Shuttle/Payload Interface Definition Document for the Payload and General Support Computer (PGSC)

Space Shuttle Integration and Operations Office

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NASA
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Lyndon B. Johnson Space Center
Houston, Texas 77058

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INTRODUCTION

The Payload and General Support Computer (PGSC) is a service used to support Shuttle and Payload on-orbit operations. The primary functions are: command and display of non-critical payloads and additional crew information services.

The number of PGSC's manifested is determined on a flight-by-flight basis. Sufficient PGSC's are always flown to satisfy the requirements of all users and to provide adequate backup capability.

In addition, the PGSC hardware is a Space Shuttle controlled resource. The "flight-like" PGSC system with power supply and communications cabling may be obtained on loan for two weeks. It has the same configuration as the regular flight PGSC and may be used by the user/experimenter for final verification of software/hardware operation and interfacing.

This document supersedes Payload and General Support Computer (PGSC) Interface Definition Document, JSC-23745 (October 1989).

Changes to this document will be controlled by the Portable Onboard Computer Control Board.

TABLE OF CONTENTS

1.0 SCOPE

1.1 PURPOSE

The purpose of this document is to:

a. Define and control the interfaces provided by the PGSC and associated components for use by payloads and crew software, and

b. Define and control constraints observed by payload and crew support users.

1.2 GENERAL

This document defines all interfaces available to the PGSC assembly and identifies configurations for the government furnished equipment (GFE) communications and power cables supplied with the PGSC assembly.

In this document, the term “PGSC 486” refers to the flight ThinkPad 755C computer as modified: whereas, the term “ThinkPad 755C” refers to the commercial ThinkPad 755C sold by the manufacturer.

In the text, the terms “shall,” “will,” and “must” are used when compliance is mandatory. “May” or “should” indicate a choice exists.

1.3 CONFIGURATION CONTROL

The SSP will maintain configuration control of this document in accordance with the Integration Control Board Configuration Management Procedures, NSTS 18468.

1.4 LOGISTICS

The payload integration plan (PIP) will clearly define the role of the PGSC for each specific payload. The SSP is responsible for maintaining flight-ready PGSC systems for operation as authorized by the PIP. Section 3 provides an overview of the various PGSC hardware items. Standards Flight PGSC configuration are provided in Annex 1. If you have questions about PGSC logistics, please contact one of the Portable Onboard Computer Control Board Co-Chairman, B. Watkins at (713) 244-1335 or N. Woodbury at (713) 244-5790.

Figure 1-1. - Payload and General Support Computer (PGSC) with Expansion Assembly

1.5 CONTACTS

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Neil Woodbury, (713) 244-5790, Portable Onboard Computer Chairman

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Payload Operations Branch
Project Engineer for applicable payload

NASA/Johnson Space Center, mail code DO3
Mission Operations Procedures Branch
POC Coordinator for applicable flight

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein. In the event of conflict between the documents referenced and the contents of this document, the contents of this document shall be considered a superseding requirement.

U.S. Government Documents

FED STD 1020A	Telecommunications Electrical Characteristics of Balanced Voltage Digital Interface Circuits
NSTS 1700.7B	Safety Policy and Requirements for Payloads Using the Space Transportation System, January 1989

NASA documents

NSTS 07700, Volume XIV	Space Shuttle System Payload Accommodations (and 10 appendixes)
NSTS 21000-IDD-MDK	Shuttle/Payload Interface Definition Document for Middeck Accommodations
JSC-22448	Portable Onboard Computer Management Plan (Appendix J to the Crew Procedures Management Plan, JSC-08969)
JSC-17038	SSP Flight Equipment Non-Critical Hardware Program Requirements Document
JSC-27394	Orbiter Communications Adapter (OCA) End Item Specification Document

Industry documents

ThinkPad	ThinkPad 755C/755Cs User's Guide, March 1994 International Business Machines Corporation Armonk, NY.
EIA STD RS232C	Electronic Industries Association (EIA) Recommended Standards (RS) 232C: Interface between data terminal equipment and data circuit-terminating equipment employing serial binary data interchange.
EIA STD RS422A	Electronic Industries Association (EIA) Recommended Standards (RS) 422A: Electrical characteristics of balanced voltage digital interface circuits.

Industry documents (continued)

ONSITE Instruments Corp.	EXP Series Expansion “Tray” User’s Guide Onsite Instruments Mountain View, CA.
SEALEVEL	ACB-530 Part #4111 users manual Sealevel Systems Incorporated, 1994 IS0-COMM part no. 3417 users manual Sealevel Systems Incorporated, 1992
WIGSD	Windows Interface Guidelines for Software Design Microsoft Corporation, 1995

3.0 OVERVIEW

The PGSC computer assembly is a ThinkPad 755C model laptop computer that is IBM AT compatible, and has been modified for use in the Orbiter environment. The PGSC computer assembly and the following hardware items are GFE and are available for use on Space Shuttle missions. This list only represents commonly used GFE items. (Note: Contact B. Watkins at (713) 244-1335 or N. Woodbury at (713) 244-5790 for current GFE hardware items, and for current versions of software).

a. PGSC 486 (IBM ThinkPad 755C)
b. removable floppy drive
c. removable hard drive (540 MB)
d. battery pack
e. expansion assembly
f. power supply power cable
g. DC power supply assembly
h. PCMMU cable (24 ft.)
I. PCMMU port mode cable (1 ft.)
j. PCMMU PC board
k. RS-422 Y cable (15 ft.)
l. RS-422 cable (25 ft.)
m. RS-422 Iso Com PC board
n. PGSC 486 expansion assembly (PCMMU board and RS-422 board)
o. TV tuner
p. TV tuner adapter cable
q. DC power cable (25 ft.)
r. DC power cable (6 ft.)
s. RS-232 quad cable
t. RS-232C cable (25-9 pin)
u. RS-232A cable (9-9 pin)
v. RS-232 Y cable
w. PDIP RS-422 Y cable
x. removable hard drive (810 MB)
y. PCMCIA SCSI card with cable
z. PCMCIA GPIB (488) card with cable
aa. PCMCIA Ethernet card with cable
bb. PGSC 486 expansion assembly (OCA board and RS-422 board)
cc. PGSC 486 expansion assembly (OCA board and PCMMU board)
dd. OCA Ku-band/Audio Cable

Figure 3-1(a) and 3-1(b) depict the standard connectors found on the rear of the ThinkPad 755C and PGSC as described in paragraph 3.1.

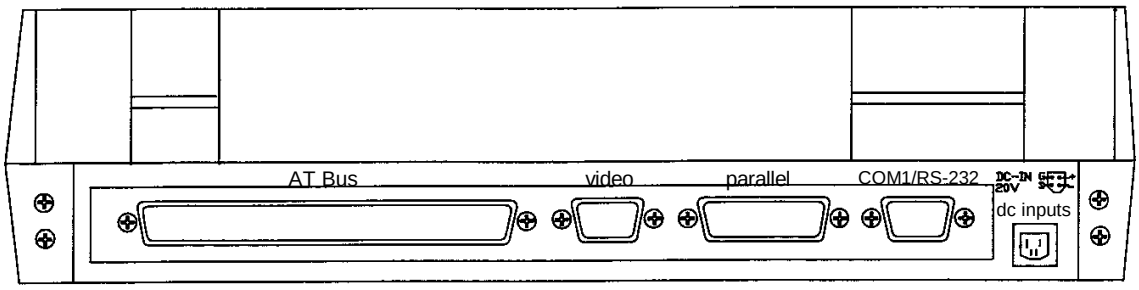
Figure 3-1(c) shows the rear of the expansion assembly.

Table 3-I is a summary comparison of the ThinkPad 755C and the PGSC assembly.

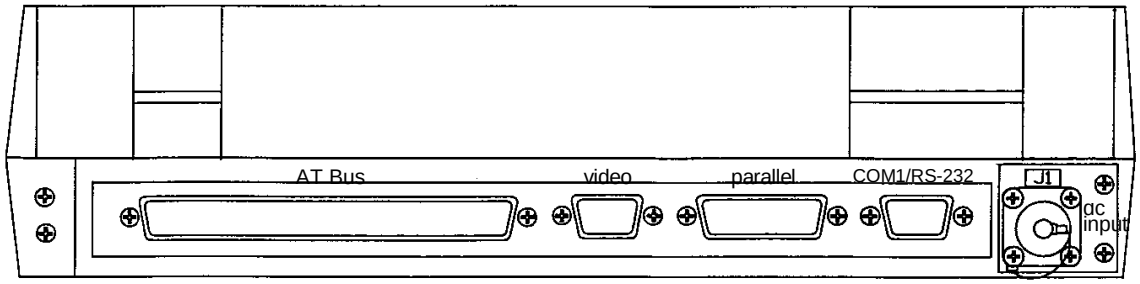
Figure 3-2 is a power interface diagram of the PGSC with cables identified.

Most information required by PGSC users can be found in the ThinkPad 755C manufacturer's information listed in Section 2.0 Applicable Documents.

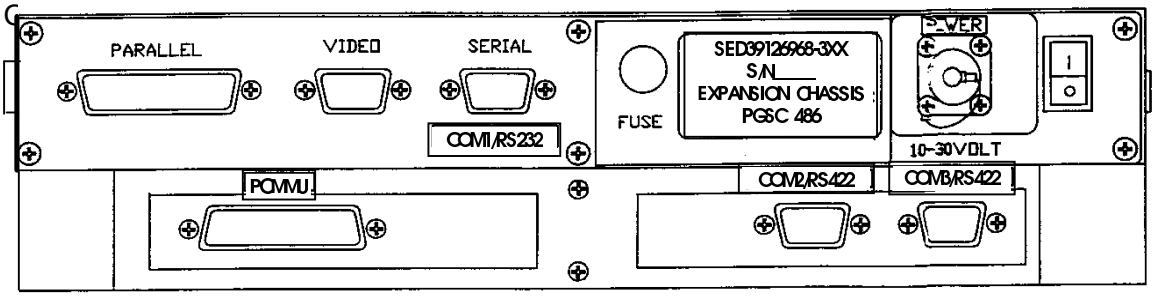
Figure 3-1. - PGSC/ThinkPad 755C rear view comparison



(a) ThinkPad 755C



(b) PGSC



(c) PGSC with Expansion Assembly

TABLE 3-I. - ThinkPad 755C/PGSC Comparison

	ThinkPad 755C	PGSC 486
32-bit 80C486 DX4 (75mhz) CPU	yes	yes
Floating Point Unit (FPU)	yes	yes
System memory (DRAM standard/optional)	4/36 Meg	12 Meg
1 Mb VRAM for display subsystem	yes	yes
128 kb BIOS Flash ROM	yes	yes
Color screen	yes	yes
640 x 480 X 256 pixel resolution	yes	yes
Bit-mapped graphic display capability	yes	yes
External SVGA compatible monitor connector	yes	yes
84 keys of standard IBM AT	yes	yes
External keyboard/mouse/keypad connector	yes	yes
One 3.5 in., 1.44 Mb internal floppy disk drive (removable)	yes	yes
External floppy drive connector	no	no
One removable hard disk drive	up to 810 Mb	540 or 810 Mb
One parallel printer port	yes	yes
One 28.8 baud modem (COM2)	optional	no*
One RS-232C port (COM1)	yes	yes
Two isolated RS-422A ports (COM2, COM3)	no	in expansion assembly
I/O expansion bus	yes	yes
28-Vdc isolated external power supply	no	yes*
Isolated internal dc power supply	yes	yes
Internal cooling fan	no	no
Internal dc power supply voltage	20V	20V
PCMCIA Connector (COM4)	yes	yes

* Modifications to the ThinkPad 755C for the PGSC

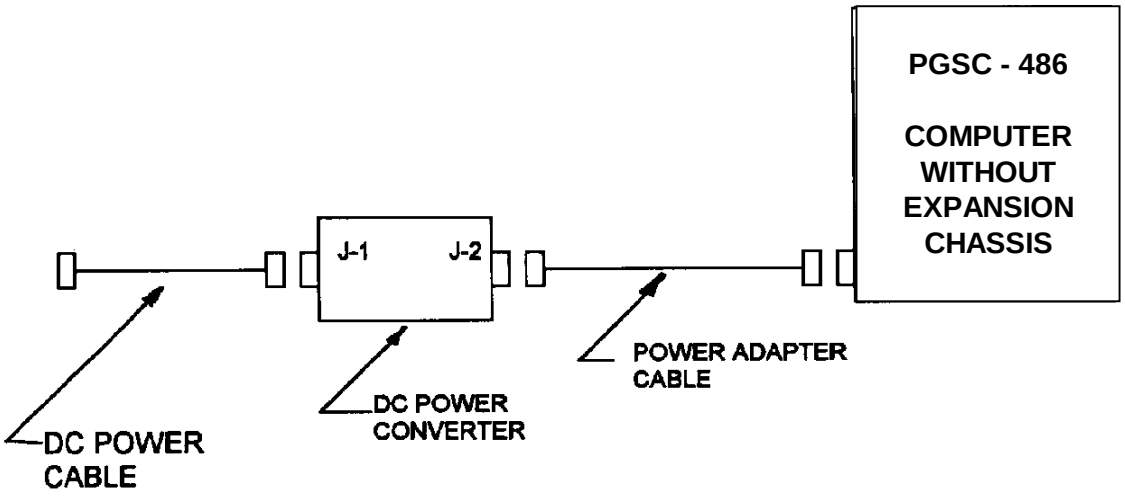


Figure 3-2. - PGSC power interface diagram

3.1 PGSC/ThinkPad 755C UNMODIFIED INTERFACES

The PGSC assembly is equipped with eight IBM standard interfaces as supplied by the original manufacturer, IBM Corporation. These are

- RS-232 serial input/output (I/O) port
- Parallel connector (Centronics)
- External input device connector
- External display connector
- PCMCIA slots (accepts two Type I or Type II PC cards, or one Type III PC card)
- Headphone jack
- Microphone/Line-in jack (supports a dynamic microphone or a self-battery-powered condenser microphone)
- System Expansion Connector

For more detailed information regarding these connectors, see IBM ThinkPad 755C/755Cs User's Guide.

3.1.1 RS-232 Serial I/O Port. The IBM ThinkPad 755C provides an IBM AT compatible RS-232 serial I/O port. For more information about this port, see section 7.

