natus® neurology

XLTEK EMU128

User and Service Manual

Publisher's Notice

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About the Xltek EMU128 Headbox

The XLTEK EMU128 package, designed specifically for epilepsy monitoring, allows for flexibility in set up and configuration. Four X 32 channel input boxes can be connected to the EMU128. The EMU128 permits single or multiple channel configurations including grid electrodes up to 128 channels.

There are two trigger inputs – one for the patient, and one for family / staff. The patient-worn input boxes are small and lightweight, for maximum patient comfort. Proven amplifier design for top-notch digital signal processing in a compact lightweight form redefines flexibility in EEG systems. This 128-channel epilepsy-monitoring unit acquires detailed readings, giving you the picture that you are looking for.

Summary of XLTEK EMU128 Features

- Flexible setup
- Flexible configuration
- Four 32 channel breakout boxes
- 32 / 64 / 96 / 128 channel setups
- Two trigger inputs
- Connects to XLTEK's desktop computer system

We strongly recommend that you read the *Warnings and Cautions* section before operating any headbox.

EMU128 Headbox Part Numbers

- EMU128 FS Headbox: 10344
- EMU128 Breakout Box: 102710

EMU 128 Headbox Specifications

Classifications

Protection against electric shock: Class II
Degree of protection against electric shock: Type BF applied parts
Degree of protection against harmful ingress of water: Ordinary
Mode of operation: Continuous

Do not use this system in the presence of FLAMMABLE ANAESTHETIC MIXTURE WITH AIR OR OXYGEN OR NITROUS OXIDE.

Operating temperature range: 10° C to 40° C
Humidity range: 30-75% RH
Transport and storage temperature range: -40° C to 70° C
Transport and storage humidity range: 10-100% RH including condensation

Transport and storage Atmospheric Pressure: 500 hPa – 1060 hPa
Altitude: up to 4600m above sea level
Atmospheric Pressure: 700 hPa – 1060 hPa
Thermal Gradient: 20° C/hour max

North America

Power Input: from Desktop Computer equipped with Excel Tech Headbox Interface Card (ISA card) or XLTEK NeuroWorks.
Fuse Rating: None

Europe

Power Input: From Desktop Computer equipped with Excel Tech Headbox Interface Card (ISA card) or NeuroWorks
Fuse Ratings: None

EMU128 Specifications (Continued)

Analog Specifications - EEG Channels	
EEG Channels	Up to 128 acquisition channels plus 1 reference channel
Reference Channels	User Selectable: External, Common
Differential Input Impedance	N/A. Inputs are not differential.
Common Mode Input Impedance	50 MOhms
Common Mode Rejection ratio	> 110 dB @ 60Hz
Input Noise	< 2µV pk-to-pk @ full bandwidth
EEG Channel Hardware Gain	156
Maximum AC input before clipping	20mV pk-to-pk
Maximum Operational DC input voltage electrode offset	+/-300mV
Anti-aliasing Filter Bandwidth	131 Hz (For 500 Hz sampling freq.)
Input Bias Current	< 20pA
Channel Crosstalk	< -60dB
Digital Specifications	
Sampling Frequency (Standard EMU128)	250 or 500 Hz, user selectable
Sampling Frequency (Advanced EMU128FS)	250, 500, 1000, 2000 Hz, user selectable
Sampling Resolution - EEG channels (Standard EMU128)	22 bits
Sampling Resolution - EEG channels (EMU128FS)	16 bits
Sampling Quantisation - EEG channels	4.8nV
Storage Resolution - EEG Channels	16 bits
Storage Quantisation - EEG channels	0.31µV
Modes of Operation	
Impedance Check	< 2.5, < 5, < 10, < 25 kOhms
Channel Test Signal	15.625Hz, 80µV pk-to-pk
Digital Post Processing	same as XLTEK EEG 32
Safety	
Dielectric Strength	4 KVAC
Patient Leakage Current	< 30 microamps for 550VAC applied between system side and patient side of the headbox. < 8 microamps for 120 VAC normal conditions.
Headbox Mechanical	
Size	~ 150 (h) x 265 (w) x 192 (d) mm
Weight	~ 2.7 Kg
General	Circuit diagrams and parts lists are available on request.

Warnings and Cautions

General Warnings

	Proper use of this device depends on careful reading of all instructions and labels that come with or on the system. Inaccurate Measures may be caused by incorrect application or use.
	The NeuroWorks system is classified as an IP0 – ordinary degree of protection against ingress of water according to IEC 529.
	Inaccurate measurements may be caused by incorrect application or use.
	Only qualified personnel should operate this equipment.
	The computer used with the NeuroWorks system must either be approved by Xltek and supplied as part of an IEC 601 approved system or it must be approved to IEC 950 or similar and kept outside of the patient environment.
	To ensure the validity of signals, do not operate the device near any sources of electromagnetic interference.
	Turn off the system power before cleaning. Prevent detergent solution or cold sterilization agents from seeping into the electronics of the system. Be careful around all connectors and edges. Do not use abrasive agents.
	Explosion Hazard: This system is not AP or APG rated. DO NOT USE this system in the presence of a flammable anesthetic mixture with air, oxygen or nitrous oxide.
	The accessories of this device may include several kinds of disposable, sterile needle electrodes. These needles are labeled as STERILE and the method of sterilization is documented on the packaging. These electrodes should not be used if the sterile packaging has been tampered with.
	The sale, distribution or use of this device is restricted to, by, or on order of a physician.

