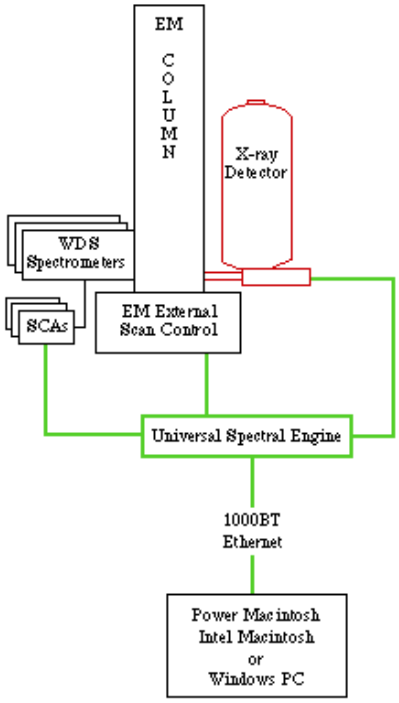
Hardware and Installation

Introduction

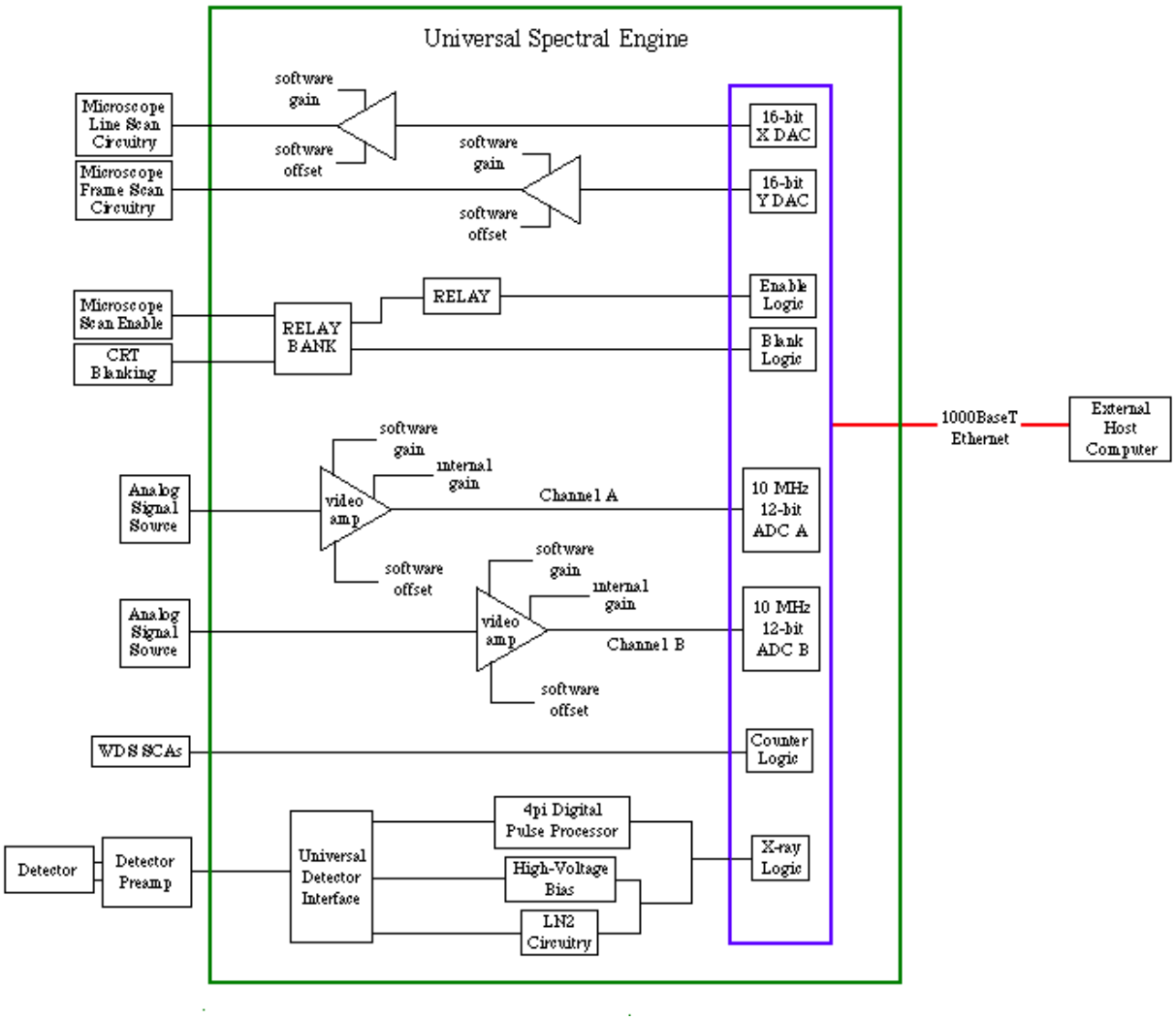
The 4pi system is part of a digital imaging (DI), EDX, and/or WDS system as shown below:

