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Description - This is an overview of the Signa Horizon (Release 8.X) systems. Sheet numbers listed at the end of some subsection titles refer to the sheet number within the System Block Diagrams found in *Direction 2153389 Signa Horizon (Release 8.X) Block Diagrams and Supplemental Schematics*.

The block diagrams show the major components, where they are located, and how they communicate with each other.

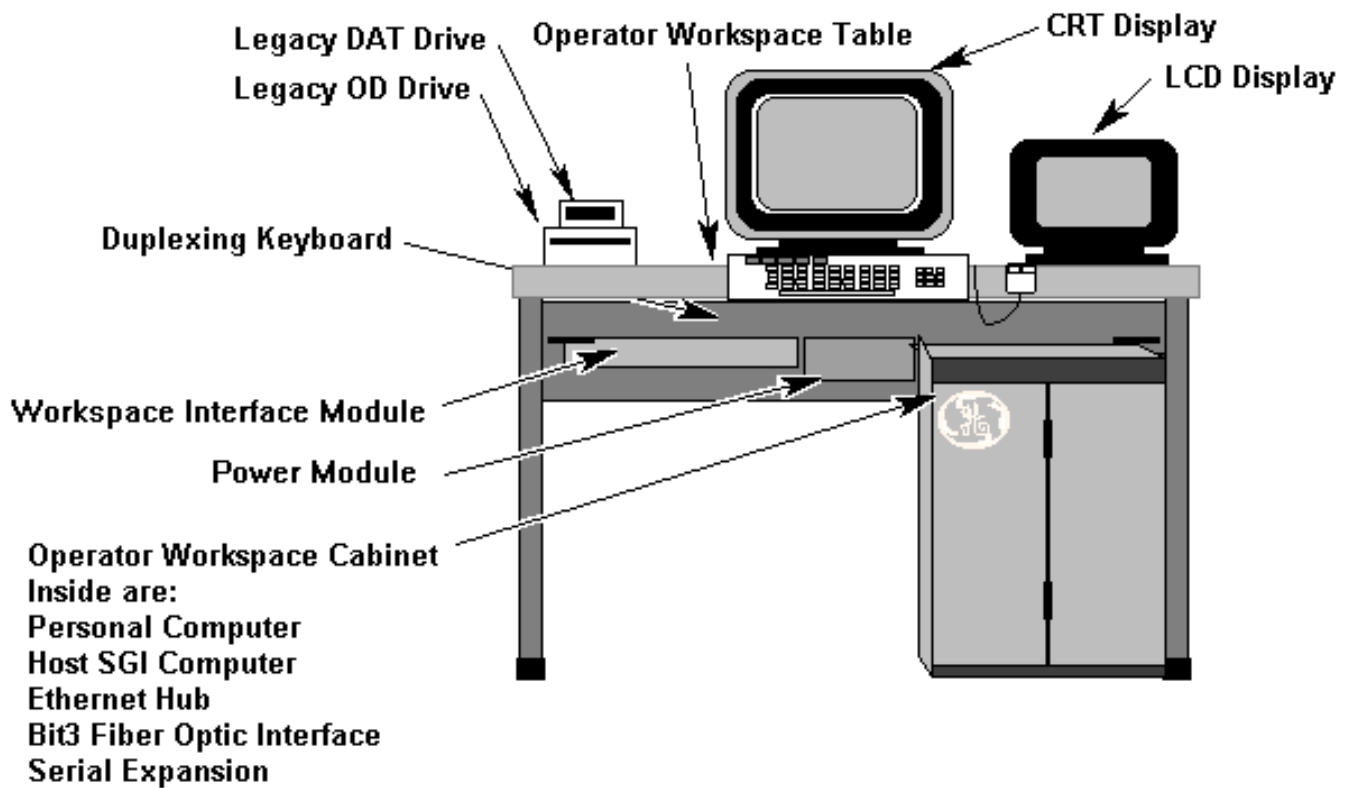
1- OVERVIEW

The Signa Horizon (Release 8.X) system is made up of a variety of subsystems. These subsystems include the Operator Workspace, Gradient Driver subsystem, RF subsystem, Magnet subsystem, Patient Handling, Gradient and RF waveform generation subsystem.

