OPERATION AND MAINTENANCE MANUAL

SPX 100/500

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CHAPTER 1

INTRODUCTION AND GENERAL INFORMATION

1.1 INTRODUCTION

This manual is the user reference for all operation and maintenance requirements of the SPX-100/500 system. It should be used by system operators and technicians in the performance of job duties related to this equipment. You will be referred to other SPX manuals for specific details of some SPX features and operations.

1.2 RELATED DOCUMENTS

The publications listed below provide information related to the SPX system. Some of the additional reference manuals (signal tracing guide, peripherals, software, modeling) are produced by Evans and Sutherland, while other manuals are produced by equipment vendors. Reference will be made to these manuals for specific information.

SPX Operation and Maintenance Manual (E&S part number 901181-460) - This manual covers installation, operation, and maintenance of the SPX system.

SPX Signal Tracing Guide (E&S part number 901181-769) - This manual includes system mechanical drawings, cabling drawings, and schematics.

SPX Backpanel Wire List (E&S part number 901181-730) - This manual contains the backpanel wirelists.

SPX Modeling Reference Manual (E&S part number 901181-459) - This manual contains information used by the modeler for model and data base design.

SPX Real-Time System Users Manual (E&S part number 901181-725) - This manual contains information for real-time system operation.

SPX Operating System Reference Manual (E&S part number 901181-833) - This manual contains information on the operating system (OS), file structures and file conventions, file management utility (FMU), file download utilities, source file editor (MED), and associated error messages.

CHEK Diagnostic Reference Manual (E&S part number 901181-832) - This manual contains information on the CHEK diagnostic language used in the SPX system for corrective maintenance.

SPX Acceptance Test Procedures Manual (E&S part number 901181-831) - This manual contains system tests, used in conjunction with the ATP database, to demonstrate system function and features.

CSM Operation and Maintenance Manual (E&S part number 901181-604) - This manual covers installation, operation, and maintenance of the CSM system.

Some manuals relating to the SPX system are produced by vendors outside of Evans & Sutherland. Typical vendor manuals included with the system are:

ICC Manual
Power supply manuals
OMTI Controller manual
Tape drive manual
System console manual
Printer manual
Winchester hard disk manual

Some system configurations may require manuals not listed above.

1.3 DOCUMENTATION CONVENTIONS

The following conventions are used throughout this manual:

- <RET> means that you should press the RETURN key.
- `Courier` type identifies computer prompts. Computer code, screen messages, menu names and selections, and user input also appear in `Courier` type.
- User input that appears directly with a computer prompt is often placed in *`italics`* to further distinguish it from the prompt.

1.4 DOCUMENT STRUCTURE

Chapter 1 is an introduction to the manual and supplies general information.

Chapter 2 gives general information about the SPX system, its capabilities, physical size, power requirements and other SPX reference documentation.

Chapter 3 is a site preparation guide.

Chapter 4 covers installation of the system, provides a list of necessary tools and test equipment, and includes repacking and reshipping instructions.

Chapter 5 describes all system operations. This chapter provides a description of the functional controls and indicators for the power controllers, system console, etc. This area of the manual instructs the operator how to perform system operations such as using system software utilities and real-time system operations and refers the operator to other reference manuals for more detailed information when appropriate.

Chapter 6 discusses the theory of operation to the Lowest Replaceable Unit (LRU). A discussion of computer image generation basics is included.

Chapter 7 discusses preventive and corrective maintenance procedures, along with subassembly removal and replacement.

1.5 SAFETY SUMMARY

The following general safety precautions are not related to any specific procedures and therefore do not appear elsewhere in this publication. These are precautions that personnel must understand and apply during operation.

1.5.1 Keep Away from Live Circuits

Operating personnel must at all times observe all safety regulations. Do not replace components or make adjustments inside the equipment with power on. Under certain conditions, dangerous potentials may exist when the power control is in the off position, due to charges retained by capacitors. To avoid injury, always remove power and discharge and ground a circuit before touching it.

1.5.2 Do Not Service or Adjust Alone

Under no circumstances should any person reach into the enclosure for the purpose of servicing or adjusting the equipment, except in the presence of someone who is capable of rendering aid.

1.5.3 Resuscitation

Personnel working with or near high voltages should be familiar with methods of resuscitation.

1.6 WARNINGS, CAUTIONS, AND NOTES

Through this manual, there may appear the following headings:

Warning: Used to describe a potential or actual threat to human safety. Appropriate precautions and remedial actions are indicated.

Caution: Used to describe a potential or actual threat to equipment safety appropriate precautions and remedial actions are indicated.

Note: Used to call attention to useful data or actions which, if observed, result in improved performance and/or understanding.

WARNING: HIGH VOLTAGES CAPABLE OF CAUSING DEATH ARE USED IN THIS EQUIPMENT. USE EXTREME CAUTION WHEN SERVICING POWER SUPPLIES OR THEIR LOAD COMPONENTS.

CAUTION: This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. This equipment has been tested and found to comply with the limits for a class A computing device pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

(This caution applies to equipment manufactured by Evans & Sutherland after October 1, 1983.)

CHAPTER 2

SYSTEM OVERVIEW

2.1 INTRODUCTION

Simulation is a cost-effective and safe means of providing training experience. Computer Image Generation (CIG) visual systems provide interactive, real time, simulated out-the-window scenes of real-world environments for use in training simulators. The SPX excels in meeting the needs of most simulated visual images.

The SPX family of visual systems is a new generation within the NOVOVIEW family of computer image generators. SPX has an entirely new architecture and draws heavily on its NOVOVIEW predecessors as well as the high-performance CT series of image generators. The SPX CIG is optimized for many demanding applications. These applications include operational and tactical training of operators of military vehicles and weapon systems, all phases of training under the rules of the FAA and other civil regulatory authorities, and many engineering applications.

The SPX system produces real-time scenes composed of light points, surfaces, and texture (optional) representing the physical training environment. The system transforms numerical model data representing the three-dimensional environment, and host simulator data defining vehicle position and viewing conditions into two-dimensional perspective images. The system then processes the image data into signals for driving the displays. The SPX CIG produces successive images at a rate sufficient to give the impression of smooth motion as the observer changes position and attitude. Day/dusk/night ambient illumination, full spectrum colors, weather effects, various model special effects, and texture may be simulated. Different visual environments can be selected for training. A combination of pilot and instructor inputs control overall visual performance during training.

The system also provides various support and maintenance functions when not in training use. These include system calibration, system test and diagnosis, utility tasks associated with the management of data and software on mass storage media, and new scene modeling and model update.

2.2 CAPABILITIES AND FEATURES

SPX's modular architecture provides a complete range of capability (resolution, color, texture, calligraphic lights) in one basic product. An SPX image generator can be configured to provide a low, intermediate, or high performance level by selection of hardware modules and associated software. Each system includes backpanels which are pre-wired for many available system features and can usually be upgraded on site to more powerful configurations by circuit card changes.

SPX CIG features include the following:

- Highly modular: configurable for applications below FAA Phase 2 and beyond FAA Phase 3 requirement, or for a broad range of military or engineering applications.
- Powerful database management techniques employed to concentrate the available polygons and lights closer to the simulated eyepoint.
- Powerful (CT5-type) anti-aliasing in all systems.
- Medium or high-resolution (pixel density) versions are available.
- Fog and other visibility effects are calculated at the pixel level for proper results on all three-dimensional objects as well as the underlying terrain.
- Effective system and channel overload management is applied at the system level to avoid disparities across channel boundaries.
- Surface texture which can be applied to any polygon in the scene.
- The system is capable of generating high-quality calligraphic light points and raster images of surfaces and other light points.
- Each channel processor contains its own environment memory, data base management processor, geometric processor and display processor. With almost no channel interdependencies, the total system capacity increases linearly with the number of channels.
- The traditional front-end general purpose (visual) computer has been replaced by a small, efficient, expandable, and self-contained microprocessor which is part of the multi-processor (MP) unit.
- Extensive use of very large scale integration (VLSI) results in higher performance and reliability at reasonable cost.
- Powerful software for inclusion of moving objects and dynamic special effects in the scene.
- Fast, board-level diagnostics.

- The image generator can drive a wide range of display systems, including projectors or direct view calligraphic and raster displays.

With the above features included as appropriate, SPX is well suited and cost effective for training or research in:

- Day, dusk, or night conditions.
- Various weather conditions.
- Landing, take-off, combat, airborne refueling and emergency procedures.
- Weapons systems operation.
- Electronic or electro-optic systems.
- Full-mission or part-task simulators.
- Flight dynamics.

2.3 SPX SYSTEM PHYSICAL DESCRIPTION

2.3.1 Simulation System Physical Description

A typical simulator which includes the image generator (see Figure 2-1) consists of the following:

Host computer

The host computer receives control and motion input from the simulation platform, and sends environmental and position data to the CIG. The CIG sends status information back to the host computer.

Simulation Platform

The simulation platform is the actual simulation of the physical vehicle. It may have a motion base used to simulate vehicle motion, or may have a stable platform used to simulate the vehicle without motion.

Computer Image Generator (CIG)

The CIG provides real time, out-the-window scenes that produce the illusion of motion.

Display Unit

The display unit is the hardware used to generate the actual image based upon the information provided by the CIG.

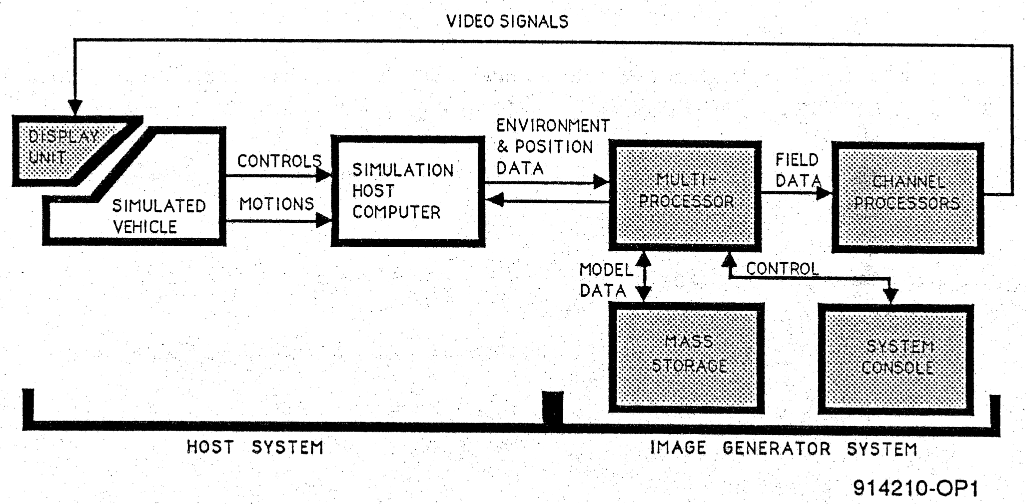


Figure 2-1. Simulation System Diagram

2.3.2 SPX Image Generator Physical Description

Except for system peripherals, all electronic units are housed in standard 19-inch width metal cabinets which have been specifically designed to provide the required EMI shielding. When the system is in operation, all doors should be closed and latched.

The lower section of each cabinet contains a power control and distribution unit, referred to as a power controller (see Figure 2-2). Main power enters these units where it is breakered then distributed to all power supplies, cooling fans, display units and peripherals. Control circuitry in the units monitors operating conditions within the cabinets and provides for normal and emergency on/off control of the system. The power controllers are linked from cabinet to cabinet, providing a single intelligent power control system.

Typically the left-most cabinet, as viewed from the front of the system, contains the multi-processor (MP) unit (see Figure 2-3). This unit consists of a slide mounted chassis containing a power supply, cooling fans, mass media storage devices (Winchester disk(s) and tape streamer), and a backplane interconnecting one or more Multiprocessor cards. The Multiprocessor card is a 68000 based computer which is part of the visual system. Space is provided for additional optional magnetic media.

The upper section of the left cabinet also contains one of the several channel processors. Each channel processor consists of a circuit card cage, a backpanel, cooling fans, an air inlet duct with filter, and a set of circuit cards. Power for the channel processor comes from several power supplies mounted in the lower part of the cabinet and within the power controller. Each additional electronics cabinet can contain one or two channel processors. Figure 2-2 shows a three-channel system where the second cabinet contains two channel processors.

The system may also include one or more cabinets to house the low voltage power supplies for the displays. These power supplies receive their AC power from an additional power controller housed in each display power supply cabinet. A separate stand-alone cabinet may also be provided to distribute power to projector power supplies.

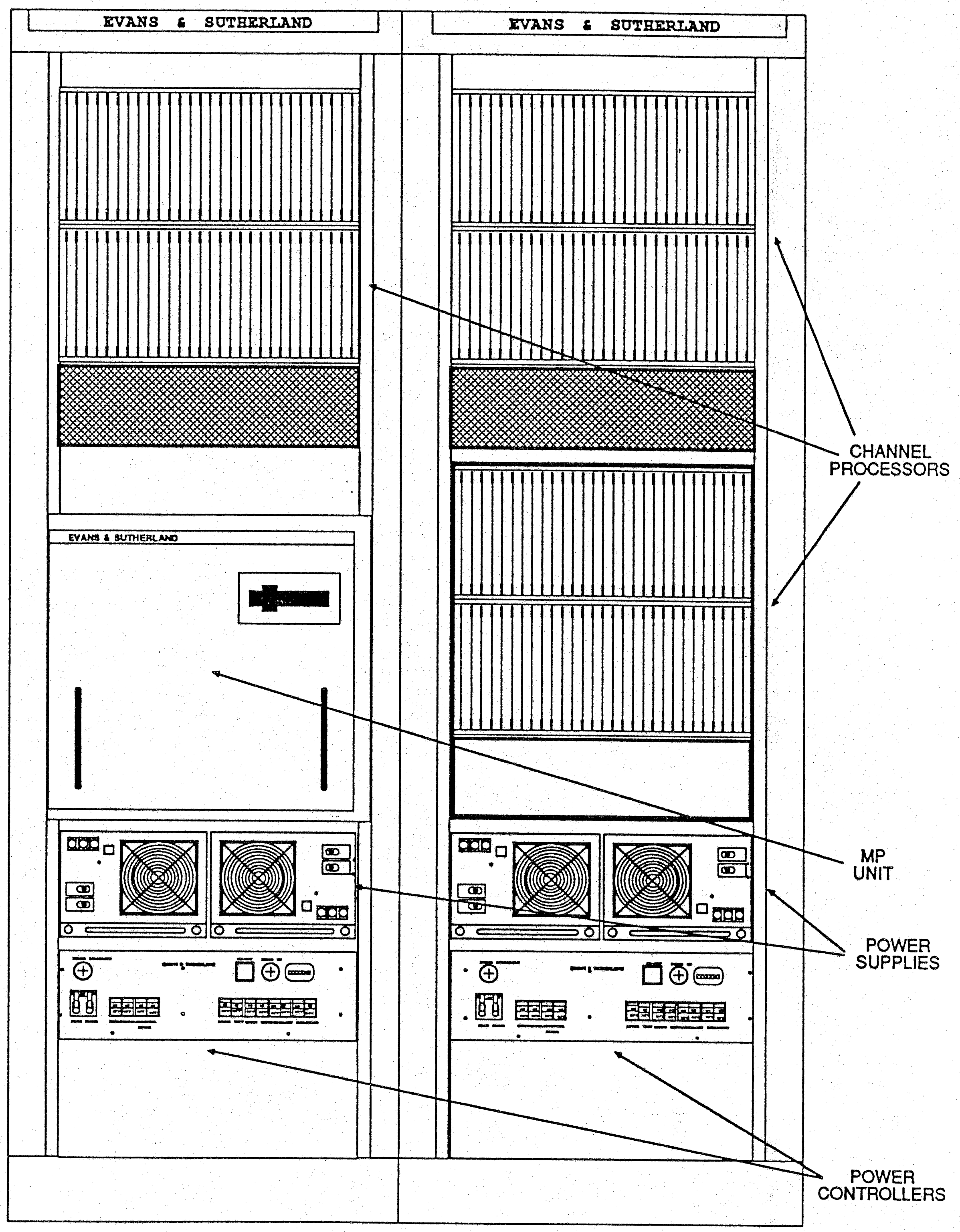


Figure 2-2. SPX Three Channel CIG System

2.3.3 SPX Peripherals Description

The peripherals used with the SPX system include a system console (terminal) and its printer, and an optional interactive control console (ICC), referred to as a flybox.

2.3.3.1 System Console

The system console is a terminal used to interface with the visual computer (the MP card). The terminal allows the operator to control the system, run diagnostics, and display system status. The terminal supplied with the system is manufactured by Digital Equipment Corporation (DEC). For specific information refer to the appropriate DEC terminal manual included in the documentation set shipped with the system. The system console is connected to the SPX system using an RS232 protocol while the ICC (see Section 2.3.3.4) uses an RS422 protocol. All console and ICC communications are routed through the System Fault Monitor.

2.3.3.2 Printer

The printer connected to the system console is used to provide hard copy for system analysis. The printer supplied with the system, also manufactured by DEC, is connected directly to the system console. For more detailed information refer to the appropriate DEC printer manual included in the documentation set shipped with the system.

2.3.3.4 ICC

The ICC is a terminal that allows the operator to fly the CIG in local mode and is used for certain maintenance functions. The ICC or flybox has a joystick and slide pot which permits movement of the eyepoint through the active database. It is connected to the system in parallel with the system console and will display the same information as the system console. Because of this parallel connection, input from the system console and flybox must not occur simultaneously.

2.3.3.5 Display

The display units commonly used with the system include raster, calligraphic, wide projector, and other currently available displays. The system can be configured to drive either raster only or raster/calligraphic displays. For more detailed description of the specific display device on your system, refer to the display documentation.

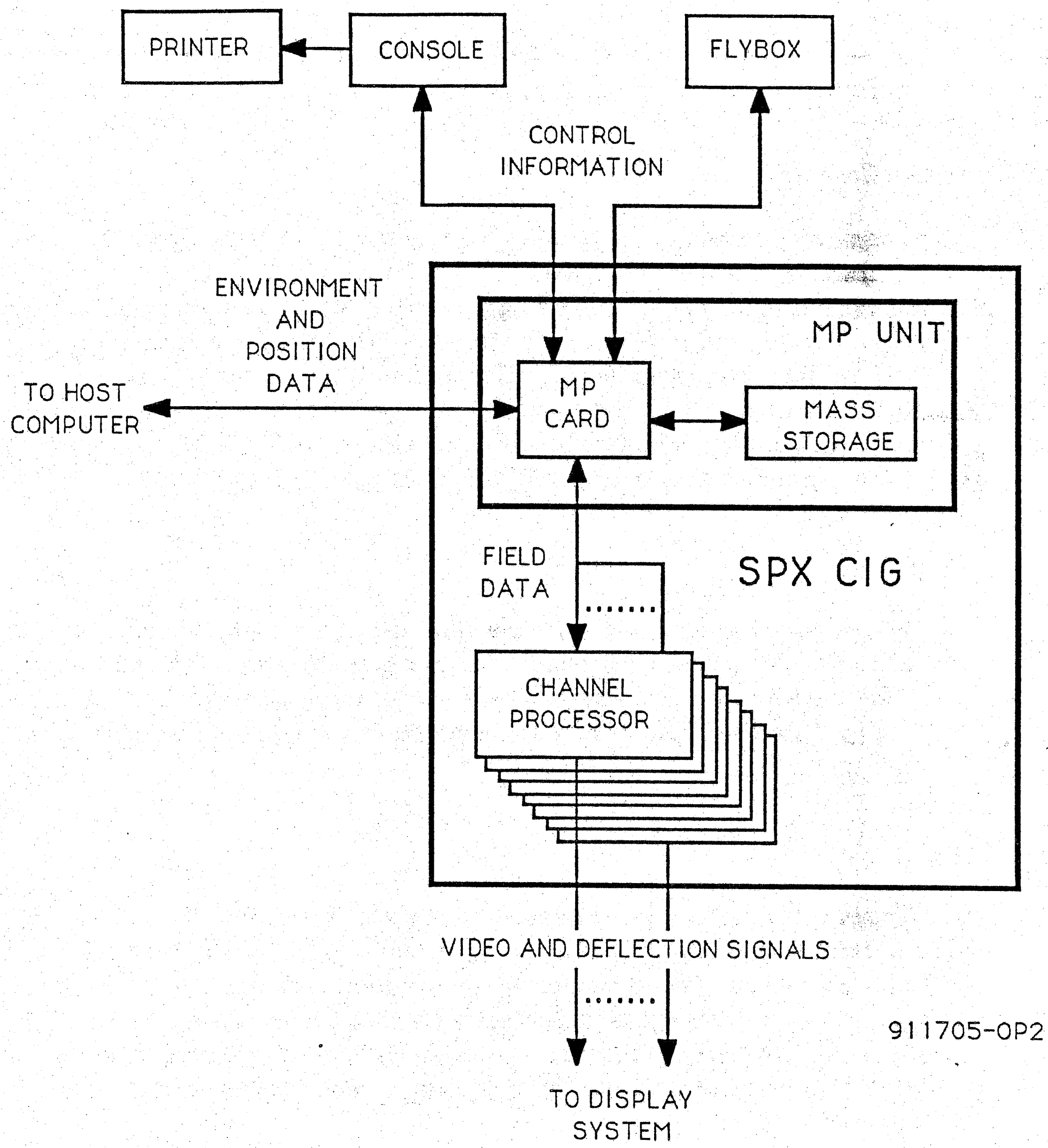


Figure 2-3. SPX System Block Diagram

2.3.4 SPX Software Description

SPX software consists of the operating system, utilities, and real-time system software which controls the unit during simulation. The SPX also includes machine level debugger firmware which is activated under special circumstances. Figure 2-4 depicts how the software interacts.

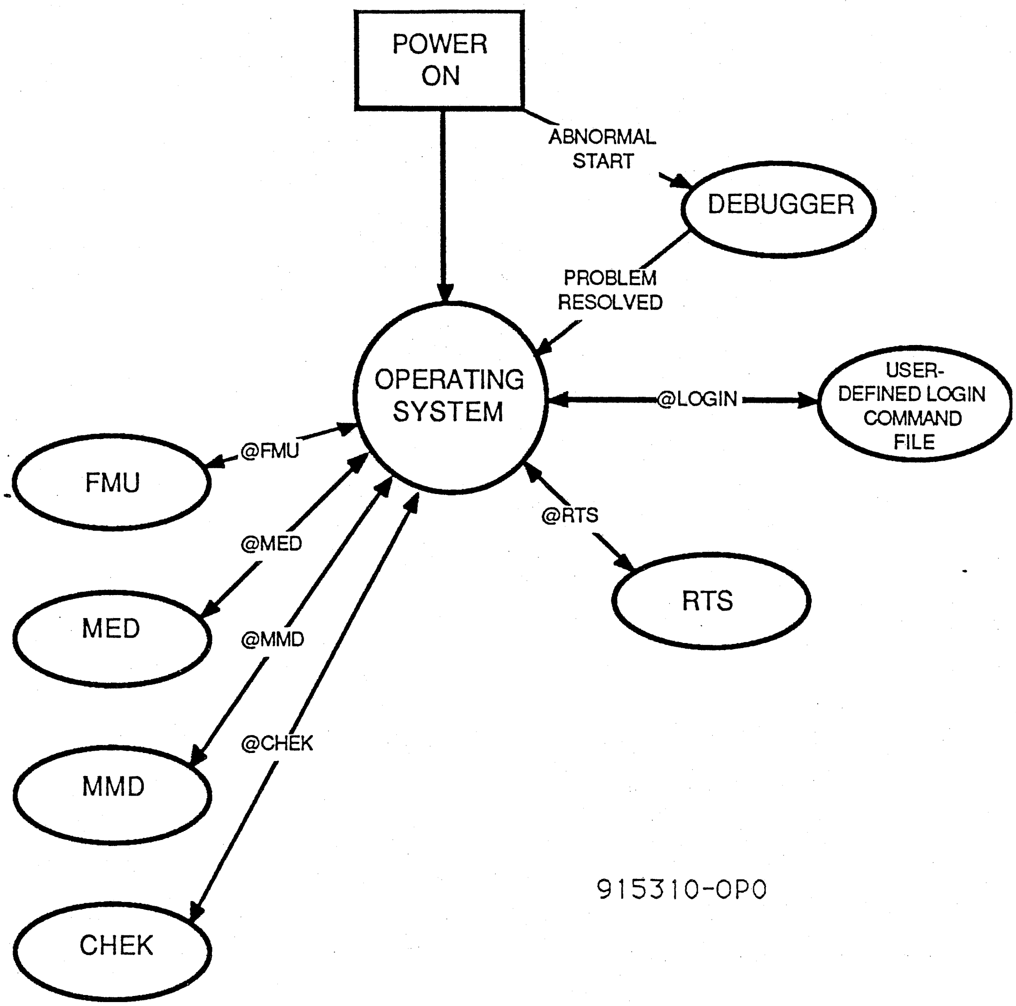


Figure 2-4. SPX Software Interaction

The following software is available in the SPX system:

SPXOS SPX Operating System. The SPX utilities and real-time system run as tasks under the operating system, which provides the functional interface to mass storage and communications devices.

RTS Real-Time System. The RTS software controls all SPX operations while simulation is in progress. For example, during simulation the RTS communicates with the host computer and sends model (data base) information from the hard disk to the SPX hardware. The RTS also monitors the system console and ICC (flybox) for input, and sends status information to these terminals when a monitored error condition occurs. For more information about this software, see the *SPX Real-Time System Manual.*

FMU File Management Utility. FMU is used to perform general disk file operations, such as copy, delete, backup, etc. For more information about this utility, see the *SPX Operating System Manual.*

MED Text Editor. MED is used as an editor for creating and editing ASCII text files. For example, the SPX site configuration file (SPX.SIT) can be created and edited using MED. For more information about this utility, see the *SPX Operating System Manual.*

MMD Magnetic Media Diagnostics. MMD is used to test the magnetic media used for mass storage. For more information about this utility, see Appendix B.

CHEK SPX diagnostics. CHEK is a diagnostic language used to test sections of the SPX Channel Processors. The CHEK diagnostics are used extensively when troubleshooting the SPX system. Because CHEK is implemented as a computer language, diagnostic routines can be written and saved as individual files. For more information about this utility, see the *CHEK Diagnostics Reference Manual.*

LOGIN The LOGIN.COM command file, if present, is executed upon power up.

2.4 HARDWARE OPTIONS AND EXPANDABILITY

The SPX system is an extremely modular system, and has been designed to cover a wide range of configurations and capabilities. Not only can the number of channels range from 1 to 8, but each channel can receive a number of optional card sets depending on system requirements. This manual is intended to cover all possible configurations for the SPX 100 and 500.

When an option is installed in the system, whether from the factory or in the field, specific installation instructions accompany the option. In general, information contained in the specific instructions will be included in this and other standard system manuals. Nevertheless, any option installation instructions should be retained with this manual.

2.4.1 Standard Configurations

The SPX architecture provides for a continuum of configurations from the relatively low performance, monochrome, low resolution system to the extremely powerful, full color, high capability system. For convenience in describing particular configurations, the full range of configurations have been divided into two categories.

The minimum configuration has been designated as an SPX-100. The basic SPX-100 system provides monochrome night/dusk images, operates at a 30 Hz field rate, displays 250 polygons and 5000 light points per channel, and has a resolution of 330,000 pixels. By the addition of various options, the SPX-100 system can be extended to a mid-range configuration.

The mid to upper range configurations have been designated as SPX-500. The basic

SPX-500 system is a day/dusk/night system, normally operates at a 50 Hz field rate, and displays 500 color polygons per channel at a resolution of 360,000 pixels. The SPX-500 light capacity per channel is 1,000 lights in day mode and 5,000 lights in a 30 Hz dusk/night mode. The SPX-500 can also be expanded by the addition of options.

All circuit cards specific to a given channel are housed in a single card cage and interconnected through an attached backpanel or mother board. The backpanel is prewired to accept all circuit card options. This allows very easy field upgrades; the option is installed by simply plugging the appropriate cards into the correct slots in the backpanel and making the necessary software changes. Generally all channels of a system will be configured identically. However, in special cases channel configurations can differ.

2.4.2 SPX-100 System Options

The following options are currently available for the basic SPX-100 system. Refer to Figure 6-2, SPX 100 Backpanel Card Allocation, for card placement.

- Texture. The texture option provides 32 on-line texture patterns which can be applied to any polygon of any orientation in the data base. Each channel of texture option is made up of five cards, including two 208125, one 208150, one 208151, and one 208152 circuit cards.

- Calligraphic Lights. This option consists of a single 208141 circuit card per channel. It provides for the capability to draw light points calligraphically. Calligraphic displays are also required for this option. The calligraphic option also allows for the calligraphic lights to be drawn in full color (with 16 colors available) even though the surfaces might remain monochrome.

- Landing Light Lobes. This option provides the effects of own aircraft landing lights on surfaces in the data base. It consists of a single 208140 circuit card per channel.

- High Resolution. The high resolution option increases the number of pixels which can be drawn each frame from 330,000 to 660,000 pixels. The option consists of four circuit cards: one 208123, one 208128, one 208129, and one 208130.

- Colored Surfaces. This option provides for full-colored surfaces and raster-drawn light points. If the system is configured as a standard resolution SPX-100, the option consists of two 208130 circuit cards. If the system is a high resolution system, four 208130 cards are required.

- SPX-500 Upgrade Kit. This option upgrades a basic SPX-100 system to a basic SPX-500 system. It includes the standard resolution Colored Surfaces option, plus two 208112, one 208128, one 208129, and one 208126 circuit card.

2.4.3 SPX-500 System Options

The following options are currently available for the basic SPX-500 system. Refer to Figures 6-3 and 6-4, SPX 500 and 500HTL Backpanel Card Allocation, for card placement.

- Texture. This option adds the capability of adding texture patterns to any modeled surface. Thirty-two patterns are available at any one time. The option consists of a total of eight circuit cards: two 208125, two 208150, two 208151, and two 208152 cards.

- Calligraphic Lights. This option consists of a single 208141 circuit card per channel. It provides for the capability to draw light points calligraphically. Calligraphic displays are also required for this option. The calligraphic option also allows for the calligraphic lights to be drawn in full color (with 16 colors available) even though the surfaces might remain monochrome.

- Landing Light Lobes. This option provides the effects of own-aircraft landing lights on surfaces in the data base. It consists of a single 208140 circuit card per channel.

- High Resolution. This option increases the number of pixels which can be drawn each frame from 360,000 to 720,000. It consists of a total addition of eight cards: one 208123, two 208128, two 208129, and three 208130 cards.

Space has been made available for the addition of up to three more MP cards to the MP unit at the front end of the visual system, larger storage disk units or more than one storage disk unit for future applications. Hardware options require some software parameters to be modified; the option installation instructions contain specific instructions relative to option installation and operation.

2.5 IMAGE GENERATOR SPECIFICATIONS

2.5.1 Physical Characteristics

The standard image generator is composed of one MP unit, one or more channel processors, a system console, a printer, and one or more power controller units. All of the electronic equipment, excluding the terminal and printer, are housed in 19-inch cabinets. Each 19-inch cabinet contains a power controller unit, and either the MP unit and one channel processor, two channel processors, or just one channel processor.

Each cabinet has removable front and back doors. These doors should remain closed and latched during operation to effectively attenuate electromagnetic radiation. The backpanels are accessible from the back of the cabinet while the individual cards are accessible from the front. Test and maintenance requirements require access to both the front and rear of each cabinet; a clearance of at least three feet is required in front of and behind each cabinet.

The maximum concentrated floor load is 200 pounds, and the maximum distributed floor loading is 1.5 pounds per square inch. The suggested raised-floor specification is as follows: the Uniform Live Load capacity is to be 250 lbs. per square foot, yielding a maximum of 0.080" deflection and providing a permanent set not to exceed 0.010". The Concentrated Load Capacity is to be 1000 lbs. per square inch, yielding a maximum of 0.080" deflection and providing a permanent set not to exceed 0.010". The Rolling Load is to be 600 lbs. as tested by the CISCA method. The stringers need to be a rigid-bolted grid system.

Facility floor space requirements are dependent upon system configuration. Nominal dimensions and weight are shown in Table 2-1.

Table 2-1. SPX Physical Characteristics

System Component	Height (ins)	Width (ins)	Depth (ins)	Weight (lbs)
MP plus 1 channel (1 cabinet)	82	25	34	700
MP plus 2 or 3 channels (2 cabinets)	82	50.5	34	1500
MP plus 4 or 5 channels (3 cabinets)	82	75.5	34	2300
MP plus 6 or 7 channels (4 cabinets)	82	101	34	3100
MP plus 8 channels (5 cabinets)	82	126	34	3700
System console terminal	15	20	26	34.5
Interactive control console (optional)	9	18	12	16
Printer	6	16	30	19
Stand-alone power controller	30	25	33	150

2.5.2 Power Requirements.

2.5.2.1 Image Generator Power

Each cabinet of the image generator requires a separate connection to a source of single-phase power. Each cabinet is shipped with a 38-foot, 3-wire, 6 gauge power cord (minus a connector on the user end). The power source shall provide an average voltage not less than 200 VAC and not greater than 250 VAC, 47 to 63 Hz single phase. Voltage fluctuation from the average voltage shall not be greater than ±5%. The power factor is 0.95 (18 degrees lagging). Maximum surge current shall not be greater than 90 amperes for 140 millisecond transient. Incoming line power is breakered at 50 amperes inside the power controller unit in each cabinet.

2.5.2.2 Peripheral Power

Peripheral power for the system console, printer, etc. is furnished through 230 volt connectors available at the power controller unit in the bottom of each of the IG cabinets. One of the three connectors, J17 (see Figure 4-10), is unswitched (i.e. remains powered when the cabinet's main contactor is de-energized) and is used to provide power to the system console.

NOTE: J17 receives power as soon as the MAIN POWER and the CONTROL POWER circuit breakers are set to ON, even though the main contactor is de-energized.

2.5.2.3 Load Balancing

Connections to main site power for all IG cabinets and display power supply cabinets should be connected to a common breaker panel. If multiple-phase power is used, image generator cabinets may be connected to different phases. However, it is the responsibility of the installer to balance the load among the phases.

2.5.2.4 Grounding

A single point electronic circuit ground is maintained internally to the IG cabinets. To help control external grounds and minimize ground loop noise, the earth or safety ground in the main power cable from all system cabinets should be tied as close to a single point as possible.

2.5.2.5 System Power Consumption

The approximate power consumption for three typical baseline image generator configurations is shown in Table 2-2. Power consumption will vary as different options are installed. Display power is not included.

Table 2-2. Typical Power Consumption

	Power in Watts		
System Component	SPX-100T	SPX-500T	SPX500HT
Image generator cabinet with MP, one channel processor, system console and printer	1,975	2,510	2,950
Image generator cabinet with one channel processor	1,765	2,300	2,740
Image generator cabinet with two channel processors	3,530	4,600	5,480

2.5.2.6 Display Power

Display power requirements varies widely depending on the display configuration. When Evans & Sutherland CSM displays are provided, up to four display low-voltage power supply units may be housed in a single cabinet, along with a power controller unit which provides AC power to the supplies and ON/OFF control of the displays. Voltage, phase, and frequency requirements for the CSM displays is identical with those for the image generator cabinets. The power controller breakers the incoming power source at 50 amperes. A 38-foot power cord is shipped with each power supply cabinet.

A power controller unit packaged in a small stand-alone cabinet is available to switch power for a projector system. Each 208071 power controller unit can supply power through a 50-ampere connection for up to 5 projectors, provided that the average and peak current draw from the cabinet do not exceed the ratings of the power controller's circuit breakers. The main circuit breaker is rated for 50 amps. Connectors J2 through J4 are protected by one 30 amp breaker. Connectors J5 and J6 are protected by a second 30 amp breaker. No single device may draw more than 15 amps.

2.5.2.7 Convenience Outlet Power

The first cabinet of the image generator comes with a 110-120 volt convenience outlet with its outlet end mounted at the bottom of the cabinet. One duplex outlet is available at the lower front of the MP cabinet. These outlets can be used as a source of power for test equipment. The convenience outlet cord should be connected to a standard 115 volt wall outlet using the three-prong plug supplied. These convenience outlets are not supplied with breaker protection, and should never be connected to 230 volt power.

2.5.3 Environmental Requirements

Table 2-3 lists the environmental conditions that are required for the Image Generator System.

Table 2-3. Environmental Conditions Requirements

	Temperature	
Condition	Operating	Storage
Equipment Air Inlet	15° to 30° C (59° to 86° F)	-18° to 50° C (0° to 122° F)
Relative Humidity (Noncondensing)	20 to 80%	0 to 90%

The building containing the Image Generator System shall be able to supply the approximate air conditioning capacity listed in Table 2-4 to accommodate the additional heat generated by the system.

Table 2-4. SPX Image Generator Cooling Requirements

	Add (BTU / hr)		
Part	SPX-100	SPX-500T	SPX-500HT
Image Generator cabinet with MP and one channel	6,750	8,600	10,100
Each additional channel	6,050	7,900	9,400

These environmental requirements are for the image generator only and do not include or necessarily apply to the display devices.

2.5.4 Host Computer Interface

The standard host computer/image generator interface is via a dedicated ethernet (IEEE 802.3) interface. This ethernet network must be collision free when the host computer and the image generator are communicating.

CHAPTER 3

SITE PREPARATION RECOMMENDATIONS

3.1 INTRODUCTION

This site preparation section is intended as a recommendation to aid in the preparation of the user site for the installation of the SPX system. The installation recommendations given in this section apply to the SPX CIG equipment only. *The system requirements found in Section 2.5 must be followed, while the guidelines discussed here are intended solely as suggestions to the user, based upon E&S's experience with many installations of this type.* With a basic understanding of the system and its installation requirements, specific questions can be answered to allow for a trouble-free system installation.

3.2 EQUIPMENT HANDLING

Any cartons received with visual damage should be noted on the bill of lading by receiving personnel with the following: "CARTON DAMAGED, ACCEPTANCE UPON INSPECTION BY VENDOR". Special handling equipment such as a fork lift or pallet jack capable of lifting 1000 lbs may be necessary for the movement of the equipment. Careful attention is required when unloading equipment from the truck to prevent damage to the cabinets.

NOTE: Retain the packing materials until the system is installed and running, in case damaged equipment must be returned.

A suitable work space, a staging area, is needed to prepare the system for installation. This area should be large enough to contain all of the equipment and allow free movement and access to the front and back of the system cabinets (15' x 10' minimum).

Survey the moving route that the equipment will follow during transportation. Make sure that all doors (36" x 83" minimum), passageways (36" wide minimum), and ramps are of adequate height and width, and that the turning radius is sufficient to allow passage of the equipment. Ensure that elevators have enough capacity for the cabinets (800 lbs maximum per cabinet).

All large system cabinets are mounted on casters and may be rolled into place. Care must be taken when rolling the cabinets that the castors do not catch on floor obstructions and tip the cabinet over. Moving a cabinet on its casters should be done by a minimum of two people. Once in place, the cabinet leveling feet must be lowered to prevent further movement of the cabinets.

3.3 FLOOR PLAN

Once the site has been selected, the floor plan and equipment arrangement must be designed. Several factors must be considered when layouts are proposed.

- The equipment should be placed with clearance in front of and behind each cabinet, giving operation and maintenance personnel adequate room to gain access to the front and back of each cabinet with the doors fully open. The minimum required clearance front and back is three feet.

- The maximum length of the signal cables which connect the displays to the IG is 160 feet.

- The equipment should be located so that the source of site power wiring is in close proximity to the equipment. A 38 foot power cord is supplied with each cabinet.

3.3.1 Floor Space Requirements

The floor space requirement for a system depends on the configuration to be installed. Refer to Table 2-1 for the system configuration being installed. Allow 30 to 50% extra space for future expansion of the system. It is desirable to store a small quantity of data medium such as magnetic disks, magnetic tapes, and paper in the system room, while bulk storage should be located in another area.

Take into account all equipment that will be located in the computer room when calculating space requirements. Equipment other than the IG may include a maintenance console, display power supply cabinets, a display power controller cabinet, the system console and printer and computer room furniture such as chairs, tables, book shelves and storage cabinets. These items are part of the SPX system and do not include the host computer and its associated hardware.

3.3.2 Recommended Floor

Raised flooring is recommended to protect interconnecting cables and power receptacles, provide air conditioning distribution, and allow for addition of equipment at minimal cost. The flooring must provide a minimum of 7 inches of clearance. More clearance may be necessary depending on the size of the room and the air conditioning system. The floor should not have exposed surface metal for safety considerations. The metal supports of the floor must be grounded to meet electrical safety codes.

Make certain the floor of your building can support the equipment. The weight of each system component is listed in Table 2-1. The maximum concentrated floor load is 200 pounds, and the maximum distributed floor loading is 1.5 pounds per square inch. The suggested raised-floor specification is as follows: the Uniform Live Load capacity is to be 250 lbs. per square foot, yielding a maximum of 0.080" deflection and providing a permanent set not to exceed 0.010". The Concentrated Load Capacity is to be 1000 lbs. per square inch, yielding a maximum of 0.080" deflection and providing a permanent set not to exceed 0.010". The Rolling Load is to be 600 lbs. as tested by the CISCA method. The stringers need to be a rigid-bolted grid system.

Pedestal type raised flooring is preferred because it increases layout flexibility by allowing cable routing in any direction.

Concrete flooring under a raised floor must be sealed to prevent the circulation of concrete dust, especially when the under-floor space is used to distribute air.

Rubber or vinyl tile is recommended as a floor covering because it is strong and easy to maintain. This type of floor covering can be cleaned with a damp mop or a vacuum cleaner. If a wax is used it should be of the type manufactured with a high conductivity to reduce static buildup.

Carpet is not recommended for use in computer rooms as it can cause excessive electrostatic buildup that can severely harm equipment. If carpeting is desired it should be the type manufactured with anti-static materials or at the very least regularly treated with an anti-static agent.

3.4 ELECTRICAL POWER REQUIREMENTS

The recommendations provided here are general in nature. Additional recommendations are available in the FIPS (Federal Information Processing Standards Publication) PUB 94 entitled *Guideline On Electrical Power For ADP Installations*. System power requirements are discussed in Section 2.5.2.

3.4.1 Electrical Environment

It is crucial that the proper electrical environment be provided to insure reliable operation and maximum availability of the system. Specific areas of concern are:

- Power Quality. This includes the magnitude and stability of voltage and frequency, protection from disturbances in excess of system specifications regarding power line sags and surges.

- Grounding. Power must be grounded with a low impedance path to earth reference to provide isolation from external electrical noise and assure the quality of the data signal integrity reference.

- Protective Control. An emergency power-off switch should be provided.

3.4.2 Distribution

Each SPX cabinet requires a separate connection at the site power distribution panel. A 38 foot electrical cable is supplied for each cabinet. The site power end of the 38 foot cable is supplied without connectors which must be supplied by the customer if a connector is necessary. Each individual branch circuit needs to be protected with its own 50 amp circuit breaker that matches the wire and receptacle load rating. Label each circuit breaker and receptacle to show the equipment it serves. Screw or bolt-in type circuit breakers in the distribution panel provide optimal performance.

The preferred site power is 230 V AC single phase. Installations using three-phase power should balance the cabinet loads of the image generator between all three phases where possible. Unbalanced phases reduce efficiency, thereby increasing power consumption and costs.

Experience has shown that video noise may be reduced if the image generator and displays receive their site power from the same breaker panel.

A remote emergency power-off switch that can control all computer equipment in the room is recommended so that interruption of power to all equipment during a fire or other emergency can be accomplished. This switch should be near all room exits.

3.4.3 Isolation

Stable, noise-free power is required. The SPX system must not be connected to the same lines as noise-producing devices such as electrical motors, air conditioners, relays, electronic dimmers, office equipment, etc. Reserve the distribution panel providing branch circuit power to the image generator for computer use only.

It is recommended that the site location take into account protection of the equipment from any sources of radiated electromagnetic interference (EMI). Typical sources of such interference include radar installations, broadcast transmitters, vehicle ignition systems, lightning strikes, etc.

A shielded isolation transformer will protect the equipment from power line noise. If power quality monitoring shows voltage variations in excess of the specified limits, voltage regulation and/or transient suppression may be required. If an isolation transformer is used it should be located as close as possible to the equipment. If it is over 150 feet away, oversized conductors are required.

The SPX system, host computer, associated peripherals, and other computing equipment should be the only loads connected to the output of the isolation transformer and the computer power distribution panel.

3.4.4 Line Conditioning Methods

Protection against voltage transients and fluctuations are important considerations to insure proper system operation. Depending upon site power, some level of power line conditioning may be necessary. Various methods of line conditioning exist which range from power line filters and isolation transformers to motor-generators and uninterruptable power systems (UPS) for extreme cases.

3.4.5 Grounding

Power grounding is provided to ensure personnel safety and to maintain data signal integrity. Grounding conductors must connect all equipment to the system earth reference for safety, while the configuration of the grounding conductors must isolate the system from alternate grounding paths that would destroy data signal integrity.

All power connections to the equipment must contain a separate, insulated grounding conductor at least equal in size to the phase conductors. These conductors and their corresponding receptacle contacts must provide a continuous, low-impedance path from the equipment to the primary power earth reference. Conduit grounding methods are not considered adequate. National and local electrical codes should be followed.

3.5 VIBRATION

Vibration transmitted to the system room can cause slow degradation of mechanical parts; severe vibration may cause data errors on disks. The system can tolerate occasional intermittent, low-intensity vibration without harm.

Any environment that will subject the system to shock or vibration above normal should be measured to determine the amount of vibration and discussed with an engineering consultant.

3.6 SAFETY CONSIDERATIONS

3.6.1 Environment

The SPX system will shut down under over-temperature conditions automatically. Do not attempt to restart the system until the cause of the over-heating condition has been resolved.

Locate the system so that it is not under pipes carrying water or in the vicinity of other such hazards; this will help prevent equipment damage should a pipe develop a leak.

3.6.2 Cable Routing

Cables may be routed either on the floor surface or beneath a raised floor. If a raised floor is not used and cables are routed on the floor surface, cable ramps should be used to ensure the safety of personnel and equipment. Cables should be run in low traffic areas to minimize the possibility of damage to the cabling and increase safety. Cabling run under a raised floor provides greater flexibility and protection, as well as a more attractive installation.

WARNING: Damp mopping the raised floor could result in serious injury due to electrical shock if electrical and data cabling are not contained in watertight conduit, ducts, or cable trays.

3.6.3 Lightning

In an area with high susceptibility to electrical storms it is desirable to provide protection at the primary power transformer with the use of lightning arresters. This will provide personnel and equipment safety by reducing the current and voltages produced by a lightning strike.

3.6.4 Fire Protection

The following are recommended for a fire alarm system:

- Redundancy of sensing devices where activation of multiple detectors is required for a valid alarm. When a single sensor is activated, a preliminary warning should sound.
- The alarm system should be connected to the central alarm system (if one exists) to insure alerting personnel even when the room is unoccupied.
- An automatic system may provide for the release of an extinguishing agent and shut down of ventilation and room power.

It is recommended that a fire extinguishing system be installed to ensure personnel and equipment safety. Halon systems are the preferred fire extinguishing systems for use in computer room environments, having the advantage of being safe for both equipment and human contact.

The following are options for a fire extinguishing system:

- Halon 1301. Halon has the advantage of being safe for both equipment and human contact.

- CO_2 units. While CO_2 is not as optimal as Halon because it will not allow normal breathing, it is available in portable units.

- Sprinkler systems. These should not be used except as a backup, as water will cause equipment damage. If a sprinkler system is used, a dry pipe installation should be employed to prevent water leaks.

3.6.5 Personnel Training

Personnel should be trained in proper emergency procedures for the protection of lives, equipment, and data, with periodic refresher training given to help insure preparedness.

3.7 ENVIRONMENTAL REQUIREMENTS

Temperature and humidity should be maintained at a level not exceeding the most critical tolerance of any one piece of equipment. The temperature and humidity range for the SPX system is listed in Table 2-3.

The optimum operating temperature of the computer room is between 65° and 75° Fahrenheit (18° to 24° Celsius), with humidity kept between 40 and 60%. The amount of temperature change should be kept within 3.6° Fahrenheit (2° Celsius) per hour. The SPX CIG will operate outside of these tolerances up to the equipment specifications; however, reliability is best when operated within the above recommended tolerance.

The air conditioning should be a dedicated system, serving only the computer room. It should be equipped with the following:

- Central shut-off switch
- Automatic shut-down if a fire is detected
- Monitor for air conditioning self shut-down (with alarm)

Air conditioning controls should be located in the computer room, along with any temperature and humidity measuring instruments. The system should be allowed to run continuously to maintain a constant temperature in the room.

Air filtering should be provided to reduce dust and other particles to a reasonable level. If salt air, corrosive gases, or other pollutants are present, special filtering may be required.

A one ton (907 Kg.) air conditioner will supply approximately 12,000 BTUs per hour (3024 Kg-cal. per hour) of cooling. To calculate the approximate number of tons (or kilograms) of air conditioning that may be needed, divide the total system BTUs per hour by 12,000 (Kg-cal. per hour by 3024). It is recommended that the air conditioner be large enough to handle future expansion.

CHAPTER 4

INSTALLATION

4.1 INTRODUCTION

This chapter discusses the installation, setup, and disassembly of the SPX system components. Subjects covered in this chapter include the tools and equipment necessary for the installation, actual installation of the system, switch settings, and preparation for reshipment.

4.2 TOOLS AND TEST EQUIPMENT

The tools and test equipment listed in Table 4-1, or equivalents, are required to install and maintain the SPX CIG System.

Table 4-1. Tools and Test Equipment

Oscilloscope:	Critical requirement: 150 MHz bandwidth. Recommend Tektronix (80009) oscilloscope, part number 2445A or equivalent. (National stock number 6625-01-178-9491)
Cart, O-Scope:	Critical requirement: Accommodate oscilloscope in order to provide on-site mobility. Recommend Tektronix (80009) oscilloscope cart, part number K212 or equivalent.
Logic Probe:	Critical requirement: TTL/CMOS probe, input current and capacitance less than or equal to 15 micro amp and 15 pF. Logic threshold TTL: Logic one, 2.0 + 0.4, -0.2V. Logic zero, 0.8 + 0.2-0.4V. Input minimum pulse width: 10 ns using ground lead. Input maximum pulse repetition frequency: TTL, 80 MHz. CMOS: 40 MHz. Power: TTL, 4.5 to 15 V DC, CMOS, 3 to 18 V DC. Recommend Hewlett-Packard (28480) logic probe, part number 545A or equivalent. (National stock number 6625-01-047-7309)

Multimeter:	Critical requirements: Voltage AC/DC: 1 mV ±3%, current: 0.01 mA To 5.0 Amps. Resistance: 0.1 thru 20 Megohms. Meter should have probe options that will increase voltage measurement range and/or allow temperature measurements. Recommend Fluke (89536) multimeter, part number 77 or equivalent. (National stock number 6625-01-178-9491)
Tool Kit:	Critical requirement: Tool kit should contain a variety of common hand tools such as screwdrivers, nut, hex and spline drivers, wrenches, pliers etc. Recommend Jensen's (52346) Tool Kit, part number JTK-17-LAL or equivalent. (National stock number 5180-01-073-3845)
Torque Wrench:	Critical requirement: 100 inch pounds and must accommodate 9/16 inch, deep, socket (1/4, 3/8, 1/2 drive). Recommend Jensen's (52346) Torque Wrench, part number J281B750 or equivalent.
3/8" Skt Set:	Critical requirement: Must contain 9/16 (deep) inch deep, socket. Recommend Jensen's (52346) 3/8" Deep Socket Set, part number J354B216 or equivalent.
Extractor:	Critical requirement: Field repair Amp Type I, II, and III connector pin and socket parts. Recommend Amp (00779) Extractor, part number 305183 or equivalent. (National stock number 5120-00-020-5926)
Heat Gun:	Critical requirement: Temperature range 500 to 700 degrees F. Master's (83284) Heat Gun, part number HG-501A or equivalent. (National stock number 4940-01-028-7493)
Heater Adapter:	Critical requirement: Must fit heat gun. Disperse heat evenly. Recommend Master's (83284) Heater Adapter Baffle part number A170-HG or equivalent. (National stock number 4940-01-251-8420)
Heater Cone:	Critical requirement: Must fit heat gun. Concentrate heat. Recommend Master's (83284) Heater Cone-1/4 Pinpoint Attachment, part number 51309 or equivalent. (National stock number 7290-01-133-4083)
Wirewrap Gun:	Critical requirement: None. Recommend Cooper Industries (24047) Wirewrap Gun, part number 27300AB8 or equivalent. (National stock number 5120-00-118-7075)
26-GA W/W BIT:	Critical requirement: Must fit wirewrap gun. Recommend Cooper Industries (24047) Wirewrap 26-GA Bit, part

	number 506445 or equivalent. (National stock number 5130-00-134-4570)
30-GA W/W BIT:	Critical requirement: Must fit wirewrap gun. Recommend Cooper Industries (24047) Wirewrap 30-GA Bit, part number 507063 or equivalent. (National stock number 5130-00-134-4572)
W/W SLEEVE:	Critical requirement: Must fit wirewrap gun. Recommend Cooper Industries (24047) Wirewrap Sleeve, part number 507100 or equivalent. (National stock number 5130-00-459-4485)
Unwrap Tool:	Critical requirement: Unwrap wire wrapped connections. Recommend Cooper Industries (24047) wire unwrap tool, part number 505084 or equivalent.
Wrist Band:	Critical requirement: Must protect components from static damage. Recommend Jensen's (52346) wrist band, static, part number J65B095 or equivalent.

4.3 SYSTEM INSTALLATION

4.3.1 SPX Cabinets

The cabinets for the SPX image generator are grouped into three categories: channel processor cabinets, display power supply cabinets, and the maintenance or instructor cabinet.

4.3.1.1 Channel Processor Cabinets

The channel processor cabinetry contains the hardware required to generate (but not display) the visual image. This hardware is contained in one to four cabinets, depending upon the number of required channels (see Figure 2-2). The first cabinet is the MP cabinet, which contains the MP unit with its magnetic media and one channel processor. The MP cabinet is always present.

If the image generator consists of more than one channel, additional channel processor cabinets are required. Each additional channel processor cabinet contains one or two channel processor backpanels with associated fans, air flow ducts, air filters and power supplies. Each image generator cabinet contains a 208070 power controller.

4.3.1.2 Display Power Supply Cabinet

Display power supply cabinets house power controller(s) or a power controller and display power supplies. Display power supply cabinets are an optional item based upon customer preference and needs. A typical display power supply cabinet contains a 208071 power controller and may contain display power supplies and/or video switching equipment. The configuration of the display power supply cabinets varies depending upon the customer's requirements. Optional with the power controller is a buck/boost transformer which, when properly strapped, is used to step the site power up or down to match the display system power requirements.

4.3.1.3 Maintenance/Instructor Cabinet

The visual system will often include an optional maintenance or instructor console. This cabinet typically contains a 208071 power controllers along with several other pieces of electronic equipment such as a video switcher and/or a video display (CRT) and its power supply.

4.3.2 Unpacking

Any cartons received with visual damage should be noted on the bill of lading by receiving personnel as follows: "CARTON DAMAGED; ACCEPTANCE UPON INSPECTION BY VENDOR".

Carefully unpack all of the equipment and, before discarding the packing material, determine that the system is complete. This is best accomplished by checking off each item listed on the Evans & Sutherland Shipping Inventory document as it is unpackaged. This inventory document is part of the documentation sent with each shipment. Remove all material used to secure parts during shipment, such as strapping tape and plastic ties used to secure cables within the cabinets and strapping tape across the front of each card cage to secure the PC cards in place. The only shipping hardware than needs to be removed are the two screws used to prevent the MP unit, which is mounted on slide rails, from moving during shipment. These screws need to be removed once the MP cabinet is in place. The EMI gasket material to be used when joining the cabinets is coiled and taped inside the IG cabinets.

All parts should be thoroughly inspected upon receipt for scratches, dents, broken connectors, and damaged cables. If damage to the equipment is discovered, make a list of these items, notify the carrier and arrange to have the shipment inspected by the carrier's agent. Inform the carrier of your intent to file a claim, and immediately notify your Evans & Sutherland representative.

4.3.3 Mechanical Installation

The following installation instructions are supported by drawings included in this manual and in the *SPX Signal Tracing Guide.*

4.3.3.1 EMI Considerations

Computer equipment emits electro-magnetic radiation that can cause interference in sensitive electronic equipment. Electro-magnetic interference (EMI) standards established by the federal government are met by Evans & Sutherland equipment. To minimize this radiation, cable shields, power line filters, and EMI cabinets are incorporated in all Evans & Sutherland equipment.

To insure that the equipment continues to meet EMI standards, disassembly and reassembly of equipment must be accomplished in a manner that maintains the system as originally manufactured and tested. Improper mechanical installation of the cabinets or its attached cables may lead to emissions of electromagnetic radiation in excess of that allowed. The integrity of the shielding requires attention to each part of the cabinet and its cables. Areas where consistent assembly procedures are critical are listed in the following paragraphs.

NOTE: Variation from these procedures may compromise the EMI integrity of the system.

4.3.3.2 Cabinet Assembly/Installation

The dimensions of each cabinet used to make up the SPX image generator are as follows:

Height	82 inches
Width	25 inches
Depth	34 inches

If the cabinet is an end cabinet with side panels, add 3/4" to the width of the cabinet per side panel. Each cabinet assembly is configured with a caster and leveling jackscrew at each corner. After the cabinet assembly is in the desired position, extend the jackscrews to level the assembly and support its weight.

EMI cabinets must be properly joined together. Abutting cabinets are attached together with bolts. Between each pair of cabinets an oval braid is installed which serves as an EMI gasket. When joining two or more cabinets, be sure that the EMI gasketing applied between the two cabinets is placed such that the wire braid portion of the gasket lies entirely on the unpainted surfaces of the cabinet frame or the side panels (see Figure 4-1). This wire mesh braiding is attached using a rubber backed adhesive. The gasket needs to be complete and follow the outer edge of the cabinet all the way around the front, bottom, rear, and top edges of the cabinet.

NOTE: If the wire braid is placed over the painted surface, it can no longer act as an EMI barrier.

Conductivity between the wire mesh and the metal cabinet is affected by dirt and oil. Before side panels are installed and adjoining cabinets connected, the surfaces where the wire mesh gasket touches should be cleaned with a lint-free cloth soaked in alcohol. This same cleaning should be performed on the metal surface under the gasket for the doors. The metal surface under the door gasket should be cleaned regularly as part of the periodic preventative maintenance program.

Cabinets are joined together using bolts through the front and rear vertical trim pieces. When tightening the bolts that connect one cabinet to another, tighten the bolts in an alternating star pattern to insure that there is an even pressure on the gasket around the entire opening. Tighten bolts securely. Loose bolts create gaps between the cabinets; such gaps can act as slot antennae.

End panels that hang on both ends of the cabinet or row of cabinets also have a ring of EMI gasket on each edge of the panel. The end panel's gasket makes contact with the bare metal of the cabinet from pressure generated by the mounting screws at the bottom of the panel.

Adjust cabinet tops so that they are properly centered at both front and rear. If the cabinet tops are not properly aligned, gaps form along the top seam or side seams and some EMI leakage may occur.

Cabinet doors are attached over the support hinges. The door has a conducting braid on each edge of the door which contacts the bare cabinet metal and is compressed by the door closure mechanism.

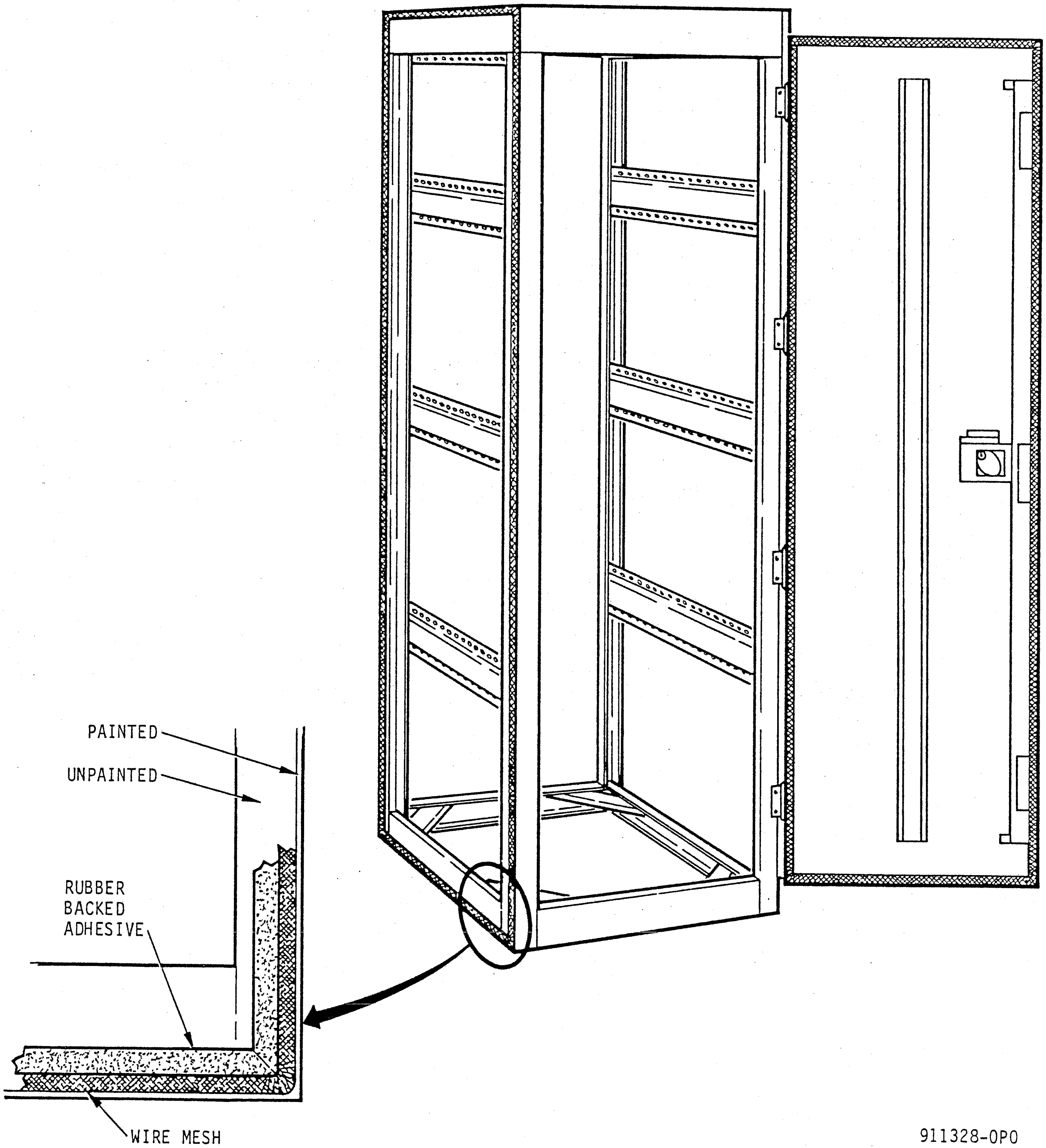


Figure 4-1. EMI Cabinet.

Cables require special installation through the EMI interface box within the SPX cabinets. For proper shielding, this EMI interface box has connectors which have ground shields attached mechanically to the metal box. All cables need to connect to the corresponding connector and the EMI interface box cover needs to be attached. Intentionally bypassing the EMI interface box with a cable will violate the EMI integrity of the system.

Within the power controller in the cabinets are line filters critical in preventing EMI radiation from the power line. Proper installation requires that these filters be connected for system operation.

4.3.3.3 Multiprocessor Unit (MPU)

The MPU is installed in a standard 19-inch equipment cabinet. The unit is mounted on slide rails. Each slide rail is configured with a stop/release mechanism to prevent an overrun when the unit is being extended or removed from the cabinet. To install the unit, extend the slide rails forward from the equipment rack, engage the unit's slide rails with the extended slide rails, and push the unit to the rear until the stop/release mechanisms are engaged.

