ZOLL

SERVICE MANUAL

ZOLL MEDICAL CORPORATION

9650-0450-01 Rev K

Warranty (U.S. Only)

(a) ZOLL Medical Corporation warrants to the original equipment purchaser that beginning on the date of installation, or thirty (30) days after the date of shipment from ZOLL Medical Corporation's facility, whichever first occurs, the equipment (other than accessories and electrodes) will be free from defects in material and workmanship under normal use and service for the period of one (1) year. During such period ZOLL Medical Corporation will, at no charge to the customer, either repair or replace (at ZOLL Medical Corporation's sole option) any part of the equipment found by ZOLL Medical Corporation to be defective in material or workmanship. If ZOLL Medical Corporation's inspection detects no defects in material or workmanship, ZOLL Medical Corporation's regular service charges shall apply. (b) ZOLL Medical Corporation shall not be responsible for any equipment defect, the failure of the equipment to perform any function, or any other nonconformance of the equipment, caused by or attributable to: (i) any modification of the equipment by the customer, unless such modification is made with the prior written approval of ZOLL Medical Corporation; (ii) the use of the equipment with any associated or complementary equipment, (iii) installation or wiring of the equipment other than in accordance with ZOLL Medical Corporation's instructions. (c) This warranty does not cover items subject to normal wear and burnout during use, including but not limited to lamps, fuses, batteries, patient cables and accessories. (d) The foregoing warranty constitutes the exclusive remedy of the customer and the exclusive liability of ZOLL Medical Corporation for any breach of any warranty related to the equipment supplied hereunder. (e) Limitation of Liability: ZOLL shall not in any event be liable to Purchaser, nor shall Purchaser recover, for special, incidental or consequential damages resulting from any breach of warranty, failure of essential purpose, or under any other legal theory including but not limited to lost profits, lost savings, downtime, goodwill, damage to or replacement of equipment and property, even if ZOLL has been advised of the possibility of such damages.

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For additional information, please call ZOLL Medical Corporation at 1-800-348-9011 (in Massachusetts: 1-781-229-0020). International customers should call the nearest authorized ZOLL Medical Corporation service center.

Software License

Read this License agreement carefully before operating any of the M Series products.

Software incorporated into the system is protected by copyright laws and international copyright treaties as well as other intellectual property laws and treaties. This software is licensed, not sold. By taking delivery of and using this system, the Purchaser signifies agreement to and acceptance of the following terms and conditions:

Grant of License: In consideration of payment of the software license fee which is part of the price paid for this product ZOLL Medical Corporation grants the Purchaser a non-exclusive license, without right to sublicense, to use the system software in object-code form only.

Ownership of Software/Firmware: Title to, ownership of and all rights and interests in the system software and all copies thereof remain at all times vested in the manufacturer, and Licensors to ZOLL Medical Corporation and they do not pass to Purchaser.

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Preface

Overview

ZOLL Medical Corporation's M 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 M 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 M 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—Disassembly Procedures describes step-by-step procedures for removing subassemblies from the M Series unit.

Chapter 4—Replacement Parts List displays a complete list of ZOLL part numbers for field replaceable parts available for the M Series, allowing the service person to identify and order replacement parts from ZOLL.

Chapter 5—Functional Description provides technical descriptions for the M Series major subassembly modules.
Appendix A—M Series Operator's Manual.

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 M 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 M Series unit.

WARNING! This unit can generate up to 4500 volts with sufficient current to cause lethal shocks.

All persons near the equipment must be warned to “STAND CLEAR” 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 Base PowerCharger^{4x4} or compatible ZOLL Battery Charging/Testing unit.

Do not use the M 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 M 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 M 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 M Series documentation. They include:

- Operator’s Guide - A comprehensive reference work that describes all the user tasks needed to operate the M-Series.

- Configuration Guide - Describes the M Series features and functions whose operation can be customized by authorized users.

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

Telephone: 1-781-229-0020; 1-800-348-9011

Fax 1-781-229-0758

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 order request number from the Technical Service representative. Return the unit in its original container to:

ZOLL Medical Corporation
32 Second Avenue
Burlington, Massachusetts 01803-4420

Attn: Technical Service Department

Telephone: 1-800-348-9011; 1-781-229-0020 FAX: 781-229-0758 (International Fax Number: 781-272-5443)

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 at the above address.

Units are available on loan while your unit is being repaired.

Chapter 1
Maintenance Tests

Overview

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

Because the M 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 M Series Operator's Guide for the Operator's Shift Checklist.)

A more thorough maintenance tests checkout needs to be performed by a qualified biomedical technician every six months to evaluate that the functions of the M Series unit work properly. This chapter describes the step by step procedures for doing the six month maintenance tests checkout. (See the Appendix of this manual for the ZOLL M Series Maintenance Tests Checklist which you should photocopy.)

This chapter describes the following maintenance tests:

- Before You Begin the Maintenance Tests
- Equipment You Need For the 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

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.
- Have an extra fully charged ZOLL M Series battery available.
- Schedule an hour to conduct the entire maintenance test.
- Photocopy the checklist in the appendix 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.
- Do the tests in the order presented.
- Do 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 Dynatech Nevada Inc. (DNI part number 3010-0378).

- Dynatech Impulse 4000 Defibrillator Analyzer with 1.06 software or higher.
- Bio-Tek® 601 Pro Series International Safety Analyzer.
- Bio-Tek® Index 2PFE SpO_2 Simulator or equivalent. (Only necessary for SpO_2 units.)
- Novametrix Medical Systems, Inc. Capnostat Simulator TB1265/7100 or equivalent. (Only necessary for $EtCO_2$ units.)
- 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.
- Zoll Data Control (ZDC) for Windows®software from Pinpoint Technologies, Version 1.5 or higher (no equivalent) or Zoll Data Control (ZDC) for DOS software, Version 5.5 or higher (no equivalent).
- Phillips #1 screwdriver.
- Phillips #2 screwdriver.
- Flatblade screwdriver.
- Needle nose pliers without teeth.
- Orange (wooden) sticks.

Equipment You Need for the M Series Options Maintenance Tests

- SpO_2 cable and sensor (if option is installed).
- $EtCO_2$ cable and sensor (if option is installed).
- Paddles.
- 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.)

1.0 Physical Inspection of the Unit

Tools Needed — None.

Test Setup — None.

Observe this...		Pass/Fail
1.1	**Housing** Is the unit clean and undamaged?	❑ ❑
1.2	Does the unit show signs of excessive wear?	❑ ❑
1.3	Does the handle work properly?	❑ ❑
1.4	Does the recorder drawer open and close properly?	❑ ❑
1.5	Are input connectors clean and undamaged?	❑ ❑
1.6	Are there any cracks in the housing?	❑ ❑
1.7	Do the front panel or selector switches have any damage or cracks?	❑ ❑
1.8	Are there any loose housing parts?	❑ ❑
1.9	Do the paddle latches work properly?	❑ ❑
1.10	**Paddles** Do the adult and pedi plates have major scratches or show signs of damage?	❑ ❑
1.11	Do the adult shoes slide on and off easily to expose the covered pedi plates?	❑ ❑
1.12	Are the paddles clean (e.g., free of gel) and undamaged? (if applicable)	❑ ❑

Observe this...		Pass/Fail
1.13	**Cables** Are all cables free of cracks, cuts, exposed or broken wires?	❑ ❑
1.14	Are all bend/strain reliefs undamaged and free of excessive cable wear?	❑ ❑
1.15	**Battery** Is the ZOLL battery fully charged?	❑ ❑
1.16	Is the battery seated in the battery well correctly?	❑ ❑
Record your results on the Maintenance Test Checklist.		

2.0 Front Panel Button Test

Tools Needed

None.

Test Setup

Do the following:

- Install strip chart paper into the recorder tray.
- 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.
- Connect the universal cable and ECG cable (3 lead, 5 lead, or 12 lead) to the ZOLL simulator, or Dynatech Impulse 4000 Analyzer (or equivalent).

	Do this...	**Observe this...**	**Pass/Fail/NA**
2.1	Turn selector switch to MONITOR (**ON** for AED). NOTE: IF testing AED unit, select MANUAL MODE.	Listen for 4 beep tones. PADS and MONITOR display on the monitor. NOTE: PADS is a factory default setting.	❑ ❑
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.	❑ ❑
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.	❑ ❑ ❑

	Do this...	Observe this...	Pass/Fail/NA
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.	❑ ❑ ❑
2.5	Press the **ALARM SUSPEND** button.	Bell 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.	❑ ❑ ❑
2.6	Press the **RECORDER** button (if equipped).	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.)	❑ ❑ ❑
2.7	Open the paper tray. Press **RECORDER** button.	CHECK RECORDER message appears on the monitor.	❑ ❑ ❑
2.8	Close the paper tray. Press **RECORDER** button.	Strip chart paper flows out of paper tray. Verify that the CHECK RECORDER message no longer displays.	❑ ❑ ❑
2.9	Press **RECORDER** button.	Strip chart paper stops flowing out of paper tray.	❑ ❑ ❑
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.	❑ ❑

	Do this...	Observe this...	Pass/Fail/NA
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.	❑ ❑
2.12	Press the **CONTRAST** button.	Contrast menu displays.	❑ ❑
2.13	(For LCD monitors only.) 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 (LCD). The brightness increases on the monitor display (EL). The bar graph increases on the display indicating an increase in contrast. Note: Electro luminescence (EL) displays have only two settings independent of the bar graph without any gradual changes. If EL brightness is already set to its highest level, brightness will not change.	For LCD monitors ❑ ❑ ❑ ❑ ❑ ❑
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 (LCD) and brightness (EL). The display contrast and brightness changes.	❑ ❑
2.15	Press the **SUMMARY** button (if available).	Summary menu displays on the monitor showing the summary report options.	❑ ❑ ❑
2.16	Press the **CODEMARKER** button (if available).	Code marker menu displays.	❑ ❑ ❑
2.17	Connect A/C current and install the battery. Turn the unit off.	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.	❑ ❑ ❑

	Do this...	Observe this...	Pass/Fail/NA
2.18	If applicable, connect D/C current and install the battery. Turn the unit off.	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. Note: If both lights flash ON/OFF, the unit is defective or no battery is installed.	❑ ❑ ❑
2.19	Remove the battery.	Note that both charge lights (green and amber) flash alternately.	❑ ❑
2.20	Replace the battery and the turn unit on.	Note that the yellow charge light illuminates.	❑ ❑
2.21	Press the **ANALYZE** button (if available).	SELECT DEFIB MODE message appears on the monitor. (For manual devices.)	❑ ❑ ❑
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.	❑ ❑ ❑
2.23	Press and hold the **ENERGY SELECT** down arrow.	Unit discharges internally and selected energy decrements to 1J.	❑ ❑ ❑
2.24	Press and release the **ENERGY SELECT** up arrow 19 times.	The following energy amounts display incrementally 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 30, 50, 75, 100, 150, 200, 300, 360J (for DSW). Biphasic: 1-10, 15, 20, 30, 50, 75, 100, 120, 150, 200J.	❑ ❑ ❑
2.25	Press the **CHARGE** button.	Note the display shows the unit charged up to 360J (200J - Biphasic) and the SHOCK button lights.	❑ ❑ ❑
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).	❑ ❑ ❑
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

Note: The M Series unit must be configured to display ECG LEAD OFF message.

Connect the lead wires appropriate to each test to the Dynatech Impulse 4000 or equivalent (Symbio CS1201).

	Do this...	**Observe this...**	**Pass/Fail/NA**
3.1	Set the selector switch to **MONITOR**. Select leads.	NO ECG LEADS OFF message displayed.	❑ ❑ ❑
3.2	Disconnect one lead from the simulator.	The ECG LEAD OFF message displays within 3 seconds (if configured).	❑ ❑ ❑
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).	❑ ❑ ❑
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.	❑ ❑ ❑
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

Make sure the unit and power supply are turned off.

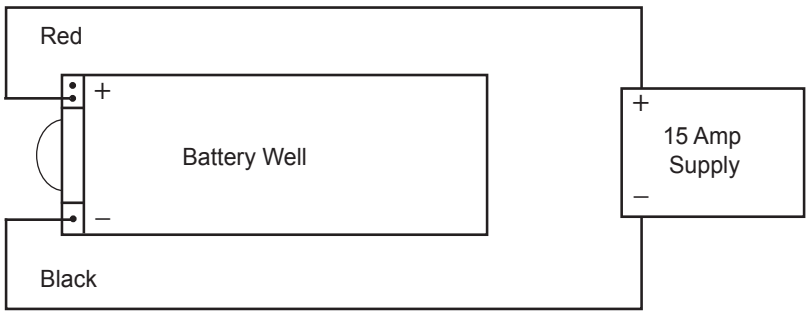
Connect one end of the black lead to the "-" terminal in the battery well.

Connect the other end of the black lead to the "-" terminal of the power supply.

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.

Set the power supply voltage to 7V.

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



Test Setup

Power Supply Test (continued) Test Setup for System Current Test

	Do this...	Observe this...	Pass/Fail
4.1	Turn unit to MONITOR. ON.	The unit should not turn on.	❑ ❑
4.2	Turn the unit off.		
4.3	Adjust the power supply voltage to 10.3V. Turn the unit ON.	The unit should turn on.	❑ ❑
4.4	**Low Battery Test** Set voltage to 9.8V.	No LOW BATTERY message displays.	❑ ❑
4.5	Set voltage to 9.3V.	LOW BATTERY message displays within 30 seconds.	❑ ❑
4.6	**Shut Down Voltage Test** Set voltage to 8.5V.	Unit should shut off within 30 seconds.	❑ ❑
Record your results on the Maintenance Tests Checklist.			

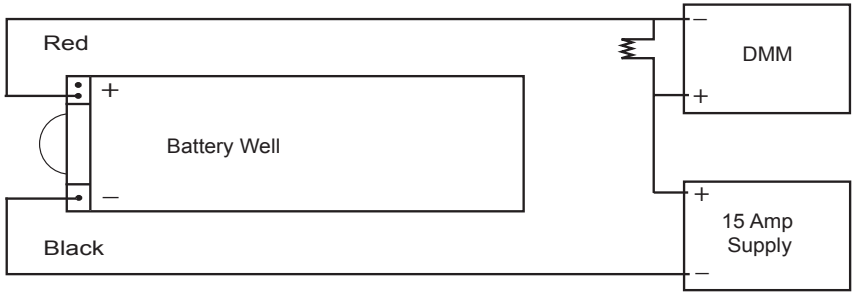
Test Setup

Remove red lead from power supply and connect to 0.1Ω resistor.

Connect other end of resistor to “+” terminal of power supply using a second red lead.

Connect multimeter across the resistor.

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.		

	Do this...	Observe this...	Pass/Fail/NA
4.8	Set Selector Switch to Monitor (ON for AED).	Voltage across resistor should be 80 mV or less (<800 mA of ON current). NOTE: Without optional parameters. a) With green screen or LCD and no options <80mV b) With yellow screen and no options <81mV c) With yellow screen and SpO_2 <104mV d) With yellow screen and voice recording <91mV e) With yellow screen, voice recording and SpO_2 <114mV f) All devices with $EtCO_2$ <121mV	❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑ ❑
4.9	Turn unit off.		❑ ❑
Record your results on the Maintenance Tests Checklist.			

Test Setup for Off Current Test

Remove 0.1Ω resistor and replace with 1KΩ.

Connect DMM across resistor.

Set voltage scale to DCV.

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).	❑ ❑
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.

Setup

See the manufacturer's instructions or supplied specifications for the leakage tester you use. Repeat leakage test with accessories: MFC, external paddles, internal 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

Tools Needed

None.

Test Setup

If applicable, connect the universal cable to the paddles. Place 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.	❑ ❑
6.2	Press and release the **ENERGY UP** button on the sternum paddle for each setting.	The energy selection increases incrementally to 360J (2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 30, 50, 75, 100, 150, 200, 300, 360J). Biphasic: 1-10, 15, 20, 30, 50, 75, 100, 120, 150, 200J.	❑ ❑
6.3	Press and release the **RECORDER** button on the sternum paddle.	The recorder turns on. Press and release again to turn off.	❑ ❑ ❑
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).	❑ ❑
6.5	Press and release the **APEX SHOCK** button.	No discharge.	❑ ❑
6.6	Press and release the **STERNUM SHOCK** button.	No discharge.	❑ ❑
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.	❑ ❑
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

Turn the selector switch to **MONITOR**. Press LEAD button until "I" displays.
Connect the ECG leads to the DYNATECH Impulse 4000 or equivalent.
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	❑ ❑ ❑
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.	❑ ❑ ❑
Record your results on the Maintenance Tests Checklist.			