The Integrated Workspace, which was new for Release 8.0, consists of devices whose function roughly corresponds to what previously was the Genesis computer and console. The Gradient Driver subsystem consists of a Gradient Cabinet (six Power Modules, or three Power Modules), the GRAM Cabinet, and the Epoxy-filled Combined Gradient Coil. The Streamlined RF/Pen Cabinet is also new with Release 8.0. The RF/Pen cabinet consists of combined penetration cabinet function, the same RF amplifier as previous release, and a newly designed power monitor and switching control signal module. The Patient Handling remains the same as with the previous release (Signa Horizon Release 5.5).

2- INTEGRATED OPERATOR WORKSPACE (OW)

Illustration L1 shows the entire Integrated Operator Workspace. There are multiple components located on the Integrated Operator Workspace (OW). Two main areas of the Integrated Operator Workspace are the OW Table, and the OW Cabinet.



Items not seen are the DASM, and the Modem. They are located on the back of the OW Table.

ILLUSTRATION L1
OPERATOR WORKSPACE

2-1 Operator Workspace Table

The Operator Workspace Table holds the host CRT display, the PC LCD panel, a duplex keyboard, mouse, modem, DASM, and a place for a DAT drive and/or OD drive from a previous Signa system. The duplexing keyboard and mouse are capable of interfacing with both the Silicon Graphics Incorporated (SGI) host computer, and with the IBM-compatible personal computer (both housed in the Operator Workspace Cabinet).

2-2 Operator Workspace Cabinet

The Operator Workspace Cabinet is an enclosure that houses the SGI host computer and the IBM-compatible PC. In addition, this cabinet houses the Bit3 fiber optic interface (used for communication with the System Cabinet), the Model 800 Ethernet Hub, and a Specialix brand serial expansion module.

3- PERIPHERALS

3-1 Imaging Camera

The system interfaces with a laser camera, which provides a means to get hardcopy output of images on film. Several formats are available on one film size.

3-2 Line Printer

This option provides a means of creating a hardcopy record of ASCII data (not used to print images or graphics).

4- ISE CHASSIS

The Integrated System Electronics (ISE) subsystem provides excitation of selected patient nuclei at the Larmor frequency, detects returning echoes, and reconstructs the raw data into an image. This is accomplished by computer-modulated waveforms input to the CERD exciter. This low-level transmitted signal is amplified by the RF amplifier. The resultant high-level signal is input to an RF coil located in the magnet. A low-level received signal (echo) is then detected from the sample, or patient, and is amplified by a preamplifier, located at the magnet. This amplified received signal is input to the CERD receiver. The receiver demodulates the signal and digitizes it so that it can be processed by the AP Board, and the reconstructed image can be transferred to the computer. The transmitter and receiver have connections via two transmit/receive (T/R) switches for two operator-selected output modes of the RF amplifier. Each coil is functionally similar to an antenna.

4-1 Transmit Subsystem

The transmit subsystem consists of six major components:

- Integrated Pulse Generator (IPG)
- CERD exciter (Digital Exciter Board (located on the CERD)) which contains the Exciter DAC Board and Narrow Band Exciter Module
- 20kW RF Amplifier (1.5T), 8kW RF Amplifier (1.0T)
- RFSC Module, containing APB Board, Comm. Mgr/Power Monitor Board, and Pin Switch Driver Board (These devices are located in the RF/Pen Cabinet)
- System Support Module (SSM), containing APM, Power Supplies, Pin Switch Driver/SPC (These devices are located in the RF/Pen II Cabinet)

4-2 Receive Subsystem

The receive subsystem consists of three major components:

- T/R Switch for each coil
- Preamplifier
- CERD receiver (Digital Receiver Board which contains the Receiver A/D Board and Narrow Band Receiver Module).

Most of the CERD subsystem hardware is contained in the System Cabinet, RF/Pen Cabinet, Magnet Enclosure, and Rear Pedestal.

4-3 System Cabinet

The System Cabinet contains the Integrated System Electronics (ISE) and the TYME-II.

