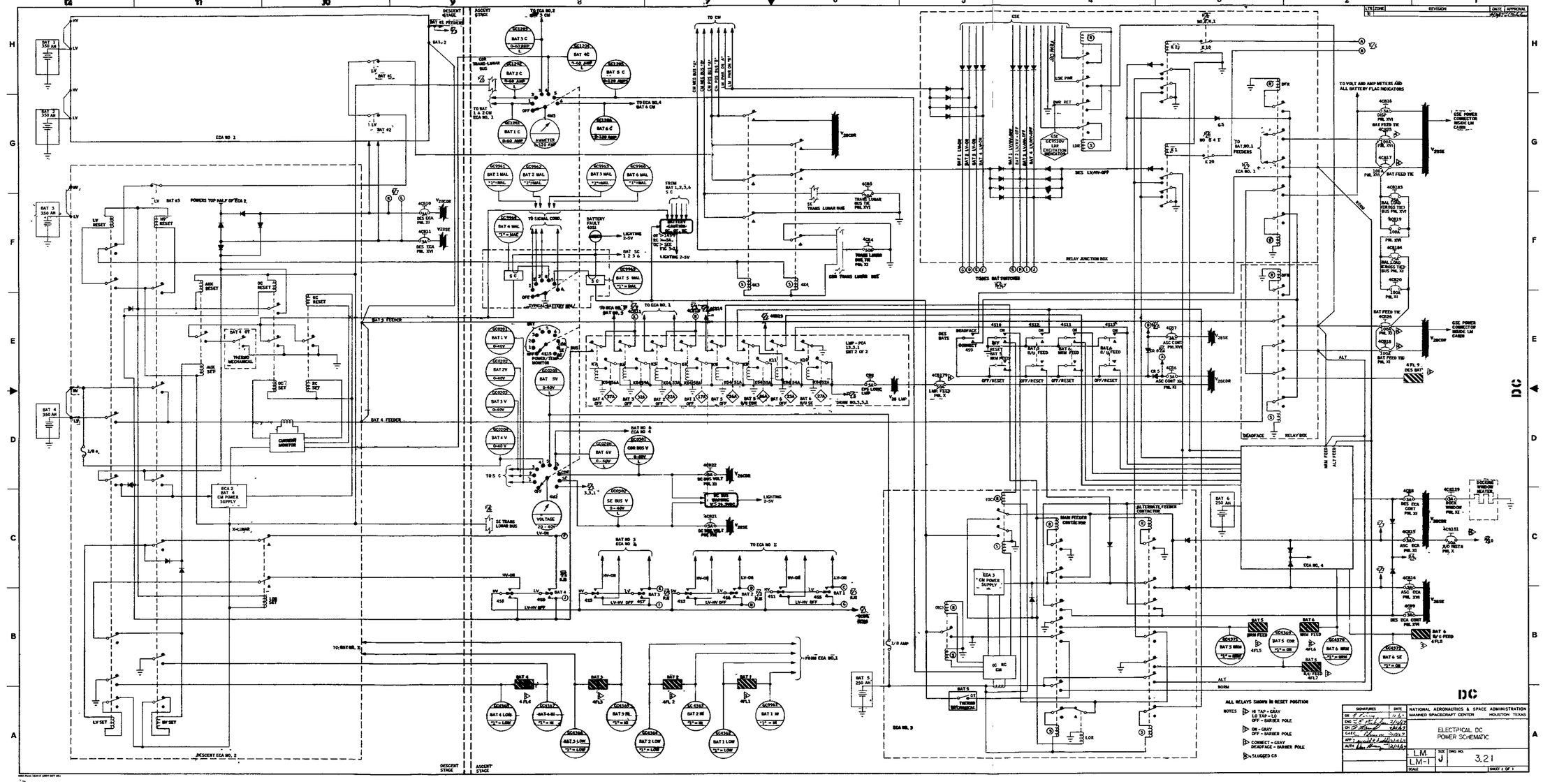
A. THE LIMITS FOR A MALFUNCTION INDICATION ARE:

OVER-TEMPERATURE	>145°±5°F (RESETS AT 125° ± 5°F)
OVER-CURRENT	SEE FIGURE 3-1
REVERSE CURRENT	-6± -10 AMPS (INDICATION WILL BE RESET AT -4 AMPS)

B. THERE WILL BE NO CAPABILITY FOR A DESCENT BATTERY MALFUNCTION INDICATION CAUSED BY A BATTERY OVER-TEMPERATURE IF THE BATTERY IS OFF

C. THERE WILL BE NO CAPABILITY FOR THE RESPECTIVE ASCENT BATTERY MALFUNCTION INDICATION CAUSED BY A BATTERY OVER-TEMPERATURE IF BAT. 5 IS NOT CONNECTED TO THE S.E.'s OR BAT. 6 IS NOT CONNECTED TO THE CDR's BUS. ALSO, THE BACKUP FEED PATHS, DO NOT HAVE AUTOMATIC OVERCURRENT PROTECTION.

DWG NO. 3.2.1
DETAIL SHEET NO.1


DESCENT STAGE
ASCENT STAGE
ECA NO. 1
DESCENT ECA NO. 2
ECA NO. 3
ECA NO. 4
BAT 1 250 AH
BAT 2 250 AH
BAT 3 250 AH
BAT 4 350 AH
BAT 5 250 AH
BAT 6 250 AH
POWERS TOP HALF OF ECA 2
BAT 5 FEEDER
BAT 4 FEEDER
TO CM
TO SIGNAL COND.
LIGHTING 2-5V
BATTERY FAULT 40A
BATTERY CAUTION LIGHT
TRANS LUNAR BUS TIE PNL XI
CDR TRANS LUNAR BUS
SE TRANS LUNAR BUS
RELAY JUNCTION BOX
TONES BAT SWITCHES
LMP - PCA 13,3,1 BAT 2 OF 2
DES BATS
DEADFACE
RELAY BOX
MAIN FEEDER CONTACTOR
ALTERNATE FEEDER CONTACTOR
TO VOLT AND AMP METERS AND ALL BATTERY FLAG INDICATORS
GSE POWER CONNECTOR MIDDEK LM CABIN
DOCKING WINDOW HEATER
ALL RELAYS SHOWN IN RESET POSITION
NOTES
HI TAP - GRAY
LO TAP - LO
OFF - BARRIER POLE
OR - GRAY
OFF - BARRIER POLE
CONNECT - GRAY
DEADFACE - BARRIER POLE
SLUGGED CB
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS
ELECTRICAL DC POWER SCHEMATIC
LM
LM-1
SIZE J
DWG NO. 3,21
SHEET 1 OF 1
DC

* SECTION 4

ENVIRONMENTAL CONTROL SUBSYSTEM

4.1 SUBSYSTEM DESCRIPTION

R-B

4.1.1 Oxygen Supply Section

A. Configuration

1. The descent oxygen tank will not be installed.
2. Each ascent oxygen tank will be evacuated to 4.35 psia. R-C
3. The Oxygen Control Module, (reduces tank oxygen pressure to breathing pressure) will not be installed.

B. Function

1. Ascent oxygen will be supplied directly to the sensing ports of both the primary and secondary water regulators. Ascent tank Number 2 will provide reference pressure to the primary regulators while ascent tank Number 1 will provide an independent source of pressure to the secondary regulator. R-B
2. The LM-1 cabin gas will not be replenished, consequently a 0.69 pound per hour N_2 leak rate may be anticipated during the mission. R-C

4.1.2 Suit Loop

A. Configuration

1. Installed but functionally disabled by opening appropriate circuit breakers.

B. Function

1. None R-B

4.1.3 Water Supply Section

A. Configuration

1. Descent water tank will be installed, however, there is no requirement to load water based on the present mission plan.

2. Ascent tanks will supply water to the primary water boiler during the entire mission. R-C
3. The water feed line to the smaller water boiler (item Number 224) will be capped since the reduced heat load precludes using this unit.

B. Function

1. To supply water to the water boiler such that proper thermal control may be accomplished.

C. Operation

1. Primary Water Feed - The water tank select valve, preset to ASCENT, allows water to flow through the primary feed path up to the primary water feed valve. At 3 minutes after liftoff, the LMP (LGC mode) will command the valve OPEN, allowing water to flow to the primary water boiler. RTC 24A, PRI H_2O FEED and RTC 25A, PRI H_2O RESET, are available to backup this onboard command. R-B
2. Primary Water Feed Verification - Prior to opening the feed valve, water pressure downstream of the regulators will be between 15.45 psia, (water was loaded using an ambient reference pressure) and ASC H_2O Tank Pressure (48 psia). Subsequent to this loading, the oxygen tanks will be evacuated to 4.35 psia resulting in a ΔP of between 11.1 (15.45 - 4.35) and 43.65 (48.0 - 4.35) psid. This will be reflected by PRI H_2O REG ΔP (GF4101P) having an off-scale high reading of 2.0 psid. Upon opening the feed valve at T + 3 minutes, H_2O ΔP will decay in order to become compatible with the ascent oxygen reference pressure. The drop in ΔP can be verified by GF4101P decreasing to the nominal value of 0.75 psid. R-C R-B R-C R-B
3. Secondary Water Feed - In the event that the primary water feed valve does not open on command, the secondary feed path may be used by sending RTC 60B, SEC H_2O FEED ENABLE and R-C

RTC 44B, SEC H_2O FEED followed by RTC 61B, SEC H_2O FEED ENABLE RESET and RTC 45B, SEC H_2O RESET. Upon receipt of this command the feed valve, in the independently regulated secondary path, will open. Water will flow through this parallel path to a point downstream of the primary feed valve where the paths are manifolded and provide a common feed to the water boiler. R-C

4. Secondary Water Feed Verification - Verification of the secondary valve opening cannot be ascertained in a manner analogous to the primary path since there is no regulator ΔP measurement. However, a continued rise in GLY TEMP GF9998U (GF2681T) is indicative of the valve not opening. R-B R-C

5. Water Regulation - Nominal regulated water pressure varies from 0.5 to 1.0 psid above oxygen tank pressure. The pressure of the water supplied to the water boiler should not exceed 6.5 psia in order to maintain optimum performance.

6. Water Boiler Operation - A porous plate sublimator rejects heat to the vacuum of space by the sublimation of ice. The heat rejection capability of the water boiler is greatly reduced if the heat load is either below the "freeze-up" point or above the "breakthrough" point of the unit. These limits are defined as follows: R-B

   a. Breakthrough - This refers to a water boiler condition where the heat load is sufficient to cause the vapor pressure at the outlet face of the plate to exceed the triple point pressure. If, at this point, the pore size is too large to support the water feed pressure, breakthrough will occur. This condition may also exist in the event that the water feed pressures become exceedingly high. Both primary water regulators must fail before the regulated pressure would reach this limit. R-C R-B R-C

When the aforementioned condition is present, heat rejection capability is reduced and water usage is high since the water may pass into the plate and escape to ambient. For anticipated temperature and Btu profiles, see Figures 4-1 (TBD) and 4-2 (TBD). R-B

b. Freezeup - If the heat load dissipated by the water boiler drops below a lower limit, the ice layer will grow so as to fill the water passages. The expanding ice layer will rupture the sublimator, rendering it and the primary loop useless. R-C

4.1.4 Glycol Loops

A. Configuration

1. Both glycol pumps will be on.
2. The primary glycol loop is installed and operable.
3. The secondary glycol loop is installed but it will be left dry and disabled since it cannot be used on this flight.
4. As a result of the LM-1 simplification program the following pieces of equipment will not require cooling since they are no longer on the vehicle. R-B
   a. VHF Transceivers
   b. Rendezvous Radar Electronics Assembly (RRE)
   c. Abort Sensor Assembly (ASA)
   d. Tracking Lights (TLE).

B. Function

1. To provide, by forced convection, thermal control of spacecraft electronic equipment.

C. Operation

1. Prelaunch Cooling - AS-206 is a launch of a powered up LM, and spacecraft cooling must be provided up to lift-off. Since the LM ECS water sublimater must be exposed to a vacuum environment to operate properly, two freon R-C

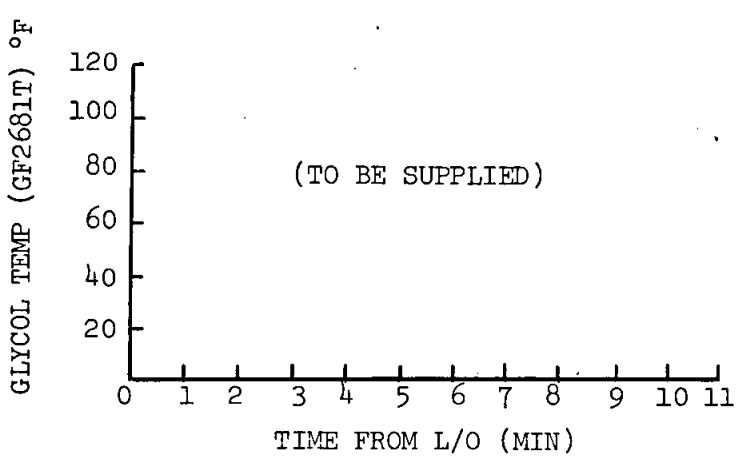
boilers are installed in the primary glycol loop. The 221 freon boiler is located upstream of the batteries and the 224 freon boiler is located downstream of the batteries.

There are three phases during which the glycol loop is in operation. The first phase begins when glycol is circulated through the vehicle via a ground based trim control unit. This unit pumps glycol through the onboard loop and out to a refrigeration unit to reject the heat. During this time, the coolant is supplied to the vehicle at 40°F with a flow rate of 390 lb/hr. At T-14 hours to liftoff, the second phase beings when, (with the trim control unit still operating) both freon boilers are activated. A total of 160 lb/hr of freon is supplied to both boilers at -20.8°F via the LUT. This concurrent operation of the freon boilers and the trim control unit lasts for 2 hours. At T-12 hours, the trim control unit is disconnected from the LM glycol loop. Glycol is then circulated through the vehicle by two onboard pumps. From T-12 hours to T-0 hours, a total freon flow of 160 lb/hr is to be maintained as long as temperature measurement GF9998U (GF2681T) is above 35°F. The total freon flow will be adjusted to maintain GF9998U at 35°F if necessary. Flyaway umbilicals terminate the freon supply at liftoff.

R-C

2. Pump Switchover - The automatic switchover circuitry is such that should a transient cause the switchover from Pump 1 to Pump 2, it is impossible to return to Pump 1 on an unmanned mission. To avoid the possibility of losing a good pump both glycol pumps will be placed on the line prior to launch. The automatic switchover circuitry has been deactivated and the capability of executing RTC 50B, (Pump 2 SEL), and RTC 51B, (Pump 1 SEL), has been deleted. R-B

3. Glycol Temperature Behavior During Launch - Since there will be no active cooling during the first three minutes of powered flight, GLY GF9998U (GF2681T) will behave as follows: R-C



R-B

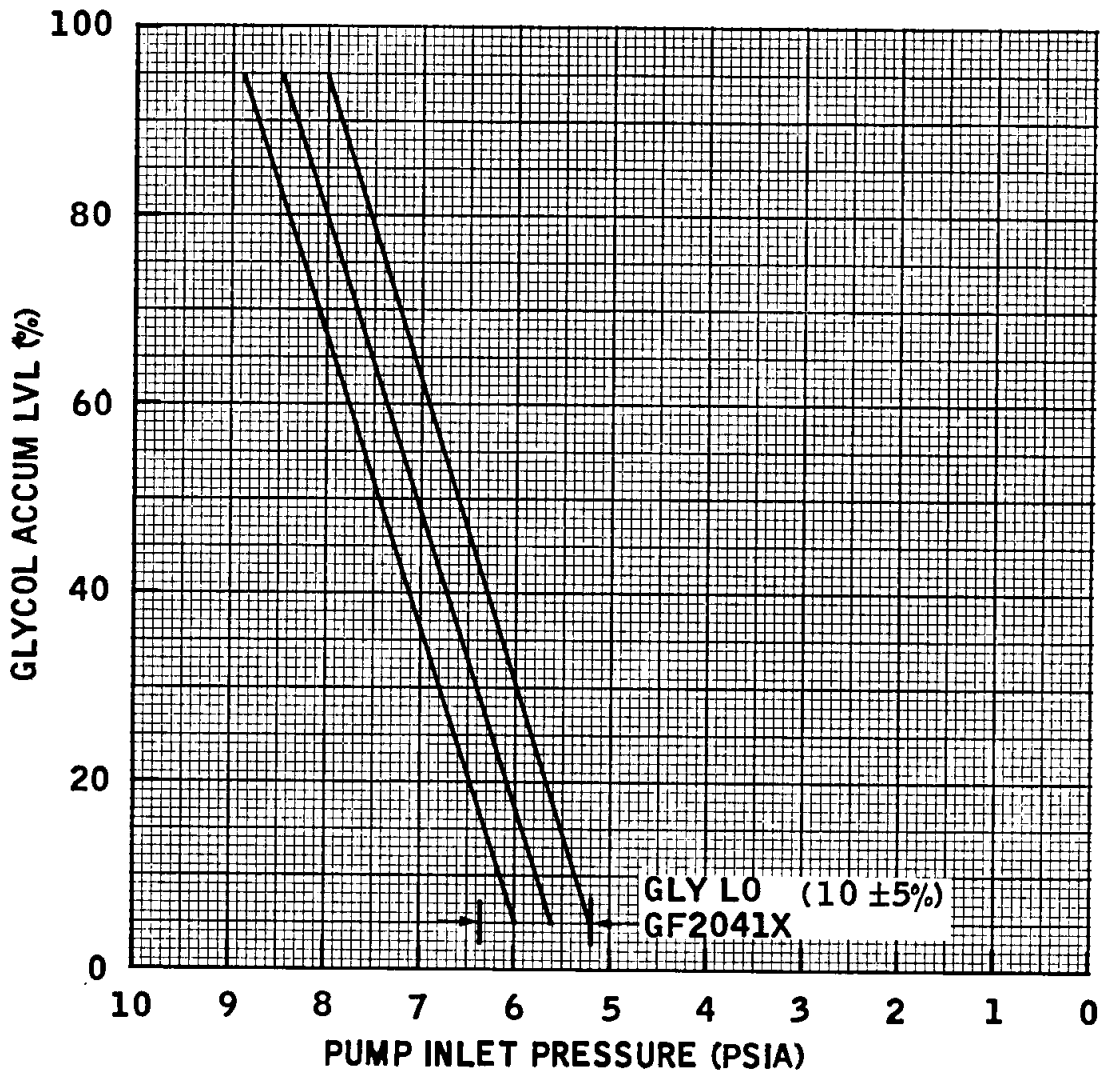


Figure 4-3 Glycol Accumulator Quantity

*

TABLE 4-1 PRELAUNCH STATUS OF VALVES AND SWITCHES

Switch/Valve Name	Position	Notes	
Oxygen Supply Section			
Desc O_2 (7-H-15) Asc O_2 No. 1 (7-H-21) Asc O_2 No. 2 (7-H-5) PLSS Fill (7-H-4) Cabin Repress (7-H-3) Demand Reg A (7-H-1)		The O_2 control module, on which these valves are located, will not be installed.	
Demand Reg B (7-H-2) Cabin Relief & Dump Valve (7-H-11) Cabin Relief & Dump Valve (7-H-20)	AUTO AUTO	Valves are present to this position in order to permit cabin "bleed" during launch.	R-B
Cabin Repress (4CB113) Cabin Fan 1 (4CB107) Cabin Fan 2 (4CB108) Cabin Fan Control (4CB109)		These circuit breakers will be opened since the associated hardware is not required on an unmanned mission.	
O_2/H_2O Qty Mon Sw (7-S-2)	ASC #1	Switch position irrelevent for LM-1.	R-C
Suit Loop			
CDR Suit Flow (7-H-6) S E Suit Flow (7-H-7) Suit Circuit Relief (7-H-9) Suit Gas Diverter (7-H-8) Cabin Gas Return (7-H-17) CO_2 Cannister Select (7-H-19) CO_2 Primary Cannister Vent (7-H-23) CO_2 Secondary Cannister Vent (7-H-24) Water Sep Sel (7-H-10)		The Suit Circuit Assembly, on which these valves are located, will be electrically disabled by pulling circuit breakers and capping electrical connectors.	R-B
Suit Fan (7-S-1)	Fan #1	Fan circuit breakers are open. Therefore, switch position is irrelevant for LM-1.	
Divert VLV (4CB112) CO_2 Sensor (4CB84) Suit Fan 1 (4CB138) Suit Fan 2 (4CB119) Suit Fan P (4CB120) Displays (4CB140)		These circuit breakers will be opened since the associated hardware is not required for an unmanned mission.	R-C
Water Supply Section			
Water Tank Select (7-H-14)	ASCENT	This setting will permit ascent H_2O flow to the water boiler via the primary feed path, when the primary feed valve is opened by the LMP.	R-B

TABLE 4-1 PRELAUNCH STATUS OF VALVES AND SWITCHES (Concluded)

Switch/Valve Name	Position	Notes	
Water Supply Section (Concluded)			R-B
PRIMARY FEED (7-S-4)	CENTER	Momentary toggle spring loaded to Center (OFF). Switch is not required to initiate H_2O flow via the LMP.	R-C
PRIM H_2O Feed (4CB98)	OPEN	Power is supplied to solenoid by the LMP.	
SEC Glycol Evap Flow (7-H-18)	CLOSE	The secondary glycol loop is dry for this mission.	
SEC Suit Evap Flow (7-H-16)	OPEN	Valve is required open to allow H_2O to the water boiler via the secondary feed path. R&D solenoid (secondary H_2O feed valve) is located downstream from this valve.	R-B
PLSS/Drink (7-H-13)	CLOSE	Not required on unmanned mission.	
O_2 Press. H_2O Qty Mon	ASC #1	Switch position irrelevant for LM-1.	
Glycol Loop			
Glycol Pump Select (7-S-3)	No. 1	Required for Pump 1 operation.	
Glycol Pump 1 (4CB117)	CLOSE	Pumps will be running simultaneously for LM-1.	R-C
Glycol Pump 2 (4CB141)	CLOSE		
Glycol Pump Sec (4CB96)	OPEN	The secondary glycol loop is dry for this mission.	
Suit Temp (7-H-22)	COLD	Suit loop temp control is not required due to the unmanned configuration.	R-B
Cabin Temp (7-H-12)	COLD	Assures minimum temperature of glycol to aft equipment bay.	
Signal Sensor (4CB132)	CLOSE	Supplies 28V to certain ECS transducers (ref. Instrumentation/Environmental Interface Diagram Drawing No. 6.3.3.)	R-C

*

4.2 ECS CONSTRAINTS

4.2.1 Water Supply Section

A. Failure of the PRIM FEED valve to open will result in equipment malfunction in _____ minutes, if SEC FEED valve is not opened. R-B

B. A failed close regulator will result in an increase of GLY TEMP (GF9998U) in _____ minutes. (Corresponds to _____ Btu/hours into water boiler.

4.2.2 Primary Glycol Loop

Loss coolant recirculation (pumps fail) will result in water boiler freezeup in 2 minutes and equipment overheating in _____ minutes. R-C

*

THIS PAGE INTENTIONALLY LEFT BLANK

ECS SYSTEMS DATA

EQUIPMENT	DATA
WATER SUPPLY SECTION	
1. H_2O REGULATORS	A. MAX. FLOW RATE = .85 LB/MIN
GLYCOL LOOP	
1. COOLANT	A. 35% ETHYLENE GLYCOL AND 65% H_2O B. QUANTITY PRIMARY LOOP = 44 LBS C. NOMINAL FLOW RATE = 420 LBS/HR D. SPECIFIC HEAT = 0.870 BTU/LB-F° AT 75°F
2. PUMP(S)	A. 7.0 LBS/MIN AT 40 °F AND ΔP = 33.0 PSID B. PAD DISCHARGE PRESSURE = 55.0 PSIA C. NOMINAL PUMP ΔP = 33.0 PSID D. NOMINAL PUMP DISCHARGE PRESSURE = 40.0 PSIA
3. PUMP RELIEF VALVES	A. CRACK = 33 PSID, FULL OPEN = MAX 36.0 PSID, RESEAT = 32 PSID
4. WATER BOILER	A MAXIMUM CAPACITY = 8,500 BTU/HR B MINIMUM LOAD (TO PREVENT FREEZEUP) = 400 BTU/HR C. THE POSSIBILITY OF FREEZEUP EXISTS BELOW HEAT LOAD OF 800 BTU/HR D. MAX H_2O PRESS. APPROX 8.5 PSIA MINIMUM ALLOWABLE H_2O PRESS. 1.5 PSIA
5. GLYCOL TEMPERATURE	A. ESTIMATED NOMINAL TEMP BAND FOR GF9998U (GF2681T) HIGH = 47 °F LOW = 36 °F B. NORMAL MAXIMUM INLET TEMP OF LOW TEMP ELECTRONICS = 50°F C. GF9998U READING 47°F IS INDICATION THAT INLET TEMP OF THE LOW TEMP ELECTRONICS IS APPROACHING UPPER LIMIT.
6. GLYCOL ACCUMULATOR (SEE FIG. 4-3)	A. 95% FULL ACCUMULATOR = 8.49 ± .42 PSIA PUMP INLET PRESSURE. B. 50% LEVEL = 5.16 ± .28 PSIA PUMP INLET PRESSURE. C. GLYCOL LEVEL AT 10 ± 5% WILL TRANSMIT A DISCRETE SIGNAL (GLY LOW GF2041X).

ECS CONSUMABLES

TANK	VOLUME FT^3	CAPACITY				ACTUAL LOADING				RESIDUAL	
		QUANTITY		PRESSURE	TEMPERATURE	QUANTITY		PRESSURE	TEMPERATURE	QUANTITY	
		LBS	%	PSIA	°F	LBS	%	PSIA	°F	LBS	%
A/1 H_2O	0.910[1]	42.5	100[2]	48.0	80					1.00	2.35
A/2 H_2O	0.910[1]	42.5	100[2]	48.0	80					1.00	2.35

HEAT CONVERSION

1. 1KWH = 3413 BTU
2. 1LB OF H_2O REJECTS ≈1040 BTU
3. ESTIMATED BTU LOAD IS SHOWN ON FIG. 4-2. (TBD)

WATER USAGE

1. AVERAGE USAGE FOR HEAT REJECTION = 5.0 TO 6.0 LB/HR
2. ESTIMATED WATER USAGE PROFILE IS SHOWN ON FIG. 4-1. (TBD)

1. THIS INCLUDES N_2 + WATER VOLUME
2. ANY WATER QUANTITY UP TO THIS FIGURE MAY BE LOADED AND THE MEASURING DEVICE ADJUSTED TO INDICATED 100%

ECS SWITCH AND VALVE POSITION AT LIFTOFF

SWITCH NO.	NAME	POSITION
7-S-1	SUIT FAN SELECT	FAN #1
7-S-2	O_2/H_2O QTY MON SW	ASC # 1
7-S-3	GLY PUMP SELECT	NO. 1
7-S-4	PRIM FEED	CENTER (OFF)
7-H-13	PLSS/DRINK VLV	CLOSE
7-H-14	H_2O TK SELECT VLV	ASCENT
7-H-16	SEC SUIT EVAP FLOW	OPEN
7-H-18	SEC GLY EVAP FLOW	CLOSE
7-H-12	CABIN TEMP CONT VLV	COLD
7-H-22	SUIT TEMP CONT VLV	COLD
7-H-11	F/H RELIEF VLV	AUTO
7-H-20	U/H RELIEF VLV	AUTO
4CB96	GLY PUMP SEC	OPEN
4CB98	PRIM EVAP FLOW	OPEN
CB1	PRIM H_2O FEED	CLOSE
CB2	SEC H_2O FEED	CLOSE
4CB179	LMP FEED	CLOSE
4CB140	ECS DISP	OPEN
4CB211	INTGR LIGHTING	OPEN
4CB148	ANUN/DOCK COMPNT	OPEN
4CB146	ANUN/DOCK COMPNT	OPEN
4CB117	GLY PUMP 1	CLOSE
4CB141	GLY PUMP 2	CLOSE
4CB132	SIG SENSOR	CLOSE

LTR	ZONE	REVISION	DATE	APPROVAL
G			6/29/67	

NOTE:
1. THE SECONDARY GLYCOL LOOP WILL NOT BE FILLED OR USED ON AS-206
2. THESE WIRES HAVE BEEN CUT, CAPPED, AND STOWED FOR LM-1

ECS

SIGNATURES	DATE
DR	10/1/67
ENG	9/11/67
CH	9/11/67
S&I C	9/5/67
APPD	9/11/67
AUTH	9/11/67

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON, TEXAS

ENVIRONMENTAL WATER SUPPLY AND GLYCOL LOOP

LM
LM-1

SIZE J | DWG NO. 4.1.1

SCALE | SHEET OF

*

THIS PAGE INTENTIONALLY LEFT BLANK

5.2 SYSTEM DATA

5.2.1 S-BAND

A. TRANSCEIVER POWER REQUIREMENTS — 36 WATTS

B. RECEIVER CHARACTERISTICS

1. PHASE LOCK RECEIVER	
2. FREQUENCY	2101.8 MHZ
3. SENSITIVITY	-127 dbm

C. TRANSMITTER CHARACTERISTICS

1. MODULATION	PM OR FM
2. FREQUENCY	FM 2282.5 MHZ
	PM $\frac{240}{221} F_R$ MHZ
3. RF POWER OUTPUT	0.75 TO 1.5 WATTS

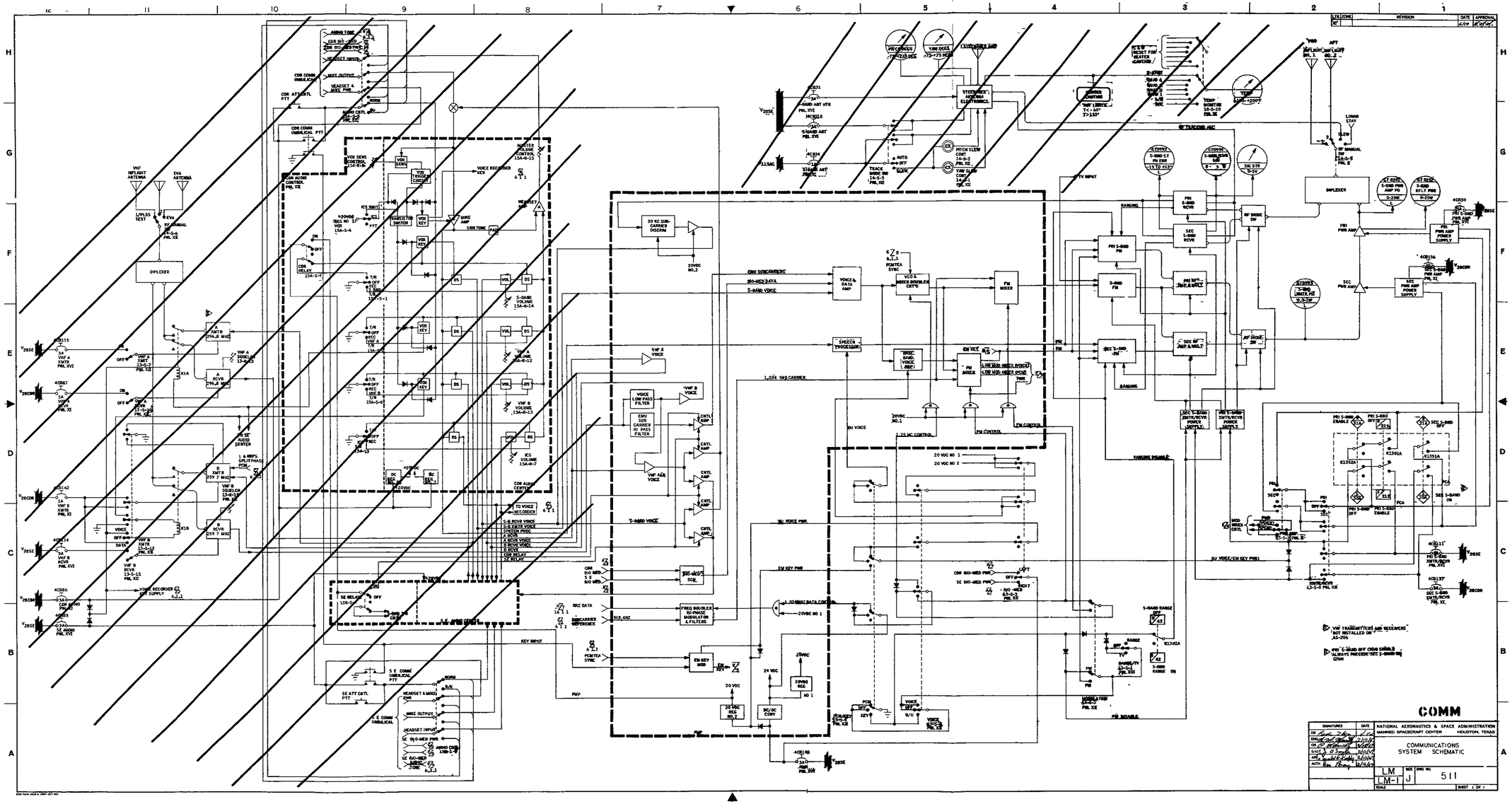
D. POWER AMPLIFIER CHARACTERISTICS

1. TYPE	AMPLITRON (QKS 1300)
2. RF DRIVE LEVEL	0.72 WATTS (MIN)
3. RF POWER OUTPUT (PRD	20 WATTS
4. POWER INPUT	68.6 WATTS

E. THE APPLICATION OF DC POWER TO THE PRIMARY OR SECONDARY POWER AMPLIFIER POWER SUPPLY WILL START AN AUTOMATIC 20 SECOND WARMUP SEQUENCE. AFTER THE WARMUP PERIOD, -1800 VDC IS APPLIED TO THE AMPLITRON ENABLING THE TUBE TO LOCK ON THE INPUT RF SIGNAL. IF THE AMPLITRON FAILS TO LOCK, THE POWER SUPPLY WILL AUTOMATICALLY REVERT TO THE WARMUP MODE AND THE CYCLE WILL BE REPEATED. THE MAXIMUM WARMUP TIME FOR A POWER AMPLIFIER IS 60 SECONDS.

TABLE 5-1 PRELAUNCH STATUS OF SWITCH/CIRCUIT BREAKER POSITIONS

SWITCH NAME	NUMBER	POSITION
AUDIO CONT	15A-S-5 AND 15B-S-5	NORM
S-BAND T/R	15A-S-1 AND 15B-S-1	OFF
ICS T/R	15A-S-3 AND 15B-S-3	OFF
RELAY	15A-S-4 AND 15B-S-4	OFF
S-BND RCVR VOL	15A-R-14 AND 15B-R-14	CCW
ICS RCVR VOL	15A-R-7 AND 15B-R-7	CCW
VOX ICS/XMTR	15A-S-6 AND 15B-S-6	PTT
VHF A T/R	15A-S-2 AND 15B-S-2	OFF
VHF B T/R	15A-S-9 AND 15B-S-9	OFF
VOX SENS	15A-R-8 AND 15B-R-8	CCW
VHF A VOL	15A-R-12 AND 15B-R-12	CCW
VHF B VOL	15A-R-13 AND 15B-R-13	CCW
MASTER VOL	15A-R-15 AND 15B-R-15	CCW
MODULATOR	13-S-5	PM
S-BND XMTR/RCVR	13-S-8	OFF
PWR AMP	13-S-2	OFF
VOICE/BU VOICE	13-S-6	OFF
PCM/KEY	13-S-4	PCM
RANGE/TV	13-S-1	OFF
VHF A XMTR	13-S-7	OFF
VHF A RCVR	13-S-10	OFF
VHF B XMTR	13-S-12	OFF
VHF B RCVR	13-S-15	OFF
BIOMED	13-S-3	OFF
SQUELCH VHF A	13-R-10	CCW
SQUELCH VHF B	13-R-15	CCW
VHF RF SW	14-S-6	1
S-BND RF SW	14-S-5	2
RECORDER	13-S-11	OFF
TRACK MODE	14-S-3	OFF
CIRCUIT BREAKER NAME		
S-BAND ANT HTR	4CB31	OPEN
S-BAND ANT	4CB34	OPEN
SEC S-BND XMTR/RCVR	4CB137	CLOSED
SEC S-BND PWR AMP	4CB136	CLOSED
VHF A RCVR	4CB87	OPEN
VHF B XMTR	4CB162	OPEN
CDR AUDIO	4CB86	OPEN
SE AUDIO	4CB85	OPEN
VHF A XMTR	4CB715	OPEN
VHF B RCVR	4CB114	OPEN
PRI S-BND PWR AMP	4CB30	CLOSED
PRI S-BND XMTR/RCVR	4CB111	CLOSED
S-BND ANT	4CB110	OPEN
PMP	4CB102	CLOSED
TV	4CB104	OPEN
DISP	4CB153	OPEN


COMM
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS
COMMUNICATIONS SYSTEM SCHEMATIC
LM
LM-1
J
511
SHEET 1 OF 1
VHF INFLIGHT ANTENNA
EVA ANTENNA
DIPLEXER
VHF A XMTR 296.8 MHZ
VHF A RCVR 296.8 MHZ
VHF B XMTR 259.7 MHZ
VHF B RCVR 259.7 MHZ
VOICE RECORDER
S-BAND ANTENNA
STEERABLE ANTENNA ELECTRONICS
S-BAND XMTR/RCVR
S-BAND PWR AMP
S-BAND RFLT PWR
DIPLEXER
RF SWITCHING ARC
RANGING
RANGING DISABLE
PM DISABLE
PCM DATA
VOICE & DATA AMP
FM MIXER
FM MODULATOR
VOX & DUCKER CKTS
VOX KEY
VOX TRIGGER CIRCUIT
VOX SENS CONTROL
MASTER VOLUME CONTROL
S-BAND VOLUME
VHF A VOLUME
VHF B VOLUME
ICS VOLUME
CDR AUDIO CENTER
VOICE RECORDER
VOICE LOW PASS FILTER
EMS CARDIAC 10 PASS FILTER
VHF A VOICE
VHF B VOICE
S-BAND VOICE
CNTL AMP
FREQ DOUBLER 90-PHASE MODULATOR & FILTERS
KEY INPUT
PCM/TEA SYNC
20 VDC NO 1
20 VDC NO 2
24 VDC
28 VDC BUS NO 2
DC/DC CONV
2.5 MC CONTROL
FM CONTROL
1.024 MHZ CARRIER
S-BAND RANGE
S-BAND RANGE ON
S-BAND PWR AMP POWER SUPPLY
PRI S-BAND XMTR/RCVR POWER SUPPLY
SEC S-BAND XMTR/RCVR POWER SUPPLY
PRI S-BAND ENABLE
SEC S-BAND ON
PRI S-BAND OFF
SEC S-BAND OFF
VHF TRANSMITTERS AND RECEIVERS NOT INSTALLED ON AS-206
PRI S-BAND OFF COMM SIGNALS ALWAYS PRECEDE SEC S-BAND ON COMM
SIGNATURES
DATE
DR
DSN
CH
SAE
AMS
AUTH

LTR	ZONE	REVISION	DATE	APPROVAL
C				

S-BAND

TO SECONDARY RECEIVER
TO PRIMARY RECEIVER
RF DIODE SWITCH
FWD INFLIGHT NO 1
AFT INFLIGHT NO 2
2 SLEW
3 SLEW
4 LUNAR STAY
1 .1455 RF MANUAL SWITCH
DIPLEXER
6 TO 20 DB
POWER AMP RF POWER OUT 0 - 25W
GT0202 S-BAND RFLCT PWR 0 - 25W
4C8136
SEC S-BAND PWR AMPL PRL X1
V_{28SCDR}
CIRCULATOR
POWER AMP SECONDARY
QKS 1300
POWER AMP CIRCULATOR PRIMARY
QKS 1300
POWER SUPPLY
POWER SUPPLY
POWER AMPLIFIERS
4C8130
PRM S-BAND PWR AMPL PRL XV1
V_{28SE}

BACK-UP VOICE FROM SPA
PM SIGNAL FROM SPA (PCM)
NB PM
WB PM
RANGE GATE
LIMITER
PHASE MOD
LIMITER
HYBRID COUPLER
PM GATE
-15V
PRI PHASE MODULATOR
AMPLIFIERS
DOUBLER
AMPLIFIERS
P.A. AND DRIVER
X 15 MULTIPLIERS AND FILTERS
PRI R F AMPLIFIERS
2282 5MHZ
FREQUENCY MODULATOR AND INSTR
RF AMP
RECEIVER AND PHASE MOD
-5.2V +4V -14V -28V +15V -15V
-1V
-1V
+28V
PRI DC/DC CONVERTER
GT0994 S-BAND RCVR SIG STR 0-5
SIG STR 0-5
AGC TRACKING TO S-BAND STEERABLE ANT ELECTRONICS
PRE CONDTR
RANGING DISABLE
2101.8 MHZ
1ST MIXER
2054.3MHZ
GAIN CONTROL 38MHZ
2ND MIXER
IF
FILTER
AMPLIFIERS
AGC DET
AGC
AGC TRACKING
RANGE DET
FILTER
MULTIPLIER CIRCUITS
DIVIDER CIRCUITS
9.5MHZ
19MHZ
PHASE DET
FILTER
VCO
PRIMARY RECEIVER
GT0992 STATIC PHASE ERROR -15° - +15°
PRE CONDTR
GT0993 SELECTED S-BAND XMTR PO 0.5-1 W
RF DET
30 KC VOICE SUB-CARRIER TO SPA
TV
FM SIGNAL FROM SPA
PM DISABLE
HIGH PASS FILTER
FM VCO
LIMITER
POWER
76MHZ
Z NETW
RF DIODE SWITCH
CIRCULATOR
FILTER
FILTER
LOW PASS
LIMITING
AC/DC CONVERTER
ADDER AND PHASE DET
DIVIDER CIRCUITS
XTAL OSC
ISOLATION
DIVIDER CIRCUITS
FREQUENCY MODULATOR
PRI S-BAND ENABLE
PRI S-BAND OFF
SEC S-BAND OFF
K1352A
K1351A
K1351A
PCA
PRI S-BAND OFF
PRI S-BAND ENABLE
SEC S-BAND ON
FREQUENCY MODULATOR AND INSTR
RF AMP
RECEIVER AND PHASE MOD
-5.2V +4V -14V -28V +15V -15V
-1V
-1V
+28V
SEC DC/DC CONVERTER
PRIM
SEC
PRIM
OFF
SEC
MOD INDEX CNTRL
PWR AMPL 1352 PRL XII
4C8111
PRIM S-BAND XMTR/RCVR PWR. XV1
V_{28SE}
4C8137
SEC S-BAND XMTR/RCVR PWR. X1
V_{28CDR}
BU VOICE EM KEY POWER
XMTR/RCVR 1358 PRL XII
SEC S-BAND XMTR/RCVR PWR. X1

BACK-UP VOICE FROM SPA
PM SIGNAL (PCM)
NB PM
WB PM
RANGE GATE
LIMITER
PHASE MOD
LIMITER
HYBRID COUPLER
PM GATE
-15V
SEC PHASE MODULATOR
AMPLIFIERS
DOUBLER
AMPLIFIERS
PA AND DRIVER
X 15 MULTIPLIERS AND FILTERS
SEC RF AMPLIFIER
2282 5MHZ
2101.8 MHZ
1ST MIXER
2054.3MHZ
GAIN CONTROL 38MHZ
2ND MIXER
IF
FILTER
AMPLIFIERS
AGC DET
AGC
AGC TRACKING
RANGE DET
FILTER
MULTIPLIER CIRCUITS
DIVIDER CIRCUITS
9.5MHZ
19MHZ
PHASE DET
FILTER
VCO
SECONDARY RECEIVER

S-BAND

SIGNATURES	DATE
DR G.P.MILLER	1-13-66
ENG	2/9/67
CH	2/9/67
GAEC	2/9/67
APP	2/14/67
AUTH	2/14/67

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS

S-BAND TRANSCEIVER DETAILED SCHEMATIC

LM
LM-1
SIZE E
DWG NO 521
SCALE
SHEET 1 OF 1

visual caution*, warning*, flag and/or indicator closures.

The C&WEA is capable of handling data in the form of analog signals, discrete voltage levels and switch closures. The C&WEA can evaluate this data and determine if the input signals are within the prescribed limits, and provide caution, warning, flag, advisory, and telemetry relay closures as required; there are three types of analog signal evaluation:

1. High limit - voltage above a specified value
2. Low limit - voltage below a specified value
3. Bandpass - voltage above or below a specified value

The C&WEA is also capable of processing inhibits which allow the C&WEA logic to ignore out-of-tolerance conditions when it is desirable to do so.

6.1.4 Pulse Code Modulation and Timing Electronics Assembly (PCMTEA)

A. The PCMTEA consists of the following components:

1. Analog multiplexer drivers
2. High-level analog multiplexer
3. Calibrator
4. Analog-to-digital converter (coder)
5. Programer
6. Digital multiplexer
7. Output register
8. Power supply
9. Timing equipment

B. Input signals for the PCM equipment are of three types: high-level analog, parallel digital, and serial digital. Some parallel digital and high-level analog inputs are supplied directly to the PCMTEA from subsystem sensors; all other signals are first processed through the SCEA.

R-B

* Definitions:

Caution - Malfunctions not requiring immediate attention but which would affect crew safety if action is not taken. Malfunctions in subsystems which time share displays. Malfunctions in subsystems whose displays are not readily visible to the astronaut.

Warning - Malfunctions that affect crew safety and require immediate attention.

C. The PCM equipment accepts the high-level analog signals through the multiplexer. The multiplexer forms pulse-amplitude-modulated (PAM) outputs representative of the analog inputs. The high-level PAM outputs of the multiplexer are supplied to high-speed gates (see Table 6-5) for application to the analog-to-digital converter on command from the programer.

D. The calibrator supplies two precision voltage outputs (4.25 and 0.75 volts dc) to the multiplexer to insure that overall accuracy of data is maintained through the PCMTEA. R-B

E. The analog-to-digital converter converts the high-level PAM outputs of the high-speed gates into eight-bit binary words. For a zero-volt input, the converter generates the binary equivalent of a decimal 1 (MSB00000001 LSB). Each additional 19.7 millivolts of input signal increases the binary output by one; therefore, with a 5.00 volt dc input, the binary output will be 254 (MSB11111110 LSB). For an input exceeding 5 volts dc, the binary output will be all ones (MSB11111111 LSB) for an input less than 0 Vdc, the binary output will be all zeros (MSB00000000 LSB). R-C R-B R-C R-B R-C

F. The programer generates the necessary commands for analog and digital data sampling and operations, and supplies the basic timing for data transfer and subcarrier frequencies required in the PCMTEA as well as other subsystems. The programer selects the high-bit rate or low-bit rate data-sampling formats by actuating Switch 13S13.

G. The output of the analog-to-digital converter is supplied to the digital multiplexer. This multiplexer gates the analog-to-digital converter outputs, along with the frame synch and format identification words from the programer and the serial digital and parallel digital data from the SCEA or from the subsystem sensors, to the output register. When these data exceed eight bits per word, the most significant eight bits R-B

are gated to the output first and then followed by the next most significant eight bits. The register converts these eight-bit words (parallel by bit) to serial outputs and routes them to the Communications Subsystem. These data are sampled and routed to the Communications Subsystem in non-returned-to-zero (NRZ) format at 51,200 bits per second (high bit rate) or 1,600 bits per second (low-bit rate), and split phase (RZ) format at 1,600 bits per second. Data generated by the LM Guidance Computer (LGC) in the Primary Guidance, Navigation, and Control (PGN&C) Subsystem are supplied to the output register in a 40-bit serial word format. Data generated by the Abort Guidance Computer (AGS) are supplied to the output register in a 24-bit serial word format. R-B

H. The timing equipment consists of an oscillator component, timing generator, time accumulator, and an output buffer. The oscillator component accepts a 1024 kc signal from the LGC, frequency doubles it, and routes it to the timing generator. The frequency doubled 1024 kc LGC signal also controls the output of an internal 2048 kc crystal oscillator. Therefore, if the LGC signal fails, the oscillator component can instantaneously switch to the crystal oscillator signal without any interruption of the signal to the timing generator.

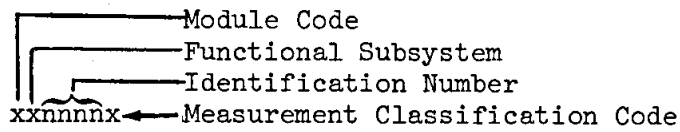
The timing generator supplies sync pulses to the Electrical Power Subsystem, the Guidance, Navigation, and Control Subsystem, and the Communications Subsystem via the timing data output buffer. R-C It also supplies the time accumulator with a 1 cps signal that is converted to mission-elapsed-time data. The time accumulator recycles to zero at 40 days or upon interruption of PCMTEA power. R-B These data are routed to the DSEA (when used) for simultaneous recording with voice.

The timing generator supplies all the timing signals required in the programer for generating frame sync, frame identification, and format identification data.

I. Internally Redundant Measurement Sampling (See Figure 6-1) - Some data words are wired redundantly within their respective multiplexer (analog or digital). This does not, in effect, double the sampling rate for such parameters because the redundant data word loading is spaced unevenly timewise. (Were the time correlation evenly spaced, then sampling would be essentially doubled or supercommutated). Refer to Figure 6-1 for a depiction of the time correlation. An example of this type of parameter would be the battery currents GC1201-1206C. Redundant transducers, which supply duplicate data concerning a particular parameter, are wired to the PCMTE external connector and may be treated as two separate data points. An example of this type of parameter would be GQ3018P and GQ3025P (LM-2 and sub) DPS HE REG PRESS. R-B

* TABLE 6-3 SPACECRAFT INSTRUMENTATION

1. MEAS ID - Measurement identification number as delineated below:



Module Code: A = Adapter - NAA
G = LM GAEC

Functional Subsystem Codes:
A = Adapter
C = Electrical Power
D = Command
F = Environmental Control
G = Navigation and Guidance
H = Stab and Control - CES
I = Stab and Control - AGS
L = Instrumentation
M = Mechanical Design
N = Radars
P = Propulsion - Ascent Engine
Q = Propulsion - Descent Engine
R = Reaction Control
T = Communications R-B
W = Programer
Y = Pyrotechnics

Measurement Classification Codes:

B = Phase
C = Current
E = Power
F = Frequency
H = Position
J = Biomedical
L = Velocity
P = Pressure
Q = Quantity
R = Rate
T = Temperature
U = Combined meas.
V = Voltage
W = Time
X = Discrete Event

2. MEAS DESCRIPTION - A brief "field title" given to each measurement.

TABLE 6-3 SPACECRAFT INSTRUMENTATION (Cont'd)

3. PAM LOCATION - The PCMTE high-speed PAM gate and sequences assigned to each indicated measurement.

4. SCERA LOCATION - The signal conditioning electronic replaceable assembly (SCERA) member and location within the assembly for the indicated measurement. R-C

5. TM DATA RANGE - Actual telemetered range of the data to be received by the ground stations.

   1. Discretes - "0" or "1" with applicable indication
   2. Analog - Lowest and highest telemetered data range for each analog measurement.

   ACC PCT - Spacecraft telemetered data range Root Sum Square (RSS) accuracy in percent of full scale.

6. ONBOARD DISPLAY RANGE - Indicated range of the spacecraft onboard display.

   ACC PCT - Onboard display Root Sum Square accuracy in percent of full scale.

7. C&W LIMITS - The low and high value of the accuating parameter inputs to the onboard caution and warning instrumentation.