9.0 Notch Filter Test

Tools Needed

Dynatech Impulse 4000 (or equivalent).

Test Setup

Connect the ECG cable to the DYNATECH Impulse 4000 or equivalent.

Connect the ECG cable to the unit.

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

10.0 Heart Rate Alarm Test

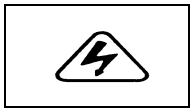
Tools Needed

Dynatech Impulse 4000.

	Do this...	Observe this...	Pass Fail/NA
10.1	Turn the selector switch to **MONITOR.** (**ON** for AED. Select Manual mode.) Connect the ECG leads to the Dynatech 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.	❑ ❑
10.2	Press **ALARMS**.	The alarm menu displays.	❑ ❑
10.3	Press **SELECT PARAM** softkey until ECG HR displays.	Cursor scrolls through parameters.	❑ ❑
10.4	Press **INC>** for state.	Cursor scrolls through ENABLE, AUTO and DISABLE.	❑ ❑
10.5	Press **DEC>**for state.	Cursor scrolls through ENABLE, DISABLE, AND AUTO.	❑ ❑
10.6	Press **INC**> until ENABLE displays.	ENABLE displays.	❑ ❑
10.7	Set LOW limit to 30, HIGH limit to 150 then, press the **RETURN** softkey.	MONITOR displays.	❑ ❑
10.8	Press **ALARM SUSPEND** button.	No alarm sounds.	❑ ❑
10.9	Remove a lead wire from the Dynatech Impulse 4000.	The bell 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.	❑ ❑

	Do this...	Observe this...	Pass Fail/NA
10.10	Reattach ECG Lead wire to Dynatech Impulse 4000 and hold the **ALARM SUSPEND** button on unit for 4 seconds.	The bell symbol has an “X through it. The heart symbol flashes with each QRS wave.	❑ ❑
10.11	Press the **ALARM SUSPEND** button.	Alarm is enabled. Bell symbol (without “X”) displays.	❑ ❑
10.12	Set simulator to 160 BPM or higher.	Heart Rate Value is highlighted, alarm tone sounds, the bell and the heart symbol both flash.	❑ ❑
10.13	Press the **ALARM SUSPEND** button in the unit.	Alarm is suspended for 90 seconds. The bell symbol has an “X” through it. The heart symbol flashes with each QRS wave.	❑ ❑
10.14	Press and hold ALARM SUSPEND for 4 seconds to disable alarms.		❑ ❑
Record your results on the Maintenance Tests Checklist.			

11.0 Defibrillator Self Test



SHOCK HAZARD!

TAKE THE NECESSRY PRECAUTIONS TO GUARD AGAINST SHOCK OR INJURY BEFORE YOU START CONDUCTING THE DEFIRBILLATOR 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 (Dynatech Nevada Part Number 3010-0378 or equivalent).

Dynatech Impulse 4000 or equivalent defibrillator analyzer.

ECG Cable.

Stop watch.

Test Setup

Ensure the unit is turned off and the ECG cable is connected to the unit and analyzer. 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** (**ON** for AED. Select Manual mode.) Set leads to PADS.	CHECK PADS/POOR PAD CONTACT message displays.	❑ ❑

	Do this...	Observe this...	Pass/Fail
11.2	Connect the universal cable to the MFC test port.	DEFIB PAD SHORT message displays.	❑ ❑
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.	❑ ❑
11.4	Press the **SHOCK** button.	Unit does not discharge. DEFIB PAD SHORT message displays.	❑ ❑
11.5	Set energy level to 30J.	Unit internally discharges.	❑ ❑
11.6	Press the **CHARGE** button.	Unit charges to 30J and displays DEFIB 30J READY. The charge ready tone sounds.	❑ ❑
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: For monophasic unit: 30 JOULES TEST OK. 37-47A JOULES DEL=30 IMPED=0. For Biphasic Unit: 30 JOULES TEST OK. TEST_CUR=10-14A DEFIB_IMPED=0. **NOTE** The impedance value may range from 0 to 2Ω.	❑ ❑
Record your results on the Maintenance Tests Checklist.			

12.0 Synchronized Cardioversion Test

Tools Needed

Dynatech Impulse 4000 or equivalent defibrillator analyzer.

Test Setup

Connect the universal cable via the adapter (D.N.I #3010-0378) to the defibrillator analyzer.

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.	❑ ❑
12.3	Select 360J (200J for Biphasic unit).		
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.	❑ ❑
Record your results on the Maintenance Tests Checklist.			

13.0 Shock Test

Tools Needed

Dynatech Impulse 4000 or equivalent defibrillator analyzer.

Test Setup

Stop watch.

Connect the universal cable via the adapter (D.N.I #3010-0378) to the defibrillator analyzer.

Ensure that a fully charged battery is installed in the unit.

NOTE: If your M Series AED does not have manual override capability, do not do this test.

	Do this...	**Observe this...**	**Pass/Fail/NA**
13.1	Set the selector switch to **DEFIB** (**ON** for AED. Select Manual mode.)		❑ ❑ ❑
13.2	Press **ENERGY SELECT** down arrow until 1J displays.	DEFIB 1J SEL displays.	❑ ❑ ❑
13.3	Press **CHARGE** button.Wait for the **SHOCK** button to illuminate.	DEFIB 1J RDY displays.	❑ ❑ ❑
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.)	❑ ❑
13.5	Repeat for all settings 1-300J (DSW); 1-150J (Biphasic)	Energy delivered is within + /- 15% or 2J of setting which ever is greater.	❑ ❑

	Do this...	Observe this...	Pass/Fail/NA
13.6	Press **ENERGY SELECT** up arrow until 360J (200J for Biphasic) displays.	DEFIB 360J SEL displays or DEFIB 200J SEL displays (for Biphasic unit).	❑ ❑
13.7	Press **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 (DSW) 4.0-8.0 sec. Charge time (Biphasic) 3.0-6.0 sec.	❑ ❑ ❑ ❑
13.8	Press the **SHOCK** button. Record the value of the discharge energy that is displayed on the analyzer.	360J discharge energy (DSW) 306-414J. 200J discharge energy (Biphasic)170-230J.	❑ ❑ ❑ ❑
13.9	(Biphasic unit only) Note the Patient Current and Defib Impedance on the strip chart.	Patient Current 22-24A. Defib Impedance 46-54 Ohms.	❑ ❑ ❑ ❑ ❑ ❑
13.10	(AED unit only) Disconnect the cable from the analyzer.	CHECK PADS audio prompt.	❑ ❑ ❑
Record your results on the Maintenance Tests Checklist.			

14.0 Summary Report Test (if applicable)

Tools Needed

None.

Test Setup

Connect the universal cable to the defibrillator analyzer. 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.	❑ ❑
14.2	Set selector knob to DEFIB. Select 300J (200J for Biphasic) using **ENERGY SELECT** button, 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.	❑ ❑
14.3	Wait 18 seconds, then press the Code Marker softkey. Press the **CPR** softkey.	The Code Markers display.	❑ ❑
14.4	Turn the unit off. Wait 10 seconds and then turn the unit on. Press the **SUMMARY** softkey and then the **PRINT CHART** softkey.	Summary report prints. The report displays the correct date, time, the shock delivered and Code Marker event.	❑ ❑
Record your results on the Maintenance Tests Checklist.			

15.0 Advisory Message Test (for AED and Manual/Advisory Units)

Tools Needed

None.

Test Setup

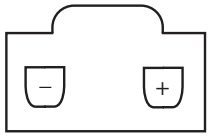
Connect the universal cable via the adapter (D.N.I #3010-0378), then attach to the defibrillator analyzer.

	Do this...	Observe this...	Pass/Fail
15.1	Connect universal cable to the simulator. Turn the selector switch to **DEFIB**. (**ON** for AED.)		
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 on later manufactured units. +If configured for auto charge.	❑ ❑
15.3	Press **SHOCK** button.	Unit discharges.	❑ ❑
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.	❑ ❑
Record your results on the Maintenance Tests Checklist.			

16.0 Pacer Test

Tools Needed

Dynatech 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 M 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

Connect the universal cable from the M Series to the External Pacer Load (TQA-17) of the Impulse 4000.

Turn the Main Selector knob of the M 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 Dynatech Impulse 4000.	CHECK PADS AND POOR PAD CONTACT message displays. The pace alarm is active.	❑ ❑
16.2	Reconnect the universal cable to the Dynatech Impulse 4000. Press Clear Pace Alarm softkey.	CHECK PADS AND POOR PAD CONTACT message disappears. The pace alarm is cleared.	❑ ❑
16.3	Set rate to 180 ppm; output to 0mA.	No output appears on the Dynatech Impulse 4000.	❑ ❑

	Do this...	Observe this...	Pass/Fail
16.4	Increase the output to 20mA.	Output on the Dynatech Impulse 4000 is 20mA +/- 5mA. Pulse width is 40mS +/-2mS.	❑ ❑
16.5	Increase the output to 40mA.	Output on the Dynatech Impulse 4000 is 40mA +/- 5 mA. Pulse width is 40mS +/-2mS.	❑ ❑
16.6	Increase the output to 60mA.	Output on the Dynatech Impulse 4000 is 60mA or +/- 5mA. Pulse width is 40mS +/-2mS.	❑ ❑
16.7	Increase the output to 80mA	Output on the Dynatech Impulse 4000 is 80mA or +/- 5mA. Pulse width is 40mS +/-2mS.	❑ ❑
16.8	Increase the output to 100mA.	Output on the Dynatech Impulse 4000 is 100mA or +/- 5mA. Pulse width is 40mS +/-2mS.	❑ ❑
16.9	Increase the output to 120mA.	Output on the Dynatech Impulse 4000 is 120mA or +/- 6mA. Pulse width is 40mS +/-2mS.	❑ ❑
16.10	Increase the output to 140mA.	Output on the Dynatech Impulse 4000 is 140mA or +/- 7mA. Pulse width is 40mS +/-2mS.	❑ ❑
16.11	Decrease the output to 60mA. Decrease the rate to 30 ppm.	Pacer rate on Dynatech is 29-31 ppm.	❑ ❑
16.12	Increase the rate to 40ppm.	Pacer rate on Dynatech is 39-41 ppm.	❑ ❑
16.13	Increase the rate to 60ppm.	Pacer rate on is Dynatech is 59-61 ppm.	❑ ❑
16.14	Increase the rate to 80ppm.	Pacer rate on Dynatech is 78-82 ppm.	❑ ❑

	Do this...	Observe this...	Pass/Fail
16.15	Increase the rate to 100ppm.	Pacer rate on Dynatech is 98-102 ppm.	❑ ❑
16.16	Increase the rate to 120ppm.	Pacer rate on Dynatech is 118-122 ppm.	❑ ❑
16.17	Increase the rate to 180ppm.	Pacer rate on Dynatech is 177-183 ppm.	❑ ❑
16.18	Decrease the rate to 50 ppm.	Pacer rate on Dynatech is 49-51 ppm.	❑ ❑
16.19	Connect the ECG cable to the M Series and Dynatech Impulse 4000. Select the ECG at 60 BPM on the Dynatech Impulse 4000.	ECG at 60 BPM is seen on the display and no stimulus markers.	❑ ❑
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.	❑ ❑
16.21	Turn off Dynatech. Set Pacer Rate to 100ppm. Press the **RECORDER ON** button.	Observe the pace stimulus markers every 15mm +/-1mm.	❑ ❑
16.22	Press and hold 4:1 button.	Observe the pace stimulus markers every 60 mm+/- 1.5 mm.	❑ ❑
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.

Bio-Tek Index 2PFE SpO_2 Simulator (or equivalent).

Test Setup

Connect the universal cable to the MFC test plug.

DO NOT connect the ECG cable to the simulator.

Install the Masimo® Patient Cable and attach the Masimo® sensor to the patient cable.

Connect the Masimo® sensor to the finger simulation post.

Place a fully charged battery into the battery well or connect to AC power (DC power, if equipped).

Ensure that the SpO_2 Simulator is off.

	Do this...	**Observe this...**	**Pass/Fail**
17.1	Set the selector switch to **MONITOR**. (**ON** for AED. Select Manual mode.)	The SpO_2 saturation percentage appears as a dashed line on the monitor.	❑ ❑
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.	❑ ❑
17.3	Press the **02+** or **02-** softkey of the simulator until the SpO_2 output is at 98%.	The M Series SpO_2 reading of 98 +/- 1% appears on the M Series monitor. Note that you may need to wait up to 2 minutes for the information to appear on the ZOLL display.	❑ ❑

	Do this...	Observe this...	Pass/Fail
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 M Series display. The heart rate of 226-234 BPM displays on the M Series monitor.	❑ ❑ ❑ ❑ ❑ ❑
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 M Series monitor.	❑ ❑ ❑ ❑
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 M Series monitor.	❑ ❑ ❑ ❑
17.7	Press Wave 2 softkey. Select the SpO_2 waveform.	Plethysmographic waveform appears on the ZOLL display.	❑ ❑
17.8	Press **RECORDER**.	The plethysmographic waveform prints on the strip chart paper.	❑ ❑
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.	❑ ❑
17.10	Select Wave 2 SpO_2.	Verify that the waveform is displayed at the correct rate. Print the waveform.	❑ ❑

	Do this...	Observe this...	Pass/Fail
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

Novametrix Capnostat Simulator Tb 1265/7100.

Test Setup

Install the battery.

On the Novatrix Simulator, set the following:

Set inspired CO_2 to OFF.

Set% CO_2 to 0.

Set Sensor Location to ZERO CELL.

Set Source Current to NORMAL.

Set CO_2 mode to CONTINUOUS.

Set Temperature to NORMAL.

	Do this...	**Observe this...**	**Pass/Fail**
18.1	Set the selector switch to **MONITOR.** (**ON** for AED. Select Manual mode.)		
18.2	Attach the $EtCO_2$ simulator to the M Series input connections.	CO_2 SENSOR WARMUP message displays. Note: You may need to wait up to 5 minutes for the warm-up message to disappear. If the message REPLACE CO_2 SENSOR displays, reinsert the Novametrix Simulator Cable. Note that the message ZEROING CO_2 SENSOR may display for an additional 20 seconds. Automatic zeroing will occur if the unit had not been zeroed at the time of its last use.	❑ ❑

	Do this...	Observe this...	Pass/Fail
18.3	On the Novametrix Simulator, set **SENSOR LOCATION** to **REF CELL.**	The $EtCO_2$ reading of 36-40 mmHg displays on the monitor. Note that you may need to wait up to 10 seconds for the unit to stabilize.	❑ ❑
18.4	On the Novametrix Simulator, set **SENSOR LOCATION** to **AA CELL.** Set% CO_2 to 10. Set CO_2 mode to **RESPIRATION**.	The $EtCO_2$ reading of 74-84 mmHg appears on the M Series display. Note that you may need to wait up to 10 seconds for the unit to stabilize.	❑ ❑
18.5	On the Novametrix Simulator, set% CO_2 to 5.	The $EtCO_2$ reading of 34-42 mmHg displays on the M Series monitor. Note that you may need to wait up to 10 seconds for the unit to stabilize. The Respiration Rate (RR) of 22-24 displays on the M Series monitor. Press WAVE 2 softkey. The $EtCO_2$ waveform displays. Press RECORDER button. The $EtCO_2$ waveform prints. Note that the CO_2 waveform is displayed and printed at 12.5 millimeters per second scale.	❑ ❑
Record your results on the Maintenance Tests Checklist.			

Chapter 2 Troubleshooting

Overview

This chapter describes the most common technical problems that biomedical technicians experience when checking the M 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 M 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 iii 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.

Reported Problem	Recommended User Action	Recommended Technical Action
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.	
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.

Reported Problem	Recommended User Action	Recommended Technical Action
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.	• Wet gel pads must be stored flat.

Reported Problem	Recommended User Action	Recommended Technical Action
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.	
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.	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.
Wandering baseline.	See "Displayed HR not accurate." above. Note that in 90% of electrode issues, size and lead changes don't help.	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 M Series unit away from RFI source.