Electrical Warnings and Cautions

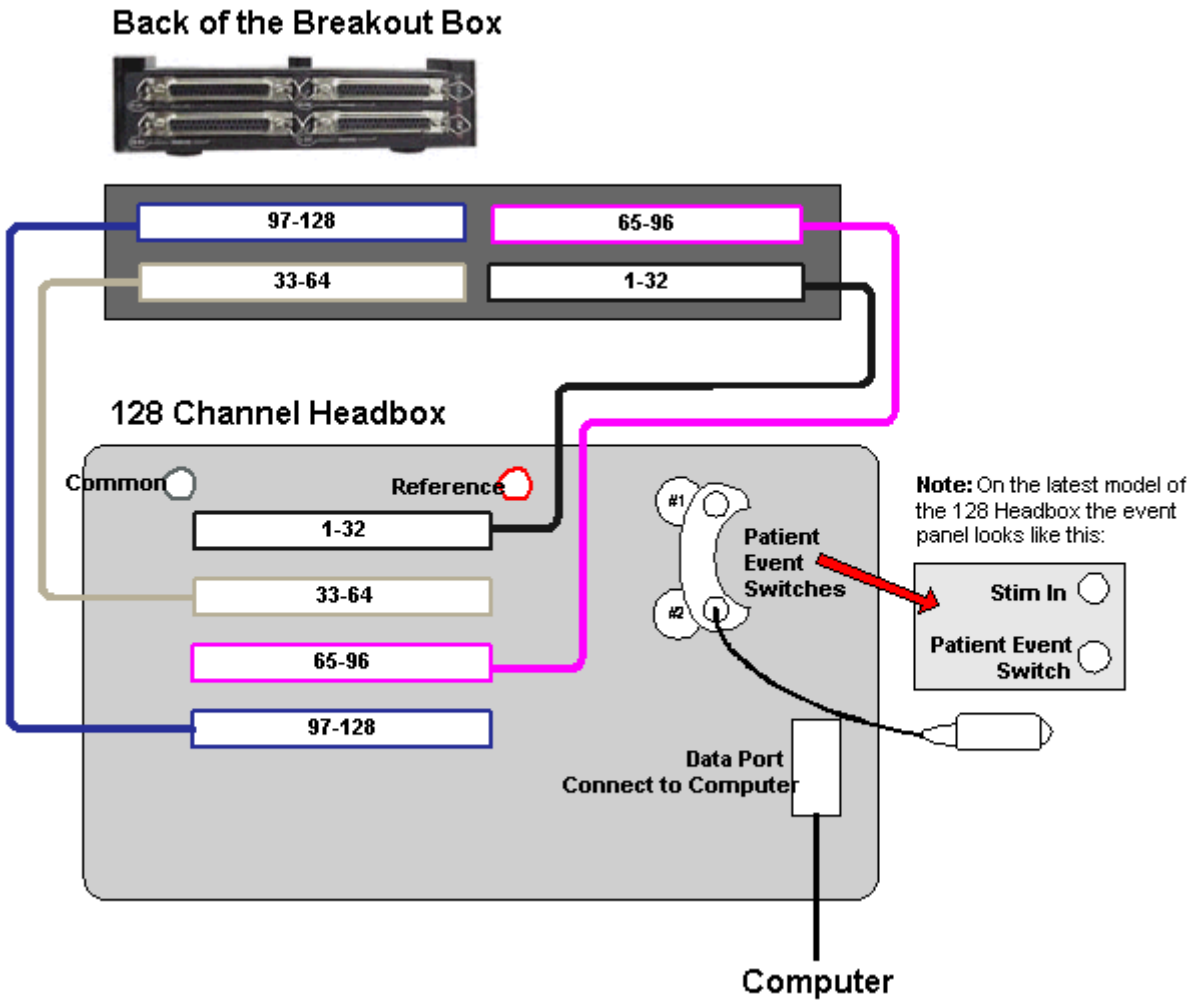
	The system is intended for connection to a properly grounded electrical outlet only
	Periodically check the *system ground integrity*, the *system leakage current*, and the *patient contact leakage current*. This should be performed at least ONCE PER YEAR.
	Do NOT turn on the system power until all cables have been connected, verified and visually inspected for any damage. *Failure to inspect the cables may result in electrocution.*
	Do NOT connect or disconnect the patient headbox with the system power on.
	ELECTRICAL SHOCK HAZARD: Do NOT connect electrode inputs to earth ground. The patient headbox contains warning symbols reminding you that the connections are intended for isolated patient connections only. Connecting to an earth ground might result in electrocution.
	ELECTRICAL SHOCK HAZARD: Do NOT service the system. Refer servicing to qualified personnel only.

	The system uses a three-wire power cord with a hospital grade plug. The system is earth grounded. For grounding reliability, only connect the device to a hospital grade or hospital-only receptacle. Inspect the power cord often for fraying or other damage. Do NOT operate the system with a damaged power cord or plug.
	Do NOT place the isolation transformer on the floor.
	Plug only XLTEK-recommended components into the isolation transformer.