4.3.3.4 System Console Terminal and Printer

The system console terminal, ICC (optional interactive console), and printer are typically placed on a desk or table. Place the terminal in an area where its air inlets and outlets are unobstructed.

4.3.4 SPX System Interconnection

After the SPX image generator system has been mechanically installed, the next task is to connect the power and signal cables between the image generator cabinets, maintenance/display cabinets, and the displays. SPX cabinets are shipped with internal cabling already in place. Refer to Figures 4-2 through 4-9 to verify cabling within any given cabinet. Figures 4-10 through 4-18 show the interconnection of cables between cabinets and peripherals, and between cabinets and site power.

4.3.4.1 Site Power

The SPX Image Generator is comprised of channel processor cabinets and optionally either display power supply cabinets or a maintenance/instructor cabinet. Interconnection of site power to these cabinets is described in the following paragraphs.

4.3.4.1.1 MP/Channel Processor Cabinet Site Power

Connect site power to the power controller in each channel processor cabinet by connecting the large power connector of the 208238 power cable to J1 (see Figure 4-10) of the 208070 power controller. Connect the other end of the power cable to the circuit breaker panel that will be providing site power to the image generator. (See Section 2.5.2 for more information regarding site power specifications.)

4.3.4.1.2 Display Power Supply Cabinet Site Power

Connect site power to the power controller in each display power supply cabinet by connecting the large power connector of the 208238 power cable to J1 of the 208071 power controller. The J1 power connector location is identical for the 208070 and 208071 power controllers (see Figure 4-10). Connect the other end of the power cable to the circuit breaker panel that will be providing site power to the image generator.

4.3.4.1.3 Projector Power Controller Cabinet Site Power

Connect site power to the power controller in the projector power controller cabinet by connecting the large power connector of the 208238 power cable to J1 of the 208071 power controller. The J1 power connector location is identical for the 208070 and 208071 power controllers (see Figure 4-10). Connect the other end of the power cable to the circuit breaker panel that will be providing site power to the image generator.

4.3.4.2 Signal Cabling

4.3.4.2.1 Common bus

Extend the common bus interconnect to adjacent channels by connecting the 208223 cables from the headers on the left of the channel processor backpanel 208040 to the headers on the right of the adjacent backpanel. The headers are located over pins 25 through pins 44 and pins 55 through 74 of slots 46 and 47 (see Figure 4-6). Continue interconnecting cabinets as shown in Figures 4-8 and 4-11. The last backpanel in the system terminates the common bus. Remove the lower header and plug the resistor terminating card (208242) onto pins P1.55 - P1.75, P2.25 - P2.44, P2.55 - P2.75, P3.25 - P3.44, and P3.55 - P3.75 of slot 47 (see Figure 4-9).

4.3.4.2.2 Ground Cable

Extend the ground between channels by connecting the 208234 cable from the left lug on the channel processor backpanels' lower ground bus bar to the same lug on the adjacent backpanel. Continue interconnecting cabinets as shown in Figures 4-8 and 4-11.

4.3.4.2.3 Power Controller

Connect all image processor power controllers together by plugging the P1 pigtail (see Figure 4-5 to locate the P1 connector), extending from the right rear of each power controller into the W3-J1 connector on the left rear of the adjacent power controllers (see Figure 4-11). Note that the pigtail extending from the MP cabinet power controller connects to the 208231 cable which connects the power controllers to the 208054-101 control power supply (see Figure 4-4).

If more than one display power supply cabinet is used, interconnect the power controllers of the cabinets by connecting the P1 pigtail from the left-most power controller (when viewed from the rear) to the W3-J1 connector on the adjacent power controller, using a 208082-100 cable (see Figures 4-13 and 4-14). The P1 pigtail of cabinet 5 is connected to a 208231-100 cable, which come from a ±15 V DC power supply. This is the control power supply for the 208071 power controller(s).

4.3.5 System Console

Connect the system console power cable (208221) from the DEC VTXXX terminal to the J17 connector of the MP cabinet's 208070 power controller. The MP cabinet is typically the left-most cabinet when facing the front of the image generator. J17 is behind the lower front cover plate of the 208070 power controller and is the left-most connector (see Figure 4-10).

CAUTION: Insure that the system console terminal is set for 240 VAC operation.

Connect the 801130 RS-232 cable to the terminal. Connect the 801103 null modem connector to the RS-232 cable. Connect the null modem to J4 of the MP cabinet's EMI interface box (see Figure 4-12).

4.3.5.1 System Printer

Connect the 208221 printer power cable to the J16 (center) connector of the 208070 power controller in the MP cabinet (see Figure 4-10). The system printer must be a model (such as the DEC LA75, LA100 or LA210 printers) which supports 240 VAC operation and is compatible with the VT2XX/VT3XX series terminals.

CAUTION: Insure that the system printer is set for 240 VAC operation.

Connect the printer signal cable between the system console and the printer (see Figure 4-12). This cable is dependent upon the model of printer used with the system.

4.3.5.2 Interactive Control Console (Optional)

Connect the interactive control console (ICC or flybox) power cable (208221) from J15 of the power controller in the MP cabinet to the ICC (see Figure 4-10). If it is desirable that the ICC be located remotely from the IG and draw its power from a conventional 115 VAC outlet, use an optional 801832-109 power cable. This configuration allows the user to power on the IG remotely from the ICC. The ICC contains a line voltage sensing power supply which automatically configures the ICC for 120 VAC or 240 VAC operation.

Connect the ICC signal cable (208240) from J8 of the MP cabinet's EMI cage to the ICC. See Figure 4-12.

4.3.6 Video Cable

Connect each display device's video cable to the interface box for its corresponding channel. Channel 0 connects to the MP cabinet's interface box (EMI cage), J1. Channel 1 connects to cabinet 1 interface box J1, channel 2 connects to cabinet 1 interface box J4, etc. (see Figure 4-12).

4.3.7 Display Power Controller Control

If the system is equipped with CSM displays, connect the 208240 cable from J7 of the last image processor cabinet's EMI cage to the 208225 cable in the display power supply cabinet. The 208225 cable is attached to the connector labeled W3-J1 on the 208071 power controller in the display power supply cabinet (see Figures 4-13 and 4-14).

If the system utilizes projector displays and requires a 208071 power controller to switch display power, connect the 208071 display power controller to the image processor cabinets using a 208240 cable from J7 of the last image processor cabinet's EMI cage to the 208225 cable in the projector display power cabinet. The 208225 cable is attached to the connector labeled W3-J1 on the 208071 display power controller (see Figure 4-18).

4.3.8 CSM Low Voltage Power Supply

If the visual system is equipped with CSM displays, the CSM low voltage power supply (LVPS) must be connected to the CSM display head. Connect the 201330 cables from each LVPS to the appropriate display head as shown in Figures 4-15 through 4-17.

4.3.9 Projector Display Power Supply

If the visual system is to be used with projector displays, interconnect the projector power controller cabinet to the SPX image processor cabinets as shown in Figure 4-18. Up to five displays can be powered from a single 208071 power controller, provided that the average and peak current draw from the cabinet do not exceed the ratings of the power controller's circuit breakers. The main circuit breaker is rated for 50 amps. Connectors J2 through J4 are protected by one 30 amp breaker. Connectors J5 and J6 are protected by a second 30 amp breaker. No single device may draw more than 15 amps.

4.4 OPTION INSTALLATION

Installation instructions are provided with all options that can be installed on site.

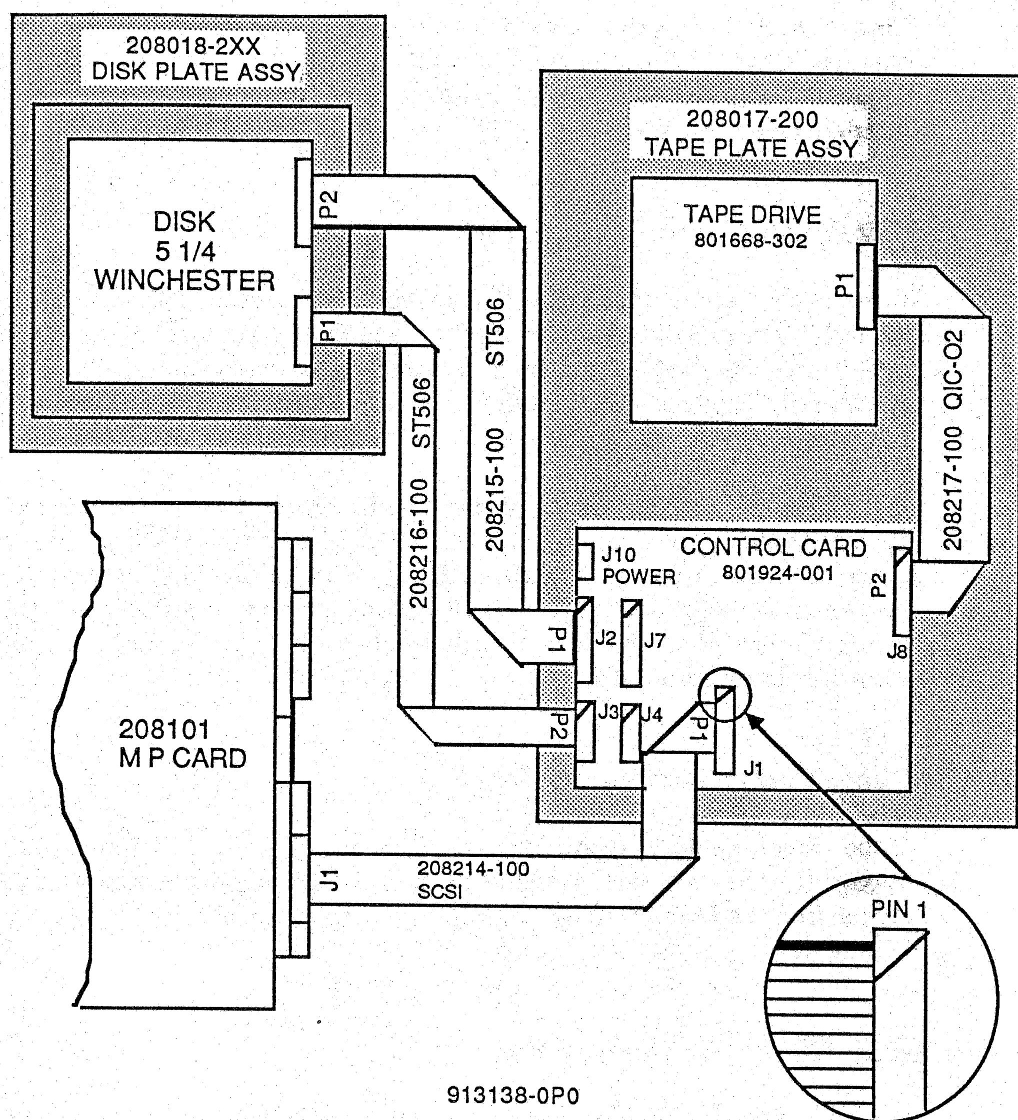


Figure 4-2. MP Unit Disk/Tape Signal Cabling

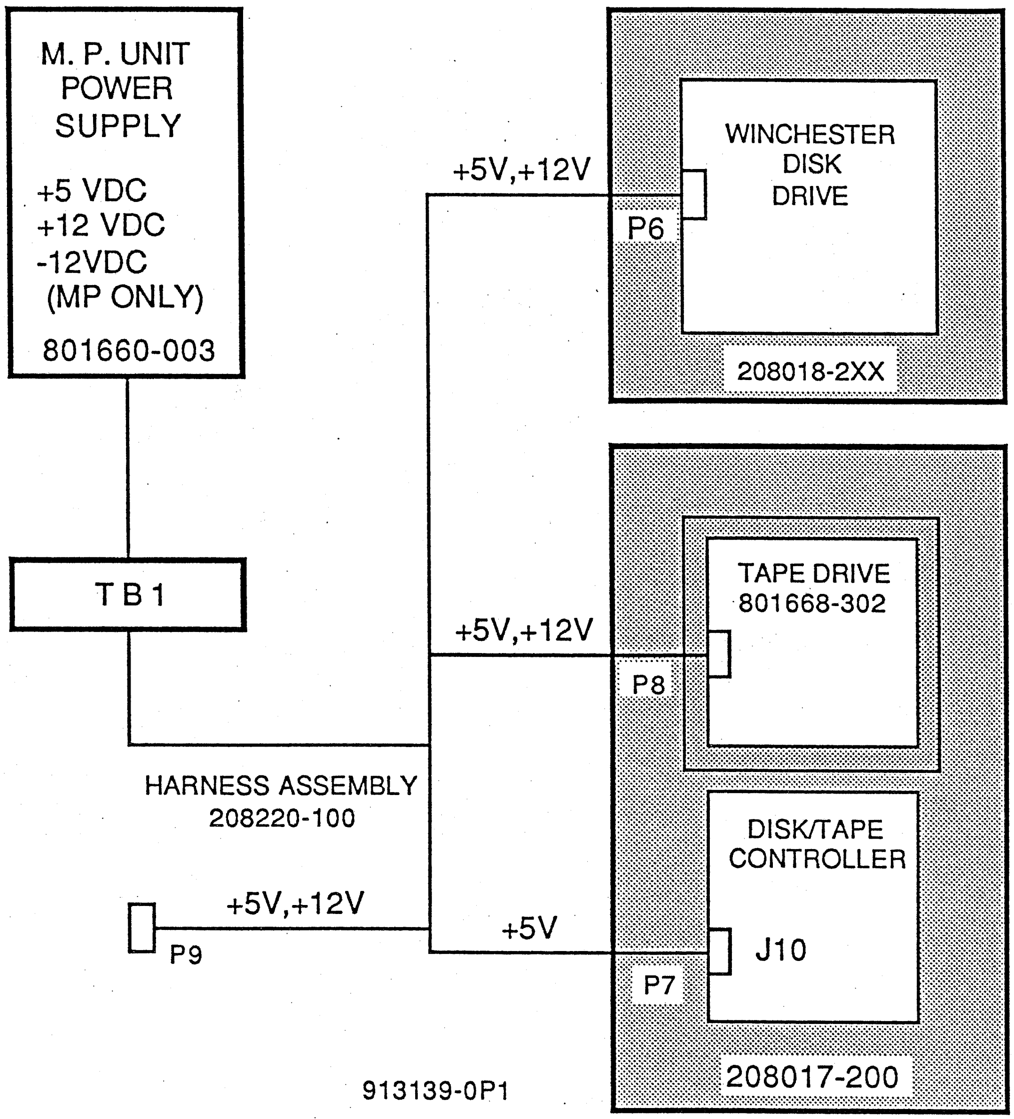


Figure 4-3. MP Unit Disk/Tape Power Cabling

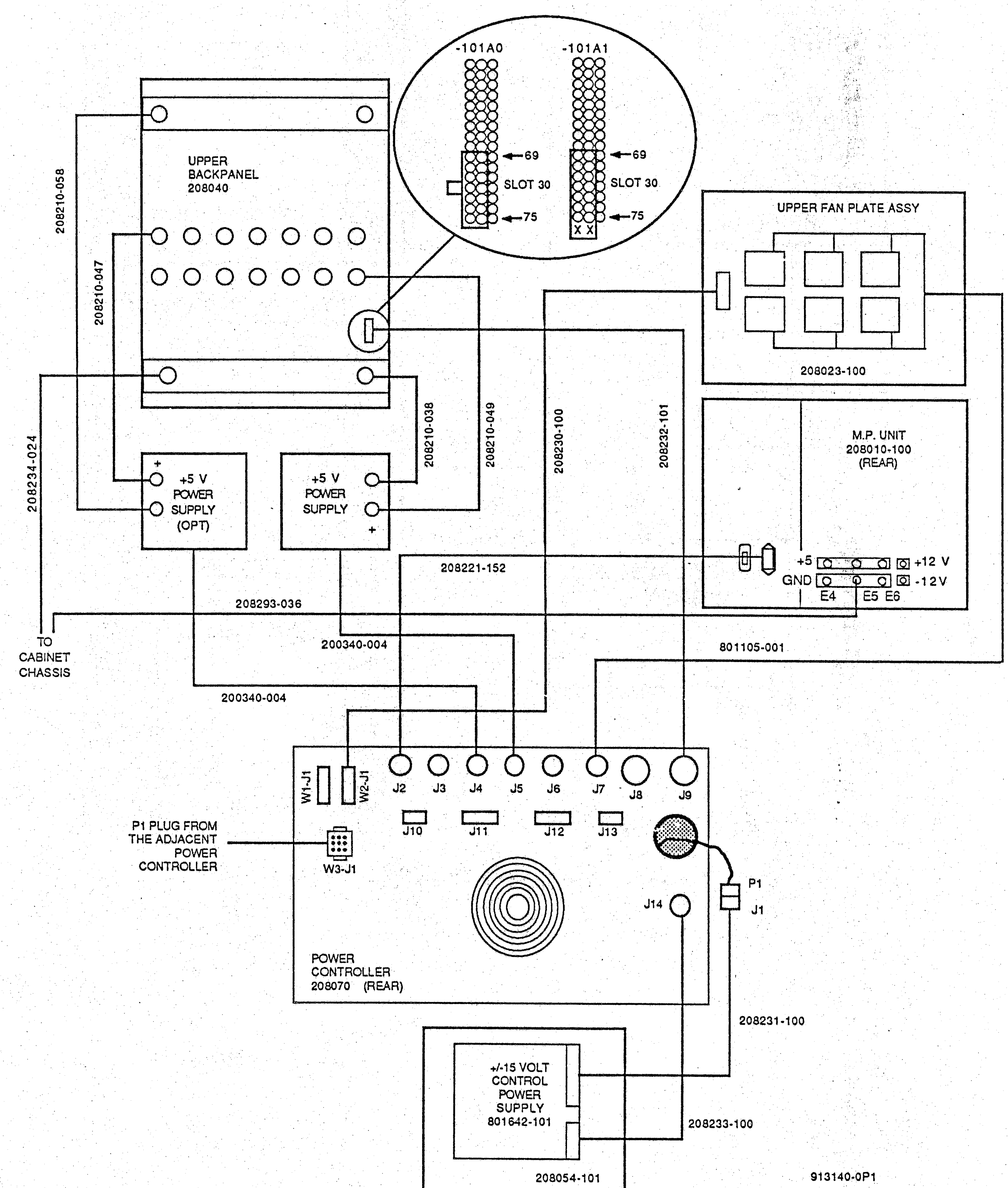


Figure 4-4. MP Cabinet Power Cabling

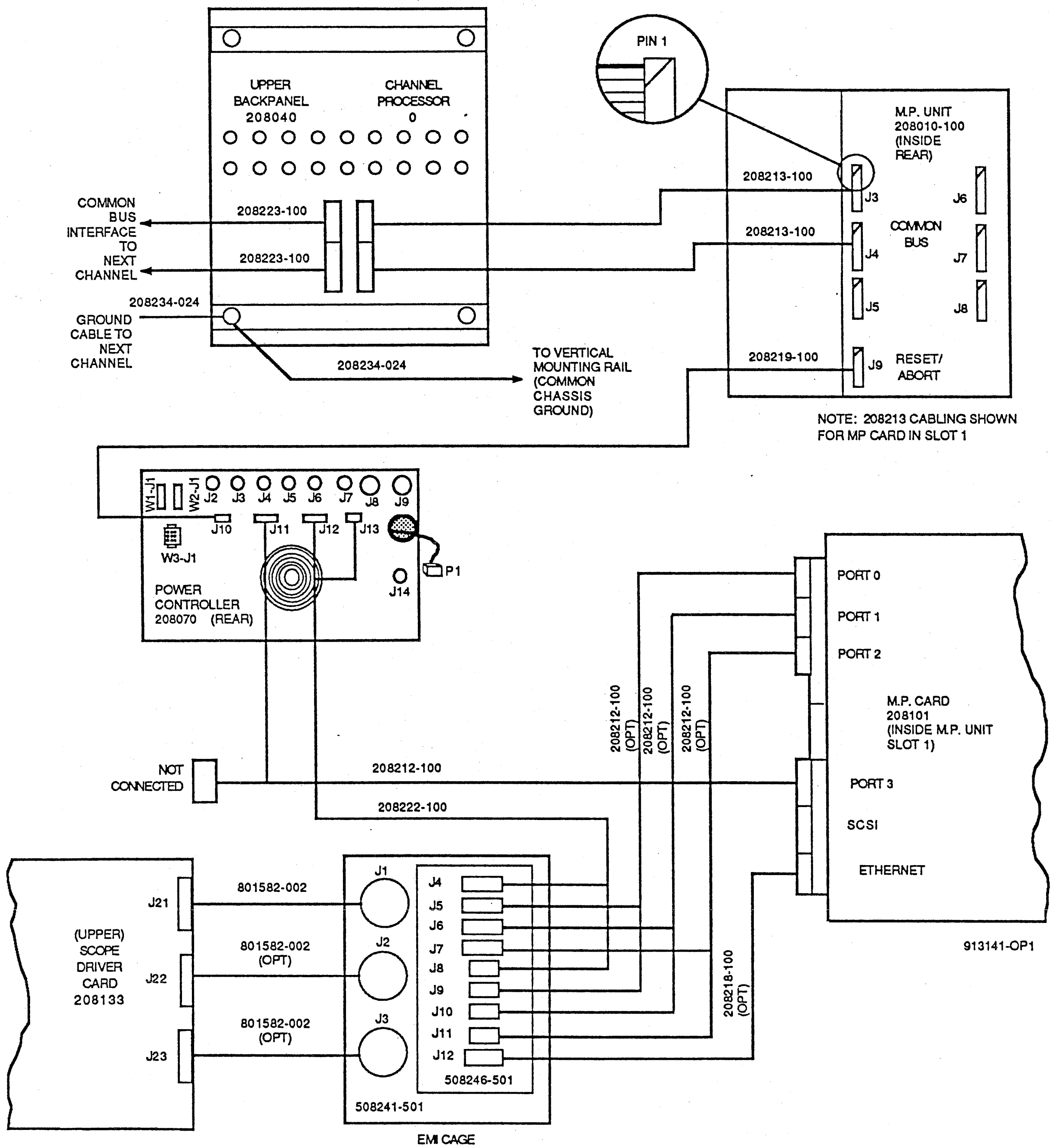


Figure 4-5. MP Cabinet Signal Cabling

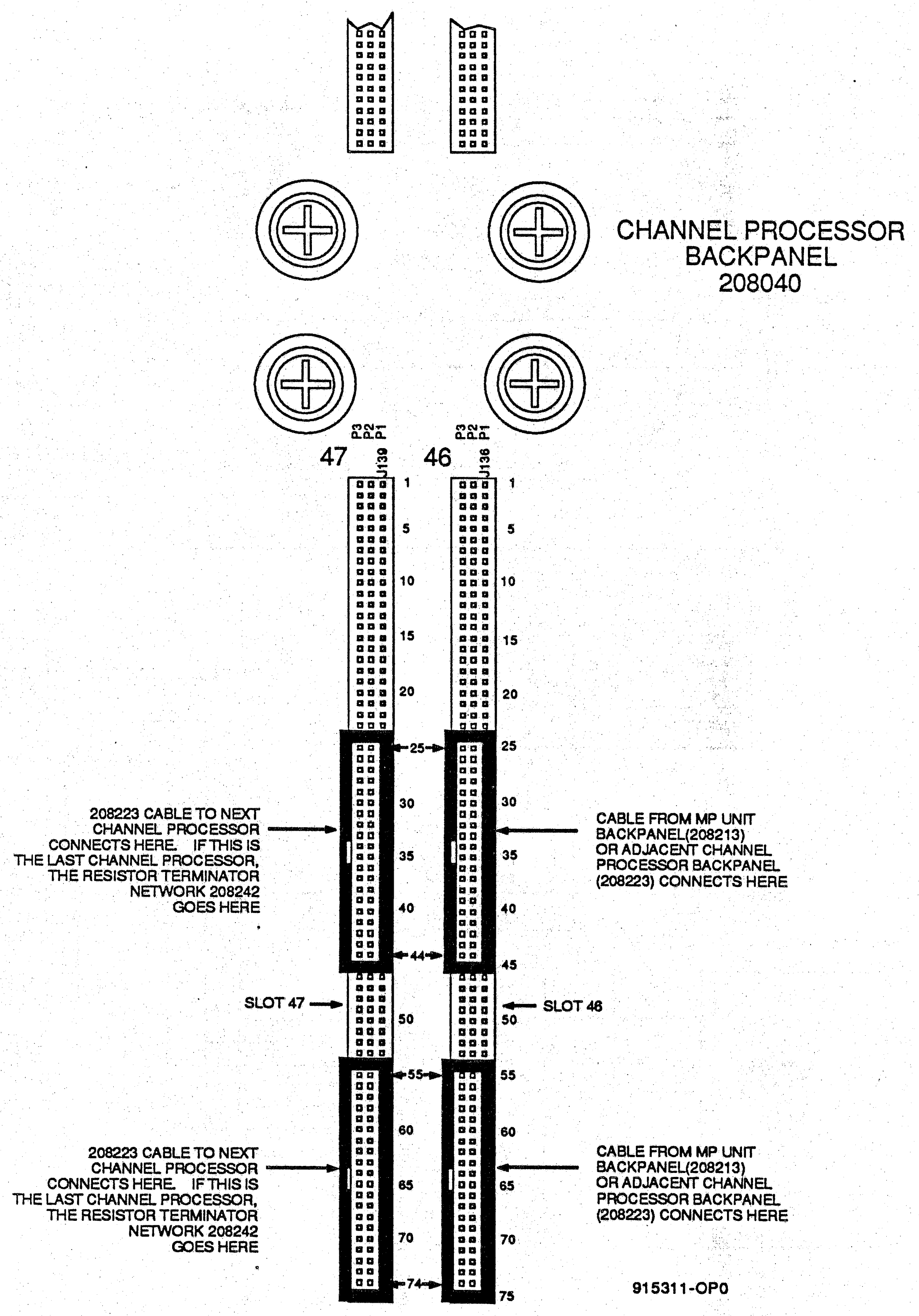


Figure 4-6. Common Bus Cable/Channel Processor Backpanel Connection

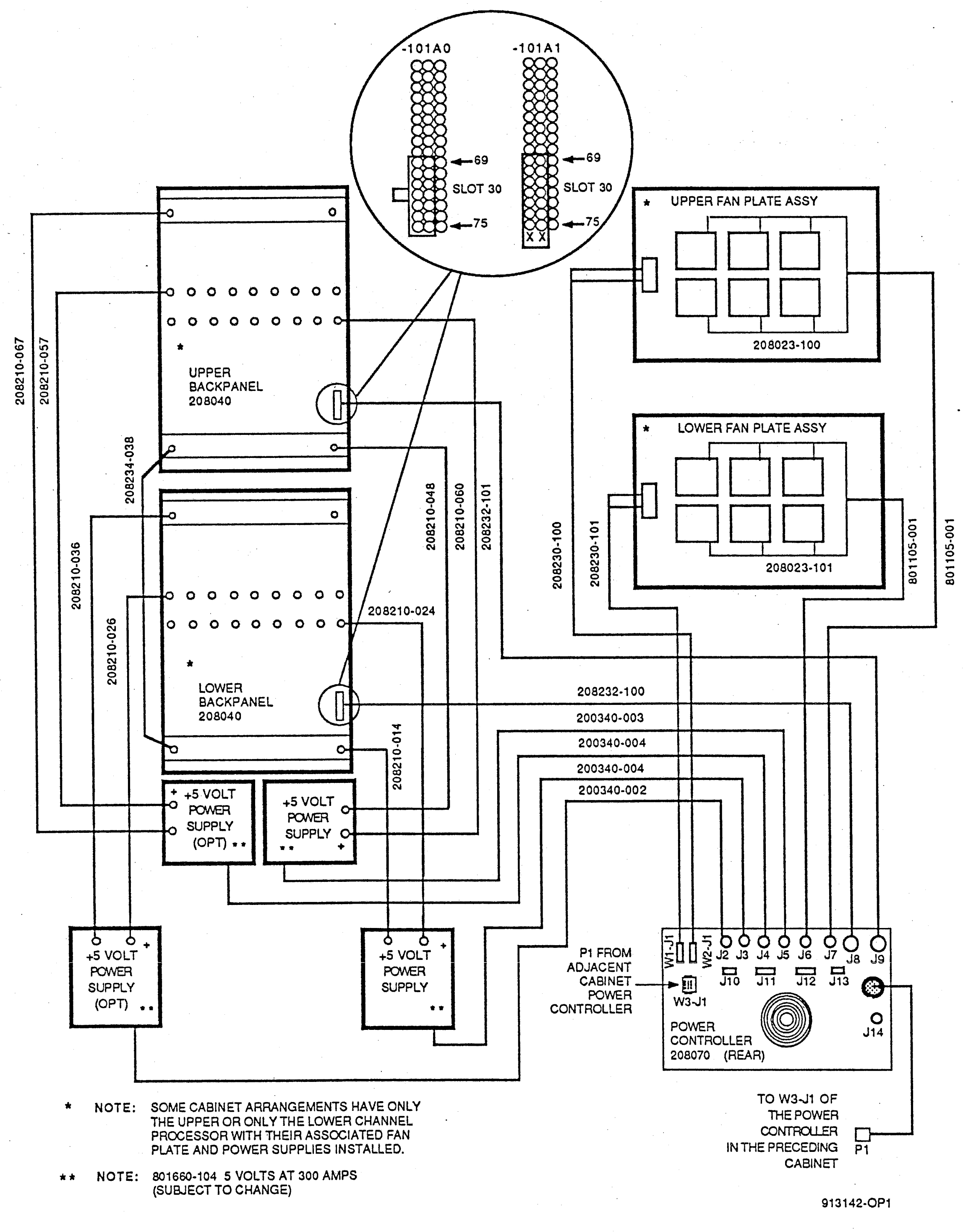


Figure 4-7. Dual Channel Processor Cabinet Power Cabling

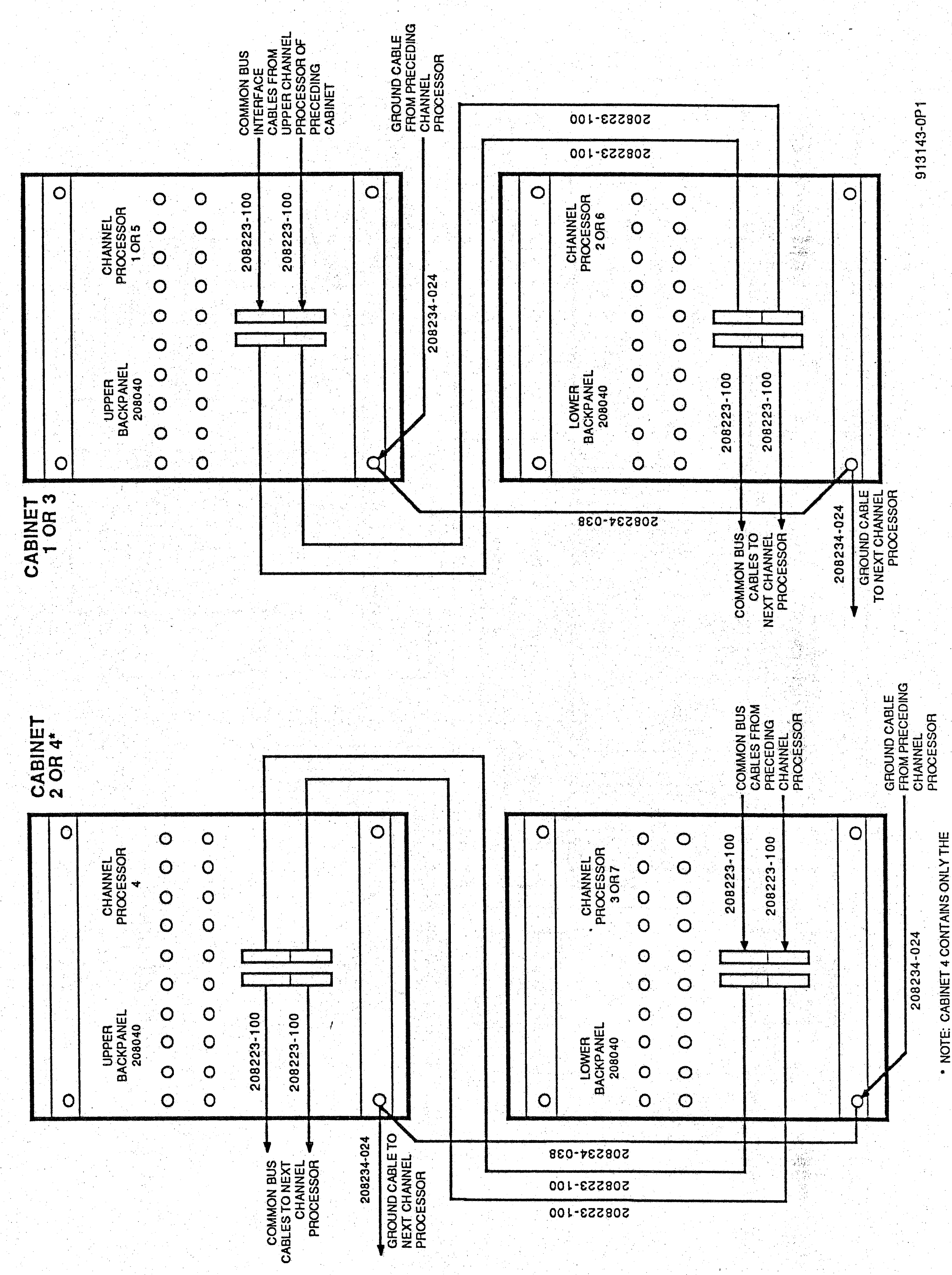


Figure 4-8. Dual Channel Processor Cabinet Signal Cabling (Rear View)

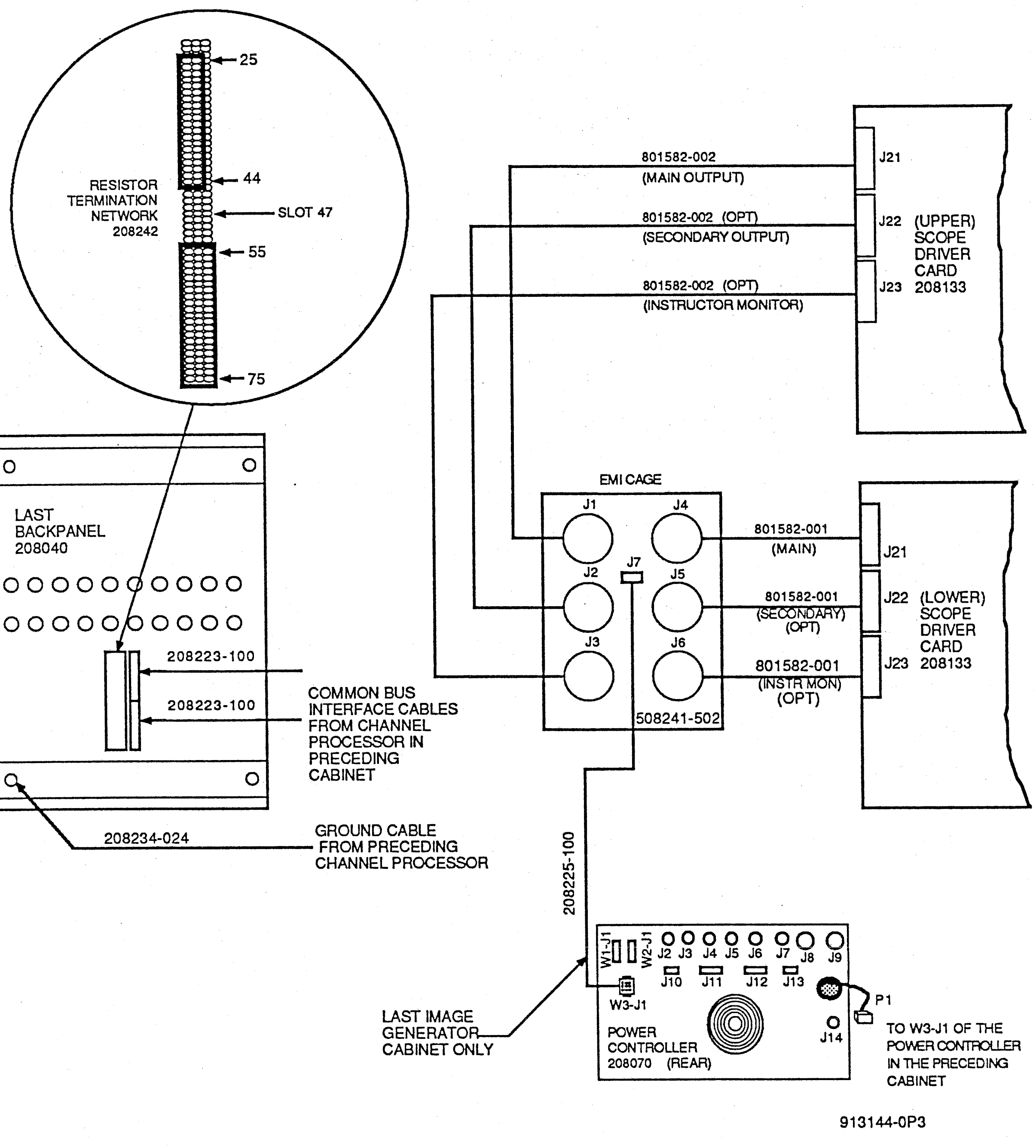


Figure 4-9. Dual Channel Processor Cabinet Video Cabling

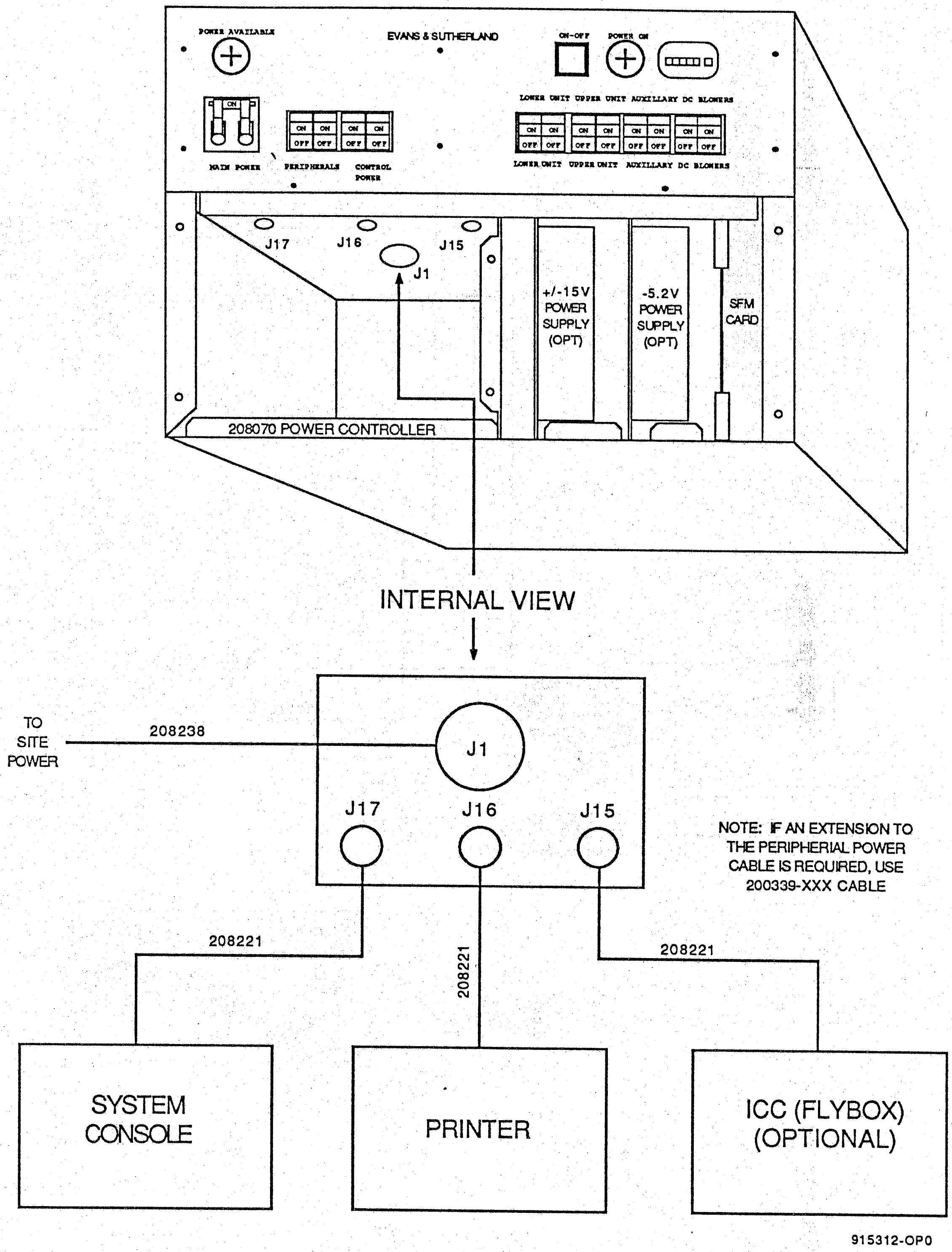


Figure 4-10. SPX Peripheral Power Cabling

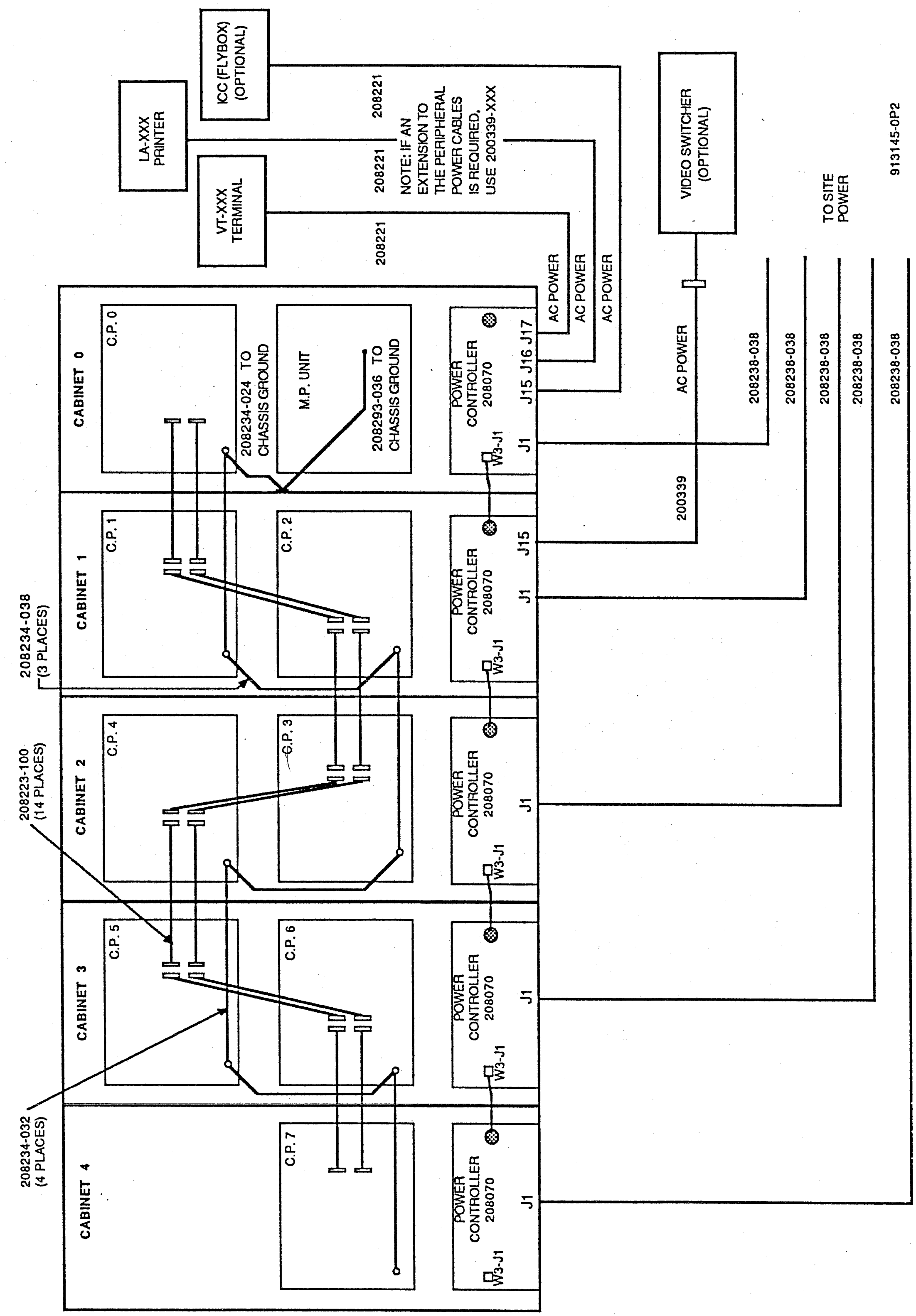


Figure 4-11. SPX Image Generator Cabinet Cabling

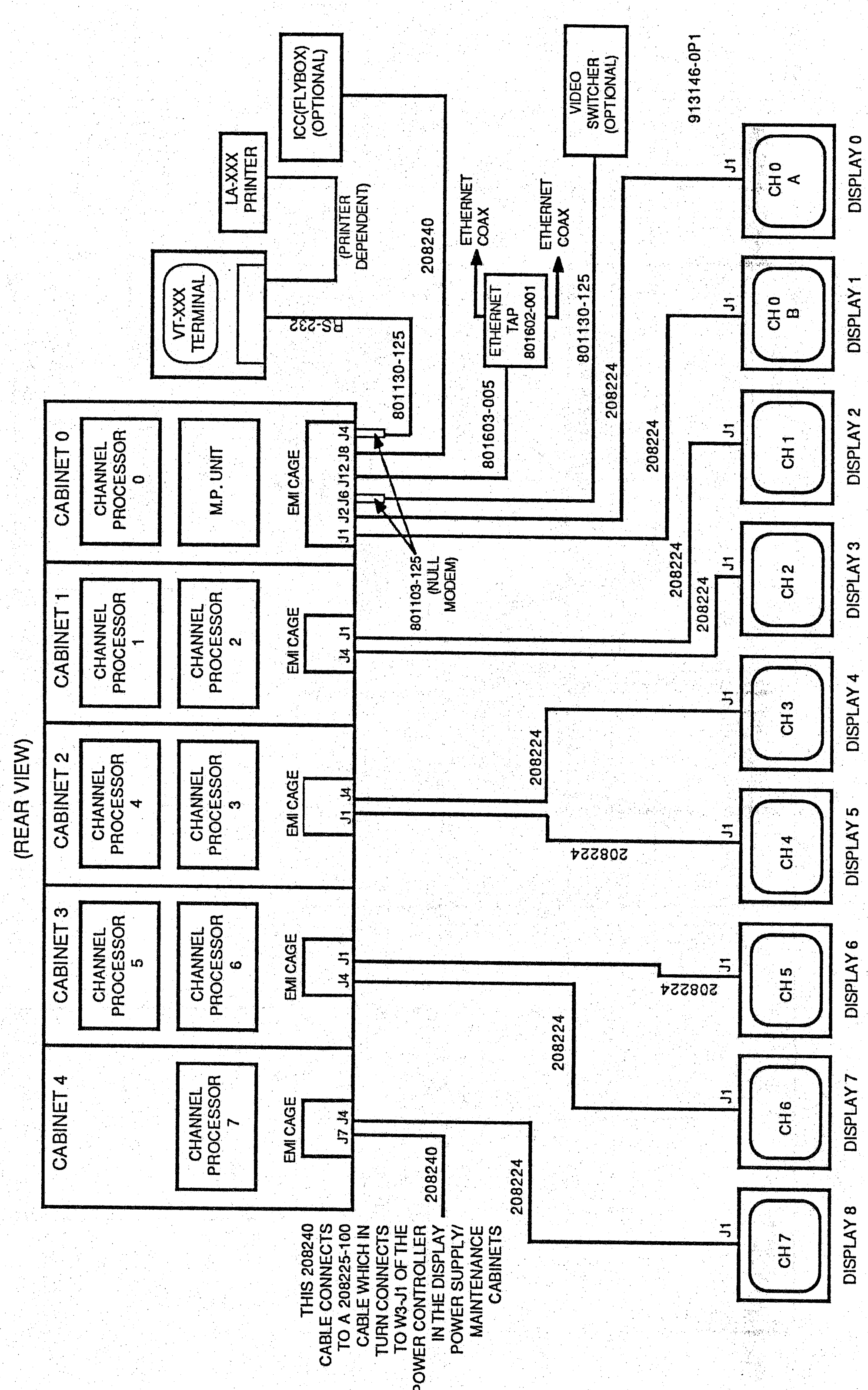


Figure 4-12. SPX Image Generator Cabinet Video/Signal Cabling (8 Channel, 9 Window Configuration)

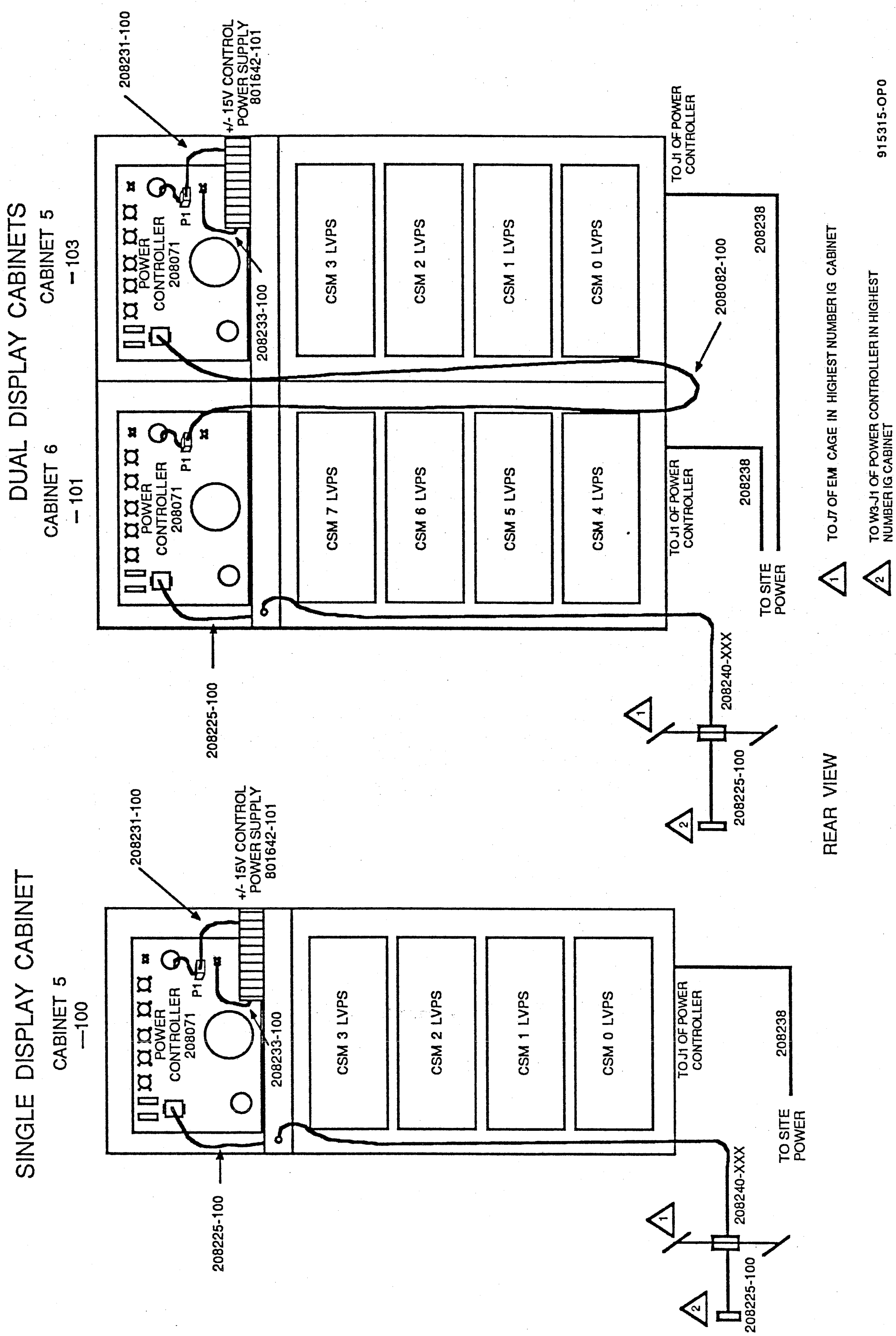


Figure 4-13. Display Cabinet Power Controller Cabling (1 and 2 Cabinet Configuration)

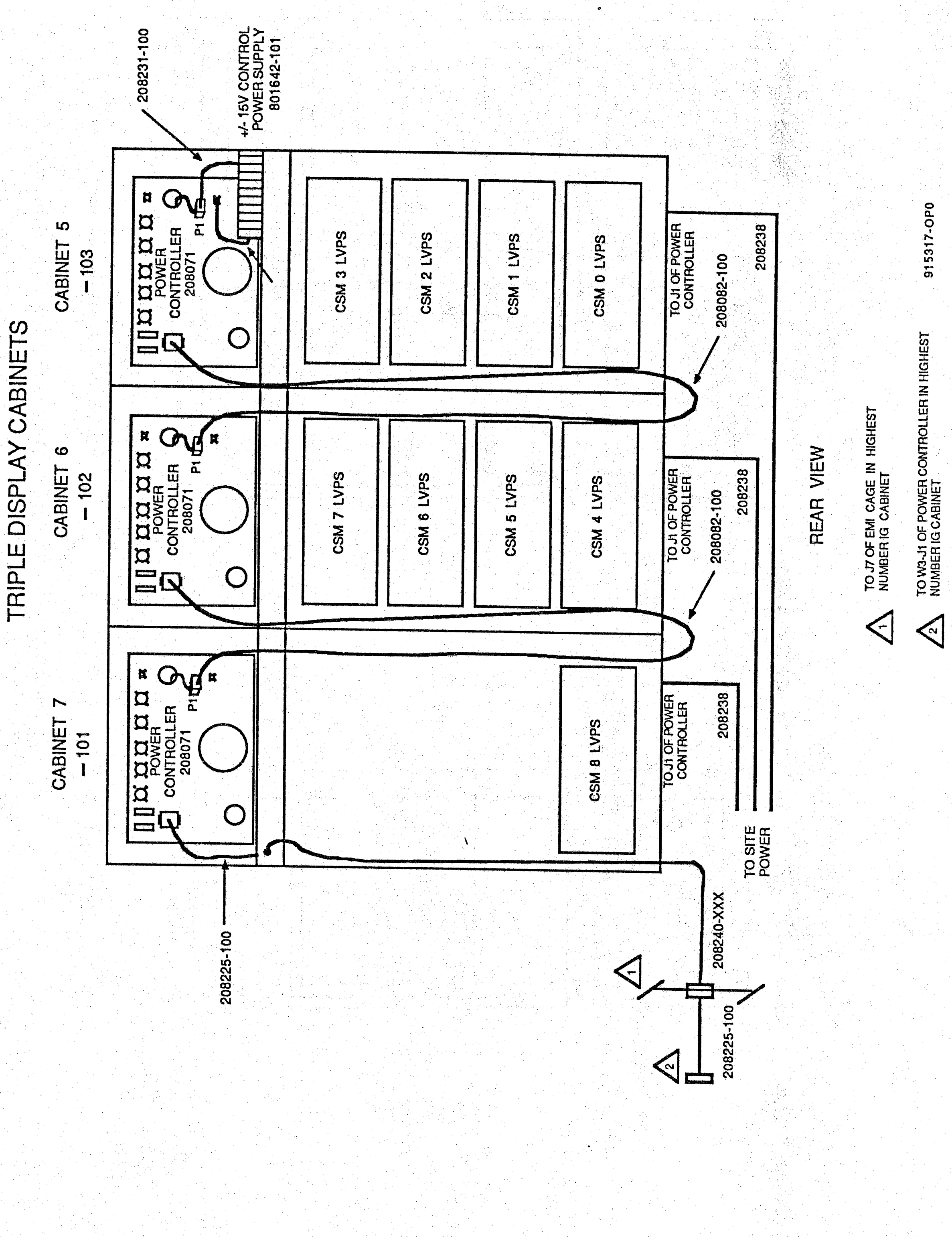


Figure 4-14. Display Cabinet Power Controller Cabling (3 Cabinet Configuration)

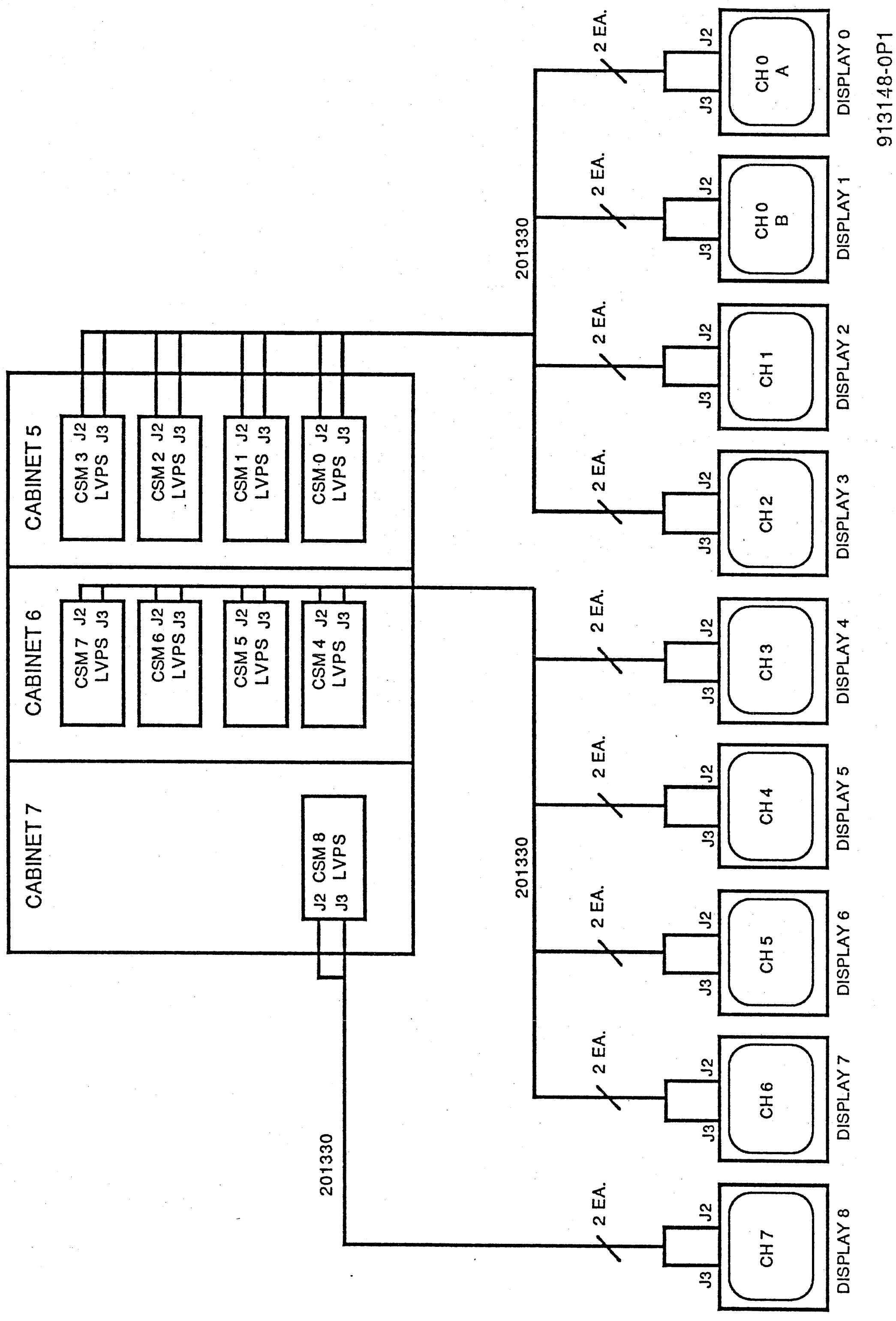


Figure 4-15. SPX Display Power Supply Cabinet Cabling (9 Window Configuration)

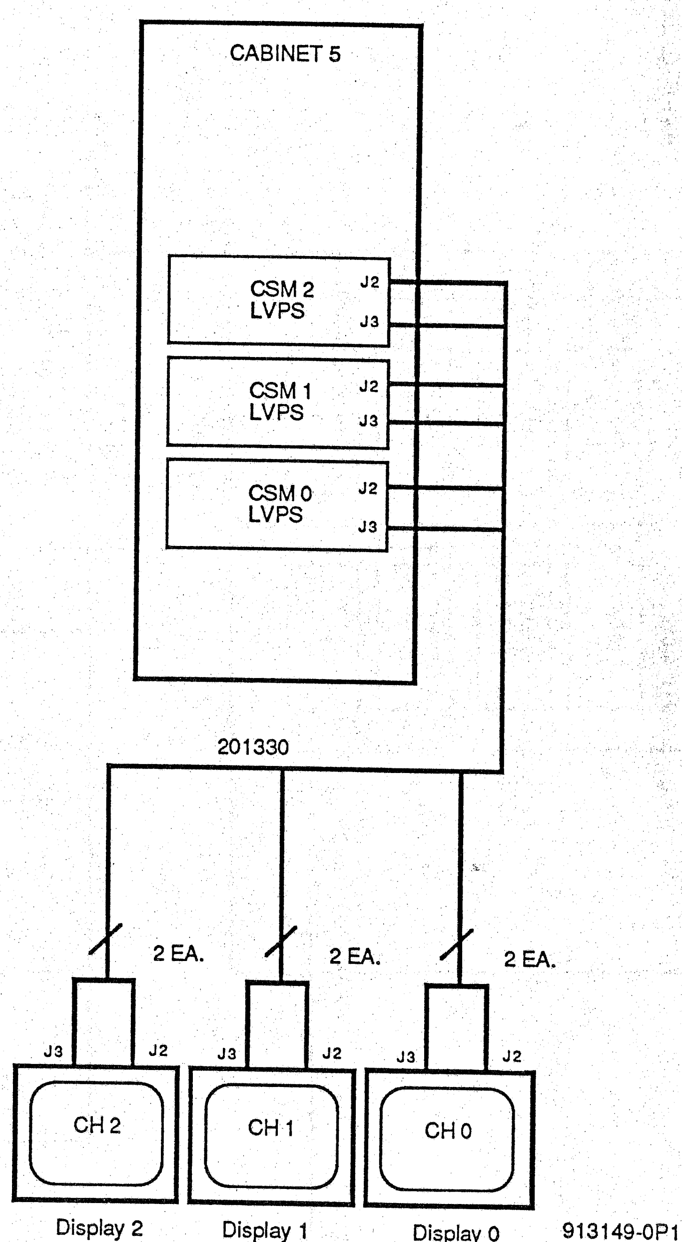


Figure 4-16. SPX Display Power Supply Cabinet Cabling (3 Window Configuration)