8. ADV - The spacecraft onboard advisory indication; light or flag designation number listed.

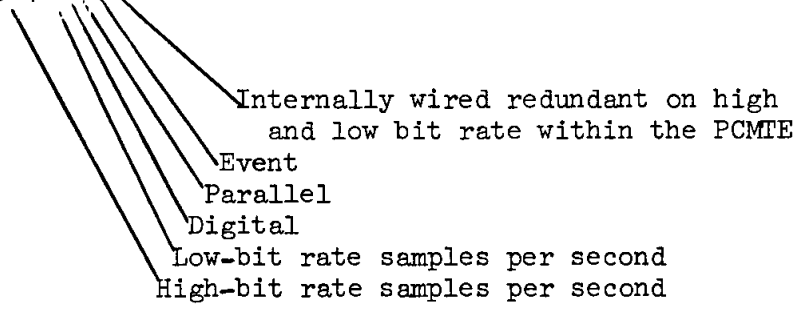
9. ESTIMATED NORMAL OPERATING LIMITS - Best engineering estimate of the low, normal, and high limits of the respective analog parameters. Discrete parameters are designated as such. R-B

10. CRITICAL LIMITS - The high and/or low limits of each measurement that will cause permanent loss of equipment and/or life, or mission.

11. S/C SAMPLING - Spacecraft PCMTE data sampling rate using the following code:

TABLE 6-3 SPACECRAFT INSTRUMENTATION (Concluded)

EXAMPLE: 50/1DPER



NOTE

Where the redundant "R" is shown as 1R/1..... the internal redundancy is wired for high-bit rate only.

R-B

Alphabetic characters utilized to describe the types of input channels to PCM:

AH = Analog, High-Level
D = Digital
P = Parallel
S = Serial
E = Event

11. NOTES - May contain any other pertinent notation concerning each respective parameter.

TABLE 6-3.1 SPACECRAFT INSTRUMENTATION FOR SLA (S-IVB/IU)

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE LOW	TM DATA RANGE HIGH	TM DATA RANGE UNITS	RSS ACC PCT	ONBOARD DISPLAY RANGE LOW	ONBOARD DISPLAY RANGE HIGH	RSS ACC PCT	C&W LIMITS LOW	C&W LIMITS HIGH	ADV	ESTIMATED NORMAL OPERATING LIMITS LOW	ESTIMATED NORMAL OPERATING LIMITS NORM	ESTIMATED NORMAL OPERATING LIMITS HIGH	CRITICAL LIMITS LOW	CRITICAL LIMITS HIGH	S/C SAMPLING	NOTES
K141-900	CAP/SLA PHYS 1			0 = SEP				-			-				DISCRETE				120 S/S	IU TM
K142-900	CAP/SLA PHYS 2			0 = SEP				-			-				DISCRETE				120 S/S	IU TM
K143-900	NOSECAP RLY A			1 = RLY CLSD				-			-				DISCRETE				120 S/S	IU TM
K144-900	NOSECAP RLY B			1 = RLY CLSD				-			-				DISCRETE				120 S/S	IU TM
K145-900	LM/SLA SEP CMD A			1 = RLY CLSD				-			-				DISCRETE				12 S/S	IU TM
K146-900	LM/SLA SEP CMD B			1 = RLY CLSD				-			-				DISCRETE				12 S/S	IU TM
K147-900	SLA DEPLOY CMD A			1 = RLY CLSD				-			-				DISCRETE				12 S/S	IU TM
K148-900	SLA DEPLOY CMD B			1 = RLY CLSD				-			-				DISCRETE				12 S/S	IU TM
K149-900	SLA PANEL DEPLOY			1 = DEPLOY				-			-				DISCRETE				12 S/S	IU TM

TABLE 6-3.2 SPACECRAFT INSTRUMENTATION FOR ELEC/COMM

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC		TM DATA RANGE LOW	HIGH	UNITS	RSS ACC PCT	ONBOARD DISPLAY RANGE LOW	HIGH	RSS ACC PCT	C&W LIMITS LOW	HIGH	ADV	ESTIMATED NORMAL OPERATING LIMITS LOW	NORM	HIGH	CRITICAL LIMITS LOW	HIGH	S/C SAMPLING	NOTES
GC0071V	AC BUS VOLT	3-10	1/17	1/18	0	125	VRMS	1.27	GREEN BAND		4.63	112		-	115.8	117	118.2	110	120	1/1 AH	GL4046 4M2 NO AC LOAD
GC0155F	AC BUS FREQ	3-14	1/16	1/18	380	420	CPS	1.27		---		398	402	-	399	400	401	390	410	1 AH	GL4046
GC0201V	BAT. 1 VOLT	1-8	2/16		0	40	VDC	1.12	20	40	4.47		---	-	28.5	29-30	32.5	31.0		1 AH	4M2 UNDER LOAD OPEN CKT
GC0202V	BAT. 2 VOLT	1-7	2/16		0	40	VDC	1.12	20	40	4.47		---	-	28	29-30	32.5	31.0		1 AH	4M2 UNDER LOAD OPEN CKT
GC0203V	BAT. 3 VOLT	1-9	2/16		0	40	VDC	1.12	20	40	4.47		---	-	28	29-30	32.5	31.0		1 AH	4M2 UNDER LOAD OPEN CKT
GC0204V	BAT. 4 VOLT	1-7	2/16		0	40	VDC	1.12	20	40	4.47		---	-	28	29-30	32.5	31.0		1 AH	4M2 UNDER LOAD OPEN CKT
GC0205V	BAT. 5 VOLT	2-5	2/17		0	40	VDC	1.12	20	40	4.47		---	-	27.5 34.0	29	30 32.0			1/1 AH	4M2 UNDER LOAD OPEN CKT
GC0206V	BAT. 6 VOLT	2-6	2/18		0	40	VDC	1.12	20	40	4.47		---	-	27.5 34.0	29	30 32.0			1/1 AH	4M2 UNDER LOAD OPEN CKT
GC0301V	CDR BUS VOLT	3-12/3-14	1/15	1/18	0	40	VDC	1.27	20	40	4.6	26.5		-	27		32.5	26.5		1/1 AH	4M2 GL4034
GC0302V	SE BUS VOLT	1-11	2/8	2/15	0	40	VDC	1.50	20	40	4.9	26.5		-	27		32.5	26.5		1/1 AH	4M2 GL4034
GC1201C	BAT. 1 CUR	1-9/3-11	---		0	60	AMPS	1.58	0	120	2.5		---	-	0		25			1/1 AHR	4M3
GC1202C	BAT. 2 CUR	3-12/1-13	---		0	60	AMPS	1.58	0	120	2.5		---	-	0		25			1/1 AHR	4M3
GC1203C	BAT. 3 CUR	1-9/3-9	---		0	60	AMPS	1.58	0	120	2.5		---	-	0		25			1/1 AHR	4M3
GC1204C	BAT. 4 CUR	3-9/3-10	---		0	60	AMPS	1.58	0	120	2.5		---	-	0		25			1/1 AHR	4M3
GC1205C	BAT. 5 CUR	1-8/3-11	---		0	120	AMPS	1.58	0	120	2.5		---	-	0		45			1/1 AHR	4M3
GC1206C	BAT. 6 CUR	1-9/3-9	---		0	120	AMPS	1.58	0	120	2.5		---	-	0		45			1/1 AHR	4M3
GC4361X	BAT. 1 HI TAP	---	2/4		ALWAYS ZERO					---			---	4FL1		DISCRETE				1 DPE	BAT HI TAPS WIRED TO LO TAP DISCRETES LM-1 ONLY
GC4362X	BAT. 1 LO TAP	---	2/4		1 = LO					---			---	4FL1		DISCRETE				1 DPE	
GC4363X	BAT. 2 HI TAP	---	2/4		ALWAYS ZERO					---			---	4FL2		DISCRETE				1 DPE	
GC4364X	BAT. 2 LO TAP	---	2/4		1 = LO					---			---	4FL2		DISCRETE				1 DPE	
GC4365X	BAT. 3 HI TAP	---	2/4		ALWAYS ZERO					---			---	4FL3		DISCRETE				1 DPE	
GC4366X	BAT. 3 LO TAP	---	2/4		1 = LO					---			---	4FL3		DISCRETE				1 DPE	
GC4367X	BAT. 4 HI TAP	---	2/4		ALWAYS ZERO					---			---	4FL4		DISCRETE				1 DPE	
GC4368X	BAT. 4 LO TAP	---	2/4		1 = LO					---			---	4FL4		DISCRETE				1 DPE	
GC4369X	BAT. 5 B/U CDR	---	2/4		1 = ON					---			---	4FL7		DISCRETE				1 DPE	
GC4370X	BAT. 6 NORM CDR	---	2/4		1 = ON					---			---	4FL6		DISCRETE				1 DPE	
GC4371X	BAT. 5 NORM SE	---	2/4		1 = ON					---			---	4FL5		DISCRETE				1 DPE	
GC4372X	BAT. 6 B/U SE	---	2/4		1 = ON					---			---	4FL8		DISCRETE				1 DPE	
GC9961U	BAT. 1 MAL	---	2/12	2/13	1 = MAL					---			OC/OT/RC	4DS1		DISCRETE				1 DPE	GL9001 GL4047
GC9962U	BAT. 2 MAL	---	2/12	2/13	1 = MAL					---			OC/OT/RC	4DS1		DISCRETE				1 DPE	GL9001 GL4047
GC9963U	BAT. 3 MAL	---	2/12	2/13	1 = MAL					---			OC/OT/RC	4DS1		DISCRETE				1 DPE	GL9001 GL4047
GC9964U	BAT. 4 MAL	---	2/12	2/13	1 = MAL					---			OC/OT/RC	4DS1		DISCRETE				1 DPE	GL9001 GL4047
GC9965U	BAT. 5 MAL	---	2/12	2/13	1 = MAL					---			OC/OT/RC	4DS1		DISCRETE				1 DPE	GL9001 GL4047
GC9966U	BAT. 6 MAL	---	2/12	2/13	1 = MAL					---			OC/OT/RC	4DS1		DISCRETE				1 DPE	GL9001 GL4047
GL0300	FRAME SYNC AND ID	---				---				---			---	-		---				50/1 DP	
GL0302	LBR	---		---		---				---			---	-		---				1/1 DP	
GL0401V	CAL 85 PCT	3-5/1-4		---	0	5.00	VDC	0.50		---			---	-	4.23	4.25	4.27	4.23	4.27	1 OR/1 AH	
GL0402V	CAL 15 PCT	3-5/4-5		---	0	5.00	VDC	0.50		---			---	-	0.73	0.75	0.77	0.73	0.77	1 OR/1 AH	
GL0501W	MET	---		---	-	40	DAYS	-		---			---	-		---				10/1 DP	
GL4054X	C&W PWR FAIL	---		---	1 = FAIL								POWER FAIL	-		DISCRETE				1/1 DPER	
GL4221X	DFI CAL ON	---		---	1 = ON					---			---	-		DISCRETE				1/1 DPER	
GL4222X	LM/SLA SEP	---		---	0 = SEP					---			---	-		DISCRETE				1 DPE	
GT0201E	S-BND PWR AMP PO	1-14		---	0	25	W							-	NOT RELIABLE ON LM-1					1/1 AH	
GT0202E	S-BND RFLT PWR	1-13		---	0	25	W							-	NOT RELIABLE ON LM-1					1 AH	
GT0441X	DCA STATUS	---		---		---				---			---	-	-99		-55			50 DP	
GT0619V	UHF SIG STR	2-5		---	-114	-59	DBM							-						1 AH	
GT0992B	S-BND ST PH ERR	2-14/2-3		---	-15	+15	DEG			---			---	-	-5		+5			10 AH	
GT0993E	S-BND XMTR PO	1-14		---	0.3	1.5	W			---			---	-						1/1AH	THIS MEASUREMENT NO LONGER INDICATES THE S-BAND TRANSCIEVER POWER OUTPUT; FOR READOUTS GREATER THAN 0.5 VDC TRANSCEIVER IS ON.
GT0994V	S-BND SIG STR	3-3		---	0	4.2	VDC		0	5			---	-	3.4		4.25	1.1	4.25	10 AH	MAINTAIN LOCK
													---	-	3.4		4.25	2.65	4.25		ACQ LOCK WITH PRI AMP
GY0111X	ED ARM A ON	---		1/14	1 = OFF					---			---	-		DISCRETE				1/1 DPER	
GY0112X	ED ARM B ON	---		1/14	1 = OFF					---			---	-		DISCRETE				1/1 DPER	
GY0121X	STG RLY A FIRE	---		1/14	1 = SAFE					---			---	-		DISCRETE				1/1 DPER	
GY0122X	STG RLY B FIRE	---		1/14	1 = SAFE					---			---	-		DISCRETE				1/1 DPER	

R-C

R-C

R-C

R-C

TABLE 6-3.3 SPACECRAFT INSTRUMENTATION FOR ECS

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE LOW	HIGH	UNITS	RSS ACC PCT	ONBOARD DISPLAY RANGE LOW	HIGH	RSS ACC PCT	CSM LIMITS LOW	HIGH	ADV	ESTIMATED NORMAL OPERATING LIMITS LOW	NORM	HIGH	CRITICAL LIMITS LOW	HIGH	S/C SAMPLING	NOTES
GF2021P	PRI GLY PUMP ΔP	1-10/3-9	---	0	50	PSID	1.87	---			---		---	35	35.3	35.7	13	36.8	1/1 AHR	
GF2041X	GLY LEVEL LOW	---	2/3	1 = LOW				---			CC		---		DISCRETE				1/1 DPER	GL4058
GF2936X	SEL GLY PUMP FAIL	---	---	---		---		---			CC		7DS3		---				---	NOT TM
GF3571P	CABIN PRESS.	1-9/3-11	---	0	10	PSIA	2.55	0	10	3.20	---		---	1.0		6.1		7.7	1/1 AHR	7M2A DURING FLIGHT R-C
GF3582P	ASC 1 O_2 PRESS	1-14	1/7	0	25	PSIA	2.62	0	100%				---	3.5	4.35	5.0	B	D	1 AH	GL4057 7M4A
GF3583P	ASC 2 O_2 PRESS	2-13	1/7	0	25	PSIA	2.62	0	100%				---	3.5	4.35	5.0	B	D	1 AH	GL4057 7M4A
																	A + B > 2.5 C + D < 6.5			
GF3591P	U/H RLF PRESS.	3-15	---	0	25	PSIA	2.55		---			---	---	1		6.1			1/1 AH	
GF3592P	F/H RLF PRESS.	1-14	---	0	25	PSIA	2.55		---			---	---	1		6.1			1/1 AH	
GF4101P	PRI H_2O REG ΔP	2-12/4-14	1/18	0	2	PSID	3.04		---			---	---	0.5	.75	1.0	A	C	1/1 AHR	
GF4511T	PRI W/B H_2O TEMP	4-15	2/6	20	160	°F			---			---	---	57	70	83	33	120	1/1 AH	
GF4582Q	ASC 1 H_2O QTY	2-6/4-8	1/8	0	100	PCT	2.91	0	100	3.49	95		---	67		100	34		1/1 AHR	GL4059 7M4B
GF4583Q	ASC 2 H_2O QTY	2-6/4-8	1/8	0	100	PCT	2.91	0	100	3.49	95		---	67		100	34		1/1 AHR	GL4059 7M4B
GF9997U	GLY PUMP PRESS	3-6	---	0	60	PSIA	2.06	0	80	2.50		---	---	41.0	42.8	44.7	19	46	1/1 AH	7M5A
GF9998U	GLY TEMP	3-11	1/10	20	120	°F	2.77	0	80	3.95	47.6		---	38	42	45	32	50	1/1 AH	7M5B GL4058

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE LOW	HIGH	UNITS	RSS ACC PCT	ONBOARD DISPLAY RANGE LOW	HIGH	RSS ACC PCT	C&W LIMITS LOW	HIGH	ADV	ESTIMATED NORMAL OPERATING LIMITS LOW	NORM	HIGH	CRITICAL LIMITS LOW	HIGH	S/C SAMPLING	NOTES
GG0061X	PGNS CMTR WORD					---			---		---		-		---				50 DS	---
GG0117H	PGS ALT (LGC)					---		0	60.5 KFT (2.35 FT)		---		-		VARIES				---	NOT TM 9M9A
GG0118L	VEL ALT RATE (LGC)					---		-700	+700 F/S (0.5 FT)		---		-		VARIES				---	NOT TM 9M9B
GG0119L	VEL FWD (LGC)					---		-200	+200 F/S 7.28		---		-		VARIES				---	NOT TM 9M2/3
GG0120L	VEL LAT (LGC)					---		-200	+200 F/S 7.28		---		-		VARIES				---	NOT TM 9M2/3
GG1040V	PGS TORQ REF	1-7/3-6		85	135	VDC	4.03		---		---		-		120				1 AHR	---
GG1110V	2.5 VDC TM BIAS	2-7/4-7		0	5	VDC	2.06		---		---		-		2.5				1R/1 AH	---
GG1201V	IMU 28 VAC 800	2-11		0	31.10	VRMS	4.03		---		---		-		28				1/1 AH	---
GG1331V	IRIG SUSP 3.2 KC	2-5		0	31.10	VRMS	4.03		---		---		-		28				1/1 AH	---
GG1513X	IMU STBY			1 = STBY					---		---		-		DISCRETE				1/1 DPER	---
GG1523X	LGC OPR	---		1 = OPR					---		---		-		DISCRETE				1/1 DPER	---
GG2001V	X PIPA OUT IN ϕ	2-1/1-2		-2.5	+2.5	VRMS	4.03		---		---		-		VARIES				50 AHR	---
GG2021V	Y PIPA OUT IN ϕ	1-1		-2.5	+2.5	VRMS	4.03		---		---		-		VARIES				50 AH	---
GG2041V	Z PIPA OUT IN ϕ	3-1/2-2	---	-2.5	+2.5	VRMS	4.03		---		---		-		VARIES				50 AHR	---
GG2107V	IG SVO ERR IN ϕ	1-1/2-1		-3	+3	VRMS	4.03		---		---		-		VARIES			{	100 AHR 100 AH	---
GG2110C	IG TORQ MTR CUR	3-2		-0.5	+0.5	AMPS	4.03		---		---		-		VARIES				100 AH	---
GG2112V	IG RSVR OUT SIN	3-3		-20.25	+20.25	VRMS	4.03		---		---		-		VARIES				10/1 AH	---
GG2113V	IG RSVR OUT COS	3-4	---	-20.25	+20.25	VRMS	4.03		---		---		-		VARIES				10/1 AH	---
GG2121V	IG RSVR SIN (EXP)	2-2	---	-5	+5	VRMS	4.03		---		---		-		VARIES				100 AH	---
GG2122V	MG RSVR OUT SIN		---			---		0	28 VRMS		---		-		VARIES				---	NOT TM 9M1/6
GG2123V	MG RSVR OUT COS		---			---		0	28 VRMS		---		-		VARIES				---	NOT TM 9M1/6
GG2137V	MG SVO ERR IN ϕ	3-1/2-1	---	-3	+3	VRMS	4.03		---		---		-		VARIES			{	100 AHR 100 AH	---
GG2140C	MG TORQ MTR CUR	3-2	---	-0.5	+0.5	AMPS	4.03		---		---		-		VARIES				100 AH	
GG2142V	MG RSVR OUT SIN	4-3/2-3	---	-20.25	+20.25	VRMS			---		---		-						10R/1 AH	
GG2143V	MG RSVR OUT COS	1-4/1-5		-20.25	+20.25	VRMS			---		---		-		VARIES			{	1/1 AH 10 AH	
GG2151V	MG RSVR SIN (EXP)	2-1		-5	+5	VRMS	4.03		---		---		-		VARIES				100 AH	
GG2152V	DG RSVR OUT SIN		---			---		0	28 VRMS		---		-		VARIES				---	NOT TM 9M1/6
GG2153V	DG RSVR OUT COS		---			---		0	28 VRMS		---		-		VARIES				---	NOT TM 9M1/6
GG2167L	DG SVO ERR IN ϕ	1-2/2-2	---	-3	+3	VRMS	4.03		---		---		-		VARIES			{	100 AHR 100 AH	---
GG2170C	DG TORQ MTR CUR	3-2	---	-0.9	+0.9	AMPS	4.03		---		---		-		VARIES				100 AH	---
GG2172V	DG RSVR OUT SIN	3-4	---	-20.25	+20.25	VRMS	4.03		---		---		-		VARIES				10/1 AH	---
GG2173V	DG RSVR OUT COS	1-3/1-8	---	-20.25	+20.25	VRMS	4.03		---		---		-		VARIES			{	1/1 AH 10 AH	---
GG2181V	DG RSVR SIN (EXP)	2-2	---	-5	+5	VRMS	4.03		---		---		-		VARIES				100 AH	---
GG2182V	AG RSVR OUT SIN	---	---			---		0	28 VRMS		---		-		VARIES				---	NOT TM 9M1/6
GG2183V	DG RSVR OUT COS	---	---			---		0	28 VRMS		---		-		VARIES				---	NOT TM 9M1/6
GG2217V	PITCH ATT ERR (PGNS)	---	---			---		-30	+30 DEG 3.92		---		-		NOT VALID ON LM-1 VARIES				10 AH ---	--- R-C NOT TM 9M1/6
GG2219V	PITCH ATT ERR	---	---	-5	+5	VRMS	4.03		---		---		-							
GG2247V	ROLL ATT ERR (PGNS)	---	---			---		-30	+30 DEG 3.92		---		-		NOT VALID ON LM-1 VARIES				10 AH ---	--- R-C NOT TM 9M1/6
GG2249V	YAW ATT ERR	---	---	-5	+5	VRMS	4.03		---		---		-							
GG2277V	YAW ATT ERR (PGNS)	---	---			---		-30	+30 DEG 3.92		---		-		NOT VALID ON LM-1 VARIES				10 AH ---	--- R-C NOT TM 9M1/6
GG2279V	ROLL ATT ERR	2--	---	-5	+5	VRMS	4.03		---		---		-							
GG2300T	PIPA TEMP	1-11/3-14	---	120	140	°F	4.03		---		---		-	120	NOT VALID ON LM-1 130	140			10 AH	R-C
GG2301T	IRIG TEMP	3-12	---	123	143	°F	4.03		---		---		-	123	133	143			1/1 AHR	
GG0320T	PIPA CAL TEMP	1-15	---	0	150	°F	4.03		---		---		-		82				1 AH	
GG9301X	LGC WARNING	---	2/3	1 = WARNING					---		CC		-		DISCRETE				1 AH	
GG9302X	ISS WARNING	---	2/3	1 = WARNING					---		CC		-		DISCRETE				1/1 DPE	GL4029
GG9303X	PGNS CAUTION	---	2/3	1 = CAUTION					---		CC		-		DISCRETE				1/1 DPE	GL4030
GH1204X	CUT DET	---	2/14	1 = OUT					---		---		-		DISCRETE				1/1 DPE	GL4045
GH1214X	AUTO CK	---	2/14	1 = ON					---		---		-		DISCRETE				1 DPE 1/1 DPE	

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE LOW	HIGH	UNITS	RSS ACC PCT	ONBOARD DISPLAY RANGE LOW	HIGH	RSS ACC PCT	CDW LIMITS LOW	HIGH	ADV	ESTIMATED NORMAL OPERATING LIMITS LOW	NORM	HIGH	CRITICAL LIMITS LOW	HIGH	S/C SAMPLING	NOTES	
GH1217X	AUTO OFF	---	2/14	1 = OFF					---		---		-		DISCRETE				1 DPE		
GH1230X	APS ARM	---	1/3	1 = ARM					---		---		-		DISCRETE				1 DPE		
GH1240V	X-TRANS CMD	1-3	2/17	-10	+10	VDC			---		---		-	-10	0	+10			10 AH	3 LEVEL DISCRETE	R-C
GH1247V	YAW ERR CMD	1-12/4-4	2/18	-13	+13	VDC	1.12		---		---		-	-13	±0.5	+13			10 AH 1/1 AH		
GH1248V	PITCH ERR CMD	1-12/2-4	2/18	-13	+13	VDC	1.12		---		---		-	-13	±0.5	+13			10 AH 1/1 AH		
GH1249V	ROLL ERR CMD	1-13/2-4	2/18	-13	+13	VDC	1.12		---		---		-	-13	±0.5	+13			10 AH 1/1 AH		
GH1260X	APS ON	---	2/2	1 = ON					---		---		-		DISCRETE				50/1 DPER		
GH1263X	ABORT STAGE	---	2/14	1 = STAGE					---		---		-		DISCRETE				50/1 DPER		
GH1266X	ENG FIRE OVER-RIDE	---	2/14	1 = ON					---		---		-		DISCRETE				1 DPE		
GH1301X	DPS ON	---	2/3	1 = ON					---		---		-		DISCRETE				1/1 DPE		
GH1311V	MAN THRUST CMD	4-12	1/15	0	14.6	VDC	5.12	0	100%	4.94	---		-		VARIES				1/1 AH	9M7B	
														2.6		2.4	2.8			NF 10%	R-C
														5.1		4.8	5.4			NF 30%	
														2.6		2.4	2.8			FIRING	
GH1313V	PITCH GDA POS	1-6/3-3	2/9	-15	+15	VRMS	1.50		---		---		-	-15	±.05	+15			10 AH 1/1 AH		
GH1314V	ROLL GDA POS	1-5/4-3	2/9	-15	+15	VRMS	1.50		---		---		-	-15	±.05	+15			10 AH 1/1 AH		
GH1323X	P TRM FAIL	---	2/3	1 = FAIL					---		CC		-		DISCRETE				1/1 DPE	GL4043	
GH1330X	R TRM FAIL	---	2/3	1 = FAIL					---		CC		-		DISCRETE				1/1 DPE	GL4043	
GH1331V	AUTO THRUST CMD	3-15/4-3	1/15	0	12	VDC	5.81	0	100% 13.56	5.50	---		-						10 AH 1/1 AH	9M7B	
															0					NF.	
													1	0		12.6	11.3	.5		FIRING FT.	
														0		8.4		8.4		FIRING < FT.	R-C
																6.3		6.3		50% AUTO THRUST CMD FIRING @ < FT.	
GH1348X	DPS ARM	---	1/3	1 = ARM		VDC			---		---		-		DISCRETE				1 DPE		
GH1401V	RGA SP MTR A-B	---	2/7			---			---				-						---	GL4026	
GH1402V	RGA SP MTR B-C	---	2/7			---			---		23	VRMS 29	-						---	GL4026	
GH1403V	RGA SP MTR C-A	---	2/7			---			---		23	VRMS 29	-						---	GL4026	
GH1405V	RGA PICKOFF EXCIT	---	1/17			---			---		23 26	VRMS 29 VRMS 30.8	-						--- ---	GL4026 GL4026	
GH1406V	+15 VDC SUP	---	2/19			---			---		14	VDC 16	-						---	GL4027	
GH1407V	-15 VDC SUP	---	2/19			---			---		-16	VDC -14	-						---	GL4027	
GH1408V	4.3 VDC SUP	---	2/8			---			---		3.8	VDC 4.8	-						---	GL4027	
GH1418V	JD 4U OUTPUT	---	1/4	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1419V	JD 4D OUTPUT	---	1/4	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1420V	JD 4F OUTPUT	---	1/4	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1421V	JD 4S OUTPUT	---	1/4	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1422V	JD 3U OUTPUT	---	1/4	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1423V	JD 3D OUTPUT	---	1/4	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1424V	JD 3F OUTPUT	---	1/4	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1425V	JD 3S OUTPUT	---	1/4	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1426V	JD 2U OUTPUT	---	1/2	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1427V	JD 2D OUTPUT	---	1/2	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1428V	JD 2F OUTPUT	---	1/2	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1429V	JD 2S OUTPUT	---	1/2	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1430V	JD 1U OUTPUT	---	1/2	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1431V	JD 1D OUTPUT	---	1/2	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1432V	JD 1F OUTPUT	---	1/2	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1433V	JD 1S OUTPUT	---	1/2	1 = ON					---				-		DISCRETE				200 DPE	GL4031	
GH1451V	RGA YAW RATE	2-3/3-4	2/10	-3.5	+3.5	VRMS	2.74		---				-		DISCRETE				200 DPE	GL4031	
GH1452V	RGA PITCH RATE	2-3/3-5	2/10	-3.5	+3.5	VRMS	2.74		---				-	-3.5	0	+3.5	-3.5	+3.5	10/1 AHR	5.5V = 25°/S	
GH1453V	RGA ROLL RATE	2-3/3-4	2/10	-3.5	+3.5	VRMS	2.74		---				-	-3.5	0	+3.5	-3.5	+3.5	10/1 AHR	5.5V = 25°/S	R-C
GH1438V	PRI -4.7 VDC	---	2/15			---			---				-	-3.5	0	+3.5	-3.5	+3.5	10/1 AHR	5.5V = 25°/S	
GH1439V	SEC -4.7 VDC	---	2/15			---			---		-5.2	VDC -4.2	-						---	GL4050	
GH1433V	+6 VDC SUP	---	2/19			---			---		-5.2	VDC -4.2	-						---	GL4050	
GH1454V	-6 VDC SUP	---	2/19			---			---		5.45	VDC 6.6	-						---	GL4027	
GH1497V	YAW RGA SIG	---	---			---VRMS		-2.8	+2.8	6.00	-6.6	VDC -5.4	-						---	GL4027	
GH1498V	PITCH RGA SIG	---	---			---VRMS		-2.8	+2.8	6.00		---	-						---	9M1/6	
GH1499V	ROLL RGA SIG	---	---			---VRMS		-2.8	+2.8	6.00		---	-						---	9M1/6	
GH1603X	MAN D-GND (INVPS LOGIC)	---	1/3	1 = 0 VDC		(WIDE)			---			---	-		DISCRETE				---	9M1/6	
GH1608X	AUTO MODE	---	2/14	1 = ON					---			---	-		DISCRETE				1 DPE	INVERSE	
GH1609X	ATT HOLD	---	2/14	1 = HOLD		(ON)			---			---	-		DISCRETE				1 DPE	GRND DIS	R-C
GH1611X	AGS SEL	---	2/3	1 = AGS SEL					---			---	-		DISCRETE				1 DPE		
GH1896X	ABEAL CPLS	---	2/14	1 = ON		(YES)			---			---	-		DISCRETE				1/1 DPE		
GL4026X	EES AC PWR FAIL	---	---	1 = FAIL					---				DCS6		DISCRETE				1 DPE 1/1 DPER	GH1401-3V	
GL4027X	EES DC PWR FAIL	---	---	1 = FAIL					---				DCS7		DISCRETE				1/1 DPER	GH1405V GH1406-8V GH1492,4V	
GW5151V	FRA COMPARE	---	---	1 = COMPARE					---												
GW5153V	FRA CLOCK ON	---	---	1 = ON					---			---	-		DISCRETE				50 DPE		
GY0050X	ABORT CMD	---	1/2	1 = CMD		(ON)			---			---	-		DISCRETE				10 DPE		
												---	-		DISCRETE				1/1 DPER		

TABLE 6-3.5 SPACECRAFT INSTRUMENTATION FOR PROPULSION

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE LOW	HIGH	UNITS	RSS ACC PCT	ONBOARD DISPLAY RANGE LOW	HIGH	RSS ACC PCT	C&W LIMITS LOW	HIGH	ADV	ESTIMATED NORMAL OPERATING LIMITS LOW	NORM	HIGH	CRITICAL LIMITS LOW	HIGH	S/C SAMPLING	NOTES	
GP0001P	APS HE 1 PRESS	1-14/2-12	1/3	0	4000	PSIA	1.96	0	4000	1.94	2993.6		-	2700		3500	1000	3500	1/1 AHR	PREPRESS.	R-C
																3500	1000	3500		POSTPRESS.	
														400		3500	150	3500		ENG. BURN	
																				GL4022	
																				10M1	
GP0002P	APS HE 2 PRESS	2-9/4-11	1/9	0	4000	PSIA	1.96	0	4000	1.94	2993.6		-						1/1 AHR	GL4022	-
																				10M1	
														2700		3500	1000	3500		PREPRESS.	R-C
														-		3500	1000	3500		POSTPRESS.	
														400		3500	150	3500		ENG. BURN	
GP0025P	APS HE REG PRESS.	3-7	1/8	0	300	PSIA	1.96		-			220.2	-						1/1 AHR	GL4041	
GP0201T	APS HE 1 TEMP	1-11/3-14	2/21	-200	+200	°F	1.78	-200	+200	1.78	-		-						1/1 AHR	10M1	
														30	70	140	30	140		PREPRESS.	
														30		140	30	140		POSTPRESS.	
														-120		140	-120	140		ENG. BURN	R-C
															70	140				POST BURN	
GP0202T	APS HE 2 TEMP	2-5/4-7	2/21	-200	+200	°F	1.78	-200	+200	1.78	-		-						1/1 AHR	10M1	
														30	70	140	30	140		PREPRESS.	
														30		140	30	140		POSTPRESS.	R-C
														-120		140	-120	140		ENG. BURN	
															70	140				POST BURN	
GP0318X	APS HE 1 CLSD		1/12	1 = CLSD					-		-		10FL1		DISCRETE			1 DPE			
GP0320X	APS HE 2 CLSD		1/12	1 = CLSD					-		-		10FL2		DISCRETE			1 DPE			
GP0718T	APS FUEL TEMP	2-13/4-12	1/8	20	120	°F	2.78	40	100	4.97	-		-	50	70	90	40	100	1/1 AHR	10M4A	
GP0908X	APS FUEL LO		2/2	1 = LO					-		CC		-		DISCRETE				1/1 DPE	GL4042	
GP1218T	APS OX TEMP	2-11/4-13	1/8	20	120	°F	2.78	40	100	4.97	-		-	50	70	90	40	100	1/1 AHR	10M4B	
GP1408X	APS OX LO	-	2/2	1 = LO					-		CC		-		DISCRETE				1/1 DPE	GL4042	
GP1501P	APS FUEL PRESS	2-8/4-10	1/19	0	250	PSIA	2.15	0	300	2.65	119.75		-						1/1 AHR	GL4022	
																				10M3A	
														100		190	100	190		PREPRESS.	
														180		203	170	203		POSTPRESS.	
														155	165	175	115	225		ENG. BURN	R-C
														178		203	170	203		POST BURN	
GP1503P	APS OX PRESS.	2-10/4-9	1/19	0	250	PSIA	2.15	0	300	2.65	119.75		-						1/1 AHR	GL4022	
																				10M3B	R-B
														100		190	100	190		PREPRESS.	
														180		203	170	203		POSTPRESS.	
														155	165	175	115	225		ENG. BURN	R-C
														178		203	170	203		POST BURN	
GP2010P	APS TCP	2-13/3-15	-	0	150	PSIA	2.06		-		-		-	115	120	125	90	155	1/1 AHR	ENG. BURN	
GP2997U	APS PROP VLVS POS		-	1 = MISMATCH					-		-		-						1 DPE		
			2/14																100 DPE		
GP2998U																					
GQ3018P	DPS HE REG PRESS.	4-8	1/19	0	300	PSIA	1.96		-		220	260	-						1/1 AH	GL4023	
														50		253	0	308		PREPRESS.	R-C
														243		248	242	253		BETWEEN BURNS	
														243	245	248	220	260		FULL THR. BURNS	
GQ3309X	DPS HE 1 CLSD		-	1 = CLSD					-		-		-		DISCRETE				1 DPE		
GQ3310X	DPS HE 2 OPN		-	1 = OPN					-		-		-		DISCRETE				1 DPE		
GQ3435P	DPS HE PRESS.	1-6/3-6	-	0	2000	PSIA	1.21	0	2000	1.35	-		-						1/1 AHR	10M1	
														500		1380	350	1560		PREPRESS.	
														350		1550	300	1710		FULL THR.	
														300		1550		1710		BETWEEN BURNS	R-C
GQ3603Q	DPS FUEL 1 QTY	2-9/4-11	-	0	95	PCT	*		SELECTED		-		-		VARIES				1R/1 AH	10M5B	
GQ3604Q	DPS FUEL 2 QTY	2-10/4-9	-	0	95	PCT	#		SELECTED		-		-		VARIES				1R/1 AH	10M5B	
GQ3605Q	DPS FUEL QTY SEL		-		-	PCT		0	99	**	-		-						-	10M5B	
GQ3611P	DPS FUEL PRESS	1-10/3-10	-	0	300	PSIA	1.87	0	300	2.69	-		-						1/1 AHR	10M3A	
														190		230	160	230		PREPRESS.	
														214	220	224	190	240		FULL THR. BURN	R-C
														229	235	239	220	260		10% THR. BURN	
														242		253	242	253		BETWEEN BURNS	
GQ3718T	DPS FUEL 1 TEMP	2-7/4-6	1/9	20	120	°F		40	100		-		-	50	70	90	40	100	1 AHR	10M4A	
GQ3719T	DPS FUEL 2 TEMP	1/4-13	1/9	20	120	°F		40	100		-		-	50	70	90	40	100	1 AHR	10M4A	
GQ4103Q	DPS OX 1 QTY	2-13/4-12	-	0	95	PCT	*		SELECTED		-		-			95	5.6		1R/1 AH	10M5A	
GQ4104Q	DPS OX 2 QTY	2-11/4-15	-	0	95	PCT	#		SELECTED		-		-			95	5.6		1R/1 AH	10M5A	
GQ4105Q	DPS OX QTY SEL		-		-	PCT		0	99	**	-		-						-	10M5A	
GQ4111P	DPS OX PRESS.	1-5/3-7	-	0	300	PSIA	1.87	0	300	2.69	-		-						1/1 AHR	10M3B	
														110		230	100	230		PREPRESS.	
														214	220	224	190	240		FULL THR. BURN	
														229	235	239	220	260		10% THR. BURN	R-C
														242		253	242	253		BETWEEN BURNS	
GQ4218T	DPS OX 1 TEMP	1-5/3-8	1-10	20	120	°F	2.78	40	100	4.97	-		-	50	70	90	40	100	1 AHR	10M4B	
GQ4219T	DPS OX 2 TEMP	1-6/3-8	1-10	20	120	°F	2.78	40	100	4.97	-		-	50	70	90	40	100	1 AHR	10M4B	
GQ4455X	DPS PROP LO	-	2/2	1 = LO					-		CC		-		DISCRETE				1 DPE	GL4024	

*ACC
0 TO 8 PCT 1.12%
8 TO 25 PCT 0.71%
25 TO 95 PCT 1.12%

**ACC
0 TO 8% QTY 1.0%
8 TO 25% QTY 0.5%
25 TO 95% QTY 1.0%

TABLE 6-3.5 SPACECRAFT INSTRUMENTATION FOR PROPULSION (CONCLUDED)

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE LOW	HIGH	UNITS	RSS ACC PCT	ONBOARD DISPLAY RANGE LOW	HIGH	RSS ACC PCT	C&W LIMITS LOW	HIGH	ADV	ESTIMATED NORMAL OPERATING LIMITS LOW	NORM	HIGH	CRITICAL LIMITS LOW	HIGH	S/C SAMPLING	NOTES
GQ8810P	RCS TCP	1-8/3-10	-	0	200	PSIA	1.87	0	1000	3.50		-	-	100	104	105	95	110	1/1 AHR	9MIA FULL T-P. BURN
GQ8810H	VAR I.U ACT POS	2-14/4-1/4-2	-	0	1	INCH	1.12		-			-	-	9 0		11 100	7 SSE CF COMMAND (G-1331)	14	50 AH 1/1 AH	I.U THR. BURN R-C
GQ7498U GQ7499U	RCS PROP VLVS OPEN	-	2/14	0	100	PCT			-			-	-	1 = Δ POSITION MISMATCH		DISCRETE			100 DPE 1 DPE	
GR1085Q	RCS PROP A QTY	1-11/3-14	-	0	100	PCT			-			-	-	0		100			1R/1 AH	
GR1089T	RCS A HE TEMP	1-11/3-12	2/20	20	120	°F			-			-	-	40		100		120	1/1 AHR	
GR1095Q	RCS PROP B QTY	1-11/3-13	-	0	100	PCT			-			-	-	0		100			1R/1 AHR	
GR1099T	RCS B HE TEMP	1-13/3-13	2/20	20	120	°F			-			-	-	40		100		120	1/1 AHR	
GR1101P	RCS A HE PRESS	2-11/4-14	1/6	0	3500	PSIA	1.96	0	4000	2.60	1696		-	1240		3000	500	3500	1/1 AHR	GL4052 8M1A
GR1102P	RCS B HE PRESS	2-12/4-12	1/6	0	3500	PSIA	1.96	0	4000	2.60	1696		-	1240		3000	500	3500	1/1 AHR	GL4052 8M1B
GR1201P	RCS A REG PRESS.	3-11/4-11	1/6	0	350	PSIA	1.96	0	400	2.60	170	200	-		NOT VALID ON LM-1				1 AH 1/1 AH	GL4032 8M1A R-C
GR1202P	RCS B REG PRESS.	4-13/3-13	1/6	0	350	PSIA	1.96	0	400	2.60	170	200	-	178	179	188	150	213	1/1 AH 1/1 AH	GL4033 8M1B
GR2121T	RCS A FUEL TEMP	2-8	2/20	20	120	°F	2.78	20	120	3.38		-	-	50		90	40	100	1/1 AH	8M2A
GR2122T	RCS B FUEL TEMP	2-8	2/20	20	120	°F	2.78	20	120	3.38		-	-	50		90	40	100	1/1 AH	8M2B
GR2201P	A FUEL MFLD PRESS.	1-1/1-7/3-6/4-1	-	0	350	PSIA	1.87	0	400	2.55		-	-	165		185	140	210	200 AHR 1R/1 AH	8M2A
GR2202P	B FUEL MFLD PRESS.	1-5/3-1/3-8	-	0	350	PSIA	1.87	0	400	2.55		-	-	165		185	140	210	200 AHR 1R/1 AH	8M2B
GR3201P	A OX MFLD PRESS.	1-7/2-2/3-7	-	0	350	PSIA	1.87	0	400	2.55		-	-	165		185	140	210	200 AHR 1R/1 AH	8M1A
GR3202P	B OX MFLD PRESS.	1-2/1-6/2-1/3-8	-	0	350	PSIA	1.87	0	400	2.55		-	-	165		185	140	210	200 AHR 1R/1 AH	8M1B
GR5031P	TCP 4U	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5032P	TCP 4D	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5033P	TCP 4F	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5034P	TCP 4S	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5035P	TCP 3U	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5036P	TCP 3D	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5037P	TCP 3F	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5038P	TCP 3S	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5039P	TCP 2U	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5040P	TCP 2D	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5041P	TCP 2F	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5042P	TCP 2S	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5043P	TCP 1U	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5044P	TCP 1D	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5045P	TCP 1F	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR5046P	TCP 1S	-	-		-				-			CC	-		DISCRETE				-	GL4031
GR6001T	QUAD 4 TEMP	4-6	1/20	20	200	°F	2.17	-100	200	2.37	36.4	186.7	-	122	126	130	120	190	1/1 AH	GL4053 18M1
GR6002T	QUAD 3 TEMP	4-7	1/20	20	200	°F	2.17	-100	200	2.37	36.4	186.7	-	122	126	130	120	190	1/1 AH	GL4053 18M1
GR6003T	QUAD 2 TEMP	4-10	1/20	20	200	°F	2.17	-100	200	2.37	36.4	186.7	-	122	126	130	120	190	1/1 AH	GL4053 18M1
GR6004T	QUAD 1 TEMP	4-13	1/20	20	200	°F	2.17	-100	200	2.37	36.4	186.7	-	122	126	130	120	190	1/1 AH	GL4053 18M1
GR9609U	RCS MAIN A CLSD	-	1/12	1 = CLSD					-				8FL5		DISCRETE				1/1 OPER	
GR9610U	RCS MAIN B CLSD	-	1/12	1 = CLSD					-				8FL7		DISCRETE				1/1 OPER	
GR9611U	ASC FEED A OPN	-	1/13	1 = OPEN					-				8FL6		DISCRETE				1/1 OPER	
GR9612U	ASC FEED B OPN	-	1/13	1 = OPEN					-				8FL8		DISCRETE				1/1 OPER	
GR9613U	A/B X-FEED OPN	-	1/13	1 = OPEN					-				8FL17		DISCRETE				1/1 OPER	
GR9661U	4A ISO CLSD	-	1/13 1/14	1 = CLSD					-				8FL14		DISCRETE				1 DPE	
GR9662U	4B ISO CLSD	-	1/13 1/14	1 = CLSD					-				8FL16		DISCRETE				1 DPE	
GR9663U	3A ISO CLSD	-	1/13 1/14	1 = CLSD					-				8FL13		DISCRETE				1 DPE	
GR9664U	3B ISO CLSD	-	1/13 1/14	1 = CLSD					-				8FL15		DISCRETE				1 DPE	
GR9665U	2A ISO CLSD	-	1/13 1/14	1 = CLSD					-				8FL10		DISCRETE				1 DPE	
GR9666U	2B ISO CLSD	-	1/13 1/14	1 = CLSD					-				8FL12		DISCRETE				1 DPE	
GR9667U	1A ISO CLSD	-	1/13 1/14	1 = CLSD					-				8FL9		DISCRETE				1 DPE	
GR9668U	1B ISO CLSD	-	1/13 1/14	1 = CLSD					-				8FL11		DISCRETE				1 DPE	

TABLE 6-4 SIGNAL CONDITIONING MEASUREMENT ASSIGNMENT

SCERA 1

SCERA LOCATION AND TYPE	ELEC/COMM	ECS	GNC	PROP	MEASUREMENT FIELD TITLES	CDH	PCM	DISP
LOC-1 GSE CHECKOUT								
LOC-2 SIGNAL ISOLATING DISCRETE BUFFER 504-2			GH1426V		JD 2U OUTPUT	X	X	
			GH1427V		JD 2D OUTPUT	X	X	
			GH1428V		JD 2F OUTPUT	X	X	
			GH1429V		JD 2S OUTPUT	X	X	
			GH1430V		JD 1U OUTPUT	X	X	
			GH1431V		JD 1D OUTPUT	X	X	
			GH1433V		JD 1S OUTPUT	X	X	
			GH1432V		JD 1F OUTPUT	X	X	
			G70050X		ABORT CMD	X	X	
					OPEN	X	X	
LOC-3 SIGNAL ISOLATING DISCRETE BUFFER 504-2			GH1603X		MIN DBND		X	
			GH1230X		APS ARM		X	
					OPEN	X		
					OPEN	X		
					OPEN	X	X	
					OPEN	X	X	
					OPEN	X	X	
					OPEN	X	X	
			GH1348X		DPS ARM	X	X	
					OPEN		X	
LOC-4 SIGNAL ISOLATING DISCRETE BUFFER 504-2					OPEN	X		
					OPEN	X		
			GH1418V		JD 4U OUTPUT	X	X	
			GH1420V		JD 4F OUTPUT	X	X	
			GH1419V		JD 4D OUTPUT	X	X	
			GH1421V		JD 4S OUTPUT	X	X	
			GH1422V		JD 3U OUTPUT	X	X	
			GH1423V		JD 3D OUTPUT	X	X	
			GH1424V		JD 3F OUTPUT	X	X	
			GH1425V		JD 3S OUTPUT	X	X	
LOC-5 SPARE					OPEN	X	X	X
					OPEN	X	X	
					OPEN	X	X	
					OPEN	X	X	
LOC-6 SIGNAL ISOLATING ANALOG BUFFER 504-1				GR1101P	RCS A HE PRESS.	X	X	X
				GR1102P	RCS B HE PRESS.	X	X	X
				GR1201P	RCS A REG PRESS	X	X	X
				GR1202P	RCS B REG PRESS	X	X	X
LOC-7 SPARE					OPEN	X	X	X
					OPEN	X	X	
					OPEN	X	X	X
					OPEN	X	X	
LOC-8 SIGNAL ISOLATING ANALOG BUFFER 504-1		GF4582Q			ASC 1 H_2O QTY	X	X	X
		GF4583Q			ASC 2 H_2O QTY	X	X	X
				GP0025P	APS HE REG PRESS	X	X	
				GP0001P	APS HE 1 PRESS.	X	X	X
LOC-9 RESISTANCE TO DC CONVERTER 506-2				GQ3718T	DPS FUEL 1 TEMP		X	X
				GQ3719T	DPS FUEL 2 TEMP		X	X
				GP0718T	APS FUEL TEMP		X	X
				GP1218T	APS OX TEMP		X	X
LOC-10 RESISTANCE TO DC CONVERTER 506-2		GF9998U			GLY TEMP	X	X	X
					OPEN		X	
				GQ4218T	DPS OX 1 TEMP		X	X
				GQ4219T	DPS OX 2 TEMP		X	X
LOC-11 SPARE					OPEN	X	X	
					OPEN	X	X	
					OPEN		X	X
					OPEN		X	X

SCERA LOCATION AND TYPE	ELEC/COMM	ECS	GNC	PROP	MEASUREMENT FIELD TITLES	CDH	PCM	DISP
LOC-12 SIGNAL ISOLATING DISCRETE BUFFER 504-4				GR9609U	RCS MAIN A CLSD	X		
				GR9610U	RCS MAIN B CLSD	X		
					OPEN		X	X
					OPEN		X	X
					OPEN		X	X
				GP0318X	APS HE 1 CLSD		X	X
				GP0320X	APS HE 2 CLSD		X	X
				GR9609U	RCS MAIN A CLSD		X	X
					OPEN	X		X
				GR9610U	RCS MAIN B CLSD		X	X
					OPEN		X	X
					OPEN		X	X
LOC-13 SIGNAL ISOLATING DISCRETE BUFFER 504-4				GR9661U	4A ISO CLSD		X	X
				GR9662U	4B ISO CLSD		X	X
				GR9663U	3A ISO CLSD		X	X
				GR9664U	3B ISO CLSD		X	X
				GR9665U	2A ISO CLSD		X	X
				GR9666U	2B ISO CLSD		X	X
				GR9667U	1A ISO CLSD		X	X
				GR9668U	1B ISO CLSD		X	X
					OPEN		X	X
				GR9611U	ASC FEED A OPEN		X	X
				GR9612U	ASC FEED B OPEN		X	X
				GR9613U	A/B XFEED OPEN		X	X
LOC-14 SIGNAL ISOLATING DISCRETE BUFFER 504-5				GR9661U	4A ISO CLSD	X		
				GR9662U	4B ISO CLSD	X		
				GR9663U	3A ISO CLSD	X		
				GR9664U	3B ISO CLSD	X		
				GR9665U	2A ISO CLSD	X		
				GR9666U	2B ISO CLSD	X		
				GR9667U	1A ISO CLSD	X		
				GR9668U	1B ISO CLSD	X		
	GY0111X				ED ARM A ON		X	
	GY0112X				ED ARM B ON		X	
	GY0121X				STG RLY A FIRE		X	
	GY0122X				STG RLY B FIRE		X	
LOC-15 ATTENUATOR 502-2					AUTO THRUST CMD		X	X
			GH1331V		MAN THRUST CMD		X	X
	GC0301V		GH1311V		CDR BUS VOLT	X		
					OPEN	X		
LCC-16 FREQ TO DC CONVERTER 505-1	GC0155F				AC BUS FREQ	X		
					OPEN	X		
					OPEN		X	
LOC-17 AC TO DC CONVERTER 503-2	GC0071V				AC BUS VOLT	X		
			GH1405V		OPEN		X	
					RGA EXCIT	X		
LOC-18 SIGNAL ISOLATING ANALOG BUFFER 504-1	GC0155F				AC BUS FREQ		X	
	GC0071V				AC BUS VOLT		X	X
	GC0301V				CDR BUS VOLT		X	X
			GF4101P		PRI H_2O REG ΔP		X	
LOC-19 SIGNAL ISOLATING ANALOG BUFFER 504-1				GP0002P	APS HE. 2 PRESS	X	X	X
				GQ3018P	DPS HE. REG PRESS	X	X	
				GP1501P	APS FUEL PRESS	X	X	X
				GP1503P	APS OX PRESS	X	X	X
LOC-20 RESISTANCE TO DC CONVERTER 506-2				GR6022T	QUAD 3 TEMP	X	X	X
				GR6005T	QUAD 2 TEMP	X	X	X
				GR6004T	QUAD 1 TEMP	X	X	X
				GR6001T	QUAD 4 TEMP	X	X	X
LOC-21 SPARE					OPEN		X	X
					OPEN		X	X
					OPEN		X	X
					OPEN	X	X	X
LOC-22 CAPPED								

