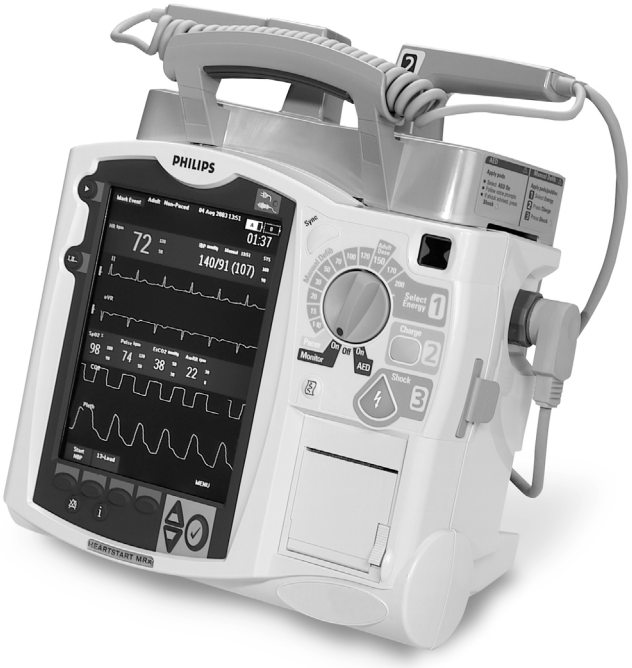
PHILIPS

HEARTSTART MRx

MONITOR/DEFIBRILLATOR



HEARTSTART MRx

Service Manual

M3535A
M3536A

Notice

About This Edition

Edition 4

Printed in the USA

Publication number M3535-90900

The information in this document applies to the HeartStart MRx product version indicated below. This information is subject to change without notice.

Philips shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

Edition History

Edition	Product Version	Print Date
1	A.00/A.01	December, 2003
2	A.02 and earlier	June, 2004
3	B.03 and earlier	November, 2004
4	B.xx and earlier	January, 2005

Copyright

SMART Biphasic is a registered trademark of Philips.

FilterLine is a registered trademark of Oridion Medical Ltd.

Use of supplies or accessories other than those recommended by Philips may compromise product performance.

THIS PRODUCT IS NOT INTENDED FOR HOME USE.

IN THE U.S., FEDERAL LAW RESTRICTS THIS DEVICE TO SALE ON OR BY THE ORDER OF A PHYSICIAN.

Medical Device Directive

The HeartStart MRx complies with the requirements of the Medical Device Directive 93/42/EEC and carries the CE 0123 mark accordingly.

Manufacturer

Philips Medical Systems

3000 Minuteman Road

Andover, MA USA 01810-1099

(978) 687-1501

Authorized EU-representative:

Philips Medizin Systeme Böblingen GmbH
Hewlett Packard Str. 2
71034 Böblingen
Germany

Canada EMC:ICES-001

Warning

Radio frequency (RF) interference from nearby transmitting devices may degrade the performance of the HeartStart MRx. Electromagnetic compatibility with surrounding devices should be assessed prior to using the monitor/defibrillator.

Conventions Used in This Manual

This Service Manual contains the following conventions:

WARNING Warning statements describe conditions or actions that can result in personal injury or loss of life.

CAUTION Caution statements describe conditions or actions that can result in damage to the equipment or loss of data.

NOTE Notes contain additional information on usage.

TIP Tips provide hands-on insight into servicing this product.

TEXT	represents messages that appear on the screen
`[Softkey]`	represents softkey labels that appear on the screen above or below the button to which they correspond.

On-line viewing only

Hypertext	represents hypertext links, which will display as blue; click on the blue link to go to that destination, then click on the blue destination to return.

Abbreviations

Name	Abbreviation
HeartStart MRx Monitor/Defibrillator	monitor/defibrillator device
Noninvasive Blood Pressure	NBP
End-tidal carbon dioxide	$EtCO_2$
Carbon dioxide	CO_2
Pulse Oximetry	SpO_2

Table of Contents

1

Introduction

This Service Manual provides the information needed to successfully service the M3535A/M3536A HeartStart MRx monitor/defibrillator. This manual provides you with information on troubleshooting, repairing, and performance verification and safety testing of the monitor/defibrillator. There is also information on the theory of operation, maintenance procedures, and ordering parts and supplies.

Who Should Use This Manual

The intended users of this manual are technical personnel who have been trained in the safe and proper servicing of the HeartStart MRx. To assist in training, the Service Training video (M3535-89300 NTSC, M3535-89310 PAL) is available.

Overview

In this chapter, you'll find general information that you should know before servicing the HeartStart MRx. Detailed information regarding controls, operation, and capabilities of the device can be found in the *Instructions for Use* that was shipped with the product. The *Instructions for Use* also provides information on setting up the device and regular maintenance procedures, such as performing operational checks and battery maintenance. We recommend you review the *Instructions for Use* before servicing this device. This Service Manual assumes you are familiar with the controls and with basic operations.

This chapter is organized into the following sections:

Features and Capabilities

The HeartStart MRx is a lightweight, portable, monitor/defibrillator. It provides four modes of operation, Monitor, Manual Defib, AED, and Pacer (optional).

In Monitor Mode you can monitor up to four ECG waveforms, acquired through a 3-, 5-, or 10-lead ECG set or multifunction electrode pads. Optional monitoring of pulse oximetry (SpO_2), noninvasive blood pressure (NBP), and carbon dioxide ($EtCO_2$) are also available. Measurements from these parameters are presented on the display and alarms are available to alert you to changes in the patient's condition.

Monitor Mode also provides an optional 12-Lead ECG function, enabling you to preview, acquire, store, and print 12-lead ECG reports, with or without analysis/interpretation.

Manual Defib Mode offers simple, 3-step defibrillation. You analyze the patient's ECG and, if appropriate: 1) select an energy setting, 2) charge, and 3) deliver the shock. Defibrillation may be performed using paddles or multifunction electrode pads. Manual Defib Mode also allows you to perform synchronized cardioversion and internal defibrillation.

In AED Mode, the HeartStart MRx analyzes the patient's ECG and determines whether a shock is advised. Voice prompts guide you through the 3-step defibrillation process, providing easy-to-follow instructions and patient information. Voice prompts are reinforced by messages that appear on the display.

Both Manual Defib and AED Mode incorporate the Philips' low energy SMART Biphasic waveform for defibrillation.

Optional Pacer Mode offers noninvasive transcutaneous pacing therapy. Pace pulses are delivered through multifunction electrode pads, using a monophasic waveform.

The HeartStart MRx is powered by rechargeable lithium ion batteries. Available battery power is easily determined by viewing the convenient battery power indicators located on the device display or by checking the indicators on the battery itself. Additionally, an external AC or DC power supply may be applied as a secondary power source and for continual battery charging.

The HeartStart MRx performs Automated Tests on a regular basis. The status of the device's critical functions are reported to the Ready For Use (RFU) indicator. Prominently displayed, the RFU indicator communicates the status of your device, letting you know if it is operating correctly, needs attention, or is unable to deliver therapy. In addition, performing the specified Operational Check ensures that the HeartStart MRx is functioning properly.

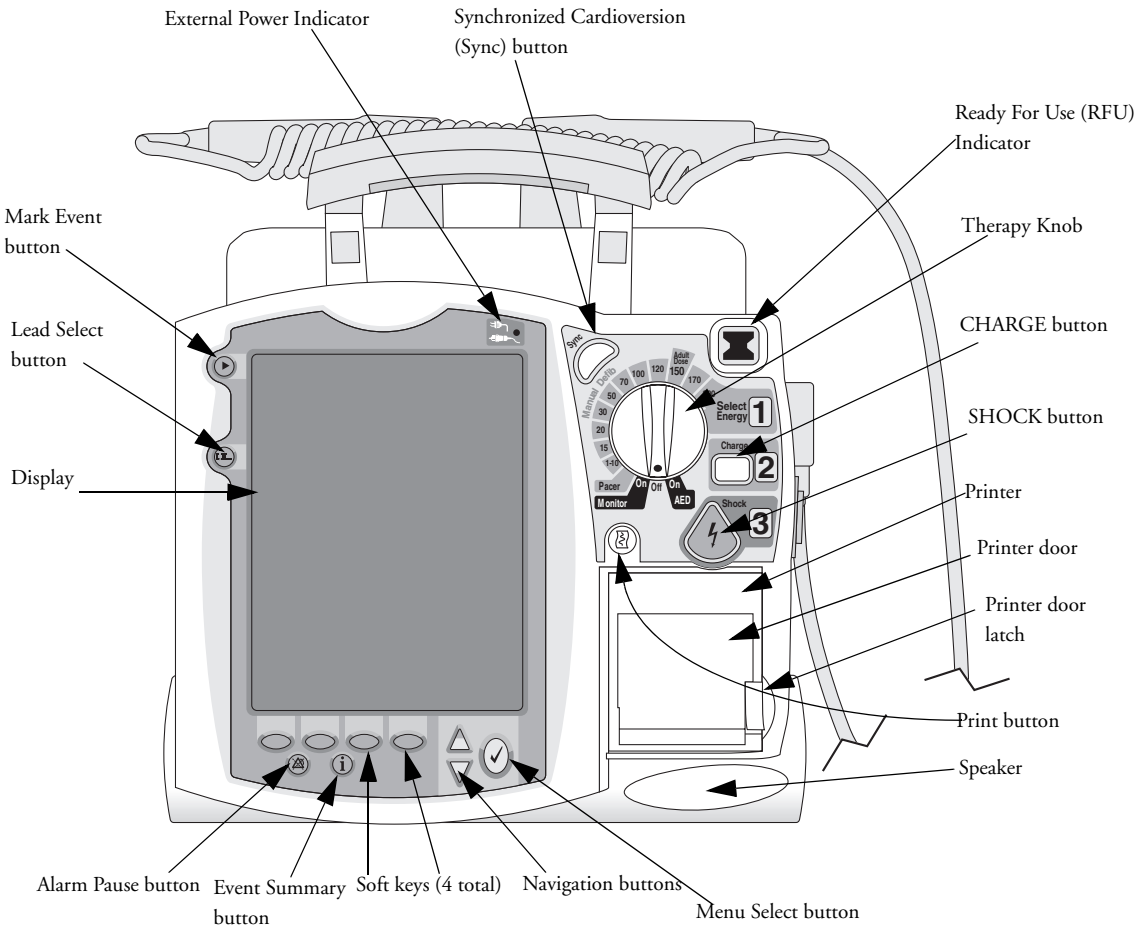
The HeartStart MRx automatically stores critical event data in its internal memory, such as Event Summaries and 12-Lead Reports. The HeartStart MRx also enables you to copy data and event information on an optional external data card for downloading to Philips' data management solution, HeartStart Event Review Pro.

The HeartStart MRx is highly configurable to better meet the needs of diverse users. Be sure to familiarize yourself with the device's configuration before using the HeartStart MRx.

Tour of the Device

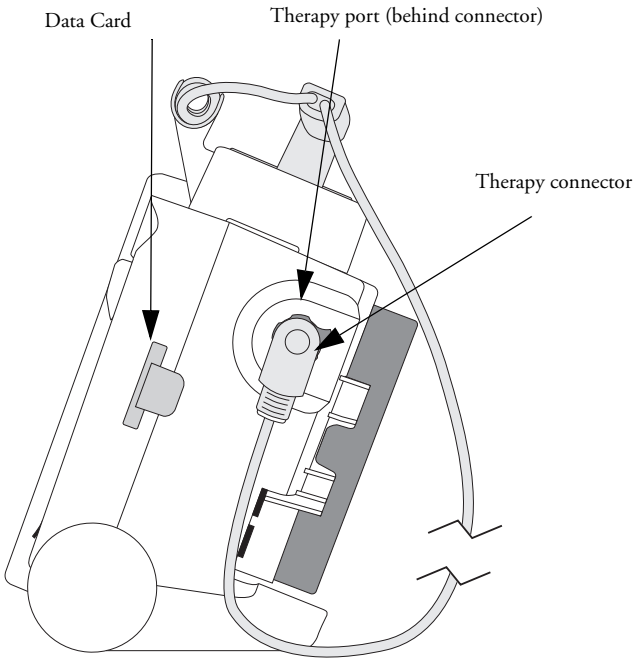
This section gives an overview of the outside of the device.

Figure 1 Front view



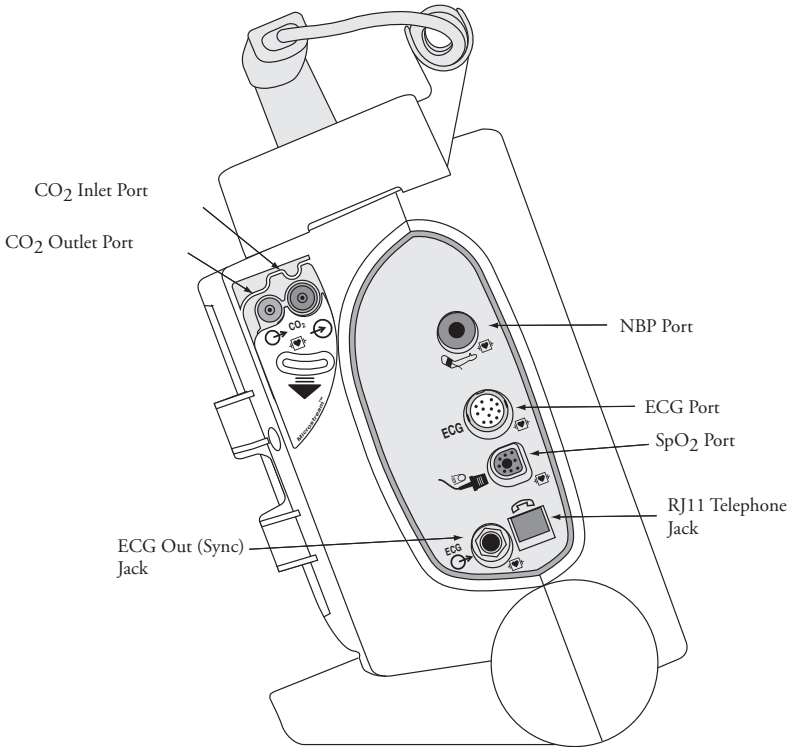
Right Side

Figure 2 Right side view



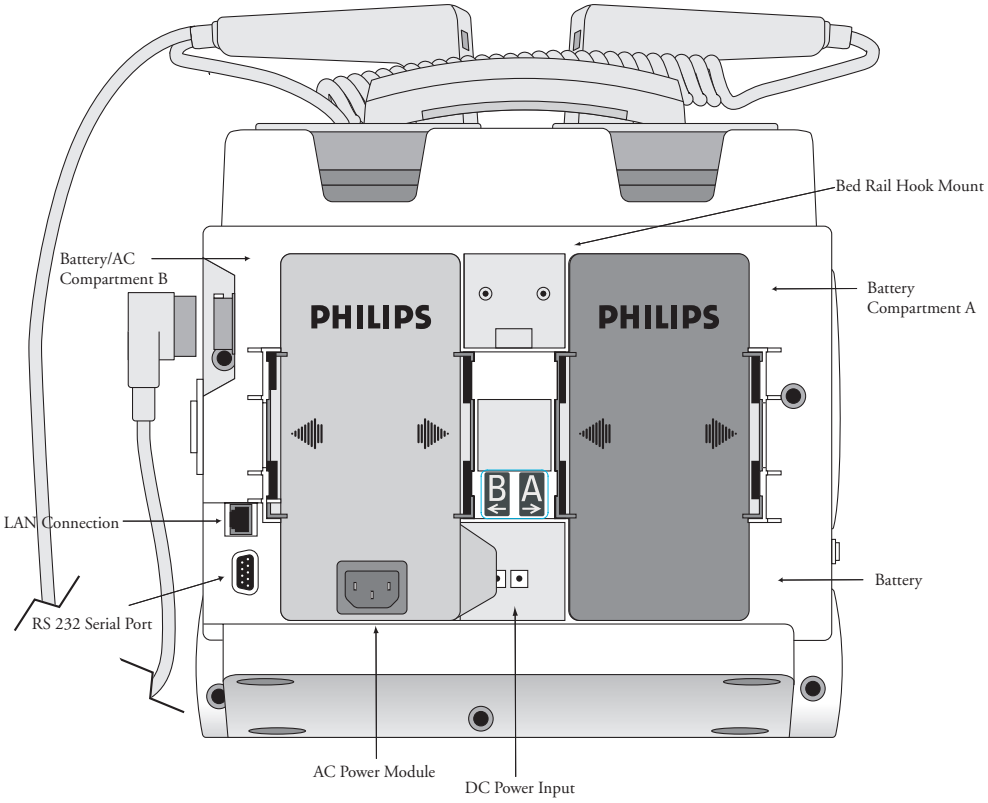
Left Side

Figure 3 Left side view



Rear

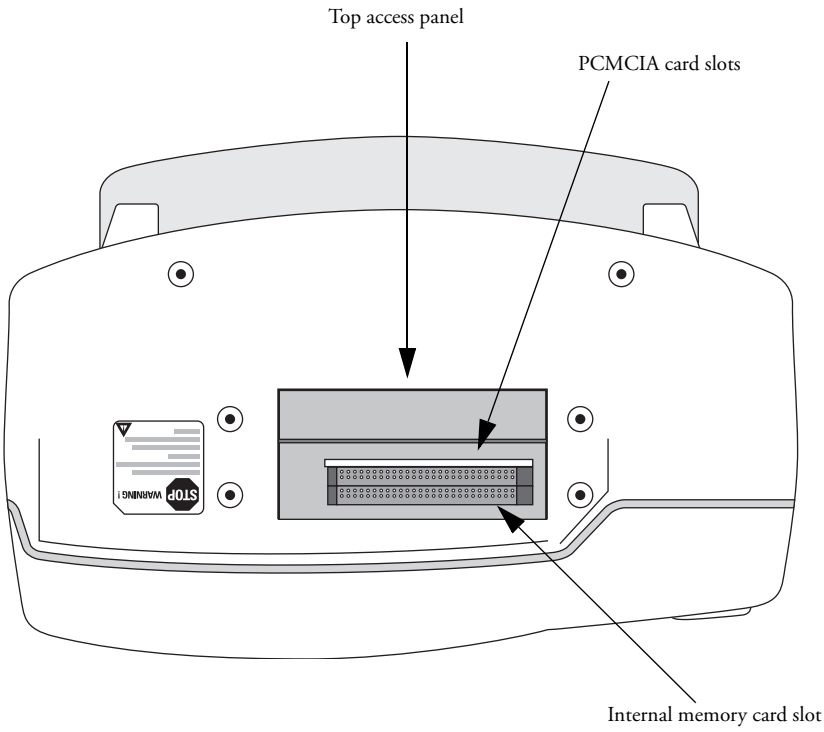
Figure 4 Rear view



NOTE The LAN port is for factory use only.

Top

Figure 5 Top view.



General Service Information

Keep the following points in mind when servicing this product.

Installation

The HeartStart MRx does not require installation. The *Instructions for Use* describes the setup required before placing the device into service, as well as configuration options. All setup activities are designed to be performed by personnel trained in the proper operation of the product. To obtain a copy of the *Instructions for Use* and other MRx documentation go to: www.medical.philips.com/goto/productdocumentation.

Display Menus

To display a menu, press the Menu Select button. Then use the up or down Navigation buttons to scroll through the available choices until the desired selection is highlighted. To activate the selection, press the Menu Select button. Press **Exit** to close the menu without activating a selection.

Passwords

In order to access different modes within the monitor/defibrillator, a password is required. The passwords are listed below:

- Service Mode: 27689
- Configuration Mode: 387466

Upgrades

Upgrades are available to add specific functionality to the device after purchase. These upgrades are:

- M3530A SpO_2
- M3531A NBP
- M3532A CO_2
- M3533A Pacing
- M3534A 12-Lead
  Option B02 - 12-lead acquisition
  Option B03 - 12-lead transmission
  Option B04 - 75 mm printer
- M4760A Handle and Cap Plate
- M5527A External paddles
- M4765A Hardware Upgrade Option B01 - Version B hardware that supports 12-lead transmission

Consult your sales representative, dealer, or distributor for the latest details.

Preventive Maintenance

Preventive maintenance and periodic operational checks are intended to be performed by the user. Both topics are covered in the Maintenance chapter of the *Instructions for Use*.

The Maintenance chapter of this manual provides procedures for the CO_2 and NBP calibration procedures, which are intended to be performed by qualified service personnel.

Repair Philosophy

Monitor/Defibrillator

The repair philosophy of the HeartStart MRx is subassembly replacement. Examples of subassemblies are the printer, the Processor Printed Circuit Assembly (PCA), Therapy PCA, and selected connectors and other items. Repairs that involve replacing components on a PCA are not supported.

CAUTION Individual component replacement should not be attempted. Component level repair is inadvisable due to the extensive use of surface mount technology and the high parts-density on the circuit boards. Unauthorized component replacement can impair performance of the HeartStart MRx.

WARNING Remove all power sources (AC, battery, DC) before opening the device. Failure to do so may allow the device to charge without warning and could result in serious injury or death.

Batteries

The M3538A Lithium Ion battery is rechargeable. The battery periodically requires a calibration. At the end of the battery's useful life, it should be discarded and replaced. Refer to the *Instructions for Use* for additional information.

For information on ordering replacements, see "Ordering Supplies and Accessories" on page 212.

WARNING Never crush, penetrate or attempt to open lithium ion batteries. Never incinerate lithium ion batteries. High case temperatures resulting from abuse of the battery could cause physical injury. The electrolyte is highly flammable. Rupture of the battery pack may cause venting and flame.

CAUTION Due to their high energy density, lithium ion batteries can deliver significant power. Use care when working with or testing lithium ion batteries. Do not short circuit the terminals.

Accessing Service Mode

CAUTION Be sure that the monitor/defibrillator is not connected to a patient when performing any function in Service Mode.

NOTE Make sure that you insert a battery charged to at least 20% into the device or connect external power when you are performing functions in Service Mode.

To access Service Mode:

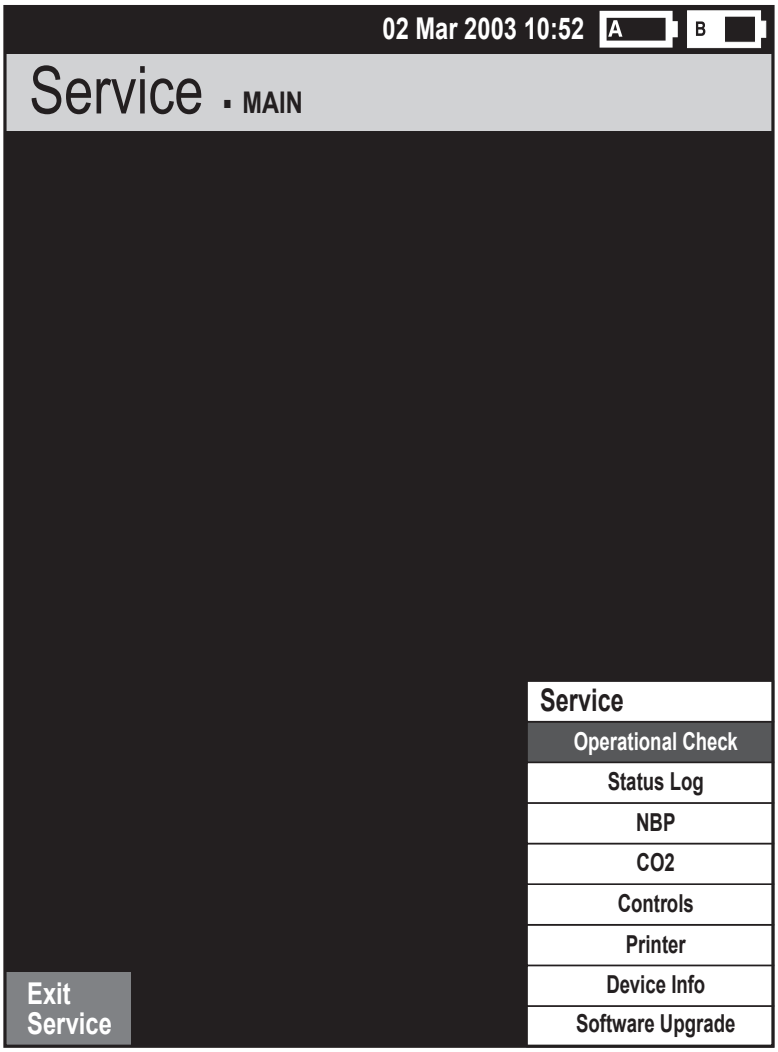
1. **Turn the Therapy Knob to Monitor.**
2. **Press the Menu Select button to display the Main menu.**
3. **Select Other.**
4. **From the Other menu select Service.**

   The message "Leaving Normal Operating Mode. Patient Monitoring is Off. To return to Normal Operating Mode, press the Exit Softkey." appears.
5. **Press the Menu Select button to acknowledge the message.**

   You are prompted to enter a password.
6. **Enter the password (27689) by scrolling through the list until the desired number is highlighted.**
7. **Press the Menu Select button to activate each selection.**
8. **Select Done when you have entered all of the numbers.**

The Service Mode Main menu is displayed, as shown in Figure 6.

Figure 6 Service Mode Main Menu



Navigating in Service Mode

Service Mode uses the same navigation controls as normal operating mode:

- To select a menu item, use the Navigation buttons to highlight your choice, then select that choice by pressing the Menu Select button.
- To exit Service Mode and return to clinical mode, press the **[Exit Service]** soft key.
- To return to the Service Mode Main menu from any service screen press the **[Main Service]** soft key.

NOTE The device's default configuration settings are restored when you return to clinical mode after exiting Service Mode.

Service Mode Functions

You can perform a variety of service related activities from Service Mode, as follows:

- Run an Operational Check - See “Operational Check” on page 39.
- View, print and clear the Status log - See “Status Log Errors” on page 55.
- Perform maintenance on the NBP module - See “Checking the NBP Module” on page 19.
- Perform maintenance on the CO_2 module - See “Checking the CO_2 Module” on page 23.
- Run the Controls test - See “Controls Test” on page 193.
- Run the Printer test - See “Printer Test” on page 194.
- View information about the device, such as model number, serial number, options enabled on the device, and the device’s language - See “Device Info” on page 13. You also use the Device Info menu to enter the serial number and to enable options on the device after a Processor PCA repair. See “Entering the Serial Number and Enabling Options” on page 128 for more information.

NOTE You can print detailed information on board and module levels through the Print Device Info option, available in normal operating mode. See “Printing the Device Information” on page 16.

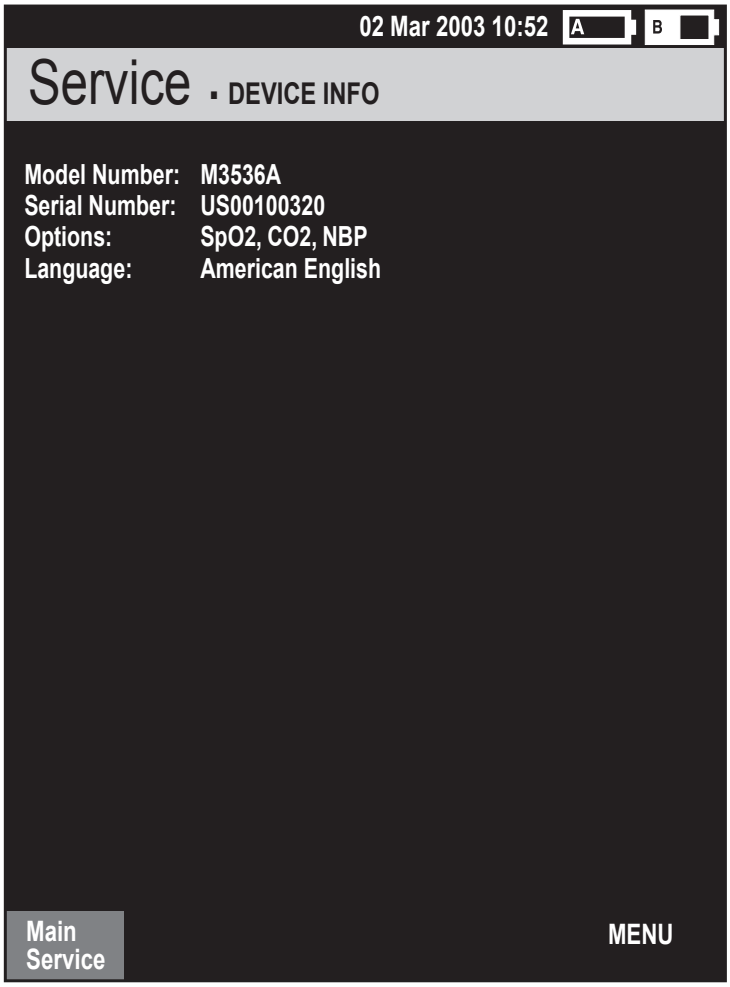
- Install software and change the device’s language using the Software Support Tool - See “Software Support Tool” on page 13.

Device Info

To view information about the device:

1. **From the Service Mode Main menu, select Device Info.**

Figure 7 Device Info Screen



Software Support Tool

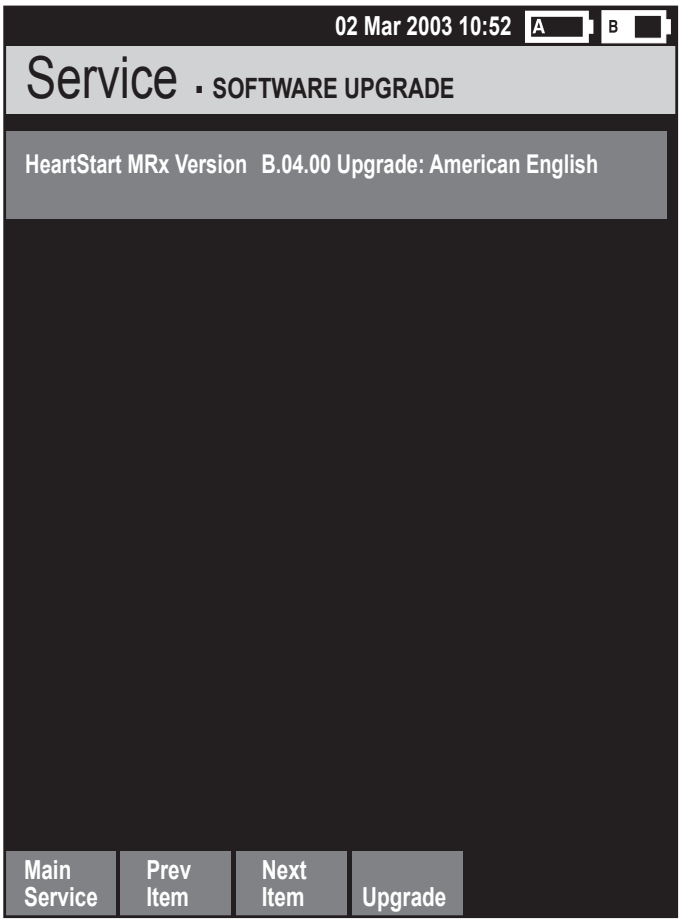
To install software onto the device or to change the device's language:

1. **Be sure an AC power module or battery charged to at least 20% is in place.**
2. **Insert the Software Support Tool into the data card slot.**
3. **From the Service Mode Main menu, select Software Upgrade.**
4. **Select the appropriate product version.**
5. **Press the `[Upgrade]` soft key.**

   The software is installed on the device. This process takes a few minutes. While the software is being updated, progress messages are displayed and the **`[Main Service]`** soft key is disabled.