The ISE performs all the data collection and reconstruction of RF signals. It receives commands and RF waveform information from the SGI Host via the TYME-II Board and the IPG Board. It communicates to the host computer through the Bit3 fiber optic interface. The Exciter Module receives IPG data via the ISE Backplane. These inputs are combined to generate real-time RF waveforms which are sent by the Digital Exciter to the RF/Pen Amplifier Cabinet. The detected signal (by the RF coil) is demodulated by the Digital Receiver. The data acquisition portion of the CERD performs any preprocessing before transferring the data to the memory board(s). The ISE AP Board reconstructs the raw data into an image file(s) which is later transferred to the host computer via the Bit3 fiber optic interface.

The TYME-II receives certain system "status" signals (E-Stop, door open, cryogenics low, etc.), processes the signals, and transmits corresponding "action" signals to the appropriate devices (PDU, TYME Board, Manifold I/F Board, etc.).

4-4 RF/Pen Cabinet

There are two possibilities for an RF/Pen Cabinet. The first is the RF/Pen Cabinet (first released with Signa Horizon (Release 5.x), and the second is the RF/Pen II Cabinet (phase into Signa Horizon LX (release 8.x).

The RF/Pen Cabinet contains the RF Amplifier, RFSC Module (APB Board, Pin Switch Driver Board, and RF Power Monitor).

The RF/Pen II Cabinet contains the RF Amplifier, System Support Module (APM, Power Supplies, and Pin Switch Driver with SPC).

The RF amplifier provides power to the RF coils (body, head, surface, extremity, etc.) The RF amplifier requires signals from several other subsystems for proper operation which include: RF input signal from the CERD via the Analog Processor Board (APB) or APM Board, mode (body or head), frequency and operating commands originating from the IPG Board, the UNBLANK signal which is received from the Digital Exciter Board via the Pin Switch Driver Board, and the Power Monitor HV REL signal to control a 12 Vdc relay as a hard-wired safety feature.

4-5 Magnet Enclosure and Rear Pedestal

The magnet enclosure and rear pedestal contain the body coil hardware, head coil hardware, and Physiological Acquisition Controller (PAC) Module.

4-5-1 Body Coil

The Body Quadrature T/R Switch and Hybrid Assembly split the output of the RF amplifier into two signals, I and Q, that are ninety degrees out of phase with each other, and apply these signals to the inputs of the body coil. A body TR bias signal is applied to the heliax cable at the RF amplifier EFB assembly. This couples the RF amplifier output to the hybrid input, and couples the reflected power signal to the internal load.

During receive, the RF amplifier and load are disconnected from the hybrid, so that all the received signals from the coil are applied to the input of the preamplifier for best receive sensitivity.

4-5-2 Head Coil

The Quad Head Coil consists of three distinct parts: the Hybrid Splitter, two Isolation Boards, and the actual RF Coil Assembly. The Hybrid Splitter splits the RF signal into two signals that are ninety degrees out of phase with each other. These two signals, I and Q, are applied to the inputs of the head coil, where a rotating RF field is produced. The two isolation boards match the transmission line to the RF coil.

The Head T/R Assembly is functionally the same as the Body Quadrature T/R Switch.

The echo from the patient is extremely small in amplitude. To keep it from being obscured by noise, the preamplifier boosts the level of the echo before transmitting it along the coaxial cable from the exam room to the receiver.

Provisions have been made on the head coil to allow use of the optional extremity coil, surface coils, spectroscopy coils, or multicoils.

4-5-3 PAC Module

The Physiological Acquisition Controller (PAC) Board acquires, digitizes, and transmits physiological signals from the patient to the IPG board. The system uses these signals to synchronize the scanner to physiological events such as patient respiration, heart beat, and pulse.

Respiratory Compensation is used during torso scans to help eliminate artifacts caused by patient breathing motion. The compensation is based on the patient's respiratory rate, which is measured by a bellows placed across the patient's chest or abdomen.

Cardiac gating is used when the specific position of the heart is important for imaging. The gating is based on the patient's heart motion, which is monitored by electrocardiogram (ECG) leads placed on the patient's chest. Peripheral gating is used to minimize the effect of blood flow through the body. A plethysmograph (photopulse sensor) is placed on the patient's finger to detect blood flow.