Patient-Related Warnings and Cautions

	Disconnect the patient's recording electrodes from the system before your turn it on and off. Disconnecting the electrodes prevents shock.
	Connect all patient electrodes to fully electrically isolated physiological devices only. Connecting patient electrodes to any other device or external outlet may result in personal injury.
	The patient headbox accepts only touch-proof style electrode inputs. Do NOT attempt to use any other style of patient electrode input.
	Patient connections are NOT intended for direct cardiac contact.
	As with all medical equipment, carefully route patient cabling to reduce the possibility of patient entanglement or strangulation.

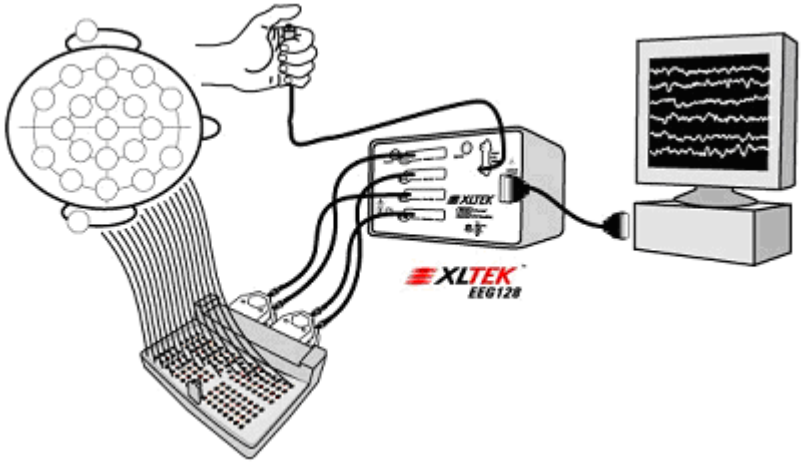
Assembly Instructions



Hardware Connections

1. Unpack the headbox and headbox cable.
2. Connect the cable between the headbox data port (labeled **Connect to computer**) and the acquisition system (a desktop computer or NeuroWorks Acquisition System). Use only the supplied headbox cable.
3. If provided, insert the patient event switch into the **Patient Event Switch** jack #2.
4. Connect the headbox to the breakout box with the required number of cables. Ensure that the cables are plugged into the appropriate ports (for example, the cable for channels 1-32 on the headbox should be plugged into the port for channels 1-32 on the breakout box, and so on). A cable must always be connected for channels 1 to 32 because this cable also connects the **Reference** input from the breakout box to the headbox.

5. A **Reference** electrode and **Common** electrode are required for a successful recording. With this headbox system, there are two sets of ground (common) and reference electrode ports: one set is found on the breakout box and one set is found on the headbox. Connect the reference electrode from the patient to the reference jack on either the headbox or breakout box. Likewise, connect the common electrode from the patient to the common jack on either the headbox or breakout box.
6. Connect the patient leads to the breakout box.



Overview of Hardware Connections

The Patient Event Switch jacks are not isolated from the patient. Only an XLTek patient event switch may be plugged into these inputs.

Testing the EMU128 Headbox

The EMU128 Headbox hardware is:

- Fully assembled, tested and calibrated prior to being shipped to you.
- Designed to work with XLTEK NeuroWorks software.

The following sections describe how to use NeuroWorks with the EMU128 Headbox to perform a channel test.

Note: A minute electric current is transferred during an impedance check. To protect grid patients, *impedance checks are disabled* for the EMU128 Headbox.

EMU128 Headbox Calibration and Verification

There is no need to calibrate the NeuroWorks Software or the EMU128 Headbox. All calibration is done at the factory before the system is shipped. To verify that the EMU128 Headbox system is correctly calibrated, perform the following procedure:

1. Connect the EMU128 Headbox to the acquisition station, then connect the acquisition station to an XLTEK DT computer. Turn on the system.
2. Start XLTEK Database (**XLDB**).
3. To start a new study, click **New**.
4. Choose **Edit**->**Settings**->**Acquisition** (tab).
5. In the Acquisition tab, set the **Reference Electrode** to **Common**.
6. Design four bipolar montages that take the difference of adjacent channels within each 32-channel group, for example, C1-C2, C2-C3, C3-C4, C32-C1.
7. Apply a sine wave of 50 microvolts, peak-to-peak amplitude, 10 Hz to all channels of the group using a signal generator.
8. Set the LFF filter to 0.1, the HFF filter to OFF and the Notch filter to OFF.
9. Apply each montage in turn.
10. Verify that no sine wave is greater than 50 microvolts peak-to-peak. 50 microvolts represents gain match to 1%.

For more information on setting up a montage, see **Creating a Montage** in the **NeuroWorks Settings** book of the online help. To open the online help, choose **Help**->**XLTEK NeuroWorks EEG Help.**

Channel Test

While in the NeuroWorks live recording screen, a channel test may be performed to verify the integrity of the signal processing from the amplifier input through to the display. A channel test applies a test signal to all channels. This allows you to examine the waveforms on the screen to see if all of the channels are functioning.

