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Description - This is an overview of the Signa TwinSpeed system. Sheet numbers listed at the end of some subsection titles refer to the sheet number within the System Block Diagrams found in *Direction 2304882 Signa TwinSpeed (Release 9.0) 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 *TwinSpeed* (Release 9.0 and higher) 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 consists of the main console and worktop, PC and patient communication device integrated into the Host/PC combined keyboard. The Gradient Driver subsystem, consists of a Gradient Cabinet (three amplifiers and 1 power supply), the ACGD, and the Twin Gradient Coil with 5-coil High Order Shim set. The RF cabinet consists of combined penetration cabinet function, the 16kW RF amplifier, and a power monitor and switching control signal module. The Patient Handling remains the same as with the other Signa systems, with the addition of the Quiet Technology™ comprising a vacuum pump, special magnet enclosures, and a low eddy-current RF Body Coil.

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.

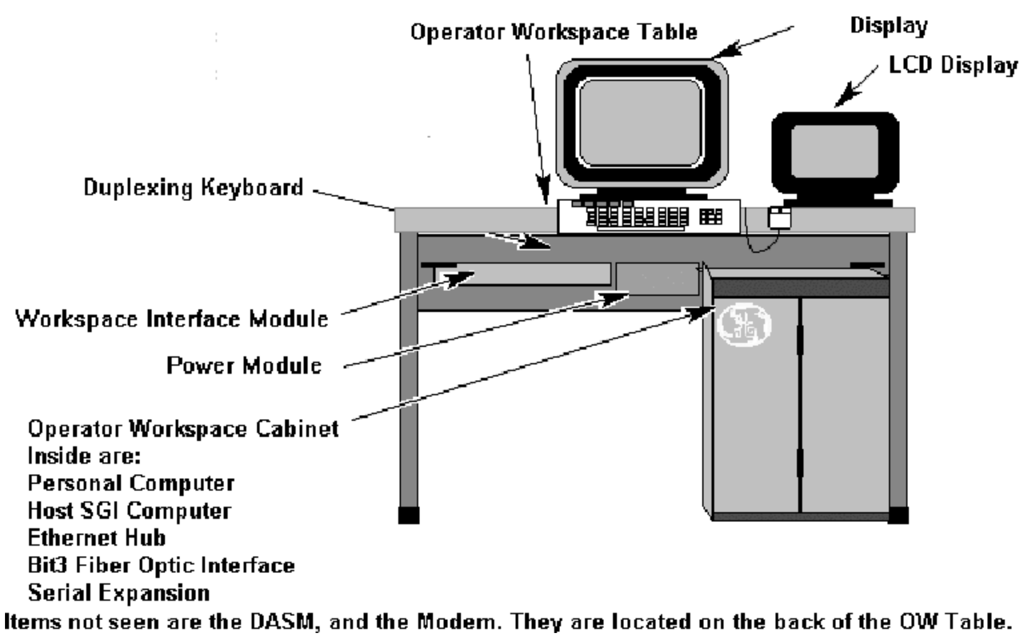

ILLUSTRATION L1

OPERATOR WORKSPACE

2-1 Operator Workspace Table

The Operator Workspace Table holds the host flat-screen 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 housed in the Operator Workspace Cabinet.

2-2 Operator Workspace Cabinet

The Operator Workspace Cabinet is an enclosure that houses the IBM-compatible PC and Host CD and MOD drives. 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 UCERD 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 UCERD 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)
- UCERD exciter (Universal Combined Exciter Receiver Detector board) which contains the Exciter DAC Board and Narrow Band Exciter Module
- 16kW 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
- UCERD receiver which contains the Receiver A/D Board and Narrow Band Receiver Module.

Most of the UCERD subsystem hardware is contained in the System Cabinet, RF 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 UCERD performs any preprocessing before transferring the data to the memory board(s). The ISE MEDCAM 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, cryogens 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 Cabinet

The RF 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 UCERD 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 LEC RF body coil. A body T/R 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 receiver 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

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

- Twin Gradient Coil Assembly (TRM)
- High Order Shim Coil Assembly (part of TRM)
- Gradient Amplifiers (SGA)
- Gradient Power Supply (PS)
- GP Board and MIF Modules (GP)
- Gradient Switch (GSW)

5-1 Twin Gradient Coil Assembly

The Twin Gradient Coil Assembly is a large cylinder constructed of fiberglass that fits into the bore of the magnet. For the Signa TwinSpeed, the Gradient Coil is epoxy-filled and water-cooled. The Gradient Coil Assembly contains two sets of 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.

