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ZOLL®

E SERIES®

SERVICE MANUAL

ZOLL MEDICAL CORPORATION

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Preface

ZOLL® Medical Corporation's E Series® Service Manual is intended for the service technician whose responsibility is to identify malfunctions and/or make repairs at the subassembly level. The ZOLL E Series Service Manual has five main sections and one appendix.

Preface—Contains safety warnings and an overview of the manual's contents. Be sure to review this section thoroughly before attempting to use or service the E Series unit.

Chapter 1—Maintenance Tests explains how to check the defibrillator's performance using a series of recommended checkout procedures to be conducted every six months.

Chapter 2—Troubleshooting provides a listing of the procedures and error messages to help the service technician detect faults and repair them.

Chapter 3—Replacement Parts List displays a complete list of ZOLL part numbers for field replaceable parts available for the E Series unit, allowing the service person to identify and order replacement parts from ZOLL.

Chapter 4—Functional Description provides technical descriptions for the E Series major subassembly modules.

Appendix A—E Series interconnect diagrams and maintenance checklists.

Safety Considerations

The following section describes general warnings and safety considerations for operators and patients. Service technicians should review the safety considerations prior to servicing any equipment and read the manual carefully before attempting to disassemble the unit. Only qualified personnel should service the E Series unit.

Federal (U.S.A.) law restricts this unit for use by or on the order of a physician.

Safety and effectiveness data submitted by ZOLL Medical Corporation to the Food and Drug Administration (FDA) under section 510(K) of the Medical Device Act to obtain approval to market is based upon the use of ZOLL accessories such as disposable electrodes, patient cables and batteries. The use of external pacing/defibrillation electrodes and adapter units from sources other than ZOLL is not recommended. ZOLL makes no representations or warranties regarding the performance or effectiveness of its products when used in conjunction with pacing/defibrillation electrodes and adapter units from other sources. If unit failure is attributable to pacing/defibrillation electrodes or adapter units not manufactured by ZOLL, this may void ZOLL's warranty.

Only qualified personnel should disassemble the E Series unit.

WARNING!	This unit can generate up to 2250 volts with sufficient current to cause lethal shocks.

All persons near the equipment must be warned to *STAND CLEA*R prior to discharging the defibrillator.

Do not discharge the unit's internal energy more than three times in one minute or damage to the unit may result.

Do not discharge a battery pack except in a ZOLL SurePower™ Charger Station or compatible ZOLL Battery Charging/Testing unit.

Do not use the E Series in the presence of flammable agents (such as gasoline), oxygen-rich atmospheres, or flammable anesthetics. Using the unit near the site of a gasoline spill may cause an explosion.

Do not use the unit near or within puddles of water.

Note: The E Series is protected against interference from radio frequency emissions typical of two-way radios and cellular phones (digital and analog) used in emergency service/public safety activities. Users of the E Series should assess the unit's performance in their typical environment of use for the possibility of radio frequency interference from high-power sources. Radio Frequency Interference (RFI) may be observed as shifts in monitor baseline, trace compression, or transient spikes on the display.

Additional Reference Material

In addition to this guide, there are several other components to the ZOLL E Series documentation. They include:

- *E Series Operator's Guide* - A comprehensive reference work that describes all the user tasks needed to operate the E Series.
- *E Series Configuration Guide* - Describes the E Series features and functions whose operation can be customized by authorized users.
- *E Series Operator's Guide Option Insert: 12-Lead ECG Monitoring*- Describes using the 12-lead ECG monitoring option with the E Series unit.
- *E Series Operator's Guide Option Insert: End Tidal Carbon Dioxide ($EtCO_2$)*- Describes using the $EtCO_2$ option with the E Series unit.
- *E Series Operator's Guide Option Insert: Non-Invasive Blood Pressure (NIBP)*- Describes using the NIBP option with the E Series unit.
- *E Series Operator's Guide Option Insert: Pulse Oximetry (SpO_2)*- Describes using the SpO_2 option with the E Series unit.
- *E Series Operator's Guide Option Insert: Non-Interpretive 12-Lead ECG Monitoring*- Describes using the non-interpretive 12-lead ECG monitoring option with the E Series unit.
- *E Series Operator's Guide Option Insert:12-Lead Reperfusion Therapy Algorithm* - Describes the reperfusion therapy algorithm option for the E Series unit.

Conventions

WARNING! Warning statements describe conditions or actions that can result in personal injury or death.

Caution	Caution statements describe conditions or actions that can result in damage to the unit.

Note: Notes contain additional information on using the defibrillator.

Service Policy Warranty

In North America: Consult your purchasing agreement for terms and conditions associated with your warranty. Outside of North America, consult ZOLL authorized representative.

In order to maintain this warranty, the instructions and procedures contained in this manual must be strictly followed. For additional information, please call the ZOLL Technical Service Department 1-800-348-9011 in North America.

Technical Service

If the ZOLL E Series unit requires service, contact the ZOLL Technical Service Department:

Telephone: 1-978-421-9655; 1-800-348-9011 (US only)

Fax 1-978-421-0010

Have the following information available for the Technical Service representative:

- Unit serial number.
- Description of the problem.
- Department where equipment is used.
- Sample chart recorder strips documenting the problem, if applicable.
- Purchase Order to allow tracking of loan equipment.
- Purchase Order for a unit with an expired warranty.

If the unit needs to be sent to ZOLL Medical Corporation, obtain a Service Request number from the Technical Service representative. Return the unit in its original container to:

ZOLL Medical Corporation
269 Mill Road
Chelmsford, Massachusetts 01824-4105
Attn: Technical Service Department, SR #

Technical Service for International Customers

International customers should return the unit in its original container to the nearest authorized ZOLL Medical Corporation Service Center. To locate an authorized service center, contact the International Sales Department at ZOLL Medical. See back cover of this manual.

Chapter 1
Maintenance Tests

Overview

The E Series has two checkout procedures: the operator's shift checklist and the extensive six-month maintenance tests checkout procedures.

Because the E Series units must be maintained ready for immediate use, it is important for users to conduct the Operator's Shift Checklist procedure at the beginning of every shift. This procedure can be completed in a few minutes and requires no additional test equipment. (See the ZOLL E Series Operator's Guide for the Operator's Shift Checklist.)

A qualified biomedical technician must perform a more thorough maintenance test checkout every six months to ensure that the functions of the E Series unit work properly. This chapter describes the step by step procedures for performing the six month maintenance test checkout. Use the checklist at the back of this document (ZOLL E Series Maintenance Tests Checklist) to record your results of the maintenance tests.

This chapter describes the following maintenance tests:

- 1. Physical Inspection of the Unit
- 2. Front Panel Button Test
- 3. 3, 5, and 12 Leads Test
- 4. Power Supply Test
- 5. Leakage Current Test
- 6. Paddles Test
- 7. Heart Rate Display Test
- 8. Calibrating Pulses on Strip Chart Test
- 9. Notch Filter Test
- 10. Heart Rate Alarm Test
- 11. Defibrillator Self Test
- 12. Synchronized Cardioversion Test
- 13. Shock Test
- 14. Summary Report Test

- 15. Advisory Message Test
- 16. Pacer Test
- 17. SpO_2 Monitor Test
- 18. $EtCO_2$ Monitor Test
- 19. Barometric Pressure Calibration Check
- 20. CO2 Accuracy Check
- 21. NIBP Monitor Test
- 22. NIBP Volume Leak Test with Fluke Biomedical NIBP Analyzer
- 23. NIBP Volume Leak Test with Fluke Biomedical Cufflink NIBP Analyzer
- 24. NIBP Transducer Calibration Test

Before You Begin the Maintenance Tests

- Assemble the tools or specialized testing equipment listed in the “Equipment You Need to Perform the Maintenance Tests” section shown below.
- Keep an extra fully charged ZOLL E Series compatible battery available.
- Schedule an hour to conduct the entire maintenance test.
- Photocopy the checklist at the back of this document and use the copy to record your results. As you conduct each step of a procedure, mark the Pass/Fail/NA check boxes on your checklist and then save it for your maintenance file.
- Perform the tests in the order presented.
- Perform all the steps of each test procedure.
- Complete all the steps of the procedure before evaluating the test results.

Equipment You Need to Perform the Maintenance Tests

For testing purposes, you can substitute an equivalent device.

- ZOLL Medical Electrode Adapter from Fluke Biomedical (part number 3010-0378).
- Fluke Biomedical Impulse 4000 Defibrillator Analyzer with 1.06 software or higher.
- Fluke Biomedical 601 Pro Series International Safety Analyzer.
- ECG Simulator; 12 Lead Simulator for 12 Lead test (e.g., Symbio CS1201).
- Stop watch.

- Standard series II PC flash memory cards.
- PCMCIA card reader and PC.
- RescueNet® Code Review V3.31 or higher from ZOLL Data Systems.
- Phillips #1 screwdriver.
- Phillips #2 screwdriver.
- Flatblade screwdriver.
- Needle nose pliers without teeth.
- Wooden cuticle sticks with beveled edges (or similar non-conducting implements).

Equipment You Need for the E Series Options Maintenance Tests

- Fluke Biomedical Index 2PFE SpO_2 Simulator or equivalent. (For SpO_2 units only.)
- SpO_2 cable and sensor (if option is installed).
- $EtCO_2$ cable, and CAPNOSTAT 5 Mainstream cable with airway adapter, or CAPNOSTAT 5 Sidestream cable with cannula (if option is installed).
- Paddles (if used).
- Printer Paper.
- Battery.
- AC line cord.
- 3 lead, 5 lead and 12 lead ECG cables. (12 lead cable needed if 12 lead option is installed.)
- Fluke Biomedical BP Pump NIBP Monitor Analyzer (For NIBP units only) with NIBP cable and cuff (if NIBP option is installed), or
- Fluke Biomedical Cufflink Analyzer (if NIBP option is installed)

Note: The Fluke Biomedical BP Pump NIBP Monitor Analyzer and the Fluke Biomedical BP Pump NIBP Analyzer use different technologies for testing NIBP monitors and therefore, the manual provides two different procedures for performing the NIBP Volume Leak test with each of these types of test equipment.

1.0 Physical Inspection of the Unit

Tools Needed: None.

Test Setup: None.

Observe this...		Pass/Fail/NA
1.1	**Housing** Is the unit clean and undamaged?	o o
1.2	Does the unit show signs of excessive wear?	o o
1.3	Does the handle work properly?	o o
1.4	Does the recorder door open and close properly?	o o
1.5	Are input connectors clean and undamaged?	o o
1.6	Are there any cracks in the housing?	o o
1.7	Do the front panel or selector switches have any damage or cracks?	o o
1.8	Are there any loose housing parts?	o o
1.9	**Paddles** Do the adult and pedi plates have major scratches or show signs of damage?	o o o
1.10	Do the adult shoes slide on and off easily to expose the covered pedi plates?	o o o
1.11	Are the paddles clean (e.g., free of gel) and undamaged? (if applicable)	o o o
1.12	**Cables** Are all cables free of cracks, cuts, exposed or broken wires?	o o
1.13	Are all bend/strain reliefs undamaged and free of excessive cable wear?	o o
1.14	**Battery** Is the ZOLL battery fully charged?	o o

Observe this...		Pass/Fail/NA
1.15	Is the battery seated in the battery well correctly?	o o
Record your results on the Maintenance Test Checklist.		

2.0 Front Panel Button Test

Tools Needed: None.

Test Setup:

1. Install strip chart paper into the recorder tray.
2. Install the battery in the unit or connect the A/C power cord to the unit and then plug the cord into an electrical outlet.
3. Connect the universal cable and ECG cable (3 lead, 5 lead, or 12 lead) to the ZOLL simulator, or Fluke Biomedical Impulse 4000 Analyzer (or equivalent).

	Do this...	Observe this...	Pass/Fail/NA
2.1	Turn the selector switch to **MONITOR**. (For AED units, turn the selector switch to **ON** and select Manual mode.)	Listen for 4 beep tones. PADS and MONITOR display on the monitor. NOTE: PADS is a factory default setting.	o o
2.2	Press the **LEAD** button; three times for the 3 lead cable and seven times for the 5 lead cable.	Each time you press the LEAD button, a different lead number appears under the LEAD heading on the display. PADS, I, II, III will display a 3 lead ECG cable if connected or no ECG cable is connected. PADS, I, II, III, AVR, AVL, AVF, V1 will display a 5 lead ECG cable.	o o
2.3	Connect the 12 lead cable to unit and simulator. Press the **LEAD** button and select the lead for each of the 12 lead settings.	A 12 Lead cable will display PADS, I, II, III, AVR, AVL, AVF, VI, V2, V3, V4, V4, V5, V6.	o o o
2.4	Set the simulator to NSR of 120 BPM. To check the size of the ECG waveform, press the **SIZE** button.	As you press the SIZE button five times (0.5, 1.0, 1.5, 2.0, 3.0), note that the size of the ECG waveform appropriately changes on the display.	o o o
2.5	Press the **ALARM SUSPEND** button.	Alarm symbol changes from disabled to enabled. If the alarm sounds, press the ALARM SUSPEND button to turn it off. The alarm will only be suspended for 90 seconds at this point. Press and hold the **ALARM SUSPEND** button for 3 seconds to disable alarms.	o o o
2.6	Press the **RECORDER** button.	The strip chart paper moves out of the unit from the paper tray. Check that the correct time, date, ECG lead annotation and waveform are recorded on the paper. (Set Time and Date, if necessary.)	o o o
2.7	Open the paper compartment door. Press **RECORDER** button.	*CHECK RECORDER* message appears on the monitor.	o o o

	Do this...	Observe this...	Pass/Fail/NA
2.8	Close the paper compartment door. Press **RECORDER** button.	Strip chart paper flows out of paper tray. Verify that the *CHECK RECORDER* message no longer displays.	o o o
2.9	Press **RECORDER** button.	Strip chart paper stops flowing out of paper tray.	o o o
2.10	Press the **VOLUME** softkey. To increase the volume of the beep, press the **Inc**. softkey.	The volume bar graph displays. Audible beep when the QRS wave displays. The bar graph increases on the display indicating an increase in volume. This action does not increase the volume which is normal. Note: The QRS tone is on or off. There is no gradual change in volume. If equipped, voice prompts are gradual. Note: The voice volume has 5 settings. Setting 3 is in the mid-range.	o o
2.11	To decrease the volume of the beep, press the **Dec**. softkey.	The bar graph decreases on the display indicating a decrease in volume. The volume shuts off at the last bar; otherwise, the volume is the same as originally set.	o o
2.12	Press the **CONTRAST** button.	Contrast menu displays.	o o
2.13	Press the **CONTRAST** button. To increase the contrast of the display, press the **Inc**. softkey.	Background light and characters display. The contrast increases on the monitor display. The bar graph increases on the display indicating an increase in contrast.	o o o o o o o o o
2.14	To decrease the contrast of the display, press the **Dec**. softkey.	The bar graph decreases on the display indicating a decrease in contrast. The display contrast changes.	o o
2.15	Press the **SUMMARY** button.	Summary menu displays on the monitor showing the summary report options.	o o o
2.16	Press the **CODEMARKER** button.	Code marker menu displays.	o o o
2.17	Connect a/c current and install the battery. Turn the unit off.	The CHARGER ON indicator lights. The amber or green lights illuminate. Note: If both lights flash ON/OFF, the unit is defective or no battery is installed.	o o o

	Do this...	Observe this...	Pass/Fail/NA
2.18	If applicable, connect d/c current and install the battery. Turn the unit off.	The CHARGER ON indicator lights. The amber or green lights illuminate. The yellow light indicates the battery is being charged. The green light indicates the battery is fully charged to present capacity. If both lights flash ON/OFF, the unit is defective or no battery is installed.	o o o
2.19	Remove the battery.	Note that both charge lights (green and amber) flash alternately.	o o
2.20	Replace the battery and the turn unit on.	Note that the yellow charge light illuminates.	o o
2.21	Press the **ANALYZE** button.	The *SELECT DEFIB MODE* message appears on the monitor. (For manual devices.)	o o o
2.22	Move the selector switch to DEFIB. Select 2J. Press the **CHARGE** button.	The display shows that the unit is charging. The **SHOCK** button lights when the unit is charged. Ready tone for DEFIB sounds.	o o o
2.23	Press and hold the **ENERGY SELECT** down arrow.	Unit discharges internally and selected energy decrements to 1J.	o o o
2.24	Press and release the **ENERGY SELECT** up arrow 19 times.	1-10, 15, 20, 30, 50, 70, 85, 100, 120, 150, 200J.	o o o
2.25	Press the **CHARGE** button.	Note the display shows the unit charged up to 200J and the **SHOCK** button lights.	o o o
2.26	Press the **SHOCK** button.	The unit discharges and the **SHOCK** button is no longer lit. A 15 second strip chart automatically prints, displaying the number of joules delivered (if equipped with recorder and configured to print event).	o o o
Record your results on the Maintenance Test Checklist.			