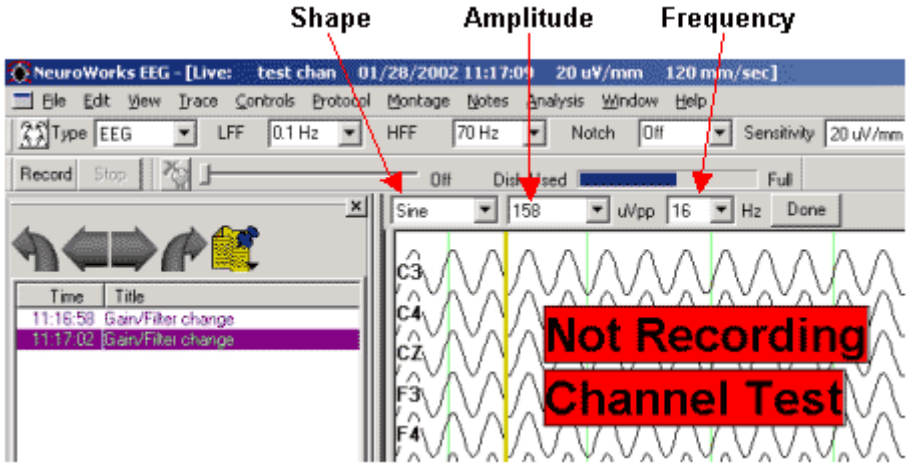
NOTE A channel test does not validate the connection from the patient electrode to the amplifier input.

To Run a Channel Test

1. In NeuroWorks EEG, choose **Edit**->**Settings**. The **Edit Settings** window appears.
2. To open the **Acquisition** dialog box, click the **Acquisition** tab.
3. Select **Common** in the **Reference Electrode** list box and click **OK**.
4. To start the channel test, open the **Controls** menu and select **Channel Test Signal**. The Channel Test control bar appears above the waveform window.
5. Using the channel test signal control, select the desired channel test shape, frequency and amplitude.
6. To stop the channel test, click **Done**.

Channel Test Signal Control

The Channel Test Signal control in NeuroWorks EEG turns on the channel test signal according to the last settings saved and displays a Test Signal toolbar. The toolbar has controls for shape, amplitude and frequency.



Channel Test Signal Toolbar is located above the Trace Display

Allowable Channel Test Signal Settings

(At a sampling frequency of 500Hz)

Shape	Sine or Square
Amplitude	Sine wave amplitude can be 79, 158, 316, 632, 1264, 2527.5, 5055 and 10110 µV peak to peak. Square wave amplitude can be 50, 100, 200, 400, 800, 1600, 3200, and 6400 µV peak to peak.
Frequency	Sine wave frequency can be 16, 32 or 64 Hz. Square wave frequency can be 0.25, 0.5 or 1 Hz

Maintenance

To keep the EMU128 Headbox system in good working condition, follow a regular schedule of preventive maintenance. Regular preventive maintenance does not involve access to the interior of the EMU128 Headbox and components. For service problems that require corrective maintenance and/or internal component service, call XLTEK's Service department at 1-800-387-7516, or contact your local XLTEK representative.

Periodically check cable connections and electrodes for damage and wear. Inspect cables for bent pins. Replace frayed or worn cables. Also, regularly inspect and clean all system components, including:

- Connectors and jack ports
- Headbox and headbox cable
- Breakout box and cable
- Electrodes and accessories

Taking basic care of the system and avoiding extreme physical abuse helps prolong the lifespan of the headbox.

Disconnect the EMU128 Headbox and breakout box from the computer before wiping. Disconnect all cables. Use a lint-free cloth. Do not use cleaners on any system component.

Be careful not to allow any fluid to seep into the internal electronic components of the headbox or breakout box.

Do NOT leave the headbox or breakout box attached to the computer when transporting the unit.

Troubleshooting

If the acquired waveforms are flat, do not appear, or do not appear correctly (or as expected), try shutting down the computer for at least 10 seconds, and then set up the test again from the beginning. Shutting down and starting over resets the headbox and sometimes solves the problem. If you are still experiencing problems, here are some more solutions to try:

Troubleshooting Checklist

☐	Ask the patient to relax.
☐	Inspect your cables.
☐	Make sure that there is a tight connection between the headbox, the breakout box and the computer.
☐	Make sure that the patient electrodes are connected to the correct channel in the headbox.
☐	Make sure that the patient electrodes fit properly into the headbox (not loosely).
☐	Make sure that there are no apparent breaks in the patient electrode cables.
☐	Are any of the electrodes touching? If so, they are causing a short circuit and will develop an artifact.
☐	Unplug any other devices on the same circuit such as printers, mechanical beds, vacuum cleaners, or other potential sources of interference.
☐	Install a medical grade ground to make sure that your clinic has a properly grounded electrical system.
☐	Change the acquisition cable. You should always have a backup acquisition cable.
☐	Check the gain and timebase settings to ensure that they are appropriate for the current test. You may also want to check the LFF, HFF, and Notch Filter settings.

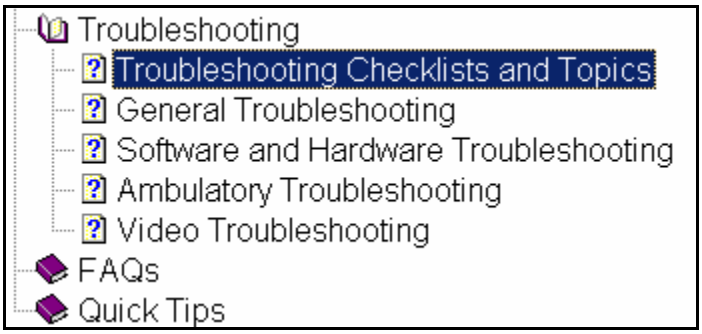
To Adjust the Gain, Timebase and Filter Settings

Choose **Edit**->**Settings**->**Montage** tab. To change the three filter settings (LFF, HFF and Notch filter), right-click a cell in the appropriate column and select a value from the menu.