5- GRADIENTS – SHEETS 1 AND 2

The gradient subsystem produces calibrated magnetic fields based on digital input received from the IPG. The gradient subsystem consists of:

- Gradient Coil Assembly
- Gradient Power Modules
- GAP Board and MIF Modules
- Gradient Ramp Acceleration Module (on Signa Horizon HighSpeed and EchoSpeed only)

5-1 Gradient Coil Assembly

The Gradient Coil Assembly is a large cylinder constructed of fiberglass that fits into the bore of the magnet. For Signa Horizon, the Gradient Coil is epoxy-filled and air/water cooled. The Gradient Coil Assembly contains three separate electrical coils (x, y, and z) that are used to produce the spatial field gradients that linearly vary the strength of the magnetic field throughout the image volume. This gradient field, together with the RF pulses, defines the image slice thickness and the image plane.

5-2 Gradient Power Modules

The Gradient Power Modules provide current to the gradient coils in response to control signals sent from the IPG, and processed through the Gradient Interface Module. The Gradient Cabinet contains the following number of Power Modules operating in master/slave configurations

- Horizon Base – six amplifiers; two per axis (master/slave)
- Horizon HighSpeed – three amplifiers; one per axis (master)
- Horizon EchoSpeed – six amplifiers; two per axis (master/slave)

5-3 GAP Board & MIF Module

The GAP Board provides a means for the IPG to communicate with the Gradient Amplifiers. The GAP Board receives optically transmitted serial data from the IPG, and transmits it to the MIF modules (one per axis). The MIF Module converts the serial optical data to electrically transmittable parallel data for the Gradient Power Modules and the GRAM Modules. The GAP Board receives Gradient Power Module and GRAM status via the MIF Modules, and transmits it back to the IPG Board.

5-4 GRAM Modules

The Gradient Ramp Acceleration Modules (GRAMs) are present only on HighSpeed and EchoSpeed systems. The GRAMs provide increased current slew rates to the gradient coils in response to control signals sent from the IPG and processed through the MIF Modules. The GRAM Cabinet contains a total of three GRAM Modules (one per axis).

6- POWER DISTRIBUTION UNIT (PDU) – SHEET 1

The PDU provides power for the entire MR system, excluding magnet room accessories (e.g., oxygen monitor and Emergency Rundown Unit, or Magnet Rundown Unit). The PDU with 75 kVA or 150 kVA transformer can transform input power between 330–520 Vac into an output voltage of 208 Vac. The Compact PDU with 50 kVA transformer can transform input power of 480 V or 380/400/415 V for international unit into an output voltage of 208 Vac.

7- PATIENT HANDLING – SHEETS 1 AND 2

Patient Handling hardware consists of the RF/Pen Cabinet, Penetration Panel, Patient Transport, Pneumatic Patient Alert System, and hardware located in the magnet enclosure and rear pedestal.

7-1 RF/Pen Cabinet

7-1-1 RF/Pen Cabinet

The RF/Pen Cabinet contains the MEPS Module, which provides power for the patient handling control equipment. The MEPS Module consists of the High-current Power Supply for the patient alignment lights, bore light, longitudinal drive, and Dock, and the Low-current Power Supply for the Scan Room Interface (SRI), PAC), and the Long Drive Power Amp Board for the Patient Transport.

7-2 Penetration Panel

All system interconnections penetrating the RF shielding surrounding the exam room are filtered to minimize RF interference. This includes electrical, fiber optic, air, and compressed gas and water lines. Systems with a Stealth Computer also contain a Fiber Optic Repeater Board, which strengthens the optical signals to and from the SRI and PAC Modules.

7-3 Patient Transport

Patient throughput is optimized by the portable Patient Transport. The Patient Transport is controlled by a combination of foot pedals and hydraulics.

7-4 Pneumatic Patient Alert System

The Pneumatic Patient Alert System is a stand-alone system that allows the patient to contact the operator even when console volume is turned down. This patient-to-operator contact occurs when the patient squeezes a hand-held air bulb; this sets off an audible and visual alarm near the operator.

7-5 Magnet Enclosure and Rear Pedestal

The Magnet Enclosure and Rear Pedestal contain the following patient handling hardware:

7-5-1 Scan Room Interface (SRI)

The SRI Module processes control and status data in the scan room, and exchanges scan room data with the TYME card (located in the TPS/ISE chassis). In the scan room, data inputs to the SRI Module come from the Longitudinal Drive Assembly, the Dock Assembly, and the Magnet Enclosure Control Switches, while data outputs go to the Magnet Enclosure Status Indicators.