SCERA 2

SCERA LOCATION AND TYPE	ELEC/COMM	ECS	GNC	PROP	MEASUREMENT FIELD TITLES	CDH	PCM	DISP
LOC-1 GSE CHECKOUT								
LOC-2 SIGNAL ISOLATING DISCRETE BUFFER 504-3					OPEN	X	X	
					OPEN	X	X	
					OPEN	X	X	
					OPEN	X	X	
				GP0908X	APS FUEL LO	X	X	
				GP1408X	APS OX LO	X	X	
					OPEN	X	X	
			GH1260X	GQ4455X	DPS PROP LO	X	X	
					APS ON	X	X	
					OPEN	X	X	
					OPEN	X	X	
LOC-3 SIGNAL ISOLATING DISCRETE BUFFER 504-3				GG9003X				
					PGNS CAUTION	X	X	
		GP2041X			OPEN	X	X	
			GH1301X		GLY LEVEL LOW	X	X	
			GH1621X		DPS ON	X	X	
					AGS SEL	X	X	
					OPEN	X	X	
					OPEN	X	X	
			GH1323X		PTRM FAIL	X	X	
			GH1330X		R TRM FAIL	X	X	
			GG9001X		LGC WARNING	X	X	
			GG9002X		ISS WARNING	X	X	
LOC-4 SIGNAL ISOLATING DISCRETE BUFFER 504-4	GC4361X				BAT. 1 HI TAP		X	X
	GC4362X				BAT. 1 LOW TAP		X	X
	GC4363X				BAT. 2 HI TAP		X	X
	GC4364X				BAT. 2 LOW TAP		X	X
	GC4365X				BAT. 3 HI TAP		X	X
	GC4366X				BAT 3 LOW TAP		X	X
	GC4367X				BAT 4 HI TAP		X	X
	GC4368X				BAT 4 LOW TAP		X	X
	GC4369X				BAT 5 B/U CDR		X	X
	GC4370X				BAT 6 NORM CDR		X	X
	GC4371X				BAT. 5 NORM SE		X	X
	GC4372X				BAT. 6 B/U SE		X	X
LOC-5 SIGNAL ISOLATING DISCRETE BUFFER 504-5					OPEN		X	
					CKTS 1-12			
							X	
LOC-6 RESISTANCE TO DC CONVERTER 506-2					OPEN		X	
					OPEN		X	
					OPEN		X	
		GF4511T			PRI W/B H_2O TEMP		X	
LOC-7 AC TO DC CONVERTER 503-2			GH1401V		RGA SP MTR A-B	X		
			GH1402V		RGA SP MTR B-C	X		
			GH1403V		RGA SP MTR C-A	X		
LOC-8 DC AMPLIFIER 501-1					OPEN	X		
					OPEN		X	X
			GH1408V		4 5 VDC SUP	X		
	GC0302V				SE BUS VOLT		X	X
LOC-9 PHASE SENSITIVE DEMODULATOR 507-1			GH1313V		PITCH GDA POS		X	
			GH1314V		ROLL GDA POS		X	
					OPEN		X	
					OPEN		X	
LOC-10 PHASE SENSITIVE DEMODULATOR 507-1					OPEN		X	
			GH1461V		RGA YAW RATE		X	
			GH1462V		RGA PITCH RATE		X	
			GH1463V		RGA ROLL RATE		X	
LOC-11 CAPPED								

SCERA LOCATION AND TYPE	ELEC/COMM	ECS	GNC	PROP	MEASUREMENT FIELD TITLES	CDH	PCM	DISP
LOC-12 SIGNAL ISOLATING DISCRETE BUFFER 504-4					OPEN	X		X
					OPEN		X	X
					OPEN		X	X
					OPEN		X	X
					OPEN		X	
	GC9961U				BAT. 1 MAL		X	X
	GC9962U				BAT 2 MAL		X	X
	GC9963U				BAT. 3 MAL		X	X
	GC9964U				BAT. 4 MAL		X	X
	GC9965U				BAT. 5 MAL		X	X
	GC9966U				BAT. 6 MAL		X	X
LOC-13 SIGNAL ISOLATING DISCRETE BUFFER 504-5					OPEN		X	
					OPEN		X	
					OPEN	X		
					OPEN		X	
					OPEN		X	
	GC9961U				OPEN		X	
	GC9962U				BAT 1 MAL	X		
	GC9963U				BAT. 2 MAL	X		
	GC9964U				BAT. 3 MAL	X		
	GC9965U				BAT 4 MAL	X		
	GC9966U				BAT. 5 MAL	X		
					BAT 6 MAL	X		
LOC-14 SIGNAL ISOLATING DISCRETE BUFFER 504-5			GH1283X		ABORT STAGE		X	
			GH1286X		END FIRE OVERRIDE		X/	
			GH1608X		AUTO MODE		X	
			GH1609X		ATT HOLD		X	
			GH1210X		OUT DET		X	
			GH1211X		AUTO ON		X	
			GH1217X		AUTO OFF		X	
			GH1896X		UNBAL CPLS		X	
				GQ7498X	DPS PROP VLVS ΔPOS		X	
				GQ7499X	DPS PROP VLVS ΔPOS		X	
				GP2997U	APS PROP VLVS ΔPOS		X	
				GP2998U	APS PROP VLVS ΔPOS		X	
LOC-15 ATTENUATOR 502-2			GH1488V		PRI -4.7 VDC	X		
			GH1489V		SEC -4 7 VDC	X		
	GC0302V				OPEN	X		
					SE BUS VOLT	X		
LOC-16 ATTENUATOR 502-2	GC0201V							
	GC0202V				BAT. 1 VOLT		X	X
	GC0203V				BAT 2 VOLT		X	X
	GC0204V				BAT 3 VOLT		X	X
					BAT 4 VOLT		X	X R-C
LOC-17 ATTENUATOR 502-2	GC0205V							
			GH1240V		BAT 5 VOLT		X	X
					X TRANS CMD		X	
					OPEN		X	
					OPEN		X	
LOC-18 ATTENUATOR 502-2	GC0206V							
					BAT. 6 VOLT		X	X
			GH1249V		ROLL ERR CMD		X	
			GH1247V		YAW ERR CMD		X	R-C
			GH1248V		PITCH ERR CMD		X	
LOC-19 ATTENUATOR 502-2			GH1406V		+15 VDC SUP	X		
			GH1407V		-15 VDC SUP	X		
			GH1493V		+6 VDC SUP	X		
			GH1496V		-6 VDC SUP	X		
LOC-20 RESISTANCE TO DC CONVERTER 506-2				GR1089T	RCS A HE. TEMP		X	X
				GR2121T	RCS A FUEL TEMP		X	X
				GR2122T	RCS B FUEL TEMP		X	X
				GR1099T	RCS B HE TEMP		X	X
LOC-21 RESISTANCE TO DC CONVERTER 506-2					OPEN		X	
					OPEN	X		X
				GP0201T	APS HE. 1 TEMP		X	X R-C
				GP0202T	APS HE. 2 TEMP		X	X
LOC-22 CAPPED								
								R-C

TABLE 6-5 TELEMETRY VERSUS PAM GATES

PAM 1

SEQ	CHANNEL(S)	ELEC/COMM	ECS	GNC	PROP
1	200AH1 (200AH4) 100AH1 (100AH9) 100AH8 100AH15 50AH1	--	--	GG2107 -- GG2107 GG2021	GR2201 --
2	200AH5 (200AH2) 100AH5 100AH12 (100AH8) 100AH19 (100AH13) 50AH5 (50AH2)	--	--	GG2167 -- GG2167 GG2001	GR3202 --
3	10AH1 10AH8 10AH18 10AH28 10AH37 (10AH13)	-- -- --	-- -- --	GH1240 -- -- GG2173 --	-- -- --
4	10AH12 10AH22 10AH32 10AH41 (10AH26)***	-- -- *GL0401	-- --	GG2143 -- --	-- --
5	1AH3 (1AH48) 1AH7** 1AH11 1AH15 (1AH44)*** 1AH19 (1AH29)			*GG2143 *GH1314	GQ4218 *GR2202 *GQ4111
6	1AH22 *1AH26 1AH30 (1AH6) 1AH34 (1AH56) 1AH38 (1AH52)**	---	---	*GH1313 ---	--- *GQ3435 GQ4219 *GR3202
7	1AH41 1AH45 (1AH14)*** 1AH49 (1AH2) 1AH53 (1AH21)** 1AH57	GC0202 GC0204		GG1040	*GR2201 *GR3201
8	*1AH60 1AH64 1AH68 (1AH102) 1AH72 1AH76 (1AH86)	--- *GC1205 GC0201	---	--- *GG2173	--- *GQ6510
9	1AH79 1AH83 (1AH98) 1AH87 (1AH75) 1AH91 (1AH106) 1AH95 (1AH63)	GC0203 *GC1206 *GC1201 *GC1203	 *GF3571		
10	1AH99 (1AH59) 1AH103 (1AH90) *1AH107 1AH111 *1AH115	--- --- ---	*GR2021 --- ---	--- GG6020 ---	*GQ3611 --- ---
11	1AH119 (1AH146)*** 1AH123 (1AH166) 1AH127 *1AH131 (1AH142) 1AH135 (1AH170)	 *GC0302 ---	 ---	 *GG2300 ---	*GR1095 *GP0201
12	1AH139 *1AH143 (1AH134) *1AH147 (1AH130) 1AH151 (1AH162) 1AH155	 ---	 	*GH1247 --- *GH1248	*GR1089 --- *GR1085
13	1AH159 1AH163 (1AH154) 1AH167 (1AH122) *1AH171 1AH175	GT0202 *GC1202	 ---	 --- *GH1249	*GR1099 ---
14	1AH179 (1AH153) 1AH183 1AH187 1AH191 1AH195	 *GT0201 *GT0993	 *GF3592 GF3582		*GP0001

PAM 2

SEQ	CHANNEL(S)	ELEC/COMM	ECS	GNC	PROP
1	200AH2 (200AH5) 100AH2 100AH9 (100AH1) 100AH16 (100AH3) 50AH2 (50AH5)			GG2151 GG2107 GG2137 GG2001	GR3202
2	200AH6 100AH6 100AH13 (100AH19) 100AH20 50AH6 (50AH3)			GG2121 GG2167 GG2181 GG2041	GR3201
3	10AH2 10AH9 (10AH40) 10AH19 (10AH43) 10AH29 (10AH45) 10AH38 (10AH34)	GT0992		*GG2142 *GH1461 *GH1462 *GH1463	
4	10AH5 10AH13 (10AH37) 10AH23 10AH33 10AH42 (10AH7)	---	---	GH1249 --- GG2279 GH1248 ---	--- ---
5	1AH1 1AH5 1AH9 1AH13 (1AH27) 1AH17 (1AH46)	GT0619 *GC0205 ---	 ---	*GG1331 ---	 *GP0202 ---
6	1AH20 (1AH54) 1AH24 (1AH50) *1AH28 (1AH12) 1AH32 1AH36	 --- --- *GC0206	*GF4582 *GF4583 --- ---	 --- ---	 --- ---
7	1AH39 1AH43 (1AH16) 1AH47 (1AH4) 1AH51 (1AH23)** 1AH55 (1AH31)	--- --- ---	--- --- ---	--- --- *GG1110 ---	--- --- GQ3718 ---
8	*1AH58 (1AH88) 1AH62 (1AH92) 1AH66 1AH70 1AH74	--- --- ---	--- --- ---	--- --- ---	--- *GP1501 *GR2121 *GR2122
9	1AH77 (1AH104)*** *1AH81 (1AH96)* *1AH85 *1AH89 (1AH65) 1AH93 (1AH100)	--- --- --- ---	--- --- --- ---	--- --- --- ---	*GQ3603 --- --- *GP0002
10	1AH97 (1AH73) 1AH101 (1AH69) 1AH105 (1AH61) 1AH109 *1AH113	--- --- --- ---	--- --- --- ---	--- --- --- ---	--- *GQ3604 *GP1503 --- ---
11	1AH117 (1AH148) 1AH121 1AH125 (1AH160) 1AH129 (1AH144) 1AH133 (1AH176)***			*GG1201	GQ3719 *GR1101 *GP1218 *GQ4104
12	1AH137 1AH141 (1AH168) 1AH145 (1AH124) *1AH149 (1AH164)*** 1AH153 (1AH179)	--- --- 	--- *GF4101 --- 	--- --- 	--- *GR1102 --- *GP0001
13	1AH157 *1AH161 (1AH152) 1AH165 (1AH116)*** 1AH169 (1AH120) 1AH173 (1AH178)	 ---	GF3583 	 --- 	 --- *GQ4103 *GP0718 *GP2010
14	1AH177 (1AH172) *1AH181 1AH185 1AH189 1AH193	--- *GT0992 ---	--- ---	--- ---	--- --- *GQ6806

PAM 3

SEQ	CHANNEL(S)	ELEC/COMM	ECS	GNC	PROP
1	200AH3 100AH3 (100AH16) 100AH10 (100AH18) 100AH17 50AH3 (50AM6)	---	---	GG2137 --- GG2137 GG2041	GR2202 ---
2	200AH7 100AH7 100AH14 100AH21 50AH7	--- ---	--- ---	--- GG2170 GG2140 GG2110 ---	--- ---
3	10AH3 10AH10 10AH20 10AH30 10AH39 (10AH15)	GT0994 --- --- ---	 --- --- ---	 --- --- GH1313 ---	 --- --- ---
4	10AH6 (10AH44) 10AH14 10AH24 10AH34 (10AH38) 10AH43 (10AH19)	---	---	--- *GG2113 *GG2172 *GH1463 *GH1461	---
5	10AH16 10AH26 (10AH41)*** 10AH36 (10AH27)*** 10AH45 (10AH29)	 *GL0401 *GL0402	 	*GG2112 *GH1462	
6	1AH2 (1AH49) 1AH6 (1AH30) 1AH10 1AH14 (1AH45)* *1AH18	 *GF9997 ---	 ---	GG1040 ---	 *GQ3435 *GR2201 ---
7	1AH21 (1AH53)*** *1AH25 1AH29 (1AH19) 1AH33 1AH37	 --- ---	 --- ---	 --- ---	*GR3201 --- *GQ4111 --- *GP0025
8	1AH40 1AH44 (1AH15)* 1AH48 (1AH3) 1AH52 (1AH38) 1AH56 (1AH34)	---	---	---	--- *GR2202 GQ4218 *GR3202 GQ4219
9	1AH59 (1AH99) 1AH63 (1AH95) 1AH67 (1AH94) 1AH71 1AH75 (1AH87)	 *GC1203 *GC1204 --- *GC1206	*GF2021 --- 	 --- 	 ---
10	1AH78 1AH82 1AH86 (1AH76) 1AH90 (1AH103) 1AH94 (1AH67)	 *GC0071 *GC1204	 	 	 *GQ6510 *GQ3611
11	1AH98 (1AH83) 1AH102 (1AH68) 1AH106 (1AH91) 1AH110 1AH114	 *GC1205 *GC1201 	*GF3571 *GF9998	 	 GR1201***
12	1AH118 1AH122 (1AH167) 1AH126 1AH130 (1AH147) 1AH134 (1AH143)	 *GC1202 *GC0301 --- 	 --- 	GG2301 --- 	 --- *GR1089
13	1AH138 1AH142 (1AH131) 1AH146 (1AH119)*** 1AH150 1AH154 (1AH163)	 --- --- 	 --- --- 	 	*GR1202 --- *GR1095 --- *GR1099
14	1AH158 1AH162 (1AH151)*** 1AH166 (1AH123) 1AH170 (1AH135) 1AH174	GC0155 *GC0301	 	 *GG2300 	 *GR1085 *GP0201
15	1AH178 (1AH173) 1AH182* 1AH186 1AH190 1AH194	 --- --- 	 --- *GF3591	 --- *GH1331 --- 	*GP2010 --- ---

PAM 4

SEQ	CHANNEL(S)	ELEC/COM	ECS	GNC	PROP
1	200AH4 (200AH1) 100AH4 (100AH12) 100AH11 100AH18 (100AH10) 50AH4	-- -- --	-- -- --	-- -- --	GR2201 -- -- -- GQ6806
2	100AH22 50AH8	--	--	--	-- GQ6806
3	10AH4 10AH11 10AH21 10AH31 10AH40 (10AH9)	--<br---	--<br---	--<br-- GH1331 GH1314 *GG2142	--<br---
4	10AH7 (10AH42) 10AH15 (10AH39) 10AH25 10AH35 10AH44 (10AH6)	--<br-- ---	--<br-- ---	--<br-- GH1247 GG2219 ---	--<br-- ---
5	10AH17 10AH27 (10AH36)	*GL0402		GG2249	
6	1AH4 (1AH47) 1AH8 *1AH12 (1AH28) 1AH16 (1AH43)	--<br---	--<br---	--<br---	GQ3718 *GR6001 --- --- R-C
7	1AH23 (1AH51) 1AH27 (1AH13) 1AH31 (1AH55) 1AH35	--	--	*GG1110 ---	R-C *GP0202 --- *GR6002
8	1AH42 *1AH46 (1AH17) 1AH50 (1AH24) 1AH54 (1AH20)	---	*GF4583 *GF4582	---	*GQ3018 ---
9	1AH61 (1AH105) *1AH65 (1AH89) 1AH69 (AH101) **1AH73 (1AH97)	--- ---	--- ---	--- ---	*GP1503 --- *GQ3604 ---
10	1AH80 1AH84 **1AH88 (1AH58) 1AH92 (1AH62)	---	---	---	*GR6003 *GR6004 --- *GP1501
11	**1AH96 (1AH81)*** 1AH100 (1AH93) 1AH104 (1AH77)*** 1AH108 1AH112	---	---	---	--- *GP0002 *GQ3603 --- *GR1201*** R-C
12	1AH116 (1AH165)*** 1AH120 (1AH169) 1AH124 (1AH145) **1AH128 1AH132	---	---	-- *GH1311	*GQ4103 *GP0718 *GR1102 ---
13	1AH136 1AH140 1AH144 (1AH129) 1AH148 (1AH117) *1AH152 (1AH161)	---	---	---	--- *GR1202 *GP1218 GQ3719 ---
14	1AH156 1AH160 (1AH125) **1AH164 (1AH149)*** 1AH168 (1AH141) **1AH172 (1AH177)	---	---	---	--- *GR1101 --- *GF4101 ---
15	1AH176 (1AH133)*** **1AH180 *1AH184 1AH188 1AH192	---	---	---	*GQ4104 --- R-C --- --- *GF4511

*LBR
**REDUNDANT HBR ONLY
***TRANSDUCER MALFUNCTIONED

( ) REDUNDANT CHANNEL

*

THIS PAGE INTENTIONALLY LEFT BLANK

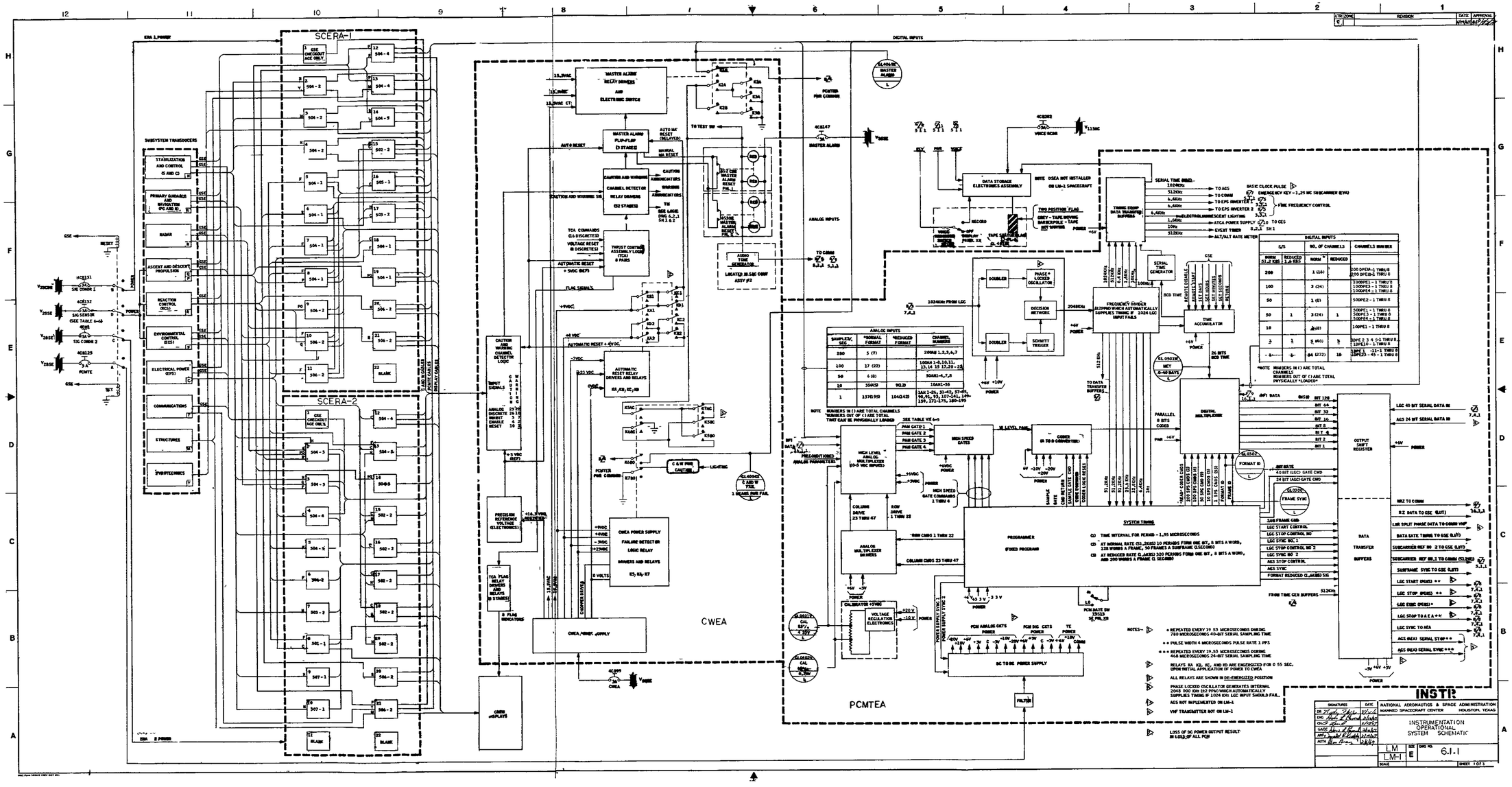
TABLE 6-7 PCMTEA SINGLE POINT FAILURES

FAILURE OF:	DATA LOST:
ANALOG MULTIPLEXER SEQUENCER	UP TO 20 ANALOG CHANNELS
ANALOG MULTIPLEXER ROW DRIVER	UP TO 20 ANALOG CHANNELS (4 SEQUENCE GATES)
ANALOG MULTIPLEXER COLUMN DRIVER	UP TO 14 ANALOG CHANNELS
HIGH-SPEED PAM GATE	UP TO 75 ANALOG CHANNELS
PROGRAMER a. ROW CMDS b. COLUMN CMDS c. HIGH-SPEED GATE CMDS	 a. UP TO 20 ANALOG CHANNELS b. UP TO 14 ANALOG CHANNELS c. UP TO 75 ANALOG CHANNELS
CODER	ALL ANALOG DATA
CALIBRATOR	LOSS OF ACCURACY CHECKS ON CODER
DIGITAL MULTIPLEXER	a. LOSS OF ALL ANALOG DATA, OR b. LOSS OF ALL DATA IN SAME BIT POSITION, OR c. LOSS OF ALL DATA
OUTPUT REGISTER	a. LOSS OF ALL SERIAL DIGITAL DATA (AGS OR PGNS), OR b. LOSS OF ALL DATA
FAILURE OF:	DATA LOST:
DATA TRANSFER BUFFERS	LOSS OF ALL DATA
POWER SUPPLY	LOSS OF ALL DATA AND TIMING OUTPUTS

TABLE 6-8 PRELAUNCH STATUS OF SWITCH AND CIRCUIT BREAKER POSITIONS

NAME		
SWITCHES	NUMBER	POSITION
MASTER ALARM; CDR	6S2	EXTINGUISHED
MASTER ALARM, SE	6S3	EXTINGUISHED
PCM	13S13	HI
TAPE RECORDER	13S11	OFF
CKT BREAKERS		
TAPE RECORDER	4CB202	OPEN
SIG CONDR 1	4CB131	CLOSED
MASTER ALARM	4CB147	OPEN
PCMTEA	4CB125	CLOSED
C&WEA	4CB99	CLOSED
SIG SENSOR	4CB132	CLOSED
SIG CONDR	4CB1	CLOSED

DWG NO. 6.1.1
DETAIL SHEET NO. 1


SCERA-1
SCERA-2
SUBSYSTEM TRANSDUCERS
STABILIZATION AND CONTROL (S AND C)
PRIMARY GUIDANCE AND NAVIGATION (PGA AND IE)
RADAR
ASCENT AND DESCENT PROPULSION
REACTION CONTROL (RCS)
ENVIRONMENTAL CONTROL (ECS)
ELECTRICAL POWER (EPS)
COMMUNICATIONS
STRUCTURES
PYROTECHNICS
CWEA
PCMTEA
MASTER ALARM RELAY DRIVERS AND ELECTRONIC SWITCH
MASTER ALARM FLIP-FLOP (3 STAGES)
CAUTION AND WARNING CHANNEL DETECTOR RELAY DRIVERS
CAUTION AND WARNING C&S STAGES
THRUST CONTROL ASSEMBLY (TCA) 8 PAIRS
AUTOMATIC RESET RELAY DRIVERS AND RELAYS
CWEA POWER SUPPLY FAILURE DETECTOR LOGIC RELAY
DRIVERS AND RELAYS
DATA STORAGE ELECTRONICS ASSEMBLY
TIMING STAMP DATA TRANSFER BUFFERS
FREQUENCY DIVIDER
TIME ACCUMULATOR
DIGITAL MULTIPLEXER
HIGH LEVEL ANALOG MULTIPLEXER (0-5 VDC INPUTS)
ANALOG MULTIPLEXER DRIVERS
PROGRAMMER
OUTPUT SHIFT REGISTER
DATA TRANSFER BUFFERS
SYSTEM TIMING
DC TO DC POWER SUPPLY
FILTER
ANALOG INPUTS
DIGITAL INPUTS
NOTES:
BASIC CLOCK PULSE
EMERGENCY KEY - 1.25 MC SUBCARRIER (EVA)
FINE FREQUENCY CONTROL
ELECTROLUMINESCENT LIGHTING
ATCA POWER SUPPLY
EVENT TIMER
ALT/VLT RATE METER
TO ACS
TO COMM
TO EPS INVERTER 1
TO EPS INVERTER 2
TO CES
TO DATA TRANSFER BUFFERS
FROM TIME GEN BUFFERS
LGC 40 BIT SERIAL DATA IN
AGS 24 BIT SERIAL DATA IN
MSFN TO COMM
RZ DATA TO GSE (LVT)
LGC SPLIT PHASE DATA TO COMM VHF
DATA RATE TIMING TO GSE (LVT)
SUBCARRIER REF NO 2 TO GSE (LVT)
SUBCARRIER REF NO 1 TO COMM (S-BAND)
SUBFRAME SYNC TO GSE (LVT)
LGC START (PGNS) **
LGC STOP (PGNS) **
LGC SYNC TO AEA
AGS (AEA) SERIAL SYNC ***
INSTR
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS
INSTRUMENTATION OPERATIONAL SYSTEM SCHEMATIC
LM
LM-1
DWG NO. 6.1.1
SHEET 1 OF 3

FRAME	WD 5	WD 37	WD 69	WD 98	WD 100	WD 101
1	10D1	10A1	10A2	11A5	11A7	10A3
2	10A4	10A5	10A6	10E1	11A27	10A7
3	10A8	10A9	10A10	10E2	11A27	10A11
4	10A12	10A13	10A14	10E3	10D2	10A15
5	10A16	10A17	10A18	10E4	11E1	10A19
6	10D3	10A20	10A21	11A5	11A7	10A22
7	10A23	10A24	10A25	10E5	11A17	10A26
8	10A27	10A28	10A29	10E6	11A27	10A30
9	10A31	10A32	10A33	10E7	10D4	10A34
10	10A35	10A36	10A37	10E8	11E1	10A38
11	10D5	10A39	10A40	11A5	11A7	10A41
12	10A42	10A43	10A44	10E9	11A17	10A45
13	10A46	10A47	10A48	10E10	11A27	10A49
14	10A50	10A51	10A52	10E11	10D6	10A53
15	10A54	10A55	10A56	10E12	11E1	10A57
16	10D7	10A58	10A59	11A5	11A7	10A60
17	10A61	10A62	10A63	10E13	11A17	10A64
18	10A65	10A66	10A67	10E14	11A27	10A68
19	10A69	10A70	10A71	10E15	10D8	10A72
20	10A73	10A74	10A75	10E16	11E1	10A76
21	10D9	10A77	10A78	11A5	11A7	10A79
22	10A80	10A81	10A82	10E17	11A17	10A83
23	10A84	10A85	10A86	10E18	11A27	10A87
24	10A88	10A89	10A90	10E19	10D10	10A91
25	10A92	10A93	10A94	10E20	11E1	10A95
26	10A96	10A97	10A98	11A5	11A7	10A99
27	10A100	10A101	10A102	10E21	11A17	10A103
28	10A104	10A105	10A106	10E22	11A27	10A107
29	10A108	10A109	10A110	10E23	10D11	10A111
30	10A112	10A113	10A114	10E24	11E1	10A115
31	10A116	10A117	10A118	11A5	11A7	10A119
32	10A120	10A121	10A122	10E25	11A17	10A123
33	10A124	10A125	10A126	10E27	11A27	10A127
34	10A128	10A129	10A130	10E28	10D12	10A131
35	10A132	10A133	10A134	10E30	11E1	10A135
36	10A136	10A137	10A138	11A5	11A7	10A139
37	10A140	10A141	10A142	10E31	11A17	10A145
38	10A144	10A145	10A146	10E32	11A27	10A147
39	10A148	10A149	10A150	10E33	10D13	10A151
40	10A152	10A153	10A154	10E35	11E1	10A155
41	10A156	10A157	10A158	11A5	11A7	10A159
42	10A160	10A161	10A162	10E36	11A17	10A163
43	10A164	10A165	10A166	10E37	11A27	10A167
44	10A168	10A169	10A170	10E38	10D14	10A171
45	10A172	10A173	10A174	10E40	11E1	10A175
46	10A176	10A177	10A178	11A5	11A7	10A179
47	10A180	10A181	10A182	10E41	11A17	10A183
48	10A184	10A185	10A186	10E42	11A27	10A187
49	10A188	10A189	10A190	10E43	10D15	10A191
50	10A192	10A193	10A194	10E45	11E1	10A195

HBR FORMAT

P F		P F		P F		P F		P F		P F		P F	
SYNC 51D1a	A	SYNC 51D1b	A	SYNC 51D1c	A	SYNC & PRIME FRAME NUMBER 51D1d	A	SEE ABOVE	A	22E1a	A	22E1b	A	12E1	A
1		2		3		4		5		6		7		8	
22A1	A	22A2	A	22A3	A	22A4	A	22A5	A	22A6	A	22A7	A	12E2	A
9		10		11		12		13		14		15		16	
12A1	A	12A2	A	12A3	A	12A4	A	12A5	A	12A6	A	12A7	A	51E1	A
17		18		19		20		21		22		23		24	
12A8	A	12A9	A	12A10	A	12A11	A	12A12	A	12A13	A	12A14	A	51E2	A
25		26		27		28		29		30		31		32	
11D1A 11A 8 9 E	B C D	11D1B 11A 9 E	B C D	11D1C 11A 10 E	B C D	11D1D 11A11 E	B C D	SEE ABOVE		22E1a	A	22E1b	A	12E3	A
33	17	34	38	35	19	36	40	37		38		39		40	
22A1	A	22A2	A	22A3	A	22A4	A	22A5	A	22A6	A	22A7	A	12E4	A
41		42		43		44		45		46		47		48	
12A15	A	12A16	A	12A17	A	12A18	A	12A19	A	12A20	A	12A21	A	12A22	A
49		50		51		52		53		54		55		56	
51A1	A	51A2	A	51A3	A	51A4	A	51A5	A	51A6	A	51A7	A	51A8	A
57		58		59		60		61		62		63		64	
11A 1 12 22 32	B C D E	11A 2 13 23 33	B C D E	11A 3 14 24 34	B C D E	11A 4 15 25 35	B C D E	SEE ABOVE		22E1a	A	22E1b	A	12E1	A
65	41	66	42	67	43	68	44	69		70		71		72	
22A1	A	22A2	A	22A3	A	22A4	A	22A5	A	22A6	A	22A7	A	12E2	A
73		74		75		76		77		78		79		80	
12A1	A	12A2	A	12A3	A	12A4	A	12A5	A	12A6	A	12A7	A	51E3	A
81		82		83		84		85		86		87		88	
12A8	A	12A9	A	12A10	A	12A11	A	12A12	A	12A13	A	12A14	A	51E4	A
89		90		91		92		93		94		95		96	
51D2	A	SEE ABOVE		SEE ABOVE		SEE ABOVE		SEE ABOVE		22E1a	A	22E1b	A	12E3	A
97		98		99		100		101		102		103		104	
22A1	A	22A2	A	22A3	A	22A4	A	22A5	A	22A6	A	22A7	A	12E4	A
105		106		107		108		109		110		111		112	
12A15	A	12A16	A	12A17	A	12A18	A	12A19	A	12A20	A	12A21	A	12A22	A
113		114		115		116		117		118		119		120	
51D51a	A	51D51b	A	51D51c	A	51D51d	A	51D51e	A	51D52a	A	51D52b	A	51D52c	A
121		122		123		124		125		126		127		128	

PF PRIME FRAME
A ALL PRIME FRAMES 1-50
B PRIME FRAMES 1 6, 11——46
C 2 7,12 ——47
D 3,8,13 ——48
E 4,9,14 ——49
F 5,10 15 ——50

WORD ABBREVIATIONS
*A ANALOG
*D DIGITAL PARALLEL
E DIGITAL PARALLEL EVENT
DS DIGITAL SERIAL

10 = 1.5 S/S
11 = 10 S/S
12 = 100 S/S
51 = 50 S/S
22 = 200 S/S

EXAMPLE:
.22 A 4
200 S/S ANALOG CHANNEL 4

10E1 GATE L H98
10E12 GATE (REDUN-DANT) L H98
10E6 GATE L H98
10E17 GATE (REDUN-DANT) L H98
10E10 GATE L H98
10E21 GATE (REDUN-DANT) L H98
10E23 GATE L H98
10E24 GATE L H100
10E25 GATE L H98
10E26 GATE L H98
10E36 GATE L H98
10E40 GATE L H98
10E41 GATE L H98
10E42 GATE L H98
51E1 GATE L H24
51E2 GATE (REDUN-DANT) L H32
10E37 (TYPICAL GATE) L AMP H98

10E2 GATE L H98
10E13 GATE (REDUN-DANT) L H98
10E7 GATE L H98
10E18 GATE (REDUN-DANT) L H98
10E8 GATE L H98
10E19 GATE (REDUN-DANT) L H98
10E11 GATE L H98
10E22 GATE (REDUN-DANT) L H98
10E27 GATE L H98
10E28 GATE L H98
10E29 GATE L H100
10E30 GATE L H98
10E38 GATE L H98
10E43 GATE L H98
10E45 GATE L H98
10D10 GATE L H100
10E44 GATE L H100

10E3 GATE L H98
10E14 GATE (REDUN-DANT) L H98
10E9 GATE L H98
10E20 GATE (REDUN-DANT) L H98
10E31 GATE L H98
10E32 GATE L H98
10E33 GATE L H98
10E34 GATE L H100
10E39 GATE L H100
51E3 GATE L H88
12E4 GATE L H48
22E1c GATE L H6
22E1b GATE L H7
10D2 GATE L H100
10D6 GATE (REDUN-DANT) L H100
10D3 GATE L H5
10D7 GATE (REDUN-DANT) L H5

10E4 GATE L H98
10E15 GATE (REDUN-DANT) L H98
10E35 GATE L H98
11E1 GATE L H100
51E4 GATE L H96
12E1 GATE L H8
12E2 GATE (REDUN-DANT) L H16
12E3 GATE L H40
10D4 GATE L H100
10D8 GATE (REDUN-DANT) L H100
10D5 GATE L H5
10D9 GATE (REDUN-DANT) L H5
51D2 GATE L H97

10E5 GATE L H98
10E16 GATE (REDUN-DANT) L H98

GL0300 SYNC — BIT CODE WT SET — MSB FIRST
SAME CODE IN NORMAL OR REDUCED
FRAME COUNTER
NORMAL 51 2KBS REDUCED 1.28 KBS GL0301 GL0302 COMPU-WORD
SYNC WORD 1 GATE 51D1a L H5 (INTERNAL)
SYNC WORD 2 GATE 51D1b L H2 (INTERNAL)
SYNC WORD 3 GATE 51D1c L H3 (INTERNAL)
SYNC WORD 4 GATE 51D1d L H4 (INTERNAL)

NOTE REDUCED FORMAT NOT AVAILABLE ON LM-1

GL0302 FORMAT — 51 21.6 BIT KBS KBS WT SET — MSB FIRST
FORMAT ID GATE 1001 L H5 (INTERNAL)

FROM DIGITAL CODED ANALOG GATE
WZ12 6.1.1 SH 3

DIGITAL PARALLEL SYSTEM COMMOX — BIT WT SET — MSB FIRST
DAYS UNITS 10's
HRS UNITS 10's
MIN UNITS 10's
SEC UNITS 10's
11D1a' GATE L H39 (INTERNAL)
11D1b L H34 (INTERNAL)
11D1c L H35 (INTERNAL)
11D1d L H36 (INTERNAL)

GL0502 MISSION ELAPSED TIME
MAX TIME 99 DAYS 23 HOURS 59 MINUTES 59 SECONDS RESET TO ZERO AT 60 DAYS OR UPON PCMTEA POWER INTERRUPTION

DCA BIT 8 — DCA BIT 1 — MSB

REDUNDANT GATES ARE REDUNDANT TO THE GATE IMMEDIATELY ABOVE AND CONTAIN SECONDARY DATA USED ONLY ON HSD CONTINGENCY FORMATS

BIT 8 IS MSB AND IS SHIFTED OUT FIRST TO THE MSFR

ACE AND GROUND STATION BIT IDENTIFICATION

GP9908 GP1408 GG9001 GG9002 GG9003 GR9661 GR9662 GR9663 GR9664 GR9665 GR9666 GR9667 GR9668 GH1230 GH1348 GH1603 GH1260 GH1283 GH1234 GH1301 GH1323 GH1350 GH1623 GC4561 GC4562 GC4563 GC4564 GC4565 GC4566 GC4567 GC4568 GR9518 GR9520 GC9961 GC9962 GC9963 GC9964 GC9965 GC9966 GL4028 GL4027 GL4054 GH1425 GH1424 GH1423 GH1422 GH1421 GH1420 GH1419 GH1418 GH1455 GH1452 GH1431 GH1430 GH1429 GH1428 GH1427 GH1426 GV0050 GV0111 GV0112 GV0121 GV0122 GC9509 GC9510 GP2041 GH1204 GH1217 GH1386 GH1608 GH1609 GH1696 GG4455 GP2997 GP2998 GQ7498 GQ7499 GC4569 GC4370 GC4371 GC4372 GL4021 GL4222 GW5153 GP2997 GP2998 GQ7498 GQ7499 GT0441 GT0442 GT0443 GT0444 GT0445 GT0446 GT0447 GT0448

1 2 3 4 5 6 7 8 — OUTPUT SHIFT REGISTER — DATA TRANSFER BUFFER — AMP

51D51 (GG9001) LGC L H121 — 40 BIT SERIAL DATA, DATA RATE SYNC, START PULSE, STOP PULSE

1024KHZ — PHASE LOCKED OSCILLATOR — TIMING GENERATOR — TIMING REFERENCE

40 BIT SYNC START STOP — BIT RATE CLOCK — DATA RATE TIMING

GATE CMDS — PROGRAMER

ROW & COLUMN CMDS TO ANALOG MUX DRIVERS WZ12 6.1.1 SHEET 3
HIGH SPEED PAM GATE CMDS (TOTAL 4) WZ12 6.1.1 SHEET 3
EXAMPLE GATE & CODE CMDS TO CODER WZ12 6.1.1 SH 3

>GATE CMDS TO ALL OTHER DIGITAL MUX GATES

DIODE GROUP 1 — DIODE GROUP 2 — DIODE GROUP 3 — DIODE GROUP 4 — DIODE GROUP 5

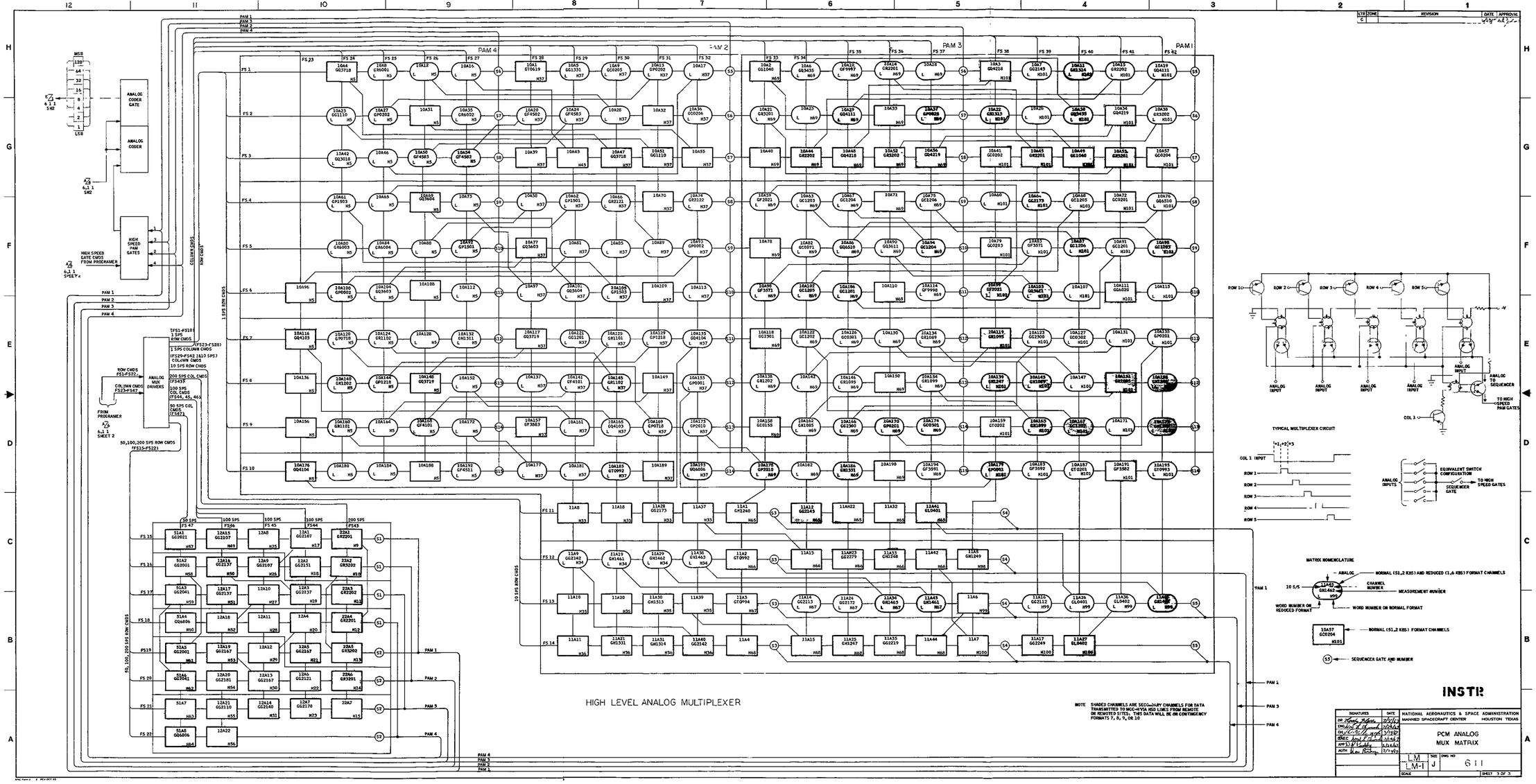
LSB BIT 1 H, BIT 2 G, BIT 3 F, BIT 4 E, BIT 5 D, BIT 6 C, BIT 7 B, BIT 8 MSB A

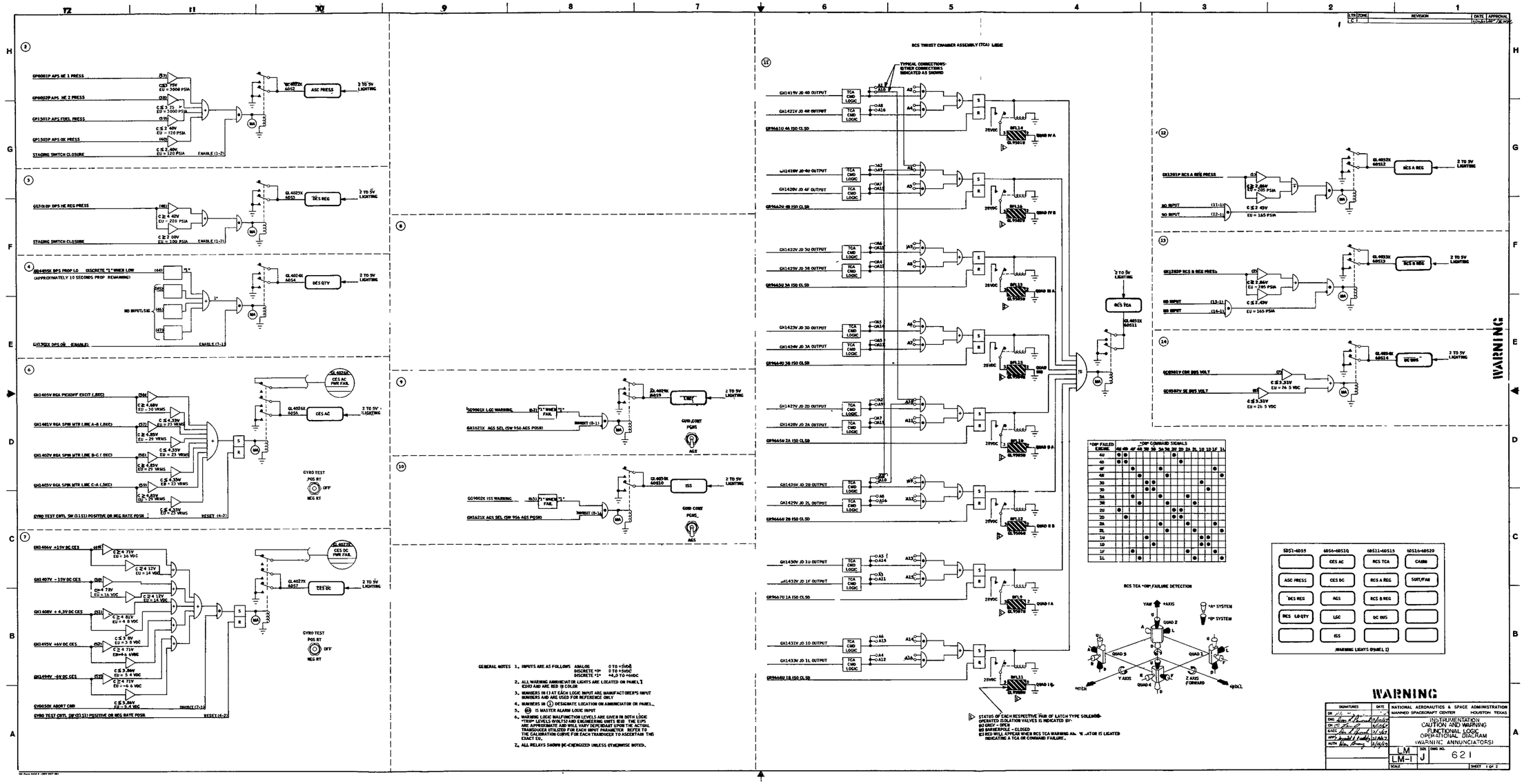
NRZ - C SERIAL DATA OUTPUT WZ 5.1.1

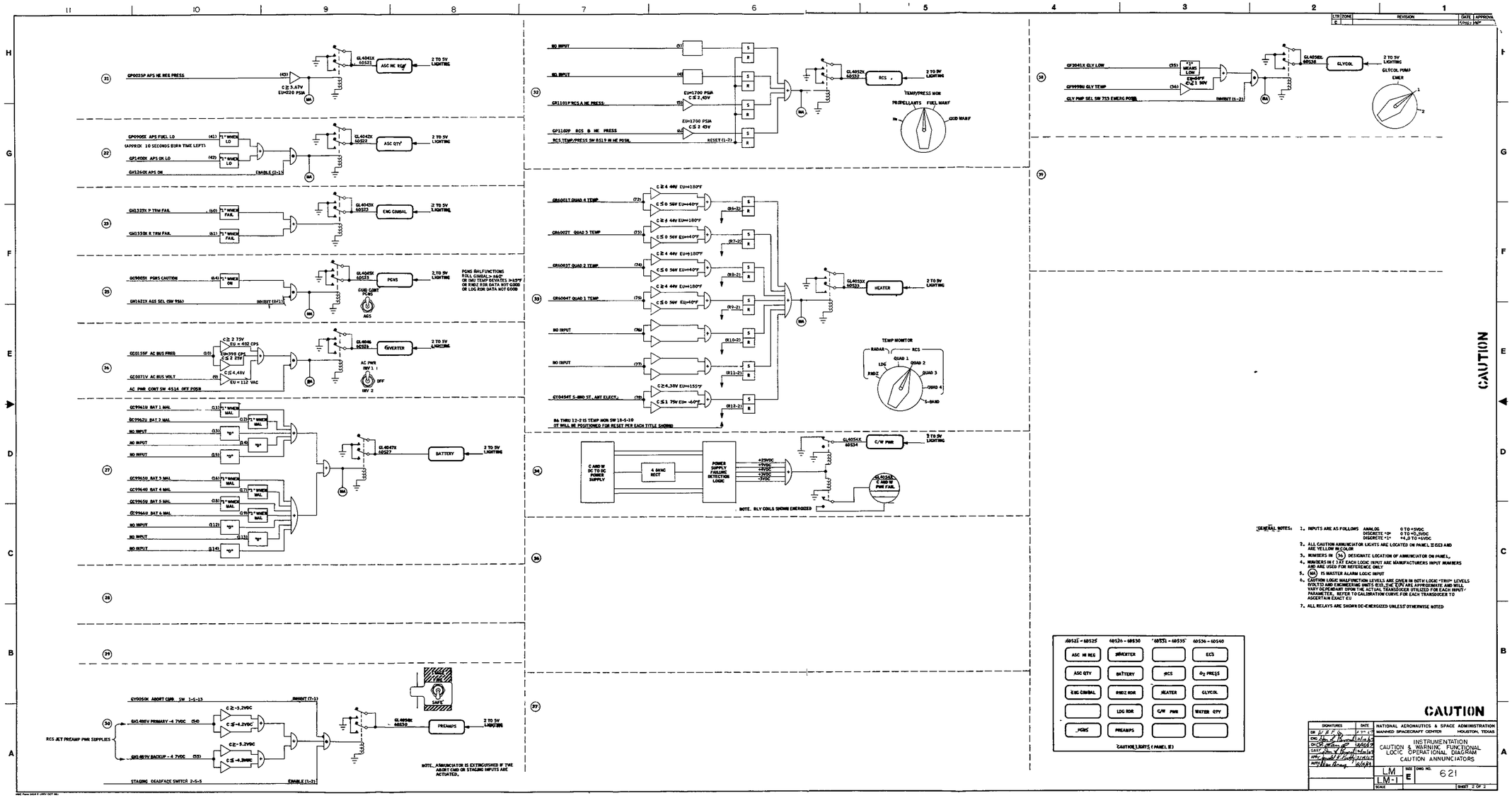
INSTR

SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER HOUSTON TEXAS
DR E. Clay	3/2/67	
ENG Jerry Pennington	3/2/67	LM-I DIGITAL MULTIPLEXING FOR DISCRETE TELEMETRY
CH D. Bellinger	3/2/67	
SPEC Ken A. Bailey	3/2/67	
APP'D W. Kinsley	3/2/67	
AUTH Ken Bailey	3/2/67	LM LM-1 — SIZE E — DWG NO. 6.1.1 — SCALE — SHEET 2 OF 3