NOTE Be careful not to interrupt the software installation process by removing the power source or turning the device off.

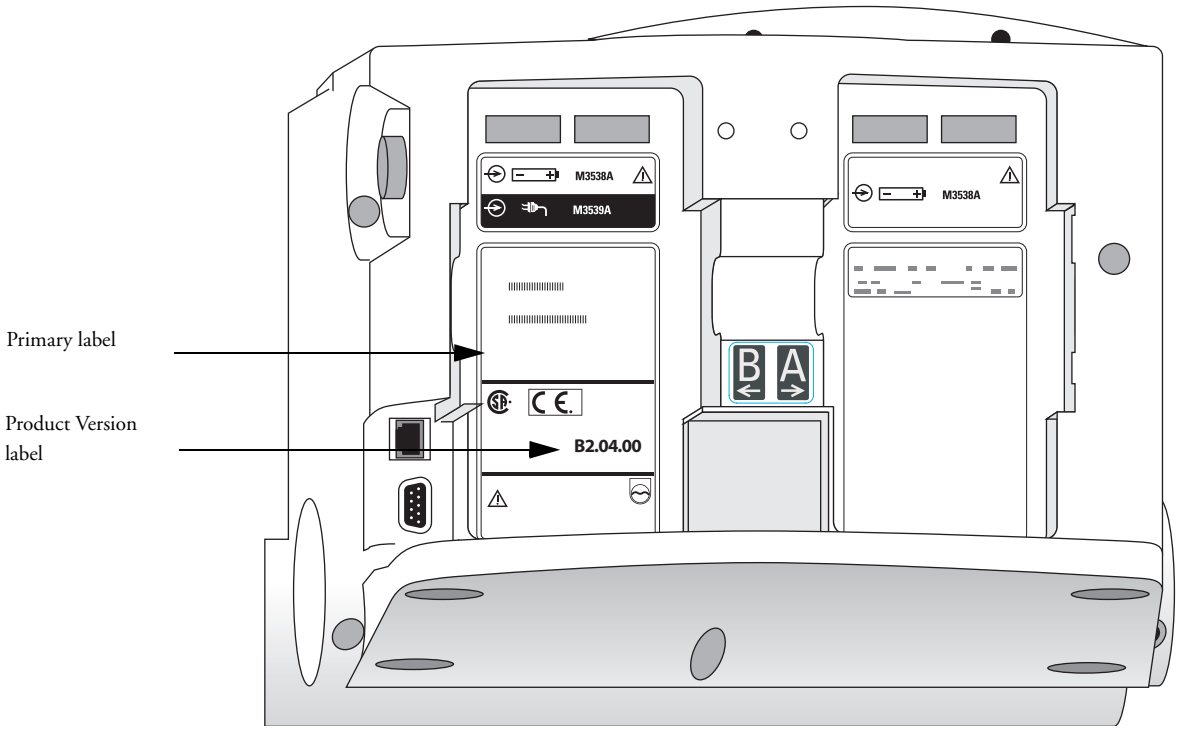
Figure 8 Software Upgrade Screen



6. **When the software or language installation process is complete, turn the device off and on.**
7. **Run an Operational Check.**
8. **Review the Operational Check results to ensure all tests have passed.**
   See "Operational Check" on page 39.
9. **Print the Device Info to ensure the product version or language is correct.**
   See "Printing the Device Information" on page 16.

10. **Affix the appropriate label found in the Software Support Tool kit to battery compartment B, as show in Figure 9. Additionally, make sure that the customer has the Instructions for Use (found on the User Documentation CD) that matches the product version.**

Figure 9 Rear case labels



NOTE The label that you apply to the device is in the format Xx.xx. This is functionally equivalent to the X.xx Product Version that appears on the Device Info and Software Upgrade screens and the printed device information report. For example, product version B2.04 is functionally equivalent to B.04.

Printing the Device Information

You can print detailed information on product versions, and board and module levels from the Print Device Info menu option. This option is available from the Other menu in clinical modes.

To print the device information:

1. **Be sure a battery charged to at least 20% is in place, or that external power is connected.**
2. **Turn the Therapy Knob to Monitor.**
3. **Press the Menu Select button to access the Main menu.**
4. **From the Main menu, select Other.**
5. **From the Other menu, select Print Device Info.**
   Detailed information about the device is printed.

Other Resources

For additional information on the HeartStart MRx, refer to the following Learning Products:

- HeartStart MRx Instructions for Use (M3535-91900)
- HeartStart MRx Service Training Video (M3535-89300 NTSC, M3535-89310 PAL)
- HeartStart MRx Lithium Ion Battery Characteristics and Care Application Note (M3535-91930)

Other documentation can be found on the Philips website at:
www.medical.philips.com/goto/productdocumentation.

2

Maintenance

This chapter describes how to perform routine maintenance on the HeartStart MRx monitor/defibrillator.

Overview

Most routine maintenance is performed by the user. This includes:

- Performing operational checks
- Replacing paper
- Charging and maintaining the lithium ion battery
- Cleaning

Refer to the *Instructions for Use* for detailed information on these maintenance procedures.

Service personnel are responsible for the following routine maintenance:

- Yearly calibration (or every 10,000 cycles) of the Noninvasive Blood Pressure (NBP) module
- Yearly calibration (or every 4000 hours) of the End-tidal Carbon Dioxide ($EtCO_2$) module

This chapter provides the following information:

Maintenance Tools and Equipment

You will need the following equipment to perform the yearly calibration procedures:

- Password to access Service Mode (27689)
- NBP
  - manometer
  - expansion chamber (volume 250 ml +/- 10%) or an NBP cuff can be used

NOTE If you are using an NBP cuff, make sure it is wrapped around a solid object.

- CO_2
  - calibration gases and regulator
    cal 1 gas 15210-64010 (5% CO_2)
    cal 2 gas 15210-64020 (10% CO_2)
    cal gas flow regulator M2267A
  - electronic flowmeter, M1026-60144
  - Gas calibration equipment
    cal tube 13907A
    FilterLine set, M1920A
  - local barometric pressure rating or reading received from a reliable local source (airport, regional weather station, or hospital weather station) which is located at the same altitude as the hospital or EMS service.
  - calculator

NOTE In addition to the items listed above, the calibration procedures require tubing and connectors typically found in a biomedical engineering shop.

Checking the NBP Module

NBP

These instructions describe how to test the NBP measurement function. A complete test consists of the following activities, which are described in detail in this chapter.

Each of the procedures assumes the monitor/defibrillator, the manometer, and the expansion chamber are still set up as they were at the end of the previous test.

If all results are as described, the device passes that portion of the test. Return to the Service Mode Main menu by pressing the **[Main Service]** soft key.

If there is any failure, begin troubleshooting and repairing the device as needed. See “Troubleshooting” on page 33.

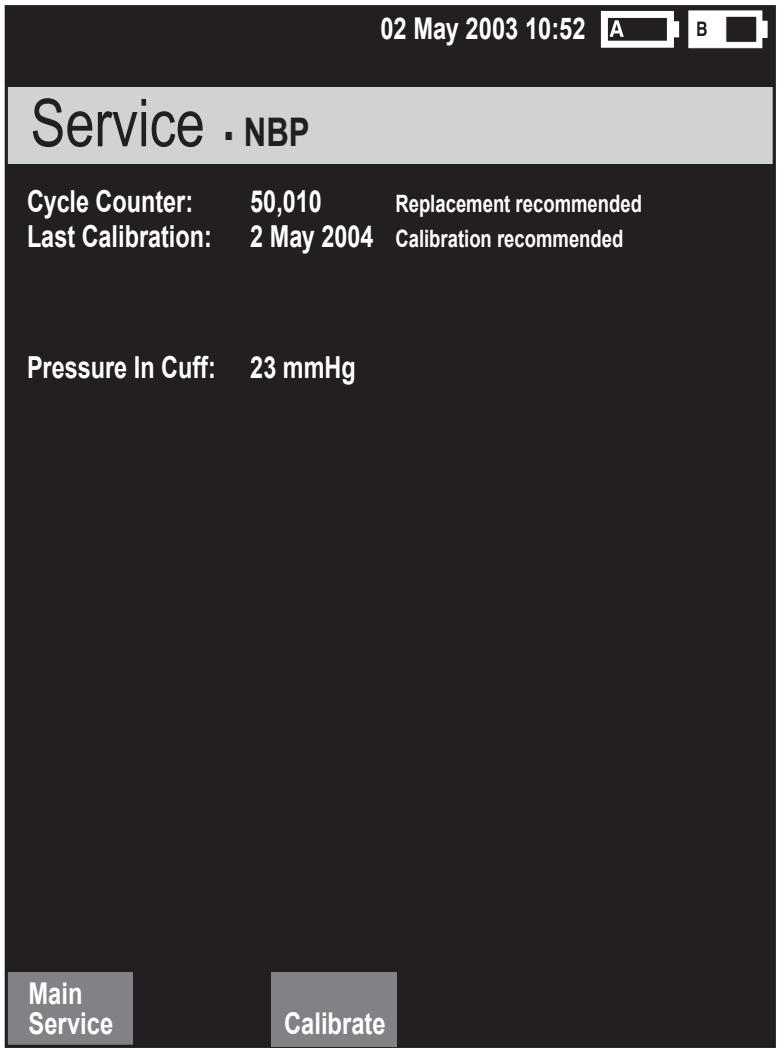
Setup

1 Access the Service Mode Main menu as described in “Accessing Service Mode” on page 10.

2 From the Service Mode Main menu, select **NBP**.
The NBP Service screen is displayed.

NOTE You will hear a high-pitch tone when you access the NBP Service screen - this is normal operation.

Figure 10 NBP Service Screen



Check the status displays

1. **Check the cycle counter.**

   Check the number of measurement cycles shown on the screen. If the NBP module has executed more then 50,000 cycles, replacement is recommended. See “NBP Module” on page 160 for instructions on replacing the NBP module.

   Following replacement, run the required Performance Verification and Safety Tests (see “Required Testing Levels” on page 180).

2. **Check the calibration status.**

   If the screen indicates that calibration is recommended, perform all of the actions described in this chapter, beginning with "Test the accuracy".

   The calibration status is automatically reset at the successful completion of a calibration.

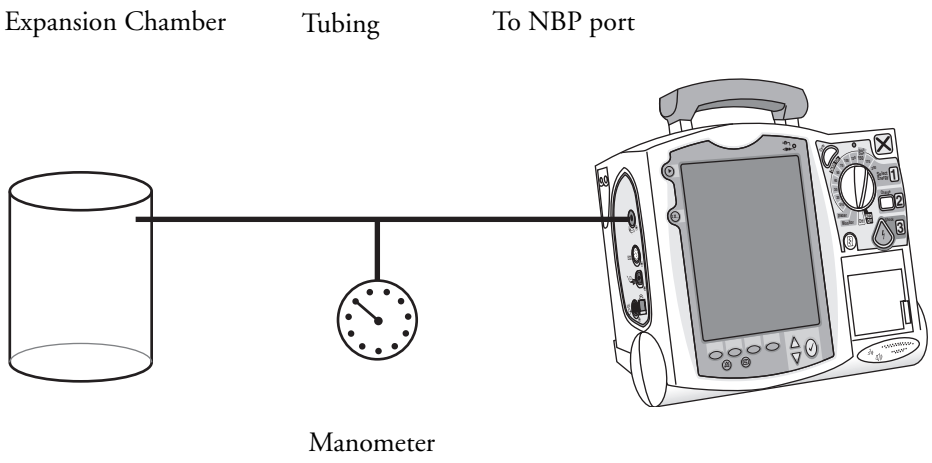
NBP Safety Timeout

Do not keep the cuff pressurized for more than 3 minutes. The NBP module times out if the pressure is greater than 5mmHg for 180 seconds. The valve opens and the pressure drops. To reset the module, exit Service Mode and press the **[Start NBP]** soft key. The inop "Cuff not deflated" is displayed. Access the NBP Service screen again to start the calibration.

Test the accuracy

1 Connect the NBP tubing to the NBP port on the monitor/defibrillator, and connect the test manometer and expansion chamber to the tubing. See Figure 11.

Figure 11 NBP Test Setup



2 Pressurize the expansion chamber to approximately 280 mmHg.

3 When the pressure stabilizes, compare the displayed pressure reading to the pressure indicated by the manometer.

4 If the difference between the manometer and the displayed pressure is >± 2mmHg, perform the steps in "Calibrate the NBP Measurement" on page 22.

Test for leaks

1 Pressurize the expansion chamber to approximately 280 mmHg.

2 Watch the displayed pressure for 60 seconds.

3 At the end of this 60 seconds record the pressure drop. Any pressure drop observed should be ≤ 6 mmHg.

4 If the pressure decreases by more than 6 mmHg, there is a leak. Replace the NBP tubing and cuff and try the leakage test again. If the pressure still decreases by more than 6 mmHg, begin troubleshooting and repairing the device as needed.

5 Release the pressure in the cuff before proceeding to the next test to avoid the safety timeout.

Test the linearity

1 Pressurize the expansion chamber to increase pressure to approximately 150 mmHg.

2 When the pressure is stabilized, compare the displayed pressure reading to the pressure indicated by the manometer.

If the difference between the manometer and the displayed pressure is >±2mmHg, perform the steps in "Calibrate the NBP Measurement". Then repeat this linearity test.

Calibrate the NBP Measurement

NOTE If the error message “Calibration failed. Check that the pressure applied is correct. Please restart calibration.” appears after entering either calibration point, re-start the calibration.

Pressing the [**Calibrate**] soft key starts the calibration process. You must complete the calibration process within three minutes or the NBP module times out and will be out of calibration.

1 Press the [**Calibrate**] soft key.
The message “Apply 0 mmHg. Select Next when ready” is displayed.

2 Release all of the pressure in the expansion chamber so that the manometer reads 0 mmHg.

3 Press the [**Next**] soft key.
The message “Apply 250 mmHg. Select Next when ready” is displayed.

4 Increase the pressure so that the manometer reads 250 mmHg.

5 Press the [**Next**] soft key.

If the calibration is successful, the message “Calibration complete. Please perform the accuracy and leakage tests to check the results.” is displayed. After several seconds the message clears and the NBP Service screen is displayed.

Run an Operational Check

You must run an operational check after calibrating the NBP module in order for the calibration status to get updated. See “Operational Check” on page 39 for instructions.

Checking the CO_2 Module

CO_2

These instructions describe how to test the CO_2 module. The CO_2 tests are as follows:

Each of the tests assumes the device and the test equipment are still set up as they were at the end of the previous test.

If all results are as described, the device passes that portion of the test. Return to the Service Mode Main menu by pressing the **[Main Service]** soft key.

If there is any failure, begin troubleshooting and repairing the device as needed. See "Troubleshooting" on page 33 for more information.

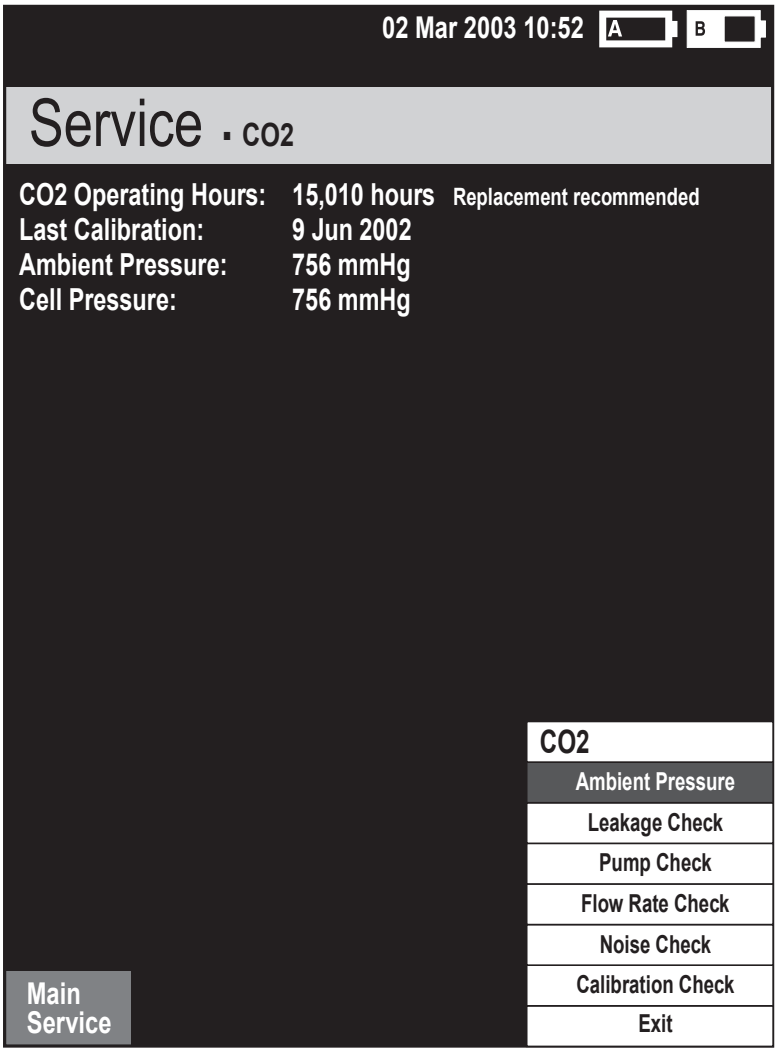
Setup

1 Access the Service Mode Main menu as described in "Accessing Service Mode" on page 10.

2 From the Service Mode Main menu, select **CO_2**.
The pump starts when you access the CO_2 Service screen.

The CO_2 Service screen is displayed, as shown in Figure 12.

Figure 12 CO_2 Service Screen



Check the Status Display

1. **Check the CO_2 Operating Hours.**

   You are directed to replace the CO_2 module after 15,000 hours of operating time. If the number of hours is more than 15,000 the message "Replacement recommended" is displayed. See "CO_2 Module" on page 162 for instructions on replacing the CO_2 module.

2. **Check calibration status.**

   Displays the date of the last calibration. The CO_2 module should be calibrated every year or after 4000 hours. If more than one year has passed or the module has operated more than 4000 hours since the last calibration, the message "Calibration recommended" is displayed. Perform all of the actions described in this section, beginning with "Ambient Pressure."

3. **Check the ambient and cell pressure.**

   Obtain a reliable measurement of local barometric pressure (reference value). This is typically available from a local airport, weather station, or the internet. Be sure the reading is taken at the same altitude as the monitor/defibrillator is at now. Check that the monitor/defibrillator's internal setting of ambient atmospheric pressure (barometric pressure) is within ± 12 mmHg of the reference value. If the ambient pressure is ***not*** within ± 12 mmHg of the reference value, adjust it through the Ambient Pressure menu. If the ambient pressure is within ± 12 mmHg of the reference value, proceed with the Leakage check.

Ambient Pressure

This menu enables you to adjust the ambient pressure setting of the monitor/defibrillator.

1 If the ambient pressure is ***not*** within ± 12 mmHg of the reference value, select **Ambient Pressure** from the CO_2 Service menu.

2 Use the Navigation buttons to enter the barometric pressure reference value.
The displayed ambient pressure is updated to the reference value.

Leakage Check

The leakage check consists of two parts:

1 Check of the internal tubing between the pump outlet and the CO_2 Outlet port on the monitor/defibrillator (device outlet). This test is done by pressurizing the outlet line between the pump and the outlet port.

2 Check of the internal tubing between the pump inlet and the FilterLine inlet. This test is done by pulling a vacuum on the inlet line between the inlet fitting and the pump.

These procedures are described in the following sections.

Outlet leakage

To perform Part 1 of the CO_2 Leakage check:

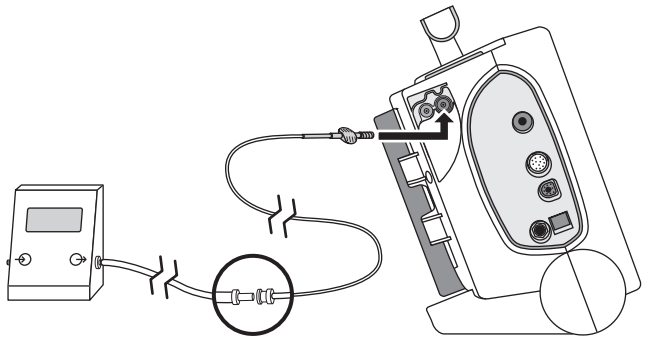
1 From the CO_2 Service menu, select **Leakage Check**.

2 Set up the flowmeter and the MRx.

a. Connect the FilterLine to the monitor/defibrillator CO_2 Inlet port.

b. Connect tubing from the flowmeter outlet to the FilterLine.

Figure 13 CO_2 Outlet Leakage Check Setup



3 Follow the instructions on the screen to perform Part 1 of the Leakage check.

4 The reading on the flowmeter should decrease to between 0 and 4 ml/min.

If this reading is correct, proceed to the second part of the leakage test (the Inlet Leakage) by pressing the **[Proceed]** soft key.

If this reading is incorrect (>4 ml/min. flow) it indicates a leak in the line between the pump outlet and the CO_2 Outlet port. Begin troubleshooting and repairing the device as needed. See “Troubleshooting” on page 33.

Inlet leakage

To perform Part 2 of the CO_2 Leakage check:

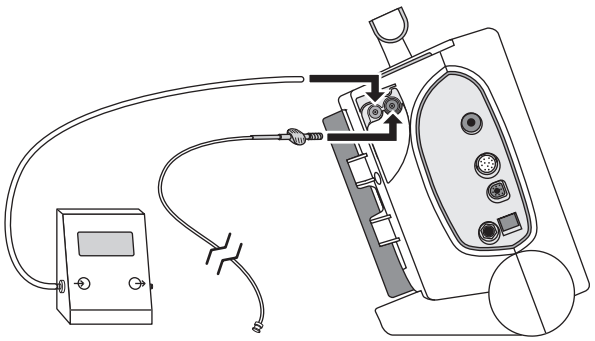
1 Set up the flowmeter and the MRx.

a. Leave the FilterLine connected to the monitor/defibrillator CO_2 Inlet port.

b. Disconnect the FilterLine from the flowmeter outlet.

c. Connect the tubing from the flowmeter inlet to the monitor/defibrillator CO_2 Outlet port.

Figure 14 CO_2 Inlet Leakage Check Setup



2 Follow the instructions on the screen to perform Part 2 of the Leakage check.

3 The reading on the flowmeter should decrease to between 0 and 4 ml/min.

If this reading is incorrect (>4 ml/min. flow) it indicates a leak in the line between the FilterLine inlet and the pump inlet. Begin troubleshooting and repairing the device as needed. See "Troubleshooting" on page 33.

Pump Check

This test checks the 'strength' of the pump by occluding the inlet and measuring how deep a vacuum the pump can pull.

NOTE It is important these tests be conducted in this order. For example, if you perform the Pump check and there's a leak you haven't found because you didn't perform the leak tests, it may appear that the device has a faulty pump when in fact it's a loose tubing connection.

1 From the CO_2 Service menu, select **Pump Check**.

2 Follow the instructions on the screen to perform the Pump check.

3 The difference between the cell pressure displayed and the ambient pressure should be more than 120 mmHg.

If the pressure reading is correct (difference >120 mmHg), the device passes the pump test.

If the pressure reading is incorrect, it indicates the pump is defective (regardless of the number of hours it has run) and the CO_2 module must be replaced. See "CO_2 Module" on page 162.

Flow Rate Check

1 From the CO_2 Service menu, select **Flow Rate Check**.

2 Follow the instructions on the screen to perform the Flow Rate check.

NOTE Be sure there are no kinks, pinches, or obstructions in any of the tubing - this can create a restriction that will diminish the flow rate and cause a false failure of this test.

3 If the flow rate is within the tolerance limit (50 ml/min ±7.5 ml/min), the test passes.
If the flow rate is ***not*** within the tolerance limit, proceed to Step 4 to calibrate the flow rate.

4 Use the Navigation buttons to increase and decrease the flow until it is as close as possible to 50 ml per minute as indicated on the flowmeter gauge.

5 When you are satisfied that the flow is set as close as possible to 50 ml, press the [**`Store Flow`**] soft key to confirm the setting. If the adjusted flow is not stored within 60 seconds of the adjustment, the old flow setting is restored.

NOTE If the flow cannot be adjusted to within tolerance, the CO_2 module must be replaced. See "CO_2 Module" on page 162.

Noise Check

This test looks for noise on the CO_2 signal due to deterioration of the IR source.

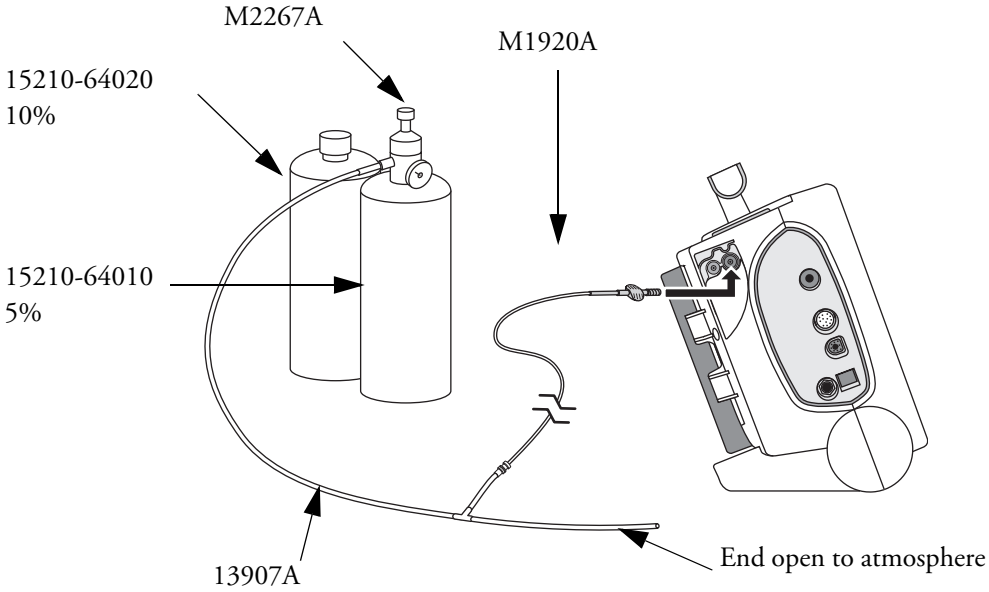
1 From the CO_2 Service menu, select **Noise Check**.

2 Set up the calibration gas as shown in Figure 15.

a. Connect the 5% calibration gas to the CO_2 Inlet port.

b. Turn on the gas.

Figure 15 CO_2 Noise and Calibration Check Setup



3 Follow the instructions on the screen to perform the Noise check.

4 Wait until the displayed CO_2 value is stable. Check the noise index reading.

5 If the noise index exceeds 3 mmHg, the CO_2 module must be replaced. See "CO_2 Module" on page 162.

Calibration Check

This tests the accuracy of the CO_2 measurement and, if needed, adjusts the measurement to meet specifications.

1 The monitor/defibrillator must be operating for at least 20 minutes prior to starting this test with the FilterLine connected to the CO_2 Inlet port.

2 From the CO_2 Service menu, select **Calibration Check**.

3 The CO_2 Calibration screen is displayed,

5% Calibration Check

4 Set up the calibration gas as shown in Figure 15.

a. Connect the 5% calibration gas to the CO_2 Inlet port.

b. Turn on the gas.

5 Wait until the displayed CO_2 value is stable.

6 Calculate the expected CO_2 reading, which depends on both the gas concentration you are using (typically 5.0%) and the ambient pressure. Calculate as follows:

[concentration of cal gas] X [ambient pressure] = expected CO_2 value

For example:

[0.05] X [736 mmHg] = 36.8 mmHg

7 Calculate the allowable tolerance, which is ±5% of the expected reading. Calculate as follows:

[±0.05] X [expected CO_2 value]] = ±[tolerance] mmHg

example:

[±0.05] X [36.8 mmHg] = ±1.8 mmHg

In this example, the reading displayed with 5% cal gas must be 36.8 mmHg ±1.8 mmHg, or between 35.0 mmHg and 38.6 mmHg.

8 Compare the displayed CO_2 value to the allowable range of values.

If the displayed value falls within the allowable range, proceed to the 10% Calibration Check section below.

If the displayed value does not fall within the allowable range, the CO_2 measurement module needs to be calibrated. Perform the steps under "CO_2 Calibration" on page 30, then begin again at step 1.

10% Calibration Check

1 Disconnect the 5% gas (and regulator, if needed) and connect the 10% gas.

2 Turn on the gas.

3 Wait until the displayed CO_2 value is stable.

4 Calculate the expected CO_2 reading, which depends on both the gas concentration you are using (typically 10.0%) and the ambient pressure. Calculate as follows:

[concentration of cal gas] X [ambient pressure] = expected CO_2 value

example:

[0.10] X [736 mmHg] = 73.6 mmHg

5 Calculate the allowable tolerance, which is ±7% of the expected reading. Calculate as follows:

[±0.07] X [expected CO_2 value]]= ±[tolerance] mmHg

example:

[±0.07] X [73.6 mmHg] = ±5.2 mmHg

In this example, the reading displayed with 10% cal gas must be 73.6 mmHg ±5.2 mmHg, or between 68.4 mmHg and 78.8 mmHg.

6 Compare the displayed CO_2 value to the allowable range of values.

If the displayed value falls within the allowable range, the device has passed its accuracy test.

If the displayed value does not fall within the allowable range, the CO_2 measurement module needs to be calibrated. Perform the steps under "CO_2 Calibration" on page 30, then begin again at step 1.

