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PHOTOGRAPHIC SYSTEM REFERENCE HANDBOOK
FOR
GAMBIT RECONNAISSANCE SYSTEM
WITH
EXTENDED ALTITUDE CAPABILITY
(EAC)

VOLUME 4

Prepared by
BIF-008

Under Contract [redacted] 25X1

Approved by:

1 July 1980

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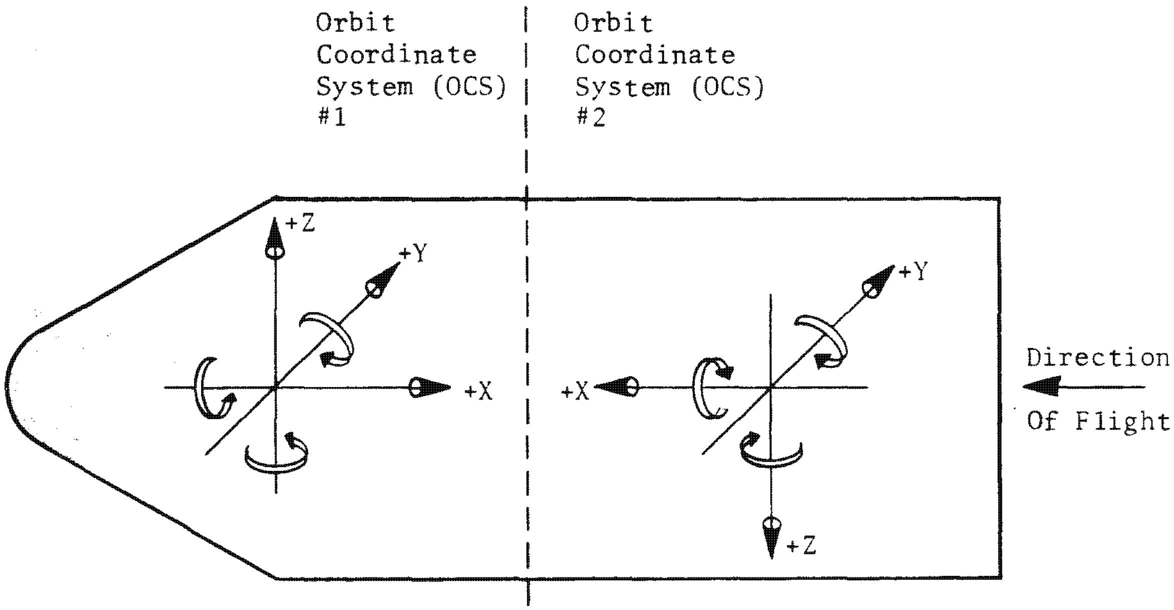

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TABLE OF CONTENTS

VOLUME 4
PART 3 - HARDWARE DESCRIPTION

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

VOLUME 4

LIST OF ILLUSTRATIONS (Continued)

VOLUME 4

LIST OF ILLUSTRATIONS (Continued)

VOLUME 4

LIST OF ILLUSTRATIONS (Continued)

VOLUME 4

LIST OF TABLES

VOLUME 4

5.0 VIEWPORT DOOR SUBSYSTEM

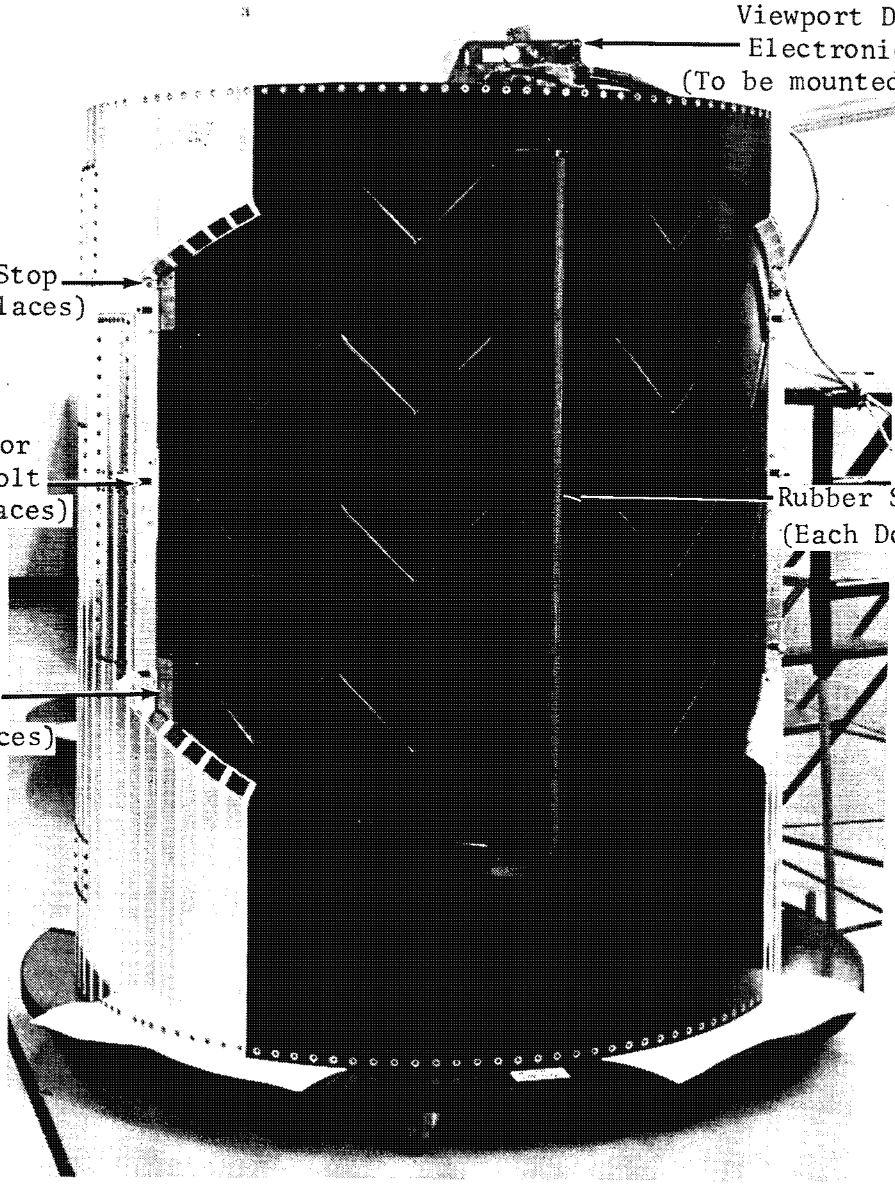
The viewport doors, mounted on the forward barrel of the camera optics module, provide the means to open and close the opening through which light enters the PPS/DP EAC optical system. The viewport door subsystem consists of the viewport door electronics, bomb bay-type doors (Figure 3.5-1) and associated drive linkages and motors, and an ejectable hatch covering the doors during shipment and launch.

The doors are opened for photographic activity and are closed during nonactive intervals for thermal control and lighttightness. Closing prevents heat losses during the dark portion of the orbit and also protects against the possibility of direct sunlight impingement on the optics, commonly referred to as SLOP and SLOS (sunlight on primary; sunlight on stereo). Opening or closing the doors during nonphotographic intervals also aids in controlling COM temperature variations through radiant heating or cooling.

Three modes of operation are provided by the viewport door subsystem: primary, backup, and door-blow. A description of each is provided in Section 5.3.

5.1 Ejectable Hatch

The ejectable hatch fits flush with the PPS/DP EAC exterior, protecting the viewport doors, and sealing the vehicle against light and contamination (rain, dust, etc.). The hatch is a nonstructural member of the PPS/DP EAC held to the forward barrel by six pin-puller assemblies. Two pyrotechnic devices are used per pin-



NOTE: Figure 3.1-20 in Part 3, Section 1 illustrates the forward barrel with the viewport doors open.

BIF-008 Vehicle Coordinates

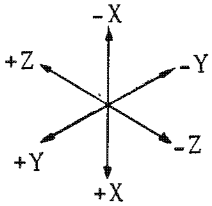


Figure 3.5-1. Forward Barrel and Viewport Doors

puller, either one of which is capable of retracting the pin. Rubber snubbers on the hatch press against the doors to prevent shaking and rubber gaskets around the hatch edge maintain a pressure-tight seal (Figure 3.5-2). Four leaf springs are used to push the hatch away from the vehicle when it is released. Ejection normally occurs subsequent to Agena cutoff (approximately 610 seconds into flight), with a maximum limit of 30 minutes after launch to ensure that the hatch moves clear of the vehicle.

5.2 Viewport Doors and Door Drive Linkage

The viewport doors are suspended on hinges and rotate about a line parallel to the vehicle X-axis. The door drive mechanism, illustrated in Figure 3.5-3, consists of torsion springs, the door actuating arms, and the primary and backup drive motors. A spider link mounted on the partial bulkhead of the forward barrel connects all of the drive components, excluding the torsion springs. The drive motors are supported by the same partial bulkhead and attach to the spider through special connecting links.

5.2.1 Viewport Door Structure

The clamshell-shaped doors are nonstructural members of the PPS/DP EAC. Each door is attached to, and driven by, a door hinge assembly, which in turn is supported by the forward barrel box beam. Rubber seals at the outer edge of each door (-Z) protect the doors when butting, and provide an excellent light seal. A metal stop on each door is used to limit the door-open position in the backup and door-blow operational modes.

The inner surface is covered by a multilayer thermal insulation blanket. A screen attached to the door covers the blanket to prevent excessive billowing

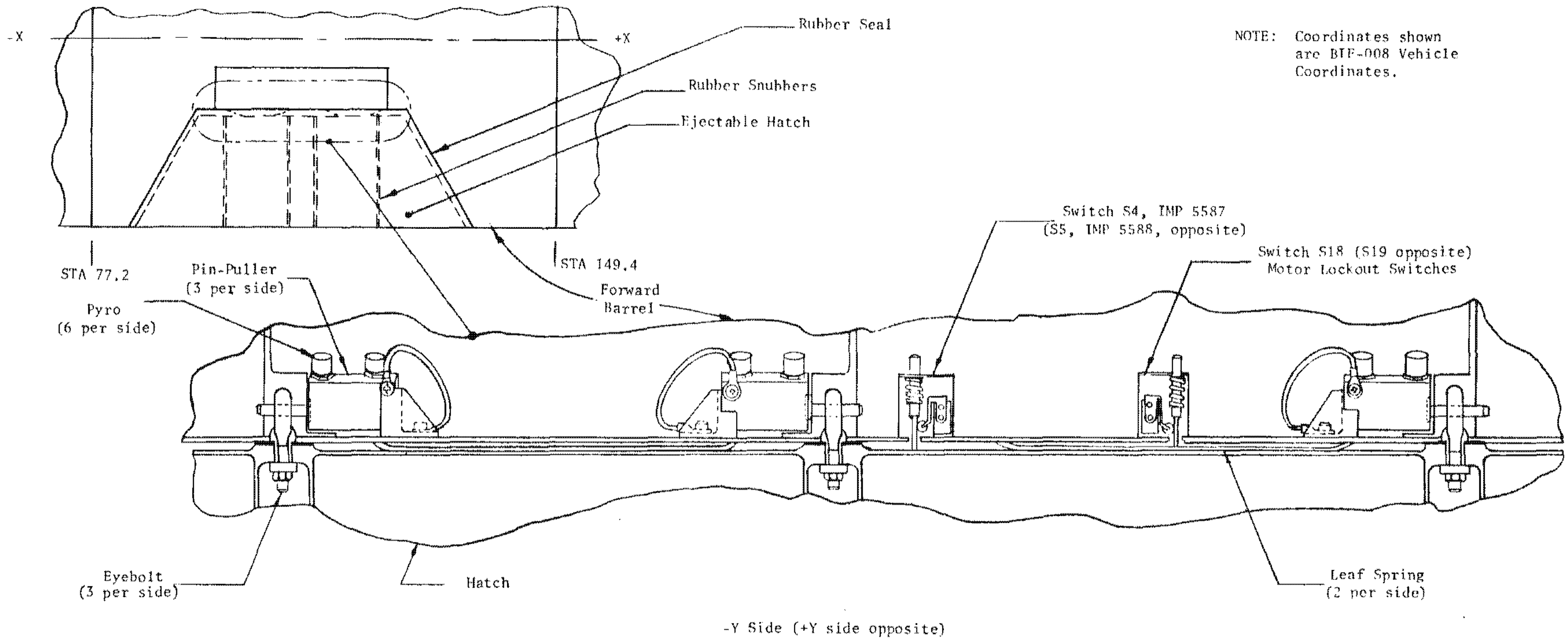


Figure 3.5-2. Hatch Ejection Mechanism

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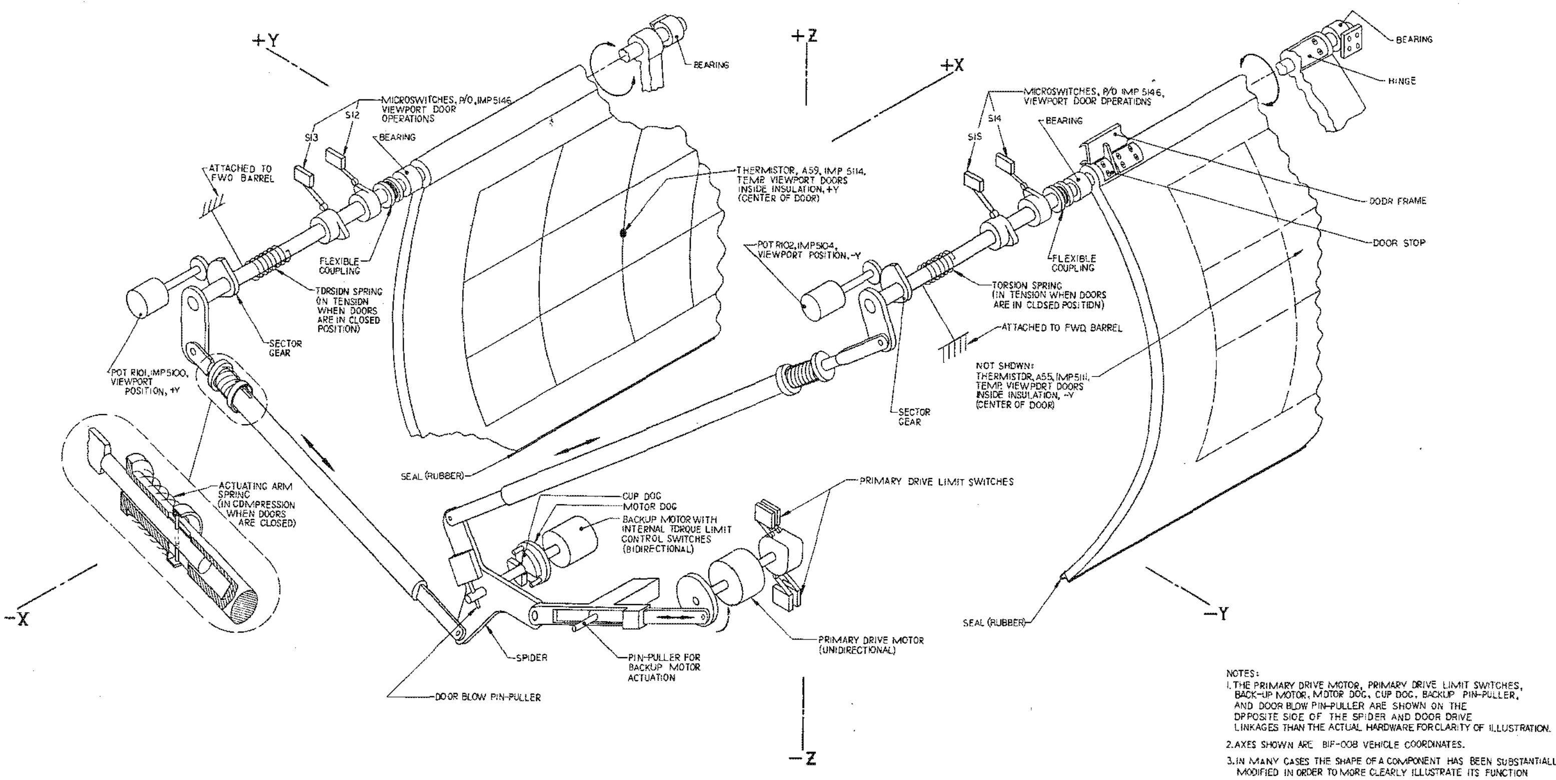

Figure 3.5-3. Viewport Door Drive Mechanism and Instrumentation

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as air escapes during launch, and supports the ground heater tapes which will be removed effective with FM-50 (reference Part 3, Section 8). Mounted at the center of each screen is a thermistor used to monitor temperatures during flight.

5.2.1.1 Door Hinge Assembly. The door hinge assembly is shown in Figure 3.5-3. The hinge shaft is supported at each end by a self-aligning bearing attached to the vehicle box beam. The door hinges attach to the shaft between the two bearings. A flexible coupler at the -X end of the hinge-support shaft connects to a shorter segment which is driven by the actuating arm and a torsion spring. Cams on this section operate the door counter microswitches, and the attached sector gear drives the door position instrumentation potentiometer.

The use of self-aligning bearings provides adequate margins of clearance between the bearings and door hinges and allows the doors to function normally during structural changes caused by thermal conditions. Normal hotdogging of the COM will not cause binding along the door-hinge line.

5.2.2 Viewport Door Drive Mechanism

The viewport door drive mechanism consists of those components necessary to operate the doors in the primary, backup and door-blow modes.

5.2.2.1 Primary Drive Motor and Linkage. Primary drive is provided by a unidirectional dc motor located on the +X side of the forward barrel partial bulkhead. The motor actuates the primary drive linkage from the spider through an eccentric which rotates in 180-degree increments for door open and door close. The primary drive linkage consists of two sections held together during primary mode operation by a pin-puller assembly. Two pyrotechnic devices are available to actuate the pin-puller upon command; either can generate sufficient force to retract the pin. When using the backup mode (pin retracted), the two parts slide, one within the other, as the spider rotates.

The primary drive motor is capable of developing sufficient torque to damage the linkage, should binding occur between the eccentric and the flexible coupling on the door support shaft. Microswitches, actuated by a cam on the motor shaft, stop the motor when it has reached its commanded position (refer to Section 5.3.1.4 for primary mode operation).

5.2.2.2 Backup Drive Motor and Linkage. In the event of a failure in the primary drive, a secondary drive system is available which can be commanded to open and close the doors after actuation of the pyrotechnic pin-puller in the primary drive linkage. The backup system utilizes a bidirectional drive motor with internal, mechanically actuated, torque-limit switches to control the motor open and close positions.

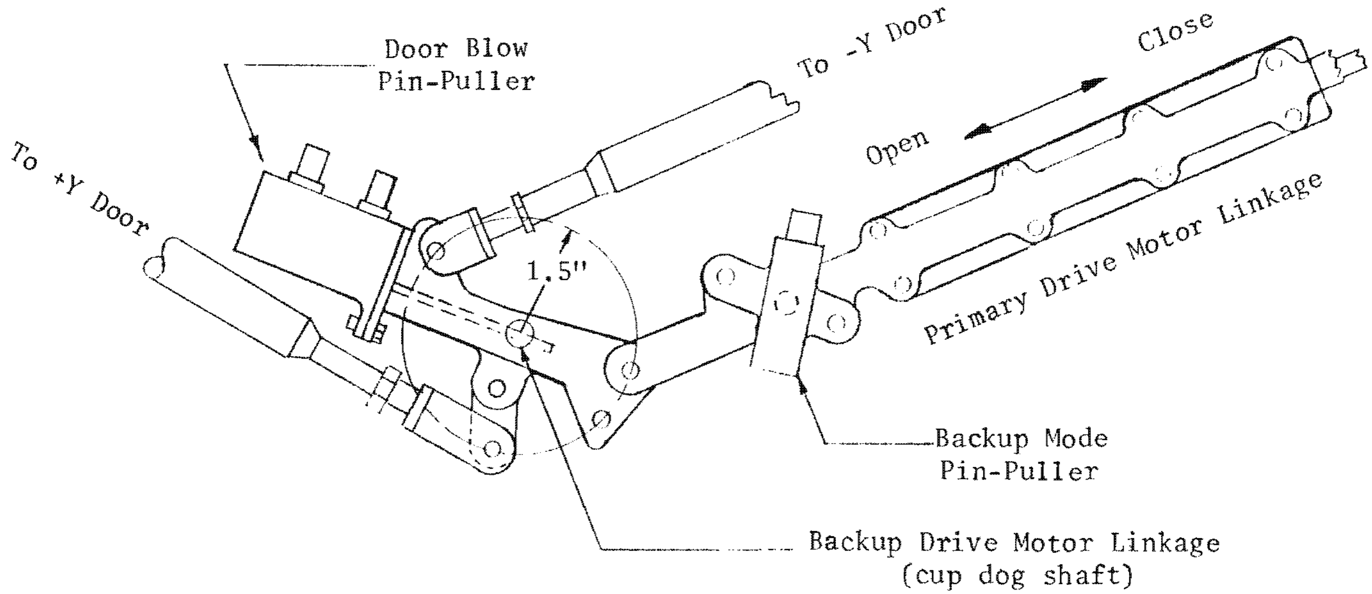
The backup motor is attached to the partial bulkhead of the forward barrel and extends into the supply electronics module section of the vehicle through a cutout provided in the aft end of the SEM. A cup and motor dog linkage (reference Figure 3.5-3) connects the backup drive to the spider assembly. Spacing between opposite shoulders of the cup dog is sufficient to allow the primary drive to open and close the doors without turning the motor dog. In the backup mode, the doors will not begin to move until the motor dog contacts the shoulders of the cup dog, providing a solid link between the motor and door actuating arms. In operation, the backup motor will supply less torque than the primary drive. Binding in the door linkage will cause the torque-sensing switches to trip before the linkage can be damaged.

5.2.2.3 Spider and Actuating Arms. The spider joins the primary and backup drives and the door actuating arms, and, in conjunction with the backup drive cup dog shaft, forms the door-blow mode disconnect point. The primary drive link and door arm attachment points lie on a 1.5-inch radius from the center of rotation. As shown in Figure 3.5-4, a pin-puller, actuated by redundant pyros, locks the spider and cup dog shaft together in the primary and backup modes. Retracting the pin (door-blow) after disconnecting the primary drive link allows the spider to rotate freely. The torsion springs will then force open the doors and hold them in the open position permanently.

Operation of the door actuating arms can best be understood by referring to Figure 3.5-3. The arm is a two-section rod, one sliding inside the other. A pin fastens the two together and holds the spring retainer cap in position. The pin moves in a slot on the outer section as the arm extends. When opening, the pin is driven up against the end of the slot (spring relaxed) and the arm is effectively a solid rod driving the doors. During closing, the spring compresses until its force exceeds that generated by the hinge-line torsion spring, and door motion begins. The motor is adjusted to drive slightly past the door closed position, compressing the arm spring further to ensure that the doors seal tightly. However, the pin does not contact the end of the slot.

5.3 Viewport Door Electronics Module

The viewport door electronics module, located on the -Y side of the SEM near Station 77 (reference Part 3, Section 1), provides the circuitry to operate the viewport door subsystem and also the telemetry to verify its operation. The unit interfaces with the command processor and the initiator electronics unit for commands, receives power from the power monitor and control unit, and provides instrumentation outputs to the instrumentation processor.



NOTES:

1. Backup drive motor removed for clarity.
2. Coordinates referenced are BIF-008 vehicle coordinates.

Figure 3.5-4. Spider Linkage (-X View)

For electromagnetic interference control the unit is compartmentalized with filters between the two sections. The "clean" side of the enclosure contains two small resistor-divider network circuit boards for forward barrel instrumentation and harnessing. The "dirty" side of the enclosure contains the relay door operations counter circuitry and the motor control circuitry. The entire unit is foam potted.

5.3.1 Viewport Door Control

Figure 3.5-5 presents a simplified electrical diagram of the door control circuitry, showing the primary and backup door drives and the hatch eject and door-blow actuation signals from the initiator electronics unit.

5.3.1.1 Hatch Eject. Ejection of the main hatch is accomplished by the actuation of six pyrotechnic pin-pullers, releasing the hatch and allowing leaf springs to push the hatch free from the vehicle. The circuitry controlling the pin-pullers is located in the initiator electronics unit along with instrumentation for command receipt and firing pulse generation verification.

Four microswitches on the +Y and -Y sides of the hatch (two per side) form part of the instrumentation and control circuit. Upon release of the hatch, one set (+Y and -Y) provides redundant 5-volt signals through the viewport door electronics to the instrumentation processor for telemetry. The second set (wired in parallel) connects the primary door motor return line to the viewport door electronics module, enabling the primary door drive.

5.3.1.2 Primary to Backup Drive Switchover. Redundant latching relays are used to switch unregulated power (24.5 vdc nominal) from the primary to the backup drive circuitry upon command. These relays are reset to the primary mode prior to launch by the LAUNCH PRESET command from the vehicle umbilical line. They cannot be reset on-orbit, therefore, primary to backup switchover is irreversible after launch.

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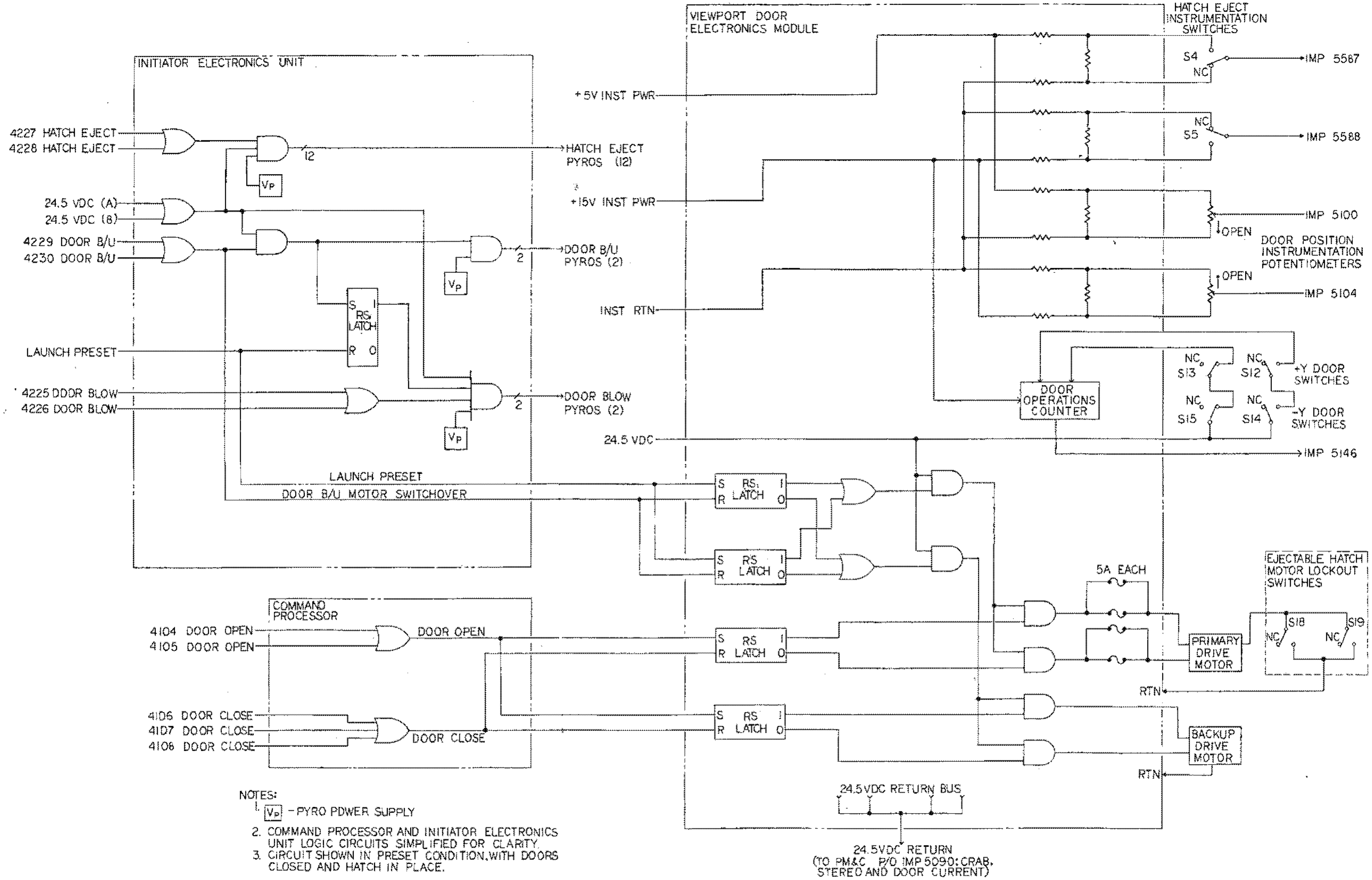

Figure 3.5-5. Viewport Door Subsystem Electronics

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5.3.1.3 Door Open/Close Circuit. The two motor-drive relays, primary and backup, are operated in parallel by the DOOR OPEN/CLOSE command inputs. Power is provided to one of the two relays as determined by the status of the primary to backup switchover circuit (Section 5.3.1.2). Power output to the motors is fused only for the primary open/close lines, using two parallel 5.0-ampere fuses per line.

5.3.1.4 Primary Drive Control and Operation. The primary drive employs a unidirectional dc motor which, upon receipt of 24.5 vdc power (DOOR OPEN or DOOR CLOSE command) from the viewport door electronics, drives to the commanded state. To prevent door operation with the ejectable hatch in place, two redundant interlock switches are connected in series with the primary motor power return (Section 5.3.1.1). Once the hatch is ejected, the switches close and complete the circuit. This is the only enabling function necessary for primary door operation.

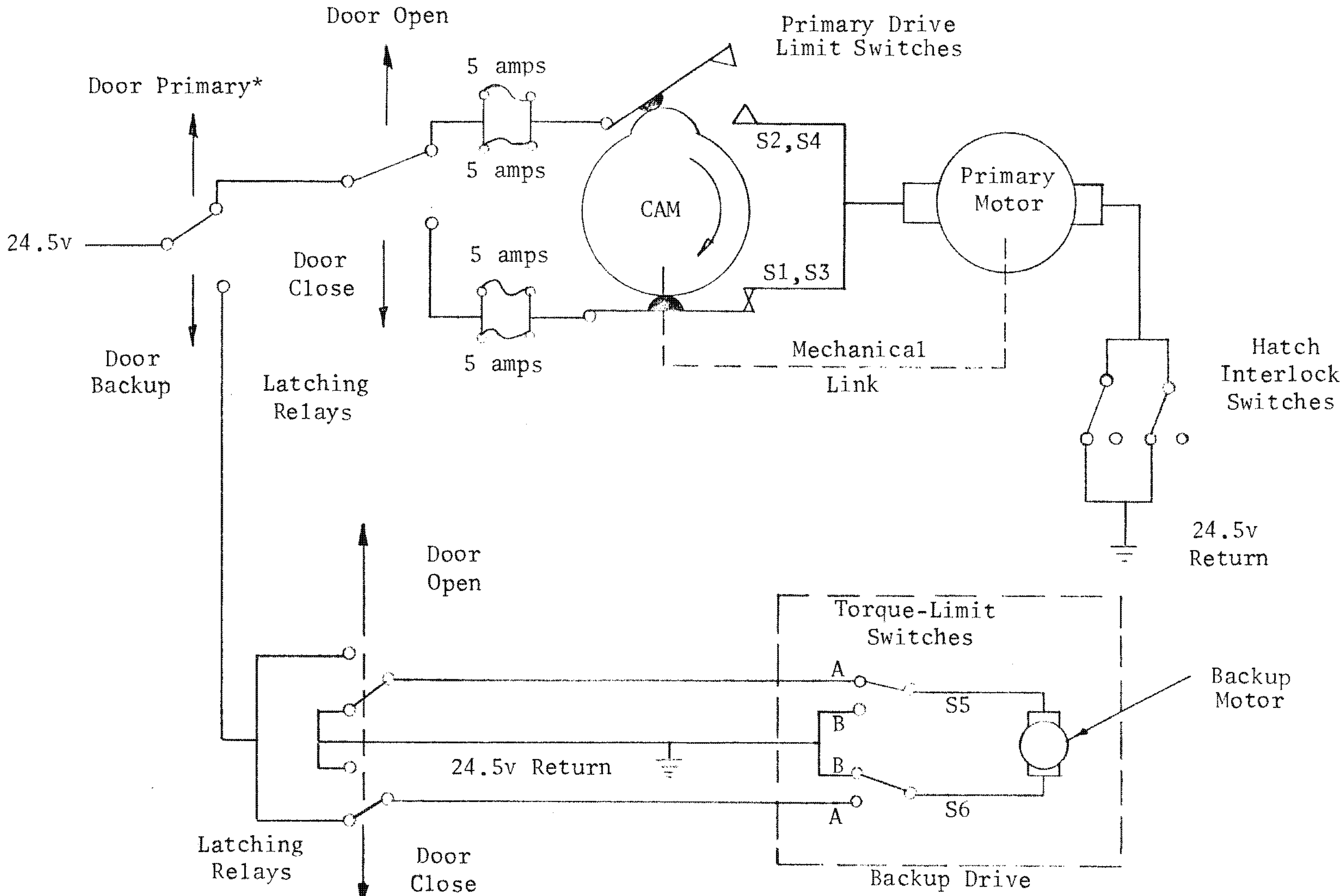
Two pair of parallel redundant limit switches, actuated by a cam on the motor shaft, remove power from the primary motor when it reaches the commanded state. Once the door open limit switches have been actuated (circuit opened), the door motor will not operate unless the DOOR CLOSE command is given. When the doors reach the fully closed position, the other pair of drive limit switches are actuated, and the doors will not move until the DOOR OPEN command is given.

The limit switches allow opposite commands to operate the subsystem only after the doors have completed one third to one half of their normal transition (normal transition time: 7 seconds). If an opposite command is given during the first part of the transition, when one of the pairs of switches are open, a loss of power will result and the motor will stop. the original command must be repeated to apply power to the motor. If both pairs of limit switches are closed and an opposite command is given during transition, the motor will satisfy the original command, and continue running (moving the doors in the reverse direction) to also satisfy the second command.

5.3.1.5 Backup Door Control and Operation. The backup drive can be commanded to open and close the doors after actuation of a pyrotechnic pin-puller, which disengages the primary drive link from the spider (Figure 3.5-4). In executing this command, the initiator electronics unit (IEU) simultaneously transmits a pulse to the primary-to-backup switchover circuitry in the viewport door electronics module, transferring power to the backup motor drive relay.

The backup motor, as previously described, is a bidirectional dc motor which drives the spider through a cup and dog linkage (reference Figure 3.5-3). The motor open and close positions are controlled by mechanically actuated torque-limit switches (S5 and S6 on Figure 3.5-6) located inside the back-up motor housing. Switches S5 and S6 are shown in their positions when the doors are fully closed. Switch S6 is tripped to position B due to torque-sensing, switch S5 is not tripped and is in position A. The operation of this system is described for the open and close cycles as follows:

(1) A DOOR OPEN command switches power of correct polarity to the motor and the motor runs allowing the torsion springs on the door hinges to open the doors. As the doors leave the closed position, switch S6 is released and trips back to position A. The cup dog follows the motor dog (the motor is restraining the springs) allowing a steady linear drive. When the doors hit the full open stop, the cup stops and the motor drives through the deadband until it hits the other cup dog shoulder. The sudden increase in motor torque at this point causes the torque-sensing mechanism to trip S5 to position B removing power from the motor.



NOTE: S5 and S6 are torque actuated.
* Launch preset command

Figure 3.5-6. Motor Drive Control

(2) A DOOR CLOSE command switches power of correct polarity to the motor. The motor drives from one cup dog to the opposite cup dog before actually starting to close the doors. As the motor begins to turn, switch S5 is released and trips back to position A. Once the cup dog is engaged, the motor drives linearly all the way (against the torsion springs) until the doors hit the fully closed stop (the door frame). The sudden increase in motor torque at this point causes the torque-sensing mechanism to trip S6 to position B, removing power from the motor.

The normal transition time for the doors to operate in the backup mode is 14 seconds. It should be noted that the backup motor will supply less opening torque than the primary motor drive.

With the viewport doors closed, the motor dog and cup dog are in such a position that commanding DOOR BACKUP results in the doors being immediately driven open by the hinge-line torsion springs. They can then be closed upon commanding DOOR CLOSE, and the backup mode will operate normally thereafter. The backup mode of operation cannot be reversed to the primary mode.

5.3.1.6 Viewport Door Blow. The DOOR BLOW command, processed in the IEU, does not literally blow open the doors as implied, but causes a pyrotechnic pin-puller to fire, disengaging the backup motor from the spider (reference Figure 3.5-3). Since the primary drive linkage is already disconnected (execution of DOOR BACKUP is necessary to enable DOOR BLOW), the torsion springs on the hinge-line will cause the doors to open fully. The doors bounce slightly before settling against the door stop and remain open. The torque exerted by the springs to open the doors is marginal, and it is very unlikely that the springs would force the doors through a mechanical bind which would prevent both the primary and backup motors from opening the doors.

Normally, the primary drive would be used unless it malfunctions, then a switch-over to the backup drive and, as a last resort, the door-blow condition which leaves the doors open permanently.

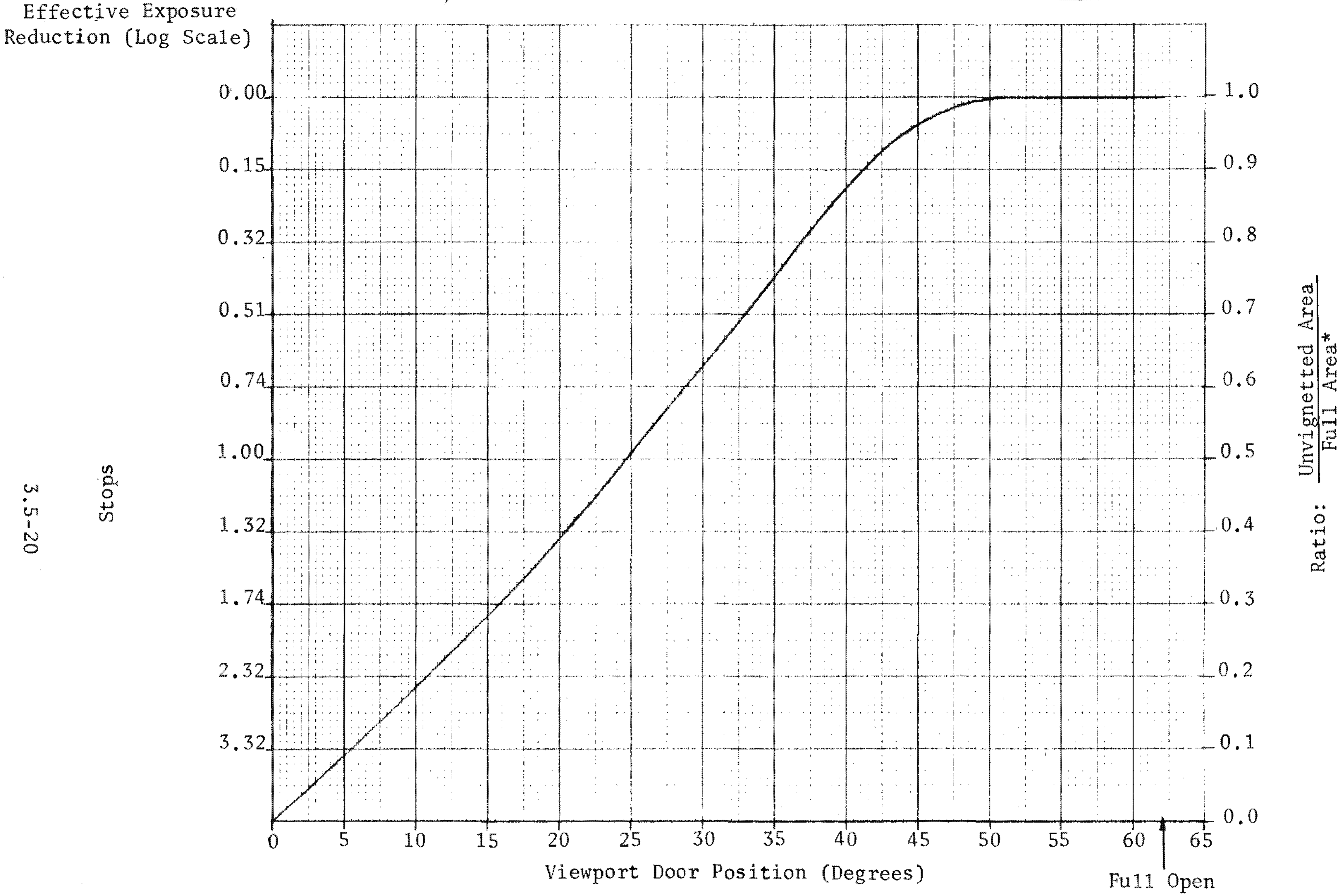
5.3.1.7 Vignetting (Incomplete Viewport Door Opening). The principal effect of having the viewport doors only partially open is a reduction in photographic exposure. Providing that the doors open wider than some minimum amount, this result can be compensated for by commanding a wider exposure slit than that which would normally be used. Expected values of exposure reduction versus door position are presented in Figure 3.5-7.

Failure of the doors to open fully, or close fully, can often be detected by variations in the focus detector input levels. As such, the focus detector instrumentation can provide useful additional information in conjunction with the normal door instrumentation.

5.3.1.8 Operational Waveforms. The following graphs (Figures 3.5-8 through 3.5-12) present typical door position and motor current traces, as applicable, for the primary, backup, and door-blow modes. The current amplitudes and door transition times are typical and should not be taken as representative of any one vehicle. For specific values, refer to the Flight Model Calibration Book supplied with each vehicle.

5.4 Viewport Door Subsystem Instrumentation

Table 3.5-1 summarizes the instrumentation associated with the viewport doors.



*Full Area : The unvignetted lens area at the field position of interest with the viewport doors fully open (excluding S1 sensor vignetting).

Figure 3.5-7. Ratio of Lens Area as a Function of Viewport Door Position

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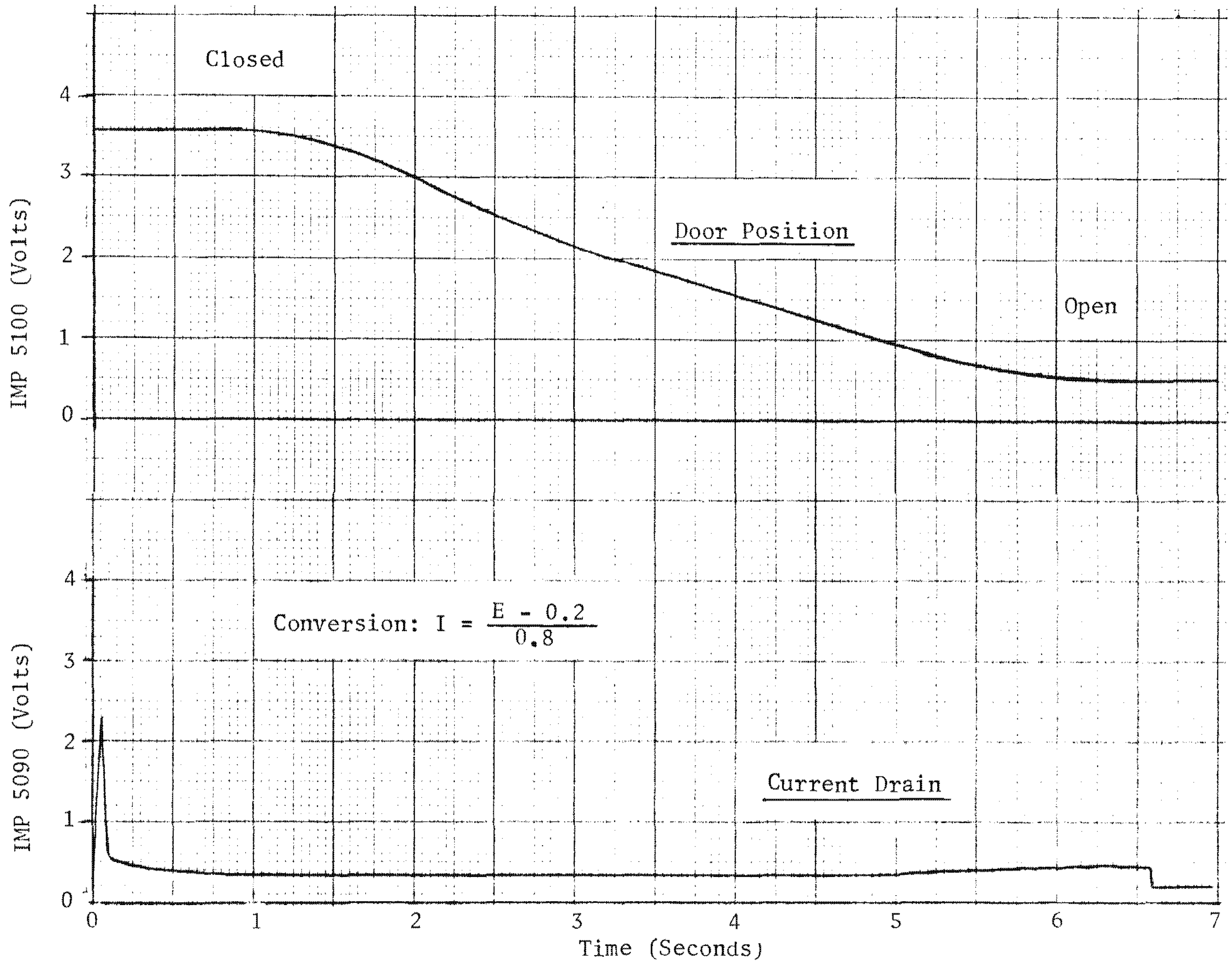

Figure 3.5-8. Door Open Primary Mode

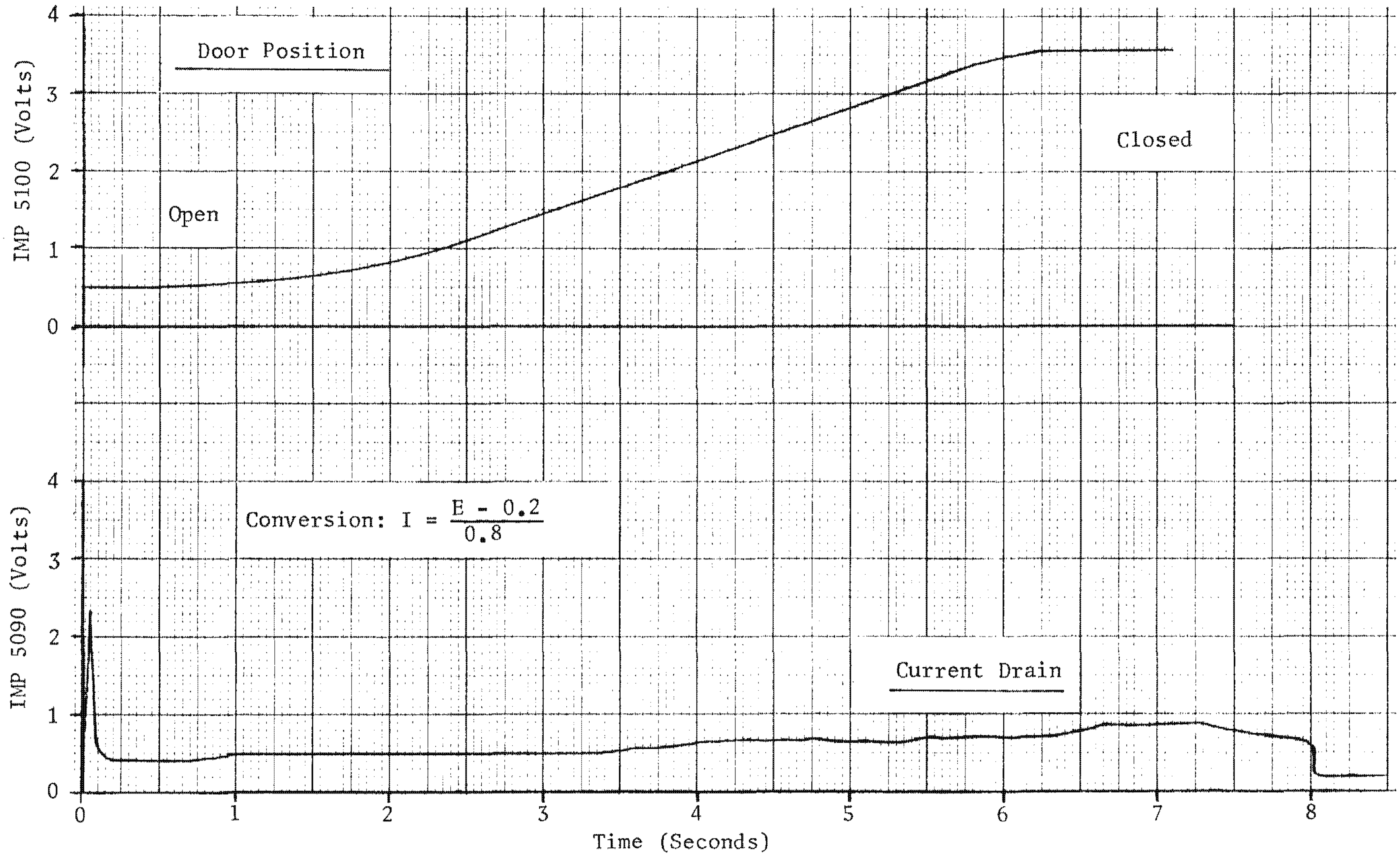

Figure 3.5-9. Door Close Primary Mode

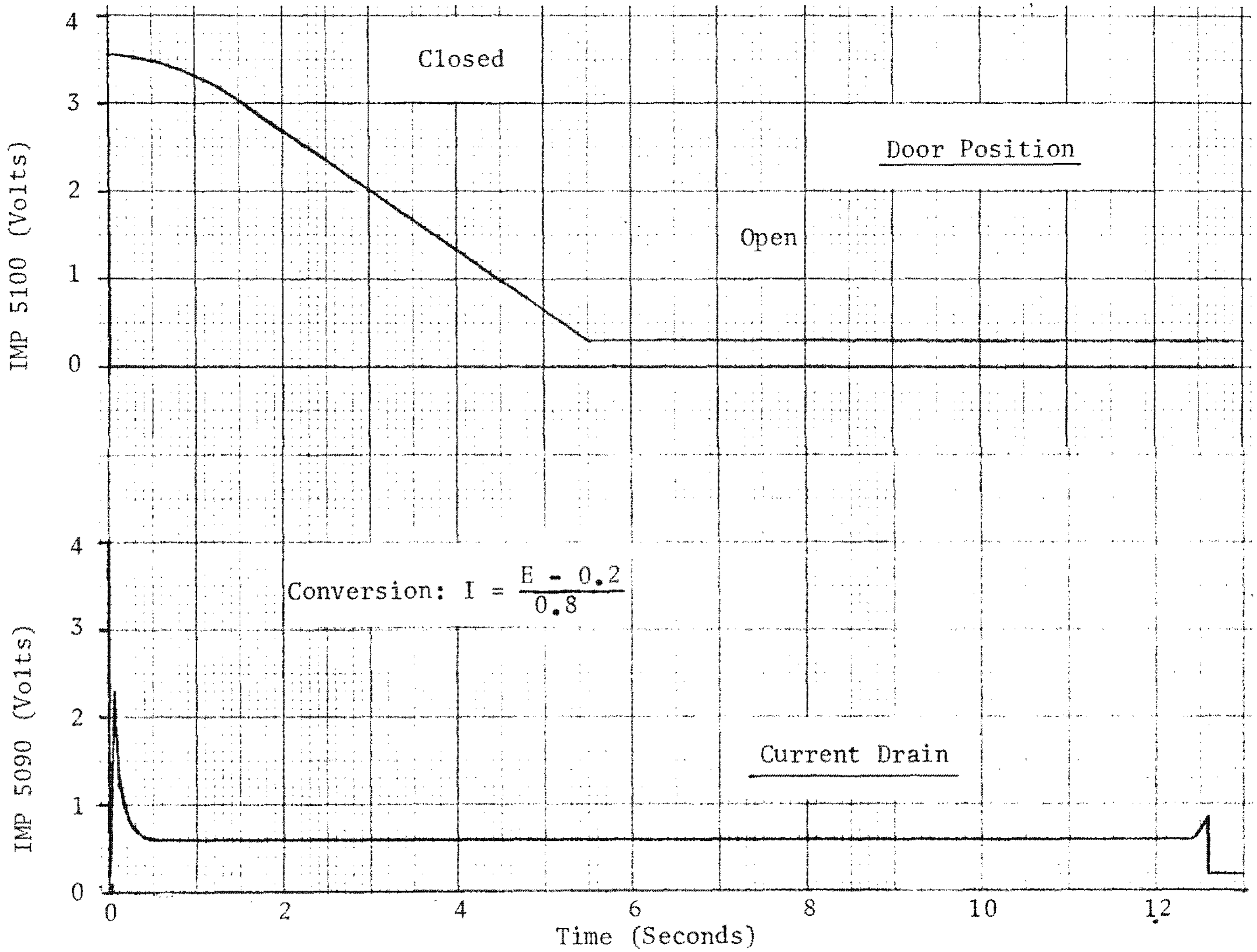

Figure 3.5-10. Door Open Backup Mode

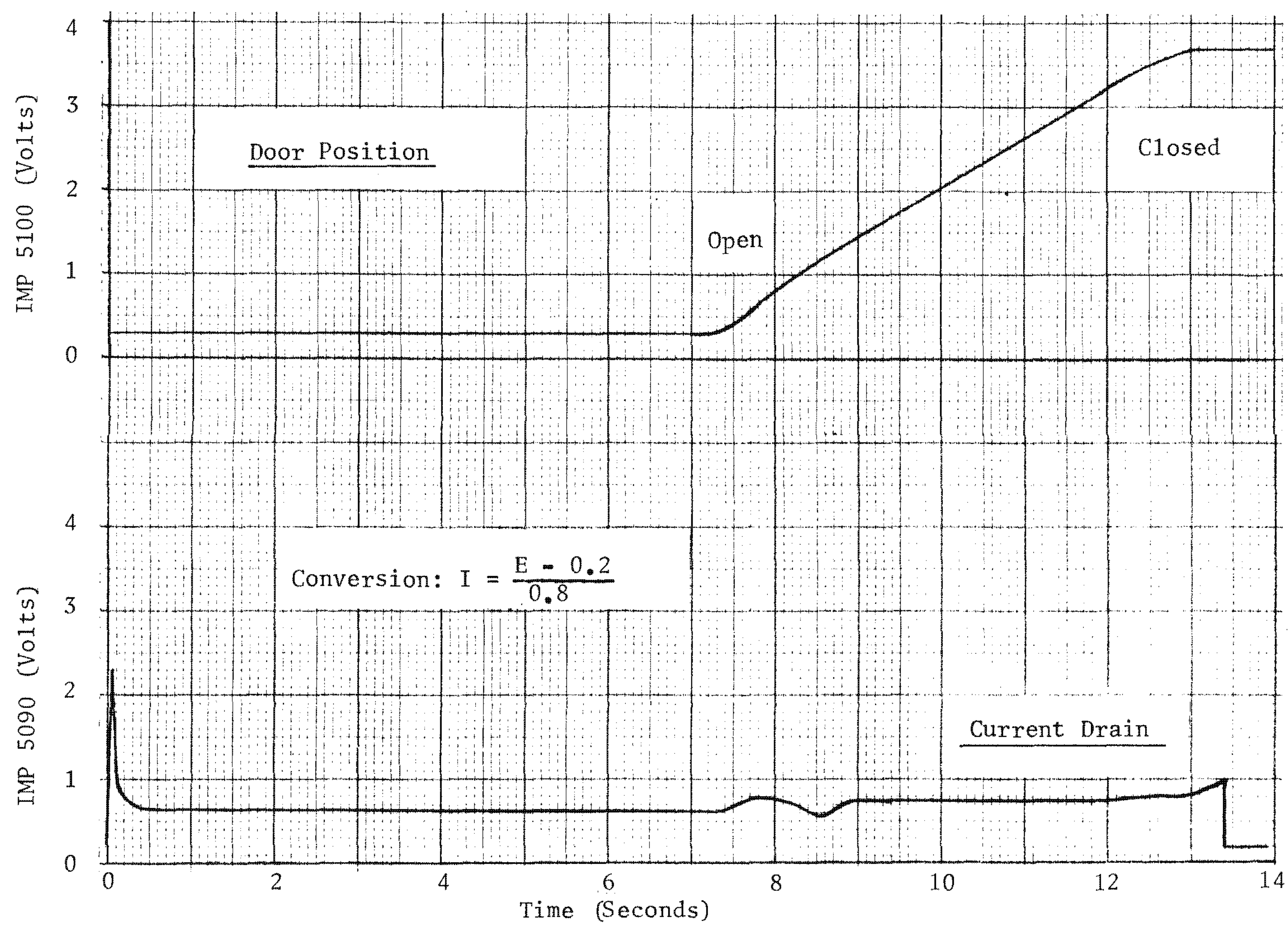

Figure 3.5-11. Door Close Backup Mode

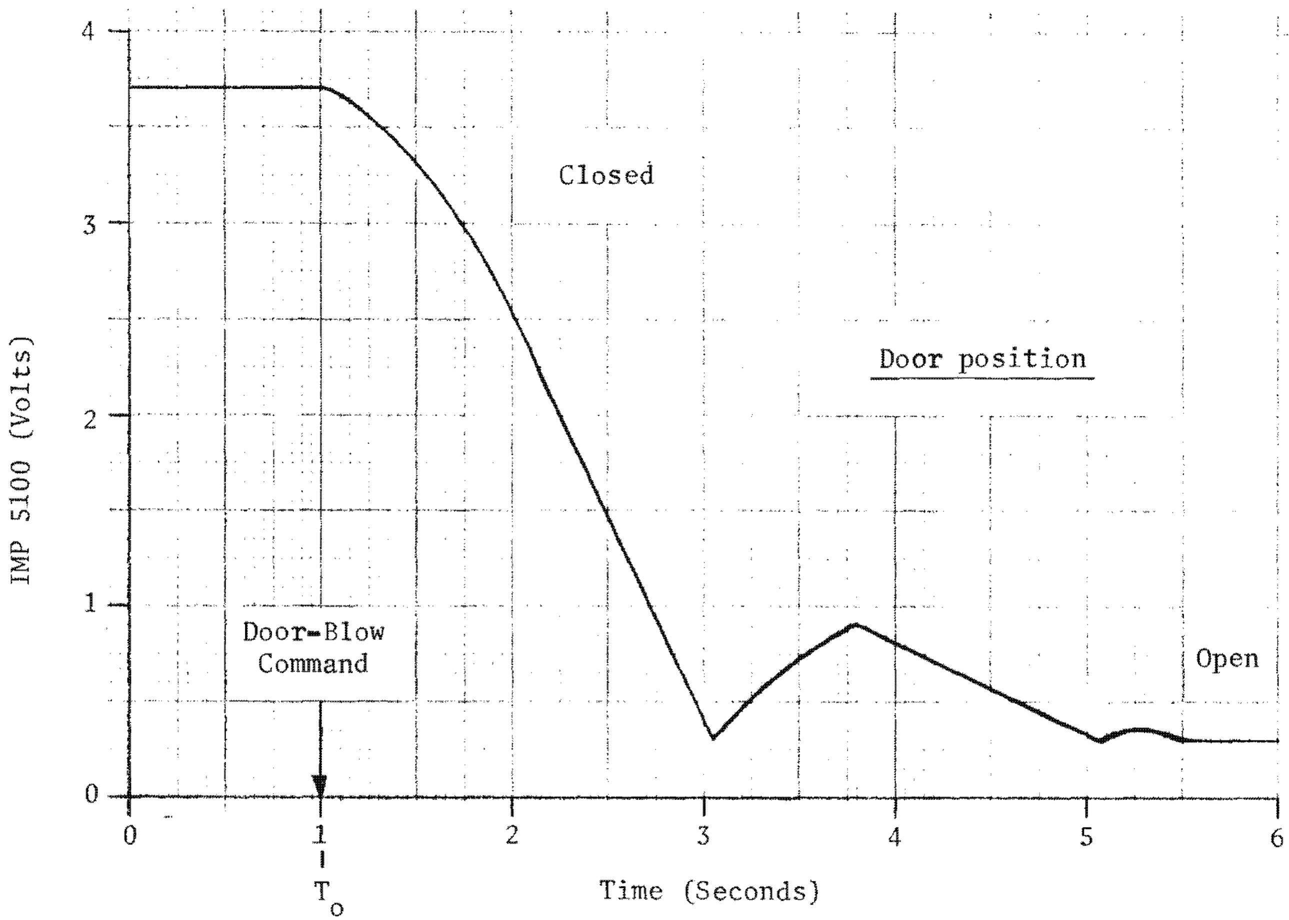

Figure 3.5-12 Door-Blow Mode

TABLE 3.5-1

VIEWPORT DOOR SUBSYSTEM INSTRUMENTATION SUMMARY

IMP	Title	Description	Power
5100	Viewport Door Position +Y	A potentiometer located on the +Y door hinge is turned by a sector gear as the door moves (see Figure 3.5-3). The potentiometer is part of a resistance network located in the viewport door electronics. The network output voltage is a linear analog of the door position (degrees): Door closed - 3.6v (0°) Door open - 0.5v (62°)	+5 vdc
5104	Viewport Door Position -Y	Similar to IMP 5100, the potentiometer is located on the -Y door hinge.	+15 vdc
5111	Temperature Viewport Door Inside Insulation -Y	A thermistor located at the center of the -Y door heater tape support screen monitors the temperature inside the -Y door. A load resistor in the instrumentation processor (IP) reduces the output to acceptable levels. The output is nonlinear, ranging from 40F (4.95v) to 100F (1.4v).	+15 vdc
5114	Temperature Viewport Door Inside Insulation +Y	Similar to IMP 5111, monitors the temperature inside the +Y door. The output, processed in the IP, is nearly linear from 32F (1.15v) to 100F (3.2v).	+5 vdc
5146	Viewport Door Operation	Microswitches actuated by cams on the viewport door hinge-line, when closed, send a controlled power pulse to the door operations counter circuit in the viewport door electronics. Two microswitches are used on each door. One switch is closed when the door is closed and the other switch is closed when the door is open. The +Y and -Y switches for each state are in series. Both must work to increment the counter (reference Figure 3.5 -3 and 3.5-5). The counter is a latching relay circuit whose output occurs in eight	+15 vdc (24.5 vdc)

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TABLE 3.5-1 (CONT'D)

IMP	Title	Description	Power
		(8) discrete steps as follows:	

Door Operation Counter

Steps	Door Position	Volts
1	Closed	1.0
2	Open	3.0
3	Closed	1.5
4	Open	3.5
5	Closed	2.0
6	Open	4.0
7	Closed	2.5
8	Open	4.5

IMP	Title	Description	Power
		Upon completion of Step 8, the counter recycles. the circuit is such that the count is not altered by removal or reapplication of power.	
		Unregulated (24.5-vdc) power is used to operate the latching relays.	
5090	Crab, Stereo, and Door Current	A current-sensing resistor in the power return line in the PM and C generates a voltage proportional to the combined currents for the crab and stereo servos, and the viewport door motor and electronics. The signal is amplified within the PM and C to produce a linear output ranging from 0.2v (0.0 amp) to 5.0v (6 amps).	±15 vdc

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TABLE 3.5-1 (CONT'D)

IMP	Title	Description	Power
5587	Hatch Eject +5 vdc	A microswitch located under the -Y side of the main hatch is released when the hatch is ejected. The associated resistor network is located in the viewport door electronics and indicates 0.5 vdc (hatch in place) or 4.5 vdc (hatch ejected). Output is digitized in the DTU yielding a binary signal: "0" = Hatch in place "1" = Hatch ejected	+5 vdc
5588	Hatch Eject +15 vdc	Similar to IMP 5587, the microswitch is located under the +Y side of the main hatch.	+15 vdc
5035	Stereo Drive Transfer Bit 1,2, Viewport Door Open/Close, Crab Polarity +/-	Latching relays tracking the command input relays of the command processor monitor the receipt of commands from the satellite control section and feed either 0.0v or 5.0v to an integrated circuit D/A converter. Four relays and one 4-bit D/A converter form the IMP. Output occurs in sixteen (16) discrete steps ranging from 0.25v to 4.75v in 0.3v increments: Bit 1 (LSB)* = Stereo Drive Transfer Bit 1 (14V WORD Bit 27) Bit 2 = Stereo Drive Transfer Bit 2 (14V WORD Bit 28) Bit 3 = Viewport Door Open/Close Bit 4 (MSB)**= Crab Polarity +/-	+5/±15 vdc
5122	CBM*** for IEU (#7)	Latching relays, operating in parallel with the command relays of the IEU, monitor the receipt of commands from	+15 vdc

*Least Significant Bit
**Most Significant Bit
***Command Bit Monitor

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TABLE 3.5-1 (CONT'D)

IMP	Title	Description	Power
		the satellite control section. Four relays and a resistance network form a D/A converter whose output occurs in sixteen (16) discrete steps ranging from 0.25v to 4.75v in 0.3v increments: Bit 1 (LSB) = Minimal Arm 1 Enable Bit 2 = Viewport Door Blow A Bit 3 = Viewport Door Backup A Bit 4 (MSB) = Hatch Cover Eject A	
5123	CBM for IEU (#8)	Similar to IMP 5122: Bit 1 (LSB) = Minimal Arm 1 and 2 Enable Bit 2 = Viewport Door Blow B Bit 3 = Viewport Door Backup B Bit 4 (MSB) = Hatch Cover Eject B	+5 vdc
5548	Hatch Eject 1	A latching relay in the initiator electronics unit monitors generation of a pyro firing pulse for pyro 1 in the hatch. The output is connected either to instrumentation return or, when closed by a firing pulse, to +5 vdc in series with an isolation resistor. The output is digitized by the DTU, resulting in a binary signal: "0" = Quiescent "1" = Fired	+5 vdc
5549	Hatch Eject 2	Similar to IMP 5548, monitors the firing pulse output to pyro 2 in the hatch.	+5 vdc
5550	Hatch Eject 3	Similar to IMP 5548, monitors the firing pulse output to pyro 3 in the hatch.	+5 vdc

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TABLE 3.5-1 (CONT'D)

IMP	Title	Description	Power
5551	Hatch Eject 4	Similar to IMP 5548, monitors the firing pulse output to pyro 4 in the hatch.	+5 vdc
5552	Hatch Eject 5	Similar to IMP 5548, monitors the firing pulse output to pyro 5 in the hatch.	+5 vdc
5553	Hatch Eject 6	Similar to IMP 5548, monitors the firing pulse output to pyro 6 in the hatch.	+5 vdc
5554	Hatch Eject 7	Similar to IMP 5548, monitors the firing pulse output to pyro 7 in the hatch.	+5 vdc
5555	Hatch Eject 8	Similar to IMP 5548, monitors the firing pulse output to pyro 8 in the hatch.	+5 vdc
5556	Hatch Eject 9	Similar to IMP 5548, monitors the firing pulse output to pyro 9 in the hatch.	+5 vdc
5557	Hatch Eject 10	Similar to IMP 5548, monitors the firing pulse output to pyro 10 in the hatch.	+5 vdc
5558	Hatch Eject 11	Similar to IMP 5548, monitors the firing pulse output to pyro 11 in the hatch.	+5 vdc
5559	Hatch Eject 12	Similar to IMP 5548, monitors the firing pulse output to pyro 12 in the hatch.	+5 vdc
5560	Backup Motor Actuate 1	Similar to IMP 5548, monitors the firing pulse output to pyro 1 in the primary motor linkage to the spider (reference Figure 3.5-3).	+5 vdc
5561	Backup Motor Actuate 2	Similar to IMP 5548, monitors the firing pulse output to pyro 2 in the primary motor linkage to the spider.	+5 vdc

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TABLE 3.5-1 (CONT'D)

IMP	Title	Description	Power
5562	Viewport Door Blow 1	Similar to IMP 5548, monitors the firing pulse output to pyro 1 in the backup motor linkage to the spider (reference Figure 3.5-3).	+5 vdc
5563	Viewport Door Blow 2	Similar to IMP 5548 monitors the firing pulse output to pyro 2 in the backup motor linkage to the spider.	+5 vdc
5059	Focus Signal Strength (A+B)	The voltage output generated in the focus electronics module provides an indication of the combined signal strength in Channels A and B of the module. The voltage output is piecewise linear. The first segment ranges from a 0.0v output (0.0v signal strength) to 3.75v output (1.5 v signal strength). The second segment ranges from 3.75v output (1.5v signal strength) to 4.75v output (10v signal strength).	±15 vdc
5231	Average Irradiation Level (Channel A)	Generated in the focus electronics module, the IMP tracks the average incident energy on the Channel A photodetector. Output is linear from 0-foot candles (0v) to 100-foot candles (5.0v).	±15 vdc
5105	Average Irradiation Level (Channel B)	Similar to IMP 5231, monitors the Channel B photodetector output.	±15 vdc

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5.5 Viewport Door Subsystem Command Summary

5.5.1 HATCH EJECT Command

(P02570, P01570, P03570)

Function: This command applies power to the pyros in the pin-pullers which release the hatch covering the viewport door.