The TRM coil consists of a large whole-body gradient coil, called the WHOLE-BODY, similar in size to the BRM, covering the maximum FOV of 48cm, with specifications of 23mT/m amplitude and 80mT/m/msec slew-rate, close in performance to the HiSpeed. The second gradient coil is a smaller one, called the ZOOM gradient, covering a smaller FOV (up to 44cm axial and 35cm sagittal/coronal), similar to the CRM, but with an internal diameter of 60cm (with the RF Body coil). It has the same specifications as the CRM, with 40mT/m amplitude and 150mT/m/msec slew-rate.

5-2 High Order Shim Coil Assembly

The High Order Shim (HOS) coil set are part of the TRM coil assembly. It consists of five different high order coils, ZX, ZY, XY, X2-Y2 and Z2, generating additional magnetic fields to correct for the inhomogeneities presented by the patient.

5-3 Gradient Amplifiers

The Gradient Amplifiers of the ACGD cabinet, SGAs, provide current to the gradient coils in response to control signals sent from the IPG, and processed through the Gradient Interface Module. There are three such amplifiers providing current to separate axes. Even though the TwinSpeed has two gradient coils, hence two sets of axes, the same three amplifiers are used by a switching device, the GSW (see below).

5-4 Gradient Power Supply

The ACGD Gradient Amplifiers are powered by a single power supply unit in the same cabinet.

5-5 GP Board & MIF Modules What does GP and MIF mean?

The GP Board provides a means for the IPG to communicate with the SGA Gradient Amplifiers. The GP 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 Amplifiers. The GP Board receives Gradient Amplifier, Power Supply and Gradient Switch (GSW) status via the MIF Modules, and transmits it back to the IPG Board.

The debug port of the GP board in the TwinSpeed is used to send instructions to the Gradient Switch via an RS232 link.

5-6 Gradient Switch

The TwinSpeed Gradient coils are powered by a single ACGD Gradient cabinet via the Gradient Switch (GSW). This unit, residing in the TwinSpeed Accessory cabinet (TAC), receives instructions along the RS232 communication line from the GP debug port in the ACGD cabinet to the Gradient Switch Control (GSC) board in the switch itself. The front panel of the GSW indicates the Gradient coil currently connected, with a LED for each axis.

The power cables from the ACGD cabinet input one set of X, Y, Z cables into this switch and two sets output from it, one set for each gradient coil.

6- POWER DISTRIBUTION UNIT (PDU)

The PDU is the lower part of the ACGD cabinet, and 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 X AND X

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

7-1 RF Cabinet

7-1-1 RF Cabinet

The RF 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 wrap-around beam pattern for the coronal, axial, and sagittal planes in the magnet bore. The three fixed lights are laser diodes for the LCC 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.

7-5-6 Vacuum Sub-System

A vacuum is pulled using a pump located in the TAC for the entire TRM coil assembly and RF Body coil. Maintaining a vacuum requires continuous use of the pump. This has a pressure sensor, which is monitored by the host computer via the Magnet monitor. Specially designed magnet enclosures are required to isolate the vacuum within the magnet bore and RF coil.

The action of the vacuum is reduced acoustic noise for the patient, the Quiet Technology™, and increased thermal insulation from the gradient coils.

8- MAGNETS & CRYOGENS – SHEETS X & X

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

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 TwinSpeed Accessory Cabinet

The TwinSpeed Accessory Cabinet (TAC) houses the Gradient Switch (GSW), the MXA-6 Shim Power supply and the vacuum pump.

8-4 High Order Shim Power Supply

The High Order Shim Power Supply, located in the TAC provides current to the 5 high order shim coils within the TRM coil assembly. Currents for each coil are calibrated per patient by the host and downloaded to the MXA-6 shim power supply via an RS232 line from the serial board of the host computer.

8-5 Main Coil and Cryostat

The 15,000 gauss (1.5T) magnetic field is produced by a superconducting magnet. The main coils are mounted in a liquid helium vessel, and are submersed 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*.

8-6 S/C Shim Coils

Superconducting 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. These are calibrated as part of the initial calibrations on the system.

8-7 Magnet Monitor Unit

The magnet cryogen level meter for the liquid helium is located in the Magnet Monitor unit. The readings are expressed as a percentage of the full magnet for the liquid helium. Pressure level of the cryostat is also displayed from this unit.

8-8 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 X

Note

The Oxygen Monitor is optional on Signa TwinSpeed 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	Sep 3, 2001	J. Gerber	Initial conversion from systhc1.doc.
1	Sep 6, 2001	J. Gerber	Updated for TwinSpeed scanner with Leo1 release.