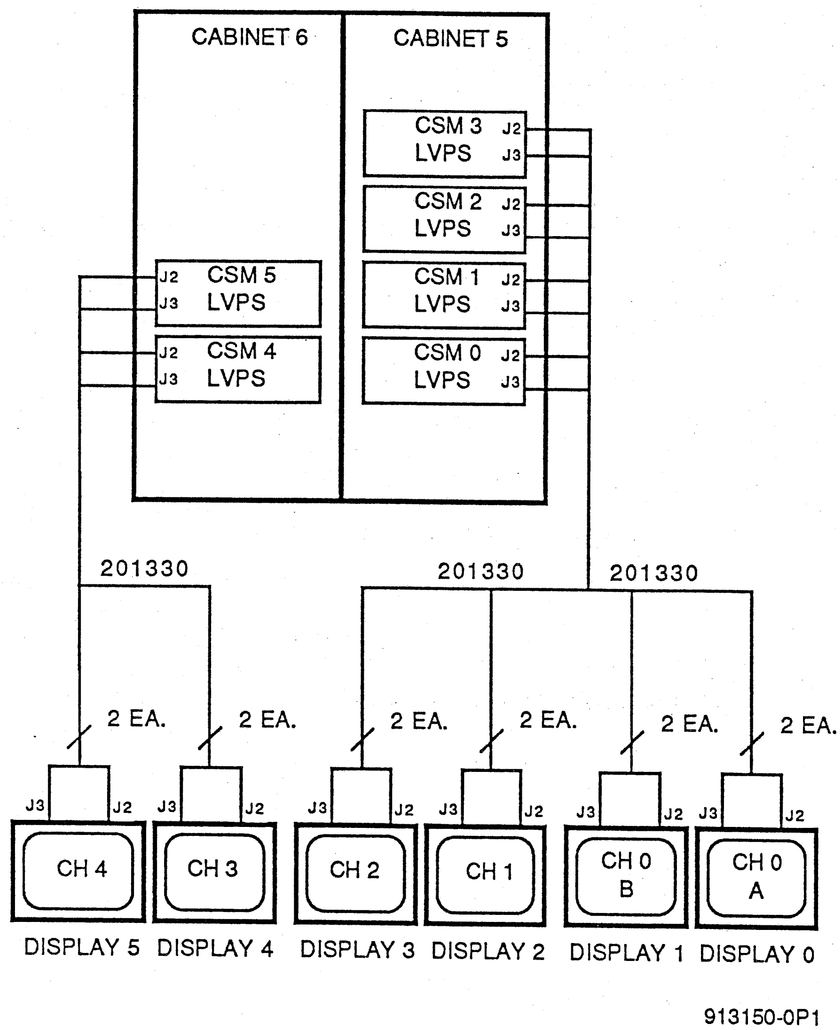


Figure 4-17. SPX Display Power Supply Cabinet Cabling (5 Channel, 6 Window Configuration)

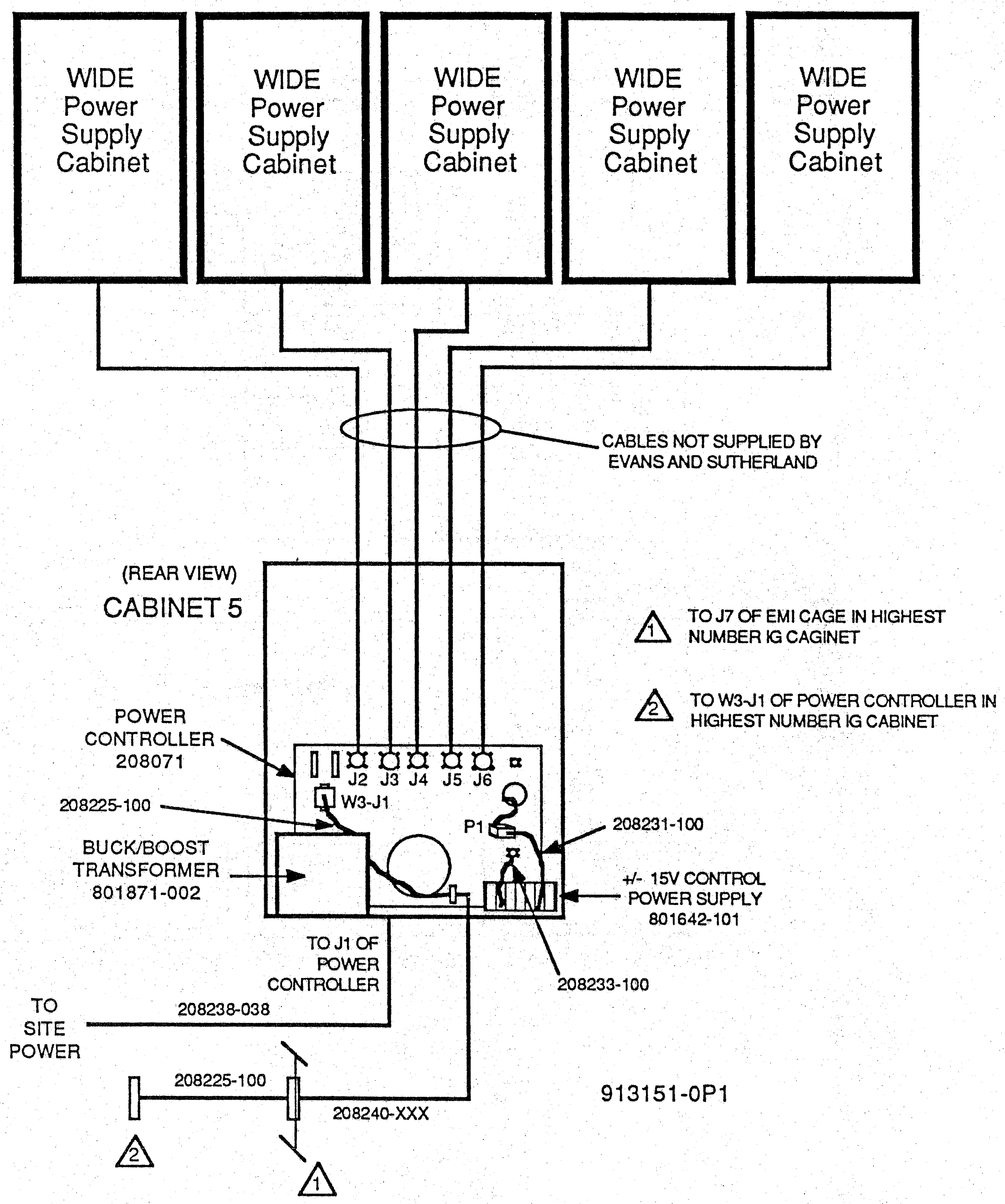


Figure 4-18. Projector Display Power Cabling (5 Window Configuration)

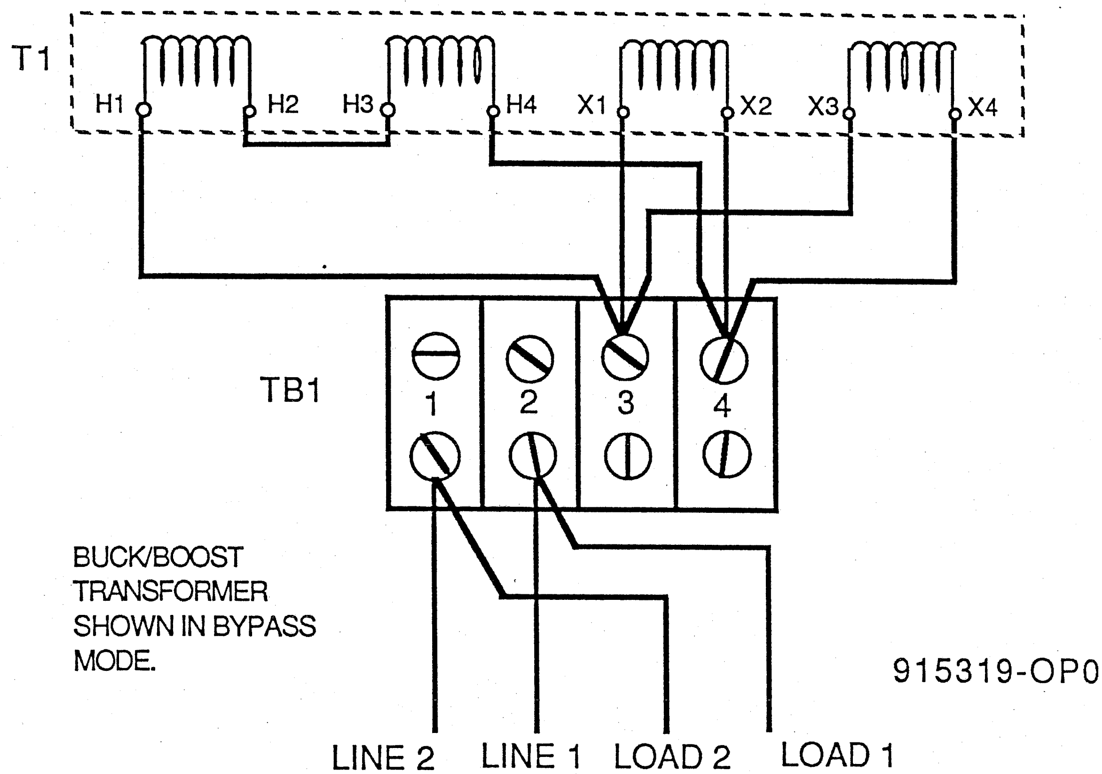


Figure 4-19. Buck/Boost Transformer in Bypass Mode

Table 4-2. SPX Buck Boost Transformer Connections at TB1

	Voltage Range			
	200-214 Volts Boost 2	215-227 Volts Boost 1	228-243 Volts Bypassed	244-259 Volts Buck 1
Wire				
Line 1	2	2	2	3
Line 2	1	1	1	1
Load 1	4	3	2	2
Load 2	1	1	1	1
H1	1	1	3	1
H4	2	2	4	2
X1	2	2	3	2
X2	3	3	4	3
X3	3	2	3	2
X4	4	3	4	3

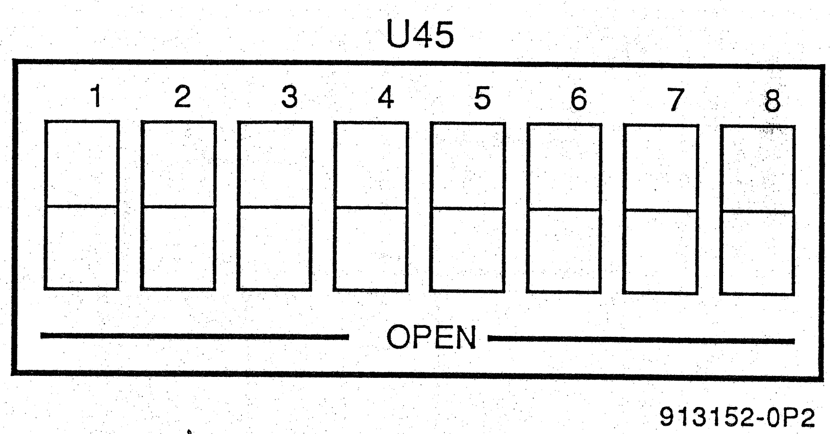


Figure 4-20. SFM Card Switches

Table 4-3. SFM Card Switch Settings

S1	S2	S3	Function
0	0	0	Station 0 (IG Master)
1	0	0	Station 1 (IG Slave)
0	1	0	Station 2 (IG Slave)
1	1	0	Station 3 (IG Slave)
0	0	1	Station 4 (IG Slave)
1	0	1	Station 5 (Display Slave)
0	1	1	Station 6 (Display Slave)
1	1	1	Station 7 (Display Slave)

S4	Not Used

S5	Function
0	Diagnostic/Debugger
1	Run

S6	Function
0	Upper Channel Not Present
1	Upper Channel Present

S7	Function
0	Lower Channel Not Present
1	Lower Channel Present

S8	Not Used

0=Closed=On 1=Open=Off

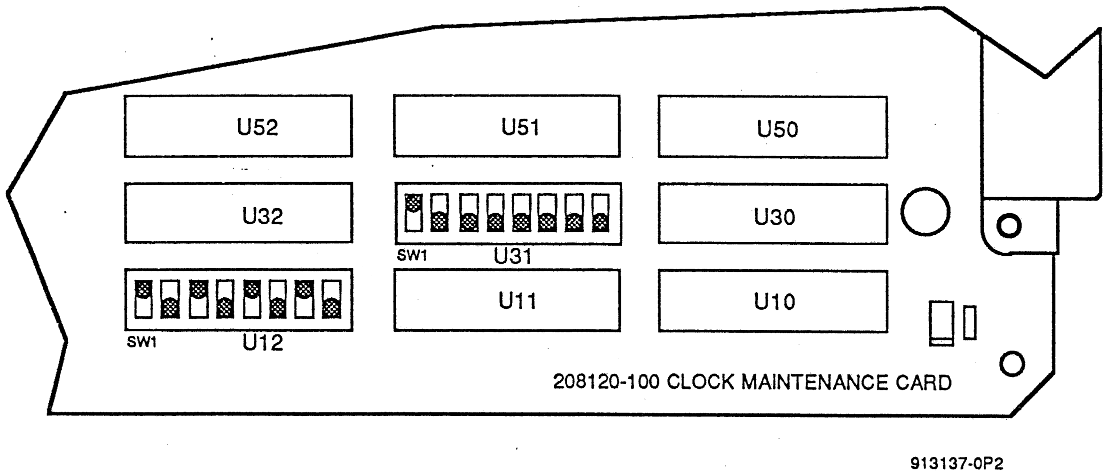


TABLE FOR U31 - CHANNEL SELECT SWITCH ON THE 208120-100 CLOCK MAINTENANCE CARD
CHANNEL 0 - SWITCH 1 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 1 - SWITCH 2 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 2 - SWITCH 3 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 3 - SWITCH 4 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 4 - SWITCH 5 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 5 - SWITCH 6 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 6 - SWITCH 7 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 7 - SWITCH 8 ON (CLOSED), OTHERS OFF (OPEN)

ONLY ONE SWITCH ON (CLOSED) AT A TIME

STANDARD CONFIGURATION FOR U12 ON THE 208120-100 CLOCK MAINTENANCE CARD
SWITCH 1 - ON (CLOSED)
SWITCH 2 - OFF (OPEN)
SWITCH 3 - ON (CLOSED)
SWITCH 4 - OFF (OPEN)
SWITCH 5 - ON (CLOSED)
SWITCH 6 - OFF (OPEN)
SWITCH 7 - ON (CLOSED)
SWITCH 8 - OFF (OPEN)

Figure 4-21. 208120-100 Clock Maintenance Card Switch Settings

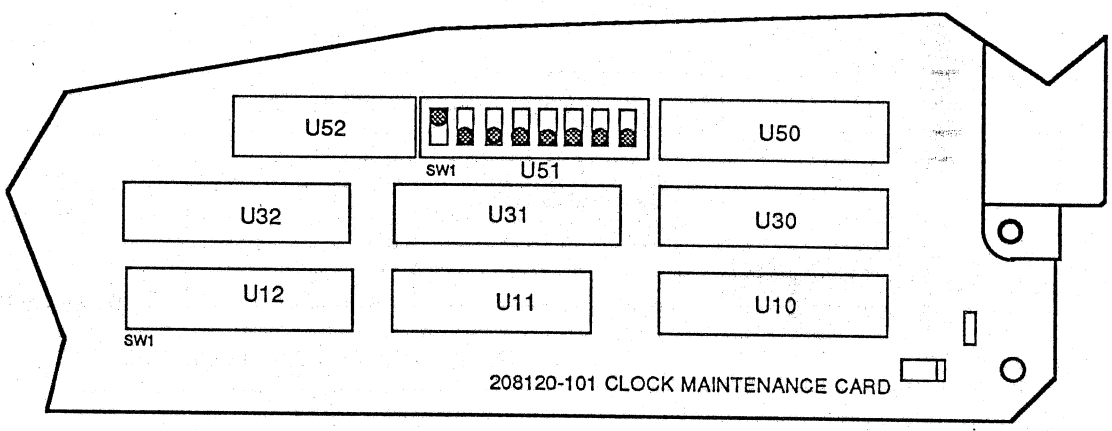


TABLE FOR U51 - CHANNEL SELECT SWITCH
ON THE
208120-101 CLOCK MAINTENANCE CARD

CHANNEL 0 - SWITCH 1 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 1 - SWITCH 2 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 2 - SWITCH 3 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 3 - SWITCH 4 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 4 - SWITCH 5 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 5 - SWITCH 6 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 6 - SWITCH 7 ON (CLOSED), OTHERS OFF (OPEN)
CHANNEL 7 - SWITCH 8 ON (CLOSED), OTHERS OFF (OPEN)

ONLY ONE SWITCH ON (CLOSED) AT A TIME

Figure 4-22. 208120-101 Clock Maintenance Card Switch Settings

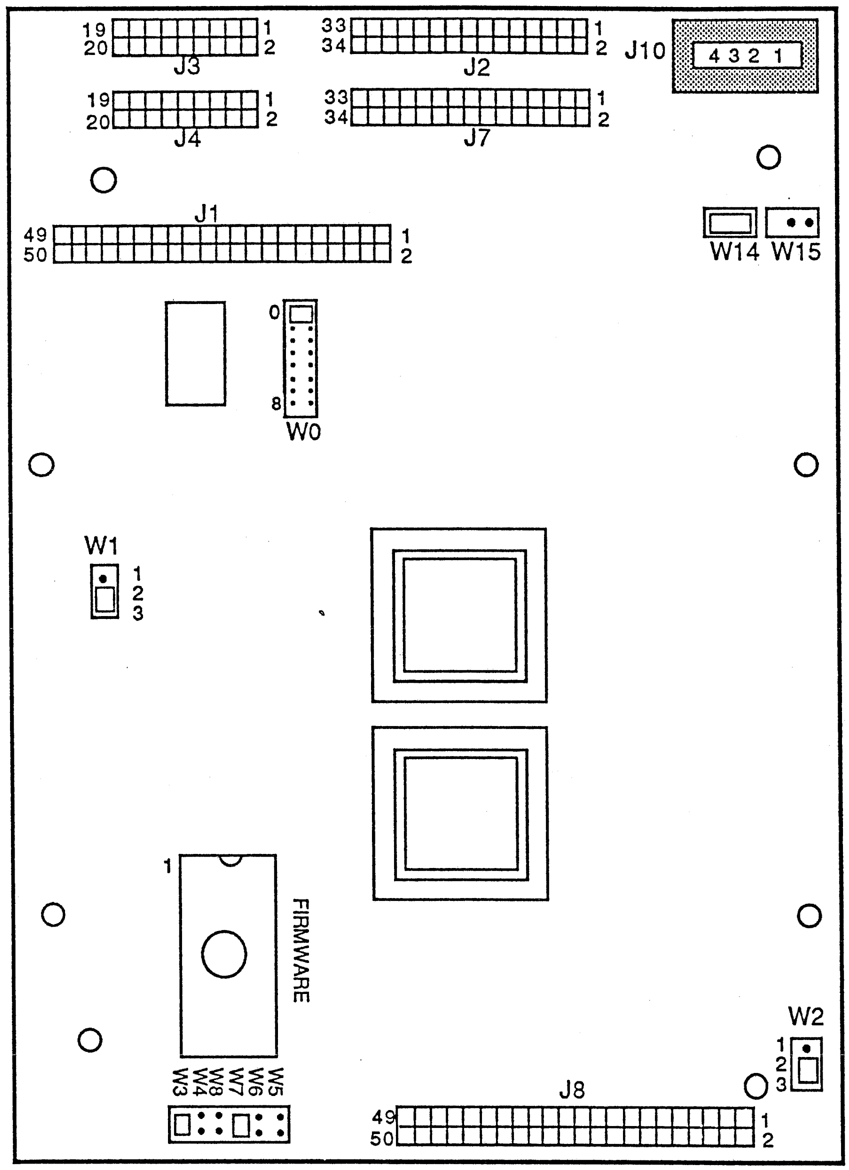


Figure 4-23. Disk/Tape Controller (OMPTI 5400) Jumper Settings

4.5 CONTROL AND SWITCH SETTINGS

When performing the initial set-up of the SPX image generator, the hardware should be brought up one section at a time to insure that no damage to the equipment occurred during shipping. The following sections indicate the proper setting of terminal setup options, power controller buck-boost strapping, system fault monitor switch settings, clock maintenance switch settings, and default jumper settings for the Winchester disk drive, the tape streamer and the disk/tape control card.

4.5.1 Terminal Set-up

The SPX system requires specific set-up parameters to be entered into the VT2XX/VT3XX series terminal which serves as the system console. These parameters are programmed into the device before it leaves Evans & Sutherland and are saved in the terminal's non-volatile memory. These parameters can be verified after the image generator power has been switched on and power has been applied to the terminal. See Appendix A for further information about these setup parameters.

4.5.2 Power Controller Configuration

The following paragraphs explain the procedure for strapping the buck-boost transformer (T1) located inside each 208070 power controller and setting the switches preparatory to turn-on. This procedure also applies for an 801871-002 buck boost transformer, which is an option to the projector power controller cabinet.

4.5.2.1 208070 Power Controller Buck Boost Strapping Procedures

The power controller is furnished with a terminal board (TB1) shown in Figure 4-19 to facilitate strapping (changing transformer windings) to compensate for high or low input AC line voltage to the peripherals and fans. Table 4-2 shows the strapping options. Perform the following steps to ensure that the buck-boost transformer output supplied to the equipment is within tolerance.

WARNING: High voltage is present at the input and output of the buck-boost transformer. When making a high voltage measurement, stand on an insulated surface and keep one hand behind your back.

1. Ensure that the main AC power source cable is NOT connected to the power controller.

2. Measure the AC site power source voltage to ascertain the voltage level. Refer to Table 4-2 to determine the wiring configuration of TB1 necessary for the measured line input voltage.

3. Remove the lower front cover of the 208070 Power Controller by unscrewing the six cover-retaining screws and pulling the cover off. To obtain the required working room in the power controller it will be necessary to remove the SFM card and the two internal auxiliary DC power supplies.

4. Change the wiring at TB1 as determined from Table 4-2. Figure 4-19 illustrates the boost/buck transformer wired in the bypassed configuration.

5. Re-install the power supplies (removed in step 3) into the power controller.

6. Repeat steps 1 through 5 for each 208070 power controller and replace the lower front cover on each power controller.

NOTE: The nominal input voltage must fall within one of the specified ranges shown in the Table 4-2. Input variation must not exceed ±5% of the nominal value.

4.5.2.2 System Fault Monitor Switch Settings

Figure 4-20 is an illustration of the DIP switches located on the system fault monitor card (208105) located in each power controller. Listed in tabular form are the positions required for cabinet selections 0 - 7, with cabinet 0 the master, cabinets 1 - 4 the slave IGs, and cabinets 5 - 7 the display slaves. Perform the following steps to set the SFM switches:

1. Remove the power controller lower front cover by unscrewing the six cover-retaining screws and pulling the cover off. (See Figure 4-10 for the location of the SFM card.)

2. On the system fault monitor card in the power controller, set switches 1 - 3 to a code 0 if the power controller is a master power controller (the power controller in cabinet 0 is the only master power controller), to code 1 for the first slave IG power controller, to code 2 for the second slave IG power controller, and so forth, up to a maximum of 4 slave IG power controllers.

NOTE: Switch 4 is not used.

3. Set switch 5 to the RUN or open position.

4. Set switch 6 open on each SFM card if there is an upper channel processor present. Always set this switch open on the SFM card in the MPU cabinet. Set this switch open on a display power controller only if a monitored blower assembly is present.

5. Set switch 7 open on each SFM card if there is a lower channel processor present. Always close this switch on the SFM card in the MPU cabinet and on the SFM cards in the display cabinets.

NOTE: Switch 8 is not used.

4.5.3 Clock Maintenance Switch Settings

In the SPX system, each channel processor backpanel will contain one clock maintenance card (208120-100 or 208120-101). The channel number for any given channel processor is designated by a channel select switch on the clock maintenance card. Each clock maintenance card in the system must have a unique channel number designation for proper system operation.

Verify the setting of the dip switches of the clock maintenance card in each channel processor backpanel. Refer to Figure 4-21 or 4-22, depending upon the version of clock maintenance card installed in each channel processor.

4.5.4 Disk and Tape Jumper Settings

The SPX system is capable of using many various ST-506 Winchester disk drives and many QIC-02 compatible tape streamers. Different manufacturers have different jumper settings. Refer to the manufacturer's user manuals for more detailed information on jumper settings.

4.5.4.1 Disk/Tape Controller Jumper Settings

The standard disk/tape control card is the OMTI 5400. It allows the user to select various controller functions as listed below. The asterisk indicates the user options required by the standard SPX product. Jumper locations are shown on Figure 4-23. For controllers other than the OMTI 5400 refer to the appropriate user manual.

W0 CONTROLLER ADDRESS

This is the physical SCSI address of the controller on the SCSI bus.

Jumper	SCSI address		
0*	shorted	=	0
1	shorted	=	1
2	shorted	=	2
3	shorted	=	3
4	shorted	=	4
5	shorted	=	5
6	shorted	=	6
7	shorted	=	7

W1 HOST PARITY

Pins 1 and 2 shorted = parity enabled

*Pins 2 and 3 shorted = parity disabled.

W2 QIC (tape streamer) PARITY

Pins 1 and 2 shorted = parity enabled

*Pins 2 and 3 shorted = parity disabled.

W3, W4 Winchester Disk Sector Size (32 x 256 bytes per sector)

*W3 - shorted
*W4 - open

W5, W6, W7, W8 - LUN assignments

These jumpers are used to select the default LUN assignments for the Winchester disk drive and the Tape streamer.

LUN	Jumper	Open	Shorted
0	W5	*WINCHESTER	Reserved
1	W6	*WINCHESTER	Reserved
2	W7	WINCHESTER	*Floppy
3	W8	*TAPE	Winchester

NOTE: The tape streamer is always LUN 3

*W14 Shorted - Floppy Motor On Override

*W15 Open - Floppy Ready Override.

* default jumper positions

4.5.4.2 Winchester Disk Jumper Settings

Jumper select options on typical Winchester disk drives are usually very simple. Generally the only ones that are user-selectable are drive select and control cable termination.

The drive select jumper is used to identify the disk drive number since the controller board is capable of accessing more than one drive. In the standard SPX system the disk drive should always be jumpered as drive number 0.

The control cable from the controller card should be terminated with a 220/330 terminating resistor package. In applications where more than one disk drive are attached to the control cable, only the last disk drive on the controller cable should be terminated. In the standard SPX system there is only one disk drive attached to the controller card so the terminating package should always be installed (or enabled with a jumper depending on the manufacturer).

4.5.4.3 Tape Streamer Jumper Settings

The tape streamer jumpers are installed at the vendor facility and should not be changed by the user.

4.6 INITIAL POWER UP

The power-up procedures for the SPX should be followed every time the system is installed or after every major reconfiguration. The following procedure will bring the system up in a controlled manner.

If problems are encountered while following these procedures, refer to the fault isolation tree in Section 7.4, correct the fault, then continue with this procedure.

Please review all of the steps, then read each step completely before proceeding with that step.

1. Ensure proper buck-boost transformer card strapping.

NOTE: Any time major changes have been made to site power it may be necessary to readjust the buck boost transformer strapping (see Section 4.5.2.1).

2. Turn off all circuit breakers on the front panel of all power controllers, including the display power controllers if so configured.

3. Connect site power to the SPX cabinets by plugging the large connector into J1 of each power controller. Verify that the power available light illuminates on each power controller.

4. Ensure that the system console is plugged into J17 on the master power controller in the MP cabinet (typically the left-hand cabinet), and that the system console's power switch is in the ON position.

5. Switch on the MAIN POWER circuit breakers and CONTROL POWER circuit breakers in all image generator power controllers. Verify that the terminal is powered on.

6. Verify that the terminal has been set-up with the proper parameters. (See Appendix A).

NOTE: Steps 7 and 8 may not apply to your terminal.

7. Initiate the answer-back sequence by pressing the <CTRL> and <BREAK> keys simultaneously. This will send the <esc>[ip sequence to the system fault monitor card directing it to send the escape sequences to the terminal to initialize the user definable keys (VT2XX/VT3XX terminals only).

8. Power up the cabinets by pressing the POWER function key (<SHIFT/F20>) on the VT2XX/VT3XX keyboard (VT2XX/VT3XX terminals only), or by pressing the ON/OFF push-button on the master power controller in the MP cabinet. The terminal should indicate POWER ON, and the POWER ON light should light on all power controllers. After seven or eight seconds the image generator should shut down and the terminal should display a status screen indicating that all fans and power supplies are out of tolerance.

9. Observe the status screen display on the console. Verify that the main power voltage level indicated on the status screen matches those measured in step 2 of Section 4.5.2.1 within a tolerance of ±5 V for all cabinets.

NOTE: The voltage measurements as displayed on the status screen are not of sufficient accuracy to be used when adjusting most power supply voltages within the IG. The SFM cards monitor various voltages within each IG cabinet to detect voltage levels which could potentially damage the system, and do not necessarily detect out-of-tolerance power supply voltages. Variability between SFM cards may result in different voltage readings. Power supply voltages can be out of tolerance without the SFM detecting an out-of-tolerance condition. See Section 7.3.1 for power supply adjustment procedures.

10. Switch on the FAN POWER and AUXILLARY DC circuit breaker in all cabinets.

11. Press the CONT function key (<SHIFT/F7>) on the terminal. Then press the POWER function key (<SHIFT/F20>) on the terminal. At this point the image generator should power on and remain on after the seven or eight second time out has expired.

12. Press the STATUS function key (<SHIFT/F6>).

13. Turn on the UPPER UNIT circuit breaker on the power controller of the MP cabinet and verify that the +5 V DC supply comes into tolerance (5 V DC ±0.05 V) on the status display screen. Balance the +5 V DC power supplies as required by following the procedure in Section 7.3.1.1.2.

14. Switch on the AUX DC circuit breaker on the MP cabinet. Verify that the ±15 (±0.2 V) comes within tolerance. Adjust the supply if required according to the procedure in Section 7.3.1.3.2.

15. If the scope driver card (located in slot 30 of the channel processor) is an E&S part number 208132-100, verify that the -5.2 V DC ±0.06 V is within tolerance. Adjust the supply if necessary, using the procedure in Section 7.3.1.4.

16. Switch on the remaining circuit breakers on the power controller in the MP cabinet.

17. For multichannel systems, locate the next channel processor backpanel (see Figure 4-11 for the order in which channel processors are installed). If the channel processor is located in the lower/upper portion of the cabinet, turn on the corresponding circuit breaker labeled LOWER UNIT or UPPER UNIT on that cabinet's power controller.

18. Verify that the +5 V DC supply just turned on comes into tolerance (5 V DC ±0.05 V) on the status display screen. Balance the +5 V DC power supplies as required by following the procedure in Section 7.3.1.1.2.

19. Verify that the ±15 V DC (±0.2 V) comes within tolerance. Adjust the supply according to the procedure in Section 7.3.1.3.2 if necessary.

20. If the scope driver card (located in Slot 30 of the channel processor) is an E&S part number 208132-100, verify that the -5.2 V DC (±0.06 V) is within tolerance. Adjust the supply if necessary, using the procedure in Section 7.3.1.4.

21. Repeat steps 17 - 20 for the remaining channel processors.

22. Switch on all 208070 power controller circuit breakers.

NOTE: Except for a few circuit breakers on the display power supply cabinets, all of the circuit breakers should now be in the ON position.

23. Turn the SPX system off by pressing the POWER function key (<SHIFT/F20>).

24. Switch on all circuit breakers in the display cabinets except the UPPER UNIT and LOWER UNIT breakers.

25. Press the POWER function key (<SHIFT/F20>) again to power on the image generator. Depending on the site configuration, the image generator will typically execute its MP confidence tests, auto-boot the operating system, auto load microcode and the flight dynamics code, then execute the real-time system.

26. When the real-time system is executing, switch on the UPPER UNIT and LOWER UNIT circuit breakers in the display cabinets, one at a time, verifying that the image on the associated display is correct.

This completes the initial power-on sequence.

4.6.1 Diagnostic Tests

Diagnostic tests described in Chapter 7 may be performed to verify image generator operation.

4.7 SOFTWARE INSTALLATION

4.7.1 System Software

The system is shipped with the software purchased from Evans & Sutherland installed on the hard disk drive. A backup of this software is also supplied in backup format on magnetic tape. Additionally a scratch tape is shipped for use with the magnetic media diagnostics which are discussed in Appendix B.

The software supplied typically consists of at least the following:

- Operating system and related software
- Real-time system and related software

- OM microcode
- GP microcode
- DP microcode
- CHEK diagnostics language
- Diagnostic tests
- Test patterns
- ATP model and supporting files

4.7.2 Custom Software

Customer-specified data bases, custom real-time software and other special software purchased from Evans & Sutherland are typically shipped installed on the hard drive and on the backup tape.

4.7.3 Software Backup Guidelines

It is always good practice to make two backup tapes. Keep at least one of the backup tapes in a location that will prevent it from being erased or destroyed. Do a system backup on a regular basis and always do a backup before and after a change is made to the software contained on the hard disk.

4.7.4 Software Updates

Installation instructions are provided with each software update supplied by Evans & Sutherland. It is extremely important that a backup of the hard disk is made before implementing the update. It is prudent to generate another backup of the disk upon successful completion of the software update. This should be done on a different tape from the one used to do the initial backup. This permits the system to be returned to its former condition should problems arise before the software update has been thoroughly tested. Follow the instructions sent with the software update.

4.8 SYSTEM INTEGRATION

The SPX image generator is just one part of the total simulation system. The integration process involves connecting the SPX to a host computer and the displays, and testing for correct interaction between these units.

The host computer typically uses an Ethernet interface to communicate with the SPX. In the event of host IG communication difficulties, an Ethernet analyzer may be required to verify correct operation. In some cases, the SPX may be connected to the host through a different type of interface. These systems may require special testing equipment and/or additional technical expertise.

After the hardware is installed, software integration is performed to complete the installation. In this case, software integration means making the SPX and host communicate properly. For example, during simulation, the host sends commands to the SPX to control the visual scene in groups called packets. These packets are sent at fixed intervals, and their content varies depending upon the action desired by the host. Each has a specific format understood by the SPX real-time system. These formats are discussed in detail in the *SPX Real-Time System Manual* (901181-725). The SPX then returns information to the host in response to host requests.

4.9 PREPARATION FOR RESHIPMENT

The following procedures should be followed when preparing the system for reshipment from the user site.

4.9.1 Disassembling the Hardware

To prepare the SPX system for repackaging, complete the following steps:

1. Turn off all power switches and breakers for the following hardware:

    a. The master power controller.

    b. Any slave power controllers.

    c. All cabinet-mounted units.

    d. All peripheral units (display power supplies, terminals, etc.).

    e. The site power panels that feed the system AC power cables.

2. Disconnect all power cables from:

    a. the rear and front panel of the power controllers.

    b. the site power panels (site AC power cables).

3. Complete the following steps for each display in the system.

    a. Disconnect the signal cable from the display. Cover the connector with protective wrapping and secure with tape. Coil the cable and tag with the serial number of the display to which it was connected.

    b. Disconnect the interconnect cable from the connectors on the rear panel of the display and the related power supply. Cover the connectors at each end of the cable with protective wrapping and secure with tape. Coil the cable and tag with the serial number of the display and the power supply.

    c. Disconnect the power cable from the rear panel of the power supply. Cover the connectors at each end of the cable with protective wrapping and secure with tape. Coil the cable and tag with the serial number of the power supply to which it was connected.

4. Cover the connectors at the AC input end of the main power cables with protective wrapping and secure with tape. Ship the power cables in a separate container.

5. Secure the coiled signal cables from the scope driver card(s) in the bottom of the cabinet.

6. Secure all circuit cards within the backpanel(s) by using a good quality shipping tape. Secure the tape across the front of the backpanel to prevent the cards from coming out of their assigned card slots during movement and/or shipment.

7. Secure all other cabinet internal cables with tape so that the tape serves as a strain relief.

8. Secure the MP unit to the vertical mounting rail by two screws. To install the shipping screws, remove the MP unit cover and insert screws into the two holes located on the lower left and right hand side of the MP unit chassis.

9. Cover the connectors of the power and data cables of the peripheral units (system control terminal, etc.) with protective wrapping and secure with tape. Coil the cables and tie them so that they remain coiled. Tag the coiled cables with the nomenclature and serial number of the unit to which they were attached.

10. Unbolt the cabinets from each other. Be careful to not damage the EMI braid. Do not remove the EMI braid (E&S PN 801336-001) from the cabinet sides. Any damaged braid will need to be replaced upon re-installation.

11. Raise the levelers on each cabinet so the cabinet can be moved conveniently. Two people are required when rolling a cabinet because the cabinets are top heavy.

12. Components such as CSMs, power supplies, and other heavy modules need to be removed from maintenance console and projector power supply cabinets, etc.

13. For shipments overseas, the cabinet needs to be crated and placed on a palette. For shipments within the United States, the cabinet may be rolled into the truck as long as the truck is an air-ride padded van. It is important that an air-ride tractor be specified.

4.9.2 Packing the Hardware

For purposes of the packing instructions for the system, the following terms are defined:

Flexible	A flexible item is one that will change shape under moderate pressure without damage.
Fragile	A fragile item is one with physical characteristics which permit shattering, fracturing, or damage due to shape change when subjected to moderate impact force.
Rigid	A rigid item is one which requires considerable force to change its shape permanently.

The units of the system should be packaged as required (refer to MIL-STD-794) by their classification to provide protection under the following circumstances:

- Multiple handling during transportation and in-transit storage.
- Shock, vibration, and static loading for shipment by truck, rail, aircraft, or ocean transport.
- Controlled warehouse environment for temporary storage periods.
- Effects of environmental exposure for short periods during shipment and in-transit delays.
- Stacking and supporting light superimposed loads during shipment and temporary storage.

For the purposes of determining packaging requirements, the units of the system are classified as listed below:

Fragile units	MPU System Control Terminal Displays and Power Supplies All other peripheral devices ICC-100 (if present)
Flexible units	All cables removed and coiled according to the disassembly procedures.
Rigid units	The SPX image generator cabinet(s) with all panels in place.

It is recommended that MIL-STD-794 be used in configuring the containers required in the following procedures.

4.9.2.1 Fragile Unit Packing

Use double containers to ensure adequate protection to package all fragile units of the system. Separate the two containers by using foam corners, die-cut cardboard inserts, or the foam-in-place technique between the containers.

4.9.2.2 Shipping Individual Circuit Cards

Individual circuit cards not shipped in the backpanels are fragile units in accordance with the definitions of MIL-STD-794. Place circuit cards in an anti-static plastic bubble pack, and ship them in a corrugated cardboard box that has been packed with foam packing material or any other packing material that will prevent movement of the circuit card while in transit.

4.9.2.3 Flexible Unit Packing

Package the flexible units of the system in a container with sufficient strength to support the weight of the contents. A flexible unit package and contents that weigh 200 lbs. or greater should be configured with skids to permit the use of lifting devices.

4.9.2.4 Rigid Unit Packing

Cover the cabinet(s) of the system with a protective cover and secure the cover in place. For overseas shipments attach the cabinet(s) to a base configured with skids, and enclose it in a container of sufficient strength to protect the unit while in shipment and/or storage.

CHAPTER 5

OPERATION

5.1 INTRODUCTION

This section provides an explanation of the SPX Image Generator controls and indicators, and operating and shutdown procedures.

5.2 MODES OF OPERATION

The SPX Image Generator has multiple modes of operation, depending upon the task being performed.

During simulation mode, the SPX is controlled by information sent from either the host computer or the system console and ICC (flybox). Commands applicable at this time are contained in the *SPX Real-Time System User's Manual.*

Routine file maintenance, such as making backups, copying, examining and editing text files (the Site and Login files, for example), etc. are done in the off-line utility mode. For further information of utility software, refer to the *SPX Operating System Reference Manual.*

In diagnostic mode, diagnostic tests on the system are performed to verify proper operation or locate problems. The CHEK program, for example, is a diagnostic language that is used for testing the channel processor. Because CHEK is a language, diagnostic software routines can be created and saved individually. Additional information on CHEK is available in the *CHEK Diagnostic Reference Manual.*

5.3 CONTROLS AND INDICATORS

5.3.1 Image Generator Power Controller Controls and Indicators

Two models of power controllers are used with the SPX image generator. A model 208070 power controller is used in each MP and channel processor cabinet while a model 208071 power controller may be used in the display and maintenance cabinets in some system configurations.

The controls and indicators on the front panel of the 208070 power controller are illustrated in Figure 5-1. The functions of these controls and indicators are listed and explained in Table 5-1.

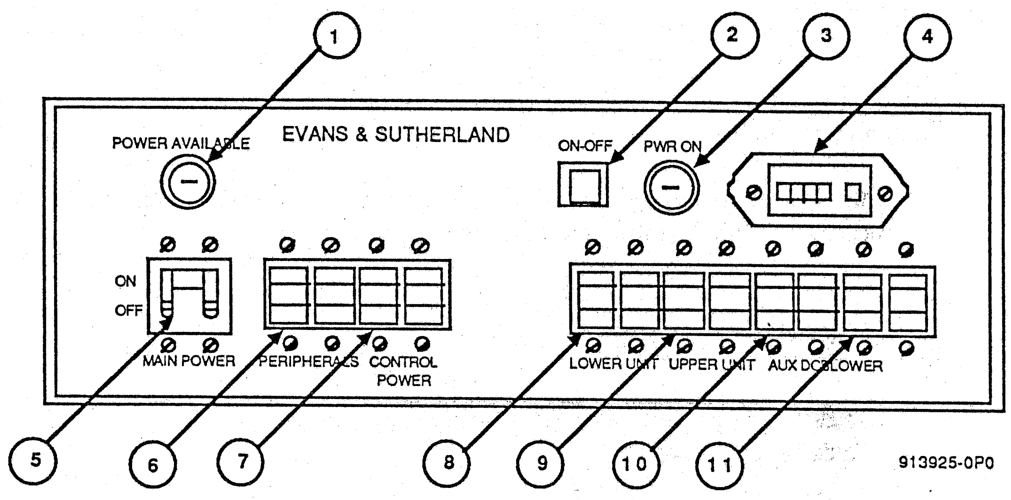


Figure 5-1. SPX Image Generator Power Controller (208070) Front Panel

Table 5-1. SPX Power Controller (208070) Controls and Indicators

Item	Control or Indicator	Description
1.	Power Available	The illumination of this lamp indicates that site power is available to the power controller.
2.	On/Off	This is an alternate-action push-button switch. The switch located on the master power controller in the MP cabinet controls the on/off state of all power controllers in the system. Switches on all other power controllers cycle power for that particular power controller.
3.	Power On	The illumination of this lamp indicates that power is applied to the SPX CIG.
4.	Elapsed time meter	This meter registers time (in hours, minutes, and tenths of minutes) that power has been applied to

		the SPX CIG.
5.	Main Power	This is a dual circuit breaker which protects the primary AC power circuit from overload. This breaker also functions as an emergency power switch.
6.	Peripherals	This is a dual circuit breaker that functions as a power switch for peripheral units connected to the power controller. This circuit breaker does not control power to J17 (the left-most peripheral connector) which in the MP cabinet supplies power to the system console (VT2XX/VT3XX). It also does not control the 115 VAC outlet at the base of the MP cabinet.
7.	Control Power	This is a dual circuit breaker that controls site power to the internal power controller fan and to the SFM card, which monitors this voltage (site power) for over/under voltage conditions. This breaker also supplies power to J17, which on the master power controller supplies power to the system console. On the master power controller, this breaker supplies site power to a ±15 VDC power supply (801642-101) via J14. This power supply also powers the SFM cards in all 208070 power controllers in the system.
8.	Lower Unit	This is a dual circuit breaker that functions as an AC power switch for the channel processor hardware mounted in the lower portion of the cabinet.
9.	Upper Unit	This is a dual circuit breaker that controls AC power for the channel processor hardware mounted in the upper portion of the cabinet.
10.	Auxiliary DC	This is a dual circuit breaker that functions as an AC power switch for auxiliary DC power supplies (-5.2V and ±15V). (*NOTE*: the -5.2 VDC power supply may not be included in some system configurations.)
11.	Blowers	This is a dual circuit breaker that controls AC power for upper and lower channel processor cooling fans.

The controls and indicators on the front panel of the 208071 display power controller is illustrated in Figure 5-2. The functions of these controls and indicators are listed and explained in Table 5-2.

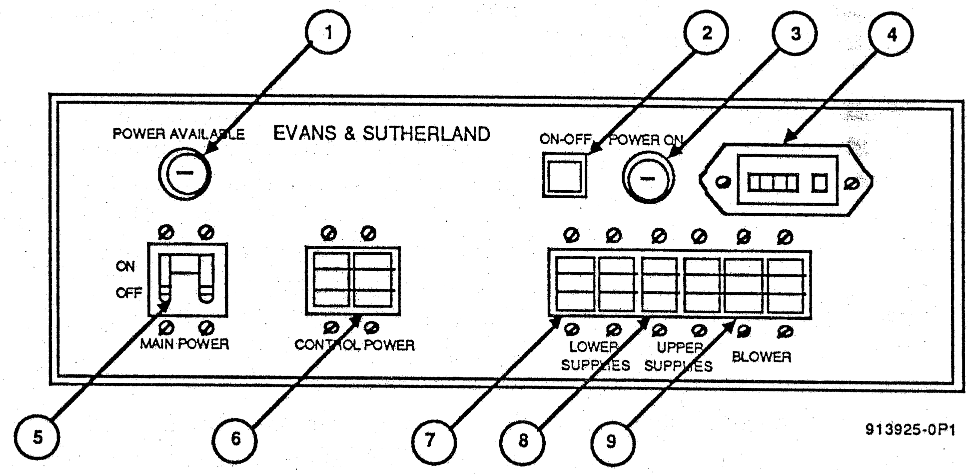


Figure 5-2. SPX Display Power Controller (208071) Front Panel

Table 5-2. SPX Display Power Controller (208071) Controls and Indicators

Item	Control or Indicator	Description
1.	Power Available	The illumination of this lamp indicates that site power is available to the power controller.
2.	On/Off	This is an alternate-action push-button switch. The switch located on the master power controller in the MP cabinet controls the on/off state of all power controllers in the system. Switches on all other power controllers cycle power for that particular power controller.
3.	Power On	The illumination of this lamp indicates that power is applied to the SPX CIG.
4.	Elapsed time meter	This meter registers time (in hours, minutes, and tenths of minutes) that power has been applied to the SPX CIG.
5.	Main Power	This is a dual circuit breaker which protects the primary AC power circuit from overload. This breaker also functions as an emergency power switch.
6	Control Power	This is a dual circuit breaker that controls power to the power controller fan and to connector J14. One of the 208071 display power controllers (typically

		located in cabinet 5, see Figures 4-13 and 4-14) has a ±15 VDC power supply (801642-101) connected to J14. This power supply provides power to the SFM cards in all the 208071 power controllers in the system.
7	Lower Supplies	This is a dual circuit breaker that functions as a power switch for display hardware powered from the display power controller connectors J2-J4.
8	Upper Supplies	This is a dual circuit breaker that functions as a power switch for display units powered from the display power controller connectors J5 and J6.
9	Blowers	This is a dual circuit breaker that controls AC power for cooling fans.

5.3.2 MP Unit Controls and Indicators

5.3.2.1 MP Card

The MP card has an LED indicator and two momentary contact switches located on the upper front edge of the card. The LED indicator flashes green while the MP card is running self diagnostics, and turns red when the self diagnostics are completed. The LED remains red during normal operation.

The two momentary switches, which are labeled on the card, are an abort switch and a reset switch. The abort switch, when pressed, will abort the present process and go into the debug routine. The reset switch causes a hardware reset of the MP card and the channel processors. When this switch is pressed, the MP card immediately begins to execute its self-diagnostics. These controls and indicators are not visible when the MPU front panel is properly in place.

5.3.2.2 Winchester Disk Drive

The Winchester disk drive has an LED to indicate that the drive is being accessed. This LED is not visible when the MPU front panel is in place.

5.3.2.3 Tape Streamer

The tape streamer has an LED which, when on, indicates that the tape is not at BOT (beginning of tape). This indicator is visible with the MPU front panel in place.

Before a tape is loaded into the tape streamer, the lever on the front of the tape streamer must be in the horizontal position. Pull out the tray which holds the tape, place the tape into the tray, slide the tray back into the unit and gently move the lever to a vertical position.

5.3.2.4 System Console

The standard system console is a DEC VT2XX/3XX terminal which is the primary means of controlling the IG. Some terminal keys are user-definable, and are programmed to provide special functions. These functions are shown in Figure 5-3.

The function keys located along the top of the keyboard send special commands or escape sequences that are used to power the IG on and off, bring up the power controller status screen, cause MP board reset and abort sequences to occur, and to power the displays on and off. The special function keys are used independently of the software the MP card is executing. For further information refer to Figure 5-3 and Table 5-3.

5.3.2.5 Printer

Anytime the <F2> key on the keyboard is pressed, the current screen contents are dumped to the printer. Pressing <CTRL/F2> (holding the control key down then pressing the <F2> key) will cause whatever is subsequently sent to the terminal screen to be sent to the printer as well until toggled off. Pressing <CTRL/F2> a second time will toggle off the printing.

Please refer to the printer manual(s) supplied with the system for information regarding the controls, indicators and general function of the printer. Due to the number of printer options, all possible printers and configurations cannot be discussed here. Only approved printers may be connected to the system console. If non-approved printers are used, these commands may not function correctly.

5.3.2.6 MP Unit

The MPU has an on/off switch located on the rear of the MP card cage. It controls the power to the MP power supply located inside the MP cabinet.

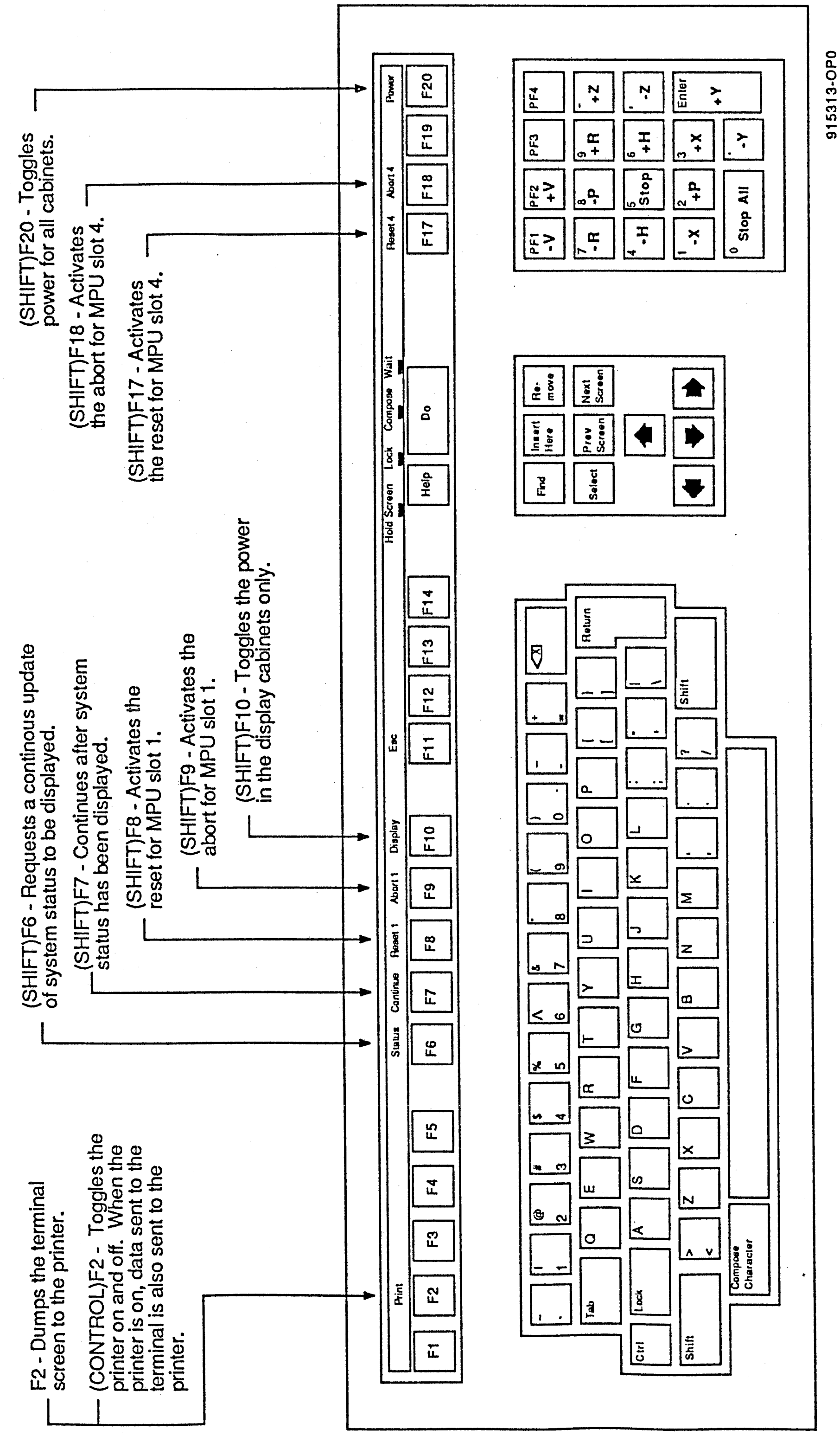


Figure 5-3. Key Combinations

5.3.3 System Fault Monitor (SFM) Status Display

Status indicators, other than IG performance for the SPX system, are generated by the SFM cards and are displayed by the system console terminal. This status display screen can be seen by pressing <Shift/F6>. If during operation any of the monitored system status functions are out of tolerance, normal system operation will be interrupted and a status display screen generated by the master SFM card will appear on the system console terminal.

The system status is displayed on the system console and/or ICC upon request from the operator or upon the event of an error. Figure 5-4 shows a typical status screen. Any out-of-tolerance condition will be displayed in inverse video. The master SFM displays all channels which it recognizes as being present. If a station does not respond, refer to Section 7.4.3.1 and Figure 7-22.

CABINET				FANS (RPM)			+5	TEMP	+15	-15	-5.2	LINE
	1	2	3	4	5	6	(V)	(1/0)	(V)	(-V)	(-V)	(V)
0 UPPER	3000	3000	3000	3000	3000	3000	5.15	0				
0 COMMON									15.2	15.2	5.20	244
1 UPPER	3000	3000	3000	3000	3000	3000	5.12	0				
1 LOWER	3000	3000	3000	3000	3000	3000	5.12	0				
1 COMMON									15.2	15.2	5.30	245
2 UPPER	3000	3000	3000	3000	3000	3000	5.12	0				
2 COMMON									15.2	15.2	4.33	234
4 LOWER	0	0	0	0	0	0	.00	0				
4 COMMON									.0	.0	.00	230
5 DSPLY	3000	3000	3000	3000	3000	3000		0	DISPLAY ON		230	

(TYPE <ESC>[cp TO CONTINUE)

Figure 5-4. System Fault Monitor Status

Information appearing on the System Fault Monitor (SFM) status display is as follows:

Cabinet — The image generator/display cabinet number being monitored.

Upper — The monitored values for this cabinet's upper channel processor.

- Fans (RPM) — Fan RPM for all six fans used to draw air through the upper backpanel.
- +5 (V) — Voltage of the upper backpanel +5 VDC power supplies.

	Temp (1/0)	A 0 indicates that the temperature of the upper backpanel is within tolerance. A 1 indicates an over-temperature condition.
Common	The monitored functions which are common to both channel processors in that cabinet.	
	±15 (V)	Voltage of the ±15 VDC power supply.
	-5.2 (V)	Voltage of the -5.2 VDC power supply. (This is not monitored in those system configurations which do not have a -5.2 VDC power supply.)
	Line (V)	Incoming or site power line voltage.
Lower	The monitored values for this cabinet's lower channel processor functions.	
	Fans (RPM)	Fan RPM for all six fans used to draw air through the lower backpanel.
	+5 (V)	Voltage of the upper backpanel +5 VDC power supplies.
	Temp (1/0)	A 0 indicates that the temperature of the lower backpanel is within tolerance. A 1 indicates an over-temperature condition.
Display	Dsply	This monitors the display cabinet that provides power to display power supplies which may or may not be installed in the cabinet.
	Fans (RPM)	Fan RPM for the six fans used to cool this cabinet (optional).
	Temp (1/0)	A 0 indicates that the temperature sensor in the fan assembly has detected an over-temperature condition (optional).
	Display On/Off	This indicates whether or not a particular display power
	Line (V)	This shows the site power line voltage.

5.4 SPX OPERATING PROCEDURES

5.4.1 Hardware

5.4.1.1 Pre-Operation Conditions

The following controls and indicators should be verified prior to turning on the system to insure proper operation:

1. The system console terminal power switch should be in the ON position.

2. All circuit breakers in the system should be in the ON position. These include:

    a. The MP unit circuit breaker located on the rear of the MP unit in the MP cabinet.

    b. All power controller circuit breakers located on the front panel of all the power controllers.

    c. The display power supply circuit breakers (if the system is configured with CSM displays) on the CSM low voltage power supplies in all display power supply cabinets.

3. Site power should be applied to the power controllers, and the power available indicators on each power controller should be illuminated.

5.4.1.2 Powering On the System

Once installation of the SPX system has been completed, the SPX system is ready for power up. The system can be powered ON by doing any one of the following.

CAUTION: Allow at least 15 seconds between switching power off and on when cycling system power.

1. If the system terminal is a VT2XX/VT3XX and has been powered OFF since the last time the system was booted, press the key board sequence <CTRL/[> <[><i><p> (while holding down the control key press the left bracket key, release the control key and press the left bracket key a second time, then the lower case i, and finally the lower case p). This will cause the escape sequences to be sent from the system fault monitor card to initialize the terminal's user-definable keys. Then, press the POWER function key <Shift/F20>. This will send the programmed user function which was previously set to <CTRL/[> <[><o><p> which turns on the image generator; or

2. If the system terminal is a VT2XX/VT3XX and has not been powered off since the last time the system was booted, press the POWER <Shift/F20> function key to turn on the system; or

3. If the system terminal is not a VT2XX/VT3XX terminal, type <CTRL/[>

<[><o><p> on the system terminal. Be sure that lower case characters are typed in the control sequence; or

4. The system can always be powered on or off by pressing the ON/OFF push button switch on the master power controller located in the MP cabinet.

Any one of the above operations will cause power to be applied to the SPX image generator. Once power is applied, the system will automatically start its power-on sequence. First, the MP card will run through its power-on confidence tests and, if successful, will continue by automatically booting the operating system. Once the operating system is booted the login command file will be executed. Typically this file will proceed to load the system microcode and the flight dynamics code. Once the flight dynamics code is loaded the system will proceed to execute the real-time system.

5.4.1.3 Shutdown Procedures

5.4.1.3.1 Normal Shutdown Procedure

The same procedure is used when turning power on or off with the SPX system. The system will toggle between the ON state and the OFF state when any of the power ON/OFF commands are given. When the system is in the ON state, any of the following actions will turn the system off.

CAUTION: Allow at least 15 seconds between switching power off and on when cycling system power.

1. On VT2XX/VT3XX terminals, press the POWER function key <Shift/F20>. This will send the programmed user function which was previously set to <CTRL/[><[><o><p>; or

2. Type <CTRL/[><[><o><p> on the system console or ICC terminal. Be sure that the characters typed in the control sequence are lower case; or

3. Press the ON/OFF push button switch on the master power controller in the MP cabinet.

5.4.1.3.2 Emergency Shutdown Procedure

Many sites have a means of shutting down power to all equipment in the computer room. If such a capability exists, this is the preferred method for emergency shutdown since site power will be removed from all equipment, not just the image generator.

If such a system is not available and it becomes necessary to turn off all of the image generator cabinets, switch off the main breaker on the MP cabinet power controller. This will disable the external ±15 V power supply in the MP cabinet which supplies power to all the IG cabinet SFMs. When the SFM in the MP cabinet power controller has been de-energized, communication between the master SFM and the slave SFMs is terminated. This lack of communication shuts down the power contactors in all system power controllers.

5.4.2 Software

Software operating procedures are provided in the *SPX Real-Time System User's Manual* and the *SPX Operating System Manual.*

5.4.2.1 System Commands

The standard control console for the SPX system is a VT2XX/VT3XX. When power is applied to the SFM or when the power ON/OFF button is pushed on the master power controller, an escape sequence is sent from the SFM to the system console. This sequence initializes the system console so that power controller commands are programmed into the function buttons <F6> to <F20> when the shift key is pressed. If another terminal, such as the interactive control console (ICC), is used to enter commands, the escape sequences must be entered directly (see Table 5-3). Figure 5-3 as well as Table 5-3 describe the commands available at the system console.

Table 5-3 Terminal Commands

Command	Entry for VT2XX/3XX Entry for VT100 or ICC	Description
Power	<Shift/F20> <CTRL/[><[><o><p>	Toggles power on and off for all cabinets.
Status	<Shift/F6> <CTRL/[><[><s><p>	Requests that the continuously-updated system status be displayed. This command also disables the MPU port.
Abort 1	<Shift/F9> <CTRL/[><[><a><1><p>	Activates the abort for MPU slot 1.
Abort 4	<Shift/F18> <CTRL/[><[><a><4><p>	Activates the abort for MPU slot 4.
Reset 1	<Shift/F8> <CTRL/[><[><r><1><p>	Activates the reset for MPU slot 1.
Reset 4	<Shift/F17> <CTRL/[><[><r><4><p>	Activates the reset for MPU slot 4.
Display	<Shift/F10> <CTRL/[><[><d><p>	Toggles the power in the display cabinets only.

Table 5-3 Terminal Commands - Continued

Command	Entry for VT2XX/3XX Entry for VT100 or ICC	Description
Continue	<Shift/F7> <CTRL/[><[><c><p>	Continues after system status has been displayed.
Initialize	<CTRL/[><[><i><p> <CTRL/[><[><i><p>	Causes the SFM to send the escape sequences to the terminal to initialize the above user-defined keys.

5.4.2.2 Simulation Mode Host Control Commands

During simulation, commands to the IG may be entered from the system console or the ICC. These instructions are called CLI (Command Line Interpreter) commands, and are covered in detail in the *SPX Real-Time System User's Manual*. Please refer to this manual for use of the CLI commands.

The CLI commands can change the visual image even as the host is sending control packets. For example, while the host is sending flight information for a clear day, commands may be entered at the system console or ICC to set ground fog; the fog would then remain until changed by the host or another CLI command.

5.4.2.3 RTS Status Screens

The SPX real-time software can display one of two status screens to monitor system performance while the IG is generating an image, either the coordinate system screen or the statistics and coordinate screen. A detailed description of both of these screens may be found in the *SPX Real-Time System User's Manual.*

The coordinate system screen is the default, and appears on the terminals when the real-time system is started. This screen provides flight information such as eyepoint, latitude, longitude, heading, pitch etc.

The statistics and coordinate screen shows system statistics such as database loading, channel processor execution times and coordinate system data. This screen can be viewed only while the real-time system is running, and is activated by typing SHOW STATS + at the SPX> prompt. The screen is exited by typing SHOW STATS -.

5.5 DISK PROCEDURES

5.5.1 Backup

Data on the SPX system disk drive should be backed up on a regular basis. The backup procedure is as follows:

1. Power on the system and wait for the operating system prompt >. Exit from the real-time software if necessary.

2. Execute the File Management Utility by typing:

   `@FMU <RET>`

3. Load an SPX formatted tape into the streamer tape drive.

4. Select the BACKUP command by typing:

   `BACKUP <RET>`

5. Enter the disk drive to be backed up by typing:

   `DR0: <RET>`

6. Enter the tape header text when requested and respond appropriately to the question `Are you sure you want to backup? (Y/N):`.

The system will proceed to backup the specified disk drive onto the magnetic tape. Multiple tapes may be required to backup the disk. Additional information can be found in the FMU section of the *SPX Operating System Reference Manual.*

5.5.2 Hard Disk Failure

Data from the SPX system disk drive should be backed up on a regular basis; this is to protect the user in the event of a hard disk failure. If a hard disk fails, it should be replaced with a spare disk if available. After the new disk is installed, the procedures in Appendix D must be performed. (If a new disk is not available, attempt to perform the procedures described in Appendix D.)

If the failure of the disk is caused by a sector or track going bad, the software stored on that portion of the disk will be lost. Reformatting the disk will locate those sectors or tracks of the disk and mark them as bad so that they will not be used. Typical disk specifications permit a number of bad sectors or tracks; as long as the number of bad sectors or tracks is not excessive, disk performance will not be significantly degraded.

If the disk failure is the result of an area of the disk going bad, restoring software to the disk without reformatting and marking bad spots may result in a continued loss of data as data stored on the bad spot will be lost. An unmarked bad section of the disk may also cause the restore operation to fail.