Interlocks: Successful completion of hatch ejection enables the primary viewport door motor-drive circuits.

Comments: The hatch should be ejected no later than 30 minutes after liftoff to insure that it is sufficiently separated from the vehicle.

5.5.2 DOOR BACKUP Command

(P02575, P01575, P03575)

Function: This command applies power to the pyros which disengage the primary viewport door drive motor. Power is switched to the backup door motor.

Interlocks: This command enables the DOOR BLOW command.

Comments: This command is irreversible.

This command is not normally given except in the event of a primary mode failure.

5.5.3 DOOR BLOW Command

(P02574, P01574, P03574)

Function: This command applies power to the pyros which disengage the backup motor from the door drive linkage.

This command permanently opens the viewport doors.

Interlocks: This command is enabled by the DOOR BACKUP command.

Comments: This command is irreversible.

This command should be used only in extreme situations, since the viewport doors cannot be closed and the camera optics module will be unable to sustain its required temperature.

5.5.4 4V WORD Command (Bit 36: Door Open/Close)

(4V0252bZ, 4V0152bZ, 4V0352bZ)

Function: This command is the normal means of operating the viewport doors. It also controls the focus subsystem and S-1/PRG operate and calibrate modes. The bit functions are:

Bit	Function
Implicit	Spare
35-1	FEP ON, S-1/PRG Enable, S-1/PRG Power ON
35-0	FEP OFF, S-1/PRG Power OFF
36-1	Door Open
36-0	Door Close
37-1	Focus Calibrate Modes
37-0	(In desired sequence;
38-1	reference Part 3,
38-0	Section 6)

Interlocks: The viewport door primary motor-drive circuits are enabled by successful ejection of the viewport door hatch.

Comments: This is the only command which opens the viewport doors except for DOOR BLOW.

The viewport doors require approximately seven seconds to move from one position to the opposite position in the primary mode. Once commanded to a position, the opposite command should not be given for at least three seconds.

In the backup mode, the doors require approximately 14 seconds transit time and, once commanded to a position, the opposite position should not be commanded for at least 15 seconds.

5.5.5 DOOR CLOSE Command (MCS)

(MN00127)

Function: This command closes the viewport doors in either the primary or backup modes.

Comments: The doors will take approximately seven seconds to close in the primary mode and 14 seconds to close in the backup mode.

There are no commands in the MCS to open the doors.

6.0 FOCUS DETECTION SUBSYSTEM

The focus detection subsystem is a self-contained electro-optical device consisting of three subassemblies; the focus sensor head assembly, the instrumentation and control module, and the signal normalizing module. The three subassemblies are pictured in Figure 3.6-1, and shown installed in the dual platen camera in Figure 3.6-2. A block diagram of the focus detection subsystem is shown in Figure 3.6-3.

6.1 System Description

A brief description of each of the three modules comprising the focus detection subsystem is included below.

6.1.1 Focus Sensor Head Assembly (Unit 15A2)

The focus sensor head assembly consists of two basic modules; the frame and optics assembly and the dual detector and signal processing module. The focus sensor head assembly is approximately 5.50 inches by 4.75 inches by 3 inches. The assembly weighs less than 2.5 pounds. A pictorial drawing of the focus sensor head assembly is provided in Figure 3.6-4.

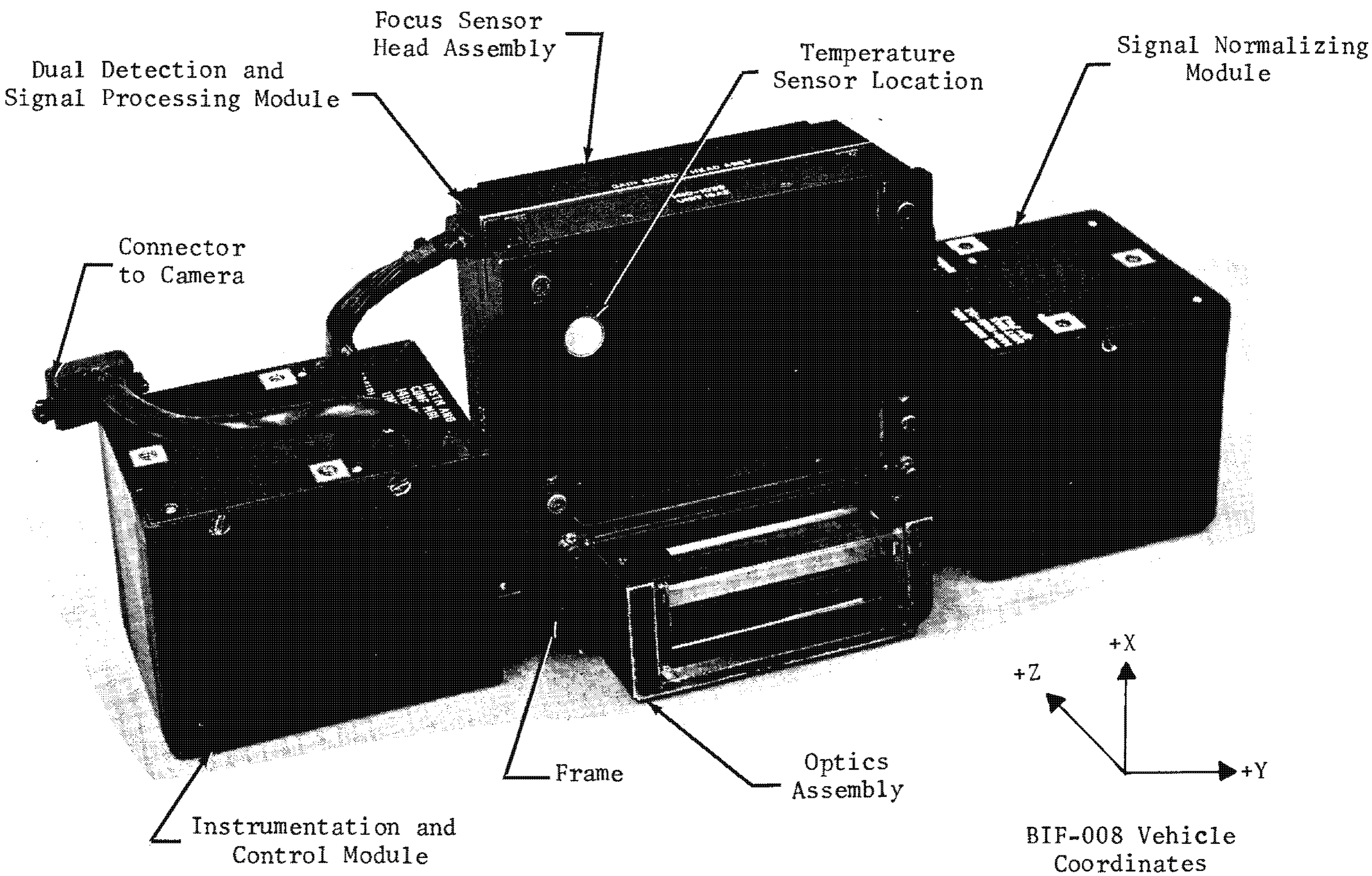

Figure 3.6-1. Focus Detection Subsystem Elements

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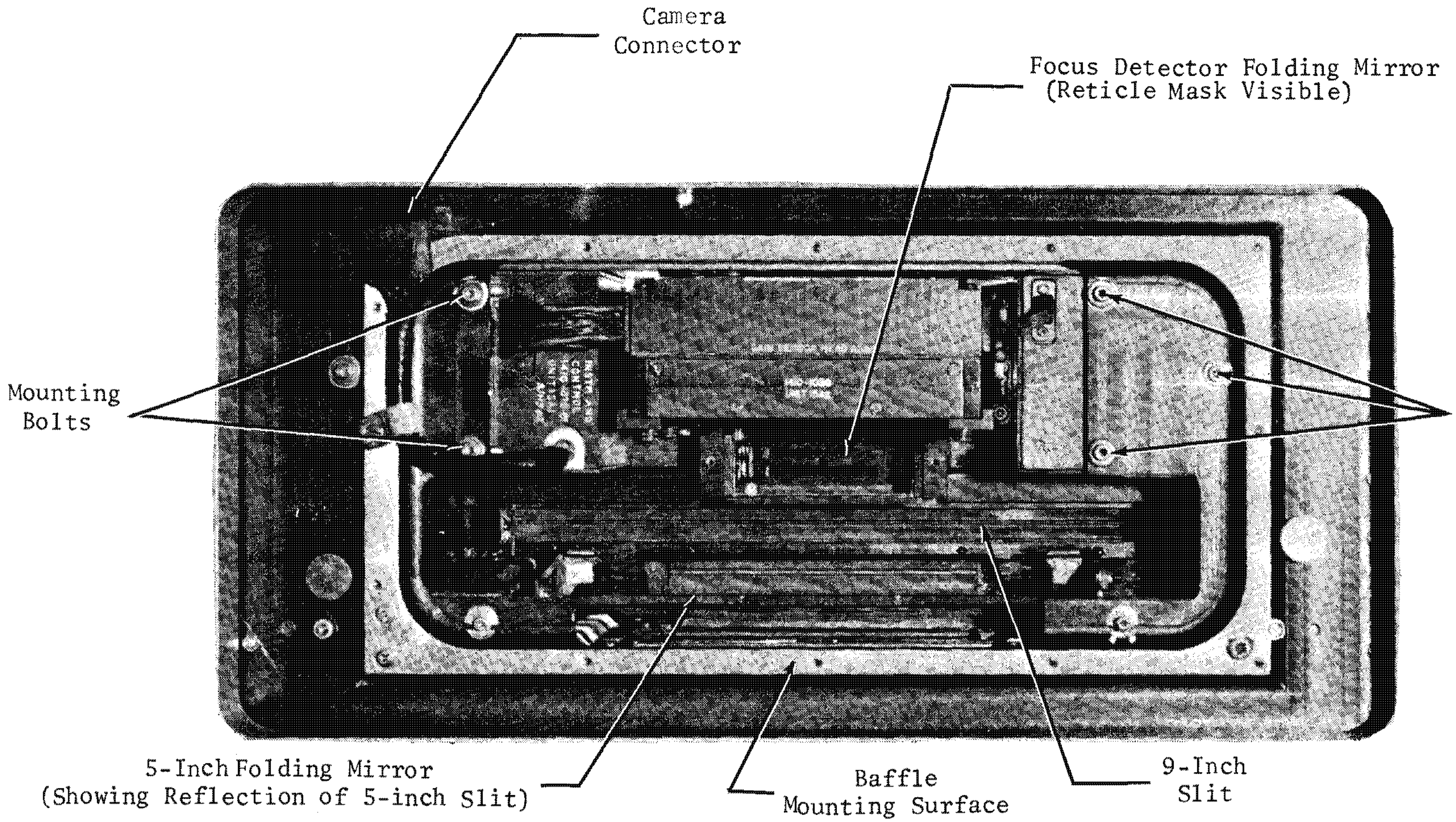

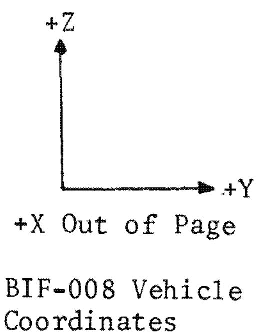

Figure 3.6-2. View into Camera (Baffle Removed)

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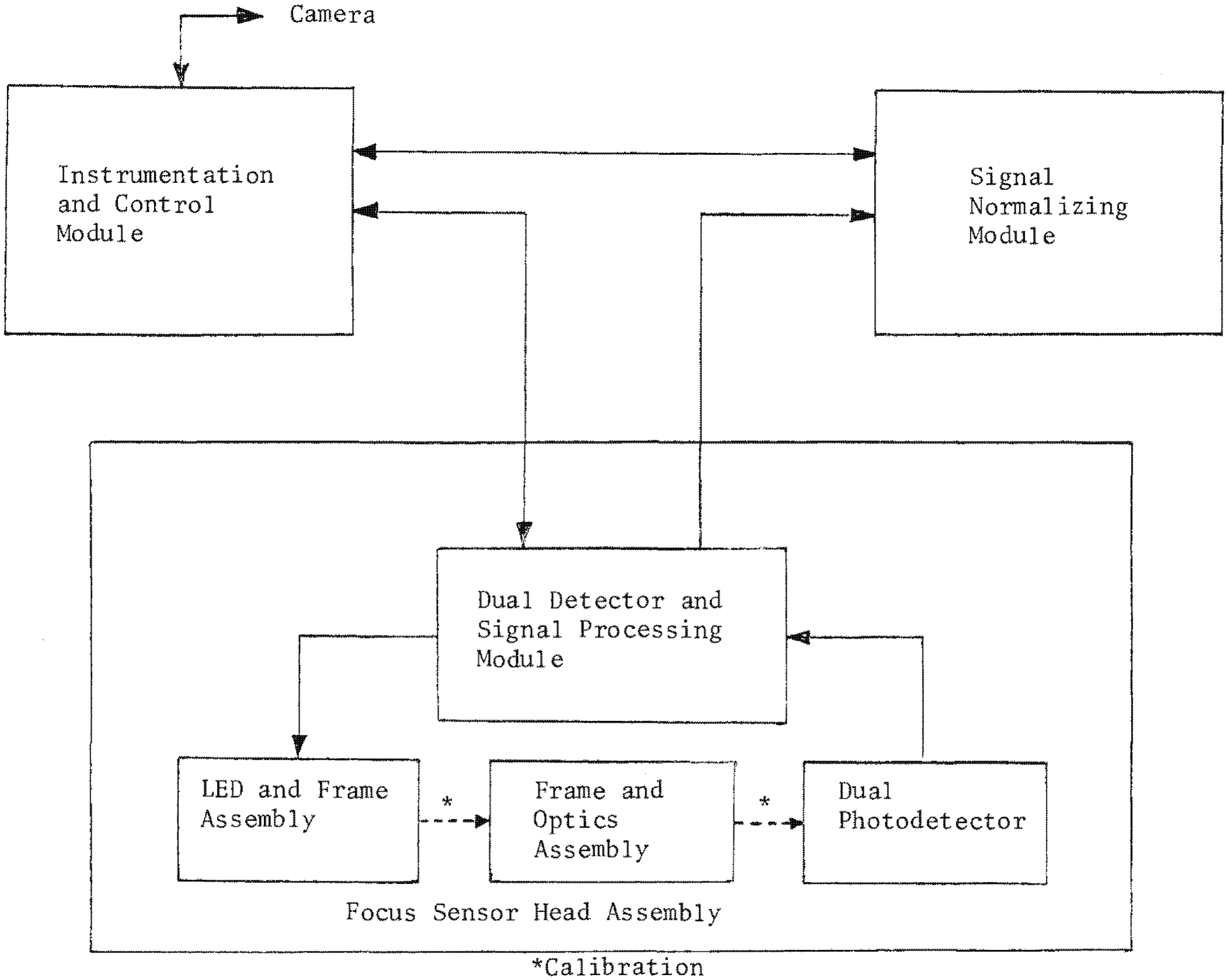

Figure 3.6-3. Focus Detection Subsystem Block Diagram

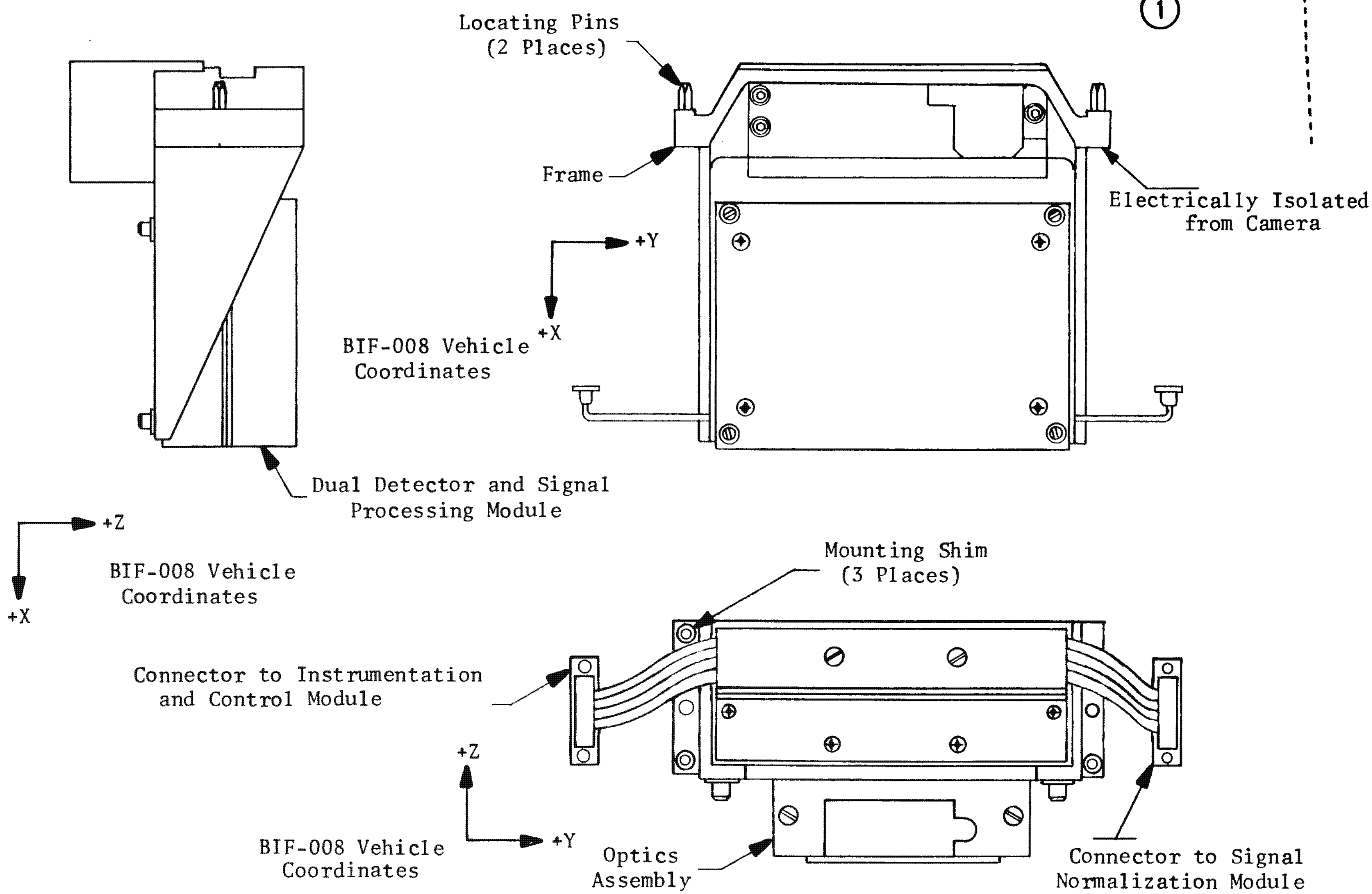

Figure 3.6-4. Focus Sensor Head Assembly

6.1.1.1 Frame and Optics Assembly. The frame and optics assembly consists of a black, anodized aluminum alloy frame to which the optical elements of the focus detection subsystem are mounted. The frame also provides mounting surfaces for the dual detector and signal processing module. The frame is shim-mounted to the 9 pivot frame of the dual platen camera. Correct rotational alignment is assured by special pins on the frame which engage holes in the pivot frame.

The optics assembly is shown in Figure 3.6-5. (See also Figure 2.5-8 found in Volume 1 of this document.) The zero-power achromat provides compensation for the dispersion arising in the beam splitter. The incoming light cone is deflected 90 degrees by the folding mirror and enters the beam splitter and reticle assembly (see Figure 3.6-6). The beam splitter divides the energy into transmitted (T) and reflected (R) portions for both Channel A (near) and Channel B (far) reticles. As described in Section 2.5, the four-reticle arrangement reduces the effect of polarization of the focus indication.

The folding mirror is a 45-degree glass prism having a surface irregularity limit of 0.010 λ RMS (at 632.8 nm). The reflecting surface is silvered with a high reflectance multilayer coating. (This coating is the same as that employed on the stereo mirror.)

The beam splitter, constructed of FK-51 glass, is of conventional design with the transmitted and reflected optical path being equal to within 2λ at 632.8 nm. Transmittance and reflectance of each unit are measured for unpolarized and for plane-polarized light in planes both perpendicular and parallel to the plane of incidence.

The reticles are constructed in matched sets of four from FK-51 glass, coated with chrome on one side to a minimum density of 2.4. The coating is etched to

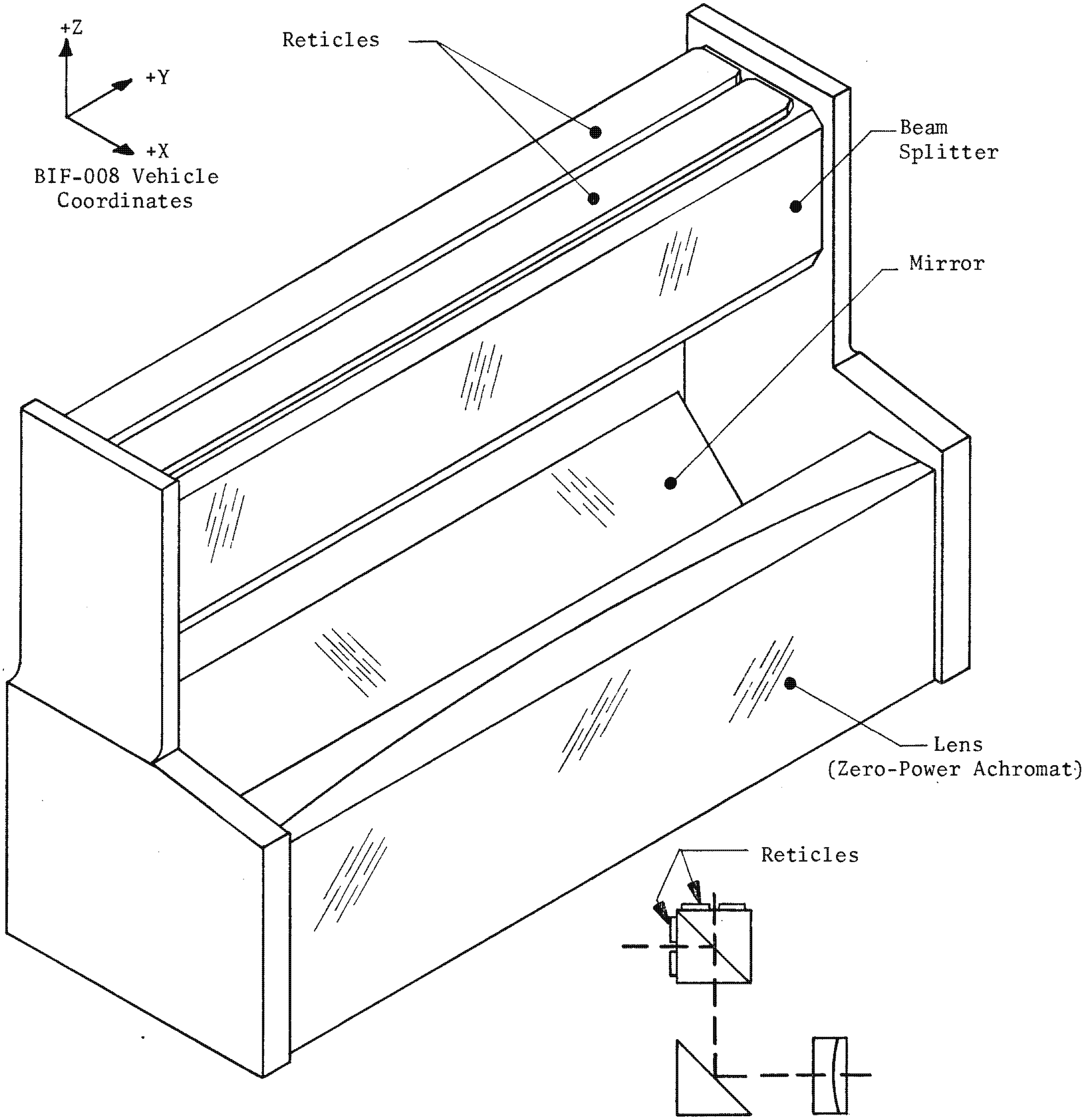

Figure 3.6-5. Focus Detection Subsystem Optics Assembly

45-Degree Chevron Reticle, 14 lpmm

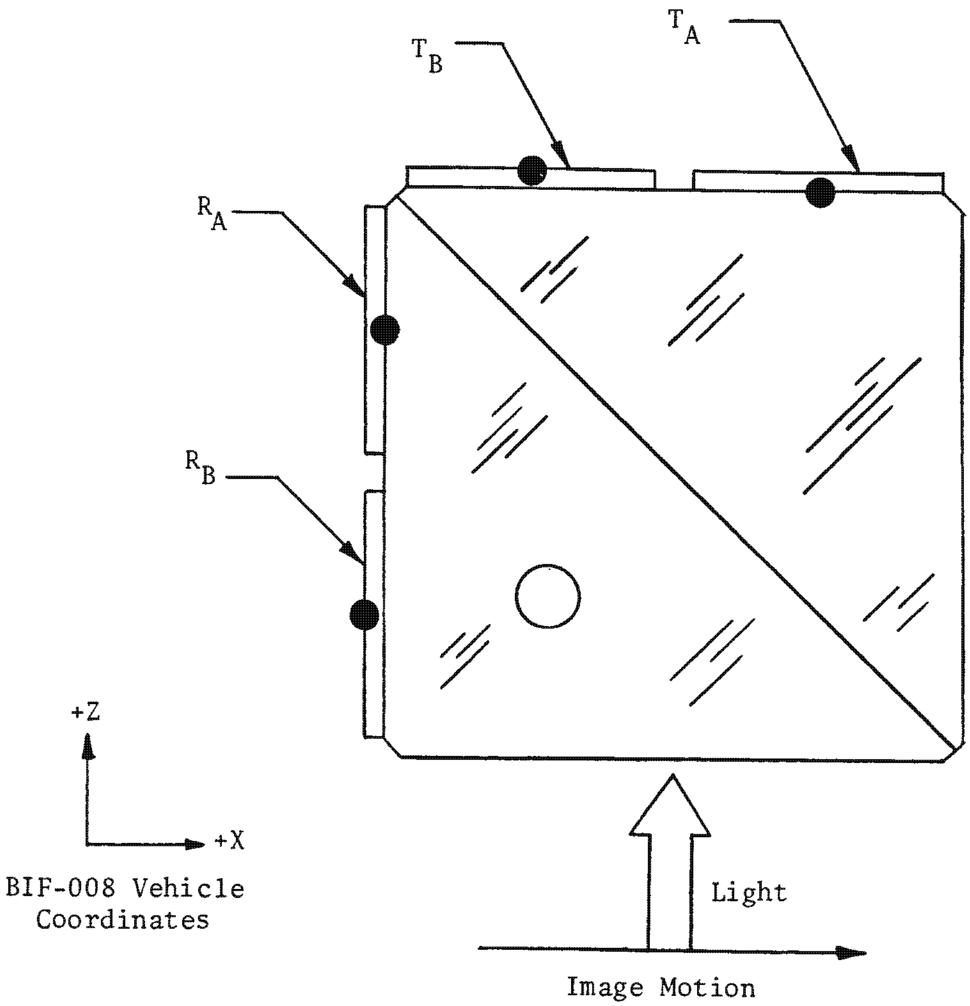

Figure 3.6-6. Beam Splitter and Reticle Assembly

generate a 45-degree chevron reticle pattern having a spatial frequency of 14 lpmm.* A typical reticle is illustrated in Figure 3.6-7. The reticles are bonded to the beam splitter with optical cement. Reticles T_A and T_B are superimposed with reticles R_B and R_A respectively within 0.001 inch to maximize scene correlation.

6.1.1.2 Dual Detector and Signal Processing Module. The dual detector and signal processing module consists of two enclosures which are mechanically mounted together. The upper one (-Z direction as installed) houses two component boards. The lower one (+Z as installed) houses one component board and contains the thermistor which provides data on the module temperature. The enclosures form an electrostatic shield around the sensitive circuitry within.

6.1.2 Signal Normalizing Module (Unit 15A3)

Mechanically, the signal normalizing module consists of an aluminum base on which are mounted studs and spacers supporting three component board assemblies. The base also has three tapped holes for attachment to the dual platen camera housing and a 9-pin microminiature receptacle which provides for electrical connection to the focus sensor head assembly. A welded aluminum sheet cover attaches to the base with four flathead screws to complete the assembly. Figure 3.6-8 shows the signal normalizing module.

The module is nearly cubical, measuring approximately 2.9 inches by 2.8 inches by 2.9 inches. The weight of the module is less than 1.5 pounds.

6.1.3 Instrumentation and Control Module (Unit 15A1)

The instrumentation and control module is constructed of an L-shaped aluminum base and a welded aluminum cover attached by four flathead screws. The base

*The ±45-degree pattern was selected to eliminate the effect of astigmatism on focus sensor indication.

NOTES:
1. Reticle spacing = 14 lines/mm at 45° (one line = 1 line and one space, equal width)
2. Reticle shown is for reflected energy and Channel B.
3. All dimensions are in inches.

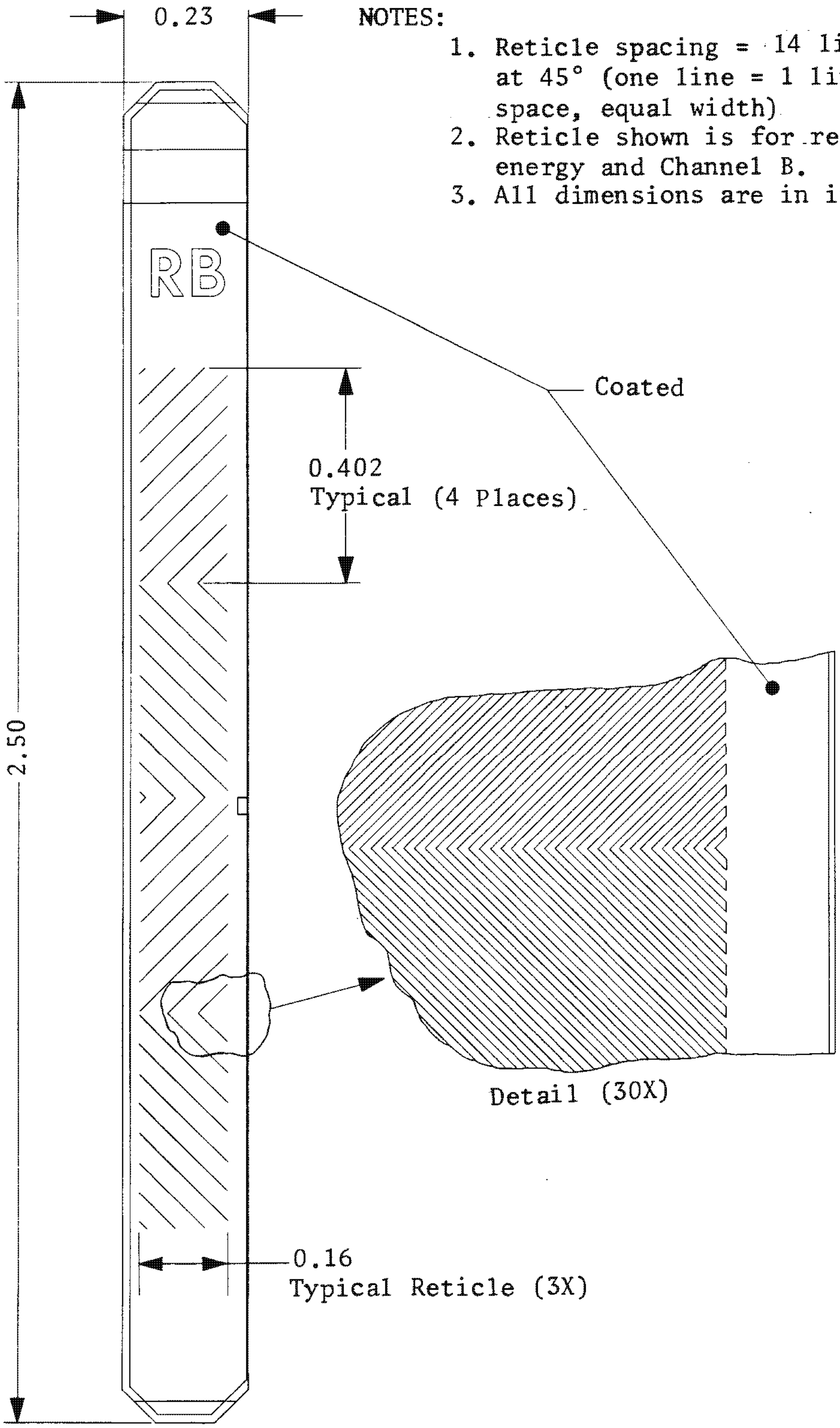

Figure 3.6-7. Typical Reticle

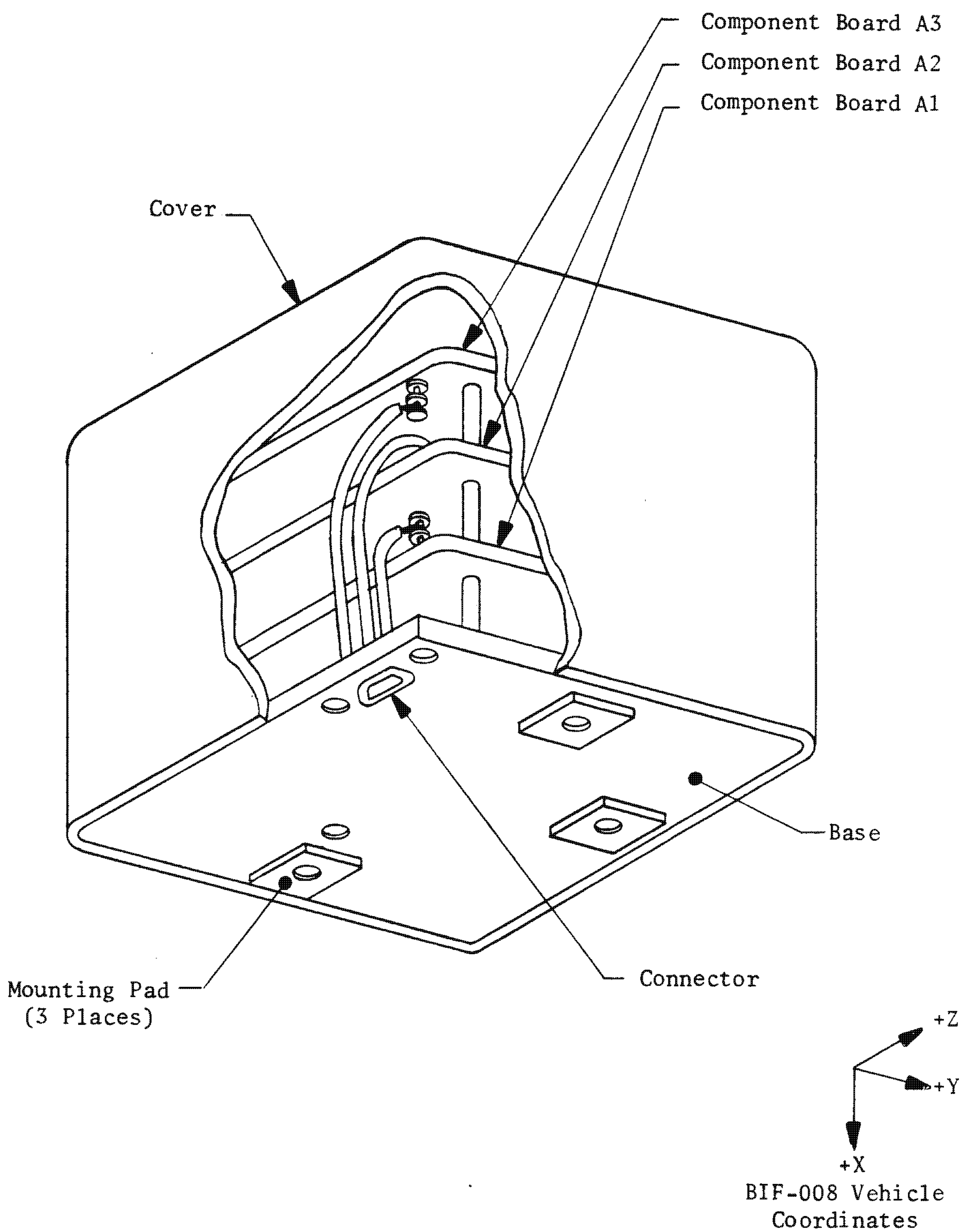

Figure 3.6-8. Signal Normalizing Module
(Unit 15A3)

incorporates three tapped holes for mounting to the dual platen camera. Studs and spacers are provided for securing four component board assemblies. A cable passes through the base and is terminated in a 31-pin, microminiature, plug-type connector. This cable carries power and signals between the focus detection subsystem and the dual platen camera. A 25-pin microminiature receptacle is also mounted to the base to provide the electrical connection to the focus sensor head assembly. The instrumentation and control module is shown in Figure 3.6-9.

The module weighs under 1.5 pounds and measures approximately 3.6 inches by 2.5 inches by 2.8 inches.

6.1.4 Dual Photodiode Detector

The dual photodiode detector consists of a black oxidized stainless steel housing within which are mounted two carefully matched pairs of enhanced sensitivity silicone photodiodes operating in the photovoltaic mode. The diodes are insulated from the housing by high-alumina ceramic insulators and the whole assembly is ruggedized by use of RTV-60 potting material. Protection is provided by fused quartz glass covers which are held in place by beveled edges and sealed by epoxy optical cement. The dual photodiode detector is shown in Figure 3.6-10.

6.1.5 Light-Emitting Diode (LED) Array

The LED array is made up of eight red (650 nm) GaAsP, hermetically sealed and matched LED's mounted to a circuit board 2.50 inches long and just under 0.438 inch wide. The board is attached to an aluminum frame. This frame attaches to the head assembly in such a manner as to allow the LED's to illuminate the face of the beam splitter not facing the dual detector or the folding mirror. The diodes are connected in series-parallel for reliability and power savings. The diodes are procured in sets of 10, matched so that the output lobes are within a 10-degree angle from center. A representation of the optics assembly with the

3.6-13

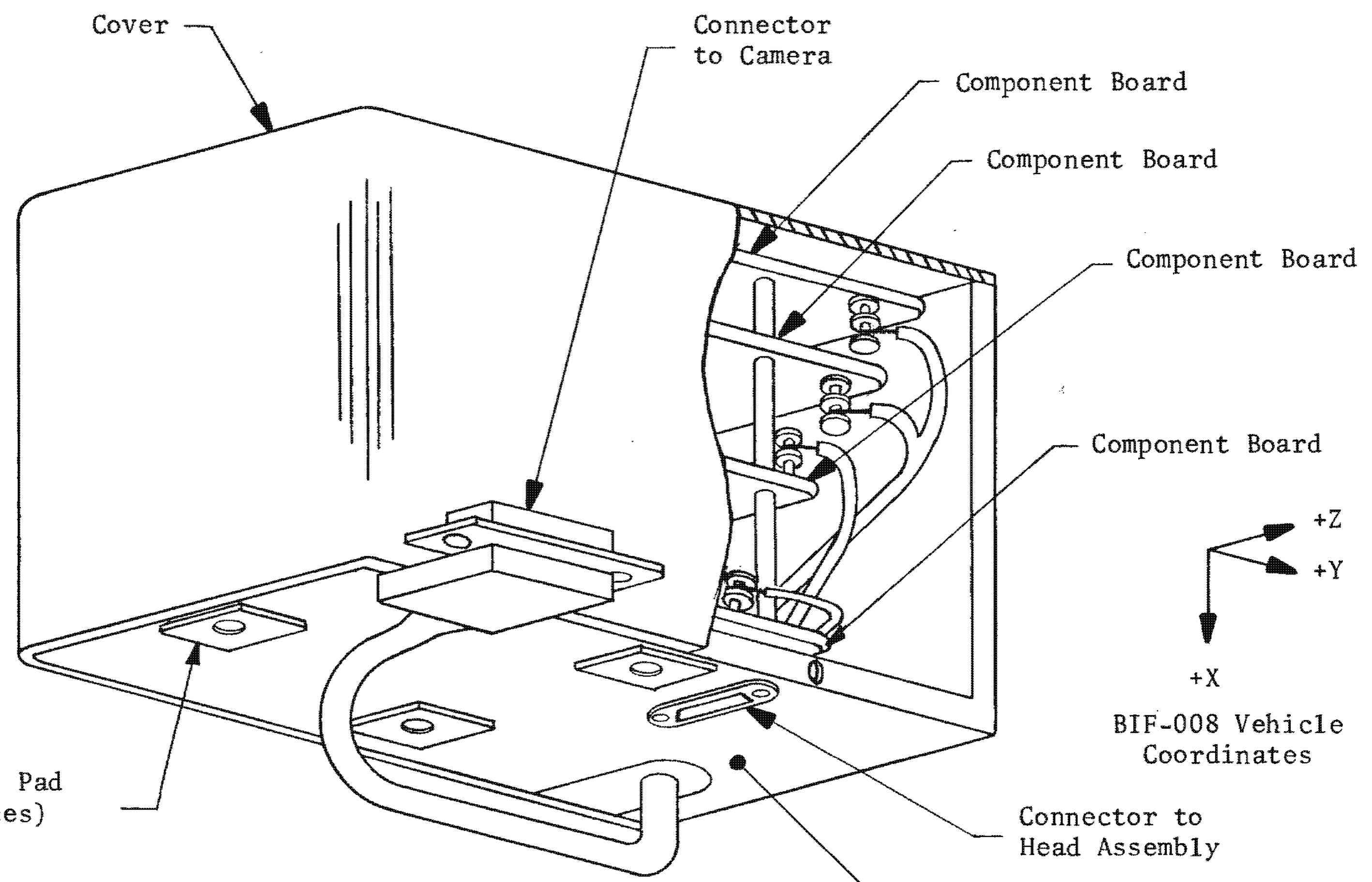

Figure 3.6-9. Instrumentation and Control Module (Unit 15A1)

3.6-14

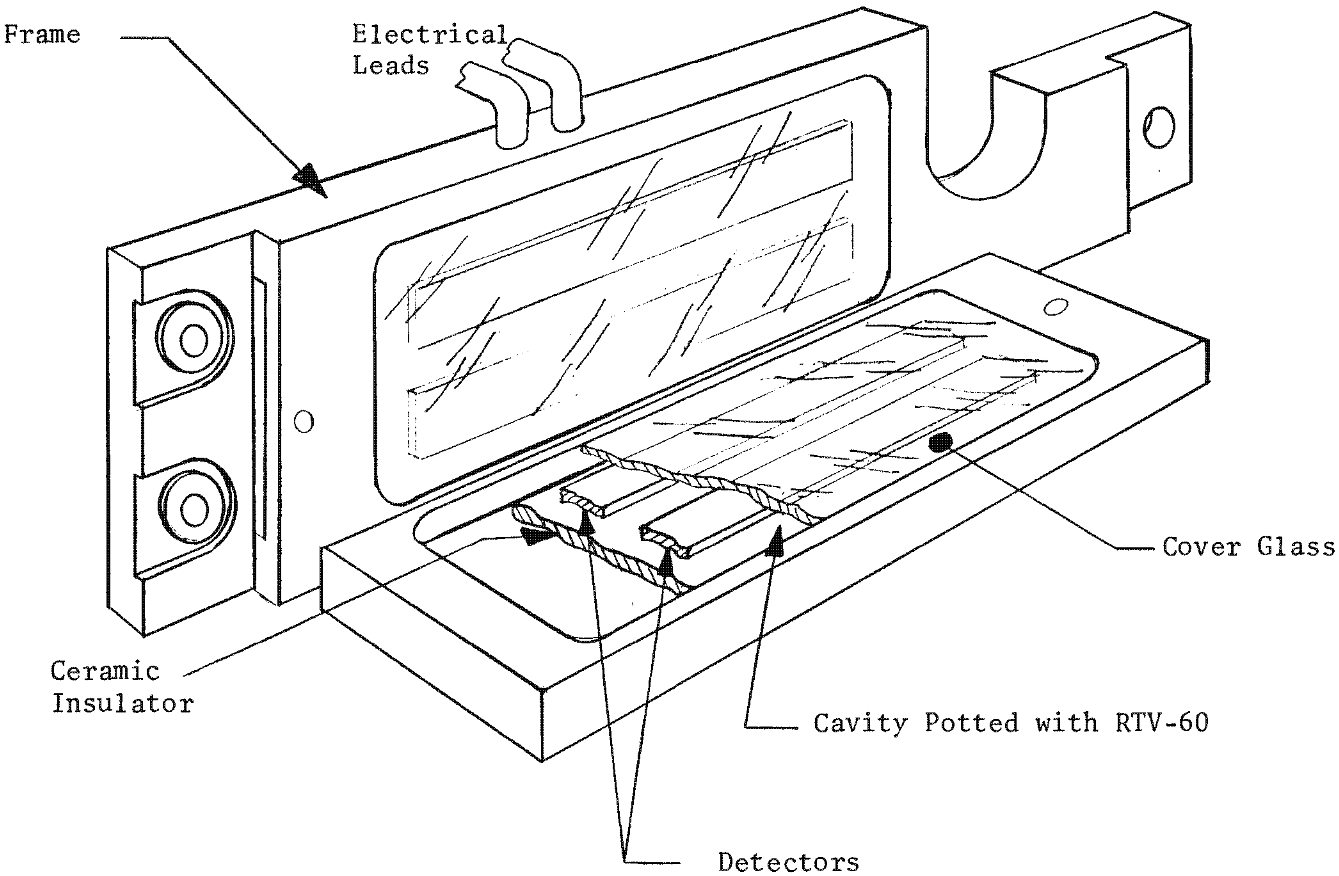

Figure 3.6-10. Dual Photodiode Detector

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dual photodiode detector and the LED array is shown in Figure 3.6-11.

6.2 System Operation

Theoretical and developmental considerations are treated in Part 2, Section 5, while this section describes the system hardware. A functional block diagram is shown in Figure 3.6-12.

6.2.1 Focus System Head Assembly

Operationally, the focus system head assembly accepts optical signals (moving scenes), converts these optical signals to electrical signals, amplifies these signals, and converts the ac signals to dc levels.

6.2.1.1 Optics Assembly. The optics assembly receives a portion of the incoming scene energy at a point 0.75 inch off the main optical axis. The scene is spatially filtered by the 45-degree chevron reticles located equidistantly ahead of (Channel A) and behind (Channel B) the nominal focal plane. These optical signals represent samples of the ±45°, 14 lpmm, off-axis MTF curve at the reticle focus positions.

6.2.1.2 Dual Detector and Signal Processing Module. The optical signals which result when the moving scene passes over the reticles at a 45-degree angle are linearly converted to their electrical analogs by the dual photodiode detector module. These electrical signals have a dc range of from 0.5 microamp to 100 microamps and a range of ac modulation (211 to 2967 Hz) from 0.066 nanoamp to 59.5 nanoamps RMS.