3.0 3, 5, and 12 Leads Test

Tools Needed: 3 lead, 5 lead, and 12 lead cables. Test each cable separately.

Test Setup:

1. The E Series unit must be configured to display *ECG LEAD OFF* message.
2. Connect the lead wires appropriate to each test to the Fluke Biomedical Impulse 4000 or equivalent (Symbio CS1201).

	Do this...	**Observe this...**	**Pass/Fail/NA**
3.1	Turn the selector switch to **MONITOR**. Select leads.	*NO ECG LEADS OFF* message displayed.	o o o
3.2	Disconnect one lead from the simulator.	The *ECG LEAD OFF* message displays within 3 seconds (if configured).	o o o
3.3	Reconnect the lead. Repeat step 3.2 with the remaining leads.	Wait for *ECG LEAD OFF* message to clear from the display (if configured).	o o o
3.4	Repeat 3.2 and 3.3 for 5 lead and 12 lead cables.	NOTE: If heart rate alarm sounds, press and hold the **ALARM SUSPEND** button for 4 seconds to disable the alarms. NOTE: When testing the 12 lead cable, the *ECG LEAD OFF* message displays when you pull off a limb lead. When you pull off a V lead, the *ECG VX LEAD OFF* message displays where “X” is the number between 1 and 6.	o o o
Record your results on the Maintenance Tests Checklist.			

4.0 Power Supply Test (Optional)

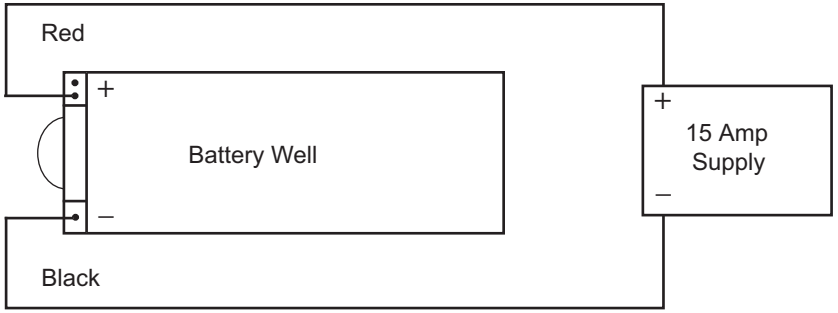
Tools Needed:

- 2 red miniature alligator to miniature alligator leads.
- 1 black miniature alligator to miniature alligator test lead.
- DC power supply (15 Amp minimum).
- 0.1Ω 1% resistor (¼W or greater).
- 1000Ω 1% ¼W resistor.
- Fluke 75 multimeter or equivalent.

Test Setup:

1. Make sure the unit and power supply are turned off.
2. Connect one end of the black lead to the "-" terminal in the battery well.
3. Connect the other end of the black lead to the "-" terminal of the power supply.
4. Connect the red lead to "+" terminal socket of the battery well. Use the middle pin with the plastic guard around it. Connect the other end of the red lead to the "+" terminal of the power supply.
5. Set the power supply voltage to 7V.

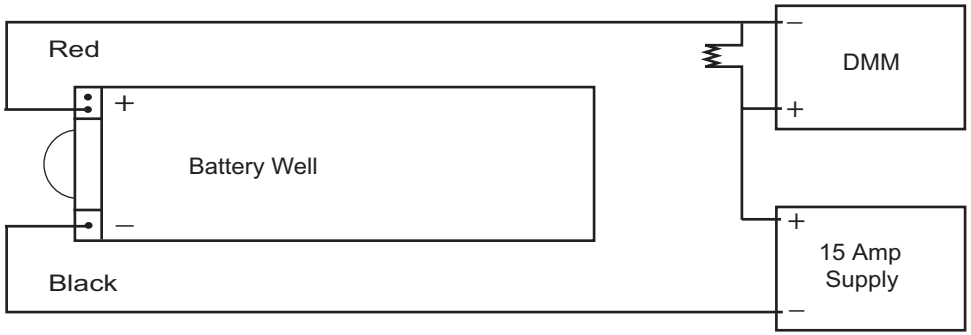
Caution Be sure to connect the power supply properly to the E Series battery well terminals or damage to the unit may result. Do NOT raise the power supply voltage above 12V.



	Do this...	Observe this...	Pass/Fail
4.1	Turn the selector switch to **MONITOR**. (For AED units, turn the selector switch to **ON** and select Manual mode.)	The unit should not turn on.	o o
4.2	Turn the unit off.		
4.3	Adjust the power supply voltage to 10.3V and turn the selector switch to **MONITOR** (for AED units, turn the selector switch to **ON**).	The unit should turn on.	o o
4.4	Low Battery Test Set voltage to 9.9V.	No *LOW BATTERY* message displays.	o o
4.5	Set voltage to 9.4V.	*LOW BATTERY* message displays within 30 seconds.	o o
4.6	Shut Down Voltage Test Set voltage to 8.5V.	Unit should shut off within 30 seconds.	o o
Record your results on the Maintenance Tests Checklist.			

Test Setup:

1. Remove red lead from power supply and connect to 0.1Ω resistor.
2. Connect other end of resistor to "+" terminal of power supply using a second red lead.
3. Connect multimeter across the resistor.
4. Set voltage scale (if DVM is not autoranging) to 220 mV



	Do this...	Observe this...	Pass/Fail/NA
4.7	System Current Test Set power supply to 10.3V.		
4.8	Turn the selector switch to **MONITOR**. (For AED units, turn the selector switch to **ON** and select Manual mode.)	Voltage across resistor should be 116 mV or less (< 1.16 A of ON current).	o o o
4.9	Turn unit off.		
Record your results on the Maintenance Tests Checklist.			

Test Setup for Off Current Test:

1. Remove 0.1Ω resistor and replace with 1KΩ.
2. Connect DMM across resistor.
3. Set voltage scale to DCV.
4. Measure voltage across resistor.

	Do this...	Observe this...	Pass/Fail
4.10	Off Current Test Measure across resistor with unit turned off.	Voltage should be less than 450 mV (<450 μA of current).	o o
Record your results on the Maintenance Tests Checklist.			

5.0 Leakage Current Test

Tools Needed: See the manufacturer's instructions or supplied specifications for the leakage tester you use.

Test Setup: See the manufacturer's instructions or supplied specifications for the leakage tester you use. Repeat leakage test with accessories: MFC, external paddles, and anterior/posterior paddles.

Maximum Leakage Acceptance Limits		
	Normal Condition	Single Fault Condition*
ECG	10μA	50μA
MFC	100μA	100μA
Earth	500μA	1000μA
*Single fault considered AC mains on applied part.		

6.0 Paddles Test (If applicable)

Tools Needed: None.

Test Setup: If applicable, connect the universal cable to the paddles and place the paddles in paddle wells.

	Do this...	Observe this...	Pass/Fail/NA
6.1	Turn the selector switch to **DEFIB**. Press and hold the **ENERGY DOWN** button on the sternum paddle.	The energy selection decreases to 1J.	o o
6.2	Press and release the **ENERGY UP** button on the sternum paddle for each setting.	1-10, 15, 20, 30, 50, 70, 85, 100, 120, 150, 200J.	o o
6.3	Press and release the **RECORDER** button on the sternum paddle.	The recorder turns on. Press and release again to turn off.	o o o
6.4	Select 30J using the paddle **ENERGY** button. Press the **CHARGE** button on the Apex paddle.	The unit charges to 30J, then the red LED charge indicator illuminates and the charge tone sounds. (Note that the front panel shock button does not illuminate).	o o
6.5	Press and release the **APEX SHOCK** button.	No discharge.	o o
6.6	Press and release the **STERNUM SHOCK** button.	No discharge.	o o
6.7	Press and hold both paddles **SHOCK** buttons.	The unit discharges. The *TEST OK* message displays and the red LED turns off. The recorder runs.	o o
Record your results on the Maintenance Tests Checklist.			

7.0 Heart Rate Display Test

Tools Needed:

- Calibrated ECG simulator with 60Hz sine wave output capability.
- Mini-phone plug for measuring output signal from **1 Volt ECG OUT** jack (optional).
- ECG Cable (3 or 5 leads).

Test Setup:

1. Turn the selector switch to MONITOR. Press **LEAD** button until “I” displays.
2. Connect the ECG leads to the Fluke Biomedical Impulse 4000 or equivalent.
3. Connect the ECG cable to the unit.

	Do this...	**Observe this...**	**Pass/Fail/NA**
7.1	Set the ECG Simulator to 120BPM.	The Heart Rate displays as 120 +/- 2 bpm	o o o
Record your results on the Maintenance Tests Checklist.			

8.0 Calibrating Pulses on Strip Chart Test

Tools Needed: None

Test Setup: None.

	Do this...	Observe this...	Pass/Fail/NA
8.1	Press the **RECORDER** button.		
8.2	Press and hold **SIZE** button to activate the calibration signal.	The strip chart displays a signal of 300 ppm with an amplitude of 10 mm +/- 1 mm. The signal also appears on the video display.	o o o
Record your results on the Maintenance Tests Checklist.			

9.0 Notch Filter Test

Tools Needed: Fluke Biomedical Impulse 4000 (or equivalent).

Test Setup:

1. Connect the ECG cable to the Fluke Biomedical Impulse 4000 or equivalent.
2. Connect the ECG cable to the unit.

	Do this...	Observe this...	Pass/Fail/NA
9.1	Turn the selector switch to **MONITOR** mode. (For AED units, turn the selector switch to **ON** and select Manual mode.)		
9.2	Select lead I, size 3x. Select 60Hz (or 50 Hz for a 50Hz unit) on the Fluke Biomedical Impulse 4000.		
9.3	Press **RECORDER** button.	Verify that the waveform amplitude on the strip chart is less than 1.5 mm.	o o o
9.4	Turn the ECG simulator off.		
Record your results on the Maintenance Tests Checklist.			

10.0 Heart Rate Alarm Test

Tools Needed: Fluke Biomedical Impulse 4000

	Do this...	Observe this...	Pass Fail/NA
10.1	Turn the selector switch to **MONITOR** mode. (For AED units, turn the selector switch to **ON** and select Manual mode.) Connect the ECG leads to the Fluke Biomedical Impulse 4000. Set the simulator to 120 BPM and the defibrillator to lead II.	*Lead II* message displays. NSR ECG at 120 BPM +/- 2 displayed.	o o o
10.2	Press **ALARMS**.	The alarm menu displays.	o o o
10.3	Press **SELECT PARAM** softkey until ECG HR displays.	Cursor scrolls through parameters.	o o o
10.4	Press **INC>** for state.	Cursor scrolls through ENABLE, AUTO and DISABLE.	o o o
10.5	Press **DEC>**for state.	Cursor scrolls through ENABLE, DISABLE, AND AUTO.	o o o
10.6	Press **INC**> until ENABLE displays.	ENABLE displays.	o o o
10.7	Set LOW limit to 30, HIGH limit to 150 then, press the **RETURN** softkey.	MONITOR displays.	o o o
10.8	Press **ALARM SUSPEND** button.	No alarm sounds.	o o o
10.9	Remove a lead wire from the Fluke Biomedical Impulse 4000.	The alarm symbol flashes and the heart symbol stops flashing. The ECG LEAD OFF alarm tone sounds. Recorder prints a stripchart showing a low heart rate, if enabled.	o o o
10.10	Reattach ECG Lead wire to Fluke Biomedical Impulse 4000 and hold the **ALARM SUSPEND** button on unit for 4 seconds.	The alarm symbol has an “X through it. The heart symbol flashes with each QRS wave.	o o o
10.11	Press the **ALARM SUSPEND** button.	Alarm is enabled. Alarm symbol (without “X”) displays.	o o o
10.12	Set simulator to 160 BPM or higher.	Heart Rate Value is highlighted, alarm tone sounds, the alarm and the heart symbol both flash.	o o o
10.13	Press the **ALARM SUSPEND** button in the unit.	Alarm is suspended for 90 seconds. The alarm symbol has an “X” through it. The heart symbol flashes with each QRS wave.	o o o

	Do this...	Observe this...	Pass Fail/NA
10.14	Press and hold **ALARM SUSPEND** for 4 seconds to disable alarms.		o o o
Record your results on the Maintenance Tests Checklist.			

11.0 Defibrillator Self Test

SHOCK HAZARD!

TAKE THE NECESSARY PRECAUTIONS TO GUARD AGAINST SHOCK OR INJURY BEFORE YOU START CONDUCTING THE DEFIBRILLATOR TESTS.

Keep hands and all other objects clear of the multi-function cable connections and defibrillator analyzer when discharging the defibrillator.

Before you discharge the defibrillator, warn everyone near the equipment to STAND CLEAR.

Caution Do NOT internally discharge the unit more than 3 times in 1 minute. Note that multiple rapidly repeating internal discharges at more than 30 Joules may damage the unit.

Tools Needed:

- MFC Test Port Connector 1004-0053-99 with universal cable.
- MFC Test Adaptor Connector (Fluke Biomedical Part Number 3010-0378 or equivalent).
- Fluke Biomedical Impulse 4000 or equivalent defibrillator analyzer.
- ECG Cable.
- Stop watch.

Test Setup:

1. Ensure the unit is turned off
2. Ensure the ECG cable is connected to the unit and analyzer.

Note: The universal cable should not be connected to any equipment at the beginning of this test.