3.1.2 Parallel Port. The parallel port is functionally equivalent to the IBM AT printer adapter. The port supports Centronics-type (parallel) printers general purpose parallel I/O port. The interface is provided through a 25-pin, D-shell, female connector located on the rear panel.

3.1.3 External Input Device Connector. This is the port where you connect an external mouse, external keyboard, or external numeric key pad.

3.1.4 External Display Connector. This is the port where you connect the external display.

3.1.5 PCMCIA slots. Accepts two Type I or two Type II PC cards, or one Type III Personal Computer Memory Card Internal Association (PCMCIA) card. The PCMCIA slots provide an interface to the computer for data storage, memory, network interface, etc.

3.1.6 Headphone jack. 1/8-inch (3.5-mm) diameter jack where a stereo headphone or external speakers connect.

3.1.7 Microphone/Line-in jack. 1/8-inch (3.5-mm) diameter jack where a stereo microphone or external audio device is connected.

3.1.8 System Expansion Connector. This is the port used to connect the expansion assembly.

3.2 EXPANSION ASSEMBLY CONFIGURATION

Details of the standard PGSC 486 Configurations are provided in Annex1. Configuration 1 (PGSC 486 without Expansion Assembly) is listed in this section only to provide completeness for standard configurations. The PGSC with Expansion Assembly (Configuration 2, 3, & 4) contains the interfaces listed in section 3.1 plus the combinations of the following:

Configuration 1

Stand alone PGSC 486 without expansion assembly

Configuration 2

- 2, 9-pin Serial RS-422 port - Refer to Sealevel users manual for details.
- PCMMU port - The Pulse Code Modulation Master Unit (PCMMU) is the Orbiter central processing unit that includes all of the Orbiter downlink (OD) telemetry. Select PCMMU data may be de-commutated by the PGSC PC-DECOM software and routed via packetized data to other PGSC's.

Configuration 3

- OCA port - The OCA includes two functionally independent sections: the Ku-band interface and the modem interface. The OCA system, consisting of a single printed circuit board, associated software, and interface cable, provides a means for two-way transfer of computer files between a ground-based computer and a Payload and General Support Computer (PGSC) on-board the Orbiter.
- 2, 9-pin Serial RS-422 port - Refer to Sealevel users manual for details.

Configuration 4

- OCA port - The OCA includes two functionally independent sections: the Ku-band interface and the modem interface. The OCA system, consisting of a single printed circuit board, associated software, and interface cable, provides a means for two-way transfer of computer files between a ground-based computer and a Payload and General Support Computer (PGSC) on-board the Orbiter.
- PCMMU port - The Pulse Code Modulation Master Unit (PCMMU) is the Orbiter central processing unit that includes all of the Orbiter downlink (OD) telemetry. Select PCMMU data may be de-commutated by the PGSC PC-DECOM software and routed via packetized data to other PGSC's.

For more detailed information regarding these connectors, see IBM ThinkPad 755C/755Cs User's Guide, Onsite documentation, Sealevel documentation, and OCA documentation.

The current expansion assembly configuration 2,3, and 4 consist of a two slot chassis and that support standard computer cards. The typical power usage with the expansion assembly with card(s) is approximately 35 watts.

3.3 EXPANDED/EXTENDED MEMORY

The standard configuration of the PGSC assembly contains 12 Mb of random access memory (RAM). IBM DOS only supports the first 640 kb of RAM (conventional memory). To utilize the memory above 640 kb on the PGSC as either expanded memory standard (EMS) or extended memory standard (XMS), the ThinkPad 755C memory management program (or an equivalent program) must be installed. Extended memory is the memory that "extends" above the 1 Mb boundary. Expanded memory is memory that is paged above 640 kb but below 1 Mb.

The ThinkPad 755C memory management program uses approximately 4 kb of conventional memory and 380 kb or more of extended memory. The actual amount of extended memory used varies, depending on the amount of memory to be managed. ThinkPad 755C conforms to the Lotus-Intel-Microsoft (LIM) Expanded Memory Specification Version 4.0.

ThinkPad 755C is implemented as a device driver so other device drivers can take advantage of XMS memory. It runs in protected mode at the topmost addresses in extended memory. When ThinkPad 755C is active, MS-DOS programs run in a special mode of the 80C386 called Virtual 8086 Mode.

For more information regarding extended or expanded memory management on the PGSC, see ThinkPad 755C User's Guide.

3.4 ROM BIOS (READ ONLY MEMORY BASIC INPUT/OUTPUT SERVICES)

The current ROM BIOS in the PGSC is version 1.13, dated 7-20-94. Upgrades to the BIOS may occur in the future. If application software is dependent upon a certain BIOS version, the BIOS version number is stored in address F000:FFF5 in the PGSC memory in American Standard Code for Information Interchange (ASCII) format.

4.0 MECHANICAL

4.1 PHYSICAL OUTLINE

The PGSC 486 has almost the same footprints as the commercial IBM ThinkPad 755C. Its dimensions are 2.0 inches high, 11.7 inches wide, and 8.3 inches in depth with display folded down in the stowed position. For the PGSC with expansion assembly the dimensions are 3.5 inches high, 12 inches wide, and 15.5 inches in depth.

4.2 THERMAL

Do not block the inlet or outlet air holes on the Expansion Assembly during operation. Two air holes are located on the left side (front and back), and one air hole is located on the right side (front) of the Expansion Assembly. There is no fan on the actual ThinkPad, but there is a fan on the Expansion Assembly. The fan in the unit allows operation in the microgravity environment with a maximum touch temperature below the 113 degree F allowable limit.

4.3 VELCRO LOCATIONS AND OUTSIDE DIMENSIONS

The structural interface with habitable modules (Space Shuttle Orbiter, Spacelab, etc.) is with velcro. Refer to drawing SED39126017-303, Computer Assembly, Payload and General Support Computer (PGSC), for details of velcro placement, connectors, and markings. See Figure 4-1 for an illustration of velcro placement.

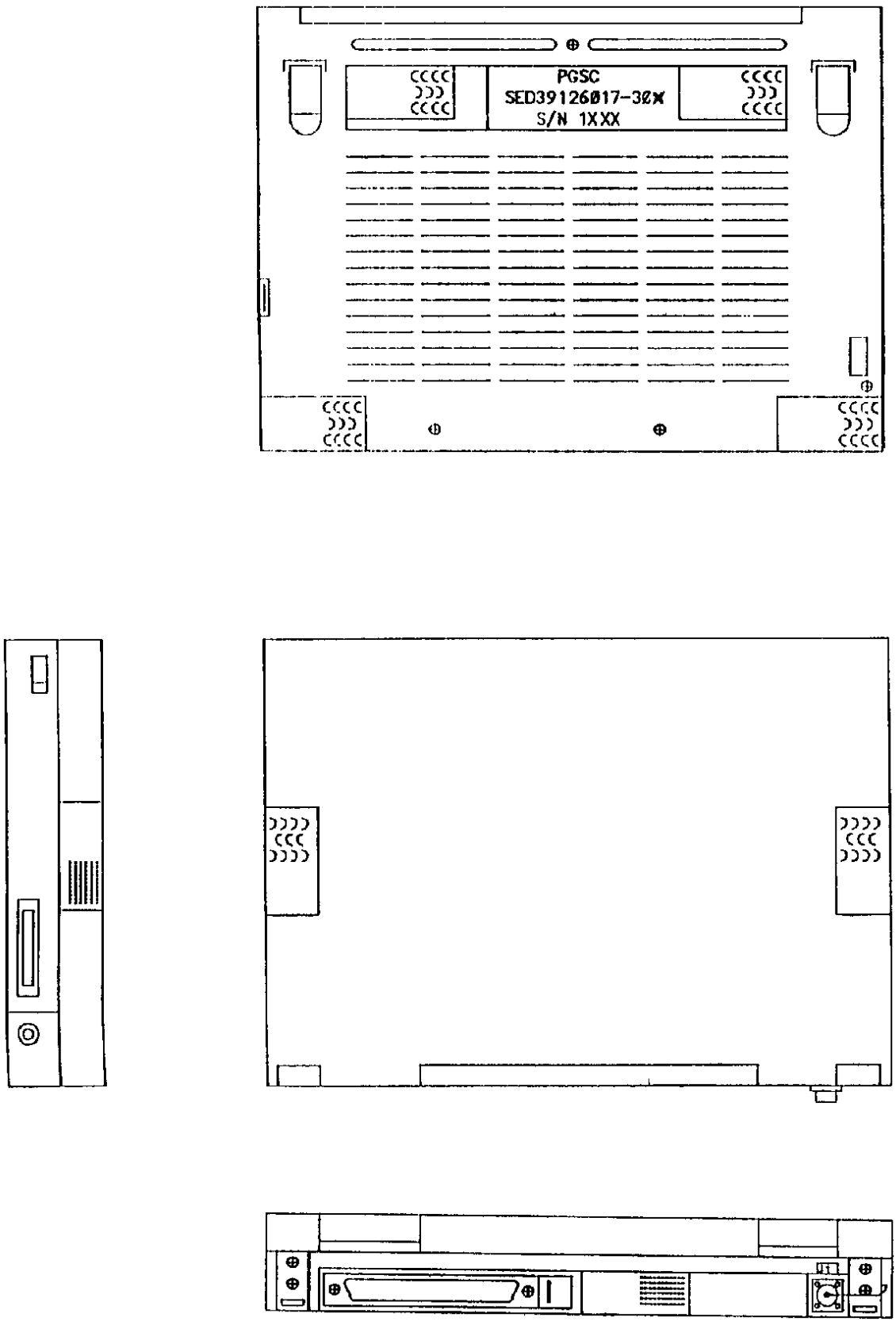


Figure 4-1. - Velcro Placement (for information only)

4.4 MOUNTING CONSIDERATIONS

Velcro strips are attached to the PGSC to aid in mounting the unit securely in a microgravity environment. When securing the unit, the following should be observed:

a. Do not block the multiple air holes located on the unit
b. Do not block access to the floppy disk port
c. Do not block access to the PGSC power switch
d. Place the unit in an area which allows the screen to be appropriately opened.

4.5 OPERATING PRESSURE RANGE

The PGSC operates at orbiter cabin pressures ranging from 14.7 to 10.2 psi.

4.6 HUMIDITY

The PGSC can operate in normal orbiter cabin humidity.

4.7 WEIGHT

PGSC assembly component weights are shown in Table 4-I.

4.8 ELECTROMAGNETIC COMPATIBILITY (EMC) CONSIDERATIONS

The PGSC is certified via the Space Shuttle Program Flight Equipment Non-Critical Hardware Program Requirements Document, JSC-17038, for on Orbit operations. EMC results for standard PGSC configurations can be made available by contacting the Portable Onboard Computer Control Board Co-Chairman, B. Watkins at (713) 244-1335 or N. Woodbury at (713) 244-5790. If payloads or experimenters have EMI concerns, they should perform proper PGSC EMC testing. All non-standard PGSC configurations will have to undergo proper EMC testing.

TABLE 4-I. - PGSC COMPONENT WEIGHTS

	Weight (lb)
PGSC 486	5.2
Removable floppy drive	0.50
Removable hard drive	0.50
expansion assembly	8.8
PCMMU PC board	0.35
RS-422 Iso Com PC board	0.5
DC power cable (25 ft)	1.25
DC power cable (6 ft)	0.5
DC power supply cable	0.75
DC power supply	1.5
PCMMU cable (24 ft)	0.75
PCMMU port mode cable (1 ft)	0.25
RS-422A Y cable (15 ft)	1.5
RS-422 cable (24 ft)	1.75
RS-232A cable (9-pin version)	1.25
RS-232C cable (25-pin version)	1.25
RS-232 Y cable	1.5
TV Tuner	0.6
TV Tuner Cable	0.1
Battery	1.25
RS 422 PDIP Y Cable	1.5
RS 232 Quad Cable	2.4
PCMCIA SCSI card/SCSI cable	0.3
PCMCIA Ethernet card/Ethernet cable	0.25
PCMCIA GPIB card/GPIB cable	0.75
OCA Board	1.5
OCA Cable	2.0
Modem Cable	0.5

5.0 POWER REQUIREMENTS

5.1 ELECTRICAL POWER CHARACTERISTICS

5.1.1 dc Power. Electrical power characteristics were determined by connecting a variable dc power supply to the PGSC. Current was measured for different input voltages, and readings were taken while the PGSC was running a program that caused approximately 75-80% of the screen pixels to be turned on. Results of the test are shown in Table 5-I.

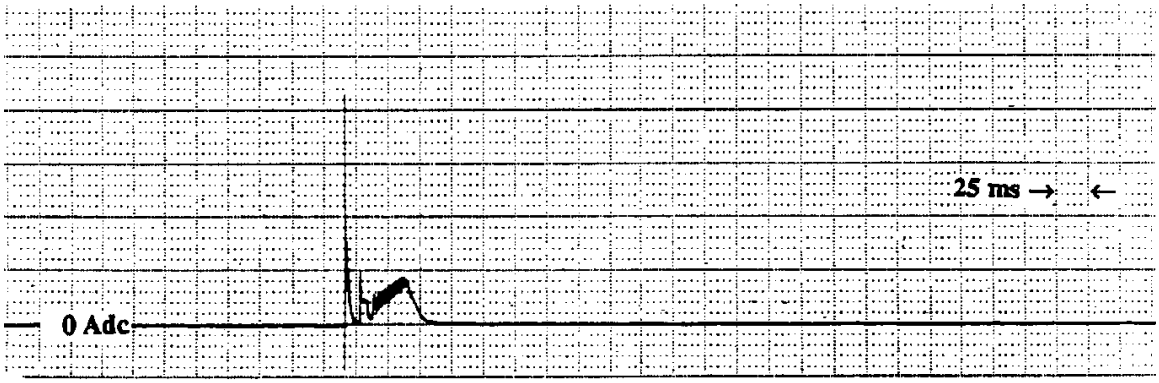
TABLE 5-I. - DC POWER TEST RESULTS

Input voltage (Vdc)	Current (amps)	Power (watts)
For PGSC only		
24.0	0.53	12.7
28.0	0.62	17.4
32.0	0.73	23.4
For PGSC with Expansion Assembly*		
24.0	1.33	32
28.0	1.17	32.8
32.0	1.03	33

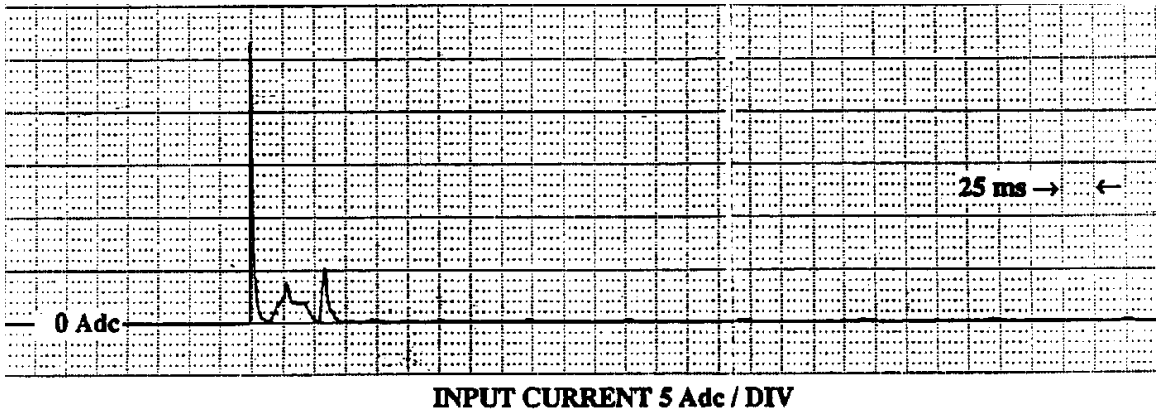
*Typical Expansion Assembly, Configurations 2, 3, and 4

5.2 CURRENT CHARACTERISTICS FOR POWER ON

Current requirements at power on are shown in Figure 5-1.



a. Current for PGSC



b. Current for PGSC with Expansion Assembly

Figure 5-1. - Power on current requirements

5.3 EXTERNAL POWER SUPPLY

An external dc to dc power supply is required for the PGSC computer without Expansion Assembly configuration.
Figure 5-2 below shows a sketch of an external power supply.