The two signals from the dual photodiode detector module are routed to a current-to-voltage converter (see Figure 3.6-13). The virtual ground configuration is required to obtain the desired frequency response with the high shunt capacity of the large-area photodiodes and to allow interconnection

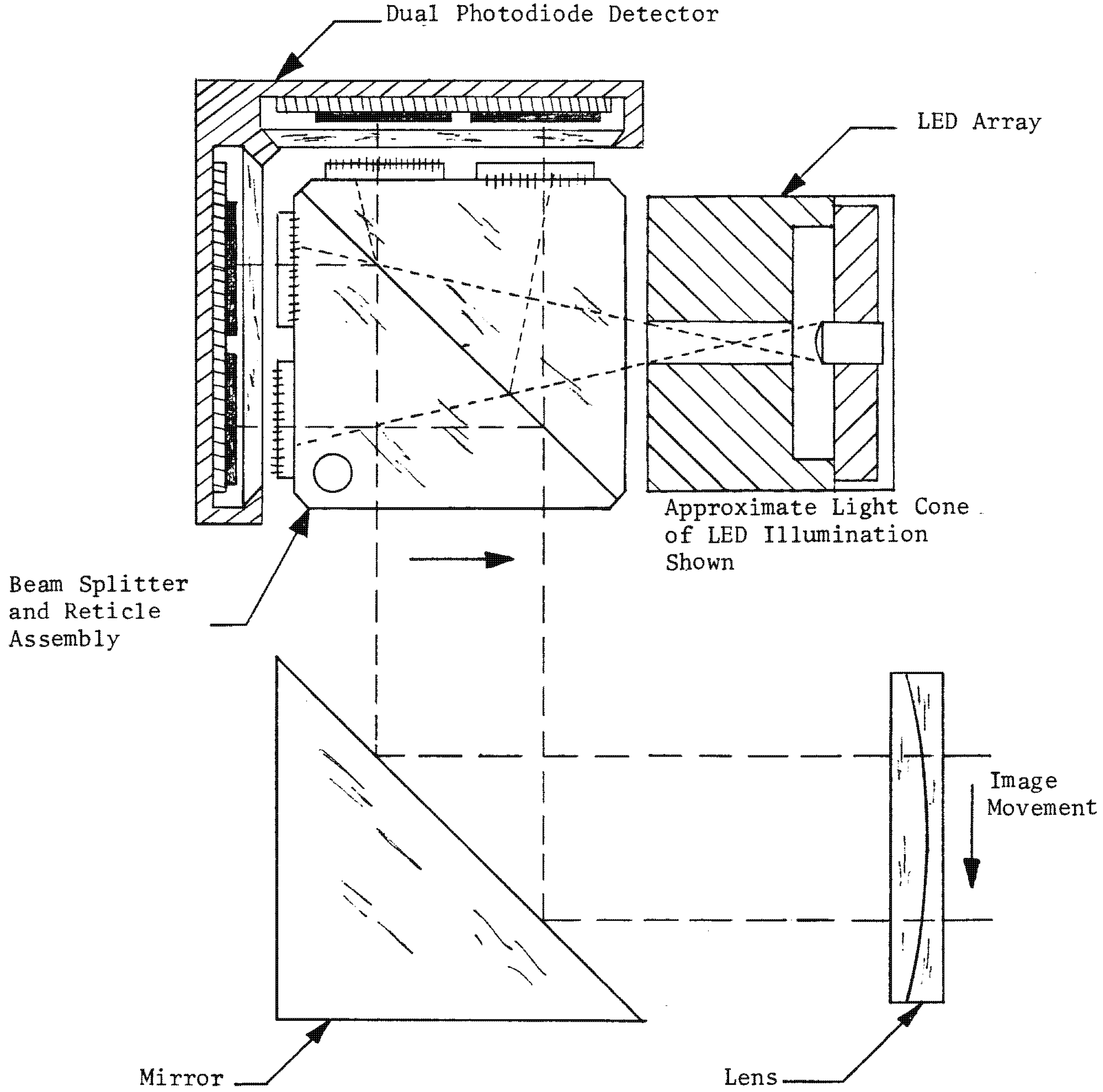

Figure 3.6-11. Optics with Dual Detector and LED Array

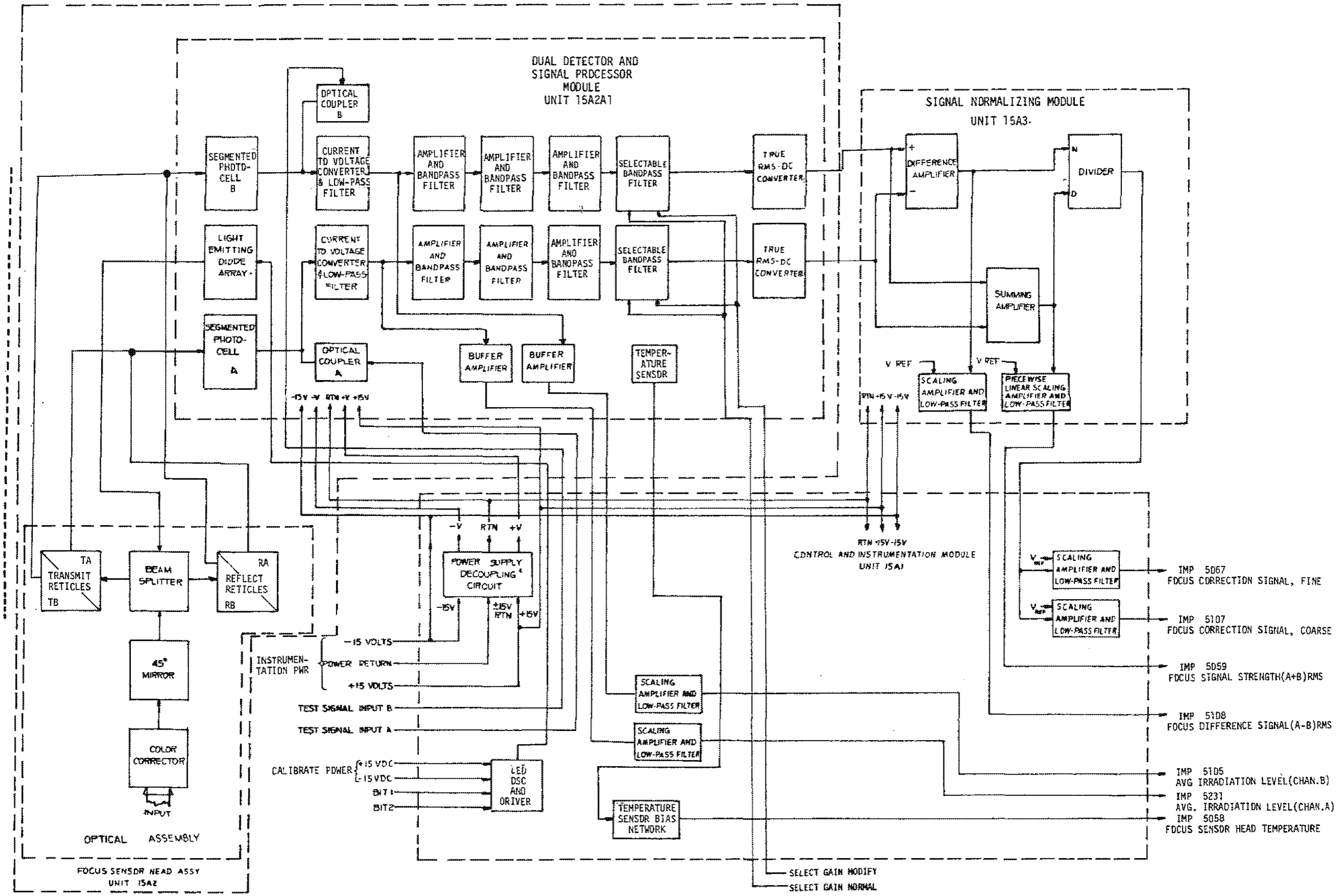

Figure 3.6-12. Systems Operation Functional Block Diagram

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3.6-19

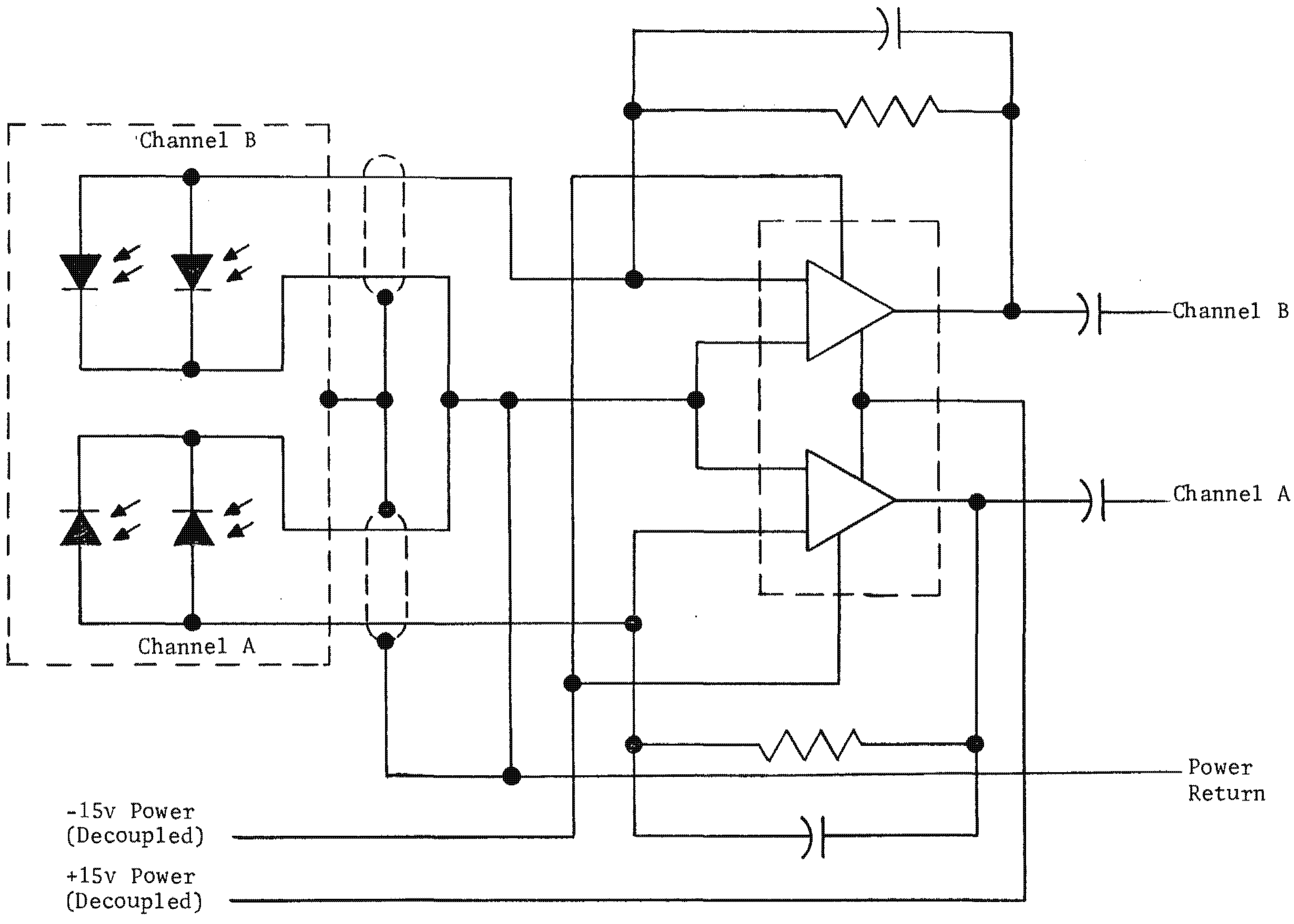

Figure 3.6-13. Detector and Current-to-Voltage Converter

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of the photodiodes. The load resistor associated with this stage is sized to to maximize signal-to-noise ratio.

Channels A and B have signal amplifiers following the current-to-voltage converters which have been carefully gain matched to allow no more than 1% difference between the A and B channel responses.

The signal amplifiers allow two possible gain-bandpass signal responses for each channel. One bandpass, termed the "Modified Mode", processes signals with frequency between 2967 Hz and 850 Hz (image velocities of 11.8 to 3.37 respectively). For signals between 850 Hz and 211 Hz, the other bandpass or "Normal Mode" would be selected. Center frequency gain of the Modified Mode occurs at 2000 Hz and amplifies the signal by 9400. The Normal Mode peaks at 850 Hz with a gain of 3500. Figure 3.6-14 shows the frequency responses for each mode.

The signal amplifiers are composed of three real pole active bandpass amplification stages each having fixed gain and frequency response. Figure 3.6-15 shows an amplifier typical of one of these stages. The fixed gain stages are followed by a selectable bandpass section which provides two possible real pole active filters for each channel, either of which can be toggled into the signal processing path. This combination provides the two ranges of gain and bandpass. Figure 3.6-16 shows the dual range amplifier. As shown, relay contacts are used to change both the feed forward and the feedback capacitor values which create the filter break-points and the gain. The relays are pulsed from Command Processor outputs.

The amplification accumulated by this series of amplifier stages provides from 0.05 volt to 5.0 volts (depending on the incoming signal) at the input to the RMS-to-dc converters.

The RMS variation for each channel is converted to a dc signal proportional to the amplitude of the true RMS signal. The signal-processing to determine the degree and direction of defocus is performed on these dc signals in the signal

3.6-21

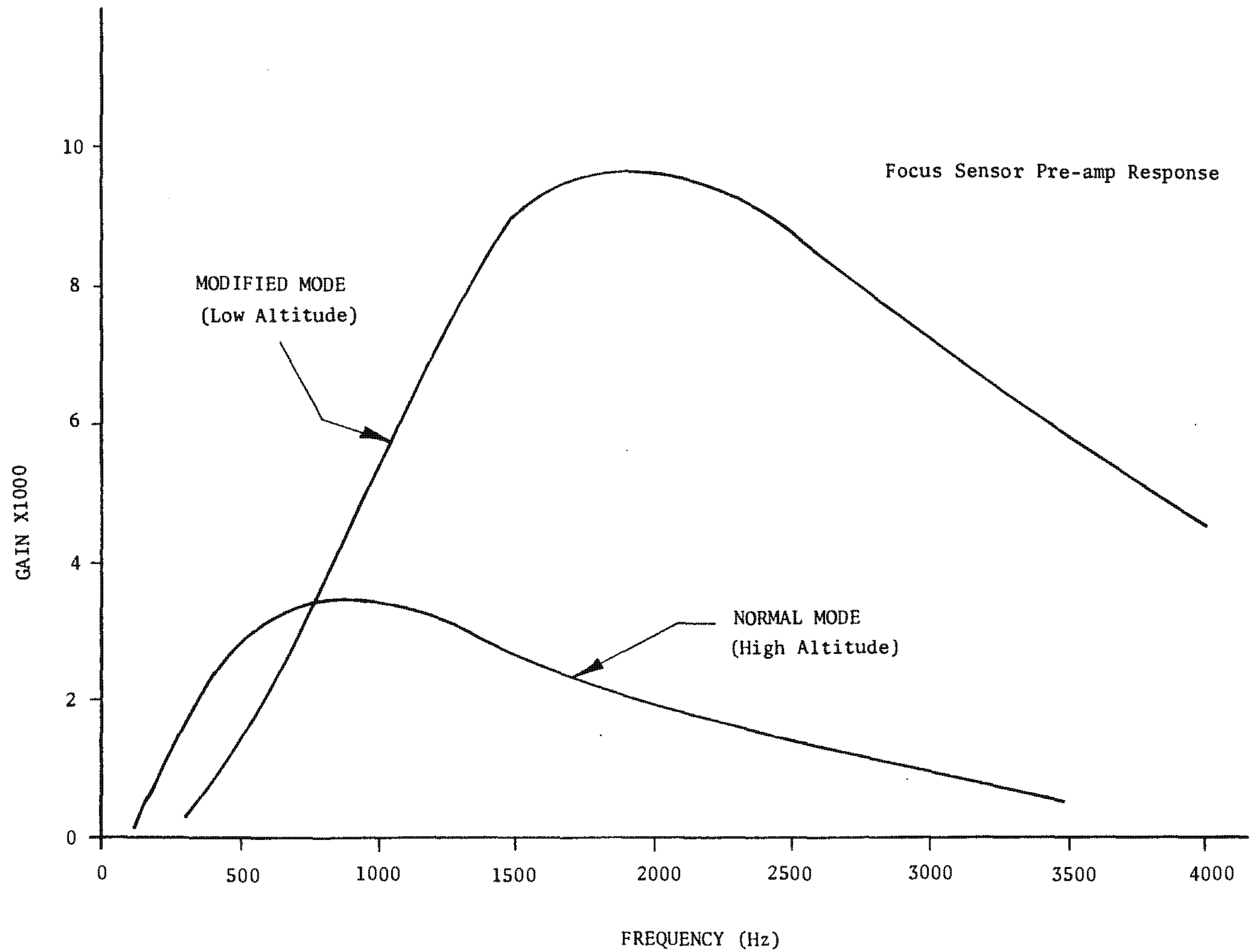

Figure 3.6-14. Frequency Response for Each Mode

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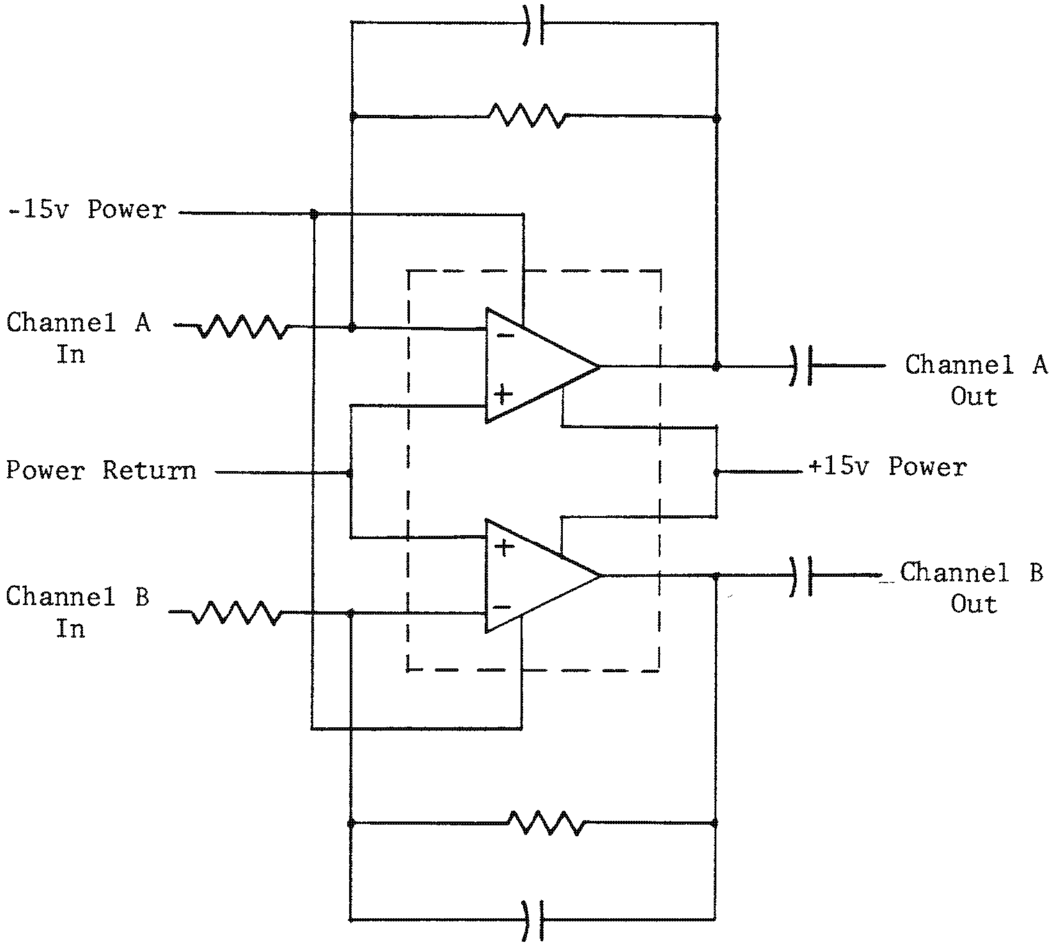

Figure 3.6-15. Typical Dual Channel Amplifier

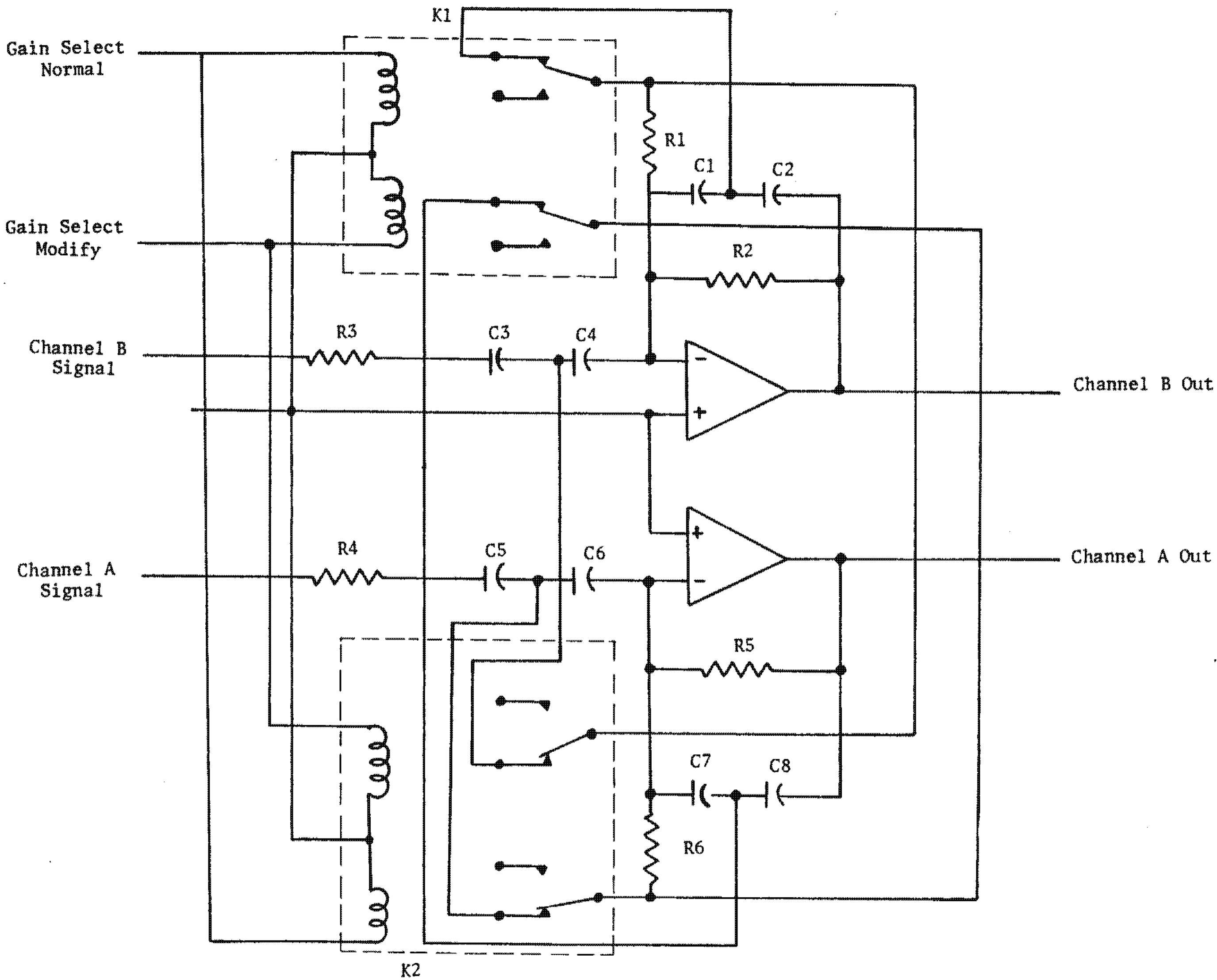

Figure 3.6-16. Dual Range Amp

normalizing module. Additional outputs are obtained through a buffer amplifier for each channel which provides a dc level proportional to the average irradiance incident on the photodiode.

6.2.2 Signal Normalizing Module

The signal normalizing module receives the dc signals from the dual detector and signal processing module. The dc signals (Channel A and Channel B) are presented to a difference amplifier and a summing amplifier. The sum and difference signals are input to a divider whose output is proportional to 2 (A-B)/(A+B). Scaling amplifiers provide outputs in the desired voltage range.

6.2.2.1 Difference Amplifier. The difference amplifier has an amplification of 2.94, hence the output is 2.94 (A-B). The range of differences presented to the difference amplifier is -3.4 volts to +3.4 volts, therefore the output range is -10 volts to +10 volts. The difference amplifier has to be accurate for a 1.7-percent error condition at the 50-millivolt level of dc input, or 0.85 millivolt. The operational amplifier is selected to have an offset voltage of less than 0.07 millivolt to minimize error at this level.

The output of the difference amplifier is presented to a scaling amplifier and low-pass filter. This amplifier is scaled to cover the range of a minimum 7.5-percent error at the 50-millivolt level (3.75 millivolts) and a maximum error of 15 percent at 1.25 volts (187.5 millivolts) for conditions of both A greater than B and B greater than A. A reference level of 2.5 volts is established for the A equal to B case. This output is telemetered to the ground as the focus difference signal (IMP 5108). The low-pass filter cuts off at 0.11 Hz (time constant = 1.5 seconds). A typical scaling amplifier and low-pass filter is shown in Figure 3.6-17.

6.2.2.2 Summing Amplifier - The range of sums presented to the summing amplifier can range from 100 millivolts to 10 volts. The summing amplifier is a non-

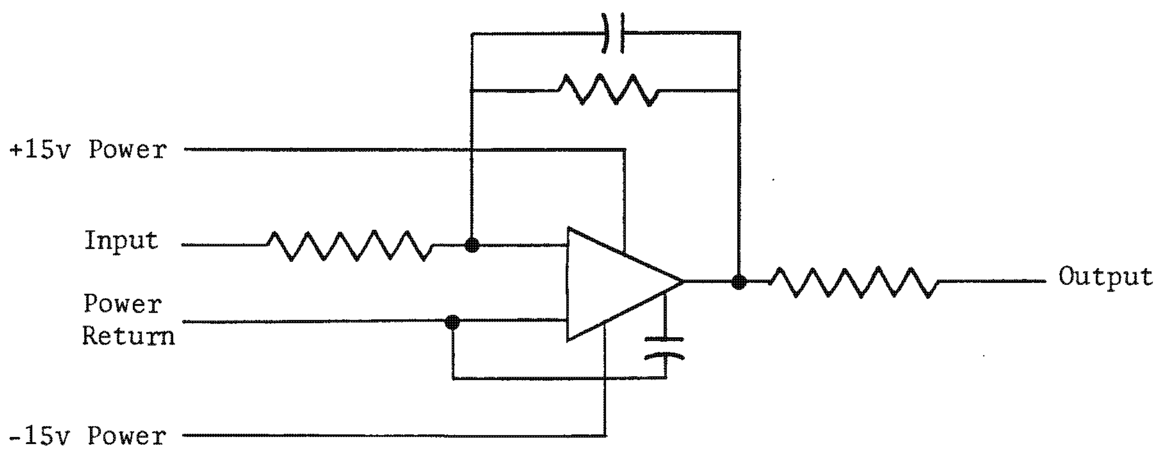

Figure 3.6-17. Typical Scaling Amplifier and Low-Pass Filter

inverting amplifier having unity amplification. The offset voltage of the summing amplifier is typically 0.2 millivolt.

The output of the summing amplifier in the signal processing module is fed into a piecewise-linear scaling amplifier and low-pass filter. The piecewise linear amplifier consists of two operational amplifiers with a zener diode in the feedback path of the first amplifier. This zener diode establishes the piecewise linear breakpoint. For an input signal of 0.1 to 1.5 volts, the amplification of the two-section amplifier is 2.5 and for an input signal of 1.5 volts to 10 volts, the amplification is 0.118. The low-pass filter has the same cut off frequency as the filter in the difference circuit; i.e., 0.11 Hz. This level is presented to the telemetry circuit as IMP 5059, focus signal strength.

6.2.2.3 Divider. The divider accepts inputs from the difference amplifier and the summing amplifier. The difference amplifier feeds the "numerator" input while the summing amplifier feeds the "denominator" input.

The divider output, representing 2(A-B)/(A+B) is routed simultaneously to two scaling amplifiers and low-pass filters in the instrumentation and control module. The divider output is 62.5 millivolts/1-percent difference. For every 1.7 percent error between the output of the rms/dc converters, the divider output changes 62.5 millivolts.

6.2.3 Instrumentation and Control Module

The instrumentation and control module contains the scaling amplifiers and low-pass filters for the focus correction signals, the LED oscillator and driver, scaling amplifiers for the average irradiation signals, and the temperature sensor bias network.

6.2.3.1 Focus Correction Signal Instrumentation. The output of the divider in the signal normalizing module is presented to the two scaling amplifier and low-pass filter sections in the instrumentation and control module. Both sections have a reference voltage adjustment so that both sections may be made equal to 2.5 volts for the A = B condition (50 millivolts to 5 vdc level). Both filters have the same cut off frequency (0.11 Hz) as the other amplifiers described earlier.

The output of the scaling amplifier and low-pass filter section with the coarse sensitivity is referred to as the focus correction signal, coarse (IMP 5107). For a defocus condition of +0.0033 inch (B > A) to -0.0033 inch (A > B)*, the output ranges from 0.5 volt to 4.5 volts for a sensitivity of -0.6 volt/0.001 inch.

The output of the scaling amplifier and low-pass filter section having the fine sensitivity is referred to as the focus correction signal, fine (IMP 5067). For a defocus condition of -0.0020 inch (B > A) to +0.0020 inch (A > B)*, the output ranges from 0.5 volt to 4.5 volts for a sensitivity of 1.0 volt/0.001 inch.

6.2.3.2 LED Oscillator and Driver. The LED array is driven, on command, by the oscillator and driver at one of four possible frequencies (300 Hz, 850 Hz, 1025 Hz and 1600 Hz) and one of two amplitudes as seen at the output of the RMS-to-dc converter (250 millivolts and 2.5 volts). Figure 3.6-18 shows a schematic of the LED oscillator. Depending on the state of the frequency range select, either the 300 Hz and 850 Hz pair (distinguished by the frequency select switch position) or the 1250 Hz and 1600 Hz pair of signal frequencies drives the LED array. (The frequency range select is slave to the "Hi-Lo" command bit.) Because of the manner in which the circuit is commanded, only 6 of the 8 possible combinations of amplitude and frequency are used. Two of the eight states produce the OFF case (see Section 6.3, Focus Detection Subsystem Commanding).

6.2.3.3 Scaling Amplifiers. The scaling amplifiers operate on the dc irradiance signal (see Section 6.2.1.2) whose source is the buffer amplifiers and low-pass filters in the dual detector and signal processing module. The scaling amplifier amplification is set to yield a 5-volt output when the dc level current into the current-to-voltage converter is 80 microamperes. The low-pass filter has a cut off of approximately 1 Hz. Figure 3.6-17 shows a typical scaling amplifier.

*Defocus indicates reticle position relative to best focus (positive reference towards the Ross corrector).

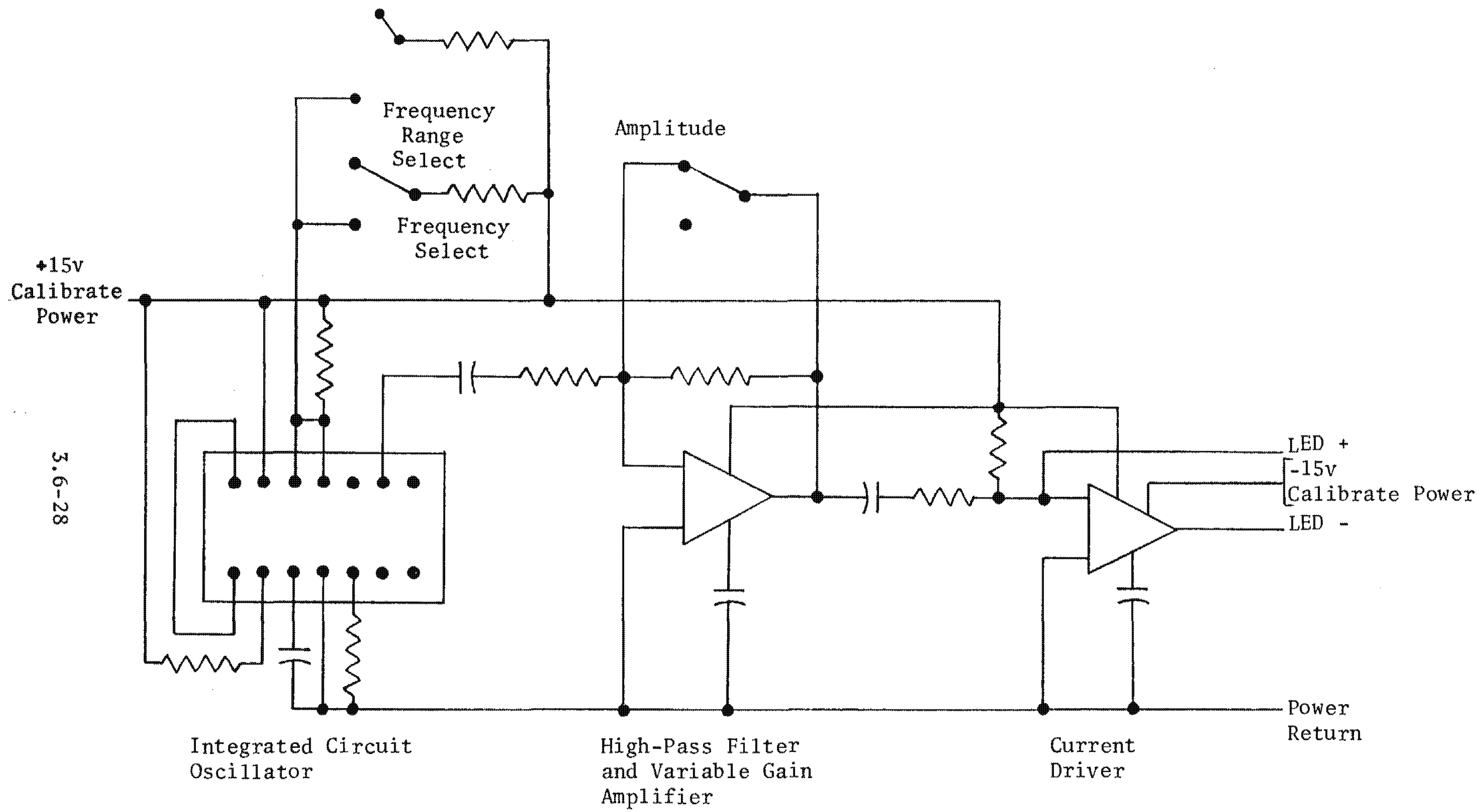

Figure 3.6-18. LED Oscillator and Driver

The average irradiation level for Channel A appears as IMP 5231 and for Channel B as 5105.

6.2.3.4 Temperature Sensor Bias Network. The thermistor temperature sensor is located on the base of the dual detector and signal processing module (see Figure 3.6-1). The bias network, shown in Figure 3.6-19, is located in the instrumentation and control module. The network is designed such that a 2.5-volt output is obtained at 70F.

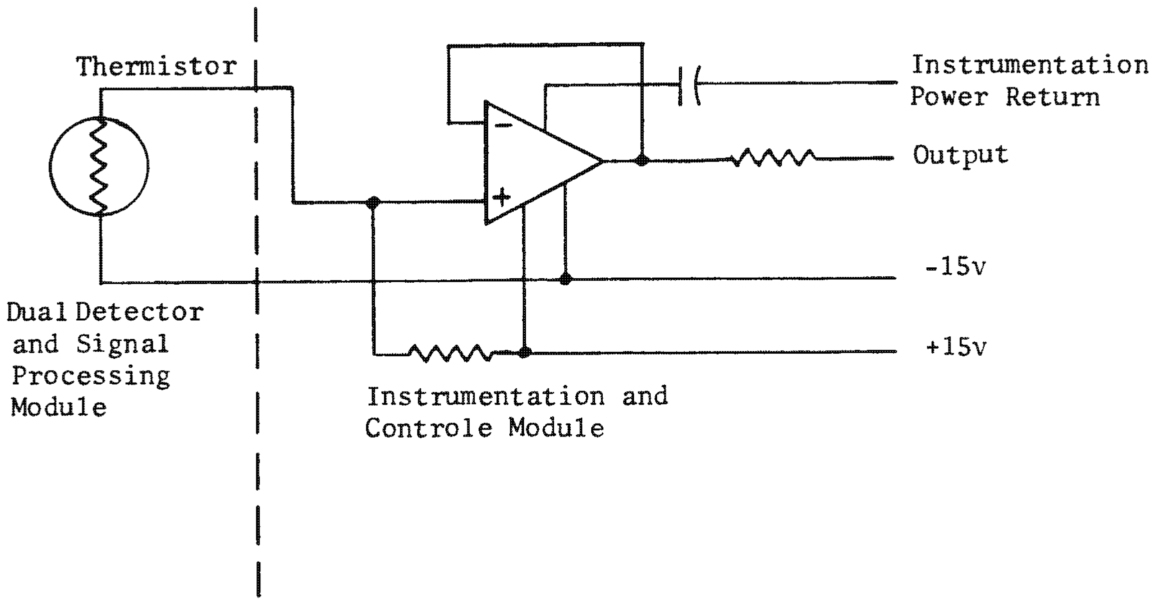

Figure 3.6-19. Temperature Sensor Bias Network

6.2.3.5 Power Decoupling. The small signal level requirements for the dual channel amplifiers result in a need to decouple the ±15-volt power from the power monitor and control unit power supply.

This decoupling is accomplished by a series inductor and by shunting any ac present on the + or -15-volt power lines to ground (power return) through capacitors, as illustrated in Figure 3.6-20.

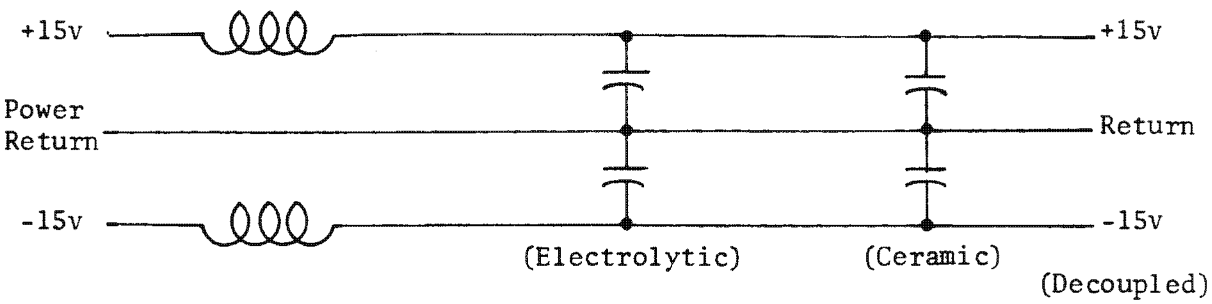

Figure 3.6-20. Power Decoupling Circuit

6.3 Focus Detection Subsystem Commanding

The focus detection subsystem is commanded explicitly by the focus electronics ON/OFF commands available through the extended command system. Additionally, the 9 OFF, 5 OFF and 9/5 OFF commands through the minimal command system will turn the focus detection subsystem off. The focus sensor operates in either the HI or LO mode. Switching is implicit with the HI/LO altitude mode selection command.

6.3.1 Focus Electronics Power

Bits 35, 37 and 38 of these 4V command words control the focus detection subsystem. (Bit 36 controls the viewport door.)

Table 3.6-1 summarizes the function of the appropriate bits with respect to the focus detection subsystem. (Other subsystems may be controlled in parallel by these bits.)

6.4 Instrumentation

There are seven instrumentation points associated with the focus detection subsystem. Table 3.6.2 summarizes the pertinent information for these seven points.

TABLE 3.6-1

FOCUS DETECTION SUBSYSTEM 4V WORD COMMAND

FOCUS Command

(4V0252bZ, 4V0152bZ, 4V0352bZ, Bits 35, 37, 38)

Bit	Function
35-1	*FEP ON, S1 - PRG ENABLE, S1 - PRG Power ON
35-0	FEP OFF, S1 - PRG Power OFF
36-1	DOOR OPEN
36-0	DOOR CLOSE
37-1 37-0 38-1 38-0	Focus Calibrate Modes (See Below)

Bit		
37-0	38-0	Focus Calibrate OFF, S1-PRG Calibrate OFF
37-1	38-0	**Focus Calibrate ON, High Frequency, Low Amplitude
37-1	38-1	**Focus Calibrate ON, High Frequency, High Amplitude
37-0	38-1	**Focus Calibrate ON, Low Frequency, High Amplitude

*Telemetry power must be ON to provide FEP (focus electronics power).

**See Section 6.2.3.2. The Focus Cal Modes are modified by the Altitude Select commands.

TABLE 3.6-2

FOCUS DETECTION SUBSYSTEM INSTRUMENTATION

IMP	Title	Description	Power
5058	Temperature, Focus Sensor Head	A thermistor, located in the dual detector and signal processing module, monitors the focus-sensor head temperature, producing a linear output from 60F (4.8v) to 75F (2.0v). The processing electronics are located in the in-instrumentation and control module.	±15vdc
5059	Focus Signal Strength (A+B)	The output is related to the sum of the Channel A and Channel B RMS signal levels. The instrumentation signal is piecewise linear in segments from 0 volt signal strength (0.0v output) to 1.5 volts signal strength (3.75v output), and from 1.5 volts signal strength (3.75v output) to 10 volts signal strength (4.75v output).	±15 vdc
5067	Focus Correction Signal, Fine	The correction signal is derived from the difference in RMS signal levels between Channels A and B, normalized by the sum of the RMS levels. A=B (zero defocus) is set at 2.5 volts and the slope is - 1.0 volts/0.001 inch defocus, where defocus indicates the position of the reticle midplane relative to the point of best focus. Defocus at the 9 platen (X_p) is related to defocus at the focus detector (X_R) by the following equation: $$X_p = \frac{X_R}{0.8524}$$	±15 vdc

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TABLE 3.6-2 (CONT'D)

IMP	Title	Description	Power
5105	Average Irradiation Level (Channel B)	The output monitors the average dc signal level from the Channel B photodiode detectors. Calibrated in terms of energy incident on the photodiodes, the output is linear from 0 foot-candles (0.0v) to 125 foot-candles (5.0v).	±15 vdc
5107	Focus Correction Signal, Coarse	Similar to IMP 5067, but with a sensitivity of 0.5 volt/0.001 inch.	±15 vdc
5108	Focus Difference Signal (A-B)	The instrumentation output indicates the difference in RMS signal levels between Channel A and Channel B (A-B) at the output of the difference amplifier in the signal normalizing module. The instrumentation signal is linear from -187.5mv (0.25v) to +187.5mv (4.75v).	±15 vdc
5231	Average Irradiation Level (Channel A)	Identical to IMP 5105 in Channel B.	±15 vdc
5002	Cal On/Off, FEP On/Off, Cal Bit A/$\bar{A}$, Cal Bit B/$\bar{B}$	Latching relays tracking the command input relays of the command processor monitor the receipt of commands from the satellite control section and feed either 0.0v or 5.0v to an integrated circuit D/A converter. Four relays and one 4-bit D/A converter form the IMP. Output occurs in sixteen discrete steps ranging from 0.25v to 4.75v in 0.3v-increments: Bit 1 (LSB)* = Cal On/Off	+5/±15 vdc

*Least Significant Bit

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TABLE 3.6-2 (CONT'D)

IMP	Title	Description	Power
		Bit 2 = FEP On/Off Bit 3 = Cal Bit A/$\bar{A}$ (command Bit 38; Bit 1 in the focus electronics) Bit 4 (MSB)** = Cal Bit B/$\bar{B}$ (command Bit 37; Bit 2 in the focus electronics)	
5594	Focus Power Monitor, +15 vdc	A voltage divider circuit connected across the focus power +15v feed in the PM and C monitors the voltage level. Output is digitized in the DTU to yield a binary signal (On/Off). "0" = Off "1" = On	+15 vdc
5595	Focus Power Monitor, -15 vdc	An optical isolator circuit (LED and photo-transistor) with the LED powered by the -15v focus power feed in the PM and C monitors the output voltage level. The instrumentation signal is digitized in the DTU to yield a binary signal (On/Off). "0" = Off "1" = On	-15/+5 vdc
5596	Focus Calibration Monitor, +15 vdc	Similar to IMP 5594, monitors the +15v focus calibration power.	+15 vdc
5597	Focus Calibration Monitor, -15 vdc	Similar to IMP 5595, monitors the -15v focus calibration power.	-15/+5 vdc

**Most Significant Bit

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7.0 POWER DISTRIBUTION SUBSYSTEM

The power required by the Photographic Payload Section/Dual Platen Extended Altitude Capability (PPS/DP EAC) for orbital operation is supplied by a single power bus located in the satellite control section (SCS). The bus, which operates from a parallel combination of batteries and solar panels, delivers direct current in the range of 22.0 to 29.7 volts (24.5 volts nominal).

Power is received in the PPS/DP EAC by the power monitor and control unit (PM and C) and the initiator electronics unit (IEU). These two provide a controlled interface between the PPS/DP EAC and SCS portions of the vehicle and act as power distribution centers within the PPS/DP EAC, the IEU for pyrotechnic power and the PM and C for all other power. To conserve battery energy during the pad cycle, the ground heater subsystem is powered directly through a vehicle umbilical line. After launch, the ground heaters are totally inoperative. Figure 3.7-1 presents a block diagram of the power distribution subsystem. Although the SCS power source is a unibus system, the PPS/DP EAC uses multibus nomenclature that is a carry-over from an earlier power supply system.

7.1 Power Source

The power source is the responsibility of Lockheed Missiles and Space Company (LMSC). The information in this section was provided to BIF-008 by LMSC as representative data for Vehicle 48. The data is not guaranteed to be the most recent figures and should be used for general information only.

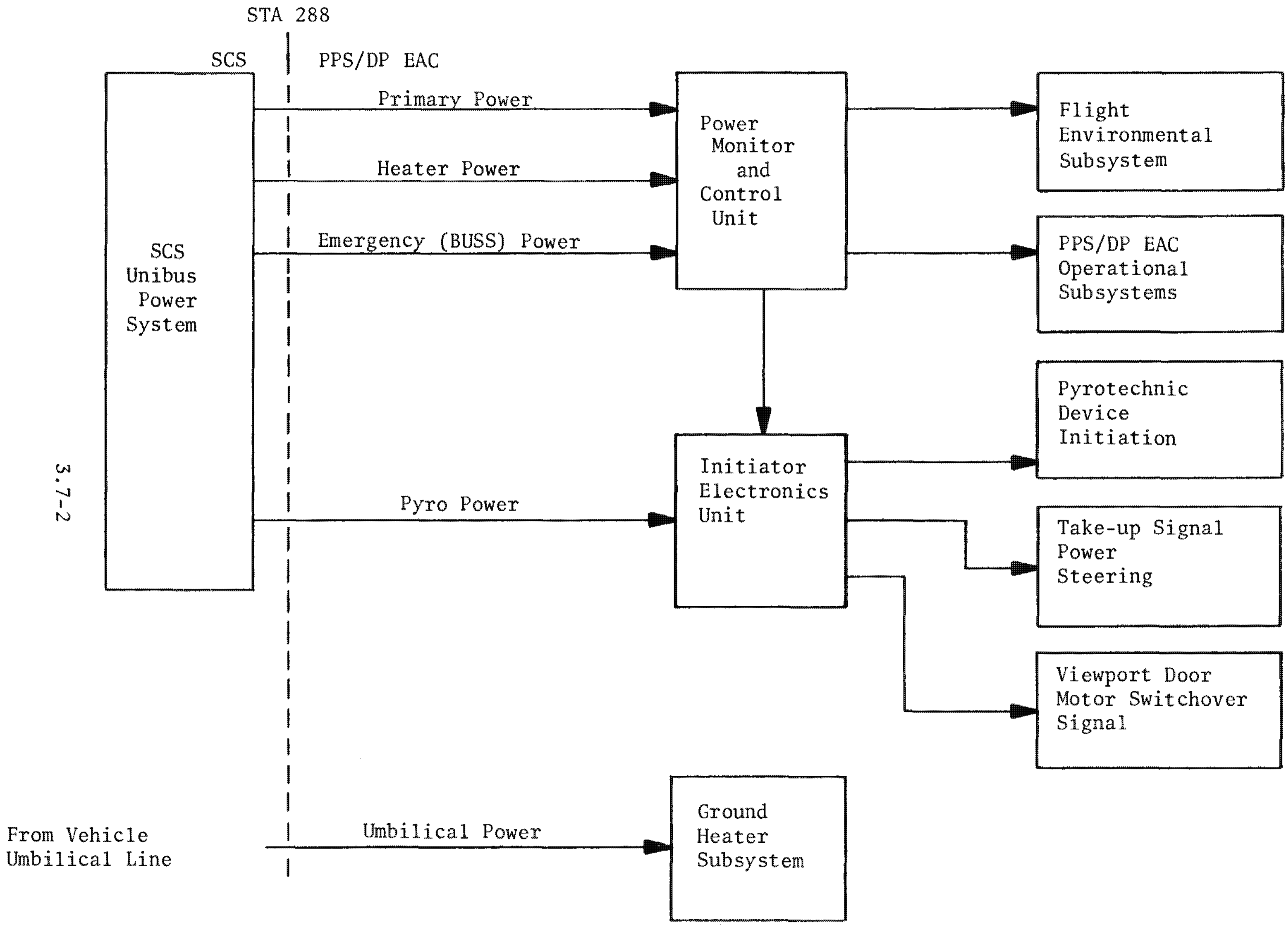

Figure 3.7-1. PPS/DP EAC Power Distribution Subsystem

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7.1.1 Power Distribution

Figure 3.7-2 illustrates the SCS power distribution system. All PPS/DP EAC flight power is received from the main and pyro busses which are in turn connected to the battery bus. The connecting switches (S1 and S2 on Figure 3.7-2) are operable only on the ground and thus the system acts as a single bus and is treated as such. The battery bus is fed by a parallel combination of batteries and the solar panel arrays. Normally 4 to 5 batteries are provided, however, the system can carry up to 8 batteries if necessary. The voltage level at the PPS/DP EAC interface exhibits maximum transients of ±3 volts within the lower and upper limits of 22.0 to 29.7 volts.

7.1.2 Solar Array

The solar array consists of 4 panels, two on each side of the SCS, with the inboard panels able to be disconnected from the battery bus upon command. The panels are approximately ten square feet each, and together are expected to supply 6 to 7 amp-hours/rev on a sun-synchronous orbit, with a peak current of 16 amperes. As shown in Figure 3.7-2, each panel consists of four separate sections. The four inboard sections on each side can be switched together by command as follows:

(1) Disconnect/connect sections 1 and 2

(2) Disconnect/connect section 3

(3) Disconnect/connect section 4

The result is that sections 5 through 8 on both sides are always connected. Sections 1 through 4 can be totally disconnected, or sections 1 and 2 can be

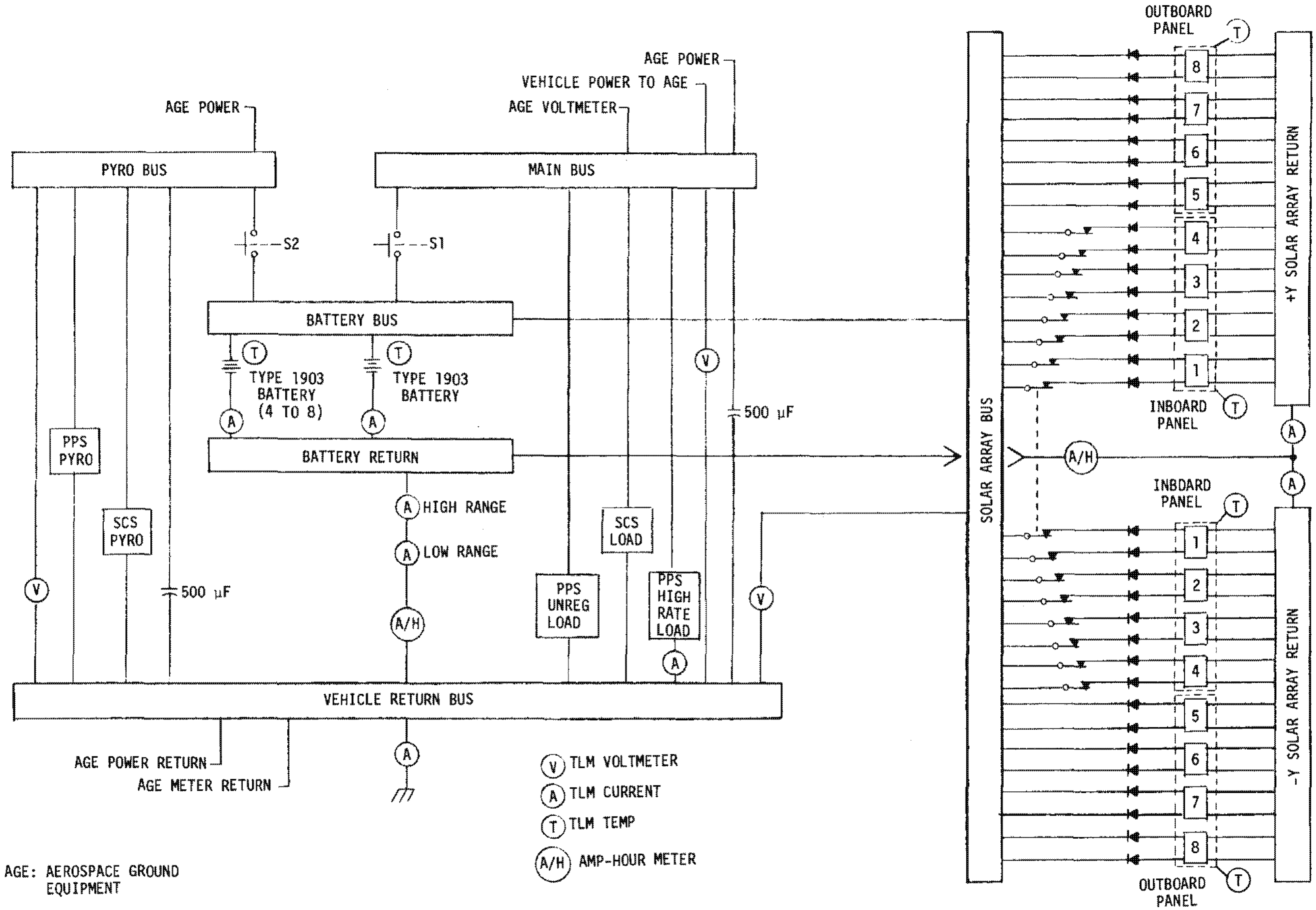


Figure 3.7-2. SCS Power Distribution System

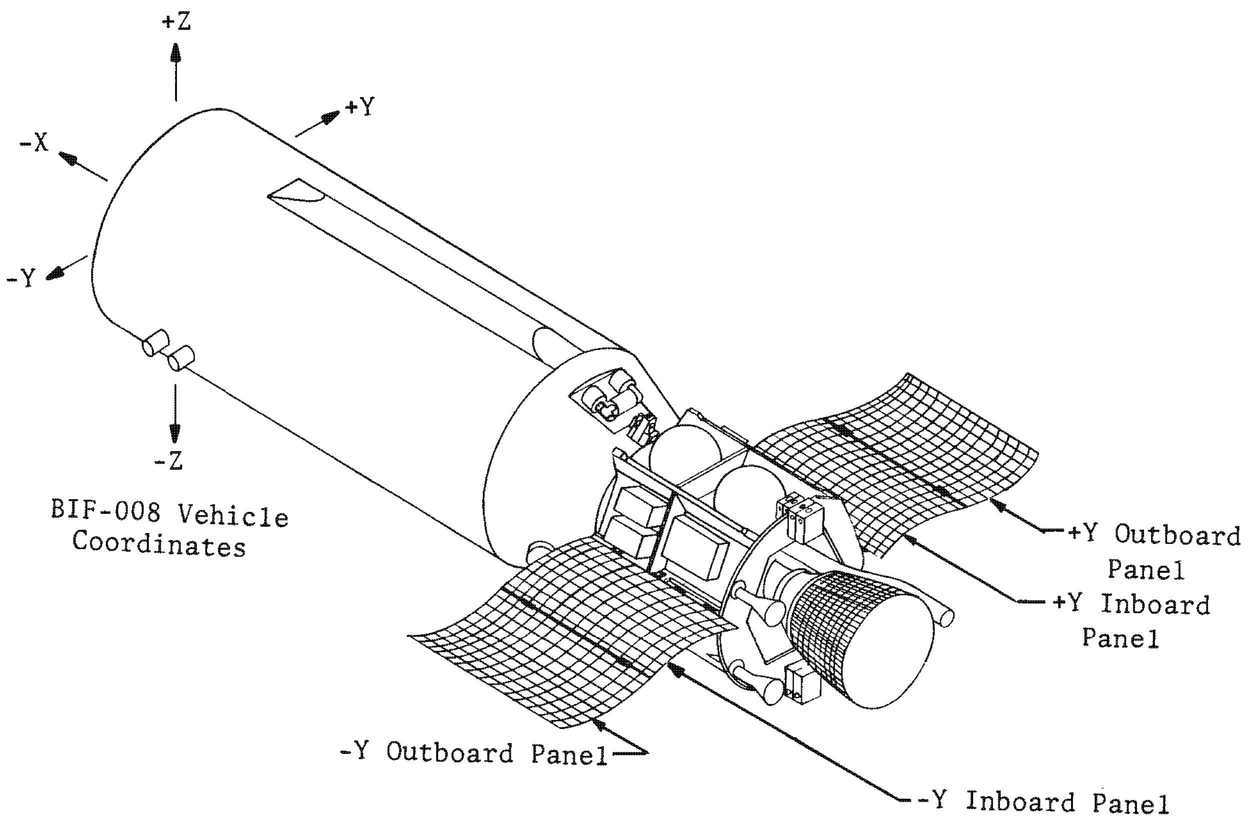
connected to give half output from each inboard panel and then build up to full power from the inboard panels in steps of one-quarter. The panels are attached to the vehicle near the aft end of the SCS as shown in Figure 3.7-3. Hinges at the SCS, and between panels, allow them to be folded against the SCS for launch. Once on-orbit, they are deployed upon command.

7.1.3 Batteries

The batteries are silver zinc type, each weighing approximately 170 pounds. Each battery is able to deliver 750 amp-hours of energy (nominal). The number of batteries needed is mainly a function of flight duration, and will be determined by LMSC. After initial charge, the batteries begin operation in the "peroxide region" which is characterized by large voltage transients from the no-load to loaded state (i.e., supplying power). This behavior disappears after a small portion of the battery energy has been used. Therefore, the batteries are normally pre-conditioned (depleted slightly) before launch to ensure any voltage variations remain within specified limits.

The batteries will exhibit a second source of voltage variation (other than normal loading) which is caused by the solar panels. The panels are connected to the battery bus for the flight duration. Any time the bus electrical load is less than the current supplied by the solar panels, the excess current will be charging the batteries. When the bus load exceeds the solar panel current, the batteries will supply the additional energy. Due to the chemistry of the batteries, the terminal voltage will be higher in the charging state than in the discharging state, and a terminal voltage step will occur as the battery alternates between charging and discharging conditions. The time constant of this change is approximately 1 millisecond at the SCS unibus.

For example: Assume the solar panels are supplying 10 amperes. As long as the current drain on the power supply is less than 10 amperes, the batteries will be charging, and the bus voltage will be stable.



NOTE: The drawing is based on the LMSC System Concept Design Review for Vehicle 48 (January, 1974). Reference LMSC publications for accurate design data.

Figure 3.7-3. SCS Solar Array

As soon as the load exceeds 10 amperes, the batteries will be discharging, supplying the additional current, and the supply voltage will drop. Figure 3.7-4 illustrates this condition. A result of this phenomenom is a periodic voltage variation (period approximately 1/3 second) when the roll joint is operated due to the pulse train characteristics of the current load for the roll joint drive.

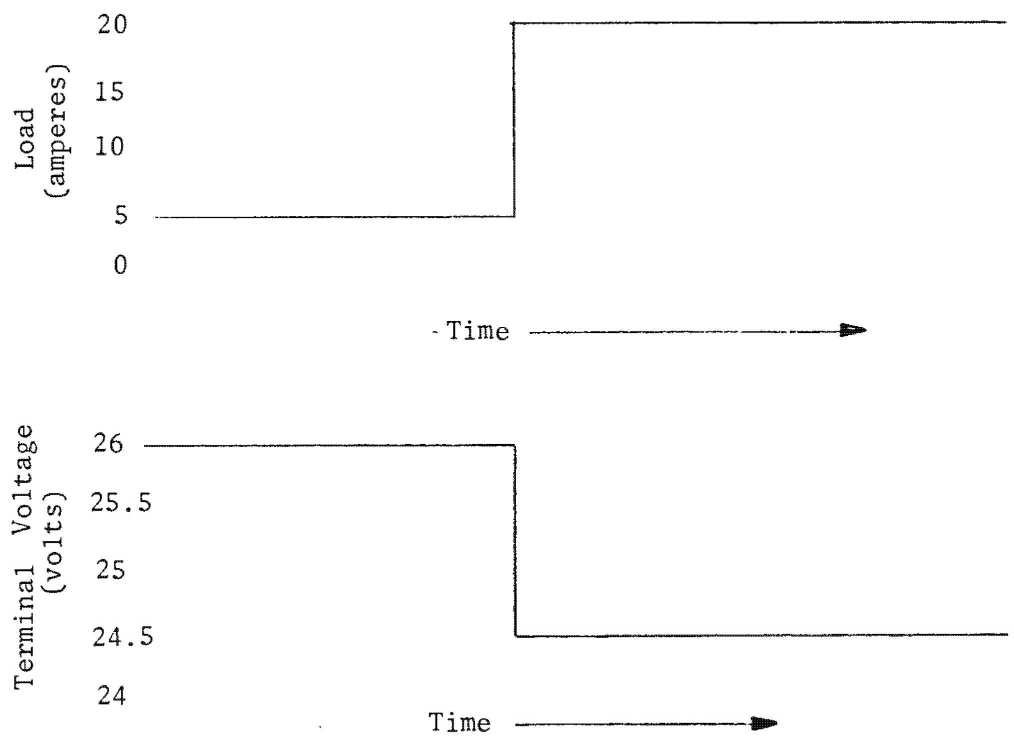


Figure 3.7-4. Voltage/Load Relationship Due to Solar Panel Effect

7.2 Power Monitor and Control Unit

The PM and C serves as the main power distribution and measurement center for the PPS/DP EAC and as a controlled interface with the SCS. Input power comes from the SCS bus on 11 feedlines (with 10 power returns) that are labelled in three groups; primary power (2 lines), emergency (BUSS) power (5 lines) and heater power (4 lines). The PM and C distributes this power to units within the PPS/DP EAC, either through commandable switch circuits, or directly to the using units. For certain functions, the PM and C switching provides logic control in conjunction with the command logic in the command processor. The PM and C also converts and regulates the BUSS power line voltage for use by the PPS/DP EAC instrumentation and focus detection subsystems, and provides current information and total ampere-hour consumption through internal instrumentation. In addition, the PPS/DP EAC unipoint ground is established within the PM and C. All load current, except pyrotechnic current is returned to this point.

A power consumption estimate for the PPS/DP EAC is presented in Table 3.7-1. Figures used to derive this table are based on computerized mission simulations and engineering estimates. This table is included only as a general guideline. Exact correlation between it and actual results cannot be expected, as power consumption can vary widely from mission-to-mission due to differing orbital parameters and operational procedures.

7.2.1 PM and C Assembly

The PM and C is located on the +Y side of the film supply enclosure (reference Part 3, Section 1). The unit is approximately 14" x 12" x 9" and weighs about 20 pounds. It consists of a stack of 4 metal boards and the top and bottom covers (see Figure 3.7-5). Boards A3, A4, and A5 are shaped like open-top boxes in which components mount, and are stacked, and bolted together. This stack is secured to the A2 board which is a flat metal plate containing the major power dissipating components and forming the mounting feet of the unit. The top and bottom covers bolt to the entire stack. The top cover supports the electrical inter-

TABLE 3.7-1

PPS/DP EAC POWER CONSUMPTION

Load	Typical Current (ma)[1]	Voltage (volts)	Power (watts)	60-Day Operating Time (hrs)[2]	Total (watt-hrs)
PPS/DP EAC Idle					
9 & 5 OP OFF	54	24.5	1.32	1292	1709
9 OP ON	237	24.5	5.8	106	614.8
5 OP ON	246	24.5	6.0	42	252
9 & 5 OP ON	411	24.5		- no est.	
Pyro Idle Load	0.1	24.5	0.0025	1440	3.6
Telemetry Loads					
DTU 1 or 2	495	24.5	12.1	220	2662
±15v Regulator	Note 3				
+5v Regulator	Note 3				
Pressure Transducer	Note 3				
Event Loads					
9 Film Drive	570	24.5	13.96	4.1	57.2
5 Film Drive	450	24.5	11.03	1.3	14.34
9 SRC	1080	24.5	26.46	0.26	6.88
5 SRC	1130	24.5	27.69	0.08	2.22
9 NPA					
Primary	540	24.5	13.23	0.14	1.85
B/U	530	24.5	12.98	-	
5 NPA					
Primary	560	24.5	13.72	0.14	1.92
B/U	540	24.5	13.23	-	
9 VEM (A & B Avg)	1120	24.5	27.44	1.4	38.4
5 VEM (A & B Avg)	1000	24.5	24.5	0.6	14.7

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TABLE 3.7-1 (CONT'D)

Load	Typical Current (ma)[1]	Voltage (volts)	Power (watts)	60-Day Operating Time (hrs)[2]	Total (watt-hrs)
Event Loads					
9 Take-up Cycle*					
Supply Full; Take-up 1 Empty Supply ½ Full; Take-up 1 Full	3370 (avg)	24.5	82.6	1.3 (note 4)	107.4
Supply ½ Full; Take-up 2 Empty Supply Empty; Take-up 2 Full	2250 (avg)	24.5	55.1	1.8 (note 4)	99.2
5 Take-up Cycle*					
Supply Full; Take-up 1 Empty Supply ½ Full; Take-up 1 Full	2530 (avg)	24.5	62.0	0.3 (note 4)	18.6
Supply ½ Full; Take-up 2 Empty Supply Empty; Take-up 2 Full	3000	24.5	73.5	0.3 (note 4)	22.1
FEP					
Operate	117	Note 5	2.87	150	430.5
Calibrate	123	Note 5	3.01	40	120.4
S1-PRG					
Operate	9	24.5	0.22	190	41.8
Calibrate: Motors OFF	9	24.5	0.22	2.5	0.55
Motors ON	320	24.5	7.84	0.15	1.18
Crab Servo	223	24.5	5.46	9.9	54.05
Stereo Servo	225	24.5	5.51	15.9	87.61
Viewport Doors Open	220	24.5	5.39	2.7	14.55
Viewport Doors Close	450	24.5	11.02	3.1	34.16
Viewport Doors Open (B/U)	500	24.5	12.25	-	
Viewport Doors Close (B/U)	600	24.5	14.70	-	
5 Parking Brake	1500	24.5	36.75	2.8	102.9

*Assumes Film Drive OFF; 5 T/U in primary mode.