	Do this...	**Observe this...**	**Pass/Fail**
11.1	Turn the selector switch to **DEFIB** mode. (For AED units, turn the selector switch to **ON** and select Manual mode.) Set leads to PADS.	*CHECK PADS/POOR PAD CONTACT* message displays.	o o

	Do this...	Observe this...	Pass/Fail
11.2	Connect the universal cable to the MFC test port.	*DEFIB PAD SHORT* message displays.	o o
11.3	Select energy level of 100J and press the **CHARGE** button.	The charge time is >2 second and <10 seconds and *SELECT 30J FOR TEST* is displayed.	o o
11.4	Press the **SHOCK** button.	Unit does not discharge. *DEFIB PAD SHORT* message displays.	o o
11.5	Set energy level to 30J.	Unit internally discharges.	o o
11.6	Press the **CHARGE** button.	Unit charges to 30J and displays *DEFIB 30J READY.* The charge ready tone sounds.	o o
11.7	Press and hold **SHOCK** button.	Unit discharges. TEST OK message and number of joules delivered message displays. For example, using the message at the top of the printed strip chart would read as follows: 30 JOULES TEST OK. TEST_CUR=10-14A DEFIB_IMPED=0. The impedance value may range from 0 to 5Ω.	o o
Record your results on the Maintenance Tests Checklist.			

12.0 Synchronized Cardioversion Test

Tools Needed: Fluke Biomedical Impulse 4000 or equivalent defibrillator analyzer.

Test Setup:

1. Connect the universal cable via the adapter (D.N.I #3010-0378) to the defibrillator analyzer.
2. Select cardioversion on analyzer. Input 1mV ECG signal at 60 -120 BPM.

	Do this...	Observe this...	Pass/Fail
12.1	Press **LEAD** button to select **PADS** and Size X1.		
12.2	Press the **SYNC** softkey on the defibrillator. Enter synchronized cardioversion timing test mode on the defibrillator analyzer.	Sync appears on display. Sync markers display on the monitor. The sync marker appears as a down arrow over the ECG R-wave peaks on strip chart and display.	o o
12.3	Select 200J.		
12.4	Press the **CHARGE** button. When the **SHOCK** button lights, press and hold the **SHOCK** button.	Observe that the R-wave to shock delay (sync delay) is less than 60 milliseconds on the analyzer display. Defibrillator discharges.	o o
Record your results on the Maintenance Tests Checklist.			

13.0 Shock Test

Tools Needed: Fluke Biomedical Impulse 4000 or equivalent defibrillator analyzer.

Test Setup:

1. Stop watch.
2. Connect the universal cable via the adapter (D.N.I #3010-0378) to the defibrillator analyzer.
3. Ensure that a fully charged battery is installed in the unit.

Note: If your E Series AED does not have manual override capability, do not perform this test.

	Do this...	Observe this...	Pass/Fail/NA
13.1	Turn the selector switch to **DEFIB** mode. (For AED units, turn the selector switch to **ON** and select Manual mode.)		
13.2	Press the **ENERGY SELECT** down arrow until 1J displays.	*DEFIB 1J SEL* displays.	o o o
13.3	Press the **CHARGE** button.Wait for the **SHOCK** button to illuminate.	*DEFIB 1J RDY* displays.	o o o
13.4	Press the **SHOCK** button.	Unit discharges 0J-2J into the simulator. (Note: The displayed rhythm may change shape for 30 seconds before it returns to an original rhythm. This is caused by the operation of the adaptive bandwidth defibrillator recovery circuit.)	o o o
13.5	Repeat for all settings 1-200J	Energy delivered is within + /- 15% or 2J of setting which ever is greater.	o o o
13.6	Press the **ENERGY SELECT** up arrow until 200J displays.	*DEFIB 200J SEL* displays.	o o o
13.7	Press the **CHARGE** button and start timing with a stopwatch. Stop timing when the **SHOCK** button illuminates.	Observe and record the value of the charge time on the stop watch. Charge time 3.0-6.0 sec.	o o o
13.8	Press the **SHOCK** button. Record the value of the discharge energy that is displayed on the analyzer.	200J discharge energy 170-230J.	o o o

	Do this...	Observe this...	Pass/Fail/NA
13.9	Note the Patient Current and Defib Impedance on the strip chart.	Patient Current 20-24A. Defib Impedance 46-54 Ohms.	o o o
13.10	(AED unit only) Disconnect the cable from the analyzer.	CHECK PADS audio prompt.	o o o
Record your results on the Maintenance Tests Checklist.			

14.0 Summary Report Test

Tools Needed: None.

Test Setup:

1. Connect the universal cable to the defibrillator analyzer.
2. If you are using paddles, place the paddles on the analyzer's discharge plates.

	Do this...	Observe this...	Pass/Fail
14.1	Press and hold the **SUMMARY** softkey for 4 to 8 seconds to erase any previously stored data.	*ERASING REPORT* displays.	o o
14.2	Set selector switch to **DEFIB**. Select 200J using the **ENERGY SELECT** button, and press the **CHARGE** button. When charged, press the **SHOCK** button to discharge into the defibrillator analyzer.	The unit successfully discharges and prints a strip chart.	o o
14.3	Wait 18 seconds, then press the **Code Marker** softkey. Press the **CPR** softkey.	The Code Markers display.	o o
14.4	Turn the unit off. Wait 10 seconds and then turn the unit on. Press the **SUMMARY** softkey, then press the **PRINT CHART** softkey.	Summary report prints. The report displays the correct date, time, the shock delivered and Code Marker event.	o o
Record your results on the Maintenance Tests Checklist.			

15.0 Advisory Message Test

Tools Needed: None.

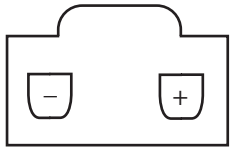
Test Setup:

1. Connect the universal cable via the adapter (D.N.I #3010-0378).
2. Attach the E Series to the defibrillator analyzer.

	Do this...	Observe this...	Pass/Fail
15.1	Connect universal cable to the simulator. Turn the selector switch to **DEFIB** mode. (For AED units, turn the selector switch to **ON**.)		
15.2	Select VF (ventricular fibrillation) on the simulator, then press the **ANALYZE** button.	*ANALYZING ECG* message displays. *STAND CLEAR* message displays.* *SHOCK ADVISED* message displays.* *PRESS SHOCK* message displays*+ *AED's audio prompts are standard. Advisory audio prompts are user configurable. +If configured for auto charge.	o o
15.3	Press the **SHOCK** button.	Unit discharges.	o o
15.4	Select the **NSR** (normal sinus rhythm) on the simulator, then press the **ANALYZE** button.	*ANALYZING ECG* message. *STAND CLEAR* message.* *NO SHOCK ADVISED* message.* *AED's audio prompts are standard.	o o
Record your results on the Maintenance Tests Checklist.			

16.0 Pacer Test

Tools Needed: Fluke Biomedical Impulse 4000 Analyzer (software 1.06 or higher) with optional external plug in pacing module (TQA-17) or equivalent.



Note: The following tests are to be performed only on E Series units equipped with the optional pacing function.

The pacer output can be measured using an oscilloscope set to DC coupling connected across a load resistor. (See diagram in column for universal cable connector polarity.) The load resistor is a 100 ohm, 5 watt or greater. The pacer output is a positive going pulse, 40 +/- 2 ms duration with an amplitude of 0.1 volt per milliamp of selected output (e.g., 40 milliamps of selected output has an amplitude of 4 +/- 0.5 volts the specified tolerance displayed on the oscilloscope).

If an external non-invasive pacer analyzer is being used, then follow the manufacturer's guidelines for measuring the frequency (ppm), output (mA) and the pulse width measured in milliseconds. Note that the analyzer pace load resistor must be less than 250 ohms.

Test Setup:

1. Connect the universal cable from the E Series to the External Pacer Load (TQA-17) of the Impulse 4000.
2. Turn the Main Selector knob of the E Series to the Pacer mode.

	Do this...	**Observe this...**	**Pass/Fail**
16.1	Set the **PACER OUTPUT** to 14 mA and disconnect MFC connector from the Fluke Biomedical Impulse 4000.	*CHECK PADS* and *POOR PAD CONTACT* message displays. The pace alarm is active.	o o
16.2	Reconnect the universal cable to the Fluke Biomedical Impulse 4000. Press Clear Pace Alarm softkey.	*CHECK PADS* and *POOR PAD CONTACT* message disappears. The pace alarm is cleared.	o o
16.3	Set rate to 180 ppm; output to 0mA.	No output appears on the Fluke Biomedical Impulse 4000.	o o
16.4	Increase the output to 20mA.	Output on the Fluke Biomedical Impulse 4000 is 20mA +/- 5mA. Pulse width is 40mS +/-2mS.	o o

	Do this...	Observe this...	Pass/Fail
16.5	Increase the output to 40mA.	Output on the Fluke Biomedical Impulse 4000 is 40mA +/- 5 mA. Pulse width is 40mS +/-2mS.	o o
16.6	Increase the output to 60mA.	Output on the Fluke Biomedical Impulse 4000 is 60mA or +/- 5mA. Pulse width is 40mS +/-2mS.	o o
16.7	Increase the output to 80mA	Output on the Fluke Biomedical Impulse 4000 is 80mA or +/- 5mA. Pulse width is 40mS +/-2mS.	o o
16.8	Increase the output to 100mA.	Output on the Fluke Biomedical Impulse 4000 is 100mA or +/- 5mA. Pulse width is 40mS +/-2mS.	o o
16.9	Increase the output to 120mA.	Output on the Fluke Biomedical Impulse 4000 is 120mA or +/- 6mA. Pulse width is 40mS +/-2mS.	o o
16.10	Increase the output to 140mA.	Output on the Fluke Biomedical Impulse 4000 is 140mA or +/- 7mA. Pulse width is 40mS +/-2mS.	o o
16.11	Decrease the output to 60mA. Decrease the rate to 30 ppm.	Pacer rate on Fluke Biomedical is 29-31 ppm.	o o
16.12	Increase the rate to 40ppm.	Pacer rate on Fluke Biomedical is 39-41 ppm.	o o
16.13	Increase the rate to 60ppm.	Pacer rate on is Fluke Biomedical is 59-61 ppm.	o o
16.14	Increase the rate to 80ppm.	Pacer rate on Fluke Biomedical is 78-82 ppm.	o o
16.15	Increase the rate to 100ppm.	Pacer rate on Fluke Biomedical is 98-102 ppm.	o o
16.16	Increase the rate to 120ppm.	Pacer rate on Fluke Biomedical is 118-122 ppm.	o o
16.17	Increase the rate to 180ppm.	Pacer rate on Fluke Biomedical is 177-183 ppm.	o o
16.18	Decrease the rate to 50 ppm.	Pacer rate on Fluke Biomedical is 49-51 ppm.	o o
16.19	Connect the ECG cable to the E Series and Fluke Biomedical Impulse 4000. Select the ECG at 60 BPM on the Fluke Biomedical Impulse 4000.	ECG at 60 BPM is seen on the display and no stimulus markers.	o o

	Do this...	Observe this...	Pass/Fail
16.20	Press the Async Pace softkey.	ECG at 60 BPM seen on the display with the pace stimulus markers displayed. Async pace message displays.	o o
16.21	Turn off Fluke Biomedical. Set Pacer Rate to 100ppm. Press the **RECORDER ON** button.	Observe the pace stimulus markers every 15mm +/-1mm.	o o
16.22	Press and hold 4:1 button.	Observe the pace stimulus markers every 60 mm+/- 1.5 mm.	o o
Record your results on the Maintenance Tests Checklist.			

17.0 SpO_2 Monitor Test for SpO_2 Option

Tools Needed:

- Masimo® Reusable Sensor.
- Masimo® Patient Cable.
- Fluke Biomedical Index 2PFE SpO_2 Simulator (or equivalent).

Test Setup:

1. Connect the universal cable to the MFC test plug.
2. DO NOT connect the ECG cable to the simulator.
3. Install the Masimo® Patient Cable and attach the Masimo® sensor to the patient cable.
4. Connect the Masimo® sensor to the finger simulation post.
5. Place a fully charged battery into the battery well or connect to ac power (dc power, if equipped).
6. Ensure that the SpO_2 Simulator is off.

	Do this...	**Observe this...**	**Pass/Fail**
17.1	Turn the selector switch to **MONITOR**. (For AED units, turn the selector switch to **ON** and select Manual mode.)	The SpO_2 saturation percentage appears as a dashed line on the monitor.	o o
17.2	Wait ten seconds. Turn on the SpO_2 simulator. Press the **SIM** softkey on the Index SpO_2 Simulator. Press the **MAN** softkey.	The *SpO_2 PULSE SEARCH* message displays.	o o
17.3	Press the **02+** or **02-** softkey of the simulator until the SpO_2 output is at 98%.	The E Series SpO_2 reading of 98 +/- 1% appears on the E Series monitor. Note that you may need to wait up to 2 minutes for the information to appear on the ZOLL display.	o o
17.4	Using the Index SpO_2 Simulator, press the **BPM+** or **BPM-** softkey until the heart rate is 230 BPM.	The SpO_2 rate 230 BPM displays on the simulator screen. Note that you may need to wait up to 2 minutes for the information to appear on the ZOLL display. The SpO_2 saturation of 96-100% appears on the E Series display. The heart rate of 226-234 BPM displays on the E Series monitor.	o o

	Do this...	Observe this...	Pass/Fail
17.5	Using the Index SpO_2 Simulator, press the **BPM-** softkey until the heart rate is 50 BPM	The SpO_2 saturation of 96-100% displays on the unit. The heart rate of 46-54 BPM displays on the E Series monitor.	o o o o
17.6	Using the Index SpO_2 Simulator, press the **02+** softkey until the SpO_2 output is at 72%.	The SpO_2 saturation of 70-74% displays on the unit. The heart rate of 46-54 BPM displays on the E Series monitor.	o o o o
17.7	Press **Wave 2** softkey. Select the SpO_2 waveform.	Plethysmographic waveform appears on the ZOLL display.	o o
17.8	Press **RECORDER**.	The plethysmographic waveform prints on the strip chart paper.	o o
17.9	Using the Index SpO_2 Simulator, press the **BPM-** softkey until the heart rate is at 230 BPM.	The SpO_2 saturation rate of 70-74% displays on the unit. The heart rate in the heart position of 226-234 BPM displays on the monitor.	o o
17.10	Select Wave 2 SpO_2.	Verify that the waveform is displayed at the correct rate. Print the waveform.	o o
17.11	Remove the Masimo® patient cable.		
Record your results on the Maintenance Tests Checklist.			

18.0 $EtCO_2$ Monitor Test (for $EtCO_2$ Option)

Tools Needed: CAPNOSTAT 5 Mainstream cable with airway adapter, or CAPNOSTAT 5 Sidestream cable with cannula.

Test Setup:

1. Install the battery.

	Do this...	Observe this...	Pass/Fail
18.1	Connect the CAPNOSTAT 5 CO2 Mainstream cable with airway adapter attached, or the CAPNOSTAT 5 Sidestream cable with the cannula attached, to the yellow connector at the back of the E Series.	NOTE: Make sure the airway adapter (for Mainstream), or the cannula (for Sidestream) is installed in the CO_2 cable.	
18.2	Set the front panel switch to MONITOR or ON. For AED units, enter Manual Mode.	*WARM UP* message appears on the display. NOTE: Warming up may take about 1 minute.	o o
18.3	When the *WARM UP* message disappears, press the **Param** softkey, then select **EtCO2** and press **Enter**.		
18.4	Press the **ZERO** softkey, then wait for the *ZERO DONE* message.	The *ZERO DONE* message appears.	o o
18.5	Press the **Return** softkey.		
18.6	Press the **Wave 2** softkey until the CO_2 waveform appears.	A flat baseline CO_2 waveform appears.	o o
18.7	Breath normally into the airway adapter.	A capnogram waveform appears.	o o
Record your results on the Maintenance Tests Checklist.			