7 Return to the CO_2 Service screen by pressing the **[Done]** soft key.

CO_2 Calibration

If you haven't already done so, perform the following three steps before proceeding with the calibration.

1 The monitor/defibrillator must be operating and a FilterLine connected to the CO_2 Inlet port for at least 20 minutes prior to starting this test.

2 From the CO_2 Service menu, select **Calibration Check** and press the Menu Select button.

3 The CO_2 Calibration screen is displayed. Wait until the display indicates the autozero is finished before proceeding.

Calibration

4 Connect the 5% calibration gas (and regulator, if needed) to the CO_2 Inlet port. Turn on the gas.

5 Wait until the displayed CO_2 value is stable.

6 Press the **[Calibrate]** soft key.

7 The screen prompts you for the value of cal gas being used. Acceptable values are from 4% to 6%. The recommended value is 5%, which is the default.

8 Using the Navigation buttons, set the correct cal gas value, then press the Menu Select button.

9 When you have selected the correct cal gas value, the monitor/defibrillator begins an auto calibration sequence, and the screen displays the message "CO_2 calibration in progress". Do not remove the gas until the monitor/defibrillator is finished as indicated by the screen prompts.

Calibration Verification

10 If it is not already connected, connect the 5% calibration gas (and regulator, if needed) to the CO_2 Inlet port. Turn on the gas.

11 Wait until the displayed CO_2 value is stable.

12 Check the displayed CO_2 value against the expected value calculated earlier. The displayed value should match the expected value within the tolerance calculated earlier.

13 Disconnect the 5% gas and connect the 10% gas.

14 Wait until the displayed CO_2 value is stable.

15 Check the displayed CO_2 value against the expected value calculated earlier. The displayed value should match the expected value within the tolerance calculated earlier.

If both the 5% and 10% values are correct, the device has been successfully calibrated.

If either value is not within tolerance, repeat the calibration beginning at step 1. If the device fails the Calibration Verification a second time, replace the CO_2 module. See “CO_2 Module” on page 162.

Run an Operational Check

You must run an operational check after calibrating the CO_2 module in order for the calibration status to get updated. See “Operational Check” on page 39 for instructions.

3

Troubleshooting

This chapter describes how to troubleshoot the HeartStart MRx monitor/defibrillator.

Overview

Here are the topics covered in this chapter:

Troubleshooting Tools and Equipment

You need the following tools and equipment:

- Defibrillator Discharge Tool (M2475-69573) — Used to discharge the defibrillator capacitor.
- 50 ohm defibrillator test load, grey plug connector (M3725A)
- 50 ohm defibrillator test load, white barrel connector (M1781A)

Obtaining Replacement Parts

See “Parts and Accessories” on page 211 for details on replacement parts.

Ready For Use Indicator

The Ready For Use (RFU) indicator, located on the upper right corner of the device, reports the status of critical functions of the device as determined by the Automated tests. These Automated tests run periodically while the device is turned off (but has a power source) and check the following critical functions of the device:

- defibrillation and cardioversion
- pacing
- pads/paddles ECG
- 3-lead/5-lead/12-lead ECG
- battery

The RFU indicator also reports failures in critical functions detected at run time, during an Operational Check, and during Service Mode tests. Always check the RFU indicator when troubleshooting the device.

Automated test failures of non-critical components (such as the NBP, SpO_2 , CO_2, and printer modules) are not reflected in the RFU indicator, but are reported through inops when the device is turned on.

The RFU indicator displays the status of the device using the following definitions.

Table 1 RFU Indicator Status

RFU Status	Meaning	Required Action
Blinking black hourglass 	Shock, pacing, and ECG functions are ready for use and sufficient battery power is available.	None
Blinking red “X” with or without a periodic chirp 	Low battery or no battery. The device can be used but run time is limited. Chirping indicates the battery is not being charged. No chirping indicates the battery is being charged.	Charge the battery as soon as possible and/or replace the battery with a charged battery. Charging may be done in the HeartStart MRx by connecting to AC/DC power, or in a Philips-approved battery support system.
Solid red “X” and a periodic chirp 	A failure has been detected that prevents the delivery of a shock, pacing, or ECG acquisition.	Turn the Therapy Knob to **Monitor**. A message describing the failure is displayed. Begin troubleshooting, as described in “Troubleshooting Methodology” on page 45. **Note:** The device displays the message for the first critical failure that is detected. To see additional failures (if any) run an Operational Check and check the status log.
Solid red “X” without a periodic chirp 	No power, or device failure (cannot turn on).	Insert a charged battery or connect to AC/DC power. Begin troubleshooting, as described in “Troubleshooting Methodology” on page 45.

NOTE The RFU indicator briefly displays a solid red “X” when initially turning on the device, switching between clinical and non-clinical operating modes, and at the start of any Automated test.

Automated Tests

The HeartStart MRx performs many maintenance activities independently, including three tests that run automatically at regularly scheduled intervals while the device is off to assess operational performance and alert you if a problem exists. Results of tests associated with critical functionality of the device are reported through the Ready For Use indicator and the Automated Test Summary report. Results are also reported through inop statements on the display when the HeartStart MRx is turned on. Table 2 provides a brief explanation of the tests and lists the frequency with which each test is performed.

Table 2 Automatic Self-Tests

Test Type/Frequency	Description
Hourly	Tests batteries, internal power supplies, and internal memory.
Daily, between 11:00 PM and 1:00 AM	Tests batteries, internal power supplies, internal memory, internal clock battery, defibrillation, pacing, ECG, SpO_2, $EtCO_2$, NBP, and printer. The defibrillation test includes low energy internal discharges. If a 3-, 5-, or 10-lead ECG cable is attached, the cable is tested as well.
Weekly (Sunday between 11:00 PM and 1:00 AM)	Performs a Daily Test plus delivers a high energy internal discharge to exercise the entire defibrillation circuitry.

NOTE Automated tests do not test the therapy cables, paddles, buttons, audio, or the display. An ECG cable is tested if connected at the time of the test.

Automated Test Summary

An Automated Test Summary (ATS), showing the results of recent tests, may be viewed or printed as evidence that the HeartStart MRx is tested regularly. To run the ATS:

1 Turn the Therapy Knob to **Monitor**.

2 Press the Menu Select button.

3 Using the Navigation buttons, select **Other** and press the Menu Select button.

4 Select **Operational Check** and press the Menu Select button.
The message “Leaving Normal Operating Mode” appears to let you know that you are exiting from clinical functionality of the device.

5 Using the Navigation buttons, select **Auto Test Summary** and press the Menu Select button.
The Automated Test Summary is displayed.

6 Press the **[Print]** soft key to print the report.

The report shows the results of the most recent hourly test, the daily tests that have run since the last weekly test, and the last 53 weekly tests. Test results are reported, as described in Table 3.

Figure 16 Automated Test Summary Screen

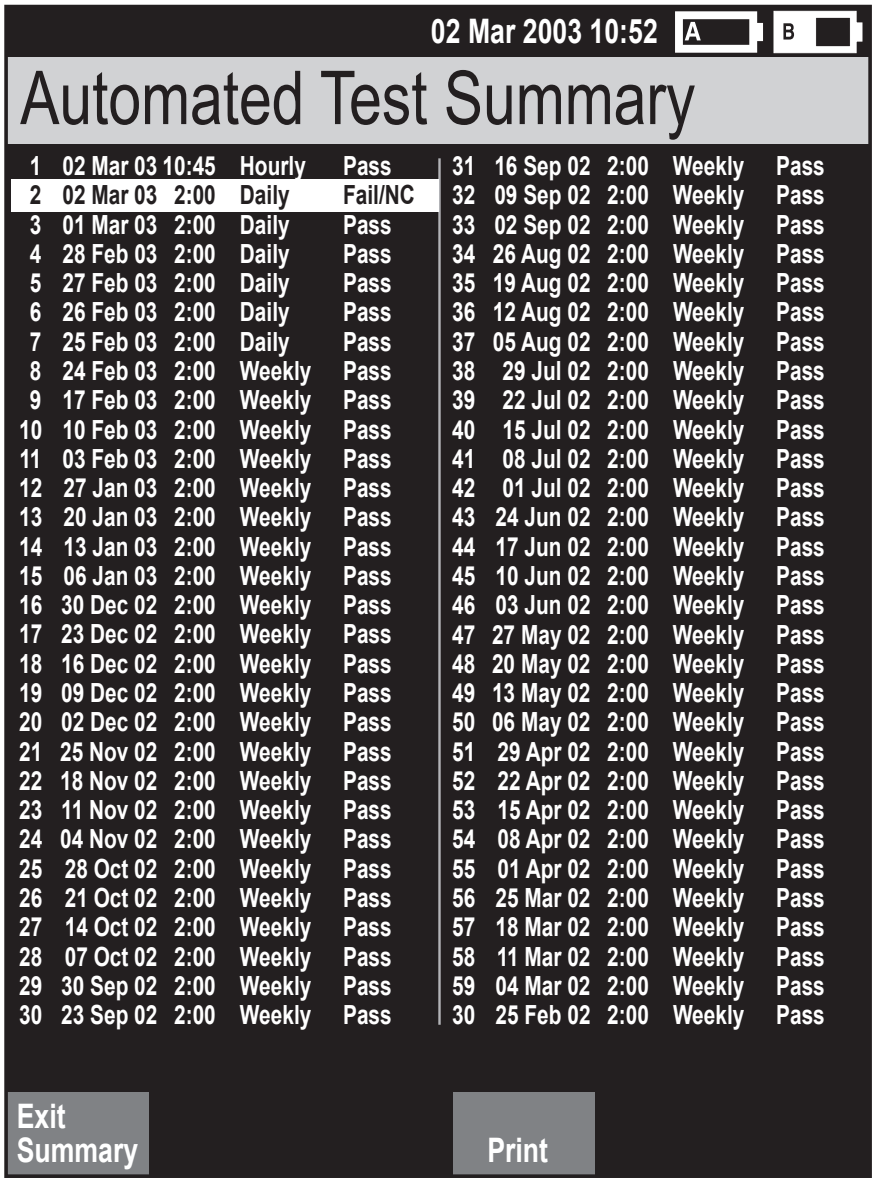


Table 3 ATS Results

Result	RFU Indicator	Definition	Required Action
Pass	Hourglass	All tests passed	None
Fail/C	Solid Red "X" accompanied by a chirp	A critical failure was detected. Critical failures impact life-saving functionality, including defibrillation, pacing, and ECG acquisition.	Respond to the RFU indicator as described in "Troubleshooting Flowcharts" on page 47.
Fail/NC	Hourglass	A non-critical failure was detected. Non-critical failures do not impact life-saving functionality.	Press the **[Exit Summary]** soft key. An inop statement indicating the failure is displayed.You can also note the time of the failed test, then check the Status log for failures logged at approximately the time of the test. Refer to the Troubleshooting Tables in this chapter for the action to take. The message will continue to display in all modes until the problem is corrected. (Refer to the Instructions for Use for a complete set of user prompts and messages,)
Fail/BF	Blinking "X"	The battery is not charged to the minimum level (20%), there is no battery present, or a battery failure was detected.	Charge the battery as soon as possible and/or replace the battery with a charged battery. Charging may be done in the HeartStart MRx by connecting to AC/DC power, or in a Philips-approved battery support system.

Operational Check

Operational Checks should be performed at regular intervals to supplement the hourly, daily, and weekly Automated Tests executed by the MRx. Automated Tests provide adequate assurance that the device is in a functional state of readiness. Operational Checks supplement the Automated Tests by verifying therapy cables, the ECG cable, paddles, audio, and display functionality, along with replicating the Weekly test. Operational Checks also notify you if the battery, NBP module, or CO_2 module need calibration.

At completion of the Operational Check, the message “Operational Check Passed” is displayed if all of the tests pass. If any test fails the message “Non-Critical Failure”, “Critical Failure”, or “Battery Failure” is displayed, depending upon the severity of the failed functionality. You must fix the problem and successfully run the Operational Check to clear the failure.

Keep in mind the following points about the Operational Check:

- The Operational Check runs the Defib test on battery power to reflect optimal operating conditions for defibrillation. The device automatically disconnects AC/DC power.
- Perform the Defib Test for each type of patient Therapy cable used on the device (multifunction defib pads, external or internal paddles). At the conclusion of the Defib Test, you can attach another Therapy cable and repeat the test.
- The message “In Progress” is displayed as each test is run. The test result (pass or fail) is displayed at the completion of each test. (See Table 4 on page 41 for a full explanation of each test.)
- Use the test results to troubleshoot and repair the device.
- Clear the Status log after all errors have been addressed and the Operational Check passes. See “Status Log Errors” on page 55 for more information.

To run the Operational Check:

1 Insert a battery charged to at least 20%.

2 Attach a Pads or Paddles therapy cable.

3 Attach an ECG cable.

4 Turn the Therapy Knob to **Monitor**.

5 Press the Menu Select button.

6 Using the Navigation buttons, select **Other** and press the Menu Select button.

NOTE You can run Operational Check from the Other menu in Monitor Mode or from the Service Mode Main menu - the Operational Check is the same in both modes. When you exit the Operational Check from Service Mode, you are returned to Monitor Mode.

7 Select **Operational Check** and press the Menu Select button.

8 Select **Run Operational Check** and press the Menu Select button.
“Leaving Normal Operating Mode. Patient Monitoring is Off. To return to Normal Operating Mode, press the Exit Softkey.” appears.

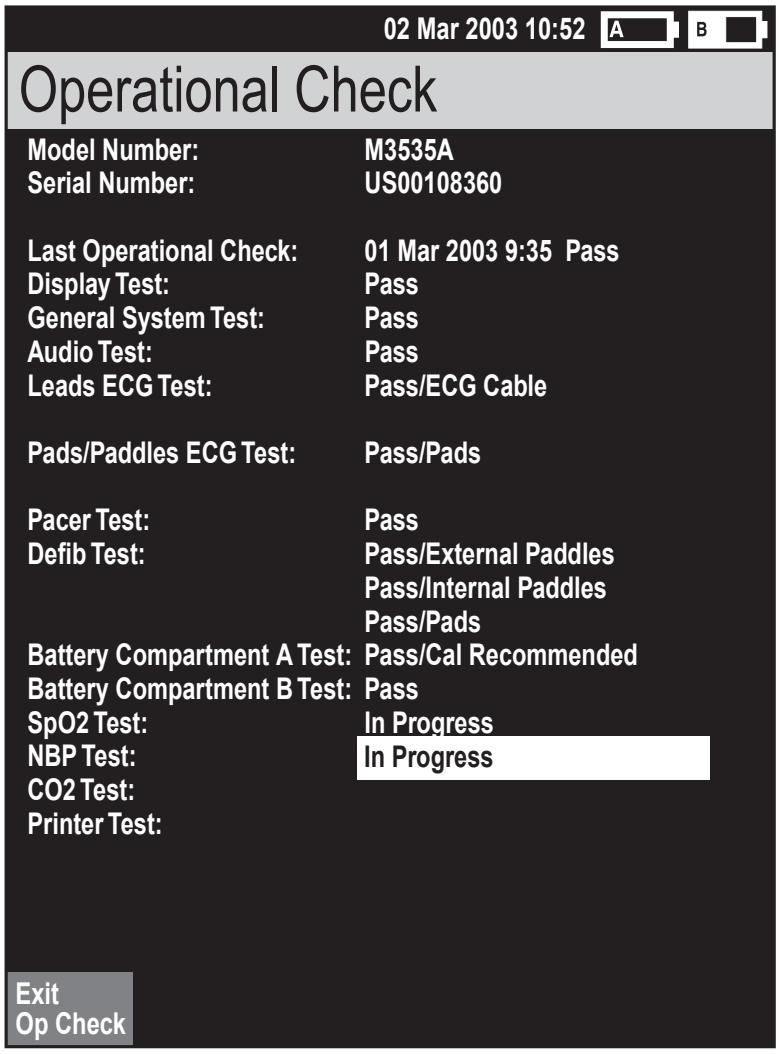
9 Press the Menu Select button to acknowledge the message.

10 Carefully read and respond to the Operational Check prompts for each test. Screen prompts are accompanied by an audio prompt to alert you of a message that should be acknowledged before proceeding with the rest of the Operational Check.

When a response is required, use the Navigation buttons to select your answer and the Menu Select button to confirm your choice. Table 4 shows the tests, in the order in which they are performed, explains the prompts that may appear, and describes the actions you should take (if any).

NOTE Options that are not on the device do not appear on the screen or printed report.

Figure 17 Operational Check Screen



WARNING Be sure to safely discharge internal and external paddles tested during the Operational Check, as described in Table 4.

Table 4 Operational Check Tests

Test	Description	Prompts	Action
Display	A test pattern is displayed; the display is filled with black, then white, then red from top to bottom, then green from left to right.	**Did you see the test pattern correctly?**	Use the navigation buttons to respond **Yes** or **No**. Then press the Menu Select button.
General System	Tests internal clock battery, power supply, and internal memory card.	None.	None.
Audio	The voice prompt, **No Shock Delivered** is annunciated.	**Did You Hear, "No Shock Delivered?"**	Use the navigation buttons to respond **Yes** or **No**. Then press the Menu Select button.
Leads ECG	Tests leads ECG acquisition and, if attached, the ECG cable. The recommended practice is to run the test with the ECG cable attached.	• **Connect ECG Cable, Cable Connected** or **Test Without Cable** • **Detach Leads**, if the ECG cable is connected to a patient or the leads are shorted together. • **Disconnect ECG Cable**, if the test fails with the cable connected.	• Connect an ECG cable and select "Cable Connected" or "Test Without Cable". • Make sure the leads are not attached to a patient, a simulator, or touching each other. • Disconnect the ECG cable.
Pads/Paddles ECG	Checks ECG acquisition through pad/paddles.	**Remove Paddles from Holders** **Place Paddles in Holders** **Connect Pads/Paddles Cable, Connect Therapy Cable**	**Note:** If testing paddles, make sure that they are secured in their pockets. If the PCI LEDs light, adjust the paddles in the pockets. If the LEDs continue to light, clean the paddle electrode surfaces. Remove the paddles from the holders. Place the paddles in the holders. Attach the Pads or Paddles cable typically used.
Pacer (only runs if the option is present)	Tests pacing functionality and delivers a paced pulse into a 50 ohm test load.	• **Connect Pads Cable**, if the Pads cable is not detected. • **Attach Test Load**, if a test load is not detected.	• Connect the Pads cable to the MRx, if prompted. • Connect the test load to the Pads cable, if prompted.

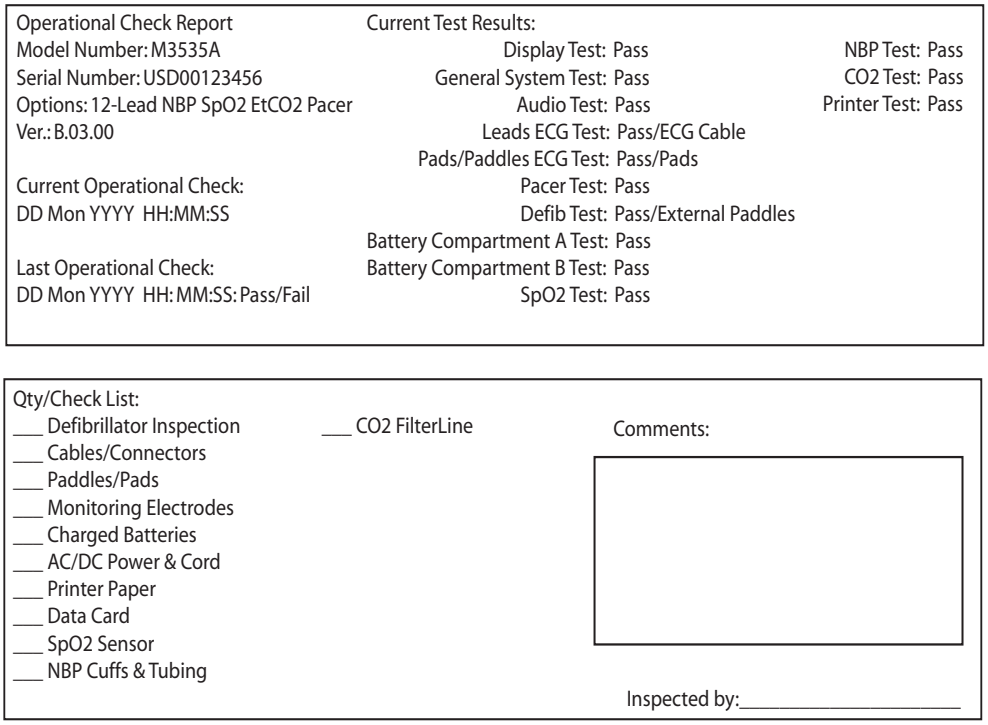
Table 4 Operational Check Tests (Continued)

Test	Description	Prompts	Action
Defib	Tests defibrillation circuitry and delivers a shock through: • pads, into a test load, and/or • external paddles, into the MRx, and/or • internal paddles, into a load.	Depending on the cable connected, as follows: • If the Pads cable is attached, you are prompted to, **Verify Test Load is Attached and Press the Charge Button**. • If external paddles are attached, you are prompted to, **Verify Paddles are in Holders and Press the Charge Button**. • If internal paddles are attached, you are prompted to, **Apply Paddles to Load and Press the Charge Button**. • If no cable is attached, you are prompted to, **Connect Therapy Cable**. Once charged the Shock button lights and you are prompted to, **Press Shock** or **Press Shock buttons on paddles**. After the test completes using one Therapy cable, you are prompted to, **Run defib test again with a different therapy cable? Yes/No**	Respond to the prompt, as follows: • Check the test load is attached and press the Charge button. • Make sure the paddles are seated in their pockets and press the Charge button. • Apply the paddles to the load and press the Charge button. • Connect a Therapy cable. Press the Shock button. Use the Navigation and Menu Select buttons to respond. Change the cable and select **Yes**, to repeat the test for another cable. You should repeat the test for each cable used. Select **No**, once all cables have been tested.
Battery A Battery B	Checks the capacity and calibration status of the batteries in Compartments A and B.	**Cal Recommended,** if battery calibration is required.	If prompted, calibrate the battery. See the *Instructions for Use* for details.
SpO_2	Checks the internal SpO_2 PCA. The SpO_2 cable is not tested.	None.	None.
NBP	Checks to see if the NBP module is functioning; determines if it is due for calibration.	None.	None.
CO_2	Checks to see if the CO_2 module is functioning; determines if it is due for calibration.	None.	None.
Printer	Runs a printer self test.	None.	None.

Operational Check Report

The Operational Check takes only a short time to complete. When it is done, a report is printed, as shown in Figure 18. The first part of the report lists test results. The second part lists checks to be performed by the user.

Figure 18 Operational Check Report



Operational Check Report
Model Number: M3535A
Serial Number: USD00123456
Options: 12-Lead NBP SpO2 EtCO2 Pacer
Ver.: B.03.00

Current Operational Check:
DD Mon YYYY HH:MM:SS

Last Operational Check:
DD Mon YYYY HH: MM:SS: Pass/Fail

Current Test Results:
Display Test: Pass
General System Test: Pass
Audio Test: Pass
Leads ECG Test: Pass/ECG Cable
Pads/Paddles ECG Test: Pass/Pads
Pacer Test: Pass
Defib Test: Pass/External Paddles
Battery Compartment A Test: Pass
Battery Compartment B Test: Pass
SpO2 Test: Pass
NBP Test: Pass
CO2 Test: Pass
Printer Test: Pass

Qty/Check List:
___ Defibrillator Inspection
___ Cables/Connectors
___ Paddles/Pads
___ Monitoring Electrodes
___ Charged Batteries
___ AC/DC Power & Cord
___ Printer Paper
___ Data Card
___ SpO2 Sensor
___ NBP Cuffs & Tubing
___ CO2 FilterLine

Comments:

Inspected by:_____

Press the **[Print]** soft key when the Operational Check is complete to print an additional copy of the report.

Operational Check Summary

The Operational Check summary lists the results from the last 60 operational checks.

To view the Operational Check summary:

1 Turn the Therapy Knob to **Monitor** (or Exit Service Mode, if applicable).

2 Press the Menu Select button.

3 Using the Navigation buttons, select **Other** and press the Menu Select button.

4 Select **Operational Check** and press the Menu Select button.

5 Select **Op Check Summary** and press the Menu Select button.
The message “Leaving Normal Operating Mode. Patient Monitoring is Off. To return to Normal Operating Mode, press the Exit Softkey.” appears. The Operational Check Summary screen is displayed.

6 Press the [**Print**] soft key to print the report.

Service Mode Tests

These tests include manual interaction on tests such as the display and controls. These tests help you to isolate any problems with the device. See “Service Mode Tests” on page 192 for more information on Service Mode tests.

Troubleshooting Methodology

We recommend using the methodology described on the following pages to isolate and repair problems with the HeartStart MRx.

1. **Decontaminate the device using local decontamination procedures.**
   Refer to the *Instructions for Use*.
2. **Check the Ready for Use (RFU) indicator.**
   See “Ready For Use Indicator” on page 35.
3. **Perform a visual inspection.**
   Thoroughly examine the device and its cables and accessories. Refer to “Visual Inspection” on page 191.

   If no further troubleshooting is needed, proceed to Step 13 to repair the device. Otherwise, continue with Step 4.
4. **Turn on the device.**
   Failures and messages appear on the display when you turn on the monitor/defibrillator.

   Continue with Step 5.
5. **Check the status log.**
   The Status log includes entries for all errors logged during normal operating mode, Automated tests, Service Mode tests, and Operational Checks. The error indicates the most likely module or PCA that failed. (See "Status Log Errors" on page 55 for more information.)

   Continue with Step 6.
6. **Run the Operational Check.**
   The Operational Check tests the functionality of all PCAs and modules present on the device. For example, if the HeartStart MRx is equipped with the Noninvasive Blood Pressure measurement, the Operational Check performs a self-test on that module, and includes the results both on the screen and on the printed report. The Operational Check results indicate the area of the device that is experiencing problems. Use this information to troubleshoot and repair the device. See “Operational Check” on page 39 for detailed instructions.

   Continue with Step 7.
7. **Check the Status log and the Automated Test summary.**
   Any errors that occur during the Operational Check are written to the Status log. Use these messages to isolate the problem. The Automated Test summary lists the results of past hourly, daily, and weekly tests and provides you with information on the device’s history.

   If no further troubleshooting is needed, proceed to Step 13 to repair the device. Otherwise, continue with Step 8.

8. **Use the Troubleshooting tables to identify the problem.**

   Use the Troubleshooting tables to find information on messages and common troubleshooting issues.

   If no further troubleshooting is needed, proceed to Step 13 to repair the device. Otherwise, continue with Step 9.

9. **Interview the user. Gather the external components.**

   If possible, talk directly with the user who reported the problem. Identify what they were doing when the problem occurred, and exactly what happened. What was on the display? Were any sounds noticed? Were there operational problems?

   If possible, obtain the cables, paddles, battery, etc., that were in use when the problem occurred and use them in your evaluation.

   If no further troubleshooting is needed, proceed to Step 13 to repair the device. Otherwise, continue with Step 10.

10. **Try to reproduce the problem.**

    Try to reproduce the problem using the Troubleshooting tables to identify the symptoms and possible solutions and perform any repairs indicated, as in Step 13.

    If the problem cannot be reproduced, an intermittent condition or operator error is likely. Check the device's repair history (Step 11.)

11. **Examine the device's repair history.**

    Some intermittent problems cannot be reproduced. If the device was returned before for the same problem, replace the most likely subassembly.

12. **Run the Service tests, if needed.**

    Use the tests available in Service Mode to focus in on possible causes. See"Service Mode Tests" on page 192 for more information.

13. **Repair any problems found.**

    Follow the procedures in the Repair chapter to replace defective parts or subassemblies. When the repair is complete, continue with Step 14.

14. **Verify the device's performance.**

    Use the procedures found in the Performance Verification chapter to verify that the device is operating properly. Be sure the testing you perform is appropriate for the level of repair. The requirements for testing are described in "Required Testing Levels" on page 180.

Troubleshooting Flowcharts

Figure 19 shows the parts of the device that are tested in each mode. Use this chart to troubleshoot the device based on failures in some tests and not in others.

Figure 20 through Figure 24 show the troubleshooting steps for each state of the RFU Indicator.