Before returning the failed disk, it is best to attempt to reformat it; if this is successful, restore the backup tape using the procedures listed in Appendix D. If this procedure is completed successfully, it is likely that the disk is operational.

5.5.3 Restore

5.5.3.1 FMU Disk Restore

If files are being corrupted or lost, the disk needs to be reformatted to locate and mark any bad sectors that are not already marked as such. The backup tape must then be restored to the disk. The preferred method for this is the FMU format and restore as described in the *SPX Operating System Manual*. If the operating system and FMU will not execute, see Section 5.5.3.2.

5.5.3.2 Debugger Disk Restore

If the operating system is inoperative at the conclusion of the MP self-diagnostics following system boot, the debugger will be activated. To restore the disk from the debugger, perform the procedure detailed in Appendix D.

5.6 ERROR MESSAGES

If a hardware or software error occurs during operation of the image generator, an error message will be printed on the system console. Further information related to the error is found in different manuals, depending upon what software was executing at the time the error occurred. Use Table 5-4 to locate which manual contains information on the error codes for each piece of software.

Table 5-4. Error Code Locations

Software	Manual Listing Error Code
Operating System	*SPX Operating System Manual*
Real-Time System	*SPX Real-Time System manual*
MIRP	*SPX Real-Time System Manual*
FMU	*SPX Operating System Manual*
MED	*SPX Operating System Manual*
DLU	*SPX Operating System Manual*
EDU	*SPX Operating System Manual*
MMD	*SPX Operation and Maintenance Manual*

5.7 DAILY SYSTEM READINESS CHECK PROCEDURE

The system operator should perform several quick daily checks of the image generator system to insure safe, uninterrupted operation. The following checks should be performed:

- Printer check
- System Fault Monitor Check
- Cooling Fan check
- Computer check
- Image Generator check
- Display Alignment check (See display manual for details)
- Data Base Operation check
- Host communication check

The daily system readiness check should be run just prior to system use. It is as follows:

System Areas: Printer, system console, displays, selected fans.

Purpose: To quickly initiate system operation, verify correct system power, to check display operation, initiate a training data base and host communication, and check the printer paper supply and ribbon condition.

Required tools or supplies:	Printer paper and ribbon (See vendor manual for specifications as to type or part number).

CAUTION: Certain sites require daily powering on and off of equipment at the start and end of system use. A procedure is attached which describes power on. However, it is strongly recommended that the SPX system be left powered on except when required otherwise for maintenance or troubleshooting tasks. Reducing the number of power on/off cycles significantly increases system reliability.

Initial Conditions: The system is assumed to have been turned off under normal operating conditions. All circuit breakers are set to ON and the system console power indicator is on.

Instruction	Response
NOTE: Skip steps 1 and 2 if the system has been left powered on as recommended above.	
1. Power on the image generator by pressing <SHIFT/F20> on the system console.	All power indicators show power on. The MP card executes its self-diagnostics and loads the operating system. The system fault monitor has checked power supply levels, site power and channel processor fans. The system console will request that the date and time be set.
2. Enter the date and time in the format *ddMMMyyyy hh:mm*, where *dd* is the number of the day (01 through 31), *MMM* is the abbreviated month, *yyyy* is the four-digit year, *hh* is the hour (00 through 23), and *mm* is the minutes (00 through 59).	If a login command file exists on the disk, it will be executed at this time.
3. Check each power controller's power-on light .	Each power controller should have its power-on light illuminated.
4. Check that each large 5V power supply fan is functioning.	Air flowing through each power supply fan will be detected.
5. Check that air is coming out of the holes located in the left-hand rear quadrant of the MP unit cabinet top.	Air flowing up through the grill work will be detected.
6. Inspect the system printer paper supply.	The amount of paper should be enough to supply the expected printing demand for the day.

7. Type <SHIFT/F6> on the system console.

The SFM Status screen will appear on the system console.

8. Verify that monitored parameters are not approaching their trip limits as shown in Table 5-5.

During normal operation of the IG it is important to review the System Fault Monitor status screen. If any of the parameters are close to their operational limits, adjust the power supplies (see Section 7.3.1) or replace fans as necessary.

Table 5-5. SFM Trip Limits

Parameter	Upper Limit	Lower Limit
+5 VDC	+5.26 ±0.01 VDC	+4.72 ±0.01 VDC
+15 VDC	+15.8 ±0.01 VDC	+13.97 ±0.01 VDC
-15 VDC	-15.8 ±0.01 VDC	-13.97 ±0.01 VDC
-5.2VDC	-5.6 ±0.01 VDC	-4.99 ±0.01 VDC
Line	262 ±1 VAC	184 ±1 VAC
Fan	3500 RPM	2000 RPM
Temperature	115 ±5 °F	NA

NOTE: Table 5-5 specifies the limits at which an SFM will turn off power to its cabinet to prevent equipment damage. The SFM does not have the accuracy required for adjusting power supplies unless otherwise specified. Power supplies can be out of tolerance and still be within the SFM trip limits.

9. On the system console press the print <F2> key.

The data on the system console screen will be printed. This verifies operation of the printer.

10. Check the print quality.

The characters should be dark enough for making photocopies. This verifies that the ribbon is good.

CAUTION: Never operate the printer without paper or ribbon installed. To do so may cause damage to the printer.

11. Type `@RTS <RET>` if the real-time software is not executing.

A picture will appear on the displays if they are turned on.

12. Type `@TSTPAT.RST` <RET>.	The system console will show the reset file being executed. The test pattern menu will appear on the system console and the grid test pattern will appear on the displays. Verify that the display image matches that seen in Figure 7-6. Display geometry is verified.
13. Type `CS N 1 SEL 2` <RET>.	The Wedge test pattern will appear on the screen. Check that the test pattern matches Figure 7-7. Check the pattern for correct balance of red, green and blue to give correct color balance for both light points and raster lines. Each display should have a uniform color intensity and balance.
14. Execute the training database.	The database used for training will appear on all channels. This validates that the database can be executed and displayed.
15. Type `SET HOST +` <RET>.	The console terminal displays information on the viewed environment and the message `Ethernet Status: Ethernet initialized <RTSxx>` appears on the system console. The host interface will be active and receiving host packets unless a status message appears saying `No data received for 5 fields`.
16. On the host computer, issue a command to change the image.	The visual scene will change under host control indicating successful host-IG communication.

CHAPTER 6

THEORY OF OPERATION

6.1 INTRODUCTION

In this section the SPX computer image generator (CIG) theory of operation is presented. This theory is given using block-diagram-level functional descriptions. A brief description of the overall CIG operation is followed by more detailed descriptions of the main functional blocks. These main block descriptions are supported by circuit card level discussions.

6.2 SPX SYSTEM THEORY

6.2.1 SPX Architecture

An SPX image generator system (see Figure 6-1) consists of a multiprocessor unit (MPU), one or more channel processors, and one or more display devices. The multiprocessor unit receives input from the host computer specifying eyepoint position and environmental conditions. It also receives commands from the system console, and returns system status to the console. The system printer is connected directly to the system console. The multiprocessor unit passes data base and positional information to the channel processors for further processing.

Up to eight channel processors can receive data base and positional information from the multiprocessor unit. The channel processor then generates scene information in the form of analog signals which are passed to the display device where they are used to generate the visual scene. The display device type can be either raster-only or raster/calligraphic.

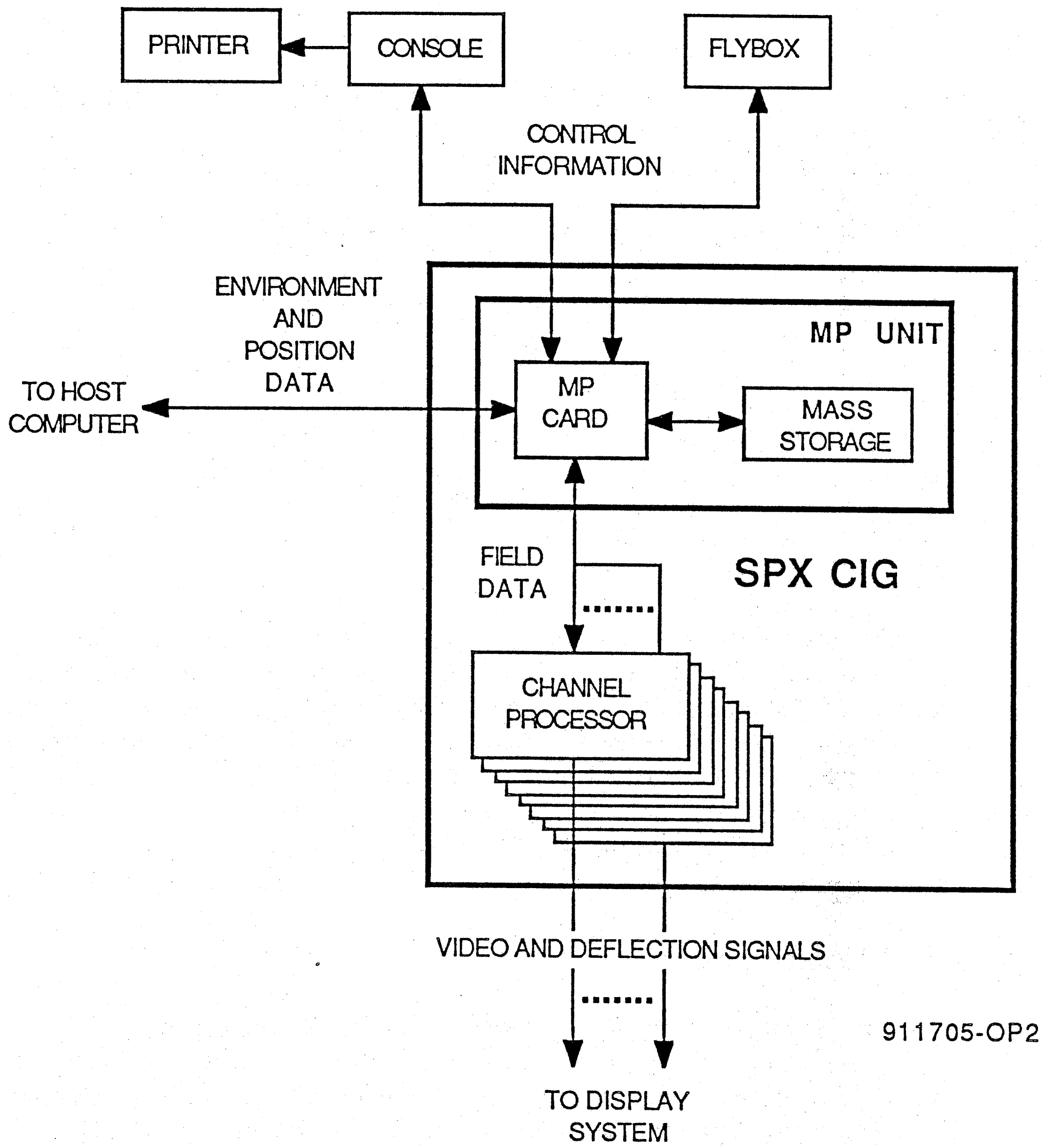


Figure 6-1. Functional System Block Diagram

6.2.2 System Multiprocessor Unit (208010)

The multiprocessor unit in an SPX system is the front-end computer of the image generator. Its tasks include real-time and off-line tasks. When running in real time, it is responsible for interfacing the image generator to the host computer, managing data base retrieval from the disk, and providing the proper data base and control blocks to the channel processors. Off-line tasks include data base development, hardware diagnostics, and execution of system utility programs.

The multiprocessor unit is mounted in the MP cabinet (typically the left-most cabinet) and contains a power supply, MP card, disk drive, tape streamer, and a disk/tape controller card. Provision has been made for up to four additional cards and an additional disk and tape drive to be placed in the MP unit to handle future configurations.

6.2.3 Channel Processor Units

The SPX image generator computes a scene to be displayed based on the current eyepoint as received from the host computer. Each view from that eyepoint (i.e. front view, right-side view, left-side view, etc.) requires a channel processor in the system. The channel processor is therefore responsible for processing the data base and determining what portions are visible in its particular field-of-view and then computing the appropriate scene that corresponds to that view. The channel processor is made up of three main sections: the object manager (OM), the geometric processor (GP), and the display processor (DP).

6.2.3.1 Object Manager (OM)

The OM section of the channel processor provides several functions. Its main function is to traverse the data base tree structure during each display frame and determine what portions of the data base are contained in the field-of-view for that channel. Those parts of the data base that are closest (i.e. have the highest priority) are sent to the GP first. Those more distant or lower in priority are sent later.

After the OM has traversed the data base tree, it will perform the pager function in the time remaining before the next frame needs to be started. The pager function is another traversal of the data base tree to identify all the parts of the data base that are potentially visible. The OM notifies the MP, executing in real-time mode, of those parts of the data base that are potentially visible. The real-time system compares the potentially-visible list with a list of the data base pieces that are already active. The real-time software then requests additional data from the disk or frees up channel processor memory based on the comparison of the two lists.

Other tasks that the OM performs are height-above-terrain (HAT) and collision-detection (CD) calculations.

6.2.3.2 Geometric Processor (GP)

The GP section of the channel processor receives a prioritized list of pointers to portions of the data base that are potentially visible in that channel. The GP reads in data blocks that define the various data base elements (i.e. polygons, light strings, command blocks), and translates and rotates them into viewer coordinates. These are then clipped against the field-of-view boundaries for that particular channel, and, if they are in the field-of-view, they are sent on to the DP. Light strings are expanded into individual light points prior to clipping, and control blocks are either used in the GP or sent directly to the DP.

6.2.3.3 Display Processor (DP)

The basic function of the display processor (DP) is to produce a displayable image of the data base as processed by the geometric processor (GP). This involves various intensity and geometric calculations to generate the appropriate video data for each pixel on the screen.

6.2.4 Display(s)

Refer to the CSM O&M manual (901080-407) or the appropriate vendor manual for a description of the displays used with the SPX system.

6.2.5 System Power

Power required by the SPX image generator is single phase 230 volts AC. Each cabinet has its own main power cable. This cable is connected to the main site power and is plugged into the power controller located in each cabinet. The power controller then distributes power to all devices internal to the cabinets and to some devices external to the cabinets. External devices include the system console, the printer, and the display devices (see Section 2.5.2.).

A separate cable is provided from the bottom of the MP cabinet to connect 115 VAC power to the convenience outlet. The convenience outlet is located at the bottom front of the MP cabinet.

6.2.5.1 Power Controller / System Fault Monitor

Each cabinet of the image generator system contains a power controller unit which is used to control, condition, and distribute power to various devices internal and external to the cabinet. Each power controller contains a system fault monitor (SFM) circuit card. These fault monitor cards continually monitor the status of site power, channel processor cooling fans, power supply voltages and other critical system parameters, and report any fault conditions to the system console.

The system fault monitor (SFM) card in the MP cabinet is designated as the master for the entire IG system. It provides a communications link with the system console and the other SFM cards in the system. The master SFM card not only monitors the status of its own cabinet, but periodically queries the other SFM cards for the status of their respective cabinets. The master SFM card is inserted in the communication path between the system console and the MP card. This allows it to inhibit normal system communication and display a status screen when a system fault has been detected.

Normally, the SFM cards are powered at all times and remain in communication with the system console. Commands to turn cabinet power on or off, or to display system status are entered by the operator through the system console. The master SFM card receives these commands and relays them to the other SFM cards. All

SFM cards then take the appropriate actions. Each SFM card has the potential of monitoring the following cabinet parameters:

1. The incoming line voltage.

2. The output voltage levels of the +15 V DC, -15 V DC, and -5.2 V DC (optional) power supplies inside the power controller.

3. The open/closed status of the over-temperature thermal switches mounted at the top of each channel processor card cage.

4. The voltage levels of the main 5 V DC power supplies at each channel processor backpanel.

5. The rotation speeds of the six cooling fans associated with each channel processor.

Safe operating ranges for the line voltage, power supply outputs, and fan rotations have been programmed into the microcode, and out-of-tolerance values constitute a system fault. All faults are reported to the system console. Critical faults, such as out-of-tolerance line voltage, improper channel processor fan speeds, and loss of analog supply voltages will also result in automatic shut down of the respective cabinet power.

When cabinet power is off, the fault monitors samples only the incoming line voltage. When cabinet power is on, all appropriate parameters are monitored. All values are sampled several times per second.

The operator can also request that current system status be displayed on the system console. Occasional examination of voltage levels and channel processor fan speeds may reveal near-fault conditions which can be corrected through preventative maintenance actions.

6.2.5.2 Power Supplies

The SPX image generator contains four different types of power supplies, excluding those associated with the displays. They are:

- MP power supply (801660). This is a multiple output supply that supplies +5 V DC and ±12 V DC to the MP card, and supplies +5 V DC and +12 V DC to the disk drive, tape streamer, and disk/tape control card.

- +5 V DC main channel processor supply (208050). These supplies are large +5 V DC supplies. Usually two of them are connected in parallel to supply power to each one of the channel processors.

- -5.2 V DC supply (208072) (optional). This supply is used to supply the -5.2 V DC power required by the ECL circuitry on the scope driver card (208133-100). The supply is located in the power controller and provides power for up to two channel processors (if both are located in the same cabinet). The 208133-101 version of the scope driver card does not require the -5.2 V DC power supply.

- ±15 V DC supply (208073). This supply is used to supply the ±15 V DC power required by the analog circuitry on the scope driver card. The supply is located in the power controller and provides power for up to two channel processors (if both are located in the same cabinet).

  This same type of supply is also used to supply power to the system fault monitor cards. When used in this configuration it is located in the bottom rear of the MP cabinet and is connected to the master power controller. One supply will power all of the SFM cards in the image generator cabinets and one more supply will power all of the SFM cards in the display power supply cabinets.

6.3 SPX SUB UNIT THEORY

6.3.1 System Multiprocessor

The multi-processor card (MP) is a single-board computer containing all circuitry necessary to perform its real-time and off-line functions. It interfaces with the host computer over a dedicated, collision-free ethernet link (IEEE 802.3). It interfaces with a Winchester disk drive and a tape streamer over a standard SCSI bus, and to the image generator over a 16-bit parallel bus referred to as the common bus.

6.3.1.1 Real-Time Operation

In its real-time mode, the MP will receive host packets from the host computer over its ethernet interface. These packets will be placed in memory where they will be time corrected and used to provide updated eyepoint and dynamic coordinate system data for the next field to be displayed.

In addition to positional data, the host computer will also send commands to change the operating state of the image generator to the day, dusk, or night mode, changes in the visibility range, changes in the settings of switchable lights or polygons, and any of the other host-controllable parameters.

The MP card interfaces the disk drive with the image generator. Based on current eyepoint position, the OM will send to the MP card a list of pointers to portions of the data base that need to be brought on-line. The MP card will request model data not already online to be retrieved from the disk drive. This model data is then passed over the common bus to the environment memory in both the OM and the GP sections of each channel processor.

Using serial interface ports, the MP card interfaces the image generator with the system console and the optional interactive control console (ICC or flybox). These two terminals are typically connected in parallel and are used to provide operator control over the image generator in either real-time or off-line modes.

6.3.1.2 Off-Line Operation

While the system is not operating in the real-time mode, the MP card interfaces the system console with the image generator and the disk and tape drives to perform various system utility and diagnostic tasks. Utilities include file management utilities that allow files to be edited, copied, deleted, renamed, etc.; file download utilities that allow various file types to be downloaded from another computer; and microcode loading utilities that allow microcode files to be downloaded from the disk drive to the image generator hardware. Hardware diagnostics are written as files that test individual cards or groups of cards. The CHEK diagnostic language will interpret commands in diagnostic test files to exercise various parts of the image generator hardware to determine if it is functioning properly. Error messages are reported if failures in the hardware are detected.

6.3.1.3 Winchester Disk Drive

The Winchester disk drive is the mass-storage device, and is located in the MP unit. This disk conforms to a standard 5 1/4 inch form factor, and utilizes the ST-506 interface standard. Utilizing devices that conform to these two standards insures that a wide variety of disk drives will be compatible with the SPX system. Currently, a variety of different disk drives are offered as options covering many disk capacities.

The Winchester disk drive is used to store all of the executable programs required to operate and maintain the SPX system, diagnostic test files, microcode files, and operational data bases.

6.3.1.4 Tape Streamer (801668)

The SPX image generator utilizes a quarter-inch tape streamer as its backup device. Data contained on the disk drive can be backed up on one or more tape cartridges. Tapes can also be used for transferring individual files from one image generator to another or to allow new or updated copies of programs or models to be transferred to the user's systems.

6.3.2 Channel Processor

The channel processor is contained in one backpanel/card cage. The card cage can contain up to 58 cards (see Figures 6-2, 6-3, and 6-4). Each channel processor contains three sections: the object manager, the geometric processor, and the display processor.

Card	Part No.	Slot	Card	Part No.	Slot
SD	208133	30	IP 0	208129	1
VA R0	208130	31			2
		32			3
		33			4
		34	EP 0	208128	5
		35			6
		36			7
LB *	208141	37			8
DC	208131	38	EG 0	208123	9
OC	208132	39			10
DD	208127	40	VG 0	208126	11
IC	208121	41			12
EF	208134	42	VS Z	208125	13
SG	208124	43	LL *	208140	14
SP	208122	44	TM 0 *	208152	15
AP OM	208112	45			16
EM OM	208111	46			17
EM GP	208111	47			18
CM	208120	48			19
PLB	208113	49			20
AP 0	208112	50	TL 0 *	208151	21
AP 1	208112	51			22
AP 2	208112	52	TR 0 *	208150	23
AP 3	208112	53			24
		54	VS Y *	208125	25
		55	VS X *	208125	26
		56			27
		57			28
		58			29

913703-0P1

CARD INSERTION SIDE

* INDICATES AN OPTIONAL CARD

Figure 6-2. SPX 100 Backpanel Card Allocation

Card	Part No.	Slot
SD	208133	30
VA R0	208130	31
		32
VA G0	208130	33
		34
VA B0	208130	35
		36
LB	208141	37
DC	208131	38
OC	208132	39
DD	208127	40
IC	208121	41
EF	208134	42
SG	208124	43
SP	208122	44
AP OM	208112	45
EM OM	208111	46
EM GP	208111	47
CM	208120	48
PLB	208113	49
AP 0	208112	50
AP 1	208112	51
AP 2	208112	52
AP 3	208112	53
AP 4	208112	54
AP 5	208112	55
		56
		57
		58

Card	Part No.	Slot
IP 0	208129	1
IP 1	208129	2
		3
		4
EP 0	208128	5
EP 1	208128	6
		7
		8
EG 0	208123	9
		10
VG 0	208126	11
VG 1	208126	12
VS Z	208125	13
LL *	208140	14
TM 0 *	208152	15
TM 1 *	208152	16
		17
		18
		19
		20
TL 0 *	208151	21
TL 1 *	208151	22
TR 0 *	208150	23
TR 1 *	208150	24
VS Y *	208125	25
VS X *	208125	26
		27
		28
		29

913703-0P2

CARD INSERTION SIDE

* INDICATES AN OPTIONAL CARD

Figure 6-3. SPX 500 Backpanel Card Allocation

SD	208133	30	IP 0	208129	1
VA R0	208130	31	IP 1	208129	2
VA R1	208130	32	IP 2	208129	3
VA G0	208130	33	IP 3	208129	4
VA G1	208130	34	EP 0	208128	5
VA B0	208130	35	EP 1	208128	6
VA B1	208130	36	EP 2	208128	7
LB	208141	37	EP 3	208128	8
DC	208131	38	EG 0	208123	9
OC	208132	39	EG 1	208123	10
DD	208127	40	VG 0	208126	11
IC	208121	41	VG 1	208126	12
EF	208134	42	VS Z	208125	13
SG	208124	43	LL	208140	14
SP	208122	44	TM 0	208152	15
AP OM	208112	45	TM 1	208152	16
EM OM	208111	46			17
EM GP	208111	47			18
CM	208120	48			19
PLB	208113	49			20
AP 0	208112	50	TL 0	208151	21
AP 1	208112	51	TL 1	208151	22
AP 2	208112	52	TR 0	208150	23
AP 3	208112	53	TR 1	208150	24
AP 4	208112	54	VS Y	208125	25
AP 5	208112	55	VS X	208125	26
		56			27
		57			28
		58			29

CARD INSERTION SIDE

913703-0P3

Figure 6-4. SPX 500HTL Backpanel Card Allocation

6.3.2.1 Object Manager

The object manager utilizes two different card types: the 208111 environment memory (EM) card and the 208112 arithmetic processor (AP) card (see Figure 6-5). The object manager performs many tasks. Among these are data base tree traversal for object prioritization and field-of-view culling, data base pager tree traversal, height-above-terrain computation, and collision-detection computation.

The data base is organized in a hierarchical tree structure. The basic unit of the tree is a mesh, each of which contains a collection of cells. Each cell can contain pointers to another mesh or an object. The entire data base is maintained on the disk drive, and only the active part, or that part that is potentially visible, is brought into memory. Each channel processor contains the same data base as any other channel processor, since it is potentially visible in each channel. That part of the data base held in memory is said to be on-line.

The major task of the OM is in the foreground and requires the OM to traverse the on-line data base tree once every field. As it traverses the tree, it tests each cell in the tree to determine whether that cell is in the field-of-view, which level of detail of the cell is appropriate for the current range to the eyepoint, and how the cell should be prioritized with respect to other cells in the same mesh. The OM continues processing the cells, which contain either mesh or object pointers, until the highest priority object is determined. Objects are encountered in the tree traversal in priority order and pointers to the objects are subsequently passed to the EM card of the GP (see Figure 6-5) where they form part of the GP command list.

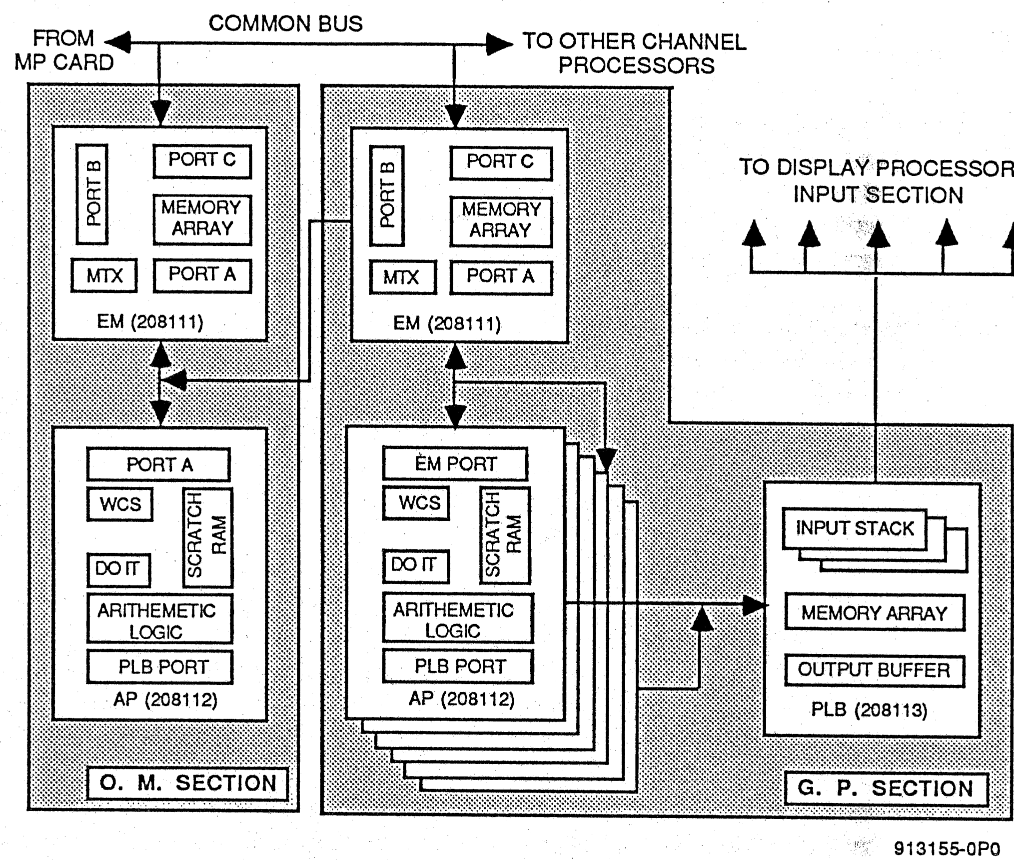


Figure 6-5. OM/GP Block Diagram

The pager task performed by the OM is a second traversal of the entire data base tree. This traversal performs only a level-of-detail test. Objects that are within the transition range for the current eyepoint position will be included in a list that is passed to the real-time system, which will compare the OM-generated list with one maintained by the real-time system that indicates current meshes and objects that are on-line. Any objects or meshes that are required but not currently on-line will be requested from the data base files on the disk; any that are currently on-line but not required will be deleted from memory.

Other foreground tasks that may be performed by the OM include height-above-terrain and collision-detection calculations. The height-above-terrain routine will traverse the data base until the highest priority object is detected. It will then return a height value that it calculates from the eyepoint to this highest priority, or closest, object. The collision detection routine will detect cases where sample points intersect with collision volumes and report these occurrences to the real-time system.

6.3.2.2 Geometric Processor

The function of the geometric processor is to process selected data base information and convert it into a formatted command/data list that is sent to the display processor, which then converts the information into a picture.

The data processed by the GP consists of DP data constants and object data blocks. DP data constants are controlled and generated by the real-time system. These consist of such things as landing light lobe patterns, draw block control information, texture maps, etc. Generally, the DP data constants are compressed for efficient usage of disk and memory space and need to be expanded and formatted by the GP before they are passed on to the DP section. Object blocks consist of polygon and light string definitions, and are processed by the GP into a format required by the DP.

The geometric processor.utilizes three different card types: 208111, 208112, and 208113. Two of these are the same card types as are used in the object manager section.

6.3.2.2.1 Input to the GP

The real-time system (RTS) and object manager (OM) provide the GP with its input information. The RTS and OM together generate a command list which is executed by the GP and contains the information necessary for the GP to convert the modeled data base into DP formatted data. The RTS interfaces with the GP through the common bus port of the environment memory card (208111). The RTS loads data base object files from the disk into the EM of the GP (see Figure 6-5), then controls the formation and execution of a GP command list.

The OM interfaces with the GP section through port B of the EM of the GP, where it stores its portion of the GP command list. This command list contains position and rotation information for the eyepoint and other dynamic coordinate systems, and the priority-ordered object list.

The GP uses the position and rotation information as it processes the ordered object list and generates the command/data list that is sent to the DP section for further processing.

6.3.2.2.2 Output from the GP

The poly/light buffer (PLB) card (208113) is used as a buffer between the GP and DP sections of the system. The PLB buffers information to be sent to the DP, allowing the GP and DP to run at different processing speeds, minimizing their timing dependencies with each other. Data is output to the DP section using a 96-bit wide data bus, and is passed to the DP section in priority order, highest priority first.

6.3.2.2.3 GP Control and Data Flow

The heart of the GP consists of from one to a maximum of eight arithmetic processor (AP) cards (208112). The AP cards are general purpose arithmetic processors which can operate in parallel, making the GP computing power adjustable to meet the demands of the application. The AP cards, which are programmable, are controlled by microcode and data which are loaded upon system boot up. The AP cards interface with the EM card of the GP through port A of the EM card. Each AP card waits for a GP GO signal issued by the RTS, and then proceeds to execute the command list contained in the EM. The first part of the command list contains information needed by all AP cards; all the AP cards operate in unison in a mode termed lock step, meaning all AP cards are locked together reading and processing the same information. While in lock step mode, the AP cards are receiving geometric descriptions of the eyepoint and dynamic coordinate systems. After receiving this information, the AP cards execute a command which breaks them out of lock step mode. They start individually passing needed constants to the DP section and processing the prioritized object lists generated by the OM.

The AP cards pass their output data to the PLB card over a 32-bit bus in priority order.

6.3.2.3 Display Processor

The architecture of the DP is designed to be expandable (see Figures 6-6, and 6-7). A given set of cards will process a set of pixels, and by adding another card set the resolution can be increased. There are four resolution configurations available: the 100, 100H, 500, and the 500H. The 100 series is normally a monochrome system running at 30 Hz, while the 500 series is usually a full color system running at 50 Hz. The H designates the high resolution version. All four configurations can include the color, calligraphic lights, landing light lobes, and texture options.

All data is fed to the DP from the output of the PLB card. The PLB card serves as a buffer between the GP and the display processor, allowing the GP to output data at different instantaneous rates than the DP inputs the data from the PLB. This data contains polygon and light point descriptions as well as various other DP data constants.

The DP transforms the display-plane representations of the polygons into a composite picture with hidden portions removed, image quality preserved, and raster scan formatting accomplished.

The span processor section of the DP operates on rectangular areas of the screen called spans. A span consists of a set of pixels which are computed in parallel, with the number of pixels in a span dependent on the configuration of the DP. Polygons are submitted to the DP from the PLB in visual priority order, and the span processor computes which spans will be influenced by the current polygon.

The video assembler is a dual video field buffer with storage for the red, green, and blue components at pixel resolution. One side of this memory is written into by the pipeline while the other side provides video output to the display.

As each new polygon is submitted to the span pipeline, a geometric description of the appropriate part of the polygon within each touched span is prepared. Areas of spans which have been previously covered by higher priority polygons will be subtracted from the current polygon description, thus providing proper occultation. The remainder, which is the visible part of the current polygon, is spatially filtered to derive the display video contribution of this polygon within the span.

Finally, the incremental effects of the polygon are summed into the video assembler memories after accounting for visibility effects, texture, transparency, and color.

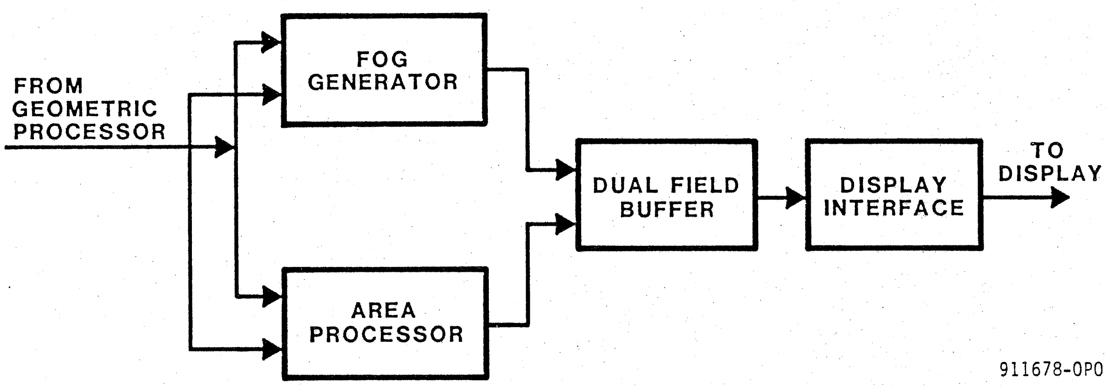


Figure 6-6. Display Processor Block Diagram (Minimum Configuration)

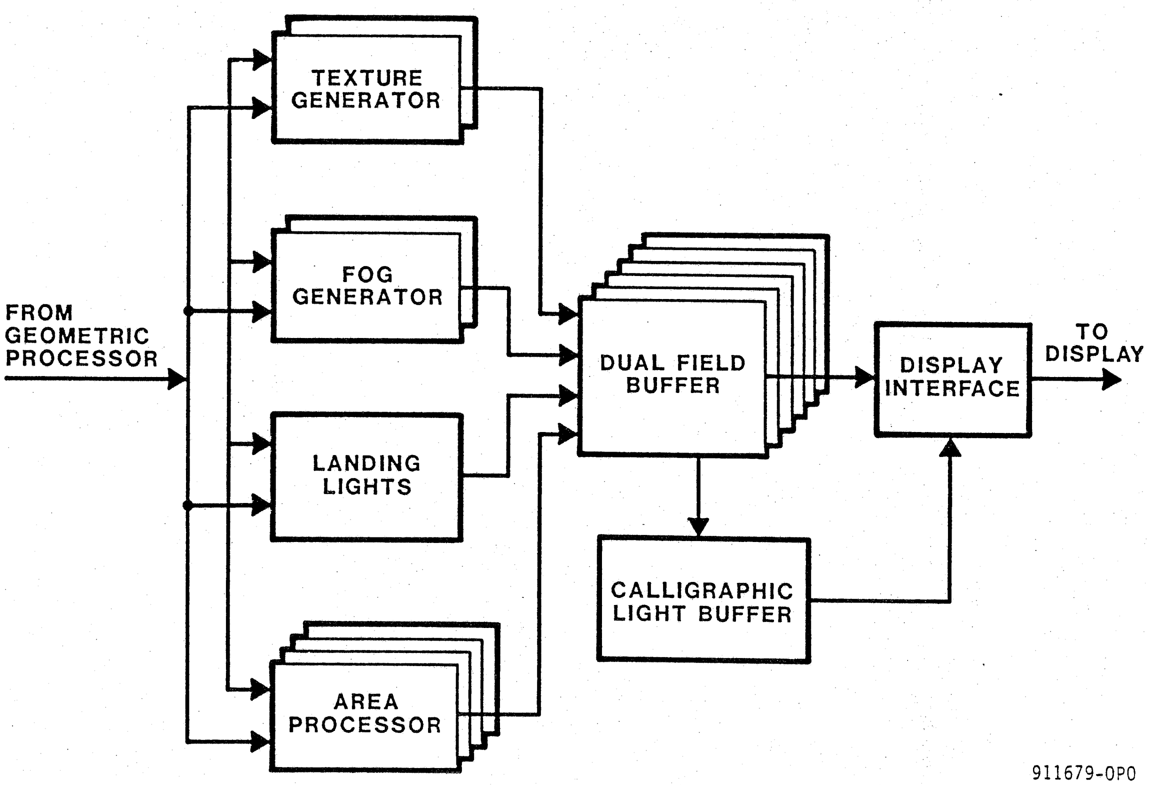


Figure 6-7. Display Processor Block Diagram (Maximum Configuration)

6.4 POWER UNITS AND DISTRIBUTION

Power for each SPX image generator cabinet and each display power supply cabinet is supplied from a site circuit breaker panel. The power is routed from the circuit breaker panel to a power controller assembly in each image generator cabinet and each display power supply cabinet. The power controller will distribute, condition and control the power for that entire cabinet.

6.4.1 Power Controller Theory

SPX power controllers are of two types. The first (208070) is used in the image generator cabinets, and differs from the type (208071) used in the display power supply cabinet in the number of circuit breakers, number of connectors, and use of a buck-boost transformer.

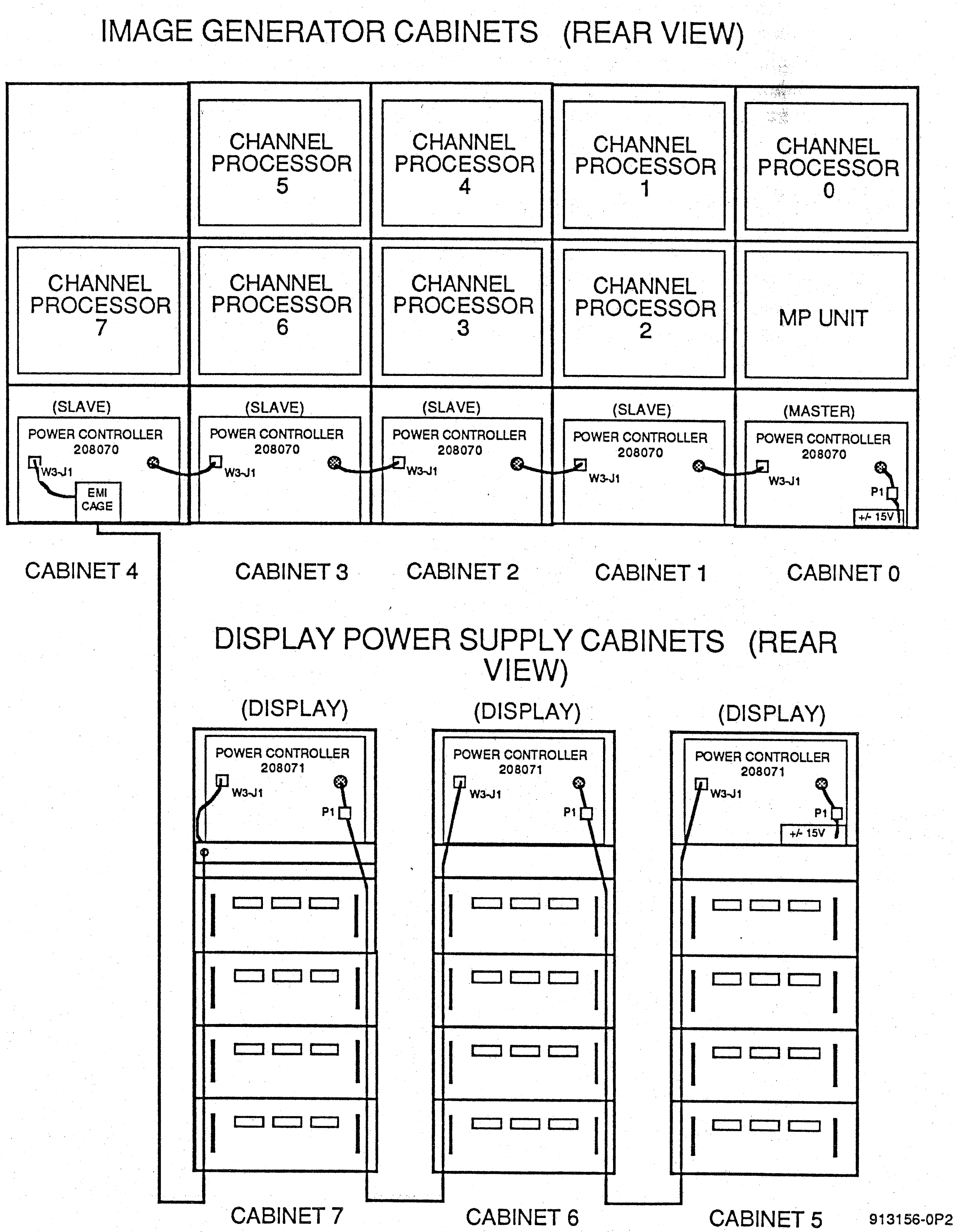


Figure 6-8. Power Controller SFM Interconnection

The image generator power controller (208070) and the display power controller (208071) both contain a system fault monitor (SFM) card, a power bus contactor, a line sensing transformer, and circuit breakers to control the power.

The image generator power controller (208070) also contains EMI filters, a buck-boost transformer for the fan power and the peripheral power, power supplies for the analog circuitry in the channel processors, and various power connectors on the rear panel of the power controller chassis.

The display power controller (208071) contains different power connectors, supplying power for up to five display devices (four CSMs or five projectors). Each 208071 power controller unit can supply power through a 50-ampere connection for up to 5 projectors, provided that the average and peak current draw from the cabinet do not exceed the ratings of the power controller's circuit breakers. The main circuit breaker is rated for 50 amps. Connectors J2 through J4 are protected by one 30 amp breaker. Connectors J5 and J6 are protected by a second 30 amp breaker. No single device may draw more than 15 amps.

Power is conditioned in the image generator power controller (208070) by the use of filters and a buck-boost transformer. The EMI filters are used to keep electromagnetic interference from being radiated from the main power line or the peripheral power lines. The buck-boost transformer is used to raise or lower the incoming line voltage to a voltage close to 230 VAC. This will insure that the fans that cool the channel processors rotate close to their specified rates and provide adequate cooling for the circuit cards within the card cage. It also provides a more controlled voltage for peripherals that may be more sensitive to line voltage levels.

Both the 208070 and the 208071 power controllers contain a system fault monitor card. All SFM cards in the system contain the same firmware in EPROM. The SFM card setup (see Section 4.5.2.2) determines whether the power controller functions as a master, a slave or as a display power controller. The firmware consists of three major routines (master, slave and display), which in turn call various subroutines based upon what functions need to be done.

6.4.2 System Fault Monitor Master Operation

The responsibilities of the master SFM are divided into three tasks. The first is the foreground task which uses many routines common to the slave fault monitors to acquire data in its own cabinet used to decide if any condition is out of tolerance and should be reported. The second task is to query the slave SFMs in each cabinet and determine if there are any other detected faults which must also be reported. The third task is to service interrupts in the background from the system console serial port and the MPU serial port. Data from the system console serial port are examined and commands directed to the SFM are stripped off and acted upon (see Figure 6-9).

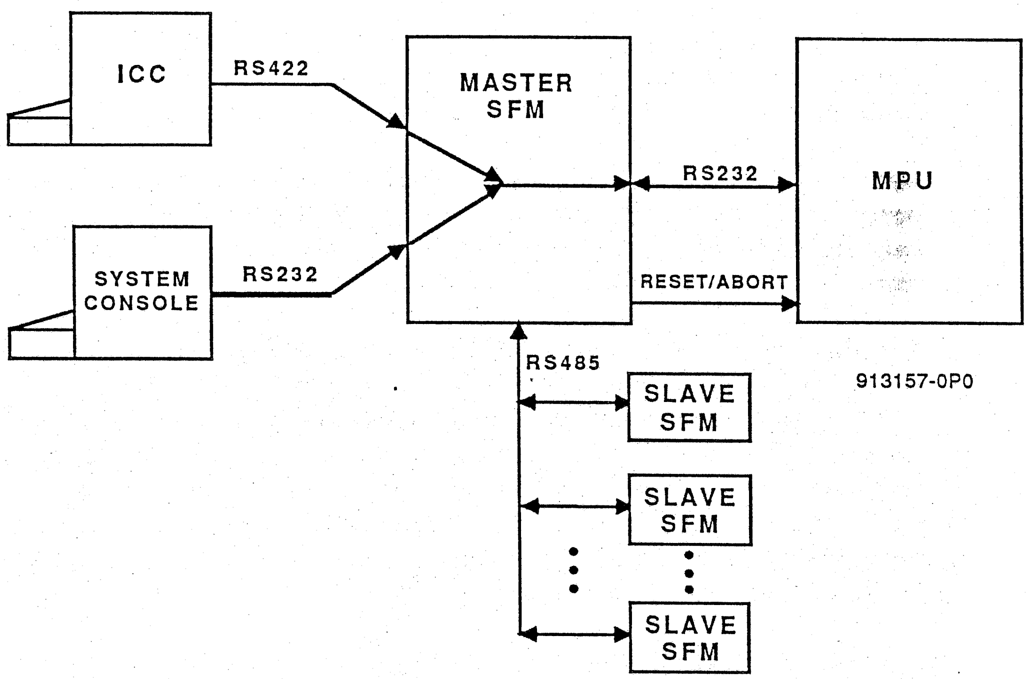


Figure 6-9. Power Controller SFM Interface Diagram

Upon power up, the SFM card will execute an initialization sequence. After various registers are initialized, the SFM will go into a 20 second delay loop while sending a WAITING FOR VTXXX INITIALIZATION message to the system console. At the conclusion of the 20 second delay the VTXXX function key initialization sequence is sent to the system console and the current version number for the SFM software will be printed on the screen.

If an ON command is received by the master SFM or if the master power controller's ON button is pressed, the master sends a query word with the ON bit set to all Slaves indicating that the cabinets should be turned on. The power bus contactors are then energized and power is applied to the cabinets. The SFM will begin its monitoring process after an adequate delay is allowed for the fans to come up to normal operating speed.

6.4.2.1 Master Status Data Format

The master has a byte of RAM reserved for the indication of the channel 0 current status. This location, named OWNST, indicates the following parameters:

7	6	5	4	3	2	1	0
	On/Off		F	U	L		

where

BIT 7 Not used

BIT 6 On/Off Displays whether the master cabinet power contactor

		is on or off.
BIT 5	Not used	
BIT 4	Fault	Set when a fault condition for this cabinet has been detected.
BIT 3	Upper	Upper backpanel present.
BIT 2	Lower	Lower backpanel present (This should never be set in the master power controller).
BIT 1	Not used	
BIT 0	Not used	

The master also has a byte reserved for the indication of current system status. This location, named SYSST, indicates the following parameters:

7	6	5	4	3	2 1 0
Display On/Off	On/Off	S/D	CF	CM	STATION

where

BIT 7	Display On/Off	Used to determine if the displays should be on or off.
BIT 6	On/Off	Indicates whether the system power is on or off.
BIT 5	Status/Data	Indicates whether status or data is requested of the slave.
BIT 4	Clear Fault	Set to indicate to the slave that the fault bit should now be cleared.
BIT 3	Command Bit	Set to indicate to the slave that a power off command is to be executed.
BIT 2	Station Bit 2	The station bits are used to indicate from which station status or data are requested.
BIT 1	Station Bit 1	
BIT 0	Station Bit 0	

6.4.2.2 System Reporting

The master's query sequence to each of the slave processors is a two step operation. The first step is to request the status word from each of the slave stations and test their fault bits to see if an error must be reported. If a fault bit is detected in any one of the stations, each station will next be requested to transmit its data table.

Before the tables are displayed, a software flag is set which instructs the interrupt routine servicing the MPU serial port to ignore data from the MPU until the system status table is displayed and a CONTINUE command sequence is entered from the control terminal.

As the master receives each data table, the tables are compared against high and low limit tables to see if an out-of-tolerance condition exists. When the out-of-tolerance condition is displayed it will be highlighted in inverse video.

Data is then scaled by an amount which is defined in a table, converted into BCD and then to ASCII and displayed on the control terminal. As the data is being displayed additional table are accessed to determine if or where the decimal point should be inserted in the displayed data and to see if zeroes should be suppressed.

As each station reports its status to the master, a bit is set in an ERROR REPORTED table if an out-of-tolerance condition exists and has been displayed. This bit is tested the next time each slave status is queued and, if the bit is set, the error is not reported even if it still exists. In order to continue to report the error, the operator must type a REQUEST for STATUS command which continuously requests data from the slaves and displays the data. A CONTINUE command is then typed to continue; if an error condition still exists, it will be reported and the ERROR REPORTED table marked so that it will not be reported again.

Data will not be displayed for any cabinet that is not present. By observing the displayed table one can determine whether or not a given slave is communicating with the master.

6.4.2.3 Master Interrupts

There are three tasks which interrupt the master SFM. The first is the real-time clock (RTC) interrupt which occurs approximately every 50 msec. During this interrupt, the ON/OFF switch is sampled, and if active, the ON/OFF bit in both the master's OWNST and SYSST words are toggled. The SYSST word is then transmitted to each station with the ON/OFF bit set or cleared. Upon receiving the system status word each slave tests the ON/OFF bit. If the bit is cleared, the ON/OFF bit in the OWNST word is cleared and the power contactor for that cabinet is disabled. If power is to be applied to the contactor, the watch-dog one-shot is poked and the contactor is energized.

The master SFM also services the control terminal read buffer full (RBF) interrupt, and decodes any sequence beginning with <ESC><[> as a possible SFM command. These characters are buffered; if the sequence turns out to not be a command sequence, the characters are then passed to the MPU software queue. Upon an interrupt from the MPU ports transmit buffer empty (TBE), the software queue is tested to see if any characters are present. If any are, they are transmitted to the MPU. Upon interrupt from the MPU RBF, characters are placed in a queue and upon interrupt from the system console terminal's TBE, the queue is tested to see if any characters are present. If any are, they are transmitted to the control terminal.

6.4.3 System Fault Monitor Slave Operation

Upon power up, the inter-processor control (IPC) port is initialized. The processor then jumps to the SFM's slave driver routine and waits for the ON command from the master SFM to be given. Until the on-off button is pressed or a turn-on sequence is initiated from the system console, the slave SFM samples only the line voltage. If an attempt is made to turn on the system while the line voltage is out-of-tolerance, the power contactor will not be energized for that cabinet. Instead the Fault bit will be set in the slave SFM's status word OWNST and upon query from the master SFM the data table will be transmitted. The master SFM will then report the out-of-tolerance line voltage to the control terminal.

If the line voltage is within tolerance, the master sends a query word with the ON bit set indicating that the cabinet should be turned on; the contactor is then energized and power is applied to the cabinet. An adequate delay is allowed for the fans to come up to normal operating speed.

6.4.3.1 Slave Status Word Format

The slave has a byte reserved for the indication of current status. This location, named OWNST, indicates the following parameters:

7	6	5	4	3	2	1	0
	On/Off		F	U	L		

where

BIT 7	Not used	
BIT 6	On/Off	Displays whether the slave cabinet power is on or off. If the master system status word does not have this bit enabled, the contactor for this station will not be allowed to turn on.
BIT 5	Not used	
BIT 4	Fault	Set when a fault condition for this cabinet has been detected.
BIT 3	Upper	Upper backpanel present.

BIT 2	Lower	Lower backpanel present.
BIT 1	Not used	
BIT 0	Not used	

6.4.3.2 Data Acquisition

Each slave samples the following parameters continuously until interrupted by a query from the master:

- Upper Blowers
- Lower Blowers
- +5 V Upper backpanel voltage
- +5 V Lower backpanel voltage
- -5.2 V power supply (optional)
- +15 V power supply
- -15 V power supply
- Upper Thermostat
- Lower Thermostat
- Line Voltage

A table is built during the measurement of the parameters. Upon completion of this data table, the values in the table are compared against upper and lower limits defined in two additional tables. If an out-of-tolerance condition is detected, another table is examined to determine if that out-of-tolerance condition should cause the power to be removed from that cabinet. If the condition qualifies, the power contactor is disabled. In either event, a fault bit is set and sampling is terminated. The master, upon sampling each slave, tests the status of the fault bit. If it is set, the data tables of all stations are displayed. The fault bit may be cleared only by command from the system console. If a CONTINUE command is entered, then the CLEAR FAULT bit is set in the query word from the master as each cabinet is queried by the master. The FAULT bit is then cleared in each cabinet.

6.4.3.3 Slave Interrupts

The only source of interrupts for the slave are the local real-time clock (RTC) and the IPC serial port. As part of the routine to service interrupts from the RTC overflow, which occurs every 50 msec, the ON/OFF button is sampled. Upon detection of a switch closure the stored status of the master is sampled and, if the master cabinet is on, the state of the Solid State Relay (SSR) is toggled. If the master station is off, no action is taken.

If the IPC port RBF flag interrupts the processor, the station bits are compared with the station code field of the master status word. If a match occurs the status/data bit is tested. If status is requested, a copy of the slave status word is transmitted to the master. If data is requested, the data table is transmitted to the master. In either case the master status word is first echoed as a preamble to insure that the master may detect that two or more slaves are not answering simultaneously.

If the RBF flag interrupts the slave and no station match occurs, the slave turns off its RBF interrupt and enables a wake-up mode for the serial port. In this mode the port will ignore all subsequent messages until 10 marks (ones) are received at the port.

6.4.4 Power Supplies

Refer to the vendor manuals listed in Section 1.2 for information on power supplies.

6.5 CIRCUIT CARD THEORY

6.5.1 Multiprocessor Card (208101)

The multi-processor (MP) card takes the place of the front-end computer found in many other image generators. Its design has been optimized to perform the functions required by the SPX image generator. Major features of the hardware found on the MP card are as follows:

1. A high speed 16-bit microprocessor (68000-12.5 MHZ).

2. A four channel direct memory access controller (68450-10 MHZ). The channels are for the SCSI disk interface and two software-selectable channels.

3. A high speed 16-bit co-processor (TMS320-20 MHz) with external program (8K bytes) and data RAM (32K bytes) which support transparent updating. The co-processor can function while the data RAM is being updated. The co-processor operates between 5 and 10 times faster than the 68000 for some computation-intensive tasks.

4. A full complement of local memory including EPROM (64K bytes, 0 wait states), SRAM (128K bytes, 0 wait states), and DRAM (1536K bytes, 1 wait state). A wait state corresponds to an additional 80 nsec, relative to a minimum cycle of 320 nsec.

0 wait states	= 320 nsec memory cycle
1 wait state	= 400 nsec memory cycle
2 wait states	= 480 nsec memory cycle

5. A bus structure called the common bus supports a global SRAM memory (64K bytes per card) that other MP cards can access on the common bus to pass messages, programs, and data. The common bus has drive capability for 8 channel processors and termination.

6. Sixteen programmable timers for use as real-time clocks, etc.

7. Vectored interrupts supporting all peripheral functions. Each interrupt may be turned off at the source, or groups of interrupts may be masked by the 68000.

8. Bus error structure and recovery from address regions not supported by the MP card.

9. Inter-processor interrupt capability. When communication between multiple MP cards is required, a message may be placed in the global memory and then the MP card for which the message is intended may be interrupted.

10. An industry standard disk subsystem interface (SCSI) with byte assembly/disassembly to minimize system bus usage.

11. Four serial asynchronous/synchronous, ports each supporting RS232 or RS422.

12. A 10 Mbits per second serial host interface, local area network (Ethernet) that supports internal DMA channels for receive and transmit buffer management.

6.5.1.1 Processor

The 68000 is a 16/32-bit processor. This implies the internal data paths on the chip are 32 bits, while the interface to the outside world is 16 bits. The 68000 programming model is quite elaborate with regard to the types of addressing and registers available. For detailed information on programming the 68000 refer to the *68000 Programmers Reference Manual.*

The resources available to the 68000 are as follows. There are 17 internal 32-bit registers in addition to the 32-bit program counter and a 16-bit status register. The first eight registers (D0 - D7) are used as data registers for byte (8-bit), word (16-bit), and long word (32-bit) data operations. The second set of seven registers (A0 - A6) and the system stack pointer may be used as software stack pointers and base address registers. In addition, these registers may be used for word and long word address operations. All 17 registers may be used as index registers.

The 68000 has 24 address bits that cover 16 megabytes of address space. The 68000 is a byte-addressable machine. The LSB of the address allows the program to access the upper (even) or lower (odd) byte of the 16-bit word. To facilitate this, the 68000 breaks the lower address bit into two distinct signals, *LDS and *UDS (lower data strobe and upper data strobe, respectively).

The 68000 supports many low- and high-level instructions. There are 56 instruction types, each with many addressing modes. In addition to many addressing modes there are several data types. Examples are bits, BCD digits, bytes, words (16 bits), and long words (32 bits). The wide range of addressing modes and data types provides the programmer with an efficient and easy-to-use instruction set.

The status register contains information about the operation of the CPU. This information is broken down into interrupt mask levels, condition codes, and state bits. The interrupt mask allows the software to set the interrupt level of the program that is currently executing. This inhibits interrupts of a lower priority level from interrupting the program that is executing at a higher interrupt level.

The data is organized in memory as follows. Bytes are individually addressable with the high-order byte having an even address the same as the word. The low-order byte has an odd address that is one count higher than the word address. Instructions and multibyte data are accessed only on word (even byte) boundaries. If a word datum is located at address *n* (where *n* is even), then the second word of that datum is located at address *n*+2.

The 68000 address, data, and control signals interface with the rest of the MP hardware. Detailed signal descriptions and timing diagrams are available in any 68000 data sheet. The description provided will aid in the understanding of the MP card as a system.

The internal address bus consists of 23 bits of unidirectional, three-state signals which provide the address for bus operation during all cycles except interrupt cycles. During interrupt cycles, address lines A1, A2, and A3 provide information about what level interrupt is being serviced while address lines A4 through A23 are all set to a logic high.

The data bus is a 16-bit, bi-directional, three-state bus. It can transfer and accept data in either word or byte length. During an interrupt acknowledge cycle, the external device supplies the vector number on data lines D0 - D7 if the device is not using an auto-vector.

Bus control signals are asynchronous and consist of the following signals, address strobe, read/write, upper and lower data strobes, and data transfer acknowledge. The address strobe starts all cycles, and signals that the address has been valid an amount of time specified in the data sheet. The R/W signal, when combined with the upper and lower data strobes, describes which byte or bytes are to be read or written. The data transfer acknowledge (DTAK) signals to the 68000 that the external circuitry has completed the cycle (read or write) allowing the processor to continue to the next operation.

The bus control can be passed to a different bus master. On the MP card there are three bus masters. The Ethernet LANCE chip, the direct memory access controller (DMAC) chip, and the 68000. They are prioritized in that order relative to bus mastership. It should be noted that the 68000 will sometimes access these bus masters, reading and writing to their internal registers. This is usually termed slave mode access, because the chips are responding as bus slaves, similar to memory. In master mode they will arbit for the system bus (from the 68000) and execute data transfers in a fashion similar to the 68000, with address strobe starting the cycle and DTAK finishing.

6.5.1.2 EPROM (64K bytes)

The EPROM used for boot up programs, debugger, and self-confidence tests consists of two each, 32K x 8, EPROMs. The memory is read-only and can be accessed with no processor wait states.

6.5.1.3 Local Static RAM (128K bytes)

The static RAM (SRAM) array, used for stacks, program, and data, consists of four each, 32K x 8 static RAMs. The memory is read/write and can be accessed with no processor wait states.

6.5.1.4 Local Dynamic RAM (1.5 M bytes)

The dynamic memory array, used for stacks, program, and data, consists of six 256K x 8 dynamic RAM modules. The memory is read/write and can be accessed with one processor wait state.

6.5.1.5 System Clocks

The system clocks on the board allow various bus masters and peripheral chips to function as fast as possible on the MP card. Listed below are the system clocks with the bus master or peripheral that they drive.

20 MHz	Ethernet, TMS320
12.5 MHz	68000
10 MHz	DMA, System Control Registers
6.25 MHz	DRAM Refresh
2.5 MHz	Common Bus Timing
2.4576 MHz	Baud Rate Generator
0.3072 MHz	Resychronization of External Interrupts, misc.

6.5.1.6 Real-Time Clocks

The timer configuration for the SPX MP board is currently defined as the following:

- Four programmable 16-bit timers
- Four programmable 8-bit timers
- Four serial port baud rate timer pairs

These timers reside in the four multi-function peripheral (MFP) chips on the MP board. Each MFP chip contains four timers (one 16-bit, one 8-bit, and one baud rate pair).

Currently, all baud rate timers are dedicated for serial port support and one timer is used exclusively by the operating system (master clock).

The operating system timer is a 16-bit timer and is used to coordinate all time-related tasks (e.g. resuming foreground activities in the real-time system, etc.).

6.5.1.7 Reset

The reset function consists of the logical OR of the following possible conditions: a momentary switch located on the board can be pressed, an external signal from the system fault monitor (SFM) card can be asserted, the MP card just powering on, or a software RESET instruction.

The 68000 is placed into reset processing by the assertion of both halt and reset. When the reset and halt lines are de-asserted the processor responds by reading the reset vector table entry (vector number zero, address $000000) and loads it into the supervisor stack pointer (SSP). Vector table entry number one at address $000004 is read next and loaded into the program counter. The processor initializes the status register to an interrupt level of seven. No other registers are affected by the reset sequence. The processor then proceeds with its self-confidence test software whose vector was loaded from address $000004.

6.5.1.8 Address Space Decode

The 68000 addresses peripherals, memory, etc. using a technique known as memory mapping. The 68000 has 24 address lines, counting upper and lower data strobe as one address line. At the start of any cycle, the 68000 places a valid address on the address lines. These lines are partially decoded into chip selects for various peripherals and memory. Because of the partial decoding, some single register peripherals will have as much as 32K bytes allocated to them.

Once a device's chip select is active and all other devices are disabled from the data bus, a bus cycle will start. The start is signaled by the 68000 asserting address strobe. The 68000 then waits until a data transfer acknowledge signal (*68DTAK) is asserted by the selected peripheral or asserted by special DTAK generation circuitry for those devices that are not capable of generating their own.

6.5.1.9 DTAK Generation

The signal *68DTAK is formed by peripherals (those that are able to generate the signal, such as the MC68901) or generated by circuitry that checks the address space decoded. Most devices on the MP card operate with no wait states (i.e. *68DTAK is generated as soon as possible, but not prior to *68LDS and *68UDS). A list of devices and their wait state operation appears below.