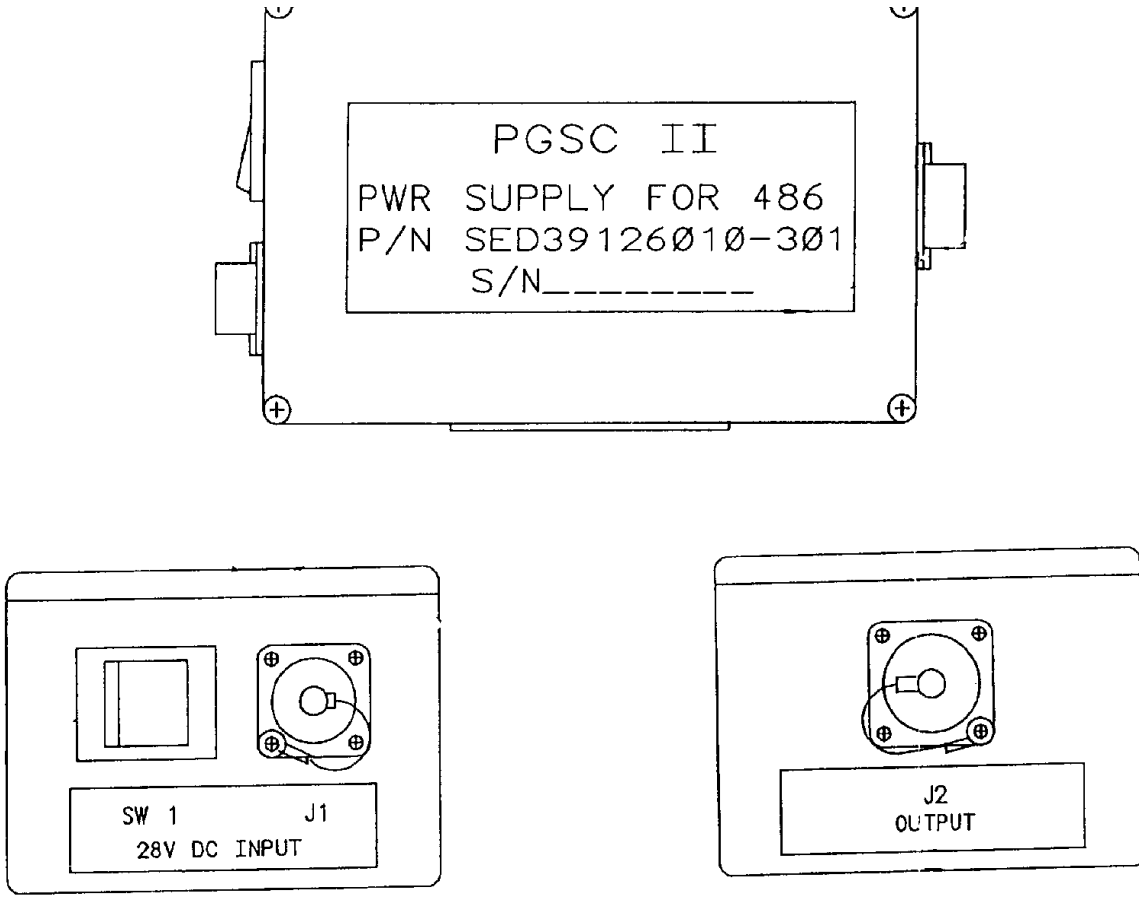


Figure 5.2 - External Power Supply

5.4 PAYLOAD-SUPPLIED POWER

Power may be provided to the PGSC through a middeck payload. The unique payload to the PGSC DC interface cable must be equivalent to the PGSC DC power cable (SED331033334).

6.0 SERIAL COMMUNICATIONS PORTS

The following tables summarize the serial communication port configurations and interrupt settings configurations for the PGSC 486 without an expansion assembly and the PGSC with expansion assembly.

Table 6-Ia. - PGSC 486 Serial Communication Ports Configuration 1

COM Port Description	COM Number	IRQ Number	I/O Address Location	DMA Channel	Controller
Internal RS-232	COM1	IRQ4	03F8-03FF	N/A	16550 UART Equivalent
PC-Card Ethernet	N/A	IRQ5		N/A	Internal to PC-Card

*IRQ 2 is also required to use IRQ9. IRQ2 is used as the cascade interrupt for controlling IRQ8 through IRQ15.

IRQ9 is also used for the PGSC 486 video controller.

Table 6-IIa. - PGSC 486 Interrupt Settings Configuration 1

Interrupt Num	Device	I/O Address	DMA Channel
IRQ0	Timer	0040-0043	N/A
IRQ1	Keyboard	0060,0064	N/A
IRQ2	Cascade Int.	N/A	N/A
IRQ3	Unused	TBD	N/A
IRQ4	RS-232 on Back	03F8-03FF	N/A
IRQ5	Ethernet PCMCIA	TBD	N/A
IRQ6	Floppy Disk	03F0-03F7	2
IRQ7	Parallel Port	03BC-03BE	N/A
IRQ8	Real Time Clock	0070-0071	N/A
IRQ9	Video Control	Video Addr*	N/A
IRQ10	Audio Card	4E30-4E3F	0 AND 1
IRQ11	Unused	TBD	N/A
IRQ12	Trackpoint II (mouse)	0060,0064	N/A
IRQ13	486 Floating Point Unit Exc (Math CoProc)	N/A	N/A
IRQ14	Hard Disk Drive	01F0-01F7 03F6-03F7	N/A
IRQ15	PCMCIA Control	03E0-03E3	N/A

Note: Chart is only valid for the PGSC 486 with no expansion unit.

*Video Addr = 03B4-03B5, 03BA, 03C0-03C9, 03CA, 03CC, 03CE-03CF, 03D4-03D5, 03DA, & 23C0-23C7

Table 6-Ib. - PGSC 486 Serial Communication Ports Configuration 2

COM Port Description	COM Number	IRQ Number	I/O Address Location	DMA Channel	Controller
Internal RS-232	COM1	IRQ4	03F8-03FF	N/A	16550 UART Equivalent
Exp. Unit RS-422 #1 (Card #1)	COM2	IRQ3	02F8-02FF	N/A	PC-16550 UART
Exp. Unit RS-422 #2 (Card #1)	COM3	IRQ7**	03E8-03EF	N/A	PC-16550 UART
Exp. Unit PCMMU (Card #2)	SCC1A and SCC1B	IRQ9*	0238-023F	1 and 3	Zilog 8530
PCMCIA (PC-CARD) Ethernet	N/A	IRQ5		N/A	Internal to PC-Card

*IRQ2 is also required to use IRQ9. IRQ2 is used as the cascade interrupt for controlling IRQ8 through IRQ15.

IRQ9 is also used for the PGSC 486 video controller.

**An interrupt conflict between the second RS-422 port and the parallel port is used at the same time. Simultaneous interrupt use should be avoided.

Table 6-IIb. - PGSC 486 Interrupt Settings Configuration 2

Interrupt Num	Device	I/O Address	DMA Channel
IRQ0	Timer	0040-0043	N/A
IRQ1	Keyboard	0060,0064	N/A
IRQ2	Cascade Int.	N/A	N/A
IRQ3	RS-422 #1	02F8-02FF	N/A
IRQ4	RS-232 on Back	03F8-03FF	N/A
IRQ5	Ethernet PCMCIA		N/A
IRQ6	Floppy Disk	03F0-03F7	2
IRQ7	RS-422 #2 & Parallel Port	03E8-03EF 03BC-03BE	N/A
IRQ8	Real Time Clock	0070-0071	N/A
IRQ9	PCMMU Card & Video Control	0238-023F Video Addr*	1 AND 3
IRQ10	Audio Card	4E30-4E3F	0 AND 1
IRQ11	Reserved for SCSI Card	CA000-CBFFF (Memory Loc)	N/A
IRQ12	Trackpoint II (mouse)	0060,0064	N/A
IRQ13	486 Floating Point Unit Exc (Math CoProc)	N/A	N/A
IRQ14	Hard Disk Drive	01F0-01F7 03F6-03F7	N/A
IRQ15	PCMCIA Control	03E0-03E3	N/A

Chart is only valid for the PGSC 486 with Configuration 2 expansion assembly.

*Video Addr = 03B4-03B5, 03BA, 03C0-03C9, 03CA, 03CC, 03CE-03CF, 03D4-03D5, 03DA, & 23C0-23C7

Table 6-Ic. - PGSC 486 Serial Communication Ports Configuration 3

COM Port Description	COM Number	IRQ Number	I/O Address Location	DMA Channel	Controller
Internal RS-232	COM1	IRQ4	03F8-03FF	N/A	16550 UART Equivalent
Exp. Unit* RS-422 #2 (Card #1)	COM3	IRQ7	03E8-03EF	N/A	PC-16550 UART
OCA/PADM	COM2	IRQ3	02F8-02FF 0200-0220	N/A	Unique
OCA/Ku-Band (KCA)	COM4	IRQ11	02E8-02EF 02E0-02E7	N/A	Unique
PC-Card (PCMCIA) Ethernet	N/A	IRQ5		N/A	Internal to PC-Card

*Only one of the two RS-422 ports available on the board will be enabled in this configuration. Placing a cap on the first port is recommended. The second RS-422 port should not be used at the same time as the parallel port due to interrupt conflicts.

Table 6-IIc. - PGSC 486 Interrupt Settings Configuration 3

Interrupt Num	Device	I/O Address	DMA Channel
IRQ0	Timer	0040-0043	N/A
IRQ1	Keyboard	0060,0064	N/A
IRQ2	Cascade Int.	N/A	N/A
IRQ3	OCA/PADM	02F8-02FF 0200-0220	N/A
IRQ4	RS-232 on Back	03F8-03FF	N/A
IRQ5	PCMCIA Ethernet		N/A
IRQ6	Floppy Disk	03F0-03F7	2
IRQ7	RS-422 Port #2 Parallel Port	03E8-03EF 03BC-03BE	N/A
IRQ8	Real Time Clock	0070-0071	N/A
IRQ9	Video Control	Video Addr*	N/A
IRQ10	Audio Card	4E30-4E3F	0 and 1
IRQ11	OCA/Ku-Band	02E8-02EF 02E0-02E7	N/A
IRQ12	Trackpoint II (mouse)	0060,0064	N/A
IRQ13	486 Floating Point Unit Exc (Math CoProc)	N/A	N/A
IRQ14	Hard Disk Drive	01F0-01F7 03F6-03F7	N/A
IRQ15	PCMCIA Control	03E0-03E3	N/A

Chart is only valid for the PGSC 486 with Configuration 3 expansion assembly.

*Video Addr = 03B4-03B5, 03BA, 03C0-03C9, 03CA, 03CC, 03CE-03CF, 03D4-03D5, 03DA, & 23C0-23C7

Table 6-Id. - PGSC 486 Serial Communication Ports Configuration 4

COM Port Description	COM Number	IRQ Number	I/O Address Location	DMA Channel	Controller
Internal RS-232	COM1	IRQ4	03F8-03FF	N/A	16550 UART Equivalent
PCMMU (Card #1)	SCC1A and SCC1B	IRQ9*	0238-023F	1 and 3	Zilog 8530
OCA/PADM (Card #2)	COM2	IRQ3	02F8-02FF 0200-0221	N/A	Unique
OCA/Ku-Band (KCA) (Card #2)	COM4	IRQ11	02E8-02EF 02E0-02E7	N/A	Unique
PC-Card Ethernet	N/A	IRQ5		N/A	Internal to PC-Card

*IRQ2 is also required to use IRQ9. IRQ2 is used as the cascade interrupt for controlling IRQ8 through IRQ15.

*IRQ9 is also used for the PGSC 486 video controller.

Table 6-IId. - PGSC 486 Interrupt Settings Configuration 4

Interrupt Num	Device	I/O Address	DMA Channel
IRQ0	Timer	0040-0043	N/A
IRQ1	Keyboard	0060,0064	N/A
IRQ2	Cascade Int.	N/A	N/A
IRQ3	OCA/PADM	02F8-02FF 0200-0221	N/A
IRQ4	RS-232 on Back	03F8-03FF	N/A
IRQ5	PCMCIA Ethernet		N/A
IRQ6	Floppy Disk	03F0-03F7	2
IRQ7	Parallel Port	03BC-03BE	N/A
IRQ8	Real Time Clock	0070-0071	N/A
IRQ9	PCMMU and Video Control	0238-023F Video Addr*	1 and 3
IRQ10	Audio Card	4E30-4E3F	0 and 1
IRQ11	OCA/Ku-Band	02E8-02EF 02E0-02E7	N/A
IRQ12	Trackpoint II (mouse)	0060,0064	N/A
IRQ13	486 Floating Point Unit Exc (Math CoProc)	N/A	N/A
IRQ14	Hard Disk Drive	01F0-01F7 03F6-03F7	N/A
IRQ15	PCMCIA Control	03E0-03E3	N/A

Chart is only valid for the PGSC 486 with Configuration 4 expansion assembly.