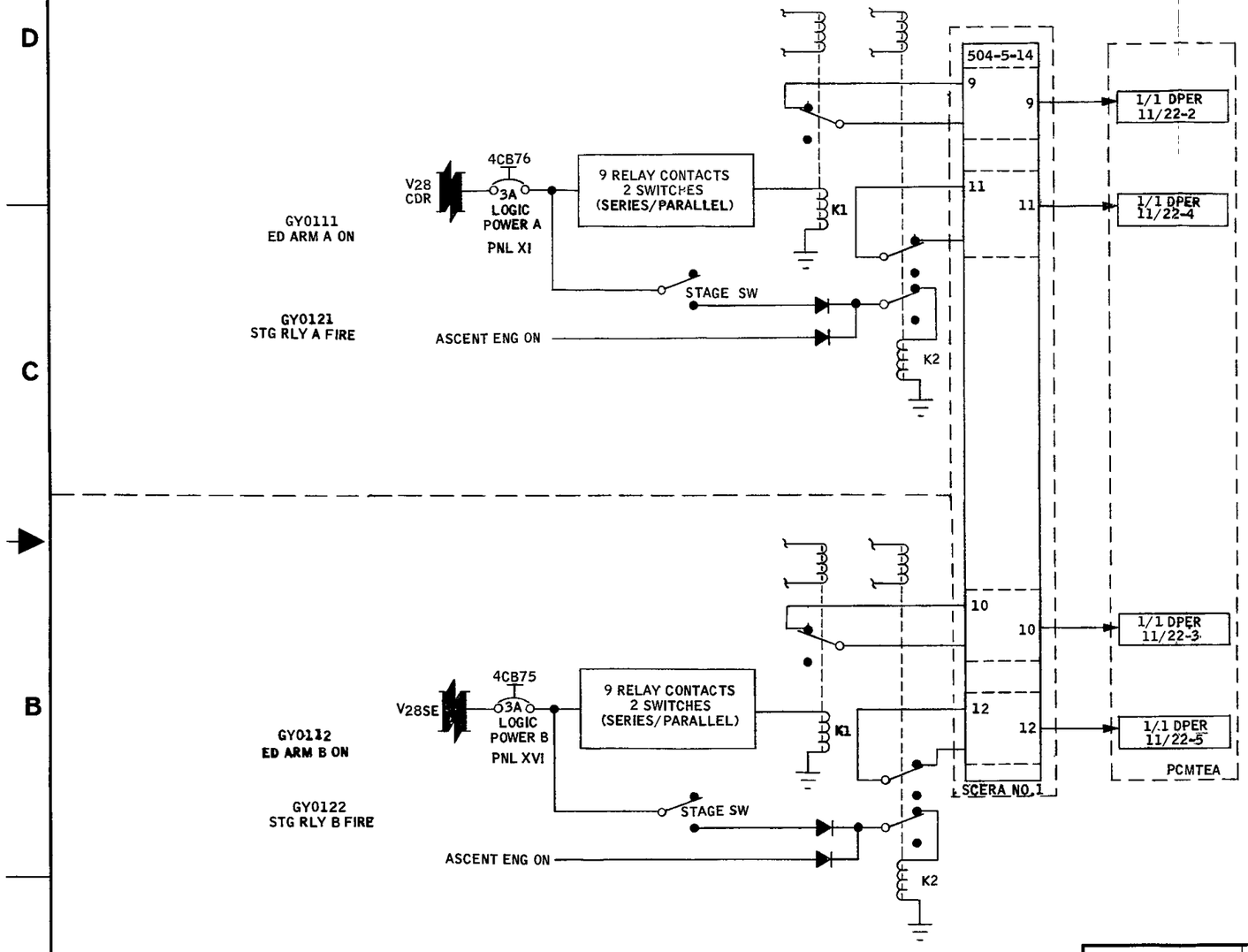
LTR	ZONE	REVISION	DATE	APPROVAL
C			8/21/67	


HIGH LEVEL ANALOG MULTIPLEXER
PAM 1
PAM 2
PAM 3
PAM 4
ANALOG CODER GATE
ANALOG CODER
HIGH SPEED PAM GATES
HIGH SPEED GATE CMOS FROM PROGRAMER
ROW CMOS
COLUMN CMOS
ANALOG MUX DRIVERS
FROM PROGRAMER
50,100,200 SPS ROW CMOS (FS11-FS221)
1 SPS ROW CMOS (FS1-FS10)
1 SPS COLUMN CMOS (FS23-FS28)
10 SPS ROW CMOS
10 SPS COL CMOS (FS244, 45, 46)
50 SPS COL CMOS (FS271)
100 SPS COL CMOS (FS23-FS47)
200 SPS COL CMOS (FS43)
TYPICAL MULTIPLEXER CIRCUIT
ANALOG INPUTS
TO HIGH SPEED PAM GATES
EQUIVALENT SWITCH CONFIGURATION
SEQUENCER GATE
MATRIX NOMENCLATURE
ANALOG — NORMAL (S1,2 KBS) AND REDUCED (1.6 KBS) FORMAT CHANNELS
CHANNEL NUMBER
MEASUREMENT NUMBER
WORD NUMBER ON REDUCED FORMAT
WORD NUMBER ON NORMAL FORMAT
NORMAL (S1,2 KBS) FORMAT CHANNELS
SEQUENCER GATE AND NUMBER
NOTE SHADED CHANNELS ARE SECONDARY CHANNELS FOR DATA TRANSMITTED TO MCC-H VIA HSD LINES FROM REMOTE OR REMOTED SITES. THIS DATA WILL BE ON CONTINGENCY FORMATS 7, 8, 9, OR 10
INSTR
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS
PCM ANALOG MUX MATRIX
LM-1
SIZE J
DWG NO 611
SCALE
SHEET 3 OF 3


WARNING
GENERAL NOTES
1. INPUTS ARE AS FOLLOWS ANALOG 0 TO +5VDC
DISCRETE "0" 0 TO +5VDC
DISCRETE "1" +4.0 TO +6VDC
2. ALL WARNING ANNUNCIATOR LIGHTS ARE LOCATED ON PANEL 1 EXCEPT AND ARE RED IN COLOR
3. NUMBERS IN ( ) AT EACH LOGIC INPUT ARE MANUFACTURER'S INPUT NUMBERS AND ARE USED FOR REFERENCE ONLY
4. NUMBERS IN ⑤ DESIGNATE LOCATION ON ANNUNCIATOR OR PANEL
5. ⑮ IS MASTER ALARM LOGIC INPUT
6. WARNING LOGIC MALFUNCTION LEVELS ARE GIVEN IN BOTH LOGIC "0" AND "1" LEVELS ONLY AND ENGINEERING UNITS FOR THE LOGIC "1" LEVEL. ENGINEERING UNITS ARE GIVEN FOR EACH TRANSDUCER UTILIZED FOR EACH INPUT PARAMETER. REFER TO THE CALIBRATION CURVE FOR EACH TRANSDUCER TO ASCERTAIN THE EXACT EU.
7. ALL RELAYS SHOWN DE-ENERGIZED UNLESS OTHERWISE NOTED.
RCS THRUST CHAMBER ASSEMBLY (TCA) LOGIC
TYPICAL CONNECTIONS- EITHER CONNECTION INDICATED AS SHOWN
GYRO TEST POS RT OFF NEG RT
GYRO/CONT PGMS AGS
GND/CONT PGMS AGS
RCS TCA
WARNING
SIGNATURES
DATE
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS
INSTRUMENTATION CAUTION AND WARNING (WARNING ANNUNCIATORS)
FUNCTIONAL LOGIC OPERATIONAL DIAGRAM
LM
LM-1
J
621
SHEET 1 OF 2


CAUTION
GENERAL NOTES:
1. INPUTS ARE AS FOLLOWS ANALOG 0 TO +10VDC
DISCRETE "0" 0 TO +0.2VDC
DISCRETE "1" +2.0 TO +10VDC
2. ALL CAUTION ANNUNCIATOR LIGHTS ARE LOCATED ON PANEL 2 (2) AND ARE YELLOW IN COLOR
3. NUMBERS IN ( ) DESIGNATE LOCATION OF ANNUNCIATOR ON PANEL,
4. NUMBERS IN ( ) AT EACH LOGIC INPUT ARE MANUFACTURERS INPUT NUMBERS AND ARE USED FOR REFERENCE ONLY
5. (MA) IS MASTER ALARM LOGIC INPUT
6. CAUTION LOGIC MALFUNCTION LEVELS ARE GIVEN IN BOTH LOGIC "TRIP" LEVELS (VOLTS) AND ENGINEERING UNITS (EU). THE "EU" ARE APPROXIMATE AND WILL VARY DEPENDANT UPON THE ACTUAL TRANSDUCER UTILIZED FOR EACH INPUT PARAMETER. REFER TO CALIBRATION CURVE FOR EACH TRANSDUCER TO ASCERTAIN EXACT EU
7. ALL RELAYS ARE SHOWN DE-ENERGIZED UNLESS OTHERWISE NOTED
60521 - 60525
60526 - 60530
60531 - 60535
60536 - 60540
ASC HI REG
HEATER
ECS
ASC QTY
BATTERY
RCS
O2 PRESS
ENG GIMBAL
RNDZ RDR
HEATER
GLYCOL
LDG RDR
C/W PWR
WATER QTY
PGNS
PREAMPS
CAUTION LIGHTS (PANEL 2)
CAUTION
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
INSTRUMENTATION
CAUTION & WARNING FUNCTIONAL LOGIC OPERATIONAL DIAGRAM
CAUTION ANNUNCIATORS
LM
LM-1
E
621
SHEET 2 OF 2

LTR	ZONE	REVISION	DATE	APPROVAL
C			6/30/67	



PYRO

SIGNATURES	DATE
DR Sandra Boyd	1/23/67
ENG Don L. Parish	2/9/67
CH D. Parish	2/13/67
GAEC Don L. Runyan	2/9/67
APP Donald P. Kelly	2/14/67
AUTH Don Bray	2/16/67

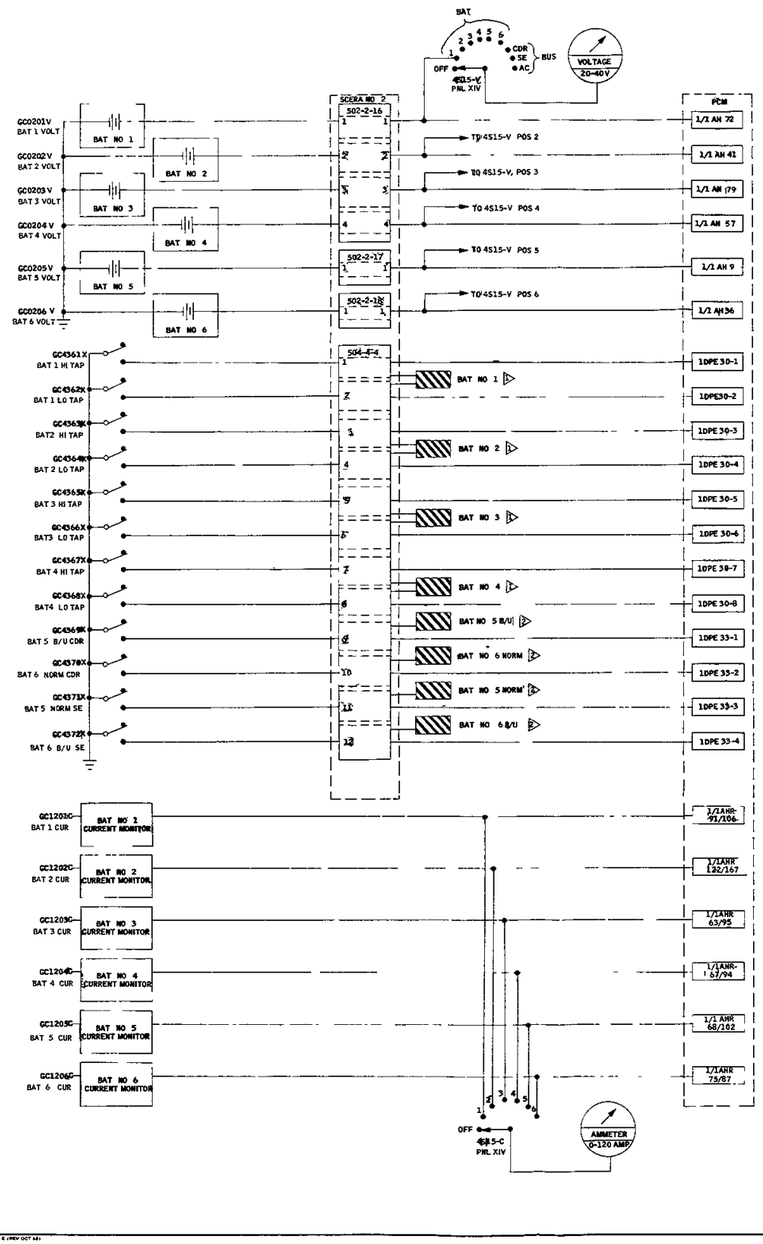
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON, TEXAS

INSTRUMENTATION PYROTECHNIC INTERFACE DIAGRAM

LM / LM-1	SIZE C	DWG NO 6.3.1
SCALE		SHEET 1 OF 1

MSC Form 1616 C (REV OCT 65)

LTR	ZONE	REVISION	DATE	APPROVAL
C				



NOTE ▷ HI TAP - GRAY
LO TAP - LO
OFF - BARBERPOLE

NOTE ▷ ON - GRAY
OFF - BARBERPOLE

ELECTRICAL

SIGNATURES		DATE
OR		1/2/67
ENG		2/24/67
CKD		2/6/67
GAEC		2/24/67
APPR		2/14/67
AUTH		2/16/67

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS

INSTRUMENTATION ELECTRICAL INTERFACE DIAGRAM

LM
LM-1

SIZE E

DWG NO. 632

SCALE

SHEET 1 OF 1

ELECTRICAL

LTR	ZONE	REVISION	DATE	APPROVAL
B				
C				

GF3582P ASC 1 O_2 PRESS

GF3583P ASC 2 O_2 PRESS

V_{28SE} — 4CB132 — 5A SIG SENSOR — GSE

FUSE ASSY SENSOR PWR 4A9

ECS RLY BOX

F 1 1/4A — ASC 1 O_2 PRESS XDUCER

F2 1/4A — ASC 2 O_2 PRESS XDUCER

PCMTEA

1AH191

1AH157

C & W RESET DES — P/T AV2

O_2/H_2O QTY MON 752 PNL II

QUANTITY

O_2 % H_2O 100 80 60 40 20 0

7M4

GF4582Q ASC 1 H_2O QTY

GF4583Q ASC 2 H_2O QTY

F7 1/4A — ASC 1 H_2O QTY XDUCER

F8 1/4A — ASC 2 H_2O QTY XDUCER

SCERA NO 1

504-1-8

1/1 AHR 20/54

1/1 AHR 24/50

GF2681T PRI W/B TEMP XDUCER

GF9998U GLY TEMP

GLY PUMP SWITCH 753 PNL II

506-2-10

C & W LOGIC — GLYCOL CAUTION — GF2041 < 10±5% GF9998 < 50°F

GF9998U

1/1 AH 114

GLYCOL TEMP PRESS °F PSIA 80 60 40 20 0

7M5

GF2041X GLY LEVEL LOW

GLYCOL LOW XDUCER

SCERA NO 2

504-3-3

PSIA

GF2041X

1/1 DPER 3/14-3

GF4101P PRI H_2O REG ΔP

F 9 1/4A — H_2O ΔP XDUCER

SCERA NO 1

504-1-18

1/1 AHR 141/168

GF2021P PRI GLY PUMP ΔP

F 6 1/4A — PRI GLY PUMP ΔP XDUCER

1/1 AHR 59/99

GF3571P CABIN PRESS

F 3 1/4A — CABIN PRESS XDUCER

PRESS SUIT PSIA CAB 10 8 6 4 2 0

7M2

1/1 AHR 83/98

GF3591P U/H RLF PRESS

F4 1/4A — U/H RLF PRESS XDUCER

1/1 AH 194

GF3592P F/H RLF PRESS

F5 1/4 A — F/H RLF PRESS XDUCER

1/1 AH 183

GF4511T W/B H_2O TEMP

W/B H_2O TEMP XDUCER

SCERA NO. 2

506-2-6

1/1 AH 192

GF9997U GLY PUMP PRESS

FUSE ASSY SENSOR PWR 4A9

F4 1/4A — GF2741P PRI PUMP PRESS XDUCER

CUT, CAPPED AND STOWED

SEC 1 2

GLY PUMP SWITCH 753 PNL II

GF9997U

1/1 AH 10

ENVIRONMENTAL

SIGNATURES	DATE
DR E P Lucy	12-17-67
ENG Neal E Bennett	2/14/67
CH Lee D	2/14/67
GAEC Leo L Pompili	2/16/67
APP Donald K Hilliard	2/16/67
AUTH Don Berry	12/14/67

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS

INSTRUMENTATION ENVIRONMENTAL INTERFACE DIAGRAM

LM | LM-1 | SIZE E | DWG NO 833 | SCALE | SHEET

LTR	ZONE	REVISION	DATE	APPROVAL
C			6/30/67	

GT0201E
S-BND PWR AMP PO

V_{28SE} — 4CB30 — 5A — PRI S-BAND PWR AMPL — PNL XVI

GT0202E
S-BND RFLT PWR

V_{28CDR} — 4CB136 — 5A — SEC S-BAND PWR AMPL — PNL XI

RF DET → SIG COND

RF DET → SIG COND

S-BAND PWR AMPS

PCM TEA

1/1 AH 187

1 AH 159

GT0454T
S-BND STEERABLE ANT TEMP

GT0454
S-BAND STEERABLE TEMP XDUCER

SCERA NO 2

500-2-21-2

RECEIV CAL/MDL

-60 °F ≤ GT0454 ≤ +195 °F

RF
1-5
QUAD I
QUAD II
QUAD III
QUAD IV
S-BAND

185AB

GT0992B
S-BND ST Φ ERR

V_{28SE} — 4CB111 — 5A — PRI S-BAND XMTR/RCVR — PNL XVI

PRI RCVR LPF ST PH ERR

SUM → PRE-CONDITIONER

1/1 AH 185

10 AH 2

V_{28CDR} — 4CB137 — 5A — SEC S-BAND XMTR/RCVR — PNL XI

PRIM / OFF / SEC

XMTR/RCVR SW 13S8 PNL XII

SEC RCVR LPF ST PH ERR

GT0993E
S-BND XMTR PO

RF DET

1/1 AH 195

PRI RCVR AGC

GT0994
S-BND RCVR SIG

SUM → PRE-CONDITIONER

10 AH 3

SEC RCVR AGC

S-BAND TRANSCEIVERS

6/177

14M1
S-BAND SIG STR
PNL XII

GT0441X
DCA STATUS

V_{28LMP} — CB5 — 3A — DCA PWR

PCA VERIFICATION INTERFACE

50 DP 2

GT0619V
UHF SIG STR

RF DET

1 AH 1

DCA

12M1
TEMP
PNL III

200
150
100
50
0
-50
-100

COMM

SIGNATURES		DATE
DR		1-67
ENG	Don L Parrish	2/10/67
CH	[illegible]	2/15/67
GAEC	Don L Parrish	2/10/67
APR	Donald K Rudd	2/11/67
AUTH	Don Bray	2/16/67

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON TEXAS

INSTRUMENTATION
COMMUNICATIONS
INTERFACE DIAGRAM

LM
LM-1

SIZE D

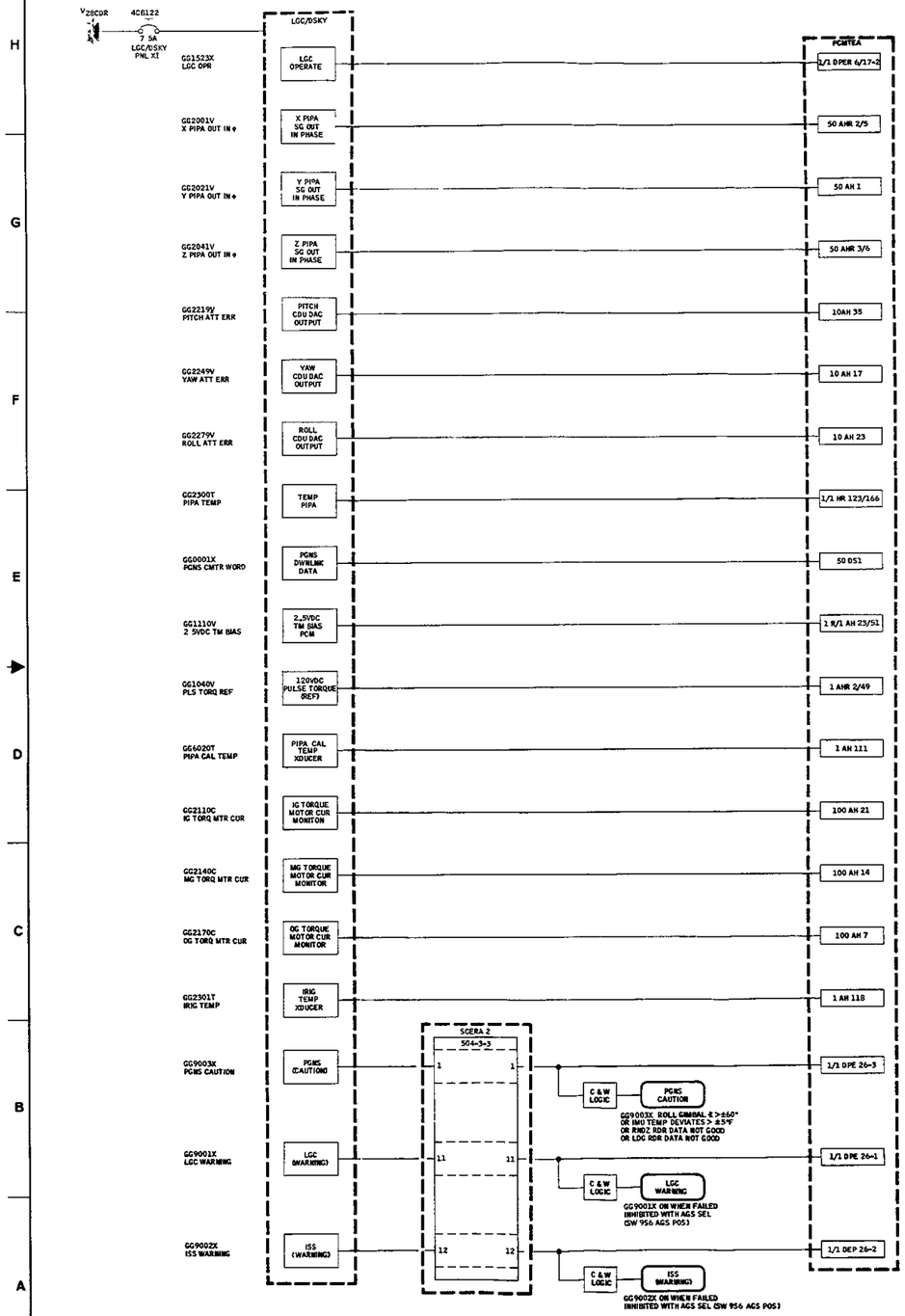
DWG NO 6.34

SCALE

SHEET 1 OF 1

MSC Form 1616 D (REV OCT 65)

LTR	ZONE	REVISION	DATE	APPROVAL
C				



GUIDANCE

SIGNATURES		DATE
DR		7/12
ENG		8/14/62
CH-SD		8/16/62
MEC		8/16/62
APP		8/16/62
AUTH		8/16/62

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS

INSTRUMENTATION GUIDANCE INTERFACE DIAGRAM

LM
LM-1

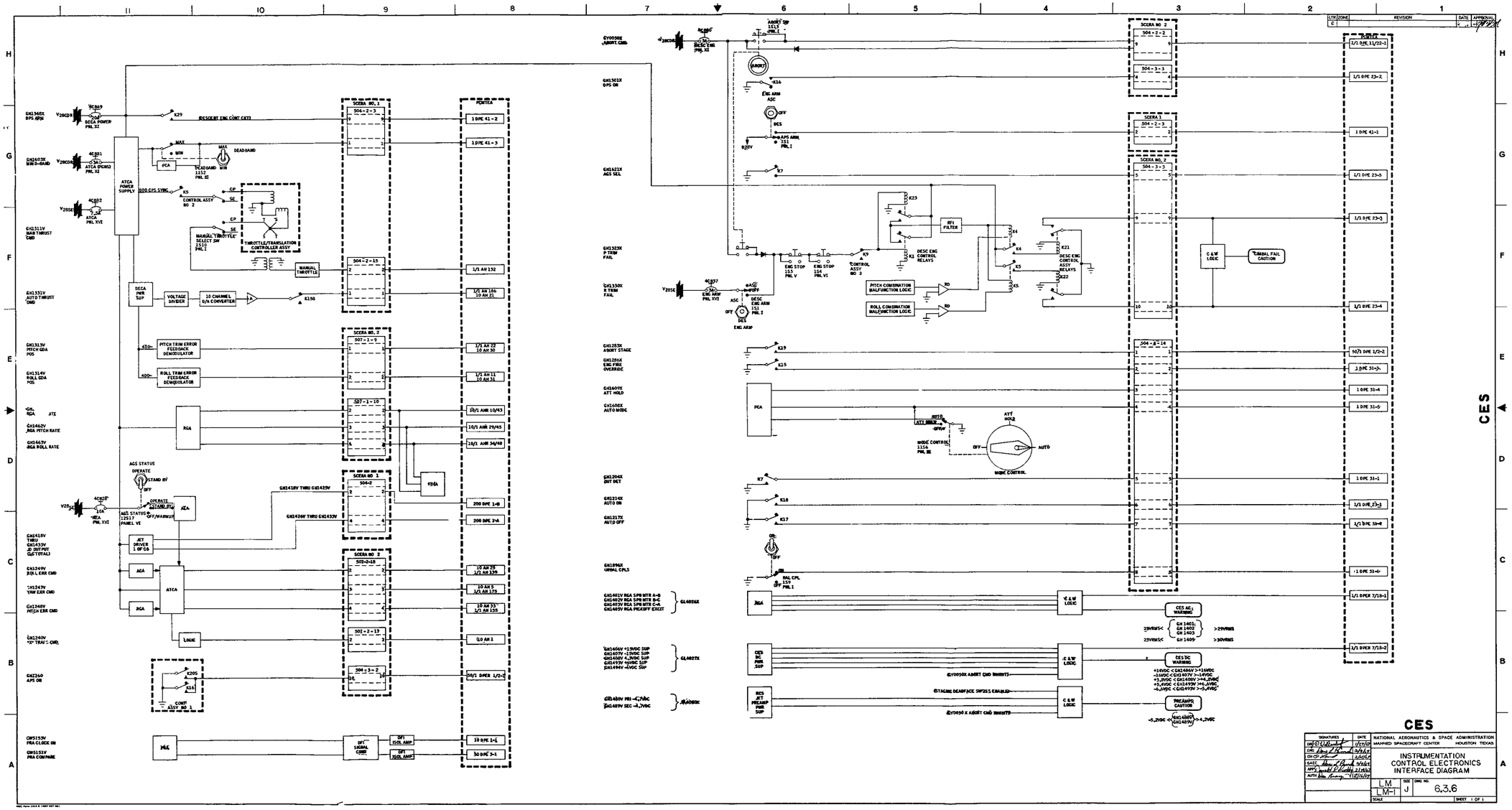
SIZE E

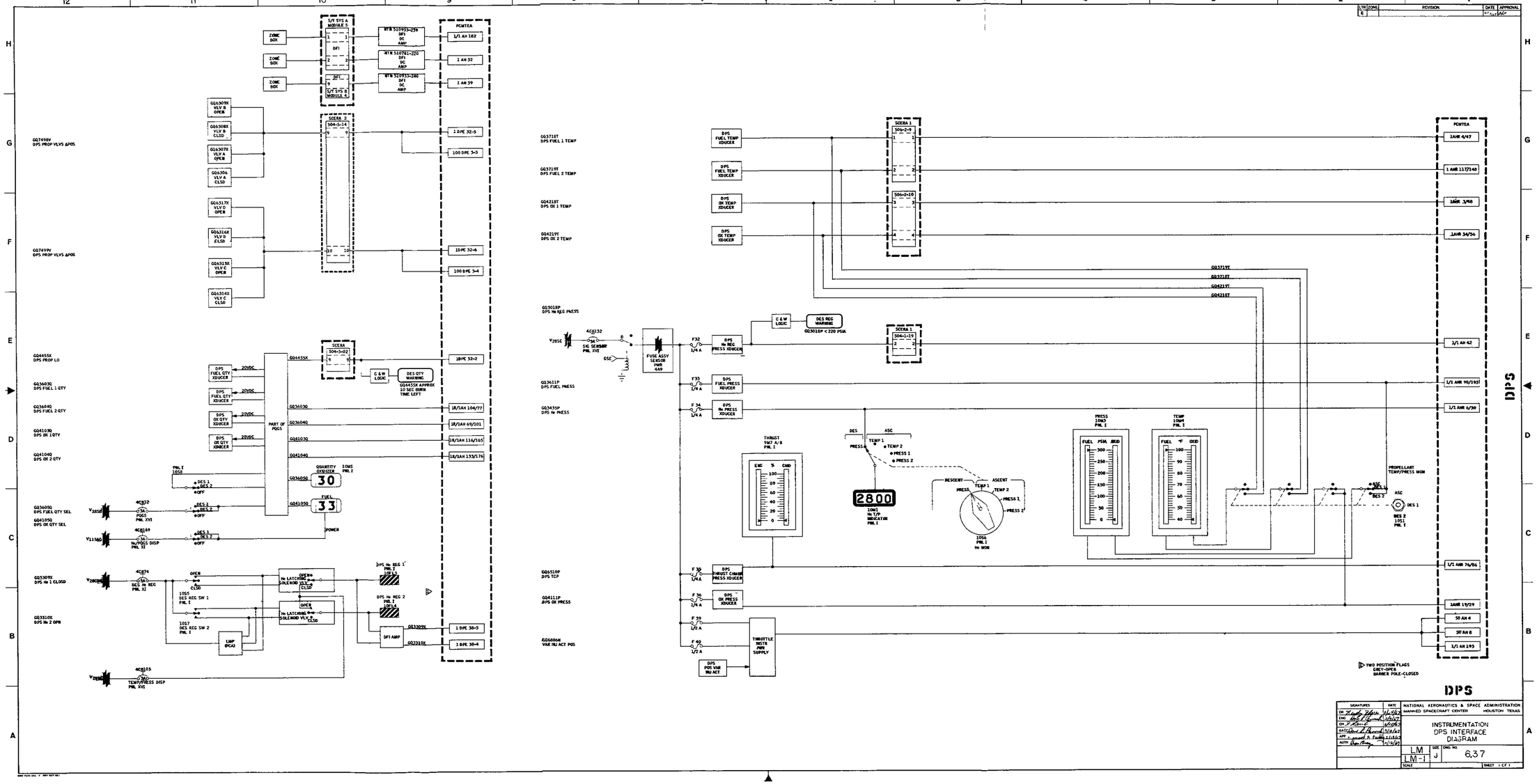
DWG NO. 6.3.5

SCALE

SHEET 1 OF 1

NSC Form 1918-E REV OC 65


CES
INSTRUMENTATION CONTROL ELECTRONICS INTERFACE DIAGRAM
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS
LM
LM-1
SIZE J
DWG NO. 6.3.6
SCALE
SHEET 1 OF 1
ATCA POWER SUPPLY
DECA PWR SUP
VOLTAGE DIVIDER
10 CHANNEL D/A CONVERTER
PCA
RGA
ATCA
ACA
AEA
JET DRIVER 1 OF 16
LOGIC
MUX
THROTTLE/TRANSLATION CONTROLLER ASSY
MANUAL THROTTLE
PITCH TRIM ERROR FEEDBACK DEMODULATOR
ROLL TRIM ERROR FEEDBACK DEMODULATOR
PCA
ATT HOLD
AUTO
OFF
MODE CONTROL
ABORT
ENG ARM
DES
RCS JET PREAMP PWR SUP
C & W LOGIC
CES AC1 WARNING
CES DC WARNING
PREAMPS CAUTION
DESCENT ENG CONT CKT
MANUAL THROTTLE
ABORT
ENG ARM
DES
ENG STOP
DESC ENG CONTROL ASSY RELAYS
PITCH COMBINATION MALFUNCTION LOGIC
ROLL COMBINATION MALFUNCTION LOGIC
RFI FILTER
C & W LOGIC
TRIBAL FAIL CAUTION
ABORT STAGE
ENG FIRE OVERRIDE
ATT HOLD
AUTO MODE
SHUT DET
AUTO ON
AUTO OFF
TRIBAL CPLS
ABORT CMD INHIBIT
STAGING DEADFACE SWPSS ENABLE
X ABORT CMD INHIBIT
SCERA NO. 1
SCERA NO. 2
SCERA 1
SCERA NO. 2
PORTSA
FDAI
DFI SIGNAL CONDR
DFI ISOL AMP
CONT ASSY NO. 1
CONTROL ASSY NO. 2



LTR	ZONE	REVISION	DATE	APPROVAL
E				

DPS

SIGNATURES	DATE
OR	11/16/67
ENG	11/21/67
CH	11/29/67
CA	12/4/67
APP	12/11/67
AUTH	12/15/67

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS

INSTRUMENTATION
DPS INTERFACE
DIAGRAM

LM
LM-1

SIZE J

DWG NO. 6,37

SCALE

SHEET 1 OF 1

LTR	ZONE	REVISION	DATE	APPROVAL
C			12/26/67	

HELIUM MON
DESCENT
ASCENT
PRESS
TEMP 1
TEMP 2
PRESS 3
PRESS 2
1056 PNL I
DES
ASC
PRESS
TEMP 1
TEMP 2
PRESS 1
PRESS 2
10MI He T/P INDICATOR PNL 1
2800

GP001P ASC He 1 PRESS
V 28SE
4CB132
5A
S/C SENSOR PNL XVI
GSE
FUSE ASSY SENSOR PWR 4A9
F23 1/4A
APS He 1 PRESS XDUCER
C & W LOGIC
ASC PRESS WARNING
GP0001P<3000 PSIA
GP0002P<3000 PSIA
SCERA 1 504-1-18
1/1 AH 37
1AHR 153/179
504-1-19
1 AHR 93/100
wP0002P ASC He 2 PRESS
F24 1/4A
APS He 2 PRESS XDUCER
GP0025P APS He REG PRESS
F25 1/4A
APS He REG PRESS XDUCER
C & W LOGIC
ASC HI REG CAUTION
GP0025P<220 PSIA
GP0908X APS FUEL LO
F26 1/4A
APS FUEL LO XDUCER
SCERA 2 504-3-02
C & W LOGIC
ASC QTY CAUTION
GP0908X APPROX 10 SEC BURN TIME LEFT
1DPE 24-1
GP1408X APS OX LO
F27 1/4A
APS OX LOW XDUCER
1DPE 24-2
GP1501P APS FUEL PRESS
F28 1/4A
APS FUEL PRESS XDUCER
SCERA 1 504-1-19
1/1 AHR 92/62
C & W LOGIC
ASC PRESS WARNING
GP1501P<120 PSIA
GP1503P<120 PSIA
GP1503P APS OX PRESS
F29 1/4A
APS OX PRESS XDUCER
1/1 AHR 61/105
GP2010P APS TCP
F30 1/4A
APS THRUST CHMBR PRESS XDUCER
1/1 AH 173/178
FUEL °F OXID
100 90 80 70 60 50 40
PNL I 1064 TEMP
FUEL PSIA OXID
300 250 200 150 100 50 0
PNL I 1063 PRESS
DES 1
ASC
DES 2
ASC
DES 1
DES 2
PROPELLANT TEMP/PRESS MON 1051 PNL I

GP0201T APS He 1 TEMP
APS He TEMP XDUCER
GP0202T APS He 2 TEMP
APS He TEMP XDUCER
SCERA 2 506-2-21
PCMTEA
1/1 AHR 135/170
1/1 AHR 13/27

OPEN
1054 ASC REG SW 1 PNL I
CLOSE
GP0318X APS He 1 CLSD
V 28SE
4CB53
5A
ASC He REG PNL XVI
OPEN
APS SOLENOID VALVE #1
CLSD
SCERA 1 504-4-12
PNL 1 10FL 1
ASC He REG #1
1DPE 43-1
OPEN
1054 ASC REG SW 2 PNL I
CLOSE
OPEN
APS SOLENOID VALVE #2
CLSD
PNL 1 10FL 2
ASC He REG #2
1DPE 43-2
GP0320 APS He 2 CLSD
V 28SE
4CB103
5A
TEMP/PRESS DISP PNL XVI
(POWER FOR 10 FL 1 & 2)

GP1218T APS OX TEMP
APS FUEL TEMP XDUCER
APS OX TEMP XDUCER
SCERA 1 506-2-9
1/1 AHR 120/169
1/1 AHR 129/144
SYSTEM "A"
GP1316X BI-PROP VLV OPEN
GP1805X BI-PROP VLV CLSD
GP1801X ISOLATION VLV CLSD
GP1811X ISOLATION VLV OPEN
GP2997U APS PROP VLVS ΔP
GP2997U
SCERA 2 504-5-14
1DPE 32-3
100 DPE 3-1
SYSTEM "B"
GP1812X ISOLATION VLV OPEN
GP1802X ISOLATION VLV CLSD
GP1806X BI-PROP VLV CLSD
GP1814X BI-PROP VLV OPEN
GP2998U APS PROP VLVS ΔP
GP2998U
1 DPE 32-4
100 DPE 3-2

GREY = OPEN
BARBERPOLE = CLOSED

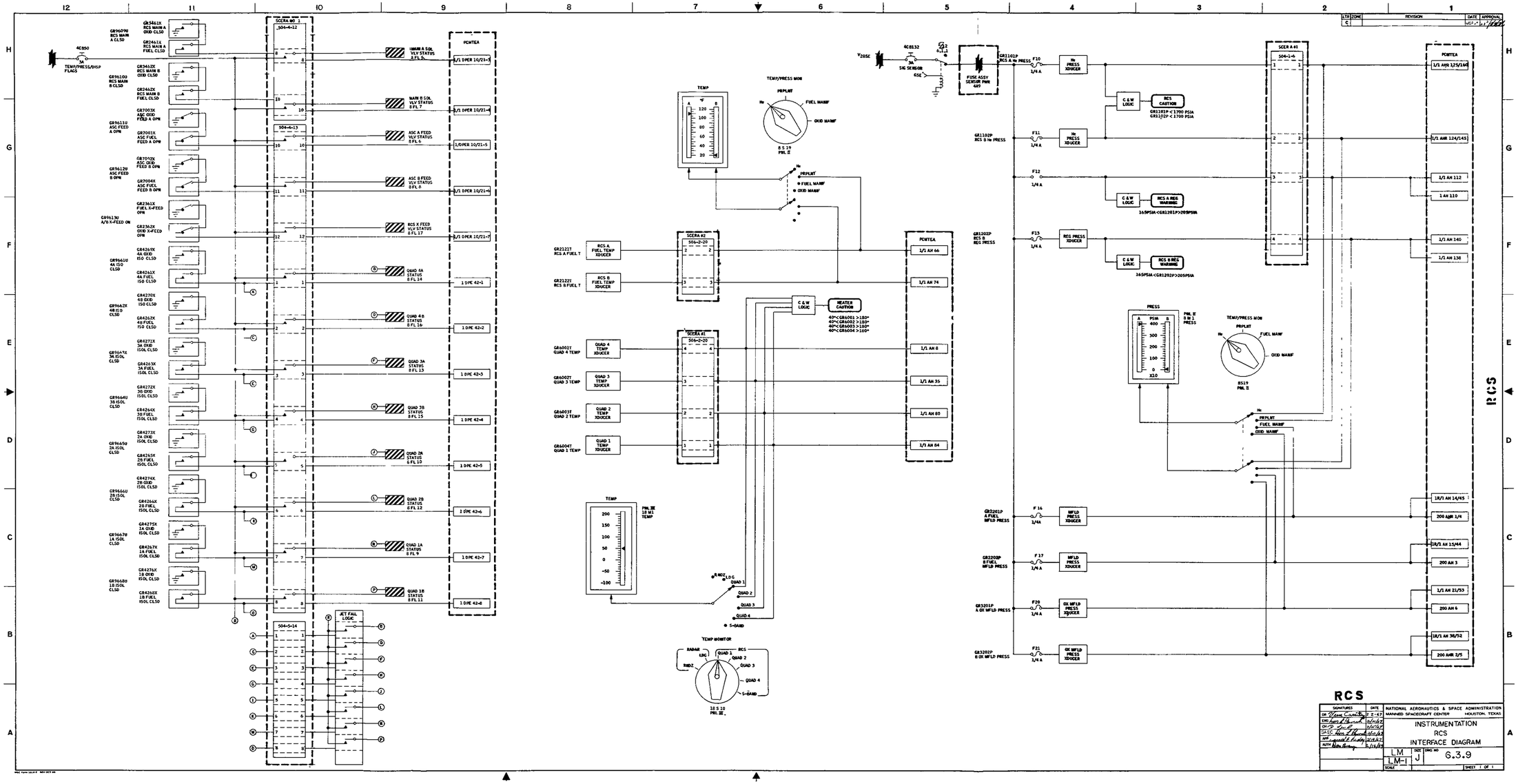
APS

SIGNATURES	DATE
DR	1/26/67
ENG	5/1/67
CH	2/10/67
APP	5/16/67
AUTH	1/26/67

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS

INSTRUMENTATION
APS INTERFACE
DIAGRAM

LM
LM-1
SIZE E
DWG NO. 6.3.8
SCALE
SHEET 1 OF 1


RCS
INSTRUMENTATION
RCS
INTERFACE DIAGRAM
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
LM
LM-1
SIZE J
DWG NO 6.3.9
SCALE
SHEET 1 OF 1
REVISION
DATE
APPROVAL
SCERA #0 1
SCERA #2
SCERA #1
SCERA #4
PCMTEA
TEMP/PRESS/DISP FLAGS
TEMP/PRESS MON
TEMP MONITOR
JET FAIL LOGIC
C & W LOGIC
HEATER CAUTION
RCS CAUTION
RCS A REG WARNING
RCS B REG WARNING
FUSE ASSY SENSOR PWR 660
SIG SENSOR
PRESS
TEMP

* SECTION 7

PGNS

7.1 GENERAL

7.1.1 General Information

The PGNS is the primary means of accomplishing guidance, navigation and control for the Lunar Module (LM). The system is designed to perform these functions in a self-contained mode, requiring no data from sources external to the LM after system initialization. On Mission AS-206 the primary mode of operation shall also be self-contained. However, provision is made for insertion of navigation, target and mode control data from the ground via the LGC (LM Guidance Computer) is desired. On AS-206, a secondary method of guidance and control is provided by the Program Reader Assembly (PRA) which replaces the LM Guidance Computer function. The Abort Guidance system which ordinarily has this backup function has been deleted on AS-206. With respect to the LM, the terms guidance and navigation are defined as: R-B

A. Guidance - The orientation of a thrust vector with respect to inertial space and the regulation of the level of thrust where possible so that specific and conditions on a desired trajectory are met.
B. Navigation - The determination of vehicle position and velocity with respect to a known coordinate frame.

7.1.2 PGNS Hardware Configuration

The Primary Guidance, Navigation and Control System for Mission AS-206 is comprised of the following assemblies:

A. Inertial Subsystem (ISS)
   1. Inertial Measurement Unit (IMU)
   2. Electronic Coupling Data Unit (ECDU) R-C
   3. Power Servo Assembly (PSA)
   4. Pulse Torquing Assembly (PTA) R-B
   5. Signal Conditioning Assembly (SCA).
B. Computer Subsystem (CSS)
   1. LM Guidance Computer (LGC) R-C
   2. Display and Keyboard (DSKY).

C. Optics Subsystem R-C
1. Alignment Optical Telescope (AOT) R-B
2. Computer Control and Reticle Dimmer Assembly (CCRD). R-C
D. Radar Subsystem (Electronic Assembly deleted on AS-206)

7.1.3 Inertial Measurement Unit (IMU)

The Inertial Measurement Unit (IMU) is the primary inertial sensing device of the LM. Three rate Integrating Gyroscopes (IRIG's) and three Pulse Integrating Pendulous Accelerometers (PIPA's) are mounted on the stable member (inner gimbal) of a three gimbal system. The stable member is held nonrotating with respect to inertial space by three gimbal servos, which derive their input error signals from three gyroscopes. The stable member is aligned at prelaunch to a known reference coordinate which is held fixed with respect to earth via gyrocompassing until Gyro Reference Release (GRR). At or near liftoff R-B GRR is initiated by sensing 1.12 acceleration, however, GRR may be backed up by RF uplink if necessary. Once the system is released to become inertial, it will remain unchanged through the flight. There is no realignment of the inertial reference after liftoff, and the system will be in the inertial reference mode continuously. Velocity changes along three orthogonal axes are sensed by accelerometers, which produce signals that represent incremental changes in velocity. Attitude of the LM is generated by the inner, middle, and outer gimbal resolvers. These attitude signals are inputs to the CDU's. IMU temperature control is completely automatic and remains in operation once power is applied R-C to the system.

7.1.4 Electronic Coupling Data Unit (ECDU)

The Coupling Data Units (CDU's) perform two basic functions: An analog-to-digital conversion (A/D) and a digital-to-analog conversion (D/A) of information. In the (A/D) conversion, the CDU's convert and R-B transfer angular information between the IMU and LGC. For each of the three inertial system CDU's, each IMU gimbal angle resolver provides the respective CDU with analog gimbal angle signals that represent the attitude of the LM with respect to the navigation base. The CDU converts

these signals to digital form and transforms them serially to the LGC in angle increments. The CDU's also have the capability of providing via the D/A portion drive signals to the IMU gimbals to coarse align the stable member to a known orientation with respect to the navigation base. On AS-206, this function will be performed prelaunch only, during initial alignment. R-C

7.1.5 Power Servo Assembly (PSA)

The purpose of the power and servo assembly (PSA) is to provide a central mounting point for the majority of the PGNS power supplies, amplifiers and other modular electronic components. The PSA is mounted on a coldplate through which water-glycol coolant flows to dissipate operating heat.

7.1.6 Pulse Torque Assembly (PTA)

The Pulse Torque Assembly (PTA) consists of a group of modular electronic assemblies used in the pulsing circuits of the gyros and accelerometers. Heat Dissipation is accomplished in the same manner as with the PSA. R-B

7.1.7 LM Guidance Computer (LGC)

The LM Guidance Computer (LGC) is the central data processing device of the PGNS system. The LGC inputs include: gimbal angle increments from the CDU's, incremental changes in velocity via the PIPA's and vehicle status inputs from the Control Electronics System (CES).

For the AS-206A Mission, the LGC will function as a completely automatic programer that will control all onboard functions for the unmanned vehicle. The PGNS will automatically accomplish all guidance, navigation, and control of the LM. An uplink command capability exists for the LM to provide a limited amount of program change, in real time, by ground control. A major failure with either the LGC or IMU will

*

7.2 PGNS OPERATION

7.2.1 PGNS Interfaces

The following list tabulates the electrical and functional interfaces between the PGNS and the remainder of the LM spacecraft. For reference consult MIT Document NEI6015000 PGNS and Control System for LM (Classified).

A. Mode and Status
   1. PGNS in control of Spacecraft
   2. Attitude Hold Mode
   3. Auto Stabilization Mode
   4. Auto Throttle Mode
   5. Stage Verify
   6. Engine Armed
   7. Abort
   8. Abort Stage
   9. Thruster Fail Discretes
   10. GDA Fail Discretes

B. Engine and Jet Control
   1. RCS Jet Commands
   2. Roll/Pitch Gimbal Trim Commands
   3. Increase/Decrease Throttle Rate
   4. Engine ON/OFF Commands

C. Angle Data Signals
   1. Attitude Errors
   2. Gimbal Angles

D. Maneuver Command Signals
   1. Translation Commands
   2. Out of Detent
   3. Attitude Rate Commands
   4. Rotation Commands

E. Timing Signals and Telemetry

R-B

F. Caution and Warning Signals

G. Power, Reference and Lighting

H. DSKY and PCA (LMP) Commands

7.2.2 Guidance and Navigation Functions

A. PGNS performs the guidance function in the following manner: The LGC senses incremental velocity changes using the PIPA information in a known inertial orientation (angular increments from ICDU's). From this information the steering signals are derived to orient the thrust vector to a near optimum position in inertial space. Engine ON commands are issued by the LGC when certain initial conditions are satisfied. For AS-206 these conditions may be an absolute time interval from some preceding event (e.g. APS - 2) or the satisfaction of trajectory conditions arrived at by some navigation function. Engine OFF commands are generated by the LGC when desired end conditions for the burn are met. R-B

B. The PGNS navigation function is handled internal to the LGC. This function is performed both during thrust phase and during coast. It is performed on a 2 second basis during thrusting and on a 585 second basis during coast. During thrusting, external inputs, gimbal angle increments and PIPA data are required from the ISS and CDU, while during coasting phases, no external system input is required. R-C R-B

7.3 INERTIAL MEASUREMENT UNIT SCHEMATIC NOTES (Drawing 7.2.1)

A. Notes

All latching relays are shown in the reset position and all unlatching relays are shown in the de-energized position.