Figure 19 Test Coverage

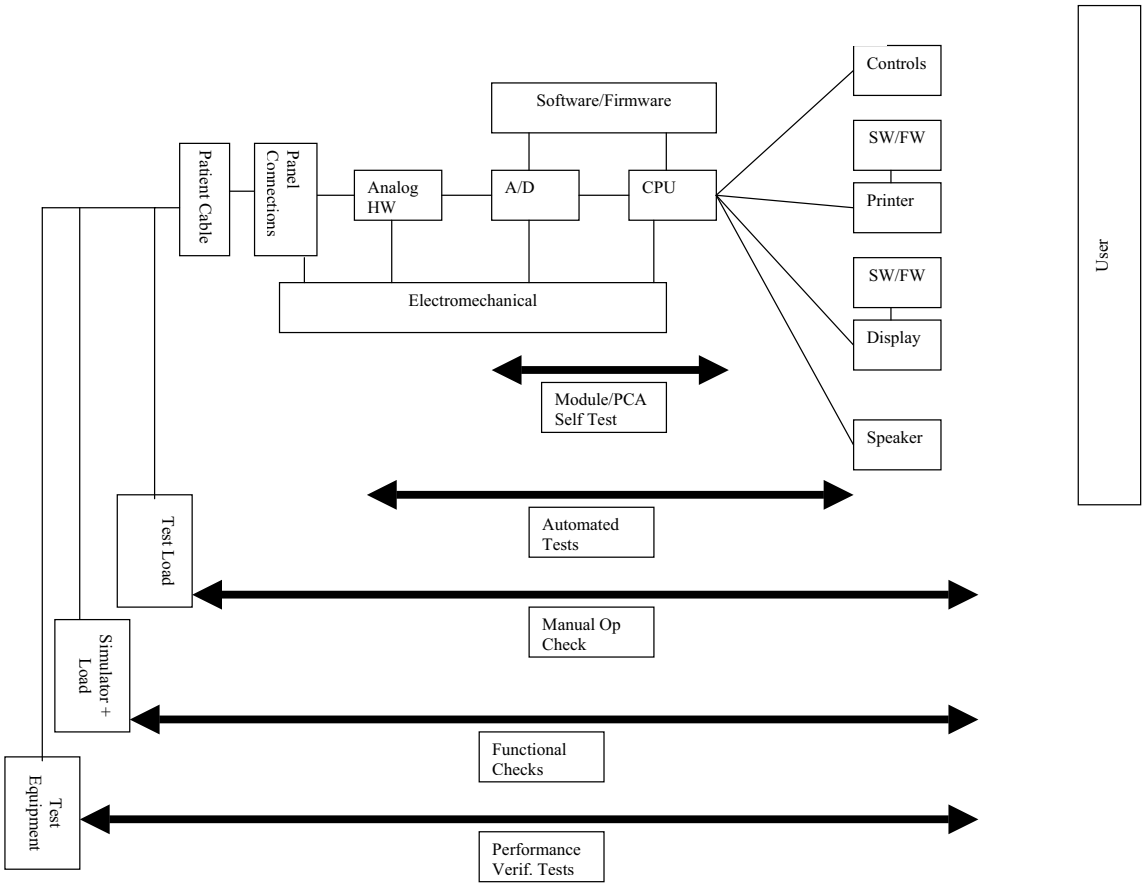


Figure 20 RFU Indicator Hourglass

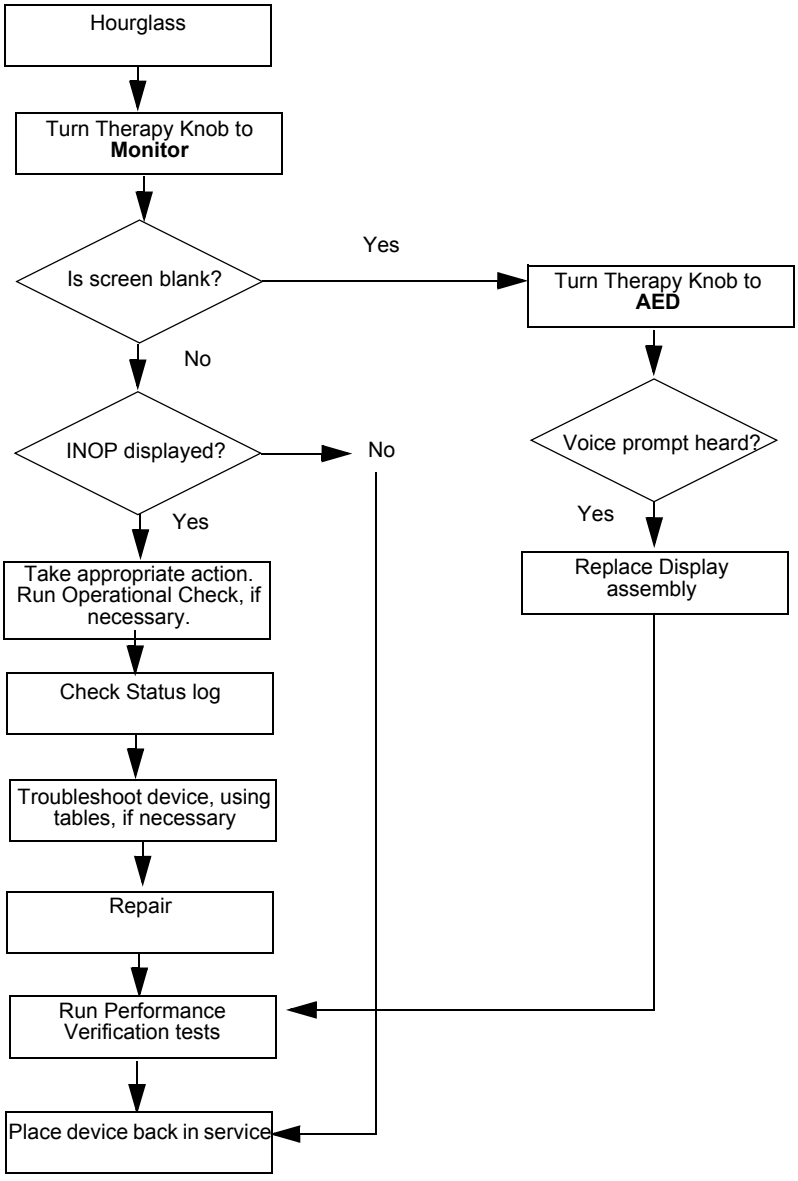


Figure 21 RFU Indicator Blinking X With Chirp

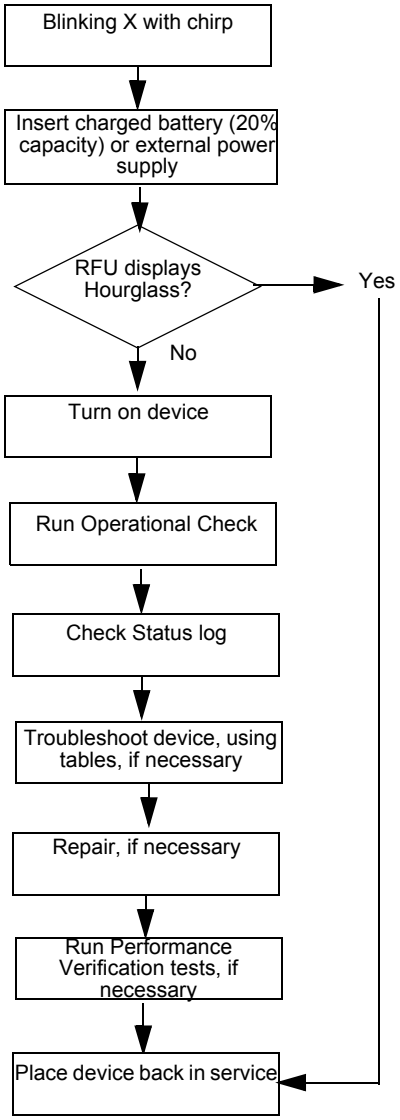


Figure 22 RFU Indicator Blinking X No Chirp

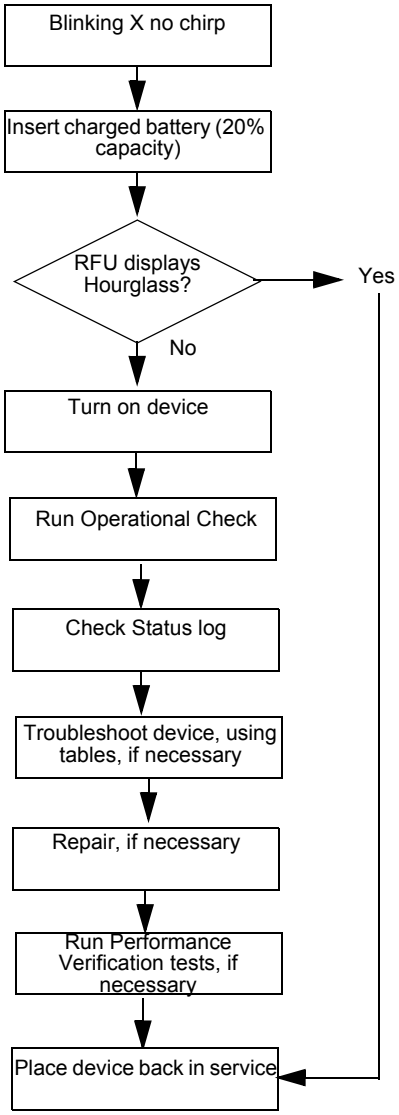


Figure 23 RFU Indicator Solid X With Chirp

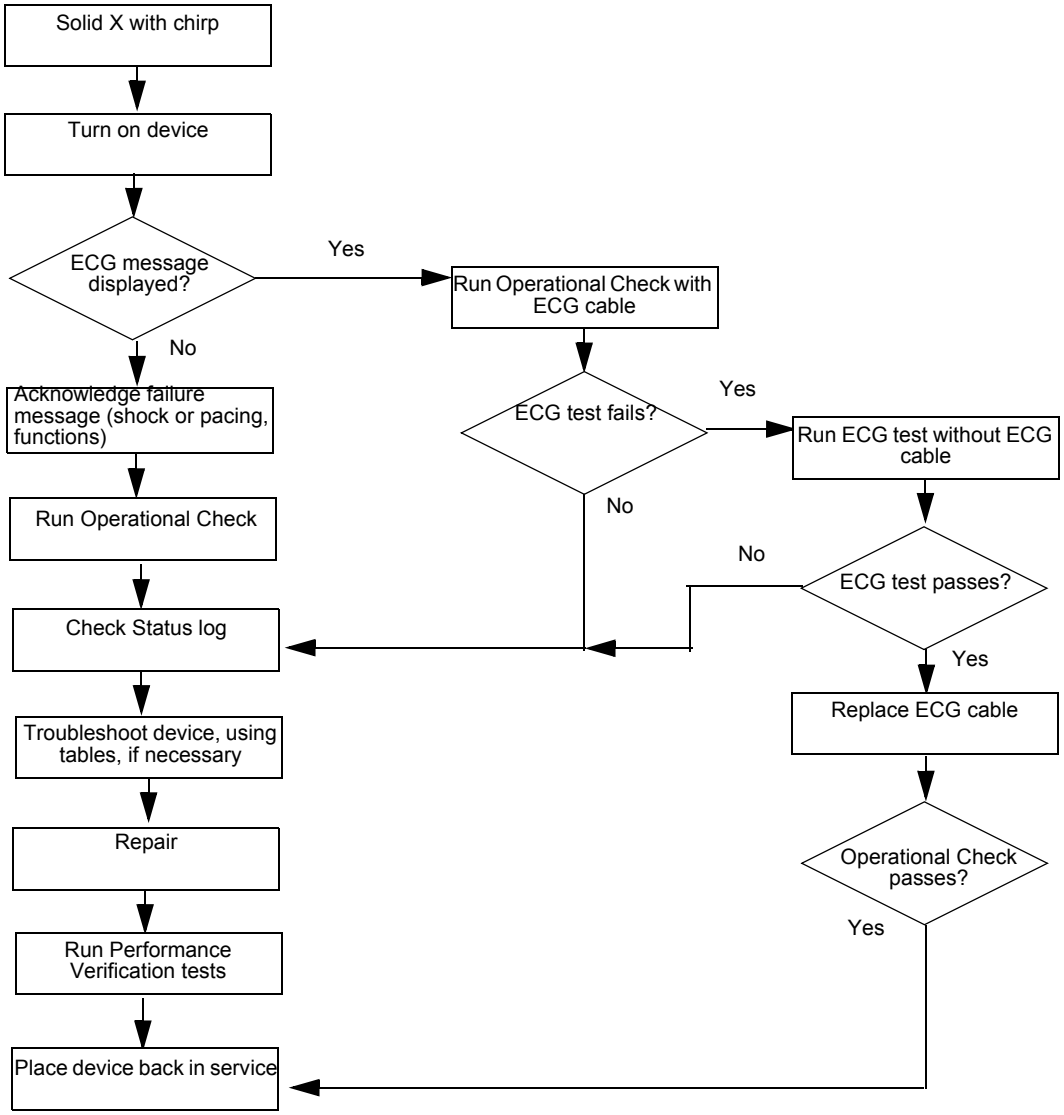
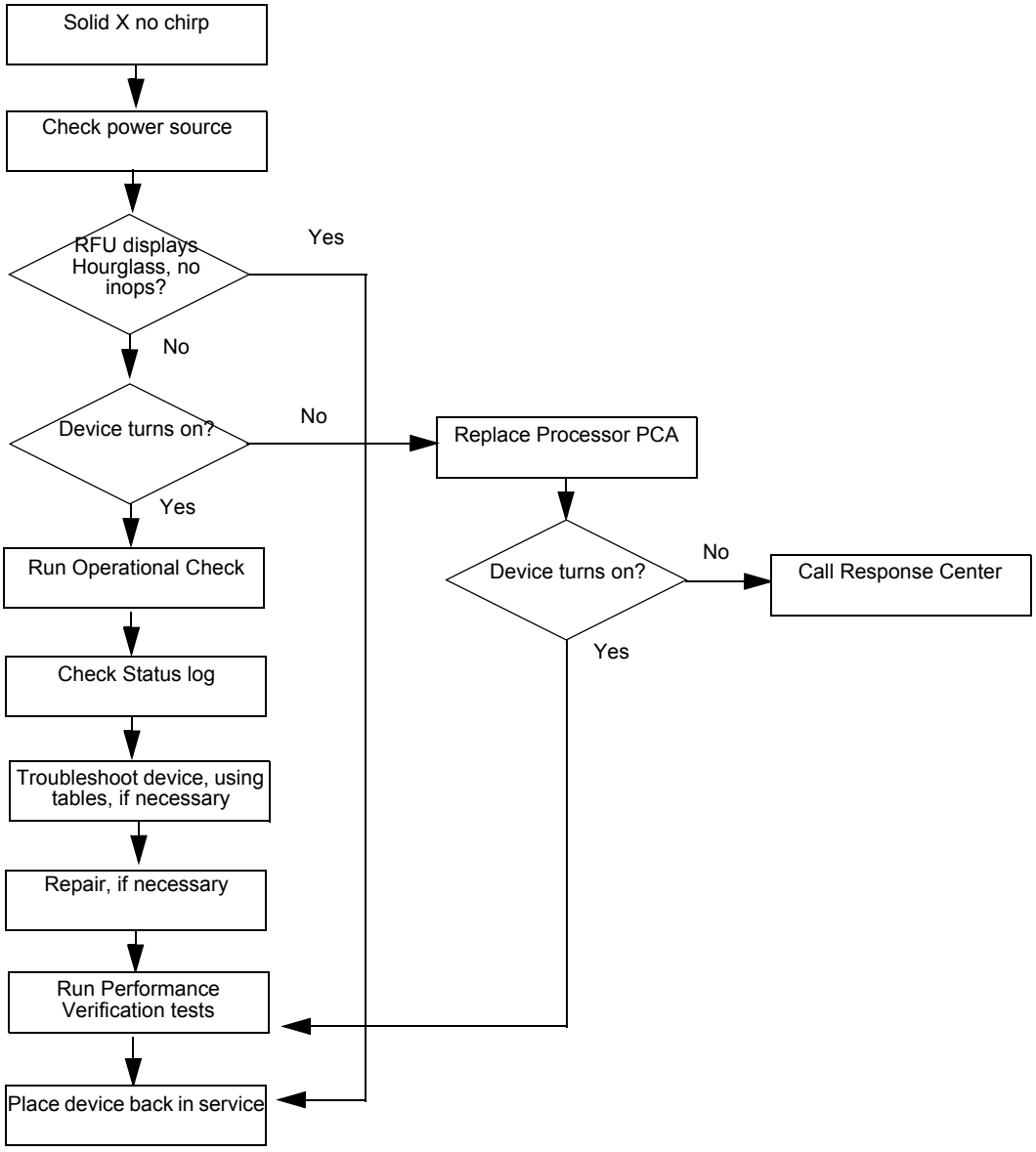


Figure 24 RFU Indicator Solid X No Chirp



Troubleshooting Tables

The Troubleshooting tables provide information on messages and common troubleshooting issues.

NOTE Before replacing any components, ***always*** run an Operational Check and check the Status log for errors. Before replacing any parts, check to see if all the cables and flex circuits are properly connected See “Repair Notes” on page 82.

This section is organized into the following tables:

Audio Tones

The HeartStart MRx emits tones to alert you to its status.

Table 5 Audio Tones

Tone/Indication	Definition
Single beep.	Message tone. Accompanies a new message on the display. Informational such as switching to the other battery.
Continuous tone, lower pitch than charged tone.	Charging tone. Generated when the Charge button is pressed and continues until the device is fully charged.
Continuous tone.	Charged tone. Generated when the selected defibrillation energy is reached and continues until the Shock button is pressed, the [**Disarm**] soft key is pressed, or the device disarmed automatically after the configured time had elapsed since pressing the Charge button.
Periodic chirp.	Low battery or RFU failure. Repeated periodically while the condition exists.
Continuous tone, alternating pitch.	Device will shut down in one minute.
Tone repeated once a second. Red alarm indicator message for applicable HR/arrhythmia, apnea, and extreme desat alarms.	**Philips' Red Alarm Tone:** Generated while at least one red alarm is occurring. 80.5 dB
High pitched tone repeated five times followed by a pause. Red alarm indicator message for applicable HR/arrhythmia, apnea, and extreme desat alarms.	**IEC Red Alarm Tone:** Generated while at least one red alarm is occurring. 76.5 dB
Tone repeated every two seconds, lower pitch than red alarm tone. Yellow alarm indicator message for applicable HR/arrhythmia, SpO_2 , NBP, and $EtCO_2$ alarms.	**Philips' Yellow Alarm Tone:** Generated while at least one yellow alarm is occurring. 67.4 dB
Lower pitched tone is repeated three times, followed by a pause. Yellow alarm indicator message for applicable HR/arrhythmia, SpO_2 , NBP, and $EtCO_2$ alarms.	**IEC Yellow Alarm Tone:** Generated while at least one yellow alarm is occurring 73.4 dB
Tone repeated every two seconds, lower pitch then yellow alarm tone. Cyan indicator message.	**Philips' Inop Tone:** Generated while at least one inop condition is occurring.
Lower pitched tone is repeated twice, followed by a pause. Cyan indicator message.	**IEC Inop Tone:** Generated while at least one inop condition is occurring.
Tone occurring synchronously with each heart beat.	QRS tone.

Status Log Errors

The Status log includes entries for all errors logged during normal operating mode, Automated tests, Service and Configuration Mode, and Operational Checks. In some cases, an inop also appears on the screen, when in normal operating mode. Non-critical conditions, such as low battery, and calibration due, are ***not*** listed in the Status log.

Each entry includes the:

- date and time of the error
- most likely module or PCA that failed
- 8-digit error code for software errors (for factory use)
- optional additional information about the error
- device operating mode at the time of the error

The status log can contain up to 50 entries, with 25 being displayed on a single screen.

NOTE Clear the Status log after a successful Operational Check by pressing the Menu Select button from the Status log menu and selecting **Clear Log**.

To view the Status log:

1 Access Service Mode.
See “Accessing Service Mode” on page 10.

2 From the Service Mode Main menu, select **Status Log** and press the Menu Select button.

3 Press the **[Print Log]** soft key if you want to print the report

Figure 25 Status Log Screen

Table 6 Status Log Errors

Inop	Status Log Error	Suggested Solution
Fan Failure	Internal Fan Failure	Replace Fan assembly.
Power Supply Failure	Processor 5V	Replace Processor PCA.
	Therapy 5V	Replace Therapy PCA.
	Therapy 5V	Replace Power PCA.
	V Standby	Replace AC/DC power module.
		Replace Power PCA.
	12V Supply	Replace Power PCA.
	3V Supply	Replace Power PCA.
	3V Standby	Replace Processor PCA.
	Ground Voltage	Replace Processor PCA.
Shock Equip Malfunction	Charge/Shock Failure	Replace Therapy PCA.
	Pacing Failure	Replace Therapy PCA.
Pacer Equip Malfunction	Pacing Failure	Replace Therapy PCA.
ECG Equip Malfunction	ECG Gain	Replace Processor PCA.
	ECG Noise	Replace Processor PCA.
	ECG 5V	Replace Processor PCA.
	ECG Front End Failure	Replace Processor PCA.
	ECG Bias	Replace Processor PCA.
ECG Cable Failure	ECG Bias	Replace ECG cable.
Pads Cable Failure	Pads Bias	Replace Pads cable.
Paddles Cable Failure	Pads Bias	Replace Pads cable.
Pads ECG Equip Failure	Pads Gain	Replace Power PCA.
	Pads Noise	Replace Power PCA.
	Pads 5V	Replace Power PCA.
	Pads PCI	Replace Pads cable/Power PCA.
	Paddles in Pockets	Replace Pads cable/Power PCA.
	Pads Impedance	Replace Pads cable/Power PCA.
	Pads Bias	Replace Power PCA.
NBP Equip Malfunction	Self test	Replace NBP module.
	Communication	Replace NBP module.
SpO_2 Equip Malfunction	Self test	Replace SpO_2 module.
	Communication	Replace SpO_2 module.

Table 6 Status Log Errors (Continued)

Inop	Status Log Error	Suggested Solution
CO_2 Equip Malfunction	Self test Communication	Replace CO_2 module. Replace CO_2 module.
Printer Malfunction	Selftest Communication	Replace printer. Replace printer.
Incompatible Printer	Unsupported language - Printer Assembly	The 50mm printer is in the device and the software is looking for the 75 mm printer. Install the 75 mm printer in the device.
None.	SW Watchdog Fail	If recurring, reload software and contact Response Center.

The following table lists additional actions to try if the suggested solution in Table 6 does not fix the problem.

Table 7 Additional Solutions

Inop	Status Log Error	Suggested Solution
NBP Equip Malfunction	Communication	• Replace NBP module cable. • Replace case interconnect ribbon cable. • Replace Processor PCA.
SpO_2 Equip Malfunction	Communication Selftest	• Replace measurement module panel. • Replace Processor PCA. • Replace Processor PCA.
CO_2 Equip Malfunction	Communication	• Replace CO_2 module ribbon cable. • Replace case interconnect ribbon cable. • Replace Processor PCA.
Printer Malfunction	Communication	• Replace printer data cable. • Replace Processor PCA.

The following table lists the messages and corresponding 12-lead transmission errors that can appear in the status log. For additional information on 12-lead transmission implementation, see the *12-Lead Transmission Implementation Guide* (M3536-90900).

Table 8 12-Lead Transmission Status Log Errors

Error Message	Status Log Error	Possible Causes	Suggested Solutions
Transmission Settings Have Not Been Configured	Missing settings - 12LXmit Config	The Hub information settings are not correct.	Modify the Hub Configuration settings on the MRx as needed.
No transmission devices detected	No response - 12LXmit Device	• The cell phone is not connected properly.	• Check that the phone is connected to the serial cable and that the serial cable is connected to the RS232 port on the MRx. For some phones, it may be necessary to disconnect the cable and reconnect it before each transmission.
		• The cell phone's RS232 port is not configured correctly.	• Work with your cell phone provider to enable the RS232 port on your cell phone.
		• The cell phone's RS232 port hardware is incompatible.	• Work with your cell phone provider to choose a phone that is compatible.
		• The serial cable is defective or incompatible.	• Work with your cell phone provider to obtain a serial cable that connects to your phone with a 9-pin D serial cable connection.
		• The cell phone is not set up properly.	• Work with your cell phone provider to ensure that the cell phone is set up as a modem using the RS232 port.
Transmission Failed. Error configuring transmission device	Configure Failed - 12LXmit Device	The Configuration String under the Serial Phone Profile settings is not correct.	Work with your cell phone provider to ensure that the Configuration String is correct.
No Dial tone	No Dial tone - 12LXmit Dialing	• The cell phone is not connected properly.	• Check that the phone is connected to the serial cable and that the serial cable is connected to the RS232 port on the MRx.
		• Cell phone service is unavailable.	• Check that the cellular signal strength is sufficient.

Table 8 12-Lead Transmission Status Log Errors (Continued)

Error Message	Status Log Error	Possible Causes	Suggested Solutions
Transmission Failed. Connection Failed	• Connect Failed - 12LXmit Dialing • Disconnect Failed - 12LXmit Dialing	• The Dial String under the Serial Phone Profile settings is incorrect. • Data transfer service is unavailable on the phone. • Wrong number.	• Work with your cell phone provider to ensure that the Dial string is correct. • Work with your cell phone provider to ensure that your cell phone plan has data transfer capability. • Check the number and re-send.
Invalid Password	• User/pw failure - 12LXmit Network • User/pw failure - 12LXmit Server	• The PPP User Name or PPP Password under the Serial Profile Phone settings is incorrect. • The server User Name or Password is incorrect.	• Modify the Serial Phone Profile setting as needed. • Modify the Hub settings as needed.
Transmission Failed	• PPP Attach Timeout - 12LXmit Network • Request Timeout - 12LXmit Server • Partial transmission - 12L Transmit • Invalid request - 12L Transmit • HTTP client error - 12L Transmit	• The network is down. • The server connection has timed out. • The phone is disconnected. • TCP/IP Failure • The web server has rejected the data.	• Check with your ISP to see if your service is down. • Re-send the 12-lead report. • Check that the phone is connected to the serial cable and that the serial cable is connected to the RS232 port on the MRx. • Re-send the 12-lead report. If still unsuccessful, check the MRx configuration settings. • Check the MRx and the12-Lead Transfer Station to ensure that the correct product versions are installed.
Transmission Failed. Connection Interrupted.	Modem Connection Lost - 12LXmit Network	The network is down.	• Check that the cellular signal strength is sufficient. • Re-send the 12-lead report.
Transmission Failed. Cannot reach server	Unreachable - 12LXmit Server	No server or the connection has been lost.	• Check that the phone is connected to the serial cable and that the serial cable is connected to the RS232 port on the MRx. • Re-send the 12-lead report.
Transmission Failed. Server unknown	DNS query failure - 12LXmit Server	• The DNS has timed out or there has been a failure in the DNS.	Work with your ISP to ensure the Serial Phone Profile and Hub settings are correct.

Table 8 12-Lead Transmission Status Log Errors (Continued)

Error Message	Status Log Error	Possible Causes	Suggested Solutions
Transmission Failed. Settings Configured Incorrectly	• Bad URL Format - 12LXmit Server • Bad proxy settings - 12LXmit Server • Bad user/pw settings - 12LXmit Server	• There is a problem with the Server URL, Proxy user name, Proxy password	Work with your ISP to ensure the Serial Phone Profile and Hub settings are correct.

Startup Errors

This section discusses errors that can occur at startup.

Table 9 Startup Errors

Message	Suggested Solution
Critical Failure Detected. Service unit.	• Check the status log. • Reload software
Device serial number has not been entered. Service unit.	• Enter the device's serial number. See "Entering the Serial Number and Enabling Options" on page 128 for more information.
None. Hourglass appears on RFU indicator but device appears frozen when you turn the Therapy Knob to **Monitor**.	• Remove all power sources (AC, DC, and/or battery). • Turn Therapy Knob to **Monitor**. • Insert a battery or apply AC/DC power module.
All settings have been set to factory default values.	• Reconfigure the device to the user's settings. See the *Instructions for Use* for details.
• Internal Memory Failure message with a beep • Internal Memory Failure inop (appears every time the device is turned on)	• None. Internal memory card is automatically reformatted. All data on the card has been erased. • Run an Operational Check and check the status log. If an Internal Memory error is listed, replace the internal memory card.

General Problems

The following table discusses general problems that can occur.

Table 10 General Monitoring Problems

Symptom	Possible Causes	Suggested Solution
Replace Clock Battery message	The clock (lithium) battery (on the Processor PCA) needs to be replaced.	• Replace clock battery on Processor PCA.
One or more controls don't respond (e.g., select lead or soft keys).	Bad connection between keys and detection circuits.	• Run Controls test in Service Mode to confirm. • Check flex circuit connections between Display assembly and Processor PCA.
	Failure in keypress detection/ processing.	• Replace Processor PCA.
	Failure in keys.	• Replace Display assembly.

ECG Monitoring Problems

TIP When troubleshooting ECG problems, always check the cable first by running an Operational Check. When troubleshooting problems with paddles, try replacing the paddles first.

Table 11 ECG Monitoring Problems - Leads

Symptom	Possible Causes	Suggested Solution
Flat line - no waveform, no **Leads Off** message.	Short in patient cable or leads.	Run the Operational Check with the ECG cable. If the test fails, run it without the ECG cable. If the test passes, replace the cable. If the test fails: • Replace measurement module panel. • Replace Processor PCA.
Poor ECG signal quality - (noisy trace, wandering baseline, etc.) from signal acquired from monitoring electrodes.	• Radio frequency interference (RFI) is causing artifact. • Problem with internal cables. • Problem with measurement module panel.	• Relocate or turn off equipment that may be causing RFI. • Be sure all internal cables are connected properly. Check the cables from the measurement module panel to the Processor PCA. • Run the Operational Check with the ECG cable. If the test fails, run it without the ECG cable. If the test passes, replace the cable. If the test fails, replace Processor PCA.
Leads Off message even though ECG cable and leads have been replaced and are properly connected.	Open circuit in internal Leads ECG wiring or front end, due to: • Problem with measurement module panel.	• Replace measurement module panel.

Table 12 ECG Monitoring Problems - Pads/Paddles

Symptom	Possible Causes	Suggested Solution
Flat line - no waveform, no **Pads Off** message.	Short in patient cable.	Run the Operational Check with the Pads cable. If the test fails, run it without the Pads cable. If the test passes, replace the cable. If the test fails: • Replace Therapy port. • Replace Power PCA.
Poor ECG signal quality - (noisy trace, wandering baseline, etc.) from signal acquired from paddles/pads.	• Radio frequency interference (RFI) is causing artifact. • Problem with internal cables. • Problem with Therapy port.	• Relocate or turn off equipment that may be causing RFI. • Be sure all internal cables are connected properly. Check the cables from the Therapy port to the Therapy PCA and from the Therapy PCA to the Power PCA. • Run the Operational Check with the Pads cable. If the test fails, run it without the Pads cable. If the test passes, replace the cable. If the test fails, replace Power PCA. • Replace Therapy port.
Pads Off message even though pads cable has been replaced and is properly connected.	Open circuit in internal Therapy port wiring or front end, due to: • Cable from Therapy port to Therapy PCA has bad connection. • Defective Therapy port or cable to Power PCA. • Problem with internal cable. • Defective Power PCA.	• Reconnect cable properly. • Replace Therapy port. • Replace Therapy-Power-High Voltage cable. • Replace Power PCA.

NBP Monitoring Problems

Table 13 NBP Monitoring Problems

Symptom	Possible Causes	Suggested Solution
NBP Equip Malfunction	NBP hardware malfunction.	• Replace NBP module.
NBP Calibration Overdue	The NBP module should be calibrated once a year or every 10,000 cycles.	• Calibrate the NBP module. See “Checking the NBP Module” on page 19.
NBP Measurement Failed	A measurement value could not be obtained.	• Check accuracy as described in “Checking the NBP Module” on page 19. Calibrate if needed.
NBP Service Required	The NBP module has reached its end of life, defined as 50,000 cycles.	• Replace NBP module.
Measurement cycle doesn’t start.	• Problem with internal tubing connections. • Failure of front panel button. • NBP module failure. • Processor PCA failure.	• Check internal tubing. Reconnect/replace as needed. • Run Controls test in Service Mode to confirm. Replace Display assembly if needed. • Replace NBP module. • Replace Processor PCA.
Pump operates, cuff inflates normally, but cuff will not deflate.	NBP module failure.	• Replace NBP module.
Reading inaccurate	• NBP module needs calibration. • NBP module failure.	• Check accuracy as described in “Checking the NBP Module” on page 19. Calibrate if needed. • Replace NBP module.