*Video Addr = 03B4-03B5, 03BA, 03C0-03C9, 03CA, 03CC, 03CE-03CF, 03D4-03D5, 03DA, & 23C0-23C7

6.1 RS-232C COMMUNICATIONS

The PGSC contains one RS-232C asynchronous serial I/O port which provides a communication link between the PGSC and an external device. This is a standard serial port as defined in EIA STD RS232C. This port is a 9-pin version compatible with an IBM PC-AT 9-pin serial port. For RS-232C cable pinouts and description, see paragraph 8.2.1.

6.1.1 Line Drivers/Receivers. The PGSC uses standard bipolar line drivers/receivers, the 1489 transmitter and the 1488 receiver.

The 1488 line driver is capable of producing 14.8 mA current. Information regarding the line drivers/receivers is readily available in published data manuals.

6.2 RS-422A COMMUNICATIONS

The RS-422A PGSC interface is a standard off-the-shelf “SEALEVEL” AT compatible PC board (part number 3417). The iso-com board uses a 16550 UART with programmable baud rate and data formats. Consult the User’s Manual for more information.

RS-422A allows very long distance (5,000 ft. at 9,600 baud) communication with virtually error free differential drive characteristics. The iso-com board provides the PGSC with two ground isolated serial ports. NOTE: Certain Expansion Chassis configurations have one of the ports disabled.

7.0 INTERFACE CABLES

7.1 POWER CABLES

The PGSC configurations use Space Shuttle 28-Vdc power supplied only through a PGSC dc power cable. If the PGSC is powered through the payload, then the proper connector mates are the following:

dc Cable connector = MS3475L-8-33S
dc Mating connector = MS3470L-8-33P

7.1.1 The PGSC Power Cable (25 feet). The dc power cable, part number SED33103334, connects the PGSC with the 28-Vdc Space Shuttle power or experiment dc power. For details see Figure 7-1.

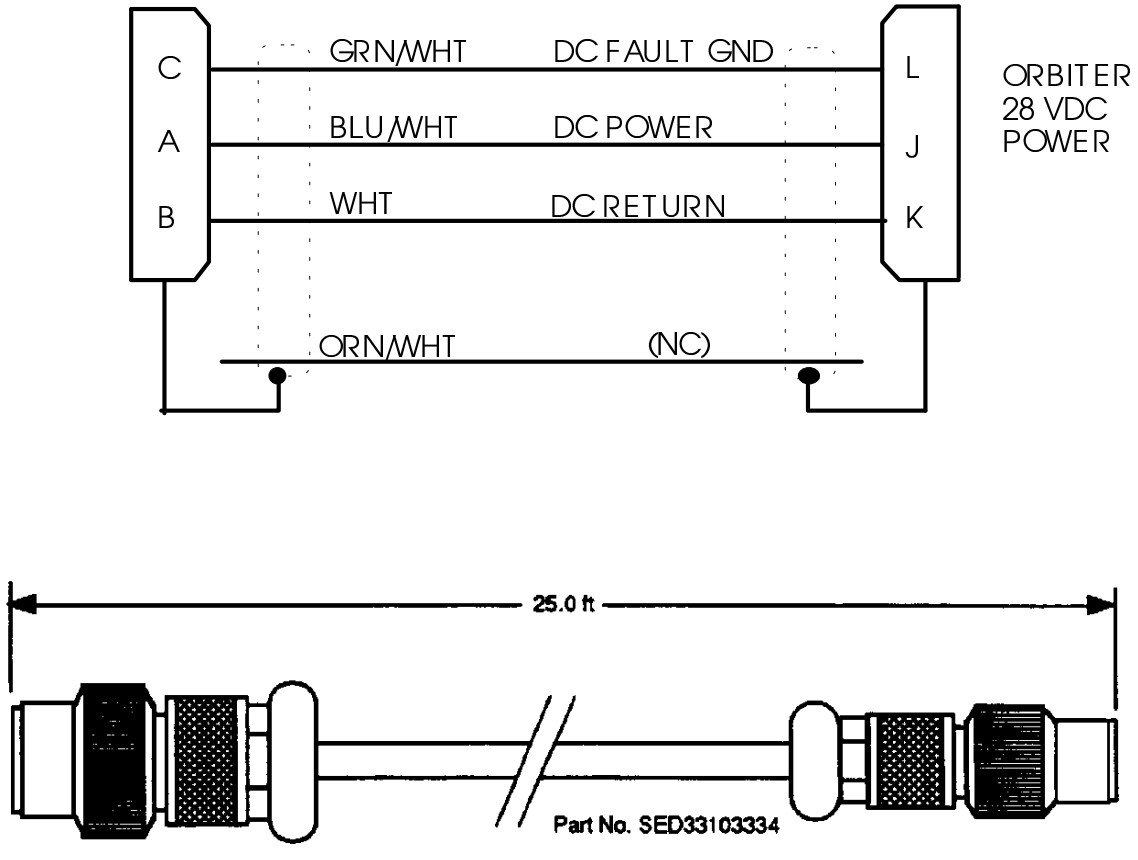


Figure 7-1. - The dc power cable (25 feet)

7.1.2 The PGSC Power Cable (6 feet). The dc power cable, part number SED39122875, connects the PGSC with either the 28-Vdc Space Shuttle power experiment 28-Vdc power. For details, see Figure 7-2.

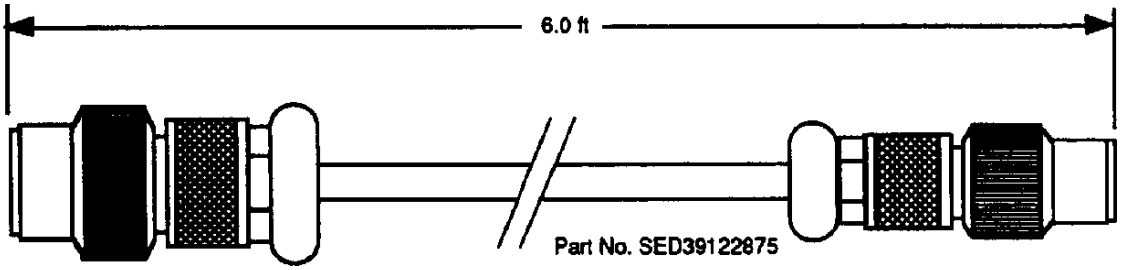


Figure 7-2. - The dc power cable (6 feet)

7.1.3 The dc Power Supply. The dc power supply cable SED39126013 is required with the PGSC power cable and dc to dc power supply to supply power to the PGSC computer configuration only. For details see Figure 7-3.

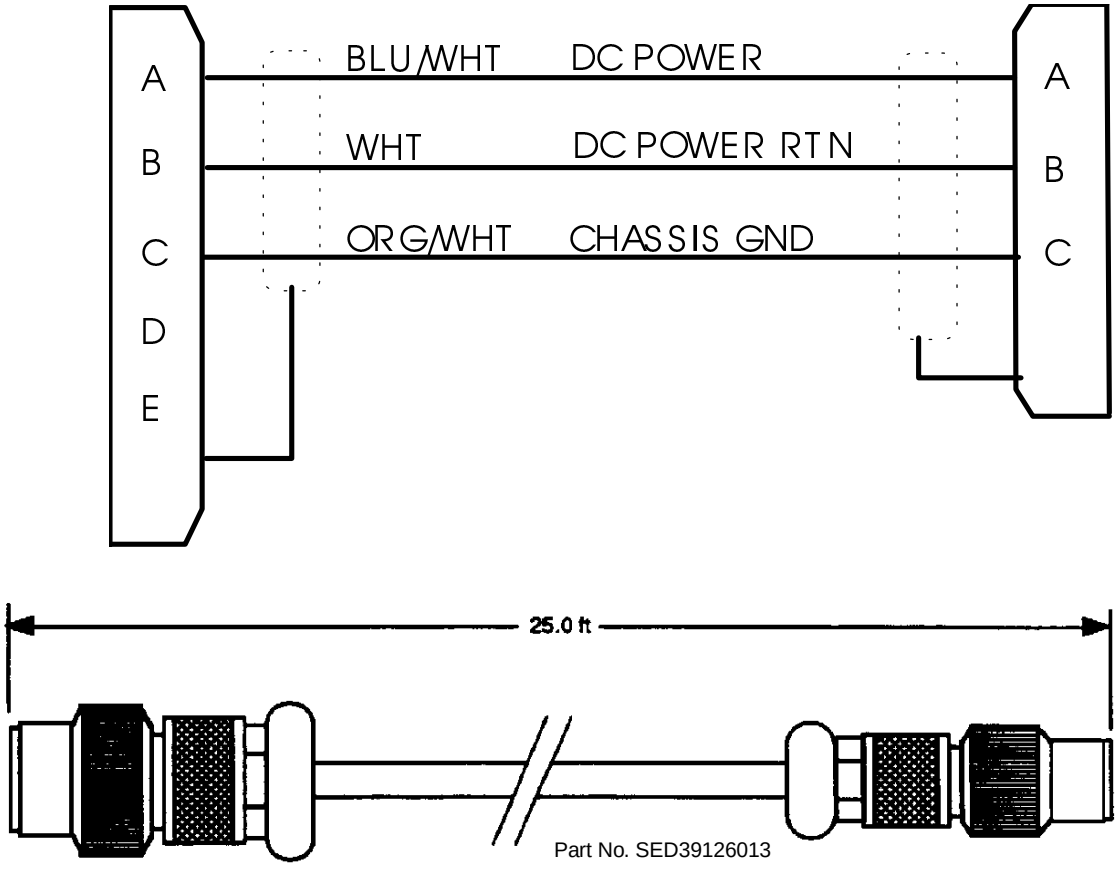


Figure 7-3. - The dc power cable (25 feet)

7.2 COMMUNICATION CABLES

Communication with payloads is accomplished via cables provided for the RS-232C port (for cabin payloads), and the two RS-422A ports (for payload bay payloads).

7.2.1 RS-232C Cables. Two 14-foot RS-232C cables are provided for experiments located in the orbiter cabin. The first cable, a DB9 (female) to DB25 (male) part number SED33103335, is fully compatible with an IBM AT serial cable. The second cable is a DB9 (female) to DB9 (male), part number SED33103348. Refer to Table 7-I for the proper connector mates. For details of each cable schematic, see Figures 7-4 and 7-5. RS-232 Y and Quad cables are also provided for PCMMU PGSC output to experiment PGSC connections.

Table 7-I. - RECOMMENDED CONNECTOR MATES FOR THE RS-232C CABLES

	Cable end	Experimenter/panel mate	Jackport
25-pin (Figure 7-4)	AMP206800-2	AMP206801-2 *	ITT D110551
9-pin (Figure 7-5)	AMP207252-2	AMP207253-2 *	ITT D110551

* or equivalent

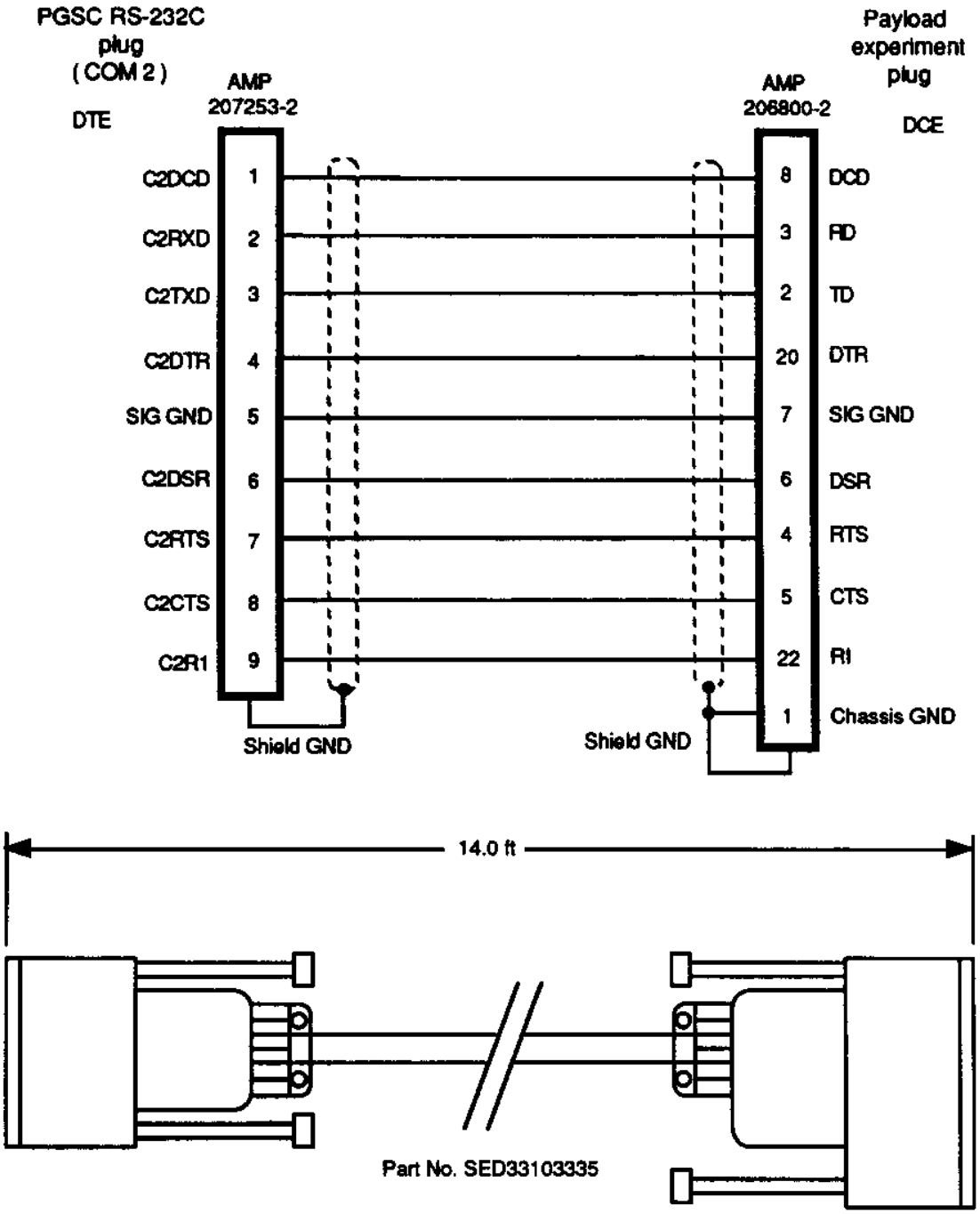


Figure 7-4. - DB9F to DB25M RS-232C cable schematic.