1. Devices with no wait state access from the 68000
   - Local Static RAM
   - System Control Registers
   - TMS Program RAM (68000 access)
   - TMS Data RAM (68000 access)
   - EPROM
   - Disk Data Register

2. Devices with one wait state access from the 68000
   - Local Dynamic RAM

3. Devices with multiple wait states
   - DMAC (slave mode)
   - Ethernet (slave mode)
   - Common Bus Resources
   - MFP Chips

Of the above devices only the DMAC, MFP, and Ethernet chips provide their own DTAK. DTAK for all no wait state devices is generated by special DTAK generation circuitry. The DRAM provides its own DTAK which is derived from its CAS signal. The common bus interface also has its own DTAK generating circuitry.

6.5.1.10 Control Registers

There are four system control registers, each 8 bits in length. These registers provide the various control signals required throughout the MP card. An example of one of the functions is turning the LED on the MP card green. To do this the 68000 addresses the system control register (048001 hex, system control register #2) and writes a 1 to the heartbeat signal. Since the control register cannot generate a *68DTAK signal, it will be generated by the external DTAK circuitry. Other control bits are handled in a similar manner. (The heartbeat signal is used only to show the successful completion of each of the confidence test phases; a green LED represents an OK status).

The registers are read/write, and the read contents always reflect the control signal status. These control signals are active low, meaning a logic low represents a 1 and a logic high represents a 0.

6.5.1.11 Bus Errors

The signal *68BERR is used to tell the 68000 to end the cycle, but not in the normal way as with *68DTAK. A bus error can occur for the following reasons: the 68000 addressed a location that is not supported, such as a 3C000 to 3FFFF, or the watch-dog timer that signals the condition where *68DTAK has not been asserted within 26 µs, or the 68000 attempts to write to EPROM, or the 68000 tries to access either TMS coprocessor data or program memory while the TMS 320 is using these areas.

6.5.1.12 Interrupts

The MP card supports many interrupts. The 68000 supports seven interrupt levels (level 7 being the highest priority). Devices are grouped into these levels by a priority encoder. A large portion of interrupts are fed through the MFP chips (68901). These chips have the ability to accept external signals as interrupts (up to 8 signals) and funnel these signals into one peripheral interrupt request to the 68000.

When the level of the requesting interrupt is greater than the current processor level, the 68000 will execute micro-code known as exception processing. This causes the 68000 to suspend current operations by stacking the complete system context and then execute an interrupt acknowledge cycle.

The interrupt acknowledge cycle is special and distinguished from other cycles by the function bits from the 68000 all being set high. The interrupt acknowledge cycle generally ends with *68DTAK, like normal cycles. The address, shown by bits A1, A2, and A3, of this cycle is the level of the device asserting the interrupt. The data is provided by the peripheral chip to supply an interrupt vector number, shown by bits D0 through D7, which points to the interrupt service routine. For more details of the interrupt cycle consult the 68000 users manual.

6.5.1.13 Status Monitoring

Various signals are monitored by the 68000. This is accomplished by routing the signals to the MFP chip's data port. The data port is a parallel port that can be initialized as either input, output, or interrupt input. When initialized as input, external signals can be monitored by the 68000 by merely accessing the appropriate MFP parallel data port.

6.5.1.14 SCSI Parallel Port With Byte Assembly/Disassembly

The MP card supports SCSI interface to the disk drive/tape controller. The SCSI bus consists of 8 control bits and 8 data bits. Since the 68000 supports a 16-bit data bus, bytes are assembled from the 8-bit SCSI bus into 16-bit words before being transferred to memory. Conversely, words are disassembled into bytes before being written to the disk drive allowing minimal impact to the 68000 bus during disk transfers. Bytes are transferred across the SCSI bus lower byte first.

6.5.1.15 Serial Ports, Software Switchable RS422/RS232

Each of the four multi-function peripheral chips provide the following capabilities:

1. Serial Communication. A serial channel with transmit and receive capability is provided with each chip.

2. Timer/Counters. Each MFP chip contains 4 timers/counters. Two of the timers operate as a pair and will always be dedicated to generating baud rates for the serial channel and is therefore not usable to time events. The three remaining 8-bit counters are configured as 16 bit timers for the real time clocks used for timing tasks, and as an 8-bit counter.

3. I/O. Inputs provided to the 68000 monitor the status of various functions within the system. Outputs from the 68000 control various functions on the MP card.

4. Interrupt Controller. Interrupts can come from three sources:

   a. Serial port interrupts occur when the transmit buffer is empty, when the receive buffer is full, when a receive error occurs, or when a transmit error occurs.

b. Timer interrupts occur when any timer has timed-out or when a counter counts to zero.

c. External interrupts occur when a transition is detected on one of the I/O bits defined as an interrupt input.

The MP card currently supports four serial ports. The ports are capable of serial data transfers up to 19.2K baud. A switchable feature allows the software to configure each serial port as either standard RS232 or RS422, a differential version that allows for longer cable lengths to be used. In either mode, the data transmitted from the MP card is always sent to both RS232 and RS422 drivers; however, data received by the MP card is switched to the appropriate receive buffer from the correct receivers via software selects.

A summary of the RS232 and RS422 signals as they appear on the MP card is given in Table 6-1.

Table 6-1 MP Card Serial Port Signals

RS 422 - 9 pin D connector (ICC).	
Pin #	Signal name
1	Chassis ground
2	+TX data (to the ICC)
3	-TX data (to the ICC)
4	+RX data (from the ICC)
5	-RX data (from the ICC)
6	Signal ground
7	Signal ground
8	Signal ground
9	Signal ground

RS 232 - 25 pin D connector (System Console).	
Pin #	Signal name
1	Chassis ground
2	Transmit data (from MP card to terminal)
3	Received data (from terminal to MP card)
4	Request to send (from MP card)
5	NC
6	Data set ready (from terminal)
7	signal ground
8	NC
9	NC
10	NC
11	NC
12	NC

Table 6-1 MP Card Serial Port Signals - Continued

RS 232 - 25 pin D connector (System Console).	
Pin #	Signal name
13	NC
14	NC
15	NC
16	NC
17	NC
18	NC
19	Secondary request to send (from MP card to term)
20	Data terminal ready (from MP card to term)
21	NC
22	NC
23	NC
24	NC
25	NC

6.5.1.16 Co-Processor, TMS320/20 MHz

The co-processor is a 16-bit processor that can run in parallel with the 68000 processor. It utilizes the Harvard architecture (separate program and data memory) which allows it to execute most of its instruction set in only one clock cycle. The total resources available to the TMS320 are:

External Program Memory - 6K bytes
External Data Memory - 2K bytes
External Data Memory - 32K bytes
Internal Data Memory - 256 bytes
Control and Status Port, Port 1
Page Register and Address Counter, Port 2

6.5.1.16.1 Program Memory

Program memory is external to the TMS320. It consists of static memory (6K bytes) that allows instruction fetches every 200 ns. The program memory is used to store the TMS320 program. Program instructions are pre-fetched one cycle ahead of their execution based on the contents of the program counter.

There is a data memory internal to the processor of 256 bytes. All arithmetic calculations are performed using operands from this memory. This implies that the user must bring data from outside the processor to the internal data RAM before calculations can be done on that data.

Access to the program memory by the 68000 is allowed, but places the TMS320 in a reset condition. Therefore this access is normally used only for initial program loading by the 68000.

Data not normally included in the program memory can be placed in the program memory and accessed via a special instruction then swaps the PC with the accumulator, fetches the addressed program location, and swaps the PC back. The instruction is known as a table read (TBLR) or table write (TBLW). This instruction takes 3 cycles or 600 ns to read a data value from the program memory into the internal data memory.

In addition to the external program RAM, there are two external static memories for use as data RAM. The data RAM areas are divided into a 2K byte and a 32K byte block.

6.5.1.16.2 2K Byte Data RAM

This data RAM supports one mode of access. Access to this data space is accomplished by writing a zero into the control/status register, bit 4. This bit informs the TMS320 that TABR and TABW instructions will access the 2K byte data RAM and not the 32K byte data RAM. The address is formed directly from the TMS320, and the 2K bytes are mapped between C00 and FFF. Notice that page bits loaded into the page register/address counter (used later) have no effect on this access.

6.5.1.16.3 32K Byte Data RAM

This data RAM supports two modes of access. The first mode of access to this data space is accomplished by writing a 1 into the control/status register, bit 4. This bit informs the TMS320 that TABR and TABW instructions will access the 32K byte data RAM and not the 2K byte data RAM.

The address of the 32K byte data RAM is formed from four page bits (16 pages, 2K bytes each) located in the MSBs of the page register/address counter and the LSBs range from TMS320 address C00 to FFF hex.

The second mode of access does not require the control/status register, bit 4 to be set. The page register/address counter should be loaded with the correct page in the MSBs (note page 0 = 0000, page 1 = 0400, page 2 = 0800, page 3 = C00, page 4 = 1000, etc. and the start of a data block (between 0 and 3FF).

Data is then fetched from the page and address specified in the page register/address counter when an IN or and OUT instruction to port 0 is executed. After the fetch or store, the address in the counter portion of the page register/address counter is incremented to the next word. Consecutive words are accessed via multiple IN/OUT instructions to port 0.

6.5.1.17 MC68450/10 MHz DMA Controller

In order to maintain high throughput, large blocks of data must be moved internally to the MP card in a quick and efficient manner with a minimum of intervention by the 68000 itself. The DMAC chip was incorporated into the MP design to facilitate these memory transfers. The DMAC supports four separate DMA channels. The functions of the channels are:

Channel 0 — Not used

Channel 1 — Disk-to-memory or memory-to-disk operations

Channel 2 — Software selectable, usually used for serial port 3, transmit, during the execution of the RTS program to output characters to the terminal.

Channel 3 — Software selectable, usually used for serial port 3, receive, during the execution of the RTS program to accept characters from the control terminal.

The above transfers can be initiated by 68000 software and, with no further intervention, the DMA transfers will occur as needed. For example, when a character is typed after the RTS program has activated the DMA channel 3 on the control terminal, the MFP chip's serial port receives the serial data from the RS232 interface and de-serializes the bit stream. The MFP chip then asserts a signal requesting DMA response. The signal is known as receive buffer full. The DMA has been previously programmed to take data from the MFP chip's receive buffer and transfer the data to some memory location for later program actions. The DMA responds to the request by:

1. Gaining control of the system bus (i.e. becoming a bus master).

2. Asserting the bus signals (address strobe, R/W, UDS/LDS, DTAK) in the necessary fashion to read data from the MFP data register into the DMA chip. Notice that this action causes the de-assertion of receive buffer full on the MFP chip.

3. Asserting the bus signals (address strobe, R/W, UDS/LDS, DTAK) in the necessary fashion to write data from the DMA data register into memory.

4. Updating memory counts, memory address, etc. internal to the DMA in preparation for the next transfer.

6. Releasing the bus mastership to the 68000.

6.5.1.18 Ethernet Local Area Network

Ethernet (IEEE 802.3) is a send and receive half-duplex broadcast mode type system. The node must function in either transmit or receive mode at any instant in time. Before transmission, the node must be sure there is no contention for the serial bus. The Ethernet CSMA/CD network access algorithm is implemented completely within the local area network controller for Ethernet (LANCE) controller chip (AM7990).

In addition to listening for a clear network before transmitting, Ethernet handles collisions in a predetermined way. Should two nodes attempt to transmit at the same time, the signals will collide and the data on the coax will be garbled. The transmitting nodes listen while they transmit and detect the collision. Both continue to transmit for a predetermined length of time to jam the network, insuring all nodes have recognized the collision. The transmitting nodes then delay a random amount of time according to the truncated binary backoff algorithm implemented in the LANCE, before attempting to transmit again. This minimizes the possibility of collision on retransmission.

In transmit mode, the LANCE initiates a DMA cycle to access data from a transmit buffer in 68000 memory. It prefaces the data with a preamble and sync pattern then calculates and appends a 32-bit cyclic redundancy check (CRC). This packet is transmitted serially to the serial interface adapter (SIA). The Manchester encoder in the SIA takes the transmitted data from the LANCE and creates the Manchester encoded (self-checking) differential signals TRANSMIT+ and TRANSMIT- to drive the transceiver cable. These differential signals are coupled through the transceiver cable to the ethernet transceiver. The ethernet transceiver buffers the signals and places them on the ethernet coaxial cable.

When carrier is present on the Ethernet coax, the Transceiver will create the differential signals RECEIVE + and RECEIVE -. These inputs to the SIA are decoded by the Manchester decoder. A phase-locked loop synchronizes to the Ethernet preamble, allowing the decoder to recover both clock and data from the encoded signals. These two signals are supplied to the LANCE chip as the TTL signals RECEIVE DATA and RECEIVE CLOCK. In addition, the SIA chip creates the signal CARRIER PRESENT while it is receiving data from the cable, indicating to the LANCE that receive data and clock are available. When these signals reach the LANCE, the CRC is calculated and compared to the CRC checksum at the end of the packet. If the calculated CRC doesn't agree with the packet CRC, an error bit is set and an interrupt generated to the microprocessor.

The LANCE chip will check the receive packet to verify that the destination address matches the destination address programmed into the LANCE chip on initialization. If a match occurs, the LANCE chip will transfer the packet to the next available receive buffer in 68000 memory.

Data transfer to and from the LANCE chip is done in much the same manner as the DMAC (68450). The LANCE chip has internally stored information regarding the structures describing from or to where data is to be transferred. When a receive packet has been received or if a transmit packet needs to be sent, the LANCE chip will request access to the 68000 bus. It will then initiate bus transfers after DMA access has been granted.

When there is no Ethernet activity, the LANCE will automatically poll its transmit buffer every 1.6 ms. This continues until the LANCE chip determines that another transmit packet needs to be sent or until interrupted after a receive packet has been encountered.

For more detailed information refer to the data sheets on the LANCE chip and the SIA chip and the Ethernet standard.

6.5.1.19 Common Bus

The common bus is the interface between the MP card and the channel processor hardware. The bus is basically an address and data extension of the 68000 with high drive capability and slower cycle times (3.1 µsec vs. 320 ns). Up to 8 channels may be connected together on to a daisy-chained bus.

The common bus has been designed to support multiple MP cards. An arbitration circuit is provided on the MP card and is only active if the MP card is plugged into slot 1. The arbiter selects which MP card may access the common bus. Only MP cards can be masters; other cards that attach to the bus cannot request access to the bus but are accessed by MP cards.

The common bus has channel-select bits that define which IG channel an MP card is accessing. Each channel includes a plane cell memory, object memory, and clock maintenance card, all of which can be accessed as bus slaves. A jumper on the clock maintenance card provides the channel hardware definition of channel. The select bits should be treated as addresses with the following exception: during reads, only one of the channel bits is allowed to be asserted (multiple channels cannot send on the bus at once). During writes more than one channel bit may be asserted. This allows the system level write data to be transferred to all selected channels with one write.

The common bus has bus masters (MP cards) and bus slaves (channel hardware). Additionally, there are other memory mapped functions, including common bus interrupts and common bus scratch memory. The reason for these resources is to coordinate multiple bus masters. In a parallel-processor environment this memory provides the communication between the processors. Jumpers on the MP card, which select common bus timing, are set at the factory and should not be adjusted by the user.

6.5.2 Object Manager and Geometric Processor Cards

The OM and GP sections of the channel processor utilize only three unique card types: the environment memory (EM) card (208111), the arithmetic processor (AP) card (208112), and the poly/light buffer (PLB) card (208113). The PLB card is used only in the GP section and the other two cards are used in both sections. Though the same cards are used, their microcode and their functions are completely different.

In the OM section the EM card is used to store mesh blocks containing descriptions of the data base cells and OM command lists. The EM card in the GP section is used to store object blocks containing polygon and light string definitions and GP command lists (see Figure 6-5). The AP card used by the OM is loaded with microcode that does such operations as field-of-view tests and level-of-detail tests, while the AP cards in the GP section are programmed to do translations, rotations, clipping, light string expansion, etc.

The following paragraphs describe the hardware contained on the various cards within the OM and GP sections. The clock maintenance card is common to all sections of the channel processor and will be described first.

6.5.2.1 Clock Maintenance card (208120)

The clock maintenance card has three modes of use.

- As a tool or interface to the hardware for the engineers to bring up the hardware the first time.
- As a test interface to determine system readiness or isolate problems.
- To supply real-time feedback to the real-time system about the hardware use or to count items as they are processed.

The clock card contains registers that are used by the diagnostics to detect errors or problems with the machine. It controls and generates the clocks and resets the system to a known state at start up or when the system needs to be reinitialized.

6.5.2.1.1 Device Decoding

Seven bits are available for binary encoding of the device enables. These seven bits are expanded into sixty-four unary enables on the maintenance card. Another 64 values from these seven bits can be used to specify multiple device selections for loading several shift loops at the same time. The device enable is used in several ways in providing the maintenance and real time functions:

- Answered by setting the It's Me flag if the signal CMLOOPOUTEN is present (a single device is enabled)
- Combines with SHIFT to become shift enable
- Selects which device is enabled to the event counter
- Decodes the SELECTED clock line for the clocking modes
- Used to enable the write pulse locally

Device enable 63 is reserved for maintenance of the registers on the clock maintenance card. When enabling this device, all other device enables are turned off and a special tri-state buffer enables the output of the shift register to the input of the shift register. This enables the testing of the serial shifting capability of this register without using any outside hardware.

The It's Me flag is used by the diagnostic language to build the software configuration table for the diagnostics. This flag is a tri-state line running through the backpanel which each device can pull low when the device enable is present; hence, when a device is not present there is no answer to the device enable. The It's Me flag may also be used by the real-time system to check the system configuration. The It's Me flag is only asserted by a device when it is decoded and the CMLOOPOUTEN signal is present. The CMLOOPOUTEN will not be active when multiple devices are decoded.

6.5.2.1.2 Clock control

The clock control provides the following functions:

- Halts
- Clocking modes
- Single-Stepping of the clocks
- Control of individual clock lines

The clock control and generation is provided by the clock maintenance card. The clocks supplied are 7.5, 10, 15, 20 and 30 megahertz. All clocks are haltable and capable of being single-stepped, but revert to 10 megahertz for shifting or single-stepping.

There are 64 clock lines with the clock maintenance card using one of them for internal clocking. Each clock line has its own individual enable. The clock maintenance card issues clocks to the selected clock line or lines, or to all of the clock lines. The clocking scheme allows clocks to be issued to any number of clock lines as they are selected.

The clock maintenance card will support multiple clocking modes as defined by Table 6-2. These clocking modes are available to the diagnostics programmer by way of commands in the diagnostic language. With halts cleared the mode bits are ignored, which is the operational mode of the system.

In Table 6-2 the term halt (H) means that the device (a group of circuit cards) will have the system clock halted, the term N-clocks (N) means the selected device will have the system clock toggled N times, and the term free (F) means the device clock will toggle continuously (run free). System clocks run in free mode during normal operation; the halt and N-clocks modes are for diagnostic use.

Table 6-2. Signal States and Device Effects

Signal State				Device Effect					
				Halt 2		Halt 1		Halt 0	
H	H	H		Devices					
2	1	0	modes	sel	not sel	sel	not sel	sel	not sel
1	1	1	00	H	H	H	H	H	H
1	1	1	00	N	N	N	N	N	N
1	1	1	01	N	F	N	F	N	F
1	1	1	10	N	H	N	H	N	H
1	1	1	11	F	N	F	N	F	N
1	1	0	00	H	H	H	H	F	F
1	1	0	00	N	N	N	N	F	F
1	1	0	01	N	F	N	F	F	F
1	1	0	10	N	H	N	H	F	F
1	1	0	11	F	N	F	N	F	F
1	0	1	00	H	H	F	F	H	H
1	0	1	00	N	N	F	F	N	N
1	0	1	01	N	F	F	F	N	F
1	0	1	10	N	H	F	F	N	H
1	0	1	11	F	N	F	F	F	N
1	0	0	00	H	H	F	F	F	F
1	0	0	00	N	N	F	F	F	F
1	0	0	01	N	F	F	F	F	F
1	0	0	10	N	H	F	F	F	F
1	0	0	11	F	N	F	F	F	F
0	1	1	00	F	F	H	H	H	H
0	1	1	00	F	F	N	N	N	N
0	1	1	01	F	F	N	F	N	F
0	1	1	10	F	F	N	H	N	H
0	1	1	11	F	F	F	N	F	N
0	1	0	00	F	F	H	H	F	F
0	1	0	00	F	F	N	N	F	F
0	1	0	01	F	F	N	F	F	F
0	1	0	10	F	F	N	H	F	F
0	1	0	11	F	F	F	N	F	F
0	0	1	00	F	F	F	F	H	H
0	0	1	00	F	F	F	F	N	N
0	0	1	01	F	F	F	F	N	F
0	0	1	10	F	F	F	F	N	H
0	0	1	11	F	F	F	F	F	N
0	0	0	xx	F	F	F	F	F	F

Legend: H = Halt, N = N - clocks, F = Free.

6.5.2.1.3 Shift Control

The shift control is formed from a combination of the device enable, the CMLOOPOUTEN line, and the shift enable line. The user will need to combine these signals to produce the shift control for local use. The data in the shift loops will not be re-circulated in the case of multiple devices selected unless the user provides for this.

The shift register is a 16-bit register which can be written to or read by the software. The hardware interface is by two serial lines in and two serial lines out. The inputs are designed for the users to supply a tri-state buffer for each shift loop's serial line to the clock card. The outputs are two lines which expect to drive a single load for each shift loop. The shift register uses only a 10 megahertz clock.

6.5.2.1.4 Event Counter

The event counter is chiefly used to gather statistics by the real-time system. Each device when enabled by the device enabling hardware of the clock maintenance card (as directed by the real-time program) gates a specific signal onto the event counter input. The event counter has the capability to count edge transitions (either high-going edges or low-going edges), or it can count the time elapsed during an event (timing can be done while the input is low or high). Each individual card must supply it's input through a tri-state buffer to the event counter. A maximum of 1,048,576 (220) events (or 100 nsec cycles in timing mode) can be counted. The event counter runs off of the 10 megahertz clock.

6.5.2.1.5 Resets

Two reset modes are implemented for the system. A system reset is implemented so that the entire system can be reset into a known state. The other reset mode is split into three parts, reset 0 for halt group 0, reset 1 for halt groups 1 and 2, and a reset for the EM cards. These resets can be used to separately reset parts of the backpanel. The system reset is sent on all three of these lines. An MP card reset is also gated into the 3 reset lines on the clock card.

6.5.2.1.6 Flags

Eight special flags are made available to the hardware. They are defined as follows:

CMFLAG 0	General Purpose Flag
CMFLAG 1	General Purpose Flag
CMFLAG 2	General Purpose Flag
CMFLAG 3	General Purpose Flag
CMMAIN2OFF	When asserted, turns display 2 off (resets to asserted)
CMMAIN1OFF	When asserted, turns display 1 off (resets to asserted)

CMINSTROFF	When asserted, turns the instructor monitor off (Resets to asserted)
*CMFORCEBLNK	When asserted, force the blanking of all screens (Resets to asserted)

The three flags which control the displays (CMINSTROFF, CMMAIN1OFF, and CMMAIN2OFF) reset to the asserted condition (high). This is to guarantee displays are not damaged when the machine is turned on.

6.5.2.1.7 System Flags (GOs and DONEs)

The clock maintenance card also provides the interface between the real-time system and the hardware. These interface signals are distributed throughout the system by way of signals which parallel the data and address bus. The signals are:

DP IN DONE	Wire-AND signal which goes high when DP input side is complete. This signal is AND with all other channels to generate a total DP IN DONE.
DP OUT DONE	Wire-AND signal which goes high when DP output side is complete. This signal is AND with all other channels to generate a total DP OUT DONE.
GP DONE	Wire-AND signal which goes high when GP has completed. This signal is AND with all other channels to generate a total GP DONE.
OM DONE	Wire-AND signal which goes high when OM has completed. This signal is AND with all other channels to generate a total OM DONE.
OM GO	Start the OM
GP GO	Start the GP
DP IN GO	Start the DP input side
DP OUT GO	Start the DP output side
DP FIELD BUFFER SELECTOR	Bit indicating which way the DP field buffer is to be used. 0 = even side being filled and odd side being output. 1 = odd side being filled and the even side being output.
PLB FIELD BUFFER SELECTOR	Bit indicating which way the PLB field buffer is to be used. 0 = even side being filled and odd side being output. 1 = odd side being filled and the even side being output.

6.5.2.1.8 Write Pulse

The write pulse can be used to supply a write signal to memory. The write pulse can be gated with the 10 megahertz clock by the user locally and used as a 100 nsec wide enable. The write pulse model is the output of a D type flip-flop which will match the clock as it appears on the back panel.

6.5.2.1.9 Signature Analysis

Signature analysis is implemented as a register that is writeable and readable from the common bus. This register has the necessary feedback to perform signature analysis on serial bit streams. The serial input is the input to the shift register, so signatures can be taken of an entire shift loop or of a particular register. Several signals control the use of this signature analysis register. The shift signal must be enabled for shifting to occur and signature taking must be enabled for this register to shift and thus take signatures. This allows the use of the shift register without disturbing the contents of the signature analysis register. The signature analysis register is cleared only by system-wide reset, or by writing zeros into the register from the common bus.

Comparison of captured signatures with expected signatures is done in the software. The software also controls which shift loop and what part (or all) of it is to be used.

6.5.2.1.10 Switch Configuration

Two versions of the clock maintenance card, 208120-100 and 208120-101, have been manufactured. The -100 version of the card has two switches, shown in Figure 4-21 at locations U31 and U12. The switch in U31 is used to determine the channel of the system into which the clock card is plugged. The switch in U12 is used in special configurations and is not normally changed. See the table in Figure 4-21 for the normal switch settings for U12 and the channel selection switch settings for U31.

The -101 version of the clock maintenance card has only one switch, as shown in Figure 4-22. It serves the same function as U31 on the -100 card, allowing channel selection for that card. The table in Figure 4-22 provides the switch setting information for this card.

6.5.2.2 Environment Memory Card (208111)

The environment memory is a multi-port, dynamic memory, capable of read and write operations from three different ports.

The EM card is designed to operate as part of the OM or as part of the GP. When the EM card is used in the GP, all of the circuitry on the card is used. As part of the OM, the port B interface and the priority chip circuitry of the EM card are not used.

The memory array can be tested in two ways. Using the common bus port, the entire memory can be written and read. This allows extensive testing of the memory at reasonable rates. Alternatively, the AP card memory ports and arbiter are tested using AP microcode designed to test the memory at operational speeds over the busses that are used in actual system operation. In addition to the memory array, EM circuitry supports the following functions:

- Memory resource arbitration between refresh, port A, port B, and port C (the common bus port).
- AP bus arbitration for port A allowing up to 12 users of this bus.
- Dynamic memory control capable of multiple read/write/refresh modes including nibble-mode read for port A users.
- Priority matrix reduction hardware used by the object manager.
- Word assembly/disassembly for port C. The common bus is 16 bits wide and the environment memory is organized 32 bits wide. The control to map the 16 to 32 bits and vise-versa is located on the EM card.
- Multiple channel write capability allowing update to all channel processors with one common bus write.
- Flexible design which allows the card to function as PLANE/CELL MEMORY in the OM or OBJECT MEMORY for the GP depending only on the card slot of the backplane.

6.5.2.2.1 Memory Arbitration

The EM card can have as many as 4 sources requesting access to its memory. These include 3 read/write ports; ports A, B, and C, and refresh. Port A interfaces to as many as 12 AP cards in the geometric processor to the EM memory array, port B interfaces the GP's EM card memory array to the OM's AP card, and port C interfaces the EM card to the common bus.

Arbitration for the memory resource occurs in round-robin fashion with priority ordered requests. The priority order of memory requests is refresh, port C (common bus), port B (object manager), and port A (geometric processor). If multiple requests are asserted they will be serviced in priority order. Any given port cannot be serviced a second time until any pending requests have been serviced.

6.5.2.2.2 Port A Bus Arbitration

The geometric processor bus can be shared by up to 12 arithmetic processor cards. An arbitration scheme allows only one of the cards to gain access at any given time. The allocation of the bus follows a round-robin algorithm. The AP cards are organized in a ring with AP0 being the first node of the ring, AP1 following AP0, etc.

If a request is asserted and the bus is idle (no other requests or grants are active) then the asserted request will receive a grant at the next clock cycle or within the next 100 ns. If a request is asserted and the bus is not idle, no arbitration takes place until the current bus master relinquishes its request. One clock cycle later the next AP card in the ring requesting the bus will receive access to the bus.

6.5.2.2.3 DRAM Controller

The DRAM controller is a state machine that executes the following types of DRAM cycles:

- Refresh. The type of refresh cycle used asserts CAS before RAS and uses the internal address counter provided by the DRAM. This cycle is run approximately every 15 micro-seconds and lasts for 300 ns (6 states @ 50 ns each).

- Common Bus Write, GP Write, OM Read, OM write. This category of DRAM cycle can be selected by devices on ports A, B, or C and will execute in 300 ns (6 states @ 50 nsec each).

- Common Bus Read. This type of DRAM cycle is executed when the common bus reads data from the memory. Notice that the read lasts as long as the common bus address strobe is asserted. The length of this type of cycle is a minimum of 400 ns and a maximum of 3.1 micro-seconds.

- GP Read. This type of DRAM cycle is executed whenever port A requests a read. The cycle fetches four 32-bit words from memory and lasts a maximum of 12 states or 600 nsec.

Further information about the controller scheme is documented by a state diagram located in the 208111-601 schematics.

6.5.2.2.4 Priority Matrix Chip

The priority matrix chip is a gate-array design that implements the nucleus of the priority sort algorithm. Only the matrix chip on the GP's EM card is used. It is accessed as a peripheral to the OM's AP card and is accessed using port B.

6.5.2.2.5 Word Assembly/Disassembly (Port C)

The common bus is a 16-bit bus while the memory is organized 32 bits wide. The meshing of the different bus widths is accomplished by the following method. A 32-bit register/transceiver is connected on one side to all 32 bits of the memory. On the other side the common bus (16 bits) is duplicated to both halves of the port. During common bus writes only half of the memory is write enabled and receives the data. During reads the entire 32 bits is enabled out of the memory but only half the data passes through to the common bus port.

6.5.2.2.6 Multiple Channel Write Capability

The SPX image generator is channelized directly after the MP card. In order to pass the large amounts of data base information efficiently to the channel processors, all data base writes are performed in parallel. In other words, the system level data is written to all channels in parallel. Information from the MP card to the channel processors utilize the EM cards port C interface. Port C writes are captured by a register, allowing the data to be transferred to memory when the memory master arbiter allows the request to be honored. Since multiple channels are connected to the common bus and writes need to occur in parallel, not all of the memories may be available, thus the write data is registered.

6.5.2.3 Programmable Arithmetic Processor Card (208112)

The AP card is a general purpose processor that is used as a basic building block of the SPX OM and GP sections. It is designed to work in parallel with other AP cards and makes the arithmetic processing power of the GP and OM sections adjustable. The AP card has two ports for data transfer. One port interfaces to one or more 208111 EM cards. The other port interfaces to the 208113 PLB card. The EM port is bi-directional and allows the AP cards to access data stored in the EM cards. In the case of the OM's AP card, OM command list data and plane and cell data base information are retrieved. In the case of the AP cards in the GP section, GP command list data and polygon and light string data is retrieved.

The second port on the AP card is the PLB port. The port's data flow is output only and is used by the GP's AP cards to pass the processed data base to the PLB. The PLB port is not used by the the OM's AP card.

6.5.2.3.1 Writeable Control Store

The AP card contains a microcode writeable control store (WCS). The WCS is loaded once, using the maintenance shift loops on initial system boot up. OM microcode is first loaded into the OM's AP card with different (GP) microcode then being loaded into all of the GP's AP cards in parallel.

6.5.2.3.2 Scratch Data Memory

The scratch data RAM is used to hold polygon and light information. The RAM address is composed of the sum of a direct address (SCADR) from the DOIT register and one of three pointers (PTRADR). This hardware supports several addressing modes.

Direct — The direct addressing mode uses an address computed at assembly time to point to a data value. This address is placed on the SCADR and the PTRADR is selected = 0.

Indexed — The start of a block of data is pointed to by the SCADR from the DOIT register and the index value is supplied on the PTRADR. Since the pointers are counters the index value can be incremented.

Base Relative — The start of a block of data is pointed to by the PTRADR and random access to the Nth entry relative to the start is provided by varying the SCADR.

Any of the three pointers may be stored or fetched from data memory. An assembly time address may also be stored into scratch memory or into a pointer register/counter.

6.5.2.3.3 AP Bus Interface

The environment memory card is accessed by the AP cards through their AP bus interfaces. All of the GP's AP cards access this memory for object data and GP command list data. There is an arbitration circuit on the EM that allows only one AP card to gain access to the bus at a time.

6.5.2.3.4 Poly/Light Buffer Interface

The poly/light buffer is a FIFO memory used to store the data output from the GP's AP cards. The GP will write data to the input side of the memory, in priority order, and the DP will extract data from the output side.

Only one AP card is allowed access to the PLB at a time, and an entire object will be output from an AP card for any given access. The objects are tagged with a priority number as they are passed from the EM to the GP's AP cards. The PLB uses this number to request objects in priority order from the AP cards. The AP cards compare the priority number requested by the PLB with the priority number transferred when the object was received from the EM. When a match occurs and the GP's processing of that object has been completed, the bus is granted to the appropriate AP, and the AP to PLB transfer takes place. The AP card then increments the PLB priority number and the process repeats.

Objects are transferred from the AP cards to the PLB card at a rate of 3 words (32 bits) in 300 ns with a minimum 100 nsec gap between each 3 word access. The gap between three word transfers may be lengthened if the DP interferes by requesting data to be output from the PLB.

6.5.2.3.5 Multiplier Array

The two multiplier chips with their associated adders, and buffers on the AP card are used to perform the 16 x 31-bit multiplies that are required for rotation of vertices and light points.

6.5.2.3.6 EPROM Reciprocator

The reciprocator is used for perspective division, slope calculations, and other divisions required in processing the data base. The input to the reciprocator comes from the normalizer chip. A value can be positive or negative.

6.5.2.3.7 ALU/Divider

The ALU/divider is a custom gate array chip designed for use in the SPX system. It performs 32-bit arithmetic and logic functions. Special circuitry is also included in the chip to perform a non-restoring divide algorithm.

6.5.2.3.8 Normalizer/Shifter

The normalizer chip is a gate array that can be used to force a shift to the right or to the left, or in a normalizing mode, generating a 32-bit normalized value and a shift code. The shift code represents the sum of the input shift code added to the number of left shifts performed.

6.5.2.4 Poly/Light Buffer Card (208113)

The poly/light buffer (PLB) card is a memory buffer between the GP section and the DP section of the image generator.

6.5.2.4.1 Input Bus Interface

The input bus (32 bits wide) from the GP to the PLB connects the GP's AP cards to a 3 deep register stack on the PLB card. This register stack is spread into a 96-bit wide bus forming the input to a DRAM memory array. The PLB has an arbitration circuit which will allow only one AP card access to the GP/PLB bus at a time.

The AP cards use the PLB's GRANT signal in conjunction with a priority count (PLB priority counter) to pass data to the PLB in priority order. Once an AP card gains control of the GP/PLB data bus, it places three words on the data bus in successive order while at the same time issuing a load signal to the register stack. This signal loads the three words into the register stack preparing the data to be passed into memory. The PLB controller will load the register stack into memory and then issue a data transfer acknowledge (DTAK) to the AP card. This DTAK to the AP card lets the AP card know when to continue with another data transfer, or if finished, to release the bus so that other AP cards can output their data.

Before releasing the GP/PLB bus, the AP card controlling the bus must first increment the priority counter on the PLB so that the AP card with the next highest priority can match its priority with the counter and take control of the bus. The priority counter on the PLB is reset each field.

6.5.2.4.2 Output Bus Interface

The output bus (96 bits wide) from the PLB is connected to most of the cards in the DP input section. Control of the PLB/DP bus is handled by the Input Control card (IC). Data is always enabled on the PLB/DP bus, which is distributed throughout the DP input section. The PLB controller issues a flag to the IC controller to tell it when data on the bus is valid. Once the data is valid the IC card will read the data and issue a data transfer acknowledge (DTAK) to the PLB controller. The DTAK will reset the data valid flag and the PLB controller will update the register driving the PLB/DP bus with new data.

Normal access of the IC controller is accomplished at 400 ns per 96-bit word. When faster access to the PLB is required by the IC card, it will issue a PAGE mode request to the PLB which will enable 200 ns per 96-bit word accesses. Page mode access is used when blocks of data (such as texture map loads, polygon formats, draw block loads, etc.) are being transferred to the DP input section.

6.5.3 Display Processor Cards

The DP can be discussed in three major sections; the span processor, the main pipeline, and the output section (See Figure 6-10). Also refer to the block diagrams contained in the *SPX Signal Tracing Guide.*

6.5.3.1 Span Processor

The span processor provides the control necessary for the main pipeline. The span processor transfers data from the poly/light buffer (PLB), in priority order to the pipeline, and calculates which spans need to be processed for that polygon or light point. The span processor is comprised of the input control, edge file, span generator, and span processor cards.

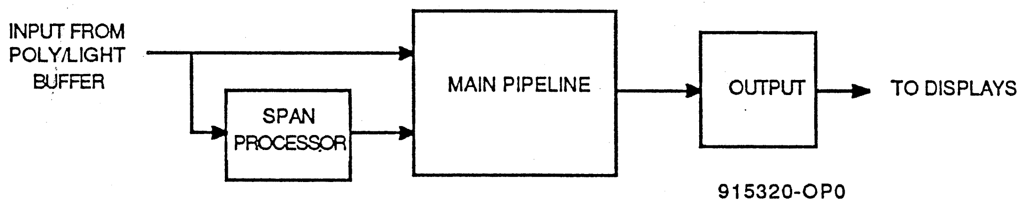


Figure 6-10. Display Processor Functional Block Diagram

Data is loaded from the PLB into the span processor and the pipeline at the same time. The input to the pipeline is loaded into a FIFO, which holds the data until the polygon or light point is passed from the span processor to the pipeline.

The span processor must find out which spans are touched by a polygon so they can be processed by the pipeline. This is done by first computing which scan lines are influenced by the polygon and then by computing which spans on those scan lines are influenced by the polygon. Any spans that have been previously covered by occulting polygons will be subtracted from this list of influenced spans. The span processor performs calculations ahead of the pipeline enabling a new span to be sent to the pipeline each cycle. When the span processor cannot output a valid span to the pipeline, the pipeline is halted and a DRAM refresh occurs.

The output of the span processor consists of the span coordinates I and J, IMOD and JMOD for off-axis fogging and texture correction, and the span address for the DRAM.

6.5.3.1.1 Input Control Card (208121)

The input control card consists of two PROM state machine controllers. One state machine, the PLB interface controller, controls the transfer of data from the PLB into the DP. This involves loading FIFOs with polygon or light point information as well as loading up data RAMs such as the color palette, visibility functions, texture maps, etc. The controller dispatches to the appropriate routine when a valid code is fetched from the PLB.

The second state machine controls pipeline processing of spans and then loads the resultant data into the video assembler dynamic memory. It also controls DRAM refresh. This controller receives dispatch information from the other span processor cards. Polygon and light point information is stacked up in the span processor so that valid span information can be sent to the pipeline each span cycle. As data is output to the pipeline, new data is brought into the span processor as fast as possible to prevent wasted span cycles. If an invalid span is presented to the pipeline, the controller will halt the pipeline and do a refresh cycle. The special maintenance (SPM) register contains a page-select bit which can only be set through the maintenance shift loop. This puts the controller in a special maintenance mode which is used for testing the dynamic memories.

A large portion of the main pipeline hardware is controlled with a four bit opcode word (ICCODE). This code halts the pipe, loads it with a new polygon or light point, or processes the current polygon or light point. Each pipeline card receives this code and decodes it using a set of small PROMs to provide the needed register control logic. Some signals require unary control flags in order to meet timing requirements. The span processor section receives a similar control word SPCODE.

This card also contains the FIFO read and write address counters, a refresh timer, and some miscellaneous holding registers for DP draw constants.

6.5.3.1.2 Edge File (208134)

The edge file card contains two FIFO sections. Both FIFOs contain the data necessary to describe a polygon edge. The first FIFO provides this edge data for the span processing section while the second FIFO presents the data to the pipeline section. The generation of the line number to be processed is also on this card.

Data is loaded into these FIFOs from the PLB. When a new polygon begins processing, the four edge descriptions are read out of the FIFO and sent down the pipe. These edges are also stored in a four-edge register file where the pipe receives its data on subsequent span calculations. This frees up the FIFO so new polygon and light point information can be stored.

The edge file card also calculates the line number I for each scan line touched by the polygon or light point. This value starts with the Y minimum value and increments until I equals or exceeds the Y maximum value.

6.5.3.1.3 Span Generator (208124)

The span generator card main function is to determine which spans need to be processed for a given polygon or light. This is done by first calculating which spans are touched by the polygon and then subtracting out the spans that are already full because of higher priority polygons. A memory is used to record which spans have been touched and which ones are now full. The output from this card is a list of spans that need to be processed for the polygon.

The polygon edge description for the current line comes from the edge file card. The resultant set of spans that need to be processed for the polygon are sequentially output to the span processor card.

6.5.3.1.4 Span Processor (208122)

The span processor card performs two functions. First is the generation and delay of various flags required by the pipeline. The second function is the generation of the pixel address data for the spans that are being processed. This includes the I and J pixel coordinate (SPI and SPJ), the span number which addresses the DRAMs, and IMOD and JMOD which are used in the fog and texture calculations.

The line number (EFI) is received from the edge file card, delayed and sent to the main pipeline. It also addresses the Span I and I Mod rams. The Span I RAM looks up the DRAM address for the first span on the current scan line. The J value, which represents how far over on the scan line the current span is, is then added to the Span I value. This gives the DRAM address for the current span.

The pixel number (SGJGROUP) comes from the span generator card and is delayed to align with I. The I Mod and J Mod values go to the visibility generator and texture reciprocator cards.

6.5.3.2 Main Pipeline

The main pipeline of the DP implements the intensity and geometry calculations necessary for each pixel. The equations are pipelined to obtain maximum speed and efficiency from the hardware.

The pipeline consists of four basic parts: anti-aliasing of edges, visibility, texture, and landing lobes. Each of these components contribute to the intensity data for each pixel touched by a polygon. This data is combined and sent to the video assembler card where it is stored.

The anti-aliasing section consists of the edge generator and edge processor cards. These cards calculate which pixels are covered by the polygon. This data is recorded to allow occultation of lower priority polygons and lights that follow.

The visibility section consists of the Z vector scanner card and the visibility generator card. These cards calculate the range to the polygon for each pixel. This range data is then used to find the fog value as well as light defocus and landing lobe attenuation data.

The texture section is optional. It consists of the X and Y vector scanner cards and the texture reciprocator, texture lambda, and texture map cards. These cards calculate the X and Y address for the texture map look-up table and apply a clamping function to reduce aliasing. The texture maps are stored in RAM so each data base can have appropriate texture patterns.

The landing lobe section is also optional. It consists only of the landing lobe card which interpolates between modeled intensity values to give a lobe shape. This data is then attenuated based on range to the polygon and mixed with the other intensity factors. If the landing lobe card is not present, the lobe defaults to an omni-directional lobe that is range attenuated.

All of these factors are combined together on the intensity processor card to produce the total intensity value for each pixel. This data is then sent to the video assembler cards where it multiplies the scaled color data and is stored in the field buffer.

The data delay and DRAM Control cards provide miscellaneous data used by many other cards within the DP.

6.5.3.2.1 Edge Generator (208123)

The edge generator card receives the I and J coordinates for the current span from the span processor card along with the edge description from the edge file card. It then calculates the relationship of the edge to the span. This data is then sent to the edge processor card.

6.5.3.2.2 Edge Processor (208128)

The edge processor card takes the parameters from the edge generator card and computes the influence of the polygon on each pixel of the span. Polygon transparency information is also considered. The mask memory keeps a record of all the screen areas that have been filled thus far in the field. When a span has been completely covered, the full span flag is sent to the span generator card.

The outputs of the edge processor cards are tied together with two data busses. The second bus is only used in the high resolution configuration. This allows two edge processor cards to sort their pixel outputs to send even pixels to one intensity processor card and odd pixels to the other. The control of the tri-state enables of the chips is programmable from the DPDRAW block. This programming is based on the resolution configuration of the system.

6.5.3.2.3 Vector Scanner (208125)

The vector scanner card is used in three places. The Z card is used in the generation of fog and texture, while the X and Y cards are used only in texture calculations. Each card receives three components (C, L, and E) from the poly/light buffer card. Then, using the I and J pixel coordinates from the span processor and input control, generates two EP values for each clock. The EP values are normalized to provide a floating point number which is used for fog and texture calculations.

A field-of-view select register (FOV) is loaded with a shift code number based on the field of view of the system. This data controls a barrel shifter to scale the C component properly. There are also delay registers for the H value for the polygon.

6.5.3.2.4 Visibility Generator (208126)

The visibility generator card calculates the ambient illumination for the current polygon or light point. This is done by combining EP Z and H data from the vector scanner Z card to obtain a ZP value. This ZP value is then limited by ZPMIN and ZPMAX. The ZP value is then multiplied by ZMOD and then by VIS. The results address a look-up table. The look-up table gives a sigma value which indicates the range related fogging of each pixel.

A scud value is stored on the data delay card. This value is subtracted from sigma to reduce the visibility for simulating patchy cloud or fog conditions. The resultant sigma value is delayed to align with other data going to the intensity processor card. An adder is used to interpolate between two adjacent pixels in the high resolution configuration. The ZP value is also used to address a landing lobe attenuation look-up table.

6.5.3.2.5 Texture Reciprocator (208150)

The texture reciprocator card receives the EP value from the Z vector scanner card and reciprocates it with a look-up table. The result is then multiplied by the EP values from the X and Y vector scanner cards for use by the texture lambda card. The IMOD and JMOD pixel attributes come from the span processor card and modify the texture clamping function.

6.5.3.2.6 Texture Lambda (208151)

The texture lambda card takes the EP X and EP Y data from the texture reciprocator card along with the ETA and ETB components calculated in the GP and generates the address for the texture map.

The EP values are multiplied by the H data from the Z vector scanner card. This, along with the ET values are processed inside the denormalize and add VLSI chips. The output of these chips is the texture map address (XT and YT).

6.5.3.2.7 Texture Map (208152)

The texture map card takes the address from the texture lambda card and looks up the texture value in memory. The texture value is scaled by the clamping function to prevent aliasing as the texture pattern becomes small compared to a pixel. There are two different texture values available which can be mixed together if desired.

The X and Y address values, along with the texture map select code address the map memory. Each polygon can address two texture maps simultaneously (A and B). These two maps can then be added together or used independently. Either map or both can be used as intensity modulation or color modulation. Map B can also be used as a transparency modulation function. The clamping calculations are completed and a PROM is used to provide a smooth clamping function.

The intensity or color modulation function goes into a contrast PROM which scales the texture as selected by the polygon data format. The resultant texture value is delayed and an interpolation adder is used to generate high resolution intermediate pixel values. If the texture map card is unplugged from the system, the intensity processor card will automatically force the texture value to 1.

6.5.3.2.8 Landing Lobe (208140)

The landing lobe card option adds modeled light lobe shapes to the illumination of a polygon. Thirty-two different lobe patterns can be stored concurrently in a look-up RAM. The real-time system loads a select switch value with the lobe switch data format. This allows several landing lights to be switched on or off independently since the RAM can contain the various combinations of lobe intensity.

The lobe shapes are modeled with an array of intensity points. The landing lobe card looks up the four closest modeled lobe points and does a bilinear interpolation to find the lobe illumination value for the current pixel. The lobe RAM is loaded during real-time system boot up with data passed through the geometric processor and into the poly/light buffer.

If the landing lobe card is not plugged into the backpanel, The intensity processor card will automatically force the lobe value to one. This allows an omni-directional lobe illumination to be used without a landing lobe card present.

6.5.3.2.9 Intensity Processor (208129)

The intensity processor card takes the antialiasing data from the edge processor card and applies a spatial filter function. Four PROMs are used to implement this filter. The PROMs are arranged geometrically: left top, left bottom, right top, and right bottom. This provides the anti-aliasing for polygon edges. The weighted filter output is called the alpha value, which scales the fog, texture, landing lobe, and modeled polygon intensity to provide the resultant intensity of the polygon for each pixel processed.

Four intensity functions are assembled: fog intensity, texture, landing lobe, and color texture. The color texture component is forced to zero if the color blend enable flag is off. This data is then sent to the video assembler cards where it is combined with the color information. The color texture value is multiplied by a different color than the intensity texture and landing lobe cycles. This gives a color modulation with texture instead of intensity modulation.

The output registers collect four pixels of data and then output them on a tri-state bus to the video assembler cards.

Calligraphic light point intensity is also accumulated on this card. A daisy-chain adder circuit is used to accumulate the intensity value from each intensity processor card to obtain the total light point intensity. IP0 passes the total intensity value to the DRAM control card for further processing.

This card also monitors several flags to see which options are present in the system. These include the texture, landing lobe, and other intensity processor cards. If any of these options are not present, the appropriate data busses will be forced to zero or one as necessary.

6.5.3.2.10 Data Delay (208127)

The data delay card provides delay for the color code, intensity, and fog data for a polygon or light. The color code then addresses a look-up table to provide the red, green, and blue color components. These are multiplied by the K value scalar which provides the overall ambient brightness control. The K values are stored in a register file which is loaded with the K data format when sent down the pipe from the real time system. The resultant K times color values are then sent to the video assembler cards. The modeled polygon intensity value is delayed and sent to the intensity processor cards.

The fog code addresses the visibility, scud, and defocus RAMs which provide some of the visibility data for the polygon or light point. The visibility defocus value is added to the range defocus value to obtain the total defocus value for each calligraphic light point.

6.5.3.2.11 DRAM Control (208131)

The DRAM control card has two sections. The first section is really part of the output section. This is a PROM control which generates the DRAM control signals used on the output side of the video assembler and light buffer DRAMs. This section also generates the output-side DRAM row and column address.

The second section provides delay for various control flags necessary to process data through the pipeline. This section also contains an unblank time and intensity RAM which provides data necessary for calligraphic lights. This takes the total calligraphic light intensity from the intensity processor card and converts it to a gamma-corrected intensity value and an unblank time. Very bright light points are obtained by lengthening the unblank time rather than increasing the intensity value. The span number is also converted to a row and column address for interface to the DRAMs.

6.5.3.3 Output Section

The output section takes the stored field from the video assembler cards and the light buffer card and sends it to the display device. The output control card provides the necessary control signals and timing. Flyback time, draw time, and the number of lines to be drawn are constants that can be modified by software with the DPDRAW data block without changing the microcode. This allows great flexibility in system configuration without major hardware impact.

The scope driver card converts the digital signals to analog so they can be sent across the cable to the display. These signals consist of red, green, and blue video, X and Y deflection, defocus, and unblank. Sync pulses are also available for interfacing to a fixed raster display.

6.5.3.3.1 Output Control (208132)

The output control card consists of a RAM state machine, double buffered register file, and the deflection settle logic. The state machine provides the control for the output section of the DP. This includes the timing necessary to interface to the display device. Since the state machine is built with RAM, the microcode can be tailored to a specific display device. The microcode is loaded during system boot up through the shift loop.

The register file contains system specific data such as the number of raster lines, flyback time, display type select, etc. This allows modification of the system configuration without modifying microcode. The register file data is connected to the OC/LB data bus. This bus is used to pass data between the output control, light buffer, and scope driver cards. X and Y position, defocus, and light unblank time are all passed on this bus. Defocus and unblank time are passed unchanged. The light buffer card presents the X and Y position information to the POS register on the output control card. Here it is multiplied by the X and Y scalar to convert the numbers from pixel coordinates into DAC coordinates. The resultant values are passed to the scope driver card. When drawing raster, the Y position (line number) comes from the DRAM Control card and is similarly scaled.

The deflection settle logic calculates the distance the electron beam in the display must move to draw the next light point. This is done by subtracting the previous light's position from the next light's position. The delta X and delta Y values address a look-up prom to find a deflection settle time. These times are loaded into counters and the state machine waits for both counters to count down to zero before unblanking the light point. The DPDRAW block contains a display type select bit which selects different deflection settle times. A select code of zero gives the deflection settle timing for a CSM display, while a code of one is used for a beam penetration display device.

6.5.3.3.2 Video Assembler (208130)

The video assembler card contains a dual field buffer. As one side is being loaded from the pipeline, the other side is outputting video data to the scope driver card. As the data is being output, it goes through a look-up RAM which provides gamma correction for the display device.

The video data is stored in dynamic memories. These memories receive their control from the input control card and the DRAM control card. The address data comes from the DRAM control card. The address and control lines are multiplexed with the side select signal. This allows one side to be receiving input data while the other side is outputting the previous field.

Each video assembler card contains eight pixels of one color component. Four pixels are read out in parallel and loaded into a parallel-to-serial shift register. As the data is shifted out, it is gamma corrected with a look-up RAM. The video output to the scope driver card is on a tri-state bus with the light buffer card.

6.5.3.3.3 Light Buffer (208141)

The light buffer card is similar to the video assembler card, but it only receives data for calligraphic light points. As a light point is written into the buffer, an address pointer is incremented. During the next field, the input and output sides of the buffer will switch, and as a light point is read out, the pointer will be decremented. When the pointer underflows, the controller will know that all light points have been displayed. The buffer consists of eight pages of 8K each. When used with a beam penetration display device, each page will contain one light color. This provides a simple way to color sort the lights on input so they can be displayed in color order. When color sorting is not necessary, all light points of any color are written into the first page. This limits the number of calligraphic light points to 8K.

This card also contains the necessary delay for the X and Y position of the light point. This data comes straight from the poly/light buffer since no processing is necessary. Defocus, unblank time, and some flags are also stored along with the red, green, and blue video data. The video data is output on the same bus as the video assembler cards. The position, defocus, and unblank time values are output on the OC/LB data bus.

6.5.3.3.4 Scope Driver (208133)

The scope driver card takes the video data from the video assembler and light buffer cards and converts it to an analog signal to be sent across the cable to the display. If the green video assembler card is not plugged into the system, or if the DPDRAW block specifies, the red video data will be passed to all three video DACs. This produces a monochrome image on a color display.

In the high resolution configuration, two video assembler cards present data to each color input. This data is multiplexed with a parallel-to-serial shift register to double the pixel rate.

This card also generates the the X and Y deflection signals for both raster scan and calligraphic lights. The Y position is presented to a DAC. The X position is presented to a similar DAC when drawing light points, but is produced with a ramp generator for raster scan.

The defocus, unblank, and sync signals are also generated here and sent out the cable. The unblank signal for raster comes from the output control card while light point unblank signals are generated with a variable unblank circuit. This circuit takes the unblank time from the light buffer card and converts it to an analog reference voltage. A ramp generator begins ramping up until its voltage equals the reference voltage. As long as the ramp generator voltage is lower than the reference voltage the unblank signal will be active.

The scope driver card is capable of driving three displays simultaneously. The three outputs are labeled main 1, main 2, and instructor. Any of these outputs can be disabled via the clock maintenance flags. Calligraphic light points also contain two unary flag bits which can allow a light to be displayed on all outputs, the instructor output only, or the two main outputs only.

6.5.4 System Fault Monitor (SFM) (208105)

The SFM is a microprocessor-based data acquisition and reporting card. It is based upon the 6803 microprocessor with 8K x 8 of EPROM and 8K x 8 of RAM.

Blower RPM data is sampled for each fan using an integrated Hall effect sensor in each blower whose output is transmitted via ribbon cable to input multiplexers on the SFM. The selected signal is presented to an edge detector input on the 6803. The time between successive edges is sampled and stored in internal RAM for comparison against predetermined high and low limits.

Backpanel and internal power supply voltages are sampled using differential amplifiers whose outputs are fed to an 8-bit A/D converter with an internal eight channel analog multiplexer. Line voltage is monitored through a 24 V transformer, then rectified and filtered and sampled by the A/D converter.

Two serial ports are supported by the microprocessor. One port is dedicated to the system console and will accept either RS232C (DTE) or RS422 signals. Terminals may be connected to both the RS232C and RS422 connectors simultaneously, as long as only one device attempts to communicate to the console port at a time. In this way the optional flybox can be connected as a remote or alternate system console. The second port is dedicated for connection to the MPU. This port supports only RS232C (DCE).

The SFM supports one RS485 port which is intended for party-line communications with other SFMs. This port is called the inter-processor communications port (IPC). The SFM in the channel zero cabinet is configured as the master processor. It acquires data from its own cabinet and then communicates through the IPC to other SFMs which are configured by DIP switch settings as slaves. Other DIP switches may be used by the slaves to identify whether an upper or lower backpanel is being monitored.

A retriggerable one-shot is used to drive the solid state relay located in the power controller chassis. This one-shot is used as a watch-dog timer and must be accessed by the microprocessor once every 170 ms in order to keep the contactor energized. Should the SFM processor fail, this circuit will automatically shut off power to the cabinet by de-energizing the contactor.

DC power from a ±15V supply, located in the rear of the MP cabinet, is supplied to each power controller in the image generator over a daisy-chained cable. The IPC party line is also connected through this daisy-chained cable. ±15 V power is supplied to support RS232C and to allow for any voltage drop from cabinet to cabinet. An on-board voltage regulator sets the voltage at +5 V DC.

One ±15 V supply is required for channels 0 through 8 of the image generator or SFM cabinets (stations) 0 through 4. Display cabinets are identified as cabinets (stations) 5, 6, and 7. These cabinets share a second ±15 V supply located in cabinet 5, and the IPC party line connects them with the main IG cabinets with an EMI-shielded twisted-pair cable.

Diagnostics of the processor and digital portion of the SFM is provided chiefly by requesting status from all stations from the control terminal and MPU. Analog portions of the SFM are debugged by observing the displayed voltage levels and comparing them with measured voltages using a conventional digital volt meter.

CHAPTER 7

MAINTENANCE

7.1 INTRODUCTION

Subjects covered in this section include preventive maintenance, adjustment and alignment, SPX troubleshooting (including fault trees and diagnostics), advanced troubleshooting techniques, and corrective maintenance procedures.

7.2 PREVENTATIVE MAINTENANCE

This section describes the weekly, monthly, and annual preventative maintenance procedures which are used to verify correct performance of the system and to identify any problems before they affect system use. To solve problems identified during preventative maintenance, consult the sections covering Adjustment and Alignment, Troubleshooting, and Advanced Troubleshooting (Sections 7.3 thru 7.5).

A regular schedule of preventive maintenance can help to ensure that optimum performance levels are maintained, and to forestall or prevent failures. The adherence to a proper preventive maintenance system aids in the detection of minor problems before they lead to more serious failures.

The procedures in this section meet the minimum preventative maintenance requirements. The daily system readiness check (Section 5.7) needs to be performed as part of the monthly maintenance check, and both the monthly maintenance check and daily system readiness check need to be performed as part of the annual maintenance check.

The display maintenance check is listed here only for reference. To perform maintenance on displays, refer to the appropriate display manual.

Display Preventative Maintenance	Display alignment check Color balance geometry Convergence (see display manual for details)

Monthly Preventative Maintenance	Channel Processor Diagnostics Magnetic Media Maintenance Air filter maintenance Power supply check, unmonitored MP Fan Check Parallel power supply balance check
Annual Preventative Maintenance	Power supply connector check EMI cabinet cleaning and integrity check Channel Processor Alignment Check Fixed Disk check and software restored Display cleaning and alignment (see display manual for details)

7.2.1 Preventative Maintenance Schedule

The schedule for preventative maintenance provided here specifies maximum intervals. Site conditions may require that these preventative maintenance procedures be performed at shorter intervals. Monthly and annual maintenance should be scheduled so that tasks are performed in parallel where possible.

7.2.2 Preventative Maintenance Procedures

For each procedure the following information is provided: the system area affected, the procedure purpose or goal, any tools or supplies needed, and a step-by-step procedure with the expected response.

7.2.2.1 Display Preventative Maintenance

Display preventative maintenance schedules and procedures are described in the relevant display manual.

7.2.2.2 Monthly Preventative Maintenance

The following preventative maintenance procedures need to be performed on a monthly basis:

System Areas: system console, tape streamer, MP cabinet, channel processors, image generator power supplies

Purpose: Execute diagnostics on the channel processors and tape streamer, record power and fan status, check system power supplies , clean air filters, check MP unit and power supply fan operation, and clean the system console and printer.

The following tools and supplies are required:

Multimeter	Recommended - FLUKE 77 National stock number 6625-01-178-9491
Scratch Tape	Recommended - 3M DC600A 600 Ft, 12,500 ftpi, 550 oersted
Soap and water	

Several of these procedures can be executed in parallel. While the channel processor diagnostics are operating, the air filters can be cleaned and the power supples and fans checked.

Initially, the system is powered ON with the SPX operating system prompt > on the system console.

Instructions	Response
NOTE: Perform the daily system readiness check procedures (see Section 5.7) before doing this procedure.	
1. On the system console press <CTRL/Print>	None; the printer is set to record all system console responses.
2. Type `SHOW TIME <RET>`	The current time and date of the diagnostic run will be printed for future reference
NOTE: If the date and time is incorrect, use the SET command to enter the correct time and date.	
3. Press <Shift/F6> (Status) to bring up the status screen.	The system fault monitor status screen will be printed on the printer.
4. Press <Shift/F7> (Continue).	The SFM status screen is no longer displayed on the system console.
5. Type `@CHEK <RET>`	The console will display `Welcome to CHEK` and the prompt >>
6. Type `@SPX <RET>`	The console will ask `SHORT OR LONG MEMORY TESTS" (S/L) GET>>`
7. Type `S<RET>`	The console will ask `WHICH CHANNEL? GET>>`

8. Type A <RET>	The diagnostic tests will be executed and the results listed on the console and printer. The diagnostics will be completed when the question WHICH CHANNEL? GET>> is displayed. The channel processors will have passed diagnostics if no error messages are printed. See Table 7-3 for approximate execution times.
9. Open the cabinet doors (front and rear as necessary) and remove the foam air filter from each channel processor.	None.
10. Clean the foam filters using warm water and soap. Let the filters air dry completely.	None.
11. Reinstall the filters after they have dried.	None.
12. Open the MP cabinet and remove the MP front panel.	None.
13. Visually check for fan rotation of each of the two fans below the MP card.	(These fans are not monitored by the SFM.)
14. Check and adjust the MP power supply as required according to the procedures in Section 7.3.1.2.	None.
15. Replace the MP unit cover.	None.
16. Check and adjust the +5 V channel processor power supplies according to Section 7.3.1.1.	None.
17. Check and adjust as required the ±15 V power supplies according to Section 7.3.1.3.	None
18. Check and adjust as required the -5.2 V power supplies according to Section 7.3.1.4. This power supply may not be present depending upon system configuration.	None

19. If CHEK has been running while the preventative maintenance procedures for the power supplies are being performed, wait until CHEK is finished, then exit CHEK by typing XIT <RET>, then load an SPX formatted scratch tape into the tape streamer.	None

CAUTION: This test will write data on the tape. All data on the tape will be overwritten and lost.

20. On the system console type: `@MMD<RET>`	The prompt `MMD>` will appear on the screen.

NOTE: The magnetic media diagnostic software has additional tests that may be performed. Those tests will destroy data on the fixed disk and are not part of the monthly preventative maintenance.

21 Type `AC 1 <RET>`	All streamer tape/disk controller tests will be run. If the test file TSTFIL.TXT does not exist, it will be created if the user responds with Y when asked if it should be created. Upon completion, MMD will inform the user of the results of these tests.
22. Type `I 1 <RET>`	Upon completion, MMD will inform the user of the results of this test.
23. Type `S 1 <RET>`	Approximately 10 minutes are required to complete this test of the hard disk. Upon completion MMD will inform the user of the results of this test.
24. Type `REW <RET>`	The streamer tape will rewind.
25. Type `TA 1 <RET>`	After a few minutes (a 450 ft. long tape takes two minutes), the user will be informed of the results of this test.
26. Remove the scratch tape from the tape streamer and return it to its protective cover.	None.
27. Power off only the system console and printer.	Power indicators will be off.

