TIMED EMC

Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics

Electromagnetic Compatibility

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Critical Design Review

2, 3, &4 December 1997

TIMED EMC

Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics

<u>Objective:</u> Provide compatible operation of all spacecraft subsystems in the anticipated environments.

- **within the spacecraft (self-compatibility)**
- **during integration and test**
- **during transport (survival)**
- **with the launch environment**
  - **tracking RADARs**
  - **local airplanes & airport operations**
  - **communications**
  - **lightning, etc.**
- **with the launch vehicle**
- **in orbit (electrostatic charging, etc.)**

EMC Control Plan

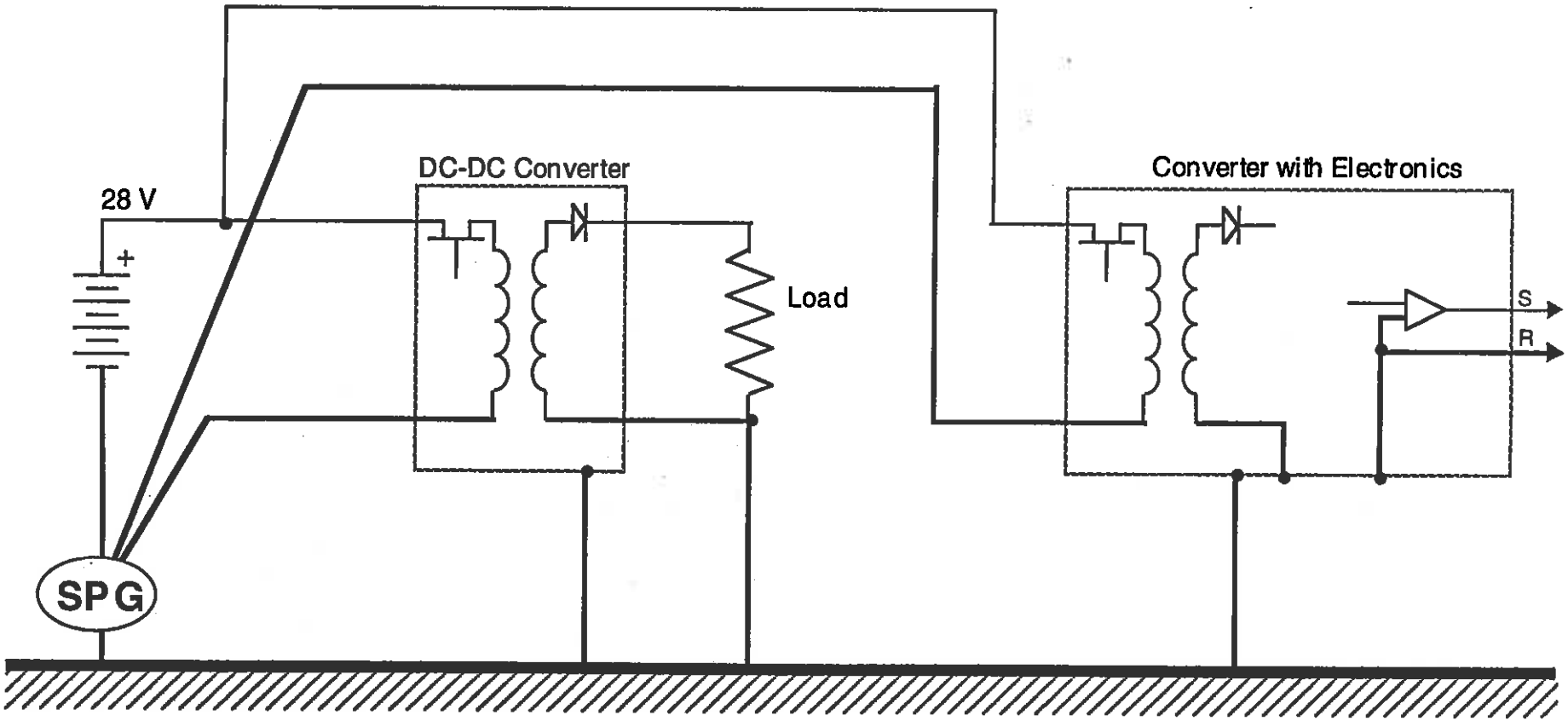
- Subsystem and Instrument EMI design and test requirements are presented in the "TIMED EMC Control Plan and EMI Performance Requirements Specification", 7363-9038.
- EMI testing is required on Instruments and subsystems per CES Table 2.6.2-1.
- Spacecraft self-compatibility tests will be performed at APL after completion of integration.