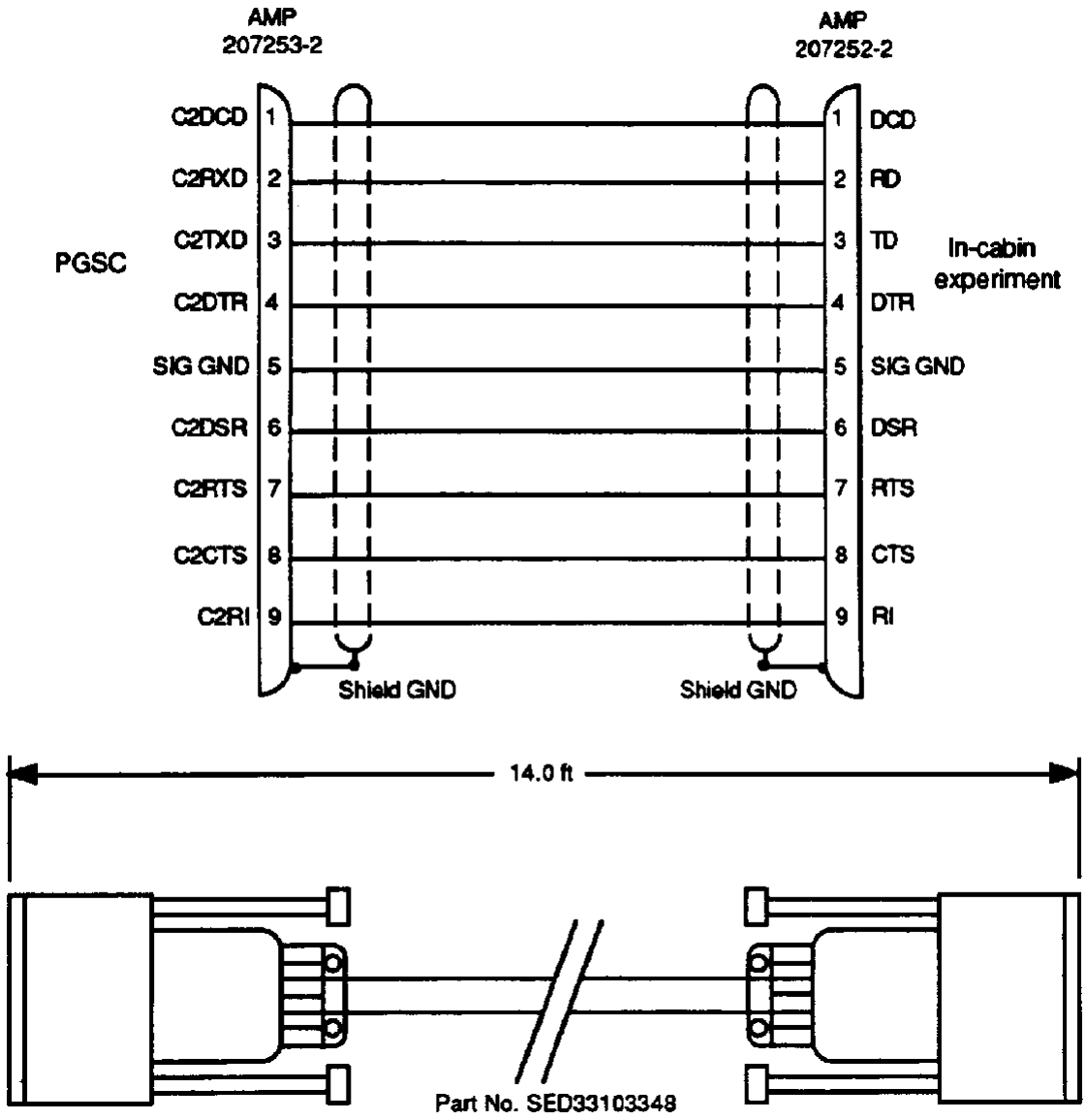


Figure 7-5. - DB9F to DB9M RS-232C cable schematic.

7.2.2 RS-422A Cables. One RS-422A cable provides a communication link between the PGSC and payload in the payload bay. This cable connects the PDIP or CIP to the PGSC. The PDIP/CIP connector has a part number of NLS6GT12-35P and is a male connector. The CIP and PDIP are shown in Figures 7-6 and 7-7. A DB9-S female connector mates with RS-422A connector located on the Expansion Assembly of the PGSC. A schematic of this cable is provided in Figure 7-8. The RS-422A Y cable is used to transfer information between two or three PGSC's. A schematic is provided in Figure 7-9.

7.2.3 PDIP RS-422 Y cable a provides communication link between the payload and two PGSC configurations. A schematic is provided in Figure 7-10.