Zoll M Series Error Messages

The following is a list of Zoll M 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.	✓	
50J MAX	Energy ≤ 50J for internal paddles. No higher energy is available.	✓	
ADJUST ECG	Unit is in sync mode and heart rate is < 20 BPM. Or, QRS size set too small for proper synchronization.	✓	
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	✓	

Error Message	Explanation	User Advisory	Technical Action
ANALYSIS RESTARTED	This is a user prompt issued simultaneously with ECG TOO LARGE or ECG TOO SMALL. Device detected ECG signals out of range, automatically adjusted ECG size and is now restarting its shockable rhythm analysis sequence.	✓	
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.

Error Message	Explanation	User Advisory	Technical Action
BATT OVERCHARGE	Charger on for > 4 hours.		Replace battery and or charger.
BRIDGE SHORT	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.
BRIDGE TEST FAILED	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.
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.
CANNOT CHARGE	Cannot charge when charge button pressed.		Replace high voltage module or capacitor.

Error Message	Explanation	User Advisory	Technical Action
REPLACE CARD	Write errors during manual or semi-automated modes.	✓	May have configuration card installed or write protection on.
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 MEMORY CARD	No card detected during manual or semi-automated modes.	✓	
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.	✓	

Error Message	Explanation	User Advisory	Technical Action
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 SITE	Low or no perfusion in monitored finger or toe.	✓	
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.
CO_2 COMM ERROR	No or invalid communication from the $EtCO_2$ module.		Replace $EtCO_2$ module and or system board.
CO_2 SENSOR WARM UP	$EtCO_2$ Sensor warming up.	✓	Wait for sensor to warm up. This process takes up to approximately one minute.
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.

Error Message	Explanation	User Advisory	Technical Action
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	General defib error.		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.

Error Message	Explanation	User Advisory	Technical Action
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 96	XPATREL or XPAT_ENABLE is faulted or one of the discharge transistors has shorted.		Replace high voltage module.
DEFIB FAULT 108	VMON voltage is less than the target energy during charging.		Replace high voltage module or capacitor.
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 NOT CHARGED	Discharge button is pressed but the unit is not charged.	✓	

Error Message	Explanation	User Advisory	Technical Action
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.
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 TOO SMALL	ECG signal too small for accurate shockable rhythm analysis.	✓	Increase ECG size.
ECG V1 LEAD OFF	Chest lead V1 is not properly attached to patient.	✓	Reattach V lead. Check cable.

Error Message	Explanation	User Advisory	Technical Action
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 w/ AED.
ERASING REPORT	Summary report being erased.	✓	
ECU CRC FAULT	Invalid ECG samples detected over a one second period.		Turn off unit and then turn on to reset. If fault persists, replace system board.
$EtCO_2$ COM ERROR	No or invalid communication from $EtCO_2$ module.		Return unit for service to ZOLL Technical Service Department.
FAX DIALING	Preparation for sending fax.	✓	
FAX DONE	Transmission complete.	✓	
FAX PREPARING	Preparing fax for transmission.	✓	

Error Message	Explanation	User Advisory	Technical Action
FAX SENDING	Transmitting fax.	✓	
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.

Error Message	Explanation	User Advisory	Technical Action
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.
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.	✓	
PLACE ON ZERO CELL	$EtCO_2$ sensor cable plugged into unit for the first time. Zeroing error or probe drift error detected.	✓	Zero sensor. Replace sensor. Return to ZOLL for service.

Error Message	Explanation	User Advisory	Technical Action
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.

Error Message	Explanation	User Advisory	Technical Action
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.
REPLACE BATTERY	Battery voltage < absolute min. Shutdown imminent.	✓	Replace with charged battery.
REPLACE $EtCO_2$ SENSOR	$EtC0_2$ SENSOR WARM UP message displays for more than five minutes. Sensor defective.	✓	Replace sensor cable.
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.

Error Message	Explanation	User Advisory	Technical Action
RESERVED 1	The watchdog timer is not functional in the unit.		Turn off unit and then turn on to reset. If fault persists, replace system board.
RETRY ANALYSIS	Advisory message in conjunction with noisy ECG. Analysis halted.	✓	
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 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.	✓	

Error Message	Explanation	User Advisory	Technical Action
SpO_2 AMBIENT LIGHT	Ambient light is too bright.		Shield sensor from ambient light. Replace $Sp0_2$ sensor. Replace $Sp0_2$ module
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.	✓	
SpO_2 SENSOR FAULT 1	Defective sensor.		Replace $Sp0_2$ sensor.
SpO_2 SENSOR FAULT 5	Unrecognized sensor.		Replace $Sp0_2$ sensor.
STAND CLEAR	(Auto defib mode only.) Single analysis mode just turned on and defib idle. Patient rhythm is being analyzed.	✓	
SYSTEM FAULT 2	MCU ROM checksum test failure or MCU RAM test failure.		Turn off unit and then turn on to reset. If fault persists, replace system board.
SYSTEM 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
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	P1MON is less than 412 counts or greater than 612 A/D counts. 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.	✓	

Error Message	Explanation	User Advisory	Technical Action
USE PADS TO PACE	External paddles detected in pace mode.	✓	
USE ROOM AIR ADAPTER	Adapter zeroing started with $EtCO_2$ in the adapter or the adapter is on the REF or “0” cell.	✓	Place CO_2 sensor on adapter in room air.
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 SENSOR	New $EtCO_2$ sensor needs to be zero calibrated.	✓	Zero $EtCO_2$ sensor.
ZERO CO_2 ADAPTER	New $EtCO_2$ airway adapter needs to be zero calibrated.	✓	Zero $EtCO_2$ adapter.

Chapter 3

Disassembly Procedures

Overview

This chapter provides instructions on how to disassemble and reassemble the M Series unit.

- Equipment You Need for the Disassembly Procedures
- Parts That May Need Replacing After Disassembly
- Safety Precautions You Need to Take
- Overview of Modules

1. ZIF Keeper
2. Front Panel

2A. Display

2B. Control Board

3. Upper Housing Assembly
4. System Board Assembly
5. Battery Interconnect Board Assembly
6. High Voltage/Charger Assembly
7. Removing the High Voltage Module Assembly
8. High Voltage Capacitor Assembly
9. System Interconnect Board
10. Printer/Recorder Motor
11. Lower Housing Assembly

12. Print Head Assembly
13. PCMCIA Card Slot Assembly
14. Paddle Release Latch

Equipment You Need for the Disassembly Procedures

- No. 1 Phillips screwdriver.
- No. 2 Phillips screwdriver.
- Exacto-knife.
- Orange wooden stick. (Available from H.A. Stiles: 1-800-447-8537)
- 90° dental pick.
- Needle nose pliers.
- Kapton tape.
- 3M copper adhesive tape, or equivalent.
- 1/2” nut driver.
- Large diagonal cutters.
- Strong glue, such as Loctite 420 or equivalent.
- Loctite needle tip dispenser.

Parts That May Need Replacing After Disassembly

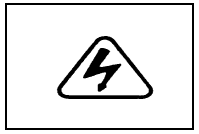
If you are removing the Control Board from the Front Panel, you need to have:

- Main Selector knob replacement (ZOLL Part Number 9310-0521)
- Pacer/Output/Rate knob replacement (ZOLL Part Number 9310-0520)

If you are removing the Battery Interconnect Board, you may need to replace it with a new one, using ZOLL Part Number 9301-0302, if connectors have been UV welded as in older M Series models.

Safety Precautions You Need to Take

WARNING! **SHOCK HAZARD!**

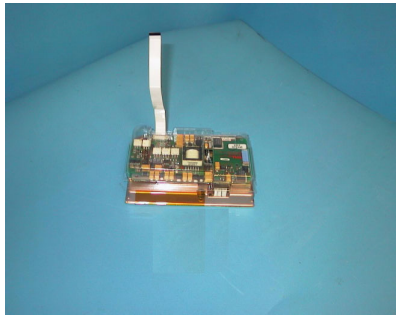


CAUTION TAKE THE NECESSARY PRECAUTIONS TO GUARD AGAINST SHOCK OR INJURY BEFORE YOU CONDUCT DEFIBRILLATOR TESTS OR REPAIRS.

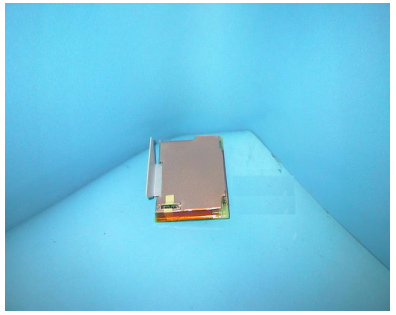
- Only properly trained technicians should service the unit.
- The unit can contain deadly voltages even if the unit is turned off.
- Make sure to discharge the unit before working with it.
- Make sure you take the necessary precautions when working with static sensitive units. For example, you must wear a conductive wrist strap (which touches your skin) connected to a grounding mat and to the earth ground. You must remove the wrist strap when you discharge high voltage or when you are working on energized equipment.

Overview of Modules

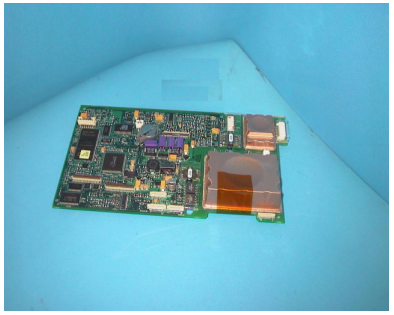
The M Series has 14 modules. These modules are shown below.



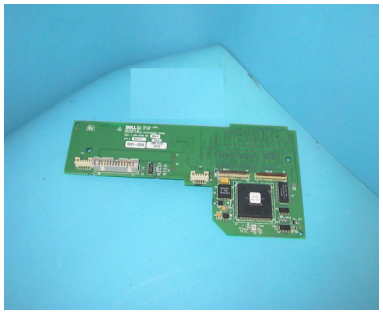
Isolated Power Supply with $EtCO_2$



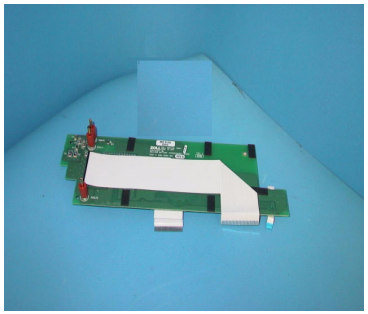
SpO_2 module with bracket for $EtCO_2$



System Board Assembly

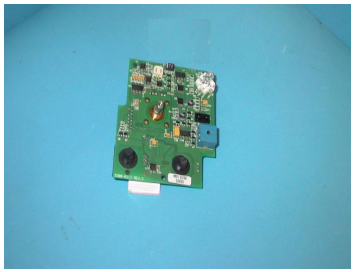


System Interconnect Board

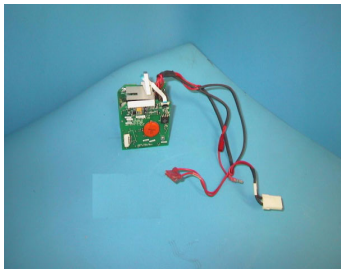


Battery Interconnect Board Assembly with 3 Battery Pin Gaskets

AC Charger Assembly

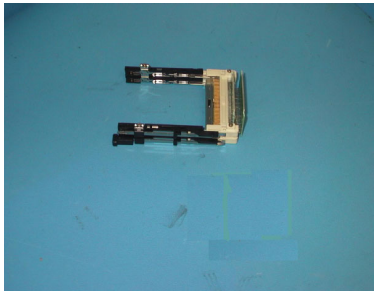


Control Board (from Front Panel)



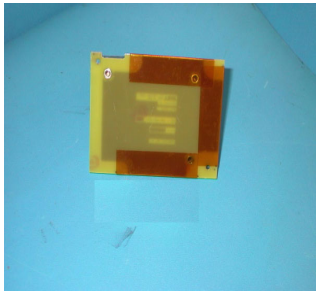
High Voltage Module Assembly

High Voltage Capacitor Assembly

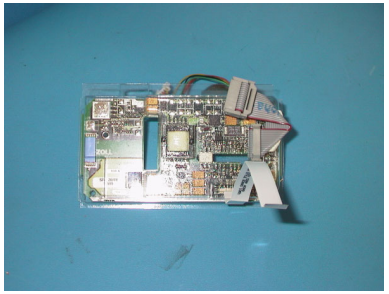


PCMCIA Card Slot

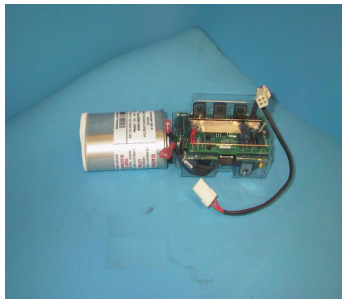
Recorder Motor



SpO_2 Module (without bracket)



Isolated Power Supply for SpO_2 Module



Biphasic Capacitor and Bridge Assembly

1. Removing the ZIF Keeper

- Orange stick

Note: It is important to know this procedure before you start disassembling the unit. Removing the ZIF (Zero Insertion Force) Keeper incorrectly can damage the unit's system board.

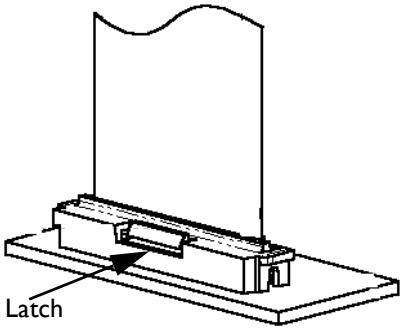
To reinstall the ZIF Keeper:

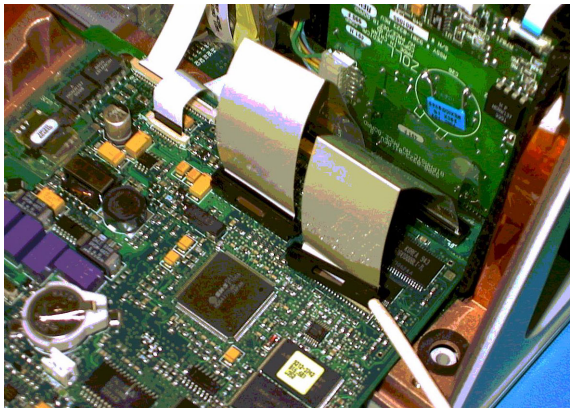
1. Place the ZIF Keeper over the laminate cable and insert the flex cable into the connector. Latch the connector.

2. Lower the left end of the ZIF Keeper over the connector end until it touches the printed wire assembly (PWBA). The other end of the connector should be angled.

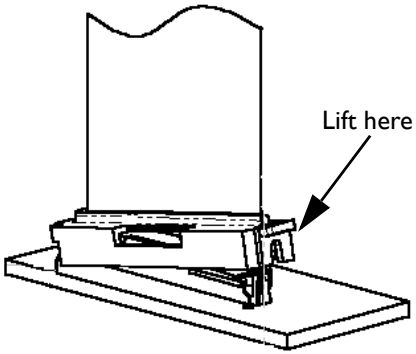
3. Press the end of the ZIF Keeper down over the end of the connector. Be careful that the ZIF Keeper snaps over the end of the connector.

Step 1: The connector must be facing you as shown in the diagram.

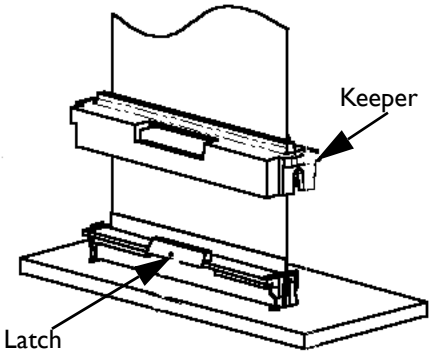




Step 2: Angle and lift up the right end of the ZIF Keeper from the connector and the board. Slide the Keeper approximately 1 mm to the left, then gently lift the left side to clear the connector.



Step 3: Gently pull the ZIF (Zero Insertion Force) Keeper over the laminate cable and rotate the latch upwards.



2. Removing the Front Panel

Tools Required

- No. 2 Phillips screwdriver
- Orange stick

To reinstall the Front Panel:

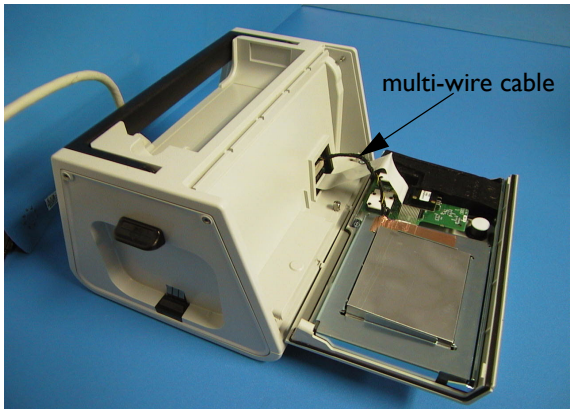
1. Reinstall the laminate cable first with the black band facing up and towards the system circuit board.
2. Reconnect the multi-wire cable from the display.
3. Reverse steps 1, 2, and 3 above to reinstall the front panel.