Design Strategy #1

Avoid injecting signal or power currents into the spacecraft structure.

- Use single point ground (SPG) for primary power circuits
- Limit common mode noise currents particularly at power converters
- Use signal return lines rather than structure
- Use of true differential line drivers / receivers for interface signals is encouraged (preferably 1553 serial bus)

Basic power distribution & grounding



Design Strategy #2

Limit power bus conducted emissions and susceptibility.

- Limit time domain primary power bus current transients and pulses
- Limit frequency domain current emissions
- Test all primary power bus loads for conducted susceptibility
- Component EMI specification similar to MIL-STD-461B
- Use multipoint grounds (MPG) for signals and secondary power
- Suppress motor brush noise at the source

Design Strategy #3

Control radiated emissions and susceptibility.

- Use reasonably shielded enclosures for all electronics
- Shield 1553 bus lines and all other "critical" lines (shielding not required for primary power lines)
- Route signal and secondary power lines well away from primary power wiring (use separate power connector w/Gnd)
- Twist power wiring to minimize magnetic coupling
- Use shielded shipping containers (S/C and Instruments)
- Radiated specification similar to MIL-STD-461B

Design Strategy #4

Protect against common impedance coupling, power faults, and radiated noise coupled signals such as lightning induced currents.

- Hardware electrical bonding to be <2.5 milliohms
- Solid package-to-structure electrical bonds preferred rather than ground straps
- Position wiring harness close to structure
- Terminate cable outer shields externally to connector shells, not through connector pins
- Ground both ends of cable shields (rare exceptions)

Design Strategy #5

Protect against ESD and spacecraft charging (on orbit).

- Always use ESD protection materials and procedures
- Provide ESD protection at all PC board interfaces
- Discharge all cable conductors before connecting
- Design antenna elements to be at DC ground
- Ground all conductive layers of multi-layer insulation
- Use ground wires across all hinges (covers, solar panels, etc.)
- Ground spacecraft to test facility, shipping container, and launch vehicle
- Avoid use of dielectric materials on exposed spacecraft surfaces
- Conductive cover slides over solar cells and optics not required

Design Strategy #6

Protect GSE interfaces.

- Electrically isolate all GSE interfaces that may be connected during or after integration with the spacecraft
- Provide overcurrent and transient protection for external battery charging circuits
- Ground GSE to same ground reference as the spacecraft while maintaining the required green wire safety ground
- Provide EMI filters and transient protection on all GSE AC power input lines (e.g., Isobar)

Spacecraft Self-Compatibility

Test Configurations to Consider

- **Pre-launch Configuration**
  - Solar panels folded
  - Grounded to vehicle
- **Coast Configuration (no test)**
  - Solar panels folded inside DPAF
- **Orbital Configuration (no test)**
  - Solar panels deployed

Pre-launch Test Configuration

- Spacecraft mounted on shaker
- Solar panels attached and folded
- Extended set of 'Pad Functional Test'
- No RF radiation
- Communication through umbilical connector
- No other GSE connected
- Battery power

Hybrid Test Configuration

- Spacecraft mounted on test dolly
- Solar panels attached and folded
- Plugs out; no GSE connected; isolated
- RF up and down links radiated
- GPS RF link radiated
- Special functional test
- Battery power