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TABLE 3.7-1 (CONT'D)

Load Env. Branches*	Typical Current (ma)[1]	Voltage (volts)	Power (watts)	60-Day Operating Time (hrs)[2]	Total (watt-hrs)
Branch 1	1050	24.5	25.7	-	
Branch 2	1520	24.5	37.2	-	
Branch 4	3270	24.5	80.1	-	7,350 (Note 6)
Branch 5	2570	24.5	63.0	-	
Branch 6	1050	24.5	25.7	-	
EPSM 1	1250	24.5	30.6	-	
EPSM 2	1250	24.5	30.6	-	

Total watt-hours = 14,679.76

Total ampere-hours = 599.2

*All tapes ON.

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TABLE 3.7-1 NOTES

(1) Currents derived from design estimates or reliability model tests.

(2) Operating times taken from mission simulation studies, engineering estimates, or extrapolated from previous flight.

(3) Included in DTU power estimate.

(4) Operating time based on 10,800 feet of 9.5-inch film and 3,000 feet of 5-inch film, and an average take-up cycle of 25 inches of film. Cycle times are averaged for take-up spool empty and full and supply spool full, half-full, and empty conditions.

(5) The focus subsystem operates from ±15 vdc regulated power. The current load indicated represents drain on the 24.5-volt bus by the power regulator.

(6) Heater power consumption varies widely, depending on orbit parameters, thermal finish, and operating procedures. Based on previous experience with a sun-synchronous orbit, and a combination of constant door open light side (CDOL) and door open dark side (DOD) activity, approximately 7,350 watt-hours are consumed. Included in the figure is the operating current for the heater controllers.

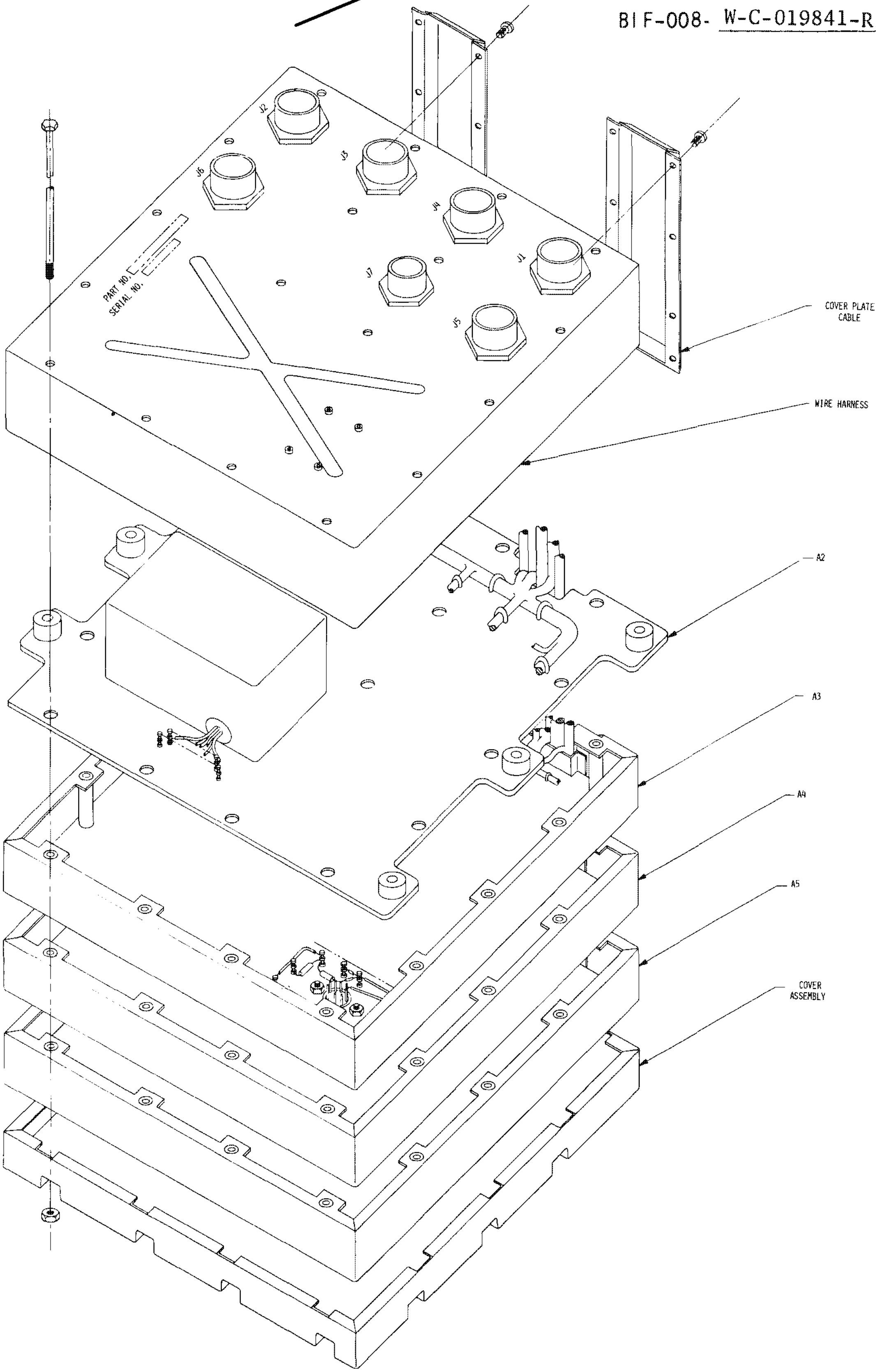


Figure 3.7-5. PM and C Assembly

face connectors and input filter capacitors between feed and return on the emergency and primary power lines (see Figure 3.7-6). Components on the various boards are soldered to terminals, and point-to-point wiring is used for interconnection. A harness assembly connects the boards to each other and to the interface connectors.

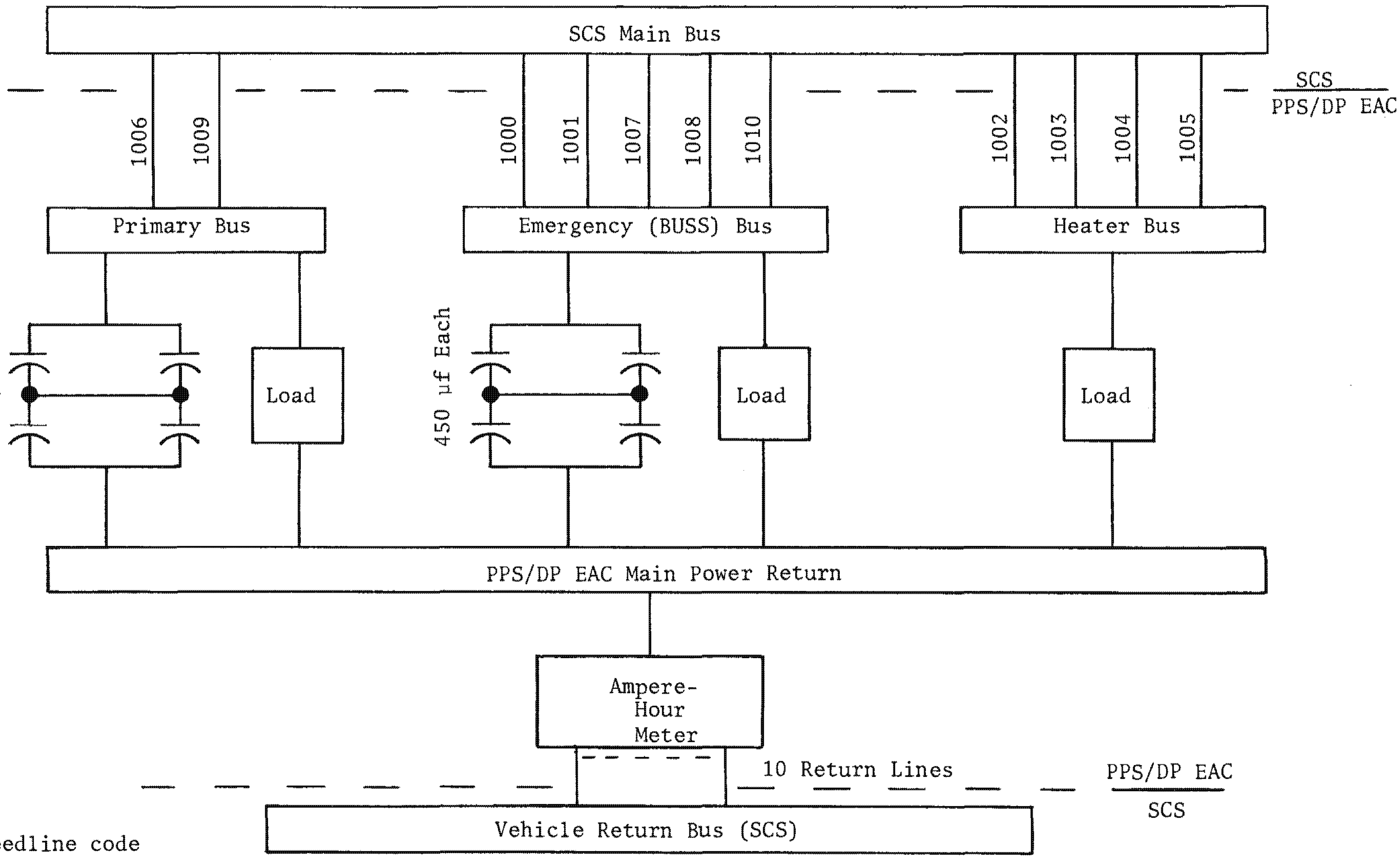
The A4 and A5 boards are devoted to power controller circuits. The A3 board contains the current flow instrumentation circuitry, and the A2 board contains the ±15-volt instrumentation regulator, the +5-volt instrumentation regulator, the ampere-hour meter, and the unipoint power return.

7.2.2 PM and C Logic

Power is distributed and controlled by the PM and C in accordance with Table 3.7-2, using the applicable logic shown in Figures 3.7-7 through 3.7-13. Unswitched signifies direct connection of the power to the output function. In general, overload protection is provided only for those functions not essential to recovery and/or accomplishment of the primary mission objectives.

The four-digit codes listed on the logic diagrams are assigned by BIF-008, and are used in the 9 x 5 Interconnection Diagram to allow tracing of signals and power through the PPS/DP EAC cabling. The codes in parenthesis following many function titles are command word codes. For an explanation of the command code format, and also of the logic symbols used, refer to Part 3, Section 9.

7.2.2.1 PM and C Switching Circuits. The switch control commands are pulses received from the command processor which activate soft switching circuits within the PM and C. These circuits consist of a latching relay paralleled by a hybrid circuit rise- and fall-time control device (Figure 3.7-14). Upon



NOTE: Feedline code numbers assigned by BIF-008

Figure 3.7-6. PPS/DP EAC Power Input and Filtering

TABLE 3.7-2

PM AND C POWER DISTRIBUTION

Power Feed	Controller Command	Function	Logic Figure	Overload Protection
Primary Power	none	9 CEA Power	Unswitched	none
	none	5 CEA Power	Unswitched	none
	none none none	Viewport Door Electronics Power* Viewport Door Electronics Power* Viewport Door Electronics Power*	Unswitched Unswitched Unswitched	6A fuse 6A fuse 0.5A fuse
	9 OP A or B or 5 OP A or B	Crab Servo Power Stereo Servo Power	3.7-7 3.7-7	2 parallel 5A fuses 2 parallel 5A fuses
	Focus Electronics Power S1-PRG DISABLE	S1-PRG	3.7-8	2 parallel 3A fuses

*Individual lines

TABLE 3.7-2 (CONT'D)

Power Feed	Controller Command	Function	Logic Figure	Overload Protection
Emergency Power	none	CP Power	Unswitched	none
	none	IEU Power	Unswitched	none
	DTU 1 DTU 2 DTU 1 or DTU 2 }	DTU 1 Power DTU 2 Power Pressure Transducer Power (IMP 5019) +5 vdc Regulator** +15 vdc Regulator** -15 vdc Regulator**	3.7-10	2 parallel 1A fuses 2 parallel 1A fuses 2 parallel 0.2A fuses 2 parallel 0.5A fuses } 2 parallel 4A fuses
	9 OP A or B	9 FPLLE Power FCE Power	3.7-7	none none
	5 OP A or B	5 FPLLE Power FHE Power	3.7-7	none none
	EPSM* 1	EPSM 1 Heater Power	3.7-13	none
	EPSM* 2	EPSM 2 Heater Power	3.7-13	none

*Environmental power SRV minimal
**Internal function

TABLE 3.7-2 (CONT'D)

Power Feed	Controller Command	Function	Logic Figure	Overload Protection
Heater Power	Heater Branch 1	Branch 1 Power	3.7-12	2 parallel 2A fuses
	Heater Branch 2	Branch 2 Power	3.7-12	2 parallel 3A fuses
	5 Parking Brake	5 Parking Brake Power	3.7-11	2 parallel 1.5A fuses
	Heater Branch 4	Branch 4 Power	3.7-12	2 parallel 6A fuses
	Heater Branch 5	Branch 5 Power	3.7-12	2 parallel 5A fuses
	Heater Branch 6	Branch 6 Power	3.7-12	2 parallel 2A fuses
+15-volt Regulator	none* none Focus Electronics Power Focus Calibration Power	+15 vdc Out to Misc +15 vdc to IEU +15 vdc Focus Electronics Power +15 vdc Focus Calibration Power	Unswitched Unswitched 3.7-8 3.7-9	Electronic Overload Protection at Regulator Output
-15-volt Regulator	none* Focus Electronics Power Focus Calibration Power	-15 vdc Out to Misc -15 vdc Focus Electronics Power -15 vdc Focus Calibration Power	Unswitched 3.7-8 3.7-9	Electronic Overlaod Protection at Regulator Output
+5-volt Regulator	none*	+5 vdc Out to Misc	Unswitched	Electronic Overload Protection at Regulator Output

*DTU 1 ON or DTU 2 ON required for +5/±15 vdc regulator power.

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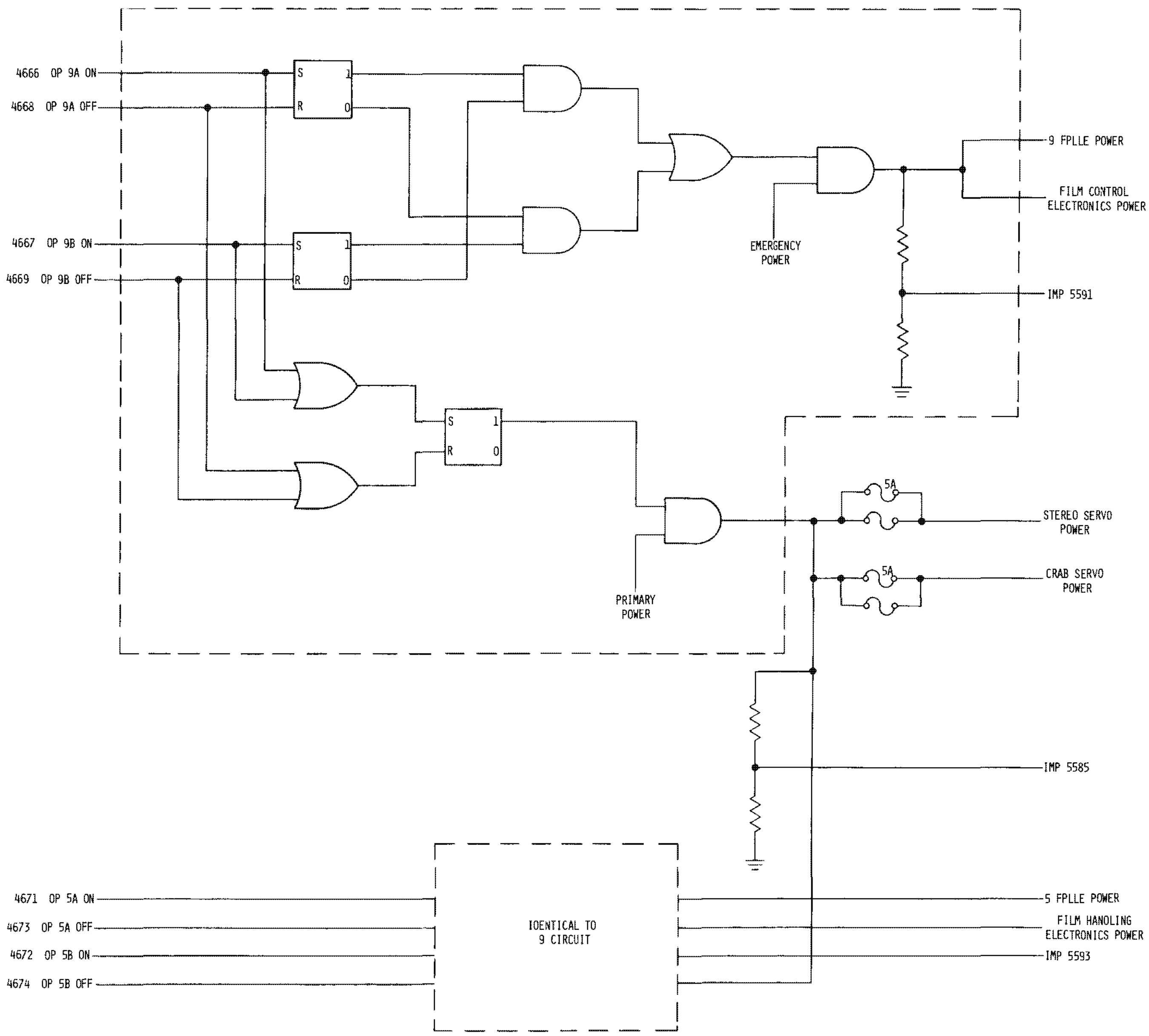

Figure 3.7-7. 9 and 5 Operational Power and Servo Power

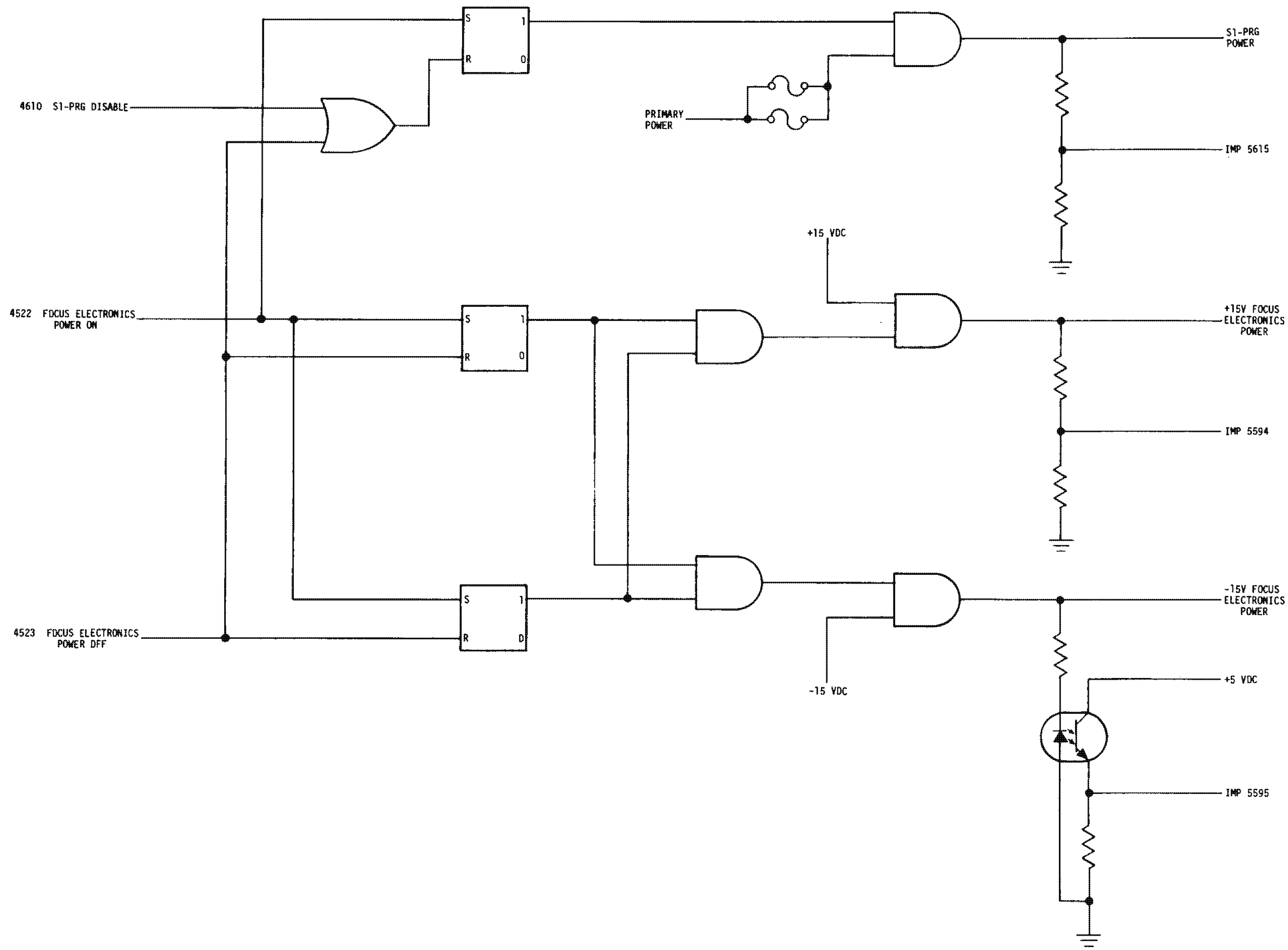

Figure 3.7-8. Focus Electronics and S1-PRG Power

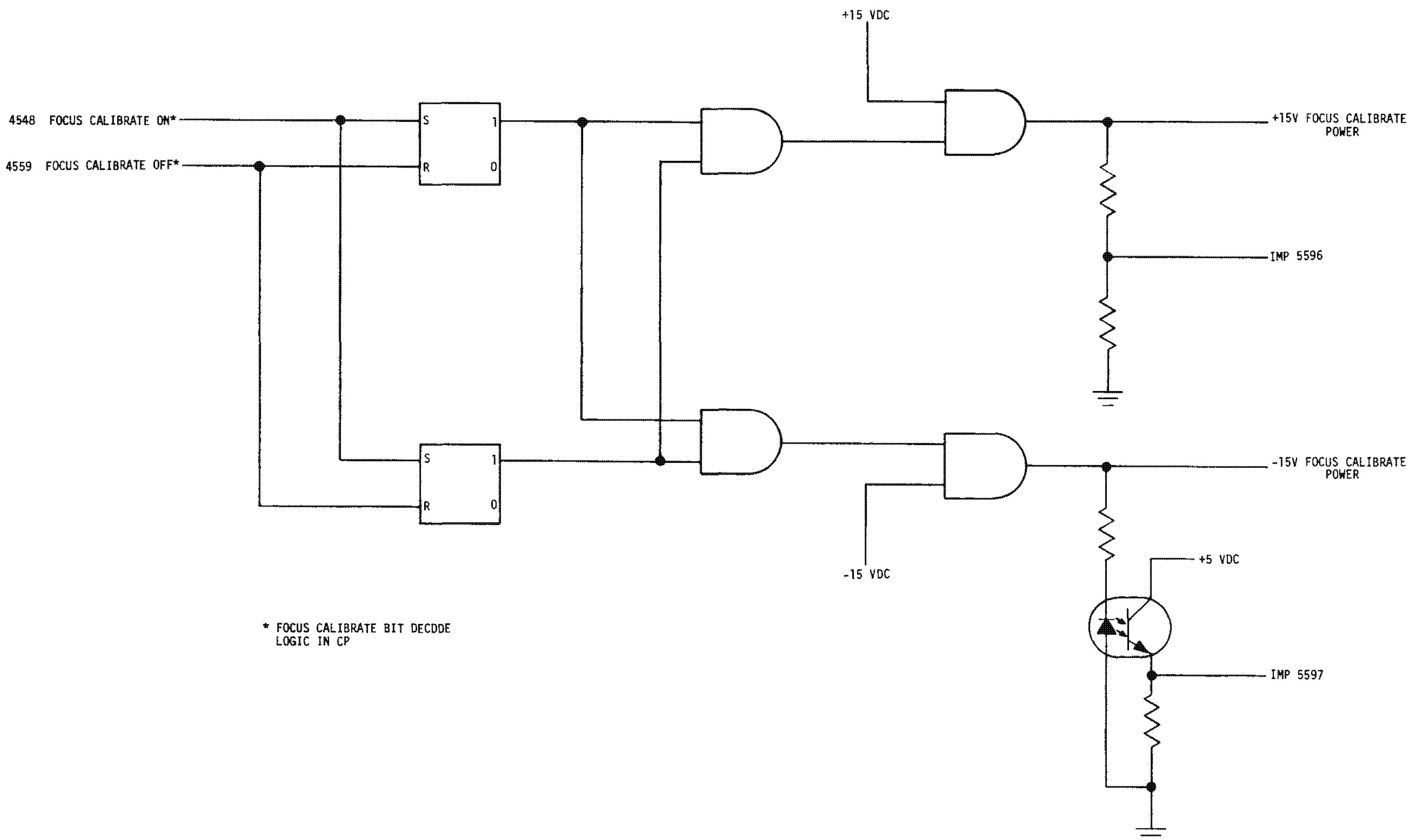

Figure 3.7-9. Focus Detection Subsystem Calibration Power

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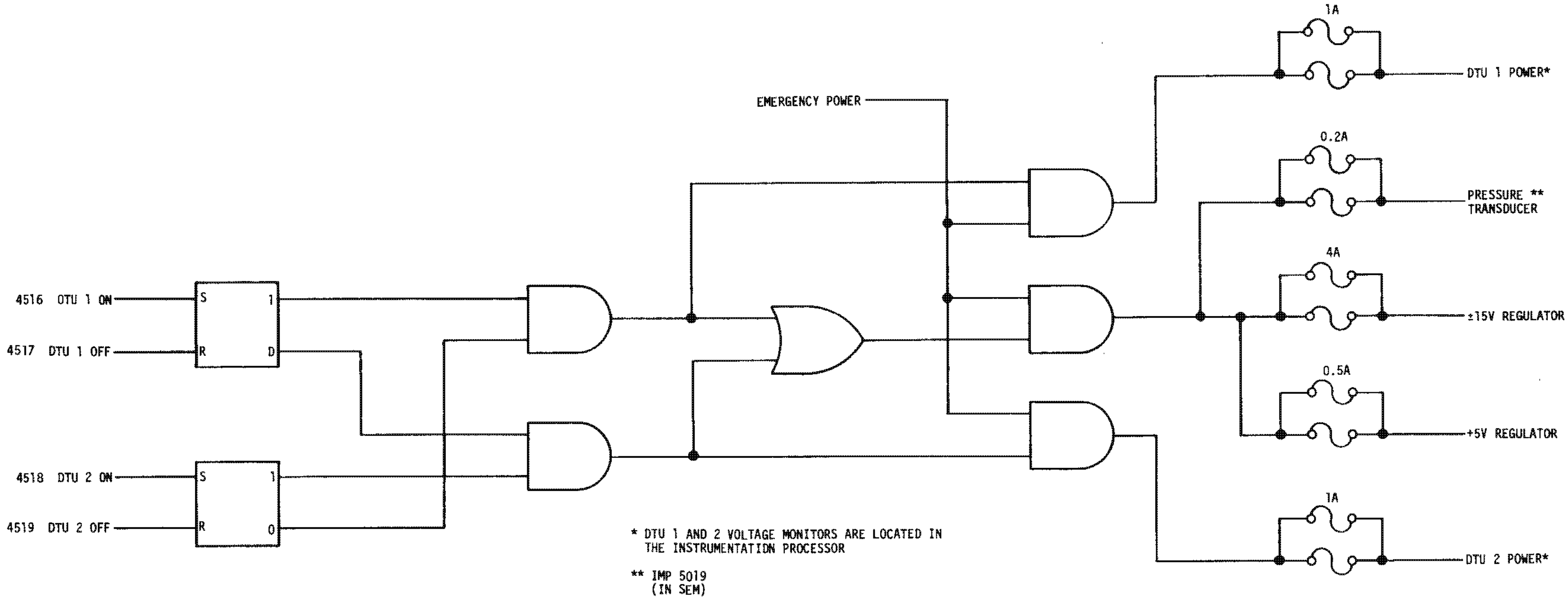

Figure 3.7-10. DTU 1 and 2 Power; Instrumentation Supply and Pressure Transducer Power

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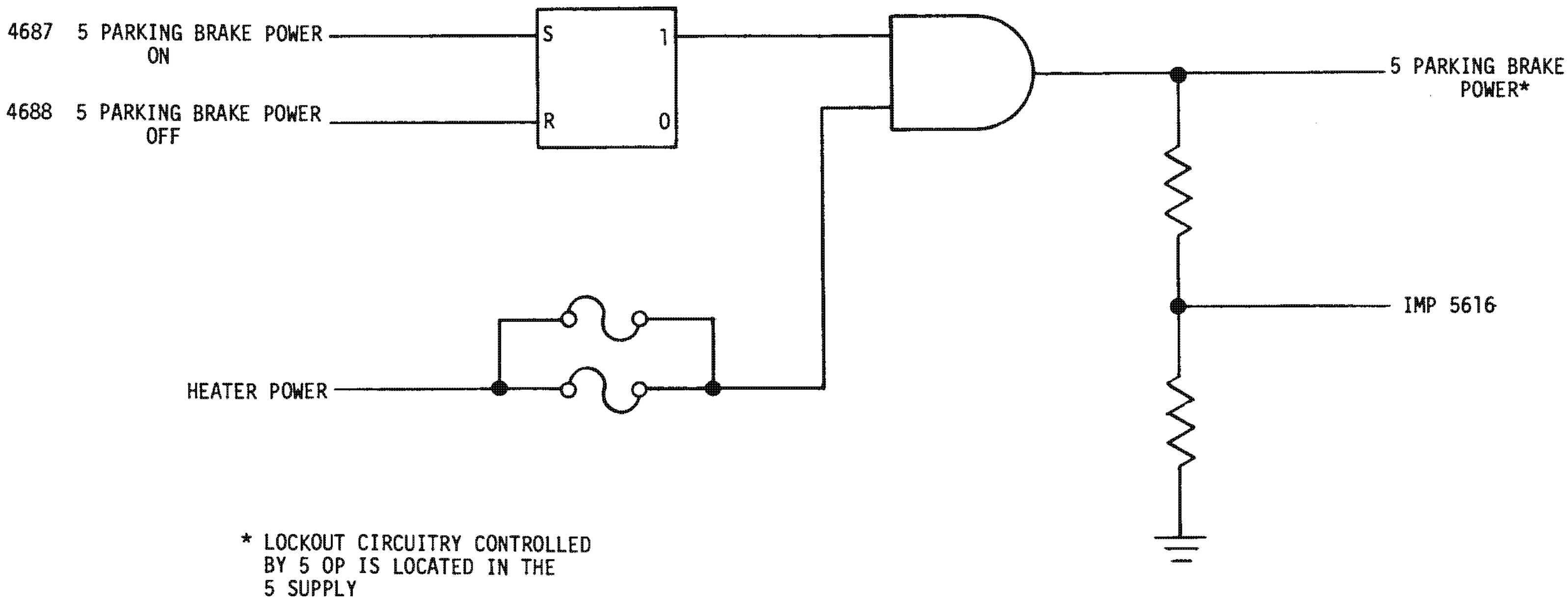

Figure 3.7-11. 5 Parking Brake Power

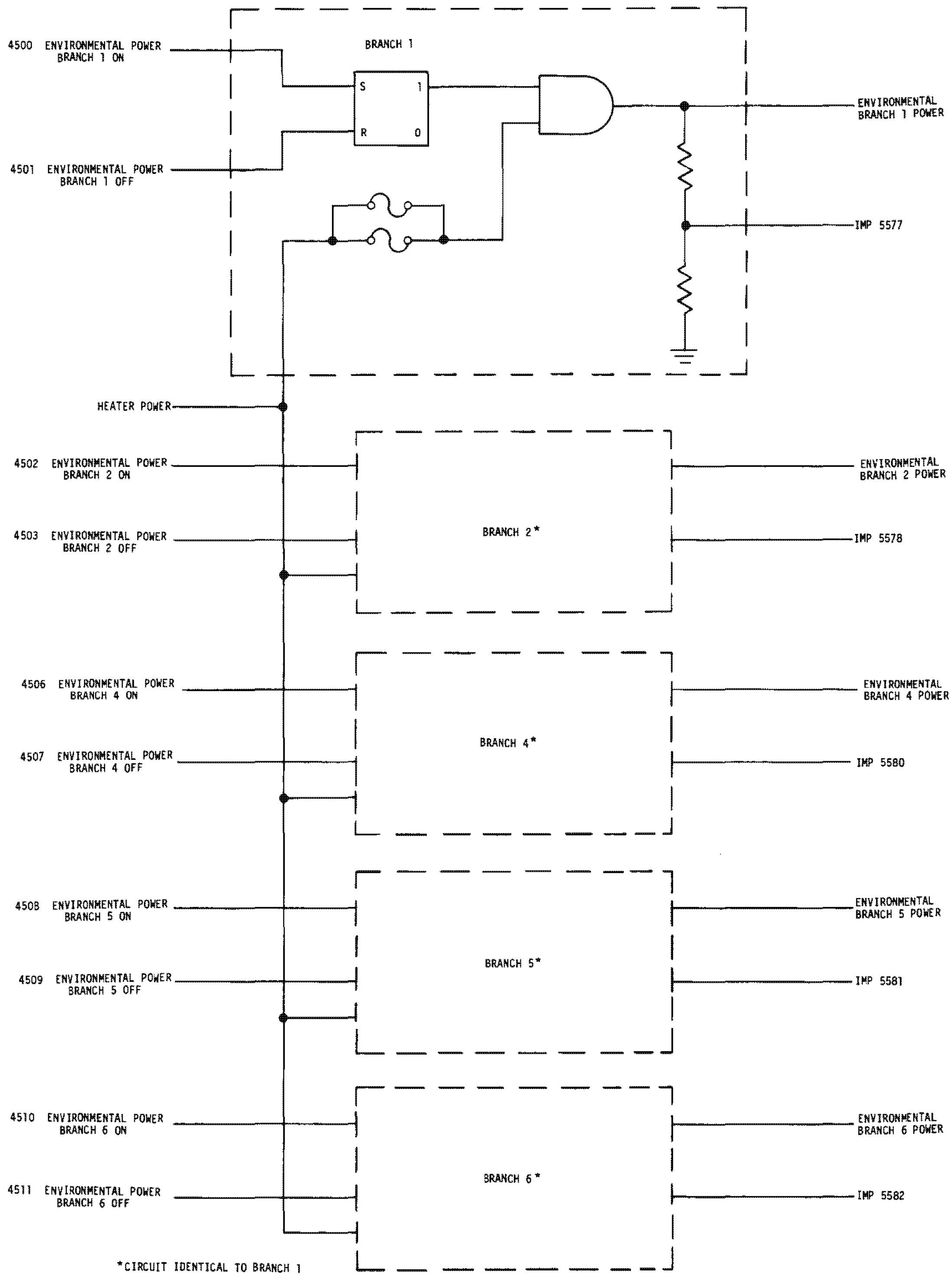

Figure 3.7-12. Environmental Branches 1, 2, 4, 5, and 6 Power

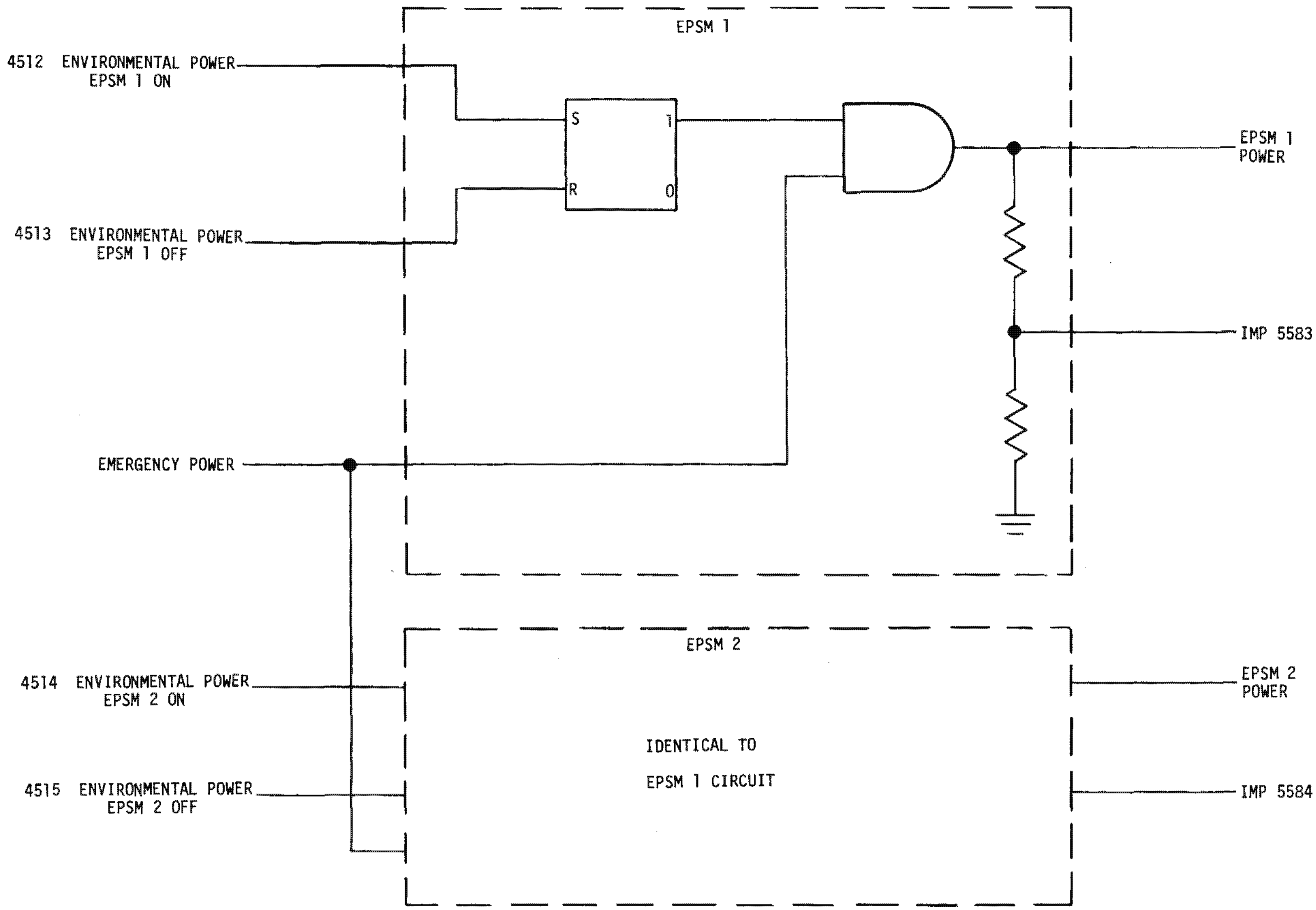

Figure 3.7-13. EPSM 1 and EPSM 2 Power

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3.7-26

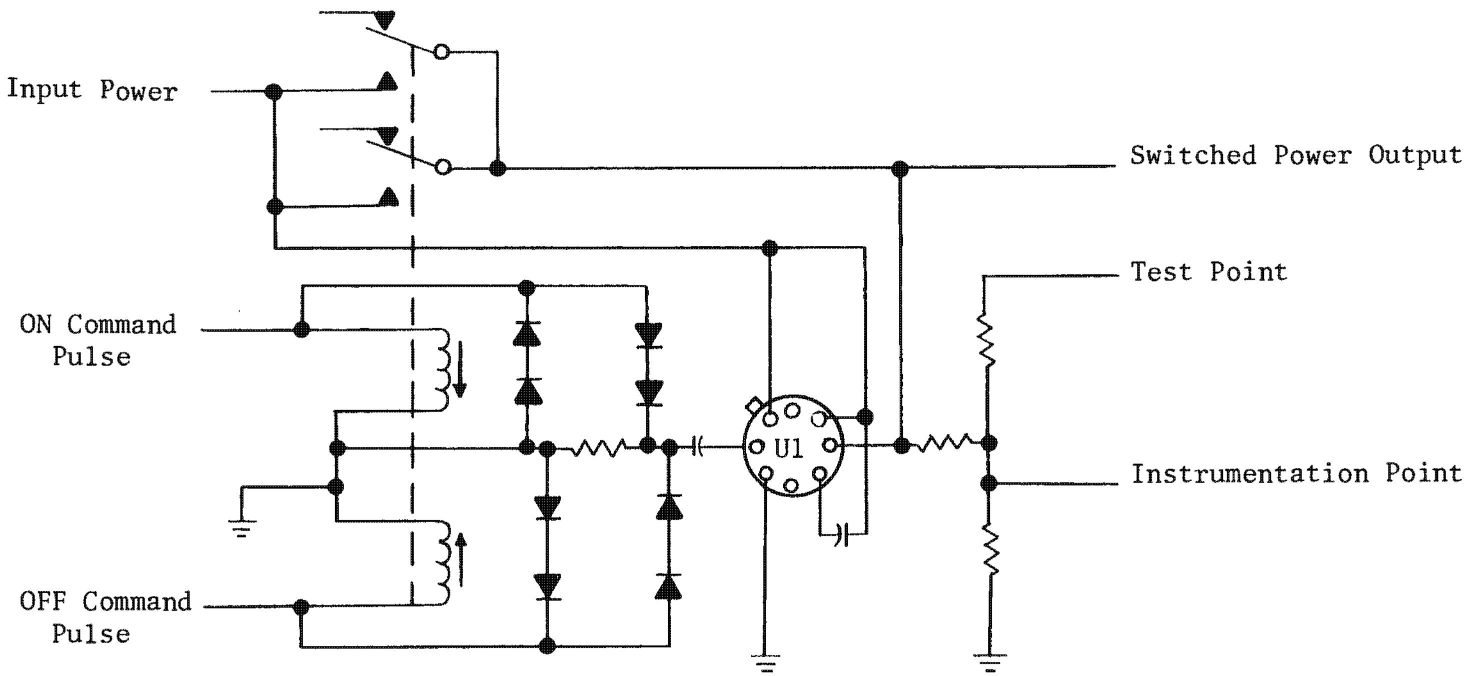

Figure 3.7-14. Standard Soft Switch Circuit

receipt of the leading edge of a command pulse, the controller (soft switch) ramps the line voltage smoothly to the load in approximately 250 μsec. The relay receives the command pulse simultaneously and transfers in about 5 msec. At the end of the controller time-out period (approximately 50 msec), the soft switch turns off, leaving the relay contacts to carry the load. An OFF command works in a similar fashion. The command pulse activates the controller which turns on in parallel with the closed relay contact. The relay contacts open in about 5 msec. The controller is now carrying the load. After the time-out period (50 msec), the controller ramps the voltage off. Since the controller does not distinguish between commands, redundant OFF commands will cause the controller to provide power to the output line for the 50 msec time-out period.

7.2.2.2 9 and 5 Operational Power and Servo Power Switching. The PM and C incorporates redundant soft switches for the control of 9 operational power and for the control of 5 operational power to preserve the redundancy provided by logic channels A and B in the command processor (see Figure 3.7-7). Each pair of switches is interconnected such that power cannot be provided simultaneously through both. In the event that one switch fails in the ON position, this interconnection gives a means to turn power OFF by commanding OP ON in the opposite channel. Normal use will not turn both switches on at once, since it results in turning power OFF. (As an operational constraint, CP logic channels are not to be switched while operational power is ON). If this does occur, power will be then supplied through one channel whenever the opposite channel is turned OFF.

As shown in the logic diagram, the operational power commands also control the servo power switches. The outputs are connected such that servo power is on whenever either 9 OP or 5 OP is on.

7.2.2.3 Focus Electronics Operating and Calibration Power and S1-PRG Power. The focus electronics power ON/OFF and focus calibrate power ON/OFF command pulses from the CP control separate soft switches for the +15-and -15-volt focus operating power and for the +15-and -15-volt focus calibration power* (see Figures 3.7-8 and 3.7-9 respectively). To prevent the application of only +15-or -15-volt power, each set of switches is interconnected such that both must operate for power to be supplied. The ±15-volt power is derived from the instrumentation power regulator. Therefore, either DTU 1 or DTU 2 must be on to provide power to the regulator circuit.

The focus electronics power ON/OFF pulses from the CP control a third relay which switches 24.5-volt power to the S1-PRG electronics. The switch is turned on by the focus operating power ON signal and is turned off by either the focus operating power OFF signal or the S1-PRG DISABLE command.

7.2.2.4 DTU 1 and DTU 2 Power. The DTU 1 and DTU 2 soft switches are interconnected to prevent the application of power to DTU 1 and 2 simultaneously (Figure 3.7-10). A command that attempts to turn both on results in power being removed from both. A situation is then created in which DTU 2 will receive power when DTU 1 is turned off, and DTU 1 will receive power when DTU 2 is turned off. The logic will be restored to normal operation by turning both switches off.

The DTU switches also control power to the instrumentation voltage regulators and to the pressure transducer (IMP 5019) in the supply electronics module. Power is supplied when either DTU 1 or DTU 2 is ON.

*Focus calibration power is turned on when either calibration bit is in the logic 1 state (see the CP logic diagram in Part 3, Section 9).

7.2.2.5 5 Parking Brake Power. Power for the 5 parking brake is supplied through a simple soft switch circuit in the PM and C (Figure 3.7-11) using the same logic as environmental branch power switches. The circuitry which is used to inhibit the parking brake when 5 operational power is ON is located in the 5 supply assembly. The power is interrupted whenever 5 OP is ON, and the circuitry is not enabled again until both 5 OP and 5 parking brake power are OFF (reference the 5 Film Handling Subsystem logic diagram in Part 3, Section 2).

7.2.3 PM and C Unipoint Power Return

The power returns from all PPS/DP EAC loads, except pyrotechnic loads, are connected within the PM and C to form a single power return point such that the potential between each return and all others approaches zero. This unipoint power ground is located on the A2 board and consists of a number of terminals connected in daisy-chain fashion. Since very small voltage differences are generated along the chain with return current flow, and since current surges cause corresponding voltage variations, the unipoint is structured very carefully to minimize these effects. Figure 3.7-15 shows the return path from a current flow viewpoint. As a general guideline, conductors that provide the reference point for the instrumentation processor unipoint instrumentation return are at the lowest potential; redundant returns for the same function are kept on the same or adjacent terminals of the daisy-chain; and loads with similar characteristics (heavy current users, operating system loads, and loads with EMI filters) are kept together to form the three branches of the chain. The resistors shown provide the sense voltage for the total current sensor.

The previously mentioned instrumentation system unipoint return, which provides a reference for all instrumentation in the PPS/DP EAC is located in the instrumentation processor and is connected to the PM and C unipoint power return according to Figure 3.7-16.

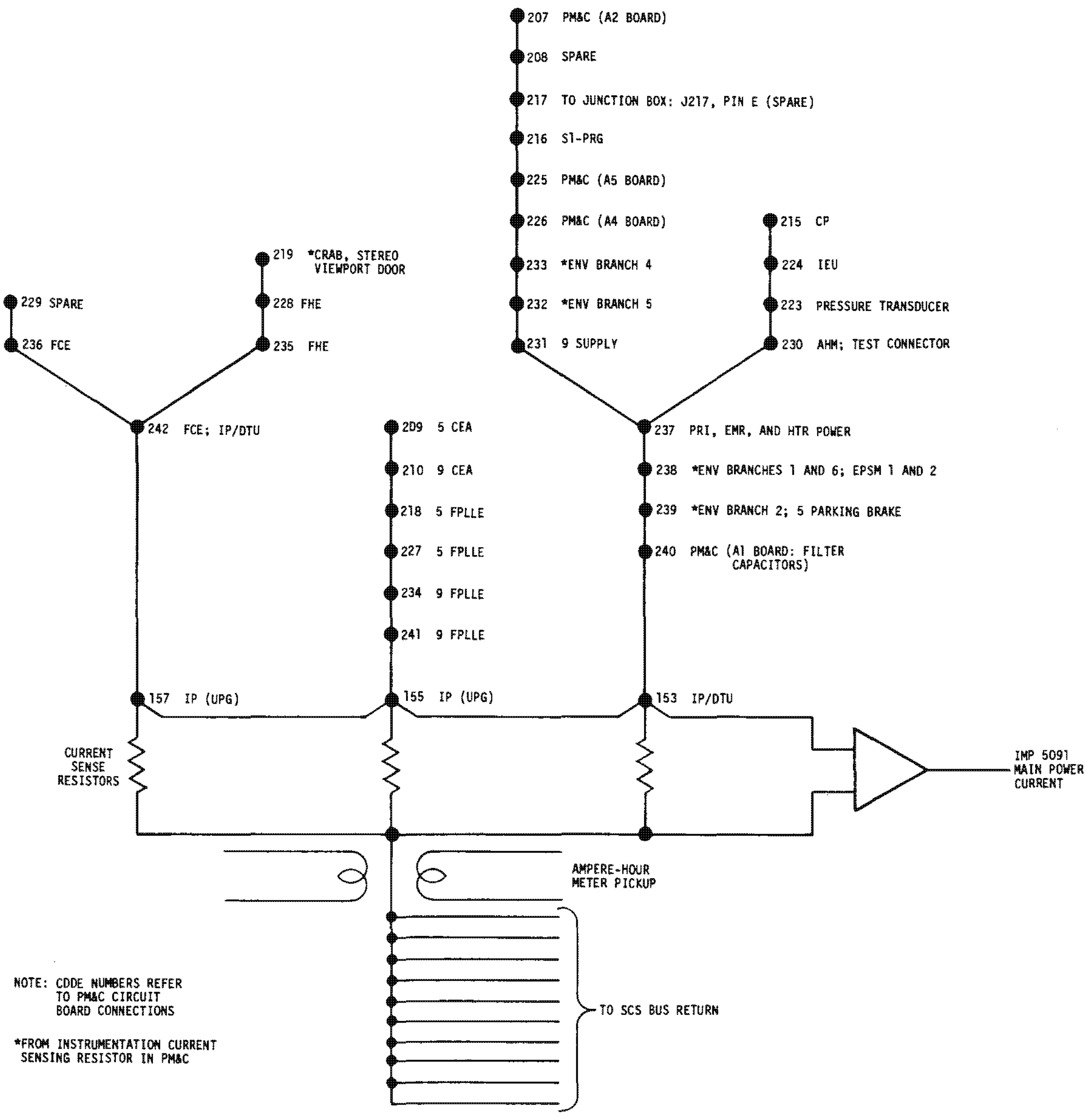

Figure 3.7-15. PM and C Unipoint Ground

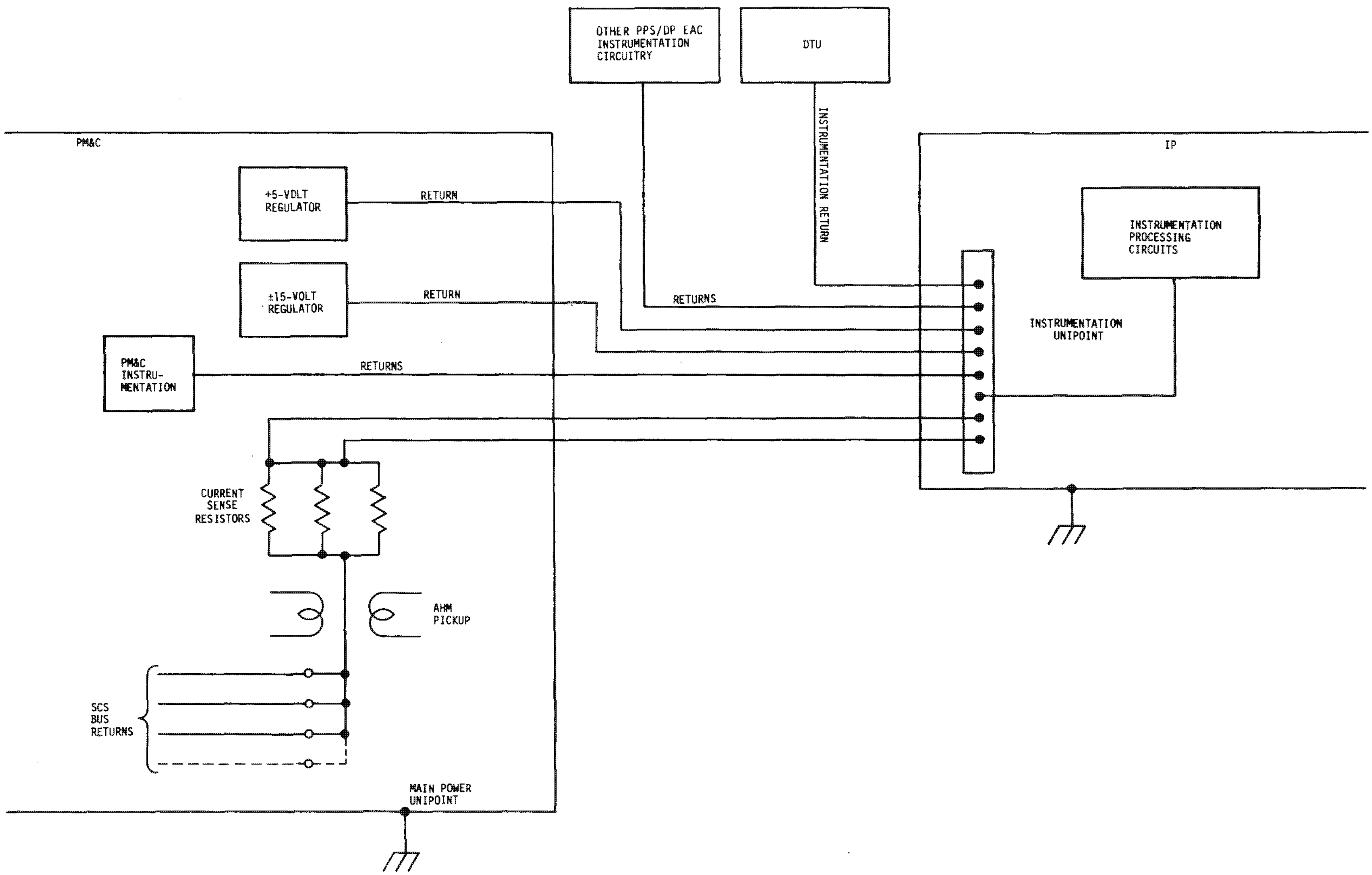

Figure 3.7-16. PPS/DP EAC Instrumentation Unipoint Ground

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7.2.4 Power Conversion (+5/±15 Volts)

Within the PM and C, power to the +5-and ±15-volt regulated supplies is provided from the emergency feed through the DTU power switches (see Figure 3.7-10). The +5-volt supply consists of a series-pass, integrated circuit regulator with power boost transistors, and is regulated to ±0.025 volt with an allowable load current up to 175 ma. The regulator incorporates electronic current limiting which reduces the output voltage to zero as the load approaches a short circuit.

A saturable transformer switching inverter circuit provides the ±15-volt regulated power. The transformer secondary is center tapped, with the voltage from each end to center exceeding 15-volts. The inverter is preceded by a series-pass pre-regulator, and followed by two integrated circuit, series-pass post-regulators, one each for +15 volts and -15 volts. Both outputs are regulated to ±0.075 volt and each can supply up to 400 ma. Electronic current limiting is used in the circuit which reduces both the +15-and -15-volt output voltages to zero as the +15-volt load approaches a short circuit, but reduces only the -15-volt supply in the event of an overload on its output. The zero potential reference and power return point for the supplies is at the instrumentation subsystem unipoint ground, which is in the instrumentation processor (reference Figure 3.7-16).

7.2.5 Ampere-Hour Meter

The ampere-hour meter (AHM) is a separate box approximately 6" x 3" x 2" and weighing about 2.5 pounds which is bolted to the A2 board in the PM and C. Power is provided from the primary bus using two external 0.5-ampere fuses in parallel for overload protection. The meter monitors and integrates total PPS/DP EAC operating current (except pyro current) through a current-sense coil around the 10 return conductors from the unipoint ground to the SCS bus (see Figure 3.7-15).

Three instrumentation outputs (coarse, medium, and fine) are produced, the sum of which corresponds to total main power consumption. Each is an 8-level counter that runs from 0.0 to 4.9 volts and resets. The fine sensor increments once for each 2 ampere-hours, the medium once for each 16 ampere-hours, and the coarse once for each 128 ampere-hours. If power is removed, the meter resets to zero.

7.2.6 PM and C Instrumentation

In addition to the ampere-hour meter instrumentation, there are three other groups of monitors in the PM and C; input power voltage monitors, switched power voltage monitors, and instantaneous current monitors. Each switch monitor provides a parallel output to a test connector on the PM and C through an isolation resistor as well as an instrumentation output for telemetry.

7.2.6.1 Main Power Voltage monitors. There are three monitors in this group; one each for the primary, emergency (BUSS), and heater power buses in the PM and C. The same basic circuit is employed for all three, and consists of a simple voltage divider with the +5-volt instrumentation power used to provide a bias level.

The output connects to the digital telemetry unit (DTU) by way of the instrumentation processor.

7.2.6.2 Switched Power Voltage Monitors. All switched power outputs (excluding DTU 1 and DTU 2 power) are monitored by voltage divider instrumentation circuits as illustrated in Figure 3.7-14. The signals are sent to the DTU where they are digitized to yield a binary level (on/off) output. The voltage monitors for DTU 1 and DTU 2 are located in the instrumentation processor, and are also digitized in the DTU. The +5-and ±15-volt regulators, which are powered through the DTU switches, are monitored by voltage divider circuits in the instrumentation processor, and the outputs are maintained as analog signals by the DTU.

7.2.6.3 Instantaneous Current Monitors. Located on the PM and C A3 board, the various current monitors measure real-time current flow. Some monitor the power of only one function, others monitor the combined current flow of multiple functions as listed:

(1) IMP 5090 Crab, stereo, and door current

(2) IMP 5091 Main power current (excluding pyro power)

(3) IMP 5133 Env. current branch 1, branch 6, EPSM 1, and EPSM 2

(4) IMP 5134 Env. current branch 2, and 5 parking brake current

(5) IMP 5135 Env. current branch 4

(6) IMP 5136 Env. current branch 5

The monitors consist of sense resistors in the power return line(s) which provide a voltage proportional to return line current to an operational amplifier. The amplifier scales the output to levels compatible with DTU input requirements and, in some cases, also provides a fixed voltage offset to the signal level.

7.3 Initiator Electronics Unit

The IEU is a separate subsystem within the PPS/DP EAC which controls all pyrotechnic functions, and termination-related events. It provides a controlled interface for its associated commands between the PPS/DP EAC and SCS, and contains enabling logic to prevent execution of potentially catastrophic command sequences. Provision is also made to accommodate the end-to-end electronics pyrotechnic testing (reference Part 4, Section 4). Following testing the

LAUNCH PRESET signal resets the box to the no-event occurred state. At the launch pad, this signal is supplied through a vehicle umbilical line.

Each pyrotechnic function within the PPS/DP EAC is controlled by two independent pyrotechnic devices which provide redundant actuation of the mechanism, and each pyrotechnic device is powered from a separate line and relay within the IEU. There are only two non pyrotechnic functions controlled by the IEU. The first involves the switchover of take-up motor control signals from SRV 1 to SRV 2. The second is an output to the viewport door electronics which transfers drive control from the primary to the backup motor (reference Part 3, Section 5).

7.3.1 IEU Assembly

The IEU is physically located on the +Y side of the film supply enclosure wall (reference Part 3, Section 1). The unit measures 8.2" x 7.7" x 18" excluding mounting feet, and weighs slightly under 34 pounds. Internally, the IEU is composed of a stack of 21 printed wiring boards which interface with the PPS/DP EAC through 11 electrical connectors mounted on the housing. Electrical components are planar mounted to the boards, with larger, discrete components bonded to the boards. Point-to-point wiring through plated holes at one edge of each board connects the boards to the assembly harness.