R-B

*

7.4 COUPLING DATA UNIT SCHEMATIC NOTES (Drawing 7.3.1)

A. The following abbreviations are applicable to the CDU schematic:

1. Θig = Inner gimbal angle (actual)
2. Θmg = Middle gimbal angle (actual)
3. Θog = Outer gimbal angle (actual)
4. $\Delta\Theta ic$ = Increment of command angle (inner gimbal)
5. $\Delta\Theta mc$ = Increment of command angle (middle gimbal)
6. $\Delta\Theta oc$ = Increment of command angle (outer gimbal)
7. AGS = Abort Guidance System
8. CDU = Coupling Data Unit
9. CS = Crew Systems
10. EX = Attitude Error signal about X-axis
11. EY = Attitude Error signal about Y-axis
12. EZ = Attitude Error signal about Z-axis
13. IMU = Inertial Measurement Unit
14. ISS = Inertial Subsystem
15. LGC = LM Guidance Computer
16. PC = Percent
17. RR = Rendezvous Radar

R-C

R-B

*

7.5 COMPUTER SCHEMATIC NOTES (Drawing 7.4.1)

(To be supplied at a later date)

R-B

* TABLE 7-1 AS-206 DOWNLINK FORMAT

WORD NUMBER	FIRST REGISTER	SECOND REGISTER	WORD ORDER CODE	
1	DOWNLIST I D	*SYNC BITS (00437-OCTAL)	0	
2	LATEST CAL STATE VEC X POS MSB	*LATEST CAL STATE VEC X POS LSB	1	
3	LATEST CAL STATE VEC Y POS MSB	*LATEST CAL STATE VEC Y POS LSB	1	
4	LATEST CAL STATE VEC Z POS MSB	*LATEST CAL STATE VEC Z POS LSB	1	
5	LATEST CAL STATE VEC X VEL MSB	*LATEST CAL STATE VEC X VEL LSB	1	
6	LATEST CAL STATE VEC Y VEL MSB	*LATEST CAL STATE VEC Y VEL LSB	1	
7	LATEST CAL STATE VEC Z VEL MSB	*LATEST CAL STATE VEC Z VEL LSB	1	
8	STATE VECTOR TIME MSB	*STATE VECTOR TIME LSB	1	
9	1d PIPADT	*DESIRED CDU X	1	R-C
10	DESIRED CDU Y	*DESIRED CDU Z	1	
11	DELV X MSB	*DELV X LSB	1	
12	DELV Y MSB	*DELV Y LSB	1	
13	DELV Z MSB	*DELV Z LSB	1	
14	OUTPUT TO LMP	*OUTPUT TO LMP	1	
15	OUTPUT TO LMP	*OUTPUT TO LMP	1	
16	OUTPUT TO LMP	*OUTPUT TO LMP	1	R-B
17	OUTPUT TO LMP	*OUTPUT TO LMP	1	
18	LMPIN	LMPOUT	1	
19	ALPHAR	EDOTP	1	R-C
20	UPVERB	*COMPNUMB	1	
21	STATE COUNT	*UPOLOMOD	1	R-C
22	ST BUFF +0	*ST BUFF +1	1	
23	ST BUFF +2	*ST BUFF +3	1	
24	ST BUFF +4	*ST BUFF +5	1	
25	ST BUFF +6	*ST BUFF +7	1	
26	ST BUFF +8D	*ST BUFF +9D	1	
27	ST BUFF +10D	*ST BUFF +11D	1	
28	ST BUFF +12D	*ST BUFF +13D	1	
29	I MODE 30	*I MODE 33	1	
30	TIME OF EVENT MSB	*TIME OF EVENT LSB	1	
31	GUIDANCE THRUST CMD MSB	*GUIDANCE THRUST CMD LSB	1	
32	MOMENT OFFSET (Q)	*MOMENT OFFSET (R)	1	
33	PREDICTED ENGINE ON TIME MSB	*PREDICTED ENGINE ON TIME LSB	1	
34	REDO COUNTER	SFAIL	1	R-C
35	TIME 6	ACTUAL CDU X	1	R-C
36	ACTUAL CDU Y	*ACTUAL CDU Z	1	
37	DERIVED RATE (P)	*DERIVED RATE (Q)	1	
38	ALPHA Q	DERIVED RATE (R)	1	R-C
39	FLAGWORD 0	*FLAGWORD 1	1	
40	FLAGWORD 2	*DAP BOOLS	1	
41	CHANNEL 11	*CHANNEL 12	1	
42	CHANNEL 13	*CHANNEL 14	1	
43	CHANNEL 30	*CHANNEL 31	1	
44	CHANNEL 32	*CHANNEL 33	1	
45	DSPTAB +0	*DSPTAB +1	1	
46	DSPTAB +2	*DSPTAB +3	1	
47	DSPTAB +4	*DSPTAB +5	1	
48	DSPTAB +6	*DSPTAB +7	1	
49	DSPTAB +8D	*DSPTAB +9D	1	
50	DSPTAB +10D	*DSPTAB +11D	1	

* TABLE 7-1 AS-206 DOWNLINK FORMAT (Concluded)

LM-1
REV C

WORD NUMBER	FIRST REGISTER	SECOND REGISTER	WORD ORDER CODE	
51	TIME 2	*TIME 1	1	
52	COMPTORK + 0	COMPTORK + 1	1	
53	COMPTORK + 2	COMPTORK + 3	1	
54	COMPTORK + 4	COMPTORK + 5	1	
55	FAILREQ + 0	FAILREQ + 1	1	
56	FAILREQ + 2	ALMCADR	1	
57	ALMCADR + 1	ERCOUNT	1	
58	PIPA X	PIPA Y	1	R-C
59	PIPA Z	RHCP	1	
60	FLAGWORD 4	LMPJFAIL	1	
61	MASS (MSB)	MASS (LSB)	1	
62	CDU Y	CDU Z	1	
63	CDU Y	CDU Z	1	
64	OUTPUT TO LMP	*OUTPUT TO LMP	1	
65	OUTPUT TO LMP	*OUTPUT TO LMP	1	
66	OUTPUT TO LMP	*OUTPUT TO LMP	1	
67	OUTPUT TO LMP	*OUTPUT TO LMP	1	
68	LMPIN	LMPOUT	1	R-C
69	DELAREA (MSB)	DELAREA (LSB)	1	
70	MISSION PHASE REGISTER 4	*MISSION PHASE REGISTER 3	1	
71	MISSION PHASE REGISTER 2	*MISSION PHASE REGISTER 1	1	R-B
72	MISSION TIME REGISTER 4	*MISSION TIME REGISTER 3	1	
73	MISSION TIME REGISTER 2	*MISSION TIME REGISTER 1	1	
74	PRESENT MISSION PHASE	IDPIPADT	1	R-C
75	TIME TO GO MSB	*TIME TO GO LSB	1	
76	BURN DATA	*BURN DATA	1	
77	BURN DATA	*BURN DATA	1	
78	BURN DATA	*BURN DATA	1	
79	BURN DATA	*BURN DATA	1	
80	BURN DATA	*BURN DATA	1	
81	BURN DATA	*BURN DATA	1	
82	BURN DATA	*BURN DATA	1	
83	BURN DATA	*BURN DATA	1	
84	BURN DATA	*BURN DATA	1	
85	TIME 6	ACTUAL CDU X	1	R-C
86	ACTUAL CDU Y	*ACTUAL CDU Z	1	
87	DERIVED RATE (P)	*DERIVED RATE (Q)	1	
88	ALPHAQ	DERIVED RATE (R)	1	R-C
89	FLAGWORD 0	*FLAGWORD 1	1	
90	FLAGWORD 2	*DAP BOOLS	1	
91	CHANNEL 11	*CHANNEL 12	1	
92	CHANNEL 13	*CHANNEL 14	1	
93	CHANNEL 30	*CHANNEL 31	1	
94	CHANNEL 32	*CHANNEL 33	1	
95	DSPTAB +0	*DSPTAB +1	1	
96	DSPTAB +2	*DSPTAB +3	1	
97	DSPTAB +4	*DSPTAB +5	1	
98	DSPTAB +6	*DSPTAB +7	1	
99	DSPTAB +8D	*DSPTAB +9D	1	
100	DSPTAB +10D	*DSPTAB +11D	1	

TABLE 7-2 MISSION AS-206 - MISSION PHASES

LM-1
REV C

*

Phase No.	Phase	Programs Executed
1	Prelaunch Alignment	01, 02, 04, 05
2	Guidance Reference Release	07, 11, 12
3	Suborbital Abort	71
4	Contingency Orbit Insertion	72
5	*	*
6	Coast - S-IVB Attached	13
7	S-IVB/LM Separate	14
8	DPS Cold Soak	15
9	DPS 1	31, 41
10	*	*
11	DPS 2/FITH/APS 1	32, 42, 43, 44, 72
12	*	*
13	APS 2	34, 46
14	*	*
15	*	*
16	*	*
17	*	*
18	*	*
19	*	*

R-C

R-B

*Not used for Mission AS-206

LTR	ZONE	REVISION	DATE	APPROVAL
C				

IMU

SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER HOUSTON, TEXAS
DR		
ENG		
CH	9/16/67	GUIDANCE-INERTIAL MEASUREMENT UNIT SCHEMATIC
PD		
APP		
AUTH		LM / LM-1 / SIZE E / DWG NO 721 / SCALE / SHEET 1 OF 1

IMU

LTR	ZONE	REVISION	DATE	APPROVAL
C				

CDU

SIGNATURES	DATE
ORIG	10 Sep
ENG	9-15-67
CHK	9-11-67
PROJ	
APP	9/21/67
AUTH	9/21/67

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS

GUIDANCE COUPLING DATA UNIT

LM
LM-1

SIZE E | DWG NO 7.31

SCALE | SHEET 1 OF 1

LTR	ZONE	REVISION	DATE	APPR
C			6/30/67	

V_{28CP} — 4CB122 — 05A — LGC/DSKY PNL XI

+28 VDC PRIMARY INPUT → POWER SUPPLY → +4V, +14V TO ALL FUNCTIONAL AREAS

FROM PGNS { MODE AND CAUTION SIGNALS } → DISPLAY AND KEYBOARD AND RELAYS → MODE AND CAUTION SIGNALS TO S/C

LGC WARNING → + → GUIDANCE SWITCH OVER TO LMP

KEYBOARD INPUTS

ISS WARNING

C±1 10 REGISTER WORD TO LM MISSION PROGRAMER, PROGRAM COUPLER ASSEMBLY RELAY (BITS 1-8 AND 12-15) ← CH 10 REGISTER ← DISPLAY DATA AND CAUTION SIGNALS

GG0001 — DIG DATA WORD — 50 SPS → 50 40 BIT WORDS/SEC TO PCM TM (B7 Z1 6.1.1)

FEXT | SELECTION | FIXED | ERASABLE — MEMORY

ADDRESS — REGISTERS — DATA

INPUT CHANNELS: CH 15, CH 16, CH17-CH27, CH 30, CH 31, CH 32, CH 33

CENTRAL PROCESSOR REGISTERS: WRITE GATES | E BANK | F BANK | G | SQ | S | A | L(CH01) | Q(CH02) | Z | B | CI | PARITY | X | Y | U | READ GATES | WRITE AMPS

OUTPUT CHANNELS: CH 05, CH 06, CH 10, CH 11, CH 12, CH 13, CH 14, CH 34, CH 35

REAL TIME

START INITIATE

SEQUENCE GENERATOR

OUTPUT LOGIC

OUTPUT INTERFACE

ENGINE ON/OFF CMDS
16 REACTION CONTROL SYSTEM JET CMDS
THROTTLE CMDS (DE)
PITCH AND ROLL GIMBAL TRIM CMDS
→ STABILIZATION AND CONTROL SYSTEM OUTPUTS

$\pm\Delta\theta_C$ - PITCH ANGLE FOR COARSE ALIGN
$\pm\Delta\theta_C$ - ROLL ANGLE FOR COARSE ALIGN
$\pm\Delta\theta_C$ - YAW ANGLE FOR COARSE ALIGN
ERROR COUNTER ENABLE
CDU ZERO
COARSE ALIGN ENABLE
DISPLAY INERTIAL DATA CMD
PIPA INTERROGATE AND DATA GATE PULSES
GYRO TORQUE ENABLE
GYRO TORQUE CMDS (SET AND RESET)
TIMING AND POWER SUPPLY SYNC SIGNALS
→ INERTIAL SUB-SECTION COUPLING DATA UNITS AND INERTIAL MEASURING UNIT OUTPUTS

1024 KHz (Z5 6.1.1) → TO INSTRUMENTATION TIMING SIGNAL
START SIGNAL (TO ALL FUNCTIONAL AREAS EXCEPT DSKY)

PROGRAM INTERRUPT PRIORITY
COUNTER PRIORITY
PRIORITY CONTROL

CONTROL PULSES

TIMER: CH03, CH04 | SCALER | MAIN TIMER

INPUT LOGIC ← INCREMENTAL PULSES

PROGRAM INTERRUPTS

INPUT INTERFACE

CONTROL ELECTRONICS SECTION INPUTS ← ±X MANUAL TRANSLATION CMDS; AUTO MODE; ATTITUDE HOLD MODE; PITCH GIMBAL OFF; ROLL GIMBAL OFF; ABORT STAGE DISCRETE; ABORT DISCRETE; ENGINE ARMED; AUTO THROTTLE SELECTED; DAP IN CONTROL

THRUSTER FAIL DISCRETES FROM RCS

FROM CONTROLS AND DISPLAY INPUTS ← DISPLAY INERTIAL DATA

DIGITAL CMD ASSEMBLY INPUTS (B7 Z8 5.2.1) ← UPLINK "1"; UPLINK "0"

PCM CENTRAL TIMING AND ELECTRONICS (B7 Z1 6.1.1) ← BIT SYNC PULSE; DN LINK START; DN LINK STOP; CLOCK SYNC SIGNAL

INERTIAL COUPLING DATA UNIT AND INERTIAL MEASURING UNIT INPUTS ← ±ΔθG - PITCH ANGLE (ACTUAL); ±ΔθG - ROLL ANGLE (ACTUAL); ±ΔθG - YAW ANGLE (ACTUAL); IMU TEMP IN LIMITS; ±ΔθP - X PIPA ΔV; ±ΔθP - Y PIPA ΔV; ±ΔθP - Z PIPA ΔV

(B7 Z9 8 2 1) ← STAGE VERIFY DISCRETE (CONTACT CLOSURE)

POWER AND LIGHTING ← LGC POWER BUS; IMU OPERATE POWER BUS; DSKY KEYBOARD & PANEL POWER; DSKY STATUS POWER; DSKY CAUTION POWER; DSKY NUMERIC DIMMER; AC POWER IN

NOTE- CH17 - CH27 ARE VACANT

——— DATA FLOW
– – – – CONTROLS

LGC

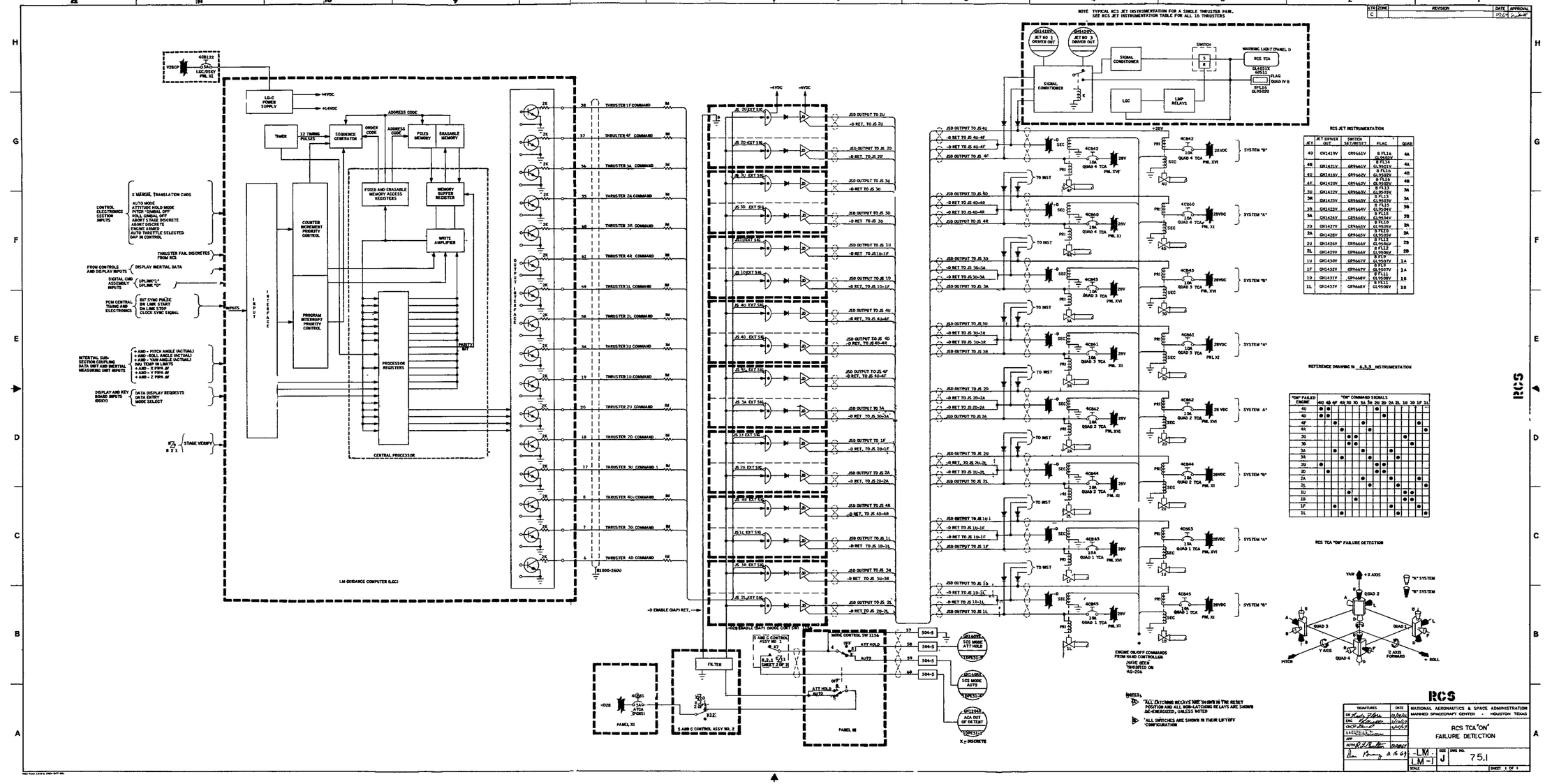
SIGNATURES	DATE
DR Landing Bays	1/30/67
ENG Rudy Gyurin	2/14/67
CH G. Hamel	2/14/67
MIT/IL	
APP	
AUTH R.J. Charlton	13 FEB 67
Don Bray	2-16-67

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON TEXAS

LM GUIDANCE COMPUTER SCHEMATIC

LM / LM-1 | SIZE D | DWG NO 741 | SCALE | SHEET 1 OF 1

MSC Form 1616 D (REV OCT 65)


LTR | ZONE | REVISION | DATE | APPROVAL
C | | | 10/24
NOTE TYPICAL RCS JET INSTRUMENTATION FOR A SINGLE THRUSTER PAIR. SEE RCS JET INSTRUMENTATION TABLE FOR ALL 16 THRUSTERS
RCS JET INSTRUMENTATION
REFERENCE DRAWING NO. 6.3.5 INSTRUMENTATION
"ON" FAILED ENGINE
"ON" COMMAND SIGNALS
RCS TCA "ON" FAILURE DETECTION
ENGINE ON/OFF COMMANDS FROM HARD CONTROLLER (WAVE OFF INHIBITED ON WS-206
NOTES:
1. ALL SWITCHES AND LIGHTS ARE SHOWN IN THE RESET POSITION AND ALL NON-LATCHING RELAYS ARE SHOWN DE-ENERGIZED, UNLESS NOTED
2. ALL SWITCHES ARE SHOWN IN THEIR LIFTOFF CONFIGURATION
X = DISCRETE
RCS
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER - HOUSTON, TEXAS
RCS TCA "ON" FAILURE DETECTION
LM-1
SIZE J
DWG NO. 75.1
SHEET 1 OF 1

8.1 GENERAL

8.1.1 Control Electronics Section (CES) Functions

The CES operates in both the primary guidance control path and the abort guidance control path.

When operating as part of the primary guidance control path in conjunction with the PGNS, the CES provides the implementation of the control signals originating from the LGC as follows: R-B

A. Converts reaction control jet commands to the required electrical power to operate the RCS jet solenoid valves.

B. Accepts discrete descent engine rotation commands. Upon receipt of a command, the descent engine is rotated about its gimbal axes at a constant angular rate until the command is removed. R-C

C. Accepts both LGC and manual engine ON/OFF commands and routes them to propulsion to fire or stop the descent or ascent engine.

D. Accepts LGC and manual thrust commands to throttle the descent engine 10 to 100 percent of its range. R-B

When operating in the abort guidance control path the CES performs the following functions:

A. Accepts rate damping signals from the RGA's and fires the proper RCS jets to achieve attitude control.

B. Accepts manual (LMP) +X translation commands and fires RCS jets to accelerate the LM in the desired direction. R-C

C. Automatically rotates the gimbaled descent engine for trim control. R-B

D. Accepts manual (LMP) engine ON/OFF commands and routes them to the descent or ascent engine. R-C R-B

E. Accepts manual (LMP) throttle commands to control the thrust of the descent engine. R-C

8.1.2 Modes of Attitude Control R-B

Two basic modes of attitude control are provided by the CES and are selectable on the control panel. One mode is fully automatic and one is

semiautomatic. In LM-1 only the automatic mode is available.

A. Automatic Mode - The automatic mode provides fully automatic attitude control of the LM.

B. In AGS mode only a rate hold capability exists since no AGS is aboard LM-1. R-C

8.1.3 Translation Control (RCS)

Both automatic and manual (LMP) translation control using the RCS thrusters are available. Automatic control consists of jet commands from the LGC to the jet drivers in the ATCA. These are used for translations of small velocity increments and ullage settling prior to main engine ignition after coasting phases. Manual control in PGNS operation consists of +X ON/OFF commands from the LMP by way of the LGC. In AGS operation only manual control is available. Control consists of +X ON/OFF commands from the LMP to the jet logic in the ATCA. The voltage is sufficient to saturate the pulse ratio modulators and give ON/OFF control of the RCS jets. R-C R-B

8.1.4 Attitude and Translation Control Assembly (ATCA)

The ATCA supplies the signals which control the firing of the reaction jets and the signals for automatic trim of the gimbaled descent engine in AGS operation. The dc voltages required in all of the CES subassemblies and the synchronized ac voltage for the RGA's, and LMP are also generated within this assembly. The input signals from the RGA's are processed in the ATCA and are directed to the appropriate jets and the descent engine control assembly. R-C

Drawing 8.2.1 Sheet 1 of 2 shows a schematic diagram of the ATCA. In PGNS operation, only the LGC preamplifiers are enabled by the guidance selector switch. LGC jet commands are amplified by the preamplifiers and jet drivers and sent to the primary solenoids of the RCS. In AGS operation, only the abort preamplifiers are enabled and jet signals from

*

the pulse ratio modulators are amplified and drive the RCS primary solenoids. Pitch, roll, and yaw signals are processed in three similar channels. The RGA rate signals are the only inputs to the ATCA for attitude control in the AGS mode. The gains of the summing amplifiers are changed when the LM is staged to account for the change in vehicle moment of inertia. The RGA ac signals are changed to dc by keyed demodulators and filters. R-B

In the roll and pitch channels the demodulator output is sent to the DECA to control the trim of the gimbaled descent engine. The deadband circuitry provides for either a wide deadband (±5 degrees) or a narrow deadband (±0.3 degrees in roll and pitch and ±0.4 degrees in yaw) depending on the mission phase. In automatic and attitude hold modes, the signals from the deadband circuits are applied to the jet select logic. The jet select logic combines the attitude and translation inputs, determines whether two or four jets will fire to control rotation and X-axis translation, and applies the resultant signals to eight pulse ratio modulators. These pulse ratio modulators generate pulses which vary in width and frequency depending on the input voltage in order to control the duty radio of the RCS jets. Each pulse ratio modulator controls two opposing jets. The jet to be fired is determined by the sign of the pulse ratio modulator input voltage. R-C R-B R-C R-B R-C R-B

8.1.5 Descent Engine Control Assembly (DECA)

The DECA contains circuitry for controlling three functions of the descent engine. Engine throttling commands from the PGNS and LMP are processed and sent to the descent engine. PGNS or ATCA signals are processed for positioning the Gimbal Drive Actuators to control engine trim. ON/OFF commands are processed in the DECA to control descent engine ignition and shutdown. The schematic diagram of the DECA is shown in Drawing 8.3.1. R-C R-B

LMP throttle commands can be applied to the descent engine with the throttle control switch on the control panel in either the manual or automatic position. Manual throttle commands consists of ac voltages from the LMP applied to the DECA. R-C R-B R-C

The DECA demodulates and filters the signal and sends a proportional dc throttle voltage to the descent engine.

Automatic throttle signals can only be applied to the descent engine when the throttle control switch is in the automatic position. The LGC sends automatic throttle commands to the DECA in the form of pulses on one of two lines. Pulses on one line advance a forward-backward counter while pulses on the other line decrease the count. A dc voltage proportional to the count is generated and sent to the descent engine for automatic throttle control.

In PGNS operation automatic trim control is provided by the LGC. When the LGC determines descent engine trim is required, it sends a trim command to the DECA on either a trim positive or a trim negative line for the roll or pitch axis. The trim signal is routed through a malfunction logic circuit to a power switching circuit. The power switching circuit applies 400 cycle, 115 volts power to the proper Gimbal Drive Actuator. The GDA rotates the descent engine and sends a 400 cycle signal proportional to its position back to the DECA. The DECA demodulates and differentiates the feedback signal and applies it back to the malfunction logic circuit. If the GDA is not moving in the commanded direction, the malfunction logic generates a trim failed signal. This signal removes the 400 cycle power from the power switching circuit and sends TRIM FAILED signals to the LGC and Instrumentation. R-B

In abort guidance operation, roll and pitch trim signals, are received from the roll and pitch error channels in the ATCA. A comparator and threshold circuit in the DECA generates trim negative or trim positive commands and sends them to the malfunction logic. The malfunction logic controls the power switching circuits the same as in PGNS operation.

8.1.6 Gimbal Drive Actuator (GDA)

The two GDA's are low-speed electromechanical devices each containing a 115V 400 cps ac motor driving a screw jack and a position transducer. Under control of the DECA the GDA's rotate the descent

engine about the pitch and roll axes so that the thrust vector goes through the LM center of gravity. One GDA controls the pitch gimbal and the other controls the roll gimbal. R-B

Each GDA is capable of extending or retracting 2 inches from the mid-position and will gimbal the descent engine a maximum of plus or minus 6 degrees about the LM Y- and Z-axis. The GDA's move at a constant speed and rotate the descent engine at a rate of 0.2 degrees per second. The position transducer receives 115V 400 cps from the DECA on its primary winding. The secondary voltage is 400 cps, 7.5 volts per inch travel from mid-position; in phase when extended and 180 degrees out of phase when retracted past the mid-position. The transducer output is sent to instrumentation for telemetry and to the DECA malfunction logic. R-C

8.1.7 CES Interfaces

The CES receives the following signals from the PGNS:

A. ON/OFF commands for each of the 16 reaction control jets.
B. ON/OFF commands for the ascent or descent engine.
C. Descent engine trim commands.
D. Thrust magnitude commands for the descent engine.
E. 800 cycle per second power to excite the LMP. R-B

The CES feeds the following signals to the PGNS in the primary mode:

A. Gimbal fail signals.
B. +X Translation ON/OFF Commands.

The CES provides the following to the descent engine:

A. Ignition and shutdown commands
B. Automatic and manual throttling commands.
C. Rotation of the gimbal engine.

The CES also interfaces with the:

A. Electrical Power Subsystem (EPS) - The CES receives required electrical power from the EPS
B. Reaction Control Subsystem (RCS) - The CES provides the signals to actuate the RCS jet solenoids.
C. Ascent Engine - The CES provides commands for ascent engine ignition and shutdown.

D. Instrumentation Subsystem - CES provides signals to the Instrumentation Subsystem for inflight monitoring. R-C

E. Environmental Control Subsystem (ECS) - The ECS provides mounting surfaces and thermal protection for the CES equipment.

F. Structure Subsystem - The Structure Subsystem provides the area and mounting accommodations to house the CES equipment within the structure.

G. Explosive Devices Subsystem (EDS) - The CES interfaces with the EDS for stage status information.

*

8.2 CONTROL ELECTRONICS SYSTEM GENERAL NOTES

A. The Control Electronics System (CES) will have power applied and will be operating prior to launch and remain on throughout the mission. The primary guidance will utilize only a portion of the CES for control of the LM.

B. Manual throttling of the Descent Engine System in degrees of 10, 30, 50, and 100 percent throttle settings can be tested if the PGNS fails AS-206 by the PRA. The reset position of the throttle is 30 percent. R-B R-C

C. There will not be an automatic closed loop guidance for the PRA/AGS control during DPS and APS burns. Should a failure occur in the PGNS, the PRA will perform a minimum alternate propulsion test. The requirements for using the PRA/AGS control for a propulsion test will depend upon the time of failure of PGNS. R-B

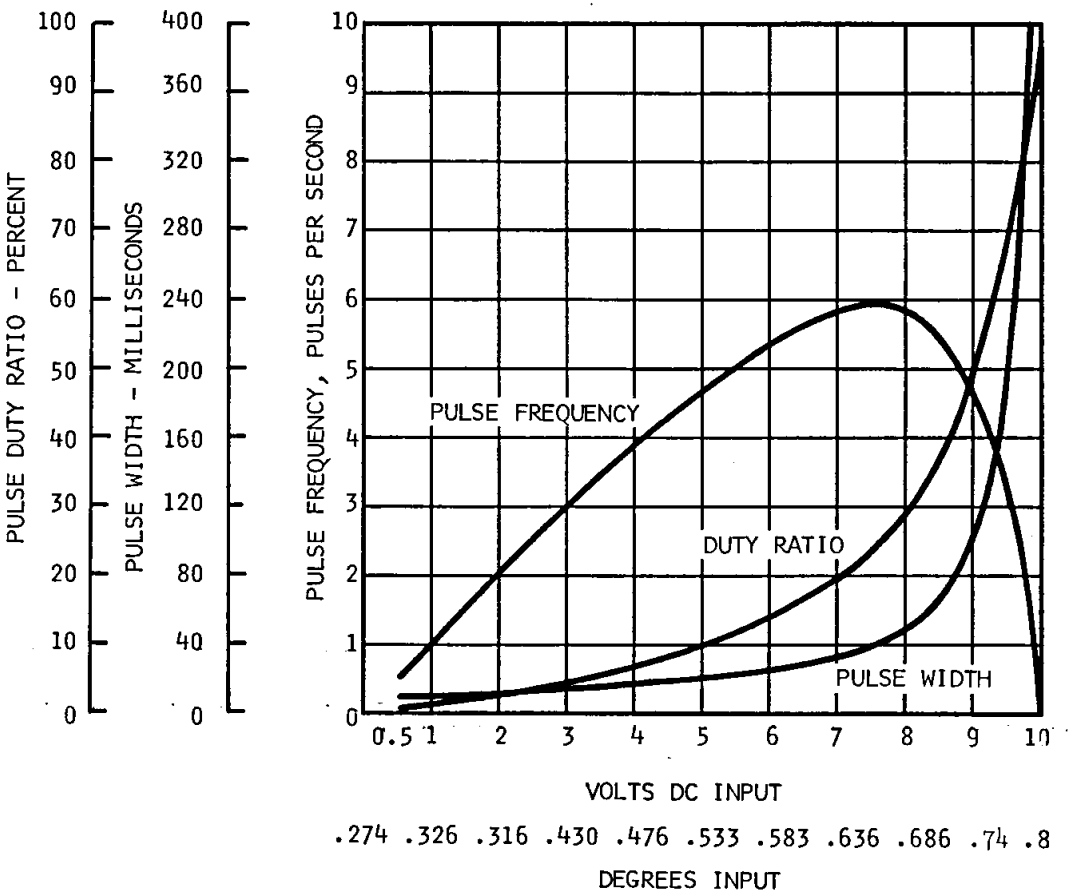


Figure 8-3 Performance of Pulse Ratio Modulator

R-C

*

TABLE 8-2 PRELAUNCH STATUS OF SWITCH POSITIONS

SWITCH NUMBER	SWITCH TITLE	SWITCH POSITION	
1-S-1	ENG ARM	OFF	
1-S-2	ENG START	OFF	R-B
1-S-3	ENG STOP	OFF	
1-S-4	ENG STOP	OFF	
1-S-5	DES RATE	CENTER	
1-S-6	X-TRANSLATION	4 JET	
			R-C
1-S-8	ENG GIMBAL	ENABLE	
1-S-9	BAL CPL	ON	
1-S-10	MAN THROTTLE	SYS ENG	
1-S-11	THRUST CONTROL	AUTO	
1-S-12	+X TRANSLATION	OFF	
1-S-13	ABORT	GUARD DOWN-SW OFF	
1-S-14	ABORT STAGE	GUARD DOWN-SW OFF	R-B
3-S-1	IMU CAGE	OFF	
9-S-2	RATE ERROR MON	CMPTR	
9-S-3	ATTITUDE MON	PGNS	
9-S-4	ALT/RNG MON	ALT/ALT RT	R-C
9-S-6	GUID CONT	PGNS	
9-S-7	RATE ERROR MON	CMPTR	
9-S-8	SHFT/TRU	± 50°	
9-S-9	MODE SELECT	PGNS	
9-S-10	ATTITUDE MON	PGNS	R-B
9-S-11	RESET/CONTROL	(RESET) UP	
9-S-12	TIMER CONTROL	CENTER POS	
9-S-17	X POINTER SCALE	HI MULT	
9-S-18	X POINTER SCALE	HI MULT	

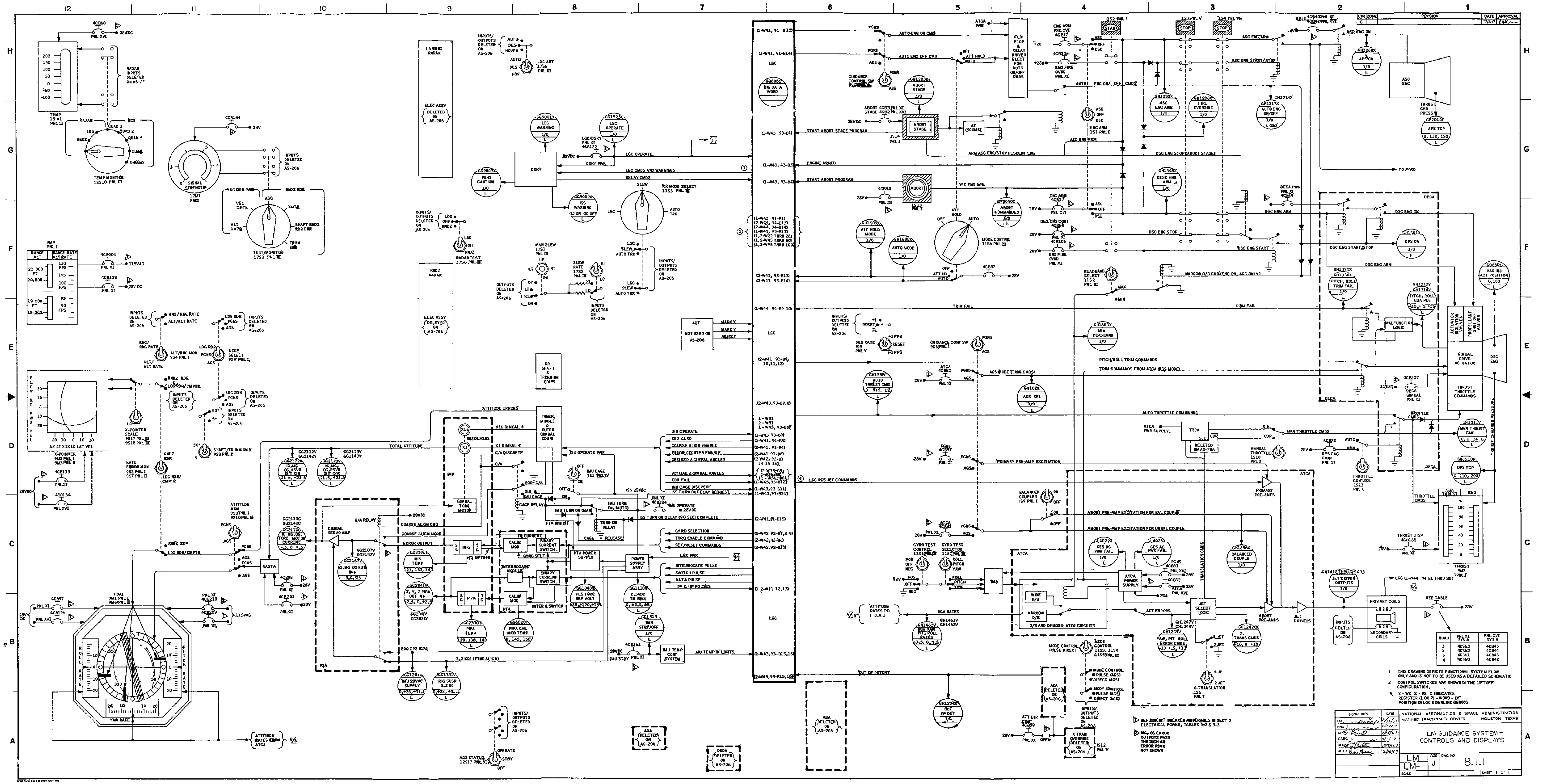
TABLE 8-2 PRELAUNCH STATUS OF SWITCH POSITIONS (Concl'd)

SWITCH NUMBER	SWITCH TITLE	SWITCH POSITION	
11-S-1	GYRO TEST	OFF	
11-S-2	DEADBAND	MIN	
11-S-3	ATTITUDE CONTROL - PITCH	MODE CONTROL	
11-S-4	ATTITUDE CONTROL - ROLL	MODE CONTROL	
11-S-5	ATTITUDE CONTROL - YAW	MODE CONTROL	
11-S-6	MODE CONTROL	AUTO	
11-S-7	GYRO TEST	ROLL	
			R-C
12-S-17	AGS STATUS	OFF	
			R-C
17-S-1	MANUAL SLEW	CENTER	
17-S-2	SLEW RATE	LOW	R-B
17-S-3	R. R. MODE SEL	AUTO TRACK	R-C
17-S-5	LDG RADAR ANT	#1 DES	
17-S-6	RADAR TEST	OFF	R-B
17-S-8	TEST MONITOR	LDG RDR PWR: ALT XMTR	R-C
18-S-10	TEMP MONITOR	RNDZ	R-B
19-S-3	LMP TCA ISOLATION	ENABLE	R-C

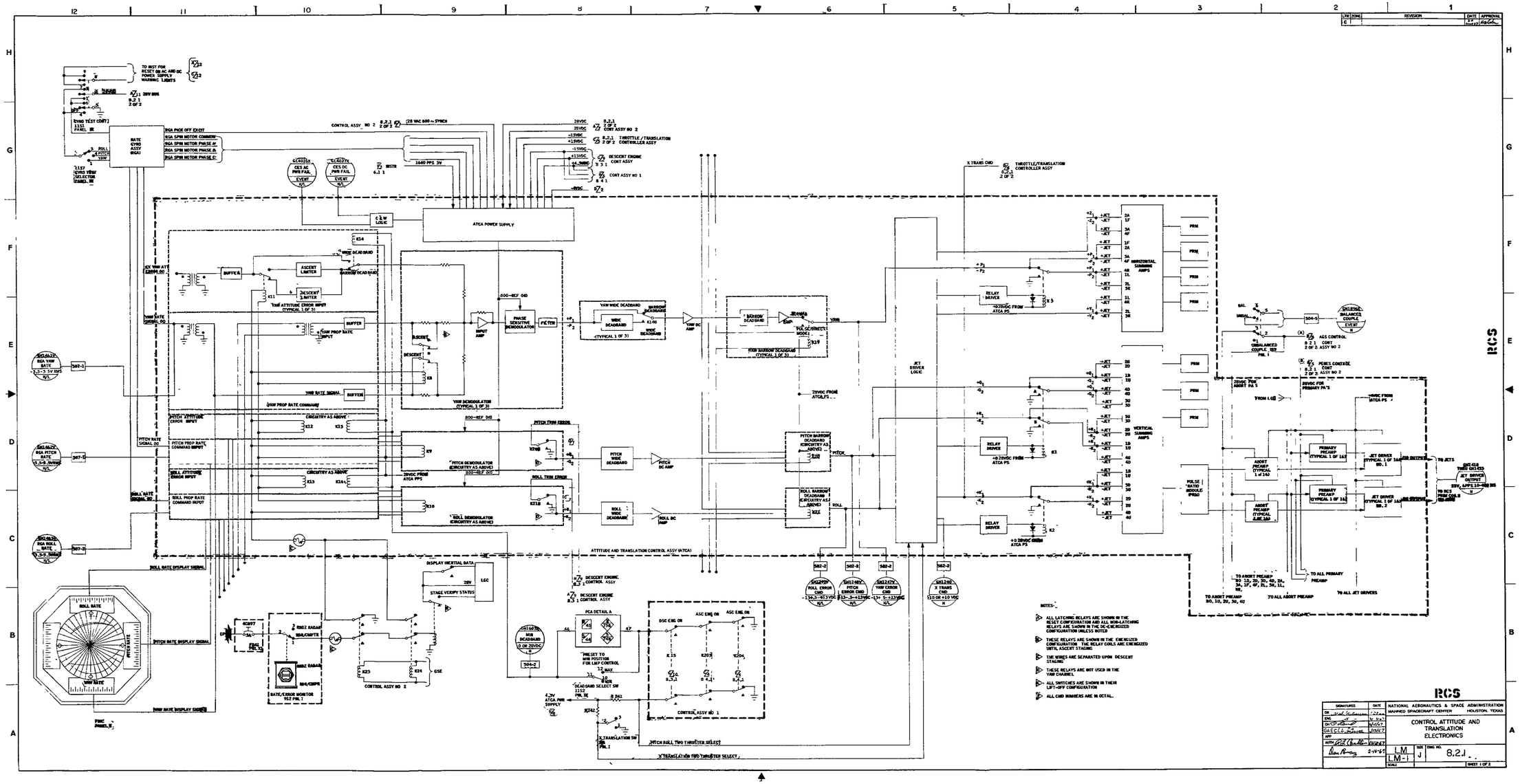
*

TABLE 8-3 PRELAUNCH STATUS OF CIRCUIT BREAKERS

CIRCUIT BREAKER NUMBER	TITLE	POSITION	
4CB2	ABORT STAGE	CLOSED	
4CB3	ABORT STAGE	CLOSED	
4CB28	AEA	OPEN	
4CB29	RNDZ PWR	OPEN	
4CB37	ENG ARM	CLOSED	
4CB40	AELD	CLOSED	
4CB41	AELD	CLOSED	
4CB59	ATT DIR CONT.	OPEN	
4CB69	DECA PWR	CLOSED	
4CB79	ASA	OPEN	
4CB80	DES ENG CONT	CLOSED	
4CB81	ATCA (PGNS)	CLOSED	
4CB82	ATCA	CLOSED	
4CB88	GASTA	OPEN	R-B
4CB105	LDG RDR	OPEN	
4CB106	ENG FIRE OVERRIDE	CLOSED	
4CB122	LGC/DSKY	CLOSED	
4CB123	ALT/ALT RT RNG/CONTROL	OPEN	
4CB124	IMU OPERATE	CLOSED	
4CB126	FDAI	OPEN	
4CB133	X-PNTR	OPEN	
4CB134	X-PNTR	OPEN	
4CB154	SIG STR DISP	OPEN	
4CB155	RNDZ RDR OPR	OPEN	
4CB156	RNDZ RDR STBY	OPEN	
4CB157	LDG RDR	CLOSED	R-C
4CB161	IMU STBY	CLOSED	R-B
4CB179	LMP FEED	CLOSED & SLUGGED	
4CB201	GASTA	OPEN	

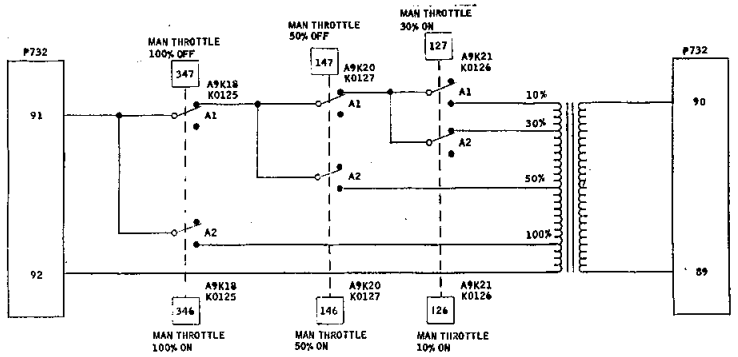


1. THIS DRAWING DEPICTS FUNCTIONAL SYSTEM FLOW ONLY AND IS NOT TO BE USED AS A DETAILED SCHEMATIC
2. CONTROL SWITCHES ARE SHOWN IN THE LIFTOFF CONFIGURATION.
3. X - WX X - 6X X INDICATES REGISTER (1 OR 2) - WORD - BIT POSITION IN LGC DOWNLINK GG0001
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS
LM GUIDANCE SYSTEM-
CONTROLS AND DISPLAYS
LM
LM-1
J
8.1.1
LGC
DSKY
ASC ENG
DSC ENG
IMU
PSA
ATCA
GASTA
FDAI
TTCA
PRIMARY COILS
SECONDARY COILS
ATTITUDE RATES FROM ATCA