Orbital Configuration Test

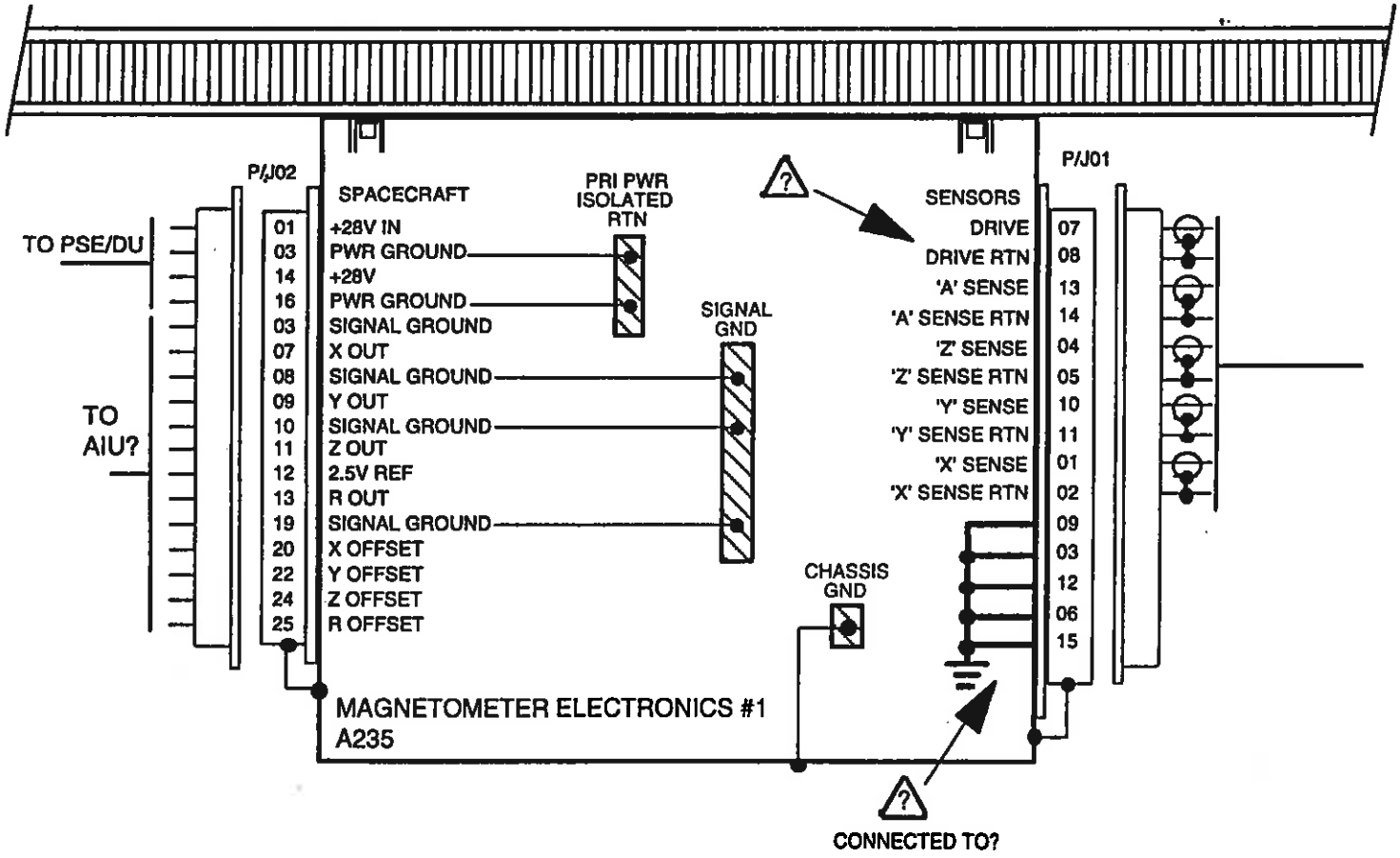
[--No test planned--]

- **Spacecraft mounted on test dolly**
- **Solar panels attached and fully deployed**
- **Plugs out; no GSE connected; isolated**
- **RF up and down links radiated**
- **GPS RF link radiated**
- **Special functional test**
- **Battery power**