The board stack is compression packaged with foam-filled panels at each end of the stack acting as compression plates. Foam shims between the boards serve to separate them and carry the compressive loads, and also act to dampen high frequency vibrations of the boards.

7.3.2 IEU Operation

The IEU pyrotechnic firing circuitry consists of normally open power switches. On receipt of a command pulse, each switch closes in response to and for the duration of its controlling command pulse, and passes current to the load. Additional circuitry directs the 9 and 5 take-up motor power, and performs the minimal ARM command enabling functions (SWRTC 1 and SWRTC 2)*.

There are 19 command inputs (not counting multiple commands which perform the same task) accepted by the IEU. All but four of the 19 command inputs actuate pyrotechnic devices as part of their function. In normal operation, redundant commands are given for each of these functions, from separate ECS** decoders. In the event of an ECS failure, the MCS** can be used as a backup for mission termination event commands. There are no commands in the MCS for the SPLICE/CUT or ROLL-IN TERMINATE events.

Commands are received on individual lines in the form of controlled pulses from the ECS/MCS command decoders, and are coupled through relays in the IEU to provide the required interface isolation. Decoupling diodes on the input lines act as logical "OR" gates to connect redundant commands and prevent feedback into the SCS. The VIEWPORT DOOR BACKUP command is the one exception to the rule in that it operates relays not only in the IEU, but also in the viewport door electronics unit.

Each ECS and MCS protected command has a switched return line associated with that particular command. ECS and MCS normal commands have common return wires. The SWRTC 1 and SWRTC 2 MCS commands have return lines which are common to the normal returns. For more detail on operation of the command subsystem, refer to Part 3, Section 9.

IEU power is received from both the PM and C and the SCS power bus. Power inputs referred to as unregulated power A and unregulated power B are separate

* Secure Word Real Time Commands. Reference Part 3, Section 9.
**Extended Command Subsystem/Minimal Command Subsystem.

unswitched inputs from the PM and C providing 24.5 volts nominal (22.0 to 29.7 volts maximum) for relay operation. Instrumentation power (+5 and ±15 vdc) is supplied by the instrumentation voltage regulators which are also in the PM and C and is filtered in the IEU at the input. Pyro firing power is derived from the SCS bus on nine input and nine return lines in twisted, shielded pairs. The minimum current to be supplied for each pyrotechnic event is controlled by interface agreement with LMSC, and is generally set at or near the "twice all-fire"* level based on maximum load resistance. Table 3.7-3 lists all PPS/DP EAC pyrotechnic events and the minimum currents required.

7.3.2.1 Cross-strap and Enabling Circuitry. Two redundant, cross-strapped command processing blocks referred to as command sections A and B comprise the IEU logic circuits. Redundant commands from ECS decoders A and B and the MCS decoder (as available) are logically connected such that any one command is able to operate both IEU circuits (see Figure 3.7-17). The two sides are powered separately by the A and B unregulated power inputs, which enables the cross-strap circuitry to be checked by providing power to only one side during testing.

The enabling circuit is used for operations where it is necessary to prevent execution of improper command sequences, and is designed to maintain the established cross-strap configuration for the second event. A typical command enable circuit is presented in Figure 3.7-18.

The schematics of Figures 3.7-17 and 3.7-18 have been greatly simplified, and do not show all the components involved. The latching and nonlatching relays have two diodes in series across the coils for EMI suppression. Relays with a potential shorted-coil failure mode are isolated from the circuits with pro-

*The all-fire current level is established by the device manufacturer.

TABLE 3.7-3

PYRO-ACTUATED EVENTS

Command Event	Type of Device	Pyros	Minimum Current Required* (amperes)
HATCH EJECT			50.00
Actuate hatch pin-pullers (6) to initiate ejection of viewport door cover.	Pin-puller	SQ16A-SQ21A SQ16B-SQ21B	
VIEWPORT DOOR BACKUP			9.02
Backup door drive actuation.	Pin-puller	SQ22A/SQ22B	
VIEWPORT DOOR BLOW			9.02
Permanently opens viewport doors.	Pin-puller	SQ23A/SQ23B	
9 SPLICE AND CUT			8.66
Operates 9 splicer mechanism. Connects 9 T/U signal to T/U 1 and T/U 2. Enables 9 ROLL-IN TERMINATE.	Latch release (dimple motors)	34SQ1/34SQ2	
5 SPLICE AND CUT			8.66
Operates 5 splicer mechanism. Connects 5 T/U signal to T/U 1 and T/U 2. Enables 5 ROLL-IN TERMINATE.	Latch release (dimple motors)	49SQ1/49SQ2	

*Current levels and conditions under which they are required are controlled by BIF-008 Interface Specification 1401-304-8.

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TABLE 3.7-3 (CONT'D)

Command Event	Type of Device	Pyros	Minimum Current Required (amperes)
CUT AND SEAL 1			55.70
Actuates:	Latch release (dimple motors)		
Cutter/sealer 1,		Internal to SRV 1	
Cutter/sealer 3,		35SQ1/35SQ2	
Cutter/sealer 4,		48SQ1/48SQ2	
9 TSRT,		36SQ1/36SQ2	
5 TSRT		50SQ1/50SQ2	
ARM 1			27.38
Activates SRV 1 recovery batteries.	Battery activation squibs	Internal to SRV 1	
Enables TRANSFER 1.			
TRANSFER 1			28.40
Activates SRV 1 thermal batteries.	Thermal battery match	Internal to SRV 1	
Starts SRV 1 recovery programmer timer.			
Actuates in-flight disconnect 1.	Delayed action disconnect	SQ15A/SQ15B	
Enables SEPARATE 1.			
Separation of IFD 1 releases blast shield valve.			
SEPARATE 1			26.10
Actuates SRV 1 pin-pullers to initiate ejection.	Pin-puller (+Z)	SQ13A/SQ13B	
	Pin-puller (-Z)	SQ14A/SQ14B	
Actuates spinoff disconnect 1.	Disconnect	SQ11A/SQ11B	

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TABLE 3.7-3 (CONT'D)

Command Event	Type of Device	Pyros	Minimum Current Required (amperes)
SPINOFF DISCONNECT 2			9.23
Actuates spinoff disconnect 2 (EA disconnect).	Disconnect	SQ12A/SQ12B	
Enables EA SEPARATE.			
EA SEPARATE			26.10
Actuates EA pin-pullers to initiate EA ejection.	Pin-puller (36°) Pin-puller (156°) Pin-puller (276°)	SQ4A/SQ4B SQ5A/SQ5B SQ6A/SQ6B	
CUT AND SEAL 2			17.80
Cutter/sealer 2	Latch release	Internal to SRV 2	
Aft backup cutter	(dimple motors)	37SQ1/37SQ2	
ARM 2			27.38
Activates SRV 2 recovery batteries.	Battery activation squibs	Internal to SRV 2	
Enables TRANSFER 1.			
TRANSFER 2			29.50
Activates SRV 2 thermal batteries.	Thermal battery match	Internal to SRV 2	
Starts SRV 2 recovery programmer timer.			
Actuates in-flight disconnect 2.	Delayed action	SQ10A/SQ10B	
Enables SEPARATE 2.			
SEPARATE 2			17.30
Actuates SRV 2 pin-pullers to initiate ejection.	Pin-puller (+Z) Pin-puller (-Z)	SQ8A/SQ8B SQ9A/SQ9B	

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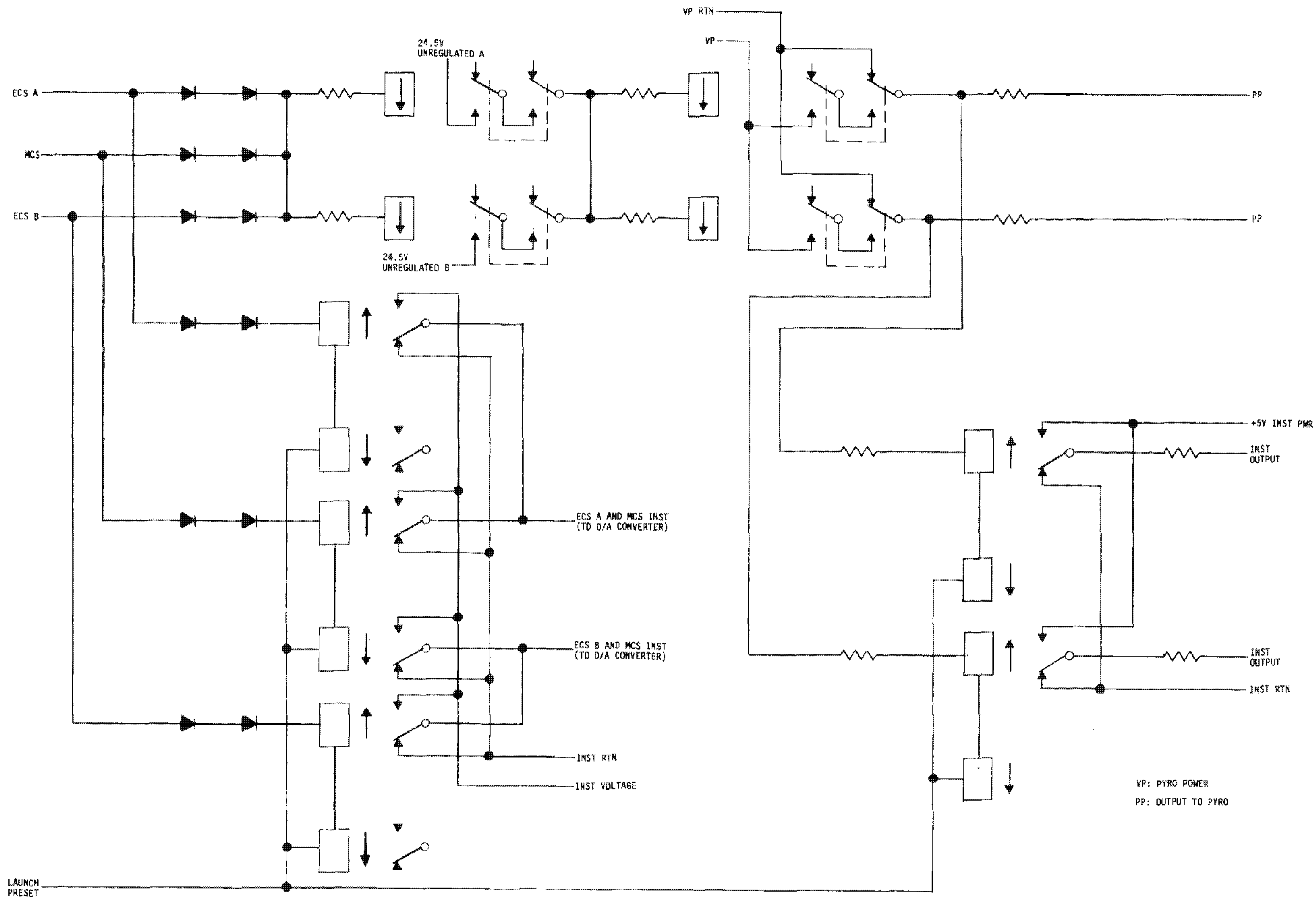

Figure 3.7-17. IEU Cross-Strap Circuit Configuration

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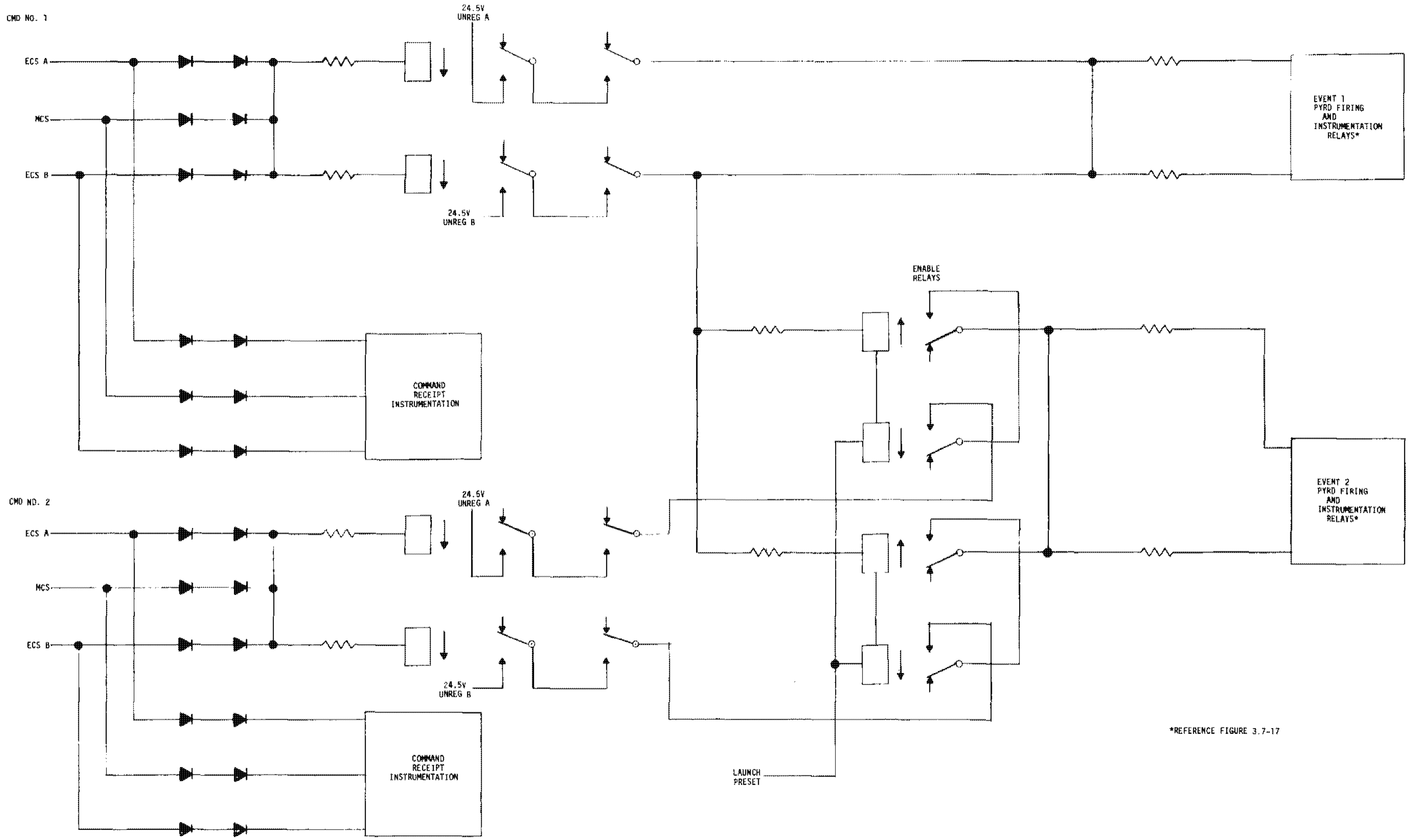

Figure 3.7-18. IEU Simplified Command Enable Configuration

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tective resistors. The digital-to-analog converter referenced for instrumentation is a resistor ladder network that accepts four separate inputs.

7.3.2.2 IEU Command and Pyro Pulse Outputs. The DOOR BACKUP command is the only command output from the IEU. The command pulse received from the SCS is diode decoupled in the IEU and then fed through a protective resistor to the viewport door electronics, where it operates the primary-to-backup motor switchover relays. At the same time, the command also operates instrumentation and pyro firing circuit relays in the IEU.

Pyrotechnic device firing pulse outputs are produced by simple relay contact closings. The circuits consist of nonlatching relays operated by unregulated power that close for the duration of the command pulse, connecting the pyrotechnic device bridgewire in series with the pyro power source. At all other times, the pyro feed is connected to the pyro power return to maintain a protective short circuit across the bridgewire.

As shown in Figure 3.7-19, the pyro output pulse feed and return lines are routed through removable arm plugs located throughout the forward portion of the vehicle. To prevent possible actuation of a pyrotechnic device during assembly and testing, the arm plugs are replaced by safe plugs which short circuit the bridgewire of the device, or test plugs are placed between the arm plug and vehicle connector to insert protective load resistors in series with the bridgewire leads.

For FM-52, all BIF-008 manufactured hardware will use test plugs to protect the pyrotechnic devices and provide for end-to-end electronics testing. Safe plugs will be used only on SRV 1 and SRV 2. Figure 3.7-20 illustrates the typical arm and safe plug wiring schemes. For more detail on the test plugs, refer to Part 4, Section 4.

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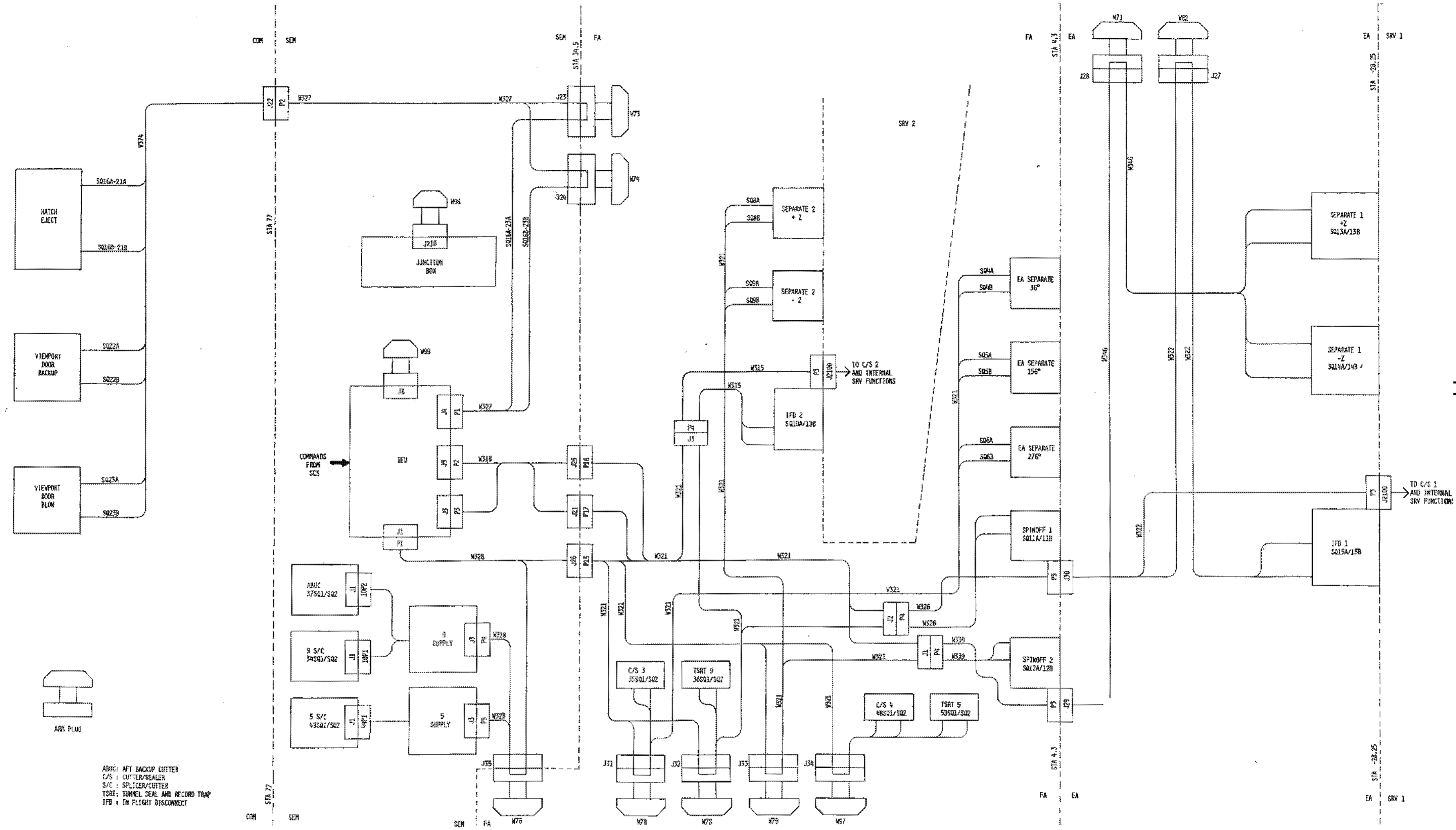

Figure 3.7-19. PPS/DP EAC Pyrotechnic Subsystem Block Diagram

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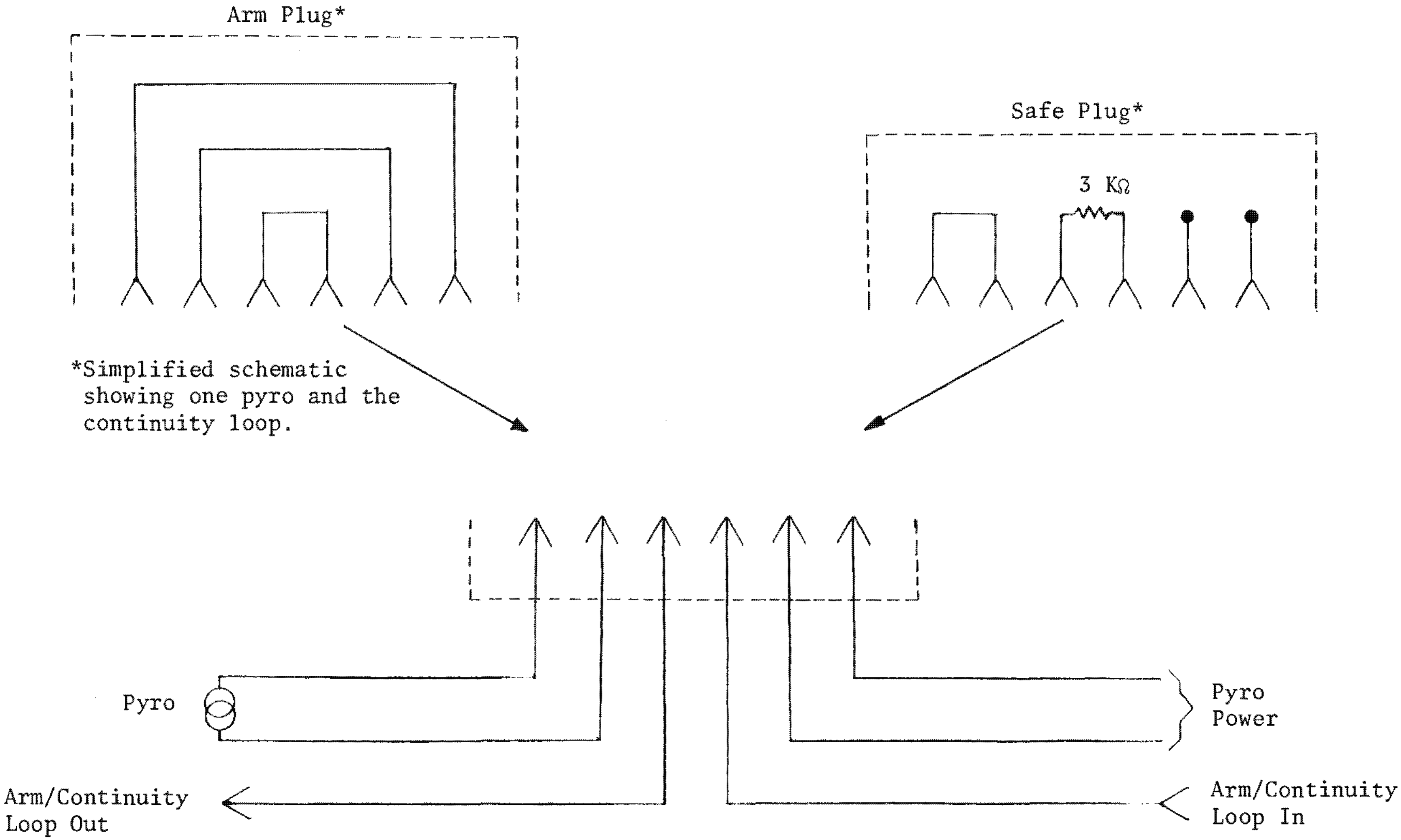


Figure 3.7-20. Arm and Safe Plugs

3.7-47

7.3.2.3 Timing and Overload Protection. Pyrotechnic device firing pulse outputs are delivered to the load within 10 msec of command receipt (i.e., pulse is at 90% of full amplitude). Where multiple devices are fired by the same command, all output pulses occur within 4 msec of each other.

To protect the IEU pyro power from overload conditions caused by shorted bridgewires, outputs are delivered through fuses or fusible ballast resistors. These are sized so as to allow minimum current to the load in the event it is shorted, but in no case constrains the current to less than twice all-fire under normal conditions. Under shorted conditions, the time to blow ballast resistors is less than 5 seconds.

7.3.2.4 EMI Control. Due to the potentially catastrophic nature of inadvertent actuation of pyro mechanisms, special EMI controls have been incorporated in the IEU subsystem ranging from isolation and shielding of the PPS/SCS pyro power feed and return lines to preferred techniques for running pyro cables through the PPS/DP EAC. The following are some examples of the controls utilized:

(1) Each pyrotechnic device is connected to a twisted, shielded pair of wires.

(2) The pyro end of each shield is grounded to its associated connector which is in turn connected to the vehicle structure through the pyro receptacle.

(3) The IEU end of each shield is grounded to the IEU chassis, which is secured to the vehicle structure.

(4) Pyro cables are routed in close proximity to the vehicle structure, wherever possible.

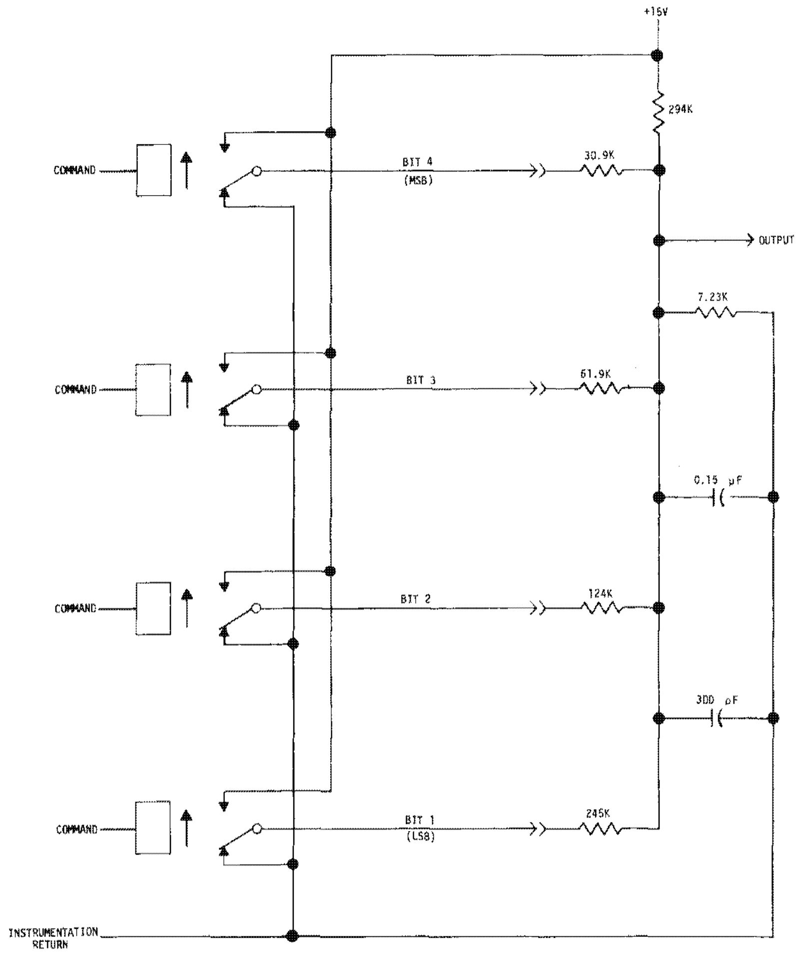
(5) Insofar as possible, pyro cables are routed separately at a distance of at least one inch from all non pyro cables.

7.3.2.5 IEU Instrumentation. The IEU generates both analog and discrete instrumentation signals. Analog instrumentation consists of nine command receipt monitors and the pyro voltage monitor. Discrete instrumentation outputs are provided by instrumentation relays monitoring each pyro output line.

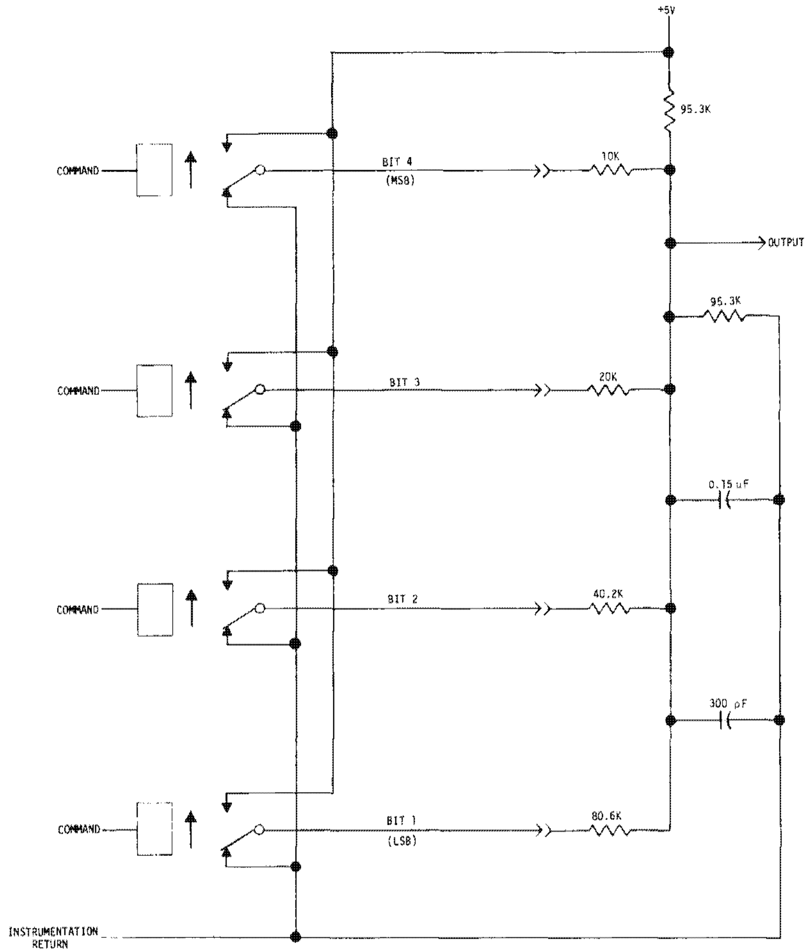
7.3.2.5.1 Command Receipt Instrumentation. Each command receipt monitor consists of a four-input, resistive ladder digital-to-analog (D/A) converter. Latching relays monitor the receipt of commands and either ground the inputs or connect them to the instrumentation supply as shown in Figure 3.7-21. The converter produces a 16-level output ranging from 0.25 volt to 4.75 volts in 0.3-volt increments that indicates the state of each of the four unique inputs.

Redundant commands from ECS decoders A and B are monitored by separate command receipt relays. Where possible, the A and B signals are connected to different D/A converters, one of which is powered from the +5-volt instrumentation supply, and the other from the +15-volt instrumentation supply. Excluding monitors for the secure word real-time commands (SWRTC 1 and SWRTC 2), the MCS command monitor relay outputs are connected in parallel with both the ECS decoder A and decoder B instrumentation relay outputs.

7.3.2.5.2 Pyro Voltage Monitor. Pyro power voltage is monitored by a high input impedance circuit as illustrated in Figure 3.7-22 which produces a voltage output proportional to the pyro voltage input. The high input impedance serves to reduce steady state current drain from the pyro bus to less than 100 μamps, and provides effective isolation between the instrumentation and power circuits. Also shown in Figure 3.7-22 are the inductor-capacitor filter networks which filter all instrumentation power entering the IEU.



+15V DIGITAL-TO-ANALOG CONVERTER



+5V DIGITAL-TO-ANALOG CONVERTER

Figure 3.7-21. Command Receipt Instrumentation Digital-to-Analog Converters

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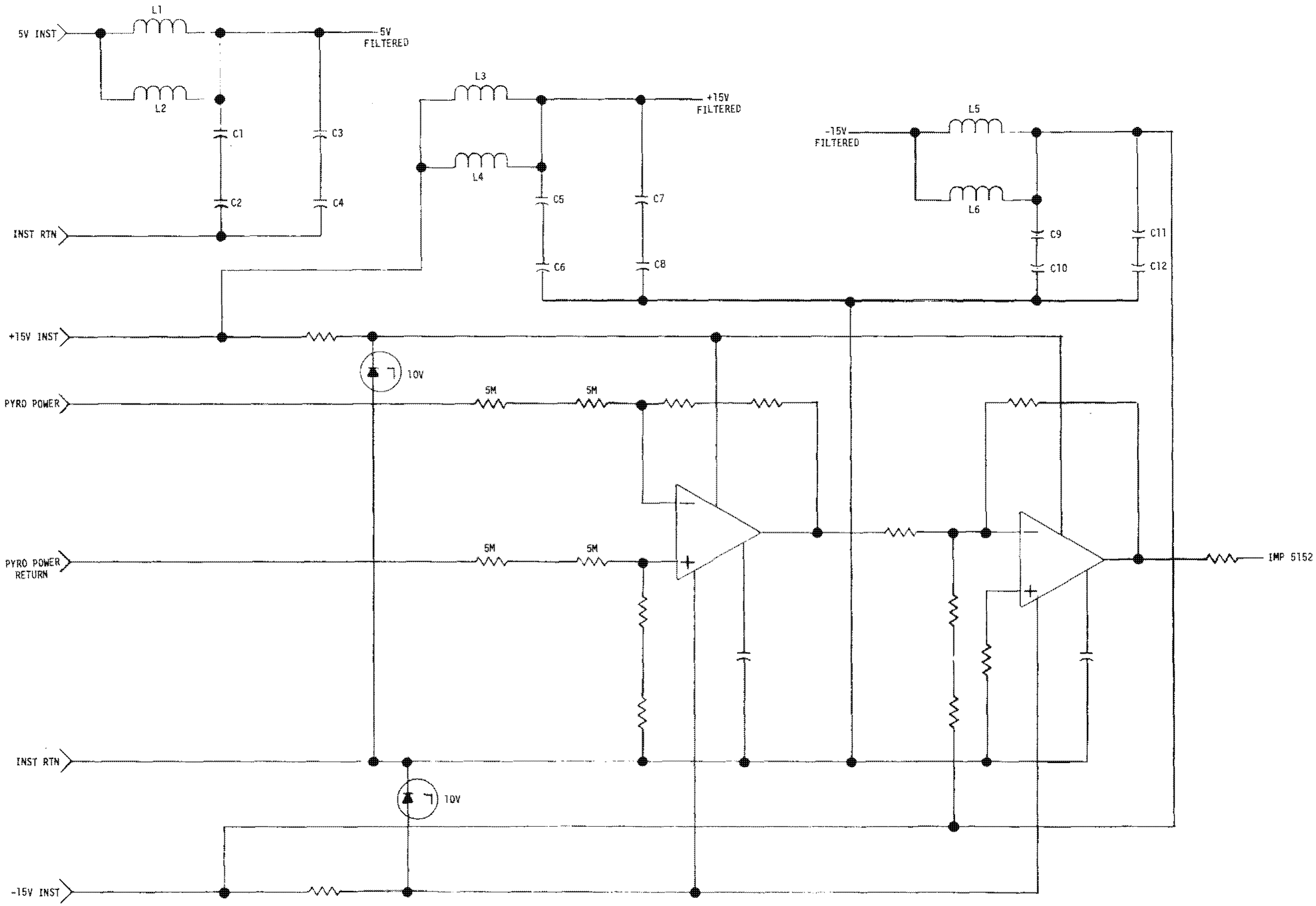

Figure 3.7-22. Pyro Power Voltage Monitor and Instrumentation Power Filters

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7.3.2.5.3 Pyro Output Line Discrete Monitors. Each pyro firing output pulse operates a latching relay which switches instrumentation voltage to a discrete output (high/low state) instrumentation point. A parallel output from each point is fed to the J11 connector of the IEU through an isolation resistor for hardline testing.

7.3.2.5.4 Continuity Loops. Two continuity loops in the PPS/DP EAC monitor the presence of arm plugs by establishing a series circuit through the plugs. The processing circuitry and outputs are located in the instrumentation processor as shown in the loop diagram of Figure 3.7-23. Provision is made in the IEU to accommodate both loops, with loop one passing through the IEU arm plug (W99).

The presence of an arm plug is indicated by a short circuit through the plug. A safe plug or test plug places a 3KΩ resistor in series with the loop. Each loop output is converted to a binary signal in the DTU and, therefore, indicates only that all arm plugs are in place, or that one or more are missing.

Continuity loop one passes through six arm plugs in the PPS/DP EAC and seven arm plugs in SRV 1. Continuity loop two passes through five arm plugs in the PPS/DP EAC and seven arm plugs in SRV 2.

7.3.3 IEU Logic

The IEU operational logic drawings employ standard logic notation, with minor exceptions. Nonlatching relays are represented by logic gates, and latching relays by set-reset flip-flops. Where several pyrotechnic devices are fired by one command, the nonlatching relays are combined into a single gate and a number representing the actual quantity of relays involved is placed at the output (reference Figure 3.7-24).

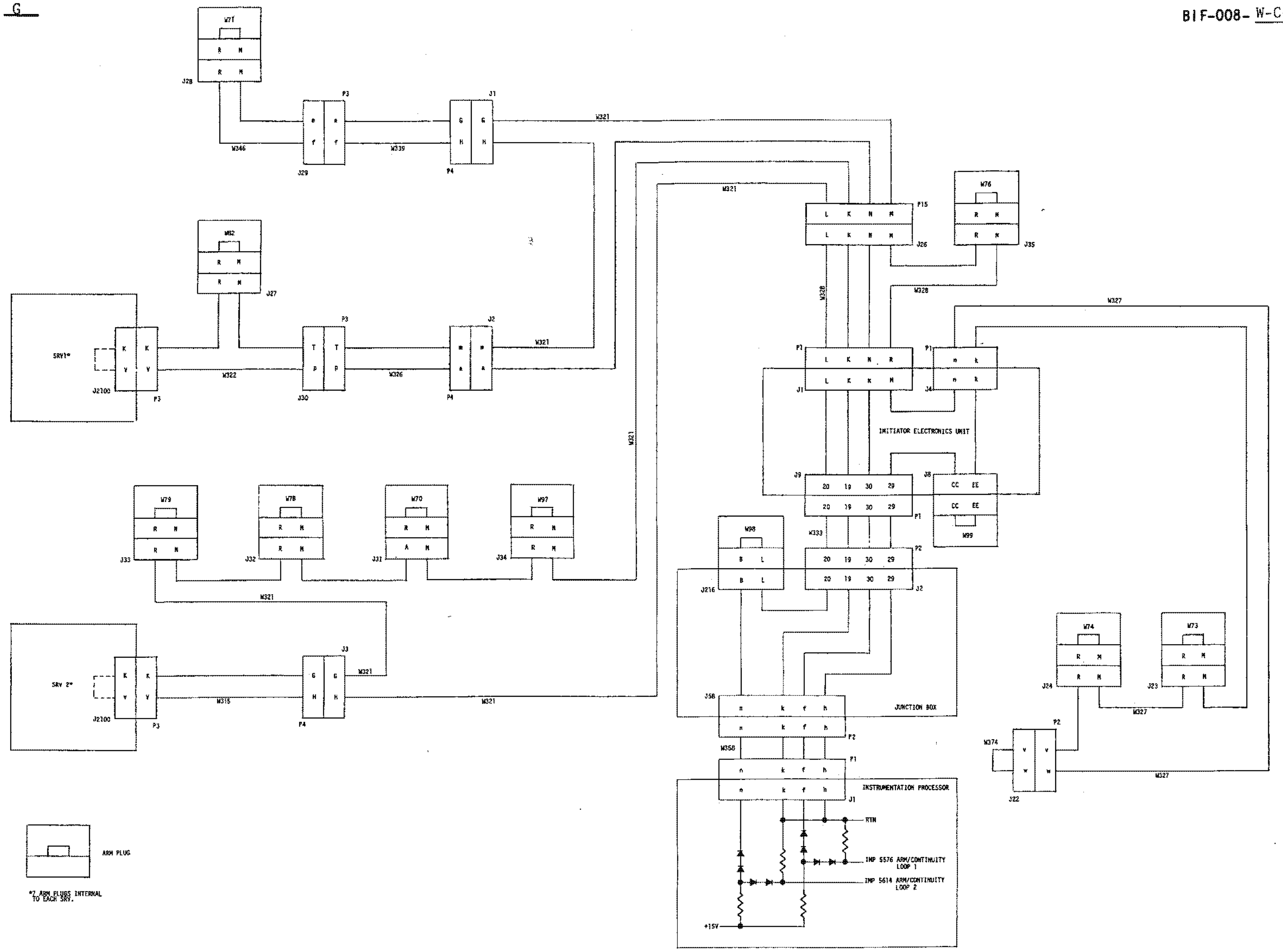

Figure 3.7-23. Arm/Continuity Loops

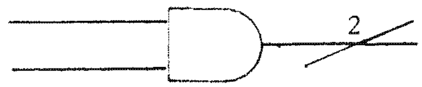

Figure 3.7-24 Multiple Relay Logic Representation

Figures 3.7-25 through 3.7-35 illustrate the logic. To maintain clarity, the diagrams have been simplified in several areas. As a result the following are not shown:

(1) Command returns

(2) Instrumentation test point outputs

(3) Redundant circuitry for sections A and B, (reference Figure 3.7-17)

(4) Output fuses and fusible resistors

Descriptions of selected functions are provided in the following sections.

7.3.3.1 Viewport Door Backup and Blow Modes. The DOOR BACKUP command from ECS decoder A and/or B switches two non-latching pyro power control relays which provide power to actuate the primary motor linkage pin-puller. The command is also fed directly from the IEU to the viewport door electronics to switch power from the primary to the backup motor. In addition, the command operates a latching relay in the IEU that enables the DOOR BLOW command circuitry (see Figure 3.7-26).

When enabled, a DOOR BLOW command from ECS decoder A and/or B will switch 2 non-latching relays that provide power to operate the backup linkage pin-puller. No output is provided to the viewport door electronics to disable the backup motor circuit.

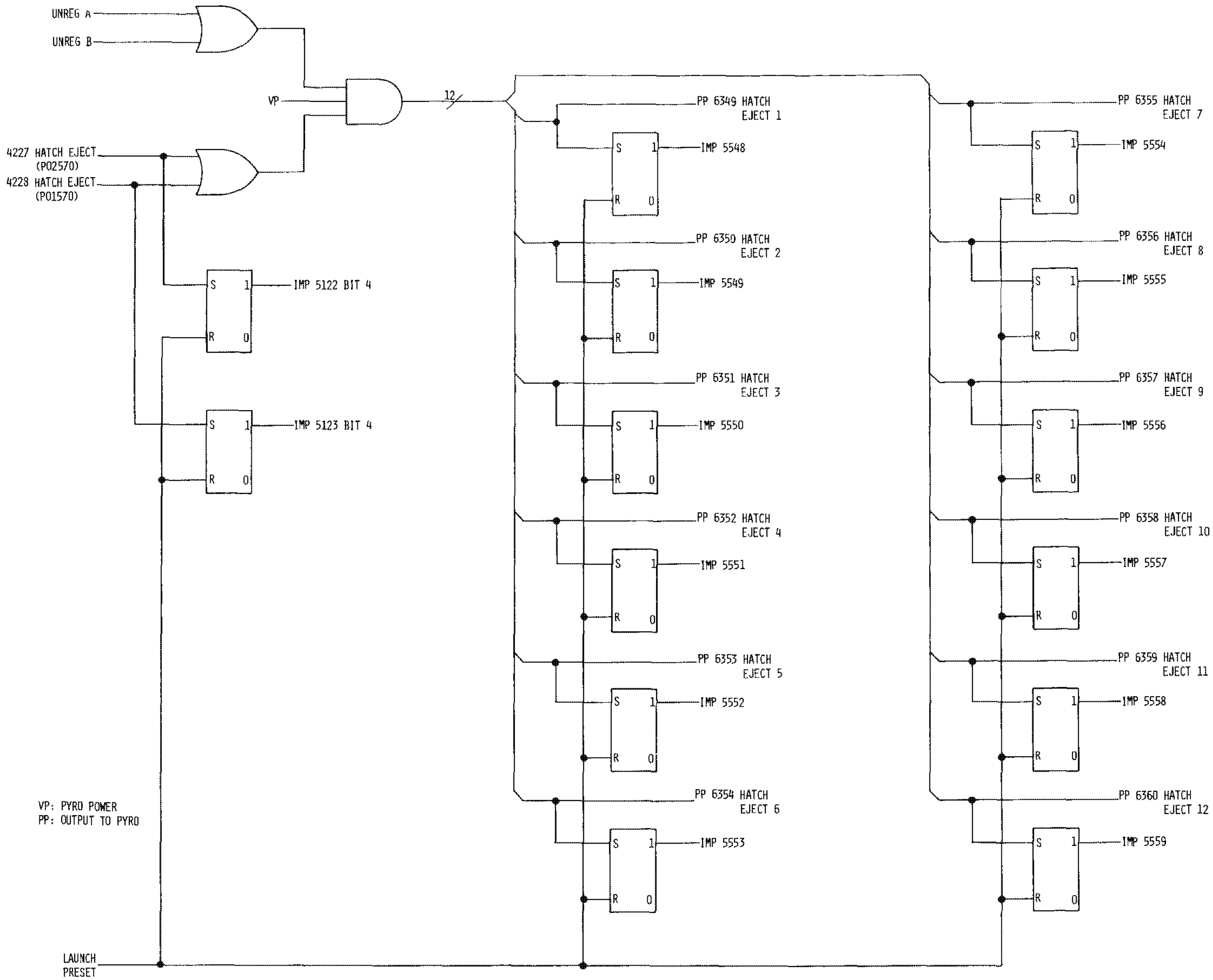

Figure 3.7-25. Hatch Eject

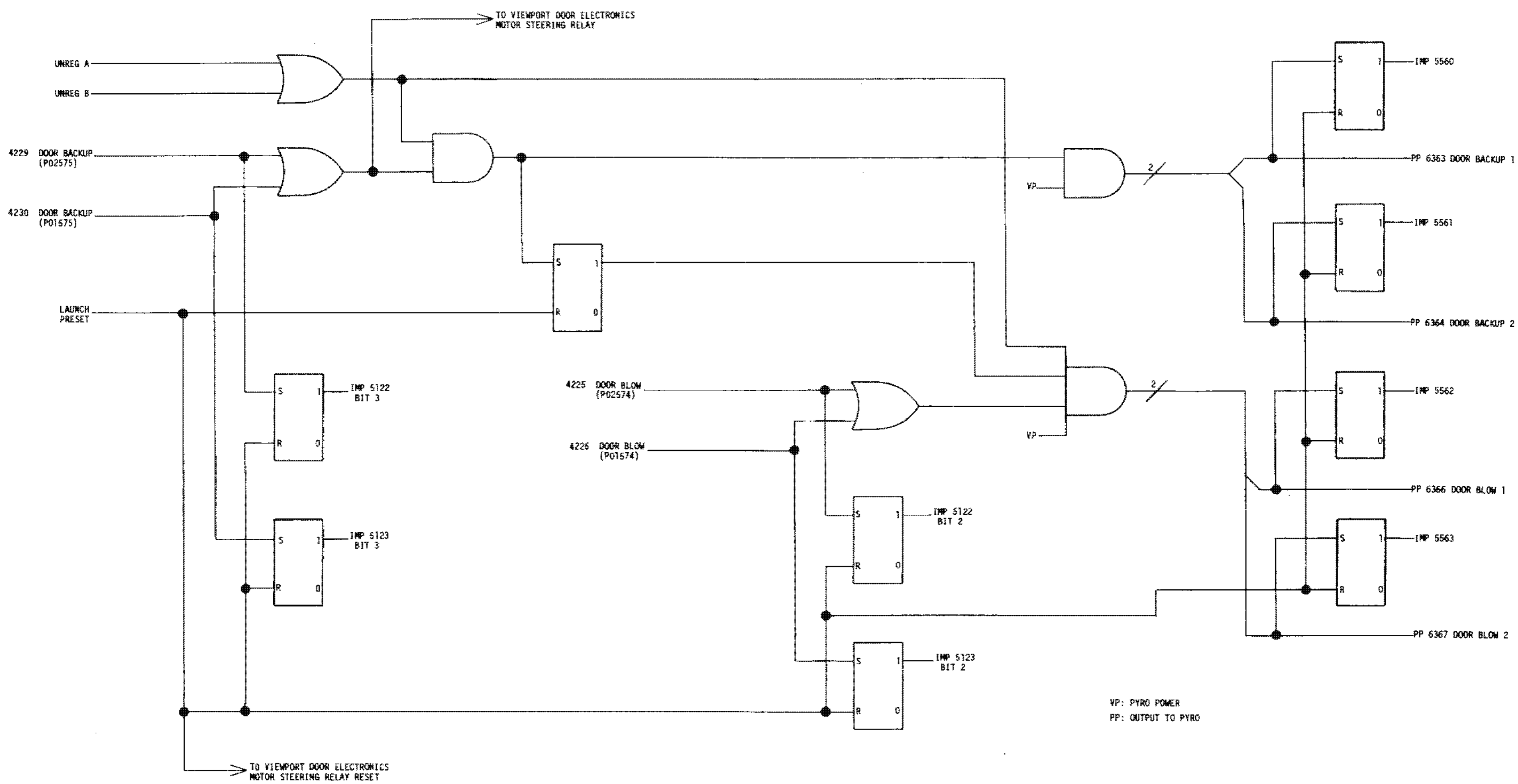

Figure 3.7-26. Viewport Door Backup and Viewport Door Blow

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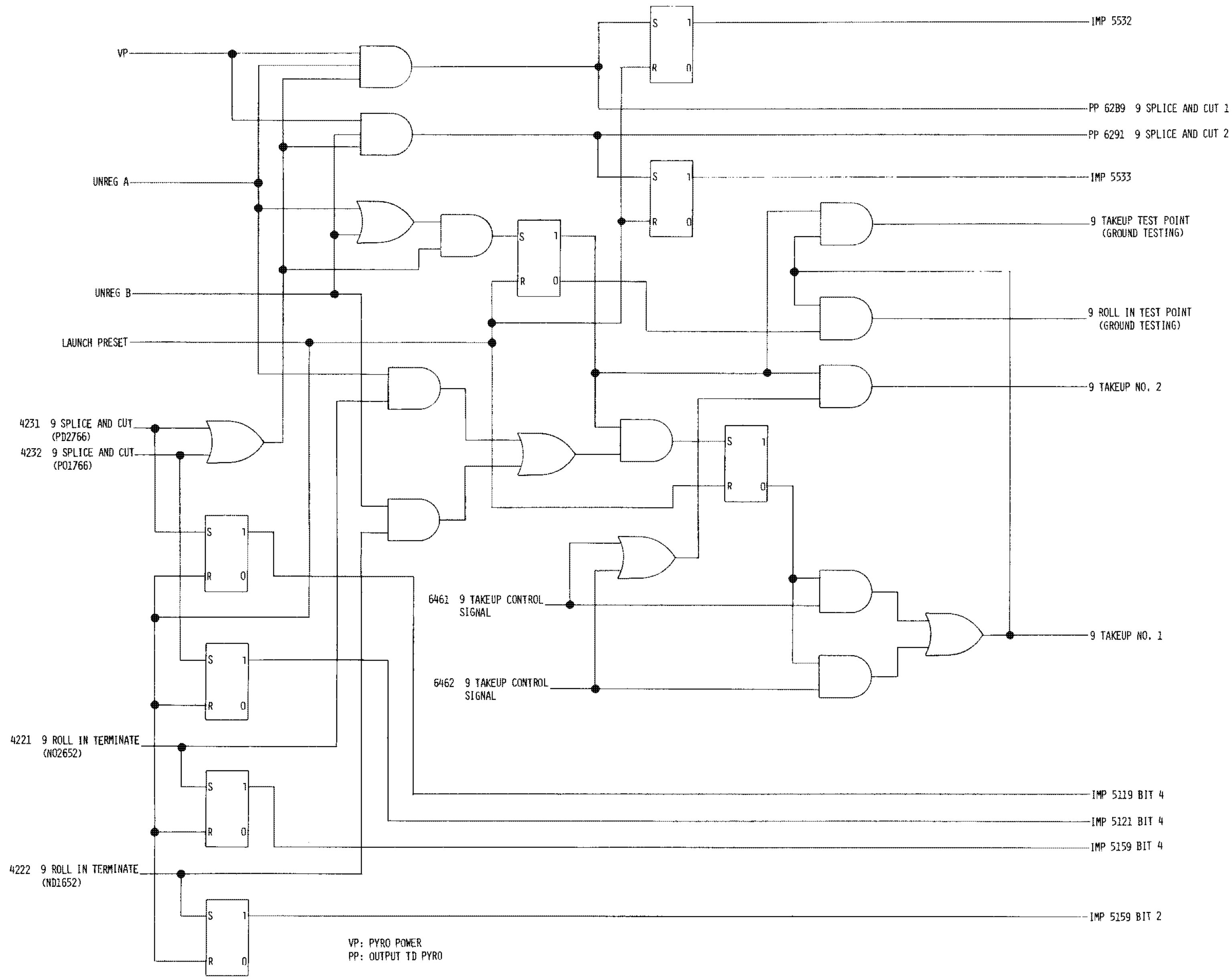

Figure 3.7-27. 9 Splice and Cut and 9 Roll-In Terminate

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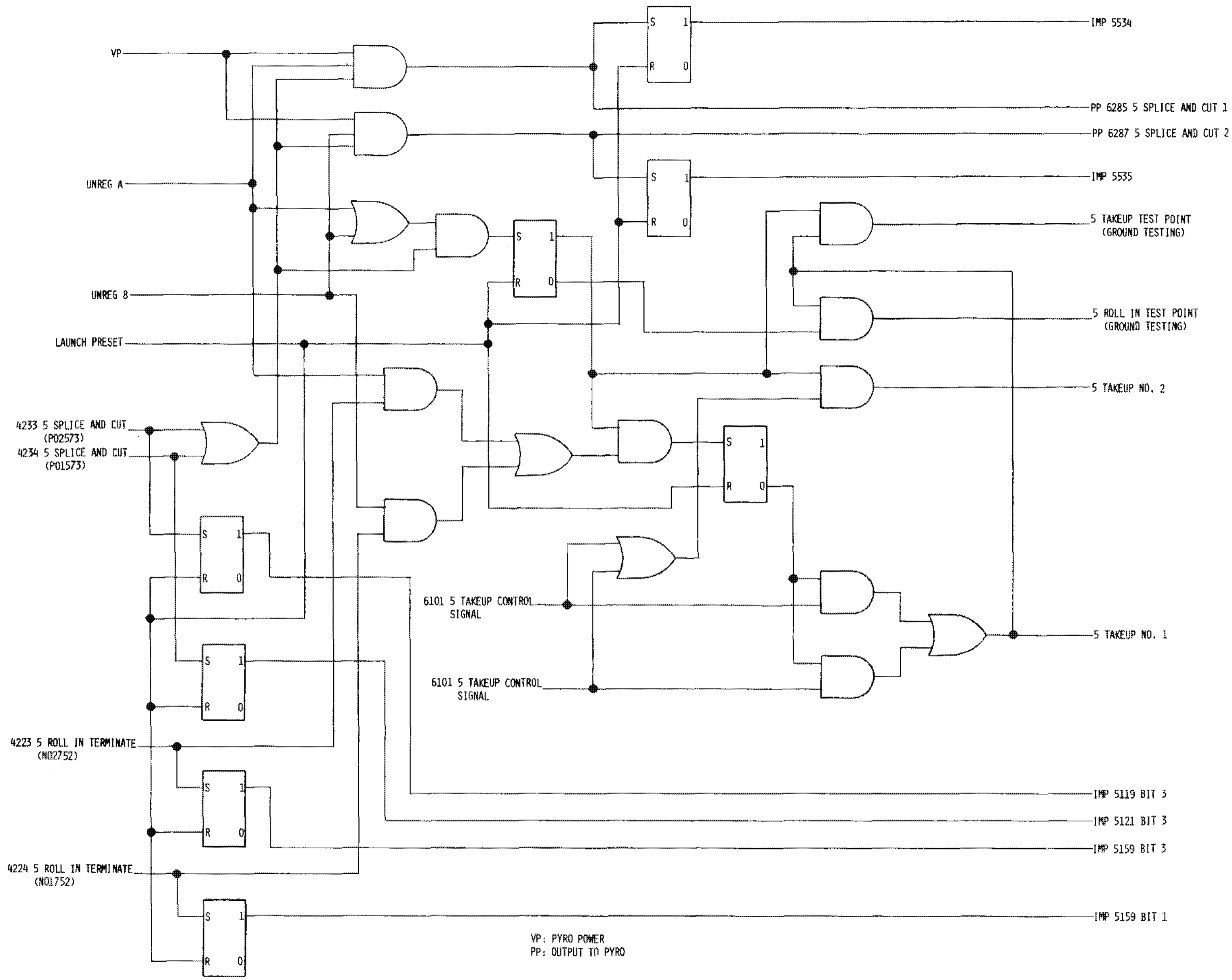