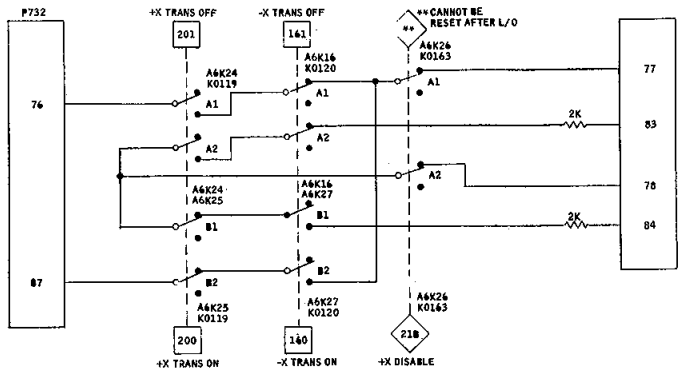

RCS
ATTITUDE AND TRANSLATION CONTROL ASSY (ATCA)
ATCA POWER SUPPLY
C & W LOGIC
JET DRIVER LOGIC
RATE GYRO ASSY (RGA)
RGA PICK OFF EXCIT
RGA SPIN MOTOR COMMON
RGA SPIN MOTOR PHASE A
RGA SPIN MOTOR PHASE B
RGA SPIN MOTOR PHASE C
GYRO TEST CONT 1151 PANEL 2R
ROLL PITCH YAW SELECTOR PANEL 1R
CONTROL ASSY NO 2
CONTROL ASSY NO 1
1680 PPS 3W
28VDC
20VDC
-15VDC
+15VDC
+13.5VDC
-13.5VDC
-5VDC
ASCENT LIMITER
DESCENT LIMITER
WIDE DEAD BAND
NARROW DEAD BAND
YAW ATTITUDE ERROR INPUT (TYPICAL 1 OF 3)
YAW RATE SIGNAL
YAW PROP RATE INPUT
YAW PROP RATE COMMAND
YAW DEMODULATOR (TYPICAL 1 OF 3)
YAW WIDE DEADBAND
YAW NARROW DEADBAND (TYPICAL 1 OF 3)
YAW DC AMP
PITCH ATTITUDE ERROR INPUT
PITCH PROP RATE COMMAND INPUT
PITCH DEMODULATOR (CIRCUITRY AS ABOVE)
PITCH TRIM ERROR
PITCH WIDE DEADBAND
PITCH DC AMP
PITCH NARROW DEADBAND (CIRCUITRY AS ABOVE)
ROLL ATTITUDE ERROR INPUT
ROLL PROP RATE COMMAND INPUT
ROLL DEMODULATOR (CIRCUITRY AS ABOVE)
ROLL TRIM ERROR
ROLL WIDE DEADBAND
ROLL DC AMP
ROLL NARROW DEADBAND (CIRCUITRY AS ABOVE)
PHASE SENSITIVE DEMODULATOR
FILTER
INPUT AMP
800-REF CKD
20VDC FROM ATCA PS
PLSE/DIRECT MODE
RELAY DRIVER
+0.20VDC FROM ATCA PS
+0.28VDC FROM ATCA PS
VERTICAL SUMMING AMPS
HORIZONTAL SUMMING AMPS
PRM
PULSE RATIO MODULATE PRMD
ABORT PREAMP (TYPICAL 1 of 16)
PRIMARY PREAMP (TYPICAL 1 OF 16)
JET DRIVER (TYPICAL 1 OF 16) NO. 1
JET DRIVER (TYPICAL 1 OF 16) NO. 2
TO JETS
TO RCS FROM CDLS
TO ALL PRIMARY PREAMP
TO ALL ABORT PREAMP
TO ALL JET DRIVERS
TO ABORT PREAMP NO. 10, 20, 30, 40, 2A, 3A, 1F, 4F, 2I, 3I, 1L, 4L
TO ABORT PREAMP NO. 10, 20, 30, 40
ATCA PWR SUPPLY
PCA DETAIL A
PRESET TO MIN POSITION FOR LM/P CONTROL
DEAD BAND SELECT SW 1151 PNL 3R
X TRANSLATION SW 1151 PNL 1
PITCH ROLL TWO THRUSTER SELECT
X TRANSLATION TWO THRUSTER SELECT
DISPLAY INERTIAL DATA
STAGE VERIFY STATUS
LGC
DSC ENG ON
ASC ENG ON
ROLL RATE
PITCH RATE
YAW RATE
ROLL RATE DISPLAY SIGNAL
PITCH RATE DISPLAY SIGNAL
YAW RATE DISPLAY SIGNAL
RATE/ERROR MONITOR 952 PNL 1
CSE
X TRANS CMD
THROTTLE/TRANSLATION CONTROLLER ASSY
ABORT PWR SWITCH 1151 PNL 2
ABORT STAGE SW 1151 PNL 2
ENGINE ARM SW 1151 PNL 2
ENGINE ARM CONTROL
ABORT STAGE CONTROL
ENGINE ARM
ABORT STAGE
AGS CONTROL
PCMEA CONTROL
CONT ASSY NO 1
CONT ASSY NO 2
DESCENT ENGINE CONTROL ASSY
THROTTLE /TRANSLATION CONTROLLER ASSY
CES AC PWR FAIL
CES DC PWR FAIL
EVENT N/A
MSTR
S62-2
S62-3
S62-8
S62-9
S62-10
S62-11
S62-12
S62-13
S62-14
S62-15
S62-16
S62-17
S62-18
S62-19
S62-20
S62-21
S62-22
S62-23
S62-24
S62-25
S62-26
S62-27
S62-28
S62-29
S62-30
S62-31
S62-32
S62-33
S62-34
S62-35
S62-36
S62-37
S62-38
S62-39
S62-40
S62-41
S62-42
S62-43
S62-44
S62-45
S62-46
S62-47
S62-48
S62-49
S62-50
S62-51
S62-52
S62-53
S62-54
S62-55
S62-56
S62-57
S62-58
S62-59
S62-60
S62-61
S62-62
S62-63
S62-64
S62-65
S62-66
S62-67
S62-68
S62-69
S62-70
S62-71
S62-72
S62-73
S62-74
S62-75
S62-76
S62-77
S62-78
S62-79
S62-80
S62-81
S62-82
S62-83
S62-84
S62-85
S62-86
S62-87
S62-88
S62-89
S62-90
S62-91
S62-92
S62-93
S62-94
S62-95
S62-96
S62-97
S62-98
S62-99
S62-100
S62-101
S62-102
S62-103
S62-104
S62-105
S62-106
S62-107
S62-108
S62-109
S62-110
S62-111
S62-112
S62-113
S62-114
S62-115
S62-116
S62-117
S62-118
S62-119
S62-120
S62-121
S62-122
S62-123
S62-124
S62-125
S62-126
S62-127
S62-128
S62-129
S62-130
S62-131
S62-132
S62-133
S62-134
S62-135
S62-136
S62-137
S62-138
S62-139
S62-140
S62-141
S62-142
S62-143
S62-144
S62-145
S62-146
S62-147
S62-148
S62-149
S62-150
S62-151
S62-152
S62-153
S62-154
S62-155
S62-156
S62-157
S62-158
S62-159
S62-160
S62-161
S62-162
S62-163
S62-164
S62-165
S62-166
S62-167
S62-168
S62-169
S62-170
S62-171
S62-172
S62-173
S62-174
S62-175
S62-176
S62-177
S62-178
S62-179
S62-180
S62-181
S62-182
S62-183
S62-184
S62-185
S62-186
S62-187
S62-188
S62-189
S62-190
S62-191
S62-192
S62-193
S62-194
S62-195
S62-196
S62-197
S62-198
S62-199
S62-200
S62-201
S62-202
S62-203
S62-204
S62-205
S62-206
S62-207
S62-208
S62-209
S62-210
S62-211
S62-212
S62-213
S62-214
S62-215
S62-216
S62-217
S62-218
S62-219
S62-220
S62-221
S62-222
S62-223
S62-224
S62-225
S62-226
S62-227
S62-228
S62-229
S62-230
S62-231
S62-232
S62-233
S62-234
S62-235
S62-236
S62-237
S62-238
S62-239
S62-240
S62-241
S62-242
S62-243
S62-244
S62-245
S62-246
S62-247
S62-248
S62-249
S62-250
S62-251
S62-252
S62-253
S62-254
S62-255
S62-256
S62-257
S62-258
S62-259
S62-260
S62-261
S62-262
S62-263
S62-264
S62-265
S62-266
S62-267
S62-268
S62-269
S62-270
S62-271
S62-272
S62-273
S62-274
S62-275
S62-276
S62-277
S62-278
S62-279
S62-280
S62-281
S62-282
S62-283
S62-284
S62-285
S62-286
S62-287
S62-288
S62-289
S62-290
S62-291
S62-292
S62-293
S62-294
S62-295
S62-296
S62-297
S62-298
S62-299
S62-300
S62-301
S62-302
S62-303
S62-304
S62-305
S62-306
S62-307
S62-308
S62-309
S62-310
S62-311
S62-312
S62-313
S62-314
S62-315
S62-316
S62-317
S62-318
S62-319
S62-320
S62-321
S62-322
S62-323
S62-324
S62-325
S62-326
S62-327
S62-328
S62-329
S62-330
S62-331
S62-332
S62-333
S62-334
S62-335
S62-336
S62-337
S62-338
S62-339
S62-340
S62-341
S62-342
S62-343
S62-344
S62-345
S62-346
S62-347
S62-348
S62-349
S62-350
S62-351
S62-352
S62-353
S62-354
S62-355
S62-356
S62-357
S62-358
S62-359
S62-360
S62-361
S62-362
S62-363
S62-364
S62-365
S62-366
S62-367
S62-368
S62-369
S62-370
S62-371
S62-372
S62-373
S62-374
S62-375
S62-376
S62-377
S62-378
S62-379
S62-380
S62-381
S62-382
S62-383
S62-384
S62-385
S62-386
S62-387
S62-388
S62-389
S62-390
S62-391
S62-392
S62-393
S62-394
S62-395
S62-396
S62-397
S62-398
S62-399
S62-400
S62-401
S62-402
S62-403
S62-404
S62-405
S62-406
S62-407
S62-408
S62-409
S62-410
S62-411
S62-412
S62-413
S62-414
S62-415
S62-416
S62-417
S62-418
S62-419
S62-420
S62-421
S62-422
S62-423
S62-424
S62-425
S62-426
S62-427
S62-428
S62-429
S62-430
S62-431
S62-432
S62-433
S62-434
S62-435
S62-436
S62-437
S62-438
S62-439
S62-440
S62-441
S62-442
S62-443
S62-444
S62-445
S62-446
S62-447
S62-448
S62-449
S62-450
S62-451
S62-452
S62-453
S62-454
S62-455
S62-456
S62-457
S62-458
S62-459
S62-460
S62-461
S62-462
S62-463
S62-464
S62-465
S62-466
S62-467
S62-468
S62-469
S62-470
S62-471
S62-472
S62-473
S62-474
S62-475
S62-476
S62-477
S62-478
S62-479
S62-480
S62-481
S62-482
S62-483
S62-484
S62-485
S62-486
S62-487
S62-488
S62-489
S62-490
S62-491
S62-492
S62-493
S62-494
S62-495
S62-496
S62-497
S62-498
S62-499
S62-500
S62-501
S62-502
S62-503
S62-504
S62-505
S62-506
S62-507
S62-508
S62-509
S62-510
S62-511
S62-512
S62-513
S62-514
S62-515
S62-516
S62-517
S62-518
S62-519
S62-520
S62-521
S62-522
S62-523
S62-524
S62-525
S62-526
S62-527
S62-528
S62-529
S62-530
S62-531
S62-532
S62-533
S62-534
S62-535
S62-536
S62-537
S62-538
S62-539
S62-540
S62-541
S62-542
S62-543
S62-544
S62-545
S62-546
S62-547
S62-548
S62-549
S62-550
S62-551
S62-552
S62-553
S62-554
S62-555
S62-556
S62-557
S62-558
S62-559
S62-560
S62-561
S62-562
S62-563
S62-564
S62-565
S62-566
S62-567
S62-568
S62-569
S62-570
S62-571
S62-572
S62-573
S62-574
S62-575
S62-576
S62-577
S62-578
S62-579
S62-580
S62-581
S62-582
S62-583
S62-584
S62-585
S62-586
S62-587
S62-588
S62-589
S62-590
S62-591
S62-592
S62-593
S62-594
S62-595
S62-596
S62-597
S62-598
S62-599
S62-600
S62-601
S62-602
S62-603
S62-604
S62-605
S62-606
S62-607
S62-608
S62-609
S62-610
S62-611
S62-612
S62-613
S62-614
S62-615
S62-616
S62-617
S62-618
S62-619
S62-620
S62-621
S62-622
S62-623
S62-624
S62-625
S62-626
S62-627
S62-628
S62-629
S62-630
S62-631
S62-632
S62-633
S62-634
S62-635
S62-636
S62-637
S62-638
S62-639
S62-640
S62-641
S62-642
S62-643
S62-644
S62-645
S62-646
S62-647
S62-648
S62-649
S62-650
S62-651
S62-652
S62-653
S62-654
S62-655
S62-656
S62-657
S62-658
S62-659
S62-660
S62-661
S62-662
S62-663
S62-664
S62-665
S62-666
S62-667
S62-668
S62-669
S62-670
S62-671
S62-672
S62-673
S62-674
S62-675
S62-676
S62-677
S62-678
S62-679
S62-680
S62-681
S62-682
S62-683
S62-684
S62-685
S62-686
S62-687
S62-688
S62-689
S62-690
S62-691
S62-692
S62-693
S62-694
S62-695
S62-696
S62-697
S62-698
S62-699
S62-700
S62-701
S62-702
S62-703
S62-704
S62-705
S62-706
S62-707
S62-708
S62-709
S62-710
S62-711
S62-712
S62-713
S62-714
S62-715
S62-716
S62-717
S62-718
S62-719
S62-720
S62-721
S62-722
S62-723
S62-724
S62-725
S62-726
S62-727
S62-728
S62-729
S62-730
S62-731
S62-732
S62-733
S62-734
S62-735
S62-736
S62-737
S62-738
S62-739
S62-740
S62-741
S62-742
S62-743
S62-744
S62-745
S62-746
S62-747
S62-748
S62-749
S62-750
S62-751
S62-752
S62-753
S62-754
S62-755
S62-756
S62-757
S62-758
S62-759
S62-760
S62-761
S62-762
S62-763
S62-764
S62-765
S62-766
S62-767
S62-768
S62-769
S62-770
S62-771
S62-772
S62-773
S62-774
S62-775
S62-776
S62-777
S62-778
S62-779
S62-780
S62-781
S62-782
S62-783
S62-784
S62-785
S62-786
S62-787
S62-788
S62-789
S62-790
S62-791
S62-792
S62-793
S62-794
S62-795
S62-796
S62-797
S62-798
S62-799
S62-800
S62-801
S62-802
S62-803
S62-804
S62-805
S62-806
S62-807
S62-808
S62-809
S62-810
S62-811
S62-812
S62-813
S62-814
S62-815
S62-816
S62-817
S62-818
S62-819
S62-820
S62-821
S62-822
S62-823
S62-824
S62-825
S62-826
S62-827
S62-828
S62-829
S62-830
S62-831
S62-832
S62-833
S62-834
S62-835
S62-836
S62-837
S62-838
S62-839
S62-840
S62-841
S62-842
S62-843
S62-844
S62-845
S62-846
S62-847
S62-848
S62-849
S62-850
S62-851
S62-852
S62-853
S62-854
S62-855
S62-856
S62-857
S62-858
S62-859
S62-860
S62-861
S62-862
S62-863
S62-864
S62-865
S62-866
S62-867
S62-868
S62-869
S62-870
S62-871
S62-872
S62-873
S62-874
S62-875
S62-876
S62-877
S62-878
S62-879
S62-880
S62-881
S62-882
S62-883
S62-884
S62-885
S62-886
S62-887
S62-888
S62-889
S62-890
S62-891
S62-892
S62-893
S62-894
S62-895
S62-896
S62-897
S62-898
S62-899
S62-900
S62-901
S62-902
S62-903
S62-904
S62-905
S62-906
S62-907
S62-908
S62-909
S62-910
S62-911
S62-912
S62-913
S62-914
S62-915
S62-916
S62-917
S62-918
S62-919
S62-920
S62-921
S62-922
S62-923
S62-924
S62-925
S62-926
S62-927
S62-928
S62-929
S62-930
S62-931
S62-932
S62-933
S62-934
S62-935
S62-936
S62-937
S62-938
S62-939
S62-940
S62-941
S62-942
S62-943
S62-944
S62-945
S62-946
S62-947
S62-948
S62-949
S62-950
S62-951
S62-952
S62-953
S62-954
S62-955
S62-956
S62-957
S62-958
S62-959
S62-960
S62-961
S62-962
S62-963
S62-964
S62-965
S62-966
S62-967
S62-968
S62-969
S62-970
S62-971
S62-972
S62-973
S62-974
S62-975
S62-976
S62-977
S62-978
S62-979
S62-980
S62-981
S62-982
S62-983
S62-984
S62-985
S62-986
S62-987
S62-988
S62-989
S62-990
S62-991
S62-992
S62-993
S62-994
S62-995
S62-996
S62-997
S62-998
S62-999
S62-1000
NOTES:
1. ALL LATCHING RELAYS ARE SHOWN IN THE RESET CONFIGURATION AND ALL NON-LATCHING RELAYS ARE SHOWN IN THE DE-ENERGIZED CONFIGURATION UNLESS NOTED
2. THESE RELAYS ARE SHOWN IN THE ENERGIZED CONFIGURATION THE RELAY COILS ARE ENERGIZED UNTIL ASCENT STAGING
3. THE WIRES ARE SEPARATED UPON DESCENT STAGING
4. THESE RELAYS ARE NOT USED IN THE YAW CHANNEL
5. ALL SWITCHES ARE SHOWN IN THEIR LIFT-OFF CONFIGURATION
6. ALL CMD NUMBERS ARE IN OCTAL.
SIGNATURES
DR
ENG
SUPV
CHECKED
APP
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS
CONTROL ATTITUDE AND TRANSLATION ELECTRONICS
LM
LM-1
SIZE J
DWG NO 8.2.1
SCALE
SHEET 1 OF 2

*

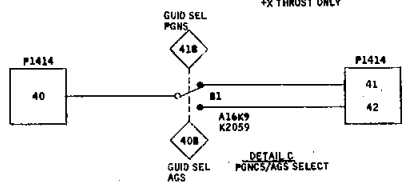
THIS PAGE INTENTIONALLY LEFT BLANK



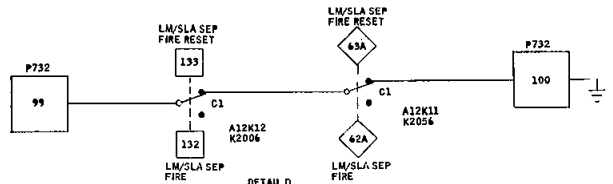
DETAIL A
MANUAL THROTTLE CONTROL



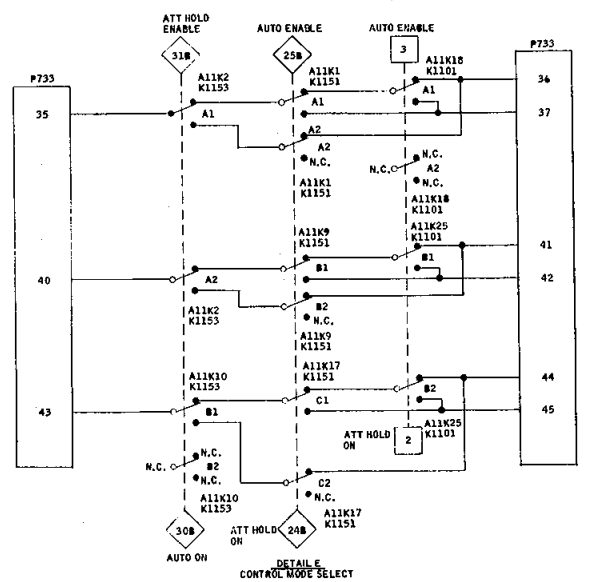
DETAIL B
THRUST/TRANSLATION CONTROLLER
+X THRUST ONLY



DETAIL C
PGNCS/AGS SELECT

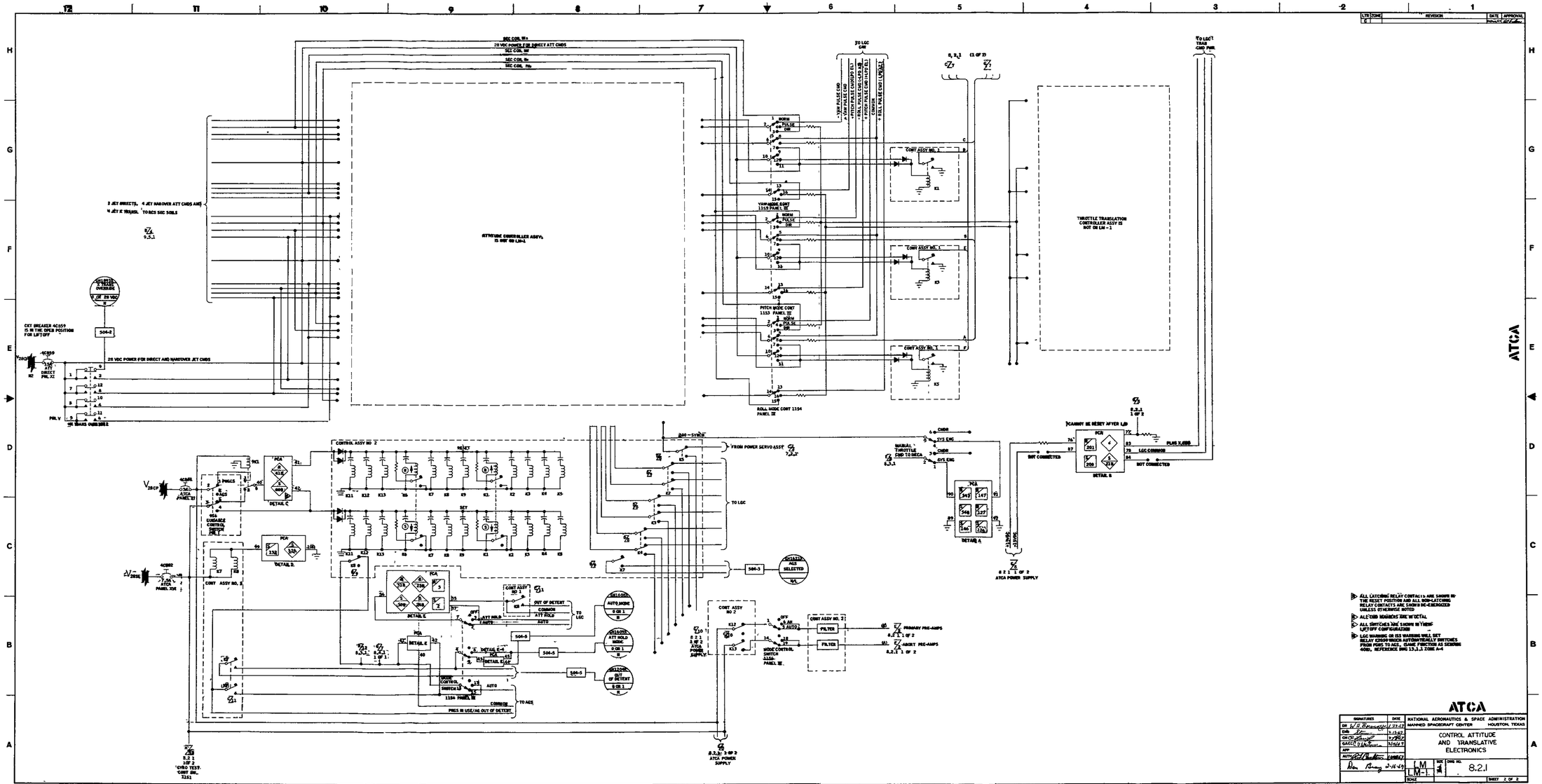


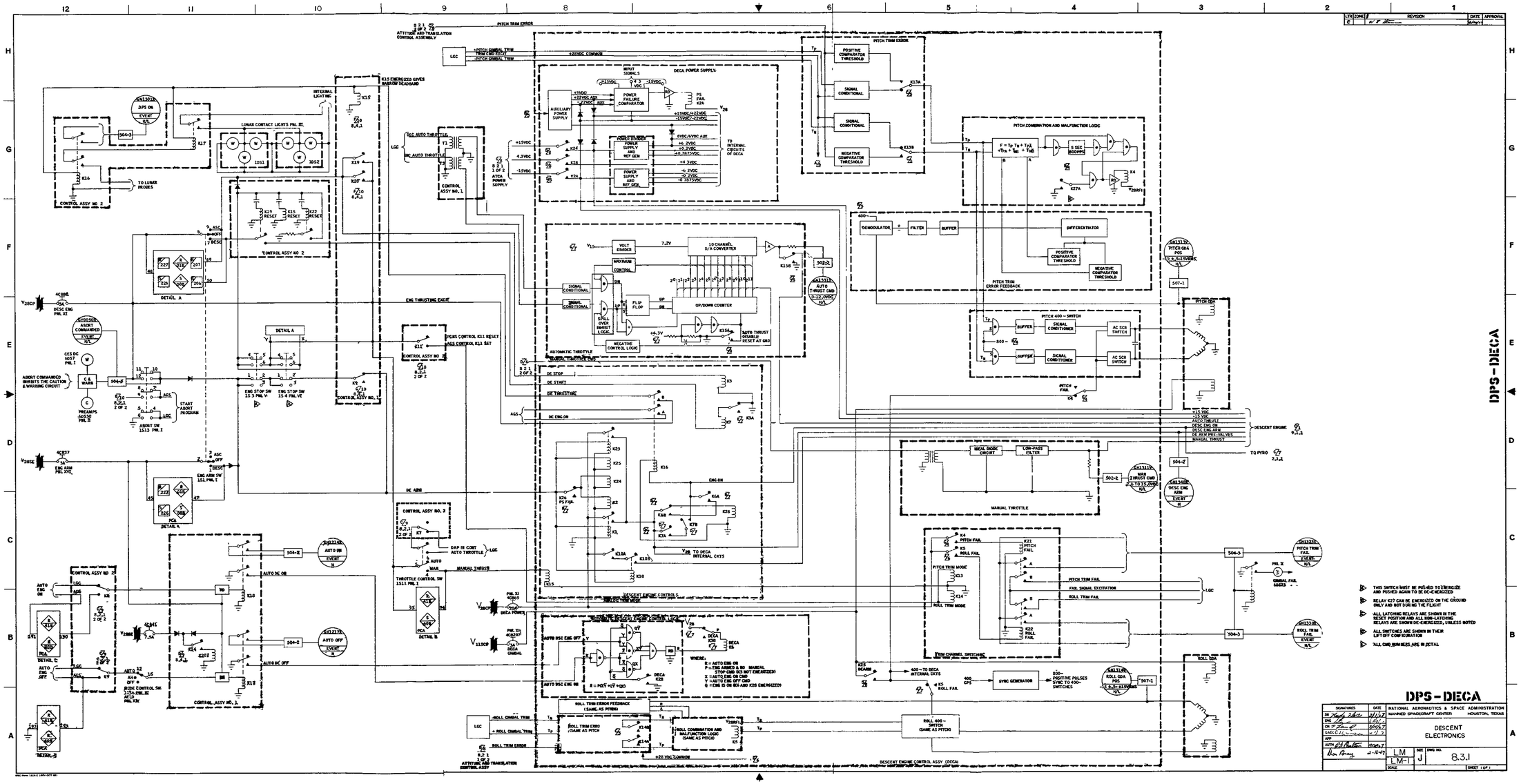
DETAIL D
LM/S-IVB SEPARATION

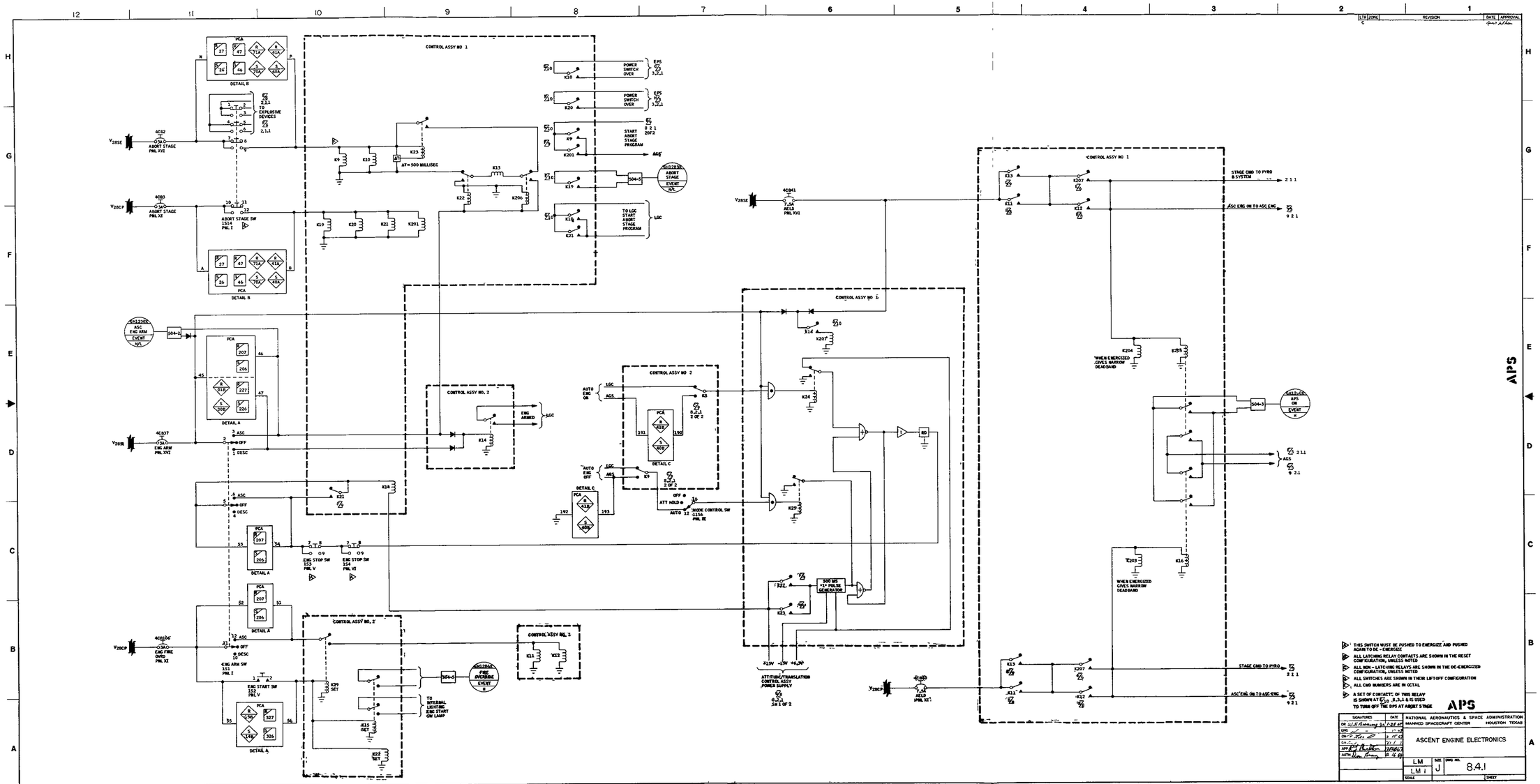


DETAIL E
CONTROL MODE SELECT

DWG NO. 8.2.1 (2 OF 2)
DETAIL SHEET NO. 1


ATCA
CONTROL ASSY NO. 2
RESET
SET
TO LGC
FROM POWER SERVO ASSY
CONT ASSY NO. 2
DETAIL A
DETAIL B
DETAIL C
DETAIL D
DETAIL E
ATT HOLD
AUTO
OUT OF DETENT
COMMON
ATT RATE
MODE CONTROL SWITCH 1155, PANEL 2
MODE CONTROL SWITCH 1156, PANEL 2
PRIMARY PRE-AMPS
ABORT PRE-AMPS
FILTER
ATCA POWER SUPPLY
THROTTLE TRANSLATION CONTROLLER ASSY 2
ROLL MODE CONT 1154 PANEL 2
PITCH MODE CONT 1153 PANEL 2
YAW MODE CONT 1152 PANEL 2
ATT DIRECT PNL X1
ATCA PANEL X2
ENDURANCE CONTROL PANEL X2
CONT ASSY NO. 1
CONT ASSY NO. 3
CONT ASSY NO. 4
CONT ASSY NO. 5
CANNOT BE RESET AFTER LIFT OFF
BOT CONNECTED
LGC COMMAND
PLUG X-2000
MANUAL THROTTLE CMD TO MECA
ALL LATCHING RELAY CONTACTS ARE SHOWN IN THE RESET POSITION AND ALL NON-LATCHING RELAY CONTACTS ARE SHOWN DE-ENERGIZED UNLESS OTHERWISE NOTED
ALL SWITCHES ARE SHOWN IN THEIR LIFT-OFF CONFIGURATION
LGC WARNING OR ISS WARNING WILL SET RELAY K2569 WHICH AUTOMATICALLY SWITCHES FROM PGNS TO ACS. SAME FUNCTION AS SIGNING 4080, REFERENCE SMD 13.1.2 ZONE A-4
SIGNATURES
DATE
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
CONTROL ATTITUDE AND TRANSLATIVE ELECTRONICS
LM
8.2.1
SHEET 2 OF 2


DPS-DECA
DESCENT ELECTRONICS
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
LM-1
J
8.3.1
SHEET 1 OF 1
DESCENT ENGINE CONTROL ASSY (DECA)
ATTITUDE AND TRANSLATION CONTROL ASSEMBLY
DECA POWER SUPPLY
AUTOMATIC THROTTLE
MANUAL THROTTLE
PITCH TRIM ERROR
PITCH COMBINATION AND MALFUNCTION LOGIC
ROLL TRIM ERROR
ROLL COMBINATION AND MALFUNCTION LOGIC
ROLL TRIM ERROR FEEDBACK
PITCH TRIM ERROR FEEDBACK
DESCENT ENGINE CONTROLS
DPS ON
DESC ENG PWL X2
ABORT COMMANDED
CES DC ASST PWL I
ABORT COMMANDED INHIBITS THE CAUTION & WARNING CIRCUIT
PREAMPS A6T30 PWL II
ABORT SW 1513 PWL I
START ABORT PROGRAM
DESC ENG ARM PWL XVI
ENG ARM SW 1511 PWL I
ENG ARM
ENG THRUSTING EXCIT
ENG STOP SW 15-3 PWL V
ENG STOP SW 15-4 PWL VI
PGNS CONTROL K11 RESET
AGS CONTROL K11 SET
DE START
DE TERMINATE
DE STOP
DE ENG ON
DE ARM
ENG ON
DAP IN CONT AUTO THROTTLE
MAN
AUTO
MANUAL THROTTLE
THROTTLE CONTROL SW 1511 PWL I
DECA POWER
DECA GIMBAL
AUTO DSC ENG OFF
AUTO DSC ENG ON
AUTO DE ON
AUTO DE OFF
AUTO ENG ON
AUTO ENG OFF
ASA OFF
BODE CONTROL SW 1356 ENG IN A6L10 PWL VIII
CONTROL ASSY NO. 1
CONTROL ASSY NO. 2
CONTROL ASSY NO 2
CONTROL ASSY NO. 1
LUNAR CONTACT LIGHTS PWL III
INTERNAL LIGHTING
TO LUNAR PROBES
DETAIL A
DETAIL B
DETAIL C
DETAIL D
DETAIL E
DETAIL F
DETAIL G
DETAIL H
DETAIL I
DETAIL J
DETAIL K
DETAIL L
DETAIL M
DETAIL N
DETAIL O
DETAIL P
DETAIL Q
DETAIL R
DETAIL S
DETAIL T
DETAIL U
DETAIL V
DETAIL W
DETAIL X
DETAIL Y
DETAIL Z
DETAIL AA
DETAIL AB
DETAIL AC
DETAIL AD
DETAIL AE
DETAIL AF
DETAIL AG
DETAIL AH
DETAIL AI
DETAIL AJ
DETAIL AK
DETAIL AL
DETAIL AM
DETAIL AN
DETAIL AO
DETAIL AP
DETAIL AQ
DETAIL AR
DETAIL AS
DETAIL AT
DETAIL AU
DETAIL AV
DETAIL AW
DETAIL AX
DETAIL AY
DETAIL AZ
DETAIL BA
DETAIL BB
DETAIL BC
DETAIL BD
DETAIL BE
DETAIL BF
DETAIL BG
DETAIL BH
DETAIL BI
DETAIL BJ
DETAIL BK
DETAIL BL
DETAIL BM
DETAIL BN
DETAIL BO
DETAIL BP
DETAIL BQ
DETAIL BR
DETAIL BS
DETAIL BT
DETAIL BU
DETAIL BV
DETAIL BW
DETAIL BX
DETAIL BY
DETAIL BZ
DETAIL CA
DETAIL CB
DETAIL CC
DETAIL CD
DETAIL CE
DETAIL CF
DETAIL CG
DETAIL CH
DETAIL CI
DETAIL CJ
DETAIL CK
DETAIL CL
DETAIL CM
DETAIL CN
DETAIL CO
DETAIL CP
DETAIL CQ
DETAIL CR
DETAIL CS
DETAIL CT
DETAIL CU
DETAIL CV
DETAIL CW
DETAIL CX
DETAIL CY
DETAIL CZ
DETAIL DA
DETAIL DB
DETAIL DC
DETAIL DD
DETAIL DE
DETAIL DF
DETAIL DG
DETAIL DH
DETAIL DI
DETAIL DJ
DETAIL DK
DETAIL DL
DETAIL DM
DETAIL DN
DETAIL DO
DETAIL DP
DETAIL DQ
DETAIL DR
DETAIL DS
DETAIL DT
DETAIL DU
DETAIL DV
DETAIL DW
DETAIL DX
DETAIL DY
DETAIL DZ
DETAIL EA
DETAIL EB
DETAIL EC
DETAIL ED
DETAIL EE
DETAIL EF
DETAIL EG
DETAIL EH
DETAIL EI
DETAIL EJ
DETAIL EK
DETAIL EL
DETAIL EM
DETAIL EN
DETAIL EO
DETAIL EP
DETAIL EQ
DETAIL ER
DETAIL ES
DETAIL ET
DETAIL EU
DETAIL EV
DETAIL EW
DETAIL EX
DETAIL EY
DETAIL EZ
DETAIL FA
DETAIL FB
DETAIL FC
DETAIL FD
DETAIL FE
DETAIL FF
DETAIL FG
DETAIL FH
DETAIL FI
DETAIL FJ
DETAIL FK
DETAIL FL
DETAIL FM
DETAIL FN
DETAIL FO
DETAIL FP
DETAIL FQ
DETAIL FR
DETAIL FS
DETAIL FT
DETAIL FU
DETAIL FV
DETAIL FW
DETAIL FX
DETAIL FY
DETAIL FZ
DETAIL GA
DETAIL GB
DETAIL GC
DETAIL GD
DETAIL GE
DETAIL GF
DETAIL GG
DETAIL GH
DETAIL GI
DETAIL GJ
DETAIL GK
DETAIL GL
DETAIL GM
DETAIL GN
DETAIL GO
DETAIL GP
DETAIL GQ
DETAIL GR
DETAIL GS
DETAIL GT
DETAIL GU
DETAIL GV
DETAIL GW
DETAIL GX
DETAIL GY
DETAIL GZ
DETAIL HA
DETAIL HB
DETAIL HC
DETAIL HD
DETAIL HE
DETAIL HF
DETAIL HG
DETAIL HH
DETAIL HI
DETAIL HJ
DETAIL HK
DETAIL HL
DETAIL HM
DETAIL HN
DETAIL HO
DETAIL HP
DETAIL HQ
DETAIL HR
DETAIL HS
DETAIL HT
DETAIL HU
DETAIL HV
DETAIL HW
DETAIL HX
DETAIL HY
DETAIL HZ
DETAIL IA
DETAIL IB
DETAIL IC
DETAIL ID
DETAIL IE
DETAIL IF
DETAIL IG
DETAIL IH
DETAIL II
DETAIL IJ
DETAIL IK
DETAIL IL
DETAIL IM
DETAIL IN
DETAIL IO
DETAIL IP
DETAIL IQ
DETAIL IR
DETAIL IS
DETAIL IT
DETAIL IU
DETAIL IV
DETAIL IW
DETAIL IX
DETAIL IY
DETAIL IZ
DETAIL JA
DETAIL JB
DETAIL JC
DETAIL JD
DETAIL JE
DETAIL JF
DETAIL JG
DETAIL JH
DETAIL JI
DETAIL JJ
DETAIL JK
DETAIL JL
DETAIL JM
DETAIL JN
DETAIL JO
DETAIL JP
DETAIL JQ
DETAIL JR
DETAIL JS
DETAIL JT
DETAIL JU
DETAIL JV
DETAIL JW
DETAIL JX
DETAIL JY
DETAIL JZ
DETAIL KA
DETAIL KB
DETAIL KC
DETAIL KD
DETAIL KE
DETAIL KF
DETAIL KG
DETAIL KH
DETAIL KI
DETAIL KJ
DETAIL KK
DETAIL KL
DETAIL KM
DETAIL KN
DETAIL KO
DETAIL KP
DETAIL KQ
DETAIL KR
DETAIL KS
DETAIL KT
DETAIL KU
DETAIL KV
DETAIL KW
DETAIL KX
DETAIL KY
DETAIL KZ
DETAIL LA
DETAIL LB
DETAIL LC
DETAIL LD
DETAIL LE
DETAIL LF
DETAIL LG
DETAIL LH
DETAIL LI
DETAIL LJ
DETAIL LK
DETAIL LL
DETAIL LM
DETAIL LN
DETAIL LO
DETAIL LP
DETAIL LQ
DETAIL LR
DETAIL LS
DETAIL LT
DETAIL LU
DETAIL LV
DETAIL LW
DETAIL LX
DETAIL LY
DETAIL LZ
DETAIL MA
DETAIL MB
DETAIL MC
DETAIL MD
DETAIL ME
DETAIL MF
DETAIL MG
DETAIL MH
DETAIL MI
DETAIL MJ
DETAIL MK
DETAIL ML
DETAIL MM
DETAIL MN
DETAIL MO
DETAIL MP
DETAIL MQ
DETAIL MR
DETAIL MS
DETAIL MT
DETAIL MU
DETAIL MV
DETAIL MW
DETAIL MX
DETAIL MY
DETAIL MZ
DETAIL NA
DETAIL NB
DETAIL NC
DETAIL ND
DETAIL NE
DETAIL NF
DETAIL NG
DETAIL NH
DETAIL NI
DETAIL NJ
DETAIL NK
DETAIL NL
DETAIL NM
DETAIL NN
DETAIL NO
DETAIL NP
DETAIL NQ
DETAIL NR
DETAIL NS
DETAIL NT
DETAIL NU
DETAIL NV
DETAIL NW
DETAIL NX
DETAIL NY
DETAIL NZ
DETAIL OA
DETAIL OB
DETAIL OC
DETAIL OD
DETAIL OE
DETAIL OF
DETAIL OG
DETAIL OH
DETAIL OI
DETAIL OJ
DETAIL OK
DETAIL OL
DETAIL OM
DETAIL ON
DETAIL OO
DETAIL OP
DETAIL OQ
DETAIL OR
DETAIL OS
DETAIL OT
DETAIL OU
DETAIL OV
DETAIL OW
DETAIL OX
DETAIL OY
DETAIL OZ
DETAIL PA
DETAIL PB
DETAIL PC
DETAIL PD
DETAIL PE
DETAIL PF
DETAIL PG
DETAIL PH
DETAIL PI
DETAIL PJ
DETAIL PK
DETAIL PL
DETAIL PM
DETAIL PN
DETAIL PO
DETAIL PP
DETAIL PQ
DETAIL PR
DETAIL PS
DETAIL PT
DETAIL PU
DETAIL PV
DETAIL PW
DETAIL PX
DETAIL PY
DETAIL PZ
DETAIL QA
DETAIL QB
DETAIL QC
DETAIL QD
DETAIL QE
DETAIL QF
DETAIL QG
DETAIL QH
DETAIL QI
DETAIL QJ
DETAIL QK
DETAIL QL
DETAIL QM
DETAIL QN
DETAIL QO
DETAIL QP
DETAIL QQ
DETAIL QR
DETAIL QS
DETAIL QT
DETAIL QU
DETAIL QV
DETAIL QW
DETAIL QX
DETAIL QY
DETAIL QZ
DETAIL RA
DETAIL RB
DETAIL RC
DETAIL RD
DETAIL RE
DETAIL RF
DETAIL RG
DETAIL RH
DETAIL RI
DETAIL RJ
DETAIL RK
DETAIL RL
DETAIL RM
DETAIL RN
DETAIL RO
DETAIL RP
DETAIL RQ
DETAIL RR
DETAIL RS
DETAIL RT
DETAIL RU
DETAIL RV
DETAIL RW
DETAIL RX
DETAIL RY
DETAIL RZ
DETAIL SA
DETAIL SB
DETAIL SC
DETAIL SD
DETAIL SE
DETAIL SF
DETAIL SG
DETAIL SH
DETAIL SI
DETAIL SJ
DETAIL SK
DETAIL SL
DETAIL SM
DETAIL SN
DETAIL SO
DETAIL SP
DETAIL SQ
DETAIL SR
DETAIL SS
DETAIL ST
DETAIL SU
DETAIL SV
DETAIL SW
DETAIL SX
DETAIL SY
DETAIL SZ
DETAIL TA
DETAIL TB
DETAIL TC
DETAIL TD
DETAIL TE
DETAIL TF
DETAIL TG
DETAIL TH
DETAIL TI
DETAIL TJ
DETAIL TK
DETAIL TL
DETAIL TM
DETAIL TN
DETAIL TO
DETAIL TP
DETAIL TQ
DETAIL TR
DETAIL TS
DETAIL TT
DETAIL TU
DETAIL TV
DETAIL TW
DETAIL TX
DETAIL TY
DETAIL TZ
DETAIL UA
DETAIL UB
DETAIL UC
DETAIL UD
DETAIL UE
DETAIL UF
DETAIL UG
DETAIL UH
DETAIL UI
DETAIL UJ
DETAIL UK
DETAIL UL
DETAIL UM
DETAIL UN
DETAIL UO
DETAIL UP
DETAIL UQ
DETAIL UR
DETAIL US
DETAIL UT
DETAIL UU
DETAIL UV
DETAIL UW
DETAIL UX
DETAIL UY
DETAIL UZ
DETAIL VA
DETAIL VB
DETAIL VC
DETAIL VD
DETAIL VE
DETAIL VF
DETAIL VG
DETAIL VH
DETAIL VI
DETAIL VJ
DETAIL VK
DETAIL VL
DETAIL VM
DETAIL VN
DETAIL VO
DETAIL VP
DETAIL VQ
DETAIL VR
DETAIL VS
DETAIL VT
DETAIL VU
DETAIL VV
DETAIL VW
DETAIL VX
DETAIL VY
DETAIL VZ
DETAIL WA
DETAIL WB
DETAIL WC
DETAIL WD
DETAIL WE
DETAIL WF
DETAIL WG
DETAIL WH
DETAIL WI
DETAIL WJ
DETAIL WK
DETAIL WL
DETAIL WM
DETAIL WN
DETAIL WO
DETAIL WP
DETAIL WQ
DETAIL WR
DETAIL WS
DETAIL WT
DETAIL WU
DETAIL WV
DETAIL WW
DETAIL WX
DETAIL WY
DETAIL WZ
DETAIL XA
DETAIL XB
DETAIL XC
DETAIL XD
DETAIL XE
DETAIL XF
DETAIL XG
DETAIL XH
DETAIL XI
DETAIL XJ
DETAIL XK
DETAIL XL
DETAIL XM
DETAIL XN
DETAIL XO
DETAIL XP
DETAIL XQ
DETAIL XR
DETAIL XS
DETAIL XT
DETAIL XU
DETAIL XV
DETAIL XW
DETAIL XX
DETAIL XY
DETAIL XZ
DETAIL YA
DETAIL YB
DETAIL YC
DETAIL YD
DETAIL YE
DETAIL YF
DETAIL YG
DETAIL YH
DETAIL YI
DETAIL YJ
DETAIL YK
DETAIL YL
DETAIL YM
DETAIL YN
DETAIL YO
DETAIL YP
DETAIL YQ
DETAIL YR
DETAIL YS
DETAIL YT
DETAIL YU
DETAIL YV
DETAIL YW
DETAIL YX
DETAIL YY
DETAIL YZ
DETAIL ZA
DETAIL ZB
DETAIL ZC
DETAIL ZD
DETAIL ZE
DETAIL ZF
DETAIL ZG
DETAIL ZH
DETAIL ZI
DETAIL ZJ
DETAIL ZK
DETAIL ZL
DETAIL ZM
DETAIL ZN
DETAIL ZO
DETAIL ZP
DETAIL ZQ
DETAIL ZR
DETAIL ZS
DETAIL ZT
DETAIL ZU
DETAIL ZV
DETAIL ZW
DETAIL ZX
DETAIL ZY
DETAIL ZZ
THIS SWITCH MUST BE PUSHED TO ENERGIZE AND PUSHED AGAIN TO BE DE-ENERGIZED
RELAY K27 CAN BE ENERGIZED ON THE GROUND ONLY AND NOT DURING THE FLIGHT
ALL LATCHING RELAYS ARE SHOWN IN THE RESET POSITION AND ALL NON-LATCHING RELAYS ARE SHOWN DE-ENERGIZED, UNLESS NOTED
ALL SWITCHES ARE SHOWN IN THEIR LIFT-OFF CONFIGURATION
ALL CWG NUMBERS ARE IN OCTAL
DESCENT ENGINE
TO PYRO
MANUAL THROTTLE
AUTOMATIC THROTTLE
PITCH GDA
ROLL GDA
PITCH TRIM FAIL
ROLL TRIM FAIL
ENGINE FAIL
ABORT
AUTO THRUST
DESC ENG ON
DESC ENG ARM
DE ARM PRELIMINARIES
MANUAL THRUST
PITCH TRIM FAIL
ROLL TRIM FAIL
PITCH TRIM MODE
ROLL TRIM MODE
PITCH FAIL
ROLL FAIL
PITCH TRIM FAIL
FAIL SIGNAL EXCITATION
ROLL TRIM FAIL
TRIM CHANNEL SWITCHING
400 CPS
SYNC GENERATOR
800-POSITIVE PULSES SYNC TO 400~ SWITCHES
ATTITUDE AND TRANSLATION CONTROL ASSY
+28 VDC COMMON
+28VDC COMMON
DECA POWER SUPPLY
AUXILIARY POWER SUPPLY
POWER FAILURE COMPARATOR
POWER SUPPLY AND REF GEN
POWER DIVIDER
TO INTERNAL CIRCUITS OF DECA
ATCA POWER SUPPLY
VOLT DIVIDER
10 CHANNEL D/A CONVERTER
MAXIMUM CONTROL
SIGNAL CONDITIONER
FLIP FLOP
UP/DOWN COUNTER
ROLL OVER INHIBIT LOGIC
NEGATIVE CONTROL LOGIC
AUTO THRUST DISABLE RESET AT GRD
POSITIVE COMPARATOR THRESHOLD
NEGATIVE COMPARATOR THRESHOLD
DEMODULATOR
FILTER
BUFFER
DIFFERENTIATOR
IDEAL DIODE CIRCUIT
LOW-PASS FILTER
AC SCR SWITCH
SIGNAL CONDITIONER
ROLL TRIM CMD (SAME AS PITCH)
ROLL COMBINATION AND MALFUNCTION LOGIC (SAME AS PITCH)
ROLL 400~ SWITCH (SAME AS PITCH)
ATTITUDE AND TRANSLATION CONTROL ASSY
WHERE:
A = AUTO ENG ON
P = ENG ARMED & DE MANUAL
(STOP CMD DCS NOT ENERGIZED)
M = MANUAL ENG ON CMD
V = AUTO ENG OFF CMD
G = ENG IS ON (K24 AND K26 ENERGIZED)
SIGNATURES
DATE
DR
CHG
CH
SPEC
APP
AUTH
11-17-67
2-16-67
2-16-67



1. THIS SWITCH MUST BE PUSHED TO ENERGIZE AND PUSHED AGAIN TO DE-ENERGIZE
2. ALL LATCHING RELAY CONTACTS ARE SHOWN IN THE RESET CONFIGURATION, UNLESS NOTED
3. ALL NON-LATCHING RELAYS ARE SHOWN IN THE DE-ENERGIZED CONFIGURATION, UNLESS NOTED
4. ALL SWITCHES ARE SHOWN IN THEIR LIFT OFF CONFIGURATION
5. ALL CMD NUMBERS ARE IN OCTAL
6. A SET OF CONTACTS OF THIS RELAY IS SHOWN AT 2.3.1 & IS USED TO TURN OFF THE DPS AT ABORT STAGE

APS

SIGNATURES	DATE
DR [illegible]	1-28-69
ENG [illegible]	1-28
CH-2 [illegible]	1-28-69
PD [illegible]	2-1-69
APP [illegible]	2/14/69
AUTH [illegible]	2-14-69

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS

ASCENT ENGINE ELECTRONICS

SIZE	DWG NO.
LM	8.4.1
LM 1	J

SCALE SHEET

*

SECTION 9
PROPULSION

9.1 REACTION CONTROL SYSTEM

9.1.1 General Description

The Reaction Control Subsystem (RCS) is composed of two parallel, independent systems ("A" system and "B" system). Each system contains identical components with the associated valves and plumbing necessary to deliver the propellants to the thrust chamber assemblies. Normally both systems are operated together, but the arrangement of the engines is such that complete rotational control in all axes is possible despite a failure of either system. R-B R-C

Helium pressurization is accomplished by an electrical RCS pressurization command to two parallel squib actuated isolation valves in each system.

Downstream are two series helium regulators which reduce the helium supply pressure for propellant tank pressurization. In normal operation, the upstream regulator is in control and reduces the pressure to the proper level, while the downstream regulator senses a demand and remains open as the sensed demand is below the setting. R-B

Normally open propellant shutoff valves, located just downstream of the propellant tanks in each system, are capable of isolating the propellant tanks of either system in case of an upstream malfunction or depletion of propellants. These valves are operated in pairs (fuel and oxidizer) for each system by prime commands from the LGC, commands from the PRA, or RTC commands from the ground.

Normally closed fuel and oxidizer manifold crossfeed valves exist, which can be opened to supply either system's propellants to all sixteen thrusters in case of a failed system. These two valves are operated as a pair by prime commands from the LGC or commands from the PRA. No RTC control exists for the crossfeed valves.

In addition, normally closed ascent feed valves, connecting ascent propellants to both systems fuel and oxidizer manifolds independently, may be opened to conserve RCS propellants. It should be emphasized that ascent propellants may be utilized in the RCS thrusters only during positive "X" axis acceleration. These ascent interconnect feed valves

*

are operated in pairs for each system by prime programed commands from the LGC or by commands from the PRA. No RTC control is available for these valves. Also, during ascent feed operation, the main shutoff valves of the appropriate systems are closed and the crossfeed valves opened.

Normally open isolation valves exist in the propellant lines feeding thruster pairs, allowing the isolation of a thruster pair containing a failed open thruster. Through an onboard failure detection logic, the LGC senses an electrically failed thruster and automatically closes the appropriate isolation valves to isolate the failed pair. No PRA or RTC control of this function is available. The LGC is also capable of controlling the vehicle's attitude and translation in the X-axis only without using the isolated thruster pair. R-C

Each of the four RCS engine clusters consists of four rocket engine assemblies, each delivering approximately 100 pounds thrust. The engine assembly consists of an oxidizer and fuel solenoid valves, injector head, and combustion chamber. Each solenoid valve is a fail safe (in closed position) electrical solenoid operated valve. The fuel valve provides a two millisecond fuel lag, which with the injector premix igniter cup insures smooth engine start in the pulse mode. The injector has eight unlike impinging doublets for main chamber ignition. Chamber cooling is provided by radiation and internal film cooling from eight fuel singlets along the injector outer periphery. R-B R-C

The RCS performs the following functions:

A. Provides small thrust impulses to stabilize the LM during descent and ascent burns.

B. Provides necessary thrust impulses to control the vehicle attitude and translation during all maneuvers.

C. Provides necessary thrust impulses to accomplish separation maneuvers.

D. Provides necessary thrust impulses to accomplish accelerations for ullage settling for the descent and ascent propellant tanks when required.

*

The RCS is capable of operating in either a pulsed or a steady-state mode and is controllable by the LGC, or by a manual Attitude Controller Assembly (ACA) during manned flights. In "Normal" mode, attitude and translational maneuvers are accomplished by commands from the LGC of variable frequency and pulse width to the primary coils of the engines. In "Pulsed" mode, the LGC sends one pulse for each out-of-detent movement of the ACA to the primary coils and in "Direct" mode, the ACA sends commands directly to the secondary coils of the RCS engines. R-B R-C R-B

*

9.2 DESCENT PROPULSION SYSTEM (DPS)

9.2.1 General

A. The descent engine is a throttleable engine over a 10:1 range and develops 10,500 pounds of thrust in a vacuum at full throttle and 1,050 pounds minimum thrust. It consists primarily of an ablative lined thrust chamber with a crushable, radiation cooled nozzle extension; a variable area injector; a pair of flow control valves; four electromechanical flow control actuators; and eight propellant shutoff valves. It is mounted in the center compartment of the descent stage and is pivoted at the throat of the combustion chamber on a gimbal ring that is an integral portion of the engine assembly. The ring is suspended in the structure, pivoted in a line 90 degrees opposite to the engine pivots, so that the engine is capable of being gimbaled ±6 degrees in any direction by means of vehicle mounted gimbal drive actuators. R-B R-C

The mechanical throttling scheme utilizes variable-area, cavitating venturi flow control valves mechanically linked to a variable area injector in order to separate propellant flow control and propellant injector functions so that each may be optimized without compromising the other, and to insure that propellant flow rates are made insensitive to downstream pressure variations in the injector and combustion chamber. At maximum thrust, operation is conventional. At approximately 70 percent thrust, cavitation commences in the valve throats. From this level down to minimum thrust, the valve functions as a cavitating venturi. As thrust is reduced, the actuator reduces the flow at the control valves and moves the injector sleeve to reduce the injector apertures. R-C R-B

B. The engine is activated and throttled by the LM Guidance Computer, which starts a sequence of events resulting in firing squibs and igniting the engine.