19.0 Barometric Pressure Calibration Check

Tools Needed: None.

Test Setup: None

	Do this...	Observe this...	Pass/Fail/NA
19.1	Connect the CAPNOSTAT 5 CO2 Sensor to the yellow connector at the back of the E Series unit, and connect an airway adapter to the sensor.		
19.2	While pressing and holding the second softkey from the left, turn the selector switch to Monitor (ON for AED units).	The unit displays $EtCO_2$ Calibration screen.	
19.3	Wait for the sensor to warm up.	The message WARM UP is displayed for approximately one minute.	
19.4	Obtain the local barometric pressure in mmHg.*		
19.5	Press the **Baro Pr.** softkey to enter the Barometric Pressure Calibration screen.		
19.6	Use the **Inc>** and **Dec<** softkeys to set the second value on the pressure display line equal to your local barometric pressure.		
19.7	Press the **Return** softkey to store the offset and return to the main $EtCO_2$ Calibration screen.		o o o
Record your results on the Maintenance Test Checklist.			

*The barometric pressure can be obtained from a calibrated barometer, or from the National Weather Service at www.nws.noaa.gov (enter your local zip code to get the local barometric pressure). Note that the barometric pressure is in inches of mercury, multiply it by 25.4 to convert to mmHg.

20.0 CO_2 Accuracy Check

Tools Needed: None.

Test Setup: None

	Do this...	Observe this...	Pass/Fail/NA
20.1	Connect the CAPNOSTAT 5 CO2 Sensor to the yellow connector at the back of the E Series unit, and connect an airway adapter to the sensor.	NOTE: Make sure the airway adapter (for Mainstream), or the cannula (for Sidestream) is installed in the CO_2 cable.	
20.2	While pressing and holding the second softkey from the left, turn the selector switch to Monitor (ON for AED units).	The unit displays $EtCO_2$ Calibration screen.	
20.3	Wait for the sensor to warm up.	The message WARM UP is displayed for approximately one minute.	
20.4	Obtain current room temperature in Centigrade (Cº).		
20.5	Press the **Select Gas Temp** softkey to enter the CO_2 Accuracy screen		
20.6	Use the **Prev**, **Next**, **Inc** and **Dec** softkeys to set each digit of the gas temperature parameter in the CAPNOSTAT 5 CO_2 Sensor until Gas Degrees C is equal to the room temperature.		
20.7	Press the **Return** softkey to store the temperature and return to the main $EtCO_2$ Calibration screen.		o o o
20.8	Press the **Zero** softkey to zero the mainstream CAPNOSTAT 5 CO_2 Sensor/Airway Adapter.		o o o
20.9	Attach a regulated flowing gas mixture of 5% CO_2, balance Nitrogen (N_2) to the airway adapter (for Mainstream) or cannula (for Sidestream).	The gas flow rate should already be preset to 2 to 5 liters per minute.	

	Do this...	Observe this...	Pass/Fail/NA
20.10	Set the Gas Balance settings of the CAPNOSTAT 5 CO_2 Sensor to that of the calibration gas mixture (N_2, N_2O, or He). The default gas balance is N_2.		
20.11	Allow a few seconds for the gas mixture to stabilize and observe the CO2 Percent value.	The expected value is 5% ± 0.26%.	o o o
20.12	1. Press the **Return** softkey to return to the main EtCO_2 Calibration screen.		
Record your results on the Maintenance Test Checklist.			

The calibration gas mixture and regulator are available from Respironics Novametrix. (Equivalent alternatives are available from other suppliers.)

- Gas Regulator: PN 6081-00
- Calibration Gas (carton of 4 tanks): PN 8964-00

21.0 NIBP Monitor Test

The NIBP monitor test verifies the accuracy of the systolic, diastolic, and mean blood pressure measurements, as well as the patient pulse rate calculation.

Tools Needed: Fluke Biomedical BP Pump NIBP Monitor Analyzer.

Test Setup:

1. Connect the Analyzer's simulator hose to the NIBP connector on the E Series unit.
2. Set the following parameters on the NIBP Analyzer:

Parameter	Value
Systolic pressure	120 mmHg
Diastolic pressure	80 mmHg
Mean pressure	93 mmHg
Heart pressure	80 bpm

Note: If you are using the Fluke® Biomedical CuffLink, you must change the shift value of the Blood Pressure Envelope to +3 on the Pressure Curve Adjust Menu.

3. Make sure the ECG cable is not connected to the E Series unit.
4. If the SpO2 option is installed, make sure that the Masimo cable is NOT connected to the E Series unit.

	Do this...	Observe this...	Pass/Fail
21.1	Turn the selector switch to **MONITOR** mode. (For AED units, turn the selector switch to **ON** and select Manual mode.)	The E Series powers on in MONITOR mode.	
21.2	Ensure that the LEADS parameters is set to PADS (default). If necessary, press the **LEADS** button to cycle through the values to select PADS.	The E Series displays PADS in the Lead selection field on the monitor.	o o
21.3	Press the **NIBP** button on the E Series front panel Verify that the values displayed are accurate within ±5 mmHg of the pressure parameters set on the NIBP Analyzer.	The E Series initiates the blood pressure measurement cycle and displays the following measurements: • systolic pressure (115 - 125 mmHg) • diastolic pressure (75 - 85 mmHg) • mean pressure (88 - 98 mmHg)	o o

	Do this...	Observe this...	Pass/Fail
21.4	Press the **SUMMARY** button on the E Series front panel.		
21.5	Select the Trend softkey, then select the **NIBP Trend** softkey.	The E Series displays a summary of the NIBP measurements, including the pulse rate reading (in the range of 77 - 83 bpm).	o o
Record your results on the Maintenance Tests Checklist.			

22.0 NIBP Volume Leak Test with Fluke Biomedical NIBP Analyzer

The volume leak test verifies the integrity of the pneumatic system on the NIBP module. This test is optional at 6 months, but should be performed annually or every 10,000 readings, whichever comes first.

Tools Needed: Fluke Biomedical BP Pump NIBP Monitor Analyzer.

Test Setup:

1. Connect the Analyzer's simulator hose to the NIBP connector on the E Series unit.
2. Configure the NIBP Analyzer for the volume leak test. For example, on the Fluke Biomedical BP Pump:
   - Press the MODE button three times to go into Tests mode.
   - Press the SELECT button twice to access the volume leak test.
3. Make sure the ECG cable is not connected to the E Series unit.
4. If the SpO2 option is installed, make sure that the Masimo cable is NOT connected to the E Series unit.

	Do this...	**Observe this...**	**Pass/Fail**
22.1	Turn the Selector Switch to OFF. After 10 seconds, press and hold the fourth softkey from the left and turn the Selector Switch to MONITOR.	The E Series powers on in the NIBP Service Mode.	
22.2	Press the **Leak Test** softkey.	The E Series displays the NIBP Leak Test Screen.	
22.3	*On the NIBP Analyzer,* set the pressure parameter to 200 mmHg.	The NIBP Analyzer displays a pressure reading of 200 mmHg.	
22.4	*On the E Series unit*, press the **Close Valves** softkey.	The Valves status changes from OPEN to CLOSED.	o o

	Do this...	Observe this...	Pass/Fail
22.5	*On the NIBP Analyzer*, press the **START TEST** softkey. **Note:** You must press the **START TEST** softkey within 30 seconds of closing the valves on the E Series unit.	After approximately 1 minutes, a number appears in the upper middle area of the NIBP Analyzer display. If the Analyzer: • displays a Volume Leak reading <5, then the E Series unit has passed the test. • displays a Volume Leak reading >5, then the E Series unit has failed the test. • displays no Volume Leak reading, but maintains a stable pressure reading at or above 200 mmHg, then the E Series unit has passed the test; there is no volume leak. In addition, the E Series displays the Analyzer's pressure reading in the "Cuff Pressure" field. After approximately 3 minutes, the valves on the E Series unit open.	o o
22.6	*On the NIBP Analyzer*, press the **STOP TEST** softkey.	The NIBP Analyzer terminates the Volume Leak Test.	o o
22.7	*On the E Series unit*, press the **EXIT** softkey twice.	The E Series returns to the main NIBP Service Mode screen, then to normal Monitor mode operation.	
Record your results on the Maintenance Tests Checklist.			

23.0 NIBP Volume Leak Test with Fluke Biomedical Cufflink NIBP Analyzer

The volume leak test verifies the integrity of the pneumatic system on the NIBP module. This test is optional at 6 months, but should be performed annually or every 10,000 readings, whichever comes first.

Tools Needed: Fluke Biomedical/Fluke Biomedical Cufflink NIBP Analyzer.

Test Setup:

1. Connect the Analyzer's simulator hose to the NIBP connector on the E Series unit.
2. Connect the Analyzer to the E Series unit as described in the manufacturer's instructions.
3. Configure the NIBP Analyzer for the volume leak test by selecting Leak Test. Note that you can also consider using the internal Digital Manometer and stopwatch.
4. Make sure the ECG cable is not connected to the E Series unit.
5. If the SpO2 option is installed, make sure that the Masimo cable is NOT connected to the E Series unit.

	Do this...	**Observe this...**	**Pass/Fail**
23.1	Turn the Selector Switch to OFF. After 10 seconds, press and hold the fourth softkey from the left and turn the Selector Switch to MONITOR.	The E Series powers on in the NIBP Service Mode.	
23.2	Press the **Leak Test** softkey.	The E Series displays the NIBP Leak Test Screen.	
23.3	*On the NIBP Analyzer,* set the pressure parameter to 200 mmHg.	The NIBP Analyzer displays a pressure reading of 200 mmHg.	
23.4	*On the E Series unit*, press the **Close Valves** softkey.	The Valves status changes from OPEN to CLOSED.	o o

	Do this...	Observe this...	Pass/Fail
23.5	*On the NIBP Analyzer*, press the **START TEST** softkey. **Note:** You must press the **START TEST** softkey within 30 seconds of closing the valves on the E Series unit.	After approximately 1 minutes, a number appears in the upper middle area of the NIBP Analyzer display. If the Analyzer: • displays a Volume Leak reading ≤10, then the E Series unit has passed the test. • displays a Volume Leak reading >10, then the E Series unit has failed the test. • displays no Volume Leak reading, but maintains a stable pressure reading at or above 200 mmHg, then the E Series unit has passed the test; there is no volume leak. In addition, the E Series displays the Analyzer's pressure reading in the "Cuff Pressure" field. After approximately 3 minutes, the valves on the E Series unit open.	o o
23.6	*On the NIBP Analyzer*, press the **F3** softkey.	The NIBP Analyzer terminates the Volume Leak Test.	o o
23.7	*On the E Series unit*, press the **EXIT** softkey twice.	The E Series returns to the main NIBP Service Mode screen, then to normal Monitor mode operation.	
Record your results on the Maintenance Tests Checklist.			

24.0 NIBP Transducer Calibration Test

The NIBP module's pressure transducers are factory-calibrated prior to shipment. However, you can perform a two-point calibration procedure periodically to ensure accurate pressure measurements.

This procedure is optional at 6 months, but should be performed annually or every 10,000 readings, whichever comes first.

Tools Needed: Fluke Biomedical BP Pump NIBP Monitor Analyzer (or equivalent).

Test Setup:

1. Connect the Analyzer's simulator hose to the NIBP connector on the E Series unit.
2. Configure the NIBP Analyzer to simulate cuff pressure. For example, on the Fluke Biomedical BP Pump:
   - Press the MODE button three (3) times to go into Tests mode.
   - Press the SELECT button once to access the Pressure Simulator screen.

Note: These instructions apply to the Fluke Biomedical BP Pump; for equivalent devices, follow the manufacturer's instructions.

3. Make sure the ECG cable is not connected to the E Series unit.
4. If the SpO2 option is installed, make sure that the Masimo cable is NOT connected to the E Series unit.

	Do this...	**Observe this...**	**Pass/Fail**
24.1	Turn the Selector Switch to OFF. After 10 seconds, press and hold the fourth softkey from the left and turn the Selector Switch to MONITOR.	The E Series powers on in the NIBP Service Mode.	
24.2	Press the **NIBP Calib** softkey.	The E Series displays the NIBP Transducer Calibration Screen.	
24.3	*On the NIBP Analyzer,* set the pressure parameter to 0 mmHg.	The NIBP Analyzer displays a pressure reading of 0 mmHg.	
24.4	*On the E Series unit*, press the **Set Low** softkey to calibrate the transducer to a 0 mmHg pressure reading.	The NIBP pressure transducer registers its voltage output at a known pressure of 0 mmHg. The field adjacent to the 0 mmHg value changes to PASS. **Note:** If the E Series displays a FAIL reading, verify the NIBP Analyzer's pressure setting and connection to the E Series and repeat the step.	o o
24.5	*On the NIBP Analyzer,* set the pressure parameter to 250 mmHg.	The NIBP Analyzer displays a pressure reading of 250 mmHg.	

	Do this...	Observe this...	Pass/Fail
24.6	*On the E Series unit*, press the **Set High** softkey to calibrate the transducer to a 250 mmHg pressure reading.	The NIBP pressure transducer registers its voltage output at a known pressure of 250 mmHg. The field adjacent to the 250 mmHg value changes to PASS. **Note:** If the E Series displays a FAIL reading, verify the NIBP Analyzer's pressure setting and connection to the E Series and repeat the step.	o o
24.7	*On the NIBP Analyzer,* set the pressure parameter to stimulate a different cuff pressure (for example, 205 mmHg).	The NIBP Analyzer displays the specified pressure reading.	
24.8	*On the E Series unit*, press the **Read Cuff** softkey. Verify that the value displayed is accurate within ±5 mmHg of the pressure parameter set on the NIBP Analyzer.	The NIBP module measures the pressure from the NIBP Analyzer and displays the value in the Cuff Pressure field.	o o
24.9	*On the E Series unit*, press the **EXIT** softkey twice.	The E Series returns to the main NIBP Service Mode screen, then to normal Monitor mode operation.	o o
24.10	Perform the NIBP Monitor Test (see "NIBP Monitor Test" on page 37) to verify functional operation of the NIBP option.	The E Series passes all the criteria for the NIBP Monitor Test.	o o
Record your results on the Maintenance Tests Checklist.			

Warning! NIBP transducer calibration can affect clinical readings of the NIBP parameter. Ensure that the NIBP Transducer Calibration procedure is performed correctly, followed by an NIBP Monitor Test for verify proper operation.

Chapter 2 Troubleshooting

Overview

This chapter describes the most common technical problems that biomedical technicians experience when checking the E Series during routine maintenance or when there is a malfunction of the unit. It also contains a list of error messages that users may see if the unit is not operating properly.

This chapter contains the following:

- Troubleshooting tables for ECG Leads Off Messages and Monitor Displays
- ZOLL E Series Error Messages

If the problems you encounter are not listed below, call ZOLL Medical Corporation's Technical Service Department for further assistance. (See page vii for contact information.)