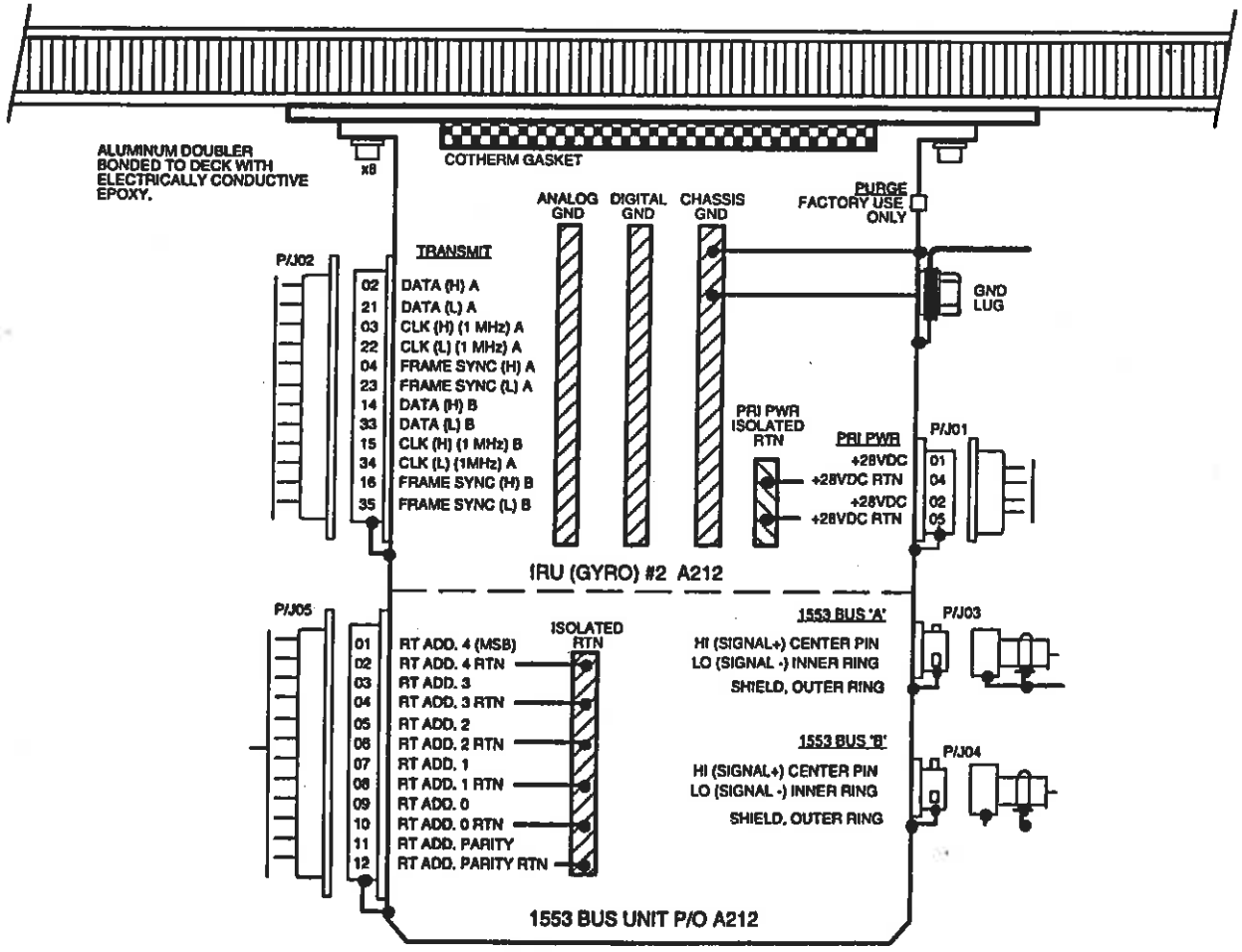
Package Mounting / Grounding

- **Flat mount (metal-to-metal) direct to structure.**
- **Metal feet around Cotherm (insulator).**
- **Two copper straps around Cotherm.**
- **G-10 or titanium insulator plus undefined strap.**
- **Optical bench straps undefined.**