28. Using the methods described in the vendor manuals, clean the terminal and printer.	None.
29. Power on the printer and terminal.	Power indicators will be on.
30. Activate the special function keys on the system console by typing <CTRL/[><[><i><p>	The SPX system fault monitor will send command sequences to the system console.
31. Check that the function keys operate by pressing <Shift/F6>.	The system fault monitor status screen will appear on the console.

7.2.2.3 Annual Preventative Maintenance

The following preventative maintenance procedures need to be performed on an annual basis. Perform the monthly maintenance procedures (see Section 7.2.2.2) before beginning these annual procedures.

System Areas: system console, tape streamer, MP cabinet, channel processor, 5V high-current power supplies, cabinet doors

Purpose: In addition to the monthly maintenance, the high current power cables will be mechanically checked, the EMI cabinet doors will be cleaned, the alignment of the scope driver card will be verified, the cabinets cleaned and visually inspected, and the fixed disk checked and software restored.

The following tools and supplies are required:

Alcohol	MIL-STD-1201A
Lint-free cloth	MIL-C-84043
Small Brush	
Vacuum Cleaner	
Multimeter	Recommended - FLUKE 77 National stock number 6625-01-178-9491
Scratch Tape	Recommended - 3M DC600A 600 Ft, 12,500 ftpi, 550 oersted
Torque Wrench	
9/16" deep socket	

Initially, the system is powered on with the operating system prompt > on the system console.

Instruction	Response
1. On the system console, turn off power by typing <Shift/F20>.	The image generator power will be turned off.
2. Open each cabinet door and remove the MP unit cover. Inspect all exposed cables, wiring and all internal subassemblies.	No damage, fraying or cracking of wires, loose connections or other damage should been found. Cables should be mechanically secure at each end. Repair or replace any damaged wiring or cabling.
3. Inspect the printed circuit cards for proper seating and the backpanels for bent pins and pulled wires.	Reseat cards and straighten backpanel pins as required.
4. Using a small brush, a clean dry cloth and a vacuum cleaner, remove all dust and lint from exposed surfaces and cables.	None.

CAUTION: Do not touch the backpanel wiring. Physical movement of the backpanel wiring may cause system failures

Instruction	Response
5. Using a dry clean cloth wetted with alcohol, clean the exposed metal around all the cabinet door frames.	Oil and dirt causing loss of EMI shielding should be removed.
6. Test tighten the nuts securing the 208210 cables to each 5 V power supply. These nuts should be tightened to 60 inch pounds. See Figures 4-4 and 4-7 for the location of the cables.	All the nuts should be tightened to 60 inch pounds.
7. Test tighten the nuts securing the 208210 cables to the backpanel. These nuts should be tightened to 100 inch pounds. See Figures 4-4 and 4-7 for the location of the cables.	All the nuts should be tightened to 100 inch pounds.
8. Perform periodic maintenance for the tape streamer as specified by the manufacturer (see the vendor manual).	Cleaning of the tape head assembly should be performed at intervals no longer than those given by the manufacturer. Typical maintenance intervals for tape streamers of this type are 20 hours of actual tape movement.

9. Replace the MP cabinet cover.	None.
10. On the system console, power on the system by pressing <Shift/F20>.	The power controllers will apply power to the MP unit and channel processors.
11. Perform the procedure outlined in Section 7.3.3 (Scope Driver Adjustment) for each scope driver card in the system.	See Section 7.3.3
12. Type `SYS E` to return to the SPX operating System.	The > prompt will be seen on the system console.
13. Type `@MMD <RET>`	The MMD prompt `MMD>` will appear on the system console.
14. Load an SPX formatted tape into the tape streamer.	The next step of this procedure will destroy any data on this tape and replace it with the current contents of the hard disk.
15. Create a backup tape of the hard disk by typing `B <RET>`	The user needs to respond to prompts generated by the backup command. Depending upon the amount of data on the disk, several tapes may be required.
16. Repeat step 15 to make a second set of backup tapes.	A second set of backup tapes will be created.

WARNING: The next step will destroy the data on the hard disk. A current backup tape is required to restore this data to the disk.

17. Type `AD 1 DR0: <RET>`	All the disk drive tests will be executed. The disk will be reformatted and all data on the disk will be destroyed. The user will be informed of the tests results upon completion of the test.
18. Restore the backup tape to the hard disk by typing `ST DR0: <RET>`	The data on the backup tape will be restored to the disk. If the data fails to restore properly, use the second set of backup tapes created in step 16 above and repeat the restore procedure.
19. Type `EX <RET>`	Exit from MMD. The operating system prompt > will be seen on the screen.

20. Type `@RTS <RET>`	The real-time system will execute verifying that the disk has been properly restored.

7.3 ADJUSTMENT AND ALIGNMENT

This section provides adjustment and alignment procedures for the power supplies, backpanels (including plug-in printed circuit cards), and displays. The alignment should be performed in the following order:

1. System power supplies
2. Scope driver cards
3. CSM displays

7.3.1 Power Supply Adjustment

Power supply adjustment procedures are provided in the following paragraphs.

WARNING: Caution should be taken when adjusting the SPX power supplies. High voltage (230VAC) is present at the input terminal strip of all power supplies. Also, even though the voltage out of the power supplies is relatively low, the current capacity of the supplies can be very high. Remove watches, rings, and any other metal objects from your hands before attempting to adjust any of the SPX power supplies, or before working on a powered backpanel.

7.3.1.1 Channel Processor 5V 200A Power Supply (208050)

The large power supplies connected to the channel processor backpanels are used to supply 5 V DC to the digital circuitry within the channel processors. These supplies should be adjusted until a reading of 5.10 ±0.05 V DC is obtained when measuring between the ground and the 5 V DC bus bars at the backpanel.

Systems can be configured with either one or two power supplies powering a single channel processor backpanel depending on which options are installed. Choose the procedure that matches the current system configuration.

7.3.1.1.1 Single +5 V DC Power Supply Adjustment Procedure

1. Prior to connecting the +5 V DC supply to the channel processor backpanel, connect 200340 cable to the power controller and power up the supply. Measure the voltage out of the supply and set it to 5.15 ±0.05 V DC by turning the output voltage adjustment screw located on the front of the power supply (see Figure 7-1).

2. Remove power from the supplies and connect the 208210 cables from the channel

processor backpanel to the power supply. Tighten the power supply lug nuts to 60 inch pounds.

3. With the cards plugged into the channel processor backpanel, power on the system. Measure the voltage between the ground and the +5 V DC bus bars.

4. Adjust the power supply until the voltage measured at the bus bars is 5.10 ± 0.05 V DC.

7.3.1.1.2 Parallel +5 V DC Power Supply Adjustment Procedure

1. Prior to connecting the +5 V DC supplies to the channel processor backpanel, connect 200340 cables from the power supply to the power controller and power up the supplies. Measure the voltage out of each supply and set it to 5.15 ±0.05 V DC by turning the output voltage adjustment screw located on the front of the power supplies (see Figure 7-1).

2. Remove power from the supplies and connect the power supplies to the backpanel using the 208210 cables. Tighten the power supply lug nuts to 60 inch pounds.

3. With the cards plugged into the channel processor backpanel, power on the system. Measure the voltage between the ground and the +5 V DC bus bars.

4. If the measured voltage is lower than 5.10 V DC, proceed to step 5; if it is higher than 5.10 V DC measure the voltage between the +5 terminals of both supplies and turn the voltage adjustment screw on one of the supplies counter-clockwise. If the measured voltage between the supplies moves further from zero, move to the other supply and turn its adjustment screw counter-clockwise until the measured voltage goes to zero. If, when adjusting the first supply, the measured voltage between the supplies moves towards zero, continue adjusting the first supply until the voltage reaches zero.

5. If the measured voltage is lower than 5.10 V DC, measure the voltage between the +5 terminals of both supplies and turn the voltage adjustment screw on one of the supplies clockwise. If the measured voltage between the supplies moves further from zero, move to the other supply and turn its adjustment screw clockwise until the measured voltage goes to zero. If, when adjusting the first supply, the measured voltage between the supplies moves towards zero, continue adjusting the first supply until the voltage reaches zero.

6. Re-measure the voltage between the bus bars at the backpanel again. If the measured voltage is higher than 5.10 V DC, turn the adjustment screws on both supplies a few degrees counter-clockwise. If the measured voltage is lower than 5.10 V DC, turn the adjustment screws on both supplies a few degrees clockwise.

7. Repeat steps 3 through step 5 until the voltage measured at the backpanel is 5.10 ± 0.05 V DC and the voltage measured between the +5 V DC terminals on the power supply is 0 ± 0.005 V DC.

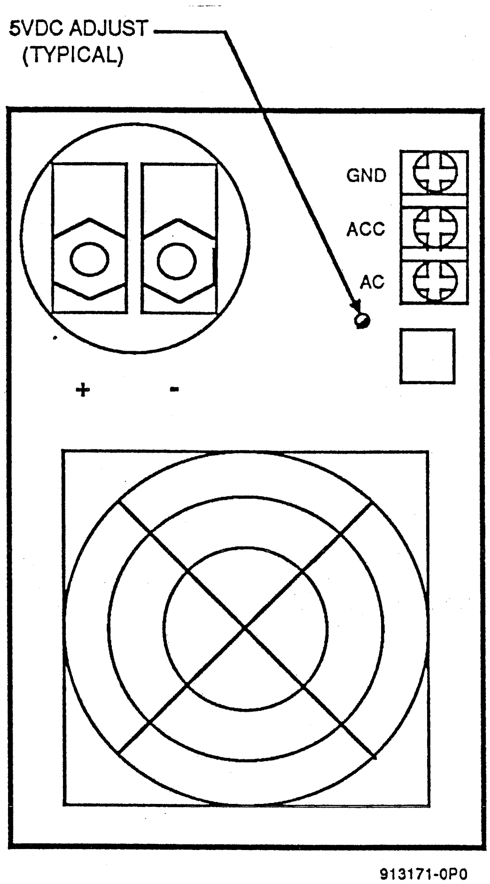


Figure 7-1. Power Supply Adjustment Screw Location

7.3.1.2 MP Unit Power Supply (801660)

The power supply used in the MP unit is a multiple output supply providing power to the MP cards, the Winchester disk drives, the tape streamer, and the disk/tape control card. It supplies +5 V DC, and ±12 V DC.

The MP card uses the +5 V DC for its logic circuitry, the ±12 V DC for its RS-232 interface circuitry, and the +12 V DC for the ethernet interface. The controller card uses +5 V DC for its logic circuitry and the disk and tape drives use both +5 V DC and +12 V DC for their logic circuitry and drive motors.

The power supply is a four-output supply. There are separate adjustment screws for each supply output. All supplies are adjusted from the rear of the MP unit with both halves of the back cover removed. The voltages for all but one of the supplies are measured on the MP backpanel. The other supply is measured using TB-1 mounted underneath the power supply. All voltages should be made with the MP card installed and the disk and tape assemblies powered. (This power supply must be partially loaded in order for proper output regulation to occur.)

CAUTION: High voltages are present in the rear of the MP unit. Refer to the high-voltage warning in Chapter 1.

7.3.1.2.1 +5 V DC Adjustment Procedure

1. Measure the voltage between the +5 V DC bus bar and the GND bus bar on the 208011 MP backpanel inside the MP unit.

2. Adjust the power supply channel 1 voltage adjustment screw (see Figure 7-2) until the voltage read is +5.10 ±0.05 V DC.

7.3.1.2.2 +12 V DC (Ch 2) Adjustment Procedure

1. Measure the voltage between the +12 V DC power lug and the GND bus bar on the 208011 MP backpanel inside the MP unit.

2. Adjust the power supply channel 2 voltage adjustment screw (See Figure 7-2) until the voltage read is +12.1 ±0.1 V DC.

7.3.1.2.3 +12 V DC (Ch 3) Adjustment Procedure

1. Measure the voltage between terminal 10 of TB-1 (the terminal nearest the rear of the MP unit on the terminal board, located directly under the power supply) and the GND bus bar on the 208011 MP backpanel inside the MP unit.

2. Adjust the power supply channel 3 voltage adjustment screw (see Figure 7-2) until the voltage read is +12.1 ±0.1 V DC.

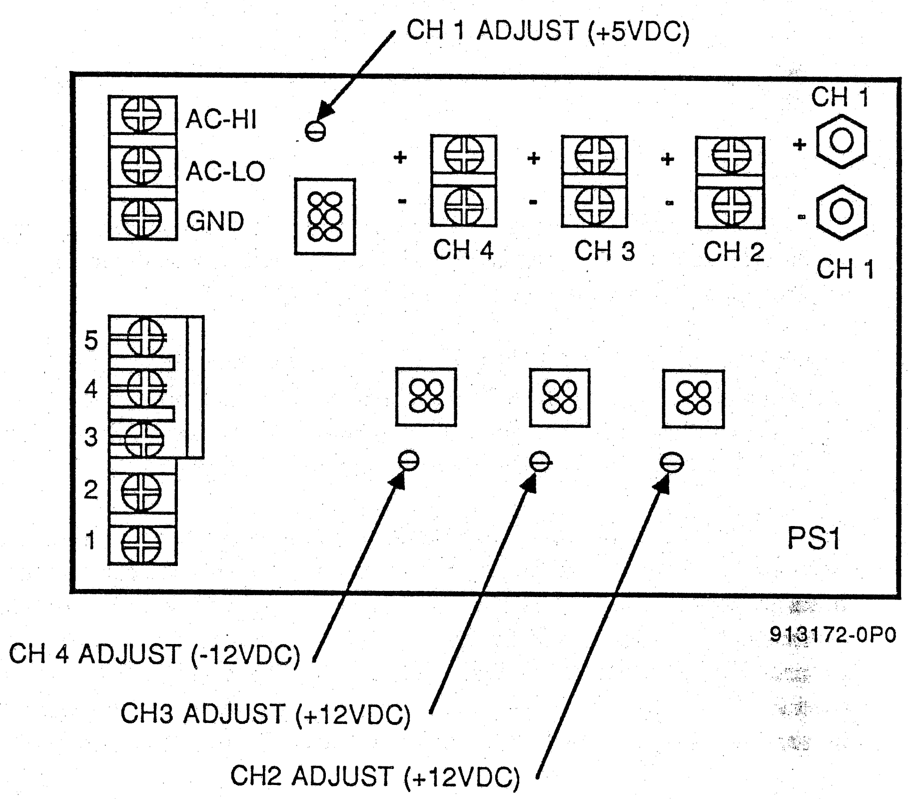


Figure 7-2. MP Power Supply Adjustment Screw Locations

7.3.1.2.4 -12 V DC (Ch 4) Adjustment Procedure

1. Measure the voltage between the -12 V DC power lug and the GND bus bar on the 208011 MP backpanel inside the MP unit.

2. Adjust the power supply channel 4 voltage adjustment screw (see Figure 7-2) until the voltage read is -12.1 ±0.1 V DC.

When all power supplies have been adjusted within the specified tolerances, reinstall the rear cover on the MP unit. When reinstalling the rear cover, insure that the cables exiting the MP unit are evenly spaced and that the pressure on the ribbon cables provides adequate strain relief.

7.3.1.3 ±15 V DC Power Supply Adjustment

The ±15 V DC power supplies are used in two different ways in the SPX. First, the ±15 V DC power supply is used as the control power supply (208054) located in the bottom-rear of the left image generator cabinet (MP) and left display power supply cabinet (if used). In this configuration it supplies the power to the system fault monitor cards located in each cabinets power controller.

Second, one ±15 V DC power supply (208073) is located in the power controller in the bottom of each image generator cabinet. This supply provides the ±15 V DC analog supply voltages to the analog circuitry on the scope driver cards in all channel processors located in that cabinet. The procedure indicates that the voltage is to be adjusted higher than the +15 V DC required on the card. This is to allow for voltage drop across the cable and backpanel connector, since this voltage is sampled within the power controller. Each configuration has its own adjustment procedure.

7.3.1.3.1 ±15 V DC Control Power Supply Adjustment Procedure

1. Insure that the main and the control power circuit breakers on the left-hand cabinet (MP cabinet) are in the on position.

2. Open the rear door of the MP cabinet and measure the +15 V DC at the DC connector of the ±15 V DC power supply. Measure +15 V DC between pin 8 (gnd) and pin 1 (+15).

3. Turn the adjustment screw located on the front of the power supply (see Figure 7-3) until the measured voltage is 15.2 ±0.09 V DC.

4. Verify that the secondary voltage (-15 V DC) is -15.0 ±0.2 V DC. Measure -15 V DC between pin 8 (gnd) and pin 13 (-15 V DC).

7.3.1.3.2 ±15 V DC Analog Power Supply Adjustment Procedure

1. Open the front door of the image generator cabinet and remove the lower panel on the front of the power controller.

2. With the system powered on, depress the status function key <Shift/F6> to view the system status screen on the system control terminal.

3. Monitor the +15V DC reading of the appropriate cabinet and adjust the voltage adjustment screw located on the front of the power supply in the appropriate cabinet (see Figure 7-4) until the status screen indicates +15.29 ±0.09 V DC.

4. Verify that the -15 V DC reading for this cabinet is -15.29 ±0.20 V DC.

5. Replace the power controllers front panel and close the cabinet door, or continue with the -5.2 V DC power supply adjustment procedure as required.

7.3.1.4 -5.2 V DC Power Supply Adjustment Procedure (208072)

Each image generator cabinet contains its own -5.2 V DC power supply. It is used to supply the ECL supply voltage to the ECL DACs and TTL/ECL level converters on the scope driver card. (Some SPX configurations use the TTL DACs and do not require this power supply to be present. If so, skip this section.) One supply provides power for the entire cabinet (up to two channel processor backpanels). The procedure indicates that the voltage is to be adjusted more negative than the -5.2 V DC required on the card. This is to allow for voltage drop across the cable and backpanel connector, since this voltage is sampled within the power controller.

Adjust the -5.2 V DC power supplies as follows:

1. Open the front door of the image generator cabinet and remove the lower panel on the front of the power controller (unless previously performed).

2. With the system powered on, press the status function key <Shift/F6> to view the system status screen on the system control terminal.

3. Monitor the -5.2 V DC reading of the appropriate cabinet and adjust the voltage adjustment screw located on the front of the power supply (see Figure 7-4) until the status screen indicates -5.29 ±0.06 V DC.

4. Replace the power controllers front panel and close the cabinet door.

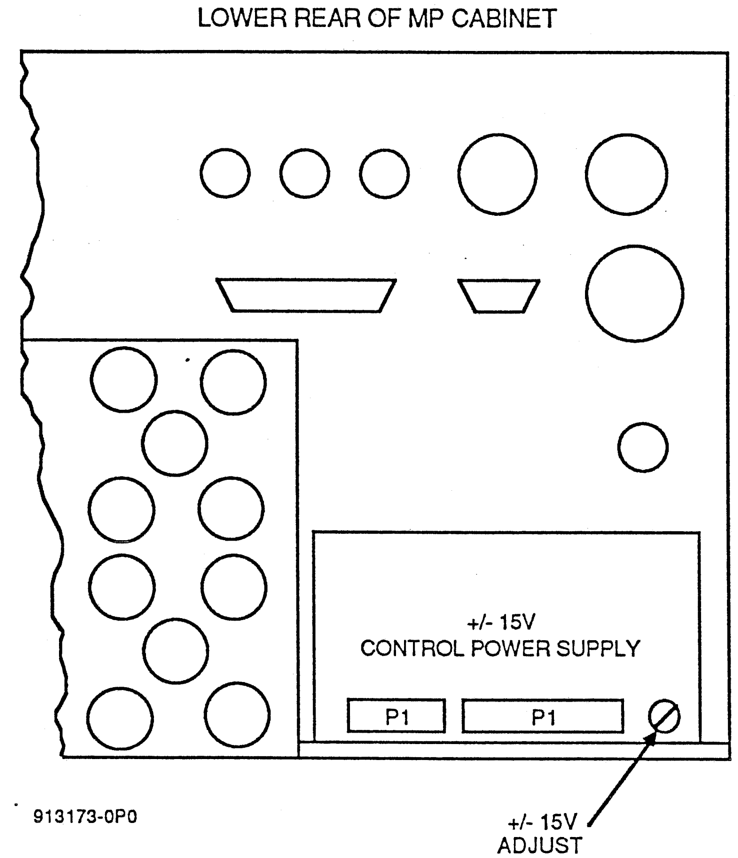


Figure 7-3. ±15 V DC Control Power Supply Adjustment Screw Location

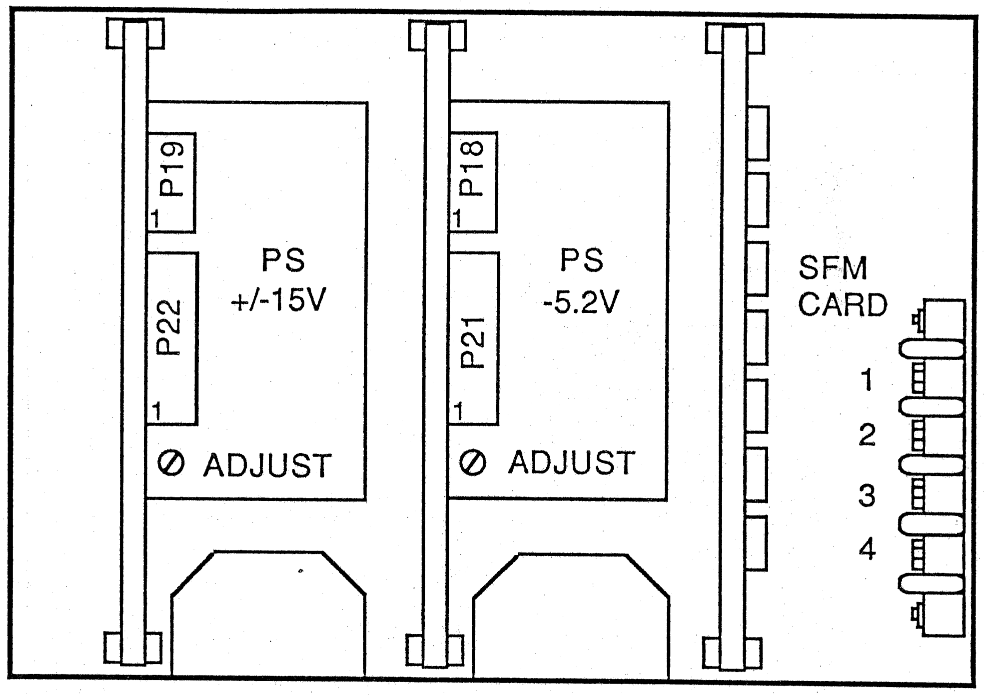


Figure 7-4. ±15 V DC Analog Power Supply Adjustment Screw Location

7.3.2 SPX System Test Patterns

Fifteen test patterns are available to demonstrate correct alignment and operation of the image generator channel processor and its display devices. This section describes each of these test patterns (see Table 7-1), how to display the test patterns (see Section 7.3.2.2), and the correct appearance of each test pattern (See Figures 7-6 through 7-16).

Table 7-1. SPX Test Patterns

Pattern number	Pattern Name	Adjustment / Alignment Function	Where Used
1	Grid	Deflection off set alignment Deflection troubleshooting Geometry alignment	CP CP, Display Display
2	Wedge	Video adjustments, Gain threshold, Color balance Video troubleshooting	CP,Display CP,Display
3	Light	Calligraphic light point convergence alignment	Display
4	Stripe	Video amplifier alignment	Display
5	Ramp	Align video offset and video glitch troubleshooting	CP, Display
6	Focus	Align dynamic focus Troubleshoot dynamic focus	Display
7	Spoke	Troubleshoot raster aliasing	CP
8	Dot	Dot size specification evaluation and deflection troubleshooting	Display
9	Color Palette 1	Displays a color palette inc. lights	CP
10	Color Palette 2	Second color palette	CP
11	Color Palette 3	Third color palette	CP
12	Color Palette 4	Fourth color palette	CP
13	Hysteresis	Align deflection hysteresis	Display
14	Surface/ Lights	Alignment of surface lines and polys relative to calligraphic light points	CP, Display
15	White Raster	Adjust video gain Adjust purity	Display Display

The test patterns are executed from the real-time system program. Prior to executing any test patterns the system should be powered on and the real-time program executed. The test pattern data base is loaded by executing a set-up file TSTPAT.RST. The channel definition for each viewing channel is set to be the same as that for channel 0. Test pattern use may require using the key pad to move or rotate the pattern.

The following instructions show how to bring up the test patterns. Responses shown do not describe all of the information that may appear. Only the last part of the message may be shown.

Initially the system is powered on and the real-time system active. A data base can be seen on the screen. The system console will display the following prompt `SPX>`.

Instruction	Response
1. Type `@TSTPAT <RET>`	The grid test pattern will be displayed on all channels. Once the test pattern reset file has finished running, the following test pattern selection menu will appear on the system console:

```
# ####################### TEST PATTERNS #######################
#GRID PATTERN    = 1 FOCUS PATTERN    = 6 COLOR PALETTE 3 =   11
#WEDGE PATTERN   = 2 SPOKE PATTERN    = 7 COLOR PALETTE 4 =   12
#LIGHT PATTERN   = 3 DOT PATTERN      = 8 HYSTERESIS      =   13
#STRIPE PATTERN  = 4 COLOR PALETTE 1  = 9 SUR/LIT ALIGN   =   14
#RAMP PATTERN    = 5 COLOR PALETTE 2  =10 WHITE RASTER    =   15
#
# TYPE "CS N 1 SEL n<CR>" WHERE n IS THE PATTERN NUMBER, TO
# SELECT THE DESIRED PATTERN.
#
#
# @TSTPAT.HLP = THIS MESSAGE
```

Figure 7-5. Test Pattern Selection Menu

2. To change the test pattern to white raster type `CS N 1 SEL 15 <RET>`	The white raster test pattern will appear on all channels.
3. To get help on test patterns Type `@TSTPAT.HLP<RET>`	The test pattern selection menu shown in Figure 7-5 will appear on the system console.

4. To exit from displaying test patterns, exit from the RTS by typing `SYS E <RET>`	The test patterns will disappear and the display screen will be blank.

The following figures show the correct appearance of the test patterns.

NOTE: The SPX ramp test pattern flickers due to the manner in which it was built. The SPX color palette test patterns have several of the squares colored black.

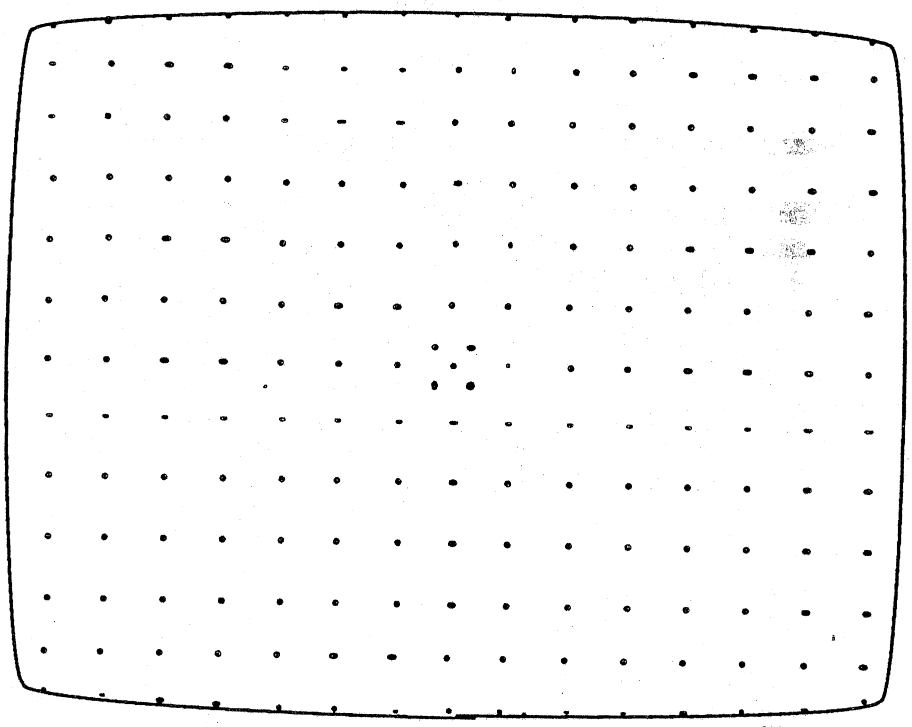


Figure 7-6. SPX Grid Test Pattern

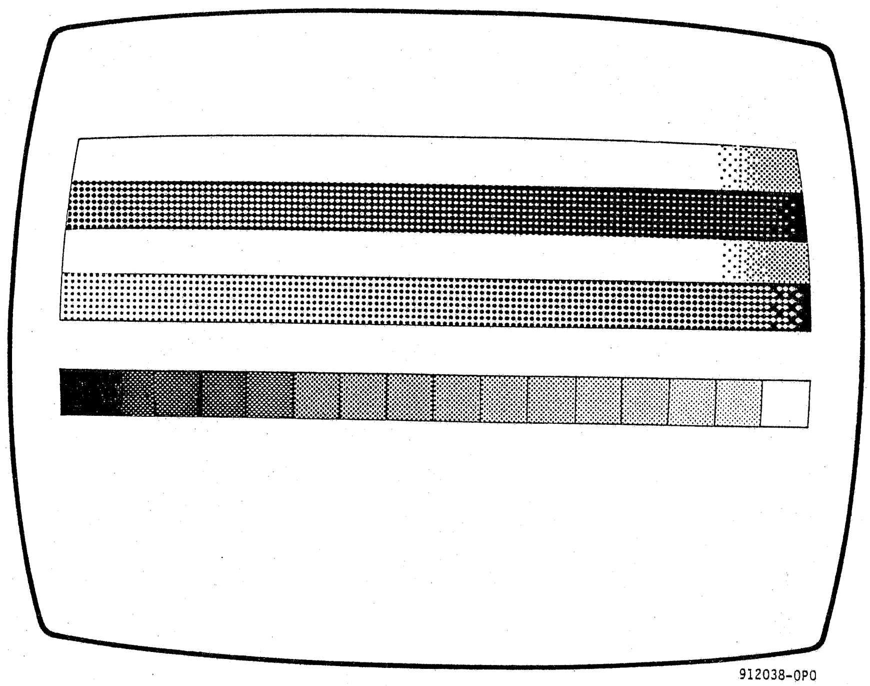
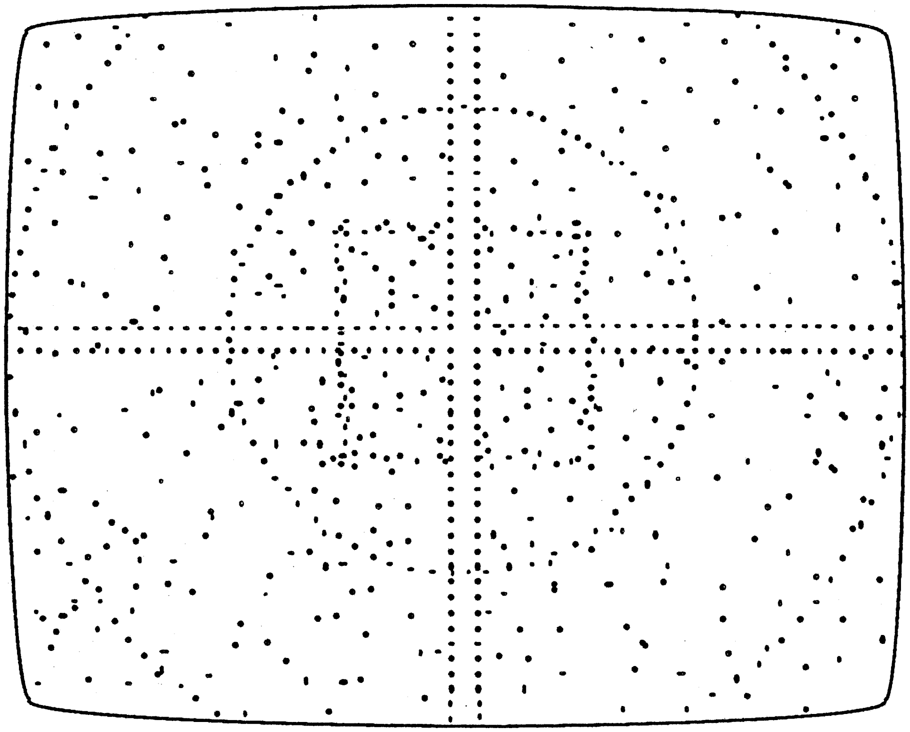
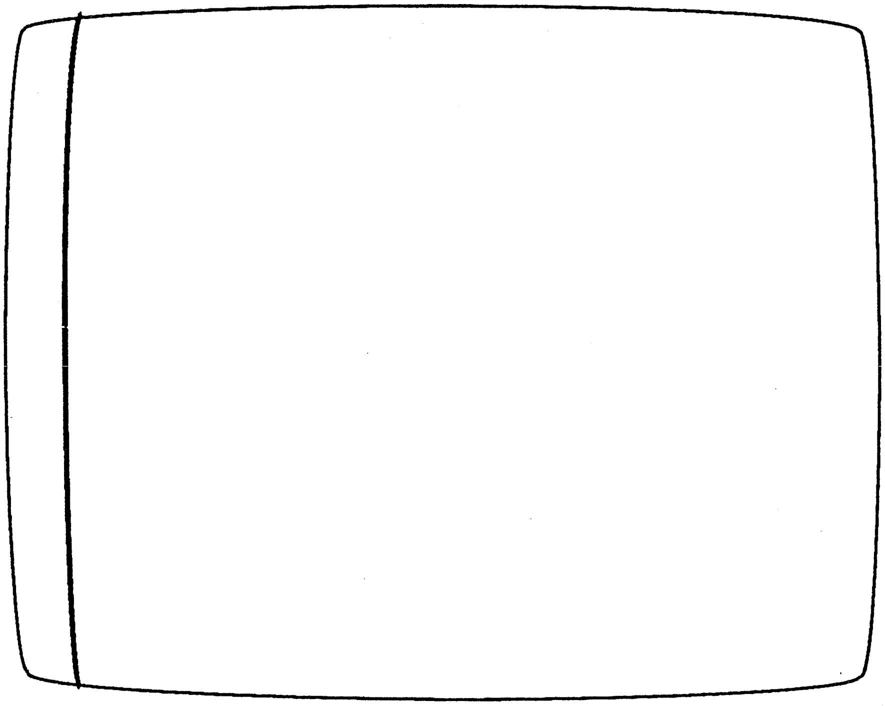


Figure 7-7. SPX Wedge Test Pattern



912037-OP1

Figure 7-8. SPX Light Test Pattern



913158-OP1

Figure 7-9. SPX Stripe Test Pattern

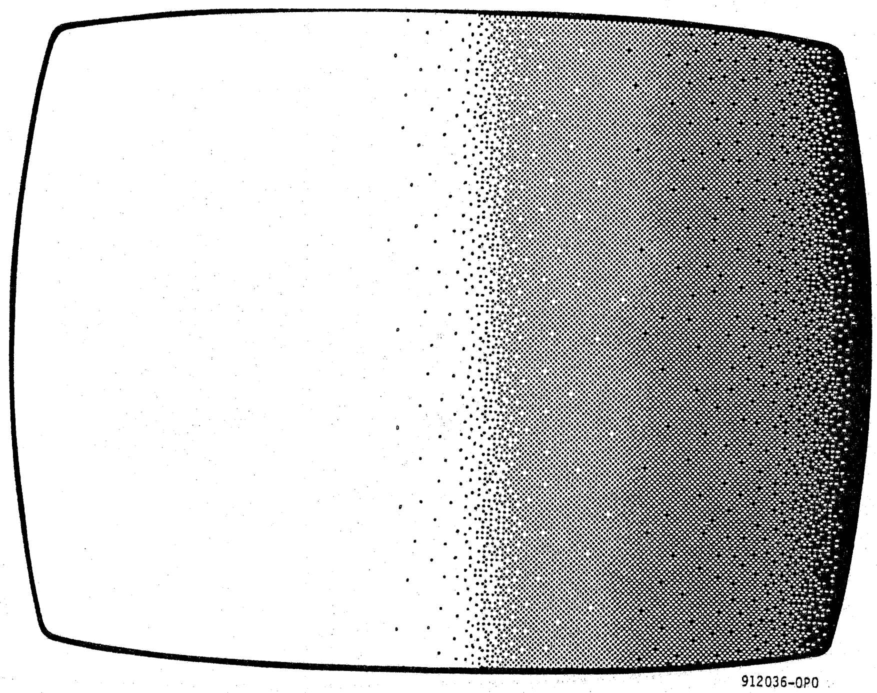


Figure 7-10. SPX Ramp Test Pattern

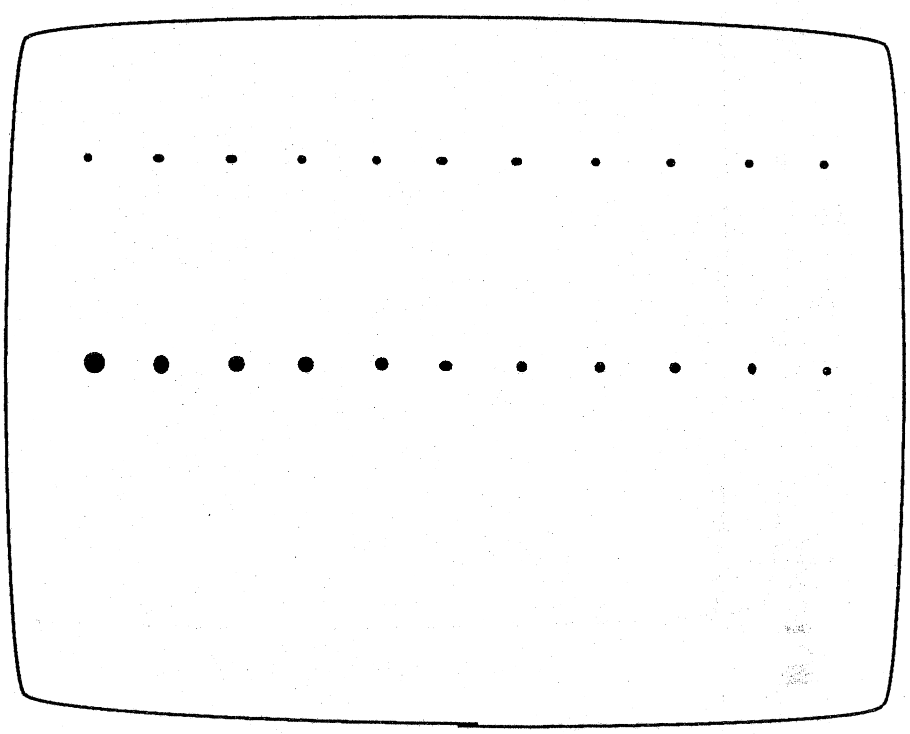


Figure 7-11. SPX Focus Test Pattern

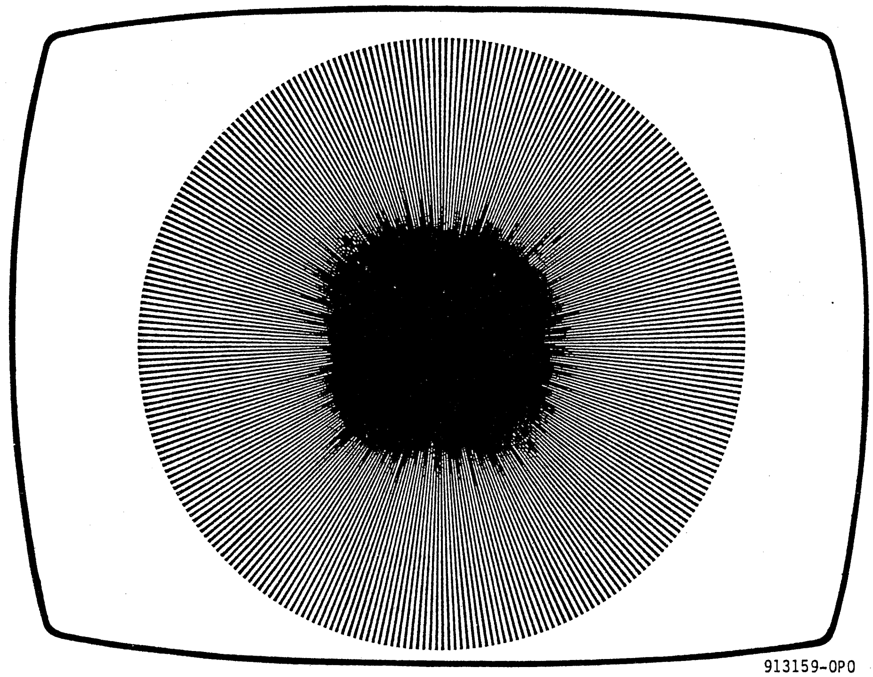


Figure 7-12. SPX Spoke Test Pattern

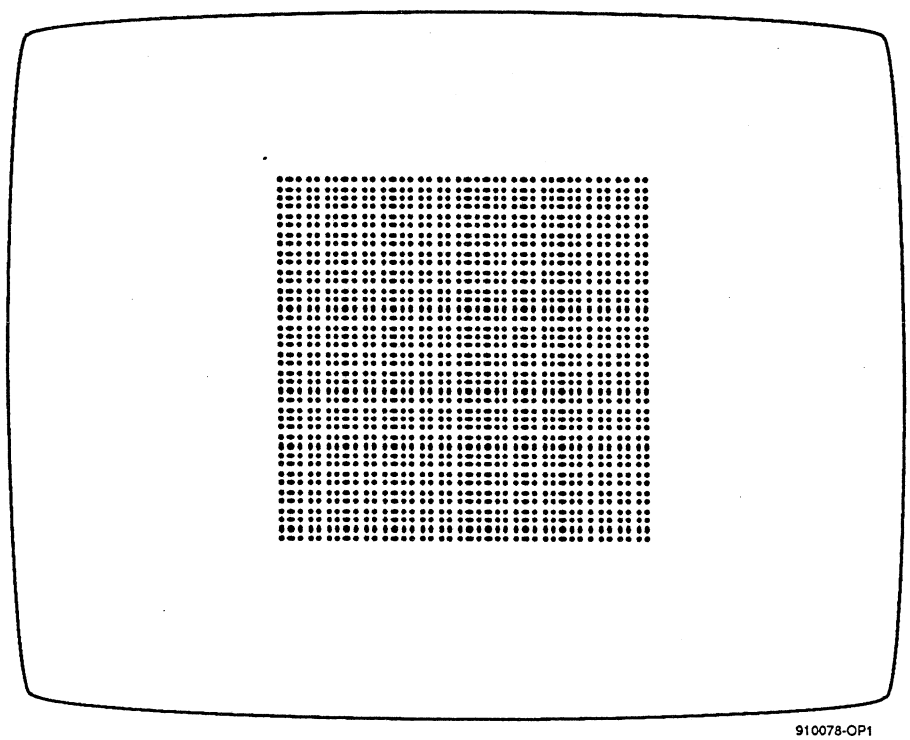


Figure 7-13. SPX Dot Test Pattern

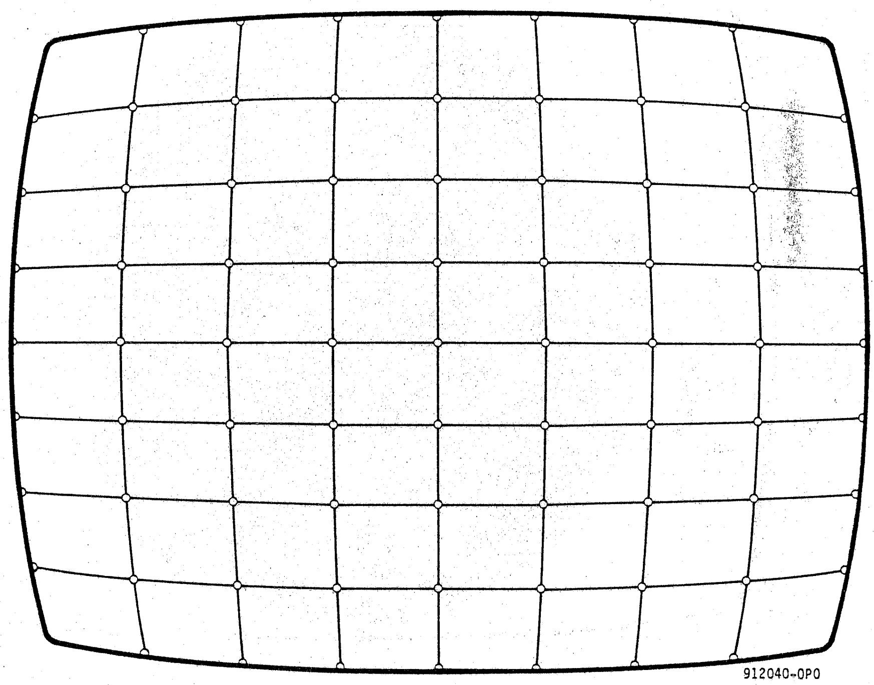
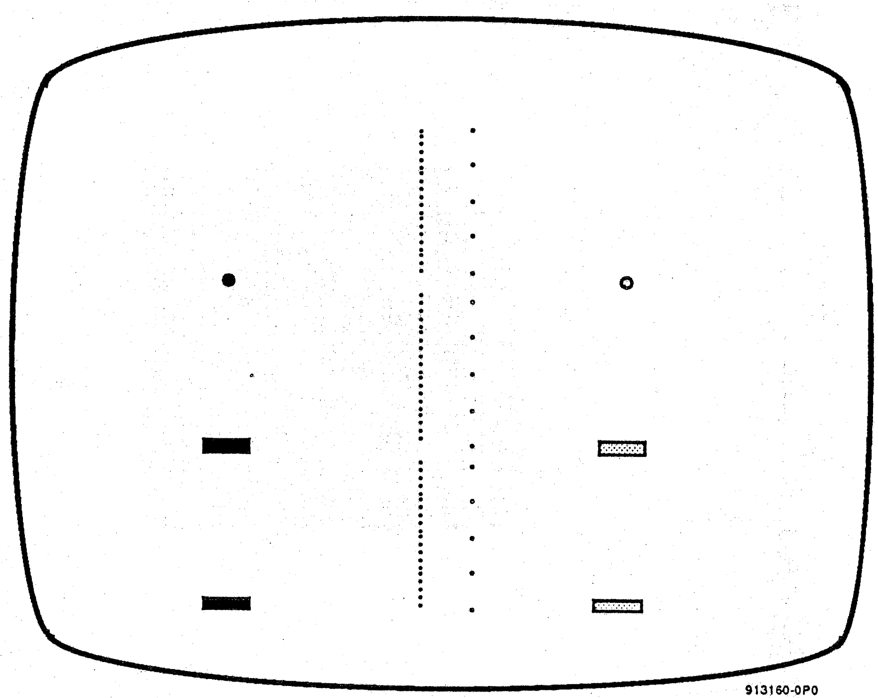


Figure 7-14. SPX Color Palette Test Pattern



NOTE: THE BLOCKS TO EITHER SIDE OF THE ROWS OF DOTS ALTERNATES OFF AND ON.

Figure 7-15 SPX Deflection Hysteresis Test Pattern

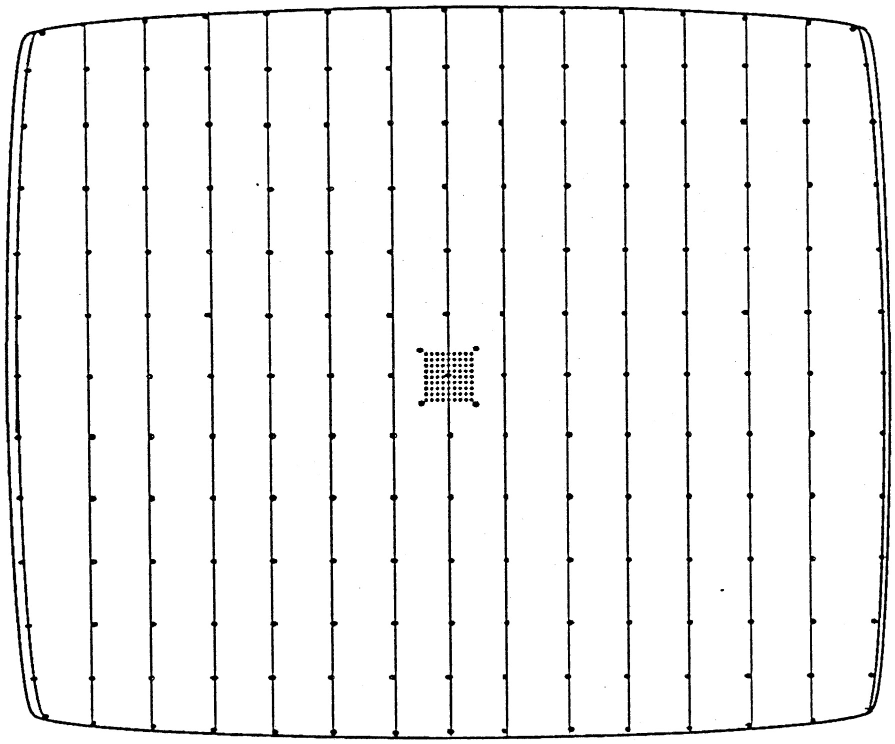


Figure 7-16 SPX Surface/Lights Test Pattern

7.3.3 Scope Driver Adjustment

This section gives the adjustment and alignment procedures required by both versions of the scope driver card (208133-100 and 208133-101) in the display processor.

The scope driver card contains several analog circuits which need adjustment to obtain a high quality image on the display. There are two major groups of adjustments, video and deflection. The video adjustments must be made for any system configuration while the deflection signals only need to be adjusted when using a calligraphic display device.

NOTE: There are no focus adjustments on the SPX scope driver card. The defocus function is performed on the data delay card (208127) and no adjustment is required (see the main pipeline card descriptions in Section 6.3.2.3).

A set of test pattern models have been created to aid in the alignment procedure. To operate the test patterns, see Section 7.3.2.2. An oscilloscope is required to make the adjustments. All of the necessary signals can be monitored on any of the cable connectors on the edge of the card. All adjustment potentiometers can also be accessed on the card edge. The output pins of the connector and potentiometers are located as shown in Figure 7-17. All adjustment potentiometers are labeled on the scope driver card.

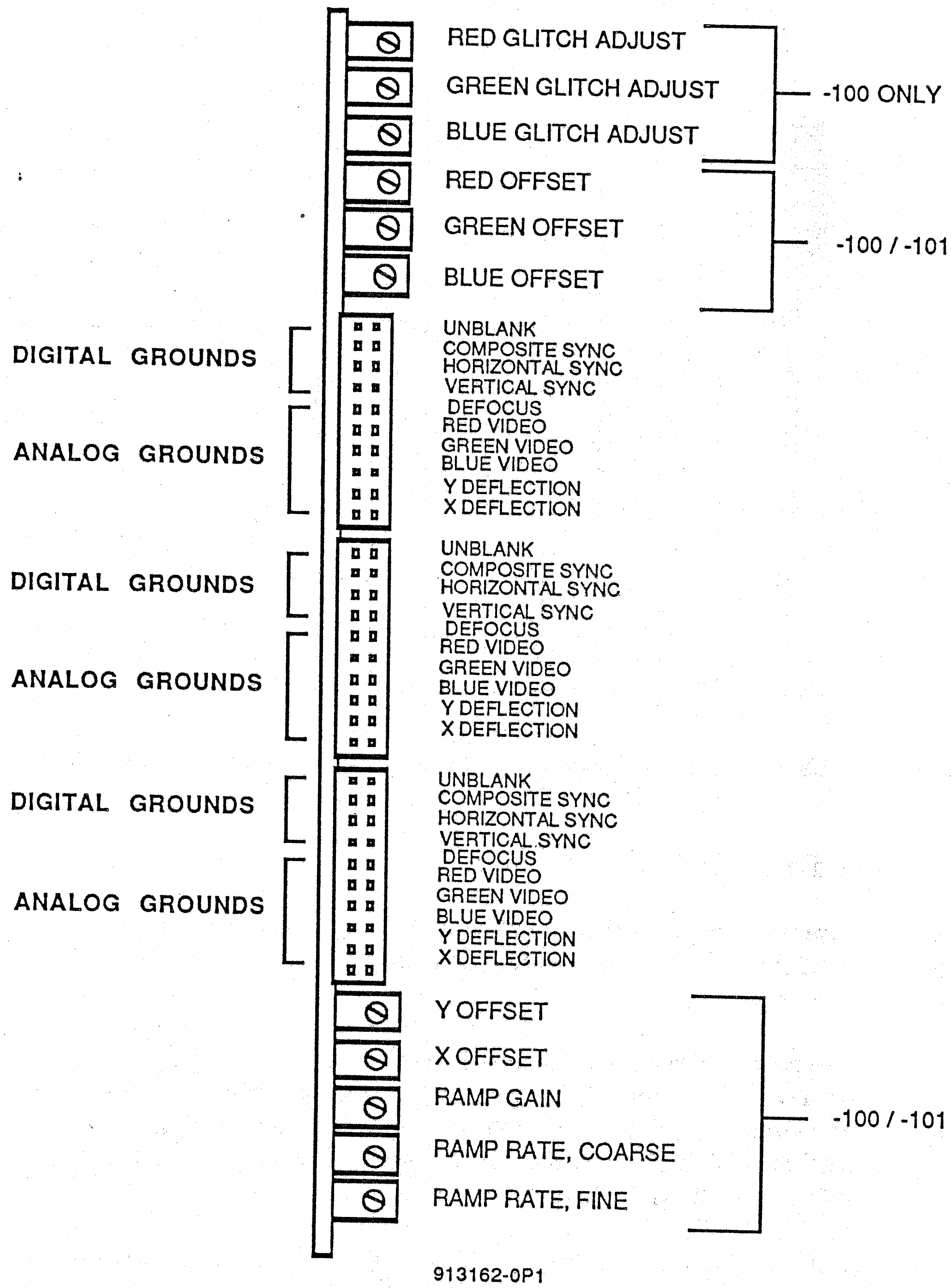


Figure 7-17. Scope Driver Card Edge View

7.3.3.1 Video Adjustments

The red, green, and blue video signals require an offset (-100/-101) and glitch adjustment (-100 only). Both of these adjustments can be done with the ramp test pattern (see Figure 7-10). Execute this pattern by typing `CS N 1 SEL 5 <RET>`. This pattern is an intensity wedge going from full brightness to zero across the screen.

7.3.3.1.1 Offset Adjustment (-100/-101)

Trigger the oscilloscope on the horizontal sync pulse while looking at the red video output (see Figure 7-17). Set the oscilloscope on 0.5 V DC/division and 10 µsec/division. The signal should be as shown in Figure 7-18. Adjust the offset potentiometer until the flat portion immediately to the right of the ramp is at zero V DC. The signal goes negative during raster retrace to force the display blank. The ramp signal is non-linear because of gamma correction.

7.3.3.1.2 Glitch Adjustment (-100 only)

Adjust the glitch potentiometer to minimize the DAC crossover glitch energy. The largest glitch is usually about midway along the ramp. It may be necessary to change the scale on the oscilloscope to see the glitch better. Repeat the offset and glitch adjustment procedures for the green and blue video outputs.

7.3.3.2 Deflection Adjustments

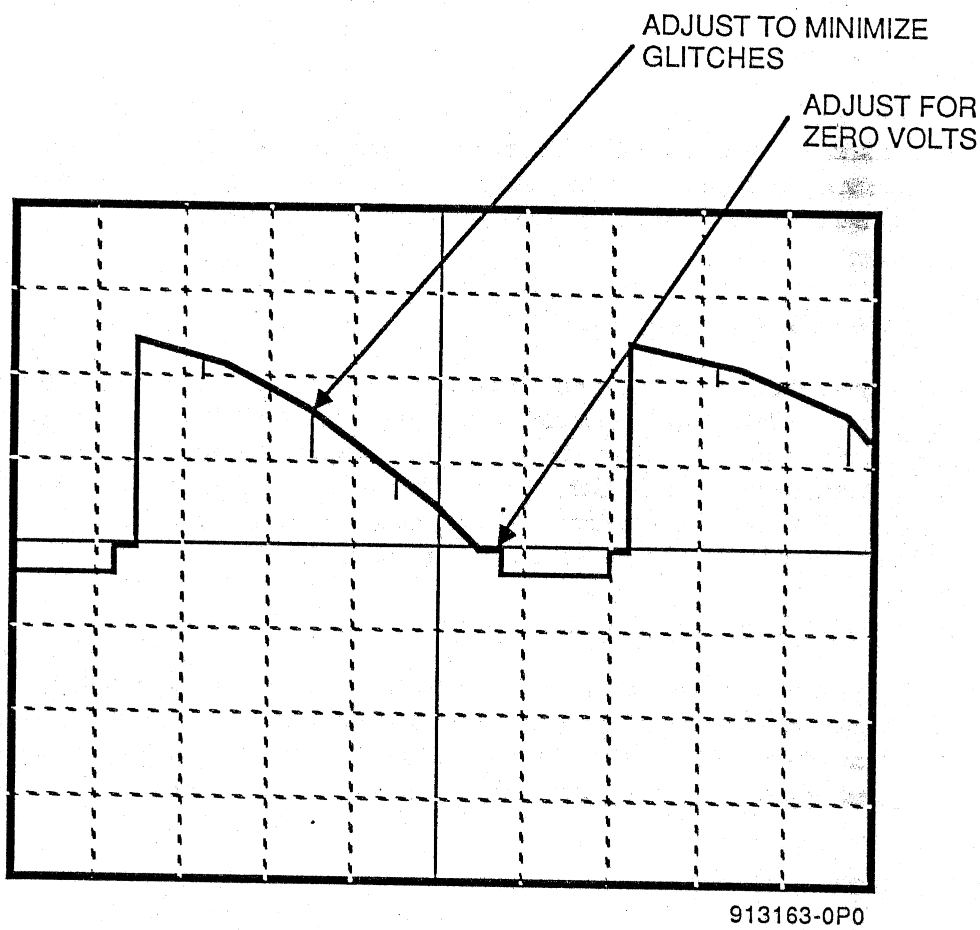
The deflection adjustments can be done with the surface/light test pattern (see Figure 7-16). Execute this pattern by typing `CS N 1 SEL 14 <RET>`.

Trigger the oscilloscope on the vertical sync pulse while looking at the Y deflection output. Set the oscilloscope on 2 V DC/division and 2 msec/division. The waveform should look like Figure 7-19.

The ramp signal is the raster scan and the horizontal lines on the right side are the light points. Adjust the Y offset until the middle light point is zero volts.

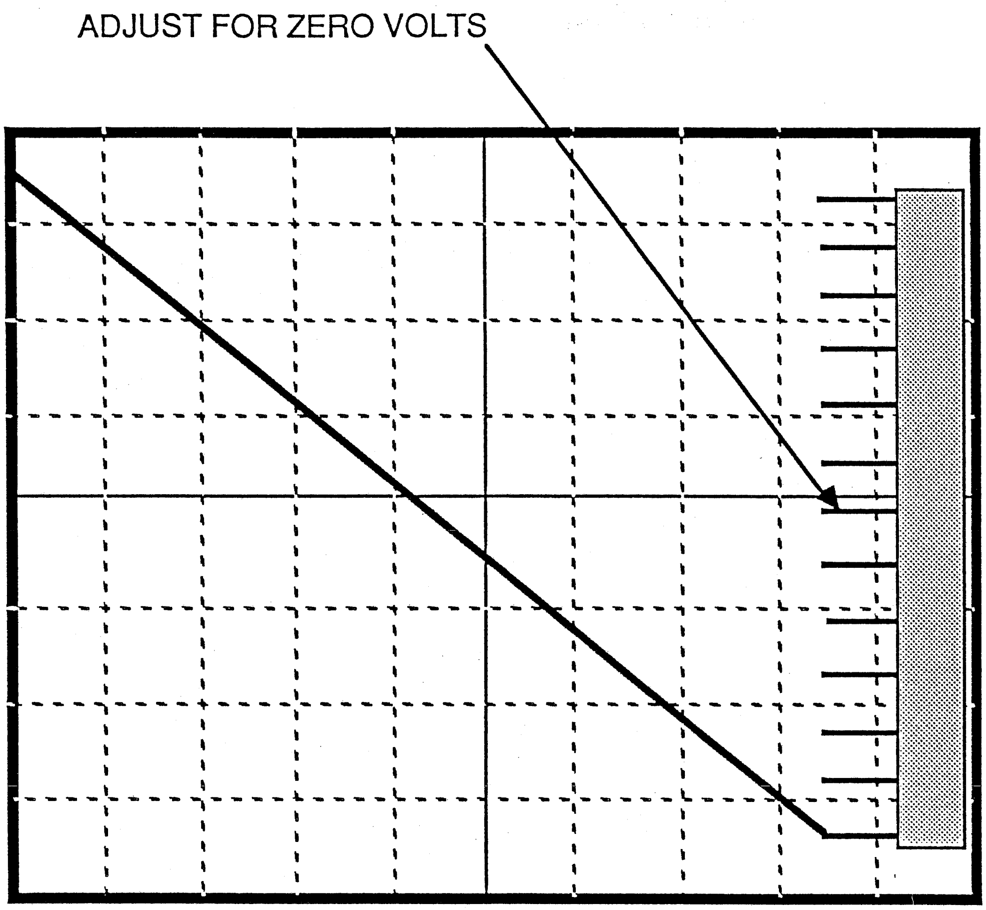
Move the oscilloscope to the X deflection output and make a similar adjustment to the X offset. This waveform should be as shown in Figure 7-20.

The gain and rate potentiometers are for aligning calligraphic light points with raster. This can also be done using the surface pattern while looking at the display. Adjust the rate potentiometer until the center column of lights aligns with the center polygon stripe. The center is marked with a square polygon with a light on each corner. Now adjust the gain potentiometer until the the lights align to the surfaces on both the left and right sides of the display. If these adjustments are not done correctly, the runway lights will not align properly with the runway.



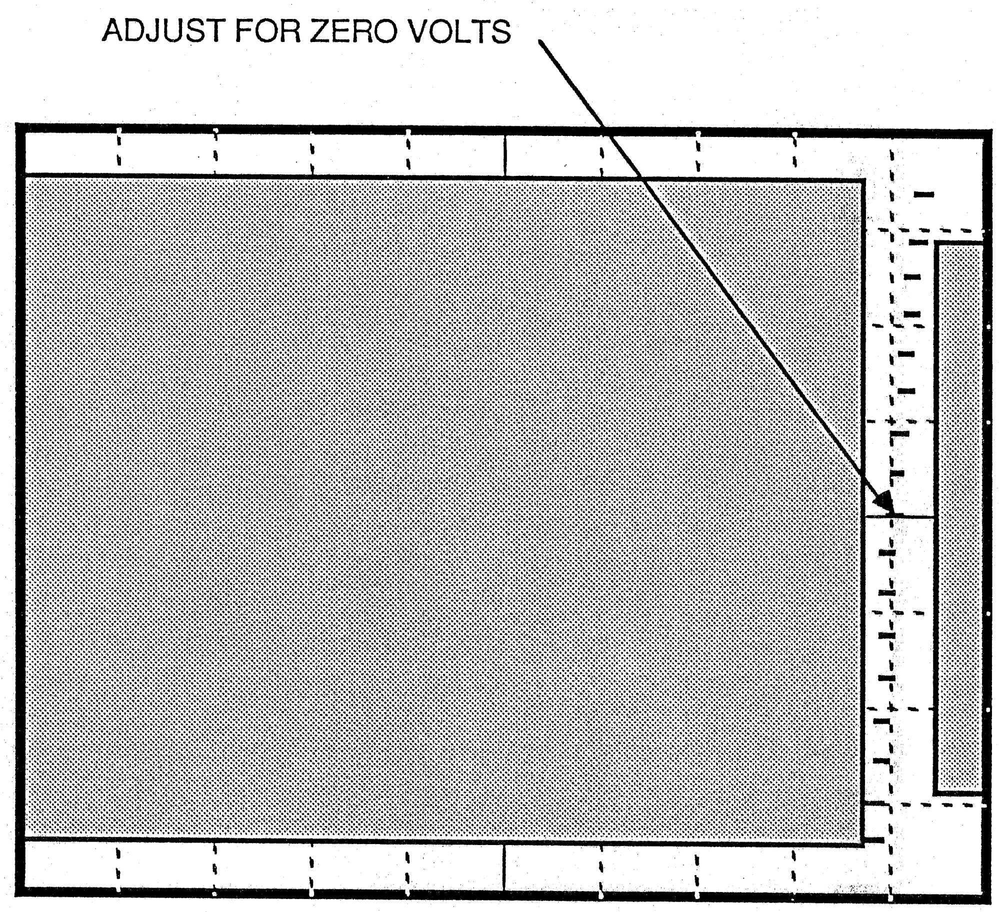
- .5 VOLTS/DIVISION
- 10 USEC/DIVISION
- TRIGGER ON H SYNC
- RAMP TEST PATTERN

Figure 7-18. Red, Green, Blue Video Waveform



- 2 VOLTS/DIVISION
- 2 MSEC/DIVISION
- TRIGGER ON V SYNC
- SURFACE TEST PATTERN

Figure 7-19. Y Deflection



- 2 VOLTS/DIVISION
- 2 MSEC/DIVISION
- TRIGGER ON V SYNC
- SURFACE TEST PATTERN

Figure 7-20. X Deflection

7.3.4 CSM Adjustment

Refer to the CSM Operation and Maintenance Manual, listed in Chapter 1, for a discussion of the adjustment of the CSM.