- **LFF** (Low Frequency Filter): Filters out low frequency interference below the set value.
- **HFF** (High Frequency Filter): Filters out high frequency interference above the set value.
- **Notch filter**: Minimizes interference from nearby electrical equipment.
- **Gain**: Increasing the gain (sensitivity) of a channel makes the traces appear larger on the screen.

Opening the Troubleshooting Section of the Online Help

1. In NeuroWorks, choose **Help** > **XLTEK NeuroWorks EEG Help.**
2. Click the **Contents** tab.
3. Double-click **NeuroWorks**.
4. Double-click the **Troubleshooting** book. The Troubleshooting book expands to show the contents.
5. Click a topic to display the content in the topic pane on the right.



Troubleshooting Section of the NeuroWorks Online Help

Theory of Operation

Introduction

This section describes the theory of operation of the 128-channel EEG, Model EMU128-S. The initial discussion is primarily signal-flow oriented. Detailed board-level theory is provided later in this section.

System Overview

Features of the EMU128-S system:
The EMU128-S performs the basic function of a digital EEG front end.

- Provides a Breakout Box to connecting patient electrodes.
- Amplifies and digitizes the electrode signals.
- Transmits the digitized waveforms to a NeuroWorks computer.
- Allows selection of reference signal.
- Provides internally-generated test signals (sine and square) for user assessment of equipment performance.
- Allows a technologist to apply a stimulus from an external stimulator to any pair of electrodes.
- Maintains continuous signal monitoring while relay closures connect the stimulus to the selected electrode pair.

Components of the Communications Link:

- Digitized waveforms are transmitted to the computer as synchronous serial data, using three differential pairs: Clock, Data and Frame Sync.
- Commands and replies are handled with a much slower asynchronous link (UART), with one differential pair in each direction.

Power Sources to the Headbox:

- 12VDC from the computer power supply is used for the communications interface only. Most of the Headbox is powered by 12VAC 40KHz, generated by the XLTEK Headbox Interface Card in the computer ISA slot or one of the PCI slots.
- For this modular design, four 32-channel groups (identical to the boards used in the XLTEK EEG32) are plugged into an Analog Back Plane PCB and a Digital Motherboard PCB to function as a system.

Circuit Board Assemblies Inside the Headbox:
(Block Diagram)

A. **Analog Back Plane Board** (Qty. 1)
- A 4 MHz crystal oscillator supplies the reference clock to all the Digital Boards.
- A 129th channel, non-digitized Reference amplifier allows the user to quickly plug in any one of the 128 acquisition channels and evaluate for suitability as a reference. The amplified reference signal is routed to all four Analog boards.

B. **Digital Motherboard PCB** (Qty. 1)
- Incorporates the I/O connector for the cable to the computer.
- Combines the time-division-multiplexed data frames from the four 32-channel groups and transmits the data on differential pairs to the computer.
- Contains differential driver and receiver for the asynchronous command channel (19.53Kbaud).

C. **Relay Matrix Board** (Qty.4)
(Older versions of EMU128 use Connector Board, P/N 101313, having no active circuitry, only connections from the input connectors to the Analog Boards.)
- Patient connections are made through these boards through 37-pin D connectors protruding through the front panel.
- Sixty-four relays per board allow connection of a stimulus current to one pair of electrodes at a time from another front-panel jack.
- EEG signals pass to the Analog PCB for amplification and conditioning.

NOTE The channel numbering on this and other boards is not the same as the EEG channel numbering.

D. **Analog Board** (Qty. 4)
- Handles amplification and DC removal for 32 channels.
- Amplifiers are designed to handle signals far in excess of even abnormally high EEG, while also providing exceptional sensitivity and resolution.
- Two time constants are available in the DC removal. A normal time constant and a short time constant for accelerated recovery during Trace Restore.

E. **Digital Board** (Qty. 4)
- Analog-to-Digital converters digitize the amplified EEG signals. Signals are periodically sampled and converted to a binary number.
- The micro controller transmits the digitized signals to the Analog Back Plane Board that in turn sends them to the computer.
- Contains non-volatile storage for calibration values.
- During factory calibration, the NeuroWorks computer calculates and transmits the channels gains to each digital board. Whenever a study starts, the computer uses these stored values to scale the digitized signals, channel by channel.
- The Digital Board for channels 1-32 is connected to the Patient Event front-panel connector. It detects an Event Switch closure and transmits it to the computer.

F. **Breakout Box**:
(Schematic diagram is SD-102697 Rev A.)
This unit is completely passive.
- Patient leads connect to the Breakout Box.
- Four cables connect the Breakout Box to the computer. The connecting cable transposes left and right pins. For example, pin 2 at the Breakout Box connects to pin 18 at the Headbox.

Board-Level Theory

Analog Back Plane

(Schematic diagram SD-102196 Rev B1)

U1 is a dual phase-locked loop chip, of which only the oscillator portion is used. The frequency is established by quartz crystal Y1. The output from pin 7 is filtered to an almost pure 4 MHz sine wave by parallel-resonant circuit C1, L1. This suppresses radiated emissions that would exceed certain regulatory limits. The signal is coupled by C2 and R1 to the FREF pins on connectors P1-P4, into which are plugged the four Digital PCBs. D1 and D2 combine the +5V from all four Digital boards. Even if there is a failure on one of the boards the oscillator is still powered. If the oscillator stops working the Headbox appears to be dead.