SpO_2 Monitoring Problems

Table 14 SpO_2 Monitoring Problems

Symptom	Possible Causes	Suggested Solution
SpO_2 Sensor Malfunction Numeric is replaced with a -?-.	The SpO_2 sensor or cable is faulty.	• Try another sensor and cable. • If this does not clear the message, replace SpO_2 PCA. • Replace measurement module panel.
SpO_2 Equip Malfunction	The SpO_2 hardware is faulty.	• Unplug and replug the PCA. • If this does not clear the message, replace SpO_2 PCA.
No response - no value on screen, no pleth bar.	• Bad sensor. • Bad internal connection. • SpO_2 PCA failure.	• Try another sensor and cable. • Try flexing the SpO_2 flex circuit to see if there is an intermittent failure that may self-correct while other tests are being conducted. • Carefully re-seat the flex circuit between SpO_2 port and SpO_2 PCA. Check that SpO_2 PCA is properly seated on Processor PCA. • Replace SpO_2 PCA.
Reads obviously wrong value.	• Bad sensor. • SpO_2 PCA failure.	• Try another sensor and cable. • Replace SpO_2 PCA.
Noisy/intermittent signal.	• Bad sensor. • Processor PCA failure.	• Try another sensor and cable. • Replace Processor PCA.

CO_2 Monitoring Problems

When troubleshooting CO_2 problems, it is recommended that you try replacing the CO_2 module first. If the problem persists, then replace all of the CO_2 internal tubing, intake receptacle wires and tubing.

Table 15 CO_2 Monitoring Problems

Symptom	Possible Causes	Suggested Solution
CO_2 Equip Malfunction	CO_2 hardware malfunction.	• Make sure that you have the correct module in the device. See "Other Electrical Assemblies" on page 216 for information on ordering the CO_2 module. • Replace the CO_2 module.
CO_2 Occlusion	A sample cannot be taken because the FilterLine is blocked.	• Check that the FilterLine is not kinked and is free of any blockages. • Disconnect and reconnect the FilterLine to reset the module. • If necessary, replace the FilterLine. • If the message still appears, replace the CO_2 internal tubing and intake receptacle wires and tubing. Replace CO_2 module.
CO_2 Calibration Overdue	The CO_2 module should be calibrated once a year or after 4,000 operating hours.	• Calibrate the CO_2 module. See "Checking the CO_2 Module" on page 23.
CO_2 Service Required	The CO_2 module has reached its end of life, defined as 15,000 operating hours.	• Replace CO_2 module, all CO_2 internal tubing and intake receptacle wires and tubing.
CO_2 Overrange	• The CO_2 value is higher than the measurement range. • Problem with internal tubing connections. • CO_2 module failure.	• Check accuracy as described in "Checking the CO_2 Module" on page 23. Calibrate if needed. • Check internal tubing. • Reconnect/replace internal tubing and intake receptacle wires and tubing, as needed. • Replace CO_2module.
Failure to display CO_2 measurement.	• CO_2 module failure. • Internal tubing broken or damaged. • Processor PCA failure. • Therapy PCA failure	• Replace the FilterLine. • Re-seat both ends of the wire between the intake receptacle and the CO_2 module. • Replace case interconnect ribbon cable. • Replace CO_2module. • Replace the CO_2 internal tubing and intake receptacle wires and tubing. • Replace Processor PCA. • Replace Therapy PCA.

Table 15 CO_2 Monitoring Problems (Continued)

Symptom	Possible Causes	Suggested Solution
Reading inaccurate.	• FilterLine is blocked or damaged • CO_2 module needs calibration. • CO_2 module failure. • Problem with internal tubing connections.	• Replace FilterLine. • Check accuracy as described in "Checking the CO_2 Module" on page 23. Calibrate if needed. • Replace CO_2module. • Check internal tubing and intake receptacle wires and tubing. Reconnect/replace as needed.
CO_2 Check Exhaust	When CO_2 is turned on, the exhaust tube or outlet port is blocked to the extent that a measurement sample cannot be taken. Note: If the exhaust tube becomes blocked during monitoring, the CO_2 waveform will be a flat line, and if alarms are on, an apnea alarm will be annunciated.	• Replace FilterLine. • Make sure the exhaust tubing is not kinked and is free of blockages. • If necessary, replace the internal tubing and intake receptacle wires and tubing. Replace CO_2 module.
The CO_2 module does not start when the FilterLine is connected to the MRx. There is no CO_2 waveform on the display.	• FilterLine is damaged. • Intake receptacle failure • CO_2 module failure or sensor failure	• Replace FilterLine. • Run an Operational Check. If the CO_2 test fails, replace the CO_2module. If the CO_2 test passes, examine the sensor for dirt or foreign objects, clean if necessary. If problem persists, replace the CO_2 internal tubing, intake receptacle wires and tubing.
Replacement recommended	CO_2 module has reached end of life	Replace CO_2 module and CO_2 internal tubing, intake receptacle wires and tubing.

Defibrillation Problems

Table 16 Defibrillation Problems

Symptom	Possible Cause	Suggested Solution
Charging Problems		
Won't charge in Manual Defib Mode using Charge button on paddles.	• Paddles not connected properly.	• Check/restore connection.
	• Paddles defective.	• Confirm paddles problem by connecting Pads and attempting to charge device using Charge button on the MRx. • Replace paddles if needed.
	• Problem with internal connections.	• Check/restore connections between Therapy port and Therapy PCA, and between Therapy PCA and Processor PCA.
	• Therapy port defective.	• Replace Therapy port.
	• Therapy PCA defective.	• Replace Therapy PCA.
	• Failure on Processor PCA.	• Replace Processor PCA.

Table 16 Defibrillation Problems (Continued)

Symptom	Possible Cause	Suggested Solution
Won't charge in Manual Defib Mode using Charge button on MRx.	• Therapy cable.	• Connect paddles or pads. Check to see if an ECG is displayed. If the device recognizes the Therapy cable but still doesn't charge, there may be a break in the Therapy cable. • Replace Therapy cable.
	• Failure of front panel button.	• Run Controls test in Service Mode to confirm. Replace Display assembly, if needed.
	• Therapy PCA defective.	• Replace Therapy PCA.
	• Failure on Processor PCA.	• Replace Processor PCA.
Won't charge in AED Mode, but charges in Manual Defib Mode.	• Failure in pads ECG front end.	• Replace Power PCA.
	• Failure on Processor PCA.	• Replace Processor PCA.
Doesn't charge to energy setting on Therapy switch.	• Therapy Knob has been replaced and installed incorrectly.	• Confirm by rotating Therapy Knob back and forth to check travel and alignment. • Run Controls test in Service Mode to test Therapy Knob. Reinstall Therapy Knob, if necessary.
	• Therapy switch failure.	• Replace Therapy switch.
	• Therapy PCA defective.	• Replace Therapy PCA.
	• Failure on Processor PCA.	• Replace Processor PCA.

Table 16 Defibrillation Problems (Continued)

Symptom	Possible Cause	Suggested Solution
Charges too slowly.	• The device is being operated with AC/DC power (no battery) or the battery power is low.	• Install a fully charged battery.
	• Battery not fully charged, or defective.	• Install a fully charged battery.
	• Therapy PCA defective.	• Replace Therapy PCA.
Discharging Problems		
Won't Shock in Manual Defib mode using Shock buttons on paddles.	• Faulty paddles.	• Confirm paddles problem by connecting Pads and attempting to discharge device using Shock button on the MRx. Replace paddles if needed.
	• Problem with internal connections.	• Check/restore connections between Therapy port and Therapy PCA, and between Therapy PCA and Processor PCA.
	• Therapy port defective.	• Replace Therapy port.
	• Therapy PCA defective.	• Replace Therapy PCA.
	• Failure on Processor PCA.	• Replace Processor PCA.
Won't Shock in Manual Defib mode using Shock button on MRx.	• Failure of front panel button.	• Run Controls test in Service Mode to see if button is operating. Replace Display assembly, if needed.
	• Therapy PCA defective.	• Replace Therapy PCA.
	• Failure on Processor PCA.	• Replace Processor PCA.
Won't Shock in AED mode when Shock button pressed.	• Failure of front panel button.	• Run Controls test in Service Mode to confirm.
	• Therapy PCA defective.	• Replace Therapy PCA.
	• Failure on Processor PCA.	• Replace Processor PCA.
Doesn't deliver correct energy into defibrillator analyzer or delivers no energy at all. "Shock Equip Malfunction" error is displayed.	• Therapy PCA defective.	• Replace Therapy PCA.
	• Failure on Processor PCA.	• Replace Processor PCA.

Table 16 Defibrillation Problems (Continued)

Symptom	Possible Cause	Suggested Solution
Discharges only partially - some energy remains after discharge.	• Therapy PCA defective. • Failure on Processor PCA.	• Replace Therapy PCA. • Replace Processor PCA.
Charges OK, but disarms when press Shock or paddle buttons.	Patient impedance sensed as too high or too low during energy delivery due to: • Pads/paddles losing contact with patient. • Pads/paddles failure. • Pads cable failure. • Therapy PCA defective. • Failure on Processor PCA.	• Replace paddles, or pads and pads cable. as needed. • Replace Therapy PCA. • Replace Processor PCA.
Charges OK, but disarms spontaneously.	Device sensed Pads Off or Cable Off due to: • Pads/paddles losing contact with patient. • Pads/paddles failure. • Pads cable failure. Therapy PCA failure. Processor PCA failure.	Replace paddles, or pads and pads cable. • Replace Therapy PCA. • Replace Processor PCA.
Doesn't measure its own delivered energy correctly.	Therapy PCA failure.	• Replace Therapy PCA.

Pacing Problems

Table 17 Pacing Problems

Symptom	Possible Causes	Suggested Solution
Doesn't deliver correct current into pacer tester or delivers no current at all.	• Failure on Therapy PCA. • Processor PCA failure.	• Replace Therapy PCA. • Replace Processor PCA.
Doesn't measure its own delivered current correctly.	Failure on Therapy PCA.	Replace Therapy PCA.
Doesn't pace at correct rate.	Processor PCA failure.	Replace Processor PCA.
Pacer Equip Malfunction	Pacer hardware failure.	Replace Therapy PCA.

Printing Problems

Table 18 Printing Prolems

Symptom	Possible Causes	Suggested Solution
Printer Malfunction	The printer is faulty or there is a problem communicating with the printer.	If the error repeats, replace the printer assembly.
Paper won't move.	• Paper improperly loaded or jammed, or paper is wet. • Printer failure.	• Reload paper or clear jam. If paper is wet, replace with fresh dry roll. • Replace printer.
Paper moves but printing is faint or absent.	• Door improperly latched. • Dirty printhead. • Operating temperature is beyond specified range. • Printer failure.	• Check door latch. • Clean printhead according to procedures in the *Instructions for Use*. • Wait until temperature is back in operating range to continue printing. • Replace printer.
Paper moves but print quality poor or some dots missing.	• Dirty printhead. • Printer failure.	• Clean printhead according to procedures in the *Instructions for Use*. • Replace printer.
Loud buzzing or grinding noise.	Door improperly latched.	Check door latch.
Waveforms or text distorted even though they look OK on display.	Printer failure.	Replace printer.
Black line running along paper.	Dots (printhead elements) stuck on due to: Printer failure.	 Replace printer.
White line running along paper.	Dirt on printhead. Dots (printhead elements) stuck off due to: • Printer failure.	• Clean printhead. • Replace printer.
Fails Printer Test in Service Mode (other than symptoms above).	• Printer failure. • Processor PCA failure.	• Replace printer. • Replace Processor PCA.
Incompatible Printer	• The 50mm printer is in the device and the software is looking for the 75 mm printer.	• Ensure that the 75 mm printer is installed in the device

Display Problems

Table 19 Display Problems

Symptom	Possible Causes	Suggested Solution
Display completely dim. No response - all light or all dark.	• Failure of backlight. • Display failure. • No power supply or power supply failure • Processor PCA failure.	• Check cable between Processor PCA and inverter. • Check display and backlight connections. • Replace Display assembly. • Replace Power PCA (only if display is all dark). • Replace Processor PCA.
Left or right half of display is dim or display is not uniformly bright.	• Backlight cable disconnected from inverter PCA. • Backlight bulb failure.	• Reseat the connector • Replace Display assembly.
Fails Display Test in Operational Check. (Display problem other then symptoms above).	• Display failure. • Processor PCA failure.	• Replace Display assembly. • Replace Processor PCA.

Audio Problems

Table 20 Audio Problems

Symptom	Possible Causes	Suggested Solution
No audio at all.	• Speaker failure. • Processor PCA failure.	• Check speaker connections. • Replace speaker/microphone assembly. • Replace Processor PCA.
Audio is distorted.	• Damage to speaker cover. • Speaker damage or failure. • Processor PCA failure.	• Replace speaker label. • Replace speaker/microphone assembly. • Replace Processor PCA.

Table 20 Audio Problems (Continued)

Symptom	Possible Causes	Suggested Solution
Buzzing noise when audio active.	• Damage to speaker label. • Debris between speaker and speaker label. • Speaker hardware loose. • Speaker failure. • Processor PCA failure.	• Replace speaker label. • Remove speaker label, clean out debris, install new speaker label. If debris is behind plastic housing, remove speaker, clean, and replace speaker. • Tighten hardware as needed. • Replace speaker/microphone assembly. • Replace Processor PCA.
Tones present but no voice prompt (in AED Mode).	• Software error or failed localization upgrade. • Processor PCA failure.	• Reload the language. • Replace Processor PCA.
Voice prompt present but no tones.	Processor PCA failure.	• Replace Processor PCA.

Controls Problems

Table 21 Controls Problems

Symptom	Possible Causes	Suggested Solution
One or more of the buttons near the Therapy Knob doesn't respond correctly (Print, Sync, Charge, or Shock).	Processor PCA failure.	• Run Controls test in Service Mode to confirm. • Check button pieces for mechanical operation. • Replace Processor PCA.
One or more of the buttons around the display doesn't respond correctly (softkeys, Event Summary, Mark Event, Lead Select, Alarm Pause, Navigation, Menu Select).	• Failure in Display assembly. • Processor PCA failure.	• Run Controls test in Service Mode to confirm. • Check connections to Display assembly. • Replace Display assembly. • Replace Processor PCA
The Therapy switch doesn't respond correctly.	• Therapy switch defective. • Processor PCA failure.	• Replace Therapy switch. • Replace Processor PCA.

Internal Memory Problems

Table 22 Internal Memory Problems

Symptom	Possible Causes	Suggested Solution
Internal Memory Failure message with a beep	Patient data cannot be stored in internal memory because the card is corrupt.	None. Internal memory card is automatically reformatted. All data on the card is erased.
Internal Memory Failure inop (appears every time the device is turned on)	Patient data cannot be stored in internal memory because the internal memory card is not recognized.	Run an Operational Check and check the status log. If an Internal Memory error is listed, replace the internal memory card.

External Data Card Problems

Table 23 External Data Card Problems

Symptom	Possible Causes	Suggested Solution
Incompatible data card message	Data card is not compatible with the HeartStart MRx.	Use only Philips M3545A data cards.
Data Card Full message	The data card has reached capacity.	Insert a new data card or erase data from the card.
Doesn't copy data to data card.	Data card full or corrupted.	Replace data card.
No Data Card present message.	• Sufficient time not allowed for data card recognition • Data card failure. • Data card not seated properly due to bent pins. • Processor PCA failure.	• Insert data card. Once inserted, wait 5 seconds before trying to access the data card. • Replace data card. • Replace Processor PCA. • Replace Processor PCA.

4

Repair

This chapter describes how to repair the HeartStart MRx monitor/defibrillator. Details are provided on disassembling the device, removing and replacing subassemblies, and reassembling the device.

These instructions are intended for use only by service providers who are specifically trained to service the HeartStart MRx.

Overview

This chapter is organized into the following sections:

Who Should Perform Repairs

Only qualified technical personnel who have been trained in the safe and proper servicing of the HeartStart MRx should open the monitor/defibrillator case, remove and replace components, or make adjustments. If your medical facility does not have qualified technical personnel, contact the Response Center or your local Philips representative.

WARNING HeartStart MRx service should only be performed by qualified service personnel, in accordance with the *HeartStart MRx Service Manual*.

Repair Philosophy

The repair philosophy of the HeartStart MRx is subassembly replacement.

Examples of subassemblies are the printer, the Processor PCA, and selected connectors and other items. Repairs that involve replacing individual components on a PCA are not supported.

CAUTION Individual component replacement should not be attempted. Component level repair is inadvisable due to the extensive use of surface mount technology and the high parts-density on the circuit boards. Unauthorized component replacement can impair performance of the HeartStart MRx.

Calling for Service

For telephone assistance, call the Response Center nearest to you, or visit our website at: www.medical.philips.com/cms and follow the links for “CMS Response Center.” Our Biomed On-Line site can be found at: http://bol.medical.philips.com.

Table 24 Response Center Phone Numbers

North America	
Canada	800-323-2280
United States of America	800-548-8833
Europe	
European International Sales	41 22 354 6464
Austria	01 25125 333
Belgium	02 778 3531
Finland	010 855 2455
France	0803 35 34 33
Germany	0180 5 47 50 00
Italy	800 825087
Netherlands	040 278 7630
Sweden	08 5064 8830
Switzerland	0800 80 10 23
United Kingdom	07002 43258472
Asia/Asia Pacific	
Australia	1800 251 400
China (Beijing)	800 810 0038
Hong Kong Macau	852 2876 7578 0800 923
India: New Delhi Mumbai Calcutta Chennai Bangalore Hyderabad	 011 6295 9734 022 5691 2463/2431 033 485 3718 044 823 2461 080 5091 911 040 5578 7974
Indonesia	021 794 7542
Japan	0120 381 557
Korea	080 372 7777 02 3445 9010
Malaysia	1800 866 188
New Zealand	0800 251 400
Philippines	02 845 7875
Singapore	1800 PHILIPS
Thailand	02 614 3569
Taiwan	0800 005 616

Repair Notes

The following sections give details of how to successfully work with the internal assemblies of the HeartStart MRx.

Safety Precautions

WARNING Remove all power sources (AC, battery, DC) before opening the device. Failure to do so may allow the device to charge without warning and could result in serious injury or death.

CAUTION Take the necessary precautions to guard against shock or injury before you conduct monitor/defibrillator tests or repairs.

- Only properly trained technicians should service the device.
- The device can contain deadly voltages even if the device is turned off.
- Make sure the device is disarmed. (To disarm the defibrillator, press [**Disarm**]. If the Shock button has not been pressed within the time period specified in the Time to Auto Disarm Configuration setting, the defibrillator disarms automatically. Additionally, when the MRx is fully charged, you can disarm it any time by turning the Therapy Knob to the "Off" position.)
- Make sure that you disconnect all power before opening the device.
- Make sure you discharge the device before working with it.
- Make sure you work in a static safe environment. Use a static control wrist band, in conjunction with an antistatic pad which is grounded per the manufacturer's instructions.
- Special cleaning technologies are used during the manufacturing of the PCAs. Be careful not to touch the surface areas of the PCAs with bare hands. Additionally, oil from hands can affect product performance.

Flex Circuit Connections

In order for flex circuit connections to function properly, they must be disconnected and reconnected as follows:

- Always unlatch the PCA-mounted connector before removing the flex circuit, and hold the latch open while reinserting the flex circuit into the connector.
- When reconnecting, align the flex circuit carefully in its receptacle. Make sure it is both centered from side to side in the connector and oriented at 90 degrees to the connector.
- Be sure the flex circuit is fully seated in the connector and the connector is properly latched.

Flex Circuit Handling

The flex circuits are delicate and can be damaged by improper handling:

- Do not bend sharply.
- Do not scrape the contact surface against other parts.
- Handle the flex with bent tip needle nose pliers whose jaws are covered with a soft material (such as plastic tubing or tape).

Internal Connections

Whenever troubleshooting indicates a particular PCA may be at fault, it is always good practice to check all the connections to that PCA and retest before replacing the PCA.

Cable and Assembly Placement

How the wires and cables are routed and dressed inside the chassis plays an important role in two areas: in preventing long term wear problems, and in reducing electromagnetic and radio frequency interference emitted by the monitor/defibrillator.

- When you disassemble any part of the device, pay special attention to how cables and wires are routed.
- When you reassemble the device, be sure to route and dress all cables and wires as they were originally.
- Return all components to their original position within the case.

Device Reassembly

If you do not reassemble the device correctly, it may no longer be properly sealed. This could result in water damage to the device. Be sure to maintain the water-resistant seal by:

- Replacing all gaskets in their proper locations.
- Correctly assembling all parts that mate with gaskets (making sure the gaskets are not wrinkled or pinched).
- Replacing all screws.
- Making sure that screws are not cross-threaded and that they are firmly tightened.
- Tightening M3 screws to 6-inch pounds and M4 screws to 10-inch pounds.

Disposal

Prior to disposal, remove the batteries. Then dispose of the device in accordance with your country's regulations for equipment containing electronic parts.

WARNING Properly dispose of or recycle depleted batteries according to local regulations. Do not puncture, disassemble, or incinerate batteries. Be careful not to short the battery terminals because this could result in a fire hazard.

WARNING Disposal of the device with the battery inserted presents a potential shock hazard.

WARNING To avoid contaminating or infecting personnel, the environment, or other equipment, make sure you disinfect and decontaminate the monitor/defibrillator appropriately prior to disposal.

Disposing of Empty Calibration Gas Cylinders

To dispose of empty calibration gas cylinders:

1 Empty the cylinder completely by pushing the pin of the regulator valve or by pulling out the pin of the fill wave using a tire valve stem wrench or a pair of needle nose pliers.

2 When the cylinder is empty, either remove the valve stem from the fill (or regulator) hole, or drill a hole in the cylinder.

3 Write "Empty" on the cylinder and dispose of it appropriately for scrap metal.

WARNING Ensure that the cylinder is completely empty before trying to remove the valve stem or drill the tank.

Repair Tools and Equipment

The following tools are needed to perform the procedures in this chapter.

- Torx T10 and T15 drivers (or Torx driver kit, part number 5181-1933). T15 driver shaft should be at least 3.5-inches (90 mm) long and less than 0.4-inches (10 mm) in diameter to reach down to recessed case screws.
- Slip-joint pliers or adjustable open-end wrench.
- Straight-bladed screwdriver.
- Nut driver (5/16”) or small adjustable wrench
- #2 Phillips screwdriver, shaft at least 5” long.
- Straight-tip needle nose pliers or tweezers.
- Bent-tip needle nose pliers whose jaws are covered with a soft material (such as plastic tubing or tape).
- Fine-nose wire cutters.
- Utility knife.
- Paper clip.
- Clip leads (at least 2, each approx. 10-18”).
- Voltmeter
- Software Support tool (see Table 30 on page 214 for part numbers).
- Defibrillator Discharge Tool (M2475-69573).

Key Components

Replacement assemblies marked with an asterisk (*) in the Replacement Parts tables contain one or more Key Components. Key Components require detailed tracking, by recording the key component part number and either the key component’s date code or its serial number. This data must be recorded for both the failed assembly and the replacement assembly.

Philips service personnel must record this information on the Customer Service Order (CSO).

The Key Components that are part of the replacement assemblies are listed in Table 40 on page 229.

External Assemblies

This section describes how to remove and replace assemblies that are external to the case. You ***do not*** need to open the case for any of these procedures.

This section is organized into the following topics:

Accessory Pouches

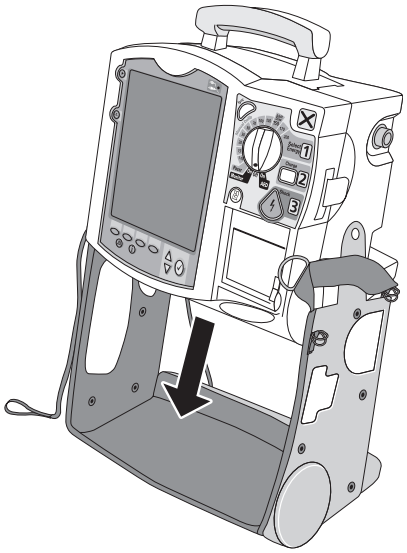
Preparation

Disconnect all external power and remove all batteries.

Installation

1. **Lower the device into the sleeve of the carry case. The rear base of the device fits in the sleeve socket.**

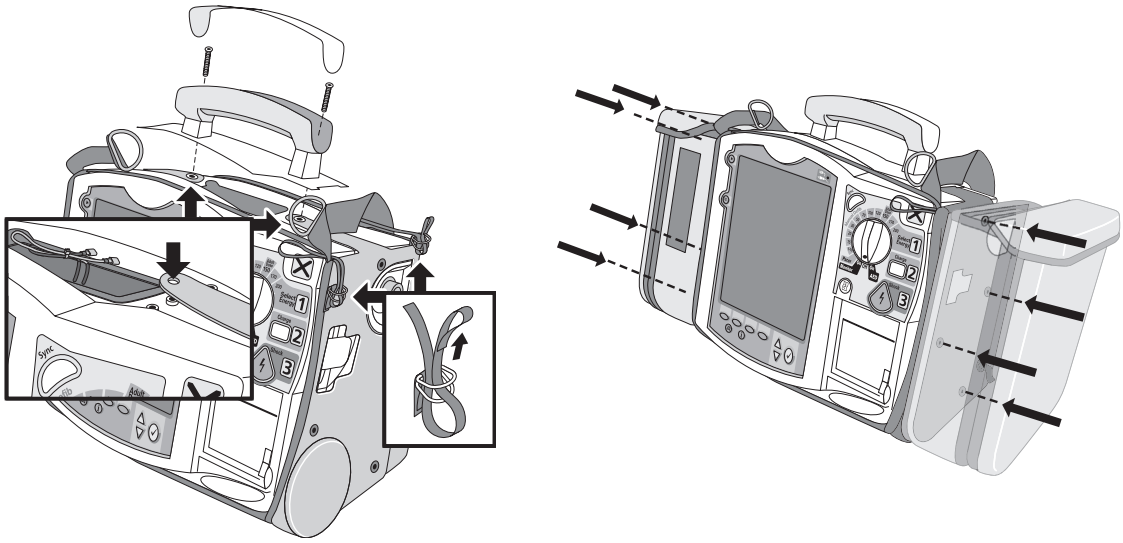
Figure 26 Accessory Pouch Assembly



2. **Lift up the paddle tray, if present.**
   a. If paddles are connected, disconnect them from the Therapy port and remove them from the paddle tray.
   b. Remove the 4 T-15 screws from the tray plates.
   c. Gently lift the paddle tray up, leaving all wires connected.
3. **Lift up the handle and cap plate, if present.**
   a. Remove the handle cover by lifting up the notch (with your fingernail or a screwdriver) and pushing in on either side of the handle cover and lifting up.
   b. Remove the 2 T-15 screws.
   c. Remove the handle.
   d. Gently lift the cap plate up.

4. Fold the two sleeve flaps over the top of the device, positioning them so that the screw holes are exposed.
5. Replace the paddle tray or cap plate, as appropriate, so that the molded openings fit over the sleeve flaps.
6. Secure the front and rear cinch straps using the metal rings provided.
7. Attach the side pouches using the snaps located inside the pouch pockets.

Figure 27 Accessory Pouch Assembly



After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Bedrail Hook Mount

Preparation

1. **Turn the device off.**
2. **Position the rear case**

   Lay the rear case on the work surface with the display facing down and the printer in the lower left corner.

Removal

1. **Loosen and remove the 2 T-15 screws.**
2. **Remove the bedrail hook mount.**

Replacement

1. **Secure the bedrail hook mount to the back of the device using the two screws.**

After Repair

Visually inspect the device to ensure that you installed the bedrail hook mount correctly. It is not necessary to run any Performance Verification and Safety testing.

Therapy Knob

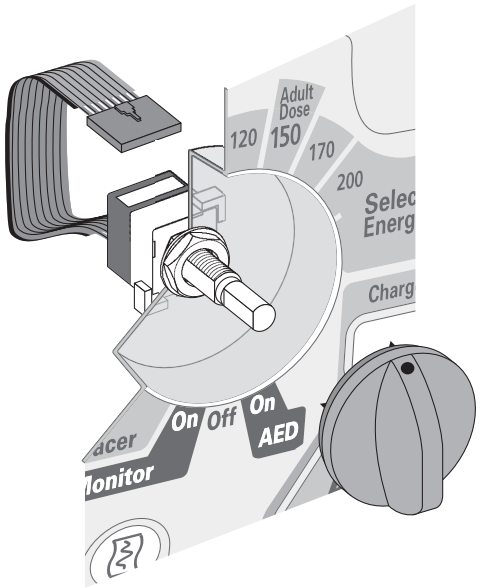
Preparation

1. **Turn the device off.**
2. **Disconnect all external power and remove all batteries.**

Removal

1. **Turn the knob to AED.**
2. **Pull the knob off its shaft.**
   Grasp the knob and pull straight out from the front of the device. Use pliers, if necessary.

Figure 28 Therapy Knob Replacement



Replacement

1. **Push the knob onto the shaft.**
   a. Align the flat side of the clip inside the knob with the flat surface on the shaft and press the knob into place. Be sure the knob is pressed fully into place.
   b. Check to be sure it rotates freely and that it points to the correct markings on the front panel.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Labels

There are six groups of labels for the HeartStart MRx: the Instruction label set, the Hazardous Shock Warning label set, the Branding label set, Speaker label set, the Connector label set, and the Product Version label. Each set of labels is one sheet containing all the labels in that set.

Instruction Label Sets

There is one instruction label set for each language. (See “Labels” on page 222 for part numbers.) This set includes labels for:

- Therapy Knob (with and without Pacing)

NOTE Each Instruction label set includes a label for devices with pacing and a label for devices without pacing. You ***must*** ensure that you place the correct label on the device.

- Paddles instructions (left and right side)
- Paddles warning
- Cap plate instructions
- Cap plate warnings
- Battery ID
- Service warning

Hazardous Shock Warning Label Set

The Hazardous Shock Warning Label set is affixed to the Power PCA shield and under the Paddle tray or cap plate.

Branding Label Set

The branding label is affixed to the front of the device, directly below the center of the display.

Speaker Label Set

The speaker label is affixed to the speaker.

Connector Label Set

This label set is shipped as part of the rear case field replacement kit. It includes the labels for the battery, AC power, DC in connector, network connectors, and patient connector (Therapy port).