The 4pi hardware is marked in **green**. The **Universal Spectral Engine** (USE) is a single box that connects to either a Power Macintosh, Intel Macintosh, or Windows-based computer via Ethernet. Remote operation is limited only by the available ethernet bandwidth and firewall rules. The USE connects to the electron microscope's external scan control, WDS spectrometer counter outputs, and/or the EDX detector.

For a complete EDX system, 4pi supplies the x-ray detector (**red**), or supplies custom cabling to your existing x-ray detector.



A more detailed block diagram of the **Universal Spectral Engine** is shown below. As indicated above, on one end it connects to the computer via Gigabit (1000BT) ethernet, and on the other end to the electron microscope scan control, WDS counters, and the x-ray detector:



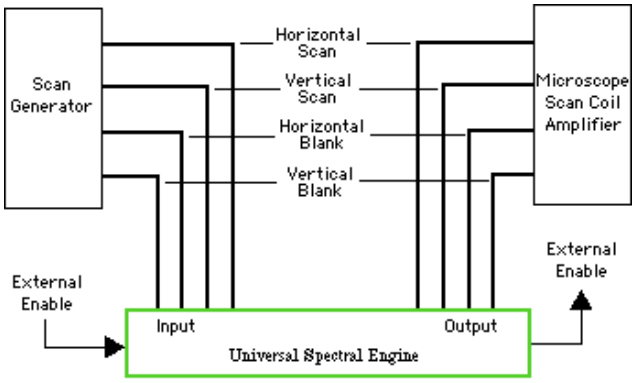
Theory of Operation

Microscope Scanning and Control Theory of Operation:

The Universal Spectral Engine (USE) creates fast line (X) and frame (Y) scan signals using 16-bit DACs. These signals are routed through buffer amplifiers, each with independent software-controlled gain and offset controls to match the scan amplitude to that required by the microscope scan circuitry. Using the Revolution software, the X-Y assignments can be reversed. The direction of each scan can be independently reversed as well.

A single enable signal controls a relay bank in the USE. The relay bank connects to the microscope scan-control circuitry to provide external scan control activation and/or switching, and video-feedback signals. When the external scan is enabled, the microscope CRT/photo-CRT displays are blanked to prevent any possibility of damage to them (i.e., burning a spot in the CRT phosphor) should the external scan prematurely stop. In the case of a digital microscope with internal frame buffer, the video signal is set to blank to avoid a distorted image on the microscope's video screen. Connections usually consist of a combination of BNC and other connectors, but may be more complicated. 4pi provides a custom cable to connect the USE to the microscope.

The USE provides a complete set of input and output connections for all control, blanking, and scan signals:



The "Scan Generator" can be one of three sources: 1) the microscope itself; 2) the Universal Spectral Engine; or 3) a third-party scan control system. The USE provides maximum configuration capability, and via relay control can switch the complete set of signals, allowing either the alternate scan control system or the 4pi system to control the microscope, all without removing any physical cables or connections.

The configuration of the USE is determined before installation and is set at the factory. Typically, final adjustments to the scan video amplitudes must be made by the installer or customer. Both the final adjustments and virtually any configuration changes can be made easily by the end-user.

The following table is a listing of the possible external connections to a microscope from the USE; pin numbers for any connector represent "signal/ground." Signal directions are shown with an arrow. Depending on the microscope, not all connections may be required:

S(T)EM Function	direction	USE Function	USE Connection
Internal/External Control	→	External Enable IN	Scanning I/O B, pin 1/14
Internal/External Control	←	External Enable OUT	Scanning I/O B, pin 2/15
Scan Gen Horz Blank	→	Horz Blank IN	Scanning I/O B, pin 9/22
Scan Gen Vert Blank	→	Vert Blank IN	Scanning I/O B, pin 10/23
Scan Gen Horz Scan	→	Horz Scan IN	Scanning I/O B, pin 11/24
Scan Gen Vert Scan	→	Vert Scan IN	Scanning I/O B, pin 12/25
Scan Coil Horz Blank	←	Horz Blank OUT	Scanning I/O B, pin 7/20
Scan Coil Vert Blank	←	Vert Blank OUT	Scanning I/O B, pin 8/21
Scan Coil Horz Scan	←	Horz Scan OUT	Scanning I/O B, pin 3/16
Scan Coil Vert Scan	←	Vert Scan OUT	Scanning I/O B, pin 4/17
BE/SE Video Amp OUT	→	SEM Video IN	Scanning I/O B, pin 5/18
CRTs etc	←	SEM Video OUT	Scanning I/O B, pin 6/19

Imaging Theory of Operation:

The USE creates an image of any analog signal by digitizing it and correlating it to the electron beam position. The maximum allowed signal is ±12 volts. Typically the analog signal source is video from either a backscattered or secondary electron detector, but it can be an analog signal from any detector connected to the microscope (e.g., absorbed current, EBIC, or cathodoluminescence detectors).