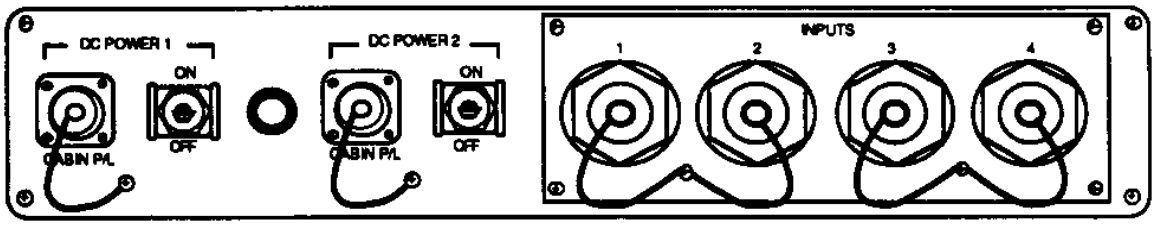


Figure 7-6. - Computer interface panel

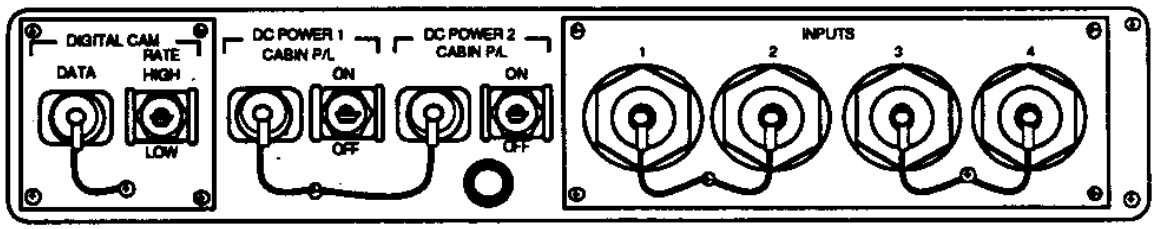


Figure 7-7. - Payload data interface panel

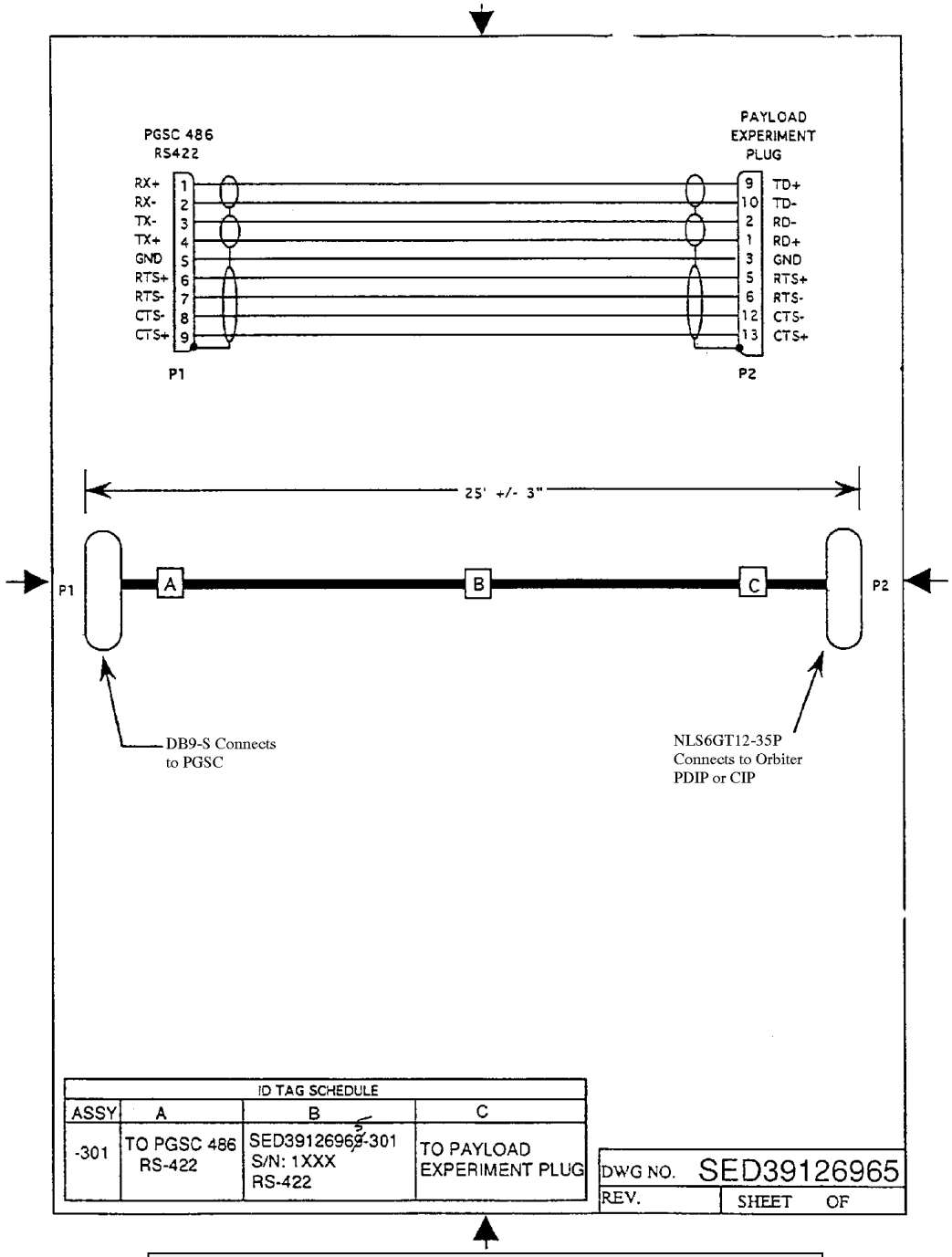


Figure 7 -8. - RS422/Channel 1 cable schematic

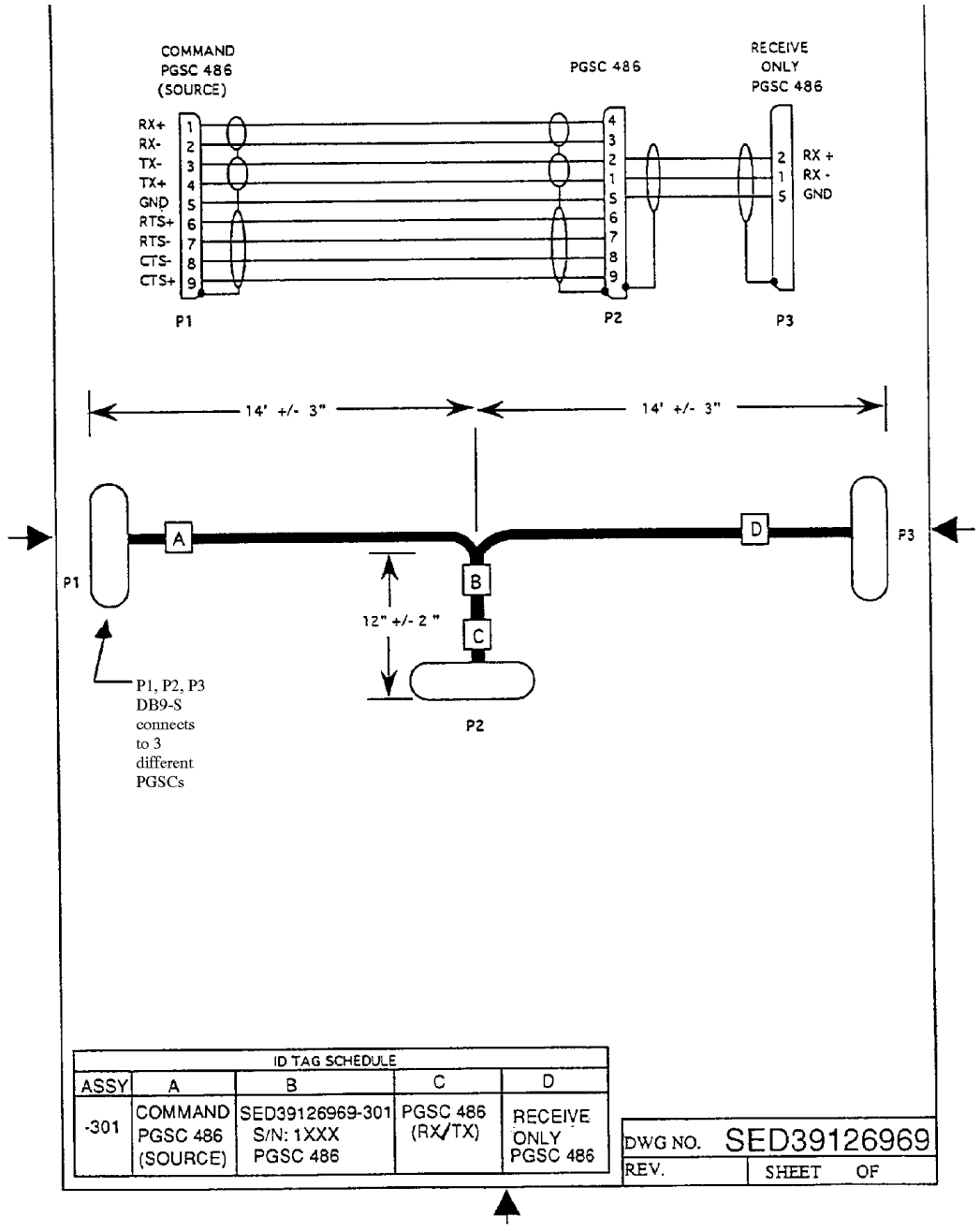


Figure 7 - 9. - RS422Y/cable schematic

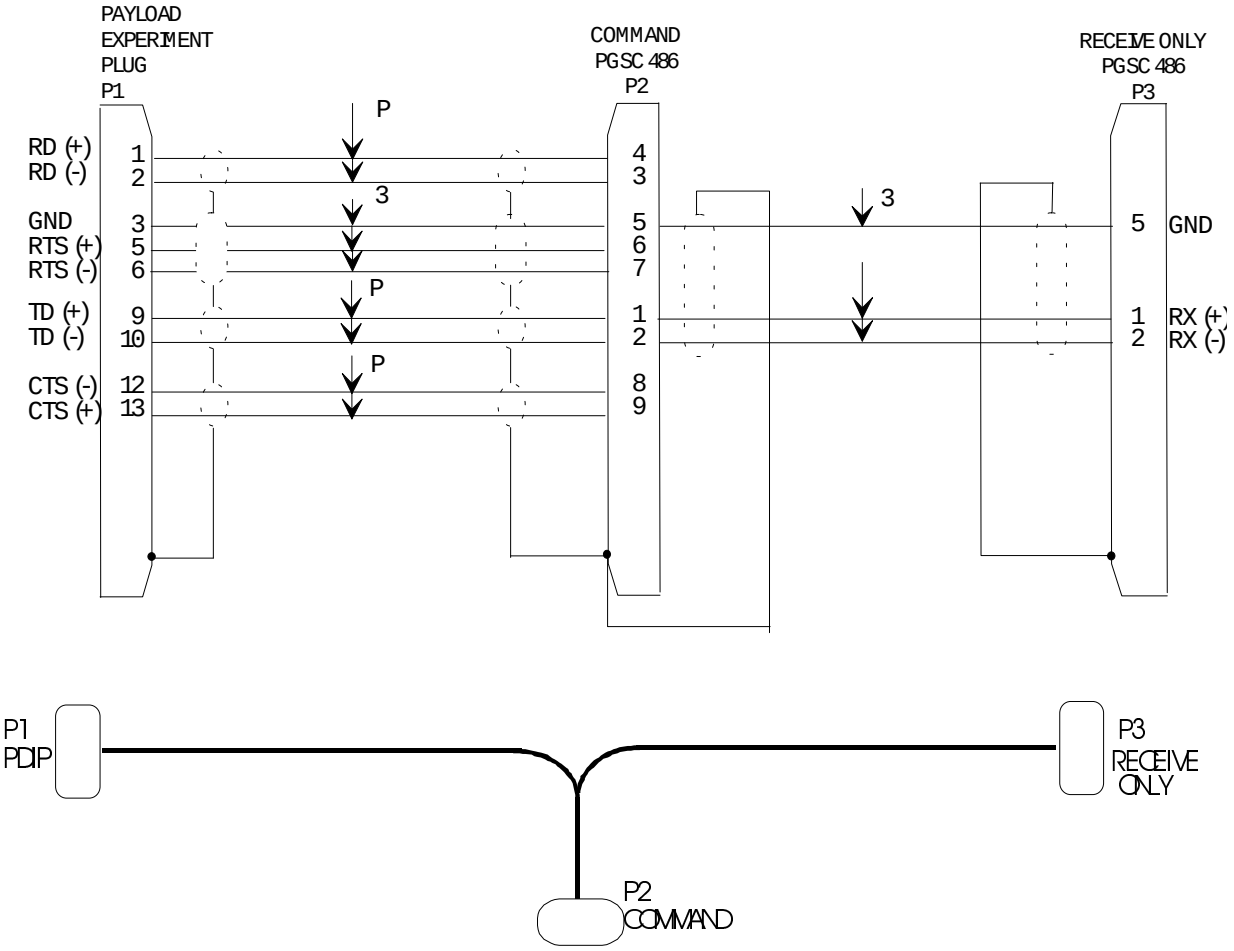


FIGURE 7-10. - SED39126972 - PDIP RS-422 Y cable

8.0 USER INTERFACE PROGRAMMING STANDARDS AND GUIDELINES

8.1 PURPOSE

User interface programming standards and guidelines have been developed to provide SSP customers with an efficient and flexible environment for development of POC applications. The approach used to develop these standards relies on using industry standards and a minimum of mandatory requirements which could constrain software development flexibility. The emphasis has been placed on establishing guidelines designed to achieve the following mission success objectives:

a. Efficient use of flight crew time while on-orbit.
b. Efficient use of flight crew and flight controller training time.
c. Minimize training.
d. Consistent input and output formats.
e. Maximize the probability and degree of mission success.
f. Efficient data entry.
g. Protection from catastrophic errors, such as loss of most or all of the data.
h. Provide a flexible software development environment.

8.1.1 SCOPE

The following standards and guidelines are applicable to all software developed for use on an SSP POC. Because the SSP currently has selected IBM-compatible machines as the PGSC, the use of DOS and Windows is assumed. Programs running under UNIX on a PGSC are encouraged to follow the DOS and Windows guidelines as much as possible. Although these guidelines specifically do not apply to COTS software, whenever possible, COTS software consistent with these guidelines is preferable to software which is not. Guidelines for UNIX and X-Windows may be developed later.

8.2 STANDARDS AND GUIDELINES

Industry standards have been developed in many User Interface Guides and it would be wasteful to repeat the work or copy the complete results here. The evolution towards Windows based operating systems and the current use of Microsoft Windows 3.1 (or later versions) on the PGSC dictate that new applications be programmed to operate in a Windows environment whenever possible. The document “The Windows Interface: Guidelines for Software Design”, Microsoft Corporation, 1995 is the primary source for defining the standards and guidelines for Windows Interfaces. Its principles easily apply to DOS applications in most situations; i.e. good DOS applications resemble Windows applications. It is strongly recommended that anyone developing programs for PGSCs read this document, abbreviated WIGSD, beginning with the introduction. To easily see examples of successful implementation of these guidelines, try using such COTS products as MS Office. The Astronaut Office uses these products, currently Word 6.0, Excel 5.0, Powerpoint 4.0, for example, as their standard office software and crews are likely to be most familiar with the WIGSD conventions these products use. The Astronaut Office is currently upgrading to WIN 95 and Microsoft Office 95 and is expected to complete the transition by October 1996.

Earlier versions of Appendix J contain guidelines and standards for DOS PGSC applications. A number of these guidelines conflict with the WIGSD. For example, DOS PGSC programs were required to use a certain keystroke sequence for toggling tones, however, that choice conflicts with the WIGSD. New development projects should use the WIGSD and this document as their

primary source for development guidelines. Please feel free to contact the POC Control Board Chairs, Bobby Watkins at (713) 244-1335 or Neil Woodbury at (713) 244-5790.

As the WIGSD document admits, it is not a complete set of guidelines. New situations will arise in which interface decisions will need to be made. A thorough understanding of the existing documentation will assist in making good decisions. In any case, common sense will always be invaluable in implementing whatever guidelines are used.

The following are broad guidelines for developers:

- Coordinate regular reviews and demos of displays and user interfaces with the crew and flight control team as early as possible in the development cycle.
- Use standard STS nomenclature in display.
- Provide or display only data important to mission success and significant in terms of crew interface.
- Protect data from inadvertent errors and hardware failures (with range checking on input, etc.)
- The customer will be assigned specific directories where all files of the application(s) will reside.
- An application cannot modify ".ini" files in the windows subdirectory, without POCCB approval.
- An application may only use one timer.
- Applications must use standard DOS Read/Write commands.
- Applications cannot be TSR (Terminate/Stay Resident) programs.
- No more than 1.5 MB of extended memory (this includes the COMMAND.COM file if a DOS application) is available.
- Applications need to be compatible with STS startup files (e.g. config.sys, autoexec.bat) and use no more than 540K conventional RAM.
- Applications must be compatible with PC-DOS 6.3 and Win 3.1 through STS-79 and to Win 95 for STS-80 and subsequent flights.

For purposes of clarity, the "Notation for Keys and Key Combinations" guidelines from the WIGSD, Introduction, page xi, as appropriate for this document are repeated here:

- Key names appear in capitals; for example, CTRL or SHIFT.
- Simultaneous key combinations are linked by plus signs; for example, CTRL+B or CTRL+SHIFT+B. This notation indicates that the user should hold down the CTRL key while pressing the B key; or hold down the CTRL and SHIFT keys while pressing the B key.

- Sequential key combinations are linked by commas; for example: ALT,F. This notation indicates that the user should press and release the ALT key, and then press and release the F key.

This notation will be used for describing key strokes in this document and is the standard notation for Flight Data File procedures as well.

8.2.1 INITIALIZATION

Initialization is an orderly procedure which must be followed to ensure proper operation of the PGSC and the software package. Automatic initialization from data files or available data streams is desirable and may also include opening files for logging data, keystrokes, or recording application messages. A message should be presented with the names of the data files to the user as part of the program initialization and termination status. If the user is presented with options during initialization the consequences of the selection should be displayed before user action is required.

In the event that the application is unexpectedly restarted without first having gone through a normal shutdown, there should be a method for the application to determine the state of any equipment to which it interfaces and report that to the user. The application should be responsible for its own recovery as much as possible.

There are two rebooting techniques:

a. Warm boot - CTRL+ALT+DEL
b. Cold boot - Power off, wait five seconds, power on

A warm boot resets registers, closes files, clears memory, and sets everything to its initial state. A cold boot does the same things, but also performs a diagnostic check first.

8.2.1.1 Hard Disk Boot

Unstow the PGSC and connect to the appropriate power. Power on the PGSC. If applicable, connect the PGSC to any external hardware. The PGSC will automatically boot to the hard disk. Most applications on the hard disk will be made accessible through the use of icons in the Windows Program Manager screen (including DOS applications). The Program Manager and its options are controlled by the POCCB.

8.2.1.2 Floppy Disk Boot

Unstow the PGSC and connect to the appropriate power. If applicable, connect the PGSC to any external hardware. Insert a bootable floppy diskette in the disk drive. Power up the PGSC. The PGSC 486 will automatically try to boot from a floppy in the floppy drive upon power up. The software application should be executed in the autoexec.bat file.

8.2.2 ACCESS TO DOS

Applications should not require the crew to access DOS at any time. Once the computer has been initialized the software should not terminate to DOS. If DOS level commands are required, developers should include a file manager option that allows only the DOS level commands required for proper operation of the application. The commands issued are to be limited to keystrokes or menu selections.

8.2.3 COMMAND AND FUNCTION EXECUTION

a. Minimize the number of keystrokes or mouse movement needed to perform simple or routine functions and commands.

b. Order the items in any menu in some logical order, either by importance or usage.

8.2.4 COMMAND ACKNOWLEDGMENT

The command-message-acknowledge sequence shall be used for all command executions that have a substantial impact on mission success. The rationale for this requirement is to prevent inadvertent command execution by the crew. Substantial impact on mission success includes, for example, rapid shutdown, discontinuing data collection, erasing data or abandoning work prematurely resulting in significant lost time.

The use of an arm-fire command execution sequence such as ALT+RETURN (and SYS REQD+RETURN) has been used extensively in previous PGSC DOS applications to protect against inadvertent commands in the zero-g environment. It is desirable that no single keystroke be able to substantially affect program operation. In the Windows environment the use of arm-fire for commands is satisfied by using the mouse, menu commands, or shortcut key sequence of greater than one keystroke. (Note: When Windows warning messages are produced, the user will acknowledge with a single keystroke, <Enter>).

The following is an example of this approach for a DOS application with no mouse capability.

Sample menu:
Options

Continue	Continue to next process step
Save	Save current data and continue processing
Exit	Terminate run, users prompted as to whether or not to save data, save data, and return to main menu

Example of user actions:

a. User selects “Exit” from menu using mouse or ALT+O.

b. Selection is followed by the message:
“Program termination requested, data has not been saved.”
“Press ALT+RETURN to confirm or ALT-S to save data first.”

c. User selects ALT+RETURN to confirm.

For an application with mouse capability, step 2 could be:

d. Selection is followed by the message:
“Program termination requested, data has not been saved.”

The two buttons might be: “OK” and “Cancel” with the default being Cancel.

8.2.5 RAPID SHUTDOWN

A rapid shutdown function must be provided in applications that generate data needing to be saved or that connect to any external device. The rapid shutdown functions will provide the crew with the capability to rapidly discontinue operation of an experiment in an orderly manner. The orderly shutdown should be designed to save accumulated data and preserve mission success to the greatest extent possible, consistent with an expeditious shutdown. This capability would be used in the event of a mission contingency that requires immediate crew attention and termination of middeck or payload activities. The rapid shutdown function should terminate operation of the application within 15 seconds.

In all applications, the rapid shutdown function will be a command-message-acknowledge sequence initiated by ALT+F4. If a rapid shutdown is different than a normal shutdown, a rapid shutdown shall be a menu item in a logical place or a choice upon selecting exit or ALT+F4. A rapid shutdown request should be followed by a message requesting confirmation. A DOS application should display:

> "You have requested RAPID SHUTDOWN of this application.
> <Mention consequences.>
> Press ALT+ to confirm."

A Windows application should display:

> "You have requested RAPID SHUTDOWN of this application.
> <Mention consequences.>
> Do you wish to continue?"

Include buttons "Yes" and "No" or "OK" and "Cancel? " The default in each case should be to cancel the rapid shutdown.

8.2.6 HELP FUNCTIONS

Help information should be provided for all programs. Help information must be provided if CTRL, ALT, SHIFT, or function key activated commands are available from a display and not explained on the display. The preferred approach to providing help information about a display is to include action and keystroke explanations on the display itself. However, if display space constraints make on-screen help information impractical or if additional information is desirable, help information may be provided by use of help windows or displays or if absolutely necessary by using a cue card. Use of cue cards should be avoided.

8.2.7 SOFTWARE VERSION IDENTIFICATION

Software shall be identified by a version number and effective date. The version and effective date should be assigned by the organization responsible for software development. Each time a software update is delivered to the POCCB, the version number must be incremented and a new effective date established. The appropriate version and effective date should be displayed on the floppy disk label and must be accessible somewhere in the program (usually in Help/About... menu/menu-item). If flight specific data is required the flight ID, version number, and effective date should be displayed.