Troubleshooting

The following tables show the most common troubleshooting issues and their solutions.

First, attempt to solve the problem with “Recommended User Action.” If these steps do not solve the problem, follow the steps listed in the “Recommended Technical Action” column.

Reported Problem	Recommended User Action	Recommended Technical Action
ECG LEAD OFF message displays. (3, 5, 12 lead cable)	• Check preparation of ECG electrode site by cleaning the site, lightly abrading the patient’s skin and/or clipping the patient’s hair at the electrode site. • If electrode gels are dry, replace electrodes with new ones from a freshly opened package. • Verify that all leads are attached. • Set monitor to another lead. • Verify that the electrodes have not exceeded their expiration date.	• Try to reproduce the problem using a simulator. • Inspect the ECG cables looking for corrosion or broken connector pins. • Check the cable for intermittent connections by flexing the cable at the yoke and snap connectors. • Check the cable connection to the defibrillator. • Inspect the ECG input connector and its pins. Replace it, if necessary. • Inspect the ECG cable connection to the system board. • Inspect the system board ECG shielding. • Remove and replace the system board.
V LEADS OFF message displays.	• If the user is not using V leads, attach V lead connector terminator plug to the cable’s V lead connector. • If a V1 lead wire metal snap comes in contact with the patient’s skin, then the system will show all V leads as OFF. • Remove V1 leads and others away from the patient. Turn off the unit and wait ten seconds before turning it back on.	

Reported Problem	Recommended User Action	Recommended Technical Action
CHECK PADS/POOR PAD CONTACT message displays.	• Remove and reinsert PADS connector into the universal cable. • Check for damaged defibrillator pads, wires and or connector. • Check for dried out or expired defibrillator pads. • Clip (not shave) the patient's hair and wipe pad contact area dry. • Connect the cable to the test plug. The DEFIB PAD SHORT message displays to indicate that the cable is functioning properly. • If the DEFIB PAD SHORT message displays, then check the connections of the pads to the patient and to the defibrillator cable. • If the DEFIB PAD SHORT message does not display, remove the defibrillator from service.	• Connect universal cable to the shorting plug. The DEFIB PAD SHORT message should display, when you SELECT PADS. If the message does not display, then: • Try another universal cable. • Check the cable from the universal cable connector to the High Voltage Module. • Check the cable from the High Voltage Module to the system board. • Remove and replace the High Voltage Module. • Remove and replace the system board. • Call ZOLL Technical Support for assistance.
Flash or arcing under defibrillator pad.	• Avoiding using alcohol and betadine in and around the treatment area because these skin preparations may lead to increased conductivity and/or bonding between the electrode's adhesive and skin. • Check for gel droop. If the gel has leaked out of the gel treatment area, replace the electrode. • Ensure pads are coupling to the patient's skin and connected to the universal cable. • Check for dried out gel on the defibrillator pad. • Clip patient's excessive hair. Do not shave hair. • Check expiration date. Replace pad if date has expired. • Do not conduct chest compression through the pads because the pads could be damaged leading to the possibility of arcing and skin burns. • Apply the back electrode first. If the front electrode is already in place when the patient is being maneuvered for placement on the back, the front may become partially lifted, possibly causing arching and skin burns.	• Ensure that wet gel pads are stored flat.
Displayed HR not accurate. No artifact present.	Verify heart rate flashes with each QRS on display. • Change lead selection. • Change ECG size. • Reposition ECG electrodes.	

Reported Problem	Recommended User Action	Recommended Technical Action
Displayed HR not accurate; artifact present.	• Reduce or eliminate ECG artifact due to electrode or patient cable movement. Route cables so that they don't pull on electrodes or swing excessively. • Ensure patient is motionless. • Check for possible excessive radio frequency interference. • Verify a good connection of electrodes to the patient. • Prepare the patient's skin prior to the electrode attachment. • Move patient cables away from other electrical equipment, especially any RFI source. • Ensure ECG cable fits snugly in unit. • Change ECG cable. • Replace/reposition ECG electrodes. • Disable "Enable Pacer Detection" to reduce the effect of artifact.	• Check for contamination on snaps. Ensure springs are intact. • Check for intermittent ECG patient cable or connector wiring. • Replace ECG input connector. • Replace ECG connector to the system board cable. • Replace system board.
False "Pacer Pulses Seen"	The patient does not have an internal pacemaker, but pacer pulses are displayed. • Disable "Enable Pacer Detection" to reduce high frequency artifact.	
Wandering baseline.	See "Displayed HR not accurate." above.	Same as above example.
Electronic interference.	Check for possible excessive radio frequency interference. Move patient cables away from other electrical equipment.	• Turn off sources of excessive RFI. • Move E Series unit away from RFI source.

ZOLL E Series Error Messages

The following is a list of ZOLL E Series error messages that may appear on your display. The “User Advisory” column informs you about an action in progress or provides feedback on a user correctable situation that typically does not require further technical support. The “Technical Action” column describes what you as a technician can do to correct the situation. Note that these messages will sometimes overlap part of the waveform display.

First, attempt to clear the message by turning the Selector Switch to OFF for ten seconds, then back to the desired operating mode. If the fault persists, call ZOLL Technical Service.

Error Message	Explanation	User Advisory	Technical Action
200J MAX BIPHASIC	User attempted to set defibrillation energy >200J on Biphasic Unit. No higher energy is available.	✓	
ANALYSIS HALTED	• ECG analysis halted due to user interaction such as: • Lead/size change • Analyze button was pressed again • Impedance fault • Charging error detected in auto defib mode	✓	
AUDIO FAULT 136	Audio DSP hardware error.		Replace audio board. Replace system board.Turn unit off and back on again.
AUDIO NOT RECORDING	Audio is not recording.		Install PCMCIA card. Replace system board.
AUDIO QUEUE FULL	Indicates that the audio output queue is full. Additional voice prompts can't be queued at this time.		None.
BATT HIGH CURRENT	Battery is charged and battery current is >.1 A or: Battery is not charged and battery current is > 1.6 A.		Unplug from A/C. Remove the battery for 20 seconds. Reconnect all above. If the problem persists, replace battery and or charger.
BATT HIGH VOLTAGE	Battery voltage > 15.5 v.		Replace battery and or charger
BATT LOW CURRENT	Battery is not charged and battery current is <.35 A.		Replace battery and or charger.
BATT LOW VOLTAGE	Battery voltage < 9.5 v.		Replace battery and or charger.
BATT OVERCHARGE	Charger on for > 4 hours.		Replace battery and or charger.

Error Message	Explanation	User Advisory	Technical Action
CABLE FAULT	(Auto defib mode only.) Incorrect A/D reading for paddle ID (similar to PADDLE FAULT).	✓	Replace paddle set, universal cable and/or system board.
CARD FULL	Memory Card Full.	✓	
CHECK CO_2 SENSOR	$EtCO_2$ Sensor is unplugged or defective.	✓	Check that sensor cable is plugged in and seated properly. Check that sensor is not exposed to excessive heat. If problem persists, replace the sensor.
CHECK CO_2 ADAPTER	Airway adapter is removed, occluded or adapter zeroing needs to be performed or was performed incorrectly.	✓	Replace/Clean airway adapter. Zeroing performed automatically.
CHECK PADS	Message displayed in conjunction with either POOR PAD CONTACT or DEFIB PAD SHORT.	✓	Ensure pads are coupled to patient. Check / replace pads and universal cable. Replace system board.
CHECK PATIENT	Background ECG analysis detects shockable rhythm.	✓	
CHECK PULSE	Alternate message for NO SHOCK ADVISED message.Message also shown after delivering third shock when auto analyze 3 times option is enabled.	✓	
CHECK RECORDER	Produced when paper tray is empty, paper jams or recorder door is opened.	✓	Replace paper sensor board, system interconnect board, and/or system board.
CHECK SPO_2 SENSOR	Reposition SpO_2 sensor on patient.		
CLOCK FAULT 11	Real time clock oscillator failure.		Replace system board.
CLOCK FAULT 12	Real time clock back-up power supply failure. Found oscillator stopped at power-up, but oscillator now running when the system is running. (Oscillator only runs when main power is applied).		Replace system board.
CLOCK FAULT 13	One of the set time units (seconds, minutes, year, etc.) is out of range.		Replace system board.

Error Message	Explanation	User Advisory	Technical Action
CONFIRM MANUAL MODE	Displayed when manual mode is entered. Alerts user to confirm that manual mode is desired.	✓	
DEFIB DISABLED	User prompt issued simultaneously with other faults if defib is disabled.		Possible configuration problem. Replace high voltage module. Call ZOLL Technical Support.
DEFIB FAULT 71	More than 50 internal dumps occurred in less than 20 minutes.		Turn the unit to OFF and back on. If fault persists, replace high voltage module.
DEFIB FAULT 72	Charging inhibited, voltage out of range.		Turn the unit to OFF and back on. If fault persists, replace high voltage module.
DEFIB FAULT 76	Capacitor voltage too high for selected energy.		Replace high voltage module or capacitor.
DEFIB FAULT 77	Capacitor voltage > than absolute rated max.		Replace high voltage module or capacitor.
DEFIB FAULT 78	Unable to charge defib cap.		Replace high voltage module or capacitor.
DEFIB FAULT 79	Defibrillator charging too slowly.		Replace high voltage module or capacitor.
DEFIB FAULT 80	4 defibrillator faults detected within 20 second period.		Replace high voltage module or capacitor.
DEFIB FAULT 81	Discharge switch in undefined state.		Replace high voltage module or capacitor.
DEFIB FAULT 84	“Upper” discharge transistor shorted (measured via applicable A/D channel).		Replace high voltage module.
DEFIB FAULT 85	“Lower” discharge transistor shorted (measured via applicable A/D channel).		Replace high voltage module.
DEFIB FAULT 86	One discharge switch closed during power up test.		Replace paddles, control board or system board.
DEFIB FAULT 87	Both discharge switches closed during power up test.		Replace paddles, control board or system board.
DEFIB FAULT 94	Processor fault causing safety monitor port to be non-functional.		Replace system board, high voltage module or capacitor.
DEFIB FAULT 95	Safe or shutdown line is not functional.		Replace high voltage module.
DEFIB FAULT 108	VMON voltage is less than the target energy during charging.		Replace high voltage module or capacitor.

Error Message	Explanation	User Advisory	Technical Action
DEFIB FAULT 109	Defib capacitor voltage is greater than selected energy when defibrillator is charging or ready.		Replace high voltage module or capacitor.
DEFIB FAULT 111	Defib capacitor voltage has exceeded the absolute maximum acceptable voltage.		Replace high voltage module, capacitor, and or system board.
DEFIB FAULT 195	Current higher than expected was detected during the Biphasic bridge test or immediately following a discharge.		Ensure pads/paddles are used properly. Attempt to clear the message by turning the Selector switch to off then back to the desired operating modes. Replace bridge or high voltage module.
DEFIB FAULT 196	Biphasic module not operating properly while charging.		Charge again. Attempt to clear the message by turning the Selector switch to OFF, then back to the desired operating mode. Replace bridge or high voltage module.
DEFIB NOT CHARGED	Discharge button is pressed but the unit is not charged.	✓	
DEFIB PAD SHORT	Measured impedance between high voltage leads of MFC.	✓	Ensure pads are coupled to patient. Check / replace pads or universal cable. Replace system board.
DISABLE SYNC	Sync mode active when analyze pressed in defib.	✓	
DISCHARGE FAULT	Defib capacitor voltage is not decreasing.		Replace high voltage module, capacitor, and/or system board.
ECG FAULT 4	Communication fault between ECG processor and main processor.		Turn off unit and then turn on to reset. If fault persists, replace system board.
ECG FAULT 5	ECU RAM test failure, or ROM checksum test failure.		Turn off unit and then turn on to reset. If fault persists, replace system board.

Error Message	Explanation	User Advisory	Technical Action
ECG LEAD OFF	One or more ECG leads are not properly connected when leads are selected as input.	✓	Check cable and patient connection. Change electrodes. Prepare patient's skin.
ECG TOO LARGE	ECG signal too large for accurate shockable rhythm analysis.	✓	Reduce ECG size.
ECG V LEAD OFF	V LEAD cable is not properly attached.	✓	Attach V LEAD cable.
ECG V1 LEAD OFF	Chest lead V1 is not properly attached to patient.	✓	Reattach V lead. Check cable.
ECG V2 LEAD OFF	Chest lead V2 is not properly attached to patient.	✓	Reattach V lead. Check cable.
ECG V3 LEAD OFF	Chest lead V3 is not properly attached to patient.	✓	Reattach V lead. Check cable.
ECG V4 LEAD OFF	Chest lead V4 is not properly attached to patient.	✓	Reattach V lead. Check cable.
ECG V5 LEAD OFF	Chest lead V5 is not properly attached to patient.	✓	Reattach V lead. Check cable.
ECG V6 LEAD OFF	Chest lead V6 is not properly attached to patient.	✓	Reattach V lead. Check cable.
ENTER ACCESS CODE	Manual mode access code needed.	✓	Enter access code to enter manual mode with AED.
ERASING REPORT	Summary report being erased.	✓	
FAX BUSY	FAX line at receiving FAX is busy.	✓	
FAX DIALING	Preparation for sending fax.	✓	
FAX DONE	Transmission complete.	✓	
FAX PREPARING	Preparing fax for transmission.	✓	
FAX SENDING	Transmitting fax.	✓	

Error Message	Explanation	User Advisory	Technical Action
INSERT CARD Check memory card	No card installed in unit during manual or semi-automated modes.	✓	
LOW BATTERY	Low battery.	✓	Replace battery or plug into AC power. Replace charger.
NO QRS DETECT	Unit is in sync mode and heart rate is < 20 BPM or QRS amplitude is too low for proper synchronization.	✓	Increase ECG size and/or change lead.
NO SHOCK ADV	No shock advised. Advisory message when analysis finds non-shockable rhythm.	✓	
NOISY ECG	Number of noisy analysis intervals exceeds threshold.	✓	Stop all patient movement. Check connections. Press Analyze button again.
OPEN AIR DISCHARGE	Cap voltage too high after discharge attempt, e.g., full energy discharge did not occur.		Replace paddles, and, or high voltage module and system board.
PACER DISABLED	User prompt issued simultaneously with other pace faults if pacing is disabled.		Replace high voltage module or system board.
PACER FAULT 115	Flyback pulse width control circuit is not under proper control of the processor and gate array.		Replace high voltage module, capacitor, or system board.
PACER FAULT 116	Failure to detect XPACE_ON.		Replace high voltage module, capacitor, and/or system board.
PACER FAULT 117	Pace relay is stuck closed.		Replace high voltage module, capacitor, and/or system board.
PACER FAULT 121	During pace, the pace pulse width <30ms or >50ms.		Replace high voltage module, or system board.
PACER FAULT 122	Pace current is more than 15mA above and below selected value.		Replace high voltage module, or system board.
PACER FAULT 123	Measured pace rate is too fast compared to selected rate.		Replace high voltage module or system board.
PACER FAULT 126	Issued in conjunction with message 122. Pace current is more than 15mA and below selected value.		Replace high voltage module.