The propellants are nitrogen tetroxide and a 50/50 blend of Unsymmetrical Dimenthyl Hydrazine (UDMH) and hydrazine called Aerozine 50. The freezing point of nitrogen tetroxide at standard conditions is 12°F; the boiling point is 70°F. The freezing point of Aerozine 50 at standard pressure is 21°F and the boiling point is 170°F. R-B

9.2.2 Helium Storage Tank

Supercritical helium is stored in a double walled cryogenic storage container. It consists of an inner spherical tank with an outer jacket; the void between the tank and its jacket is filled with aluminized mylar insulation and evacuated to minimize heat transfer. The material used for the tank is titanium. The tank has associated fill and vent ports and a pressure relief device consisting of two burst discs, in series. Inside the inner tank is a helium/helium heat exchanger constructed of titanium tubing. R-C

9.2.3 The Propellant Shutoff Valves

The shutoff valves are fuel pressure-actuated ball valves, fuel is introduced to the valve actuators through solenoid operated pilot valves, all of which are energized simultaneously during engine startup. During the start, the solenoids unseat the caged balls from the actuator inlet ports and seat them against the overboard vent ports. Fuel enters the actuator cavities; the actuator pistons connected to rack and pinion linkages twist the ball valves 90 degrees to the open position, permitting flow to the injector. The series parallel redundancy in the valve arrangement provides for positive start and cutoff. During shutdown, the solenoids are de-energized, opening the vent ports. The spring loaded actuators close the shutoff valves and residual actuating fuel is vented overboard into space. A mismatch circuitry is tied in with this system. It takes the output of eight magnetoswitches and puts them through a summing network. The output of this network is then telemetered to ground indicating any disparity in valve positions. R-B R-C R-B

*

9.2.4 Propellant Quantity Gaging System (PQGS)

A capacitance type quantity gaging system is used to provide propellant quantity information via telemetry to the ground during positive "G" conditions. The PQGS will be a continuous gaging system with capabilities for gaging propellants in each descent stage tank between 95 percent of propellants remaining and one inch of the tank bottom. The accuracy of the system between 95 percent and 25 percent of the propellants remaining is ±1.0 percent of full tank capacity. Between 25 percent of propellants remaining and one inch of the tank bottom, the system accuracy is ±0.5 percent of full tank capacity. Due to component heating in a vacuum, the system is constrained to 15 minutes of operation at any one time, however, the total operating life is 5000 hours. The LGC is programed to automatically turn the PQGS ON and OFF before and after each burn. In addition the PQGS will provide a discrete signal when the propellant level is a predetermined distance from the tank bottom, nominally corresponding to 120 seconds engine operating time remaining at 25 percent thrust. R-B R-C

9.2.5 Fuel/Helium Heat Exchanger R-B

This heat exchanger absorbs heat from the engine fuel which has been circulated from the fuel tanks directly to the heat exchanger, before its ultimate delivery to the engine. It is a two pass heat exchanger. Helium from the storage tank absorbs heat from the fuel on the first pass, then flows back to the helium/helium heat exchanger inside of the storage tank, and then is reheated on the second pass. R-C

9.2.6 Thrust Chamber

The thrust chamber consists of a composite ablative cooled nozzle extension (area ratio of 16:1), a crushable radiation cooled nozzle extension (area ratio of 49:1), and a gimbal ring assembly. The ablative components are encased in a continuous titanium shell and jacketed in a stainless steel foil/glass wool composite thermal blanket. The radiation cooled nozzle extension is made from columbium. The nozzle extension is flanged to the titanium chamber shell. The gimbal assembly is located at the chamber throat plane and provides a ±6 degree gimbal of the R-B R-C R-B R-C R-C

*

thrust vector during flight. The assembly is manufactured from aluminum alloy, except for the bearings, which are made of high strength steel.

9.2.7 Flow Control Valves

Flow control valves are non-redundant venturis with movable pintle sleeves. Engine throttling is initiated by an electrical signal to the throttle actuator commanding an increase or decrease in engine thrust. Operation of the throttle actuator drives the linkage cross beam to a new position, thus repositioning the pintles in the flow control valves. This axial movement of the pintles results in decreasing or increasing the pintle flow areas the precise amounts to control propellant weight flow rate and thrust.

9.2.8 Throttle Actuator

The throttle actuator is an electromechanical linear servoactuator powered by redundant motors. It is located between the fuel and oxidizer flow control valves on the engine head end. The output shaft of the actuator is attached to the throttle linkage. Three torque motors drive the jack screw. The actuator is designed to operate within specification using two motors, or at a reduced rate using only one. The actuator case is hermetically sealed to prevent cold welding in a vacuum environment. Although the actuator could operate without lubrication, a compound with a known off-gasing rate is included to maintain a small positive pressure if the actuator case leaks. Performance redundancy is provided by designing each of the three separate servo channels to have equal output performance. For a null-type or inoperative failure, two separate servo channels failing can be tolerated. The two malfunctioning motors will be driven along with the load by the one operating motor. In the case of a saturated or hardover-type failure of one servo channel, the load is effectively increased by the two operating motors which have the capability of overriding the malfunction and providing the required output performance. R-B

9.2.9 Pressure Regulators

There are two regulators, one in each parallel leg of the system, the primary leg being normally open and providing helium at 245 psia downstream. Each leg has a solenoid valve upstream of the regulator which is controlled from the cabin or maybe commanded from the ground. The secondary leg is normally closed (but may be opened as required). It also provides 245 psi downstream.

9.2.10 Quadcheck Valves

There are two such valves, one in each of the lines leading to the propellant tanks. They are made up of four check valves arranged in a series - parallel configuration, the primary purpose being to prevent propellant vapors from mixing in the upstream manifold. R-B

9.2.11 Propellant Tanks (Titanium)

There are four propellant tanks, two each for oxidizer and fuel. They are interconnected on top and on bottom, within each system to insure equal usage and pressure. Each tank has a volume of 63 cubic feet.

9.2.12 Supercritical Helium

The helium pressure timeline begins with the loading of the supercritical helium, which is completed at about 15 hours before lift-off. At completion of loading the pressure is approximately 550 psia. Due to the heat transfer from the surroundings, the helium pressure increases at the rate of approximately 10 psi per hour until the descent engine is fired. During low level thrust, the pressure builds up at a rate of 200 psi per minute. Subsequently, after engine shutdown, the R-C pressure rises sharply at about 50 psi per hour for 1 hour, after which time, the pressure again increases at the rate of 10 psi per hour.

The first descent burn pressure should start at about 750 psia and end with a pressure of about 900 psia. The second descent burn R-B should start at about 1000 psia and reach a peak of about 1400 psia before the pressure starts decreasing. Too high a pressure (1870 to 1968 psia) could rupture the burst disc, thus terminating pressurization which results in degraded "limited blowdown" mode.

an engine stop command automatically or the engine is disarmed by RTC.

2. Subsequent APS burns.
   At the end of the FITH the system is fully pressurized and in operational standby mode. The engine may be ignited by either a normal programed LGC fire command sequence or RTC fire override command. Either method fires the engine by opening the isolation and actuator isolation valves. Fuel pressure operates the actuator mechanism which opens both the oxidizer and fuel shutoff valves and allows propellant flow to the thrust chamber. Shutdown of the engine is accomplished by LGC command or RTC engine stop override.

9.3.2 Notes

A. Pressure Reducing Regulators. This regulating system uses two regulators in a parallel arrangement, each regulator housing contains dual regulators in series. This arrangement provides the overall regulation system with added redundancy. Each regulator contains a pilot valve and seat assembly which modulates inlet pressure to control the opening of a main poppet valve and seat assembly, and reduces the upstream pressure to that required to provide correct propellant tank pressurization. Minimum operating inlet pressure is 500 psi for rated output. Below 500 psi the regulated output is 179 ± 1 psi. R-B R-C R-B

B. Propellant Shutoff Valves. The propellant shutoff valves are a series parallel arrangement of eight ball valves, four each, oxidizer and fuel. This arrangement is to insure continued operation of the engine in the event of valve failure. The valves are operated by a piston actuator assembly which is controlled by fuel pressure through solenoid isolation and actuator isolation valves.

*

TABLE 9-1 CAPABILITIES AND LIMITATIONS APS, DPS, AND RCS

	APS	DPS	RCS	
HELIUM SOURCE PRESS.				
VOLUME	5800 IN3	5.87 FT3	920 IN3	R-B
PRESSURES				
BURST	5250 PSI	3420 PSI	7000 PSI	
PROOF	4660 PSI	2045 PSI	4650 PSI	
NOMINAL LIFTOFF PRESS.	3050 PSI	550 PSI	3050 PSI	R-C
REGULATORS				
CONFIGURATION	SERIES/PARALLEL	PARALLEL	SERIES	
CLASS I				
PRIMARY				
SETTING	184±4 PSI	$245\pm\frac{3}{2}$ PSI	179±2 PSI	
LOCKUP	192±3 PSI	$250\pm\frac{3}{2}$ PSI	188 PSI	
SECONDARY				R-B
SETTING	190±4 PSI		185±2 PSI	
LOCKUP	197±3 PSI		194 PSI	
CLASS II				
PRIMARY				
SETTING	176±4 PSI	$245\pm\frac{3}{2}$ PSI		
LOCKUP	183±3 PSI	$250\pm\frac{3}{2}$ PSI		
SECONDARY				
SETTING	182±4 PSI			
LOCKUP	189±3 PSI			
MINIMUM OPERATING PRESSURE	500 PSI	400 PSI	400 PSI	
QUAD CHECK VALVES				
PRESSURE				
BURST	810 PSI	810 PSI	750 PSI	
PROOF	540 PSI	540 PSI	500 PSI	
ΔP DROP	5 PSI	5 PSI	4±1 PSI	
CRACKING ΔP	2±5 PSI	2±.5 PSI	2±.5 PSI	

*

TABLE 9-1 CAPABILITIES AND LIMITATIONS APS, DPS AND RCS (Cont'd.)

	APS	DPS	RCS	
COMPATIBILITY VALVES				
	SERIES/PARALLEL	SERIES	N/A	
ACTUATION TIMES				
OPEN	0.1 SEC	0.1 SEC	N/A	
PRESSURE DROP	0 PSI	0 PSI	N/A	
PROOF	540 PSI	540 PSI	N/A	
BURST	810 PSI	810 PSI	N/A	
TANK ASSEMBLY				
BURST DISC RUPTURE	238±12 PSID	288±20 PSID	234±12 PSID	
BLEED VALVE				
CRACK	0 PSI	0 PSI	0 PSI	
RESEAT	20-80 PSI	20 PSI	80 PSI	
RELIEF VALVE				
CRACK	225 PSI	260 PSI	238±12 PSI	
FULL FLOW	250 PSI	275 PSI		
RESEAT	225 PSI	254 PSI	220 PSI	R-B
PROP TANKS				
VOLUME				
FUEL	34 FT^3	126 FT^3	1.91 FT^3	R-C
OX	34 FT^3	126 FT^3	2.38 FT^3	
PRESSURES				
BURST	375 PSI	405 PSI	375 PSI	
PROOF	333 PSI	358 PSI	333 PSI	
FUEL HELIUM HEAT EXCHANGER				
PRESSURES	N/A		N/A	
PROOF FUEL	N/A	540 PSI	N/A	
HELIUM	N/A	2200 PSI	N/A	R-B
BURST FUEL	N/A	810 PSI	N/A	
HELIUM	N/A	3300 PSI	N/A	
MAIN SHUTOFF, TCA ISOL, X FEED, APS INNCT VALVES	N/A	N/A		
ACTUATION TIMES	N/A	N/A		
OPEN			0.25 SEC	
CLOSE	N/A	N/A	0.25 SEC	

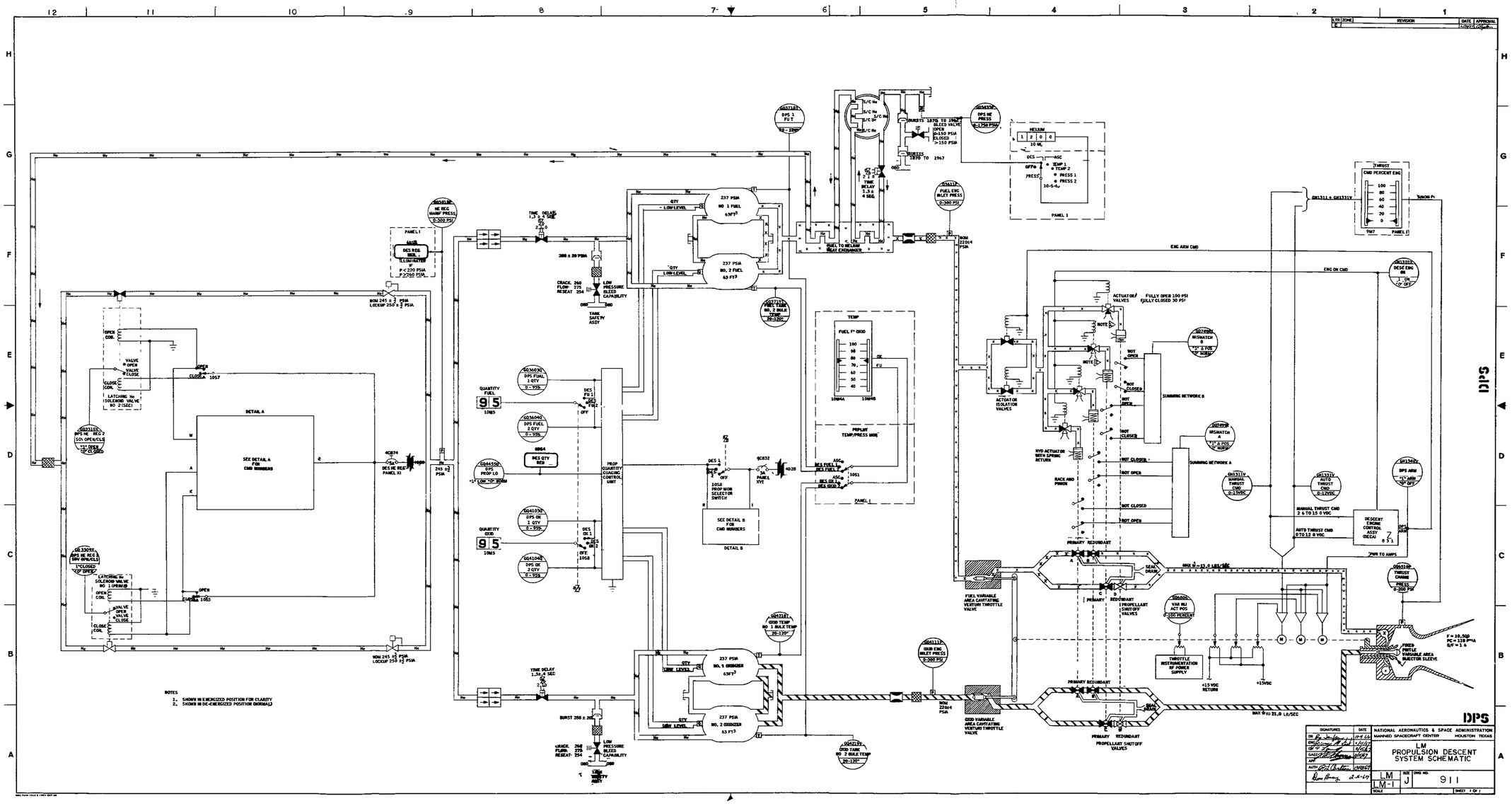
Table 9-1 CAPABILITIES AND LIMITATIONS APS, DPS, AND RCS (Cont'd)

	APS	DPS	RCS	
ACTUATION VOLTAGE				
MAX	N/A	N/A	32.0 VDC	
MIN	N/A	N/A	18.0 VDC	
PRESSURES	N/A	N/A		
PROOF	N/A	N/A	360 PSI	
BURST	N/A	N/A	1050 PSI	
DROP	N/A	N/A	2.0±.25 PSI	
ACTUATOR ISOLATION VALVES				
ACTUATION TIMES				
OPEN	0.03 SEC	.03 SEC	N/A	
CLOSE	0.03 SEC	0.03 SEC	N/A	
ACTUATION VOLTAGE				
MAX	32V	32V	N/A	
MIN	21V	21V	N/A	
PRESSURES				
BURST	1350 PSI	750 PSI	N/A	R
PROOF	500 PSI	500 PSI	N/A	-C
PROPELLANT SHUTOFF VALVES				
ACTUATION VOLTAGE				
MAX	32V	32V	N/A	R-
MIN	21V	21.5V	N/A	B
PRESSURES				
OPEN				
CRACK	80 PSI	60 PSI	N/A	
FULL OPEN	120 PSI	100 PSI	N/A	
CLOSE				
START	70 PSI	90 PSI	N/A	
FULL CLOSE	30 PSI	30 PSI	N/A	
DROP			N/A	
ENGINES				
NOMINAL THRUST	3500	10500-1050	100	
COOLING	FILM & ABLATIVE COOLING	FILM & RADIATION	FILM & RADIATION	R-
LIFE	460 SEC	960 SEC	500 SEC PULSE 500 SEC STEADY STATE	C
INJECTOR TYPE	TRIPLET ORIFICES (2 OX & 1 FUEL) IN A GRID PATTERN ON INJECTOR FACE. ON OUTER PERIPHERY ORIFICES ARE DOUBLETS (1 OX & 1 FU) TO PROVIDE REDUCED TEMP BARRIER AT ABLATIVE CHAMBER WALL	VARIABLE AREA	8 FUEL FOR COOLing 8 ON 8 FOR MAIN CHAMBER 1 ON 1 FOR PRE-IGNITER	

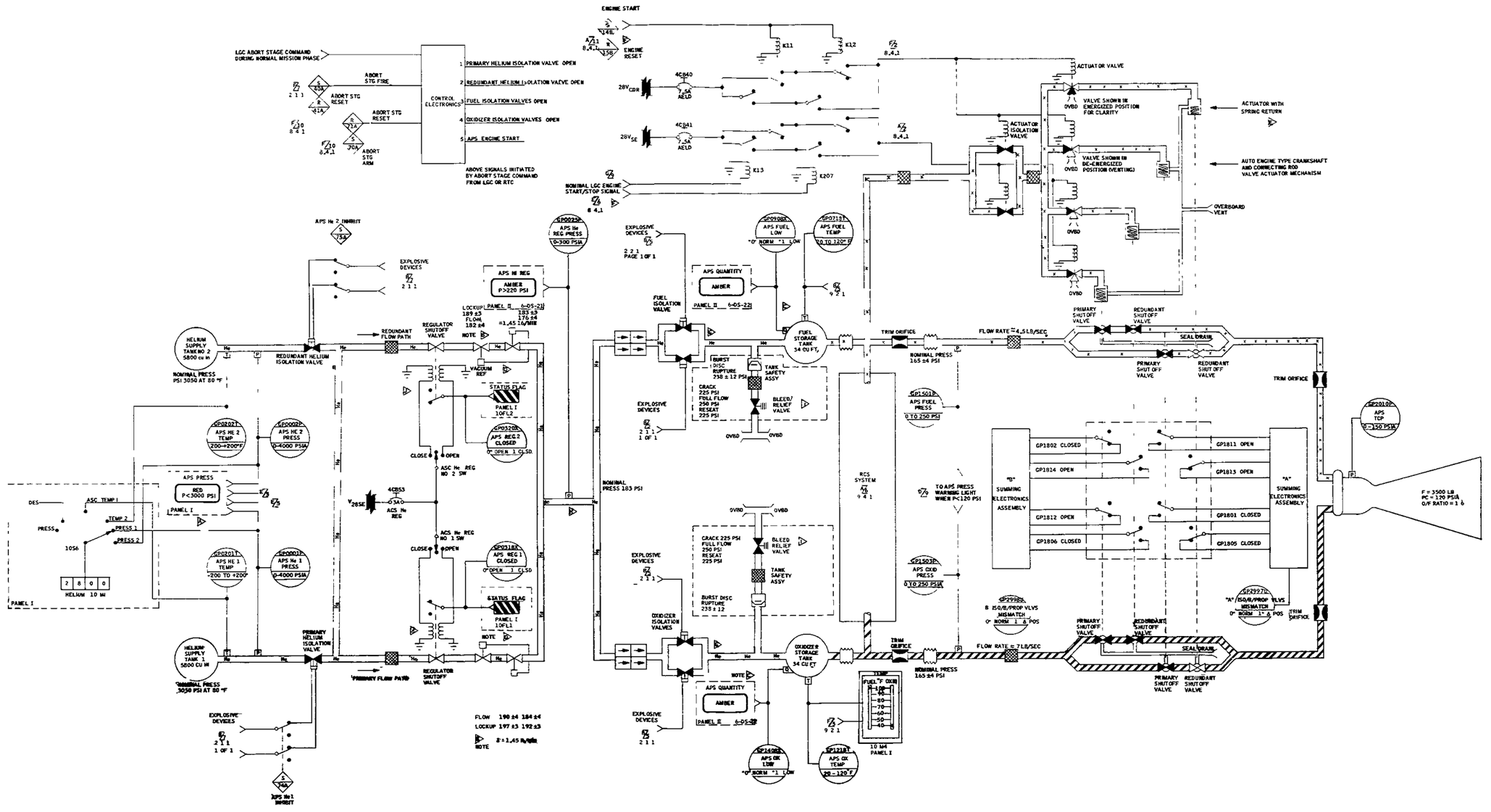
*

TABLE 9-1 CAPABILITIES AND LIMITATIONS APS, DPS, AND RCS (Concluded)

	APS	DPS	RCS	
O/F RATIO	1.6/1	1.6/1	2.0/1	
FLOW RATES				
OXID (lb/SEC)	7.0	21 (MAX)	0.24	R-B
FUEL (lb/SEC)	4.3	13 (MAX)	0.12	R-B
THRUST CHAMBER PRESSURE	120 PSI	110 PSI (MAX)	96 PSI	R-C
MINIMUM OPERATING TIME	1.0 SEC	N/A	0.013 SEC	


DPS
LTR ZONE REVISION DATE APPROVAL
C 1/26/65
PANEL 1
PANEL 2
PANEL 3
PANEL 4
PANEL 5
DETAIL A
SEE DETAIL A FOR CMD NUMBERS
DETAIL B
SEE DETAIL B FOR CMD NUMBERS
FUEL TO HELIUM HEAT EXCHANGER
TANK SAFETY ASSY
PROP QUANTITY GAGING CONTROL UNIT
FUEL TEMP/PRESS MON
PROPLNT TEMP/PRESS MON
ACTUATOR ISOLATION VALVES
RACK AND PINION
SUMMING NETWORK A
SUMMING NETWORK B
PRIMARY REDUNDANT
PROPELLANT SHUTOFF VALVES
FUEL VARIABLE AREA CAVITATING VENTURI THROTTLE VALVE
OXID VARIABLE AREA CAVITATING VENTURI THROTTLE VALVE
FIXED ORIFICE VARIABLE AREA INJECTOR SLEEVE
THROTTLE INSTRUMENTATION RF POWER SUPPLY
DESCENT ENGINE CONTROL ASSY (DECA)
MANUAL THRUST CMD 2 TO 15 0 VDC
AUTO THRUST CMD 0 TO 12 8 VDC
THRUST CHAMB PRESS 0-200 PSI
DPS ARM
DESCENT ENG ARM
ENG ARM CMD
ENG ON CMD
ACTUATOR VALVES
FULLY OPEN 100 PSI FULLY CLOSED 30 PSI
HELIUM
10 ML
BURSTS 1870 TO 1967
BLEED VALVE OPEN ≤150 PSIA CLOSED ≥150 PSIA
DPS HE PRESS 0-1750 PSIA
FUEL ENG INLET PRESS 0-300 PSI
OXID ENG INLET PRESS 0-300 PSI
OXID TANK NO 2 BULK TEMP 20-120°
OXID TANK NO 1 BULK TEMP 20-120°
FUEL TANK NO 2 BULK TEMP 20-120°
FUEL TANK NO 1 BULK TEMP 20-120°
DPS HE REG MANIF PRESS 0-300 PSI
DPS HE REG A SOL OPEN/CLS "CLOSED" "OP OPEN"
DPS HE REG B SOV OPN/CLS "CLOSED" "OP OPEN"
DPS HE REG A PANEL XI
DPS HE REG B PANEL XI
DPS FUEL 1 QTY 0-95%
DPS FUEL 2 QTY 0-95%
DPS OX 1 QTY 0-95%
DPS OX 2 QTY 0-95%
DPS PROP LO
QUANTITY FUEL 95
QUANTITY OXID 95
FUEL T° OXID
OX
FU
MISMATCH A "FU" 2 POS "OP WORD"
MISMATCH B "FU" 2 POS "OP WORD"
VAR INJ POS 2 POS RESERVE
THRUST CMD PERCENT ENG
ENG ARM CMD
ENG ON CMD
DESCENT ENG ON "ON" "OFF"
DPS ARM "ARM" "OFF"
DESCENT ENG ARM "ARM" "OFF"
MAX @ 22.0 LBS/SEC
MAX @ 20.0 LBS/SEC
F = 10,500 PC = 119 P^1.4 O/F = 1.6
+15 VDC RETURN
+15VDC
PWR TO AMPS
SEAL DRAIN
PRIMARY REDUNDANT PROPELLANT SHUTOFF VALVES
NOTES
1. SHOWN IN ENERGIZED POSITION FOR CLARITY
2. SHOWN IN DE-ENERGIZED POSITION (NORMAL)
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS
LM PROPULSION DESCENT SYSTEM SCHEMATIC
LM J 911
LM-1
SHEET 1 OF 1

LTR	ZONE	REVISION	DATE	APPROVAL
C				



NOTES

A. APS PRESS INDICATOR INHIBITED AFTER STAGING FOR LOW APS HELIUM STORAGE PRESS INPUT TO APS PRESS WARNING LIGHT

B. 500 PSI MINIMUM INLET PRESSURE FOR REGULATOR OPERATION

C. APS QUANTITY ILLUMINATED WHEN APS ENGINE ON AND 10 SEC BURN TIME REMAINING AND INHIBITED WHEN ENGINE NOT OPERATING

D. MAXIMUM LOCKUP IS 203 PSIA

E. PROPELLANT VALVE ACTUATORS FULLY OPEN AT 115 PSIA, FULLY CLOSED AT 27 PSIA FUEL PRESSURE

F. NORMAL ENGINE/STOP COMMANDS FROM LGC OR RTC WHICH REMOVES POWER FROM PROPER RELAYS RTC FOR ENGINE STOP OVERRIDE IS RTC 10 B

G. PREPRESSURIZED TO 180 PSI NOMINAL

H. PREPRESSURIZED TO 120 PSI NOMINAL

I. BLEED/RELIEF VALVE BLEEDS INTERNAL PRESSURE FROM 1.3 PSI TO 20 PSI BLEED VALVE CLOSED AT 20 TO 80 PSI RELIEF VALVE RELIEVES PRESSURE AT NOMINAL VALUES

J. REGULATOR SHUTOFF VALVES CANNOT BE CLOSED ON LM-1

APS

SIGNATURES	DATE
DR Lynda Clay	1/16/68
DAC Bruce Blevins	1/17/68
OPCR Stan Hall	1/16/68
GAC Clifford Chenney	1/16/68
APR Ken Cantor	1/18/68
AUTH Ken Bray	2-16-68

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS

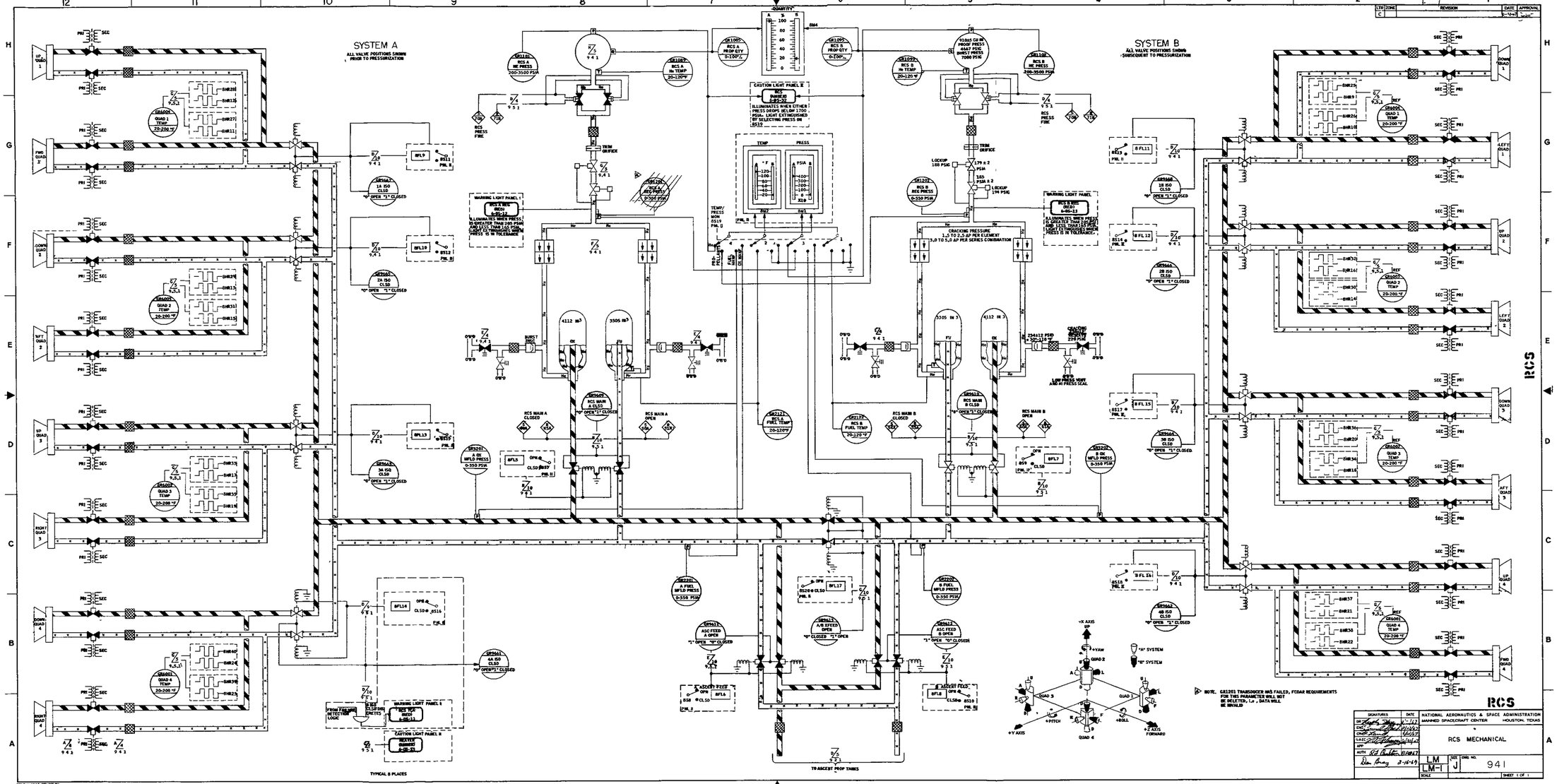
LM I
PROPULSION
ASCENT SYSTEM
SCHEMATIC

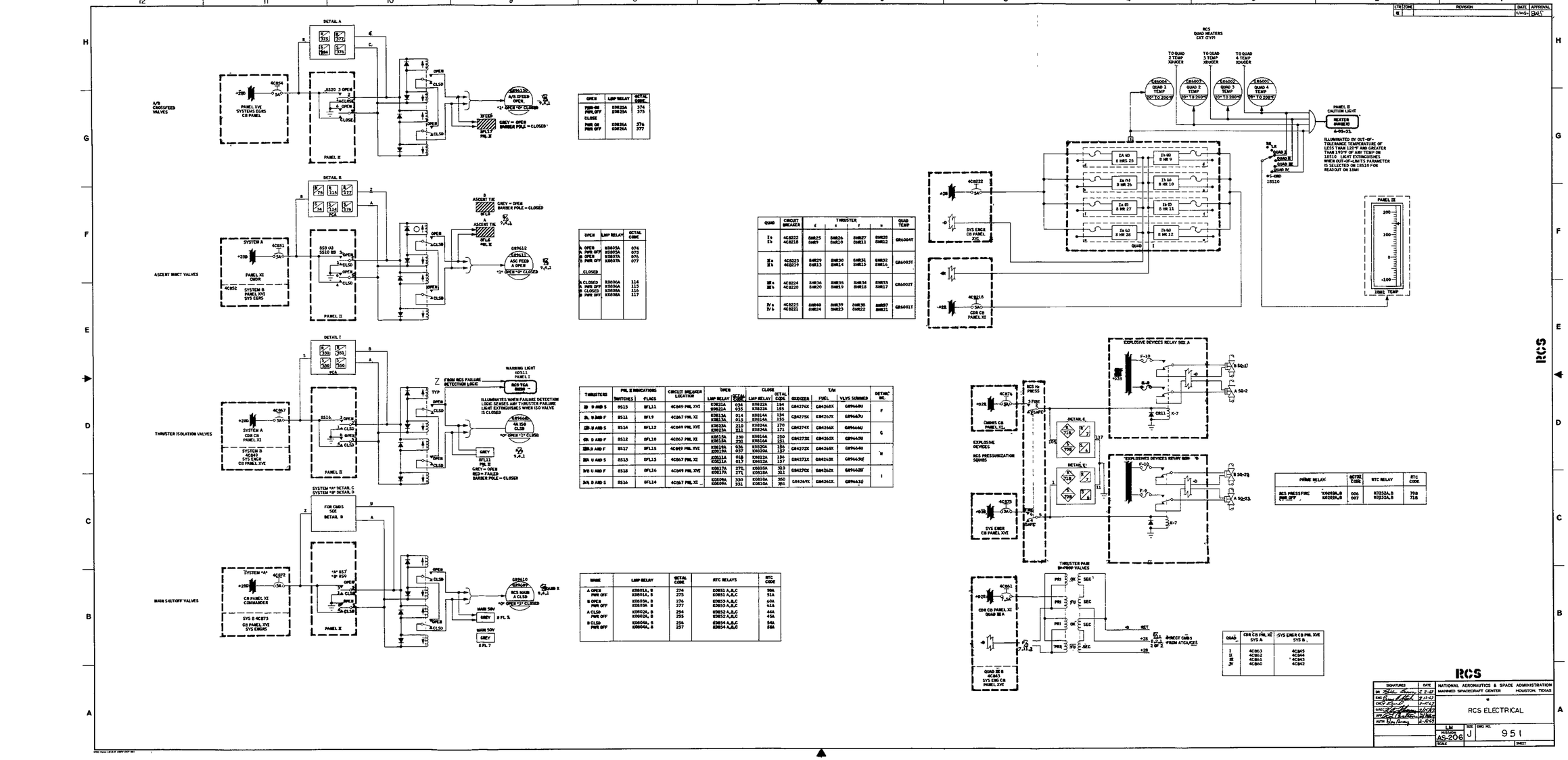
LM	SIZE	DWG NO.
LM-1	J	921

SCALE

SHEET 1 OF 1

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS
LM-1
ASCENT/DESCENT
PROPULSION INTERGRATED
ELECTRICAL SCHEMATIC
SIGNATURES
DATE
DR
ENG
CH
GAE
APP
AUTH
LM
LM-1
SIZE
E
DWG NO
931
SCALE
SHEET


SYSTEM A
ALL VALVE POSITIONS SHOWN PRIOR TO PRESSURIZATION
SYSTEM B
ALL VALVE POSITIONS SHOWN SUBSEQUENT TO PRESSURIZATION
QUANTITY
CAUTION LIGHT PANEL II
RCS RANGE ID A-B-31-32
ILLUMINATES WHEN EITHER PRESS DROPS BELOW 1700 PSIA. LIGHT EXTINGUISHED BY SELECTING PRESS ON GSI9
WARNING LIGHT PANEL I
RCS A REG PRESS A-B-31-32
ILLUMINATES WHEN PRESS IS GREATER THAN 295 PSIA AND LESS THAN 305 PSIA. LIGHT EXTINGUISHED WHEN PRESS IS IN TOLERANCE
WARNING LIGHT PANEL
RCS B REG PRESS A-B-31-32
ILLUMINATES WHEN PRESS IS GREATER THAN 295 PSIA AND LESS THAN 305 PSIA. LIGHT EXTINGUISHED WHEN PRESS IS IN TOLERANCE
CRACKING PRESSURE 1.5 TO 2.5 AP PER ELEMENT 3.0 TO 5.0 AP PER SERIES COMBINATION
LOW PRESS VENT AND RF PRESS SEAL
TYPICAL 8 PLACES
TO ASCENT PROP TANKS
NOTE: GR1201 TRANSDUCER HAS FAILED, FCOAR REQUIREMENTS FOR THIS PARAMETER WILL NOT BE DELETED, i.e., DATA WILL BE INVALID
RCS
RCS MECHANICAL
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
LM
LM-1
941
SHEET 1 OF 1



OPEN	LMP RELAY	OCTAL CODE
PWR-ON PWR OFF	K08025A K08035A	376 375
CLOSE		
PWR ON PWR OFF	K08026A K08026A	376 377

OPEN	LMP RELAY	OCTAL CODE
A OPEN A PWR OFF	K08005A K08005A	076 075
B OPEN B PWR OFF	K08037A K08037A	076 077
CLOSED		
A CLOSED A PWR OFF	K08036A K08036A	114 115
B CLOSED B PWR OFF	K08038A K08038A	116 117

QUAD	CIRCUIT BREAKER	THRUSTER c	a	f	b	QUAD TEMP
I a I b	4C8222 4C8218	8MR25 8MR9	8MR26 8MR10	8MR27 8MR11	8MR28 8MR12	GR6004T
II a II b	4C8223 4C8219	8MR29 8MR13	8MR30 8MR14	8MR31 8MR15	8MR32 8MR16	GR6003T
III a III b	4C8224 4C8220	8MR36 8MR20	8MR35 8MR19	8MR34 8MR18	8MR33 8MR17	GR6002T
IV a IV b	4C8225 4C8221	8MR40 8MR24	8MR39 8MR23	8MR38 8MR22	8MR37 8MR21	GR6001T

THRUSTERS	PNL II INDICATIONS SWITCHES	FLAGS	CIRCUIT BREAKER LOCATION	OPEN LMP RELAY	OPEN OCTAL CODE	CLOSE LMP RELAY	CLOSE OCTAL CODE	T/M QUADIZER	T/M FUEL	T/M VLVS SUMMED	DETAIL* NO.
2D, 3 AND 5	8S13	8FL11	4C849 PNL XVI	K0823A K0823A	034 035	K0822A K0822A	134 135	GR4276X	GR4266X	GR9646U	F
2A, 3 AND F	8S11	8FL9	4C867 PNL XI	K0813A K0813A	014 015	K0814A K0814A	134 135	GR4275X	GR4267X	GR9647U	
2B, 3 AND 5	8S14	8FL12	4C849 PNL XVI	K0823A K0823A	210 211	K0824A K0824A	170 171	GR4274X	GR4266X	GR9646U	G
4D, 1 AND F	8S12	8FL10	4C867 PNL XI	K0815A K0815A	230 231	K0816A K0816A	250 251	GR4273X	GR4265X	GR9645U	
4B, 1 AND F	8S17	8FL15	4C849 PNL XVI	K0819A K0819A	036 037	K0820A K0820A	156 157	GR4272X	GR4265X	GR9644U	H
4A U AND 5	8S15	8FL13	4C867 PNL XI	K0811A K0811A	018 017	K0812A K0812A	158 159	GR4271X	GR4263X	GR9643U	
3B, 1 AND F	8S18	8FL16	4C849 PNL XVI	K0817A K0817A	270 271	K0818A K0818A	310 311	GR4270X	GR4262X	GR9642U	I
3A, 1 AND 5	8S16	8FL14	4C867 PNL XI	K0809A K0809A	330 331	K0810A K0810A	350 351	GR4269X	GR4261X	GR9641U	

BANK	LAMP RELAY	OCTAL CODE	RTC RELAYS	RTC CODE
A OPEN PWR OFF	K08051A, B	274	K0851 A,B,C K0853 A,B,C	50A
	K08051A, B	275		51A
B OPEN PWR OFF	K08053A, B	276	K0833 A,B,C K0855 A,B,C	60A
	K08053A, B	277		61A
A CLSD PWR OFF	K08052A, B	254	K0852 A,B,C K0852 A,B,C	44A
	K08052A, B	255		45A
B CLSD PWR OFF	K08044A, B	256	K0854 A,B,C K0854 A,B,C	54A
	K08044A, B	257		55A

PRIME RELAY	OCTAL CODE	RTC RELAY	RTC CODE
RCS PRESSFIRE PWR OFF	K0203A,B K0203A,B	006 007	K0252A,B K0253A,B	708 718

QUAD	CDR CB PNL XI SYS A	SYS ENGR CB PNL XVI SYS B
I	4C863	4C845
II	4C862	4C844
III	4C861	4C843
IV	4C860	4C842

SIGNATURES	DATE
DR	2-7-67
ENG	4-11-67
QAO	2-7-67
PCO	2-7-67
APD	2-7-67
AUTH	2-7-67

RCS

side of the center section, formed by the beams (along the Z and Y axis), house the four main propellant tanks for the Descent Engine.

Additional support and strut assemblies are secured to the main beams forming diagonal bays or quadrants. The entire Descent Stage (top view) is shaped to form a modified octagon aluminum alloy. Outriggers extend from the ends of each of the two pairs of beams, providing for four points of attachment to the Spacecraft LM Adapter (SLA). R-B

C. The landing gear are removed from LM-1.

10.2 SYSTEM DATA

APPROXIMATE VEHICLE WEIGHTS	
SECTION	WEIGHT, LB
LM Ascent Stage (DRY)	4820.9
LM Descent Stage (DRY)	3564.6
RCS Propellants	551.8
DPS Propellants	17374.0
APS Propellants	5019.0
TOTAL	31330.3

R-B

R-C

*

A. DCA System Description

The DCA consists of a UHF Receiver, two decoders and interface circuits of the LM Guidance Computer (LGC), Program Reader Assembly (PRA), and Program Coupler Assembly (PCA). The DCA will accept and process six each LGC commands, or two PRA commands, or two Real-Time Commands (RTC's) or two DCA Test Commands per second. R-B

1. The bit configuration for each type of command is as follows:

   a. LGC (22 Bits)

1 2 3	4 5 6	7	8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Vehicle Address	System Address	Synch Bit	Triple Redundant 5-Bit Word

   b. PRA (22 Bits)

1 2 3	4 5 6	7 8 9 10 11 12	13	14	15	R-C
Vehicle Address	System Address	Time Word	Clear	Forward Search	Reverse Search	

16	17 18 19 20 21 22	
Initiate	Fill Bits	R-C

   c. RTC (12 Bits)

1 2 3	4 5 6	7 8 9 10 11 12
Vehicle Address	System Address	Command Function

   d. DCA Test (22 Bits)

1 2 3	4 5 6	7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Vehicle Address	System Address	Test Word

2. The DCA Test Commands are used to test the operational capability of the DCA. The following test commands are available for the DCA checkout and analysis. R-B

TEST	BIT CONFIGURATION "1-6"	BIT CONFIGURATION "7-22"	FUNCTION
DCA ENABLE	011 101	000 000 000 000 000 0	ENABLE BOTH DECODERS
DECODER A TEST	011 101	000 100 000 000 000 0	INHIBITS DECODER "A"
DECODER B TEST	011 101	001 000 000 000 000 0	INHIBITS DECODER "B"
DCA SELF TEST	011 101	001 100 000 000 000 0	SELF TESTS BOTH DECODERS

*

11 Control Electronics

13 Communications

20 Development Flight Instrumentation

13.2 LM MISSION PROGRAMER (LMP) SYSTEM SCHEMATIC NOTES

A. The MASTER RESET function resets all prime relays except the following:

1. LND Radar (267)
2. C-Band Transponder (Off) (153)
3. Flight Control Auto Enable (3)

R-B

B. The automatic guidance switchover function switches from PGNS to AGS, enables the prime relay matrix to accept PRA commands and put the PRA in the "standby" mode.

C. LM/SLA antenna switchover is an automatic function occurring at LM/SLA separation. Two microswitches on the plus Y outrigger enable the switchover contacts at separation. R-C

D. LMP Operational Capabilities

1. APS started by LGC/PRA can be stopped by "engine stop override" ground or prime relay command.
2. DPS can be started from ground by descent arm and engine start override.
3. DPS started by ground can be stopped by "engine stop override."
4. APS started by LGC abort stage prime relay cannot be stopped by ground engine stop override. To stop APS in this mode a prime relay master reset or PGNS/AGS - AGS select is required from the ground. An LGC updata instruction to the LGC to issue an auto engine off will stop the the engine in this mode.
5. APS cannot be started by a ground abort stage function when PGNS/AGS switch is in AGS.
6. APS may be started by an ascent arm prime relay and an engine start override RTC. An engine stop override RTC will stop the APS.
7. APS may be started by an ascent arm prime relay and an ascent on prime relay. An engine stop override RTC will

stop the APS.

8. An APS started by PRA while in AGS select mode requires a ground descent engine arm to stop the ascent engine by RTC.
9. In the AGS mode, the FITH is accomplished with an "engine arm" of the ascent engine by prime relay and an "engine start override" by prime or RTC relays.
10. While in the AGS select mode, the normal "abort stage" function on the present LMP configured vehicle cannot be performed by either ground or prime relay.
11. The ground relays in the PCA must be in the initial "reset" position if the LGC/PRA mode is to operate normally. Except as listed below, all ground relays set by ground should be reset at the end of each operation.
12. The reset position of the manual throttle is 30 percent thrust in the LMP. A master reset RTC will perform this.
13. An abort stage signal should be sent prior to ascent engine operation. This provides for ascent helium pressurization on the unmanned LM.
14. If the ground isolates both ascent helium Tanks 1 and 2, the ascent porpulsion system cannot be pressurized by either real-time ground commands, LMP, prime relays, or by an astronaut onboard.
15. A prime relay failure will require the PGNS/AGS switch to be in PGNS and an "abort stage" by ground command to start APS by the updata link control.
16. A PCA total power failure (circuit breaker) will disable the auto switchover from PGNS to AGS and will disable all prime relay control.
17. A PCA power supply failure will disable all prime relay control and will necessitate complete backup of the LM by ground commands. The auto function for direct interface from the LGC to LM would still function normally while in the PGNS mode of control.

TABLE 13-1 LM-1 PRA SEQUENCES

REV C

Sequence No.	Description	ΔT Sequence	Binary Time Word	
I	Nominal Separation	1:47	111111	
II	No Vent Separation	0:20	111110	
III	Minimum Requirement Sequence	4:45	111101	
IV	PRA Suborbit Sequence	1:15	111100	R-C
V	No DPS/FITH Minimum Requirement Sequence	2:25	111011	
VII	Second APS	1:50	111001	
XV	5-second APS (APS restart with abort sequence)	0:22	110001	
XVI	Interconnect Closeout	0:10	110000	

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE

LM-1
REV C
NEW PAGE

SEQUENCE 1 - NOMINAL SEP
(BINARY TIME WORD 111111)

GENERAL DESCRIPTION: TOTAL SEQUENCE TIME EQUALS 1 MIN. 47 SEC. CONSISTS OF A 40 SEC. RCS COLD PURGE, THE RCS PRESSURIZATION ROUTINE, THE STANDARD SEPARATION/TRANSLATION MANEUVER, AND TURNS ON S-BAND COMMUNICATIONS.

USE: THIS SEQUENCE MAY BE USED UNDER THE FOLLOWING CONDITIONS.

A. NOMINAL SPACECRAFT SEPARATION HAS NOT OCCURRED.
B. THE RCS PRESSURIZATION ROUTINE ASSOCIATED WITH LGC MISSION PHASE 7 HAS NOT OCCURRED.
C. SEE MISSION RULES.

IT WOULD BE DESIRABLE TO NOMINALLY LOAD THIS SEQUENCE PRIOR TO CRO AOS ON REV 1. IF THIS CANNOT BE ACCOMPLISHED, IT SHOULD BE LOADED ONLY ON AN AS REQUIRED BASIS.

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
00:00	+X TRANS ON		GH1419V	JD 4D OUT	1	200
			GH1423V	JD 3D OUT	1	
			GH1427V	JD 2D OUT	1	
			GH1431V	JD 1D OUT	1	
00:40	+X TRANS OFF			+X JD'S	0	201
00:45	RCS MAIN A OPEN		GR9609U	A MAIN CL	0	274
	RCS MAIN B OPEN		GR9610U	B MAIN CL	0	276
	MASTER ARM ON		GY0111X	ED ARM A ON	0	
			GY0112X	ED ARM B ON	0	4
00:46	RCS MAIN A OPEN RESET					275
	RCS MAIN B OPEN RESET					277
00:47	RCS PRESS. FIRE		GR2201P	A FU P	172 PSIA	6
			GR2202P	B FU P	172 PSIA	
			GR3201P	A OX P	172 PSIA	
			GR3202P	B OX P	172 PSIA	
00:48	RCS PRESS. RESET					7

R-C

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

GENERAL DESCRIPTION: TOTAL SEQUENCE TIME EQUALS 75 SEC. CONSISTS OF AN RCS PRESSURIZATION ROUTINE, THE STANDARD SEPARATION/TRANSLATION MANEUVER, A 5 SEC DPS BURN AT 10% THROTTLE, A 4 SEC COAST, RE-IGNITION OF THE DPS FOR 21 SEC AT 10% WITH 5 SEC AT 100% THROTTLE, ABORT STAGE WITH A 5 SEC APS BURN, COAST FOR 3 SEC, AND A 9 SEC APS BURN.

USE: THIS SEQUENCE MAY BE USED DURING MODE 3 AND THE INITIAL 15 SEC OF THE MODE 2 ABORT REGION IF AN LGC FAILURE OCCURS. IT MAY BE LOADED PRELIFTOFF AND SHOULD BE REPLACED WITH SEQUENCE 3 - MRS FOLLOWING NOMINAL SEPARATION. (SEE MISSION RULES)

SEQUENCE 4 PRA SUBORBIT SEQUENCE
(BINARY TIME WORD 111100)

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
00:00	MASTER ARM ON		GY0111X	ED ARM A ON ED ARM B ON	0 0	4
	RCS MAIN A OPEN RCS MAIN B OPEN		GR9609U GR9610U	A MAIN CL B MAIN CL	0 0	274 276
00:02	RCS PRESS. FIRE		GR2201P GR2202P GR3201P GR3202P	A FU P B FU P A OX P B OX P	172 PSIA 172 PSIA 172 PSIA 172 PSIA	6
00:03	RCS PRESS. RESET					7
00:04	+X TRANS ON		GH1419V GH1423V GH1427V GH1431V	JD 4D OUT JD 3D OUT JD 2D OUT JD 1D OUT	1 1 1 1	200
00:05	MAN THROTTLE-10% ON		GH1311V	MAN THRUST	2.6VDC	126
00:06	LM/SLA SEP ARM		K145-900 K146-900	LM/S SEP A LM/S SEP B	1 1	72

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
	LM/SLA SEP FIRE		GH4222X	LM/SLA SEP	1	132
	RCS MAIN A OPEN RESET					275
	RCS MAIN B OPEN RESET					277
00:07	DPS ARM		GH1348X	DPS ARM	1	226
00:16	ENG START		GH1286X	FIRE O/R	1	326
00:17	ENG START RESET		GH1286X	FIRE O/R	0	327
00:21	ENG STOP O/R					246
00:22	ENG STOP RESET					247
00:26	ENG START		GH1286X	FIRE O/R	0	326
00:28	ENG START RESET					327
00:47	MAN THROTTLE-100% ON		GH1311V	MAN THRUST	14.6VDC	346
00:52	ABORT STG ARM					46
00:53	ABORT STG FIRE		GH1283X	ABRT STGD		26
	DPS RESET		GH1348X	DPS ARM	0	227
	APS ARM		GH1230X	APS ARM	1	206
00:58	ENG STOP O/R		GH1286X	FIRE O/R	0	246
01:00	ENG STOP RESET					247
01:03	ENG START		GH1286X	FIRE O/R	1	326
01:04	ENG START RESET					327
01:13	ENG STOP O/R		GH1286X	FIRE O/R	0	246
01:14	ENG STOP RESET					247
01:15	+X TRANS OFF			+X JD'S	0	201

LM-1
REV C
NEW PAGE

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

SEQUENCE 5 - NO DPS/FITH MRS
(BINARY TIME WORD 111011)

GENERAL DESCRIPTION: TOTAL SEQUENCE TIME EQUALS 2 MIN 29 SEC CONSISTS OF 12 SEC ULLAGE, AN ABORT STAGE SEQUENCE AND A 5.535 SEC APS BURN. THE SECOND APS BURN IS A BURN TO DEPLETION COUPLED WITH AN RCS INTERCONNECT TEST.