The Reference amplifier on sheet 3 is powered by N5VL and P5VL (-5V and +5V) from P5. The amplifier output gets fed to the four Analog boards on pin 17, XREFIN2, of board connectors P5-P8. Signal SREC, P5-18, transmits to analog switch U2 control input. This closes the circuit from VFBH01 to VFBL01 and shortens the DC removal time constant during Trace Restore.

The amplifier on sheet 3 uses two gain stages plus an integrator for DC removal. This is equivalent to AC coupling but achieves a very low cutoff frequency without needing a large value of capacitance. The Reference signal, REFIN, is applied to non-inverting amplifier U3-A. Diode D3 protects against Electro-Static Discharge (ESD). Capacitor C12 prevents interference from powerful stations in the standard AM broadcast band. The 50 Meg ohm input resistor provides a path for the tiny bias current of the input stage of the op amp and establishes the input impedance of the amplifier. The feedback resistors in RN35 yield a gain of 4.05 for this stage. The gain of the second stage, U4-A, is -(140/15.4)= -9.09. C10 and C11 low pass filter the output with a corner frequency of approximately 8 KHz. Any DC on the electrode (caused the reaction of the electrode metal with the patient's skin) is integrated by U4-B. The opposite polarity is then applied to the second gain stage through voltage divider R4, R5. The corner frequency is approximately a tenth of a Hz and is determined by components C3, R4, R5, R6, R7, RN35(1K), as well as the gain of the second stage. The amplified reference signal is fed to the four Analog boards as signal XREFIN2. U3-B is not active. You can tell if the amplifier is working because, with the reference set to External (**Edit**->**Settings**->**Acquisition** tab), a signal of any sort on this input should appear on all channels.

Digital Motherboard

(Schematic diagram SD-102194 Rev D3)

J7 is the connector for plugging in the cable to the computer. U1 converts the +12V to +5V for powering the rest of the chips on this board. VPW1 and VPW2 are the two wires of a 12VAC 40KHz power source on the XLTEK Headbox Interface Card in the computer. The high frequency allows the use of miniature ferrite transformers in the headbox. The letter D in a triangle is the ground return for the +12V and the ground reference for the differential communication pairs, which are the rest of the signals on J7. SATX± is the pair for the TX UART in the computer, transmitting commands to the headbox at 19.53Kbaud, 1 start bit, 9 data bits, 1 stop bit. SARX± is for the replies. A failure of these signals at U4 or U13 results in the message "Please connect a headbox before starting study." A command or reply failure on an individual Digital PCB results in the message, "Attempt to send command to unconnected board." The other three pairs are used for the digitized waveforms, sent in synchronous serial format with serial clock frequency of 5 MHz. SSCK±=Clock, SSDAT±=Data, SSFS±=Frame Sync. The Frame Sync pulse is one clock period duration and shows where a word begins.

The chips are differential drivers and receivers. A driver converts a digital logic level to voltages more suitable for transmission along the cable. Conversely a receiver converts the balanced differential voltage on the cable to a digital logic signal. Receiver U13 processes SATX± and applies the logic level to drivers U14 and U15 for generating individual differential drives to the four Digital PCBs. Diode D2 is for protection only. R17 terminates the twisted pair in its characteristic impedance. Drivers U3-U6 operate on signals SCK, SFS, SDAT, and SARX. Driver U2 is not populated on the board. Because the latter signals come from the open-collector outputs of optocouplers on the four Digital PCBs, they are combined when they are connected together. In this product the pull-up resistors for these signals are left off the individual Digital PCBs and are shown instead on this assembly as R18-R21.

Relay Matrix Board

(Schematic diagram SD-102910E)

EEG signals enter the headbox through J6. For example, in normal operation the first channel relays, K1 and K33, are de-energized. The signal flows from K1-5 to K1-1 (sheet 3), then from K33-4 to K33-1 (sheet 4), then through R1 to J4-31 (sheet 2) where it continues to the Analog PCB. To apply a stimulus voltage, K1 or K33 must be energized to connect the patient electrode to the STIM+ input (J1-2 on sheet 2), or the STIM- input, respectively. The voltage travels through the Normally Open contact. Under these conditions, the EEG signal path is through R34 or R66 instead of the Normally Closed relay contact. The resistance is such as to still give accurate signal acquisition while protecting the amplifier from the stimulus voltage. Back-to-back zener diodes D2 and D3 keep the stim voltage from exceeding 200V, which could harm the headbox.

The relay coils are driven directly from shift register U65-U72 outputs. On command from the computer, the Digital PCB transmits the new setting to the shift registers. SCDAT is the data, SCSTB is the clock, and nLEDEN latches the new setting. Network

R33/C11/D1 delays enabling the outputs until the Digital PCB clears any random setting at power up. No more than two relays are supposed to be energized at a time.