Error Message	Explanation	User Advisory	Technical Action
PADDLE FAULT	Cannot detect type of accessory attached to the universal cable.		Replace paddles, internal paddles, system board, high voltage module and/or universal cable.
PERFORM CPR	Advisory message in AED auto defib mode.	✓	
POOR LEAD CONTACT	One or more ECG leads are poorly connected or not connected to patient. (User configurable.)	✓	Check electrode attachment to patient, cable connector to electrode, cable to unit connector. Broken unit.
POOR PAD CONTACT	Electrode impedance exceeds threshold.	✓	Ensure pads are coupled to patient. Check / replace pads or universal cable. Check impedance circuit calibration. Replace system board.
PRESS ANALYZE	Alternate message for check patient prompt.	✓	
PRESS CHARGE	Advisory message in conjunction with shock advised.	✓	
PRESS SHOCK	Prompt issued in AED auto defib mode when defib is charged (ready).	✓	
RECORDER FAULT 142	Strip chart system error.		Check paper tray and paper path. Replace the print head, system interconnect board and or the system board.
RECORDER FAULT 143	Strip chart failed power-up echo test. Communications error.		Check paper tray and paper path. Replace the system interconnect board and/or the system board. Turn unit off and back on again.
RECORDER FAULT 147	Strip chart printhead over temperature.		Check paper tray and paper path. Replace the print head, system interconnect board and/or the system board.
RELEASE BUTTONS	Simultaneous external paddle button presses detected before unit reached full defib charge (ready state).	✓	Release buttons.
RELEASE SHOCK	Discharge switch(es) closed when pressing charge button. Discharge button pressed before defib reached ready state.	✓	Release shock button. Check paddles. Replace controls board.

Error Message	Explanation	User Advisory	Technical Action
REPLACE BATTERY	Battery voltage is less than absolute minimum. Shutdown imminent.	✓	Replace with charged battery.
REPLACE CARD	Write errors during manual or semi-automated modes.	✓	May have configuration card installed or write protection on.
REPORT FULL	Summary report memory full.	✓	Erase summary report.
REPORT HALTED	Summary report stops printing unexpectedly.		Turn unit off and then back on again. Print Summary again. If fault persists, replace system board.
SELECT 30J FOR TEST	Attempt to run a self test at an energy other than 30J.	✓	
SELECT DEFIB MODE	Analyze button pressed in pace or monitor mode.	✓	
SELECT LEADS	12 Lead monitor determined the user selected MFE.		
SELECT LIMB LEADS	Paddles or augmented ECG leads selected when continuous analysis active or started.	✓	Select limb leads I, II, III or MFE
SELECT PADS	Lead I, II, or III selected when analyze pressed.	✓	
SET CLOCK	Real time clock failure: invalid date or time.		Set date and time and/or replace system board.
SET PACE mA	Multiple copy errors are the product of intended software or memory errors. If error reoccurs other than on entering pace the first time or after more than 10 minutes in other mode, the unit could be broken.	✓	Set pace current. If broken, replace system board.
SET PACE RATE	Multiple copy errors are the product of intended software or memory errors. Multiple copies of pace rate don't match. If error persists, unit could be broken	✓	Set pace rate. If broken, replace system board.
SHOCK ADVISED	Advisory message when analysis finds a shockable rhythm.	✓	
SpO_2 AMBIENT LIGHT	Ambient light is too bright.		Shield sensor from ambient light. Replace $Sp0_2$ sensor. Replace $Sp0_2$ module

Error Message	Explanation	User Advisory	Technical Action
SpO_2 COMM ERR	No transmissions from SpO_2unit received. Communication error or no communication from $Sp0_2$ module.		Replace $Sp0_2$ module and/or system board.
SpO_2 PULSE SEARCH	Pulse search in progress.	✓	
STAND CLEAR	(Auto defib mode only.) Single analysis mode just turned on and defib idle. Patient rhythm is being analyzed.	✓	
SYSTEM FAULT 1	No Watchdog.		Turn off unit and then turn on to reset. If fault persists, replace system board.
SYSTEM FAULT 6	No communications received from ECU for 4 seconds.		Turn off unit and then turn on to reset. If fault persists, replace system board.
SYSTEM FAULT 7	The A/D converter is not performing conversions in a timely manner.		Replace system board.
SYSTEM FAULT 36	PS_MON is out of range. Pace/defib is disabled as long as condition exits.		Replace system board.
SYSTEM FAULT 37	Disable pace/defib and MFE monitoring.		Replace system board.
SYSTEM FAULT 38	Failure to shutdown after “shutdown order” is written to the RTC.		Replace system board.
TEST FAILED	MCU performed ipeak test (defib peak current) and unit failed during 30J self test.	✓	Replace universal cable, paddles or high voltage module, capacitor, or system board.
TEST OK	MCU performed ipeak test (defib peak current) and unit passed 30J self test.	✓	
USE PADDLE DISCHG	Front Panel discharge button is pressed when either external paddles or internal spoons with discharge buttons are connected.	✓	
USE PADS	(AUTO DEFIB MODE ONLY.) Attempt to defib with paddles in auto defib (AED) mode. Defib only allowed using PADS in AED modes.	✓	
USE PADS TO PACE	External paddles detected in pace mode.	✓	

Error Message	Explanation	User Advisory	Technical Action
USER SETUP REQ	Both copies of stored cal/config data are bad or have never been programmed.	✓	Perform configuration setup.
VF ALARMS OFF	VF alarms disabled in pace mode or when paddles are selected as leads.	✓	
VX LEADS OFF	V lead not properly attached to patient. “X” denotes lead number.	✓	Reattach V lead.
ZERO CO_2 ADAPTER	New $EtCO_2$ airway adapter needs to be zero calibrated.	✓	Zero $EtCO_2$ adapter.

Chapter 3
Replacement Parts

This section contains a listing of the replacement parts available for the ZOLL E Series devices.

Replacement parts may be ordered through an authorized ZOLL distributor or directly from ZOLL Medical Corporation. The prices for parts are available from ZOLL Medical Corporation's Technical Service Department.

When ordering parts, please provide the following information:

- ZOLL E Series device model and serial number
- Field Replaceable unit part number
- Description of the replacement part
- Description of problem

To order by mail from ZOLL Medical Corporation, address your request to:

ZOLL Medical Corporation

269 Mill Road

Chelmsford, MA. 01824-4105

Attention: Technical Service Department

1-978-421-9655; 1-800-348-9011; Fax: 1-978-421-0010

Note: ZOLL reserves the right to substitute different parts to reflect modifications and improvements in ZOLL E Series circuitry and design.

Replacement Parts

Description	Part Number
12-Lead Connector	1001-0232
Cable, AC Receptacle to AC Charger	9500-0739
Cable, Access Detect to ECG Out 7 POS	9500-0726
Cable, Battery Interconnect to AC Charger	9500-0717
Cable, Battery Interconnect to HV Module	9500-0718
Cable, Battery Interconnect to HV Module Defib	9500-0720
Cable, Battery Interconnect to HV Module Pace	9500-0719
Cable, Battery Interconnect to System Interconnect	9500-0721
Cable, Control to Display	9500-0712
Cable, Control to System I/O	9500-0713
Cable, Control to System Video	9500-0313
Cable, ECG Input	9500-0727
Cable, Flex, System to Isolated PS 20 POS	9500-0728
Cable, Ground Wire Assembly	9500-0302
Cable, Isolated Power Supply to ETCO2 20 POS	9500-0731
Cable, MFC Signal to HV Module	9500-0734
Cable, MS-11 PCB to SPO2 Connector	9500-0732
Cable, MS-11 to Isolated Power Supply	9500-0730
Cable, Paddle Harness	9500-0737
Cable, Ribbon Chart Card to Interconnect	9500-0736
Cable, Sensor to Printer Interconnect	9500-0729
Cable, Speaker	9500-0735

Description	Part Number
Cable, SPO2 Module Assembly	1005-0160
Cable, System Interconnect to Communications Carrier	9500-0724
Cable, System Interconnect to NIBP	9500-0723
Cable, System Interconnect to PCMCIA	9500-0710
Cable, System Interconnect to Printer Interconnect	9500-0725
Cable, System to Battery Interconnect 51 POS	9500-0716
Cable, System to Biphasic DAC 20 POS	9500-0733
Cable, System to System Interconnect 51 POS	9500-0715
Cable, System to System Interconnect USB Interface	9500-0722
Connector Panel	9310-0905
Connector Panel Assembly No Options	1005-0013-01
Connector Panel Assembly with SPO2/ETCO2	1005-0013-02
Connector Panel Assembly with SPO2/ETCO2/NIBP	1005-0013-03
Data Entry Membrane Switch	9170-0500
Display Assembly, Color LCD	1005-0009
ECG Connector Assembly	9301-0318
Handle, EMS	9310-0915
HV Capacitor	9126-0006
Knob, Main	9310-0521
Knob, Pacer	9310-0520
Left Rail	9310-0908
Lower Housing, EMS	9310-0900-90
NIBP Fitting	9330-0517

Description	Part Number
Output ESD PCB Assembly	9301-0354
Paper Tray Out Sensor	9301-0385-01
PCMCIA Connector Assembly	3001-0300
Printer Frame	9310-0918
Printer Interconnect	9301-0387-01
Printer Leafspring	9320-0300
Printhead	0350-0350
Printhead Brush	9340-0102
Recorder Motor Assembly	3000-0100
Recorder Roller	9330-0300
Right Rail	9310-0907
Speaker Assembly	1005-0002
Upper Housing	9310-0902-90

Field Replacement Parts

Description	Part Number
AC Charger PCB	9301-0388-01
AED Control Board with Pace	9301-0384-03
AED Control Board without Pace	9301-0384-04
Battery Interconnect	9301-0389-01
Bi-phasic Bridge	9301-0370-02
Bluetooth Module	3001-0104
Communications PCB with GPS	9301-0390-01
Communications PCB with GPS And Bluetooth	9301-0390-02
Control Board with Audio, with Pace	9301-0384-07
Control Board with Audio, without Pace	9301-0384-08
Control Board with Pace	9301-0384-01
Control Board without Pace	9301-0384-02
HV Module Assembly	1001-0278-02
Isolated Power Supply	9301-0383-01
Masimo SPO2 MS-11 PCB	3005-0001
NIBP Suntech Advantage 2 Assembly (Neonatal)	1001-0450
Printer Assembly	1005-0001
System Interconnect	9301-0381-01
System PCB	9301-0380-01

Chapter 4
Functional Description

This chapter provides functional descriptions of the components contained in the ZOLL E Series and the E Series options. Refer to the interconnect diagram that delineates the different components of the defibrillator.

This chapter includes:

- Main System Board
  - Main System Board Functions
  - Power Supply
  - User Interface
  - Audio I/O Module
  - ECG Front End
  - Multifunction (MFE) Paddles
  - Main CPU and EPU
- High Voltage Modules
  - Defibrillator Charging and Discharging
  - High Voltage Capacitor Module
  - Pacer and Defibrillator Control Signals
  - Internal Discharge Resistor Module
- AC/DC Charger
  - AC/DC Charger Module
- System Interconnect Board
  - Stripchart Recorder

  - PCMCIA Slots
  - Front Panel and Display
- E Series Options
  - 12 Lead Monitoring
  - Pulse Oximetry ($SpO_{2)}$
  - End Tidal Carbon Dioxide ($EtCO_{2)}$
  - Noninvasive Blood Pressure

Main System Board

The E Series electrical circuitry consists of several functional modules. Each module is physically located on one or more of the printed wiring board assemblies (PWBA). In some cases, a functional module is distributed across several assemblies within the unit. The main components of the E Series include:

- Display
- Main System Board
- High Voltage Module
- AC/DC Charger
- Battery Interconnect Module
- System Interconnect Module
- High Voltage Capacitor

Some units are equipped with E Series options. These options include:

- 12 Lead ECG
- Pulse Oximetry (SpO_2)
- End Tidal Carbon Dioxide ($EtCO_2$)
- Noninvasive Blood Pressure

Refer to the E Series Interconnect diagram to identify unit components described in this manual.

Module	Location
Main Central Processing Unit (CPU) and ECU	Main System PWBA
Pacer/Defib Charging and High Voltage Control (Defib/Pace)	High Voltage Module Biphasic Bridge Module
Internal Discharge Resistor	HV Module
AC or DC Power Supply/Battery Charger	AC Charger PWBA DC Charger PWBA Main System PWBA
ECG Front End Signal Acquisition	Main System PWBA
Battery Pack or Smart Battery	Battery Interconnect PWBA
User Interface and Controls	Controls PWBA
PCMCIA Interface	System Interconnect, Main System
Stripchart Recorder	System Interconnect, Main System
Audio I/O (optional)	Main System PWBA Audio Display PWBA Controls PWBA
SpO_2 (optional)	Pulse Oximetry PWBA Isolated Power Supply PWBA
$EtCO_2$ (optional)	Isolated Power Supply PWBA
12 Lead (optional)	Main System PWBA
NIBP (optional)	NIBP PWBA

Main System Board Functions

The Main System Board contains the major computing and control elements for the E Series unit. The printed wiring board assembly (PWBA) receives signals from the front panel control switches, ECG input connectors and functional modules, such as the AC/DC charger, pacer/defibrillator modules, stripchart recorder and PCMCIA card interfaces, and if applicable, the SpO_2, $EtCO_2$ and NIBP modules. The Main System Board monitors and processes these input signals to produce other signals that: 1) control the operation of other modules within the system; 2) drive the unit's front panel display and audio outputs and; 3) store data for retrieval via Summary Reports, PCMCIA cards and/ or a modem.

The electronic circuitry and software contained on the main system board performs the following major E Series functions:

1. Main CPU and memory.
2. ECG signal acquisition and processing for ECG leads including,
   - A/D conversion.
   - ECG signal filtering.
   - QRS detection.
   - Implanted pacemaker detection.
   - Heart Rate counting.
   - Shockable ECG rhythm analysis.
3. Data communications with and control over the SpO_2, $EtCO_2$ and NIBP modules.
4. Control over and safety monitoring of pacer and defibrillator functions performed by the High Voltage module and Biphasic Bridge module.
5. Physiological alarm processing.
6. Control switch monitoring for the front panel, accessory connection monitoring and control over the system response to switch activation or accessory connection to the E Series.
7. Format and updating of the front panel display.
8. Primary power supplies for the unit.
9. Audio output generation and control (e.g., alarms, voice prompts, warning tones).
10. Audio signal processing, data compression and storage of voice recording data.
11. Real time clock and other time keeping functions.
12. Summary Report, 12 Lead ECG Reports data storage.
13. Monitoring of battery status and control over Battery Charging functions performed by the AC or DC Charger PWBA.
14. Data transmission to and control over the System Interconnect PCB functions, including the stripchart recorder and the PCMCIA slot functions.

Power Supply

The power supply converts DC power from a removable battery or the AC/DC Battery Charger module to voltages required by the E Series hardware.

The power supply circuit converts the raw battery or the Charger PWBA output voltages of +8.5 VDC to +16 VDC into the voltages shown in the table below, including load and line regulation.