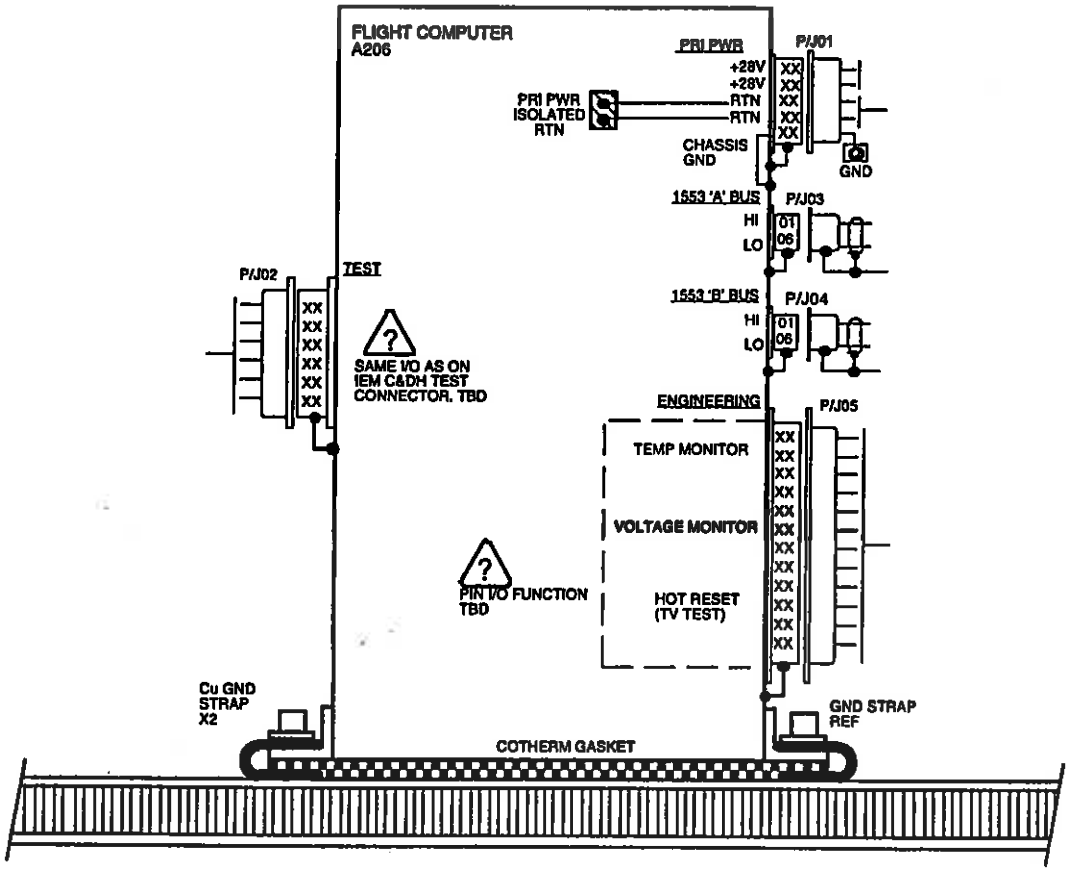
Flat Mount Direct to Structure



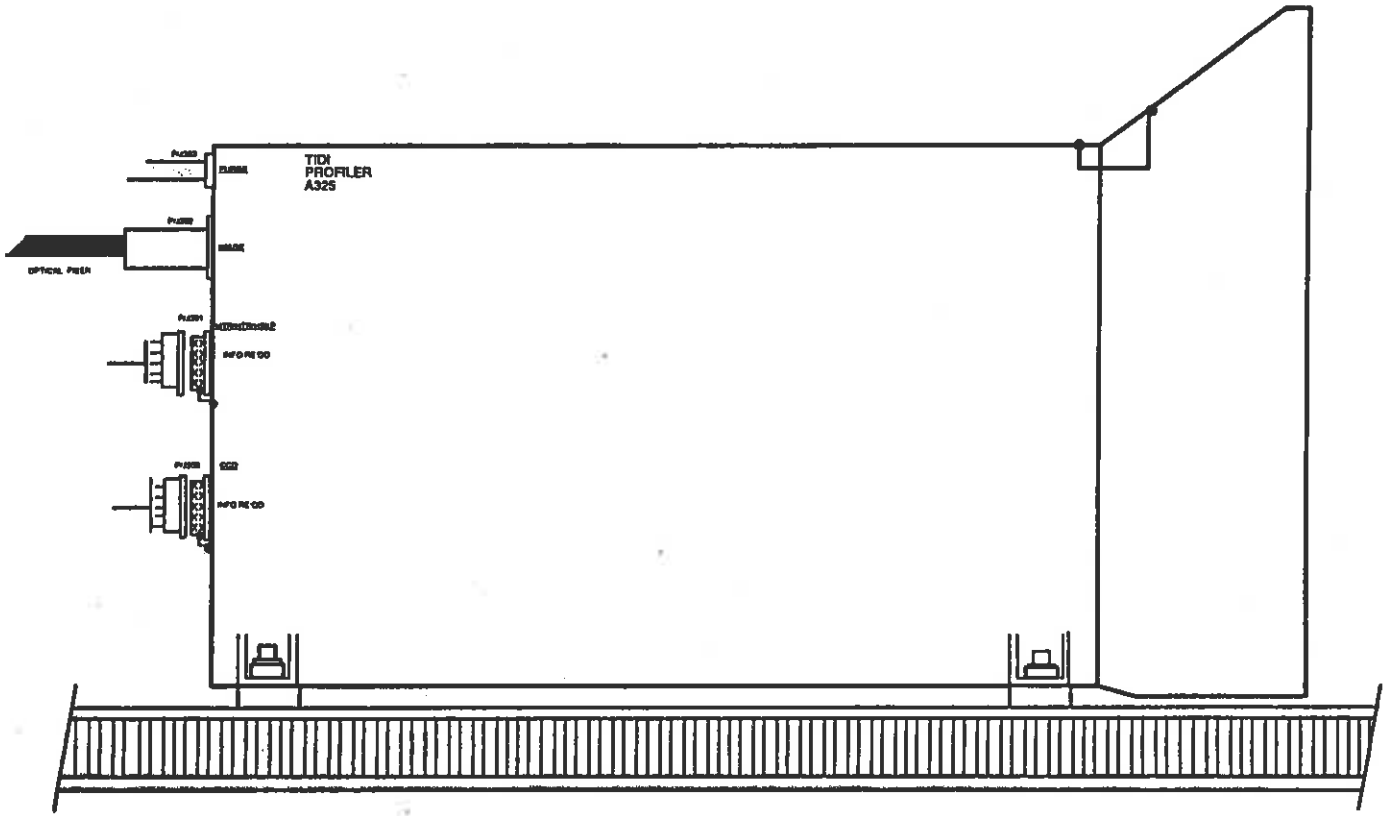
Metal Feet Around Cotherm



Copper Strap Around Cotherm



G-10 or Titanium Insulator & Strap



IEM Grounding Diagram

LYNN HANSON DRAWN BY	SER SECTION	10-23-97 DATE	THE JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY JOHNS HOPKINS ROAD LAUREL, MD. 20723		
G SEYLAR EMC	THERMAL		GROUNDING DIAGRAM INTEGRATED ELECTRONICS MODULE IEM TIMED SPACECRAFT		
SYSTEM	MECH				
RELIABILITY	HARNESS				
APPLICATION MINICAD7, V7.1, MACINTOSH			FSCM NO. 88898	SIZE J	DWG NO. 7363-8166 REV a
			SCALE ——	DO NOT SCALE PRINT	SHEET 1 OF 1

NO.	TITLE	REF	ZONE
01	HOUSING	7363-2105	XX
02	FRONT COVER	7363-2105	XX
03	REAR COVER	7363-2104	XX
04	MOTHER BOARD	7363-2120	XX
05	FLEX CABLE	7363-2120	XX

NO.	TITLE	REF	ZONE
01	CMD AND TLM CKT CARD	A6	XX
02	DC/DC CONVERTER #1 CKT CARD	A1	XX
03	DC/DC CONVERTER #2 CKT CARD	A9	XX
04	DOWNLINK CKT CARD	A7	XX
05	GNS RECEIVER CKT CARD	A4	XX
06	GNS PROCESSOR CKT CARD	A5	XX
07	PROCESSOR, CMD AND DATA HANDLING CKT CARD	A2	XX
08	SOLID STATE RECORDER CKT CARD	A3	XX
09	UPLINK CKT CARD	A8	XX