7.4 SPX TROUBLESHOOTING

7.4.1 SPX System Fault Tree

Basic troubleshooting procedures are shown in Figure 7-21. Additional procedures are given in the following paragraphs.

7.4.2 SPX Power Fault Tree

Power controller and SFM problems may be diagnosed by using the procedure in Figure 7-22.

7.4.3 SPX Diagnostic Tools

The SPX image generator hardware has three different ways of diagnosing various hardware failures. First, the SFM card in the power controller continuously monitors that hardware which could cause damage to other components. Second, the MP card contains its own diagnostic tests that are run every time the system is powered up and every time that the MP card is reset (see Section 5.3.2.1 and Table 5-3 for reset commands). And third, an extensive set of off-line diagnostic programs have been written to detect failures on cards in the channel processors.

7.4.3.1 Power Controller Diagnostics

The SPX power controller contains the SFM card which was designed to monitor hardware which, if it failed, could cause other pieces of hardware to fail. It monitors the incoming line voltage for either overvoltage or undervoltage conditions, the power supplies that provide power to the channel processors, the fans that cool the channel processors, the temperature sensors on each channel processor fan plate. Failures of any of these critical items will cause the cabinet in which the fault is occurring to power down. A status screen will be displayed on the system terminal (and ICC if connected) when a failure occurs. If the fault occurs in the MP cabinet (cabinet 0) the entire system will shut down. See Sections 5.3.3, 6.4, and 6.5.4 and Figure 7-22 for further information.

7.4.3.2 MP Diagnostic Tests

The MP card contains its own diagnostic tests that are executed every time the system is powered up and every time that the MP card is reset. These tests verify proper operation of all sections of the card. They include testing of the 68000 MPU, all RAM and ROM memory arrays, the DMA chip, the Ethernet chip, the disk interface circuit and the MFP serial port circuits; the TMS320 onboard parallel processor, and the address error and bus error detection circuitry.

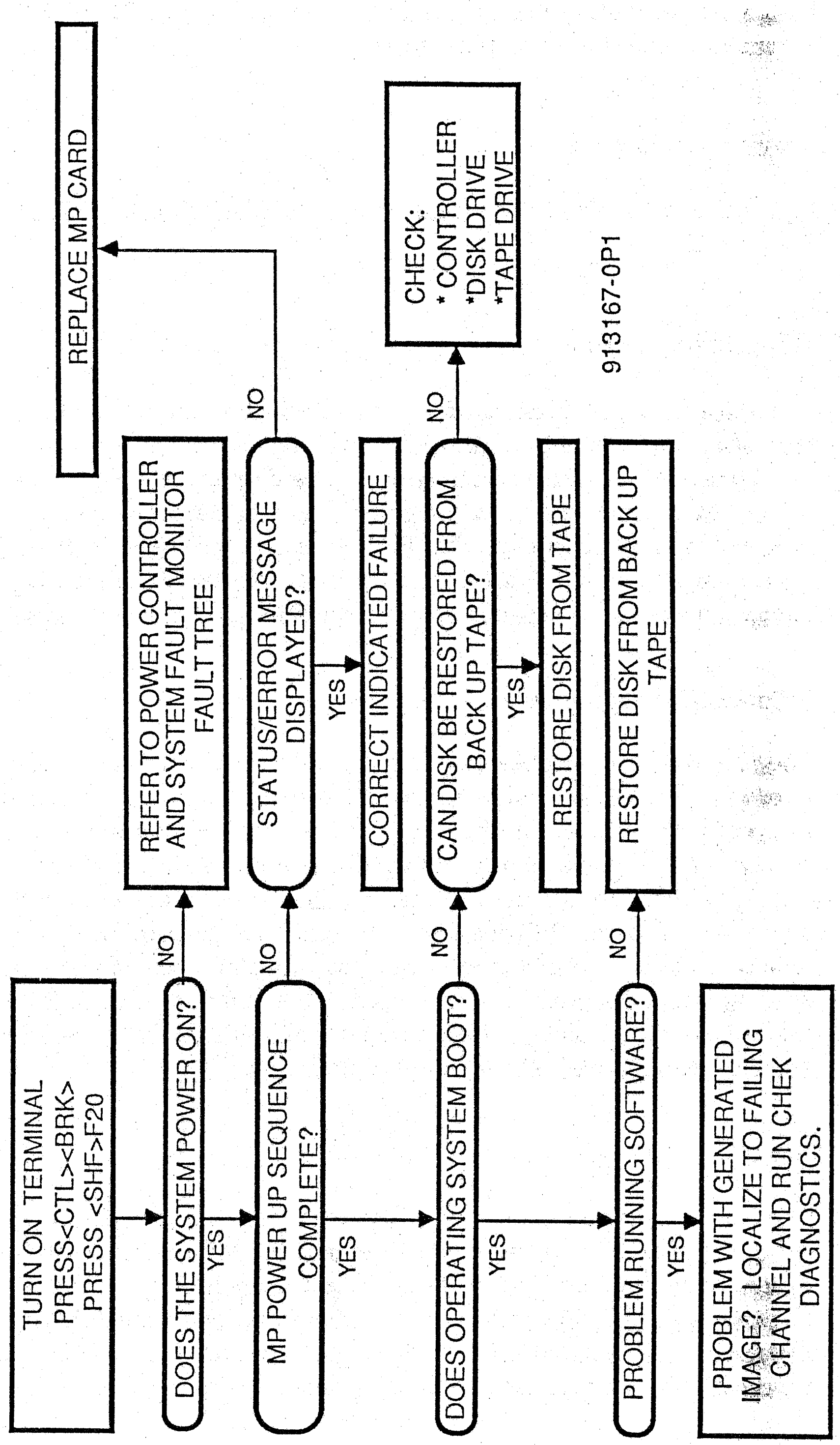


Figure 7-21. SPX System Fault Tree

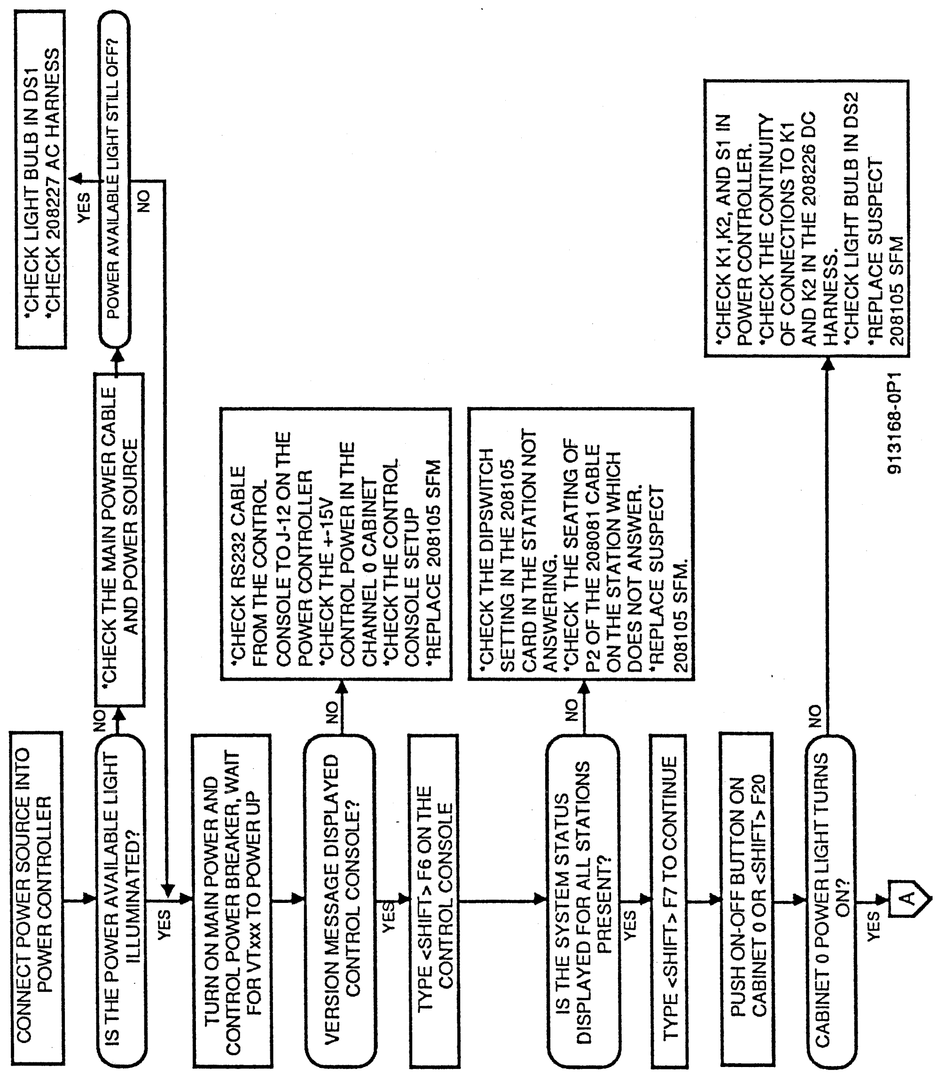


Figure 7-22. Power Controller and System Fault Monitor Fault Tree (Sheet 1 of 4)

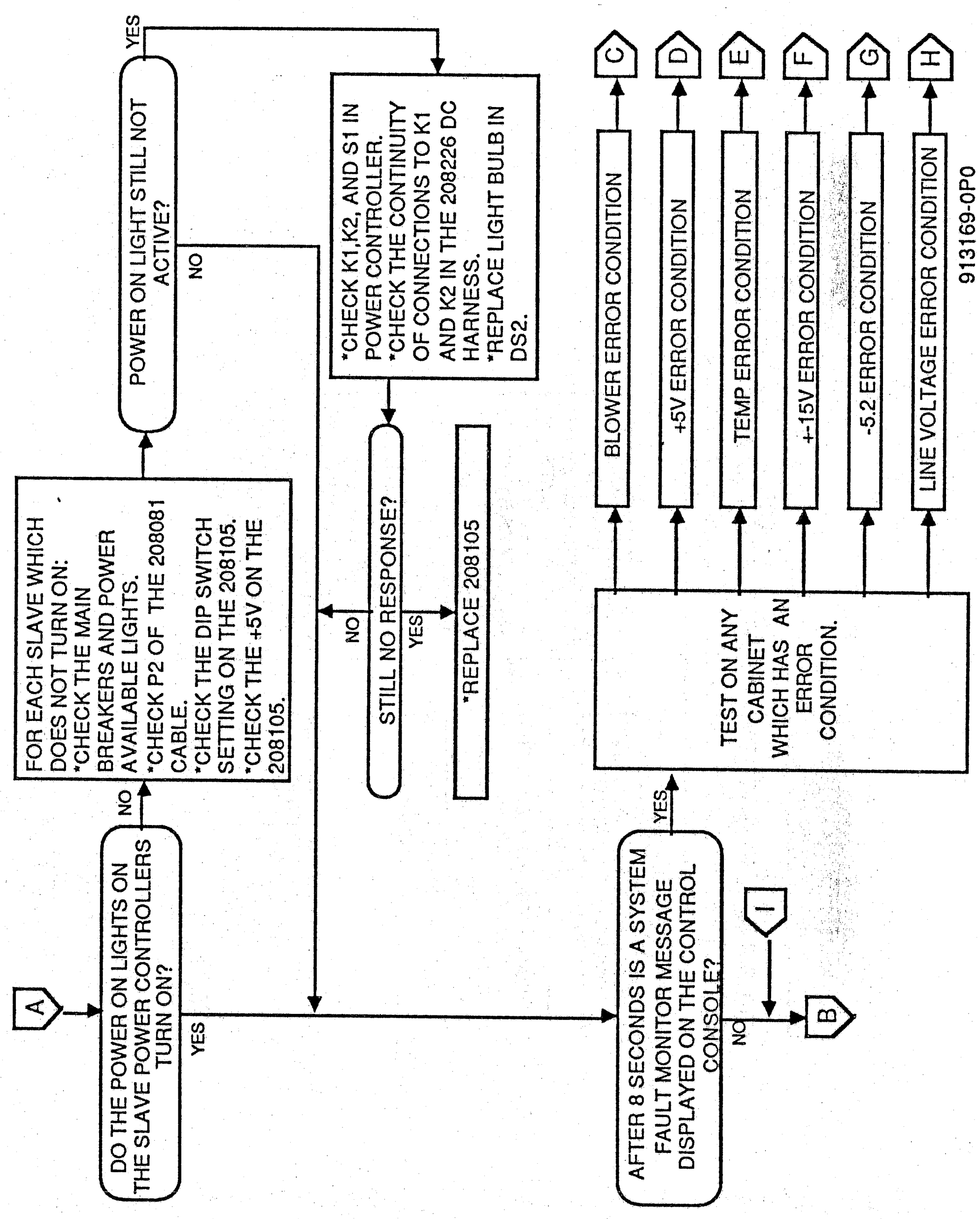


Figure 7-22. Power Controller and System Fault Monitor Fault Tree (Sheet 2 of 4)

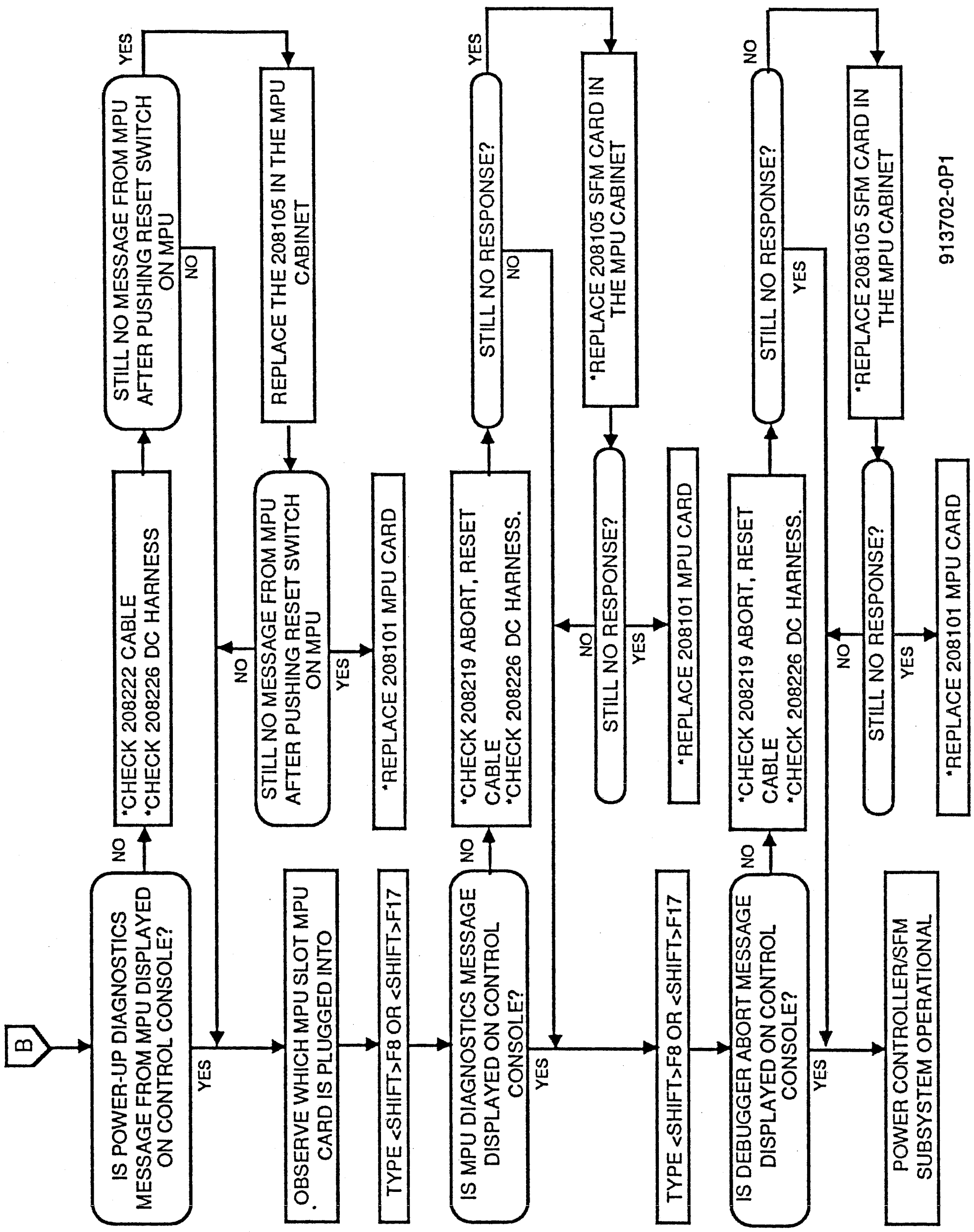


Figure 7-22. Power Controller and System Fault Monitor Fault Tree (Sheet 3 of 4)

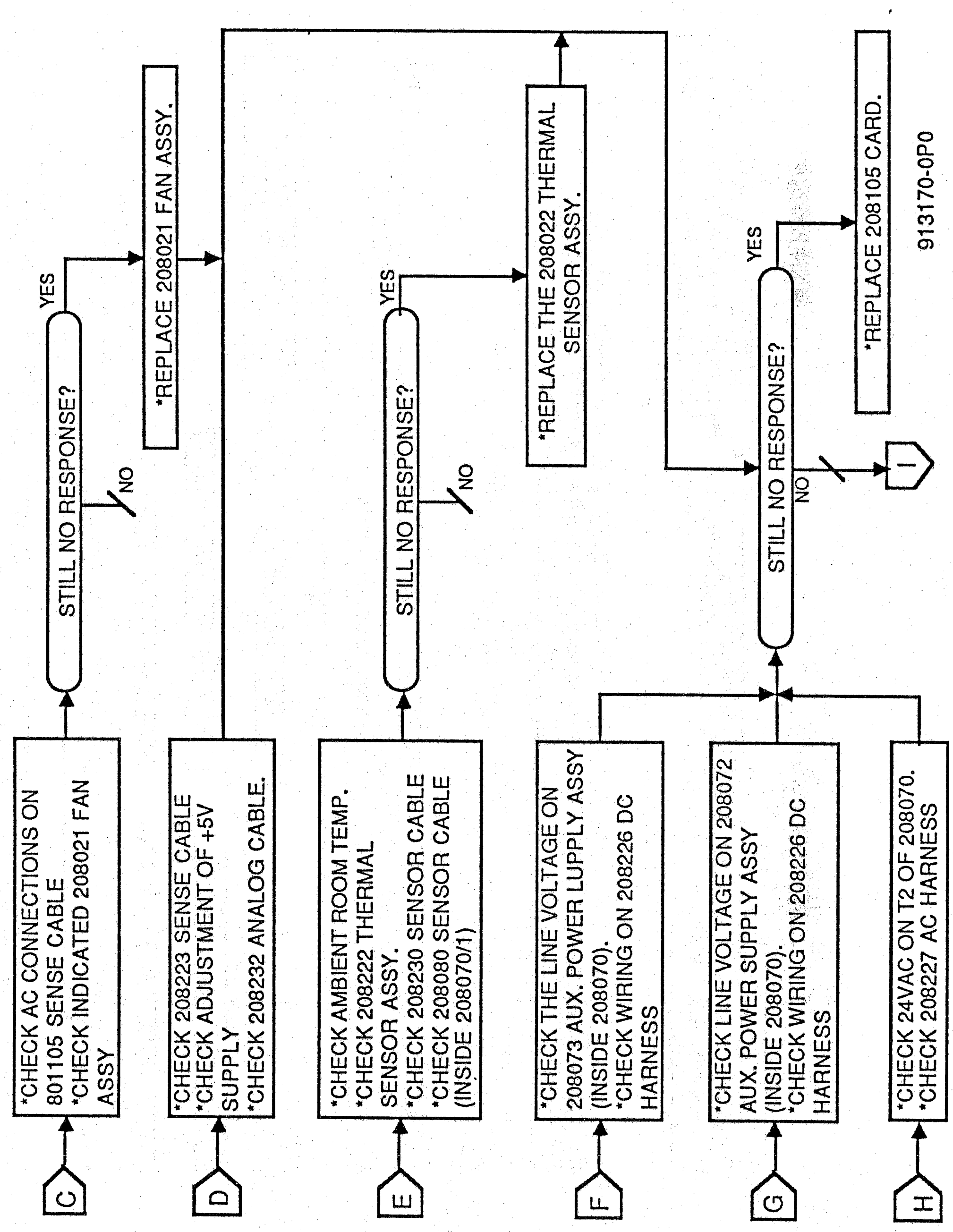


Figure 7-22. Power Controller and System Fault Monitor Fault Tree (Sheet 4 of 4)

Successful completion of the MP card test will result in an autoboot of the operating system. The following is a printout for a successfully completed MP diagnostic power on sequence.

```
MP Card Tests   V1.0 1-JUN-86
EPROM checksum test passed
Testing MFP serial port devices ...
Testing static memory ...
Testing dynamic memory, (type ctrl C to abort) ...
Testing DMA controller ...
Testing co-processor ...
Testing ethernet interface ...
Testing common bus mail box memory ...
Testing disk/tape controller ...
---booting operating system, please wait ---
```

See Appendix B for documentation on the Magnetic Media Diagnostic (MMD) software

7.4.3.3 Channel Processor Tests

The CHEK program is a language that allows testing of the channel processor card sets. The language permits the user to operate the hardware using the following:

1. Individual commands
2. CHEK tests
3. Execution of user prepared card tests

The CHEK program must be executed from the system monitor (see Figure 7-23). CHEK is specifically written to operate with the hardware, which is accessed through shift loops on each card attached to the clock maintenance card.

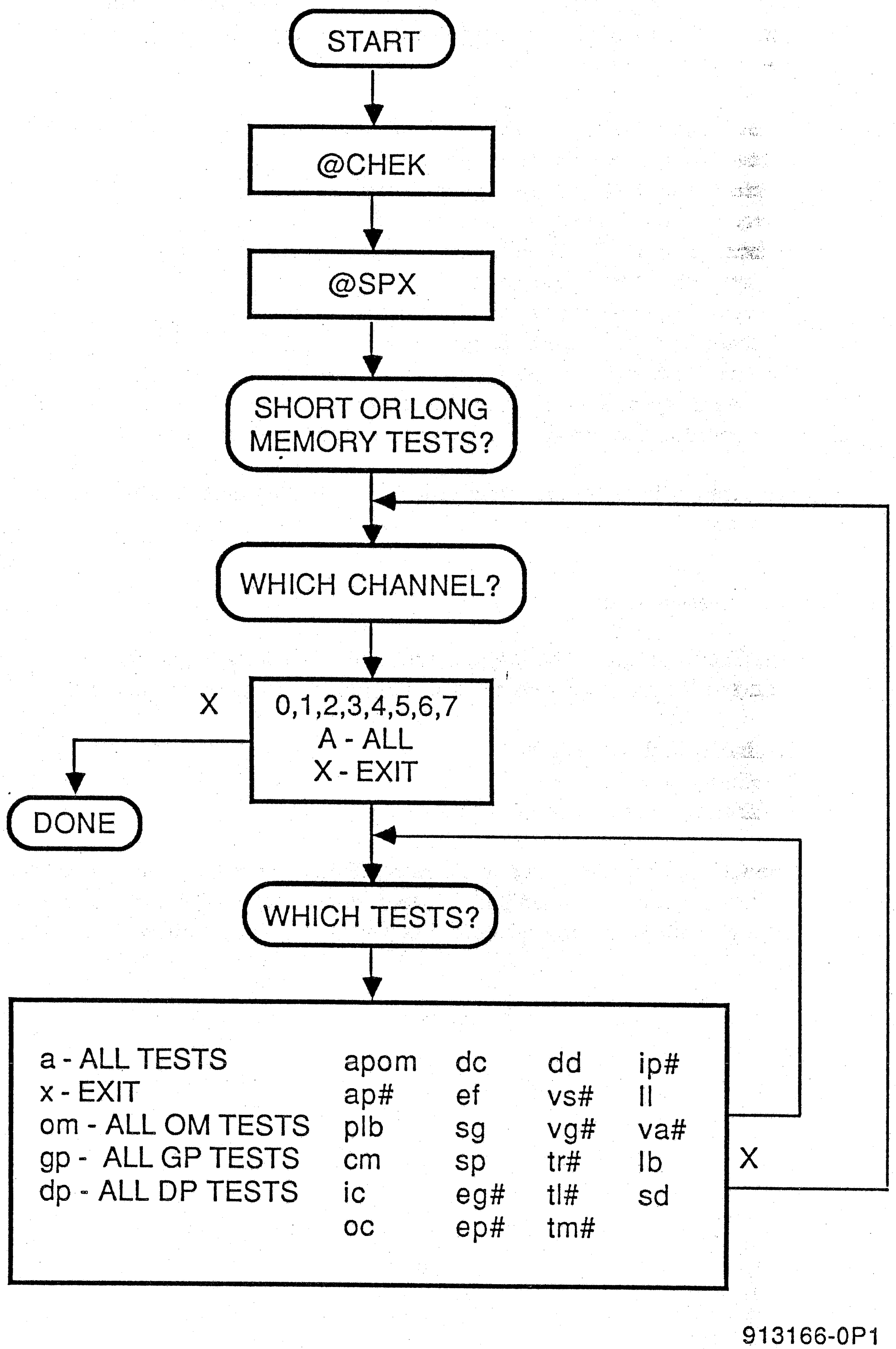


Figure 7-23. CHEK Diagnostic Program Execution

7.4.3.4 Shift Loops

A shift loop is a serial data path through serial registers on the circuit cards. Each shift loop is identified by a device name (see Table 7-2), and contains a set of registers that can be accessed with CHEK. Each register can be accessed with a CHEK register name. These names are printed on the card schematics near the hardware register. Shift loops are tested using the SLV command. The maintenance station verify (MSV) command tests the integrity of the clock maintenance card and the interface to the MP unit.

Table 7-2. SPX Shift Loops

Device Name	In*	Out*	Card Part Number
APOM	45.29	45.37	208112
AP0	50.29	50.37	208112
AP1	51.29	51.37	208112
AP2	52.29	52.37	208112
AP3	53.29	53.37	208112
AP4	54.29	54.37	208112
AP5	55.29	55.37	208112
AP6	56.29	56.37	208112
AP7	57.29	57.37	208112
PLBD	49.29	49.37	208113
PLB	49.29	49.37	208113
IC	41.29	41.37	208121
EG0	9.29	9.37	208123
EG1	10.29	10.37	208123
VSX	26.29	26.37	208125
VSY	25.29	25.37	208125
VSZ	13.29	13.37	208125
VG0	11.29	11.37	208126
VG1	12.29	12.37	208126
DD	40.29	40.37	208127
EP0	5.29	5.37	208128
EP1	6.29	6.37	208128
EP2	7.29	7.37	208128
EP3	8.29	8.37	208128
IP0	1.29	1.37	208129
IP1	2.29	2.37	208129
IP2	3.29	3.37	208129
IP3	4.29	4.37	208129
VAINR0	31.29	31.37	208130
VAINR1	32.29	32.37	208130
VAING0	33.29	33.37	208130
VAING1	34.29	34.37	208130
VAINB0	35.29	35.37	208130
VAINB1	36.29	36.37	208130

Table 7-2. SPX Shift Loops - Continued

Device Name	In*	Out*	Card Part Number
VAOUTR0	31.29	31.37	208130
VAOUTR1	32.29	32.37	208130
VAOUTG0	33.29	33.37	208130
VAOUTG1	34.29	34.37	208130
VAOUTB0	35.29	35.37	208130
VAOUTB1	36.29	36.37	208130
DCIN	38.29	38.37	208131
DCOUT	38.29	38.37	208131
OC	39.29	39.37	208132
SD	30.29	30.37	208133
LL	14.29	14.37	208140
LBIN	37.29	37.37	208141
BOUT	37.29	37.37	208141
TR0	23.29	23.37	208150
TR1	24.29	24.37	208150
TR0	21.29	21.37	208151
TR1	22.29	22.37	208151
TM0	15.29	15.37	208152
TM1	16.29	16.37	208152
SP **	42.29	42.37	208134
SP **	43.29	43.37	208124
SP **	44.29	44.37	208122

* In/out numbers (XX.YY) represent circuit card slot (XX) and connector (YY) pin numbers.

** The SP device is comprised of three different cards.

7.4.3.5 SPX Diagnostic Organization

CHEK allows the user to set up known data in the hardware, issue clocks, and read data back. There are also logical and mathematical commands which can be used to simulate what the hardware should be doing. This allows tests to be written which can exercise small portions of the hardware so a fault can be isolated to a small section of hardware. The CHEK tests supplied with the system are geared to card-level fault isolation. For more detailed information, see the *CHEK Diagnostic Language Reference Manual.*

The CHEK diagnostics package performs various tests on the image generator hardware. These tests are designed to locate malfunctions within the cards. The tests will indicate the most probable faulty card by an error message printed on the terminal.

The CHEK diagnostics package contains individual card tests, driver files, and configuration files. The configuration file contains system specific parameters such as the resolution configuration of cards. It also contains expected signatures for PROMs in the system. This allows changes in PROMs or system configuration without changing individual card tests.

CAUTION: To avoid possible damage should an abnormal condition occur, it is recommended that the display power be turned OFF before running any CHEK diagnostic tests.

7.4.3.6 SPX Diagnostic Procedures

The driver file allows the user to specify which channels and which card tests should be executed. This provides a user-friendly interface for running the diagnostic tests. To execute the driver file, start CHEK and execute a driver command file as follows:

```
RUN CHEKxx
```

or

```
@CHEK
@SPX
```

After running CHEK, the system will respond with a >> herald. At this point, CHEK command files, subroutines, or individual instructions can be executed. The command @SPX executes a command file which runs the diagnostics driver.

The driver file will first load in a name table containing all of the shift loop device names as well as the register names. It will then read in the configuration file followed by the channel driver. The configuration file contains information such as channel configuration and expected signatures for various PROMs in the system.

The channel driver asks if short or long memory tests are desired. The short version will test the integrity of all address and data lines of the large RAM arrays, but will not thoroughly test the RAM chips. The long version will test the entire RAM array. Typical short tests will run in about two minutes, while some of the long tests require about ten to 45 minutes per card. Typical test run times are listed in Table 7-3. The user can change from short to long memory tests or visa versa by exiting the driver and reentering, or by typing <CTRL/U>, which toggles a CHEK flag that is used by the test files to determine if long or short tests are to be run.

Next, the driver asks which channel is to be tested. If all channels are requested, the driver will prompt for the numbers of the channels that are configured. Card tests will be automatically run on all of the channels that are configured. If only one channel is entered, a card driver file will be executed which asks the user which card tests are to be run.

Table 7-3. Typical CHEK Test Times (-500H)

Card	Short	Long	All Short	All Long
Driver	0:41	0:41	0:41	0:41
111 EM	8:50	12:25	8:50	12:25
112 AP	1:17	9:27	*6:00	*51:00
113 PLB	0:36	17:18	2:00	16:00
120 CM	0:49	0:49	0:49	0:49
121 IC	0:50	0:50	0:47	0:47
122 SP	3:21	3:31	3:04	3:04
123 EG	0:14	0:14	0:28	0:28
124 SG	0:41	5:22	0:45	5:00
125 VS	0:24	0:24	1:15	1:15
126 VG	1:16	12:38	2:24	22:20
127 DD	0:52	7:00	0:52	6:25
128 EP	1:20	1:20	5:20	5:20
129 IP	0:33	0:33	2:12	2:12
130 VA	0:23	4:57	2:36	27:00
131 DC	2:24	3:35	1:56	3:10
132 OC	3:52	3:52	3:49	3:49
133 SD	0:12	0:12	0:12	0:12
134 EF	1:20	1:20	1:18	1:18
140 LL	0:12	18:12	0:13	16:05
141 LB	0:52	0:52	0:40	0:40
150 TR	2:34	2:34	4:10	4:10
151 TL	2:04	2:04	3:44	3:44
152 TM	2:11	50:00	4:20	88:40
Total			46:30	> 5 hrs

* Assumes there are 7 AP cards in the system.

NOTE: Test times vary depending upon the revision level of the card being tested.

After the channel has been specified, a maintenance station verify (MSV) and shift loop verify (SLV) will be done on all of the cards in that channel.

The card driver program has several options for running tests. The user can run all tests in the selected channel, all OM tests, all GP tests, all DP tests, or individual card tests. If a card test if requested and the card is not in the system, a message will be printed indicating this.

At any level in the driver file where user input is required, entering a question mark will produce a list of available commands.

The channel driver and card driver programs can be exited by typing X. When the channel driver is exited, a printout lists the total number of errors encountered during this session of diagnostics. This allows the user to see if any errors have occurred which may have scrolled off screen.

Two other toggle flags that are useful in troubleshooting are <CTRL/H> (hold and loop) and <CTRL/L> (loop on error). <CTRL/H> will cause the CHEK test to loop continually on the current test. This can be useful in finding intermittent failures. <CTRL/L> will allow the test to run normally until an error is encountered, at which time the hold and loop flag will automatically be set causing the failing test to be run continuously. <CTRL/G> can be used to turn off the bell which occurs on each occurrence of an error.

7.4.3.7 CHEK Diagnostics Example

The following is an example of the CHEK diagnostics test run. User input is prompted for with the `GET>>` prompt of CHEK. After entering CHEK and running the diagnostics command file, the first choice is whether to run the long or short memory tests. Entering a question mark will obtain a help menu. If an illegal input is used, the program will ignore it and repeat the input prompt.

After selecting a valid channel, a maintenance station verify is performed and all of the shift loops in that channel are tested.

The next level requests which card tests in the selected channel are to be executed. Again a question mark will yield a selection menu. If a card test is selected and that card is not present in the system, the not present message will be displayed.

The scope driver test is an example of an error message. The error message will ring the terminal bell to indicate an error has been received. It will also display the expected and received data, the register that failed, and which cards to suspect. The error number references the failure to the test file listings.

After completing all of the desired tests in the selected channel, the driver program can be exited by typing `X`. The channel driver can be exited in the same manner. Upon exiting the channel driver, a summary of all the cards that received errors is displayed. This is helpful when running diagnostics on many cards since the error messages may have scrolled off screen.

```
@CHEK
>> Welcome to CHEK
>> @SPX

SHORT OR LONG MEMORY TESTS? (S/L)
      GET>> s

WHICH CHANNEL?
      GET>> ?

0,1,2,3,4,5,6,7 - CHANNEL NUMBER
A - ALL CHANNELS
```

```
X - EXIT

WHICH CHANNEL?
      GET>> 0

CHANNEL 0 DIAGNOSTICS

MAINTENANCE STATION VERIFY
DONE
SHIFT LOOP VERIFICATIONS
DONE

WHICH CARD TESTS?
      GET>> ?

**** SECTION TEST COMMAND OPTIONS ****

A - ALL CARD TESTS
OM - ALL OBJECT MANAGER CARD TESTS
GP - ALL GEOMETRIC PROCESSOR CARD TESTS
DP - ALL DISPLAY PROCESSOR CARD TESTS

X - EXIT

**** OM AND GP CARD TEST COMMAND OPTIONS ****

APOM - OM ARITHMETIC PROCESSOR CARD 208112
AP# - GP ARITHMETIC PROCESSOR CARD (# = 0-7)    208112
PLB - POLY/LIGHT BUFFER CARD  208113
CM - CLOCK MAINTENANCE CARD   208120

**** ENTER COMMAND OR TYPE ? FOR MORE HELP ****
      GET>> ?
**** DP CARD TEST COMMAND OPTIONS ****

IC - INPUT CONTROL CARD 208121
OC - OUTPUT CONTROL CARD      208132
DC - DRAM CONTROL CARD  208131
EF - EDGE FILE CARD     208134
SG - SPAN GENERATOR CARD      208124
SP - SPAN PROCESSOR CARD      208122
EG# - EDGE GENERATOR CARD (# = 0-1) 208123
EP# - EDGE PROCESSOR CARD (# = 0-3) 208128
DD - DATA DELAY CARD    208127
VS# - VECTOR SCANNER CARD (# = X,Y,Z)     208125

**** ENTER COMMAND OR TYPE ? FOR MORE HELP ****
      GET>> ?
**** DP CARD TEST COMMAND OPTIONS ****
```

```
VG# - VISIBILITY GENERATOR CARD (# = 0-1) 208126
TR# - TEXTURE RECIPROCATOR CARD (# = 0-1) 208150
TL# - TEXTURE LAMBDA CARD (# = 0-1) 208151
TM# - TEXTURE MAP CARD (# = 0-1)    208152
IP# - INTENSITY PROCESSOR CARD (# = 0-3)  208129
LL - LANDING LOBE CARD  208140
VA# - VIDEO ASSEMBLER CARD (# = R0-1,G0-1,B0-1) 208130
LB - LIGHT BUFFER CARD  208141
SD - SCOPE DRIVER CARD  208133

WHICH CARD TESTS?
      GET>> LB

-------- LB CARD NOT PRESENT --------

WHICH CARD TESTS?
      GET>> sd
SD TEST
*ERROR* ***********************************************
SYNC INPUT OR REGISTER FAILURE
SYNC = >4, >5 (REC, EXP)
SUSPECT SD CARD 208133
ALSO SUSPECT OC CARD 208132
FAILED AT ERROR NUMBER 3.0

ERRORS = >1 TOTAL ERRORS = >1

WHICH CARD TESTS?
      GET>> X

WHICH CHANNEL?
      GET>> X

SPX TESTS COMPLETED

************************************************
1 ERRORS RECEIVED
************************************************

-------- FAILING TESTS IN CHANNEL 0 --------
SD

-------- FAILING TESTS IN CHANNEL 1 --------

-------- FAILING TESTS IN CHANNEL 2 --------

-------- FAILING TESTS IN CHANNEL 3 --------
```

```
-------- FAILING TESTS IN CHANNEL 4 --------

-------- FAILING TESTS IN CHANNEL 5 --------

-------- FAILING TESTS IN CHANNEL 6 --------

-------- FAILING TESTS IN CHANNEL 7 --------

        >> XIT or <CONTROL/Z>
```

7.5 ADVANCED TROUBLESHOOTING TECHNIQUES

The CHEK diagnostics package will find most hard failures, but sometimes an intermittent failure or timing problem may exist which cannot be found with CHEK. By understanding the basic operation of each section of the system, it is sometimes possible to isolate a failure quickly while looking at the display. Each section of the system is unique and will create a unique problem when a failure occurs. The following tips may help in isolating the failure to a small set of cards in the system. The list of suspected cards can further be reduced by running CHEK diagnostics or by replacing the suspected cards with known good cards.

The image seen on the display device can be a very powerful debugging tool. The first step in isolating a failure is to determine in which channel the failure is occurring. If the system is timing out, the real-time system will print out the faulty channel number. This could be caused by a bad data base, a bad control card, or corrupted microcode. If the system does not time out, but has visible errors in the scene, observe these errors carefully to determine if they are related to an object, a polygon, a light, or some section on the screen, and which channel they appear in.

If multiple channels exhibit a similar failure, suspect the MP unit, common bus interface cable, or data base. These are the only components that are common across multiple channels. If the failure occurs in one channel only, examine the failure and proceed as follows.

If an entire object is in error, suspect the OM or GP cards. Problems in the OM section can result in large portions of the data base being misplaced or completely rejected.

If a polygon is in error, suspect the GP or DP cards. Failures such as a misplaced vertex, or polygons that fail when partially off screen are probably GP-related problems. If a failure changes to different polygons or appears cyclical, this could be a faulty AP card in the GP.

If the GP section is suspected as the source of the problem, use the KILL AP command in CLI (see the *SPX Real Time System Users Manual*) to individually turn off AP cards. If the problem changes but is not omitted, it is because the distribution of objects to AP cards has changed and the bad AP card is still present. Continue turning off AP cards until the problem is eliminated. Disabled AP cards can be turned on again by enabling the cards and doing a system reset (The CLI command

SYS R).

The AP cards microcode and data memories are loaded during boot up. If this data is corrupted for any reason it could cause the system to hang; rebooting is the only way to recover. This can occur by an AP card receiving bad data. If this occurs, suspect the environment memory cards or a faulty data base.

A failure in the DP can often times be isolated quickly since each card in the DP performs a fixed task, whereas the AP card in the OM and GP is performing many different tasks. For example, the span processor section determines which spans should be processed for a given polygon or light. A failure in this section could cause polygons to have span size stair steps along edges or completely omit a section of the polygon.

The edge processor and edge generator cards perform the anti-aliasing of edges. Any failures that cause jagged edges, transparent effects, or scintillation of light points under motion would most likely originate in these cards.

Failures in polygon intensity could be caused by the visibility, texture, or landing lobe sections. These can be tested by unplugging different options and seeing if the problem still exists. The texture option can be disabled by unplugging the texture map cards. The visibility section can be disabled by unplugging the visibility generator cards. Similarly the landing lobes can be disabled by unplugging the landing lobe card.

CAUTION: Be sure to power down the system before plugging cards in or out.

If a failure appears only in every other raster line, the problem might be in the main pipeline section of the DP, which includes the anti-aliasing, visibility, and texture cards. This type of problem can often be seen easier by disabling interlace. The real-time system can display odd or even fields or full interlace (this option is only available with a calligraphic display).

Errors in calligraphic lights can be caused by faulty light buffer, intensity processor, DRAM control, or scope driver cards. First, force the lights to be raster lights by unplugging the light buffer card. If the problem still exists, the problem is not unique to calligraphic lights and should be caused by some other card.

Errors in the video assembler cards will usually just affect one of the three primary color components. The primary colors can be observed independently using the color switches on the display device.

Failures in the output section would appear as errors drawing the raster or lights. For example, uneven raster spacing, bouncing calligraphic light points, or jittery raster.

7.6 CORRECTIVE MAINTENANCE

Corrective maintenance is accomplished by removing defective modules and then installing operative modules. Procedures for removing and installing modular components of the SPX computer image generator are provided in the following paragraphs.

7.6.1 EMI Interface Box Removal

Normal maintenance may require gaining access to the connectors inside the EMI interface box (EMI box). The entire box is not normally removed. Use the following procedure for normal maintenance.

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).

2. Remove the EMI box cover by removing the four attaching screws.

3. Service the connectors/cables inside the box as required.

7.6.2 EMI Interface Box Installation

After servicing the connectors inside the box use the following procedure to re-install the box.

1. Ensure that all the EMI box connectors are secure.

2. Install the EMI box cover with the four attaching screws.

3. Close and secure all cabinet doors prior to operating the system.

7.6.3 Power Controller Modules

Modules mounted inside a power controller may include:

1. System fault monitor (SFM) circuit card.

2. Power supply PS1, +15V DC.

3. Power supply PS2, -5V DC.

7.6.3.1 System Fault Monitor Circuit Card Removal

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).

2. Turn off the control power circuit breaker located on the MPU cabinet power controller.

3. Remove the lower front access panel from the power controller by removing the six attaching screws.

4. Use the plastic levers to unseat the SFM card from the connector.

5. Remove the card and place it in a protective anti-static plastic bag.

7.6.3.2 System Fault Monitor Circuit Card Installation

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).

2. Turn off the control power circuit breaker located on the MPU cabinet power controller.

3. Carefully remove the card from the plastic bag and place the card in the card slot.

4. Seat the card in the connector and lock it in place by using the plastic levers.

5. Check system operation before installing the lower front power controller access panel; install the panel with six attaching screws.

7.6.3.3 Power Supply (±15 V DC or -5.2 V DC) Removal

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).

2. Remove the lower front access panel from the power controller by removing the six attaching screws.

3. Disconnect the two wire harness connectors from the power supply.

4. Remove the power supply by sliding the mounting plate out of the card guides.

7.6.3.4 Power Supply (±15 V DC or -5.2 V DC) Installation

1. Install the power supply by sliding the mounting plate into the card guides.

2. Connect the two wire harness connectors to the power supply.

3. Check system operation before installing the lower front power controller access panel with six attaching screws.

7.6.4 Power Controller Removal

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).

2. Turn off the system power at the site circuit breaker and verify that the power available light on the power controller front panel goes out.

3. Remove the lower front access panel from the power controller by removing the six attaching screws.

4. Disconnect the cabinet input power cable and peripheral cables (J15-J17) and store them under the cabinet.

5. Disconnect and tag all cables connected to the power controller rear panel one at a time.

6. Remove the three attaching bolts and slide the power controller forward out of the cabinet.

7.6.5 Power Controller Installation

CAUTION: Check the boost/buck transformer strapping connections (inside the power controller) before installing the power controller (see Section 4.5.2.1).

1. Slide the power controller into place in the cabinet and secure it with three attaching bolts.

2. Connect cables to rear panel.

3. Connect the cabinet input power cable and peripheral cables (J15-J17) under the front panel.

4. Ensure that the power supplies (PS1 and PS2) and the system fault monitor card are secure. Attach the power controller lower front access panel with six attaching screws.

7.6.6 +5V Power Supply Removal

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).

2. Disconnect the +5V power supply AC input power cable from the +5V power supply.

3. Disconnect the +5V DC output power cables from the +5V power supply.

4. Unfasten the two captive retainer screws that hold the +5V power supply mounting shelf to the cabinet.

5. Remove the power supply and mounting plate assembly from the cabinet.

7.6.7 +5V Power Supply Installation

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).
2. Install the power supply and mounting plate assembly in the cabinet and secure it with two captive retainer screws.
3. Connect the +5V DC output power cables to the +5V power supply. Tighten the power supply lug nuts to 60 inch pounds.
4. Connect the +5V power supply AC input power cable to the +5V power supply.
5. Perform the power supply adjustment procedure found in Section 7.3.1.1.

7.6.8 ±15V Control Power Supply Removal

(This power supply is located in the lower rear of the MP cabinet.)

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).
2. Disconnect the two wire harness connectors from the ±15V power supply.
3. Remove the grounding screw.
4. Remove the power supply and mounting plate assembly from the cabinet.

7.6.9 ±15V Control Power Supply Installation

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).
2. Install the power supply and mounting plate assembly in the cabinet and secure it with the grounding screw.
3. Connect the two wire harness connectors to the ±15V power supply.
4. Perform the power supply adjustment procedure found in Section 7.3.1.3.1.

7.6.10 Channel Processor Card Cage Cooling Fan Removal

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).
2. If the fan is located in the top of the cabinet, remove its top cover by removing 12 attaching screws.
3. Disconnect the AC power cable from the fan and the Hall effect sensor cable from the sensor cable connector. The sensor cable connector is located on the fan plate assembly, not on the fan. Some plastic cable ties may have to be cut.

4. Remove four mounting screws and the finger guard from the fan.

5. Remove the fan.

7.6.11 Channel Processor Card Cage Cooling Fan Installation

1. Install the finger guard and fan with four mounting screws.

2. Connect the AC power cable to the fan and the Hall effect sensor cable to the sensor cable connector. The sensor cable connector is located on the fan plate assembly; not on the fan. Verify that the Hall effect sensor is plugged in correctly by comparing it to the label on the fan plate assembly. Replace any plastic cable ties that may have been cut.

3. Turn AC power on and visually check fan operation.

4. Turn AC power off and install the cabinet top cover with 12 attaching screws.

7.6.12 Backpanel Circuit Card Removal

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).

2. Tag and disconnect any cables that are connected to the card.

CAUTION: Do not bend pins on wire-wrapped circuit cards.

3. Use the plastic levers to unseat the card from backpanel.

4. Remove the card and place it in a protective anti-static plastic bag.

7.6.13 Backpanel Circuit Card Installation

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).

CAUTION: Do not bend pins on wire-wrapped circuit cards. If card contains switches, see Section 4.5.3, and ensure that all switches are properly set; also visually inspect backpanel connectors for bent pins (and straighten them) before installing the circuit card.

2. Carefully remove the card from the plastic bag and place it in the card slot.

3. Seat the card in the backpanel and lock it in place by using the plastic levers.

4. Connect the required cables to the card.

5. Ensure that a card filler (508235-001) is installed in all empty card slots to

maintain proper cooling air flow through the card cage.

6. Check system operation and perform adjustments if needed.

7.6.14 Backpanel Removal

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1) and open cabinet door(s).

NOTE: It is not necessary to disconnect any cables from circuit card connectors to remove the backpanel.

2. Use the plastic levers to unseat all of the cards from the backpanel. Do not remove cards from the card cage.

CAUTION: Do not bend wire wrap pins on backpanel.

3. Tag and disconnect all cables from the rear of the backpanel.

4. Remove the eight attaching screws, and remove the backpanel. Place the backpanel in a protective bag.

7.6.15 Backpanel Installation

CAUTION: Do not bend backpanel wire wrap pins. Visually inspect backpanel connectors for bent pins (and straighten them) before installing.

1. Install the backpanel and attach it loosely in place with eight screws.

2. Carefully seat circuit cards at each of the four corners of the backpanel by using the plastic levers. This helps to align the backpanel to the card cage.

3. Tighten the eight backpanel attaching screws.

4. Carefully seat all circuit cards in the backpanel by using the plastic levers.

5. Connect DC power and ground cables to the rear of the backpanel. Tighten the backpanel lug nuts to 100 inch pounds.

6. Connect other (previously tagged) cables to the rear of the backpanel.

7. Close the doors and power-up the system.

8. Run diagnostics (see Section 7.4.3.3) to verify correct operation.

7.6.16 Slide Out The MP Unit

The MP unit is mounted on chassis slides to provide easy access to serviceable components. Slide the MP unit out of the cabinet as follows:

NOTE: Normal maintenance does not require the MP unit to be removed from the cabinet.

1. Turn off the MP unit power at the rear of the MP unit chassis (CB1).

2. If the shipping screws have not been removed unscrew the six captive fasteners on the MP unit front panel and remove the front panel.

CAUTION: Do not damage cables as the unit slides forward.

3. Remove the two shipping screws (if present) from the front of the MP unit chassis and slide the unit out of the cabinet until the chassis slide latches actuate.

7.6.17 Slide In the MP Unit

1. Push in the chassis slide latch buttons and slide the MP unit into the cabinet.

NOTE: The two MP unit retaining screws are for shipping only.

2. Install the front panel and fasten with the six captive screws on the front panel.

3. Turn the MP unit power on with the switch at the rear of the MP unit chassis (CB1).

7.6.18 MP Unit Components

Removal and installation procedures for the MP unit modular components (except the power supply) are provided in the following paragraphs.

7.6.18.1 MP Unit Cooling Fan Removal

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1) and open the MP cabinet door.

2. Unscrew the six captive fasteners on the MP unit front panel, and remove the front panel.

3. Disconnect the MP unit cooling fan power cable (J2 on the bottom left hand side of the MP unit).

4. Slide the fan plate assembly forward and out of the MP unit.

5. Disconnect the fan power connector (P1 or P2, depending upon which fan is being removed).

6. Remove the fan by removing four screws.

7.6.18.2 MP Unit Cooling Fan Installation

1. Install the fan on the fan plate with four screws.

2. Connect the appropriate fan power cable (P1 or P2) to the fan.

3. Slide the fan plate assembly into the MP unit.

4. Connect the MP unit cooling fan power cable connector J2.

5. Turn on power and visually check the MP unit cooling fan operation.

6. Install the MP unit front panel and fasten it with the six captive screws on the front panel.

7. Close the MP cabinet door and power on the system sao that the MP card will run self diagnostics to verify correct operation.

7.6.18.3 Tape Streamer / Disk Controller Card Plate Assembly Removal

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1), open cabinet door(s) and remove the MP unit front panel.

2. Unscrew the tape streamer plate assembly captive retainer.

3. Slide the tape streamer plate assembly part way out and disconnect the cables from the rear of the unit:

   Connector P1 (cable part number 208214-100) from J1
   Connector P1 (cable part number 208215-100) from J2
   Connector P2 from J3
   Connector P7 from J10.

4. Remove the tape streamer plate assembly.

7.6.18.3.1 Tape/Disk Controller Card Removal

The tape/disk controller card is attached to the bottom of the tape streamer plate assembly; remove it as follows:

1. With the tape streamer plate assembly on the workbench, disconnect the ribbon cable connector P2 from the J8 on the tape/disk controller circuit card.

2. Remove seven attaching screws from the tape/disk controller circuit card.

3. Place the tape/disk controller circuit card into a protective anti-static bag.

7.6.18.3.2 Tape/Disk Controller Card Installation

1. With the tape streamer plate assembly on the workbench, remove the tape/disk controller circuit card from the protective anti-static bag.

2. Connect the ribbon cable connector P2 to J8 on the tape/disk controller circuit card.

3. Attach the tape/disk controller circuit card to the tape streamer plate assembly with seven attaching screws and spacers.

7.6.18.4 Tape Streamer / Disk Controller Plate Assembly Installation

1. Verify that system power is off and remove the MP unit front panel.

2. Guide the tape streamer plate assembly part way into the MP unit chassis.

3. Connect the following cables to the rear of the unit:

   Connector P1 (cable part number 208214-100) from J1
   Connector P1 (cable part number 208215-100) from J2
   Connector P2 from J3
   Connector P7 from J10

4. Slide the tape streamer plate assembly all the way in and secure it with the captive retainer screw.

7.6.18.5 Hard Disk Plate Assembly Removal

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1), open the MP cabinet door and remove the MP unit front panel.

2. Unscrew the hard disk plate assembly captive retainer.

3. Slide the hard disk plate assembly part way out and disconnect the cables whose connectors are labeled P1, P2, and P6 from the rear of the unit.

7. Remove the hard disk plate assembly.

7.6.18.6 Hard Disk Plate Assembly Installation

1. Verify that system power is off and remove the MP unit front panel.

2. Guide the hard disk plate assembly part way into the MP unit chassis.

3. Connect the cables whose connectors are labeled P1, P2, and P6 at the rear of the disk assembly.

4. Slide the hard disk plate assembly all the way in and secure with the captive retainer screw.

7.6.18.7 MP Unit Circuit Card Removal

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1) and open cabinet door(s).

2. Unscrew the six captive fasteners on the MP unit front panel, and remove the front panel.

3. Tag and disconnect all ribbon cables from the front of the card.

4. Use the two plastic levers to unseat the card from the backpanel.

5. Remove the circuit card and place it in a protective anti-static bag.

7.6.18.8 MP Unit Circuit Card Installation

1. Carefully guide the card into the card guide slots.

2. Use the plastic levers to seat the card in the backpanel and lock it in place.

3. Connect the cables to the front of the MP card.

4. Install the MP unit front panel and fasten it with the six captive screws on the front panel.

5. Close doors, then check system operation and perform adjustments if needed. Power on the system so that the MP card will run self diagnostics to verify correct operation.

7.6.19 MP Unit Power Supply Removal / Installation

To remove/install the MP unit power supply perform the following procedures.

7.6.19.1 Remove MP Unit From Cabinet

1. Perform the normal system shutdown procedure (see Section 5.4.1.3.1).

2. Remove the EMI box cover by removing the four attaching screws.

3. Tag and disconnect all (up to nine) the cables from the connector panel insert, inside the EMI box. (These cables are leaving the cabinet.)

NOTE: Do not disconnect any cables from the other side of the panel insert.

4. Remove the four screws that attach the connector panel insert. This allows the panel insert (with cables attached) to be removed from the cabinet with the MP unit.

5. Disconnect the AC power cable from the MP unit rear panel.

NOTE: If the shipping retainer screws under the MP unit front panel are in place; they will have to be removed before proceeding.

CAUTION: Do not damage cables as the unit slides forward.

6. Carefully slide the MP unit forward out of the cabinet.

7. From the front of the cabinet, slide the MP unit out until the chassis slide latches engage.

CAUTION: Two people are required to perform the following two steps.

8. With the help of an assistant on the opposite side of the MP unit push in the chassis slide latch buttons and slide (and lift) the unit out of the cabinet and clear of the chassis slides.

9. With the help of an assistant, lift the MP unit onto a table.

NOTE: A workbench or cart may be used.

7.6.19.2 MP Unit Power Supply Removal

With the MP unit out of the cabinet and on a workbench, perform the following steps:

1. Unscrew the six captive fasteners on the MP unit front panel, and remove the front panel.

2. Remove the tape streamer plate assembly (see Section 7.6.18.3.)

3. Remove the hard disk plate assembly.

NOTE: The MP unit power supply is attached to the right-side panel.

4. Remove the six attaching screws from the MP unit right-side panel.

5. Lay the right-side panel down on the table.

6. Tag and disconnect all the wires from the power supply.

7. Turn the side panel/power supply assembly over on the table.

8. Remove the four power supply attaching screws from the assembly.

9. Lift off the side panel and remove the power supply.

7.6.19.3 MP Unit Power Supply Installation

1. Attach the MP unit right-side panel to the power supply with four attaching screws.

2. Connect all previously tagged wires to the power supply.

3. Position the side panel/power supply assembly upright against the MP unit, and fasten the side panel in place with six attaching screws.

4. Install the hard disk plate assembly.

5. Install the tape streamer plate assembly.

6. Install the MP unit front panel and fasten with the six captive screws on the front panel.

7.6.19.4 Install MP Unit In Cabinet

1. With the help of an assistant, lift the MP unit and guide it into the chassis slides in the cabinet.

2. Slide the MP unit all the way into the cabinet on the chassis slides.

3. Install the connector panel insert (with MP unit cables attached) in the EMI box, and fasten with four attaching screws.

4. Connect all (up to nine) previously tagged cables to the connector panel insert.

5. Install the EMI box cover and fasten with four attaching screws.

6. Connect the AC power cable to the MP unit rear panel.

7. Apply system power and perform the power supply adjustment procedure in Section 7.3.1.2.

8. Reset the MP card (see Table 5.3) and the MP card will run self diagnostics to verify correct operation.

APPENDIX **A**

TERMINAL SETUP

A.1 VT2XX AND VT3XX TERMINAL SETUP

In order for the terminal to properly interact with the SPX, the necessary parameters must be set up in the terminal. The list below describes the non-default parameters required for proper operation (default parameters are not included in the following list).

Because terminals vary in their setup procedure, refer to the terminal user's guide for setup instructions. In any case, set the default parameters first, then change the other parameters as listed below. Unless indicated otherwise, these parameters apply to all VT2XX and VT3XX terminals.

Global Setup	(VT3XX) Use Defaults
General Setup	(VT2XX) Application Keypad
Display Setup	(VT3XX) 6 x 24 Page Size (VT3XX) No Status Display Jump Scroll
Communications	4800 Baud Receive and Transmit (VT3XX) Enable Transmit Rate Limit (VT3XX) Answerback Msg: (CTRL [) [ip (VT3XX) No Auto Answerback
Printer	(VT3XX) Multinational Character Set Disable Printer to Host 7-bit, Space Parity (VT2XX) XON/XOFF Protocol
Keyboard	(VT2XX) No Auto Answerback (VT2XX) Answerback Msg: (CTRL [) [ip (VT3XX) Application

Local Editing (VT3XX) All (In Erasure Mode)

A.2 INTERACTIVE CONTROL CONSOLE (IC100) SETUP

An optional configuration of the SPX includes a Terabit ICC100 Flybox. The following steps describe how to install and setup the ICC100.

A.2.1 Installation

Install the ICC by following these steps:

1. Verify that the ICC100 power switch is in the off position.
2. Connect AC power.
3. Connect the RS422 communications line to the connector on the back of the ICC100.
4. Power on the ICC100.

A.2.2 Set-up Parameters

The set-up mode of the ICC100 is entered and exited by pressing the <Set-up> key. The various setup features are scrolled through using the <PF1> key on the keypad. The parameter of the feature is changed using the <PF2> key on the keypad, with the exception of the TAB stops and ANSWERBACK message.

The TAB stops can be set by using the arrow keys to change the number of the column (1-80). The left arrow key causes the column number to decrease and the right arrow key causes the column number to increase. The tab stop may be set or cleared for each column by toggling the <PF2> key.

The ANSWERBACK message is set at the factory and should not be changed.

When the set-up mode is entered, the ICC100 displays the following information on the screen:

```
                    ICC100

PF1-NEXT    PF2-SELECT  S-SAVE     R-RESET     SET UP-QUIT
```

The following are the proper parameters for the ICC100 to interact with the SPX.

1.	Set Baud Rate Transmit Rate:	4800
2.	TX Rate = RX Rate:	Yes
3.	Set Baud Rate Receive Rate:	4800
4.	Online:	Online
5.	Parity:	Off
6.	Parity Sense:	Even
7.	Chaarcter Length:	8 bits
8.	New Line:	Line Feed
9.	Attribute:	Block
10.	ANSI Mode:	ANSI (VT100)
11.	Scroll:	Jump
12.	Video:	Normal
13.	Wrap Around:	No Wrap
14.	Auto Repeat:	On
15.	Tab at Column:	01 clear
16.	Margin Bell:	Off
17.	XON/XOFF:	On
18.	Key Click:	On
19.	UK or US #:	US
20.	Answer Back:	ICC-100
21.	Screen Save:	Ignore Host

The ICC100 parameters are now compatible with the SPX. Save this configuration by pressing the <S> key on the ICC100. Exit the set-up mode by pressing the <Set-up> key on the ICC100.

APPENDIX B

MAGNETIC MEDIA DIAGNOSTICS

B.1 INTRODUCTION

Magnetic media diagnostic (MMD) is a program designed to check the various operations of a hard disk, a floppy disk, a controller, and a streaming tape. MMD supports the following functions:

Controller Tests

D(buffer)	Data buffer controller write/read
E(cc)	ECC disk write/controller read test
R(am)	RAM controller test

Disk Tests

DI(sk)	Disk write/read test
F(disk)	Format disk
I(dread)	Read sector id disk test
S(eek)	Seek disk test
T(rack)	Track-to-track disk disturbance test

Tape Tests

FT(ape)	Format tape

TA(pe)	Tape write/read test

Comprehensive Tests

A(lltest)	Test all of the above functions
AC(ontrol)	Test all of the controller-related tests (Dbuffer, Ecc, and Ram)
AD(isk)	Test all of the disk-related tests (Disk, Fdisk, Idread, Seek, and Track)
AT(ape)	Test all of the tape-related tests (Ftape and Tape)

Utilities

B(ackup)	Backup disk to tape
ER(reset)	Reset the total errors to 0
EX(it)	Exit
H(elp)	Print all valid commands
RE(set)	Reassign disk parameters (prompt new parameters).
REW(ind)	Rewind tape
ST(ore)	Restore disk from tape

B.2 EXECUTING MMD

To execute MMD, type

```
@MMD <RET>
```

at the shell prompt. The program is loaded from the disk, and the MMD sign-on message is displayed. The MMD> prompt is then given, and MMD commands may then be entered.