Analog Board

(Schematic diagram SD-101315 Rev D3)

Sheet 1 shows the connectors. P2-P5 bring in the EEG signals from the Relay Matrix Board. P1 conveys the amplified signals to the Digital Board. J101 connects to the Analog Back Plane and brings in the amplified Reference signal. Sheet 2 shows the shift registers that control analog switches. The shift registers give the Digital PCB control of modes of operation and allow the Digital PCB to short circuit individual channel inputs (sheets 5-8). The computer commands this when a channel is not in use or during impedance checking.

U1205 controls the modes of operation as follows:

- Signal SREC controls analog switches in each channel whose closure accelerates the time constant of the DC removal circuitry (as previously described for the Analog Back Plane).
- Signals REFON1, REFON2, XREFON1 and XREFON2 control reference selection (sheets 3, 4). One of these may be on (logic 1), or none (if the user sets the reference to Common).

CALON sets a path (sheet 3) for the Channel Test signal from the Digital PCB to do an end-to-end verification of amplifier operation.

IMPON makes the path for **VSIG** to supply a current to channel inputs for impedance checking. Impedance checking is not enabled for the EMU128. Sheet 3 shows the amplifiers for the reference signal and the Channel Test signal (designated **VCAL**).

Sheets 9 through 40 show circuit diagrams for the 32 amplifier channels. These are all the same except that Channels 8 and 24 make available the outputs of the second gain stage for use as a reference. This feature is provided to enable the “linked ears” (A1+A2/2) reference for the EEG32 and is not used by EMU128 software.

The amplifier works as previously described for the Reference amplifier on the Analog Back Plane, with these differences:

- The 50 Meg ohm input resistor is returned to the output of **U1302-A** for impedance checking when the assembly is used in an EEG32.
- The second gain stage output gets applied to the 4.7K input resistor of a third gain stage configured for an inverting gain of 4.34.
- The Reference signal is scaled and inverted by **U1301-A** so that when it is summed in the third gain stage, it ends up being subtracted from the signal that is being monitored.
- The negative input of an inverting stage functions as a summing junction for signals applied to all resistors tied to this junction.

Digital Board

(Schematic diagram SD-102817 Rev D2)

Sheet 2 shows the connectors.

- J1 brings in the amplified EEG signals from the Analog Board and communicates the serial data to its shift registers.
- J101 brings in the 4 MHz reference frequency from the Analog Back Plane. The clock signals CLK20M and CLK7M168 (sheet 9) are locked to this reference by dual phase-locked loop U9.
- J100 is a 26-pin high-density D connector that sticks through the front panel for plugging in the cable to the computer.

Sheet 3 shows the optocouplers that transmit the digital data and commands and protect the patient from hazardous voltages. Drivers and receivers U100-U102 are not populated when this assembly is used for EMU128.

Sheet 4 shows the micro controller U11 that runs the board, EEPROM U7 that provides nonvolatile storage of factory calibration values, and digital-to-analog converter U18 that generates the Channel Test signal for equipment diagnostics.

Sheets 5 to 8 show the analog-to-digital converters that convert the EEG signals from alternating voltages to binary numbers for transmission to the computer.

Sheet 9 has the clock generator U9. Crystal Y1 is not populated in EMU128, only EEG32. Event switch jack J4 allows plugging in a pushbutton switch whose closure is sensed by the micro controller and reported back to the computer.

Sheet 10 shows the power supply section. T1 is populated for EMU128. It is a miniature ferrite transformer that steps down the 12 VAC 40KHz provided by the Headbox Interface Card in the computer. Positive and negative voltages are rectified by D1, filtered by L1 and L2 and regulated by VR1-VR3. Separate power busses are used for analog and digital circuitry. VR4 and associated components are not populated in EMU128.

How the Digital Board Works

When power is applied, the micro controller PIC16C65A (referred to hereafter as the PIC) serially writes the control words to PLL U9 to program the frequencies of operation. For this it uses lines SCDAT, FSSTBA and FSSTBB. It then waits for commands from the computer. When the user starts a study, the PIC is commanded to reply with the channel calibration values from the EEPROM U7. It reads the device with lines EEPREN, SCSTB and EEDAT. Then sampling starts when the PIC uses its SPI serial port to write the control word to the ADCs (lines ADSDAT, ADSCLK, nADTFS). The ADCs are clocked by CLK7M168 at a frequency of 7.168 MHz, and typically give 500 samples/second. 2.500 VDC from precision voltage reference U8 sets the input range of the ADCs (±2.5V for full scale). The ADCs are self-timed and do not require a periodic start-convert command. When a conversion has been done, the nADRDY line is asserted and interrupts the PIC through the INT input (U11-36). The PIC responds to the interrupt by reading the conversion result, asserting CASCIN0 and nADRFS and using ADSCLK to clock out data ADSDAT. The ADCs on all boards sample and get read

simultaneously, but only one Digital Board at a time sends data to the computer. This is fundamental to serial communication. Signals HSFS, HSSCK and HSSDAT are used (U11-18, U19-11, U19-8).

If a sine or square wave Channel Test signal is commanded, the PIC writes a scaled value from a lookup table to Digital-to-Analog Converter (DAC) U18 at each sample time (signals DADAT, DALD, DASTB). Precision voltage reference U12 establishes the full-scale DAC output. Together with the intrinsic very high accuracy of the DAC, this gives amplitude accurate to a fraction of a percent.

Patient Event Switch closures are detected by the PIC on Port B4 (U11-41). Only the Digital PCB for Channels 1-32 detect Patient Event Switch closures.