Step 1: Remove the battery from the battery well and place it in front of the unit.

Step 2: Rotate unit on to its back side. Remove the two Phillips head screws located on the left and right sides on the bottom of the unit.

Step 3: Place your thumbs in the main selector switch cup and push up on the front panel to release the panel from the unit. After the front panel is removed, use the battery as a support for the panel. **Do not use the main selector switch as point of leverage.**

Step 4: Disconnect the multi-wire cable from the system board by gently pulling the beige connector by its sides towards the front of the unit. Remove the ZIF keeper from the laminated ribbon cable and then disconnect it. Lift the right side first with the unit facing you.



2A. Removing the Display

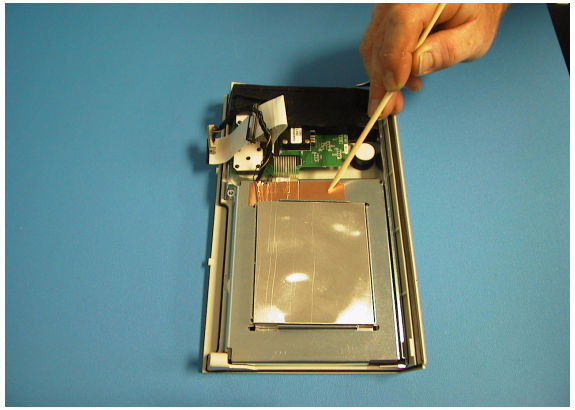
Tools Required

- No. 2 Phillips Screwdriver
- Exacto-Knife
- 3M Copper Adhesive Tape

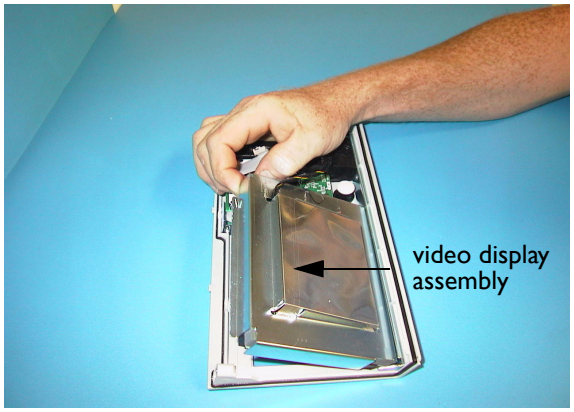
To reinstall the Display

Reverse steps 1 through 3.

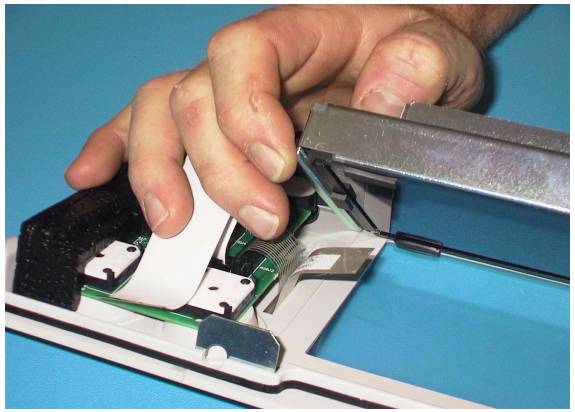
Step 1: Remove the grounding copper tape from the outer display shield.



Step 2: Remove the Video Display Assembly by rotating the display upwards from the lower portion of the display panel assembly.



Step 3: Remove the Video Display Assembly.



2B. Removing the ControlBoard

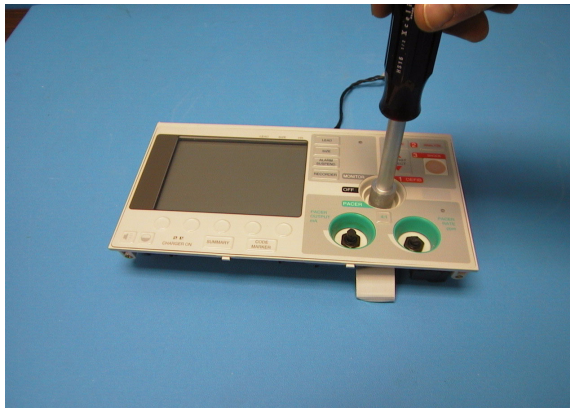
Tools Required

- No. 2 Phillips Screwdriver
- Orange (Wooden) Stick
- 1/2” Nut Driver
- Large Diagonal Cutters
- Strong Glue, such as Loctite 420 or equivalent

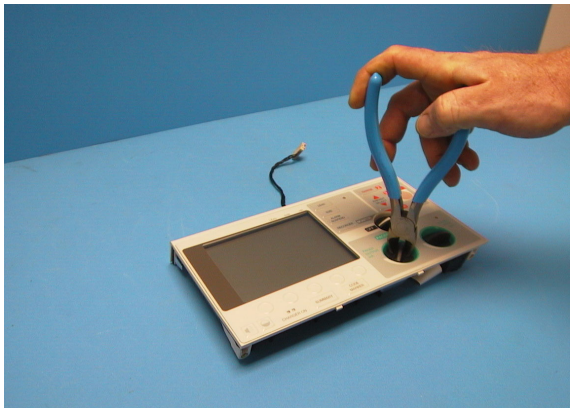
Note: If you are removing the Control Board from the Front Panel you may need to replace the following parts:

- Main Selector knob replacement (ZOLL Part Number 9310-0521)
- Pacer Output/Rate knob replacement (ZOLL Part Number 9310-0520).

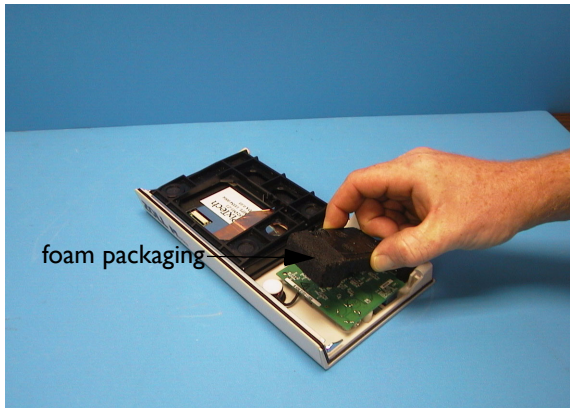
Step 1: (Caution: The knob will be damaged during this step.) Gently insert the cutters at the edge of the main selector knob and pry outward until the knob is removed. Then carefully remove the 1/2” nuts without damaging the Selector Switch.



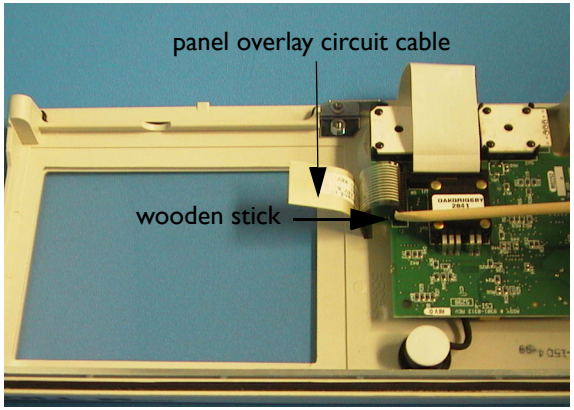
Step 2: Gently insert the cutters at the edge of the pacer knobs and pry outward until the knobs are removed. Then carefully remove the 1/2” nuts without damaging the Pacer Switches and green pace cups.



Step 3: Rock the foam packaging back and forth from the control panel board to remove the foam.



Step 4: Remove the panel overlay circuit cable from the control board by lifting the sides of the lock lever located under the front of the control board. (See 1. Removing the ZIF Keeper.)

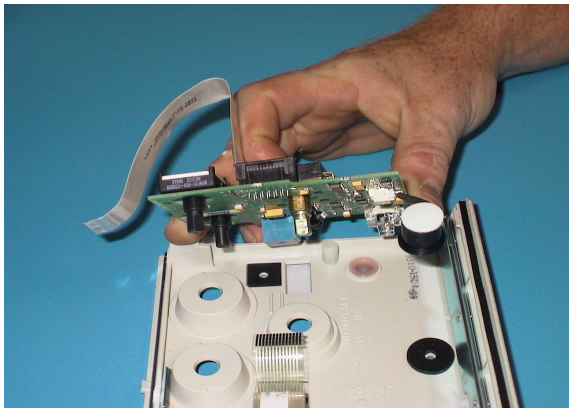


2B. Removing the Control Board (Continued)

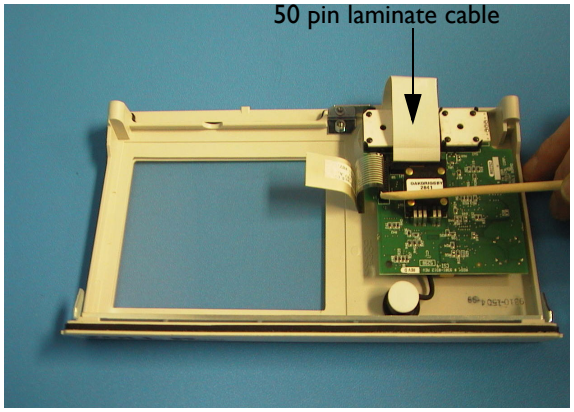
To reinstall the Control Board

1. Set the dip switches and attach the SHOCK button LED actuator.
2. Place a small amount of strong glue on the end of the mode selector switch. Slide the replacement knob on. After the glue dries, rotate the selector knob to ensure that it is properly glued in place.
3. Replace the Pacer Output/Rate knobs, if applicable.

Step 5: Disconnect the speaker microphone cable. Remove the Control Panel Board from the Front Panel Assembly. **Important:** Note the position of the dip switches because they must be in the same position for reinstallation.



Step 6: Remove the 50 pin laminate cable from the control board. See *1.0 Removing the ZIF Keeper.*



3. Removing the Upper Housing Assembly

Tool Required

- No. 1 and 2 Phillips screwdriver

Set-up

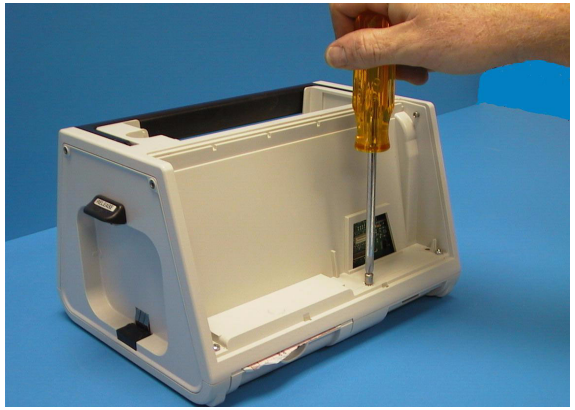
Remove Front Panel (See Step 2.)

1. Remove the two screws securing the universal cable.
2. Do not lose the O-ring when removing the universal cable.
3. Remove the three Phillips screws in the front of the Upper Housing.

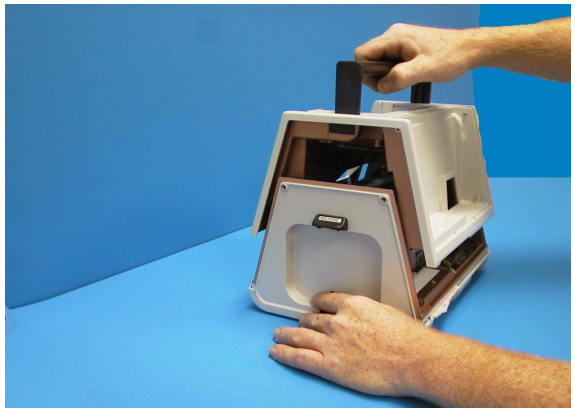
To reinstall the Upper Housing Assembly, reverse the above steps.

Ensure the battery pin gaskets are properly set.

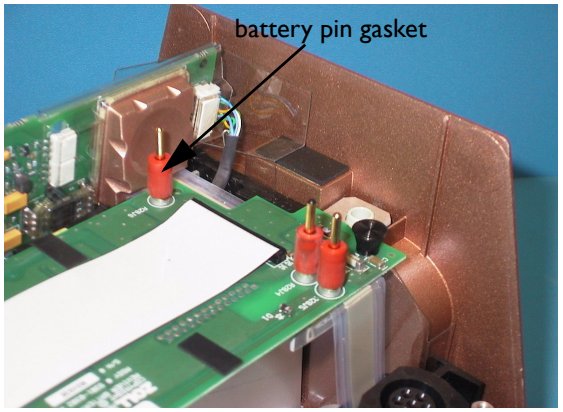
Step 1: Remove two screws from the back side of the Upper Housing Assembly and three screws from the front.



Step 2: Secure lower housing to the table by pressing downward in the paddle well. Using the carry handle, lift the Upper Housing upward.



Step 3: Make sure that the rubber gaskets are covering the battery contact pins. If the gaskets are still seated in the housing, remove and place them onto the contact pins. Before installing the Upper Housing ensure that the battery pin gaskets are set properly.



4. Removing the System Board Assembly

Tools Required

- #1 and #2 Phillips Screwdriver
- Grounding Mat
- Grounding Wrist Strap
- Needle Nose Pliers
- Orange Stick

WARNING! You can damage the hardware of the unit. You must use ESD grounding before you handle any printed circuit boards on the unit.

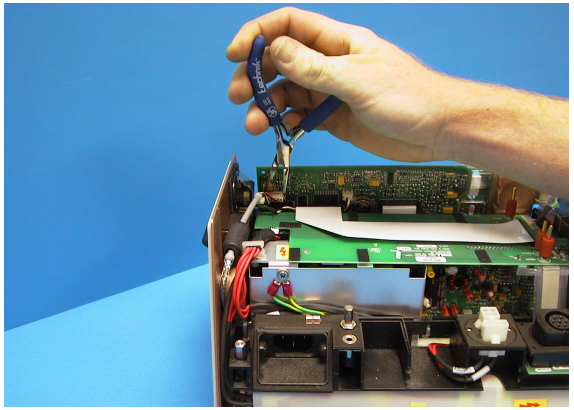
Setup

Before you begin this procedure, make sure you are grounded.

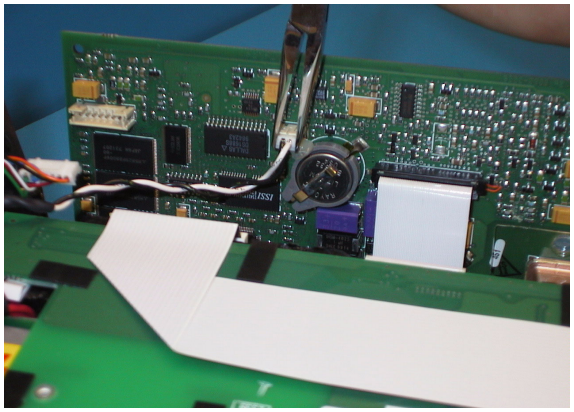
1. Know or review *1.0 Removing the ZIF Keeper* procedure.
2. Remove the Front Panel Assembly.
3. Remove the Upper Housing Assembly.

To reinstall the System Board Assembly, reverse the steps.

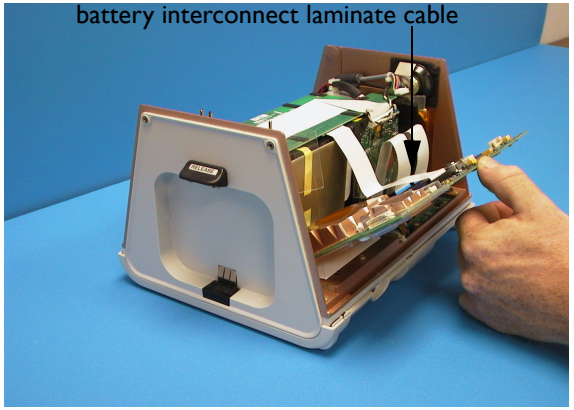
Step 1: Using needle nose pliers, remove left and right multi-wire cables on the back side of the system board. To avoid damage to the cable, do not pull the wires. Hold system board securely with one hand. DO NOT let it fall forward to prevent excess tension on the unit's wires.