8.2.8 DATA INPUT

a. If data is needed in an application, it should be accessed directly or automatically rather than by crew input. If crew input is required, a reference to the data source should be displayed on-screen. (e.g. A static display can be applied to indicate the SPEC or GPC display number where the data can be found).

b. To the extent possible, verify crew inputs and provide out-of-limits response messages and instructions to re-enter data.

c. Offer default values for inputs. When possible, provide numeric input units and valid range limits on the input display screen. Values should be fully editable with all the normal editing keys available: RIGHT and LEFT ARROW, HOME, END, and BACKSPACE. TAB, SHIFT-TAB, PGUP, PGDN, and RETURN should all be used per the WIGSD for navigating between values and Dialog boxes.

d. Lock out or trap invalid keystrokes. For example, if valid menu selections include only ALT+A, ALT+B, and ALT+C, the application should provide some indication that an invalid input has been made.

e. The software developer should consider providing an internal clock update capability in the software application. The PGSC internal clock is set to GMT prior to launch with an accuracy delta of about five seconds per day. If greater accuracy is desired, an internal update capability should be accessed and the crew should be instructed to check clock accuracy regularly. In addition, the PGSC internal clock is powered by the internal battery pack during stowage prior to launch and may require resetting if the battery pack should discharge.

8.2.9 OUTPUTS

a. The amount of data presented and displayed should probably be proportional to the amount of crew training and on-orbit time. Therefore, it is important to carefully consider which data to provide and/or display to the crew. Data which is most important to mission success and the crew interface should receive priority and emphasis. Additional data, which may be interesting or has a lower potential for being useful, should be placed in secondary displays or be optionally available.

b. Use graphic displays and limit tabular displays to focus on important crew interface information.

c. Output displays which extend to more than one screen or window at a time should be scrolled with the arrow keys and PgUp/PgDn.

d. Reference frame, units and other pertinent information should be displayed to the user on the output screen. Select the appropriate units for displaying your data. If more than one set of units are used, the user should be able to select which is used.

8.2.10 USER HELP FUNCTION CONVENTIONS

The software developer should provide the capability for on-screen user help whenever possible. To minimize training, this Help capability should use the Windows Help System.

a. The Help system should, at a minimum, provide a brief explanation on all menu selections.

b. Include a prompt message when requesting an action from the crew. The prompt should direct the user to the appropriate action or indicate that a choice of actions is available. Pertinent information should be included in the Dialog box.

8.2.11 ENHANCED USER OPTIONS

The program developer should keep in mind that the user's general computer knowledge and familiarity with software applications may vary from extensive to minimal, and the amount of time available for the crew to train with an application is very limited. The above guidelines have been established with this in mind.

In some cases, however, the user may be very knowledgeable in computer applications. For this user, the developer should enhance user operation by providing the capability to use shortcut keys and allow the user to move more quickly through the program.

Also the developer may allow the user to add or remove elements of the display. This allows the experienced user to focus on what is important at any given moment.

8.2.12 PROGRAM STATUS AND MALFUNCTION INFORMATION

a. Tones may be used to indicate parameter out-of-limit conditions or other situations that require crew attention. However, tones may not be the sole source for drawing crew attention to the PGSC (WIGSD, Miscellaneous Topics, page 213). The ambient noise environment of the Space Shuttle is such that a tone may not always be audible. Other means should also be employed, such as dialog boxes or blinking status indications. A means to toggle the tones on and off must be provided. The recommended shortcut key sequence is CTRL+T.

b. A brief program status indication should generally be placed at the top of the screen. This should include at least the program name and perhaps the current mode of operation, MET, and/or experiment time.

c. For more complex programs, the use of a status page to summarize the status of various systems is recommended.

d. Informational messages should generally be placed at the bottom of the display. Flashing messages are useful to draw attention. A method to easily disable flashing displays should be provided.

e. Error or fault messages should either be at the bottom of the display, or if important, may perhaps deserve a dialog box of their own.

f. A fault summary page (FSP) is an important feature that can be included in POC software and also referred to as an Error Log file. The FSP should contain a listing of all error messages encountered while the program is executing. The fault messages should be numbered, time-stamped, and saved as they occur. The FSP serves as a guide for attempting to solve anomalies and may also help determine if the cause of a problem was POC hardware, software, or non-POC equipment.

8.2.13 MESSAGES AND PROMPTS

a. Keep messages short and concise.

b. Do not display many messages at the same time.

c. Do not rely on messages as the only means of achieving or preventing a critical response as they may not always be read the first time.

d. Use messages and prompts to indicate when an action is required and what the action should be.

e. Provide a message indicating that a command or function is in progress if the time to the response is significant; for example, loading a large initialization file. Always try to minimize time spent by the user waiting for input/output displays.

8.2.14 MISCELLANEOUS GUIDELINES

The following are clarifications or extensions to the WIGSD:

a. Dialog boxes should have borders to help distinguish them from the background.

b. Applications with multiple screens which might normally be used at the same time should have default sizes and positions which make sense. Newly created windows should not be opened with random sizes and positions if there is a default which makes sense.

c. Status indications should be close to the text describing them or the action they status.

d. The PGSC 486 is a VGA active matrix color screen. Developers should be sensitive to the tradeoffs between populating a screen with useful information and simply putting too much in a small space. Common sense will be important here. The information, alphanumerics or graphics, must be useful! Easily read numbers on multiple screens will do more to ensure mission success than one screen containing every bit of information, but difficult to read or understand.

e. Buttons should be neither excessively large, requiring too much real estate, nor too small, causing problems with legibility and difficulty with activation. Also, they should all be accessible via keyboard entries.

f. Information shall not be displayed solely by color (WIGSD, Miscellaneous Topics, p213.. For example, it may be used to draw attention to certain features on the screen, but simply changing the color of a feature may not be used as the only cue for something which requires user action or notice.

g. Whenever possible, the mouse shall not be the only means of implementing an action (WIGSD, Introduction, page x). All application options should be accessible using menus and should implement the ALT+(underlined letter) technique for accessing menu options. In addition to menu options, frequently used commands should have a button or a shortcut key sequence defined for the experienced user. All shortcut keys must be defined either next to their menu option or in a master list in the Help utility.

h. Automated processes should be utilized as much as possible when developing applications. Some experiments and applications lend themselves naturally to this. However, to take advantage of the crew's ability to interact in real time with an experiment or process, it is advisable to include the options to perform all actions or tasks manually, if required. Because the opportunity to fly experiments or development projects in space is

limited, it may also make sense to include some sort of experiment diagnostics software, either as a part of the primary application or as a separate program. Such a package may permit the crew to achieve mission success by troubleshooting the problem independently or working in conjunction with the experimenter. Including such features as diagnostics and saving files with keystroke audits may be particularly appropriate for contingency operations or for infrequently manifested applications. These capabilities might then be scrubbed should the application become certified or used routinely.

8.3 GUIDELINES FOR DOS

The user interface guidelines established in this section are intended to provide software developers with some insight into unique aspects of the microcomputer/user interface in the SSP environment. Incorporation of these guidelines into applications, to the degree that it is practical, optimizes the crew interface. The SSP recognizes the need to maintain a flexible environment for software development. These guidelines may not be applicable in all cases and the developer is encouraged to identify incompatibilities early in the development process. Early identification of incompatibilities allows effective coordination with the user and flight control community and ensures an optimum user interface. In general, the software developer should keep in mind the following broad guidelines when developing applications:

a. Get early coordination with the crew and flight control team.

b. Provide or display only data which is important to mission success and is significant in terms of the crew interface.

c. Protect data against inadvertent errors and hardware failures.

Use these guidelines to the extent practical for your application and bring inconsistencies to the attention of the crew and flight control community.

8.3.1 DATA INPUT

a. If required data is available in an application, the data should be accessed directly rather than by crew input.

b. To the extent possible, verify crew inputs and provide out of limits response messages and instructions to reenter data. (See section 8.3.8, Messages and Prompts)

c. Offer default values for inputs. When possible, provide numeric input units and valid range limits on the input display screen.

d. Lock out or trap invalid keystrokes. For example, if valid menu selections include only [Alt]/[A], [Alt]/[B] and [Alt]/[C], other keystrokes should not be allowed. The application should either not respond until a valid input is provided or it should provide an invalid input response message.(See section 8.3.8, Messages and Prompts)

e. The software developer may wish to consider providing a mission elapsed time (MET) or Greenwich mean time (GMT) update capability in the software application. The PGSC internal clock accuracy is 5 sec/day. If greater accuracy is desired, an MET/GMT update capability should be provided and the crew should be instructed to check clock accuracy regularly. In addition, the PGSC internal clock is powered by the internal battery pack

during stowage prior to launch and may require resetting if the battery pack should discharge.

8.3.2 COMMAND AND FUNCTION EXECUTION

a. The use of menus to execute program functions and commands is preferred over other means of execution such as the use of function keys, Alt or Control key combinations, or command lines. In some cases, the use of menus will not be possible and the use of these other means of function or command execution will be necessary. When these other means are used, on-display messages or prompts and/or help screens called by [F1] are strongly recommended or required.

b. Minimize the number of keystrokes needed to perform simple or routine functions and commands.

c Order the items in any menu from most important (or most used) at the top to least important (or least used) at the bottom.

d. Use the [Alt]/[Return] combination to select irreversible menu selections.

e. Major functions and commands with a potential to significantly impact mission success should use the key message-key approach to command execution described in section 8.2.4.

8.3.3 OUTPUTS

a. Data presented and displayed is proportional to crew training and on-orbit time. Therefore, it is important to carefully consider which data to provide and/or display to the crew. Data which is most important to mission success and the crew interface should receive priority and emphasis. Additional data, which may be interesting or has a lower potential for being useful, should be placed in secondary displays or be optionally available.

b Use graphic displays and limit tabular displays to focus on important crew interface information.

c. Output displays which extend to more than one screen or window at a time should be scrolled with the arrow keys.

d. Reference frame, units and other pertinent information should be displayed to the user on the output screen.

8.3.4 DISPLAY AND MENU CONVENTIONS

a. Provide menu-driven paths to the previous displays. Enhancements for the more advanced user are also encouraged. (See section 8.3.6, Enhanced User Options.)

b. Use [Esc] to return to the previous display. In the event that program termination could result in loss of significant work, a warning message indicating the potential loss of data and requiring a confirmation response (e.g., [Alt]/[Return]) prior to continuation, should be provided. (See section 8.3.8, Messages and Prompts.) In general, program termination menu selections should be provided in the program base menu to allow termination with and without a data save capability.

c. Use the arrow keys to move up and down menu selections.

d. The [PgUp] and [PgDn] keys may also be used to move forward and backwards in a series of menus. The use of [Esc] to return to the previous display should also be available.

8.3.5 USER HELP FUNCTION CONVENTIONS

The software developer should provide the capability for on-screen user help whenever possible.

a. Provide descriptive names and brief explanations for menu selections as part of the menu.

b. Include help screens for [Alt], [Ctrl], or [Function] key activated commands which do not have on-screen explanations.

c. Include a prompt message when requesting an action from the crew. The Prompt should direct the user to the appropriate action or indicate that a choice of actions is available.

8.3.6 ENHANCED USER OPTIONS

The program developer should keep in mind that (1) the prior general computer knowledge and familiarity of the user with software applications may vary from extensive to minimal, and (2) the amount of time available for the crew to train with an application is very limited. The above guidelines (such as providing menu paths throughout the program and providing extensive on-screen help capabilities) have been established with this in mind.

In some cases, however, the user may be very knowledgeable in computer applications. For this user, the developer may want to enhance user operation by providing the capability to shortcut menu systems and allow the user to move more quickly through the program.

a. Provide [Alt], [Cntl], and/or [Function] key-based commands that bypass (but do not replace) menu driven activities.

b. Allow [Alt]/[letter] selection from menus. In this case, highlight the letter that makes the selection. For example:

   Copy - use [Alt]/[C]
   Erase - use [Alt]/[R]

c. Allow the user to add or remove elements of the display. This allows the experienced user to focus on what is most important at the particular time.

8.3.7 PROGRAM STATUS AND MALFUNCTION INFORMATION

a. Tones may be used to indicate parameter out-of-limit conditions or other situations that require crew attention. If tones are used, [Alt]/[T] must be available from all displays to disable/enable the tone.

b. Brief program status indicator should generally be placed at the top of the screen. These could include current mode of operation, mission or experiment elapsed time.

c. For more complex programs, the use of a status page to summarize the status of various systems is recommended.

d. Error or fault messages should generally be placed at the bottom of the display. Such flashing messages are useful to draw attention to the message.

e. The fault summary page (FSP) is an important feature that can be included in POC software. The FSP should contain a listing of all error messages encountered while the program is executing. The FSP serves as a guide for attempting to solve anomalies encountered. The FSP may also help determine if the cause of a problem was POC hardware, software, or non-POC hardware. The fault messages should be numbered and/or time-stamped and saved as they occur. This FSP inclusion may help identify any error(s)/anomalies) and assist in their elimination on future flights.

f. The PGSC application should be written to allow maximum data retention and recovery since a reboot may have to be performed at any time.

There are two rebooting techniques:

a. Warm boots - [Ctrl]/[Alt]/[Del]
b. Cold boots - Power off, wait 5 seconds, power on

A warm boot resets registers, closes files, clears memory, and sets everything to its initial state. A cold boot does the same things, but also performs a diagnostic check first. A cold boot is mandatory when moving between payload and STS applications.

8.3.8 MESSAGES AND PROMPTS

a. Keep messages short and concise.

b. Do not display many messages at the same time.

c Do not rely on messages as the only means of achieving or preventing a critical response (they are not always read the first time).

d. In general, messages should be located at the bottom of the page.

e. Use messages and prompts to indicate when an action is required and what the action should be.

f. Provide a message indicating that a command or function is in progress if the time to the response is significant (e.g., loading a large file). Always try to minimize time spent by the user waiting for input/output displays.

8.4 SUMMARY OF KEYSTROKE CONVENTIONS

These conventions apply to software developed specifically for a POC. COTS software does not need to meet these requirements and recommendations.