Figure 3.7-28. 5 Splice and Cut and 5 Roll-In Terminate

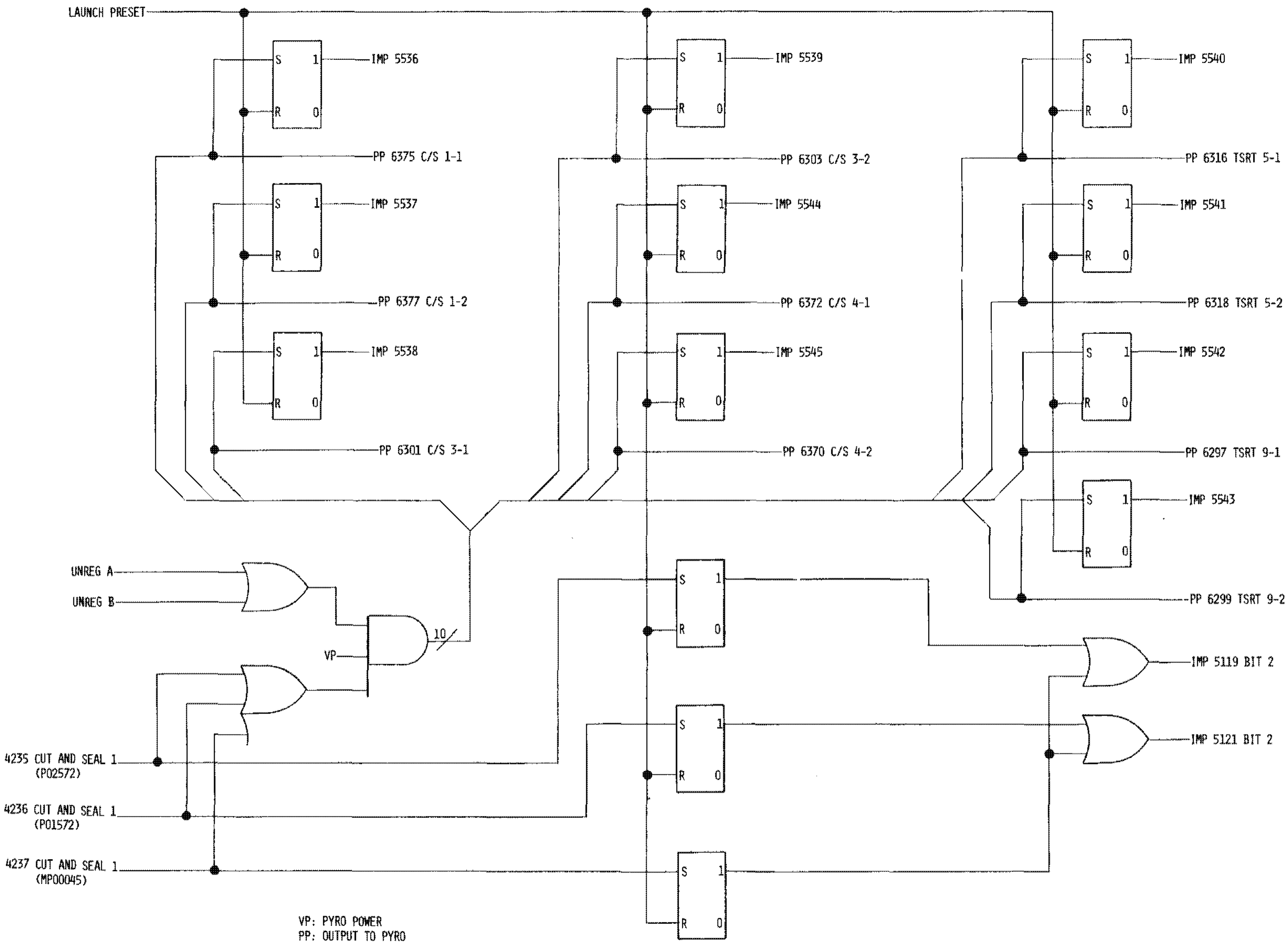

Figure 3.7-29. Cut and Seal 1

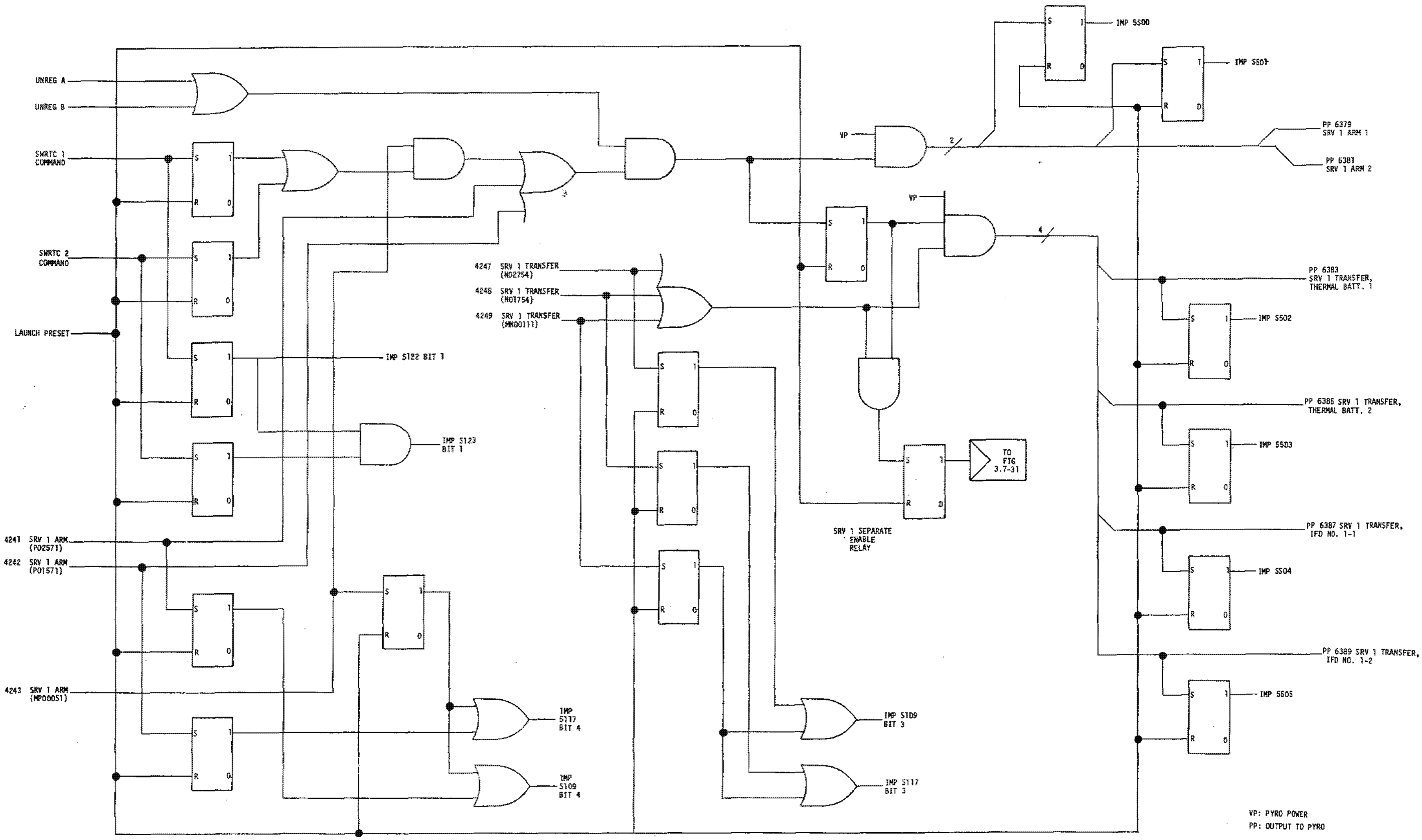

Figure 3.7-30. SRV 1 Arm and Transfer

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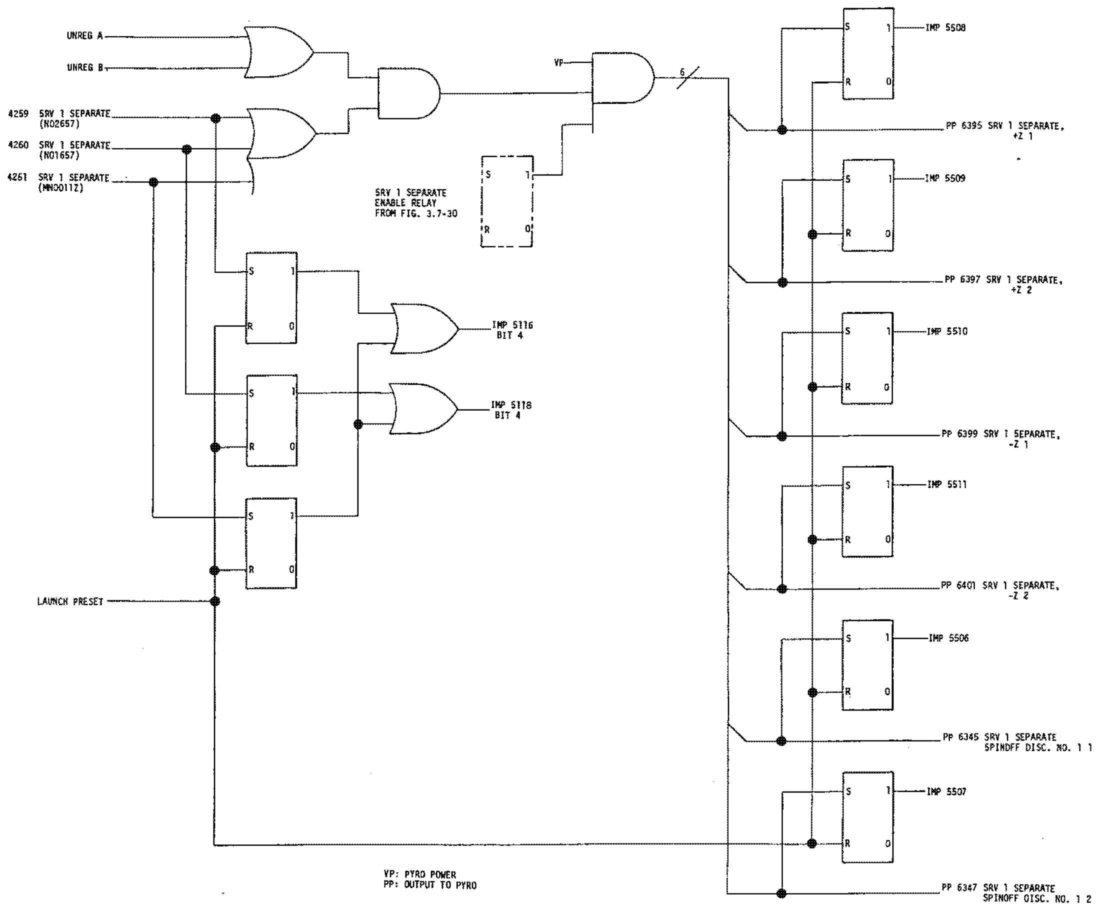

Figure 3.7-31. SRV 1 Separate

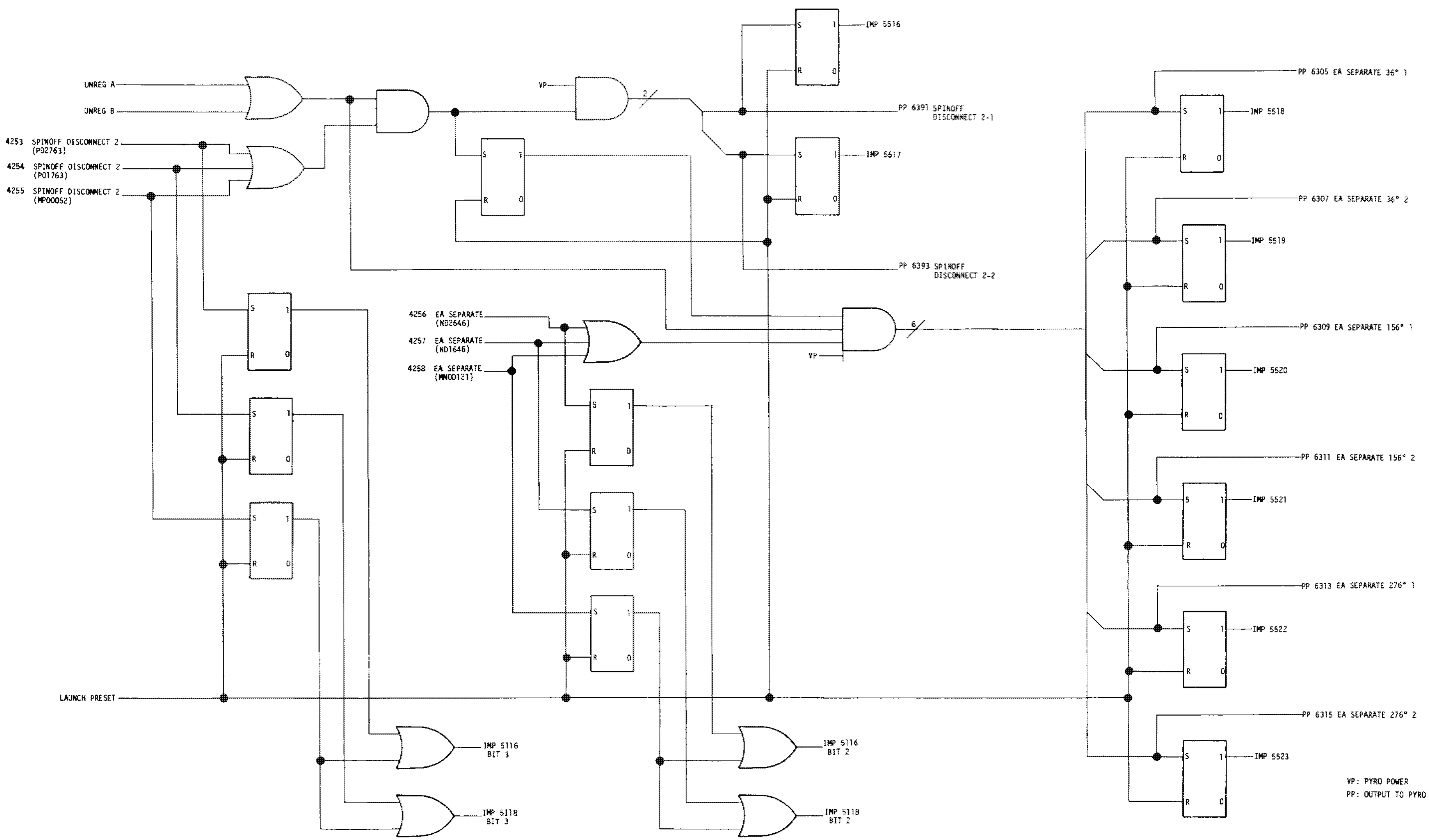

Figure 3.7-32. Spinoff Disconnect 2 and EA Separate

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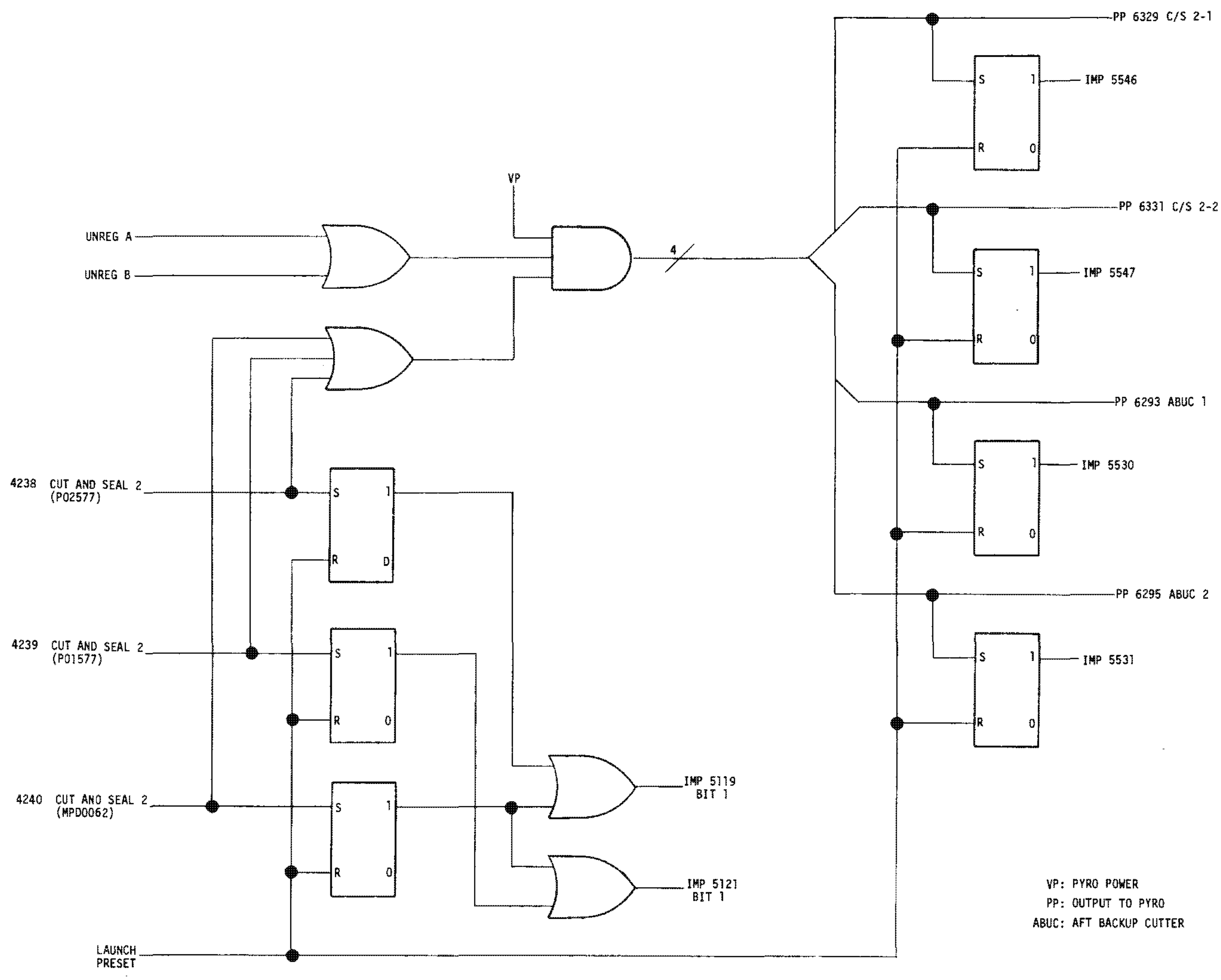

Figure 3.7-33. Cut and Seal 2

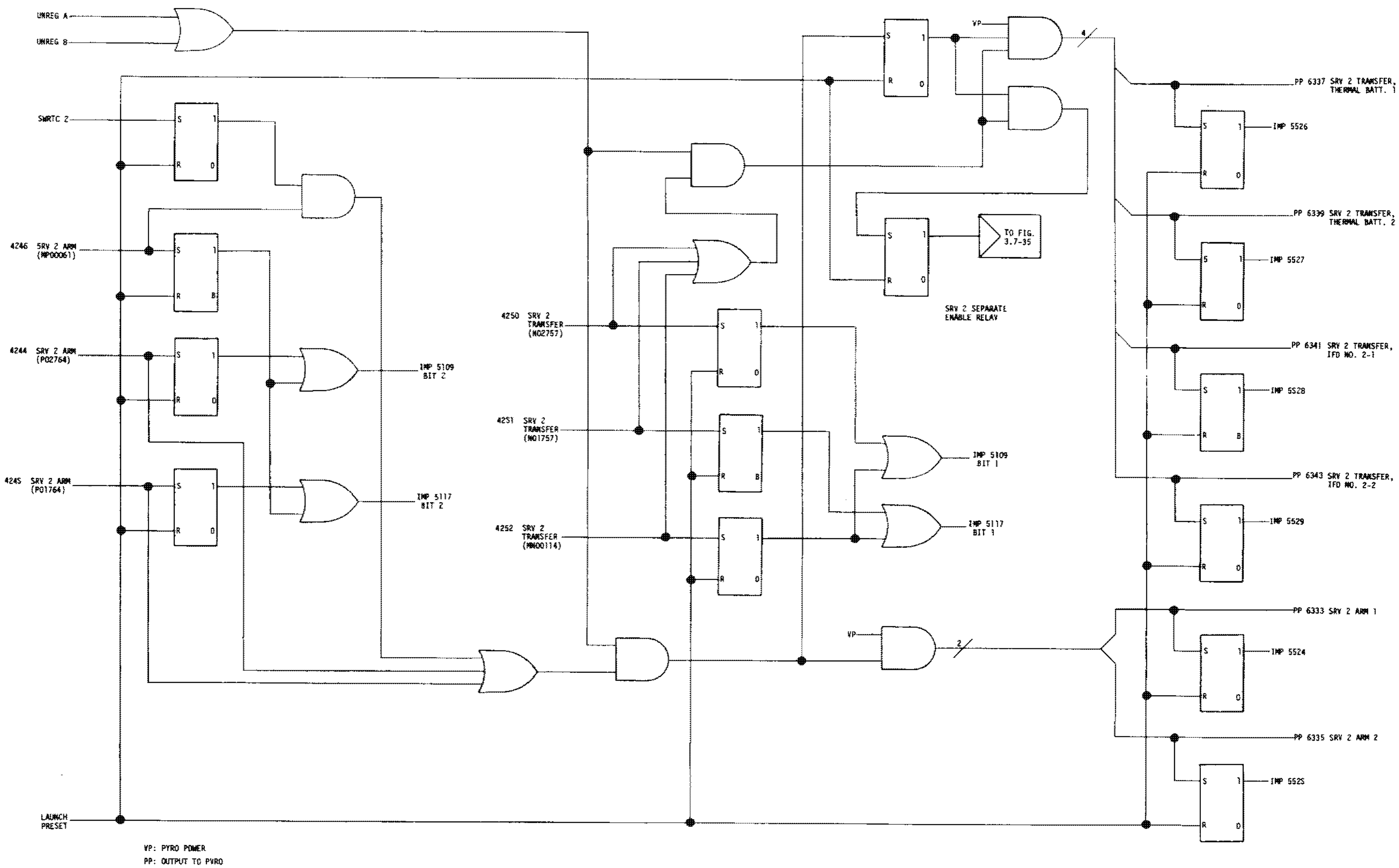

Figure 3.7-34. SRV 2 Arm and Transfer

Handle via BYEMAN
Control System Only

~~TOP SECRET~~ G

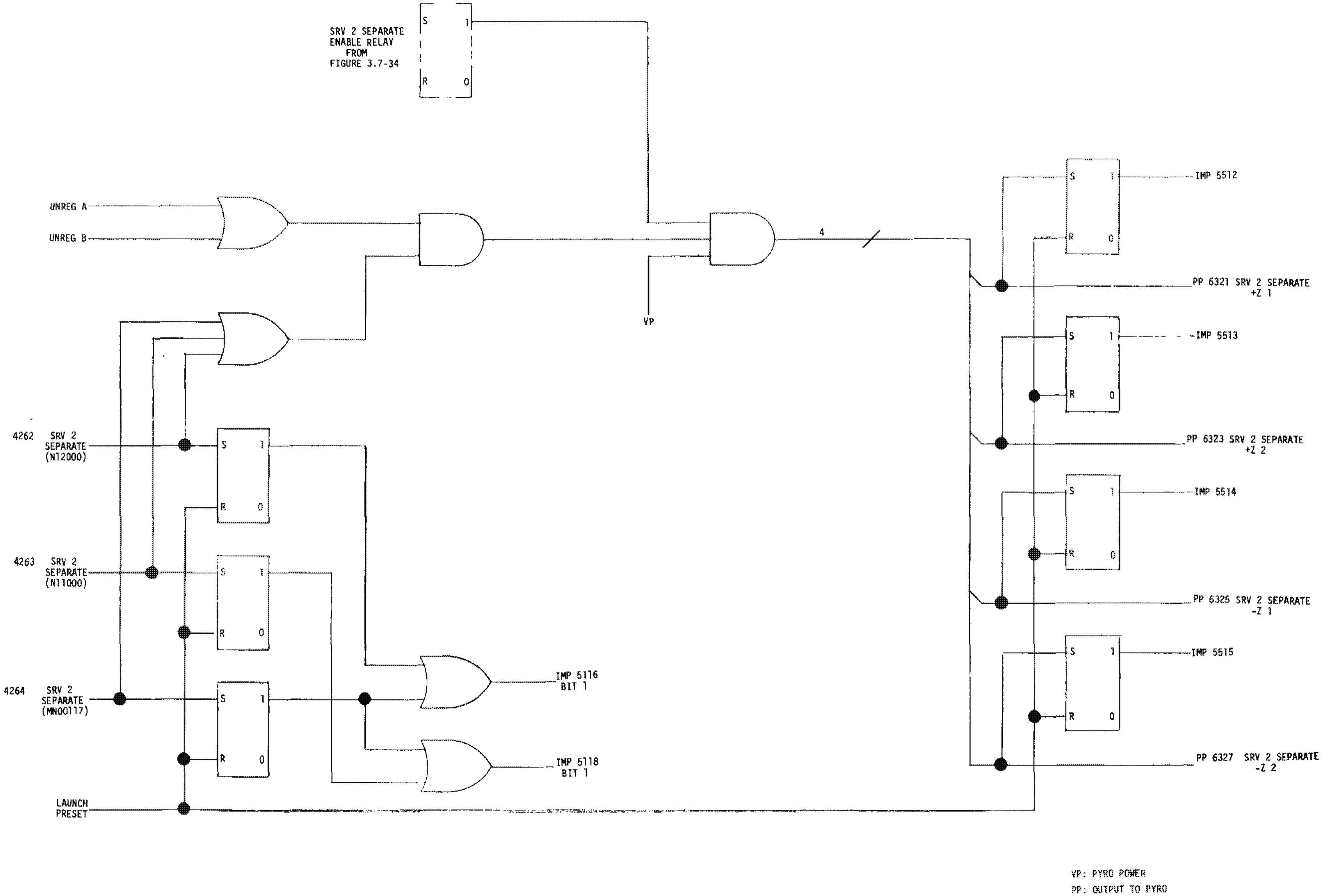

Figure 3.7-35. SRV 2 Separate

7.3.3.2 SPLICE AND CUT and ROLL-IN TERMINATE (9 or 5). The 9 and 5 SPLICE AND CUT and ROLL-IN TERMINATE functions operate identically (Figures 3.7-27 and 3.7-28). The following applies to either.

Upon command, two nonlatching relays provide actuation power to the splicer mechanism dimple motor squibs to initiate the SPLICE/CUT operation. The command also operates two latching relays which connect the SRV 1 take-up signal electrically in parallel with the take-up in SRV 2. Therefore, whenever a take-up cycle is performed, both take-up spools (one in SRV 1 and one in SRV 2) are powered. A third latching relay operated by the SPLICE AND CUT command enables the ROLL-IN TERMINATE command circuitry. Execution of ROLL-IN TERMINATE then removes the take-up control signal from SRV 1.

7.3.3.3. SWRTC 1 and SWRTC 2. The two secure word real-time commands (SWRTC 1 and 2) from the MCS provide command protection for the SRV 1 and SRV 2 ARM command processing circuits. SWRTC 1 enables SRV 1 ARM from the MCS. SWRTC 2 enables both SRV 1 ARM and SRV 2 ARM from the MCS. Execution of the ECS ARM commands is not affected by SWRTC 1 or SWRTC 2. Instrumentation monitoring the receipt of SWRTC 1 and SWRTC 2 is interconnected in such a way that no indication of command receipt will be given if SWRTC 2 is executed without having executed SWRTC 1 (reference Figure 3.7-30).

7.3.3.4 ARM/TRANSFER/SEPARATE. To prevent execution of an incorrect command sequence, SRV ARM enables SRV TRANSFER, which enables SRV SEPARATE (see Figures 3.7-30 and 3.7-31 for SRV 1 and 3.7-34 and 3.7-35 for SRV 2).

The SRV 1 and SRV 2 ARM and TRANSFER commands function identically. SRV ARM powers the recovery battery activation squibs. SRV TRANSFER powers the de-orbit subsystem thermal battery activation matches, and the SRV in-flight disconnect squibs.

SRV 1 and SRV 2 SEPARATE are somewhat different in their operation. SRV 1 SEPARATE powers squibs in the two pin-puller assemblies holding SRV 1, and powers the squibs for spinoff disconnect 1. SRV 2 SEPARATE powers only the two pin-pullers which are holding SRV 2.

7.4 PPS/DP EAC Electromagnetic Interference (EMI) Control

The object of the EMI control effort is to ensure that the PPS/DP EAC subsystems function compatibly, and that, when the PPS/DP EAC is integrated with the SCS, and subsequently put into operation, there will be no malfunctions or interactions between systems due to electromagnetic interference. A common baseline, MIL-E-6051-C, is used by all associate contractors for their system testing and hardware design to guarantee a sufficient margin between the emission level of EMI generated during operation, and the existing threshold of susceptibility which would cause a malfunction.

The "EMI Control Plan", BIF-008 specification 1402-524, provides detailed requirements for the design and test of new hardware. The specification uses MIL-STD-461A Notice 3, and MIL-STD-462 Notice 2, as a general basis for its requirements, with some modification to fit the particular circumstances of the PPS/DP EAC. For example, a higher power fluctuation test is required due to the use of solar power panels on the SCS.

In order to make the individual components comply with the requirements, and to prevent interaction when the components are connected to form subsystems, the following have been given special consideration.

7.4.1 Filters

EMI filtering has been kept to a minimum in order to prevent ac currents from being coupled into the structure through the filter ground to structure, and then coupling into other systems which also have filters tied to the structure. To eliminate much of the need for filters, all power switching circuits* are designed with voltage rise-and fall-time controls (excluding pyro firing circuitry in the IEU). However, in the case of brush-type dc motors, the commutator switching transients must be suppressed by means of filters tied to the structure.

7.4.2 Grounding

At the complete system level (PPS/SCS), the main power, pyro power, and telemetry systems are all tied to the structure at a single point (located in the SCS) to eliminate current flowing through the structure. All power returns in the PPS/DP EAC are isolated from the structure. The main power returns are connected together at the unipoint ground in the PM and C and this in turn is carried back to the SCS unibus return which is tied to structural ground. Pyro power is isolated from all other power in the PPS/DP EAC and is returned on isolated lines from the IEU to the unibus return. Telemetry power in the PPS/DP EAC is referenced to the telemetry unipoint which is located in the instrumentation processor and is tied to the main power unipoint in the PM and C.

To eliminate additional sources of EMI caused by grounding techniques, all components in the PPS/DP EAC are attached to the system structure with a resistance of 2.5 milliohms or less. The resistance between one point on the structure and any other point is held to less than 10 milliohms.

*Voltage changes of 5 volts or less, and associated current changes of 10 milliamperes or less on control or signal lines are not required to meet EMI restrictions.

7.4.3 Power Distribution

Large capacitors are connected from the SCS power input lines to the unipoint ground in the PM and C (reference Figure 3.7-6). Placed at this point, they have the greatest effect in reducing the amplitude of noise on the power input lines, and limiting the coupling of power line noise between components. As an added measure, all power lines between components are twisted with their corresponding return line using at least three turns per foot.

7.4.4 Shielding

Shielded wires which pass through noncoaxial connectors have their shields carried through the connector on a separate pin, with the length of unshielded wire held to a minimum. The shielding on all pyro lines is connected to the structure only at the pyro connector and IEU ends.

7.5 Instrumentation Summary

Tables 3.7-4 and 3.7-5 summarize the instrumentation associated with the main and pyro power subsystems respectively. Instrumentation circuits monitoring the actual occurrence of events, such as the SRV separation monitors, are not included here as they are too numerous. Reference should be made to the appropriate sections of Part 3 for these points.

7.6 Command Summary

Table 3.7-6 summarizes the command logic circuits for the IEU and the PM and C and references the appropriate logic diagrams. No attempt is made to describe each individual command involved. Instead, the table lists a section to which reference can be made for a description of all commands associated with a particular function.

TABLE 3.7-4

MAIN POWER SUBSYSTEM INSTRUMENTATION*

IMP	TITLE	DESCRIPTION	POWER
5002	Cal ON/OFF, FEP ON/OFF, cal bit A/$\bar{A}$, cal bit B/$\bar{B}$	Latching relays tracking the command input relays of the command processor monitor the receipt of commands from the satellite control section and feed either 0.0v or 5.0v to an integrated circuit D/A converter. Output occurs in sixteen discrete steps ranging from 0.25v to 4.75v in 0.3v increments: Bit 1 (LSB)** = Cal ON/OFF Bit 2 = FEP ON/OFF Bit 3 = Cal bit A/$\bar{A}$ Bit 4 (MSB)*** = Cal bit B/$\bar{B}$	+5/±15 vdc
5003	Environmental branches 1, 2, 4 and 5 parking brake ON/OFF	Similar to IMP 5002: Bit 1 (LSB) = Environmental branch 1 ON/OFF Bit 2 = Environmental branch 2 ON/OFF Bit 3 = 5 parking brake ON/OFF Bit 4 (MSB) = Environmental branch 4 ON/OFF	+5/±15 vdc
5004	Environmental branch 5, 6, EPSM 1, EPSM 2 ON/OFF	Similar to IMP 5002: Bit 1 (LSB) = Environmental branch 5 ON/OFF Bit 2 = Environmental branch 6 ON/OFF Bit 3 = EPSM 1 ON/OFF Bit 4 (MSB) = EPSM 2 ON/OFF	+5/±15 vdc

*Primary, Emergency (BUSS), and Heater Power
**Least Significant Bit
***Most Significant Bit

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TABLE 3.7-4 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5007	5 focus drive enable/inhibit, 5 minus/stop, 5 plus/stop, S1-PRG cal ON/OFF	Similar to IMP 5002: Bit 1 (LSB) = 5 focus drive enable/inhibit Bit 2 = 5 minus/stop Bit 3 = 5 plus/stop Bit 4 (MSB) = S1-PRG cal ON/OFF	+5/±15 vdc
5024	9 focus drive enable/inhibit 9 minus/stop, 9 plus/stop, S1-PRG disable/enable	Similar to IMP 5002: Bit 1 (LSB) = 9 focus drive enable/inhibit Bit 2 = 9 minus/stop Bit 3 = 9 plus/stop Bit 4 (MSB) = S1-PRG disable/enable	+5/±15 vdc
5029	9 CAM ON/OFF, 5 CAM ON/OFF, 9 OP ON/OFF, 5 OP ON/OFF	Similar to IMP 5002: Bit 1 (LSB) = 9 CAM ON/OFF Bit 2 = 5 CAM ON/OFF Bit 3 = 9 OP ON/OFF Bit 4 (MSB) = 5 OP ON/OFF	+5/±15 vdc
5032	PCM* 1 ON/OFF, PCM 2 ON/OFF, FDS bits 9, 10	Similar to IMP 5002: Bit 1 (LSB) = PCM 1 ON/OFF Bit 2 = PCM 2 ON/OFF Bit 3 = FDS bit 9 Bit 4 (MSB) = FDS bit 10	+5/±15 vdc
5130	BUSS power supply	A voltage divider network located in the PM and C monitors the voltage level of the emergency (BUSS) power supply. The output is linear and ranges from 0.2v (0 bus-volts) to 4.8v (35 bus-volts).	+5 vdc

*Pulse Code Modulation (used to indicate digital telemetry unit).

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TABLE 3.7-4 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5131	Environmental power supply	Similar to IMP 5130; monitors the voltage level of the heater (environmental) power input in the PM and C.	+5 vdc
5141	Primary PPS power supply	Similar to IMP 5130; monitors the voltage level of the primary power input in the PM and C.	+5 vdc
5090	Crab, stereo, and door current	A current sensing resistor in the power return line in the PM and C generates a voltage proportional to the combined currents for the crab and stereo servos, and the viewport door motor and electronics. The signal is amplified within the PM and C to produce a linear output that ranges from 0.2v (0.0 amp) to 5.0v (6.0 amps).	±15 vdc
5091	Main power current	Three parallel current sensing resistors in series between the primary, emergency, and heater power return lines to the SCS and the return lines from PPS/DP EAC subsystems generate a voltage proportional to the PPS/DP EAC main power usage. The signal is amplified in the PM and C to produce an output that ranges from 0.0v (0.0 amp) to 5.11v (35 amps).	±15 vdc
5133	Environmental current branch 1, branch 6, EPSM 1, EPSM 2	Similar to IMP 5090, the sensor monitors the combined currents for environmental branches 1 and 6, and EPSM 1 and 2. The output is linear and ranges from 0.2v (0.0 amp) to 4.48v (4.0 amps).	±15 vdc

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TABLE 3.7-4 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5134	Environmental current branch 2, and 5 parking brake current	Similar to IMP 5090; the sensor indicates the combined currents for environmental branch 2, and the 5 parking brake. The output is linear and ranges from 0.18v (0.0 amp) to 5.0v (5.0 amps).	±15 vdc
5135	Environmental current branch 4	Similar to IMP 5090; the sensor indicates the environmental branch 4 current drain. The output is linear from 0.2v (0.0 amp) to 4.87v (6.0 amps).	±15 vdc
5136	Environmental current branch 5	Similar to IMP 5090; the sensor indicates the environmental branch 5 current drain. The output is linear from 0.18v (0.0 amp) to 5.0v (5.0 amps).	±15 vdc
5138	PPS main power consumption (coarse)	A triple output ampere-hour meter located in the PM and C senses by magnetic pick-up the current in the PPS/DP EAC main power return lines to the SCS. The current levels are integrated over time to indicate total PPS/DP EAC power consumption (excluding pyro power). The meter cycles in 0.7v increments (steps) from 0.0v to 4.9v for each range. One cycle (8 steps) for the fine is 16 ampere-hours and is one step for the medium. Eight steps of the medium (128 ampere-hours) produce one step of the coarse. The sum of the readings on all three ranges is the total PPS/DP EAC main power consumption. The meter is reset automatically if power is removed.	24.5 vdc
5139	PPS main power consumption (medium)		24.5 vdc
5140	PPS main power consumption (fine)		24.5 vdc

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TABLE 3.7-4 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5196	+15 vdc supply	A divider circuit in the instrumentation processor produces a voltage proportional to the voltage level of the +15 vdc regulated supply. The output is linear from 0.0v (0.0v supply level) to 4.0v (15.0v supply level).	+15 vdc
5198	+5 vdc supply	A divider network in the instrumentation processor produces a voltage proportional to the voltage level of the +5v regulated supply. The output varies linearly from 0.0v (0.0v supply level) to 4.0v (5.0v supply level).	+5 vdc
5200	-15 vdc supply	A divider network which uses the +5 vdc supply as a bias source, produces an output proportional to the voltage level of the -15 vdc supply. The output is linear from 4.0v (0.0v supply level) to 1.0v (-15.0v supply level).	+5/-15 vdc
5577	Environmental branch 1 voltage monitor	A voltage divider network across the environmental branch 1 power feed in the PM and C monitors the voltage output level. The output is converted in the DTU to yield a binary signal (on/off): "0" = Off "1" = On	Self
5578	Environmental branch 2 voltage monitor	Similar to IMP 5577; monitors the environmental branch 2 power feed.	Self

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TABLE 3.7-4 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5580	Environmental branch 4 voltage monitor	Similar to IMP 5577; monitors the environmental branch 4 power feed.	Self
5581	Environmental branch 5 voltage monitor	Similar to IMP 5577; monitors the environmental branch 5 power feed.	Self
5582	Environmental branch 6 voltage monitor	Similar to IMP 5577; monitors the environmental branch 6 power feed.	Self
5583	EPSM 1 voltage monitor	Similar to IMP 5577; monitors the EPSM 1 power feed.	Self
5584	EPSM 2 voltage monitor	Similar to IMP 5577; monitors the EPSM 2 power feed.	Self
5585	Servo voltage monitor	Similar to IMP 5577; monitors the servo power feed.	Self
5589	DTU 1 on/off	A voltage divider network in the instrumentation processor is connected across the main power feed to DTU 1, and produces a voltage proportional to the main voltage. The output is converted in the DTU to yield a binary signal (on/off): "0" = Off "1" = On	Self
5590	DTU 2 on/off	Similar to IMP 5589; monitors the DTU 2 power feed.	Self
5591	9 OP voltage monitor	Similar to IMP 5577; monitors the 9 operational power feed.	Self

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TABLE 3.7-4 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5593	5 OP voltage monitor	Similar to IMP 5577; monitors the 5 operational power feed.	Self
5594	Focus power monitor +15 vdc	Similar to IMP 5577; monitors the +15v focus power feed.	+15 vdc
5595	Focus power monitor -15 vdc	An optical isolator circuit (LED and phototransistor) with the LED connected across the -15v focus power feed in the PM and C monitors the voltage level. The output is converted in the DTU to yield a binary signal (on/off): "0" = Off "1" = On	+5/-15 vdc
5596	Focus calibration monitor +15 vdc	Similar to IMP 5577; monitors the +15v focus calibration power feed.	+15 vdc
5597	Focus calibration monitor -15 vdc	Similar to IMP 5595; monitors the -15v focus calibration power feed.	+5/-15 vdc
5615	S1-PRG power monitor	Similar to IMP 5577; monitors the S1-PRG power feed.	Self
5616	5 parking brake voltage monitor	Similar to IMP 5577; monitors the 5 parking brake power feed.	Self

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TABLE 3.7-5

PYRO POWER SUBSYSTEM INSTRUMENTATION

IMP	TITLE	DESCRIPTION	POWER
5109	CBM for IEU (#1)	Latching relays which operate in parallel with the command input relays of the IEU monitor the receipt of commands from the satellite control section. Four relays and a resistance network form a D/A converter, the output of which occurs in sixteen discrete steps ranging from 0.25v to 4.75v in 0.3v increments: Bit 1 (LSB) = TRANSFER 2A* Bit 2 = ARM 2A Bit 3 = TRANSFER 1A Bit 4 (MSB) = ARM 1A	+15 vdc
5116	CBM for IEU (#2)	Similar to IMP 5109: Bit 1 (LSB) = SEPARATE 2A Bit 2 = EA SEPARATE A Bit 3 = EA DISCONNECT A Bit 4 (MSB) = SEPARATE 1A	+15 vdc
5117	CBM for IEU (#3)	Similar to IMP 5109: Bit 1 (LSB) = TRANSFER 2B Bit 2 = ARM 2B Bit 3 = TRANSFER 1B Bit 4 (MSB) = ARM 1B	+5 vdc
5118	CBM for IEU (#4)	Similar to IMP 5109: Bit 1 (LSB) = SEPARATE 2B Bit 2 = EA SEPARATE B Bit 3 = EA DISCONNECT B Bit 4 (MSB) = SEPARATE 1B	+5 vdc

*A refers to ECS decoder A.

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TABLE 3.7-5 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5119	CBM for IEU (#5)	Similar to IMP 5109: Bit 1 (LSB) = CUT AND SEAL 2A Bit 2 = CUT AND SEAL 1A Bit 3 = 5 SPLICE AND CUT A Bit 4 (MSB) = 9 SPLICE AND CUT A	+15 vdc
5121	CBM for IEU (#6)	Similar to IMP 5109: Bit 1 (LSB) = CUT AND SEAL 2B Bit 2 = CUT AND SEAL 1B Bit 3 = 5 SPLICE AND CUT B Bit 4 (MSB) = 9 SPLICE AND CUT B	+5 vdc
5122	CBM for IEU (#7)	Similar to IMP 5109: Bit 1 (LSB) = Minimal arm 1 enable Bit 2 = VIEWPORT DOOR BLOW A Bit 3 = VIEWPORT DOOR BACKUP A Bit 4 (MSB) = HATCH COVER EJECT A	+15 vdc
5123	CBM for IEU (#8)	Similar to IMP 5109: Bit 1 (LSB) = Minimal arm 1 & 2 enable Bit 2 = VIEWPORT DOOR BLOW B Bit 3 = VIEWPORT DOOR BACKUP B Bit 4 (MSB) = HATCH COVER EJECT B	+5 vdc
5159	CBM for IEU (#9)	Similar to IMP 5109: Bit 1 (LSB) = 5 ROLL-IN TERMINATE B Bit 2 = 9 ROLL-IN TERMINATE B Bit 3 = 5 ROLL-IN TERMINATE A Bit 4 (MSB) = 9 ROLL-IN TERMINATE A	+15 vdc

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TABLE 3.7-5 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5152	Pyro voltage IEU	A high input impedance voltage monitor circuit in the IEU monitors the pyro power voltage input from the satellite control section. The signal is scaled to levels compatible with DTU input requirements and ranges linearly from 0.2v (0.0 bus-volts) to 4.54v (30 bus-volts).	±15 vdc
5576	Arm/Continuity, 1	A series loop passes through 13 connectors in the PPS/DP EAC to monitor the presence or absence of the arm plugs or safe/test plugs. Each arm plug puts a jumper wire in series with the loop while each safe or test plug places a 3KΩ resistance in series with the loop. The output of the processing circuitry in the instrumentation processor is converted to a binary signal in the DTU which indicates that all arm plugs are in place or that one or more arm plugs are missing or have been replaced by safe or test plugs.	+15 vdc
5614	Arm/Continuity, 2	Similar to IMP 5576; loop 2 contains only 12 arm plug sockets.	+15 vdc

IMPs 5500 through 5563

The circuits for IMPs 5500 through 5563 are identical. The pyro firing pulse output operates a latching relay in the IEU, the output of which is either connected to instrumentation return (quiescent) or to +5v (fired). A resistor in series with the output isolates the monitor circuit from the DTU. The output is converted in the DTU to a binary signal:

"0" = Quiescent
"1" = Fired

The title of each IMP indicates the pyrotechnic device actuator being fired by the monitored pulse:

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TABLE 3.7-5 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5500	SRV 1, arm 1		+5 vdc
5501	SRV 1, arm 2		↑
5502	SRV 1, transfer, thermal battery 1		
5503	SRV 1, transfer, thermal battery 2		
5504	SRV 1, transfer, IFD 1 1		
5505	SRV 1, transfer, IFD 1 2		
5506	SRV 1, separate, spinoff disconnect 1 1		
5507	SRV 1, separate, spinoff disconnect 1 2		
5508	SRV 1, separate +Z 1		
5509	SRV 1, separate +Z 2		
5510	SRV 1, separate -Z 1		
5511	SRV 1, separate -Z 2		
5512	SRV 2, separate +Z 1		
5513	SRV 2, separate +Z 2		
5514	SRV 2, separate -Z 1		
5515	SRV 2, separate -Z 2		
5516	Spinoff disconnect 2 1		
5517	Spinoff disconnect 2 2		
5518	EA separate 36° 1		
5519	EA separate 36° 2		
5520	EA separate 156° 1		
5521	EA separate 156° 2		
5522	EA separate 276° 1		
5523	EA separate 276° 2		
5524	SRV 2, arm 1		
5525	SRV 2, arm 2		
5526	SRV 2, transfer, thermal battery 1		
5527	SRV 2, transfer, thermal battery 2		
5528	SRV 2, transfer, IFD 1 1		
5529	SRV 2, transfer, IFD 1 2		
5530	Aft backup cutter 1		
5531	Aft backup cutter 2		
5532	9 splice/cut 1		
5533	9 splice/cut 2		
5534	5 splice/cut 1		↓
5535	5 splice/cut 2		+5 vdc

TABLE 3.7-5 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5536	Cut/seal 1 1		+5 vdc
5537	Cut/seal 1 2		
5538	Cut/seal 3 1		
5539	Cut/seal 3 2		
5540	TSRT 5 1		
5541	TSRT 5 2		
5542	TSRT 9 1		
5543	TSRT 9 2		
5544	Cut/seal 4 1		
5545	Cut/seal 4 2		
5546	Cut/seal 2 1		
5547	Cut/seal 2 2		
5548	Hatch eject 1		
5549	Hatch eject 2		
5550	Hatch eject 3		
5551	Hatch eject 4		
5552	Hatch eject 5		
5553	Hatch eject 6		
5554	Hatch eject 7		
5555	Hatch eject 8		
5556	Hatch eject 9		
5557	Hatch eject 10		
5558	Hatch eject 11		
5559	Hatch eject 12		
5560	Backup motor actuate 1		
5561	Backup motor actuate 2		
5562	Viewport door blow 1		
5563	Viewport door Blow 2		+5 vdc

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TABLE 3.7-6

COMMAND LOGIC SUMMARY

FUNCTION(S)	LOGIC FIGURE(S)	COMMAND DESCRIPTION
9 and 5 operational power and servo power ON/OFF	3.7-7	Part 3, Section 2
S1-PRG power ON/OFF	3.7-8	Part 3, Section 13
Focus electronics power ON/OFF	3.7-8	Part 3, Section 6
Focus calibration power ON/OFF	3.7-9	Part 3, Section 6
DTU 1 and 2 power ON/OFF	3.7-10	Part 3, Section 10
5 parking brake power ON/OFF	3.7-11	Part 3, Section 2
Environmental branch power ON/OFF	3.7-12 3.7-13	Part 3, Section 8
Hatch eject	3.7-25	Part 3, Section 5
Viewport door backup	3.7-26	Part 3, Section 5
Viewport door blow	3.7-26	Part 3, Section 5
9 Splice and cut and 9 roll-in terminate	3.7-27	Part 3, Section 12
5 splice and cut and 5 roll-in terminate	3.7-28	↕
Cut and seal 1	3.7-29	↕
SRV 1 arm and transfer	3.7-30	↕
SRV 1 separate	3.7-31	↕
Spinoff disconnect 2 and EA separate	3.7-32	↕
Cut and seal 2	3.7-33	↕
SRV 2 arm and transfer	3.7-34	↕
SRV 2 separate	3.7-35	Part 3, Section 12

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8.0 ENVIRONMENTAL CONTROL

Control of the PPS/DP EAC internal environment is required from initial fabrication through recovery of the exposed film. This includes control of temperature, humidity, pressure, and particulate contamination, as well as control of skin temperatures and temperatures of the internal components within prescribed ranges (particularly of optics, films and electronic components).

Throughout the manufacturing and assembly cycles, environmental control is provided by factory facilities, the PPS/DP EAC shipping container and shipping jackets, and launch pad facilities. Ground powered heaters and conditioned air flow are used during the prelaunch period following gantry rollback.

Flight hardware design provides the required thermal control during the ascent, orbital, and recovery phases. This is accomplished by passive means to the greatest extent possible, using flight heaters where required to supplement the passive control. The external finish (paint pattern) is designed to maintain the average skin temperature at the required level with a minimum of variation. Internal radiation and conduction isolation are used to decouple internal components from the skins and force them to react to the average temperature.

8.1 Ground Conditioning

During the manufacturing, shipping, and launch-pad phases, control of temperature, humidity, and contamination is required. Condensates must be kept from all internal payload parts so that correct reflectance can be maintained on optical surfaces. Excessive dirt must be kept from the slit blades and precision mechanical components to prevent streaking or physical damage to the film, and jamming of moving parts. The film emulsions must not become moisture-softened or film transport rollers may become contaminated. The film must be protected from overheating, because the rate of sensitometric deterioration becomes significant at temperatures above 90F.

8.1.1 Manufacturing Environment

To prevent any reduction in final product performance, all flight hardware manufacturing and testing is performed in controlled environments in which temperature, humidity, component materials, and especially cleanliness are controlled factors.

Small bits of contamination or foreign material can jam gears, bearings and other moving parts. Microscopic bits of contamination on the camera slit can cause low exposure streaks and loss of information on the film.

Cleanliness is controlled as follows:

a. Facility - The manufacturing and testing areas are maintained to provide a clean environment.

b. Hardware - All prime and support equipment is kept clean. Contaminant samples are analyzed periodically to determine their source and measures are taken to eliminate or control the contaminant sources.

c. Film - Extreme attention is given to handling and cleanliness of film. The camera slit is the most critical area with respect to cleanliness. Film acts as a conveyor belt for contamination since it passes within a few mils of the slit. Each handling step associated with the film is accomplished in a carefully controlled clean environment, the film is frequently cleaned, and any contaminants are collected and analyzed.

Photographic film is extremely sensitive to certain materials and will be degraded if brought into contact with them. All materials in or around prime hardware are considered for film compatibility. Materials or parts used must be included in the Reliability Approved Parts List. Everything on this list has been fog tested for compatibility with film.

8.1.1.1 Manufacturing and Testing Facilities. Various controlled areas and clean rooms are maintained for all prime hardware manufacturing and testing. BIF-008 facilities include Class II and III cleanliness controlled areas, and Class IV and VI clean room facilities for this activity as defined in the BIF-008 contamination control handbook. In general, the greater the numerical designation, the stricter the controls are over contamination. The Class IV and VI clean rooms correspond to class 100,000 and class 100 clean rooms respectively as defined in Federal Standard 209B.

Table 3.8-1 presents general characteristics of the BIF-008 clean area and clean room facilities, and lists typical examples of usage.

8.1.1.2 Special Cleaning Tasks and Tests. At various times during component, module, and PPS/DP EAC assembly level manufacturing, critical components are cleaned and/or tested to assure control of particulate contamination.

8.1.1.2.1 Camera Inspection and Cleaning. After vibration testing of the camera, the assembly is partially disassembled in a laminar-flow tent and thoroughly cleaned with special vacuum equipment. It is inspected using black light which illuminates contaminant particles.

The 9 and 5 camera slits are tested for contamination by exposing film. Following the exposure test, each slit is carefully cleaned using special probes to remove any contaminant shown in the exposure test.

TABLE 3.8-1

CLEAN AREA AND CLEAN ROOM CHARACTERISTICS AND USAGE

Level	General Characteristics	Use
Class II	Positive pressure Entry restricted to authorized personnel Wet mopping of floor; wet wiping of all equipment Special clean room garment usage (coats, hats) Equipment and material restricted to approved design Maintenance of clean, filtered air	For assemblies requiring some dirt generating operations not permitted in Class III or higher areas (e.g., thermal and electrical assembly steps for the COA, thermal blanket and electronic box construction)
Class III	Controls of a Class II area plus: Full clean-room type garments (coat, hood, boots) Operations restricted to non-dirt generating Greater restrictions on airborne particle contamination	For assemblies not requiring microscopic contaminant control but requiring greater control than Class II clean areas offer (e.g., COA, servos, film supplies and take-ups)
Class IV	Controls of a Class III area plus: Air shower entries More frequent wet mopping and wet wiping Greater restrictions on manufacturing operations Greater restrictions on airborne particle contamination (Federal Class 100,000)	For critical assemblies whose performance and reliability depend on cleanliness (e.g., the camera, all major modules)
Class VI	Laminar-flow tent Airborne particle contamination per Federal Class 100	For final cleaning of the camera and subsequent operations which expose the camera

After testing and cleaning, the camera is sealed with ultraclean plastic to prevent future contamination.

8.1.1.2.2 Film Handling. Film is shipped from the vendor in a specially designed container which is prepared for use and certified by the contamination control group.

The vendor takes precautions to prevent film contamination by wrapping the spool in an ultraclean, antistatic plastic bag. The spool is sealed in its shipping container.

Film is unpacked in a Class VI clean area in total darkness. Contamination samples are taken and analyzed.

8.1.1.2.3 COM Bellows Assembly. The bellows is assembled to the camera in a Class VI laminar-flow tent. During bellows assembly, the camera opening and bellows are inspected with black light and thoroughly cleaned. After assembly, the bellows opening is sealed.

8.1.1.2.4 SEM Film Supply Enclosure. Precautions are taken to keep the film supply enclosure (FSE) area closed unless work is required inside. The FSE walls are coated with a noncuring adhesive to trap contaminants, and therefore cannot be cleaned.

8.1.1.2.5 DRM Film Tunnels. The DRM film tunnels and gaskets are thoroughly cleaned during assembly. After cleaning, the openings are sealed with ultraclean plastic until ready for mating.

8.1.1.2.6 PPS/DP EAC Cleaning and Testing. Slit exposure tests are made at the final PPS/DP EAC level of assembly to show any particles on the slit-blade edges that could cause local narrowing of the slit and resultant low exposure streaks in the end use.

A special vacuum probe is used to clean the 9 and 5 slit blades to remove any contaminant.

Thermal surfaces on all external structures, and thermal blankets, are sensitive to contamination and are handled at all times with gloves. The external thermal finish receives a final cleaning with freon and water-dampened, lint-free wipes during final PPS/DP EAC assembly.

8.1.2 Storage and Shipment

Strict control of all environmental factors is maintained throughout any storage period required, either at the factory or other locations, and through the transportation cycle. Maintaining the necessary conditions requires cooperation among all parties involved: BIF-008, the United States Air Force, and Lockheed Missiles and Space Company (LMSC). Procedures for storage and shipment are discussed in Part 4, Section 5 of this document.

8.1.3 Launch Site Ground Conditioning

The requirement for launch site ground conditioning of the PPS/DP EAC begins at the time the PPS/DP EAC is removed from its shipping container. Suitable protection is provided by the container and auxiliary equipment up to this time. Figure 3.8-1 provides a graphic summary of the required ground conditions and will aid in understanding the following data.

The purpose of the ground conditioning system is twofold:

(1) to precondition the PPS/DP EAC components to their on-orbit temperature levels, and

(2) to prevent moisture and other foreign material (dust, dirt) from entering the vehicle.

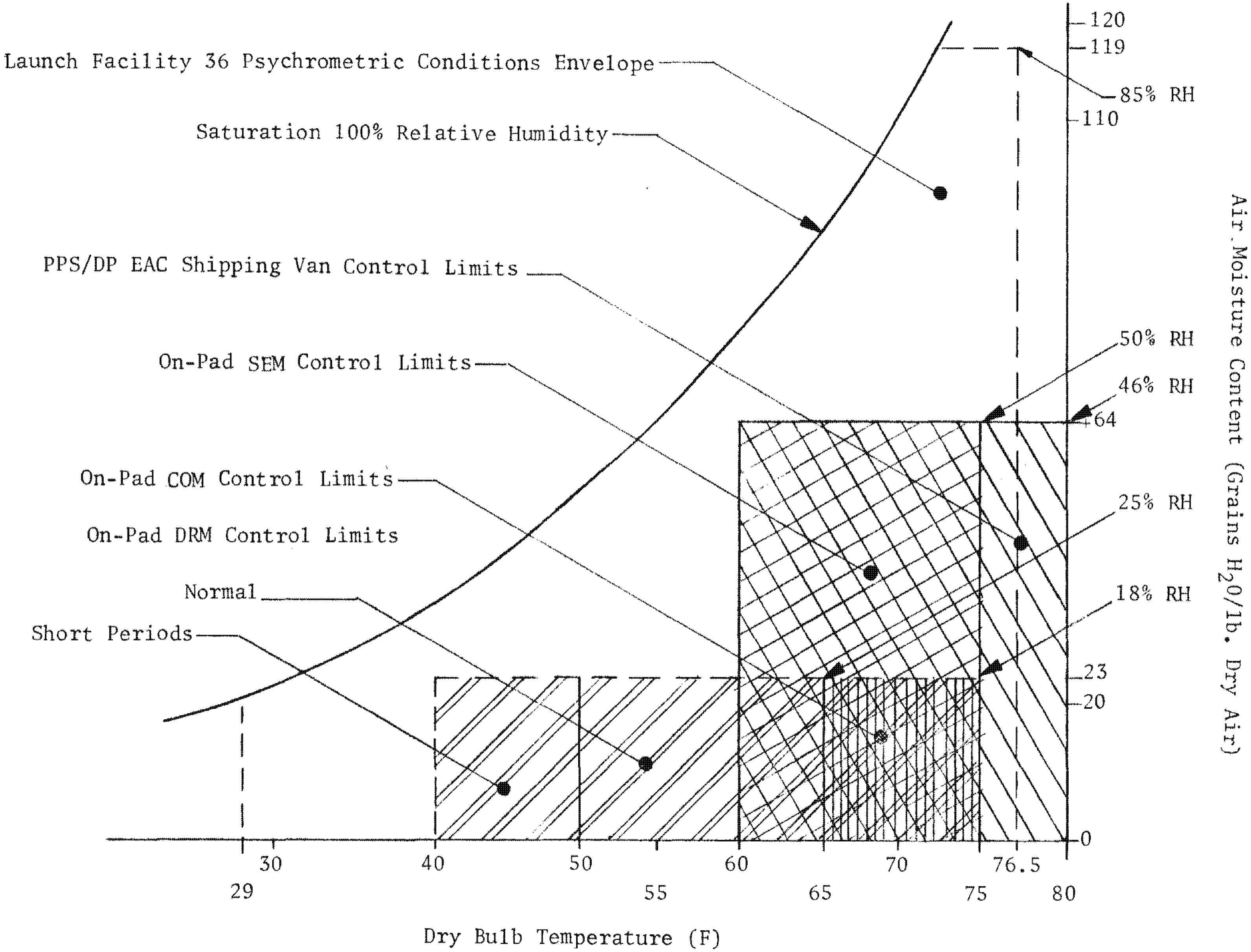

Figure 3.8-1. Ground Conditioning at Launch Facility

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The ground conditioning system is designed to provide adequate protection against the launch facility weather extremes as presented in the psychrometric summary for the launch facility. This United States Air Force (USAF) Air Weather Service document, for the period 1959 through 1962, shows the coldest dry-bulb temperature as 29F (with a specific humidity of 23 grains of moisture per pound of dry air) and the highest dew-point temperature to be 72F.

During the transfer phase (from the shipping container to the gantry clean room), the shipping jackets covering the PPS/DP EAC provide protection from dirt and dust as well as moisture. The jackets, constructed of polyurethane foam, also offer a good deal of thermal insulation from the external environment. Jacket openings are provided to allow access to the PPS/DP EAC handling rings and for exposing the aft area for mating with the satellite control section (SCS). In the event of inclement weather, mating is postponed. After mating, the shipping jackets are removed as required, and all jackets are removed prior to gantry rollback.

The prime concern during the transfer phase is the prevention of internal condensation that could be caused by either the intrusion of warm, moist air into a vehicle whose temperature is less than the dew point of the introduced air, or by allowing the PPS/DP EAC to cool to 55F or less (55F is the maximum dew-point temperature of the PPS/DP EAC in the shipping container). The possibility of intrusion of warm air is eliminated by keeping the structure vents and ports tightly sealed until conditioned air is supplied. Protection against cooling of the PPS/DP EAC to 55F is provided by the heater jackets if there is a long delay between removal from the container and the commencement of conditioned air flow or ground-heater actuation.

8.1.3.1 Launch Pad. Environmental control on the pad is accomplished by maintaining positive pressure in the PPS/DP EAC with conditioned air, and by self-contained heaters located in the COM, the FSE, the SRV's, and the film chutes (reference Section 8.3.5.4). The on-pad conditioning configuration is shown in Figure 3.8-2. Environmental control necessary within the SEM and DRM is established by the requirement to maintain the film supply enclosure temperature and relative humidity at levels such that film emulsions will not become moisture-softened. Environmental control is maintained by the heaters on the film supply enclosure walls and by operational limitations on the duration of PPS/DP EAC exposure to ambient temperatures below 40F or above 80F with the gantry rolled back.

The COM components require much closer temperature control because of the greater temperature sensitivity and the long thermal time constants of the mirrors. The COM temperatures must be as close as possible to the on-orbit equilibrium temperatures or the optics could take nearly a day to stabilize. The COM is held at 67 ± 2F by the use of conditioned air and the COM ground heaters.