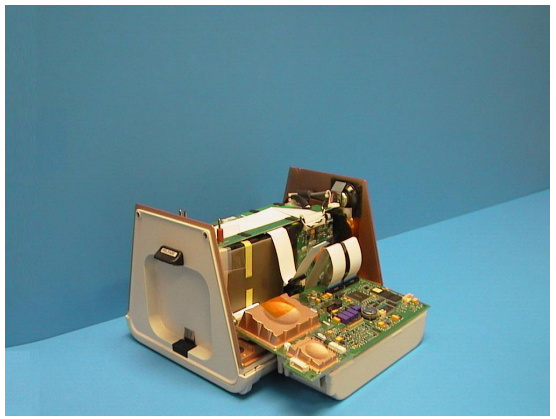
Step 2: Remove the two wire speaker cable (if applicable).



Step 3: Lower the system board with one hand and remove the battery Interconnect laminate cable from the center of the system board. (See *1. Removing the ZIF Keeper.)*

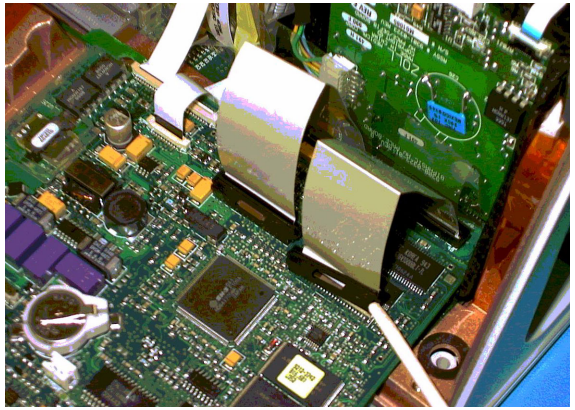


Step 4: Gently roll the system board forward and rest it on the battery.

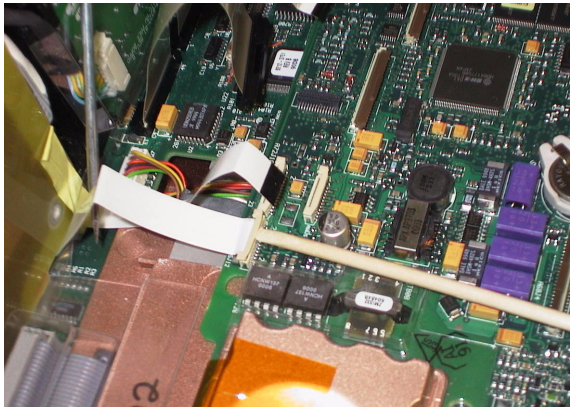


4. Removing the System Board Assembly (Continued)

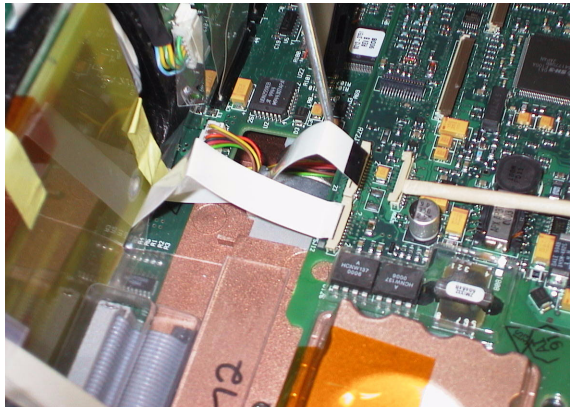
Step 5: Remove the ZIF Keeper. *(See 1. Removing the ZIF Keeper.)*



Step 6: For Biphasic M Series units only: Remove the 20 pin power cable by lifting the slide locking tab upwards.



Step 7: For M Series units with the SpO_2 and/or SpO_2 with $EtCO_2$ only: Remove the 20 pin power cable by lifting the slide locking tab upwards.



5. Removing the Battery Interconnect Board Assembly

Tools Required

- Orange stick

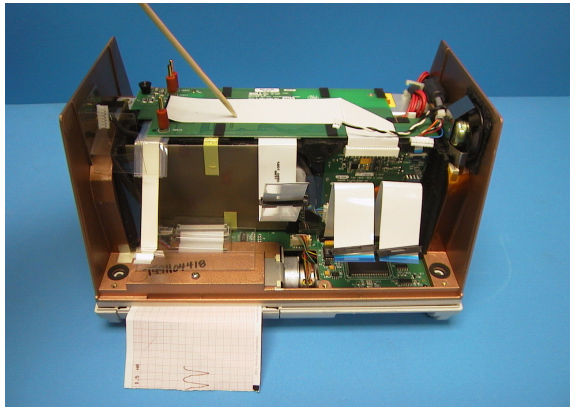
Setup

1. Remove the Front Panel Assembly.
2. Remove the Upper Housing Assembly
3. Remove the System Board Battery Cable.

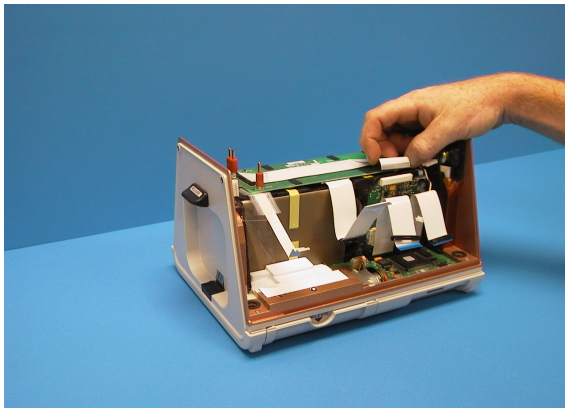
To reinstall the Battery Interconnect Board, reverse the steps.

Note: For Step 4, remember to carefully remove the cable from the Charger Assembly when disassembling and reinstalling it.

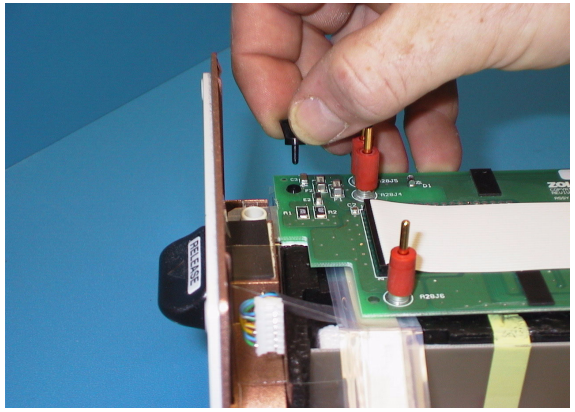
Step 1: Identify the Battery Interconnect Board.



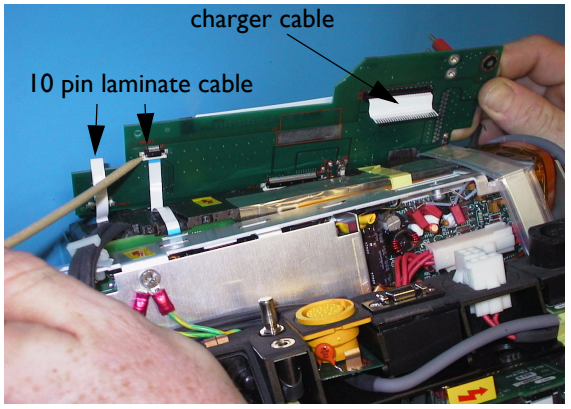
Step 2: Remove the wide laminate cable from the high voltage module connector by lifting the cable vertically.



Step 3: Remove the push pin and small insert collar.



Step 4: Rotate the unit around so that the rear of the unit faces you. Rotate the Battery Interconnect Board upwards toward the front of the device. Hold the board vertically while removing the 10-pin laminate cable from connectors by lifting the connector lock.



6. Removing the High Voltage/ Charger Assembly

Tools Required

- #2 Phillips screwdriver
- Orange stick
- Small needle nose pliers

Setup

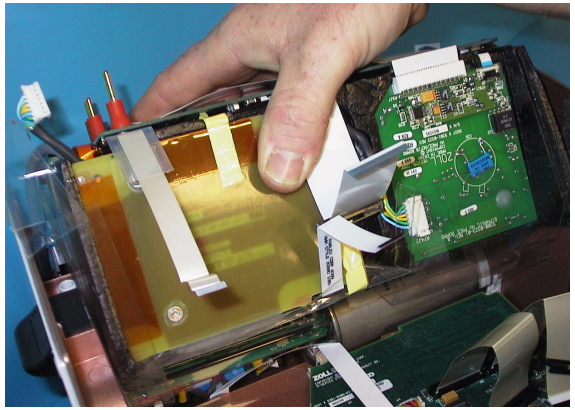
1. Remove the Front Panel Assembly.
2. Remove the Upper Housing Assembly.
3. Remove the System Board.
4. Remove the Battery Interconnect Board.

To reinstall the High Voltage Charger Assembly, reverse the steps.

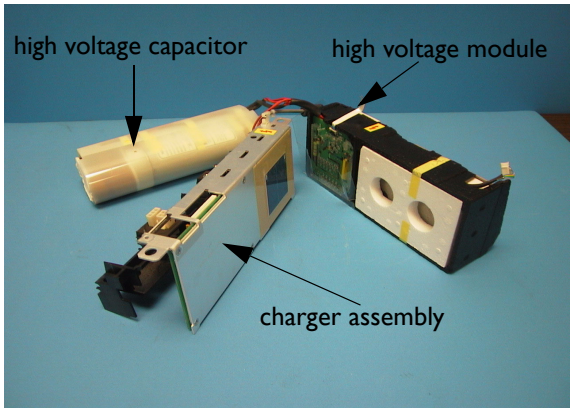
WARNING! This unit may contain lethal voltages. You MUST completely discharge the high voltage capacitor before removing from unit.

DO NOT SHORT THE TERMINAL ENDS OF THE CAPACITOR. Refer to Section 8, Step 2.

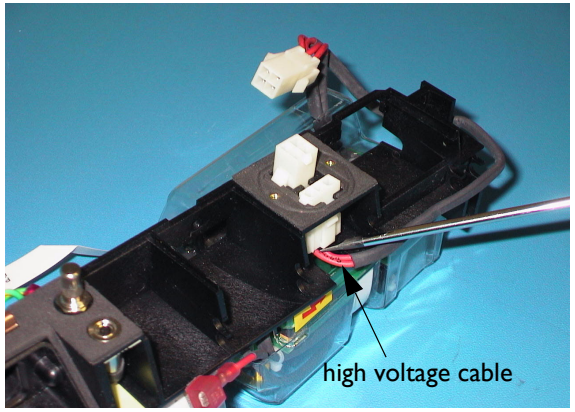
Step 1: Remove the High Voltage/Charger Assembly from the main housing by lifting the High Voltage/ Charger Assembly upwards and rotating it towards the back of the unit.



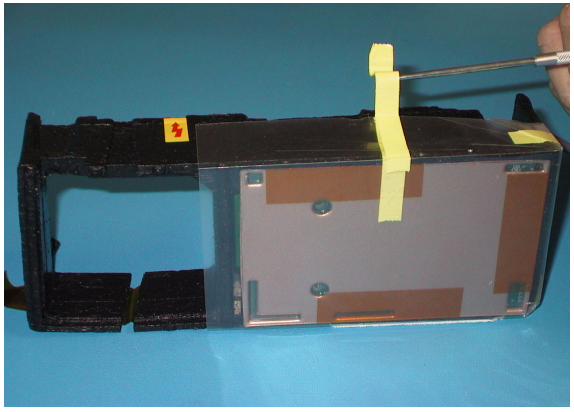
Step 2: Set the Assembly on the table. Pull apart the High Voltage Module from the Charger Assembly. These three components are referred to as the "Module Cluster".



Step 3: Depress the lever on the High Voltage Cable to remove it from the mounting panel. Cut the tie wrap attached to the mounting bracket that secures the cables.

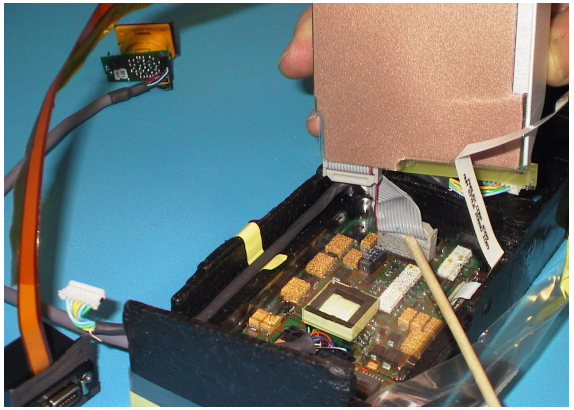


Step 4: (SpO_2 units only) To remove the SpO_2 module from the Isolated Power Supply, remove the Mylar® tape. $EtCO_2$ module and power supply are one assembly at the same location.

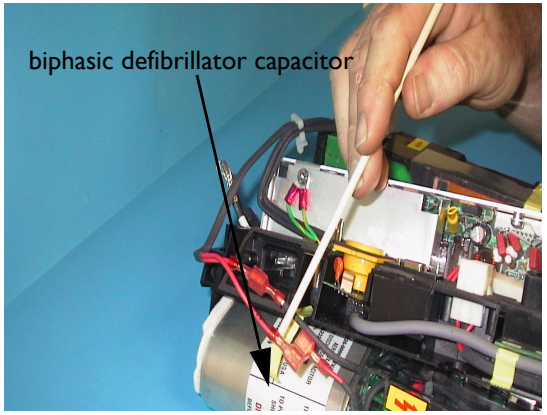


6. Removing the High Voltage/ Charger Assembly (Continued)

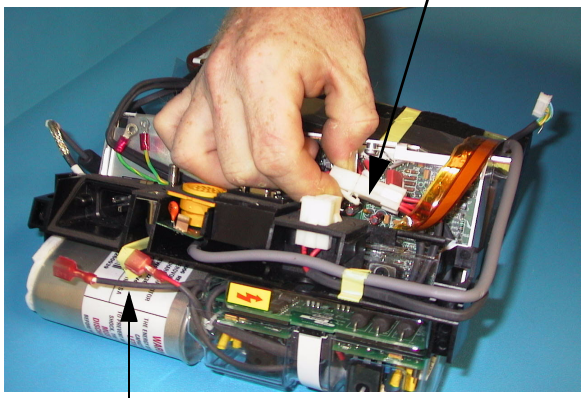
Step 5: Lift the SpO_2 module straight up from the foam and disconnect the ribbon cable from the Isolated Power Supply.



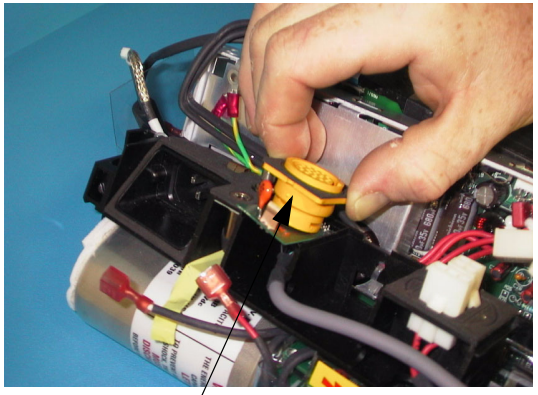
Step 6: (Biphasic units only) Disconnect the biphasic defibrillator capacitor from the rear panel connector.



Step 7: (Biphasic units only) Disconnect the Molex connector from the biphasic module.



Step 8: ($EtCO_2$ units only) Remove the $EtCO_2$ connector by gently lifting the connector away from the back panel. To remove the $EtCO_2$ and isolated power supply, refer to Step 5.



7. Removing the High Voltage Module Assembly

Tools Required

- #2 Phillips screwdriver
- Exacto-Knife

WARNING! This unit may contain lethal voltages. You must completely discharge the high voltage capacitor by changing the energy selection during the charge cycle of the defibrillator. Power off unit. Wait three minutes before disassembly.