4pi's digital imaging hardware must be able to access to the analog signal sources. Often these connections are available via panels supplied by the microscope manufacturer and are terminated with BNC or other standard connectors; however, this may not be the case if the microscope is not configured for external scan control. 4pi works with the customer and, if necessary, the electron microscope manufacturer to verify a microscope's external scan configuration. These details are resolved during the ordering process.

The USE independently buffers multiple analog channels (default configuration is 2 channels; additional channels can be added, 2 at a time). All channels have software-controlled fine gain and offset, and an internal hardware coarse-gain control. These controls are typically used to set brightness and contrast independently of their instrument sources.

Each analog input has a dedicated ADC, which allows for the fastest possible independent operation.

EDX Theory of Operation:

Energy Dispersive X-ray Spectroscopy (EDX) is the technique of measuring the energies of x-rays emitted as the result of electron bombardment of a sample. 4pi's **digital pulse processor** digitizes the detector preamp signal for display as a spectrum. The pulses are binned in 4096 channels, each channel corresponding to a range of x-ray energies. This information is then passed via the host communication channel to Revolution for display and analysis.

The USE is designed to be interfaced to virtually any existing x-ray detector preamp; no 3rd party pulse processor is required. The USE design typically incorporates the preamp cable provided by the detector manufacturer; 4pi supplies custom cables when necessary.

X-ray Mapping Theory of Operation:

The EDX spectrum acquisition and microscope scanning control and imaging capabilities of the USE are independent; however, the two can be combined to build an image of x-ray count intensity at each pixel for a particular x-ray region of interest (ROI) or set of ROIs. A full spectrum at every pixel is acquired and saved, for maximum flexibility in real-time or post-acquisition analysis.

WDS Theory of Operation:

Wavelength Dispersive Spectroscopy (WDS) refines the EDX technique by using a crystal spectrometer to significantly narrow the detected X-ray energy linewidth. Typically, a single channel analyzer (SCA) generates pulses, one for each x-ray detected by the crystal spectrometer. The source of the pulses will depend on the design of your WDS system. Some manufacturers provide convenient BNC external outputs for tapping the spectrometer's detected x-ray counts. The pulses should be TTL-level (0 or +5 VDC) and may be either positive or negative logic. 4pi Analysis does not supply any hardware or software to control the operation of wavelength spectrometers — you must use other software/hardware to position the spectrometer on the x-ray peak and to set the spectrometer electronics.

The USE counts the pulses on any of four independent counter inputs. Revolution creates a map based on the counts. Individual WDS counters are selected in Revolution just as for analog channel selection.

The following table is a listing of the external connections to the crystal spectrometers from the SIU; pin numbers for the Scanning I/O C connector represent "signal/ground." Signal directions are shown with an arrow.

Crystal Spectrometer Function	direction	SIU Function	SIU Connection
SCA Output 1	→	WDS Counter 1	Scanning I/O C, pin x/xx
SCA Output 2	→	WDS Counter 2	Scanning I/O C, pin x/xx
SCA Output 3	→	WDS Counter 3	Scanning I/O C, pin x/xx
SCA Output 4	→	WDS Counter 4	Scanning I/O C, pin x/xx

Unpacking

All items shipped FOB Durham NC are packed in standard cardboard containers. **Unless otherwise instructed, 4pi strongly recommends not opening any containers, especially for the X-ray detector or CCD camera, unless there is a need to inspect**