VOLTAGE	DESCRIPTION	VOLTAGE VDC (Nominal)	COMMENTS
FUSE_PWR	Fused Input Power from Battery/Charger	12	
SW_PWR	Switched Input Power after Power Switch	12	
3VDD	+ 3.3 VDC Power for Digital circuits	3.3	Switching @ 300 kHz
5VDD	+ 5.0 VDC Power for Digital circuits	5.0	Switching @ 300 kHz
-5VSS	- 5.0 VDC Power for Analog circuits	-5.0	Linear
12VEE	+ 12.0 VDC Power for Analog circuits	12.0	Linear
15VDD	+ 15.0 VDC Power for VPP and 12VEE	15.0	Switching @ 300 kHz
LCD_BS	LCD BIAS Power for LCD display	- 18	Switching @ 100 kHz
3_3REF	+ 3.3 VDC Reference	3.3	Linear

ECG Front End

The ECG front end provides an electrically isolated serial interface between the main system board functions and patient interface ECG connectors. It performs the following:

- Analog ECG amplification and signal conditioning.
- Pacemaker pulse detection.
- ECG signals acquisition and analog to digital conversion.
- ECG 3/5/12-lead detection.
- ECG leads off detection.
- Front-end defibrillator protection.
- Isolated power conditioning.
- Patient impedance measurement via MFE or paddles.

Multifunction Electrode (MFE)/PADS (System Board and High Voltage Module)

Selected for optimal performance for the application, a dedicated ECG amplifier with a limited bandwidth processes the signal. It is then chopper modulated and coupled to the system side via an isolation transformer. On the system side, the signal is synchronously demodulated, converted by a 10 bit A/D at 250 samples per second and digitally processed by the main control unit of the system board.

To measure thoracic impedance, a high frequency (HF) measuring current passes through the patient's chest and measures the resulting voltage across the electrodes. After amplification, the impedance signal is synchronously demodulated. It is then converted to a stream of pulses with frequency proportional to the measured impedance.

CPU and EPU

The Main System Board contains two microprocessors. A Motorola HC-11 single chip microprocessor is used to acquire, convert and process ECG signals, (ECU). A Hitachi SH-3 RISC microprocessor acts as the system's main CPU. The SH-3 CPU has an integrated on-chip multiplier, a cache memory, a memory management unit as well as data protection and virtual memory functions. It also has a timer, a real time clock, an interrupt controller, a serial communication interface (SCI), and other peripheral functions necessary for the system operation. The memory circuitry includes Flash ROM, internal flash non-volatile memory and DRAM.

The EPU acquires ECG data and runs the A/D convertor that sends data in the form of a serial stream to the CPU.

High Voltage Module

The High Voltage (HV) module includes the high voltage circuitry required for pacing and defibrillation, including the defib charge circuitry, patient relay, safety relay, defib capacitor, defib choke and front end protection circuitry for the MFC ECG.

The following table describes the high voltage board components:

Component	Function
Solid State Patient Relay	Controls the delivery of therapeutic energy to patient.
Safety Relay	Discharges Defib capacitor into the internal discharge resistor when defibrillator is not in use.
Defibrillator Capacitor	Stores energy for therapy.
Defibrillator Choke	Conditions waveform delivered to the patient.(DSW)
Front End Protection Circuitry for the MFC ECG	Protects ECG front end against defibrillator pulses.

Defibrillator Charging and Discharging

The defibrillator charges and discharges high voltage capacitor energy. A user can initiate a charge in three ways by 1) pressing the charge button on the front panel; or (2) pressing the charge button on the paddles; or (3) configuring unit to charge automatically when it detects a shockable rhythm following an ECG analysis. To initiate a discharge, a user depresses both shock buttons on the paddles or depresses a single shock button on the front panel.

The defibrillator circuit charges the high voltage capacitor to the energy level the user specifies.This circuit also provides feedback to the main system board on the high voltage capacitor's voltage level and discharges the high voltage capacitor energy through paddles or the universal cable. The defibrillator portion of the high voltage circuitry is active only when the front panel selector switch is set to DEFIB (or set to ON for AED units).

Charging

The charging process starts when the Main System Board detects a charge request. The defibrillator circuits begin charging the high voltage capacitor to the target voltage or energy that the user selects on the front panel display. The Main System Board continuously monitors the capacitor voltage signal to ensure that the high voltage capacitor charges at the proper rate. When the target voltage is reached, the Main System Board initiates a continuous beeper tone to indicate that defibrillator is ready to discharge. The target energy level displays on the display screen.

The defibrillator holds the energy for 60 seconds for manual units and 15 seconds for AED units, refreshing the energy level as necessary. An intermittent beep tone sounds during the last ten seconds (five seconds for AED unit) of the hold period. After the 60 second period, if the defibrillator has not been

discharged, the energy is dissipated into the internal discharge resistor by closing the safety relay (XSAFREL). The unit discharges internally and displays a warning message if it is not functioning properly.

Unlike previous ZOLL designs that isolated the patient from defib circuitry via an electromechanical patient relay, the E Series utilizes a bank of silicon-controlled rectifiers (SCRs). As the defibrillator capacitor is charged, the voltage is monitored via R1 - R4, which drive differential amplifiers referred to the system ground. These resistor dividers split the capacitor voltage more or less equally above and below ground in order that the positive capacitor terminal is approximately 1100 volts above ground, and the negative capacitor terminal is approximately 1100 volts below ground (at 200J setting). The voltage at the patient electrodes is set by the divider RN1 and RN2. These networks are each 5X 25 M (125 M total) whose total resistance is specified to be 125 M +\- 1%. As a result, the patient is nominally at ground and the hot switch bank is split into a ‘positive’ side and a ‘negative’ side.

Discharging

Initiating a discharge provides voltage to the patient relay and notification to the Main System Board through the PADMON signal. The Main System Board then controls activation of the patient relay. Energy delivered to the patient goes through the biphasic bridge/DAC assembly to create a defibrillation waveform. When the patient discharge SCRs are deactivated, the safety relay closes to internally dissipate any remaining energy.

If the E Series is in the self test mode, the energy is delivered internally. The microprocessor calculates the actual delivered energy from the current waveform and displays a TEST OK message on the display, if the self test meets the appropriate criteria. If the criteria are not met, a TEST FAILED message displays.

High Voltage Capacitor Monitor

Before charging the defibrillator, the High Voltage Capacitor monitor runs a self test to check the pace relay. The pace relay controls the high voltage circuitry configuration either for generating pace pulses or for charging the high voltage defibrillation capacitor.

The defibrillator capacitor is shunted for safety reasons with a resistor and relay to internally dissipate any energy remaining. When the Main System Board initiates a charge, this relay opens by providing a low level on signal XSAFREL. The safety relay is a biased reed switch. The relay is driven by Q318.

The pace relay driver is a grounded source switch Q308 that is biased on by R593. It is held off by Q330 when XPACEREL is '1' false. When XPACEREL comes true, Q330 is turned off, and Q308 is no longer clamped off.

The high voltage capacitor is charged by converting the system battery voltage to a pulsed high voltage by way of transformer T1. The basic operating frequency signal that is used to switch transistor Q1 providing current in the primary windings of the transformer T1 originates in the system board’s gate array.

When the high voltage capacitor is charging, the Main System Board independently monitors the capacitor voltage through signal VMON. If the Main System Board detects an improper level, it halts operation by setting SAFE high. This disables the SCR discharge circuitry and flyback transformer drive.

The patient relay discharges via the signal PATREL_DRV generated by XPATREL and Q304, Q323, and Q322. PATREL_DRV is disabled when XPACE_SEL is at a logic low.

When the patient relay activation completes, the Main System Board releases the XPATREL signal. Several hundred milliseconds later, the safety relay closes to ensure the high voltage capacitor energy is completely dissipated.

The Pacer circuit produces and delivers user-controllable pace pulses to the pacing electrodes. To initiate pacing, the front panel switch is turned to PACER and the OUTPUT and RATE controls are set. Pacing current amplitude is constant during the pulse and is determined by the position of the front panel PACER OUTPUT dial. Pacing pulse rate is determined by the position of the front panel PACER RATE dial. The pacing pulse duration is fixed at 40 milliseconds.

Pacer/Defibrillator Control Signals

The Pacer/Defibrillator Control charges the high voltage capacitor to a voltage requested by the main system board in response to user energy selections. It delivers defibrillator energy to the patient through the patient connector to the paddles and pacer electrodes or multi-function electrodes (PADS). This control also generates pacing pulses at rates and amplitudes requested by the main system board in response to user selections, controls biphasic waveform defibrillation, and measures pace current and high voltage capacitor voltage by two independent channels.

The following signals control the operation of the Pacer/Defibrillator subsystem:

Analog Voltage	Operation	Comment
VCAP	Analog voltage spanning 0 - 2.5 V for 0 - 5000V capacitor voltage.	Used by the defib charging controller.
VMON	Analog voltage spanning 0 - 2.5 V for 0 - 5000V capacitor voltage.	Used by the defib monitor.
VSNS	Pace duty cycle voltage, scaled as 0 - 2.5 V for 0 - 100% duty cycle.	When multiplied by the pulse width (as read from PW_READ) battery voltage is proportional to the actual pace current.
VCTL	Analog control voltage scaled 0 - 2.5 V for pace current of 0 - 140 ma.	Only active in pace mode.
FET_MON	Analog voltage monitors the condition of the discharge transistors.	Provides a signature voltage in case of a fault.
PAT_CUR	Bound on the range of 0 - 2.5 V and accommodates defib currents of -50 to +100 A	Analog signal representing the patient current during a defib discharge.

Logic Control Signal	Operation
XPWR_ENABLE	This logic signal from the gate array enables the charging circuit when true, and inhibits the charging circuit when false.
SAFE	This logic control signal is generated by the Main System Board to halt the pace/defib function in the event of a detected fault.
SHUTDOWN	This logic signal is true during reset and fault conditions. (VCC error, watchdog error, etc.) and halts operation of the PD generator.
XPACE_ON	This logic signal is generated by an optocoupler, and indicates that the pace output circuit is active. It is '0' true when pace current is flowing.
XSAFREL	Logic signal from the GA that operates the safety relay when '0' true.
XPACEREL	Logic signal from the GA that operates the pace relay when '0' true. XPATREL: Logic signal from the GA that operates the solid state patient relay when '0' true.
XPAT_ENABLE	Logic signal from the processor controlled by the monitor that grants operation of the solid state patient relay. It is false during pacing.
XPACE_SEL	Hardware only signal from the front panel switch that is at '0' during pace. Used as an additional safety interlock on the solid state patient relay so that operation of the relay during pacing is additionally disabled.

Internal Discharge Resistor Module

The Internal Discharge Resistor Module contains the internal discharge resistor, and a means for dissipating the heat generated by the internal discharge.

AC/DC Charger Module

The AC/DC Power/Battery Charger provides a universal (IEC 320) connection to the AC mains or to a DC source, input line filtering and double-pole fusing (for a mains input), AC-DC and DC-DC conversion and isolation barrier between the E Series and power sources. This module also provides the power necessary to run the E Series in any mode of operation, as well as providing additional charging current to the battery. When the E Series is turned off but connected to an external AC or DC source, the charger module controls battery charging currents and voltages needed to charge the E Series battery. These voltages and currents are controlled in response to the main CPU signals that manage the battery charging process.

System Interconnect Module

The system interconnect PWBA receives signals from the Main System Board and in turn controls operation of the stripchart recorder and PCMCIA functions.

Stripchart Recorder

The Stripchart Recorder module includes a microprocessor, serial interface to the main system board and circuitry which drive the stripchart recorder's motor and printhead in response to the main CPU signals. Based upon signals sent by the main CPU, the recorder's main processor drives the recorder stripchart motor, formats data for printing on the chart and drives the printhead. It also detects when the sensor drawer is not properly fitted into the unit, when the paper supply is out and needs to be refilled and the print head temperature.

PCMCIA Slots

The PCMCIA interface module supports two PCMCIA slots which accept Type I and/or Type II PCMCIA cards. These cards may be read or written to. Data sent by the main CPU is passed to the installed PCMCIA card via the system interconnect PWBA.

Front Panel and Controls PWBA

The User Interface Module provides several functions that enable the user to operate the unit. The user interface has a display monitor and three rotary selector switches. One selector switch is for three modes: pacer, monitor and defibrillation. The two other knobs are for pacer output and pacer rate. The unit interface also has specific buttons for defibrillation, including the ENERGY SELECT button, the CHARGE button, the ANALYZE button and the SHOCK button. The five softkeys underneath the display provide specific operations depending on the unit's configuration. The other push buttons (from left to right) are used for volume control, monitor illumination, summary report, and code markers. The CHARGER ON indicator displays the status of the unit's power supply.

This input module on the front panel and the Main System Board provides a beeper for the AC/DC Power/Battery Charger.

The Controls PWBA is physically located in the front panel assembly. Units that are equipped for voice recording include a microphone and audio signal conditioning circuitry on the Controls PWBA.

Isolated Power Supply Module

The Isolated Power Supply Module provides electrically isolated power to the $EtCO_2$ and SpO_2 modules. It also provides the electrically isolated serial communications and isolated control signals between the $EtCO_2$ and SpO_2 modules and the main system PWBA.

E Series Options

The following sections describe the E Series options.

12 Lead Option

The ZOLL E Series 12 lead option is used to acquire ECG data needed to assist in the diagnosis of myocardial infarction (“heart attack”), often caused by a coronary artery occlusion. The 12 lead ECG can be viewed on the display one lead at a time in monitoring and diagnostic bandwidths and printed in the standard 4x3 format with 12 simultaneously acquired leads.

The 12 lead option provides for the recording, printing and automated analysis of 12 lead ECG using GE Marquette 12SL™ Analysis and supports the transmission of these reports by fax to a remote location, such as a hospital. In the pre-hospital environment, the 12 lead reports can be faxed to a physician as the patient is en route to the Emergency Department. As a result, the physician can initiate hospital accommodations immediately, such as activating the staff of the cardiac catheterization lab, prior to the patient’s arrival and subsequent treatment. Or the patient may be treated in the pre-hospital environment with thrombolytic agents.

The 12 lead cable is required to produce 12 lead reports. E Series unit must have the 12 lead option installed. All limb leads and V-leads must be connected to initiate a 12 lead acquisition. Printed 12 Lead bandwidth is user configurable to be either 0.05-150 Hz (per AAMI EC11) or 0.05-40 Hz. The 0.05-40 Hz bandwidth selection is used to reduce noise artifact in the high end of the diagnostic frequency range. Reports can be printed in a standard 4x3 or Cabrera format. Faxed reports can be configured in a 2x6 format in addition to 4x3 and Cabrera formats.

The GE Marquette 12SL Analysis algorithm provides measurements of the 12 lead waveforms along with interpretive statements. The algorithm is interpretive, not “diagnostic.” (A physician should always confirm interpretive statements. A diagnosis requires a complete clinical assessment including other modalities, such as a physical examination.) 12SL produces global waveform measurements as well as a measurement matrix containing measurements on each lead. Both the interpretive statements and measurement matrix are configurable to be printed or not printed.

The acquired 12 lead with 12SL may be faxed to a remote location using landline or cellular phone technology. Specific PCMCIA fax modems are supported and the modem determines the specific phone compatibility. The E Series supports Group 3 facsimile, Class 1, Class 2 and Class 2.0. 12 lead reports may be re-printed or re-transmitted using the Patient Records capability. Individual patient records may be selected based on patient ID, date, and time.

Pulse Oximetry (SpO_2)

The ZOLL E Series pulse oximetry option enables the user to continuously, noninvasively, and painlessly monitor the percentage of oxygen saturation of arterial hemoglobin at a peripheral measurement site (i.e.foot, toe or finger.)