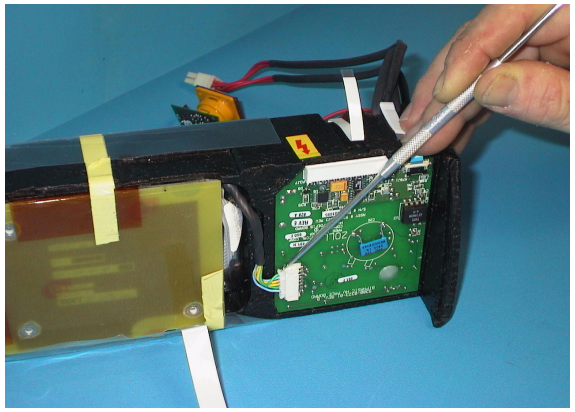
DO NOT SHORT THE TERMINAL ENDS OF THE CAPACITOR. Refer to Section 8, Step 2.

Setup

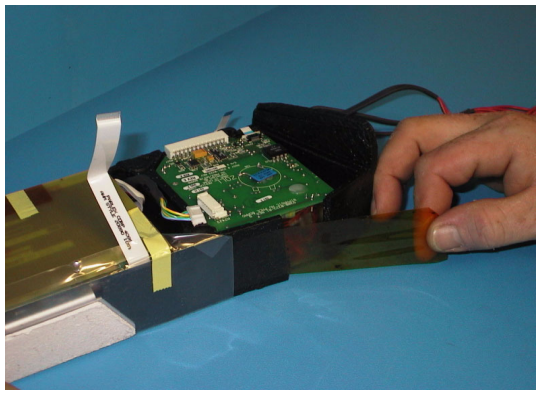
1. Remove the Front Panel Assembly.
2. Remove the Upper Housing Assembly.
3. Remove the System Board.
4. Remove the Battery Interconnect Board.
5. Remove the High Voltage/Charger Assembly

To reinstall the High Voltage Module Assembly, reverse the steps.

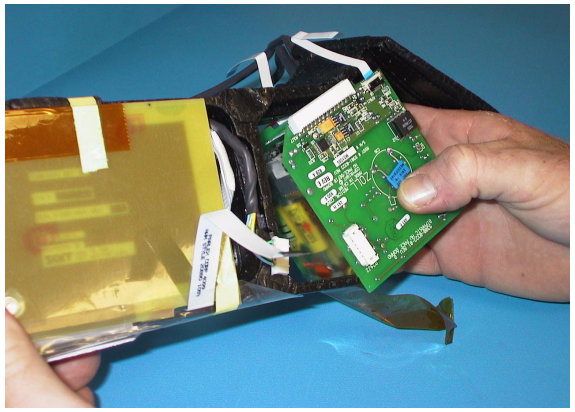
Step 1: Remove the signal cable from the High Voltage module.



Step 2: Remove the Kapton tape on the bottom of the foam surrounding the High Voltage Module.



Step 3: Separate the High Voltage Module from the foam.



8. Removing the High Voltage Capacitor Assembly

Tools Required

- #2 Phillips screwdriver
- Exacto-Knife
- Mylar® tape

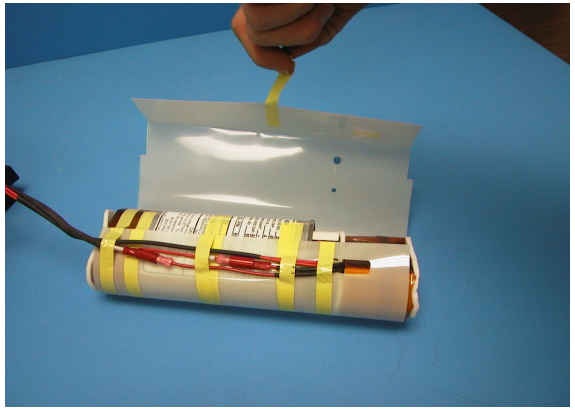
Setup

1. Remove the Front Panel Assembly.
2. Remove the Upper Housing Assembly.
3. Remove the System Board.
4. Remove the Battery Interconnect Board.
5. Remove the High Voltage Charger Assembly.
6. Lift the Capacitor Assembly upwards from the chassis. (The Capacitor Assembly is still connected to the High Voltage Module Assembly.)

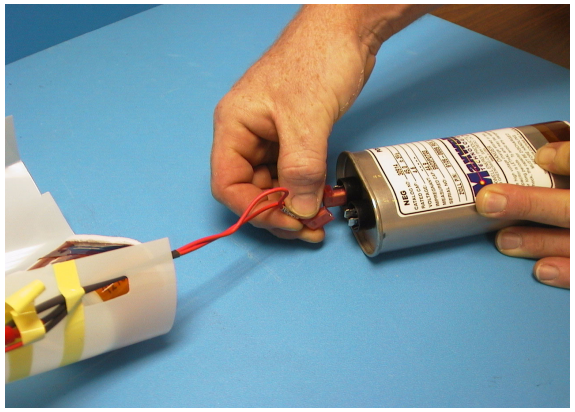
To reinstall the High Voltage Capacitor Assembly, reverse the steps.

WARNING! This unit may contain lethal voltages. You MUST completely discharge the high voltage capacitor before removing from unit. DO NOT SHORT THE TERMINAL ENDS OF THE CAPACITOR

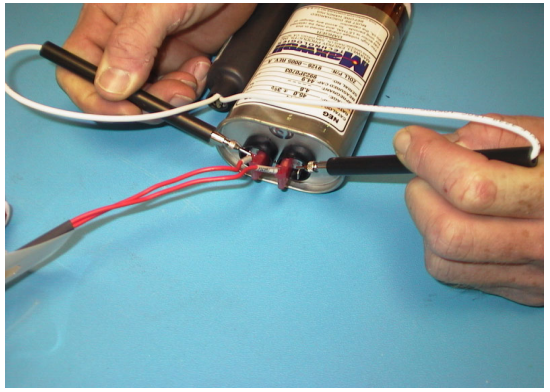
Step 1: Open the High Voltage Capacitor plastic isolator by lifting the Mylar tape.



Step 3: When the capacitor voltage is at 0 VDC, disconnect the inductor wires and capacitor terminal wires.



Step 2: Bleed the excess voltage using a resistor with values of approximately 5 kohms, 25 watts for 10-20 seconds. Measure the voltage on the capacitor terminals.



9. Removing the System Interconnect Board

Tools Required

- #2 Phillips screwdriver

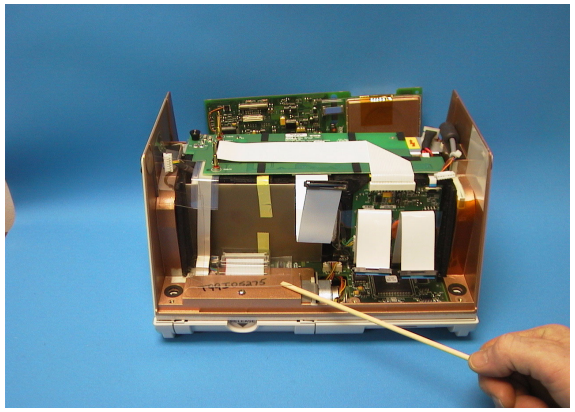
Setup

1. Remove the Front Panel Assembly.
2. Remove the Upper Housing Assembly.
3. Remove the System Board.
4. Remove the Battery Interconnect Board.
5. Remove the High Voltage/Charger module.
6. Remove the clear plastic print head isolater.
7. Remove the motor cable, cable print head and paper sensor cable.

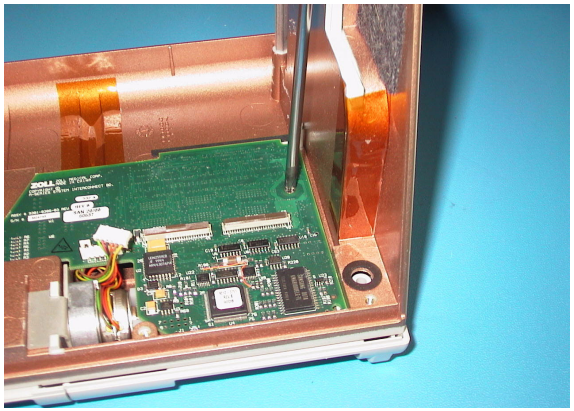
To reinstall the System Interconnect Board:

1. Install the laminate cables and keepers.
2. Ensure that the PCMCIA slots with gaskets are located to the right rear of the board and seated properly.
3. Install two screws.
4. Reconnect all the cables and reverse the steps.

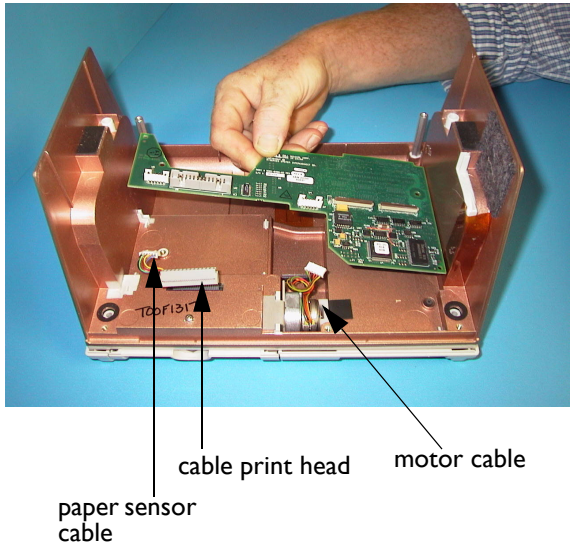
Step 1: Remove the clear plastic head isolater.



Step 2: Remove two screws from each side of the System Interconnect Board.



Step 3: Disconnect the cables and lift the System Interconnect Board out of the unit.



10. Removing the Printer/Recorder Motor

Tools Required

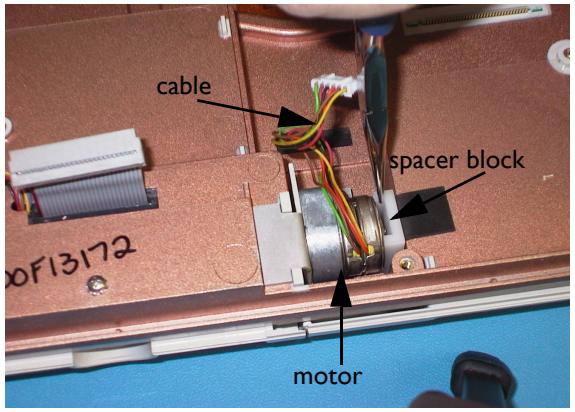
- #2 Phillips screwdriver
- Exacto-Knife
- Kapton tape

Setup

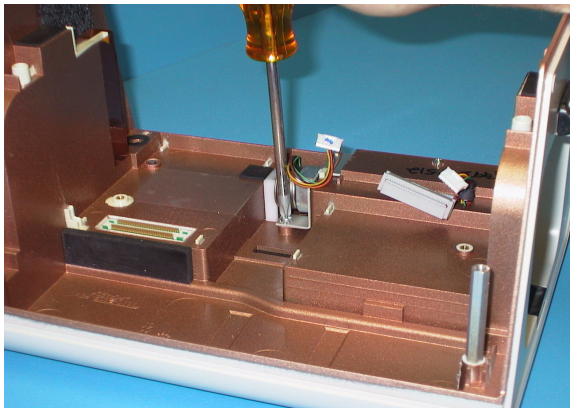
1. Remove the paper tray, pull out and press up on the locking tab at the rear of the tray.
2. Remove the Front Panel Assembly.
3. Remove the Upper Housing Assembly.
4. Remove the System Board.
5. Remove the Battery Interconnect Board.
6. Remove the High Voltage Module Assembly.
7. Remove the sensor, printhead and motor cables.
8. Remove the System Interconnect Board.

To reinstall the Printer/Recorder Motor, reverse the steps.

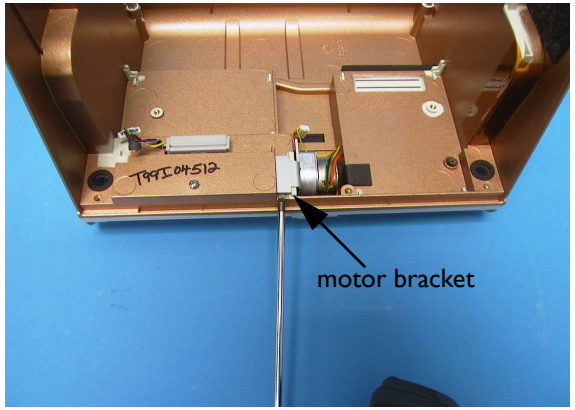
Step 1: Using the needle nose pliers, carefully lift the spacer block upwards.



Step 2: Remove the motor bracket mounting screw



Step 3: Lift the motor upward by prying on the motor bracket with the screwdriver.



11. Removing the Lower Housing Assembly

Tools Required

- #2 Phillips screwdriver

Setup

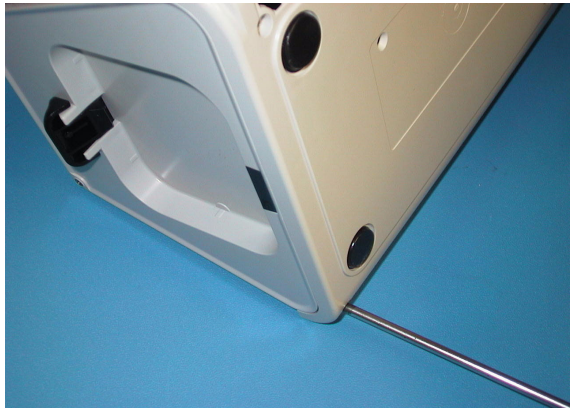
- Remove all power sources, such as the battery and power cord.

To reinstall the Lower House Assembly, reverse the steps.

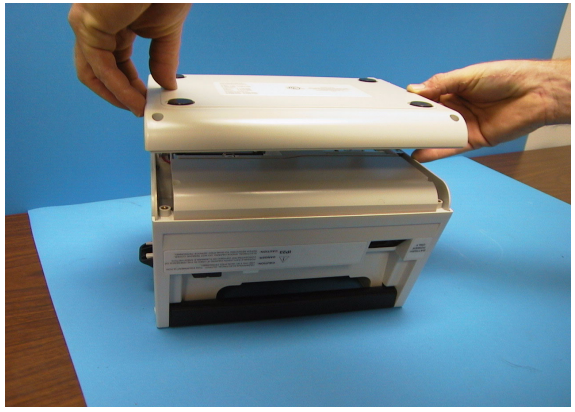
Step 1: Remove the paper tray by pulling it out and pressing the locking tab upwards at the rear of the tray.

Step 2: Remove the screw at the bottom of the unit to remove the PCMCIA FAX/Modem card's plastic protector.

Step 3: Remove the remaining screws from the bottom of the unit.



Step 4: Lift the lower housing assembly straight up and out from the unit.



12. Removing the Print Head Assembly

Tools Required

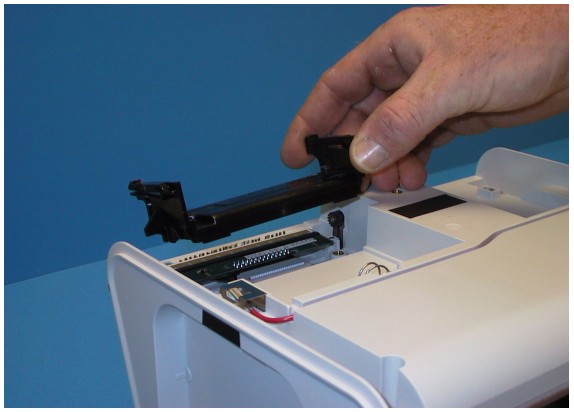
- #1 Phillips screwdriver

Setup

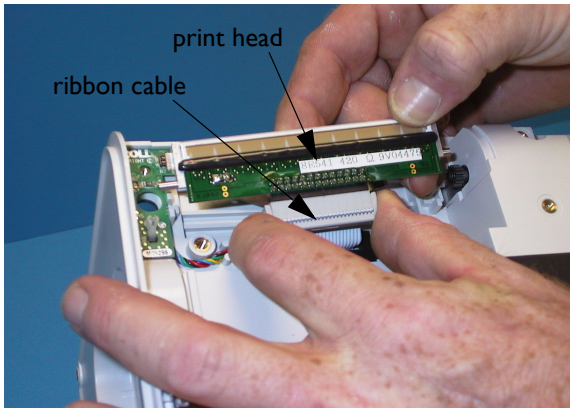
- Remove the Lower Housing Assembly.

To reinstall the Print Head Assembly, reverse the steps.