Product Version Label

This label is shipped as part of the Processor PCA kit. It lists the product version and is affixed to battery compartment B.

Removing and replacing labels

Preparation

1. **Turn the device off.**
2. **Disconnect all external power and remove all batteries.**

Removal

1. **Start at one corner.**

   Using a sharp tool such as a utility knife, pick up one corner of the label.

2. **Peel up the label.**

   Peel the label up by pulling slowly and evenly on the loosened corner.

Replacement

1. **Clean the surface.**
   a. Remove any adhesive residue by rubbing the dry surface with your finger and "rolling up" the adhesive residue. Solvents are ineffective, as is scraping with a tool.
   b. Clean the surface with isopropyl alcohol. Allow it to dry.
2. **Peel off the backing.**

   Peel the backing off the new label. Avoid touching the label adhesive as this can prevent the label from bonding properly.

3. **Apply the label.**
   a. Align one edge of the label with the recess on the case, then roll the label down slowly into position.
   b. Press firmly all over the label, especially the edges, to ensure it adheres to the case.

After Repair

Visually inspect the device to ensure that you installed the labels correctly. It is not necessary to run any Performance Verification and Safety testing.

Printer Assembly

The HeartStart MRx can have either the 50 mm printer or the 75 mm printer. Follow the instructions for the printer installed in your device. Some of the illustrations show only the 50 mm printer as the procedure for both printers are the same.

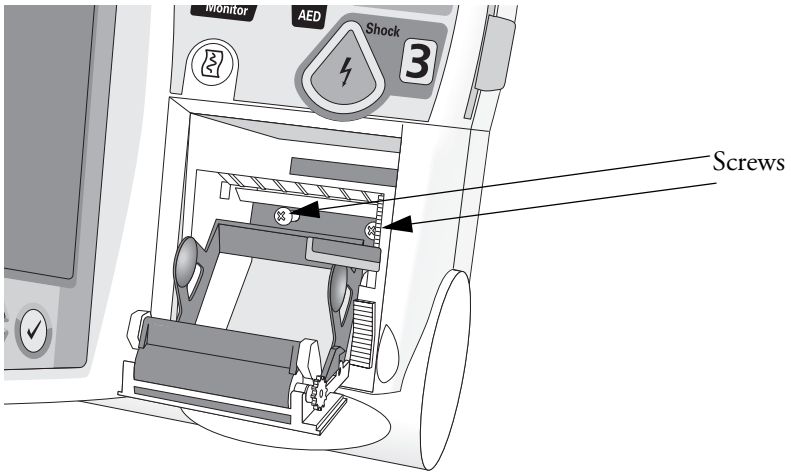
Preparation

1. **Turn the device off.**
2. **Disconnect all external power and remove all batteries.**
3. **Wait at least one full minute before proceeding. This allows time for the internal power supplies to discharge stored energy.**

Removal

1. **Open the printer and remove the paper.**
   a. Push in the printer door latch and open the printer door.
   b. For the 75 mm printer, pull up on the white plastic cover holding the paper roll to remove it.
   c. Remove the paper.
2. **Loosen the screws.**
   Loosen the two captive Phillips screws at the back of the printer, being careful not to damage the wires. Close the door slightly to improve access to the screws. Figure 29 shows the screws on the 50 mm printer. The screws are in the same location for the 75 mm printer.

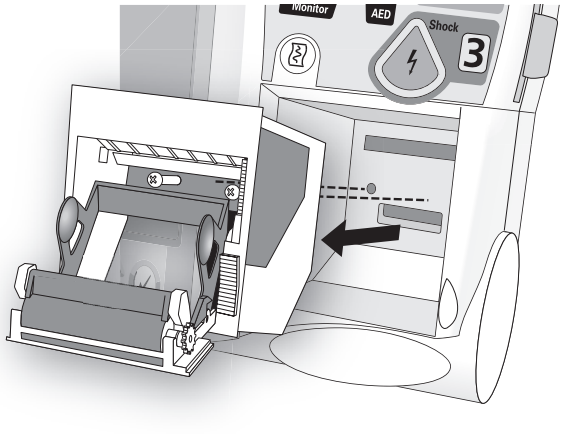
Figure 29 Printer Screws



3. **Remove the printer**

   Remove the printer by grasping the inside and pulling it straight out of the printer well.

Figure 30 Removing the Printer



Replacement

1. **Slide in the printer.**

   a. Slide the printer straight into the printer well. For the 75 mm printer, turn the printer so that the printed circuit assembly is to the right as you face the device.

   b. Push in gently until it is fully seated.

2. **Tighten the screws.**

   Open the printer door and tighten the two screws. For the 75 mm printer, access the screws through the screw holes in the white plastic cover.

3. **Replace the paper and close the door. (See the label on the inside of the printer door or the *Instructions for Use* for additional instructions.)**

After Repair

Perform Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Paddle Tray

There is a 50 ohm load resistor pre-assembled inside the tray, which is used to test the paddles.

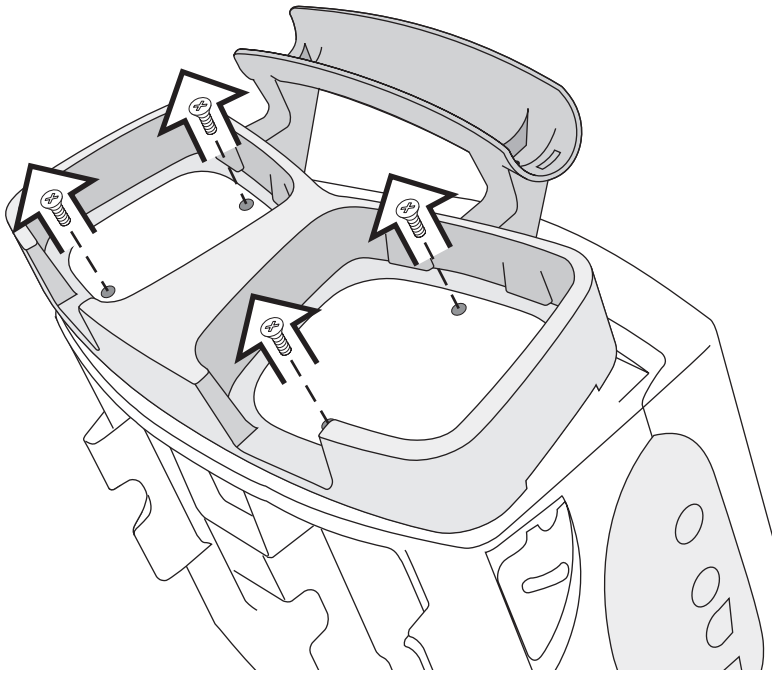
Preparation

1. **Turn the device off.**
2. **Disconnect all external power and remove all batteries.**

Removal

1. **Remove the paddles from the tray.**
   Disconnect the paddles from the Therapy port. Snap both paddles out of the paddle tray and lay them aside.
2. **Remove the screws from the tray plates.**
   Loosen and remove the 4 T-15 screws.
3. **Gently lift the paddle tray to gain access to the wires.**
4. **Pull the spade connectors straight off of the tabs, being careful not to bend the tabs.**
5. **Remove the paddle tray.**

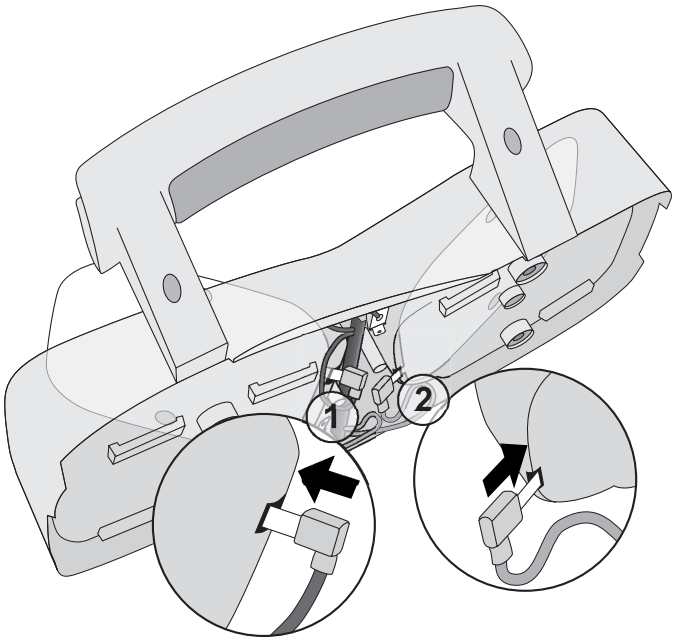
Figure 31 Removing the Paddle Tray



Replacement

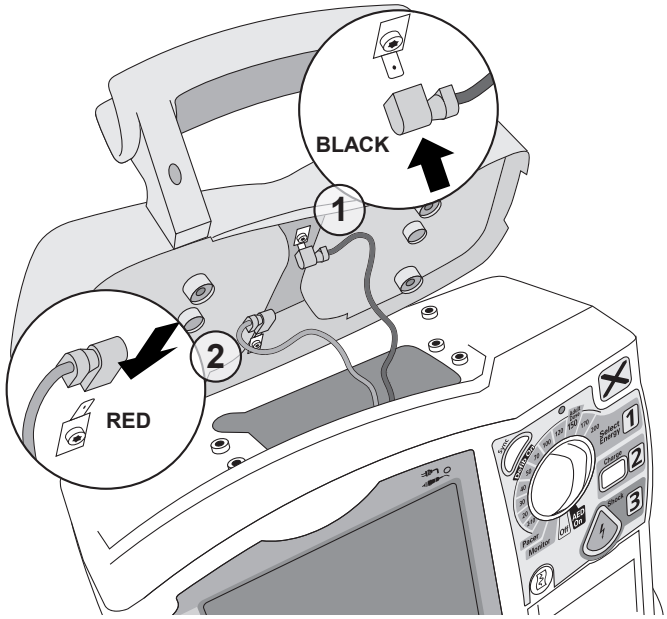
1. **Install the tray plates into the tray.**
   a. Hold the paddle tray so that the connections are facing towards you and the handle is on top.
   b. Holding the tray plate at an angle, place one plate into the left tray, inserting the tab through the hole.
   c. While holding the plate at an angle, connect the spade connector from the black wire to the tab **(1)**.
   d. Holding the tray plate at an angle, place the other plate into the right tray, inserting the tab through the hole.
   e. While holding the plate at an angle, connect the spade connector from the red wire to the tab **(2)**.

Figure 32 Installing the Tray Plates



2. **Connect the paddle tray to the device.**
   a. Connect the spade connector from the black wire to the tab with the black wire on the resistor. **(1)**
   b. Connect the spade connector from the red wire to the tab with the red wire on the resistor. **(2)**

Figure 33 Connecting the Paddle Tray



3. **Place the paddle tray into position on the device.**
   Line up the screw holes in the paddle tray and tray plates with the threaded inserts on the device. Be careful not to pinch the wires under the threaded inserts.
4. **Replace the screws.**
   Replace the 4 T-15 screws and tighten.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Paddle Tray 50 ohm Load Resistor

The 50 ohm load resistor comes pre-assembled in the paddle tray. However, if it fails, you can replace it using the following procedures.

Preparation

1. **Turn the device off.**
2. **Disconnect all external power and remove all batteries.**
3. **Remove the paddle tray.**
   See “Paddle Tray” on page 95.

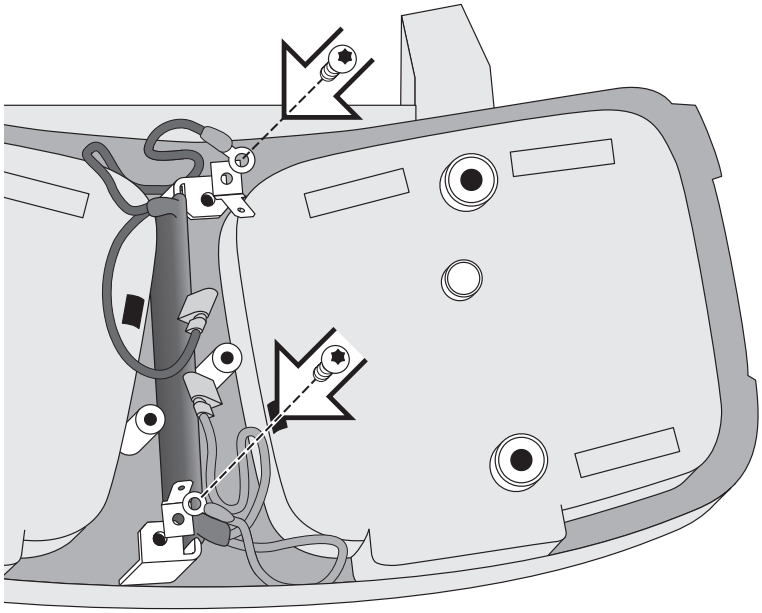
Removal

1. **Disconnect the spade connectors from the paddle tray tabs.**
2. **Unscrew the 2 T-10 screws.**
3. **Lift the 50 ohm load resistor out of the paddle tray.**

Replacement

1. **Place the 50 ohm load resistor into the paddle tray.**
   Make sure that the black wires are closest to the handle.
2. **Place each screw through the ring terminal, through the spade connector, and through the metal bracket on the resistor. Fasten to the threaded insert in the paddle tray.**
3. **Make sure the wires and connectors are oriented as shown in Figure 34.**
4. **Tuck the wires into the paddle tray.**

Figure 34 Replacing the 50 ohm Load Resistor



5. **Replace the paddle tray.**
   See “Paddle Tray” on page 95.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Handle and Cap Plate

Preparation

1. **Turn the device off.**
2. **Disconnect all external power and remove all batteries.**

Removal

1. **Remove the handle cover.**

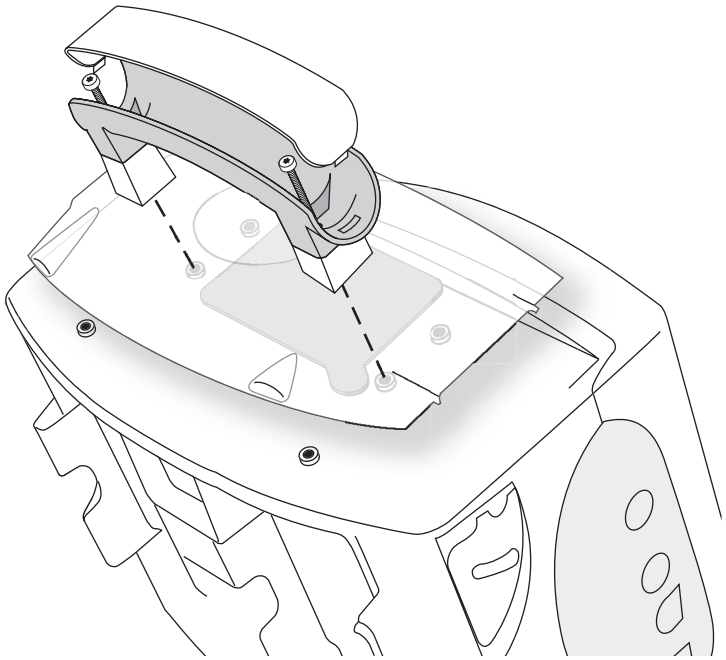
   Lift up the notch (with your fingernail or a screwdriver) and push in on either side of the handle cover and lift up.

2. **Remove the screws located on either side of the handle.**

   Loosen and remove the 2 T-15 screws.

3. **Remove the handle.**
4. **Remove the cap plate.**

Figure 35 Removing the Handle and Cap Plate

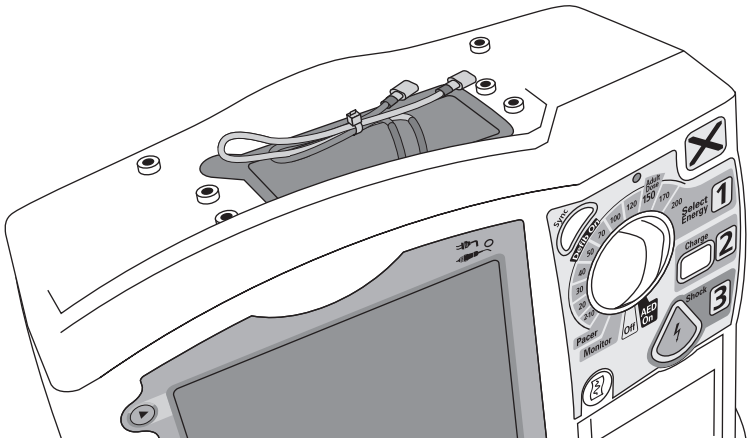


Replacement

1. **Secure the PCMCIA hole plug wires.**

   Group the wires together and secure with the cable tie wrap. Cut off any excess tie wrap.

   Figure 36 PCMCIA Hole Plug Cable Tie Wrap



2. **Replace the cap plate.**

   a. Lay the cables flat against the PCMCIA hole plug, being careful not to pinch the cables under the ridges on the cap plate.

   b. Line up the screw holes with the threaded inserts.

3. **Replace the handle.**

   Line up the handle with the shaped posts on the cap plate.

4. **Replace the screws.**

   Replace the 2 T-15 screws and tighten.

5. **Replace the handle cover.**

   Line up the handle plate and snap into place.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Opening the case

To open the sealed case safely, perform the following steps, in the order listed:

1. **Discharge the power supply capacitors (see ""Discharge the Power Supply Capacitors"" below).**
2. **Separate the case (see "Separate the Case" below).**
3. **Discharge the Therapy capacitor (see "Discharge the Therapy Capacitor" on page 105).**
4. **Disconnect the case halves (see "Disconnect the Case Halves" on page 106).**

Each step is described in more detail in the following sections.

WARNING Remove all power sources (AC, battery, DC) before opening the device. Failure to do so may allow the device to charge without warning and could result in serious injury or death.

Discharge the Power Supply Capacitors

Always discharge the power supply capacitors before servicing the HeartStart MRx.

1. **Disconnect external power and remove all batteries.**

   The power supply capacitors are now discharging. Wait at least 60 seconds before unplugging any internal connections.

Separate the Case

Separate the front and back case from each other by performing the following steps.

WARNING Dangerous voltages may be present on components and connections exposed during device disassembly. Use extreme caution while the device cover is removed.

CAUTION Be sure to work in a static free environment. Use an electrostatic wrist band. The work surface and area surrounding it must be static free. Use an antistatic pad which is grounded per the manufacturer's instructions.

1. **Remove accessory pouches, if present.**

   See "Accessory Pouches" on page 87.

2. **Remove the bed rail hook mount, if present.**

   See "Bedrail Hook Mount" on page 89

3. **Remove the paddle tray or handle and cap plate.**

   See "Paddle Tray" on page 95 or "Handle and Cap Plate" on page 100.

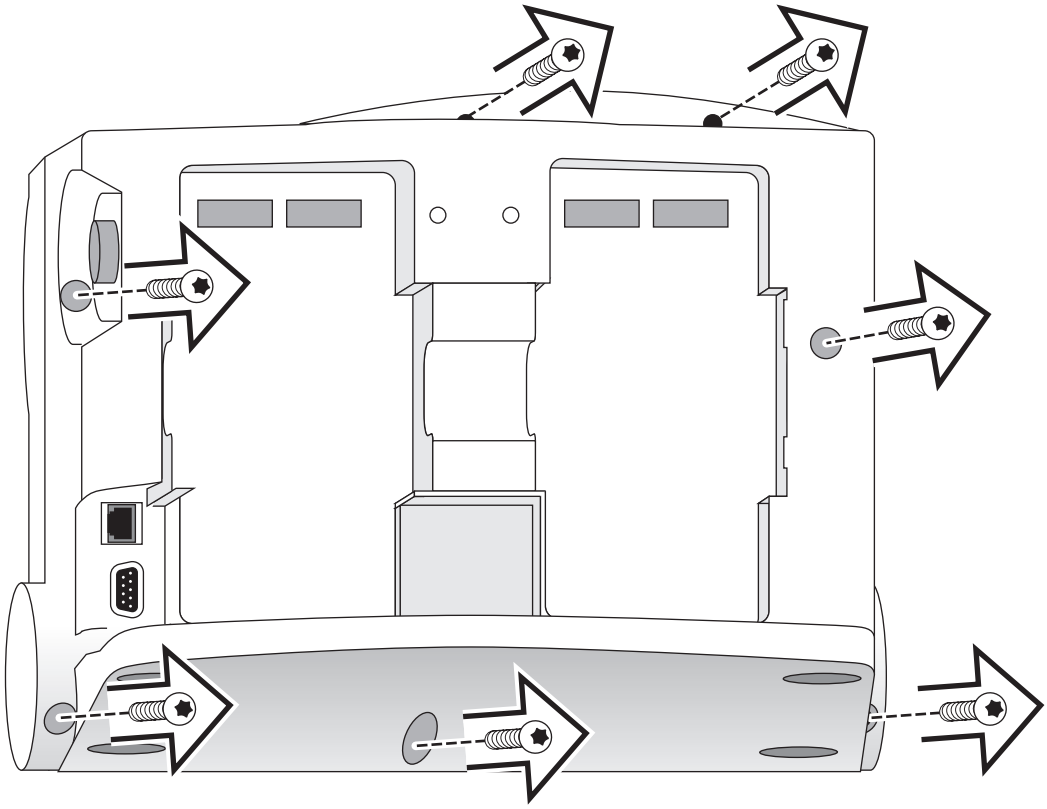
4. **Lay the device down.**

   Lay the device on a padded work surface with the display facing down and the bottom of the device nearest to you.

5. **Remove the case screws.**

   a. Loosen the seven T15 screws in the back of the case.

Figure 37 Case screws



   b. Hold the case halves together with your hands, and turn the device over so the display is facing up. The case screws will fall out of their holes as you do this.

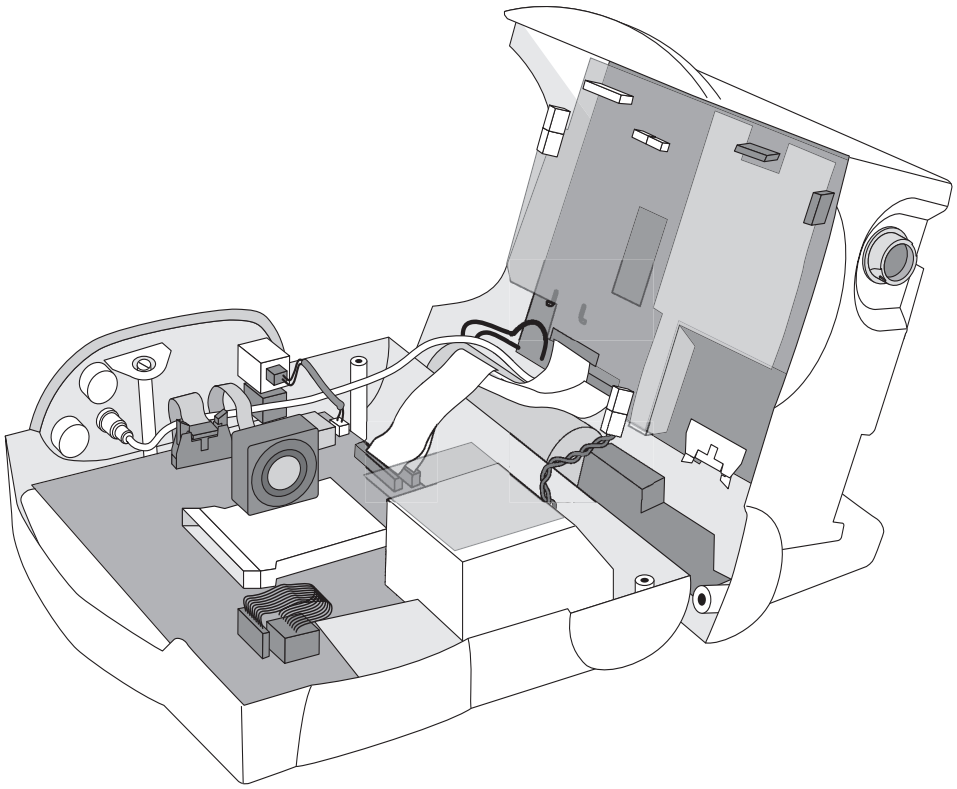
   c. Once the screws are all out and accounted for, stand the device on the work surface with the display facing you.

6. **Open the case.**

   a. Swing the front case away from the rear case separating the therapy port side first. Be careful not to pull on the cables that connect them. (You may need to use some force to separate the halves.)

   b. If you are having difficulty separating the halves, remove the data card tray. Place one hand with your fingers in the data card slot and grasp the therapy port with the other hand. Pull the case halves apart while applying steady pressure until the seal starts to break. (This can sometimes take up to one minute.)

Figure 38 Clamshell Open Case

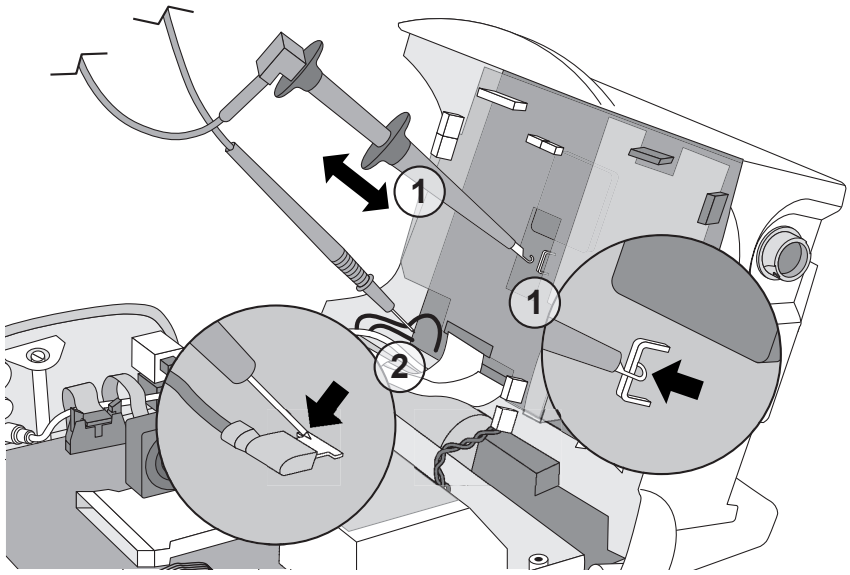


Discharge the Therapy Capacitor

WARNING Use extreme caution in the following steps. Dangerous voltages may be present on components and connections. Do not touch any components or connections until you are sure the capacitor is discharged.

1. **Position the rear case.**
   Stand the rear case up on its base with the large blue Therapy capacitor facing you.
2. **Using the Defibrillator discharge tool, clip the hooked end onto the resistor that looks like a large staple on the Therapy PCA. (1)**
3. **Touch the other end of the discharge tool to the metal portion of the Therapy capacitor's red spade connector and hold in place for at least 5 seconds. (2)**

Figure 39 Using the Discharge Tool



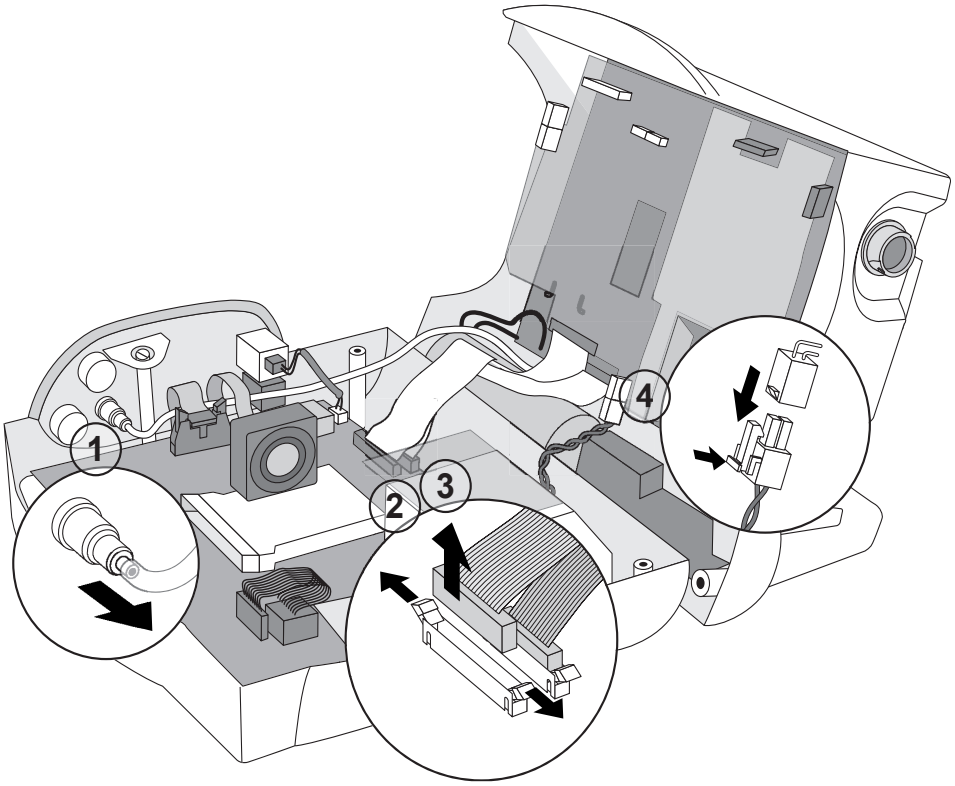
4. **Once you make contact for at least 5 seconds,** ***the Therapy capacitor is now discharged.***

NOTE The Therapy PCA prevents dangerous voltages from existing on the Therapy capacitor after the device is turned off. If there are sparks or any other evidence of significant electrical current when you apply the discharge tool, replace the Therapy PCA.

Disconnect the Case Halves

1. **Disconnect the case halves.**
   a. Disconnect the NBP tubing from the measurement module panel. **(1)**
   b. Disconnect the two ribbon cables from the Processor PCA by releasing their latches and pulling straight out. **(2,3)**.
   c. Disconnect the two-wire printer power cable from the Power PCA by releasing the latch and pulling straight down toward the bottom of the case. **(4)**

Figure 40 Disconnecting the Case Halves



2. **Pull the halves of the case apart.**
   Separate the halves of the case and set them on the work surface.