Spacecraft Grounding Diagram

LYNN HANSON DRAWN BY	SER SECTION	10-23-97 DATE	THE JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY JOHNS HOPKINS ROAD LAUREL, MD. 20723	
G SEYLAR EMC	THERMAL		GROUNDING DIAGRAM SOLAR ARRAY TIMED SPACECRAFT	
SYSTEM	MECH			
RELIABILITY	HARNESS			
APPLICATION MINICAD7, V7.1, MACINTOSH	FSCM NO. 88898	SIZE J	DWG NO. 7363-8100	REV a
	SCALE —	DO NOT SCALE PRINT	SHEET 1 OF 8	

NO.	TITLE	'A' REF	ZONE
01	ACTUATOR, +X (MOTOR DRIVE)	AXXX	XX
02	ACTUATOR, -X (MOTOR DRIVE)	AXXX	XX
03	CONTROL UNIT, +X	AXXX	XX
04	CONTROL UNIT, -X	AXXX	XX
05	FUSE/JUNCTION BOX #1	AXXX	XX
06	FUSE/JUNCTION BOX #2	AXXX	XX
07	SOLAR ARRAY, +X	AXXX	XX
08	SOLAR ARRAY, -X	AXXX	XX

Sheet 1 of 8

Spacecraft Grounding Diagram

LYNN HANSON SER 10-23-97 DRAWN BY SECTION DATE		THE JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY JOHNS HOPKINS ROAD LAUREL, MD. 20723	
G SEYLAR EMC	THERMAL	GROUNDING DIAGRAM OPTICAL BENCH, -Z DECK TIMED SPACECRAFT	
SYSTEM	MECH		
RELIABILITY	HARNESS		
APPLICATION MINICAD7, V7.1, MACINTOSH		FSCM NO. 88898	SIZE J
		DWG NO. 7363-8100	REV a
		SCALE ——	DO NOT SCALE PRINT SHEET 2 OF 8