8.4.1 REQUIRED KEYSTROKE CONVENTIONS

a. [Ctrl]/[Alt]/[[Esc] - Rapid shutdown

b. [F1] - Help

c. [Alt]/[T] - Toggle tones on/off

8.4.2 RECOMMENDED KEYSTROKE CONVENTIONS

a.	[Ctrl]/[S]	Save data, continue running application
b.	[Ctrl]/[X]	Save data, exit application
c.	[Alt]/[Q]	Quit application without saving data. Requires confirmation
d.	[Alt]/[letter]	Select corresponding menu choice
e.	[Alt]/[RET]	Confirm an entry or menu selection
f.	[up] [dn]	Move up or down within a menu
g.	[PgUp] [PgDn]	Move between menus or displays
h.	[ESC]	Return to previous menu or display

9.0 MISCELLANEOUS

9.1 APPROVED FLOPPY DISKS

The Customer is responsible for providing floppy disks needed to support their payload. The following floppy disks have been tested and approved for flight:

- 3M Micro Diskettes, 3.5” double-sided, high density, 2.0 MB, manual part number 051111-12513
- Dysan Micro Floppy Disks, 3.5” double-sided, high density, 2.0 MB manual part number 814937-01

Approved labels are as follows:

- Avery Diskette Laser Labels, 3.5” diskette laser labels, blue, manual part number 5896
- Fasson double-sided adhesive film, manual part number 489
- Xerox paper, 8.5” x 11” and 8.5” x 14”, white, type 4200, manual part number 3R721

APPENDIX A - ACRONYMS AND ABBREVIATIONS

A/G	air-to-ground
ac	alternating current
ASCII	American Standard Code for Information Interchange
ATU	audio terminal unit
BIOS	basic input/output services
bps	bits per second
CGA	color graphics adapter
CIP	Computer Interface Panel
CMOS	Complementary Metal Oxide Silicon
COM	communication
CPU	central processing unit
CTS	clear to send
dB	decibel(s)
dBM	decibel(s) referred to 1 milliwatt
dc	direct current
DPSK	differential phase shift keying
DRAM	Dynamic random access memory
EIA	Electronics Industries Association
EMC	Electromagnetic Compatibility
EMS	extended memory standard
FPU	Floating Point Unit
FRR	Flight Readiness Review
FSP	fault summary page
ft	foot, feet
GDU	ground development unit
GFE	Government furnished equipment
GMT	Greenwich mean time
GPC	General Purpose Computer
GPIB	General Purpose Interface Bus
Hz	hertz

I/O	input/output
in.	inches
IRQ	interrupt request
ISO	International Organization for Standardization
JSC	Johnson Space Center
kb	kilobyte
lb	pound
LCD	liquid crystal display
LIM	Lotus-Intel-Microsoft
mA	milliampere
Mb	megabyte
MCC	Mission Control Center
Meg	megabyte
MET	mission elapsed time
MΩ	megohm
MS-DOS	Microsoft-disk operating system
NASA	National Aeronautics and Space Administration
OCA	Orbiter Communications Adapter
P/N	part number
PADM	portable audio data modem
PC	personal computer
PCMCIA	Personal Computer Memory Card Internal Association
PCMMU	Pulse Code Modulation Master Unit
PDIP	payload data interface panel
PGSC	payload and general support computer
PIP	Payload Integration Plan
POC	Portable Onboard Computer
POCCB	Portable Onboard Computer Control Board
PS	power supply
psi	pounds per square inch
PTT	push to talk
PWR	power
RAM	random access memory

RGB	red/green/blue
RMS	root mean squared
ROM	read only memory
RS	recommended standard
RTS	request to send
SCSI	small computer system interface
SIP	System Integration Plan
SpOC	Shuttle portable computer
SSP	Space Shuttle Program
SVGA	Super Video Graphics Array
TSR	Terminate/Stay Resident
Vac	volts, alternating current
Vdc	volts, direct current
VGA	Video Graphics Array
W	watt(s)
WIGSD	Windows Interface Guidelines for Software Design
XMS	extended memory standard

APPENDIX B
CMOS AND PS2 SETTINGS FOR PGSC(486)

The following is the procedure to verify the CMOS and PS2 settings prior to loading the PGSC 486 for flight.

1.0 Configure ThinkPad CMOS Settings
____ If attached, Expansion Assembly pwr - ON
____ ThinkPad pwr - ON while holding F1 key down
____ Select Config
____ Select System Board
____ √ that BIOS date is 7/20/94; if not, update it using version 1.13 of IBM Flash ROM BIOS
____ Click exit
____ Select Serial setup (RS-232)
____ √ that Serial 1 is enabled (circle has dot in it)
____ Disable Internal Serial
____ Click OK
____ Select Memory
____ Enable Parity Check (no check mark); this setting may change on a flight by flight basis depending on requirements
____ Click OK
____ Click Exit
____ Click Restart
____ Click OK

2.0 Set PS2 Settings
____ Insert 3.5" disk labeled ThinkPad PC-DOS, Version 6.3, into ThinkPad floppy drive A
____ Type a:PS2 at the DOS prompt and press Enter key

____ Select Power features
_____ Power Mode (AC)
_____ Power Serial Port (ON)
_____ Disk Drive Compartment (ON)

_____ Select F5

_____ Timer Suspend (0)
_____ Screen Off (0)
_____ HDD Stop Timer (5)
_____ Processor Speed (Fast)
_____ Discharge Battery Pack (OFF)
_____ Press Enter twice to execute
_____ Select F3

_____ Select F8
_____ LCD not Suspend Option (ON)
_____ Hibernation Option (OFF)
_____ Resume Timer (OFF)
_____ Resume From Incoming Call (ON)
_____ Press Enter twice to execute
_____ Select F3
_____ Select F3

____ Select Sound features
_____ Volume (10)
_____ Low Battery Alarm (ON)
_____ Low Power Control beep (ON)
_____ Speaker Indicator (OFF)
_____ Press Enter twice to execute
_____ Select F3

____ Select Display features
_____ Display Device (LCD)
_____ Vertical Expansion (X)(ON)
_____ Press Enter twice to record changes
_____ Select F3

___ Select System Information
_____ Audio IRQ (10)
_____ Audio DMA (* 0 and 1)
_____ I/O Address (4E30h)
_____ Press Enter twice to execute
_____ Select F3 twice to exit

Use the battery CMOS settings only if a battery is flying

```
**************************************************************************
*____ Unplug ThinkPad (install battery if not installed)                 *
*                                                                        *
*____ Type a:PS2 at the DOS prompt and press Enter key                   *
*                                                                        *
*____ Select Power features                                              *
*_____ Power Mode (High)                                                 *
*_____ Power Serial Port (ON)                                            *
*_____ Disk Drive Compartment (ON)                                       *
*                                                                        *
*_____ Select F5                                                         *
*_____ Timer Suspend  (0)                                                *
*_____ Screen Off     (0)                                                *
*_____ HDD Stop Timer (5)                                                *
*_____ Processor Speed (Fast)                                            *
*_____ Press Enter twice to execute                                      *
*_____ Select F3                                                         *
*                                                                        *
*_____ Select F8                                                         *
*_____ LCD not Suspend Option (ON)                                       *
*_____ Hibernation Option (OFF)                                          *
*_____ Resume Timer (OFF)                                                *
*_____ Resume From Incoming Call (ON)                                    *
*_____ Press Enter twice to execute                                      *
*_____ Select F3                                                         *
*_____ Select F3 twice to exit                                           *
**************************************************************************
____ Remove the PC-DOS diskette
____ ThinkPad pwr - OFF
```

ANNEX 1
Standard PGSC Flight Configurations

PGSC Flight Computer Configuration 1 (part number SED39126017-3XX)
In this configuration, the PGSC is an IBM Thinkpad 755C laptop computer, modified for flight, with no Expansion Assembly. The external DC Power Supply is required with this configuration. The Thinkpad computer comes with an 80C486 CPU.

Standard Installed Equipment:

Nomenclature	Part Number
Battery	SED39126025-301
Removable Floppy Drive	SED39126023-301
Removable Hard Drive (540 MB)	SED39126024-301

Support Equipment:

Nomenclature	Part Number
DC Power Adapter Cable	SED39126013-301
DC Power Supply Assembly	SED39126010-301
DC Power Cable (6 ft.)	SED39122875-301
DC Power Cable (25ft.)	SED33103334-311
RS-232A Cable (9-9 pin)	SED33103348-307
RS-232C Cable (25-9 pin)	SED33103335-305
PGSC TV Tuner	SED39126985-301
PGSC TV Tuner Adapter Cable	SED39126984-301
RS-232 Quad Cable	SED39126980-301
RS-232 Y Cable	SED39124826-301
* PCMCIA Ethernet Card	SED39129313-301
* Network Cable (3ft.)	SED39129316-301
* Network Cable (25ft.)	SED39129317-301
* Network “T” Connector	SED39129318-301
* Network Terminator	SED39129319-301
* PCMCIA GPIB (488) Card with Cable	SED39129312-301
* PCMCIA SCSI Card with Cable	SED33107171-301

* Available STS-81 and Subs.

PGSC Expansion Assembly Configuration 2 (Part number SED39126968-3XX)
In this configuration, the PGSC is an IBM Thinkpad 755C laptop computer and a Onsite Expansion Tray that contains a Sealevel ISO-COM 3417 dual RS-422 PC Card and a Sealevel ACB-530 advanced communication board for PCMMU. All units have been modified for flight.

Standard Installed Equipment:

Nomenclature	Part Number
486 Computer	SED39126017-3XX
Expansion Assembly	SED39126011-301
PCMMU PC Board	SED39126967-301
RS-422 ISO COM PC Board	SED39126966-301
Removable Floppy Drive	SED39126023-301
Removable Hard Drive (540 MB)	SED39126024-301
NO BATTERY	

Support Equipment:

Nomenclature	Part Number
DC Power Cable (6 ft)	SED39122875-301
DC Power Cable (25 ft)	SED33103334-311
RS-232A Cable (9-9 PIN)	SED33103348-307
RS-232C Cable (25-9 PIN)	SED33103335-305
PCMMU (24 FT) Cable	SED39126005-301
PCMMU PORT Mode (1 ft) Cable	SED39126026-301
RS-422 Cable (25 ft)	SED39126965-301
RS-422 PDIP Y-Cable	SED39126972-301
RS-232 Y Cable	SED39124826-301
RS-422 Y Cable	SED39126969-301
RS-232 Quad Cable	SED39126980-301
PGSC TV Tuner Adapter Cable	SED39126984-301
PGSC TV Tuner	SED39126985-301
* PCMCIA Ethernet Card	SED39129313-301
* Network Cable (3ft.)	SED39129316-301
* Network Cable (25ft.)	SED39129317-301
* Network “T” Connector	SED39129318-301
* Network Terminator	SED39129319-301
* PCMCIA GPIB (488) Card with Cable	SED39129312-301
* PCMCIA SCSI Card with Cable	SED33107171-301
* Available STS-81 and Subs.	

PGSC Expansion Assembly Configuration 3 (Part number SED39129314-3XX)
In this configuration, the PGSC is an IBM Thinkpad 755C laptop computer and a Onsite Expansion Tray that contains a Sealevel ISO-COM 3417 dual RS-422 PC Card and a OCA PC board for Ku-band and Modem interfaces. All units have been modified for flight.

Standard Installed Equipment:

Nomenclature	Part Number
486 Computer	SED39126017-3XX
Expansion Assembly	SED39126011-301
OCA PC Board	SED16102686-301
RS-422 ISO COM PC Board	SED39126966-301
Removable Hard Drive (540 MB)	SED39126924-301
Removable Floppy Drive	SED39126923-301
NO BATTERY	

Support Equipment:

Nomenclature	Part Number
DC Power Cable (6ft)	SED39122875-301
DC Power Cable (25 ft)	SED33103334-311
RS-232A Cable (9-9 PIN)	SED33103348-307
RS-232C Cable (25-9 PIN)	SED33103335-305
PCMMU (24 ft) Cable	SED39126005-301
PCMMU PORT Mode (1 ft) Cable	SED39126026-301
RS-232 Y Cable	SED39124826-301
RS-232 Quad Cable	SED39126980-301
PGSC TV Tuner Adapter Cable	SED39126984-301
PGSC TV Tuner	SED39126985-301
OCA Ku-band/Audio Cable	SED16102693-301
Modem Cable (25 ft.)	SED33104173-301
* PCMCIA Ethernet Card	SED39129313-301
* Network Cable (3ft.)	SED39129316-301
* Network Cable (25ft.)	SED39129317-301
* Network “T” Connector	SED39129318-301
* Network Terminator	SED39129319-301
* PCMCIA GPIB (488) Card with Cable	SED39129312-301
* PCMCIA SCSI Card with Cable	SED33107171-301
* Available STS-81 and Subs.	

PGSC Expansion Assembly Configuration 4 (Part number SED39129315-3XX)

In this configuration, the PGSC is an IBM Thinkpad 755C laptop computer and a Onsite Expansion Tray that contains a Sealevel ACB-530 advanced communication board for PCMMU and a OCA PC board for Ku-band and Modem interfaces. All units have been modified for flight.

Standard Installed Equipment:

Nomenclature	Part Number
486 Computer	SED39126017-3XX
Expansion Assembly	SED39126011-301
OCA PC Board	SED16102686-301
PCMMU PC Board	SED39126967-301
Removable Hard Drive (540 MB)	SED39126924-301
Removable Floppy Drive	SED39126923-301
NO BATTERY	

Support Equipment:

Nomenclature	Part Number
DC Power Cable (6ft)	SED39122875-301
DC Power Cable (25 ft)	SED33103334-311
RS-232A Cable (9-9 PIN)	SED33103348-307
RS-232C Cable (25-9 PIN)	SED33103335-305
PCMMU (24 ft) Cable	SED39126005-301
PCMMU PORT Mode (1 ft) Cable	SED39126026-301
RS-232 Y Cable	SED39124826-301
RS-232 Quad Cable	SED39126980-301
PGSC TV Tuner Adapter Cable	SED39126984-301
PGSC TV Tuner	SED39126985-301
OCA Ku-band/Audio Cable	SED16102693-301
Modem Cable (25 ft.)	SED33104173-301
* PCMCIA Ethernet Card	SED39129313-301
* Network Cable (3ft.)	SED39129316-301
* Network Cable (25ft.)	SED39129317-301
* Network “T” Connector	SED39129318-301
* Network Terminator	SED39129319-301
* PCMCIA GPIB (488) Card with Cable	SED39129312-301
* PCMCIA SCSI Card with Cable	SED33107171-301
* Available STS-81 and Subs.	