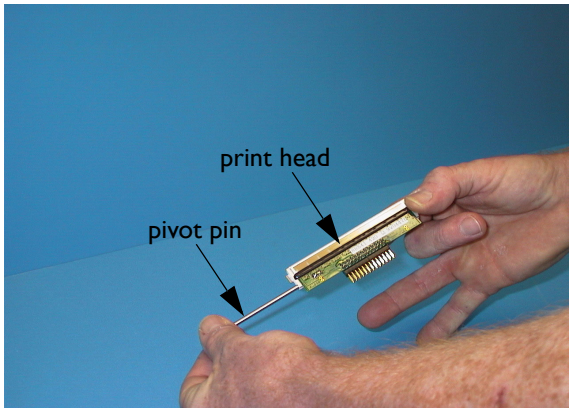
Step 1: Remove two screws from the paper tray guide and remove the paper tray guide.



Step 2: Disconnect the ribbon cable from the print head.



Step 3: Remove the pivot pin for re-use.



13. Removing the PCMCIA Card Slot Assembly

Tools Required

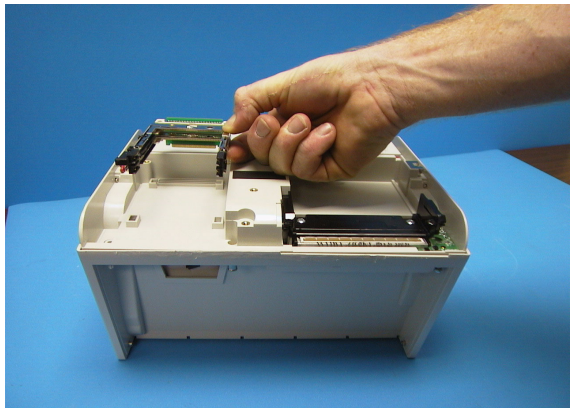
- #2 Phillips screwdriver

Setup

- Remove the Lower Housing.

To reinstall the PCMCIA card slot, reverse the steps.

Step 1: Remove the two screws holding the card slot retainer. Lift up card slot assembly.



14. Removing the Paddle Release Latch

Tools Required

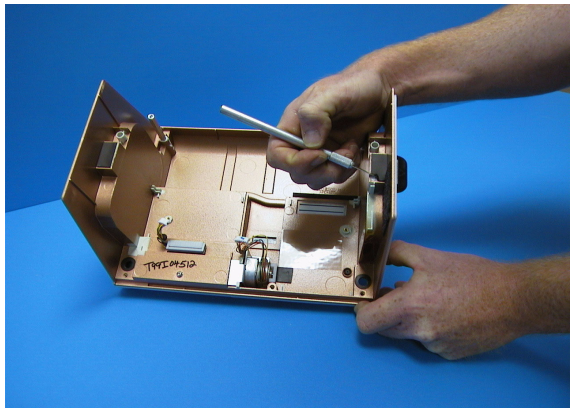
- #2 Phillips screwdriver
- Exacto-Knife
- Upper Latch Seal (9330-0304)

Setup

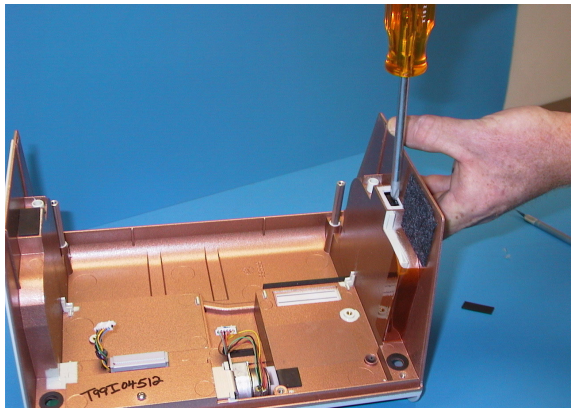
1. Remove the Front Panel Assembly.
2. Remove the Upper Housing Assembly.

To reinstall the Paddle Release Latch, reverse the steps.

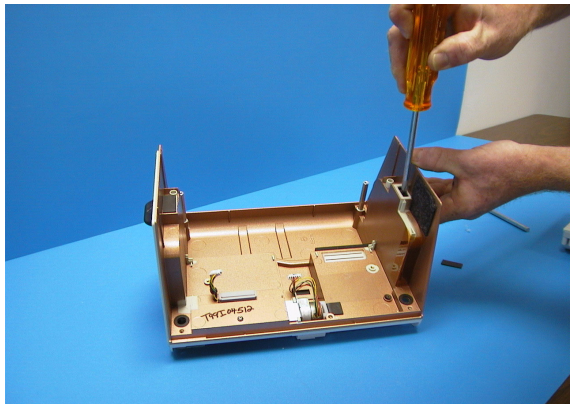
Step 1: Using the Exacto Knife, remove the adhesive seal on the unit's chassis.



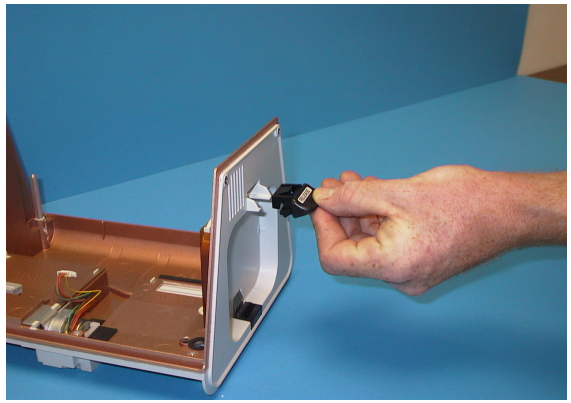
Step 2: Insert the screwdriver into the opening under the adhesive seal.



Step 3: Gently push the screwdriver until the Paddle Release Latch is dislodged.



Step 4: Pull Paddle Release button away from the unit.



Chapter 4
Replacement Parts

Overview

This section contains a listing of the replacement parts available for the ZOLL M 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 M Series device model and serial number
- Field Replaceable unit part number
- Description of the replacement part

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

ZOLL Medical Corporation

32 Second Avenue

Burlington, MA. 01803-4420

Attention: Technical Service Department

1-781-229-0020; 1-800-348-9011; Fax: 1-781-229-0758

Note

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

Replacement Parts

Description	Part Number
12 Lead ECG Cable	1001-0031-01
3M 12 Conductor Cable - LCD	0500-6000
4-40 x 1/4, System Interconnect Board, Mounting Screw	0163-0626
4-40 x 3/8 Modem Bezel Screw	0163-0153
6/32 x 3/8 Screws, Housings	0163-0912
AC Power cord w/ferrite	1001-0195-01
AC Receptical Assembly	1001-0114
Access/Detect Cable	9500-0500
Adhesive Barrier, Speaker	9330-0324
AED Non-Pacing Membrane	1001-0187-01
Assembly Cable, EL (Yellow) Display	1001-0171
Assembly Cable, ECG out, Cable Sense	9500-0500
Assembly Capacitor & Choke (DSW)	1001-0134
Assembly Paddle Test Harness	1001-0102
B/W LCD Cable Assembly	1001-0173
Barrier, Isolation, Chassis, Print Head Cable	9330-0332
Barrier, Moisture, Speaker	9330-0305
Bezel, Modem, Center Open	9310-0512

Description	Part Number
Bracket, Speaker Mount	9320-0409
Brush, Static Dissipation	9340-0102
Bumper, Chassis, High Voltage, Capacitor	9330-0205
Cable Flex CRT. 312 TO System Board	9500-0519
Cable Laminate, 50 Pin	9500-0501
Cable, Laminate, ECG Connector to System Board	9500-0506
Cable, Recorder Print Head	9500-0400
Configuration Manual	9650-0201-01
Connector Assembly SPO2 (din connector)	1001-0160
ECG Connector 12 Lead	1001-0232
ECG Input Connector Assembly	1001-0132
ECG Laminated Cable	9500-0506
EL (Yellow) Display only	9355-0505
EL Display	1011-0029
FED Display	0208-0011
Front Panel Membrane Switch Assembly	1001-0135-01
Front Panel Screw, 6-32x 1 3/4	0163-0211
Gasket, Battery Pin	9330-0317
Gasket, Die Cut, Printer Motor	9340-0101

Description	Part Number
Gasket, MPPM Port and Motor Support, Chassis	9330-0303
Gasket, PCMCIA Connector, System Interconnect Board	9330-0312
Gasket, Print Head Cable	9330-0314
Handle (Part One)	9310-0545
Handle Insert (Part Two)	9310-0546
Isolator, High Voltage Module, Folded	1001-0146v
Isolator, Left Side Chassis	9310-0552
Keeper, 50 Pin Laminate Cable	9310-0573
Knob, Main Selector	9310-0521
Knob, Pace Control	9310-0520
Latch Paddle Release	9310-1514
Latch Spring	0190-0100
LCD Display	9355-0510-99
LCD Frame	9310-0595
Leafspring, Print Head	9320-0300
Lower Housing	1001-0124
Lower Latch, Paddle	9310-0511
Lower Latch, Pivot	9320-0065
Main Chassis	9310-2502-90
MFC Signal Cable	9500-0517

Description	Part Number
Motor Support (Teflon Piece)	9330-0355
M Series Main Label Set	9305-0527-01
Noncharger Substitute Board	9301-0311
O-ring, MFC, M Series	0160-6950
Paddle Shoes	1001-0148
Paper Tray Assembly	1001-0103
PCMCIA Conn., Assembly	3001-0101
PCMCIA Stabilizer Board	9320-0304
Pivot Rod, Printhead	9320-0401
Print Head Assembly	1001-0101
Print Head Support/Paper Tray Guide	9310-0510
Recorder Motor Assembly	1001-0104
Retainer, Latch Paddle Release	9310-1515
Rubber Foot x 4	0310-0311
Seal, Pace and Main Selector Knobs	9310-0548
Snap Rivet, Battery Interconnect Board	0163-1709
Spacer, Lower Latch, Paddle well	9320-0315
Speaker Assembly	1001-0115
Spring, Recorder Tray	0190-0101
Tape, Copper Adhesive, Roll (54')	0550-0037

Description	Part Number
Tape, Kapton, Roll (108')	0550-0003
Tape, Yellow Mylar, Roll (108')	0550-0125
Universal cable	1001-0196-01
Upper Housing	1001-0126
Upper Latch Seal	9330-0304

Field Replacement Parts

Description	Part Number
Battery Interconnect for units $EtC0_2$	9301-0303
HV Assembly Module (DSW) Defib Only	1001-0105-03
System Board 50 MHz 9301-0300-01	1001-0130-01
System Board 50 MHz (LCD only) 9301-0300-02	1001-0130-02
System Board 3/5 lead w/audio 9301-0337-02	1001-0130-14
System Board 12 lead w/audio 9301-0337-02 and 9301-0304	1001-0130-15
LCD Interface PWB for use with New Inverter	9301-0313
Biphasic Bridge Cap Assembly	1001-0181
Biphasic HV Module	1001-0182
AC Charger with $EtCO_2$ Heatsink	1001-0108-02
HV Assembly Module (DSW) Pace/Defib	1001- 0105

Description	Part Number
Battery Interconnect (pre $EtCO_{2)}$	9301-0302
Paper Sensor Board	1001-0131
System Interconnect	9301-0306
AC Charger Board with Heatsink	1001-0108
Control Board with Pace	9301-0312
LCD Display Interface Board	9301-0308
SpO_2 Board (Masimo)	1001-0158
Power Supply, Isolated, SpO_2	1001-0159
DC Charger Board with Heatsink	1001-0107
100 Mhz AED/SpO_2 non 12 Lead (901-0300-04)	1001-0130-04
System PCB. (Biphasic only 9301-0300-03)	1001-0130-03
100 Mhz 12 Lead/SpO_2 (9301-0307)	1001-0130-05
System Interconnect 12 Lead Faxing	9301-030602
PCB Control with Pace Non-AED	9301-0312-05
Assy PCB Connector $EtCO_2$	9301-0325
$EtCO_2$ Isolated power supply includes EtCO2 PCB	1001-0015 3001-0103
PCB control no pace	9301-0312-02
PCB control AED with pace	9301-0312-03
PCB control AED no pace	9301-0312-04

Description	Part Number
12 Lead Based (9301-0337-01)	1001-0130-09
3/5 Lead With Audio 9301-03 37-02 and 9301-0304	1001-0130-10
12 Lead (9301-0307-01)	1001-0130-06
3/5 Lead/Biphasic (9301-0307-02)	1001-0130-07
System Interconnect Board with Faxing Capability	9301-0306-03
PCB control without pace non AED	9301-0312-06
PCB control with pace AED	9301-0312-07
PCB control without pace	9301-0312-08

Chapter 5
Functional Description

Overview

This chapter provides functional descriptions of the components contained in the ZOLL M Series and the M 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 Module

- 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

M Series Options

12 Lead Monitoring

Pulse Oximetry ($SpO_{2)}$

End Tidal Carbon Dioxide ($EtCO_{2)}$

Biphasic Module

Main System Board

The M 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 M 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 M Series options. These options include:

- 12 Lead ECG
- Pulse Oximetry (SpO_2)
- End Tidal Carbon Dioxide ($EtCO_2$)
- Biphasic Defibrillation Waveform

Refer to the M 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)	$EtCO_2$ PWBA Isolated Power Supply PWBA
12 Lead (optional)	Main System PWBA

Main System Board Functions

The Main System Board contains the major computing and control elements for the M 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 and $EtCO_2$ 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 M 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 and $EtCO_2$ 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 M 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 M 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). An Hitachi SH-3 RISC microprocessor acts as the system's main CPU. The SH-3 CPU and 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, solid state patient relay, safety relay, defib capacitor, defib choke and front end protection circuitry for the MFC ECG. There are two different types of HV Modules: a damped sinusoidal waveform HV module and a Biphasic (HV) module.

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.
Monophasic HV	Provides damped sinusoidal waveform therapeutic energy. (Monophasic units only.)
Biphasic HV	Provides biphasic waveform therapeutic energy. (Biphasic units only.)

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.

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 M 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 2500 volts above ground, and the negative capacitor terminal is approximately 2500 volts below ground (at 360J 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 solid state patient relay and notification to the Main System Board through the PADMON signal. The Main System Board then controls activation of the solid state patient relay (for DSW only). Energy delivered to the patient goes through a wave shaping inductor to create a defibrillation waveform compliant with AAMI Standards. When the patient discharge SCRs are deactivated, the safety relay closes to internally dissipate any remaining energy.

If the M 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 solid state 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 solid state 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 damped sinusoidal waveform and 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.
VSENS	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.

Analog Voltage	Operation	Comment
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.

Logic Control Signal	Operation
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.

AC/DC Charger Module

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 M Series and power sources. This module also provides the power necessary to run the M Series in any mode of operation, as well as providing additional charging current to the battery. When the M 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 M 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

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.

M Series Options

This section describes four options for the M Series unit.

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.

12 Lead Option

The ZOLL M 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. M Series unit must have the 12 lead option installed. All limb leads and at least one V-lead 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. Several PCMCIA fax modems are supported and the modem determines the specific phone compatibility. Cellular phone support includes analog AMPS phones (in the U.S.) and GSM phones (internationally). The M-Series supports Group 3 facsimile, Class 1 and Class 2. 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 M 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 M 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 M 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 M Series system board. The M 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 M Series $EtCO_2$ Novametrix technology and Capnostat® sensor 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.

The $EtCO_2$ option incorporates, without modification, the Novametrix respiratory carbon dioxide technology, including a printed circuit board, and a patented and proprietary mainstream CO_2 sensor and reusable/disposable airway adapters. Carbon dioxide measurements are monitored by using a solid-state infrared Capnostat® sensor which works on the principles of infrared absorption.

The M Series system board software transmits commands to the Novametrix board to set parameters (averaging mode, oxygen, and nitrous oxide compensation) and retrieves CO_2 waveform, $EtCO_2$, and respiration rate data. The M Series software formats the data for output to the display and strip chart recorder. In addition, the M Series software performs range checking of the Novametrix data to determine the presence of low or high $EtCO_2$ and respiration rate alarm limit violations. If the limits have been violated, the software issues audio and visual alarms.