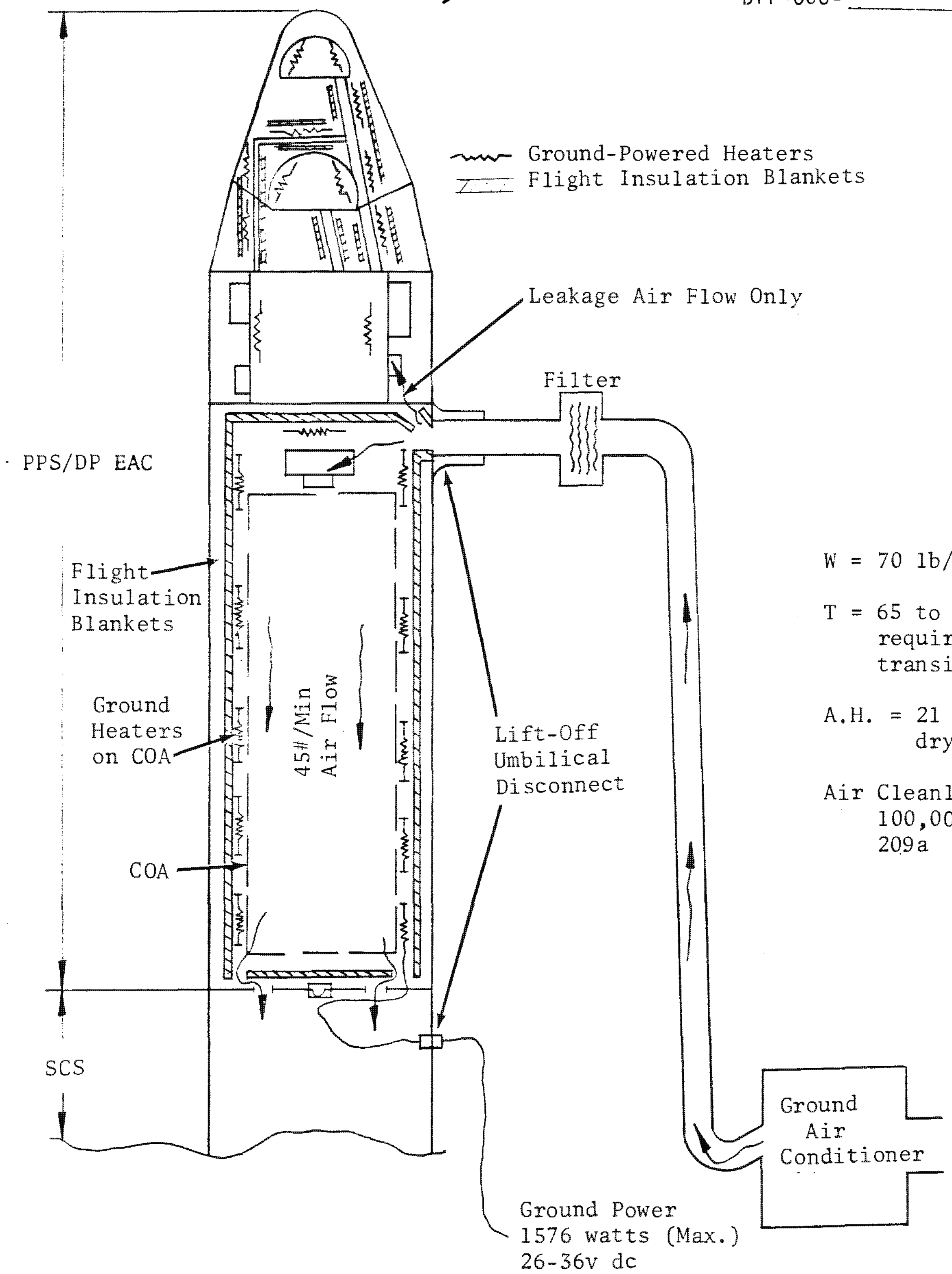
The positive pressure created by the conditioned air also serves to prevent foreign material from entering the PPS/DP EAC. A thermistor, located inside the COM near the air inlet, monitors the temperature of the incoming ground air. The output of this sensor (umbilical (BIL) point 8010) is available only through an SCS umbilical line.

8.1.3.1.1 Gantry Clean Room. The gantry clean room was established for controlled-environment storage of certain equipment and to perform film handling and other critical operations as required during the prelaunch period. Two areas are provided:

(1) a clean work station (Area A)

(2) a clean room (Area B/C)

Figure 3.8-3 shows a floor plan of the areas.



W = 70 lb/min

T = 65 to 70F with special requirements on transients

A.H. = 21 grains H_2O/lb dry air maximum

Air Cleanliness: Class 100,000 per Fed Std 209a

Figure 3.8-2. PPS/DP EAC On-Pad Conditioning System

3.8-11

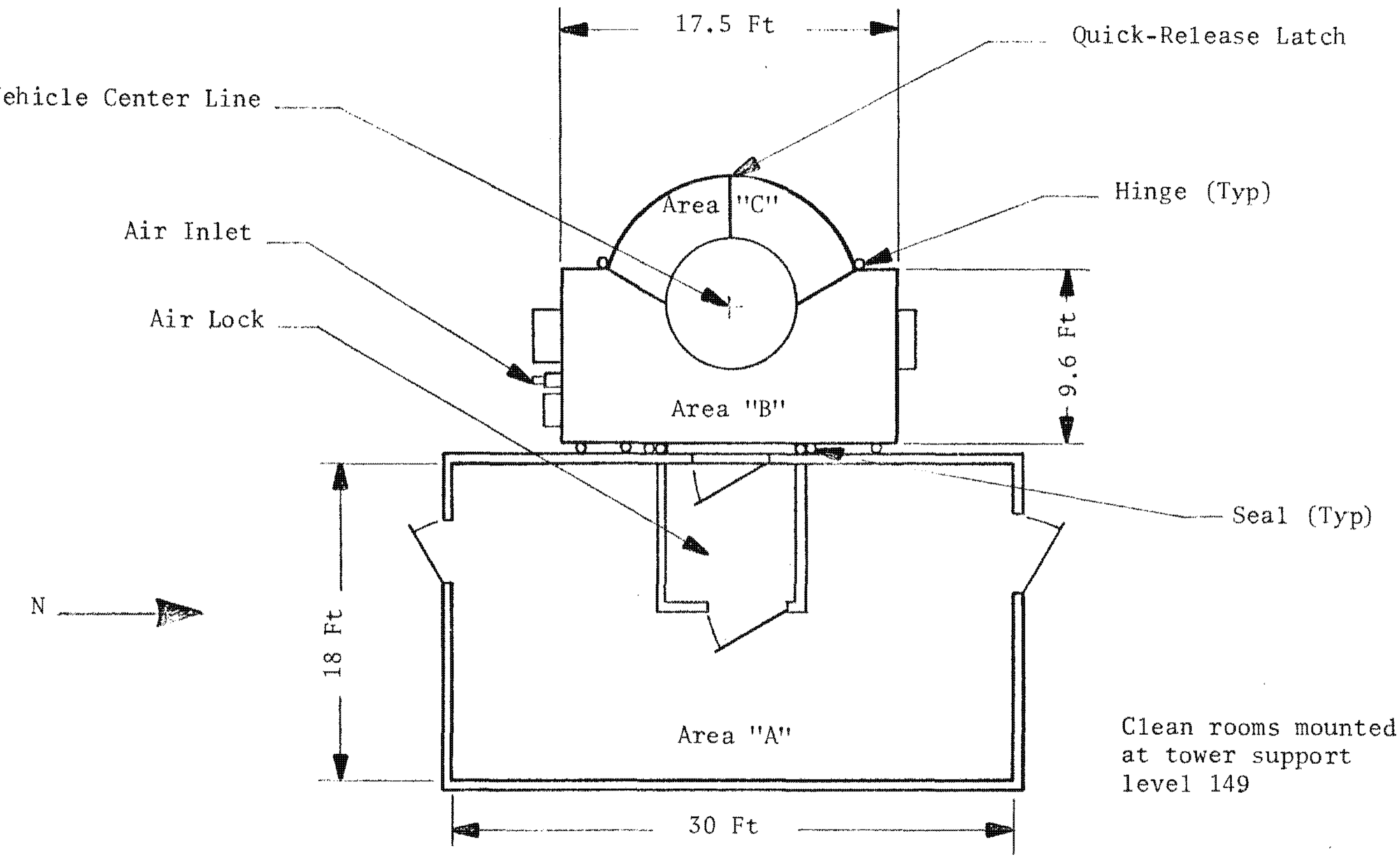


Figure 3.8-3. Floor Plan, Gantry Clean Rooms

8.1.3.1.2 Clean Work Station (Area A). This area is defined as a clean area suitable for the handling, storage, and cleaning of testing devices and critical mechanical items. The area was built in conformance with Federal Standard 209a and provides the following controlled environment:

Air Temperature	70 ± 5F
Air Change	1 every 10 minutes
Differential pressure (inside to outside ambient)	0.03 to 0.05 psig
Humidity	<50 percent RH
Dust-control filter	High-efficiency particulate air, 99.97 percent efficiency for 0.3 micrometer particles.

Conditioned air is supplied only when a vehicle is in position; however, an auxiliary air conditioner may be used between pad cycles.

8.1.3.1.3 Clean Room (Area B/C). This area encloses a portion of the PPS/DP EAC (from the approximate middle of the ejectable hatch, forward) and is capable of providing an environment suitable for operations requiring access to the film path. Although this type of operation is no longer performed due to the implementation of the "factory-to-pad" concept,* the capability does exist and could be activated under extraordinary circumstances.

This area was built in compliance with Federal Standard 209a, Section 40.1.1 through 40.1.8 and BIF-008 manual 401-119, Chapter 18, and is designed for a

*Refer to Part 4, Section 3.

maximum of six people. It provides the following controlled environment.

Air temperature	70 ± 5F
Air change	1 every 3 minutes
Differential pressure (inside to outside ambient)	0.03 to 0.06 psig
Humidity	<45 percent RH*
Cleanliness	Class 100,000 per Fed Std 209a
Filter	High-efficiency particulate air, 99.97 percent efficiency for 0.3 micrometer particles.

8.1.3.1.4 General. A portable dehumidifier is maintained in the clean room during the times that a vehicle is not in position. In the event of air conditioning failure, no outside air can enter the controlled areas.

Conditioned air will exhaust from the vehicle into the clean room when access panels are removed. Figure 3.8-4 shows the recommended lower limit of flow of conditioned air to the vehicle versus clean room pressure.

8.1.3.2 Prelaunch. Throughout the prelaunch period following gantry rollback, the PPS/DP EAC is entirely exposed to the external environment. During this time, ground heaters together with the flow of conditioned air are used to continue the conditioning of the COA to its operating temperature and to provide condensation protection.

As only leakage air flow is experienced in the SEM/DRM, an analysis was necessary to determine what internal temperatures might be expected on a hot launch day

* During film handling and arming operations, the relative humidity of the room will be maintained between 40 and 55 percent.

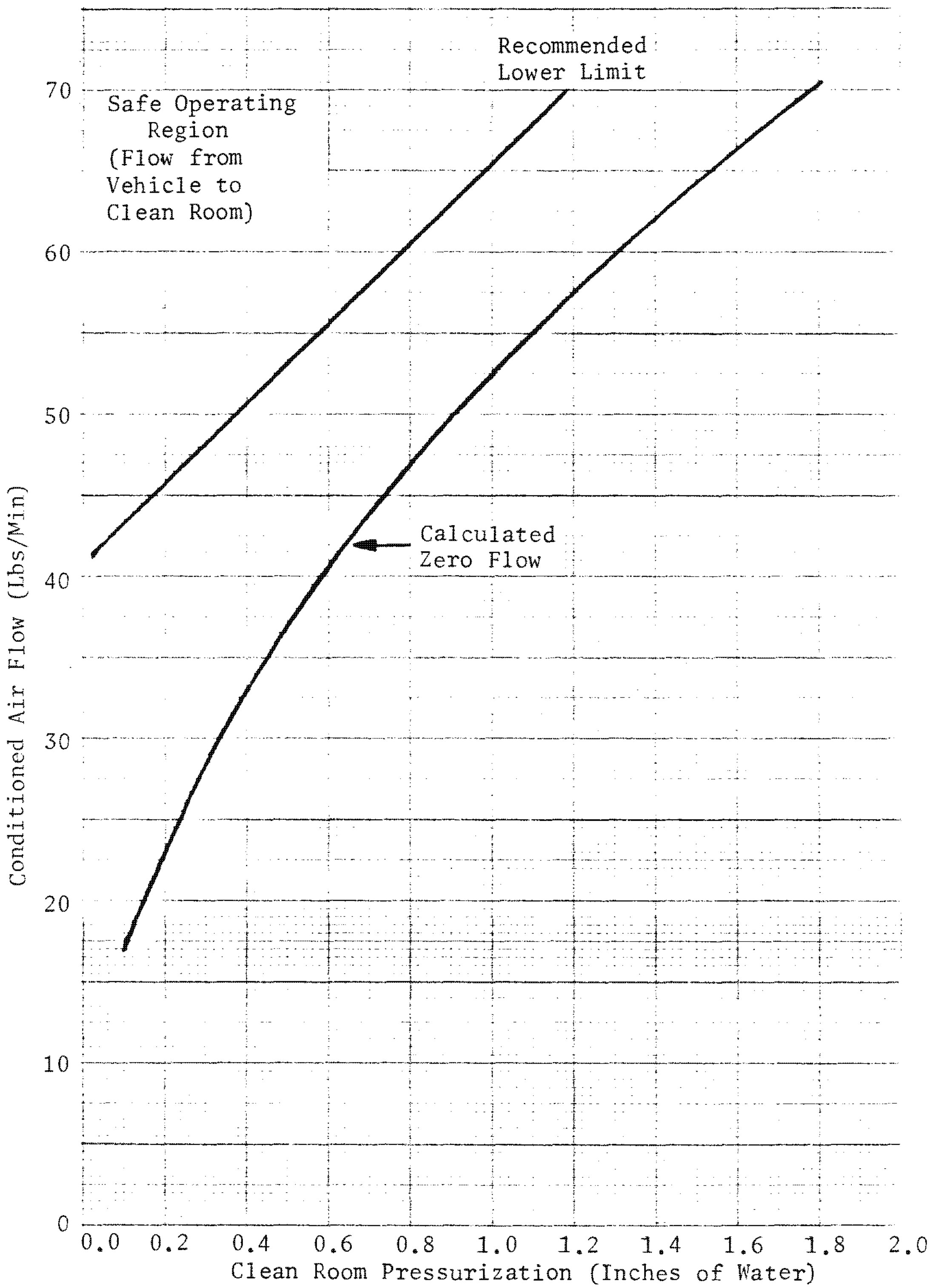


Figure 3.8-4. Recommended Operating Limits for Clean Room

(Part 2, Section 14.1.2). No problems were identified by this analysis. Although a high film temperature was calculated in the lower (-Z) EA travel viewer box, it is not considered a problem since that portion of the film is not used for photography and the predicted temperature did not approach a level where the physical properties of the film would be of concern.

Cold launch day conditions were also analyzed to determine what cooldown rate might be expected in the film supply enclosure in the event of a SEM ground heater failure. That analysis (Part 2, Section 14.1.1) resulted in a general equation for predicting supply temperature as a function of exposure time and external temperature which, when combined with a knowledge of dew-point temperature within the supply, allows determination of the time available before condensation occurs.

8.2 Ascent

During the ascent phase, both temperature and internal pressures must be maintained within specified limits. Skin temperatures must be limited to 400F maximum, a requirement imposed by external finish adhesives. In addition, the temperatures of pin-pullers and electronic units must remain below the specification limits. Internal pressures are controlled by design provisions which permit all sections of the PPS/DP EAC to vent air during ascent without damage to components, bulkheads, or the structure itself.

8.2.1 Ascent Thermal Environment

The ascent heat pulse experience is of short duration (approximately 3 minutes), and is determined by the selected trajectory. The trajectory, together with the emittance of the external skin finish and the skin thickness, primarily determine the skin temperatures. Although the external patterns are designed mainly to meet the orbital requirements, the use of large areas of high-emittance materials is of advantage during the ascent phase.

The thermal capacitance of the internal SEM components, together with appropriate radiation resistances, serve to limit the temperatures experienced by the components. The use of fiberglass insulation in conduction paths from the skin to component mounts, and the application of a low-emittance finish to the internal skin surfaces isolate the internal components from the SEM skin. This isolation is needed to meet the orbital passive requirements but also serves the ascent requirements.

For pin-pullers mounted near the skin, the thermal capacity of the skin and substructure, together with conduction isolation, established to a great degree by substructure to skin contact conduction resistances, is sufficient to maintain temperatures within acceptable limits*.

Satisfactory component temperatures are predicted for lift-off temperatures of 80F or less. For lift-off temperatures greater than 80F, a one-revolution cooldown period may be required to return all components to their operating ranges (reference Part 2, Section 14.2).

8.2.2 Ascent Venting

All sections of the PPS/DP EAC are provided with openings or other means to permit internal venting during ascent, and in turn, the entire PPS/DP EAC is vented into the SCS through four filtered openings in the Station 285 bulkhead.

*Reference BIF-008-W-N-012057-OH-73, B^2 Dual Recovery Module Ascent Thermal Structure Load Test Report.

Electronic boxes (except the mirror positioning servos) are not sealed units and, therefore, vent by natural leakage. The film path enclosure (the film tunnels, FSE, camera, and SRV's) is a sealed system which is vented by six poppet valves (cracking pressure 0.29 psid) and a fixed orifice vent. Relief valves on the SRV's open at a higher pressure and will assist in venting only if that pressure is exceeded.

Air which is contained among the layers of the multilayer, aluminized Mylar insulation must be vented rapidly enough during ascent to prevent excessive balloning of the blanket and possible reduction of its usefulness. Additionally, interlayer pressures must be close to ambient during orbit to prevent gaseous conduction from reducing the insulating value of the blanket. Holes are used to allow trapped air to escape in a controlled manner from the space between the layers of the insulation blanket.

Analysis of PPS/DP EAC venting was performed using a computer program which has the capability of analyzing interrelated, multivolume configurations. The results of this effort were presented to LMSC for incorporation in the combined vehicle venting model (PPS/DP EAC-SCS-Titan), and are summarized in Part 2, Section 13. Locations of the various PPS/DP EAC vent openings are described in Part 3, Section 1.

8.3 Orbital Environment

Orbital thermal requirements include control of optics temperatures within defined ranges so that the full potential of the optical system may be realized, control of film temperatures to avoid deterioration of the film at high temperatures or brittleness at low temperatures, and control of electronic box temperatures to within design ranges. This control is provided by passive means to the greatest extent possible with a minimum of heater power being consumed. Flight parameters include minimum altitude ranges between 65 and 85 nautical miles with beta angles between +60 and -60 degrees, and also the extended altitude parameters with range of 68 to 400 nautical miles with beta angles of +40 and -40 degrees. The minimum or extended altitude range shall be determined and set before launch.

In the near-vacuum of space, outgassing of materials must also be controlled. Liquids or gases may be exhausted from materials in the PPS/DP EAC which could fog the film or build up on the optical surfaces, reducing their performance. For this reason, and for safety considerations in manufacturing and testing, no components (excluding the film) are used in the PPS/DP EAC which exhaust liquids or gases that are corrosive, explosive, noxious, or moisture-generating, or which can cause fogging of photographically sensitive materials.

Film despooling during orbital flight results in water vapor within the FSE (film outgassing). The pressure generated within the film path enclosure is controlled by a fixed orifice vent on the FSE sidewall which allows the water vapor to vent.

8.3.1 Optics

The PPS/DP EAC optical components are required to be maintained at 70 ± 5F. Experience has shown that the temperatures vary much less than this, remaining close to the flight heater set point (65F). Achieving this degree of control is accomplished both through hardware design and operational techniques. The hardware design aspects, involving conductive and radiative isolation of the optical components from structural temperature variations are discussed in Section 8.3.5.3.

Operational techniques basically involve restricting the times at which the viewport doors may be opened, and the length of time they may remain open. The use of low-coefficient-of-expansion materials for the mirrors has reduced the transient thermal effects associated with viewport door open time under either door open darkside (DOD) or door open lightside (DOL) conditions. Although long DOL times create a thermal gradient (ΔT) from front-to-back on the stereo mirror, experience cannot identify any resultant degradation. However, as the incident energy increases the overall COA temperature, a defocusing condition does occur. The amount of defocus is a function of door open time, has an observed effect on best electrical focus (BEF) provided by the focus detection subsystem, and affects photographic focus in a similar way. A model of this effect has been developed and is used in the operational software to adjust the platen position as a function of DOL time and thereby maintain the correct focus setting. The upper temperature limit is controllable, and can be stabilized by using controlled amounts of DOD time to cool the COA as necessary. Extremely long DOD times, which would result in a net energy loss and increase heater power consumption, are restricted by operational considerations.

In addition to thermal control, contamination of the optical surfaces and the resultant performance loss is also of major concern on-orbit. By eliminating the largest source of contamination (material outgassing) the problem is virtually eliminated. Only in the area of the Ross Corrector is there need for any further efforts. The last Ross element seals the film path and is subject to contamination from both film outgassing and particles shed from the film. Particulate control is achieved by thoroughly cleaning the film prior to loading in the vehicle. Outgassing of water vapor is controlled by the fixed vent on the FSE sidewall.

8.3.2 Film

Applicable films begin to deteriorate at temperatures above 90F, with an absolute tolerable temperature of 125F. Keeping limits for spooled high-resolution aerial negative films as a function of temperature and relative humidity are presented in Figure 3.8-5 along with the limiting envelopes, which are independent of relative humidity. Additional information on the physical characteristics and sensitometric behavior of film is provided in Part 2, Section 7.

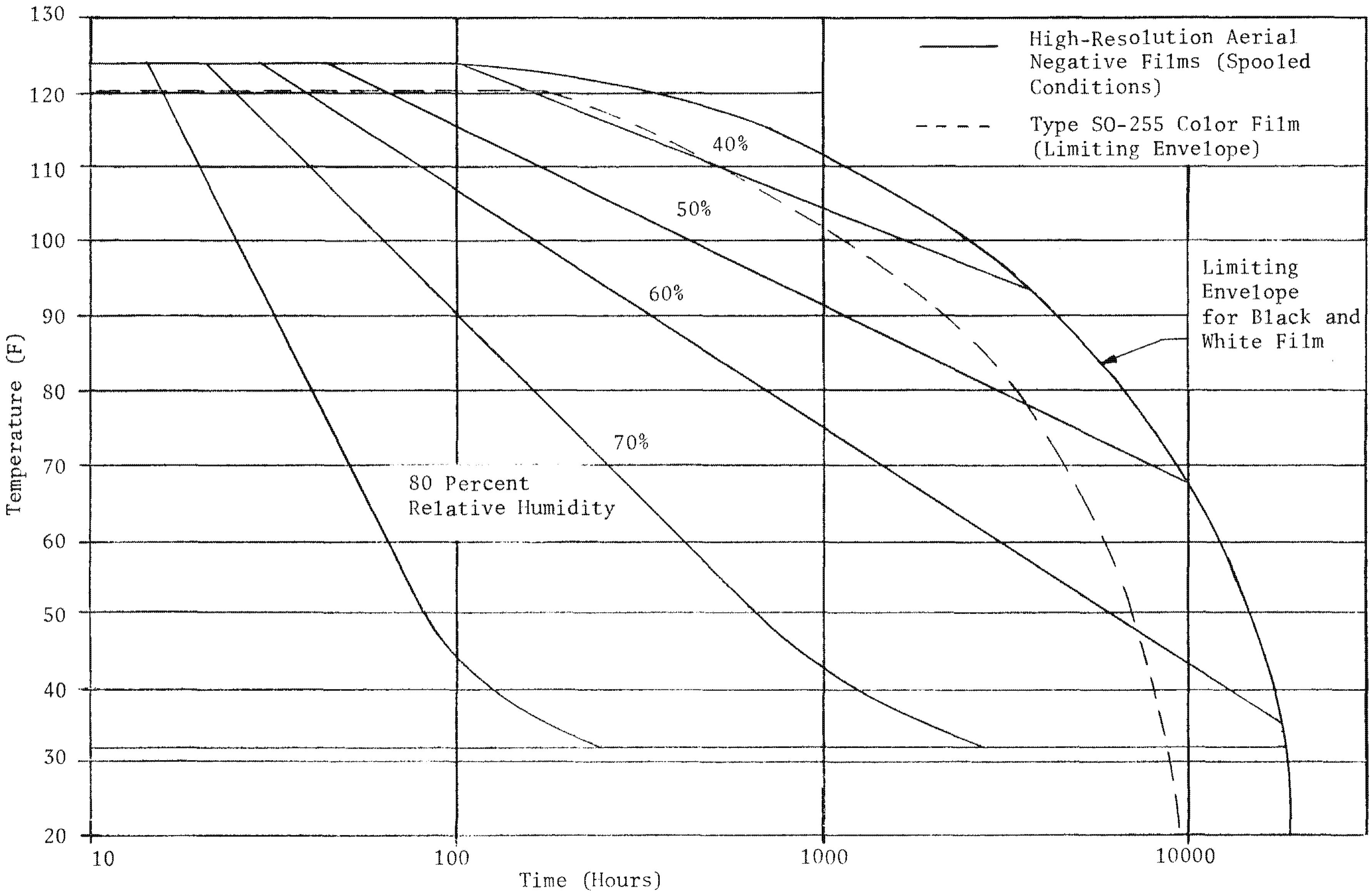


Figure 3.8-5. Film Temperature vs Time Keeping Limits

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8.3.3 Electronic Boxes

To simplify the design of stable electronics, the sink temperature operating limits for PPS/DP EAC boxes were established at 30F minimum and 110F maximum. For several boxes, the maximum limit was established at 100F in order to maintain the 30F minimum and limit the calibration range to 70F.

8.3.4 External Thermal Control Finishes

Orbital temperature control is made as passive as possible by means of the external finish pattern selection. This is accomplished by designing the pattern to minimize the variation of the average (space and time average) skin temperature throughout the range of the design orbital parameters. Internal conduction and radiation resistances are provided to force internal components to react to the skin average temperature.

The PPS/DP EAC external finish patterns are illustrated in Figure 3.8-6 and described in Table 3.8-2. To cope with the full range of altitudes and beta angles, three DRM patterns are required. This is necessitiated by the large variations of aerodynamic heating which are experienced by the conic sections (EA and FA). The basic SEM pattern is designed to encompass the entire design range of minimum altitudes and beta angles. A second SEM pattern is available for beta angles of +48 to -48 degrees, while a third SEM pattern is optimized for the +16 to -4 sun-synchronous range of beta angles. A fourth SEM pattern is available for extended altitudes to 500 nautical miles with beta angles of +40 to -40 degrees. Six COM patterns, each capable of the full design range of minimum altitude, are provided. The COM pattern selection offers an optimization with respect to beta angle with an accompanying savings of environmental heater power and also provides symmetric and asymmetric beta angles of +40 and -40 degrees for the extended altitude range patterns.

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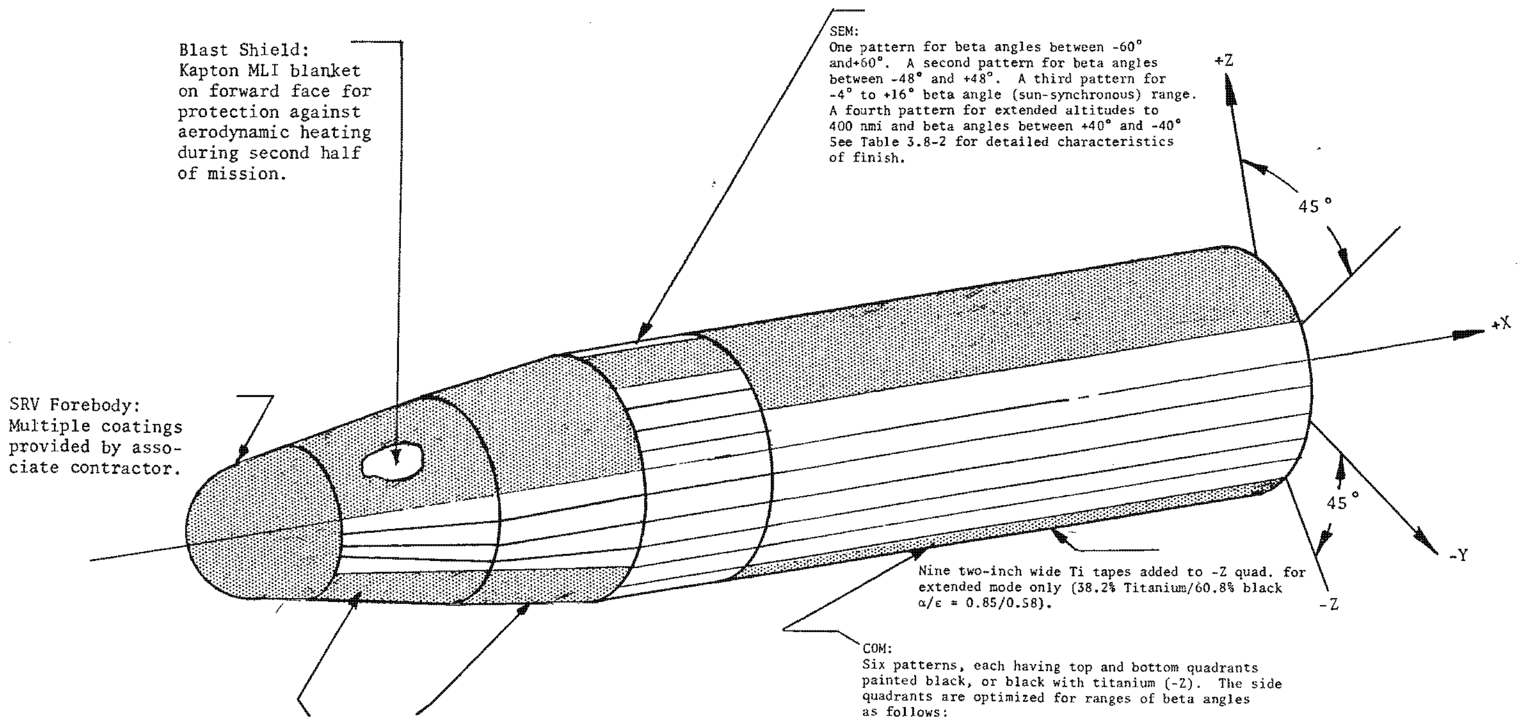

EA and FA:
Three patterns; one for minimum altitudes between 67 nmi and 85 nmi, one for minimum altitudes between 65 and 73 nmi, and one for altitudes between 68 and 500 nmi.

β Range	Percent White Paint	Percent Aluminum Foil Tape	α/ε
-30° to +30°	13.8	86.2	0.16/0.15
-48° to +48°	20.2	79.8	0.16/0.22
-60° to +60°	24.4	75.6	0.16/0.24
- 4° to +16°	0.0 +Y quad	100.0 +Y quad	0.15/0.04
(sun synchronous)	24.4 -Y quad	75.6 -Y quad	0.16/0.24
-40° to +40°	17.0	83.0	0.16/0.18
0° to +40°	0.0 +Y quad	100.0 +Y quad	0.15/0.04
Asymmetric	39.3 -Y quad	60.7 -Y quad	0.17/0.36
-40° to 0°	39.3 +Y quad	60.7 +Y quad	0.17/0.36
Asymmetric	0.0 -Y quad	100.0 -Y quad	0.15/0.04

Figure 3.8-6. PPS/DP EAC External Thermal Control Finishes

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TABLE 3.8-2

CHARACTERISTICS OF EXTERNAL THERMAL CONTROL FINISHES

Module	Minimum Altitude Range (nmi)	Beta Angle Range (Degrees)	Paint Pattern
FA			Three black segments one 60° area centered on +Z axes the other two 30° to 60° off -Z axes on both sides (α/ε = 0.96/0.89). One 50% black/50% titanium segment for 60° centered on -Z axes (α/ε = 0.83/0.50) and two segments 30° to 60° off +Z axes on both sides which are 85% titanium/15% black (α/ε = 0.74/0.22). Remainder is a mixture of black, white, and aluminum stripes as follows:
FA	68 to 500	±40	35% black/15% white/50% aluminum (α/ε = 0.44/0.46).
EA and FA**	(non-extended mode)		120° black segments centered on +Z and -Z axes (α/ε = 0.96/0.89).* Remainder is a mixture of black, white, and aluminum longitudinal stripes as follows:
EA	67 to 85	±60	20% black/40% white/40% aluminum (α/ε = 0.33/0.54)
EA	65 to 73	±60	0% black/75% white/25% aluminum (α/ε = 0.19/0.66)
EA	68 to 500	±40	15% black/45% white/40% aluminum (α/ε = 0.29/0.54)
FA	67 to 85	±60	10% black/6% white/40% aluminum (α/ε = 0.23/0.17)
FA	65 to 73	±60	10% black/35% white/55% aluminum (α/ε = 0.25/0.41)
SEM:			47° black segments centered on +Z and -Z axes (α/ε = 0.96/0.89). Remainder is a mixture of white and aluminum longitudinal stripes as follows:

*α = solar absorptance
ε = infrared emittance

**Titanium will be painted black

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TABLE 3.8-2 (Continued)

Module	Minimum Altitude Range (nmi)	Beta Angle Range (Degrees)	Paint Pattern
SEM	65 to 85	±60	20% white/80% aluminum (α/ε = 0.16/0.20) with 23% aluminum segments located adjacent to the -Z black segment (α/ε = 0.15/0.04).
		±48	13% white/87% aluminum (α/ε = 0.16/0.15) with 23% aluminum segments located adjacent to the -Z black segment (α/ε = 0.15/0.04).
		-4 to +16	20% white/80% aluminum (α/ε = 0.16/0.20) on -Y side and a 23° segment of the +Y side adjacent to the +Z black segment. 0% white/100% aluminum (α/ε = 0.15/0.04) remainder of +Y side.
SEM	(extended mode)***		99° black segment centered on +Z axes and 47° black segment centered on -Z axes with adjacent 50% titanium/50% black
	68 to 400	±40	(α/ε = 0.083/0.50) for 23% on each side of -Z black segment. Remainder is 20% white/80% aluminum (α/ε = 0.16/0.20).
COM			See Figure 3.8-6.

*SEM panels will be replaced.

To implement this multiple pattern approach, a master pattern is applied to the PPS/DP EAC in the factory with the appropriate modifications, consisting of tape removal, painting of titanium foil and SEM panel replacement in the field upon identification of the flight parameters.* Painting of titanium and SEM panels replacement will be done in the factory if the selected pattern has been established early enough. Since repeated removal and replacement of the vehicle access panels could result in damage to the tape, a special application procedure is followed. The forward edge of each tape strip is wrapped under, while the trailing edge is cut flush with the edge of the skin. In this way, sufficient clearance is allowed between the tape stripes, and the leading edge is held securely to withstand the ascent environment.

The materials used for external thermal control surfaces are:

a. Aluminum foil tape
b. White silicone elastomer paint
c. Black silicone elastomer paint
d. Titanium foil tape

The black and white paints are silicone elastomeric base with appropriate pigments to achieve the desired absorptance and emittance. The black paint has values of 0.96 and 0.89 for solar absorptance and infrared emittance respectively. The white paint has corresponding values of 0.20 and 0.86, and the aluminum foil tape used for the aluminum portion of the finish has corresponding values of 0.15 and 0.04. The titanium foil has corresponding values of 0.70 and 0.10.

The following considerations apply to the determination of the external patterns:

a. A high solar absorptance material is required on the vehicle top to absorb sufficient solar energy to maintain temperatures above lower limits during a low energy, 0-degree beta angle orbit.

*Reference BIF-008-W-C-017752-RH-79 (drawing 1405-223), PPS/DP Operational Finishes.

b. High solar absorptance/high infrared emittance materials are used on the PPS/DP EAC bottom to take advantage of the stabilizing influence of the relatively constant (with respect to beta) flux inputs (earth emittance and albedo).

c. Low solar absorptance/low infrared emittance materials are used on the PPS/DP EAC sides to attenuate the temperature extremes between orbits due to the large variation of incident flux as a function of beta angle.

d. High infrared emittance surfaces are of advantage in rejecting energy resulting from aerodynamic heating at low altitudes.

8.3.5 Internal Design

Environmental control within each module involves several design techniques. Insulation blankets, electrical heaters, and low-emittance finishes on the inside skin, as well as selection of materials for their heat conduction characteristics (isolating or conducting heat) all contribute to thermal control in the PPS/DP EAC. Electromagnetic interference (EMI) is controlled through proper grounding of electrical units and other components, by restricting power switching rates, and through shielding of cables susceptible to EMI problems. Stray light entering the vehicle when the viewport doors are open is controlled within the COA and camera by low reflectance coatings and baffles (reference Part 3, Sections 1 and 2). Venting of the vehicle during ascent, and of the FSE on-orbit, has been discussed previously in Sections 8.2.1 and 8.3 respectively.

Various combinations of the thermal control design techniques are used within each module of the PPS/DP EAC. As an added concern, the DRM must also be protected from SRV 1 retro-rocket exhaust during the recovery sequence.

8.3.5.1 Dual Recovery Module. The DRM is temperature controlled on-orbit by passive means with the exception of the satellite reentry vehicles (SRV's).

Although heater circuits are provided in both SRV 1* and SRV 2, passive control is such that SRV 2 heaters are not required during orbital flight.

Because the conduction paths between the SRV's and the DRM, as well as the conduction paths between the film chutes and the DRM are not large, the temperatures of the internal components are controlled primarily by radiant heat transfer.

The interior of the ejectable adapter (EA) forward of the blast shield is covered with an aluminized tape which provides a decoupling of the SRV 1 thrust cone and retro-rocket (which are also aluminized) from the skins.

The improved blast shield (IBS), located in the EA, consists of an aluminized fabric shield with a Kapton multilayer insulation (MLI) blanket attached to the forward surface. This provides an effective barrier against the external environment during the second half of the flight as well as a radiation barrier between the EA and the FA during ascent and the first half of the flight.

The IBS, in conjunction with the cutter/sealer and tunnel seal and record trap (TSRT) mechanisms which seal the film tunnels in the fixed adapter, also serves to protect the PPS/DP EAC from contamination by exhaust gases at the time of SRV 1 retrofire.

MLI blankets (see Section 8.3.5.3) are used throughout the DRM to enclose film path components. These blankets serve to decouple the film path components from the skins and force them to respond to a local average environment. In addition, a temperature stabilizing effect is realized by radiation "tunneling" effects within the chutes.

*SRV 1 internal temperatures and heater power requirements are primarily established by the SRV associate contractor's thermal design.

8.3.5.2 Supply Electronics Module. SEM orbital thermal control is accomplished entirely by passive means. The SEM is designed such that the film supply enclosure (FSE) is centrally located. Electronic boxes are mounted to rails located on the FSE sidewalls and to webs (reference Part 3, Section 1). Fiberglass spacers are used to achieve conduction isolation of the equipment mounts and the FSE from the external skin and longerons. A fiberglass spacer is also used between the FSE and the SEM forward ring to attenuate the influence of the DRM. Conductive contact is maintained between the electronic boxes and their mounting rails to assist in rejection of internal power dissipation.

Radiation isolation of the SEM interior is provided by use of low-emittance surface finishes on the interior of the SEM skins, the forward surface of the SEM/DRM bulkhead, and the aft surface of the FSE at the SEM/COM interface. Additional isolation of the COM from the SEM is achieved by the use of multilayer insulation blankets on the COM.

SEM components are finished with high-emittance black finishes to facilitate the rejection of internal power dissipation. The FSE is also coated with a high-emittance black finish both inside and out. This coating is of advantage in reducing SEM internal temperature gradients. The exterior of the +Z and -Z FSE panels, because of their close proximity to the skin, are aluminized to decouple them from the rapid changes of skin temperature.

To achieve compatibility with the COM, the SEM external paint pattern is adjusted to maintain the SEM aft bulkhead average temperature below the set point of the COM heaters. This arrangement prevents a net heat transfer from the SEM to the COM and allows the COM to be controlled by its heaters. Maintenance of the SEM aft bulkhead temperature close to the COM heater set point is desired to minimize the heater power consumption.

8.3.5.3 Camera Optics Module. COM temperature control is provided by a flight heater system supplemented to the greatest extent possible by passive control techniques.

Conductive heat transfer between the external structure and the COA is controlled by minimizing the number of physical contacts between them and by using flight-proven, high thermal resistance materials and configurations at the necessary contact points. Specifically, the COA is mounted to the external structure at only three places; two A-frame structures forward, and one uniball joint in the center of the aft bulkhead. Thermal conduction resistance (R) is a function of path length (L), material conductivity (k), and cross-sectional area (A) for heat flow in the following relationship:

$$R = \frac{L}{kA}.$$

High thermal-conduction resistance is achieved by designing long paths having small cross-sectional areas for conductive heat flow and by using materials (plastics, titanium) which have a low conductivity.

The two A-frame arms are constructed of titanium, and the hinges are isolated from the COM support ring by insulation blocks. The aft bulkhead is isolated from the COM structural ring and skin by a fiberglass splice.

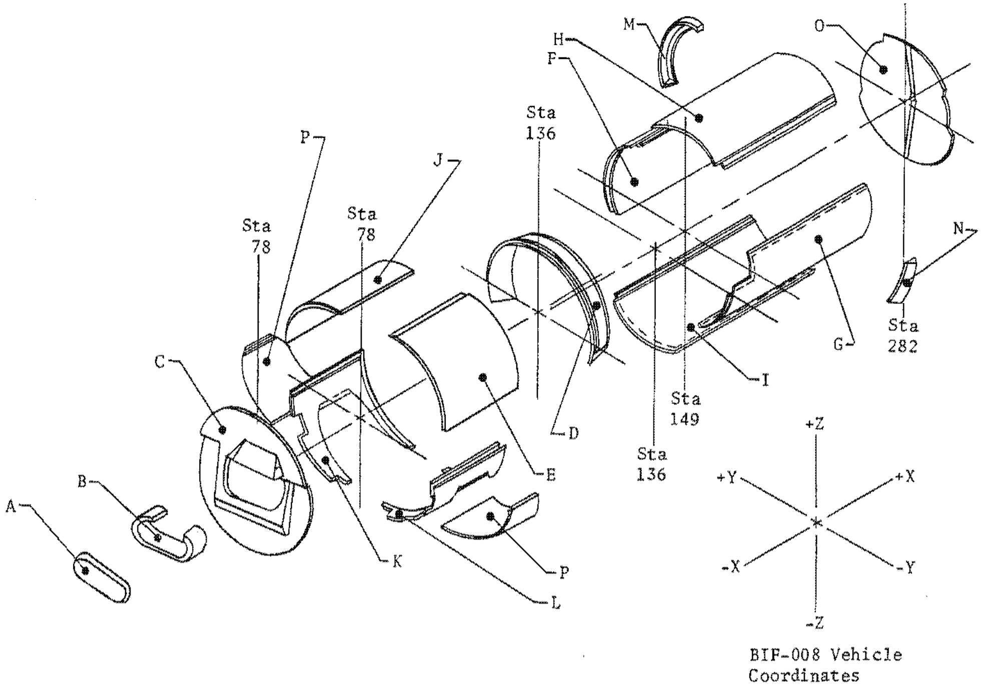
Within the COA, temperatures are smoothed by a high-radiation exchange and the optics are further isolated. The finish of the mirrors is such that the thermal resistance between any part of the mirrors and its surrounding environment is relatively high (compared to the thermal resistance between any other components). Consequently, the mirrors respond to the average temperature within the COA rather than any locally high or low temperature. Power dissipating components within the COA (servo mechanisms and primary camera) are finished with low-emittance surfaces to further decouple them from the optical components.

Multilayer insulation blankets are used to insulate the COA from the external structure to prevent the COA from reacting to short-term local variations in the external structure skin temperature. Figure 3.8-7, an exploded diagram, shows the location of these thermal blankets. As shown, blankets are provided at the COM forward bulkhead to provide isolation from the SEM as well as at the end bell to provide isolation from the SCS. A low-emittance, aluminized bulkhead aft of the COA provides further isolation from the SCS.

All blankets, excluding those on the viewport doors and on the blast shield, are constructed of aluminized Mylar sheets. Each blanket consists of 50 layers of embossed, 0.25-mil thick, aluminized Mylar, with an outer layer on each side of plain 1-mil thick aluminized Mylar. The layers are tied together with fiberglass cord and buttons (with button covers). Venting holes 0.050 inch in diameter, spaced on 3-inch centers, allow air to escape from between the layers during launch and during transportation by aircraft. For ease of assembly and removal, the blankets attach to the structure using Velcro pads. The blankets on the end bell and camera cover include electrical heater tapes on the inner surface.

The viewport door and blast shield blankets use Kapton in place of Mylar to allow the blast shield blanket and leading edges of the door blankets to withstand the high temperatures encountered at low altitudes. The blast shield blanket also incorporates a separator material between layers for increased effectiveness.

The COM external paint pattern is designed such that the average temperature at hot orbital conditions (low altitude, high beta angle) is equal to the heater system set point. Adequate heater capacity is provided to heat the COA to the heater set point under cold orbital conditions (high altitude, zero beta angle). Six COM external paint patterns are available, allowing pattern optimization with respect to beta angle range.



COM THERMAL BLANKET ASSEMBLIES

Item	Title
A	Blanket Assy, Thermal, Camera Cover*
B	Blanket Assy, Thermal, Camera Housing
C	Blanket Assy, Thermal, Bulkhead
D	Blanket Assy, Thermal, Transition Collar
E	Blanket Assy, Thermal, Bay Area, Upper -Y
F	Blanket Assy, Thermal, +Y Aft
G	Blanket Assy, Thermal, -Y Aft
H	Blanket Assy, Thermal, +Z Aft
I	Blanket Assy, Thermal, -Z Aft
J	Blanket Assy, Thermal, Bay Area, Upper +Y
K	Blanket Assy, Thermal, Bay Area, Lower +Y
L	Blanket Assy, Thermal, Bay Area, Lower -Y
M	Blanket Assy, Thermal, Cables, +Y
N	Blanket Assy, Thermal, Cables, -Y
O	Blanket Assy, Thermal, End Bell*
P	Blanket Assy, Thermal, Bay Door

*Contains electrical heater tapes.

Figure 3.8-7. COM Thermal Blanket Assemblies

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The heater system design attains high reliability through the use of many small heaters, so that an individual failure, either ON or OFF, cannot upset the thermal balance of the payload. There are 35 separate heaters and controllers surrounding the COA, with heater sizes varying from 2 to 6 watts. The set point (heater ON) tolerance (±0.3F) and hysteresis (0.6F maximum) of the controllers allow only very small temperature differences to occur between adjacent heater systems. Predictions of COM heater power consumption for each paint pattern are shown in Part 2, Section 14, Figures 2.14-13 through 2.14-16, for varying conditions of beta angle, minimum altitude, and time of year. Maximum, expected, and minimum values, as determined by the external finish properties, are included in the figures. The total PPS/DP EAC heater power requirement is determined by summing the COM requirement and the SRV 1 requirement.

8.3.5.3.1 Temperature Induced Curvature (Hotdogging). Another consideration in the design of the COM is "hotdogging" (the bending of the external structure) resulting from a nonuniform circumferential temperature distribution.

Hotdogging is of concern as it causes misalignment of the COA optical axis with respect to the SCS axis which, if uncorrected, would result in pointing errors. The derivation of the misalignment is presented in Part 2, Section 14.6.2; the magnitude of the misalignment is shown as a function of external structure radii of curvature in Figure 2.14-19; and a discussion of the method used to implement the correction in the pointing software is included in Section 14.3.3.4.

Displacements between components of the film handling system also result from hotdogging. Radii of R_Y = 17,000 inches and R_Z = 25,000 inches have been included in the film tracking budget and are considered as the operating curvature limits of the system. The design of the COM external paint pattern ensures that these curvatures will not be exceeded for all conditions of level orbital flight. Predicted curvatures for an orbit having a 0-degree beta angle and a 60-degree beta angle orbit are shown in Figures 2.14-17 and 2.14-18 respectively.

In addition to the operating curvature limits, a nonoperating curvature limit has been imposed on the PPS/DP EAC to avoid interference between the internal and external structures which could occur at large curvatures. A hardware review and analysis* identified those areas at which interference is predicted and is the basis for the nonoperating curvature limits for the PPS/DP EAC illustrated in Figure 2.14-32.

8.3.5.4 PPS/DP EAC Electrical Heaters. The passive thermal control features of the PPS/DP EAC are supplemented by electrical heaters both at the launch pad (by the ground heater system) and on-orbit (by the flight heaters). The ground heater system cannot be used on-orbit as it is powered only through the vehicle umbilical line.

The heater systems consist of many individual heater assemblies, each having three components:

(1) An insulated resistance heater strip (tape which enables uniform heating of large surface areas), or several strips electrically connected (parallel or series),

(2) A precision thermistor mounted in the heater area to monitor temperature, and

(3) An electronic controller to monitor thermistor output and switch power to the heater as needed.

8.3.5.4.1 Ground Heater System. The ground heaters are divided into zones as follows:

Zone	Location	Station Number
1	SEM	77 - 34.5
2	Stereo-Mirror Bay	77 - 136

*Reference BIF-008-W-N-014194-OH-75, PPS/DP Radius of Curvature Study and Part 2, Section 14.6.2 of this document.

Zone	Location	Station Number
4	COA Tube Forward, Middle	136 - 223
5	DRM	34.5 - (-56.07)
6	COA Tube Aft + End Bell	223 - 285

In each zone there are several heaters which are resistive tapes bonded to the various structures with contact adhesive, except HR72 and HR73 which are part of the end bell insulation blanket. The heater tapes are approximately 0.6-inch wide and are covered by aluminum overlay tape over their entire length. The heater controllers, heaters and their associated loads are listed in Table 3.8-3. Heater locations are shown in Figure 3.8-8.

Figure 3.8-9 is a simplified diagram of the ground heater controller used to power all ground heaters except those in the satellite reentry vehicles. Twenty four of these ground controllers are used on each vehicle. The ground heater controller applies power to the heater whenever the temperature of the sensor located near the heater drops to 65 ±0.3F. The OFF trip-point is +0.6F maximum above the ON trip-point.

The temperature sensor is a thermistor that has a nominal resistance of 70.77 KΩ at 65F. The sensor and resistors R1, R3, and R4 form a temperature dependent resistance bridge. AR1 is a type 741 operational amplifier which compares the voltage at the center of the bridge. Assuming that the sensor temperature is sufficiently low, the voltage at the inverting input of AR1 will be less than that at the noninverting input. The voltage at the output of AR1 will rapidly increase turning Q1 and Q2 on. Feedback through R5 increases the voltage at the noninverting input above its former value (hysteresis). When the sensor temperature is sufficiently high, the voltage at the output of AR1 will decrease turning Q2 off.

TABLE 3.8-3

GROUND HEATER SYSTEM

Zone	Heater Controller	Heater Designation	Location	Nominal Power (watts) (at 31 volts)
1	A50	H50R1 in series with H50R2	FSE -Y Side, Exterior	85.4
1	A51	H51R1	FSE -Y Side, Exterior	85.4
1	A52	H52R1	SES +X Side, Aft Bulkhead	85.4
1	A53	H53R1	FSE +Y Side, Exterior	85.4
1	A54	H54R1 in series with H54R2	FSE +Y Side, Exterior	85.4
1	A55	H55R1	FSE +Z Panel, Exterior	85.4
1	A56	H56R1	SES -X Side, Forward Bulkhead	85.4
1	A57	H57R1	FSE -Z Panel, Exterior	85.4
2	A102	HR61A in parallel with HR61B	Front Tape Support Screen	67.4
2	A103	HR62A in parallel with HR62B	COA Hood, Exterior	51.9
2	A104	HR63A, HR63B, HR63C, HR63D in parallel	COA Hood, Exterior	64.1
2	*	-	SRV 1	44
2	*	-	SRV 2	44
3	A105	HR64A in parallel with HR64B	COA Forward, Interior	60.4

*Heaters, sensors, and controllers are provided by General Electric Reentry and Environmental Systems Division (GE RESD). Each heater is a rectangular strip 5.50 inches by 8.20 inches. Four strips are used in each SRV (one per quadrant) and are mounted within the recoverable capsule portion of the SRV. The ON trip-point temperature is 67 ± 3F.

TABLE 3.8-3 (CONT'D)

Zone	Heater Controller	Heater Designation	Location	Nominal Power (watts) (at 31 volts)
4	A106	HR65A in parallel with HR65B	COA Forward, Interior	70.7
4	A107	HR66A in parallel with HR66B	COA Forward, Interior	70.7
4	A108	HR68A in parallel with HR68B	COA Middle, Interior	70.7
5	A60	H60R1, H60R2, H60R3, H60R4, H60R5 in parallel	EA Film Tunnels	16.1
5	A70	H70R1 in parallel with H70R2	FA Film Tunnels	14.9
5	A71	H71R1 in parallel with H71R2	FA Film Tunnels	14.9
6	A109	HR70A in parallel with HR70B	COA Aft End, Interior	70.7
6	A110	HR71A in parallel with HR71B	COA Aft End, Interior	76.9
6	A111	HR72	Primary Mirror -Z Blanket	28.6
6	A112	HR73	Primary Mirror +Z Blanket	28.6

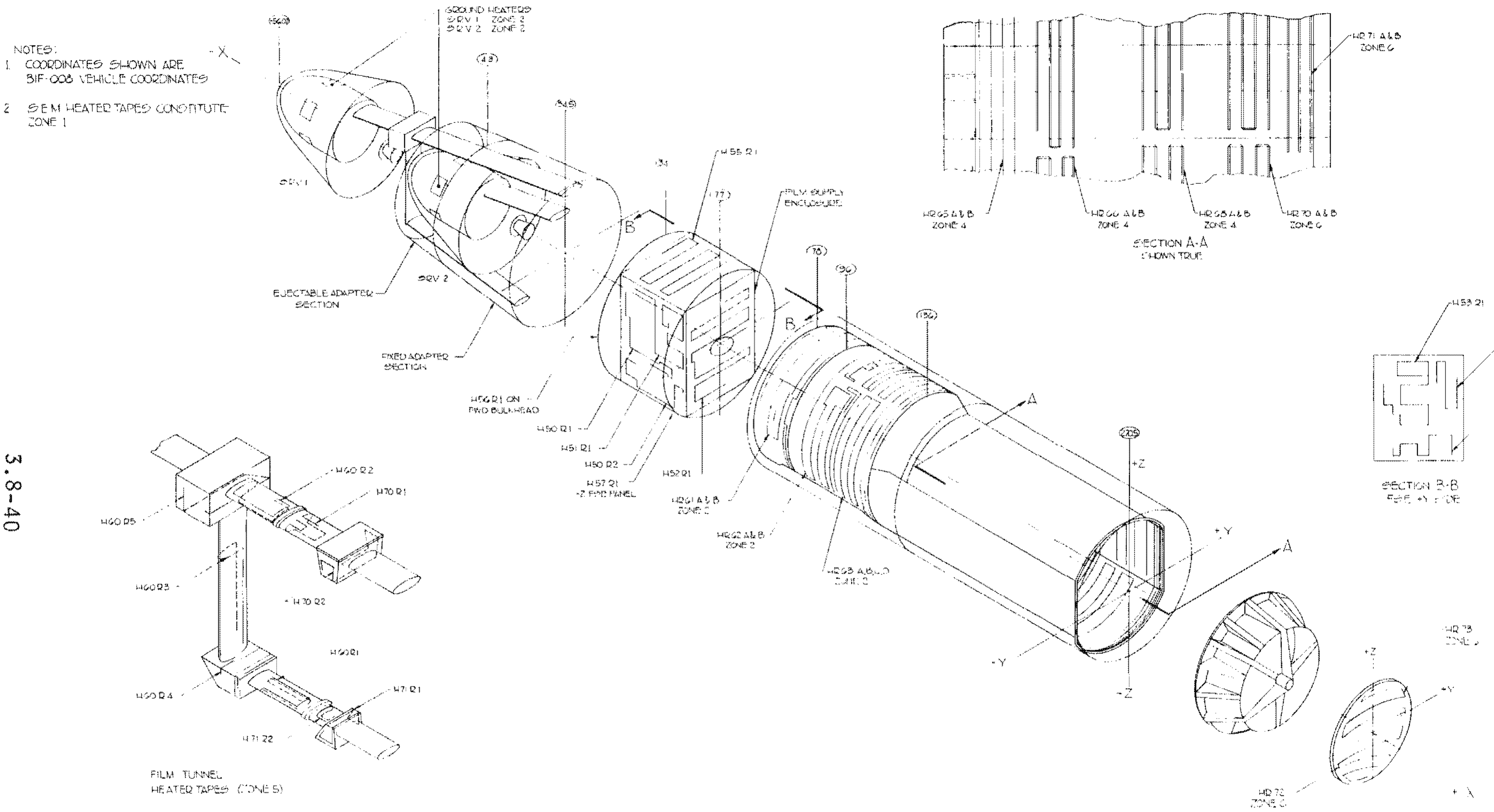

Figure 3.8-8. Ground Heater Tape Locations

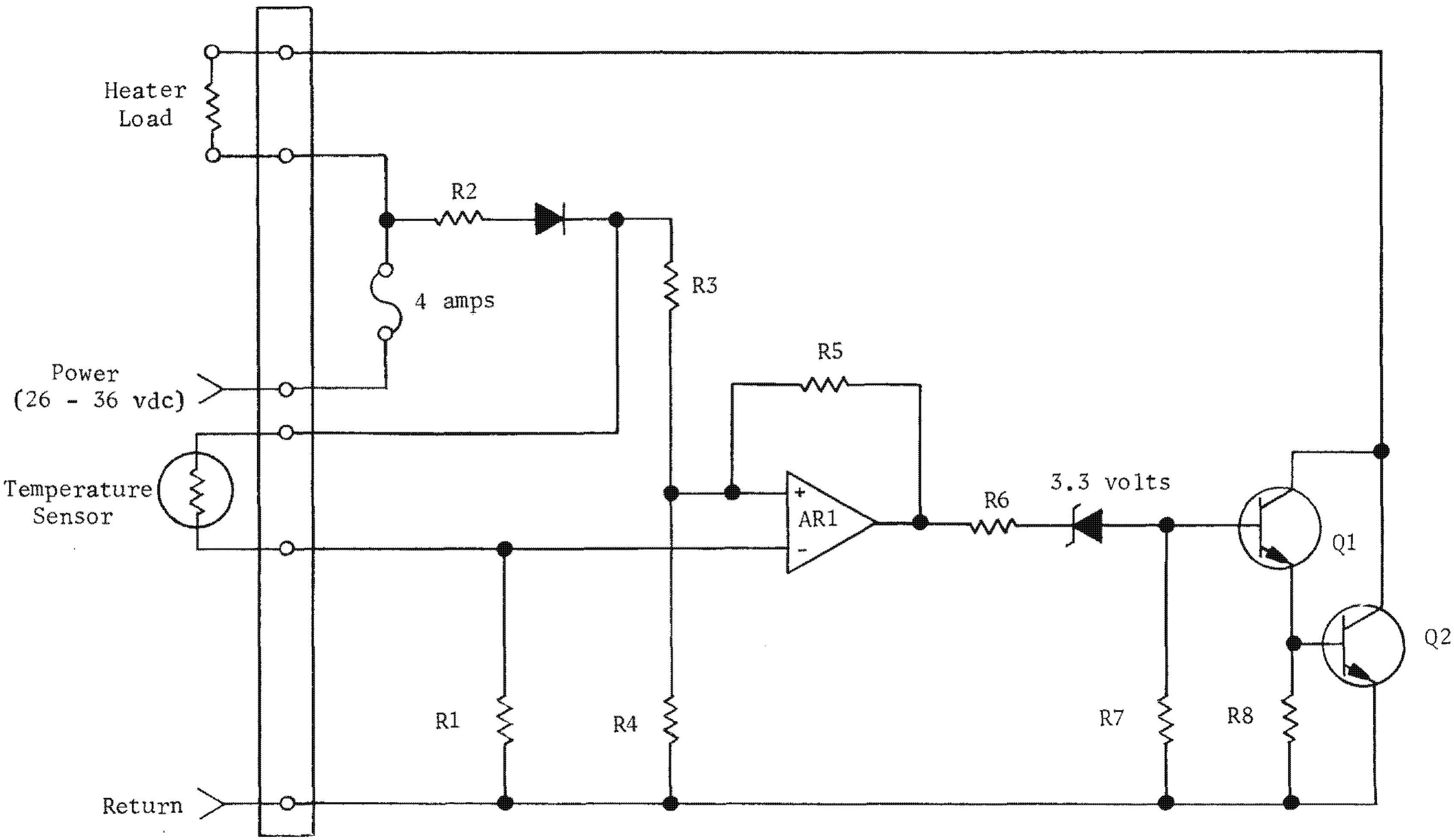

Figure 3.8-9. Ground Heater Controller Schematic

8.3.5.4.2 Flight Heater System. Flight heater power is supplied by the main batteries in the satellite control section (SCS) through the heater-power feedlines and returns in the power monitor and control unit (PM and C). These power feedlines end in terminal strips which divide the heaters into branches as follows:

Branch		Station Number
1	SRV 1	-
2	Stereo-Mirror Bay	77 - 136
4	COA Forward, Middle	136 - 223
5	COA Aft	223 - 270 + end bell
6	SRV 2	-
*EPSM 1	SRV 1	-
*EPSM 2	SRV 2	-

In each branch there are several heaters (see Figure 3.8-10). COM heaters are resistive tapes bonded to the various structures with contact adhesive, except HR2, HR3, and HR48 which are part of the insulation blankets, and HR1 which is a discrete wirewound resistor. The heater tapes are approximately 0.6 inch wide and are covered by aluminum overlay tape over their entire length. Power to the branches is controlled by commandable power switches in the PM and C unit, and power to each heater is controlled by an electronic circuit (heater controller). Table 3.8-4 lists the ON and OFF trip-points of the heater controllers. The various heaters and their associated power loads are listed in Table 3.8-5, and the location shown in Figure 3.8-11.

* Supplied through the BUSS (emergency) power feedlines and returns in the PM and C.