The oximetry sensor contains two light emitting diodes, or LEDs, that transmit red and infrared light through the body’s extremities. A photodetector receives the transmitted light. Oxygen saturated blood absorbs light differently than unsaturated blood. Thus the amount of red and infrared light absorbed

by the blood flowing through a suitable peripheral area of the body, such as the finger in adults and the foot in neonates, can be used to calculate the ratio of oxygenated hemoglobin to total hemoglobin in the arterial blood. The monitor displays this ratio as percent SpO_2. Normal values typically range from 95% to 100% at sea level.

The E Series uses a Masimo® Pulse Oximetry Circuit Board which features a fundamentally distinct method of acquiring, processing and reporting arterial oxygen saturation and pulse rate. The E Series' SpO_2 module (Masimo® Circuit Board) connects to the Masimo sensors and reports monitoring results (oxygen saturation, pulse rate, pulse waveform, etc.) via a serial digital interface to the E Series system board. The E Series system provides isolated DC power and serial communication to the SpO_2 Board via the Isolated Power Supply board.

End Tidal Carbon Dioxide ($EtCO_2$)

The ZOLL E Series $EtCO_2$ option continually and noninvasively monitors the patient's carbon dioxide in respiratory gases and from these measurements computes End Tidal CO_2 and respiration rate. The unit can display and print a recording of $EtCO_2$ readings, respiration rates, and capnograph waveforms. In addition, the unit can configure an alarm to sound when the unit detects $EtCO_2$ values and respiration rates that are above or below acceptable ranges as set by the user. This option is intended for use in all critical monitoring environments including ventilator support, patient transport, and anesthesia and is intended for monitoring all patient types, including adult, pediatric, and neonatal.

E Series units equipped with software revision 2.00.000 or higher support two End Tidal Carbon Dioxide ($EtCO_2$) monitoring options for the continuous measurement of respiratory carbon dioxide (CO_2) and respiration rate. These options use the same connector on the E Series unit and may be used interchangeably.

The first option uses a unique, mainstream, solid-state, infrared sensor called the CAPNOSTAT® 5 Mainstream CO_2 Sensor. The CAPNOSTAT 5 CO_2 sensor is attached to an airway adapter that connects to an endotracheal (ET) tube or other airway and measures gases flowing through these breathing circuit components. A disposable mouthpiece may be connected to the adapter for monitoring non-intubated patients. A $CAPNO_2$*mask*™ is also available for use with non-intubated patients. This option provides for O_2 delivery while monitoring expired CO_2.

The second option is a sidestream sampling system called the LoFlo™ CO_2 Module. The LoFlo module contains a gas sampling pump, which draws small samples of gas from the patient's airway via a nasal/oral cannula or airway adapter, and passes these gases through a solid state infrared sensor (located away from the patient's airway) that measures CO_2. While the sidestream system is typically used on non-intubated patients, it can also be used for $EtCO_2$ measurement on intubated infant, pediatric and adult patients. The sidestream system should not be used, however, on patients who cannot tolerate the 50ml/min removal of the sample gases from their breathing circuit. The sidestream module uses specially designed cannulas and airway adapters for sampling airway gases and passing them through an integrated sample cell, which connects to the LoFlo module's CO_2 sensor. These cannulas incorporate a filter and sample cell, providing maximum filtration of fluids and contaminants, and protecting the system from aspiration of these fluids.

In both systems, the CO_2 sensor generates infrared light and beams it through the airway adapter or sample cell to a detector on the opposite side. CO_2 from the patient, flowing through the mainstream airway adapter or sample cell, absorbs some of this infrared energy. The E Series unit determines CO_2 concentration in the breathing gases by measuring the amount of light absorbed by gases flowing through the airway or sample cell.

The E Series unit displays EtCO2 (the concentration of carbon dioxide detected at the end of each exhalation) as a numerical value in millimeters of mercury (mmHg), percent (%), or kilopascals (kPa). In addition, the unit can display a capnogram. This capnogram is a valuable clinical tool that can be used to assess patient airway integrity and proper endotracheal (ET) tube placement. The unit calculates respiration rate by measuring the time interval between detected peaks of the CO2 waveform. The technology differentiates between waveforms caused by breathing and those caused by cardiogenic oscillations and artifact.

Noninvasive Blood Pressure

The Non-Invasive Blood Pressure (NIBP) option on the E Series unit allows you to take a single blood pressure measurement, STAT measurements (automatically repeated measurements over a 5 minute period), or automatic measurements at repeating pre-selected intervals.

The ZOLL E Series NIBP option is indicated for the non-invasive measurement of arterial blood pressure for resting patients in critical care and transport. The NIBP option is designed to measure blood pressure for adult and pediatric patients.

The patient blood pressure cuff and hose connect to the E Series unit through the NIBP connector on the rear panel of the unit. The NIBP button on the front panel of the E Series allows you to initiate and terminate blood pressure measurements. You can also initiate and terminate measurements using the softkeys on the NIBP menu.

The NIBP module measures the oscillometric pulses transmitted through the blood pressure cuff and hose, and calculates the blood pressure measurements accordingly. The blood pressure information (including the patient’s systolic, diastolic and mean blood pressure values) is shown on the E Series monitor.

Appendix A
Overview

This appendix includes:

- Interconnect Diagram for the E Series Unit
- ZOLL E Series Maintenance Tests Checklist

  Photocopy the checklists and use the copies to record the results of the maintenance tests performed on the E Series equipment; keep them for your records.

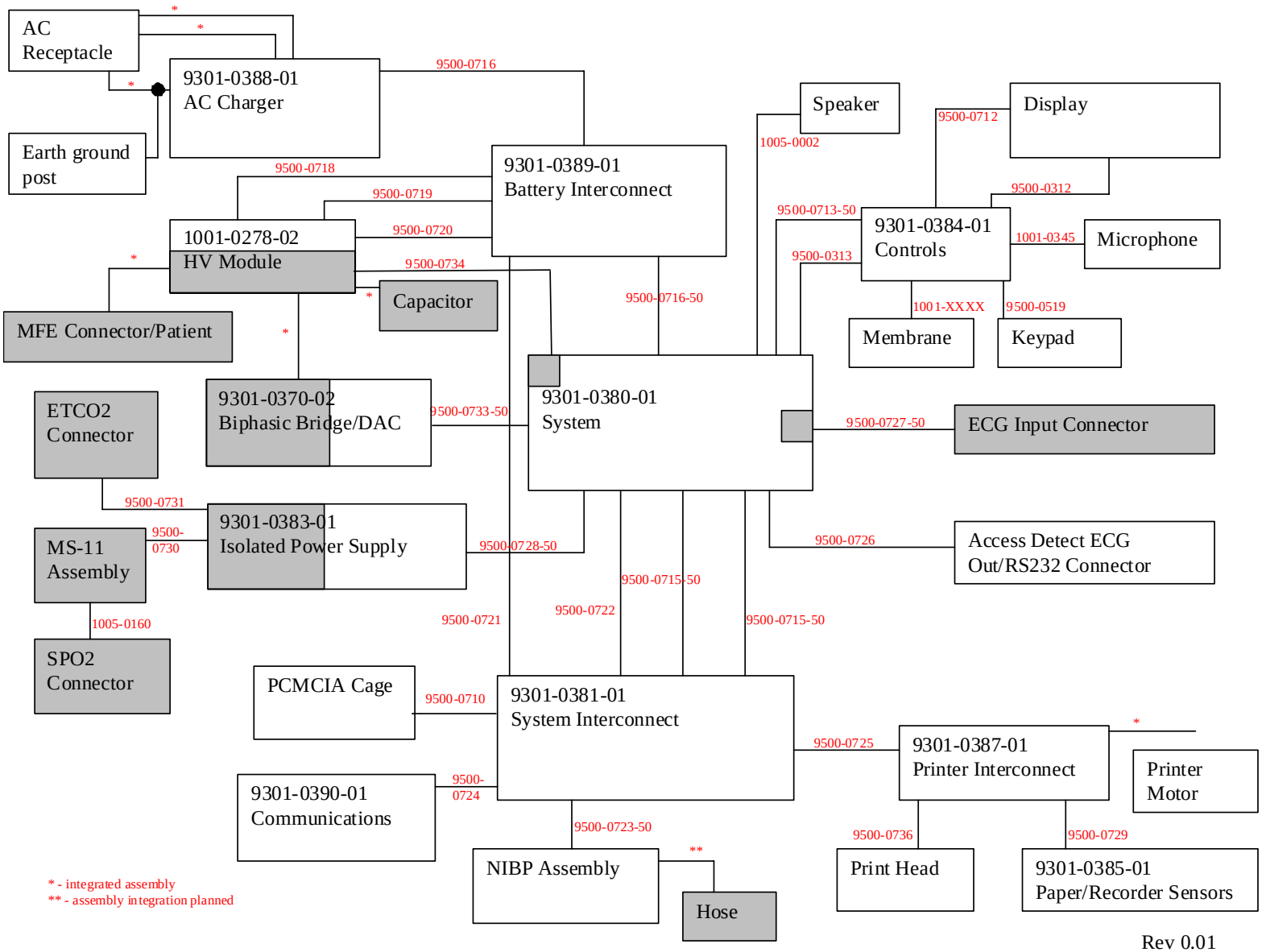


Figure 1: Interconnect Diagram for E Series Unit

ZOLL E Series
Maintenance Test Checklist

Serial No. _____ Location _____

Tester _____ Signature _____ Date _____

Result of Check:

- o No action required
- o Minor problems corrected
- o Disposable supplies replaced
- o Major problems identified (unit out of service)

Additional Remarks

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

1.0 Physical Inspection

	Pass	Fail	N/A
1.1	o	o	o
1.2	o	o	o
1.3	o	o	o
1.4	o	o	o
1.5	o	o	o
1.6	o	o	o
1.7	o	o	o
1.8	o	o	o
1.9	o	o	o
1.10	o	o	o
1.11	o	o	o
1.12	o	o	o
1.13	o	o	o
1.14	o	o	o
1.15	o	o	o

2.0 Front Panel Button Test

	Pass	Fail	N/A
2.1	o	o	o
2.2	o	o	o
2.3s	o	o	o
2.4	o	o	o
2.5	o	o	o
2.6	o	o	o
2.7	o	o	o
2.8	o	o	o
2.9	o	o	o
2.10	o	o	o
2.11	o	o	o
2.12	o	o	o
2.13	o	o	o
2.13a	o	o	o
2.13b	o	o	o
2.14	o	o	o
2.15	o	o	o
2.16	o	o	o
2.17	o	o	o
2.18	o	o	o
2.19	o	o	o
2.20	o	o	o
2.21	o	o	o
2.22	o	o	o
2.23	o	o	o
2.24	o	o	o
2.25	o	o	o
2.26	o	o	o

3.0 Leads Test

	Pass	Fail	N/A
3.1	o	o	o
3.2	o	o	o
3.3	o	o	o
3.4	o	o	o

4.0 Power Supply Test

	Pass	Fail	N/A
4.1	o	o	o
4.3	o	o	o
4.4	o	o	o
4.5	o	o	o
4.6	o	o	o
4.8	o	o	o
4.10	o	o	o

5.0 Leakage Current Test

	Pass	Fail	N/A
5.1	o	o	o

6.0 Paddles Test

	Pass	Fail	N/A
6.1	o	o	o
6.2	o	o	o
6.3	o	o	o
6.4	o	o	o
6.5	o	o	o
6.6	o	o	o
6.7	o	o	o

7.0 Heart Rate Display Test

	Pass	Fail	N/A
7.1	o	o	o

8.0 Pulse Calibration Test

	Pass	Fail	N/A
8.2	o	o	o

9.0 Notch Filter Test

	Pass	Fail	N/A
9.3	o	o	o

10.0 Heart Rate Alarm Test

	Pass	Fail	N/A
10.1	o	o	o
10.2	o	o	o
10.3	o	o	o
10.4	o	o	o
10.5	o	o	o
10.6	o	o	o
10.7	o	o	o
10.8	o	o	o
10.9	o	o	o
10.10	o	o	o
10.11	o	o	o
10.12	o	o	o
10.13	o	o	o
10.14	o	o	o

11.0 Defibrillator Self Test

	Pass	Fail	N/A
11.1	o	o	o
11.2	o	o	o
11.3	o	o	o
11.4	o	o	o
11.5	o	o	o
11.6	o	o	o
11.7	o	o	o

12.0 Synchronized Cardioversion Test

	Pass	Fail	N/A
12.2	o	o	o
12.4	o	o	o

13.0 Shock Test

	Pass	Fail	N/A
13.2	o	o	o
13.3	o	o	o
13.4	o	o	o
13.5	o	o	o
13.6	o	o	o
13.7	o	o	o
13.8	o	o	o
13.9	o	o	o
13.10	o	o	o

ZOLL E Series
Maintenance Test Checklist

Serial No.		Location	
Tester		Signature	Date

14.0 Summary Report Test

	Pass	Fail	N/A
14.1	o	o	o
14.2	o	o	o
14.3	o	o	o
14.4	o	o	o

15.0 Advisory Message Test

	Pass	Fail	N/A
15.2	o	o	o
15.3	o	o	o
15.4	o	o	o

16.0 Pacer Test

	Pass	Fail	N/A
16.1	o	o	o
16.2	o	o	o
16.3	o	o	o
16.4	o	o	o
16.5	o	o	o
16.6	o	o	o
16.7	o	o	o
16.8	o	o	o
16.9	o	o	o
16.10	o	o	o
16.11	o	o	o
16.12	o	o	o
16.13	o	o	o
16.14	o	o	o
16.15	o	o	o
16.16	o	o	o
16.17	o	o	o
16.18	o	o	o
16.19	o	o	o
16.20	o	o	o
16.21	o	o	o
16.22	o	o	o

17.0 SpO_2 Monitor Test

	Pass	Fail	N/A
17.1	o	o	o
17.2	o	o	o
17.3	o	o	o
17.4	o	o	o
17.5	o	o	o
17.6	o	o	o
17.7	o	o	o
17.8	o	o	o
17.9	o	o	o
17.10	o	o	o

18.0 $EtCO_2$ Monitor Test

	Pass	Fail	N/A
18.2	o	o	o
18.4	o	o	o
18.6	o	o	o
18.7	o	o	o

19.0 Barometric Pressure Calibrationt

	Pass	Fail	N/A
19.7	o	o	o

20.0 CO_2 Accuracy Test

	Pass	Fail	N/A
20.7	o	o	o
20.8	o	o	o
20.11	o	o	o

21.0 NIBP Monitor Test

	Pass	Fail	N/A
21.2	o	o	o
21.3	o	o	o
21.5	o	o	o

22.0 NIBP Volume Leak Test with Bio-Tek NIBP Analyzer

	Pass	Fail	N/A
22.4	o	o	o
22.5	o	o	o
22.6	o	o	o

23.0 NIBP Volume Leak Test with Fluke Biomedical Cufflink NIBP Analyzer

	Pass	Fail	N/A
23.4	o	o	o
23.5	o	o	o
23.6	o	o	o

24.0 NIBP Transducer Calibration

	Pass	Fail	N/A
24.4	o	o	o
24.6	o	o	o
24.8	o	o	o
24.9	o	o	o
24.10	o	o	o

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