NO.	TITLE	'A' REF	ZONE
01	ANTENNA, GPS	A150	XX
02	ANTENNA, GPS	A151	XX
03	ANTENNA, S-BAND	A145	XX
04	ANTENNA, S-BAND	A141	XX
05	C&DH 1553 BUS 'B'	BC02-A030	XX
06	C&DH 1553 BUS 'B'	BC05-A030	XX
07	DIPLEXER, S-BAND	A134	XX
08	DIPLEXER, S-BAND	A133	XX
09	G&C 1553 BUS 'B'	BC10-A030	XX
10	G&C 1553 BUS 'B'	BC11-A030	XX
11	G&C 1553 BUS 'B'	BC12-A030	XX
12	G&C 1553 BUS 'A'	BC07-A030	XX
13	G&C 1553 BUS 'A'	BC08-A030	XX
14	G&C 1553 BUS 'A'	BC09-A030	XX
15	IRU (GYRO) #1	A210	XX
16	IRU 1553 BUS UNIT #1	A210	XX
17	IRU (GYRO) #2	A212	XX
18	IRU 1553 BUS UNIT #2	A212	XX
19	PWR SPLITTER, S-BAND	A136	XX
20	PWR SPLITTER, S-BAND	A137	XX
21	RF INTERFACE, S-BAND	A010	XX
22	RF INTERFACE, S-BAND	A011	XX
23	RIU #6A/6B	A115/125	XX
24	RIU #5A/5B	A115/125	XX

NO.	TITLE	'A' REF	ZONE
25	SEE INSTRUMENT	A400	XX
26	TIDI ELECTRONICS DECK ASSEMBLY	A320	XX
27	TIDI INTERFACE BR'KT	A320	XX
28	TIDI TELESCOPE #1	A300	XX
29	TIDI TELESCOPE #2	A301	XX
30	TIDI TELESCOPE #3	A302	XX
31	TIDI TELESCOPE #4	A303	XX
32	TIDI PRIMARY PWR RTN DISTRIBUTION BLOCK	A330-D801	XX
33	TIDI PROFILER	A325	XX
34	TRANSFER SW, S-BAND	A130	XX
35	TRANSFER SW, S-BAND	A132	
36	SOLAR ARRAY +X ACTUATOR SEE SHEET 1	AXXX	----
37	SOLAR ARRAY -X ACTUATOR SEE SHEET 1	AXXX	----
38	SOLAR ARRAY CONTROL UNIT AXXX SEE SHEET 1	AXXX	----

Sheet 2 of 8

Spacecraft Grounding Diagram

LYNN HANSON DRAWN BY	SER SECTION	10-23-97 DATE	THE JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY JOHNS HOPKINS ROAD LAUREL, MD. 20723	
G SEYLAR EMC	THERMAL		GROUNDING DIAGRAM +X PANEL TIMED SPACECRAFT	
SYSTEM	MECH			
RELIABILITY	HARNESS			
APPLICATION MINICAD7, V7.1, MACINTOSH	FSCM NO. 88898	SIZE J	DWG NO. 7363-8100	REV a
	SCALE —	DO NOT SCALE PRINT	SHEET 3 OF 8	

NO.	TITLE	'A' REF	ZONE
01	PSE/DU	A150	XX
02	PSE/DU, RELAY CARDS	A150	SHEET 4

Sheets 3 & 4 of 8

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G SEYLAR EMC	THERMAL		GROUNDING DIAGRAM +X PANEL TIMED SPACECRAFT	
SYSTEM	MECH			
RELIABILITY	HARNESS			
APPLICATION MINICAD7, V7.1, MACINTOSH	FSCM NO. 88898	SIZE J	DWG NO. 7363-8100	REV a
	SCALE —	DO NOT SCALE PRINT	SHEET 4 OF 8	

NO.	TITLE	'A' REF	ZONE
01	PSE/DU, RELAY CARDS	A150	XX
02	PSE/DU	A150	SHEET 3

Spacecraft Grounding Diagram

LYNN HANSON SER 10-23-97 DRAWN BY SECTION DATE		THE JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY JOHNS HOPKINS ROAD LAUREL, MD 20723		
EMC G SEYLAR	THERMAL	GROUNDING DIAGRAM +Y PANEL TIMED SPACECRAFT		
SYSTEM	MECH			
RELIABILITY	HARNESS			
APPLICATION MINICAD7, V7.1, MACINTOSH		FSCM NO. 88898	SIZE J	DWG NO. 7363-8100 REV a
		SCALE ——	DO NOT SCALE PRINT	SHEET 5 OF 8