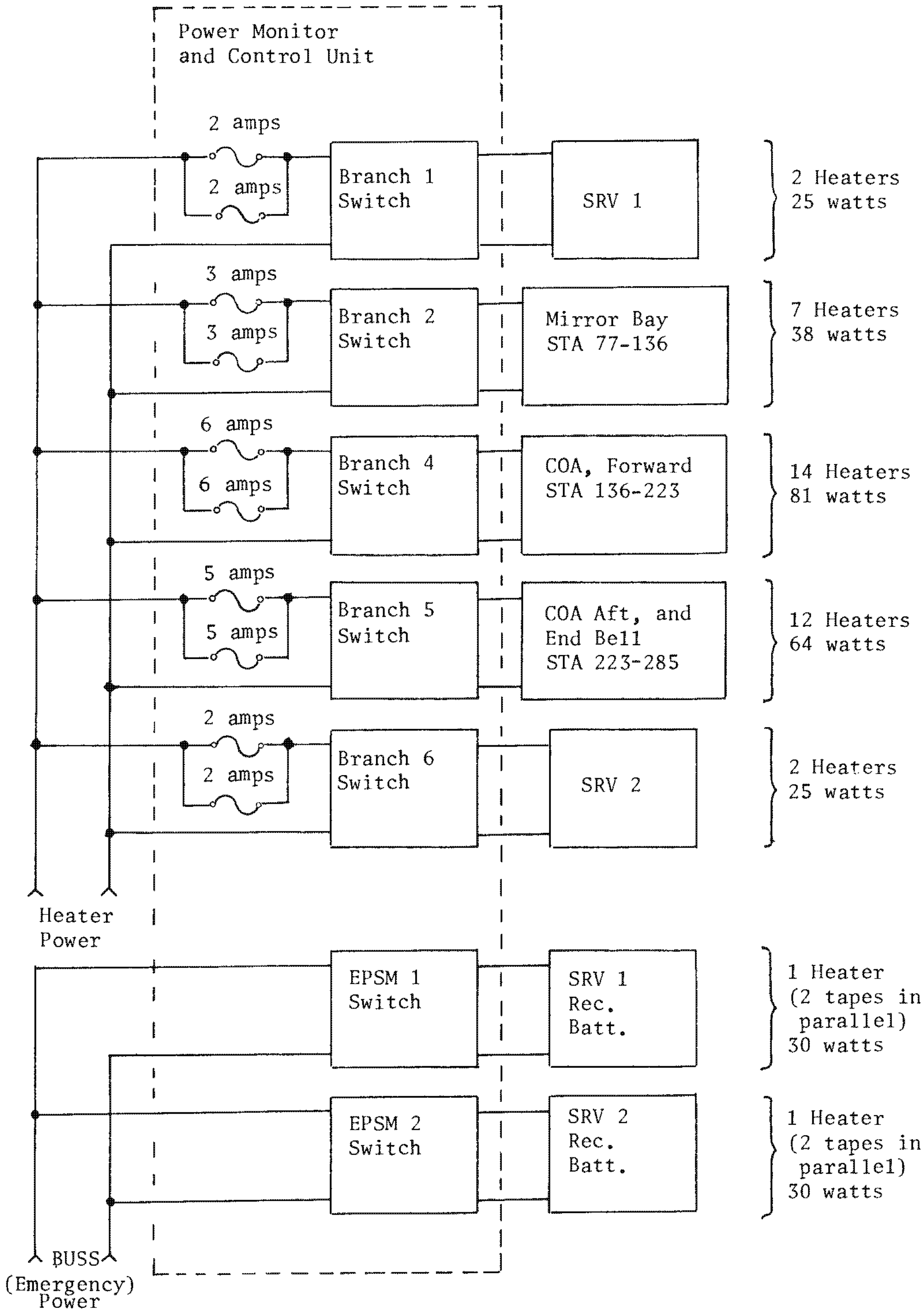

Figure 3.8-10. Flight Heater Branch Block Diagram

TABLE 3.8-4

HEATER CONTROLLER SET POINTS

	ON (degrees F)	OFF (degrees F)
COM	65 ± 0.3	+0.6 maximum from on point
SRV Capsules (Branches 1 and 6)*	35 ± 4	+2 to +5 from on point with backup thermostat to switch off at 67F nominal
SRV Batteries (EPSM 1 and 2)*		Controller switches heaters off at 100F nominal

A simplified diagram of the flight heater controller used to power all orbital heaters except those in SRV 1 and 2 is shown in Figure 3.8-12. Thirty three of these controllers are used in each vehicle. The flight heater controller applies power to the heater whenever the temperature of the sensor located near the heater drops to 65 ± 0.3F (see Figure 3.8-13 for sensor locations). The OFF trip-point is +0.6F maximum above the ON trip-point.

The temperature sensor is a thermistor that has a nominal resistance of 70.77 KΩ at 65F. The sensor and resistor R1 form a temperature dependent voltage divider. Assuming that the sensor temperature is sufficiently high, the heater controller is in the OFF state and the transistors in the heater controller are in the following states:

Q1 - OFF
Q2 - ON
Q3 - ON
Q4 - OFF
Q5 - OFF

*Heater controllers are provided by the SRV associate contractor. The SRV battery heaters are not normally powered until near recovery time.

TABLE 3.8-5

FLIGHT HEATER TAPE LOCATIONS

Location and Remarks	Env Branch	Number of Heaters	Single Heater Power Input (watts) (at 24.5 v)
1. Shaft to Spherical Bearing: Spot heater (wirewound resistor) on end bell	5	1 (HR1)	2
2. +Z Primary Mirror Insulation Blanket: Heater attached to -X surface of blanket	5	1 (HR2)	6
3. -Z Primary Mirror Insulation Blanket: Heater attached to -X surface of blanket	5	1 (HR3)	6
4. End Bell: Heater tapes located inside end bell, in three 120-degree zones beginning at +Z axis	5	3 (HR4-H46)	4.2
5. COA Aft End (Sta 223 to 270): Heater tapes arranged parallel to X axis, between longerons, in six 60-degree zones, symmetrical about the Z axis, on the outside of the COA	5	6 (HR7-HR12)	6.2
6. COA Middle (Sta 180 to 223): Heater tapes arranged parallel to X axis, between longerons, in six 60-degree zones, symmetrical about the Z axis, on the outside of the COA	4	6 (HR13-HR18)	6.2
7. COA Forward End (Sta 136 to 180): Heater tapes arranged parallel to X axis, between longerons, in six 60-degree zones, symmetrical about the Z axis, on the outside of the COA	4	6 (HR19-HR24)	6.2
8. COA A-Frames: Heater tapes located inside the COA directly beneath the 2 A-frame mounts (Sta 139)	4	2 (HR25,HR26)	3.4

TABLE 3.8-5 (CONT'D)

Location and Remarks	Env Branch	Number of Heaters	Single Heater Power Input (watts) (at 24.5 v)
9. Heater Tape Support Screen (Sta 78-96), and COA Hood (Sta 96-136): Heater tapes arranged parallel to X axis, between longerons, in four 60-degree zones (approximate), symmetrical about Z axis, on outside of structure ("A" heater tapes on the screen; "B" heater tapes on the COA hood)	2	4 (HR27A/B, HR28A/B, HR29A/B, HR30A/B; each pair in series:	5.4
10. Shield Assembly (Sta 78): Zigzag pattern running symmetrically about Z axis	2	2 (HR33, HR34)	5.1
11. Camera Cover Insulation Blanket: Heater attached to camera housing side of blanket	2	1	6
12. SRV - Orbital: Heaters, sensors, and controllers provided by GE RESD. Two circumferential strips, 1.75 inches wide and 38 inches long inside the recoverable capsule	1 (SRV 1) 6 (SRV 2)	4 (2 each SRV)	12.5
13. SRV Recovery Batteries: Heaters, sensors, and controllers provided by GE RESD. Heaters are internal to the batteries (2 per SRV)	EPSM 1 (SRV 1) EPSM 2 (SRV 2)	2 (2 tapes in parallel, each SRV)	30

NOTES:
1. COORDINATES SHOWN ARE BIF-008 VEHICLE COORDINATES
2. INTERNAL STRUCTURE STA 78-96 IS FRONT TAPE SUPPORT SCREEN

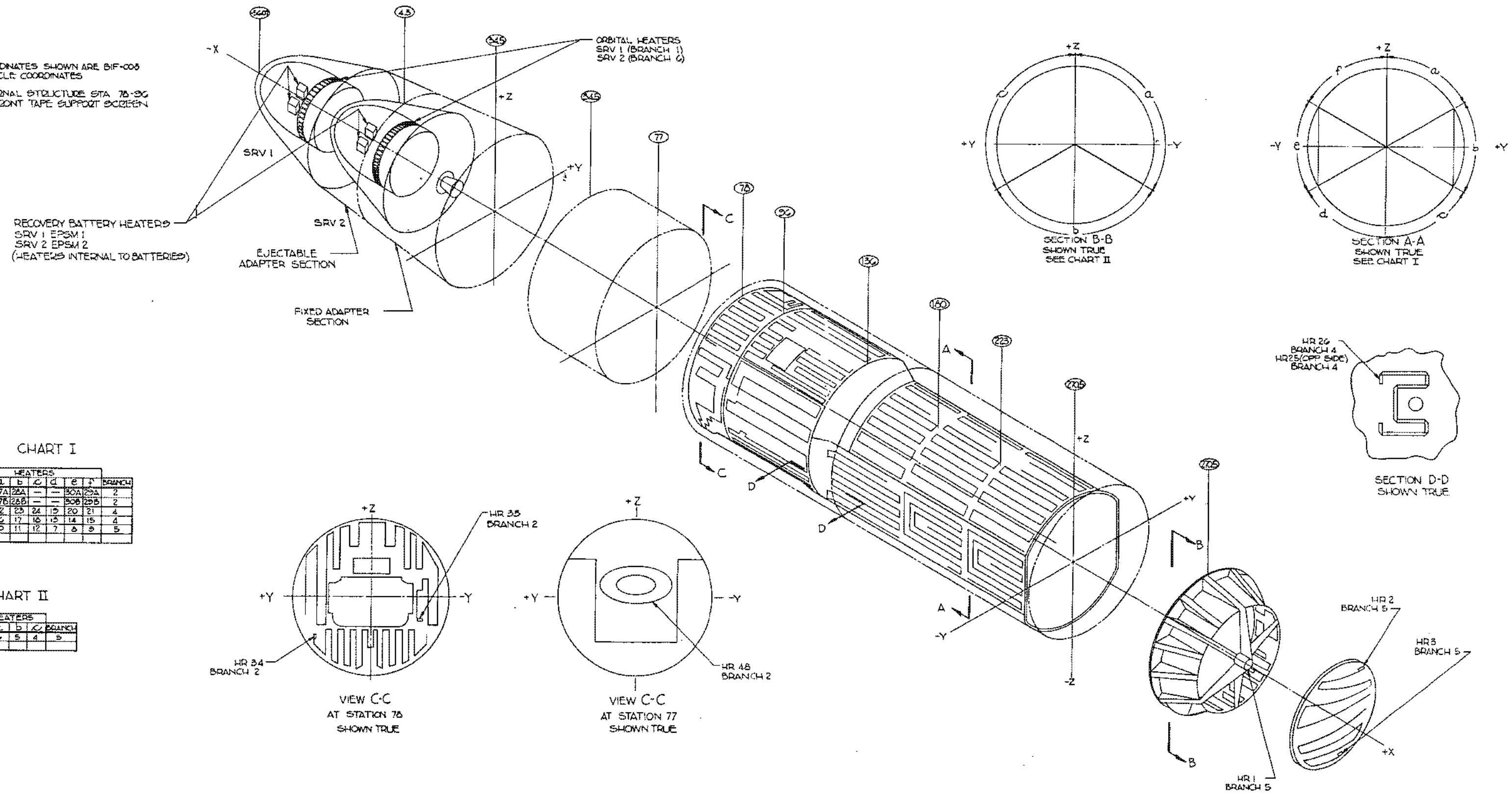

CHART I

STA. \ ZONE	HEATERS a	b	c	d	e	f	BRANCH
78-96	27A	28A	—	—	30A	29A	2
96-136	27B	28B	—	—	30B	29B	2
136-180	22	23	24	19	20	21	4
180-223	16	17	18	13	14	15	4
223-270.5	10	11	12	7	8	9	5

CHART II

STA. \ ZONE	HEATERS a	b	c	BRANCH
270.5	6	5	4	5

Figure 3.8-11. Flight Heater Tape Locations

3.8-49

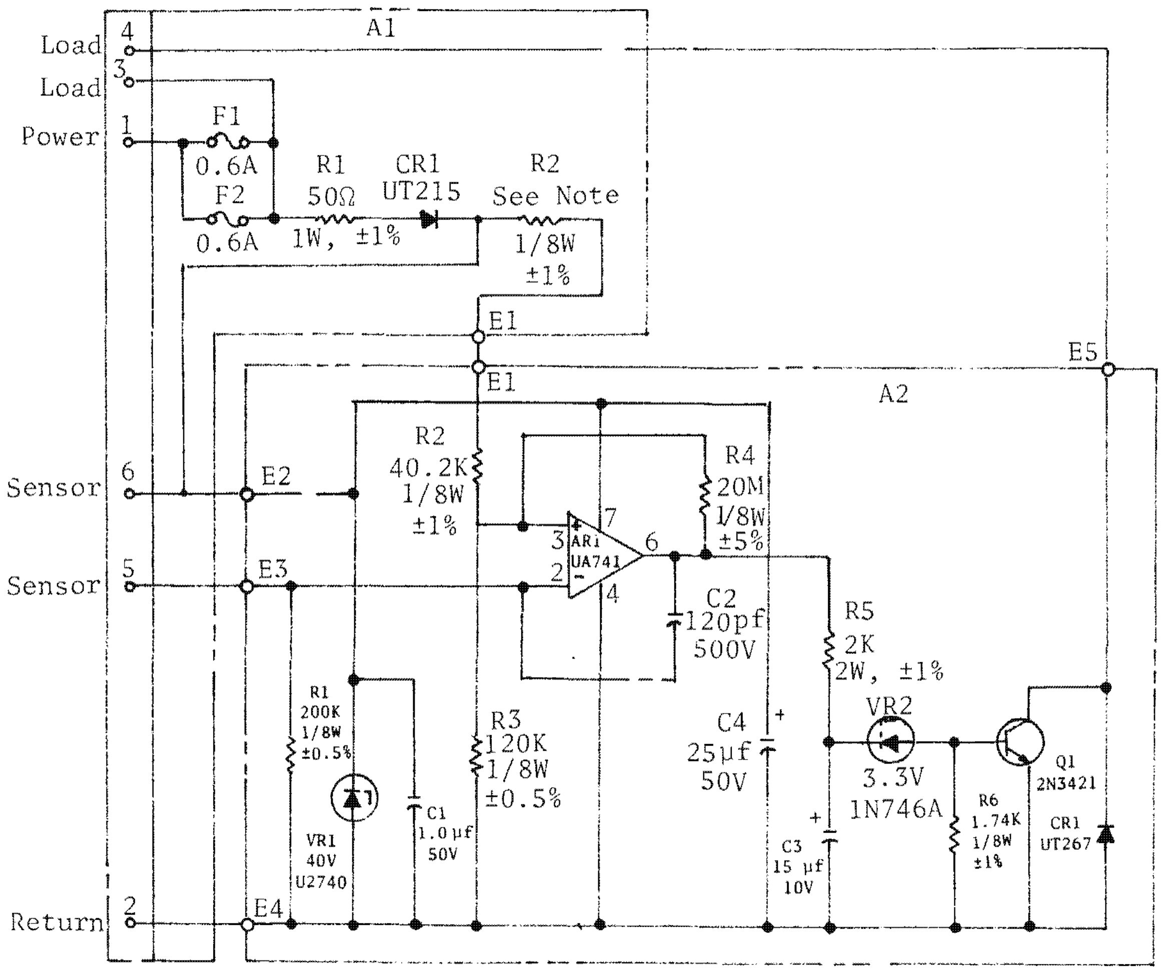

Figure 3.8-12. Flight Heater Controller Schematic

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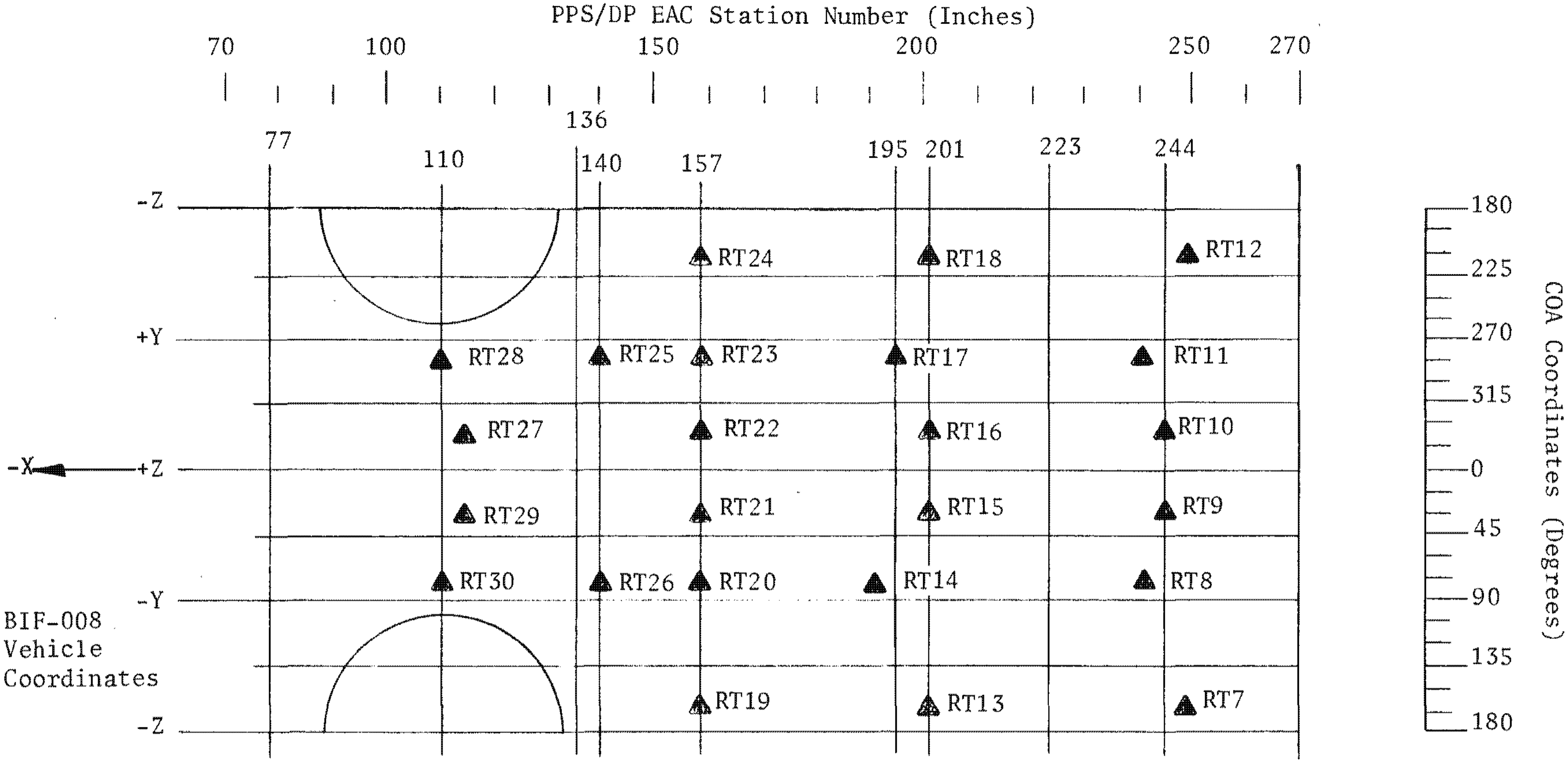

Notes:

1. RT1, RT4 - RT6 are on the end bell; RT2 and RT3 are on the primary mirror blankets

   RT33 and RT34 are on the front surface of the tape support screen; RT48 is on the camera cover blanket.

2. The numerical number of each sensor corresponds to the numerical number of the heater it controls.

Figure 3.8-13. COA Heater Controller Temperature Sensor Locations

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As the temperature decreases, the base voltage of Q1 increases until Q1 starts turning on. As Q1 starts turning on, the current through Q3 begins decreasing until the trip-point is reached where Q4 turns on, which turns on Q5, applying power to the heater. Heat supplied by the heater decreases the resistance of the thermistor lowering the voltage at the base of Q1. The collector voltage of Q1 increases turning Q3 on, Q4 off and Q5 off. The thermistor turn-off resistance is less than the turn-on resistance (hysteresis) since, when Q4 turns on, the emitter voltage of Q3 is increased above its former value requiring a higher base voltage for Q3 to turn on again.

25X1

8.3.5.6 Thermal Control During SRV and EA Ejection Sequences. The operational sequence for SRV ejection includes nose aft flight for up to three revolutions, a pitchdown and hold maneuver during ejection, and then a pitchup or retrim maneuver to return the PPS/DP EAC to a level attitude*. The EA is ejected while the PPS/DP EAC is in a nose aft, level attitude. No restrictions are placed on recovery maneuvers for EA or SRV 2 ejection. However, since the predicted COM curvature during a recovery revolution could exceed the operating curvature constraint, it is required that the COM be in a nonoperating state (viewport door operation and film movement prohibited) during the recovery revolution. This constraint applies to SRV 1 ejection as well.

Additional problems arise during the ejection sequence for SRV 1 which are not of concern during EA or SRV 2 ejection. To meet these, special operational techniques have been established to ensure proper thermal control. Particular emphasis is given to limiting skin temperatures and COM curvature, and to limiting EA/FA pin-puller temperatures due to localized aerodynamic heating during pitchdown at low altitudes**. The techniques employed depend on the minimum altitude range at the time of the ejection sequence, and can include high-rate powered pitch maneuvers and roll joint rotation of the PPS/DP EAC to a specified position. A powered pitch (as opposed to an inertial pitch) reduces the length of time spent in a non-level attitude. PPS/DP EAC rotation provides a more favorable orientation of the EA/FA pin-pullers with respect to the windstream (see Figure 3.8-14).

Requirements and recommendations for SRV 1 ejection are summarized by minimum altitude range:

(1) Less than 68 nmi: Powered pitchdown and powered retrim immediately after ejection are required. Dwell time in pitchdown state must be minimized.

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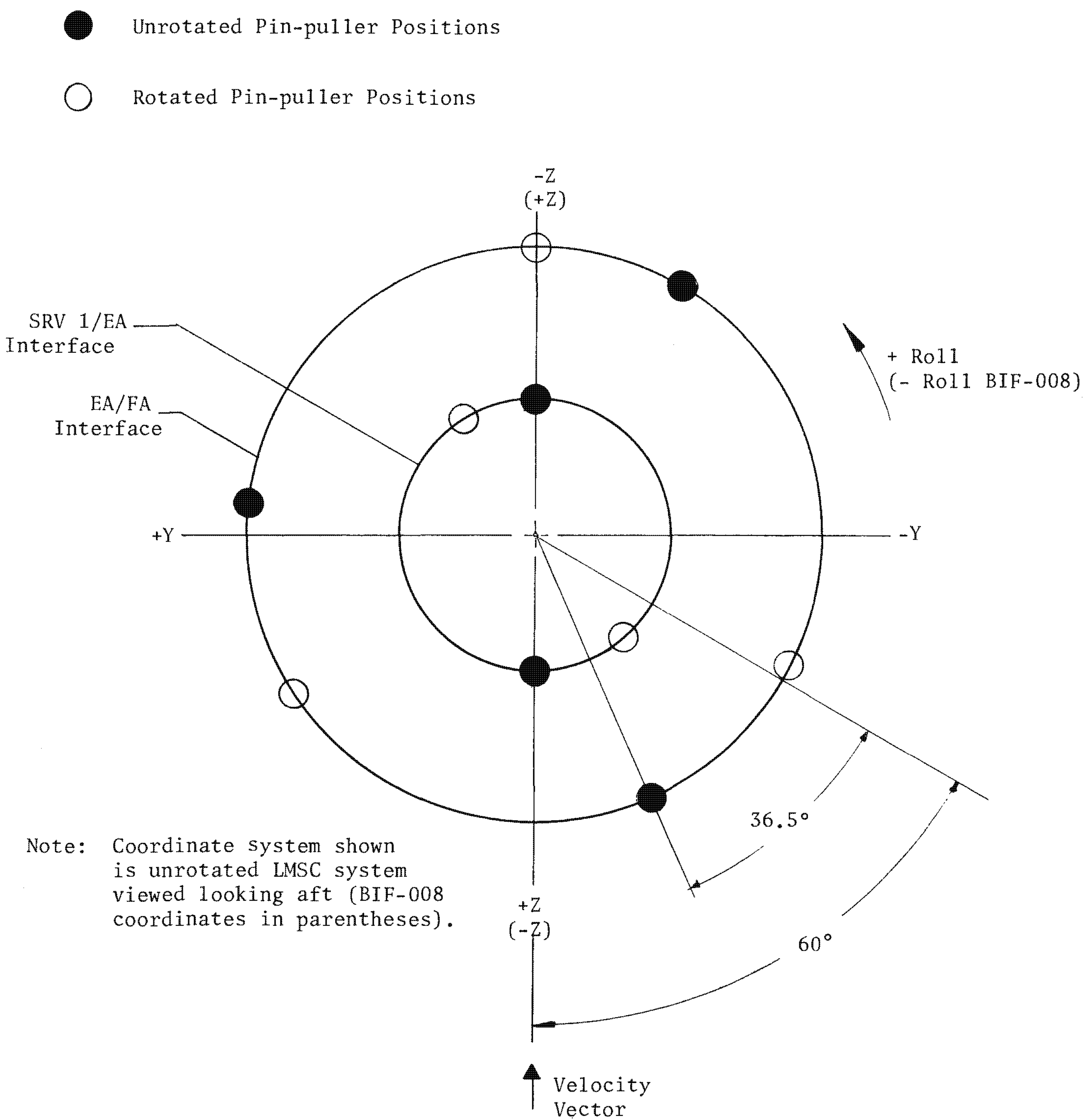
* Refer to Part 3, Section 12 for a further description of the recovery sequence.
**Reference BIF-008-W-C-003745-OH-74, Summary: Pin-puller Thermal Analysis.



Note: Coordinate system shown is unrotated LMSC system viewed looking aft (BIF-008 coordinates in parentheses).

Figure 3.8-14. EA/FA Pin-Puller Locations

(2) Greater than 68 nmi, but less than 73 nmi: Inertial (nonpowered) pitchdown is acceptable; either powered retrim or PPS/DP EAC rotation during entire sequence is required.

(3) Greater than 73 nmi: No restrictions.

(4) All altitudes: PPS/DP EAC rotation is recommended.

8.4 Instrumentation

Table 3.8-6 summarizes those instrumentation points related to the PPS/DP EAC environment which are monitored on-orbit. Figures 3.8-15 through 3.8-17 illustrate the locations of the DRM and SEM skin temperature sensors, and the COA structure temperature sensors respectively. Figures in Part 3, Section 1 illustrate the locations of all other temperature sensing thermistors except those within the satellite reentry vehicles (SRV's). For the locations of thermistors within the SRV's, refer to Part 3, Section 12.

While they are not flight monitors, the umbilical instrumentation points (BIL's) are useful environmental monitors at the launch pad. For this reason, a summary of these points is provided in Table 3.8-7.

TABLE 3.8-6

ENVIRONMENTAL SUBSYSTEM INSTRUMENTATION SUMMARY

IMP	Title	Description	Power
5003	Environmental Branches 1,2, and 4, and 5 Parking Brake On/Off	Latching relays tracking the command input relays of the command processor monitor the receipt of commands from the satellite control section and feed either 0.0v or 5.0v to an integrated circuit D/A converter. Four relays and one 4-bit D/A converter form the IMP. Output occurs in sixteen discrete steps ranging from 0.25v to 4.75v in 0.3v increments: Bit 1 (LSB) = Env Branch 1 On/Off Bit 2 = Env Branch 2 On/Off Bit 3 = 5 Parking Brake On/Off Bit 4 (MSB) = Env Branch 4 On/Off	+5/±15 vdc
5004	Environmental Branch 5,6, EPSM 1, EPSM 2 On/Off	Similar to IMP 5003: Bit 1 (LSB) = Env Branch 5 On/Off Bit 2 = Env Branch 6 On/Off Bit 3 = EPSM 1 On/Off Bit 4 (MSB) = EPSM 2 On/Off	+5/±15 vdc
5130	BUSS Power Supply	A fixed resistor divider network in the PM&C monitors the voltage at the PM&C on the BUSS (Emergency) power input lines from the satellite control section (SCS). The output is linear from 0.0v (0.2v output) to 35v (4.83v output).	+5 vdc
5131	Environmental Power Supply	Similar to IMP 5130, monitors the voltage at the PM&C on the environmental power input lines from the SCS.	+5 vdc

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TABLE 3.8-6 (CONT'D)

IMP	Title	Description	Power
5577	Environmental Branch 1 Voltage Monitor	A two resistor voltage divider circuit connected across the branch 1 power feed line in the PM&C monitors the voltage level. Output is digitized in the DTU to yield a binary signal (On/Off). "0" = Off "1" = On	Self
5578	Environmental Branch 2 Voltage Monitor	Similar to IMP 5577, monitors the branch 2 power feed in the PM&C.	Self
5580	Environmental Branch 4 Voltage Monitor	Similar to IMP 5577, monitors the branch 4 power feed in the PM&C.	Self
5581	Environmental Branch 5 Voltage Monitor	Similar to IMP 5577, monitors the branch 5 power feed in the PM&C.	Self
5582	Environmental Branch 6 Voltage Monitor	Similar to IMP 5577, monitors the branch 6 power feed in the PM&C.	Self
5583	EPSM 1 Voltage Monitor	Similar to IMP 5577, monitors the EPSM 1 power feed in the PM&C.	Self
5584	EPSM 2 Voltage Monitor	Similar to IMP 5577, monitors the EPSM 2 power feed in the PM&C.	Self

TABLE 3.8-6 (CONT'D)

IMP	Title	Description	Power
5133	Environmental Current Branch 1, Branch 6, EPSM 1, and EPSM 2	A current sensing resistor in the power return line in the PM&C generates a voltage proportional to the combined currents for branches 1 and 6, and EPSM 1 and 2. The signal is amplified within the PM&C to produce a linear output ranging from 0.0 ampere (0.2v) to 4.48 amperes (5.0v).	±15 vdc
5134	Environmental Current Branch 2, and 5 Parking Brake Current	Similar to IMP 5133, the voltage is proportional to the combined current for branch 2, and the 5 parking brake. The output is linear from 0.0 ampere (0.18v) to 5.0 amperes (4.9v).	±15 vdc
5135	Environmental Current Branch 4	Similar to IMP 5133, produces a voltage proportional to the branch 4 current drain. Output is linear from 0.0 ampere (0.2v) to 6.0 amperes (4.9v).	±15 vdc
5136	Environmental Current Branch 5	Similar to IMP 5133, produces a voltage proportional to the branch 5 current drain. Output is linear from 0.0 ampere (0.18v) to 5 amperes (5.0v).	±15 vdc
5019	Film Path Pressure	A diaphragm responds to slight differential pressures of the inside of the FSE with respect to the outside. A coil is located on each side of the diaphragm to sense the motion. The corresponding inductance changes	24.5 vdc (DTU switched power)

TABLE 3.8-6 (CONT'D)

IMP	Title	Description	Power
5019 (Cont'd)		determine the frequency of an oscillator which is demodulated into a proportional analog output voltage. The range of the IMP is 0 mm of Hg (0.37v) to 4.63 mm of Hg (5.0v).	
5360	Blast Shield Valve	A potentiometer attached to the blast shield valve monitors the valve position, providing a linear output from 0°, or closed (4.5v), to 70°, or open (0.5v).	+5 vdc
5013	Temperature, Primary Film Supply	A thermistor, mounted on the back of the 9 film quantity sensor assembly, monitors the temperature near the 9 supply spool. The output is scaled in the instrumentation processor producing a nonlinear signal from 10F (4.75v) to 130F (0.54v).	+15 vdc
5057	Temperature, Camera Housing	A thermistor mounted on the +Z surface of the camera housing, centered on the X-axis at approximately station 79.2, monitors the internal temperature. The output is processed in the housing, producing a nonlinear signal from 30F (4.82v) to 100F (1.02v).	±15 vdc
5058	Temperature Focus Sensor Head	A thermistor mounted on the base plate (-Z) of the RMS to DC converter module in the focus sensor head assembly monitors the focus sensor head temperature. The output is processed by an integrated circuit differential amplifier in the focus detector instrumentation and control module, producing a linear signal from 60F (4.75v) to 80F (1.06v).	±15 vdc

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TABLE 3.8-6 (CONT'D)

IMP	Title	Description	Power
5060	Temperature, 5 Tilt Frame	A thermistor mounted on the outer side of the 5 pivot frame near the platen drive motor monitors the frame temperature. Processing circuitry is located in the camera housing. The output is linear from 60F (4.5v) to 80F (0.87v).	±15 vdc
5061	Temperature, 9 Tilt Frame	Similar to IMP 5060. The thermistor is mounted on the outer edge of the 9 pivot frame near the platen drive motor.	±15 vdc
5076	Temperature, Secondary Film Supply	A thermistor, mounted on the +Y side of the 5 supply frame near the supply spool support, monitors the supply temperature. The output is scaled in the instrumentation processor, generating a nonlinear signal from 10F (4.75v) to 130F (0.54v).	+15 vdc
5078	#2 Battery Temperature, SRV 2	A thermistor, mounted on the -X side of the number 2 recovery battery in SRV 2, monitors the battery temperature. The IMP output is provided by a resistor/thermistor voltage divider circuit in SRV 2, yielding a non-linear signal from 30F (3.8v) to 130F (1.35v).	+5 vdc
5079	#2 Battery Temperature, SRV 1	Identical to IMP 5078, a thermistor on the -X side of recovery battery number 2 in SRV 1 monitors the battery temperature.	+5 vdc

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TABLE 3.8-6 (CONT'D)

IMP	Title	Description	Power
5099	Temperature, Stereo Mirror	A thermistor, mounted on the back surface of the stereo mirror, monitors the mirror temperature. The output is processed by an integrated circuit differential amplifier in the instrumentation processor, producing a linear signal from 60F (4.75v) to 80F (1.06v).	±15 vdc
5110	Temperature, Corrector, Camera Spacer	Similar to IMP 5099, the thermistor is mounted on the top plate of the Ross Corrector, at the +Y edge approximately 2 3/4 inches from the camera interface.	±15 vdc
5111	Temperature, Viewport Door Inside Insulation -Y	A thermistor, located at the center of the -Y viewport door heater tape support screen, monitors the temperature inside the -Y door. A load resistor in the instrumentation processor (IP) reduces the output to acceptable levels. The output is nonlinear, ranging from 40F (4.95v) to 100F (1.4v).	+15 vdc
5112	Temperature, Lens Tube Forward, Sta 175, 279 Degrees	A circuit, identical to that used for IMP 5111, monitors the COA temperature. The thermistor is mounted on the COA structure at station 175, 279 degrees, and, with a resistor in the IP, forms a voltage divider network producing a nonlinear signal from 40F (4.95v) to 100F (1.4v).	+15 vdc
5113	Temperature Lens Tube Aft, Sta 244, 5 Degrees	Similar to IMP 5099, the thermistor is mounted on the inner surface of the COA at station 244, 5 degrees.	±15 vdc

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TABLE 3.8-6 (CONT'D)

IMP	Title	Description	Power
5114	Temperature Viewport Door Inside Insulation +Y	A thermistor, located at the center of the +Y viewport door on the heater tape support screen, monitors the temperature inside the +Y door. The thermistor, and a resistor in the IP, form a voltage divider network yielding a nearly linear output from 32F (1.15v) to 100F (3.2v).	+5 vdc
5115	Temperature Lens Tube Forward, Sta 175, 99 Degrees	Similar to IMP 5099, the thermistor is mounted on the outer surface of the COA at station 175, 99 degrees.	±15 vdc
5120	Temperature Insulation Inner, Sta 108, 7 Degrees	Similar to IMP 5099, the thermistor is mounted on the COA structure at station 108, 7 degrees.	±15 vdc
5145	Temperature Primary Mirror 2 (-Y)	A thermistor, mounted on the front surface of the primary mirror, approximately 8 inches from the center along the -Y axis, monitors the primary mirror surface temperature. The thermistor, and a resistor in the IP, form a voltage divider network yielding a nonlinear signal from 40F (4.5v) to 100F (1.25v).	±15 vdc
5150	Temperature Primary Mirror 1 (+Y)	Similar to IMP 5099, the thermistor is mounted on the front surface of the primary mirror, approximately 8 inches from the center, along the +Y axis.	±15 vdc
5155	Temperature, Insulation Inner, Sta 244, 186 Degrees	Similar to IMP 5099, the thermistor is mounted on the COA structure at station 244, 186 degrees.	±15 vdc

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TABLE 3.8-6 (CONT'D)

IMP	Title	Description	Power
5235	Temperature SRV 1 Film Take-up Assembly	Similar to IMP 5013, the instrumentation thermistor is glued to a take-up frame cross member, and is centered on the Z axis just below (-Z) the 5 wobble roller.	+15 vdc
5236	Temperature SRV 2 Film Take-up Assembly	Similar to IMP 5235, monitors the temperature of T/U 2.	+15 vdc
5238	Temperature SRV 1 Recovery Battery +Y Side	Similar to IMP 5078, the thermistor is mounted on the -X side of recovery battery number one in SRV 1.	+5 vdc
5239	Temperature SRV 2 Recovery Battery +Y Side	Similar to IMP 5078, the thermistor is mounted on the -X side of recovery battery number one in SRV 2.	+5 vdc
5240	Temperature SRV 1 Thrust Cone Retro Attach Point	A resistor/thermistor voltage divider circuit with the thermistor mounted on the thrust cone retro attach point at approximately 345 degrees. The output is non-linear, ranging from 10F (4.15v) to 140F (1.15v).	+15 vdc
5241	Temperature SRV 2 Thrust Cone Retro Attach Point	Similar to IMP 5240, monitors the temperature of the T/C retro attach point in SRV 2.	+15 vdc
5242	Temperature SEM Internal, +Y	A resistor/thermistor voltage divider circuit, with the thermistor attached to a mounting rail on the FSE +Y exterior near the 9 camera electronics assembly, monitors the SEM temperature. The output is non-linear from 20F (0.55v) to 120F (4.14v).	+15 vdc

Approved for Release: 2017/02/14 C05097222

TABLE 3.8-6 (CONT'D)

IMP	Title	Description	Power
5243	Temperature SEM Internal, RSE/RAM-5	Similar to IMP 5114, the thermistor is mounted on the 5 supply assembly splicer mechanism mounting pad.	+5 vdc
5244	Temperature SRV 1 Forebody Liner Skirt, X Axis	A resistor/thermistor voltage divider circuit, with the thermistor mounted inside the forebody on the X axis, monitors the SRV 1 forebody temperature. The output is linear from -150F (1.53v) to 300F (5.0v).	+15 vdc
5245	Temperature SRV 2 Forebody Liner Skirt, X Axis	Similar to IMP 5244, monitors the SRV 2 forebody temperature.	+15 vdc
5246	Temperature SRV 1 Forebody Liner Skirt, +45 Degrees	A resistor/thermistor voltage divider circuit with the thermistor mounted inside the forebody at approximately station -38, +45 degrees monitors the forebody temperature. The output is nonlinear from -150F (1.88v) to +200F (5.0v).	+15 vdc
5247	Temperature SRV 2 Forebody Liner Skirt, +45 Degrees	Similar to IMP 5246, monitors the SRV 2 forebody temperature.	+15 vdc
5248	Temperature SRV 1 Forebody Liner, -45 Degrees	Similar to IMP 5244, the thermistor is mounted inside the forebody at approximately station -38, -45 degrees.	+15 vdc
5249	Temperature SRV 2 Forebody Liner Skirt, -45 Degrees	Similar to IMP 5246, the thermistor is mounted inside the forebody at approximately station -38, -45 degrees.	+15 vdc

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TABLE 3.8-6 (CONT'D)

IMP	Title	Description	Power
5250	Temperature Skin Fixed Adapter Sta 16, +Z	A resistor/thermistor voltage divider circuit mounted to the internal side of the skin in the fixed adapter (FA) at station 16, +Z monitors the skin temperature. The output is nonlinear from -50F (0.16v) to +200F (4.5v).	+5 vdc
5251	Temperature Skin FA, Sta 16, +Y	Similar to IMP 5250, the thermistor is mounted inside the FA skin at station 16, +Y.	+5 vdc
5252	Temperature Skin FA, Sta 16, -Z	Similar to IMP 5250, the thermistor is mounted inside the FA skin at station 16, -Z.	+5 vdc
5253	Temperature Skin FA, Sta 16, -Y	Similar to IMP 5250, the thermistor is mounted inside the FA skin at station 16, -Y.	+5 vdc
5254	Temperature Skin SEM, Sta 57.5, +Z	A resistor/thermistor voltage divider circuit located near the SEM skin on the surface of a longeron at station 57.5, +Z. The output is nonlinear from -50F (0.03v) to +400F (4.8v).	+5 vdc
5255	Temperature Skin SEM, Sta 63.5, +Y	Similar to IMP 5254, the thermistor is mounted near the SEM skin at station 63.5, +Y.	+5 vdc
5256	Temperature Skin SEM, Sta 57.5, -Z	Similar to IMP 5254, the thermistor is mounted near the SEM skin at station 57.5, -Z.	+5 vdc

TABLE 3.8-6 (CONT'D)

IMP	Title	Description	Power
5257	Temperature Skin SEM, Sta 63.5, -Y	Similar to IMP 5254, the thermistor is mounted near the SEM skin at station 63.5, -Y.	+5 vdc
5258	Temperature Skin EA, Sta -9.7, 335 Degrees	A resistor/thermistor voltage divider circuit with the thermistor mounted on the inside surface of the ejectable adapter (EA) skin at station -9.7, 335 degrees monitors the EA temperature. The output is nearly linear from 0.0F (1.55v) to 700F (4.2v).	+15 vdc
5259	Temperature Skin EA, Sta -9.7, 244 Degrees	Similar to IMP 5258, the thermistor is mounted on the inside surface of the skin at station -9.7, 244 degrees.	+15 vdc
5260	Temperature Skin EA, Sta -9.7, 117 Degrees	Similar to IMP 5258, the thermistor is mounted on the inside surface of the skin at station -9.7, 117 degrees.	+15 vdc
5261	Temperature SEM Internal, +Y Side, CP Mounting Rail	Similar to IMP 5242, the thermistor is located on the -X side of the command processor (CP) mounting tray.	+15 vdc
5262	Temperature SEM Internal, +Y Side, PM&C Mounting Rail	Similar to IMP 5242, the thermistor is mounted near the lower (-Z) foot of the PM&C on the mounting rail attached to the FSE +Y wall at station 53.	+15 vdc
5263	Temperature SEM Internal, -Y Side, 5 FPLL Aft Mounting Rail	Similar to IMP 5242, the thermistor is mounted on the lower (-Z) portion of the 5 frequency phase lock loop electronic (FPLLE) aft mounting rail on the FSE -Y side at station 52.	+15 vdc

TABLE 3.8-6 (CONT'D)

IMP	Title	Description	Power
5301	Temperature SEM Internal, -Y Side, IP Mounting Rail	Similar to IMP 5242, the thermistor is mounted near the upper (+Z) foot of the instrumentation processor (IP) mounting rail attached to the FSE -Y side at station 45.	+15 vdc
5302	Temperature SEM Internal, RSE/RAM-9	Similar to IMP 5114, the thermistor is located on the 9 supply assembly splicer mechanism mounting pad.	+5 vdc
5303	Temperature SEM Internal, Sta 76	Similar to IMP 5242, the thermistor is located on the SEM aft bulkhead, external to the FSE.	+15 vdc
5330	Temperature Telemetry Unit Section 1	The temperature inside digital telemetry unit 1 (DTU 1) is monitored by a thermistor located on the power supply board. The output is nonlinear from -20F (5.05v) to +155F (0.7v)	+15 vdc
5331	Temperature Telemetry Unit Section 2	Similar to IMP 5330, monitors the temperature inside DTU 2.	+15 vdc
5375	Differential Temperature, Stereo Mirror Lower	Two matched thermistors are mounted in the front and back plates of the stereo mirror. The two outputs are processed by a differential amplifier in the instrumentation processor, producing a differential temperature signal, ΔT (front minus back), ranging linearly from -1.0F (0.5v) to +3.0F (4.98v).	±15 vdc

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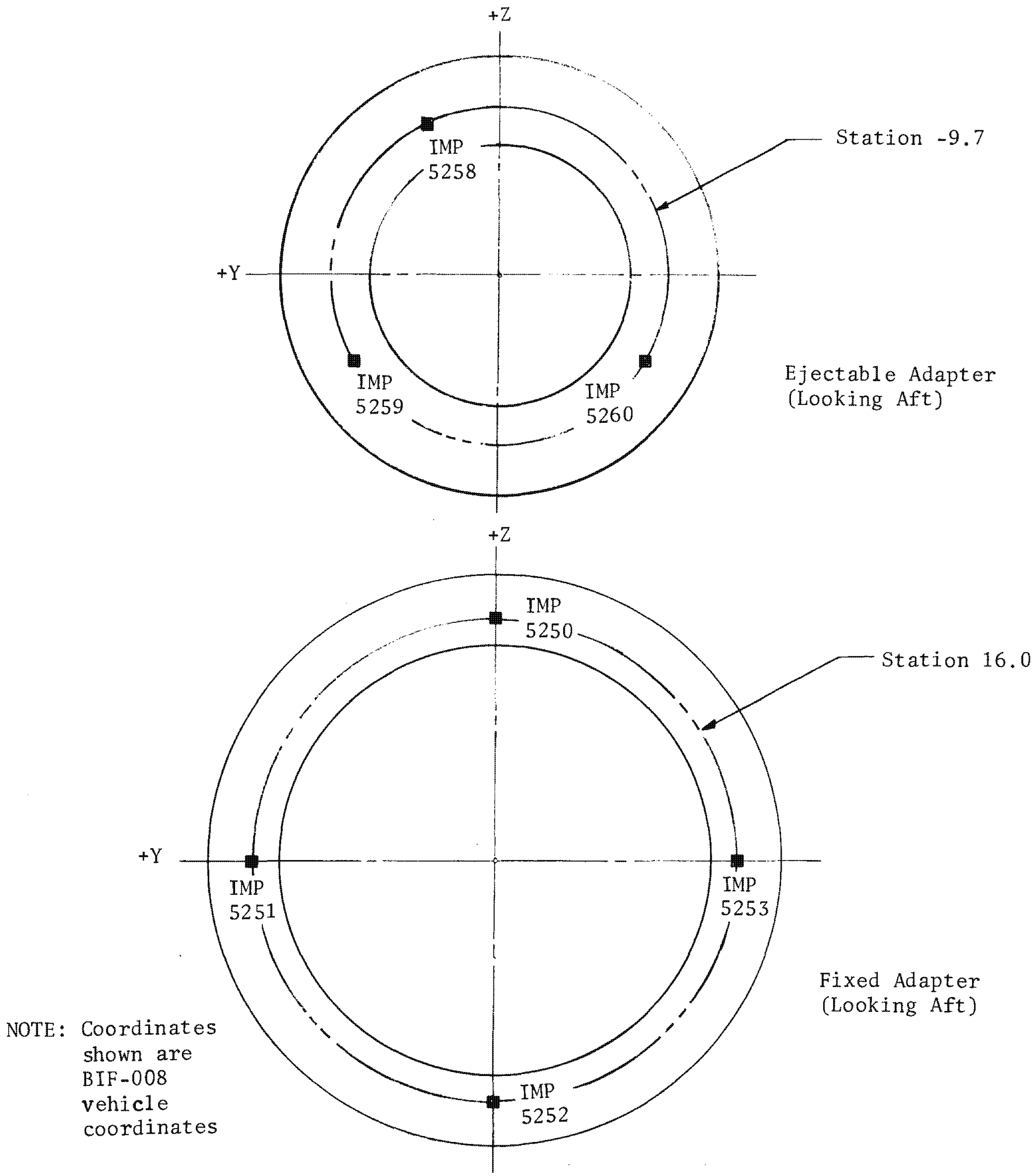


Figure 3.8-15. DRM Skin Temperature Instrumentation Points

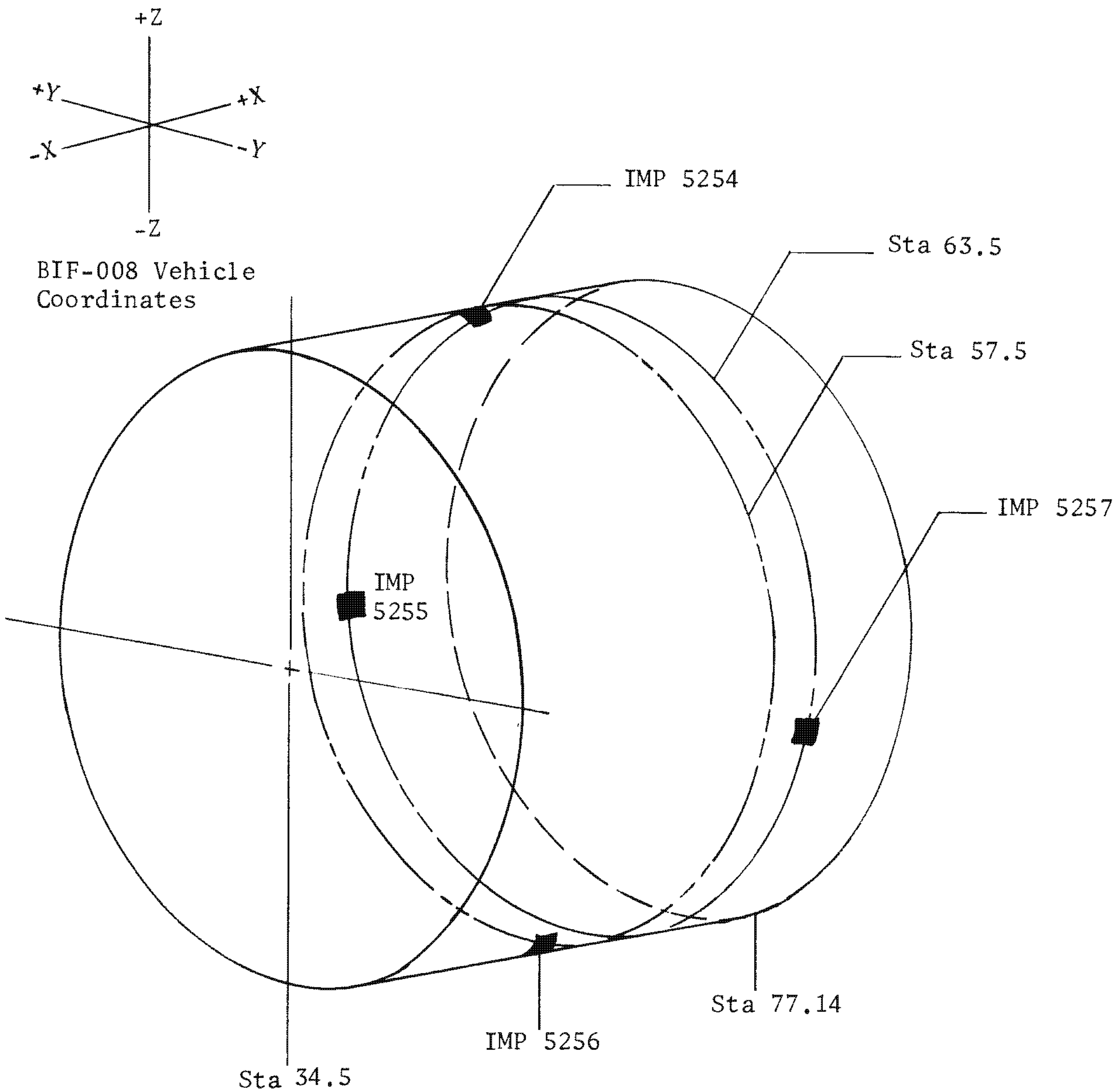
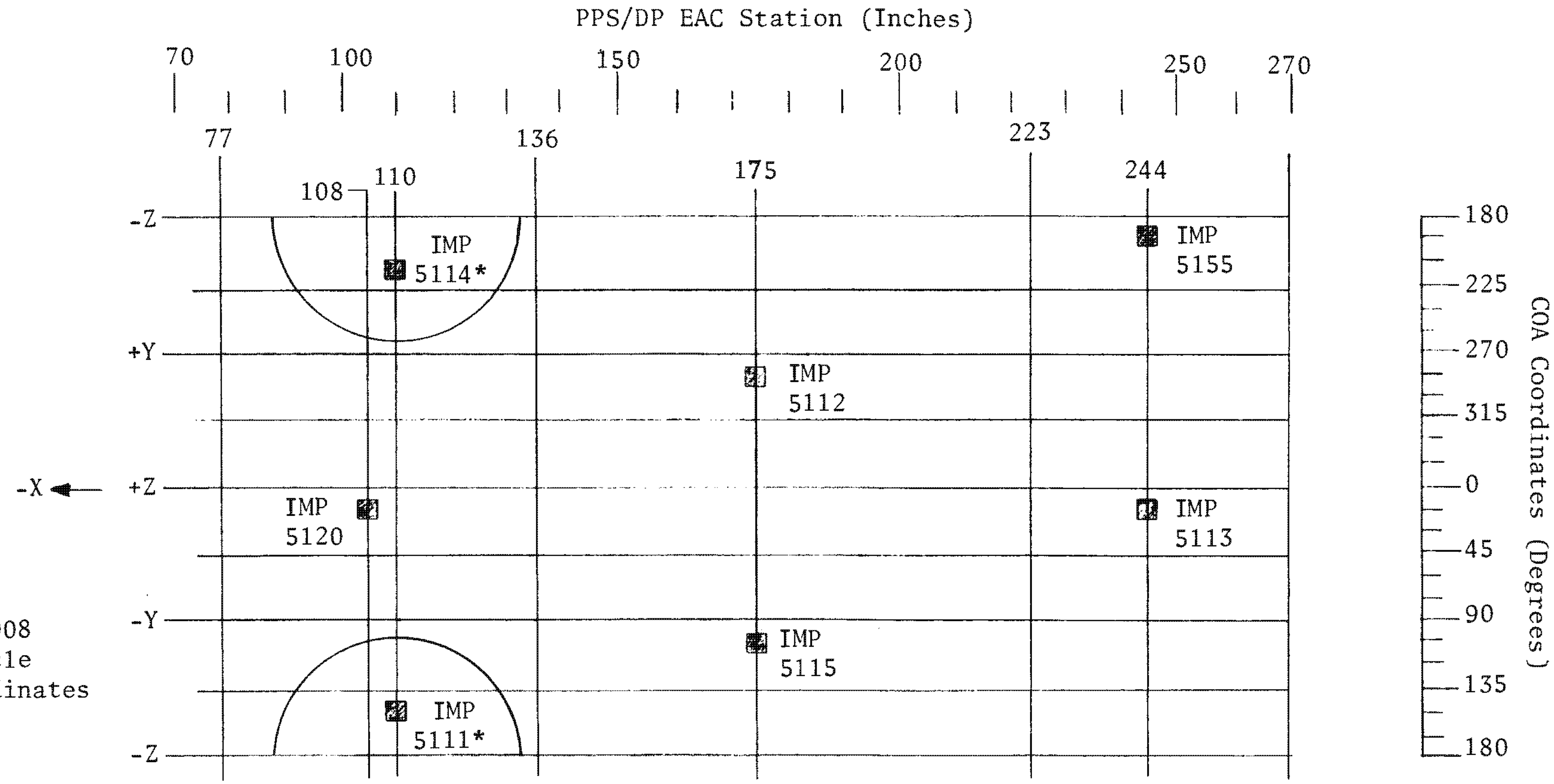


Figure 3.8-16. Supply Electronics Module Skin Temperature Instrumentation Points



*On Viewport Doors

Figure 3.8-17. COA Structure Temperature Sensor Locations

TABLE 3.8-7

UMBILICAL INSTRUMENTATION SUMMARY

BIL	Title	Description	Power
8000	Differential Temperature, Stereo Mirror Lower	The output of IMP 5375 (see Table 3.8-6) is monitored at the umbilical output. An isolation resistor is placed in series between the normal IMP output and the BIL output in the instrumentation processor (IP).	±15 vdc
8001	Temperature Primary Mirror 1 (+Y)	The output of IMP 5150 (see Table 3.8-6) is monitored at the umbilical output. An isolation resistor is placed in series between the normal IMP output and the BIL output in the IP.	±15 vdc
8002	Temperature Viewport Door Inside Insulation +Y	The output of IMP 5114 (see Table 3.8-6) is monitored at the umbilical output. An isolation resistor is placed in series between the normal IMP output and the BIL output in the IP.	+5 vdc
8006	Temperature, Corrector, Camera Spacer	The output of IMP 5110 (see Table 3.8-6) is monitored at the umbilical output. An isolation resistor is placed in series between the normal IMP output and the BIL output in the IP.	±15 vdc
8007	Temperature, Lens Tube Forward, Sta 175, 279 Degrees	The output of IMP 5112 (see Table 3.8-6) is monitored at the umbilical output. An isolation resistor is placed in series between the normal IMP output and the BIL output in the IP.	+15 vdc

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TABLE 3.8-7 (CONT'D)

BIL	Title	Description	Power
8008	Temperature Primary Mirror 2 (-Y)	The output of IMP 5145 (see Table 3.8-6) is monitored at the umbilical output. An isolation resistor is placed in series between the normal IMP output and the BIL output in the IP.	+15 vdc
8010	Temperature, Inlet Air	A thermistor located inside the PPS/DP EAC near the umbilical conditioned air inlet monitors the temperature of the incoming air. The thermistor and a resistor in the IP form a voltage divider circuit whose output is non-linear from 60F (4.4v) to 100F (2.1v). Although powered whenever the instrumentation power is on, the output is available only through the umbilical line, it is not monitored on-orbit.	+15 vdc
8012	Temperature Stereo Mirror	The output of IMP 5099 (see Table 3.8-6) is monitored at the umbilical output. An isolation resistor is placed in series between the normal IMP output and the BIL output in the IP.	±15 vdc

8.5 Environmental Control Command Summary

8.5.1 Heater Power On

HEATER POWER AND 5 PARKING BRAKE ON
(N02661, N01661, N03661)

Function: This command provides power to all heater branches, including EPSM 1 and EPSM 2, and to the 5 parking brake

Interlocks: Commanding 5 OP ON or 9/5 RUNOUT ON will disable the 5 parking brake circuit. Removing 5 operational power will remove the disable if the 5 parking brake power is off. Otherwise, the disable will not be removed until both 5 OP and 5 parking brake power are off.

8.5.2 Heater Power Off Commands

HEATER BRANCH 1 OFF (N02755, N01755, N03755)
HEATER BRANCH 2 OFF (N02751, N01751, N03751)
HEATER BRANCH 4 OFF (N02746, N01746, N03746)
HEATER BRANCH 5 OFF (N02743, N01743, N03743)
HEATER BRANCH 6 OFF (N02742, N01742, N03742)

Function: These commands remove power from the indicated heater branches.

8.5.3 EPSM On Commands

EPSM 1 ON (N02747, N01747, N03747)
EPSM 2 ON (N02655, N01655, N03655)

Function: These commands provide power to the orbital heaters in the indicated SRV (EPSM 1 in SRV 1; EPSM 2 in SRV 2).

Comments: Normally given four revolutions prior to recovery of the associated SRV, depending on the SRV temperature.

8.5.4 EPSM Off Commands

EPSM 1 OFF (N02644, N01644, N03644)
EPSM 2 OFF (N02745, N01745, N03745)

Function: These commands remove power from the orbital heaters in the indicated SRV (EPSM 1 in SRV 1; EPSM 2 in SRV 2).

8.5.5 Heater Power On/Off (M6V WORD)

M6V002YZ (Bits 35-38, and Implicit)

Function: This command controls the heater branch circuits, the DTU states, and the 5 parking brake power.

Bit No.	Function
Implicit	Spare
33-1	DTU 1 ON
33-0	DTU 1 OFF
34-1	DTU 2 ON
34-0	DTU 2 OFF
35-1	Heater branches 1, 2, 4, 5, and 6, and 5 parking brake power ON
35-0	Heater branches 1, 2, 4, 5, and 6, and 5 parking brake power OFF
36-1	EPSM 1 ON
36-0	EPSM 1 OFF
37-1	EPSM 2 ON
37-0	EPSM 2 OFF
38-1	Spare
38-0	Spare

Interlocks: A. DTU 1 and 2 are logically interlocked to preclude simultaneous operation. Only one DTU should be commanded ON at any given time.

b. Commanding 5 OP ON or 9/5 RUNOUT ON will disable the 5 parking brake circuit. Removing 5 operational power will remove the disable, if the 5 parking brake power is off. Otherwise, the disable will not be removed until both 5 OP and 5 parking brake power are off.

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