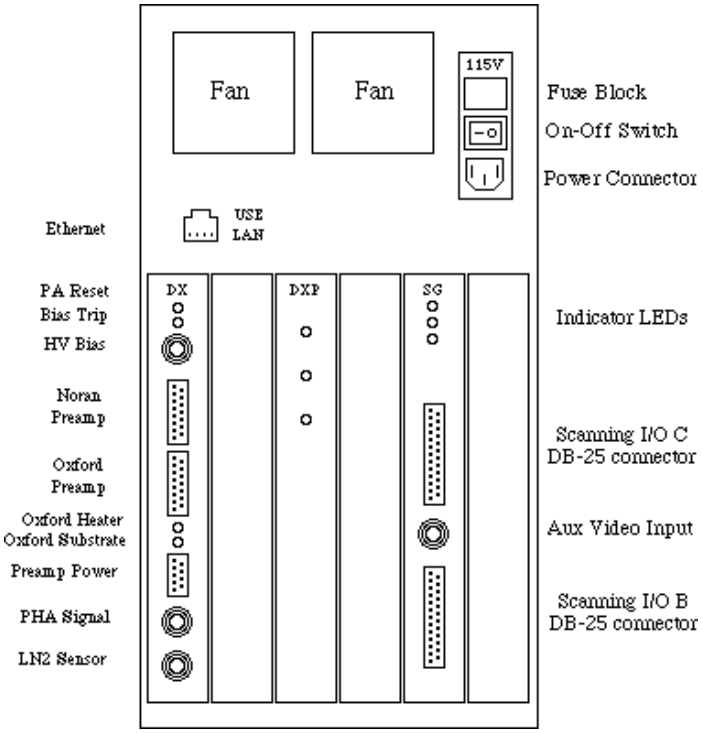
for apparent damage. Handle all contents with the level of care typically expected for sensitive or fragile electronic equipment. Take special care to avoid damaging connectors while removing packing material. Obey static electricity handling procedures. Do not stress cables by inadvertently straining connectors or bending the cables.

Immediately report any shipping damage to 4pi Analysis and to the shipping company. All items, packed and unpacked, should be set aside until the installer arrives on site, or other instructions are received from 4pi technical support.

Step-by-Step Installation Instructions

0. *Note: Customers may be referred to this page by 4pi technical support to troubleshoot minor installation issues. This summary is not official installation documentation! Only trained installer personnel are authorized to perform complete installations.*

1. Familiarize yourself with the rear-panel layout of the 4pi Universal Spectral Engine, shown below. A full system will have 3 cards installed: DX (x-ray preamp interface), DXP (x-ray digital pulse processor), and SG (scan generator, analog inputs).



2. Connect a computer to the USE ethernet port with an Cat5e or better cable.

3. If the system is to acquire digital images, connect the SEM cable(s) to the **Scanning I/O B** connector on the rear of the USE. If present, connect the auxiliary video cable to the **Aux Input**. Unless additional video capabilities have been specified, only the Scanning I/O B and Aux Input cables will be present. Connect the other end of the SEM cable(s) to the appropriate external scan control and/or image connectors on the SEM. Cable labeling has been provided at both ends to make this as straightforward as possible; however, there are often questions involving the precise connections. Contact 4pi technical support for assistance. Scanning I/O B pin definitions are provided above for reference.

4. If the system is to acquire EDX x-ray spectra and/or x-ray maps, connect the EDX preamp cable to the appropriate connectors on the rear of the USE. Connect the other end of the EDX cable to the appropriate connectors on the detector preamp (the connections will vary depending on the detector). Cable labeling has been provided at both ends to make this as straightforward as possible; however, there are often questions involving the precise connections. Contact 4pi technical support for assistance.

5. If the system is to acquire WDS maps, the **Scanning I/O C** connector will also have a cable to connect to the crystal spectrometer(s). Labeling has been provided to make this as straightforward as possible. The WDS pin definitions are provided above for reference.

6. **Preamp (DX) connections are not detailed here. Incorrect connections can damage the detector to the extent that a**

complete (expensive!) rebuild is necessary. In addition, some systems may not be configured to factory specs and will require special instructions. Contact 4pi directly for assistance BEFORE making any preamp connections.

7. **Hasp Installation**. Revolution software requires the use of a hasp (also known as a key, or dongle), a small USB device that can be hot-plugged. If Revolution does not detect the presence of a hasp, it will revert to demo mode. There is no recommendation as to which USB port to plug the USB hasp into; however, if there are any problems, we recommend trying to plug the hasp directly into a rear panel USB port. See the Software Install instructions for information on installing the hasp drivers (Mac, Win). Note: the USB hasp is connected to the computer, not the Universal Spectral Engine.

8. Properly connect the USE power cord to a power outlet. Be sure all connectors are securely fastened. The hardware installation is complete.

9. **Before turning power on to the USE, make sure that the detector has been cooled to liquid-nitrogen temperature for at least 2 1/2 hours.** The Bias Trip indicator will light red if the LN2 level is too low.

10. Turn on the USE. After a minute or two, the SG indicator lights will begin to blink. Shortly after, the DXP indicator lights and DX rate light will begin to blink. During this sequence, a number of clicks should be heard from inside the box as relays are exercised. Finally, a faint "ring ring" tone will be heard, indicating that the boot sequence is complete and the USE is accepting socket connections.