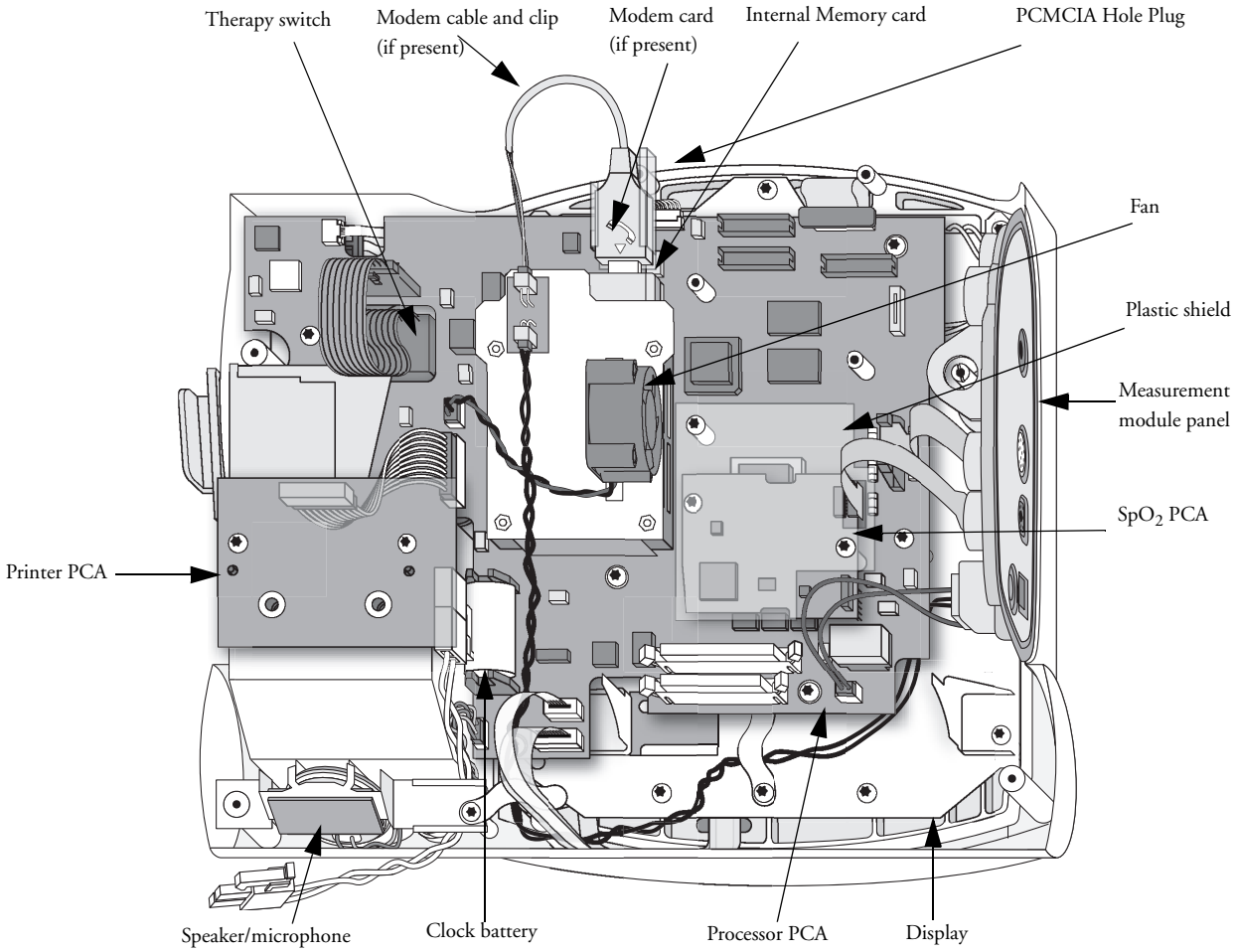
Internal Assemblies - Front Case

This section is organized into the following topics:

Overview of Front Case

Refer to Figure 41 to identify assemblies in the front case.

Figure 41 Front case overview



PCMCIA Hole Plug

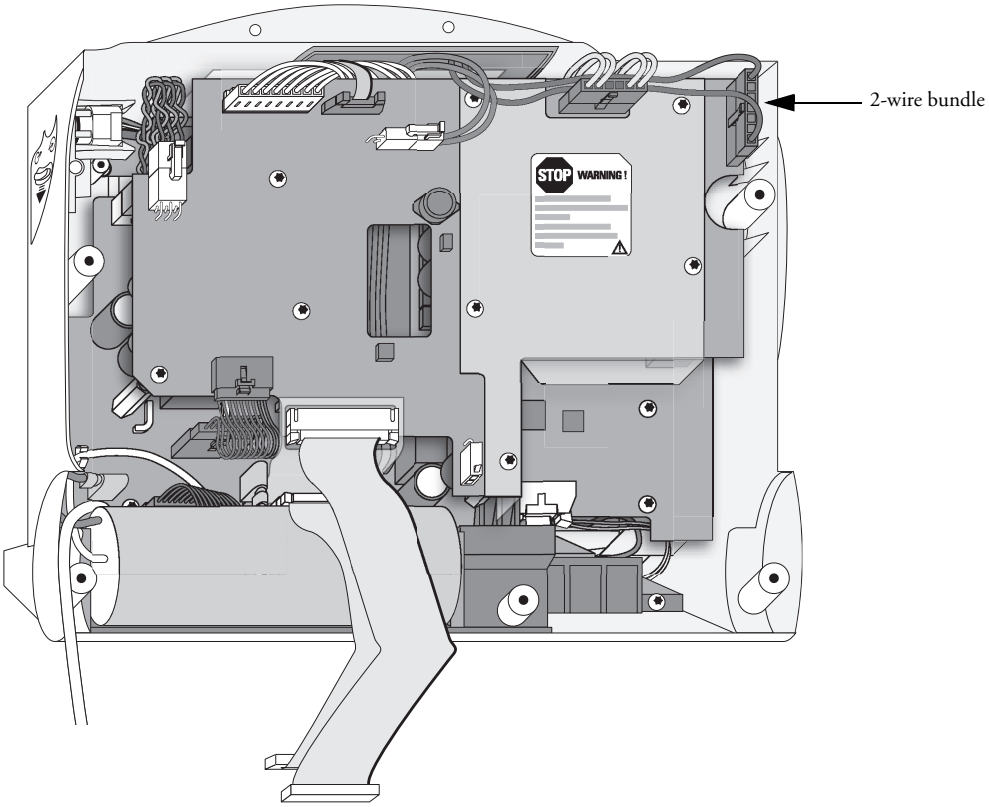
Preparation

1. **Remove either the paddle tray or handle and cap plate.**
   See “Paddle Tray” on page 95 or “Handle and Cap Plate” on page 100.
2. **Open and separate the case.**
   See “Opening the case” on page 102.
3. **Position the rear case**
   Lay the rear case on the work surface with the PCAs facing up and the Therapy port on the right.

Removal

1. **Disconnect the PCMCIA hole plug connector from the Power PCA.**
   Unplug the 2-wire bundle from the Power PCA.

Figure 42 Disconnecting the PCMCIA Hole Plug



2. **Remove the PCMCIA hole plug.**
   Grasp the PCMCIA hole plug by the corner tab and pull up. Use pliers, if necessary.

Replacement

1. **Guide the 2-wire bundle through the hole.**
   Make sure the wire is routed as show in Figure 42.
2. **Connect the 2-wire bundle to the Power PCA.**

3. **Replace the PCMCIA hole plug.**
   a. Press in all of the corners.
   b. Work your way around the plug, pressing it into place.
4. **Close the case.**
   See “Closing the case” on page 176.
5. **Replace the paddle tray or handle and cap plate.**
   See “Paddle Tray” on page 95 or “Handle and Cap Plate” on page 100.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Speaker and Microphone Assembly

The speaker and microphone assembly can be removed without removing any other front case assemblies.

Preparation

1. **Open and separate the case.**

   See “Opening the case” on page 102.

2. **Position the front case**

   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.

Removal

1. **Disconnect the speaker and microphone from the Processor PCA.**

   Unplug the four-wire connector by pulling straight up **(1)**.

2. **Remove the screw.**

   Loosen and remove the T-10 screw that fastens the plastic shield and bracket to the case.

3. **Remove the shield and bracket.**

   Lift the shield and bracket straight up **(2)**.

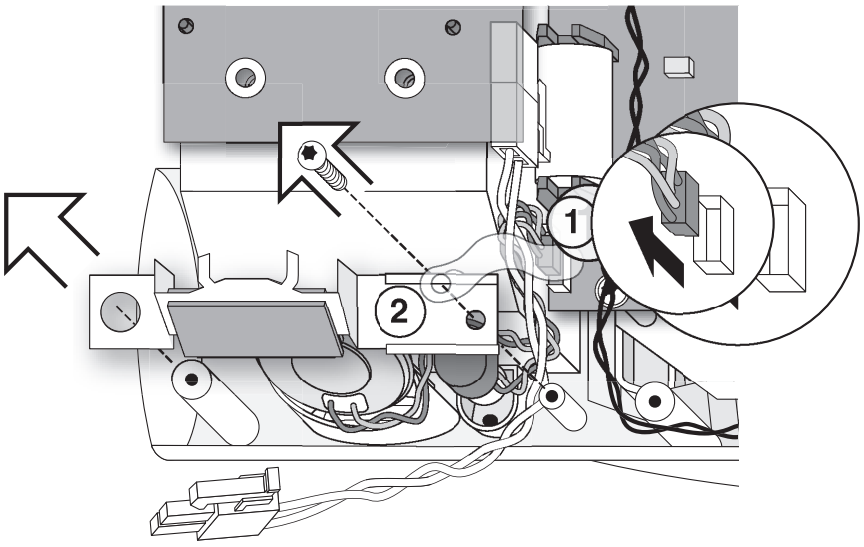
4. **Note the position of the speaker, microphone, and the cables for each.**

   The speaker lays forward against the speaker support at an angle. The microphone fits into an appropriately shaped recess in the case. See Figure 43.

5. **Remove the speaker and microphone.**

   Neither is attached to the case; simply pull both straight up.

Figure 43 Removing the Speaker and Microphone



Replacement

1. **Place the speaker and microphone into position.**
   a. Position the speaker connections at the bottom, as shown in Figure 43. There are two ribs at the bottom of the speaker support- the speaker sits on top of the ridges.
   b. Place the microphone into its recess. Align the microphone wires with the notch in the recess.
2. **Place the shield and bracket in position.**
   Make sure the red and black 4-wire bundle and the white 2-wire bundle pass under the bracket, as shown in Figure 43.
3. **Replace the screw and tighten.**
4. **Connect the speaker/microphone assembly.**
   Connect the four-wire connector to the Processor PCA.
5. **Close the case.**
   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Internal Memory Card

The internal memory card resides in the PCMCIA slot on the Processor PCA. The internal memory card can be removed without removing any other front case assemblies.

Preparation

1. **Open and separate the case.**

   See “Opening the case” on page 102.

2. **Position the front case**

   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.

Removal

1. **Remove the shoulder screw. (1)**

   Loosen and remove the T-10 shoulder screw on the Processor PCA.

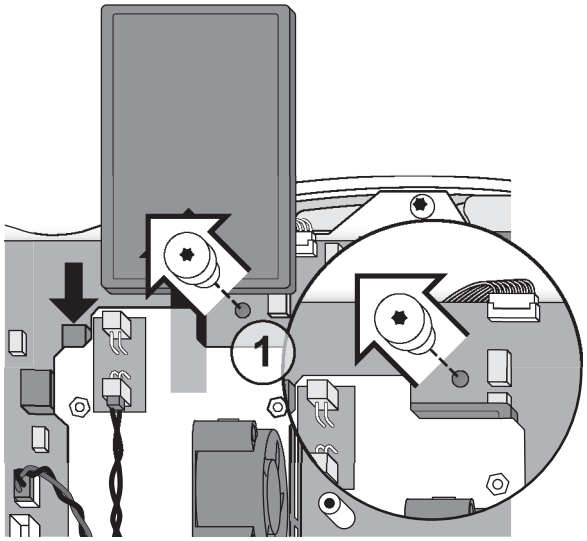
2. **Stand the front case up with the display facing away from you.**

3. **Remove the internal memory card.**

   a. Press the black eject button. **(2)**

   b. Pull the card out.

Figure 44 Removing the Internal Memory Card



Replacement

1. **Insert the internal memory card into the PCMCIA slot closest to the Processor PCA.**

   a. Align the card so that the CE label is facing the Processor PCA.

   b. Push the card into the slot as far as it can go.

2. **Replace the shoulder screw.**

3. **Close the device.**

   See “Closing the case” on page 176.

NOTE Make sure that you set the device’s configuration values to the institution’s settings. See the “Configuration” chapter in the *Instructions for Use* for more information.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

SpO_2 PCA

The SpO_2 PCA can be removed without removing any other front case assemblies.

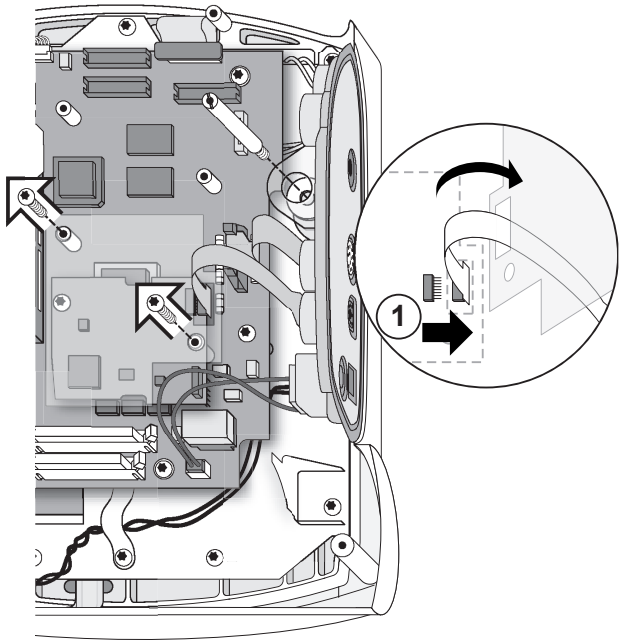
Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the front case**
   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.

Removal

1. **Move the plastic shield.**
   a. Loosen and remove the two T-10 screws.
   b. Lift up the plastic shield.
2. **Disconnect the SpO_2 flex circuit from the SpO_2 PCA.**
   a. Grasp the connector and pull sideways. **(1)**

Figure 45 Disconnecting the SpO_2 PCA

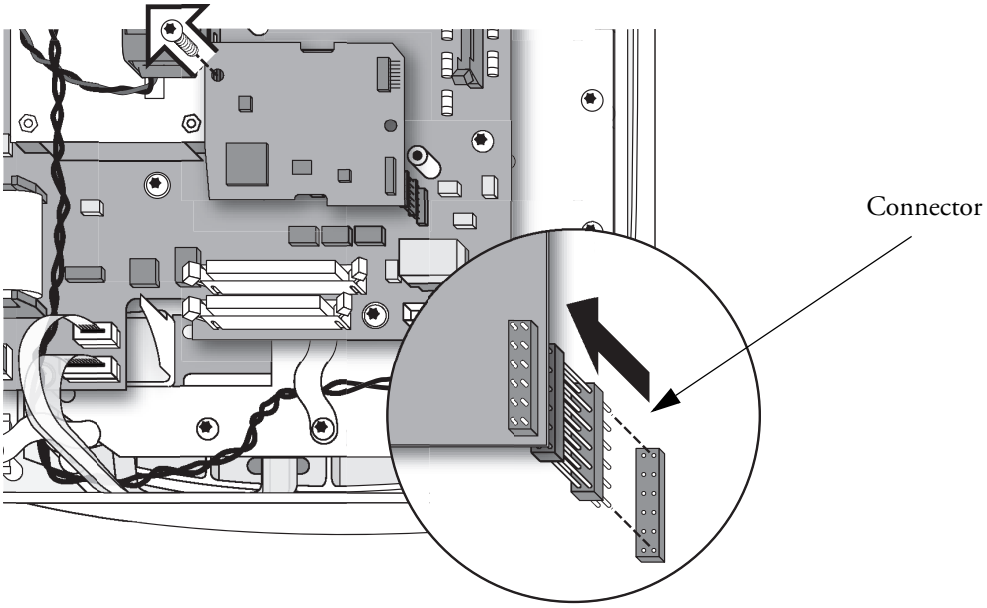


3. **Remove the screw.**
   Loosen and remove the T-10 screw.

4. **Lift the SpO_2 PCA.**

   As you lift the SpO_2 PCA it will disconnect from the Processor PCA. The connector may lift up with the SpO_2 PCA or it may stay secured to the Processor PCA. In either case, keep the connector as you will need it for the replacement procedure.

Figure 46 Removing the SpO_2 PCA



Replacement

1. **Place the SpO_2 PCA in position.**

   a. If the connector is secured to the Processor PCA, leave it in place. If not, secure the connector to the Processor PCA.

   b. Line up the pins on the SpO_2 PCA with the connector on the Processor PCA.

   c. Line up the screw holes on the SpO_2 PCA with the standoffs on the Processor PCA. As you push gently down the pins on the SpO_2 PCA will connect to the Processor PCA.

2. **Replace the one T-10 screw in the left corner of the PCA.**

3. **Connect the SpO_2 PCA.**

   Connect the SpO_2 flex circuit to the SpO_2 PCA. Make sure it slides in all of the way.

4. **Place the plastic shield over the SpO_2 PCA and secure.**

   Replace and tighten the two T-10 screws.

5. **Close the case.**

   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Measurement Module Panel

There are different measurement module panels depending on the options in the device.

Preparation

1. **Open and separate the case.**

   See “Opening the case” on page 102.

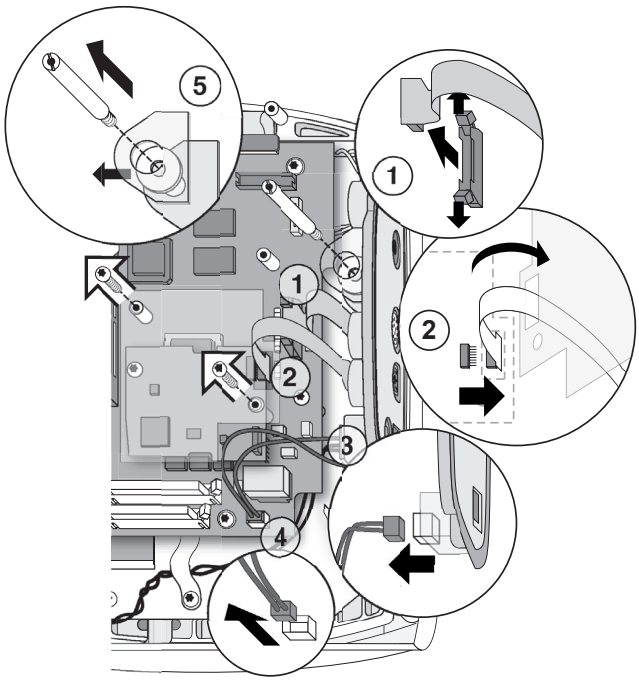
2. **Position the front case.**

   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.

Removal

1. **Move the plastic shield from the SpO_2 PCA.**
   a. Loosen and remove the two T-10 screws.
   b. Lift up the plastic shield.
2. **Disconnect the measurement module panel.**
   a. Disconnect the ECG connector cable from the Processor PCA by releasing the latches at the edges of the connectors. **(1)**
   b. Disconnect the SpO_2 flex circuit from the SpO_2 PCA. **(2)**
   c. Disconnect the modem wire (if present) from the measurement module panel. **(3)**
   d. Disconnect the ECG Out jack wire from the Processor PCA. **(4)**
3. **Remove the standoff and washer using a straight-blade screwdriver. (5)**

Figure 47 Removing the Measurement Module Panel



4. **Remove the measurement module panel.**
   Lift the module straight up out of its groove in the front case.

Replacement

1. **Place the measurement module panel into position.**
   Align its gasket with the groove in the case and lower the module into position. Be careful not to cut, pinch or crush the soft gasket.

NOTE Make sure that you carefully seat the measurement module panel without skewing it or crushing the gasket.

2. **Replace the washer and standoff.**
3. **Loop the SpO_2 flex circuit through the plastic shield.**
4. **Connect the measurement module panel.**
   a. Connect the ECG connector cable to the Processor PCA. Be sure that the connector is properly centered and both latches are locked.
   b. Connect the SpO_2 flex circuit to the SpO_2 PCA.
   c. Connect the ECG Out jack wire to the Processor PCA.
   d. Connect the modem wire (if present) to the measurement module panel.
5. **Replace the plastic shield over the SpO_2 PCA.**
   Replace and tighten the two screws.
6. **Close the case.**
   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Therapy Switch

Preparation

1. **Remove the Therapy Knob.**
   See “Therapy Knob” on page 90.
2. **Remove the nut and washer.**
   Loosen and remove the nut (9/16-inch) and washer.
3. **Open and separate the case.**
   See “Opening the case” on page 102.
4. **Position the front case.**
   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.

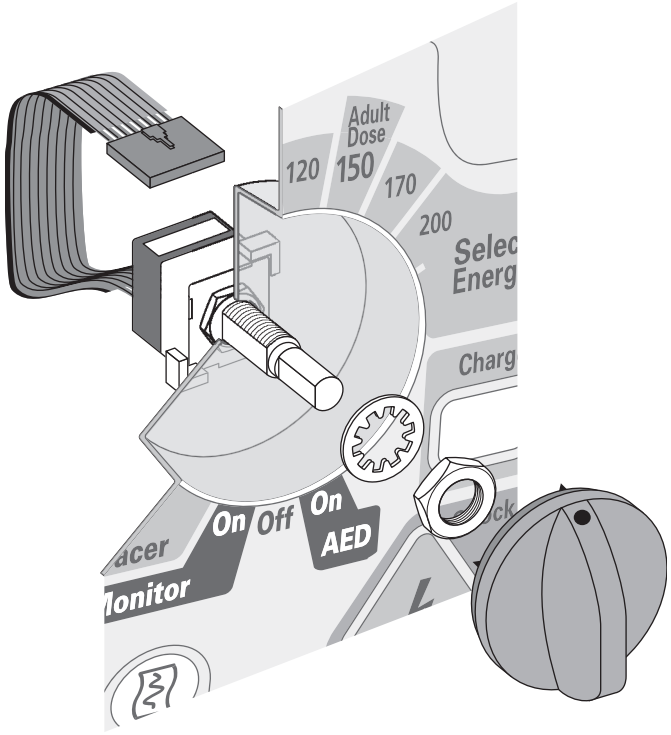
Removal

1. **Unplug the ribbon cable from the Processor PCA.**
2. **Remove the Therapy switch.**

Replacement

1. **Position the switch, as shown in Figure 48.**
   Orient the switch so the black stripe on the ribbon cable is on the edge closest to the fan.

Figure 48 Orientation of Therapy Switch



2. **Connect the ribbon cable to the Processor PCA without twisting or kinking the cable.**
3. **Replace the washer and nut.**
   Tighten the nut. Do not overtighten.
4. **Check the orientation.**
   a. Slide the Therapy Knob onto the shaft, ensuring that the flat part of the knob recess aligns with the flat part of the shaft.
   b. Rotate the knob fully in both directions. Check that the knob aligns properly with the panel markings.
5. **Close the case.**
   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Fan Assembly

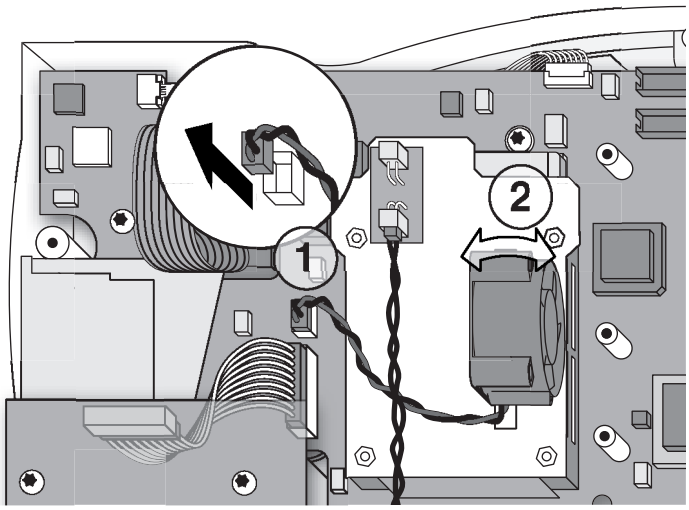
Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the front case**
   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.

Removal

1. **Unplug the braided fan cable from the Processor PCA. (1)**
2. **Remove the fan.**
   a. Slowly bend the fan back and forth to loosen it, being careful not to damage the sheet metal. **(2)**
   b. When the fan is loose, lift it off of the adhesive.

Figure 49 Replacing the Fan



3. **Peel the adhesive off of the sheet metal.**
   Make sure that all of the adhesive is removed.

Replacement

1. **Clean the fan and the PCMCIA aluminum plate.**
   Wipe both the fan and the PCMCIA aluminum plate with 70% isopropyl alcohol and let them dry. Do not touch the surfaces once you have cleaned them.
2. **Remove one side of the adhesive backing and secure it to the fan.**

3. **Position the fan.**

   Position the fan so that the label on the fan's hub is facing the external data card guide and the 2-wire bundle is closest to the speaker microphone assembly. The bottom of the fan contains the molded CE mark.

4. **Peel off the adhesives backing and install the fan between the 2 tabs on the PCMCIA sheet metal.**

   Press and hold the fan in place for 10 to 20 seconds to secure it to the PCMCIA aluminum plate.

5. **Connect the fan cable to the Processor PCA.**

6. **Close the device.**

   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Processor PCA

The Processor PCA contains the device's operating software. All Processor PCAs are American English, part number 12NC - 453563478461; 5x5 - M3535-68101.

When you install a new Processor PCA you must also:

- Enter the device's serial number and enable options using the Service Mode menus.
- Set the device's language (if other than American English) using the appropriate Software Support tool. See Table 30 on page 214 for part numbers.

Removing the Processor PCA involves disconnecting many cables and removing many screws. Take your time and be methodical.

Preparation

1. **Save the configuration settings to a data card.**

   If possible, save the customer's configuration settings to a data card so the configuration can be restored after the repair is complete. See the *Instructions for Use* for information.

2. **Remove the data card tray.**

3. **Open and separate the case.**

   See "Opening the case" on page 102.

4. **Position the front case**

   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.

Removal

1. **Remove the SpO_2 PCA.**

   See "SpO_2 PCA" on page 115.

2. **Remove the measurement module panel.**

   See "Measurement Module Panel" on page 117.

3. **Disconnect all cables.**

   See Figure 50 on page 124 and Table 25 on page 125. The order in Table 25 begins with the left edge of the Processor PCA and then works around the front case in a clockwise direction.

Figure 50 Processor PCA Connections

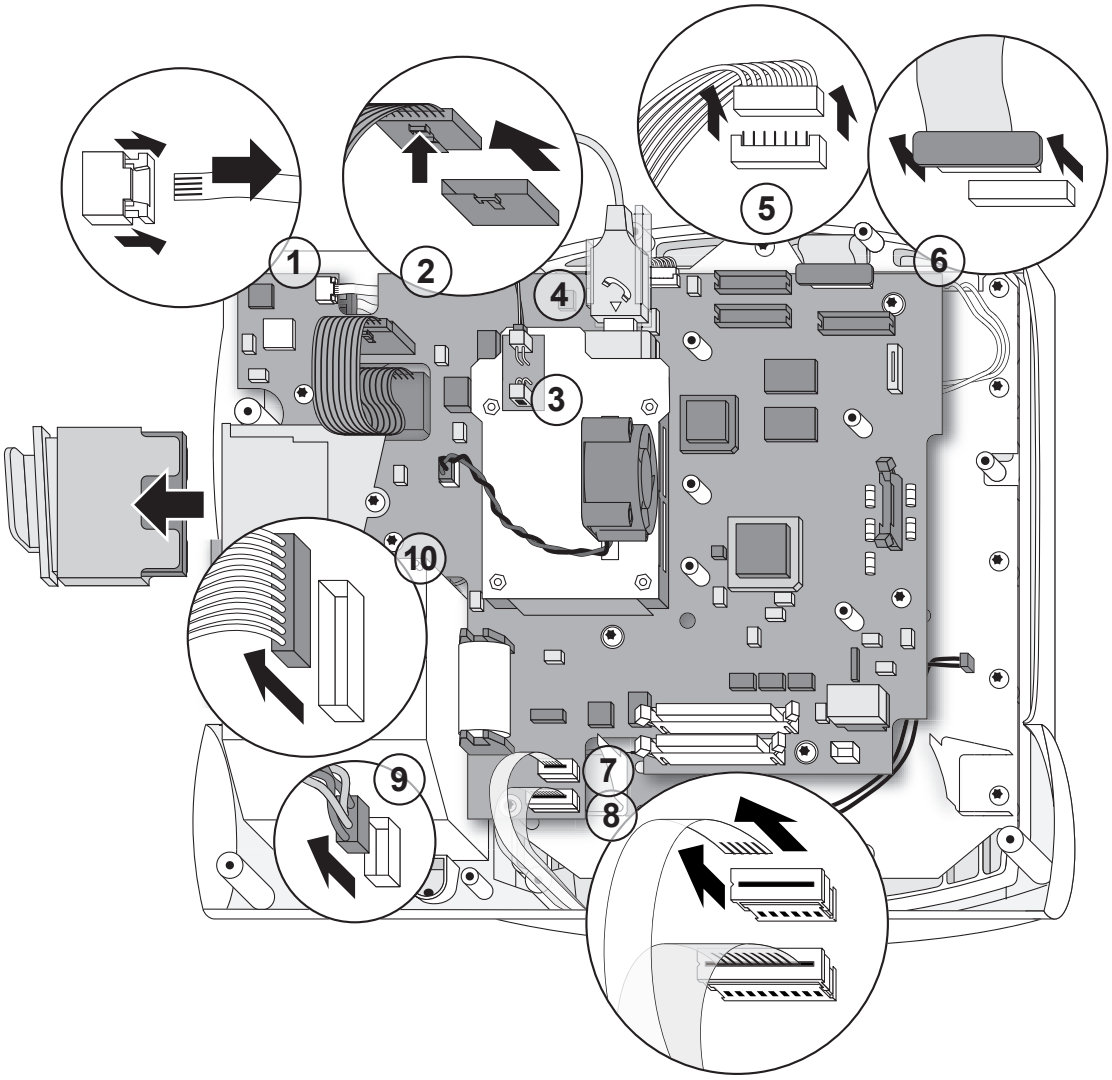


Table 25 Processor PCA Connections

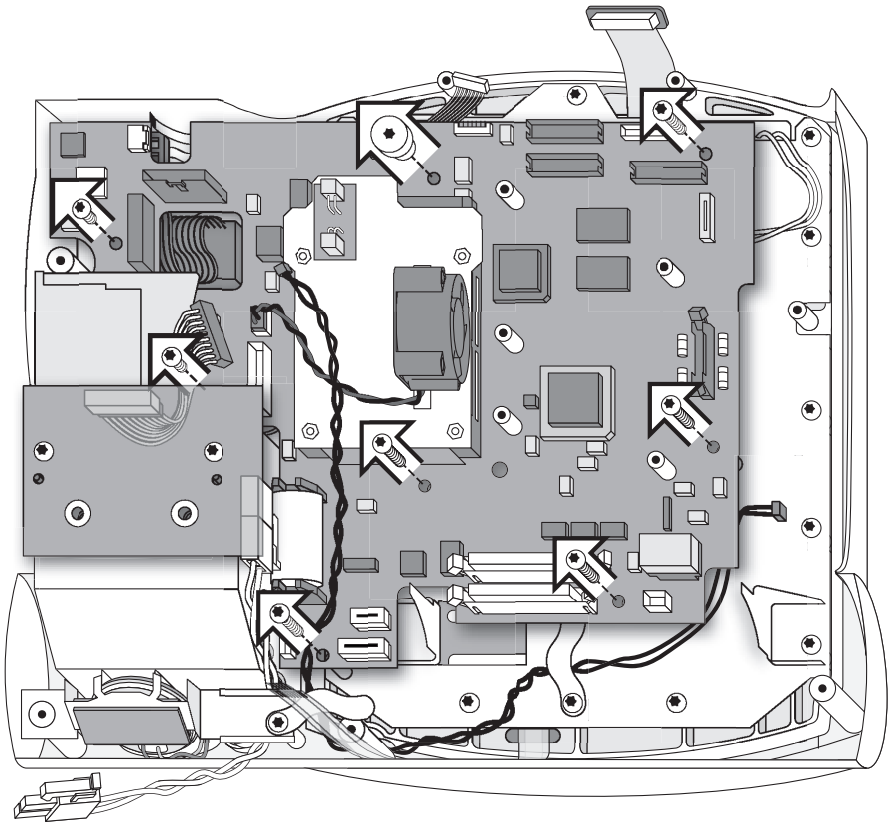
Ref. No.	Description	Connects To	Disconnect By
1	small flex circuit	RFU indicator	Push out latch, slide out flex
2	ribbon cable	Therapy switch	Push on latch, pull straight up
3	2-wire black twisted cable (if present)	RJ-11 telephone jack	Pull, wiggle
4	wire with plastic shield (if present)	modem	Pull out
5	8-wire bundle	Display	Push on latch, pull straight out
6	flex circuit	Display	Pull or pry straight up
7	flex circuit	Display	Pull up on latch to release, pull
8	flex circuit	Display	Pull up on latch to release, pull
9	4-wire bundle	Speaker/microphone	Pull, wiggle (use needle nose pliers, if necessary)
10	10-wire bundle	Printer PCA	Pull, wiggle (use needle nose pliers, if necessary)

4. **Remove the screws.**

   a. Loosen and remove the 7 T10 screws.

   b. Loosen and remove the shoulder screw, using the T 10 driver.