USE: IN THE EVENT OF DISABLED DPS

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
00:00	MASTER ARM ON		GY0111X	ED ARM A ON ED ARM B ON	0	004
00:01	DPS RESET		GH1348X	DPS ARM	0	227
00:02	+X TRANS ON		GH1419V GH1423V GH1427V GH1431V	JD 4D OUT JD 3D OUT JD 2D OUT JD 1D OUT	1 1 1 1	200
00:07	ABORT STG ARM					046
00:14	ABORT STG FIRE APS ARM ENG START		GH1283X GH1230X GH1286X	ABRT STGD APS ARM FIRE O/R	 1 1	026 206 326
00:16	ENG START RESET					327
00:19	+X TRANS OFF			+X JD'S	0	201
00:20	ENG STOP O/R		GH1286X	FIRE O/R	0	246
00:21	ABORT STG FIRE RESET ENG STOP RESET ABORT STG RESET					027 247 047

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
00:44	+X TRANS ON		GH1419V	JD 4D OUT	1	200
			GH1423V	JD 3D OUT	1	
			GH1427V	JD 2D OUT	1	
			GH1431V	JD 1D OUT	1	
00:57	ENG START		GH1286X	FIRE O/R	1	326
00:58	ENG RESET		GH1286X	FIRE O/R	0	327
01:02	+X TRANS OFF			+X JD'S	0	201
01:06	ASC FEED ARM					176
01:07	ASC FEED A OPEN		GR9611U	A A/FEED	1	074
	RCS MAIN A CLSD		GR9609U	A MAIN CL	1	254
01:08	ASC FEED A OPEN RESET					075
	RCS MAIN A CLSD RESET					255
01:17	ASC FEED B OPEN		GR9612U	B A/FEED	1	076
	RCS MAIN B CLSD		GR9610U	B MAIN CL	1	256
01:18	ASC FEED B OPEN RESET					077
	RCS MAIN B CLSD RESET					257
01:27	X-FEED OPEN		GR9613U	X-FEED OP	1	374
01:28	X-FEED OPEN RESET					375
02:16	X-FEED CLSD		GR9613U	X-FEED OP	0	376
02:17	X-FEED CLSD RESET					377
	RCS MAIN A OPEN		GR9609U	A MAIN CL	0	274
	ASC FEED A CLSD		GR9611U	A A/FEED	0	114
02:18	RCS A OPEN RESET					275
	ASC FEED A CLSD RESET					115
02:27	RCS MAIN B OPEN		GR9610U	B MAIN CL	0	276
	ACS FEED B CLSD		GR9612U	B A/FEED	0	116
02:28	RCS MAIN B OPEN RESET					277
	ASC FEED B CLSD RESET					117
02:29	ASC FEED RESET					177

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

SEQUENCE 7 - SEC APS
(BINARY TIME WORD 111001)

GENERAL DESCRIPTION: TOTAL SEQUENCE EQUALS 1 MIN 50 SEC CONSISTS OF AN APS BURN TO DEPLETION COUPLED WITH AN RCS INTERCONNECT TEST.

USE: THIS SEQ IS TO BE USED IF A FAILURE IN THE LGC OCCURS AFTER THE FIRST APS BURN.

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
00:00	APS ARM		GH1230X	APS ARM	1	206
00:07	+X TRANS		GH1419V	JD 4D OUT	1	200
			GH1423V	JD 3D OUT	1	
			GH1427V	JD 2D OUT	1	
			GH1431V	JD 1D OUT	1	
00:20	ENG START		GH1286X	FIRE O/R	1	326
00:21	ENG RESET					327
00:25	+X TRANS OFF			+X JD'S	0	201
00:27	ASC FEED ARM					176
00:28	ASC FEED A OPEN		GR9611U	A A/FEED	1	074
	RCS MAIN A CLSD		GR9609U	A MAIN CL	1	254
00:29	ASC FEED A OPEN RESET					075
	RCS MAIN A CLSD RESET					255
00:38	ASC FEED B OPEN		GR9612U	B A/FEED	1	076
	RCS MAIN B CLSD		GR9610U	B MAIN CL	1	256
00:39	ASC FEED B OPEN RESET					077
	RCS MAIN B CLSD RESET					257

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
00:48	X-FEED OPEN		GR9613U	X-FEED OP	1	374
00:49	X-FEED OPEN RESET					375
01:37	X-FEED CLSD		GR9613U	X-FEED OP	0	376
01:38	X-FEED CLSD RESET					377
	RCS MAIN A OPEN		GR9609U	A MAIN CL	0	274
	ASC FEED A CLSD		GR9611U	A A/FEED	0	114
01:39	RCS MAIN A OPEN RESET					275
	ASC FEED A CLSD RESET					115
01:48	RCS MAIN B OPEN		GR9610U	B MAIN CL	0	276
	ASC FEED B CLSD		GR9612U	B A/FE	0	116
01:49	RCS MAIN B OPEN RESET					277
	ASC FEED B CLSD RESET					117
01:50	ASC FEED RESET					177

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

SEQUENCE NO. 15 5 SEC APS
(BINARY TIME WORD 110001)

GENERAL DESCRIPTION: TOTAL SEQUENCE TIME EQUALS 0 MIN 22 SEC. CONSISTS OF AN ABORT STAGE SEQUENCE AND A 5 SEC APS BURN.

USE: THIS SEQUENCE MAY BE USED TO SEPARATE THE LM ASCENT STAGE ONLY FROM THE S-IVB. IT WOULD NOT BE REQUIRED UNLESS THERE ARE FAILURES ASSOCIATED WITH THE LM/SLA SEPARATION CIRCUITRY. (SEE MISSION RULES).

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
00:00	+X TRANS ON		GH1419V	JD 4D OUT	1	200
			GH1423V	JD 3D OUT	1	
			GH1427V	JD 2D OUT	1	
			GH1431V	JD 1D OUT	1	
00:07	ENG START		GH1286V	FIRE O/R	1	326
00:11	MAN THROTTLE 100% ON		GH1311V	MAN THRUST	14.6VDC	346
	MASTER ARM ON		GV0111X	ED ARM A ON	0	004
				ED ARM B ON		
00:12	ABORT STG ARM					046
00:13	ABORT STG FIRE		GH1238X	ABRT STGD		026
	DPS RESET		GH1348X	DPS ARM	0	227
	APS ARM		GH1230X	APS ARM	1	206
00:19	ENG STOP O/R		GH1286X	FIRE O/R	0	246
	+X TRANS OFF			+X JD'S	0	201
	ENG RESET					327
00:20	APS RESET		GH1230X	APS ARM	0	207
	ENG STOP RESET					247

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

NEW PAGE

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
00:21	ABORT STG FIRE RESET ABORT STG RESET					027 047
00:22	MASTER ARM OFF MAN THROTTLE 100% OFF					005 347

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONCL'D)

SEQUENCE NO. 16 INTERCONNECT CLOSEOUT
(BINARY TIME WORD 110000)

GENERAL DESCRIPTION: TOTAL SEQUENCE TIME EQUALS 0 MIN 10 SEC. CONSISTS OF A RCS MANIFOLD RECONFIGURATION (INTERCONNECT SHUTDOWN).

USE: THIS SEQUENCE MAY BE USED IF THE LGC FAILS DURING THE APS 2 BURN AND THE RCS ASCENT FEED IS OPEN. IT MAY BE LOADED UPON COMPLETION OF LGC MISSION PHASE 2 (DPS 2/FITH/APS 1). (SEE MISSION RULES).

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
00:00	+X TRANS ON		GH1419V	JD 4D OUT	1	200
			GH1423V	JD 3D OUT	1	
			GH1427V	JD 2D OUT	1	
			GH1431V	JD 1D OUT	1	
00:01	X-FEED CLSD		GR9613U	X-FEED OP	0	376
	RCS MAIN A OPEN		GR9609U	A MAIN CL	0	274
	ASC FEED A CLSD		GR9611U	A A/FEED	0	114
	RCS MAIN B OPEN		GR9610U	B MAIN CL	0	276
	ASC FEED B CLSD		GR9612U	B A/FEED	0	116
00:02	X-FEED CLSD RESET					377
	RCS MAIN A OPEN RESET					275
	ASC FEED A CLSD RESET					115
00:03	RCS MAIN B OPEN RESET					277
	ASC FEED B CLSD RESET					117
00:04	ASC FEED RESET					177
00:10	+X TRANS OFF			+X JD'S	0	201

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
01:17	MASTER ARM SAFE					5
01:27	PLUS-X TRANS ON			+X JD'S	1	200
01:28	PRI S-BND ENABLE		GT0994V	RCVR SIG	-4V	212
01:31	LM/SLA SEP ARM		K145-900 K146-900	LM/S SEP A LM/S SEP B	1 1	72
01:32	LM/SLA SEP FIRE		GL4222X	LM/SLA SEP	1	132
01:37	+X TRANS OFF LM/SLA SEP ARM RESET LM/SLA SEP FIRE RESET			+X JD'S	0	201 73 133
01:42	+X TRANS ON			+X JD'S	1	200
01:47	+X TRANS OFF			+X JD'S	0	201

NOTES:

CONSTRAINTS: DO NOT RUN THIS SEQUENCE WITH THE RCS PRESSURIZED AS PLUS-X TRANSLATION CAN BE ACTIVE FOR ONLY 20 SEC WITHOUT CAUSING DAMAGE TO DESCENT STAGE THERMAL INSULATION.

IF THE LGC FAILS PRIOR TO SEPARATION FROM THE S-IVB AND LM LIFETIME IS 1 REV, THIS SEQUENCE WILL BE USED (IF THE RCS HAS NOT BEEN PRESSURIZED) OVER THE WEST CALIFORNIA SHIP. THIS SEQUENCE WOULD BE FOLLOWED BY SEQUENCE III - MRS. (SEE MISSION RULES).

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

NEW PAGE

SEQUENCE NO. 2 NO VENT SEP
(BINARY TIME WORD 111110)

GENERAL DESCRIPTION: TOTAL SEQUENCE TIME EQUALS 20 SEC. CONSISTS OF THE STANDARD SEPARATION/TRANSLATION MANEUVER AND TURNS ON S-BAND COMMUNICATIONS.

USE: THIS SEQUENCE MAY BE USED IN THE EVENT THAT A SEPARATION/TRANSLATION MANEUVER IS REQUIRED WITH THE RCS ALREADY PRESSURIZED. IT WILL NOT BE NOMINALLY LOADED DURING THE MISSION. (SEE SOP'S)

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
00:00	+X TRANS ON		GH1419V GH1423V GH1427V GH1431V	JD 4D OUT JD 3D OUT JD 2D OUT JD 1D OUT	1 1 1 1	200
00:01	PRI S-BND ENABLE		GT0994V	RCVR SIG	-4VDC	212
00:04	LM/SLA SEP ARM		K145-900 K146-900	LM/SLA SEP A LM/SLA SEP B		72
00:05	LM/SLA SEP FIRE		GL4222X	LM/SLA SEP		132
00:10	+X TRANS OFF LM/SLA SEP RESET LM/SLA SEP FIRE RESET			+X JD'S	0	201 73 133
00:15	+X TRANS ON		GH1419V GH1423V GH1427V GH1431V	JD 4D OUT JD 3D OUT JD 2D OUT JD 1D OUT	1 1 1 1	200
00:20	+X TRANS OFF			+X JD'S	0	201

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

NEW PAGE

SEQUENCE NO. 3 - MRS
(BINARY TIME WORD 111101)

GENERAL DESCRIPTION: TOTAL SEQUENCE TIME EQUALS 4 MIN. 45 SEC. CONSISTS OF A 36 SEC. DPS BURN (26 SEC. AT 10% THROTTLE AND 10 SEC. AT 100% THROTTLE), A 32 SEC. COAST, A 56 SEC. DPS BURN (26 SEC. AT 10% THROTTLE AND 30 SEC. AT 100% THROTTLE), ABORT STAGE WITH A 6 SEC. APS BURN, A 40 SEC. COAST, AND AN APS BURN WITH ASC INTERCONNECT (LENGTH OF BURN VARIABLE - RTC TERMINATION.)

USE: THIS SEQUENCE MAY BE USED SUBSEQUENT TO NOMINAL INSERTION TO ACCOMPLISH PRIMARY MISSION OBJECTIVES IN THE EVENT OF AN LGC FAILURE OR TIME CRITICAL FAILURE.

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
00:00	MASTER ARM ON		GY0111X GY0112X	ED ARM A ON ED ARM B ON	0 0	 4
00:05	DPS PQGS ARM (#1) DPS PQGS (#2) ON					344 324
00:06	DPS PQGS (#1) ON DPS PQGS ARM (#2)					364 304
00:07	DPS ARM		GH1348X	DPS ARM	1	226
00:15	+X TRANS ON		GH1419V GH1423V GH1427V GH1431V	JD 4D OUT JD 3D OUT JD 2D OUT JD 1D OUT	1 1 1 1	200
	MAN THROTTLE - 10% ON		GH1311	MAN THRUST	2.6VDC	126
00:23	ENG START		GH1286X	FIRE O/R	1	326
00:24	ENG START RESET					327
00:28	+X TRANS OFF			X JD'S	0	201

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

LM-1
REV C

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.	
00:49	MAN THROTTLE 100% ON		GH1311V	MAN THRUST	14.6VDC	346	
00:59	ENG STOP O/R		GH1286X	FIRE O/R	0	246	
01:01	ENG STOP RESET					247	
	MAN THROTTLE-100% OFF		GH1331V	MAN THRUST	2.6VDC	347	
	MAN THROTTLE-10% OFF		GH1311V	MAN THRUST	5.1VDC	127	
01:04	DPS RESET		GH1348X	DPS ARM	0	227	
01:22	DPS ARM		GH1348X	DPS ARM	1	226	
01:23	+X TRANS ON		GH1419V	JD 4D OUT	1	200	
			GH1423V	JD 3D OUT	1		
			GH1427V	JD 2D OUT	1		
			GH1431V	JD 1D OUT	1		
	MAN THROTTLE 10% ON		GH1311V	MAN THRUST	2.6VDC	126	
01:31	ENG START		GH1286X	FIRE O/R	1	326	
01:32	ENG RESET					327	
01:36	+X TRANS OFF			+X JD'S	0	201	
01:57	MAN THROTTLE 100% ON		GH1311V	MAN THRUST	14.6VDC	346	
02:26	ABORT STG ARM					46	
02:27	ABORT STG FIRE		GH1283X	ABRT STGD		25	
	DPS RESET		GH1348X	DPS ARM	0	227	
	APS ARM		GH1230X	APS ARM	1	206	R-C
02:33	ENG STOP O/R		GH1286X	FIRE O/R	0	246	
02:34	MAN THROTTLE-100% OFF		GH1311V	MAN THRUST	2.6VDC	347	
	MAN THROTTLE-10% OFF		GH1311V	MAN THRUST	5.1VDC	127	
	DPS PQGS (#1) OFF					365	
	DPS PQGS (#2) RESET					305	
	DPS PQGS (#1) RESET					345	
	DPS PQGS (#2) OFF					325	

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
02:35	ABORT STG FIRE RESET					27
	ENG STOP RESET					247
	ABORT STG RESET					47
03:00	+X TRANS ON			+X JD'S		200
03:13	ENG START		GH1286X	FIRE O/R	1	326
03:14	ENG START RESET					327
03:18	+X TRANS OFF			+X JD'S	0	201
03:22	ASC FEED ARM					176
03:23	ASC FEED A OPEN		GR9611U	A A/FEED	1	74
	RCS MAIN A CLSD		GR9609U	A MAIN CL	1	254
03:24	ASC FEED A OPEN RESET					75
	RCS A CLSD RESET					255
03:33	ASC FEED B OPEN		GR9612U	B A/FEED	1	76
	RCS MAIN B CLSD		GR9610U	B MAIN CL	1	256
03:34	ASC FEED B OPEN RESET					77
	RCS MAIN B CLSD RESET					257
03:43	X-FEED OPEN		GR9613U	X FEED OP	1	374
03:44	X-FEED OPEN RESET					375
04:32	X-FEED CLSD		GR9613U	X FEED OP	0	376
04:33	X-FEED CLSD RESET					377
	RCS MAIN A OPEN		GR9609U	A MAIN CL	0	274
	ASC FEED A CLSD		GR9611U	A A/FEED	0	114
04:34	RCS A OPEN RESET					275
	ASC FEED A CLSD RESET					115

TABLE 13-2 LM-1 (AS-206A) PRA COMMAND/TIMELINE (CONT'D)

TIME	FUNCTION	NOTES	TM VERIFICATION MEAS ID	TM VERIFICATION TITLE	CUE	PRIME OCTAL NO.
04:43	RCS MAIN B OPEN		GR9610U	B MAIN CL	0	276
	ASC FEED B CLSD		GR9612U	B A/FEED	0	116
04:44	RCS B OPEN RESET					277
	ASC FEED B CLSD RESET					117
04:45	ASC FEED RESET					177

NOTES:

1. SEQUENCE 3 SHOULD BE INITIATED OVER THE NEXT STATESIDE PASS. (SEE MISSION RULES).
   A. IF THE LGC FAILS PRIOR TO SEPARATION AND LM LIFETIME IS 1 REV (WILL SEQUENTIALLY FOLLOW SEQUENCE 1 - NOMINAL SEP OR SEQUENCE 2 - NO VENT SEP DEPENDING ON WHETHER THE RCS HAS BEEN PRESSURIZED OR NOT).
   B. IF THE LGC FAILS AFTER SEPARATION BUT PRIOR TO DPS 1.
   C. IF THE LGC FAILS AFTER DPS 1 BUT PRIOR TO DPS 2 (AN EXTRA DPS BURN RESULTS).

TABLE 13-3 LMP REAL-TIME COMMANDS BY CODE (CONCLUDED)

CODE	MATRIX POINT	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME	
45B	10-3R	A17K11(R)	K0752A	ENVIRONMENTAL - SEC H_2O RESET	
50B	11-3S	A17K14(S)	K0751A		
51B	11-3R	A17K14(R)	K0751A		
54B	12-3S	A17K9(S)	K2060A	COMMUNICATIONS - DFI CAL ON	
55B	12-3R	A17K9(R)K1(S)	K2060A,K2060B	COMMUNICATIONS - DFI CAL OFF	R-B
60B	13-3S	A17K7(S)	K0155A,B	SEC H_2O FEED ENABLE	R-C
61B	13-3R	A17K7(R)	K0155A,B	SEC H_2O FEED RESET	
64B	14-3S	A11K4(S),K5(S)	K0251A,B	PYRO - MASTER ARM ON	
65B	14-3R	A11K4(R),K5(R)	K0251A,B	PYRO - MASTER ARM OFF	
70B	15-3S	A11K6(S),K7(S)	K0252A,B	RCS VALVES - RCS PRESS. FIRE	
71B	15-3R	A11K6(R),K7(R)	K0252A,B	RCS VALVES - RCS PRESS. RESET	
74B	16-3S	A11K8(S)	K1152A	FLT CONTR - DEADBAND MIN	
75B	16-3R	A11K8(R)	K1152A	FLT CONTR - DEADBAND LMP CONTR	

TABLE 13-4 LMP PRIME (LGC&/OR PRA SEQUENCED) COMMAND

OCTAL	DECIMAL CODE	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
2	2	A11K18(S),25(S)	K1101A, B	FLT CONTR - ATT HOLD ON
3	3	A11K18(R),25(R)	K1101A, B	FLT CONTR - AUTO ENABLE
4	4	A11K12(S),13(S)	K0201A, B	PYRO - MASTER ARM ON
5	5	A11K12(R),13(R)	K0201A, B	PYRO - MASTER ARM OFF
6	6	A11K14(S),15(S)	K0202A, B	RCS VALVES - RCS PRESS. FIRE
7	7	A11K14(R),15(R)	K0202A, B	RCS VALVES - RCS PRESS. RESET
~~10~~	~~8~~	~~A10K21(S),27(S)~~	~~K0203B, A~~	~~LANDING GEAR DEPLOY - FIRE OK~~
~~11~~	~~9~~	~~A10K21(R),27(R)~~	~~K0203B, A~~	~~LANDING GEAR DEPLOY - OFF~~
12	10	A12K14(S)	K0034	SPARE
13	11	A12K14(R)	K0034	SPARE
14	12	A13K8(S)	K0813A	RCS VALVES - RCS 1A OPEN
15	13	A13K8(R)	K0813A	RCS VALVES - RCS 1A OPEN RESET
16	14	A14K8(S)	K0811A	RCS VALVES - RCS 3A OPEN
17	15	A14K8(R)	K0811A	RCS VALVES - RCS 3A OPEN RESET
20	16	A11K19(S)	K0028	SPARE
21	17	A11K19(R)	K0028	SPARE
22	18	A11K20(S)	K0029	SPARE
23	19	A11K20(R)	K0029	SPARE
24	20	A11K21(S)	K0030	SPARE
25	21	A11K21(R)	K0030	SPARE
26	22	A11K26(S)	K0206	FLT CONTR - ABORT STG FIRE
27	23	A11K26(R)	K0206	FLT CONTR - ABORT STG FIRE RESET
~~30~~	~~24~~	~~A10K13(S),14(S)~~	~~K0204A, B~~	~~DPS HELIUM PRE-PRESSURIZATION FIRE (DEM 2&3)~~
~~31~~	~~25~~	~~A10K13(R),14(R)~~	~~K0204A, B~~	~~DPS HELIUM PRE-PRESSURIZATION OFF (LEM 2&3)~~
~~32~~	~~26~~	~~A12K26(S)~~	~~K1702A~~	~~LANDING RADAR SELF TEST - ON~~
~~33~~	~~27~~	~~A12K26(R)~~	~~K1702A~~	~~LANDING RADAR SELF TEST - OFF~~
34	28	A13K9(S)	K0821A	RCS VALVES - RCS 1B OPEN
35	29	A13K9(R)	K0821A	RCS VALVES - RCS 1B OPEN RESET
36	30	A14K9(S)	K0819A	RCS VALVES - RCS 3B OPEN
37	31	A14K9(R)	K0819A	RCS VALVES - RCS 3B OPEN RESET
~~40~~	~~32~~	~~A11K22(S)~~	~~K1103A~~	~~AGS STATUS - ASA - STANDBY/OPERATE~~
~~41~~	~~33~~	~~A1K22(R)~~	~~K1103A~~	~~AGS STATUS - ASA - WARMUP~~
42	34	A11K23(S)	K1302A	COMMUNICATIONS S-BND RNG ON
43	35	A11K23(R)	K1302A	COMMUNICATIONS S-BND RNG OFF
44	36	A11K27(S)	K1102A	FLT CONTR DEADBAND LMP CONTR
45	37	A11K27(R)	K1102A	FLT CONTR DEADBAND LMP

R-B

TABLE 13-6 LM COMMAND CARD RELAY REFERENCE

RTC	PRIME	ON OR OPEN	SYSTEM	OFF OR CLOSE PRIME		RTC	PRIME RELAYS (FUN.)ON/OFF	PRIME RELAYS (MOD)ON/OFF	GND RELAYS (FUN.)ON/OFF	GND RELAYS (MOD)ON/OFF	
			FLIGHT CONTROLS								
25B	(AUTO EN)		ATT ENABLE		(ATT HD EN)	31B			K1151 A,B,C	A11K19,17	
30B	(AUTO ON)	3	ATT ON	2	(ATT HOLD ON)	24B	K1101 A,B	A11K18, 25	K1151&53 A,B	A11K2,10	
75B	(LMP CTR)	44	DEADBAND	45	◇(MIN)	74B	K1102 A	A11K27	K1152 A	A11K8	
41B	(PNGS)	N/A	GUID SEL	N/A	(AGS)	40B			K2059 A,B,C,D	A16K17,9,16,8	
:::: 34B	(RESET)	N/A	PRIME RELAY	N/A	(OFF)	35B			K2057 A,C	A16K5, 15	
70A	(ARM)	46	ABORT STAGE	47	◇(RESET)	71A	K0205 A,B,C	A10K3,4,5	K0254 A,B,C	A10K9,10,11	
40A/41A	(FIRE/FIRE RESET)	26/27	ABORT STAGE	N/A		N/A	K0206A	A11K26	K0257 A	A15K9	
			EECOM								
			PYRO								
64B	(ON)	4	MASTER ARM	5	◇(OFF)	65B	K0201 A,B	A11K12,13	K0251 A,B	A11K4,5	
~~41A~~/~~46A~~	(ARM)/(ARM RESET)	72/73	LM/SLA SEP	N/A		47A	K2001 A,B	A12K3, A13K14	K0251 A,B	A11K4,5	R-C
62A/63A	FIRE/FIRE RESET	132/133	LM/SLA SEP	N/A	-	N/A	K2006 A,B,C	A12K12,20 A13K16	K0256 A,B	A10K2,7	
			ELECTRICAL								
N/A	-	N/A	BAT. 1	N/A	(OFF)	17A			K0458 A	A12K24	
N/A	-	N/A	BAT. 2	N/A	(OFF)	22A			K0453 A	A12K16	
N/A	-	N/A	BAT. 3	N/A	(OFF)	32A			K0459 A	A12K13	
N/A	-	N/A	BAT. 4	N/A	(OFF)	37A			K0456 A	A12K22	
N/A	-	N/A	BAT. 5	N/A	(OFF)	26A			K0451 A	A12K7	
36A	B/U COR	N/A	BAT. 5	N/A	-	N/A			K0455 A	A12K21	
N/A	-	N/A	BAT. 6	N/A	(OFF)	23A			K0454 A	A12K16	
27A	B/U SE	N/A	BAT. 6	N/A	-	N/A			K0452 A	A12K8	
16A	SEL	N/A	INVERT 2	N/A	-	N/A			K0457 A	A12K23	
			ENVIRONMENT								
24A/25A	(FEED/RESET)	272/273	PRI H_2O	N/A	-	N/A	K0704 A	A15K3	K0753 A	A15K2	
44B/45B	(FEED/RESET)	336/337	SEC H_2O	N/A	-	N/A	K0703 A	A17K6	K0752 A	A17K11	
60B	ENABLE		SEC H_2O FEED COMM	61B	(RESET)						R-C
N/A	(ON)	42	S-BAND RANGE	43	◇(OFF)	N/A	K1302 A	A11K23			
31A	(ENABLE)	212	PRI S-BND	213	◇(OFF)	30A	K1301 A	A15K5	K1352 A	A15K1	
20A	(ON)	N/A	SEC S-BND	N/A	(OFF)	21A			K1351 A	A15K14	
53A	(ON)	152	:::: C-BND	153	(OFF)	+52A	K2005 A	A12K17	K0255 A,B	A10K1,6	
54B	(ON)	354	DFI CAL	355	◇(OFF)	+55B	K0107 A,B	A6K19,11	K2060 A,B	A17K9,1	

::::CMD AVAILIBILITY DEPENDS ON COCKPIT SW.

::::WARNING - DON'T SEND MASTER RELAY RESET DURING ASC ENG OPERATION.

◇INDICATES POSITION AFTER MASTER RELAY RESET IS GIVEN.

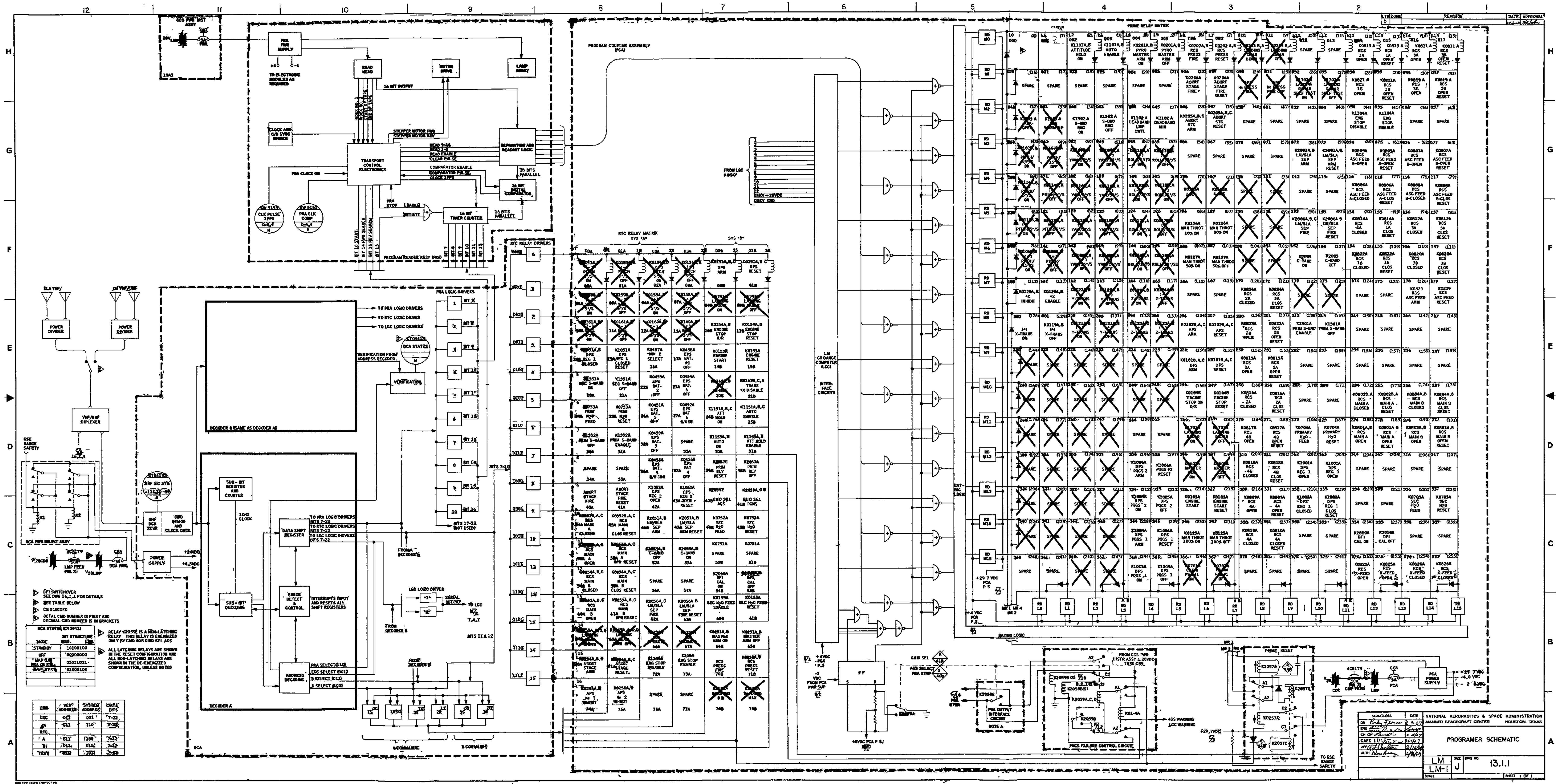
TABLE 13-6 LM COMMAND CARD RELAY REFERENCE (Concluded)

RTC	ON OR OPEN PRIME		SYSTEM	OFF OR CLOSE PRIME		RTC	PRIME RELAYS (FUNCTIONAL) ON/OFF	(MOD) ON/OFF	GND RELAYS (FUN.) ON/OFF	(MOD) ON/OF
			PROPULSION							
			THROTTLE CONTROL							
N/A	100% ON	346	MAN THROTTLE	347	OFF	N/A	K0125 A	A9K18		
N/A	(50% ON)	146	MAN THROTTLE	147	50% OFF	N/A	K0127 A	A9K20		
N/A	(30% ON)	127 ◇	MAN THROTTLE	N/A		N/A	K0126 A	A1K21		
	(10% ON)	126	MAN THROTTLE							
			TRANSLATION CNTR							
N/A	(ON)	200	+X TRANSLATION	201 ◇	(OFF)	N/A	K0119 A,B	A6K24,25		
N/A	----	N/A	+X		(DISABLE)	21B*			/K0163 A,B,C	A8K26,A6K26 A7K26
			ENG ON-OFF							
N/A	L (ARM)	206	APS	207 ◇	(RESET)	N/A	K0102 A,B,C	A9K15,7,23		
L 003	L (ARM)	226	DPS	227 ◇	(RESET)	01B	K0101 A,B,C	A9K14,6,22	K0151 A,B,C	A9K16,8,14
14B/15B	(START/RESET)	326/327	ENG	N/A	----	N/A	K0103 A	A9K10	K0153 A	A9K11
10B	(OVERRIDE)	246	ENG STOP	247 ◇	(RESET)	11B	K0104 B	A9K4	K0154 A,B	A9K13,5
L 72A	(DISABLE)	54	ENG STOP	55 ◇	(ENABLE)	73A	K1104 A	A11K11	K1155 A	A11K24
74A	(INHIBIT)	N/A	APS HE. 1	N/A	----	N/A			K0255 A,B	A10K1,6
75A	(INHIBIT)	N/A	APS HE. 2	N/A	----	N/A			K0256 A,B	A10K2,7
			DE REG VAL CNTR							
N/A	(OPEN/RESET)L	312/313	DPS REG 1	332/333	(CLOSED/RESET)	14A*/15A	K1001A/K1002A	A15K4/13		
N/A	-----	N/A	DPS REG 2	N/A	(OPEN/RESET)	42A/43A				
			DPS PQGS							
N/A	(ARM)	344	PQGS #1	345	(RESET)	N/A	K1004A	A8K7		
N/A	(ON)	364	PQGS #1	365	(OFF)	N/A	K1003A	A8K8		
N/A	(ARM)	304	PQGS #2	305	(RESET)	N/A	K1006A	A8K4		
N/A	(ON)	324	PQGS #2	325	(OFF)	N/A	K1005A	A8K6		
			RCS VALVES							
70B/71B	(FIRE/RESET)	6/7	RCS PRESS.	N/A		N/A	K0202 A,B	A11K14,15	K0252 A,B	A11K6,7
N/A	(ARM)	176	ASC FEED	177 ◇	(RESET)	N/A	K0829 A	A13K3		
N/A	L (OPEN/RESET)	74/75	ASC FEED "A"	114/115	(CLOSE/RESET)	N/A	K0805/6 A	A13K3/4		
N/A	L (OPEN/RESET)	76/77	ASC FEED "B"	116/117	(CLOSE/RESET)	N/A	K0807/8 A	A14K3/4		
N/A	L (OPEN/RESET)	374/375	CROSSFEED	376/377	(CLOSE/RESET)	N/A	K0825/26 A	A17K2/4		
50A+/51A	L (OPEN/RESET)	274/275	RCS MAIN "A"	254/255	(CLOSE/RESET)	44A+/45A	K0801/02 A,B	A13K18,22/ 13,21	K0851/52 A,B,C	A13K6,5,20/ A13K2,1,19
60A+/61A	L (OPEN/RESET)	276/277	RCS MAIN "B"	256/257	(CLOSE/RESET)	54A+/55A	K0803/04 A,B	A14K18,22/ 13,21	K0853/54 A,B,C	A14K6,5,20/ A14K2,1,19
N/A	L (OPEN/RESET)	14/15	RCS 1 "A"	134/135	(CLOSE/RESET)	N/A	K0813/14 A	A13K8/10		
N/A	L (OPEN/RESET)	34/35	RCS 1 "B"	154/155	(CLOSE/RESET)	N/A	K0821/22 A	A13K9/11		
N/A	L (OPEN/RESET)	230/231	RCS 2 "A"	250/251	(CLOSE/RESET)	N/A	K0815/16 A	A16K3/4		
N/A	L (OPEN/RESET)	210/211	RCS 2 "B"	170/171	(CLOSE/RESET)	N/A	K0823/24 A	A16K2/1		
N/A	L (OPEN/RESET)	16/17	RCS 3 "A"	136/137	(CLOSE/RESET)	N/A	K0811/12 A	A14K8/10		
N/A	L (OPEN/RESET)	36/37	RCS 3 "B"	156/157	(CLOSE/RESET)	N/A	K0819/20 A	A14K9/11		
N/A	L (OPEN/RESET)	330/331	RCS 4 "A"	350/351	(CLOSE/RESET)	N/A	K0809/10 A	A16K12/11		
N/A	L (OPEN/RESET)	270/271	RCS 4 "B"	310/311	(CLOSE/RESET)	N/A	K0817/18 A	A16K14/13		

*PERMANENTLY INHIBITS FUNCTION
EN - ENABLE
L - INTERLOCK - UNLESS RESET CMD IS SENT, OTHER CMDS ARE INHIBITED
+ RTC - PERMANENTLY INHIBITS PRIME CMD CONTROL

NOTE: ON ALL VALUES WITH (OPEN/RESET) LISTED THE CMD IS OPEN AND OPEN RESET OR CLOSE AND CLOSE RESET.

R-C



1. DFI SWITCHOVER SEE DWG 16.1.1 FOR DETAILS
2. SEE TABLE BELOW
3. CB SLUGGED
4. OCTAL CMD NUMBER IS FIRST AND DECIMAL CMD NUMBER IS IN BRACKETS
5. RELAY K2059E IS A NON-LATCHING RELAY THIS RELAY IS ENERGIZED ONLY BY CMD 40B GUID SEL AGS
6. ALL LATCHING RELAYS ARE SHOWN IN THE RESET CONFIGURATION AND ALL NON-LATCHING RELAYS ARE SHOWN IN THE DE-ENERGIZED CONFIGURATION, UNLESS NOTED

DCA STATUS (GT0441)

MODE	BIT STRUCTURE MSB. LSB.
STANDBY	10100100
OFF	00000000
MAP (LGC, PRA OR RTC)	01011011
MAP TEST	01000100

CMD	VER ADDRESS	SYSTEM ADDRESS	DATA BITS
LGC	011	001	7-22
PA	011	110	7-22
RTC			
A	011	100	7-12
B	011	011	7-12
TEST	[illegible]	101	7-22

SIGNATURES		DATE
DR	Ricky Flores	2-3-67
ENG	[illegible]	[illegible]
CH	[illegible]	2-15/67
GAEC	[illegible]	2/15/67
APP	R. L. Carlton	2/16/67
AUTH	[illegible]	2/16/67

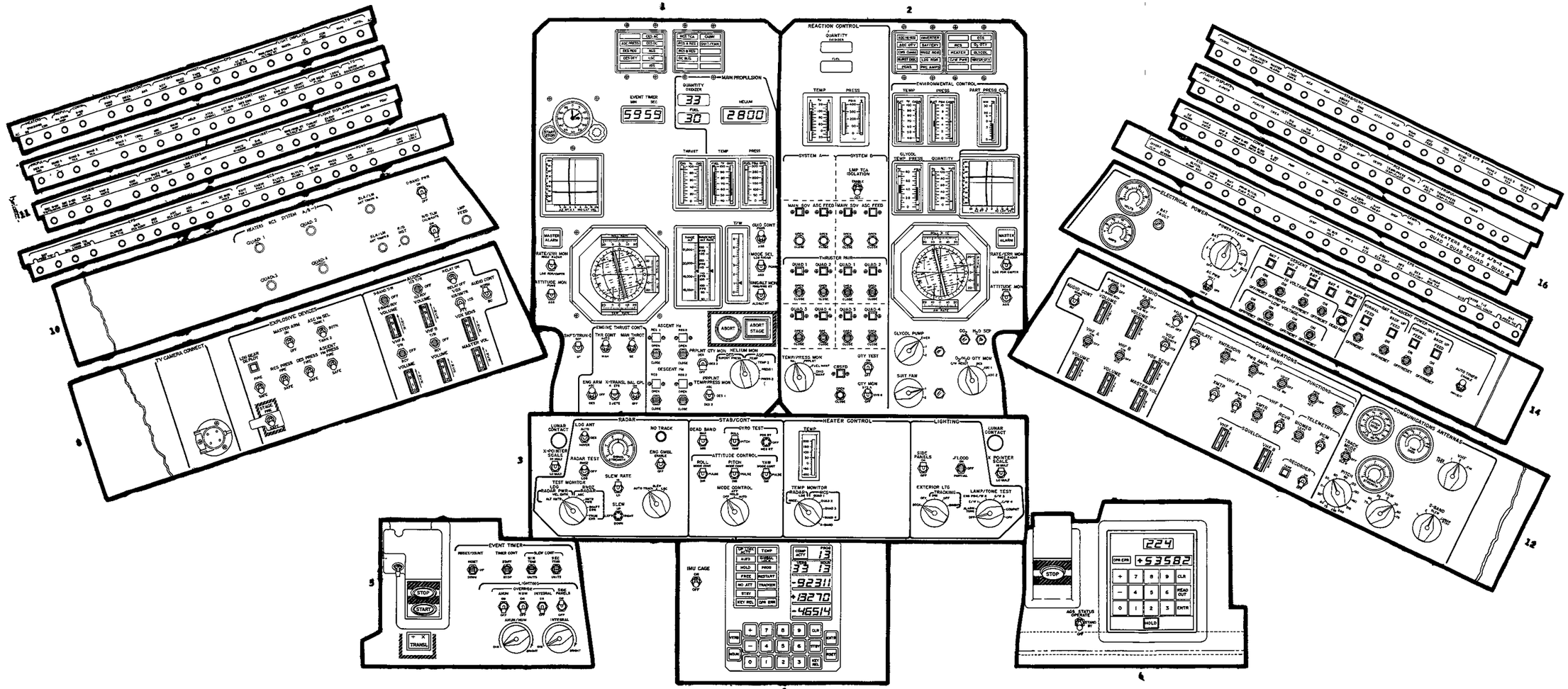
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS

PROGRAMER SCHEMATIC

LM / LM-1 | SIZE J | DWG NO. 13.1.1
SCALE | SHEET 1 OF 1

MSC Form 1610 E (REV OCT 66)

LTR	ZONE	REVISION	DATE	APPROVAL
C			4-9-67	



SIGNATURES	DATE
DR Landon Boyd	2/16/67
ENG [illegible]	2-9-67
CH [illegible]	2/14/67
GAEC [illegible]	2-9-67
APP Donald B Reddy	2/14/67
AUTH Don Brazy	2-10-67

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON TEXAS

LM-1 PANEL LAYOUT

LM / LM-1	SIZE D	DWG NO 15.1.1
SCALE		SHEET 1 OF 1

MSC Form 1616 D (REV OCT 65)

*

THIS PAGE INTENTIONALLY LEFT BLANK

16.2 SYSTEMS DATA

16.2.1 DFI/COMM

A. VHF TRANSMITTER

1. RF POWER OUTPUT	10 WATTS
2. POWER INPUT	56 WATTS

B. C-BAND BEACON CHARACTERISTICS

1. RECEIVER	
a. FREQUENCY	5690 MHZ
b. SENSITIVITY	-70 dbm
c. INTERROGATION PULSE WIDTH	0.5 to 0.8 μs
d. DECODER PULSE SPACING	3.5 ± 0.1 μs
2. TRANSMITTER	
a. FREQUENCY	5765 MHZ
b. PULSE WIDTH	0.75 ± 0.1 μs
c. BEACON PULSE DELAY	3.0 ± 0.1 μs
d. PRF	0-2670 PPS
e. PEAK POWER OUTPUT	500 to 750 WATTS
f. P_{AVG} (PEAK PWR - 750 WATTS	0 to 1.5 WATTS
(PEAK PWR - 500 WATTS)	0 to 1 WATT

C. DCA RECEIVER CHARACTERISTICS

1. FREQUENCY	450 MHZ
2. SENSITIVITY	-99 dbm

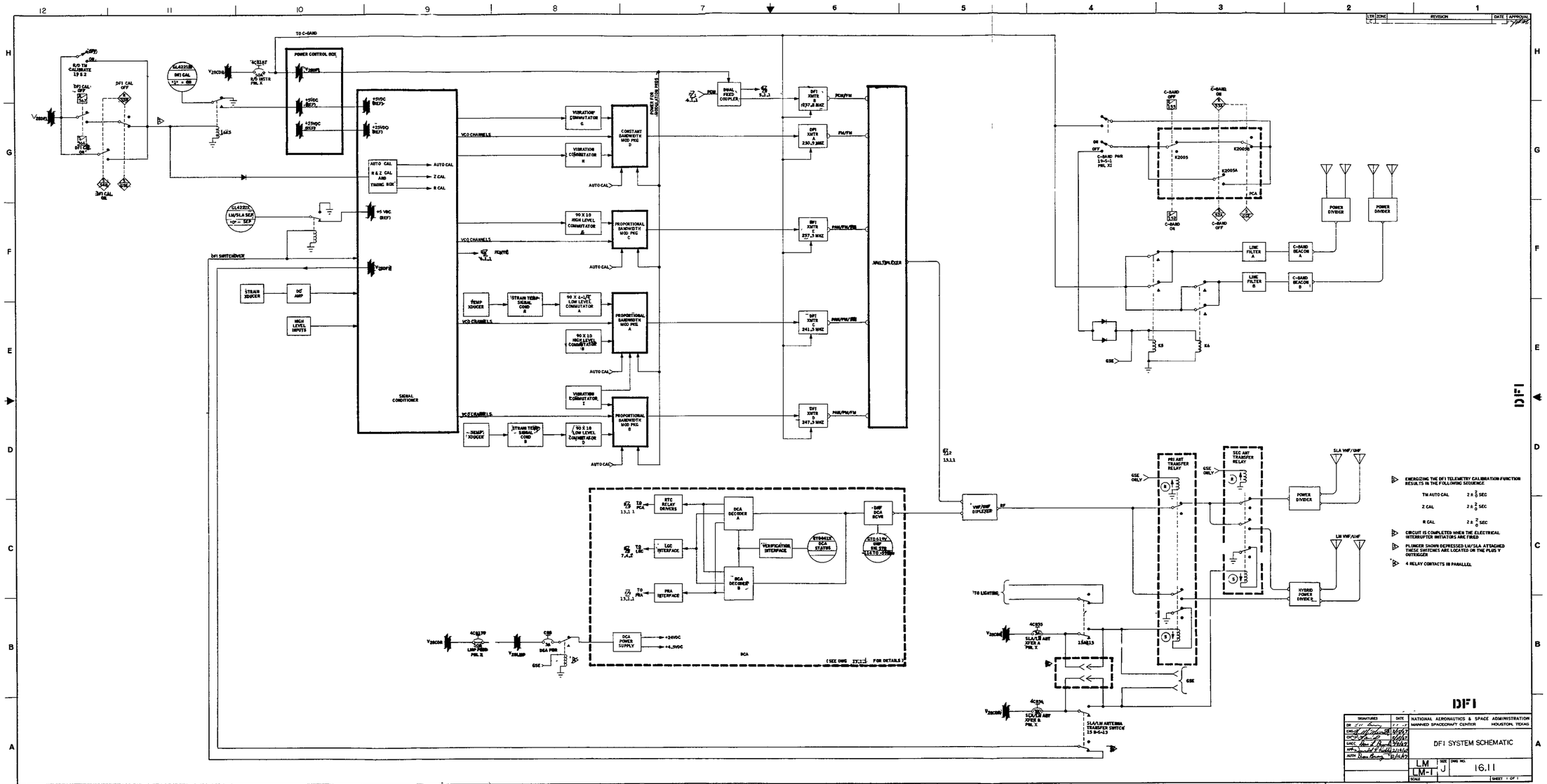
TABLE 16-1 PCM MEASUREMENTS AFFECTED BY DFI CAL

MEAS NO.	MEAS DESCRIPTION	CAL APPLIED
6L4221X	DFICAL	INDICATES A "1" AND REMAINS "ON" DURING CAL COMMAND

TABLE 16-2 PRELAUNCH STATUS OF SWITCH/CIRCUIT BREAKER POSITIONS

NAME	NUMBER	POSITION
SWITCH		
R/D TM CALIBRATE	19S2 P8L X	OFF
C-BAND PWR	19S1 P8L X	ON
CIRCUIT BREAKER		
R/D INST	4CB181	CLOSED
SLA/LM ANT XFER A	4CB35	CLOSED
SLA/LM ANT XFER B	4CB36	CLOSED
DCA PWR	CB5	CLOSED

DWG. NO. 16.1.1
DETAIL SHEET NO. 1


DFI
POWER CONTROL BOX
SIGNAL CONDITIONER
AUTO CAL R & Z CAL AND TIMING BOX
VIBRATION COMMUTATOR C
VIBRATION COMMUTATOR H
CONSTANT BANDWIDTH MOD PKG D
90 X 10 HIGH LEVEL COMMUTATOR E
PROPORTIONAL BANDWIDTH MOD PKG C
TEMP XDUCER
STRAIN TEMP SIGNAL COND B
90 X 4-1/2 LOW LEVEL COMMUTATOR A
90 X 10 HIGH LEVEL COMMUTATOR G
PROPORTIONAL BANDWIDTH MOD PKG A
VIBRATION COMMUTATOR I
PROPORTIONAL BANDWIDTH MOD PKG B
STRAIN XDUCER
DC AMP
HIGH LEVEL INPUTS
DFI SWITCHOVER
DFI CAL
DFI XMTR 1837.8 MHZ
DFI XMTR 230.9 MHZ
DFI XMTR 257.3 MHZ
DFI XMTR 241.5 MHZ
DFI XMTR 247.3 MHZ
MULTIPLEXER
VHF/UHF DIPLEXER
RTC RELAY DRIVERS
LGC INTERFACE
PIRA INTERFACE
DCA DECODER A
DCA DECODER B
VERIFICATION INTERFACE
DCA STATES
DMP DCA RCVR
DCA POWER SUPPLY
DCA
C-BAND ON
C-BAND OFF
K2005
K2005A
PCA
C-BAND BEACON A
C-BAND BEACON B
LINE FILTER A
LINE FILTER B
POWER DIVIDER
PRI ANT TRANSFER RELAY
SEC ANT TRANSFER RELAY
SLA VHF/UHF
LM VHF/UHF
HYBRID POWER DIVIDER
SLA/LM ANTENNA TRANSFER SWITCH
TO LIGHTING
GSE
GSE ONLY
EMERGIZING THE DFI TELEMETRY CALIBRATION FUNCTION RESULTS IN THE FOLLOWING SEQUENCE
TM AUTO CAL 2 ± 1/2 SEC
Z CAL 2 ± 1/2 SEC
R CAL 2 ± 1/2 SEC
CIRCUIT IS COMPLETED WHEN THE ELECTRICAL INTERRUPTER INITIATORS ARE FIRED
PLUNGER SHOWN DEPRESSED LM/SLA ATTACHED THESE SWITCHES ARE LOCATED ON THE PLUS Y OUTRIGGER
4 RELAY CONTACTS IN PARALLEL
DFI
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS
DFI SYSTEM SCHEMATIC
LM-1
J
16.11

APOLLO

LM

LUNAR MODULE SYSTEMS HANDBOOK

VEHICLE LM-1

AS-204/LM-1
REV C

FCD
MSC
NASA