MMD02 requires a site file named SPXUTL.SIT. This file is also common to other utilities, and should be located on disk drive #0. When MMD02 is executed, the information in the site file is read. This information contains the available devices on the SPX system. If the site file is not found, MMD02 will assume a minimum configuration. The configuration of the SPX system is displayed each time MMD02 is executed, and appears to the right of the sign-on message in square brackets. Each number enclosed in the square brackets represents a valid disk or tape drive.

A valid entry consists of

COMMAND [REPETITIONS] [DRIVE]

If the number of repetitions and/or drive number are not included in the entry, but are needed to perform the command, they will be prompted with the following:

```
Repetitions or C?
```

and

```
Please enter drive number:
```

Up to 99 repetitions or C (continuous mode) is valid. The drive number must be in the format DR*n*:, where *n* is the drive number.

Any MMD command may be aborted by entering a <RET> at the `Repetitions or C?` prompt.

After a command begins execution, that command may be pre-maturely aborted by entering a <CTRL/Z>. The software checks for a keyboard entry of a <CTRL/Z> after each repetition. In some cases it may be several minutes before a repetition is completed.

The user may inquire the number of repetitions which have been completed during the execution of any command without halting the execution of that command by entering a <CTRL/R>. The software checks for a keyboard entry of a <CTRL/R> after each repetition. In some cases it may be several minutes before a repetition is completed.

Example:

<CONTROL/R>
```
DBUFFER CONTINUING EXECUTION AFTER 204 REPETITION(S)
```

Data destructive commands (FDISK, TRACK, STORE, FTAPE, BACKUP) will give the user a chance to abort the command with the message:

```
THIS FUNCTION WILL ERASE THE TAPE. Continue ?
```

or

```
THIS FUNCTION WILL ERASE THE DISK. Continue ?
```

In the event of an error, error messages will be displayed during command execution. An error report will follow the completion of any command. An error summary will follow each MMD session (see Section B.5).

The ECC and DISK commands require a file named TSTFIL.TXT to be on the disk. If there is not one, the user will be prompted with: `'TSTFIL.TXT' is needed for this test and doesn't exist. Would you like to create 'TSTFIL.TXT' and proceed? Y/N`. If the user responds with a Y, MMD will automatically generate the file.

ALLTEST and ADISK commands use TSTFIL.TXT, and create it following a disk format, therefore a user prompt is not necessary.

MMD may also be executed from a command file. The command file must begin with

```
$ RUN MMDnn.EXE
```

(where *nn* is a two digit number representing the version number of MMD). The command file may contain any MMD commands, and must end with `EX` (to exit MMD), then `$ EX` (to exit the command file). An example follows.

Using MED, create a file with the name DIAG.COM. An example of a MMD command file is:

```
$ RUN MMDnn.EXE
DB 50
ECC 5 DR0:
Y
RAM 3
EX
$EX
```

This command file is then run by typing

```
@DIAG <RET>
```

The current version of MMD does not include any implementation for a floppy disk drive.

B.3 MMD COMMANDS

A detailed explanation and example of each command is given below. In the command descriptions below, the portion of the command shown in parentheses is option, and does not need to be entered. The portion outside of the parentheses is required, and must be entered to distinguish it from other commands.

B.3.1 Controller Tests

D(buffer)

This function writes a block of the pattern >A0A0 using the data buffer write command. Then using the data buffer read command, it reads and verifies that block.

```
MMD> DBUF <RET>

      Repetitions or C ? 24 <RET>

      Errors = 0  Total Errors = 0
      DBUFFER SUCCESSFULLY COMPLETED : 24 REPETITION(S)
```

E(cc)

This function writes a pattern of >6C6C to a sector and explicitly writes the ECC (error correction code) with the WRITE ECC command. It is then checked by reading the sector. If there is an error it will appear when the read is made. It requires a file on the disk named TSTFIL.TXT. If this file does not exist the user is given the option to create it and proceed.

```
MMD> ECC <RET>

      Repetitions or C ? 8 <RET>
      Please enter drive number : DR0: <RET>
      'TSTFIL.TXT' is needed for this test and doesn't
      exist. Would you like to create 'TSTFIL.TXT' and
      proceed ? Y/N Y <RET>
      TSTFIL.TXT CREATED

      Errors = 0  Total Errors = 0
      ECC SUCCESSFULLY COMPLETED : 8 REPETITION(S)
```

R(am)

This function is a read/write RAM controller test. It reads and writes data patterns into the controller RAM and compares for verification.

```
MMD> RAM <RET>

      Repetitions or C ? 2 <RET>

      Errors = 0  Total Errors = 0
      RAM SUCCESSFULLY COMPLETED : 2 REPETITION(S)
```

B.3.2 Disk Tests

DI(sk)

This function writes and reads a series of different data patterns to the disk to verify correct write and read operations. It requires a file on the disk named TSTFIL.TXT. If this file does not exist the user is given the option to create it and proceed.

```
MMD> DISK <RET>

        Repetitions or C ? 11 <RET>
        Please enter drive number : DR0: <RET>
        'TSTFIL.TXT' is needed for this test and doesn't
        exist. Would you like to create 'TSTFIL.TXT' and
        proceed ? Y/N Y <RET>
        TSTFIL.TXT CREATED
              DISK in progress...

        Errors = 0  Total Errors = 0
        DISK SUCCESSFULLY COMPLETED : 11 REPETITION(S)
```

F(disk)

This function formats a given disk, reports any bad tracks, and assigns each bad track an alternate track. The user is given an opportunity to set the disk parameters before formatting if desired. Following the formatting, the volume identifier block (sector 0) and sector allocation table are rebuilt.

```
***WARNING***
This command is disk data destructive. A backup tape should
be made prior to execution.

MMD> FDISK <RET>

        Repetitions or C ? 1 <RET>
        Please enter drive number : DR0: <RET>
        This function will erase the disk. Continue? Y <RET>
        Would you like to set new disk parameters ? N <RET>
              FDISK in progress...

        Track 70E is assigned an alternate track 1FE1

        Errors = 0  Total Errors = 0
        FDISK SUCCESSFULLY COMPLETED : 1 REPETITION(S)
```

I(dread)

This function reads the ID field of a random selected logical address using the READ ID command. It then compares the cylinder, head, and sector returned, with that address set into the command. Any differences are reported. This is done 512 times for one repetition.

```
MMD> IDREAD <RET>

      Repetitions or C ? 3 <RET>
      Please enter drive number : DR0: <RET>
            IDREAD in progress...

      Errors = 0  Total Errors = 0
      IDREAD SUCCESSFULLY COMPLETED : 3 REPETITION(S)
```

S(eek)

This function tests the seeking capability of the given disk. It selects six positions (first sector, second sector, halfway sector, halfway + 1 sector, last - 1 sector, and the last sector) and seeks from each position to every first sector of each cylinder on the disk and back.

```
MMD> SEEK <RET>

      Repetitions or C ? 3 <RET>
      Please enter drive number : DR0: <RET>
            SEEK in progress...

      Errors = 0  Total Errors = 0
      SEEK SUCCESSFULLY COMPLETED : 3 REPETITION(S)
```

T(rack)

This function writes a data pattern to two sets (high and low on the disk) of five adjacent cylinders, then writes a different pattern on alternating adjacent tracks of those cylinders. It then reads the tracks with the first pattern and verifies that they are undisturbed.

```
***WARNING***
This command is disk data destructive. A backup tape should
be made prior to execution.

MMD> TRACK <RET>

      Repetitions or C ? 5 <RET>
      Please enter drive number : DR0: <RET>
      This function will erase the disk. Continue ? Y <RET>
```

```
Errors = 0  Total Errors = 0
TRACK SUCCESSFULLY COMPLETED : 5 REPETITION(S)
```

B.3.3 Tape Tests

FT(ape)

FTAPE uses the tape verify command to format the tape. It then writes an SPX header on the tape.

```
***WARNING***
This command is tape data destructive.

MMD> FTAPE <RET>

        Repetitions or C ? 1 <RET>
        THIS FUNCTION WILL ERASE THE TAPE. Continue ? Y <RET>
              FTAPE in progress...

        Errors = 0  Total Errors = 0
        FTAPE SUCCESSFULLY COMPLETED : 1 REPETITION(S)
```

TA(pe)

This function writes and reads a variety of patterns and filemarks to a streaming tape. It then reads and compares these patterns to verify the write, read, space-forward, rewind, and read-header functions. This routine requires the tape header to be labeled SCRATCH. If it is not the user is given the option to rename the header and proceed. The tape must have a header of some kind to execute successfully.

```
MMD> TAPE <RET>

        Repetitions or C ? 4 <RET>
        SPX VERSION 2.0 --- DISK 1 BACKUP is the header label
        The tape must have the label 'SCRATCH' for this test
        Would you like to change it ? Y <RET>
              TAPE in progress...

        Errors = 0  Total Errors = 0
        TAPE SUCCESSFULLY COMPLETED : 4 REPETITION(S)
```

B.3.4 Comprehensive Tests

A(lltest)

Alltest tests all of the above functions in MMD including: DBUFFER, ECC, RAM, DISK, FDISK, IDREAD, SEEK, TRACK, FTAPE, and TAPE. It also creates the file TSTFIL.TXT for the DISK and ECC tests following each iteration.

```
***WARNING***
This command is disk data destructive. A backup tape should
be made prior to execution. It is also a tape destructive
command.

MMD> ALLTEST <RET>

      Repetitions or C ? 4 <RET>
      Please enter drive number : DR0: <RET>
      This function will erase the disk. Continue ? Y <RET>

      SPX VERSION 2.0 --- DISK 1 BACKUP is the header label
      The tape must have the label 'scratch' for this test
      Would you like to change it ? Y <RET>
            ALLTEST in progress...

      Errors = 0  Total Errors = 0
      ALLTEST SUCCESSFULLY COMPLETED : 4 REPETITION(S)
```

AC(ontrol)

This function tests all of the controller-related functions which include DBUFFER, ECC, and RAM. This function requires the file TSTFIL.TXT on the disk. If it doesn't exist, the user will be given the option of creating it.

```
MMD> ACONTROL <RET>

      Repetitions or C ? 6 <RET>
      Please enter drive number : DR0: <RET>
      'TSTFIL.TXT' is needed for this test and doesn't
      exist. Would you like to create 'TSTFIL.TXT' and
      proceed ? Y/N Y <RET>
      TSTFIL.TXT CREATED
            ACONTROL in progress...

      Errors = 0  Total Errors = 0
      ACONTROL SUCCESSFULLY COMPLETED : 6 REPETITION(S)
```

AD(isk)

This function tests all of the disk related functions which include DISK, FDISK, IDREAD, SEEK, and TRACK. This test is data-destructive. It will give the user the option to abort if a backup has not been made. This function requires the file TSTFIL.TXT on the disk. If it doesn't exist, the user will be given the option of creating it.

```
***WARNING***
This command is disk data destructive. A backup tape should
be made prior to execution.

MMD> ADISK <RET>

        Repetitions or C ? C <RET>
        Please enter drive number : DR0: <RET>
        This function will erase the disk. Continue ? Y <RET>
              ADISK in progress...
        [CTL] Z
        Errors = 0  Total Errors = 0
        ADISK SUCCESSFULLY COMPLETED AND ABORTED AFTER: 2
        REPETITION(S)
```

AT(ape)

This function performs all of the tape related tests which include FTAPE and TAPE. It is tape data destructive. It also requires the use of a tape labeled SCRATCH. If the tape is not labeled SCRATCH, the user is given the option to label it. The tape must have a header of some kind to execute successfully.

```
***WARNING***
This command is tape data destructive.

MMD> ATAPE <RET>

        Repetitions or C ? 17 <RET>
        SPX VERSION 2.0 --- DISK 1 BACKUP is the header label
        The tape must have the label 'SCRATCH' for this test
        Would you like to change it ? Y <RET>
        THIS FUNCTION WILL ERASE THE TAPE. Continue ? Y <RET>
              TAPE in progress...

        Errors = 0  Total Errors = 0
        ATAPE SUCCESSFULLY COMPLETED : 17 REPETITION(S)
```

B.3.5 Utilities

B(ackup)

This function will backup the disk to a streaming tape. This is not a test, but is an aid in other MMD tests. It includes the capability to backup multiple streaming tapes if necessary.

```
***WARNING***
This command is tape data destructive.

MMD> BACK <RET>

        Please enter drive number : DR0: <RET>
        THIS FUNCTION WILL ERASE THE TAPE. Continue ? Y <RET>
        Please enter the new tape header
        BACKUP TAPE DRIVE 0
        Approximately 40 megabyte(s) of tape space will be
        required

        Mount tape cartridge 1: Continue ? (Y/N) Y <RET>
        Backup in progress (tape 1)...
        Tape is full, Rewinding tape

        Mount tape cartridge 2: Continue ? (Y/N) Y <RET>
        Backup in progress (tape 2)...
        Rewinding tape

        Errors = 0  Total Errors = 0
        BACKUP SUCCESSFULLY COMPLETED : 1 REPETITION(S)
```

ER(reset)

Resets the total errors to 0.

EX(it)

Exits an MMD session.

H(elp)

Prints all of the valid MMD commands.

RE(set)

Reassigns the disk parameters for the given drive (prompts for new parameters).

```
MMD> RES <RET>

        Please enter drive number : DR0: <RET>

        --> 1) Step pulse width [1]
        Please enter new parameter, or return 1 <RET>

        --> 2) Step period [1]
        Please enter new parameter, or return 1 <RET>

        --> 3) Step mode [0]
        Please enter new parameter, or return 0 <RET>

        --> 4) Maximum number of heads [6]
        Please enter new parameter, or return 6 <RET>

        --> 5) Maximum cylinder address high (MSB) [4]
        Please enter new parameter, or return 4 <RET>

        --> 6) Maximum cylinder address low (LSB) [8D]
        Please enter new parameter, or return 8D <RET>

        --> 7) WSI/ Write precompensation cylinder [0]
        Please enter new parameter, or return 0 <RET>

        --> 8) Drive type identifier [0]
        Please enter new parameter, or return 0 <RET>

        --> 9) Maximum sector address [1F]
        Please enter new parameter, or return 1F <RET>

        --> 10) Reserved [0]
        Please enter new parameter, or return 0 <RET>

        Errors = 0          Total Errors = 0
        RESET SUCCESSFULLY COMPLETED : 1 REPETITION(S)
```

REW(ind)

This command rewinds the streaming tape. This is not a test, but is an aid in other MMD tests.

```
MMD> REWIND <RET>

        REWINDING TAPE 1 REPETITION(S)
```

ST(ore)

This function restores the disk from a streaming tape. This is not a test, but is an aid in other MMD tests. It includes the capability to restore multiple streaming tapes if necessary.

```
***WARNING***
This command is disk data destructive. A backup tape should
be made prior to execution.

        MMD> STORE <RET>

        Please enter drive number : DR0: <RET>
        THIS FUNCTION WILL ERASE THE DISK. Continue ? Y <RET>

        Mount tape cartridge 1: Continue ? (Y/N) Y <RET>
        Restore in progress (tape 1)...
        Tape exhausted, Rewinding Tape

        Mount tape cartridge 2: Continue ? (Y/N) Y <RET>
        Restore in progress (tape 2)...
        Rewinding Tape

        Errors = 0  Total Errors = 0
        STORE SUCCESSFULLY COMPLETED : 1 REPETITION(S)
```

B.4 EXECUTION TIME

The amount of execution time will vary according to the size of the disk and tape. The following figures have been calculated for a 67Mb disk and a 40 Mb tape, and are approximations.

Table B-1. Command Execution Time

Function	(minute:second) Repetition	Repetition/ Second
D(buffer)	----	134.0
E(cc)	----	30.0
R(am)	----	1.8
DI(sk)	----	2.7
F(disk)	9:08	----

Table B-1. Command Execution Time - Continued

Function	(minute:second) Repetition	Repetition/ Second
I(dread)	0:15	----
S(eek)	10:24	----
T(rack)	----	1.6
FT(ape)	14:50	----
TA(pe)	1:02	----
A(lltest)	35:37	----
AC(ontrol)	----	1.7
AD(isk)	19:48	----
AT(ape)	16:00	----
Function	**Time / Megabyte**	**Considerations**
B(ackup)	0:12 / megabyte	+ rewind time + (2:09 * number of tapes needed)
ER(reset)	----	----
EX(it)	----	----
H(elp)	----	----
RE(set)	----	----
REW(ind)	0:03 / megabyte	----
ST(ore)	0:12 / megabyte	+ rewind time

B.5 MMD MESSAGES

There will be a brief error report following each MMD command executed (see examples in command section). This report includes the number of errors in that command, the total number of errors in this session, the command name, the execution status, and the number of completed repetitions.

Following an MMD session an error summary will be given. This summary will include: the total number of errors in that MMD session, which command each error occurred in, and the total number of errors in those commands for the session. This report has been designed to be no larger than the terminal screen.

There are 4 types of messages in MMD.

1. ERRORS - These are errors detected in the hardware resulting in the failure of an MMD command. They are included in the error report and error summary.

2. MESSAGES - These messages reported are not test failures, but are either a message accompanying an error or an error in setting up the MMD command. These are not reported in the error report or error summary.

3. WARNINGS - Warnings are either user interface warnings or backup and restore tape warnings.

4. TAPE STATUS MESSAGES - These messages deal with the tape streamer and accompany tape errors.

B.5.1 Errors

ERROR! Alternate track address read incorrectly with no ECC error
During accessing the specified sector, the controller found a track with the "bad track" and "alternate track assigned" flags set in the id field.

ERROR! Attempted to directly access an alternate track
The alternate track cannot be accessed directly by a data transfer command.

ERROR! Bad block found
The controller detected a track labeled bad.

ERROR! Bad block not located.
The bad block was not located.

ERROR! Cartridge changed
The door was opened and closed again.

ERROR! Comparing error
A data miscompare occurred between two buffers.

ERROR! Data address mark not found
The controller did not detect the address mark.

ERROR! Drive disconnected.
No connection was made between the drive and the controller.

ERROR! Drive not ready
The selected drive not ready.

ERROR! Drive not selected
Controller has attempted to select a drive and this drive did not assert its selected signal.

ERROR! DMA time out during handshake on the QIC 02 bus.
The DMA encountered a time out error during the handshake on the QIC 02 bus.

ERROR! FDC 765 error
An FDC chip hung in an unexpected state.

ERROR! Id read miscompare a difference of #
A read id error occurred.

ERROR! Illegal disk address. Address beyond the maximum address
The controller received a command with a logical block address beyond the capacity of the drive.

ERROR! Illegal function for the current drive type
The controller received an illegally formatted command for that drive type.

ERROR! Illegal QIC 02 command.
The given QIC 02 command was illegal.

ERROR! Incorrect interleave factor
A mismatch in the interleave factor occurred.

ERROR! Invalid command received from the host
The controller decoded an unsupported command code.

ERROR! Maximum sector address passed during a multiple sector read/write
A multiple sector command tried to access beyond the capacity of the disk.

ERROR! Multiple Winchester drives selected
More that one drive asserted its drive selected signal.

ERROR! No error status
No specific sense information was reported about the designated drive.

ERROR! No index signal
The drive is ready but the controller does not detect the drives beginning-of-track index signal.

ERROR! No seek complete
The controller did not receive the drive's seek complete signal indicating the function had completed.

ERROR! No track
No track 0 found during recalibration.

ERROR! Power on reset occurred.
There was an error in the power on reset routine.

ERROR! RAM error or power up self test error
The internal controller tests, at the power up, detected an error condition.

ERROR! Record not found. Found correct cylinder, head, not sector
The controller was unable to find the id field address mark.

ERROR! Rewind in progress.
A command was issued while a tape rewind operation was in progress.

ERROR! Seek error. R/W head positioned on wrong cylinder
The controller could not find the specified id field.

ERROR! Seek in progress
The drive was busy seeking to the location defined by the previous command.

ERROR! Tape drive failure
Tape drive interface handshake failed.

ERROR! Tape parity error.
The tape streamer encountered a tape parity error.

ERROR! Uncorrectable data error during a read
The controller detected a data field error that could not be corrected by the ECC.

ERROR! Unrecoverable data error.
An unrecoverable data error was encountered in the tape streamer.

ERROR! Unselected tape drive.
The specified drive did not assert its selected signal.

ERROR! Write fault
A write fault was received from the drive.

ERROR! Write operation in progress.
A non-write operation was attempted while the tape streamer was in write mode.

ERROR! Write protected
The drive sent the write protect signal to the controller during a write command.

B.5.2 Status Messages

Backup is not complete
An error was encountered while backing up a disk, making it an unsuccessful backup.

Backup with header operation failed
An error was encountered while trying to execute the backup-with-header operation.

Bad track with alternate assigned
A bad track was detected in the read id command.

Can't read the streaming tape
An error occurred while reading the tape header.

Restore is not complete
An error was encountered while restoring a disk, making it an unsuccessful restore.

Restore mirror-image operation failed
An error was encountered while executing a restore command.

Sense testing error
An error occurred while attempting to read the sense bytes for the previous operation.

Streaming tape interrupted # times
The number of times a tape was interrupted during a tape related command.

Too many bad tracks on disk
There are too many bad tracks encountered on the disk.

Unable to read the disk SAT
The SAT is unable to be read from the tape.

Write # blocks or read retries = #
This is the number of times the function (read or write) that failed was retried.

B.5.3 Warnings

Bad disk number given
An illegal disk number was specified.

Not a backup tape
The tape was not last used as a backup tape.

Not an SPX tape
The tape header did not begin with the SPX id name.

Tape not a part of current tape group!!! Correct tape group is ___.
This tape was not part of the same backup tape group.

Tape number incorrect
The restore sequence of tapes was not consistent with the backup sequence.

This tape is write protected
A write operation was attempted with a protected tape.

Track # is assigned an alternate track #
This is the reassigned track address if a bad track is found during disk formatting.

Unable to read tape header
The controller is unable to read the header from the tape.

User warning, illegal command
An illegal command was entered.

User warning, out of range
The number repetitions specified was out of range.

WARNING! Correctable data field error
The ECC correction algorithm corrected this error.

WARNING! Tape exception
A condition occurred involving a tape error or warning.

WARNING! The SPX utility file 'SPXUTL.SIT' was not located.

B.5.4 Tape Status Messages

Beginning of media (BOT)
The beginning of the tape was encountered.

Cartridge not installed
There is no tape cartridge is the tape streamer.

End of data recorded on the tape
The end of data recorded on the tape was encountered.

End of media (EOT)
The end of tape was encountered.

File mark detected
A file mark was detected.

No data detected
A search of the tape detected no data.

No header found
An attempt to read the header found no header.

Off line
The tape streamer is not on line.

On line
The tape streamer is on line.

Write protected cartridge
The tape has it's write protection set.

APPENDIX C

GLOSSARY

Active Object Data Base

The active object data base represents the surviving data base after an object-level, field-of-view cull of the on-line data base. An active object is generally intruding or contained within one or several channel viewcones, depending on size, channel configuration, and instantaneous viewing conditions. The 360° scene is thus reduced to the window specific data for each channel, which is called the display data base.

Aliasing

Aliasing is the appearance of spatial and temporal image artifacts in a raster image due to interaction between the discrete sampling of the raster/pixel format and the spatial/temporal frequencies inherent in the image of the computed edges, surface fragments, and point features. Manifestations of aliasing include edge stair-step, scintillation of small scene surfaces, breakup of long narrow surfaces, and positional or angular motion of edges in discrete jumps or steps.

Anti-Aliasing

Anti-aliasing is a combination of image processing techniques that reduce the perception of aliasing phenomena. Anti-aliasing techniques include processing to higher resolution than that of the raster format followed by image filtering to reduce both spatial and temporal aliasing.

ASCII Text File

An ASCII text file is a file composed of ASCII text characters; these characters are not computer specific, and may be used by any type of system. ASCII text files used by the SPX system include reset files and site files.

Available Data Base

The available data base can include one or several distinct models among which the instructor or the automatic data base management system selects. Each such model typically represents one airfield and its surrounding areas. The available data base resides on the disk storage device and those objects which are within visible range are transferred either in total or in incremental portions to the online data base.

Backfacing Polygon

A polygon is backfacing for a given eyepoint position with respect to the polygon, when viewrays from the eyepoint strike the polygon on its nonvisible, or back side. A backfacing polygon is removed from scene processing and display to aid the occultation solution and reduce unnecessary computational loading.

Baud Rate

Baud rate is bits per seconds, the rate at which data and control information is transferred between hardware devices. Included in the baud rate calculation are the start and stop bits as well as any parity and data bits.

Boot

To boot a system is to load or reload the operating system and initialize the computer system. This is initially done at the time the system is powered up, and is also done when the system is reset.

Buffer

A buffer is a consecutive number of bytes allocated for temporary storage in memory.

Calligraphic Lights

Calligraphic lights are non-raster light point drawn on the display screen. Because the light point is not rasterized, as are all other lights and objects in the scene, it must be drawn separately from all raster lines on the display, requiring a second pass over the screen by the electron gun; this increases the processing time required for the scene, but also results in a sharper light point and a much wider dynamic range of intensities. Calligraphic light points should be positioned as close together and number as few as possible to increase display efficiency.

CD

(see Collision Detection)

Cell

A cell is a member of the hierarchical data base which is used as the decision point for the object manager; at the cell level the OM will decide to display a high or low level of detail and whether or not to display the contents of the cell or the other objects and meshes pointed to by the cell. A cell contains pointers to objects or meshes.

CGI

(see Computer Generated Imagery)

Channel Assignment

Channel assignment is that operation by which scene objects are determined to be potentially in the FOV and are assigned to the channel (or channels in case of overlap) in which they could be seen for given viewing conditions.

Channel Processor

The channel processor is the specialized electronics subsystem that converts three-dimensional model data into two-dimensional image data representative of the perspective view for particular eyepoint viewing geometries. The channel processor is a subsystem of the image generator, and contains the object manager, geometric processor, and the display processor..

Channel

A channel is a defined portion of the observer's total viewing field for which a corresponding unique scene is presented. The term Channel is also associated with the increment of image generator hardware and software required to produce a unique FOV image.

CHEK

CHEK is the SPX diagnostic language used to create all off-line diagnostic programs used in troubleshooting system failures. See the *CHEK Diagnostic Manual*, part number 901181-832, for more information on this topic.

CIG

(see Computer Image Generation)

CLI

(see Command Line Interpreter)

Collision Detection

Collision detection is the process of testing whether a collision test point, usually a point offset from the eyepoint, has entered a defined volume. When collision detection is enabled, the OM will make a traversal of the data base for each collision test point to see if the point being tested is within a collision volume. The OM makes a traversal for any given test point when the real-time system places instructions to do so in the OM command list; this may occur every field or only once every several fields. The traversal for each point is in addition to the visual traversal.

Command File/Reset File

A command file, also called a reset file, is a text file containing a list of commands known to the command line interpreter or the operating system. When this file is run, the commands in the file are run as if they had been individually entered on the command line.

Command Line Interpreter

The command line interpreter is the part of the operating system or real-time system that interprets commands entered by the user on the command line.

Command List

A command list is a list of commands used by the object manager, geometric processor, and display processor to perform various calculations.

Computer Generated Imagery

Computer generated imagery refers to the images produced by means of computer image generation.

Computer Image Generation

Computer image generation is the technology or techniques for generating real-time pictures by digital processing of model data representing a visual operating environment.

Console

The console is the text monitor and keyboard used for system operation and maintenance.

Coordinate System

A coordinate system is the reference system for all constructs in the data base. Placing an object in relation to the coordinate system determines where in the scene the object will appear. Up to 16 coordinate systems may be present in the model:

0:	eyepoint coordinate system
1:	ground coordinate system
2:	sky coordinate system
3-15:	dynamic coordinate systems

Any object may be tied to a coordinate system. The sky and ground coordinate systems remain in one place and do not move, while dynamic coordinate systems may move in relation to other coordinate systems in real time. For example, the eyepoint (CS 0) may move in relation to the ground coordinate system (CS 1).

(see also Dynamic Coordinate System)

Coordinate

A coordinate is the location of any point relative to the origin of the coordinate system to which the point belongs. For example, a point that is 10 units in the X direction from the origin, and 15 units in the Y direction, and 20 units in the Z direction away from the origin, has XYZ coordinates of (10,15,20).

CS

(see Coordinate System)

Data Base Manager

The data base manager is the part of the RTS responsible for having the correct parts of the database available to the hardware. This is a two part process. First the RTS determines which parcels are on-line and sends the parcel descriptors to the OM. The OM then requests the parts of the database within range of the eye that are not on-line, and the data base manager retrieves these from the system disk.

Data Base

A data base is a numerical representation of a visual scene that can be viewed in real-time with the visual system. The data base will contain records defining various objects, cells, meshes, and etc. In this usage, data base is synonymous with model.

DCS

(see Dynamic Coordinate System)

Display Database

The display data base results from transforming the active object data base into channel-specific perspective image coordinates. The transformation includes translations, rotations, and perspective computations that map three-dimensional definitions of polygons and light points into the display plane. This transformation also includes clipping of the scene at display plane edges, thus discarding light points and polygon fragments outside the channel FOV.

Display Plane

The display plane is a flat rectangular area on which the image of the scene is computed as defined by window geometry and eyepoint. The display plane is perpendicular to the sight line through the center of each channel FOV. The image embodied in the signals that drive the display thus corresponds to a flat display plane.

Display Processor

The display processor is the hardware logic responsible for displaying the image as a set of lines, pixels, and calligraphic light points. This is a two part process, both occurring each field. First, the polygons, lights and visibility information is combined into a single frame buffer, representative of the display screen. During the next field this buffer is output to the screen as the previous process is loading a new frame buffer.

Display

The display is the hardware device used to display the visual image. This includes both monitors and projectors.

Displayed Video

The displayed video represents the final visible scene data to be presented by the display(s) associated with each channel. The display video for surfaces and raster light points results from the scan conversion (or rasterization) of the image plane description in the display data base. This transformation includes final occultation, visibility, anti-aliasing, shading calculations and the addition of any special effects. Where applicable, the display video for calligraphic lights is presented to the display device at a time separate from the raster video.

DONE Interrupt

When a hardware device (e.g., OM, GP, DP) has finished its current field's task, it notifies the RTS by generating a DONE interrupt. The RTS uses this information in its control logic to manage the field rate and re-start the hardware devices for the next field.

DP

(see Display Processor)

Dynamic Coordinate System

A dynamic coordinate system is any coordinate system that may be moved in real time in relation to other coordinate systems. For example, the eyepoint (CS 0) may be moved in relation to the ground coordinate system (CS 1) which does not move. An aircraft or other object may be attached to the DCS and can be moved by moving the DCS; all objects attached to a DCS move along with it. A dynamic coordinate system is assigned to each moving object that is active within the simulation.

(see also Coordinate System)

Edge

An edge is a straight line segment defined by two vertices of a polygon. Scene edges represent boundaries in the scene where either the shape, color, brightness or texture of the scene detail changes.

Element or Raster Element

(see Pixel)

EM

(see Environmental Memory)

Environmental Memory

Environmental memory is the memory shared between the hardware subsystems and the real-time system. The OM and the GP both have their own EM. This is the memory that the RTS uses both to communicate with the OM and the GP, and for the storage and manipulation of data base entities.

EPROM

EPROM is an acronym for Erasable Programmable Read Only Memory, which is read-only memory which can be programmed, erased, and reprogrammed.

Ethernet Interface

Ethernet is the standard interface through which the host and the SPX communicate in a standard IG system. SPX only responds to the host and does not initiate the communication. This makes it a collision free interface when a dedicated ethernet line is used. SPX uses the IEEE 802.3 standard for its hardware and software.

Ethernet

The ethernet is a local communications network in which all stations monitor the signal on a coaxial cable (the ether) during their own transmission, terminating transmission immediately if a collision is detected. Because of its widespread commercial use and availability, Ethernet was selected as the standard SPX host interface.

Eyepoint

The eyepoint is the point in space representing the position of the observer. The eyepoint may be moved to simulate the movement of the pilot's aircraft. The eyepoint has its own dynamic coordinate system. The scene that is displayed is a function of the eyepoint's position and orientation, and field of view information. Eyepoint is roughly synonymous with ownship, as ownship effects (landing light lobes, beacons, collision detection, etc.) are relative to the eyepoint position.

Field

A field is half of a frame. The image is generated as two separate fields, one containing the even-numbered scan lines, and the other containing the odd-numbered.

Field Time

Field time is the time required to draw one complete scene on the display screen. On a 50Hz computer, the screen will be redrawn 50 times a second; the field time is the upper limit for the speed of flashing lights, animation sequences, and etc. Field times can be slowed by the overload manager if the number of objects in the scene exceeds the system's capability to process them within the allotted time. Frame rate relates to the time required to draw a complete image; field rate relates to the time required to draw the odd or the even set of raster lines. With a 2:1 interlace ratio, the field rate will be twice the frame rate.

Field-of-View

The field-of-view is the horizontal and vertical subtended angels from the eyepoint to the boundaries of a CIG channel. This is also referred to as a channel FOV as it is associated with the angle of view provided by a single CIG computing channel.

Filename

The name of a file consists of two parts, a name and an extension. The name consists of up to eight alphanumeric characters, the first character of which must be a letter. The extension consists of a period followed by up to three alphanumeric characters, and identifies the file type; command files commonly use the extension .COM, site files use .SIT, and executable files use .EXE. The real-time system requires only the name part of the filename, and supplies the default extension. The user may specify the extension if desired.

Flag

Flags are variables within a software program used to indicate a condition or state. Other commonly used names for these types of variables include switch and semaphore. Flags may be used within a program to indicate on/off status, warning or error conditions, or other status information. By using CLI commands, users may set flags internal to the SPX Real-Time System. For example, the command HAT + activates the height above terrain feature by setting an internal flag. The height above terrain code checks the value of this flag to determine whether to perform further processing.

Flicker

Flicker is perceptible temporal variation in luminance, and is a function of scene brightness, persistence, and the refresh rate.

Flight Dynamics Mode

The SPX image generation system is usually used as a component of a complete flight simulator. However, it is often desirable to simulate flight when SPX is not connected to the host computer. Accordingly, the real-time system software performs a small subset of the host computations; the flight dynamics module accepts user input from the flybox or the console keypad, and updates the eyepoint position based on speed and the Euler angles.

Flybox

(see ICC-100)

Fog

Fog and other visibility limiting effects are simulated by causing the color and the brightness of surfaces to tend toward white/grey (or other color for haze, smog, etc.) in day or night as a function of range. Light points will decrease in intensity with an increase in the simulated fog. Fog at night may be augmented by a glare condition under low runway visual range and ground fog situations.

FOV

(see Field of View)

Frame Buffer

A frame buffer is a large random-access memory in which the information representing each pixel of the image is stored.

Geometric Processor

The geometric processor is that part of the hardware which performs object translation, rotation, clipping, and perspective computations, as well as special effects processing such as texture motion and flashing, rotating, and strobe lights.

GP

(see Geometric Processor)

HAT

(see Height Above Terrain)

Height Above Terrain

The Height Above Terrain function calculates the height of the eyepoint above the terrain; this is used to provide height information for simulation altimeters, etc. The eyepoint must be above terrain polygons that are specified as providing HAT information before this information may be calculated by the system.

Host Block

The host block is an ethernet packet containing host opcodes which is transferred between the host computer and the SPX image generator.

Host Computer

The SPX image generator is usually used as a component of a complete flight simulator. In addition to the visual system, other components of the flight simulator may include a simulated cockpit with controls and instrumentation, a motion system to provide physical cues, and a host computer which translates inputs from the cockpit into commands for the instrumentation, visual, and motion systems. For the SPX image generator, the host computer is the source of position and environmental control data.

Host Interface

The host interface is the subsystem of a visual system which transfers signals between the host computer and the image generator multi-processor unit (MPU).

ICC-100

The ICC-100 is an input/output device that includes a keyboard, display monitor, slide control, and joystick. The flybox can substitute for the system console for purposes of command entry, plus may be used to navigate the eyepoint of other DCS through the scene by use of the joystick and slide pot.

IEEE 802.3

IEEE 802.3 is a hardware standard for communications between devices. The purpose of standards is to fix specifications that will allow manufacturers to make their devices communicate with devices manufactured by others. Communications network standards have initially focused on physical specifications (electrical, mechanical, functional control of data circuits), and data link specifications (establish, maintain, and release data links, error and flow control).

As Ethernet has become widely used, at least two standards have been defined: the Ethernet standard and the IEEE 802.3 standard. These standards specify that data will be transferred in a frame. The principal differences between the two standards are in the frame definition. The Ethernet standard frame consists of preamble, synchronization, destination address, source address, type, data, and error checking (FCS or CRC) fields. The IEEE 802.3 standard frame specifies length rather than type, and allows the use of a PAD field in the data section of the frame while Ethernet specifies a minimum packet size of 64 bytes.

The SPX host interface protocol uses the IEEE 802.3 standard.

IG

(see Image Generator)

Image Display

The image generator is the subsystem of a visual system which converts the signals from the image generator into visual scenes. The display devices may be CRT or projector based.

Image Generator

The SPX image generator consists of a multiprocessor unit, one or more channel processors, and one or more display devices. The multiprocessor unit receives inputs from the host computer and console, and passes data base and position data to the channel processors. Up to eight channel processors generate scene information in the form of analog signals. These signals are passed to the display device where they are used to generate the visual scene.

Imagery

Imagery is collectively the representation of objects and areas produced electronically on display devices or other media.

Instantaneous Field-of View

The instantaneous field-of-view is the FOV visible from a given eyepoint position. The instantaneous FOV is equal or less than the total FOV, due to viewing obstructions such as the glare shield or window frame, or optical limitation.

Interlace

Interlace is a technique used to increase apparent resolution on raster scan display devices. Each image, or frame, is generated as two separate fields. One field consists of all even-numbered scan lines, and the other consists of all odd-numbered scan lines.

Interrupt

An interrupt is a signal indicating a hardware or software condition, usually used to stop the execution of a running program in order to run a program of higher priority. For example, the host computer transfers data independent of the SPX field rate; because the transfer may occur at any time, an interrupt is generated to signal when new host data is available. The RTS saves the contents of all registers, then services the host interrupt.

The 68000 microprocessor provides seven levels of interrupt priorities, numbered from one to seven, with level seven being the highest priority. The highest level used by the RTS, level six, indicates a host interrupt. More information about 68000 interrupts is available in the M68000 Programmer's Reference Manual, Section 4.4.2.

IO Device

IO is an abbreviation for input/output device. Generally an IO device is used to communicate with the user, allowing commands to be entered by the user and messages to be returned by the computer.

Joystick

A joystick is a mechanical input device used for two-dimensional analog positioning. The flybox used with the SPX visual system includes a joystick which may be used to manipulate the position of the eyepoint or other coordinate systems.

KLOD

KLOD is an acronym for Constant (K) for Level Of Detail. This is a constant generated by the RTS to manage overload conditions. This constant is used by the OM to proportionately reduce the transition ranges for all objects and thus reduce the processing time by replacing highly detailed representations of objects with less detailed representations.

Landing Light Lobes

Landing light lobes are simulations of lights on an airplane generally used during landings and taxiing. This is simulated by illuminating specified polygons in a lobe pattern.

Lat/Lon System

A lat/lon system is a data base model that is configured to use latitude and longitude coordinates instead of XY coordinates for the placement of data base entities and dynamic coordinate systems. The real-time system translates the lat/lon coordinates into XY for use by the hardware.

Level of Detail

The modeler may create different representations of an object area or scene detail, with each representation geared to a certain viewing distance. As the eyepoint moves through the simulated environment, the image generator selects the version of each scene detail that is appropriate to its viewing distance. When the eyepoint reaches a specified distance from the modeled object, the image generator may switch from a low level-of-detail to a high level-of-detail representation of the object. Thus, for example, relatively distant items may be drawn from comparatively simple representations, freeing up IG resources so that nearby scene details can be made more complex.

Light Point

A light point is a simulated light-emitting radiator at a specific location in the scene.

Light String

A light string can be any of a number of different types of data base entities modeled to represent real-world lights. The light points within the string are equally spaced along a straight or curved line, and have the same defined color and intensity. Special light point attributes may further define such characteristics as flashing, strobe cycling, horizontal/vertical directionality, rotation, and sequencing.

Lines Per Frame

Lines per frame refers to the number of raster lines drawn in one frame time.

LOD

(see Level of Detail)

Login File

The login file is the file LOGIN.COM which the operating system seeks and executes upon system boot. The file may contain a list of commands for configuring the system and/or starting tasks. If the real-time system task is started by the login file, then the system is considered to be turn-key.

Matrix Switcher

The matrix switcher is an optional video switcher used to select which channel's video signal goes to the instructor monitor CSM. The RTS communicates the desired channel over a dedicated serial port.

Mesh

A mesh is a collection of cells. Different types of meshes may define animation sequences, collision detection, or the visual priority of the cells within the mesh.

Metafile

A metafile is a hierarchical data base file containing records which describe data base elements such as verticies, objects, polygons, cells, meshes, etc. This is the file which holds the data accessed by the data base modeling tools.

MIRP

(see Mission Record and Playback)

Mission Record and Playback

Mission Record and Playback (MIRP) is a real-time system feature which allows recording and playing back a mission. The recorded mission may also be modified at a later time. The MIRP commands are entered through the CLI.

Model

(see Data Base)

Modeling

Modeling is the act of creating/editing a data base model and the entities in it. See the *SPX Modeling Reference Manual*, E&S part number 901181-459, for more information about this process.

MP

(see Multi-Processor Card)

Multi-Processor Card

The multiprocessor (MP) card is the front-end computer for the SPX image generator. The SPX operating system, real-time system, modelling tools, and many utility programs can run on the M68000 microprocessor. In addition, the MP card contains hardware to interface with the host computer over an Ethernet link, with a Winchester disk drive and tape streamer over a standard SCSI bus, with the system console over serial interface ports, and with the channel processors over a parallel bus.

Multi-Processor Unit

The multi-processor unit is the cabinet and its associated devices that contain and support the multiprocessor. The unit includes the multiprocessor card, Winchester disk drive, streaming tape drive, power supplies, card cage, and cooling fans.

Object Manager

The object manager is the part of the hardware that manages the data base, sending to the geometric processor only those objects that will appear in the scene in priority order, based upon the eyepoint's field of view. Objects not appearing in the scene are not transmitted to the geometric processor by the object manager, thus freeing memory and computation capabilities.

Object

An object is any data base construct that can be displayed. An object is an collection of polygons or light strings, for example to represent a building or an aircraft.

Occultation

Occultation is the visual obstruction of scene lights and/or surfaces by other surfaces. Occultation may appear as the partial or total hiding of given light points or polygons in the model by other polygons, in response to the position of the observer.

OM

(see Object Manager)

On-Line

When a data base entity is in the environment memory it is considered to be on-line. When the OM requests database from the RTS, the RTS brings that part of the data base off the disk and into the environment memory or on-line.

On-Line Data Base

The on-line data base is stored in high speed environmental memory (EM) which is accessed for real-time scene processing, and may represent all or only a portion of the available data base.

Operating System

The operating system is the software part of the system that performs Input/Output control for all system devices and performs the file management function. The operating system starts a task, then remains in the background managing the system while various tasks or applications such as the real-time system are being run.

Overload

Overload is a condition in which one or more of the system processing capabilities are exceeded by the demands of the instantaneous on-line data base content.

Overload Management

Overload management is the overall strategy used to assure orderly scene processing reductions during periods of overload. Overload response techniques provide non-distracting adjustments to the scene complexity, and minimize visual distractions during the overload condition.

Own Ship

The ownship is essentially the eyepoint. Used in the general sense of the aircraft instead of the pilot's eye. The ownship beacon and strobe radiate from the aircraft not the eyepoint, but in terms of simulation they are the same place.

Pager

The pager is a software routine responsible used for determining what parts of the data base are needed and bringing those desired parts of the database from the disk into the environment memory.

Paging

Paging is the process of determining what parts of the data base are needed and bringing those desired parts of the database from the disk into the environment memory.

Parcel

A parcel is the data structure called out in the world file which groups the various data base components into individual data bases. Parcels may be either placeable for dynamic objects such as aircraft or clouds or they may be local for fixed data bases such as airports.

Perspective Image

Perspective image is the appearance of a scene image formed by projecting points in the visual environment back along straight line viewrays, converging at the eyepoint, onto a flat display plane. This display plane is ordinarily the plane of the image.

Pixel

Pixel is a contraction of picture element, and is the smallest element of resolution along a display scan line of raster.

Polygon

A polygon is a planar convex surface bound by three or four defining vertices, or points, and the implied bounding edge segments connecting the ordered vertices. A polygon is defined for potential visibility on only one of its two sides. Color, reflectance, and texture represent other defining attributes of a polygon. The intensity of a polygon can be influenced by sun-directionality and ambient illumination.

Priority

Priority is the scheme that determines what part of the data base occults or hides another part of the data base.

Prompt

A prompt is a predefined character(s) which, when displayed, indicates that the computer program is waiting for user input.

Protocol

A protocol is a formally agreed-upon method of communication. A protocol is used in the host/SPX communication described in Chapter 6.

Raster

A raster is the structure of parallel scanlines covering the usable display screen area and forming the picture.

Raster Light

A raster light is any light or light string that is drawn in the raster structure. A raster light will be drawn on the display screen at the same time that the raster lines are drawn on the display, as opposed to calligraphic lights which are drawn individually after the raster has been completely drawn.

Raster Line

A raster is the structure of parallel scan lines covering the usable display screen area and forming the picture. A raster line is one horizontal scan of the electron beam across the screen of the display.

Real Time

Any event occurring instantaneously or immediately is said to occur in real time. This is any motion or movement of objects on the display to simulate movement or motion in the real world.

Real-Time System

The real-time system is the software part of the SPX system responsible for providing the instantaneous control of the image generator system. The RTS acts as a high-level interface between the host, peripherals, and the IG hardware.

Refresh Rate

Refresh rate is the frequency at which the display image fields are drawn. Slowing the refresh rate increases the field rate and increases the visual system transport delay.

RTS

(see Real-Time System)

Scanline

A scanline is one of a set of parallel lines of the raster covering the usable display screen area and forming the picture by means of variation in color and brightness.

Scene

The scene is the simulation of a real world visual environment reconstructed from the modeled data base that the observer views at any given moment.

Scene Illumination

Scene illumination is comprised of two components. Ambient scene illumination is the day/dusk/night nondirectional component of scene illumination. Directional illumination produces a variable intensity for selected polygons as a function of the angle between the illumination source and the polygon surface.

Separating Plane

A separating plane is a non-visible element of the data base which is used to establish the priority relationship between two cells. The position of the eyepoint relative to the separating plane is evaluated in real time to determine which of the two cells is of higher priority.

Site Configuration File

A site configuration file contains a list of commands used to configure the real-time system. These commands may be any CLI command. The CLI TABLE command is used most often in site files. The default site file SPX.SIT will be run when the RTS is started unless a different file is specified.

Software

Software may refer to computer programs in a machine-usable form, the program documentation, program source code, or system documentation.

Software Source

Software source is the entry, or original, form of software designed in a given programming language usually appearing as digital or text information on appropriate media such as disk, magnetic tape, paper, etc.

Source Material

Source material is the input media (map, chart, engineering drawing, aerial photograph, etc.) from which a digital data base is developed.

Special Effects

Special effects refer to those real-time modifications to the basic numerical scene model to depict environmental conditions and effects. Special lighting and weather effects are often included.

SPXED

SPXED is an acronym for the SPX Modeling Editor, which is used to create and edit models that may be used on the SPX visual display system. (See the *SPX Modeling Reference Manual*, E&S part number 901181-459, for further information on this topic.)

SPXOS

SPXOS is an acronym for the SPX Operating System. (See the *SPX Operating System Reference Manual*, E&S part number 901181-833, for further information on this topic.)

Statistics Processor

The statistics processor is that part of the real-time system which keeps statistics on system performance. The statistics processor tracks the time required for all hardware devices (e.g., OM, GP and DP) and main software real-time routines to finish their tasks and conveys this information to the overload manager to take the appropriate action.

Streaming Tape

A streaming tape is a tape storage device used to backup data from the hard disk storage device or to transfer files from one hard disk to another.

Surface

(see Polygon)

Texture

Texture is the enhancement of a polygon by applying an intensity modulated, color modulated, or transparency modulated two-dimensional pattern or combination of patterns to the surface.

Timeout

The RTS monitors the amount of extra time (i.e., the time past the field rate) that a hardware device (e.g., OM, GP and DP) requires to finish its task. If this time exceeds a site-configurable time, the RTS does a warm reset. If three consecutive timeouts occur, the system is paused and a message is sent to the operators console describing which hardware device in which channel has extended its processing cycle.

Total Field-of-View

The total field-of-view is the FOV which is displayed by the image display and is potentially available to the viewer anywhere within the defined viewing volume.

Transport Delay

Transport delay is the time required for the visual system to respond to a change in host data. Visual system transport delay does not include the variable delay associated with the asynchronous host/MP interface or with the host simulator delay contribution.

Update Rate

Update rate is the frequency at which new perspective images of the scene are computed in order to convey the proper impression of scene motion. This can also be defined as the number of changes in eyepoint position and /or attitude per second.

Vertex

A vertex is any point in three-dimensional Cartesian space. The vertex may be attached to and defined within any of the coordinate systems. Verticies are used to define other data base constructs i.e. polygons, light points, separating planes, etc.

Visual System

The visual system includes all the hardware and software components necessary to generate the visual scenes. The hardware system components include the image generator, display device, and host interface.

World File

The world file is the highest level of data structure in the data base. It will include a list of available parcels (local and placeable), appropriate positioning data, color palette definition and the list of texture maps required.

FORMAT AND RESTORE A NEW DISK FROM DEBUGGER

D.1 INTRODUCTION

This procedure is to be used to format and restore new disk drives. All similar procedures of an earlier date should be disregarded. The entire procedure takes about 30 minutes to execute. This procedure supports the 3 types of disk drives that are available on the SPX System. They are listed below:

801922-301	Seagate	26/20 MByte
801587-051	Vertex	51/40 MByte
801587-085	Vertex	85/67 MByte

Data is also included with this procedure to configure the disk controller for these drives.

D.2 POWER ON THE SYSTEM

Before the procedure can be started, the SPX system must be powered on. Upon power up, the system console should print the following messages (the version numbers and dates are represented with Xs because they may change):

```
MP Card Tests XX.X XX-XXX-XXXX
EPROM checksum test passed
Testing MFP serial port devices ...
Testing static memory ...
Testing dynamic memory, (type ctrl C to abort) ...
Testing DMA controller ...
Testing co-processor ...
Testing ethernet interface ...
Testing common bus mail box memory ...
Testing disk/tape controller ...
```

```
Bus Error- Inst=XXXX PC=XXXX SR=XXXX USP=XXXX TIME= XXXX
D0-D7= XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX
A0-A7= XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX
 *
```

If the disk drive connected to the system is indeed unformatted, the system will jump to the debugger after trying to boot the operating system (which is not on the disk). Once debugger has been reached, the disk format and restore procedure can be started.

D.3 MEMORY BUFFER LOADING

The first step in the disk format and restore procedure is to enter into a memory buffer the correct parameters for the disk being formatted. These parameters vary depending on the disk used. Loading the memory buffer is done through the SPX Debugger program. Because the parameters do vary, the values are not shown in the procedure listings below, but place holders are shown. The place holders should be replaced with the correct numbers (shown in Table D-1) when the procedure is done.

D.3.1 Enter the Debugger

If the system was powered on with an unformatted disk, the power-up confidence tests will jump to the debugger automatically after trying to boot the operating system. If you are in the operating system, the debugger can be entered by entering a <CTRL/D>. This is done by holding down the <CONTROL> key and at the same time pressing the <D> key. When the debugger is entered, the following message is printed to the console:

```
Debug- PC=XXXX SR=XXXX USP=XXXX TIME=XXXX
D0-D7= XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX
A0-A7= XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX
*
```

The asterisk (*) is the prompt for the debugger.

D.3.2 Enter the Data

Once the debugger has been entered, the data can be entered by using the following procedure. Remember the numbers that should be inserted for the place holders, [byte0] - [byte9], can be found in Table D-1.

```
*OB 80000
00080000 00 *I [byte0] <RET>
00080001 00 *I [byte1] <RET>
00080002 00 *I [byte2] <RET>
```

```
00080003 00 *I [byte3] <RET>
00080004 00 *I [byte4] <RET>
00080005 00 *I [byte5] <RET>
00080006 00 *I [byte6] <RET>
00080007 00 *I [byte7] <RET>
00080008 00 *I [byte8] <RET>
00080009 00 *I [byte9] <RET>
```

The <RET> symbol represents the entering of a carriage return. Once this has been completed, the parameters for the disk have been entered into the memory buffer.

Table D-1. Disk Drive Parameters

	801922-301 Seagate 26 MByte 20 MB Frmtd	801587-051 Vertex 51 MByte 40 MB Frmtd	801587-085 Vertex 85 MByte 67 MB Frmtd	801587-085 Vertex 85 MByte 40 MB Frmtd
[byte0]	1	1	1	1
[byte1]	1	1	1	1
[byte2]	0	0	0	0
[byte3]	3	4	6	6
[byte4]	2	3	4	2
[byte5]	66	DA	8D	BF
[byte6]	0	0	0	0
[byte7]	0	0	0	0
[byte8]	1F	1F	1F	1F
[byte9]	0	0	0	0

D.4 LOAD THE DISK PARAMETERS

After loading the disk parameters into the memory buffer, they must be loaded into the disk controller. This is done by using the debugger FT command. You should already be in the debugger and at the asterisk (*) prompt.

```
*FT
Build disk/tape command
Command code (0-EF): C2 <RET>
Disk LUN # (0-2): 0 <RET>
RAM buffer address (400-9FFFF): 80000 <RET>
*
```

Once the asterisk (*) prompt returns, the controller has been loaded with the correct disk parameters from the memory buffer. One important thing to remember is that now that the disk controller has been loaded with the correct parameters, they will stay that way until the machine is turned off and then on again, or a reset is issued. Upon power-up and at reset, the MP card reads the disk controller parameters from sector 0 of the disk and loads them into the controller.

WARNING: From this point in the procedure, DO NOT RESET THE SYSTEM.

D.5 FORMAT THE DISK FROM THE DEBUGGER

Now that the correct disk parameters have been loaded into the disk controller, the controller is ready to format the disk drive. This again is done using the debugger FT command. You should already be in the debugger and at the asterisk (*) prompt.

```
*FT
Build disk/tape command
Command code (0-EF): 04 <RET>
disk LUN # (0-2): 0 <RET>
Interleave factor (0-10): 1 <RET>
Control field (0-FF): 0 <RET>
*
```

After the command has been entered, the disk light should go on during the format process. The actual formatting lasts for about two to five minutes. When the asterisk (*) prompt returns, the formatting has completed.

D.6 RESTORE THE DISK

This is a process of copying onto the disk from the streamer tape all of the files that were once on the disk. The tape used in this restore process MUST have been created by a backup process from the FMU utility. The reason this restoration is even done at all is so you can run the FMU utility to do the actual formatting. This again is done using the debugger FT command. You should already be in the debugger and at the asterisk (*) prompt. Install the backup tape into the tape streamer drive before starting the procedure below. The tape SAFE switch must be in the OFF position.

```
*FT
Build disk/tape command
Command code (0-EF): 23 <RET>
Disk LUN # (0-2): 0 <RET>
Sector address (0-1FFFFF): 0 <RET>
Long block count (0-FFFFFF): FFFFFF <RET>
Control field (0-FF): 0 <RET>

Command error: Status= 62Completion= 00
*
```

Once the restore is completed, the command error line is printed. Both the disk and tape lights should be on during the restore process. The entire restore takes approximately 10 minutes (longer times may be required for backup tapes with large amounts of data). When the asterisk (*) prompt returns, the formatting has completed. This restoration process will erase the disk parameters stored in sector 0 of the disk and if the backup tape used to do the restore was from a different size disk, the disk parameters stored in sector 0 of the disk will be incorrect. But as long as no reset is given, it will not effect the rest of the procedure.

D.7 BOOT THE SYSTEM AND RUN FMU

Now that the operating system and FMU are on the disk drive, the system can be booted and the file management utility can be run. The boot-up process is started by using the debugger BO command. You should already be in the debugger and at the asterisk (*) prompt. Remember, do not reset the MP card to boot the system. Resetting the MP card at this point will read the disk parameters from sector 0 and then use these parameters to set up the controller card. Depending on the disk parameters now in sector zero, this may make the disk unreadable.

```
*BO <RET>
Welcome to the SPX Operating System
SPXOS Version X.X XX-XXX-XXXX

XX-XXX-XXXX 00:00


> @fmu

SPX File Management Utility

FMU>
```

The FMU utility will be loaded and be running when the FMU> prompt is displayed on the console.

D.8 DO THE FINAL FORMATTING

With FMU running, you are now ready to do the final formatting of the disk drive. The formatting and restoring done above were only to get FMU running so that the actual formatting could be done. Formatting the disk from FMU will test each disk sector on the disk, identify faulty sectors, and reassign bad tracks. This formatting is done as is shown by the procedure listed below. The numbers entered at each of the questions are shown with place holders. The actual numbers for the place holders should be used and they can be found in Table D-1.

```
FMU> format dr0: <RET>
Enter step pulse width (01): [byte0] <RET>
Enter step period (01): [byte1] <RET>
Enter step mode (00): [byte2] <RET>
Enter number of heads - 1 (03): [byte3] <RET>
Enter ms number of cylinders - 1 (02): [byte4] <RET>
```

```
Enter ls number of cylinders - 1 (66): [byte5] <RET>
Enter WSI/write precompensation (00): [byte6] <RET>
Enter drive type identifier (00): [byte7] <RET>
Enter number of sectors/track - 1 (1F): [byte8] <RET>
Enter sector interleave factor (01): 1 <RET>
```

NOTE: The sector interleave factor is not byte 9 from the table.

```
*** WARNING *** Formatting erases the disk !!!
Are you sure you want to format ? (Y/N): y <RET>

FMU>
```

This process not only does the formatting, but checks all of the sectors to guarantee that all of them can hold data. If there is an error in a sector, that sector is marked as a bad sector and the sector is reassigned. The disk light should be on during the format process and the entire process takes about 5.5 minutes to complete. Once the FMU prompt has returned, the formatting is complete. Make sure that after the formatting is done, that you don't exit the FMU utility before completing the next step in Section D.9.

D.9 RESTORING THE DISK

Now that the disk has been properly formatted, the disk must again be restored from the tape streamer. The same tape used in Section D.6 above should be used for this process. Also, you should still be in the FMU utility from the previous step in the procedure. Remember the SAFE switch on the tape cartridge should be in the OFF position.

```
FMU> restore dr0: <RET>

*** WARNING *** Restoring erases the disk !!!
Are you sure you want to restore ? (Y/N): y <RET>

FMU>
```

This process takes 10 minutes or more to complete; you will know that the process has finished when the FMU prompt returns. Both the disk light and the tape light should be on during this process.

At the completion of the step in the procedure, the disk drive should be totally re-formatted and restored with the proper contents.

If an error occurs while attempting to restore the disk, retry the above procedure.

With FMU version 01, attempting to to restore a backup tape onto a disk drive having different disk parameters than those of the disk from which the backup tape was made will result in a restore error. With FMU versions 02 and later, this is not a problem as long as the disk contains sufficient storage space for the data.

D.10 SPECIAL DISK RESTORATION

If, as you begin this second restoration process a restore error immediately occurs, the disk controller parameters stored in sector 0 of the disk do not match those found in the first data block of the backup tape. This would be the case if the backup tape was created from a disk of a different size or vendor. If you desire to restore the disk from the non-compatible tape, either enter Y to indicate that you want to proceed anyway, or (if using the first released version of FMU) step through the following procedure.

D.10.1 Enter the Debugger

The system is currently running the FMU utility and the verification of the disk parameters in sector 0 must be done from the debugger. You can enter the debugger by entering a <CTRL /D>. This is done by holding down the <CONTROL> key and at the same time pressing the <D> key. When the debugger is entered, the following message is printed to the console:

```
Debug- PC=XXXX SR=XXXX USP=XXXX TIME=XXXX
D0-D7= XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX
A0-A7= XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX XXXXX
*
```

The asterisk (*) is the prompt for the debugger.

D.10.2 Read Sector 0

Using the following procedure, copy into memory the information in sector 0 of the disk drive. This uses the FT command of the debugger.

```
*FT
Build disk/tape command
Command code (0-EF): 8 <RET>
LUN # (0-3): 0 <RET>
Sector address (0-1FFFFF): 0 <RET>
Sector count (0-FF): 1 <RET>
Control field (0-FF): 0 <RET>
RAM buffer address (400-9FFFF): 80000 <RET>
*
```

When the asterisk (*) prompt returns, the information in sector 0 has been loaded into memory beginning at location 80000.

D.10.3 Save the Current Disk Parameters

After sector 0 has been loaded into memory, the memory locations can be printed out. This is to retrieve the disk controller parameters stored in sector 0. From the debugger, the following command can be used to read memory and do the verification. Notice that when the memory locations are printed out, that they should have the numbers shown in Table D-1. Write down these numbers as they will be later restored.

```
*L 80040 <RET>
 <RET>
00080040 [byte0] [byte1] [byte2] [byte3] [byte4] [byte5]
[byte6] [byte7] [byte8] [byte9] 01 XX XX XX XX XX *
```

In the above line, the debugger will print all of the values on one line, but the line above has been split into two parts due to limitations of the documentation.

D.10.4 Rewind the Tape and Restore the Disk from the Backup Tape

Using the following procedure, rewind the tape

```
*FT
Build disk/tape command
Command code (0-EF): 1 <RET>
LUN # (0-3): 3 <RET>
Control field (0-FF): 0 <RET>
*
```

Using the following procedure, restore the disk from the backup tape

```
*FT
Build disk/tape command
Command code (0-EF): 23 <RET>
disk LUN # (0-2): 0 <RET>
sector address (0-1FFFFF): 0 <RET>
long block count (0-FFFFFF): FFFFFF <RET>
Control field (0-FF): 0 <RET>
```

After the restore process is complete the following message should be displayed.

```
Command error: Status= 62Completion= 00
*
```

D.10.5 Restoring the Disk Parameters

After the tape has been loaded onto the disk, read sector 0 into memory and restore the original disk parameters.

Read sector 0 by using the following procedure.

```
*FT
Build disk/tape command
Command code (0-EF): 8 <RET>
LUN # (0-3): 0 <RET>
Sector address (0-1FFFFF): 0 <RET>
Sector count (0-FF): 1 <RET>
Control field (0-FF): 0 <RET>
RAM buffer address (400-9FFFF): 80000 <RET>
*
```

Using the debugger commands restore the original disk parameters saved in Section D.10.3.

```
*OB 80040
00080040 XX *I [byte0] <RET>
00080041 XX *I [byte1] <RET>
00080042 XX *I [byte2] <RET>
00080043 XX *I [byte3] <RET>
00080044 XX *I [byte4] <RET>
00080045 XX *I [byte5] <RET>
00080046 XX *I [byte6] <RET>
00080047 XX *I [byte7] <RET>
00080048 XX *I [byte8] <RET>
00080049 XX *I [byte9] <RET>
0008004A XX *I 1 <RET>
*
```

Where byte 0 through byte 9 are those saved in Section D.10.3.

D.10.6 Write Sector 0 Back Out to Disk

Use the following procedure to write sector 0 back out to the disk.

```
*FT
Build disk/tape command
Command code (0-EF): A <RET>
LUN # (0-3): 0 <RET>
Sector address (0-1FFFFF): 0 <RET>
Sector count (0-FF): 1 <RET>
Control field (0-FF): 0 <RET>
RAM buffer address (400-9FFFF): 80000 <RET>
```

D.10.7 Boot the system.

With the correct disk parameters restored in sector 0 you can now reset the MP card. The system should boot up normally from the restored disk.

D.11 DISK DRIVE PARAMETERS FOR FORMATTING

Table D-1 lists the parameters used in both format steps in the disk formatting procedure (Sections D.3, D.8, and D.10). Listed are the four sets of data for the three supported disk drives.