Servicing

We do not recommend that the owner try and repair the equipment, because the factory is better equipped for servicing. The factory has proper equipment to test the patient safety isolation barrier for 4KVAC dielectric strength after re-assembly. The following guidance is provided for the extreme case in which a repair is urgently required.

The usual diagnostic methods apply, narrowing down from the general to the specific. For example:
1. Inspect the cables and connectors.
2. To make sure the problem is in the headbox, not the computer, connect another EMU128 or an EEG32 to the NeuroWorks computer.
3. Find out which board assembly has failed.

Problems Starting a Study

The circuit description of the Digital Motherboard explains how to distinguish a failure on the Motherboard from a failure on a Digital PCB when a study fails to start. To diagnose which Digital PCB has failed, probe U21-6, HSATX, and U100-2 to see if the commands are getting through, then U17-2, HSARX, for the replies. Since the baud rate is 19.53K, a good timebase setting for the oscilloscope is 250µs. Make sure to connect the probe ground to the correct side of the patient isolation barrier. If the study starts but the scroll bar doesn't move across the screen, there is a problem with the digitized waveform data and those signals should be probed. Start from the Digital Motherboard and work back through to the Digital PCBs.

Problems with Signal Quality

If there is a missing or bad signal, first try swapping cables to the Breakout Box. If you are still experiencing problems, try running a channel test.

Run a Channel Test
1. On the montage settings toolbar, set **LFF** to 0.1 Hz.
2. Choose **Controls**->**Channel Test**. The Channel Test control bar appears above the waveform display.

3. Point to the first menu on the Channel Test control bar and click **Sine** or **Square**. The Sine wave setting is good for general use. A low-frequency Square wave setting can reveal problems in the integrator of the DC removal stages on the Analog Board.
4. Adjust the waveform frequency and amplitude on the Channel Test control bar as required.

The Channel Test signal is applied to the first amplifier stage; therefore, it tests the amplifiers and ADCs but cannot check the connection to the front panel connector.

Use the Reference to Diagnose the Problem
The Reference channel can be used to narrow a problem down within a particular amplifier channel. To set the reference channel, choose **Edit**->**Settings**->**Acquisition** and then point to **Reference** menu and click **External**.

- If a Reference signal is visible on a problem channel, then the output stage is working.
- If the channel is noisy or unstable when jumpered to **Common** on the Breakout Box and referenced to Common, it is possible that an op-amp is defective.

Keep in mind that the channel numbers on the schematics do not correspond to the channel numbers on the screen. To determine the affected channel, touch a small wire to the pins of the 37-pin D connector one at a time, and then trace through the schematics.

Other Causes

- A broken solder joint on one of the 80-pin connectors between Analog and Digital Boards may cause a flat line on a channel.
- Because the ADCs have four channels each, a problem that affects a multiple of four channels can be ADC-related (an unlikely failure mode).

Disassembly

1. To gain access to the tabs that retain the side panels (handles), remove the back-panel screws.
2. To see the hardware that fastens the box to the front panel and chassis, pry the panels off.
3. If disassembling the boards in the chassis, keep detailed notes of the sequence of disassembly and what hardware was used. Do not mix up the boards because the calibration will be invalidated. The top board in a stack is the Relay Matrix, then Analog PCB, then Digital PCB.
4. Pay attention to the orientation of the Analog Backplane.

If doing a rework on the Analog PCB or the Analog Backplane do not clean with a liquid or the film capacitors may be degraded.

Adjustments

There are no adjustments. The precision of the components renders this unnecessary.

Getting Help

XLTEK is committed to providing you with support so you can operate the EMU128 Headbox with ease and confidence. If you need help, follow these steps to find a solution:

Step 1: Document the Incident

Carefully document the incident. If possible, note error messages, dialog box names and what you did before the problem occurred.

Step 2: Search NeuroWorks Online Documentation

To open the EMU128 Headbox Tutorial:

1. In NeuroWorks, Choose **Help**->**NeuroWorks Help**. The NeuroWorks Help window appears.
2. Click the Contents tab.

Click the **EMU128 Headbox Tutorial** book in the table of contents.

Step 3: Restart the Computer

Often restarting the computer will solve a problem.

1. Close all applications.
2. Click the **Start** button on the Windows taskbar.
3. Choose **Shut Down…** from the Start menu.
4. Select **Restart the computer** and click **Yes**.

Step 4: Shut Down the Computer

Sometimes you need to shutdown the computer completely in order to solve a problem.

1. Click the **Start** button on the Windows taskbar.
2. Choose **Shut Down…** from the Start menu.
3. Select **Shut Down** and click **Yes**.
4. Turn the power off to the unit. Wait for 10 seconds. Turn the power back on.

Step 5: Contact Technical Support

First, write down the serial number of your computer (located on the back) and the serial number of your EMU128 amplifier. Then contact your local XLTEK distributor or ***XLTEK*** Customer Support at **1-800-387-7516** or Oakville_Technical_Service@xltek.com.

We welcome your feedback and suggestions regarding any aspect of the NeuroWorks system and software, the online help, our line of accessories, and our support services.

A Total Service Solution

Natus Systems are backed by a comprehensive and extendable warranty. Our support team is available around-the-clock. Our technical staff provides phone and remote PC support, while our nationwide network of service engineers can be dispatched quickly when required.

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