7-5-2 Patient Comfort

The Patient Comfort Module consists of a bore vent, fiber optic bundles for bore lighting, and a microphone and speaker for patient-to-operator communication.

7-5-3 Patient Alignment Lights

Three fixed patient alignment lights are mounted on the front face of the magnet frame. These provide a perfectly aligned wraparound beam pattern for the coronal, axial, and sagittal planes in the magnet bore. The three fixed lights are laser diodes for Cx magnets and halogen lights for non Cx magnets.

7-5-4 Longitudinal Drive

The Longitudinal Drive system moves the patient cradle in and out of the magnet bore.

7-5-5 Dock

The Dock provides the means to secure the Patient Transport to the magnet enclosure and controls the vertical positioning of the cradle on the magnet enclosure.

8- MAGNETS & CRYOGENS – SHEETS 1 & 2

8-1 Magnet Power Supply

The magnet is energized with current from the Magnet Power Supply. The power supply is used only when bringing the magnet to field, or when changing the strength of the field.

8-2 Superconducting Shim Power Supply

Note

The Cx Magnet does not have S/C shim coils and does not use Resistive Shim coil. Therefore, the power supplies associated with these coils are not applicable to the Cx Magnet.

All GE magnets except Cx magnet use superconducting (S/C) shim coils. The S/C Shim Power Supply is used only during the initial energizing period. It can then be disconnected from the S/C shim coils after the shim currents are set.

8-3 Resistive Shim Power Supply

Note

The Cx Magnet does not have S/C shim coils and does not use Resistive Shim coil. Therefore, the power supplies associated with these coils are not applicable to the Cx Magnet.

The Resistive Shim Power Supply provides current to the resistive shim coils and remains on at all times. Resistive shims are used on all Oxford magnet subsystems, and spectroscopy sites with GE magnets.

8-4 Main Coil and Cryostat

The 15,000 and 10,000 gauss magnetic fields are produced by a superconducting magnet. The main coils are mounted in a liquid helium vessel, and are submerged in liquid helium. The helium vessel is surrounded by radiation shields and is suspended within a vacuum chamber. The overall assembly is called the *cryostat*.

8-5 Shim Coils

Shim coils provide auxiliary magnet fields to compensate for inhomogeneities in the main magnetic field, which are due to tolerances in manufacturing, or the effect of ferrous material in the environment. Oxford magnets have resistive shim coils, whereas GE magnets (except for Cx Magnet) have S/C shim coils; however, resistive shim coils are an option on some GE magnets.

8-6 Cryogen Level Meters

The magnet cryogen level meters (liquid helium and/or liquid nitrogen) are located in the System Cabinet.

8-6-1 Liquid Helium Meter

The liquid helium meter monitors the level of liquid helium in the cryostat helium vessel. The readings are expressed as a percentage of the full state.

8-6-2 Liquid Nitrogen Meter

The liquid nitrogen meter monitors the level of liquid nitrogen in the cryostat nitrogen vessel (Oxford fixed and GE S-I magnets only). Other magnets use a shieldcooler refrigeration system in place of the nitrogen vessel.

8-7 Magnet Rundown Unit

The Magnet Rundown Unit quickly removes the magnetic field in a few minutes. During a rundown, over 75% of the liquid helium within the helium vessel is converted to gas, and is exhausted through the customer provided vent system. Therefore, the Magnet Rundown Button should be activated only in emergencies.

9- OXYGEN MONITOR – SHEET 2

Note

The Oxygen Monitor is optional on Signa Horizon systems.

Air normally contains 20.9% oxygen by volume. If a significant decrease in the oxygen content of air occurs in a confined area, the atmosphere becomes hazardous to human life. A remote Oxygen Sensor Module (OM3) senses the atmosphere in the magnet room, where depletion of oxygen can occur due to displacement by cryogen boil-off during a refill, or a quench. The sensor module transmits a signal to an oxygen monitor (OM1) located in the control room, near the operator work space. If the oxygen level drops to the alarm point (18.0%), the monitor provides audio and visual alarms in the control room, and transmits a signal to the sensor module causing audio and visual alarms in the magnet room.

REVISION HISTORY

REV	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
0	August 5, 1998	M. Whitlow	Initial conversion from Toolbook to Word.
1	Oct 13, 1999	M. Keber	Added correct proprietary heading to document.