NO.	TITLE	'A' REF	ZONE
01	C&DH1553 BUS 'A'	BC03-A030	XX
02	C&DH 1553 BUS 'B'	BC06-A030	XX
03	IEM #1	A101	XX
04	IEM #2	A102	XX
05	MAGNETOMETER ELECTRONICS #1	A235	XX
06	MAGNETOMETER ELECTRONICS #2	A237	XX
07	RIU #1A-RIU#1B	A110/120	XX
08	SABER	A500	XX
09	TORQUE ROD X AXIS	AXXX	XX

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EMC G SEYLAR	THERMAL		GROUNDING DIAGRAM +X PANEL TIMED SPACECRAFT	
SYSTEM	MECH			
RELIABILITY	HARNESS			
APPLICATION MINICAD7, V7.1, MACINTOSH	FSCM NO. 88898	SIZE J	DWG NO. 7363-8100	REV a
	SCALE —	DO NOT SCALE PRINT	SHEET 6 OF 8	

NO.	TITLE	'A' REF	ZONE
01	AIU	A200	XX
02	ARMING (PYRO) PLUG	A035	XX
03	BATTERY, +X	AXX	XX
04	C&DH 1553 BUS 'A'	BC01-A030	XX
05	C&DH 1553 BUS 'B'	BC04-A030	XX
06	PPTCM 'SIDE 2'	A055	XX
07	TEST CONNECTOR PANEL	A026	XX
08	TORQUE ROD Y AXIS	AXX	XX

Sheets 6 & 7 of 8

LYNN HANSON DRAWN BY	SER SECTION	10-23-97 DATE	THE JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY JOHNS HOPKINS ROAD LAUREL, MD. 20723	
EMC G SEYLAR	THERMAL		GROUNDING DIAGRAM -X PANEL TIMED SPACECRAFT	
SYSTEM	MECH			
RELIABILITY	HARNESS			
APPLICATION MINICAD7, V7.1, MACINTOSH	FSCM NO. 88898	SIZE J	DWG NO. 7363-8100	REV a
	SCALE —	DO NOT SCALE PRINT	SHEET 7 OF 8	

NO.	TITLE	'A' REF	ZONE
01	BATTERY, -X	AXXX	XX
02	FLIGHT COMPUTER #1	A205	XX
03	FLIGHT COMPUTER #2	A206	XX
04	GUVI ELECTRONICS CONTROL UNIT	A625	XX
05	PPTCM 'SIDE 1'	A054	XX
06	RIU #4	A113/123	XX
07	RIU #2	A111/121	XX
08	SUN SENSOR 1B'	AXXX	XX
09	SUN SENSOR '2B'	AXXX	XX
10	SUN SENSOR '2A'	AXXX	XX
11	SUN SENSOR '2A'	AXXX	XX
12	TORQUE ROD, Z AXIS	AXXX	XX

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G SEYLAR EMC	THERMAL		GROUNDING DIAGRAM +Z DECK, PAYLOAD ADAPTER TIMED SPACECRAFT	
SYSTEM	MECH			
RELIABILITY	HARNESS			
APPLICATION MINICAD7, V7.1, MACINTOSH			FSCM NO. 88898	SIZE J
			DWG NO. 7363-8100	REV a
			SCALE ——	DO NOT SCALE PRINT
			SHEET 8 OF 8	

Sheet 8 of 8

NO.	TITLE	'A' REF	ZONE
01	ANTENNA, BAND	A146	XX
02	ANTENNA, S-BAND	A145	XX
03	GUVI FPE #1	A610	XX
04	GUVI FPE #2	A612	XX
05	GUVI HVPS #1	A620	XX
06	GUVI HVPS #2	A622	XX
07	GUVI SIS ELECTRONICS	A605	XX
08	GUVI SIS OPTICAL HOUSING	A600	XX
09	REACTION WHEEL #1	A241	XX
10	REACTION WHEEL #2	A243	XX
11	REACTION WHEEL #3	A245	XX
12	REACTION WHEEL #4	A247	XX
13	RF INTERFACE	A009	XX
14	RF INTERFACE	A008	XX
15	RIU #3A - RIU #3B	A111/112	XX
16	SENSOR MAGNETOMETER #1	A235	XX
17	SENSOR MAGNETOMETER #2	A237	XX
18	SEPARATION SWITCH	AXXX	XX
19	SEPARATION SWITCH	AXXX	XX
20	UMBILICAL, PURGE	AXXX	XX
21	UMBILICAL CONNECTOR	A024-J1	XX
22	UMBILICAL CONNECTOR	A024-J2	XX