The Capnostat® mainstream sensor is attached to an airway adapter that connects to an endotracheal tube, similar airway, or disposable mouthpiece. The sensor generates infrared light and beams it through the airway adapter to a detector on the opposite side of the airway. As a result of respiration, CO_2 flowing through the airway adapter absorbs some of this infrared energy. The monitor relates the amount of detected energy to the amount of CO_2 in the airway adapter. The CO_2 display reflects the maximum concentration of CO_2 detected during expiration. End-Tidal Carbon Dioxide ($EtCO_2$) displays as a numerical value in millimeters of mercury (mmHg), percent (%), or kilopascals (kPa) on the unit. In addition, a capnogram waveform may display underneath the ECG waveform.

The $EtCO_2$ option uses Non-Dispersive Infrared (NDIR) absorption and dual wavelength ratiometric-True Single Beam Optics. The Capnostat® sensor contains the NDIR light source. Carbon dioxide, flowing in the airway adapter as a result of respiration, absorbs some of this light energy.

Biphasic Waveform

The M Series Biphasic Waveform Defibrillator produces a rectilinear biphasic defibrillator waveform similar to the chart shown at the end of this section. The electrical energy is delivered in two successive current phases of opposite polarity. As compared to the monophasic waveform, the biphasic waveform typically defibrillates with substantially less current than the earlier monophasic waveform used by most defibrillators.

The M Series Biphasic Defibrillator system consists of circuitry and software located on the following assemblies:

1. Main System PWBA.

2. High Voltage Module.

3) Biphasic Bridge PWBA Module.

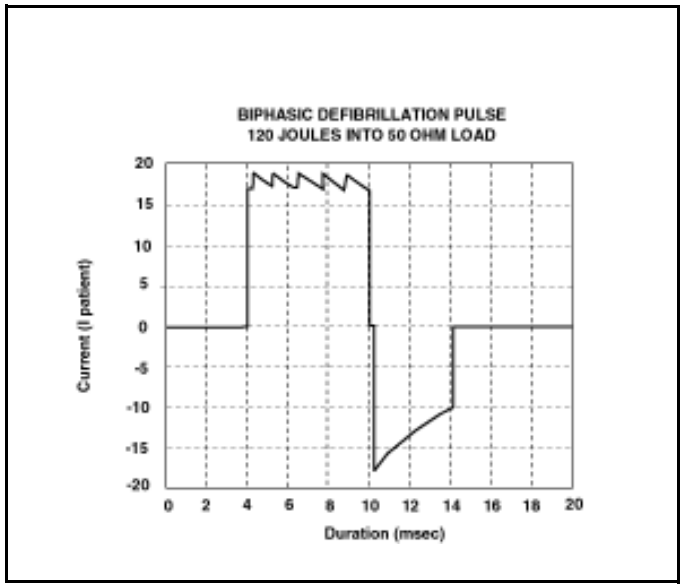
The High Voltage module controls the monitoring, charging, and internal discharges of the defibrillator capacitor. The Bridge module controls capacitor discharge, including waveform polarity control, patient current and voltage monitoring during discharge and real-time control over defibrillator internal impedance to create the rectilinear waveshape. The main CPU controls the waveform timing and resistor switching performed by the Bridge Module based upon measured patient transthoracic impedance.

The Biphasic Bridge Assembly is constructed as two printed wire board assemblies (PWBAs) containing the power and isolation circuits required to deliver a biphasic defibrillation pulse. These boards produce a defibrillation pulse consisting of a positive current pulse followed by a negative current pulse. The positive portion of the pulse is shaped to be rectilinear by switching resistors in series with the patient to compensate for droop in the capacitor voltage as it delivers energy to the patient load.

The ZOLL Biphasic units produce a rectilinear waveform whose shape remains essentially constant from patient to patient. The rectilinear biphasic waveform consists of a 6 millisecond, essentially constant current first phase followed by a 4 millisecond, truncated exponential second phase. The first and second phases of the defibrillation waveform are of opposite polarity and their amplitudes vary based on the user selected therapeutic energy level. The initial amplitude of this waveform's second phase is approximately equal to the first phases's final amplitude. This wavefrom has an integrated patient impedance measurement sensing pulse at the beginning of the waveform. The positive and negative phases are separated by 100 µsec.

Electronics and software control the shape of the waveform's first phase and compensate for different transthoracic impedances to maintain an essentially constant current throughout the first phase.When the highest energy setting is selected and patient impedance exceeds 85 ohms, the first phase of the waveform will droop. All other waveform parameters (phase duration, inter-phase delay and integrated impedance measurement sensing pulse) remain the same.

The following Rectilinear Biphasic Waveform is produced when the M Series with Biphasic option is discharged into a 50 ohm load at the default energy setting of 120 joules. The vertical axis is in amperes; the horizontal axis is in milliseconds. (See following diagram.)



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Appendix

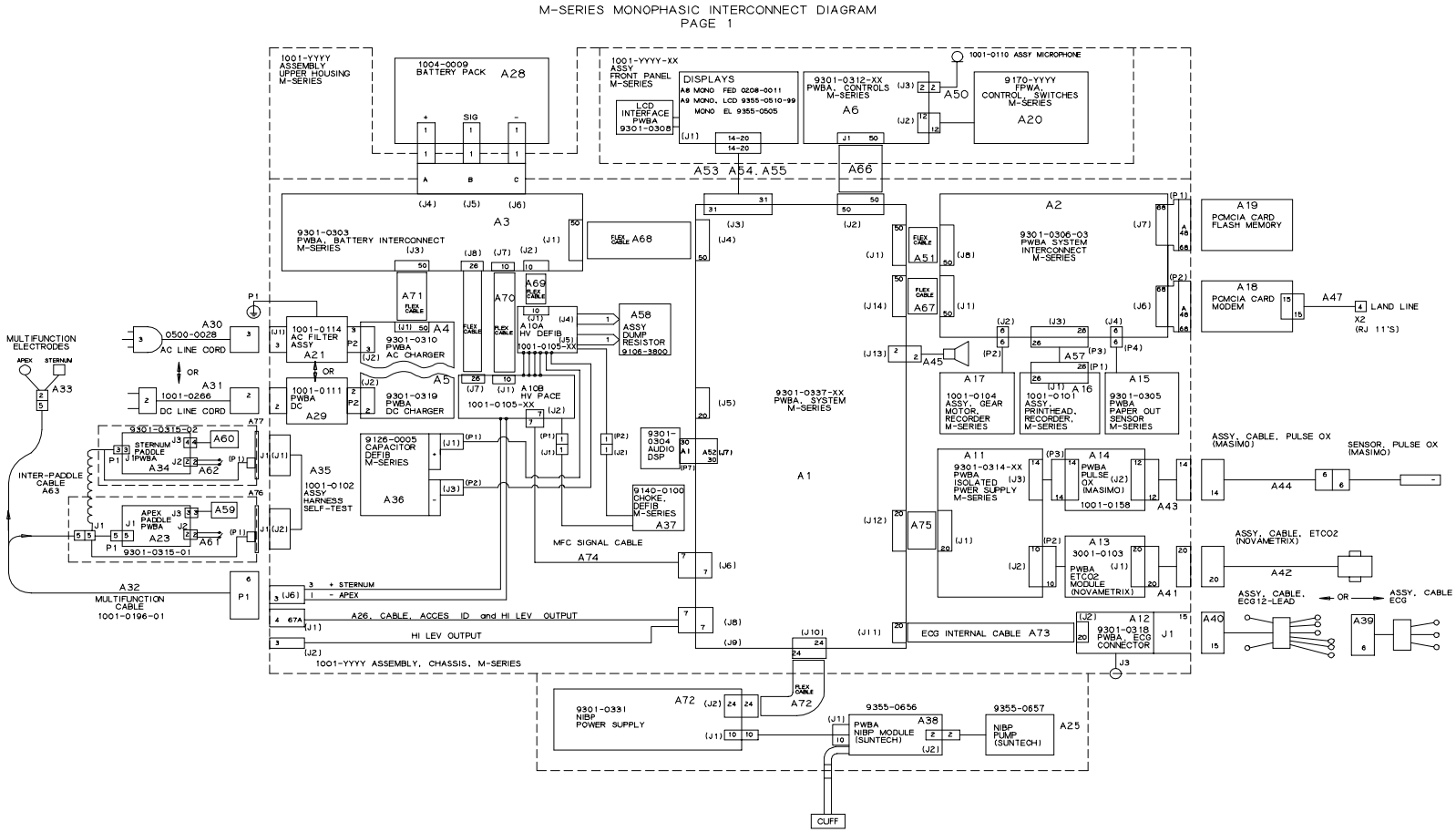
Overview

This appendix includes:

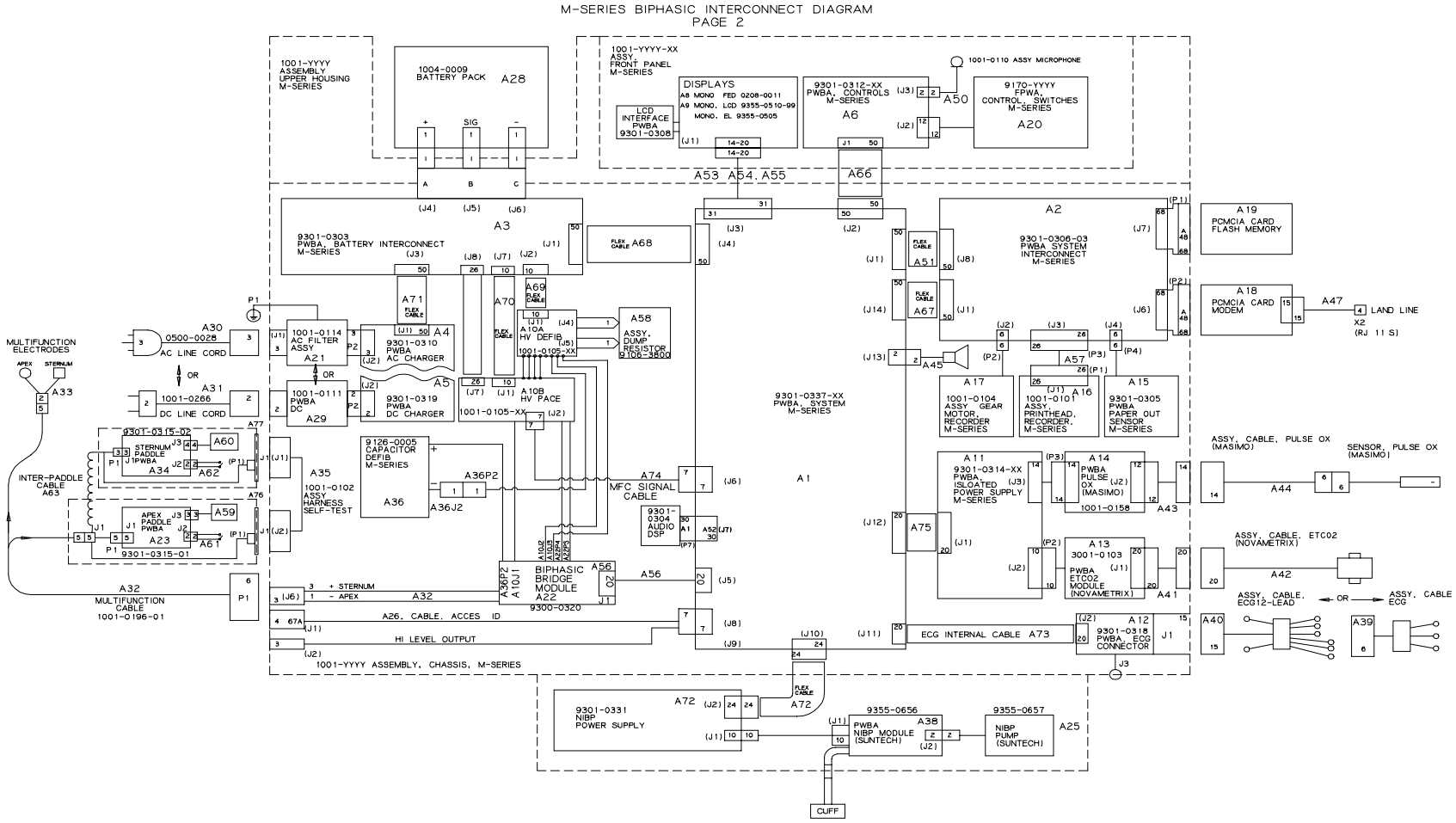
- ZOLL M Series Interconnect diagrams
- ZOLL M Series Maintenance Tests Checklist

Photocopy the ZOLL M Series Checklist to use it for your six month maintenance checklist of the M Series equipment.

Interconnect Diagram for M Series Monophasic Unit



Interconnect Diagram for M Series Biphasic Unit



ZOLL M Series Maintenance Tests Checklist

Serial #_____ Location _____ Test Date___/___/___

Tester_____ Signature_____

Result of Check:

- ☐ No action required
- ☐ Minor problems corrected
- ☐ Disposable supplies replaced
- ☐ Major problems identified

(Unit out of service)

Additional Remarks

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Inspection Test

	Pass	Fail	NA
1.1	☐	☐	
1.2	☐	☐	
1.3	☐	☐	
1.4	☐	☐	
1.5	☐	☐	
1.6	☐	☐	
1.7	☐	☐	
1.8	☐	☐	
1.9	☐	☐	
1.10	☐	☐	
1.11	☐	☐	
1.12	☐	☐	
1.13	☐	☐	
1.14	☐	☐	
1.15	☐	☐	
1.16	☐	☐	

Front Panel Button Test

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

Leads Test

	Pass	Fail	NA
3.1	☐	☐	☐
3.2	☐	☐	☐
3.3	☐	☐	☐
3.4	☐	☐	☐

Power Supply Test

	Pass	Fail	NA
4.1	☐	☐	
4.3	☐	☐	
4.4	☐	☐	
4.5	☐	☐	
4.6	☐	☐	
4.8	☐	☐	☐
4.10	☐	☐	

Leakage Current Test

	Pass	Fail	NA
5.0	☐	☐	

Paddles Test

	Pass	Fail	NA
6.1	☐	☐	
6.2	☐	☐	
6.3	☐	☐	☐
6.4	☐	☐	
6.5	☐	☐	
6.6	☐	☐	
6.7	☐	☐	

Heart Rate Display Test

	Pass	Fail	NA
7.1	☐	☐	☐

Calibrating Pulse Test

	Pass	Fail	NA
8.2	☐	☐	☐

Notch Filter Test

	Pass	Fail	NA
9.3	☐	☐	☐

Heart Rate Alarm Test

	Pass	Fail	NA
10.1	☐	☐	
10.2	☐	☐	
10.3	☐	☐	
10.4	☐	☐	
10.5	☐	☐	
10.6	☐	☐	
10.7	☐	☐	
10.8	☐	☐	
10.9	☐	☐	
10.10	☐	☐	
10.11	☐	☐	☐
10.12	☐	☐	☐
10.13	☐	☐	
10.14	☐	☐	

Defibrillator Self Test

	Pass	Fail	NA
11.1	☐	☐	
11.2	☐	☐	
11.3	☐	☐	
11.4	☐	☐	
11.5	☐	☐	
11.6	☐	☐	
11.7	☐	☐	

Synchronized Cardioversion Test

	Pass	Fail	NA
12.2	☐	☐	
12.4	☐	☐	

Shock Test

	Pass	Fail	NA
13.1	☐	☐	☐
13.2	☐	☐	☐
13.3	☐	☐	☐
13.4	☐	☐	
13.5	☐	☐	
13.6	☐	☐	
13.7	☐	☐	
13.8	☐	☐	
13.9	☐	☐	☐
13.10	☐	☐	☐

ZOLL M Series Maintenance Tests Checklist

Serial #_____ Location _____ Test Date___/___/___

Tester_____ Signature_____

Summary Report Test

	Pass	Fail	NA
14.1	☐	☐	☐
14.2	☐	☐	☐
14.3	☐	☐	☐
14.4	☐	☐	☐

Advisory Message Test

	Pass	Fail	NA
15.2	☐	☐	☐
15.3	☐	☐	☐
15.4	☐	☐	☐

Pacer Test

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

SpO_2 Monitor Test

	Pass	Fail	NA
17.1	☐	☐	☐
17.2	☐	☐	☐
17.3	☐	☐	☐
17.4	☐	☐	☐
17.5	☐	☐	☐
17.6	☐	☐	☐
17.7	☐	☐	☐
17.8	☐	☐	☐
17.9	☐	☐	☐
17.10	☐	☐	☐

$EtCO_2$ Monitor Test

	Pass	Fail	NA
18.2	☐	☐	☐
18.3	☐	☐	☐
18.4	☐	☐	☐
18.5	☐	☐	☐