Figure 51 Processor PCA Screws



5. **Lift the Processor PCA out of the case.**
   a. Be careful to guide the many cables out of the way so the Processor PCA can be lifted clear.
   b. Leave the clock (lithium) battery in place when returning the PCA for repair. This helps preserve information for factory troubleshooting.
6. **Remove the internal memory card.**
   Press the black eject button and pull the card out.

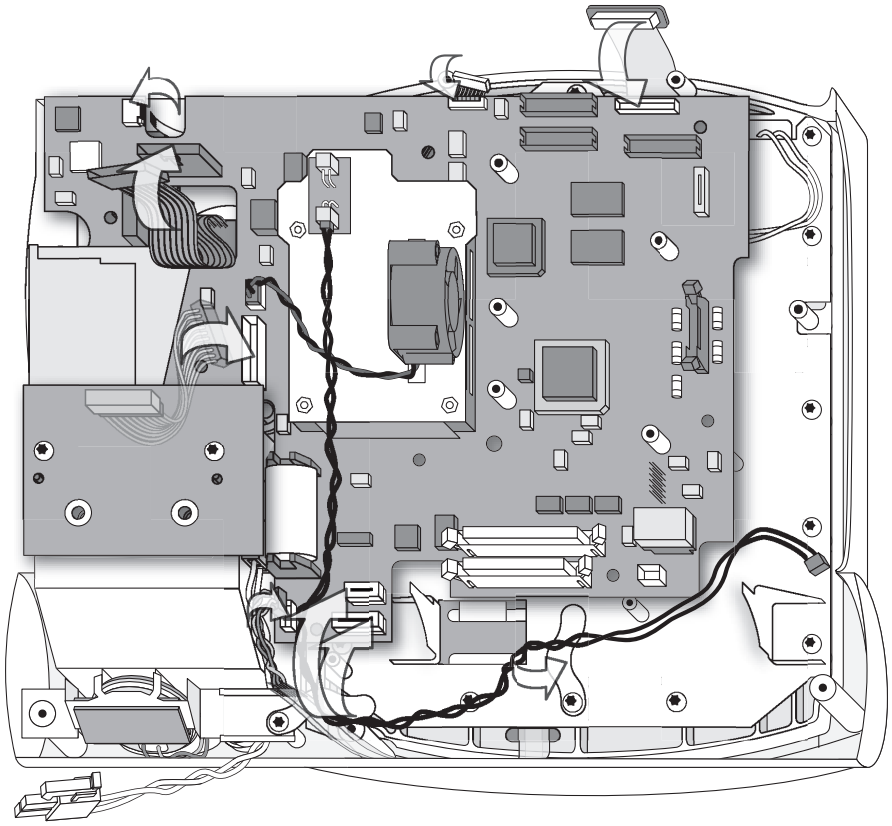
Replacement

1. **Install the clock (lithium) battery.**
   See “Clock Battery” on page 132.
2. **Install the replacement fan assembly.**
   See “Fan Assembly” on page 121.
3. **Replace the internal memory card.**
   a. Insert the internal memory card into the slot farthest from the fan.
   a. Align the card so that the CE label is facing the Processor PCA.
   b. Push the card into the slot as far as it can go.
4. **Place the Processor PCA in position,**
   Guide the cables out of the way. Line up the holes in the Processor PCA with the threaded standoffs underneath. Make sure there are no cables or wires trapped underneath the PCA.
5. **Replace the screws.**
   a. Replace the 7 T10 screws and tighten.
   b. Replace the shoulder screw and tighten.
6. **Replace the SpO_2 PCA.**
   See “SpO_2 PCA” on page 115.
7. **Replace the measurement module panel.**
   See “Measurement Module Panel” on page 117.

8. **Connect the Processor PCA.**

   Refer to Figure 52 and Table 25 on page 125. The order in Table 25 begins with the left edge of the Processor PCA and then works around the front case in a clockwise direction.

Figure 52 Replacing the Processor PCA



9. **Close the device.**

   See "Closing the case" on page 176.

10. **Replace the data card tray.**

Entering the Serial Number and Enabling Options

After you have replaced the Processor PCA, you must enter the device's serial number in the HeartStart MRx for it to be operational. If the serial number is not entered the device powers up with the message "Device serial number has not been entered. Service unit." ***Normal operation is not possible*** and the device powers up into Service Mode, where you can enter the serial number. Additionally, if you enter the options key incorrectly, the device's options will not function.

To enter the serial number and enable options:

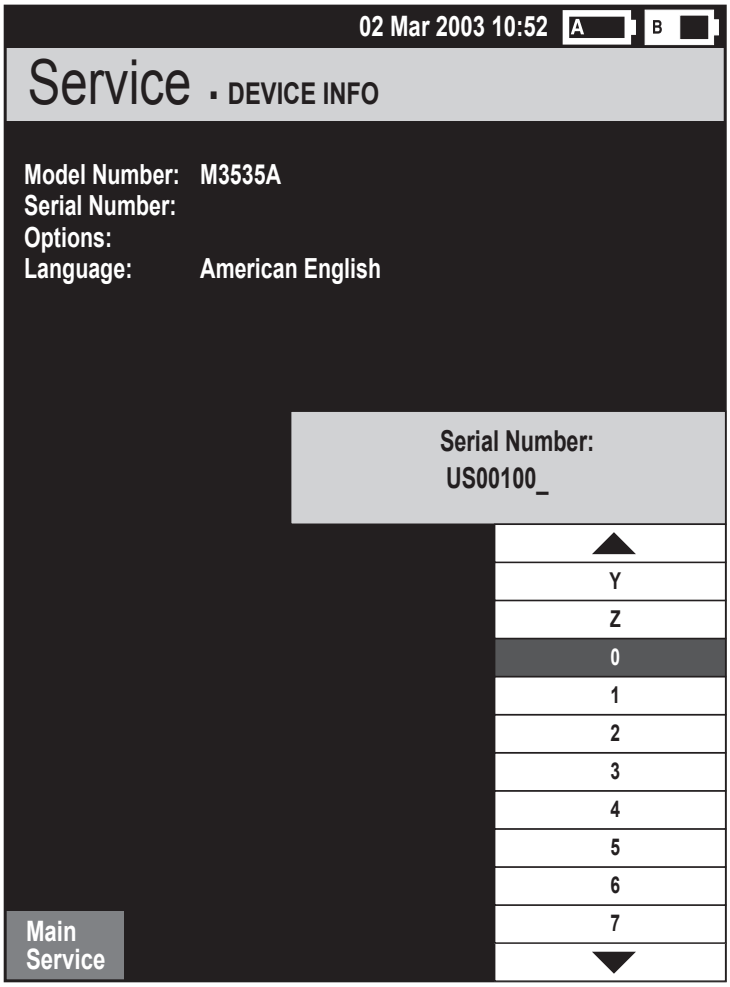
1. **Turn the device off.**
2. **Disconnect all external power and remove all batteries.**

   The primary and secondary labels, which contain the model number, serial number and options key, are now visible.

3. **Record the model number, serial number, and options key(s) from the labels on the back case.**

4. **Insert the AC power module or the battery (charged to at least 20%) and turn the Therapy Knob to Monitor.**
   The device powers up into Service Mode.
5. **From the Service Mode Main menu, select Device Info.**
6. **From the Device Info menu, select Model Number.**
   Select the model number.
7. **From the Device Info menu, select Edit S/N.**
   An alphanumeric menu is displayed.

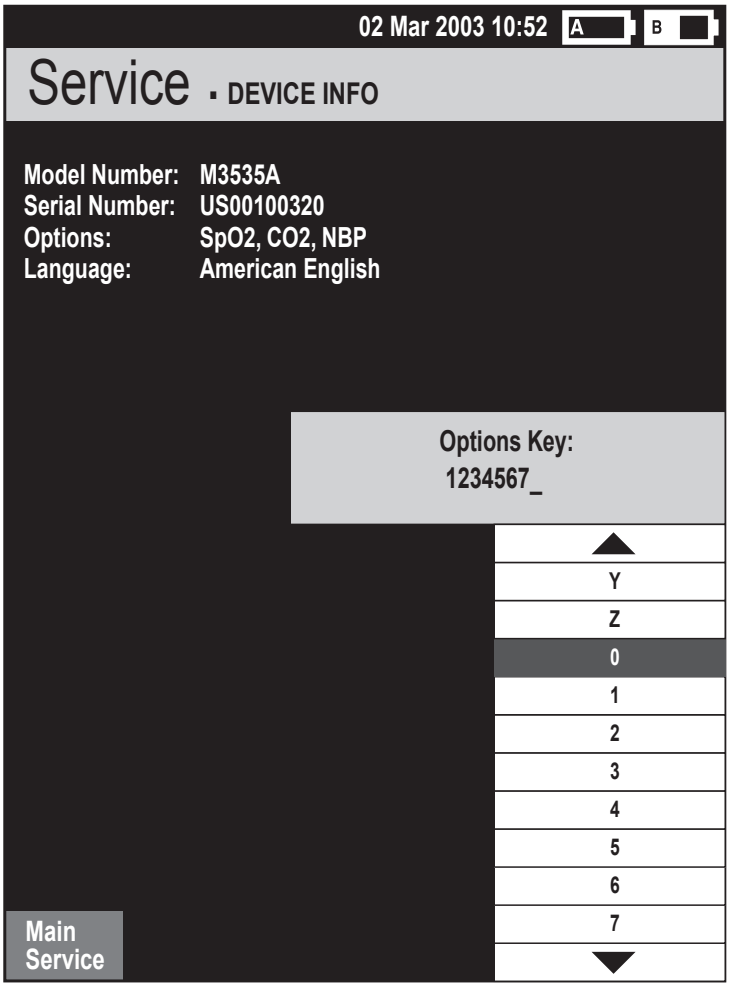
Figure 53 Entering Serial Number



8. **Enter the serial number using the Navigation buttons to scroll through the letters and numbers. Press the Menu Select button to complete each selection.**
   Select Cancel or backspace to cancel a selection.
9. **Scroll through the list and select Done when you have finished entering the serial number.**

10. **From the Device Info menu, select Options Key.**
    An alphanumeric menu is displayed.

Figure 54 Enabling Options



11. **Enter the options key using the Navigation buttons to scroll through the letters and numbers. Press the Menu Select button to complete each selection.**
    Select Cancel or backspace to cancel a selection. When the options key has been entered the corresponding product options are displayed.
12. **Select Done when you have finished entering the options key.**
13. **Repeat steps 10 through 12 for each options key.**
14. **Check the information on the screen to ensure it is correct, especially the options.**

NOTE If you clear or change the serial number, the options are cleared and you must re-enter them.

Installing the Software

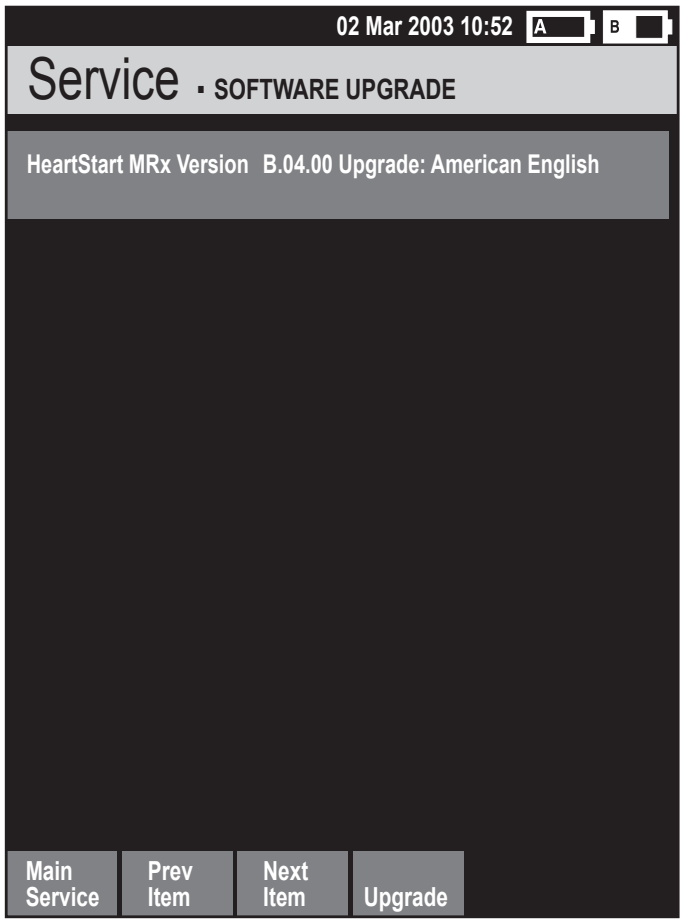
The HeartStart MRx (and all Processor PCA field kits) ship in American English with the latest product version. If you need to change device's language, follow these steps.

15. **Insert the Software Support Tool into the data card slot.**
16. **Select Software Upgrade from the Service Mode Main menu.**
17. **Select the appropriate software version.**
18. **Press the `[Upgrade]` soft key.**

    The software is installed on the device. This process takes a few minutes. While the software is being updated, progress messages are displayed and the **`[Main Service]`** soft key is disabled.

NOTE Be careful not to interrupt the software installation process by removing the power source or turning the device off.

Figure 55 Installing Software



19. **When the software installation process is complete, turn the device off and on.**

After Repair

Restore the customer's configuration settings from the data card. Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Clock Battery

The clock (lithium) battery resides on the Processor PCA. A cable tie wrap and a package of ProGold wipes are included in the replacement kit. Make sure you clean the contact clips and the new battery terminals with a ProGold wipe and replace the cable tie wrap that holds the battery in place.

Preparation

1. **Open and separate the case.**

   See “Opening the case” on page 102.

2. **Position the front case**

   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.

3. **Remove the Processor PCA.**

   See “Processor PCA” on page 123.

Removal

1. **Remove the battery from the Processor PCA.**

   a. Using a pair of fine nose wire cutters, cut and remove the cable tie wrap that holds the battery in place.

   b. Remove the battery from the holder.

Cleaning

1. **Thoroughly clean the contact clips and new battery terminals with a ProGold wipe.**

Replacement

1. **Insert the new battery into the holder.**

CAUTION Make sure that you install the new battery with the correct orientation. Follow the polarity markings on the battery holder (under the battery).

2. **Secure the battery with the cable tie wrap. Cut off the excess tie wrap.**
3. **Replace the Processor PCA.**

   See “Processor PCA” on page 123.

4. **Close the case.**

   “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Printer Connector PCA

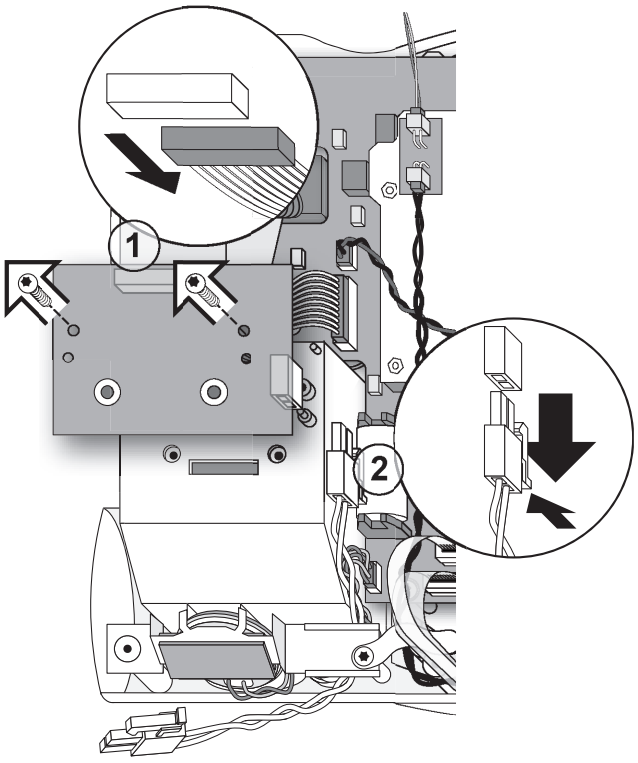
Preparation

1. **Remove the Printer.**
   See “Printer Assembly” on page 93.
2. **Open and separate the case.**
   See “Opening the case” on page 102.
3. **Position the front case**
   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.

Removal

1. **Disconnect the Printer PCA**
   a. Unplug the 10-wire bundle by pulling straight down away from the PCA. **(1)**
   b. Unplug the 2-wire bundle by pushing up on the latch and pulling out. **(2)**
2. **Remove the screws.**
   Loosen and remove the two T-10 screws.
3. **Lift up the Printer Connector PCA.**
   Lift the PCA up off the back of the printer well.

Figure 56 Removing the Printer PCA



Replacement

1. **Place the Printer Connector PCA in position.**

   Align the printer connector with the hole in the printer well and lower the PCA into position, with the foam gasket side down. The two locating posts on the back of the well should protrude through the PCA.

2. **Install the screws.**

   Replace and tighten the two T-10 screws.

3. **Connect the Printer Connector PCA.**

   a. Connect the 10-wire bundle to the Printer Connector PCA by pushing straight up toward the PCA.

   b. Connect the 2-wire bundle to the Printer Connector PCA by pushing in until the latch clicks.

4. **Close the case.**

   See “Closing the case” on page 176.

5. **Replace the printer.**

   See “Printer Assembly” on page 93.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Display Assembly

The Display assembly contains all keypads, the Inverter PCA, the display shield, and the metal frame.

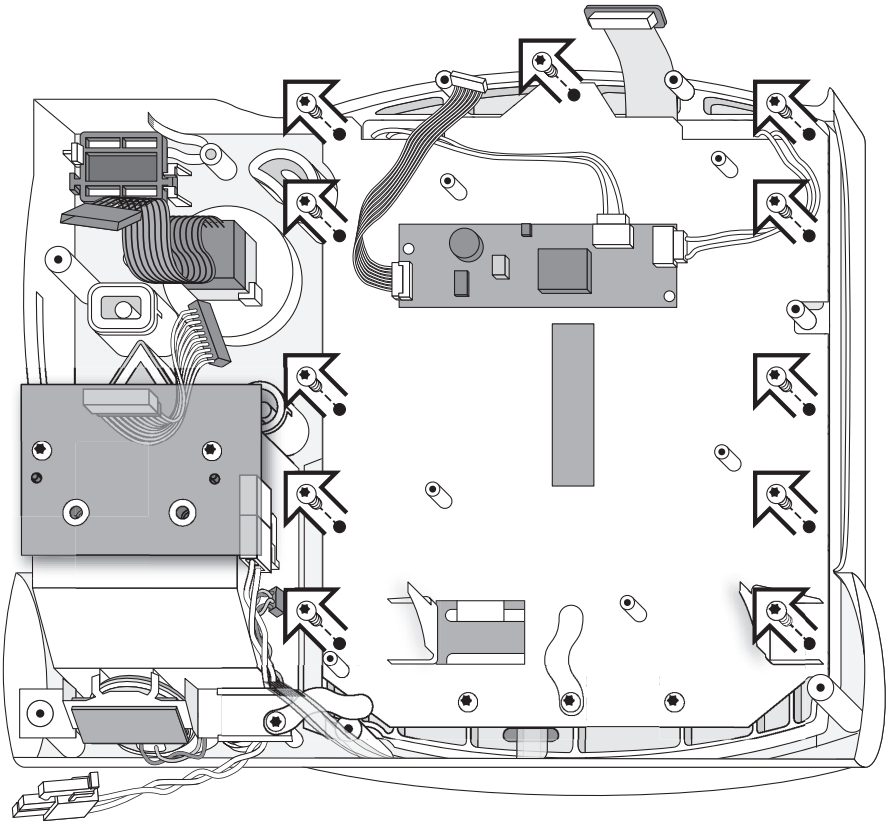
Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the front case**
   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.
3. **Remove the measurement module panel.**
   See “Measurement Module Panel” on page 117
4. **Remove the Processor PCA**
   See “Processor PCA” on page 123.

Removal

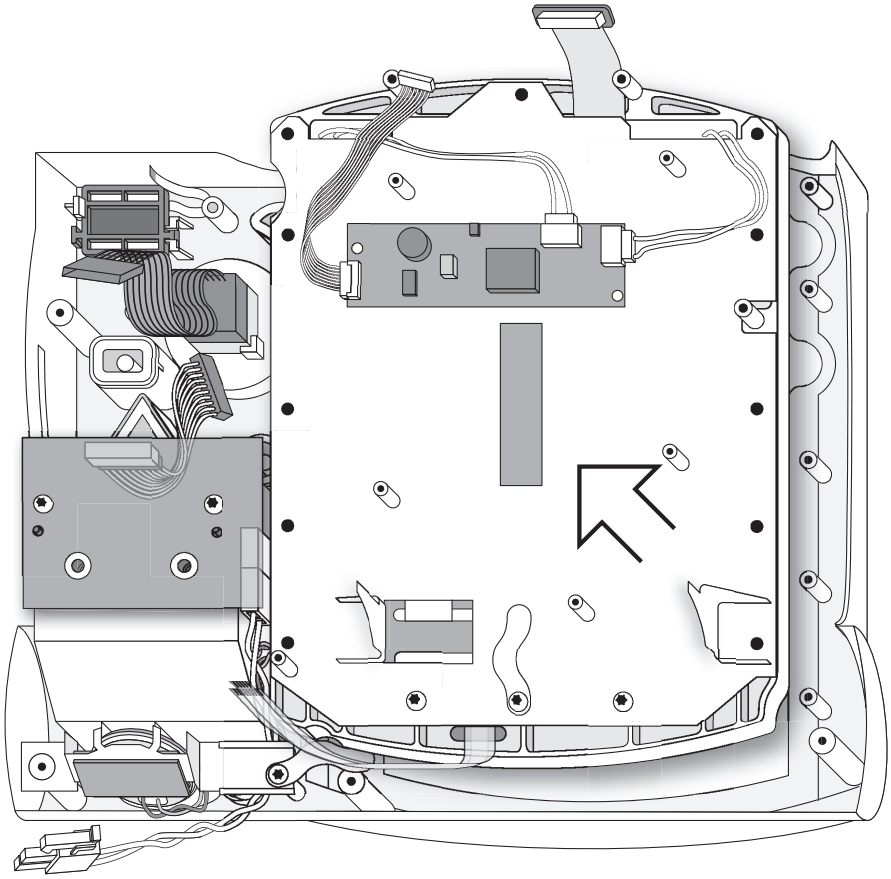
1. **Remove the screws.**
   Loosen and remove the 11 T-10 screws as shown in Figure 58. Do ***not*** remove the bottom 3 screws as they connect the shield to the display.

Figure 57 Display Screws



2. **Lift the Display assembly.**
   Lift the Display assembly straight up out of the case.

Figure 58 Removing the Display



Replacement

1. **Remove the rectangular piece of black foam from the sheet metal.**
   The black foam protects the cables during shipment.
2. **Place the Display assembly into position.**
   Lower the Display assembly into position into the front case. Be sure the metal housing fits down over the molded posts in the front case. Make sure that no cables are trapped underneath.
3. **Replace the screws.**
   Replace and tighten the 11 T-10 screws.
4. **Replace the Processor PCA**
   See “Processor PCA” on page 123.
5. **Replace the measurement module panel.**
   See “Measurement Module Panel” on page 117.
6. **Close the case.**
   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Ready For Use Indicator

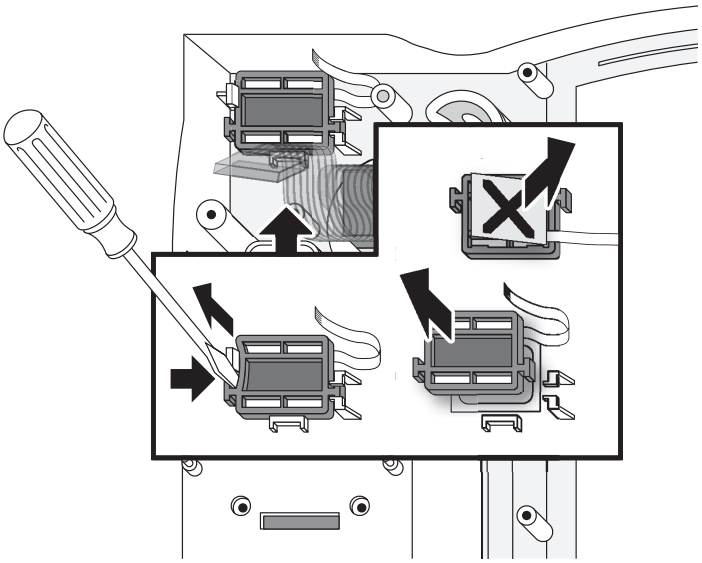
Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the front case**
   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.
3. **Remove the Processor PCA**
   See “Processor PCA” on page 123.

Removal

1. **Pull up the alignment tabs.**
   Using a small screwdriver on the black rubber piece, lift the RFU Indicator out of the white tab.
2. **Lift out the RFU Indicator.**
   Lift up on the right end of the RFU Indicator, and slide it out from under the retaining catch. Lift it out of the case.

Figure 59 Removing the RFU Indicator



Replacement

1. **Remove the protective plastic from the LCD.**
2. **Place the RFU Indicator in position.**
   Slide the left end of the RFU Indicator under the retaining catch. Line up the tabs with the alignment slots.

3. **Press the tabs into place.**

   Using a small screwdriver, press each flexible tab down into the alignment slot until it reaches the bottom of the slot.

4. **Replace the Processor PCA**

   See “Processor PCA” on page 123.

5. **Close the case.**

   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Front Panel Buttons

Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the front case.**
   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.
3. **Remove the Processor PCA**
   See “Processor PCA” on page 123.

Removal

1. **Remove the buttons.**
   Grasp each button and pull out from the case.

NOTE If your device has a white, hollow plastic insert for the Shock button, discard it and use the clear plastic insert that comes in the replacement kit. If your device already has the clear plastic Shock button insert, you can re-use it and discard the one that came in the kit. Keep the plastic inserts for the other buttons for replacement.

Replacement

1. **Place the buttons in position.**
   Slide each plastic insert into its button. Be sure it slides in all the way.
2. **Insert the buttons into the case.**
   Line up the notches on the buttons with the slots in the case and push into place.
3. **Replace the Processor PCA**
   See “Processor PCA” on page 123.
4. **Close the case.**
   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Front Case Assembly

The front case replacement involves moving existing parts from the old case to the new and replacing the labels.

Preparation

1. **Remove the printer.**
   See “Printer Assembly” on page 93.
2. **Remove the Therapy Knob.**
   See “Therapy Knob” on page 90.
3. **Open and separate the case.**
   See “Opening the case” on page 102.
4. **Position the front case**
   Lay the front case on the work surface with the display facing down and the printer in the lower left corner.

Removal

1. **Remove the speaker/microphone assembly.**
   See “Speaker and Microphone Assembly” on page 111.
2. **Remove the Printer PCA.**
   See “Printer Connector PCA” on page 133.
3. **Remove the measurement module panel.**
   See “Measurement Module Panel” on page 117.
4. **Remove the Processor PCA and SpO_2 PCA together.**
   Leave the SpO2 PCA in place on the Processor PCA, then remove the Processor PCA from the Front Case. See “Processor PCA” on page 123.
5. **Remove the Display assembly.**
   See “Display Assembly” on page 135.
6. **Remove the Therapy switch.**
   See “Therapy Switch” on page 119.
7. **Remove the RFU Indicator.**
   See “Ready For Use Indicator” on page 138.
8. **Remove the front panel buttons.**
   See “Front Panel Buttons” on page 140.

Replacement

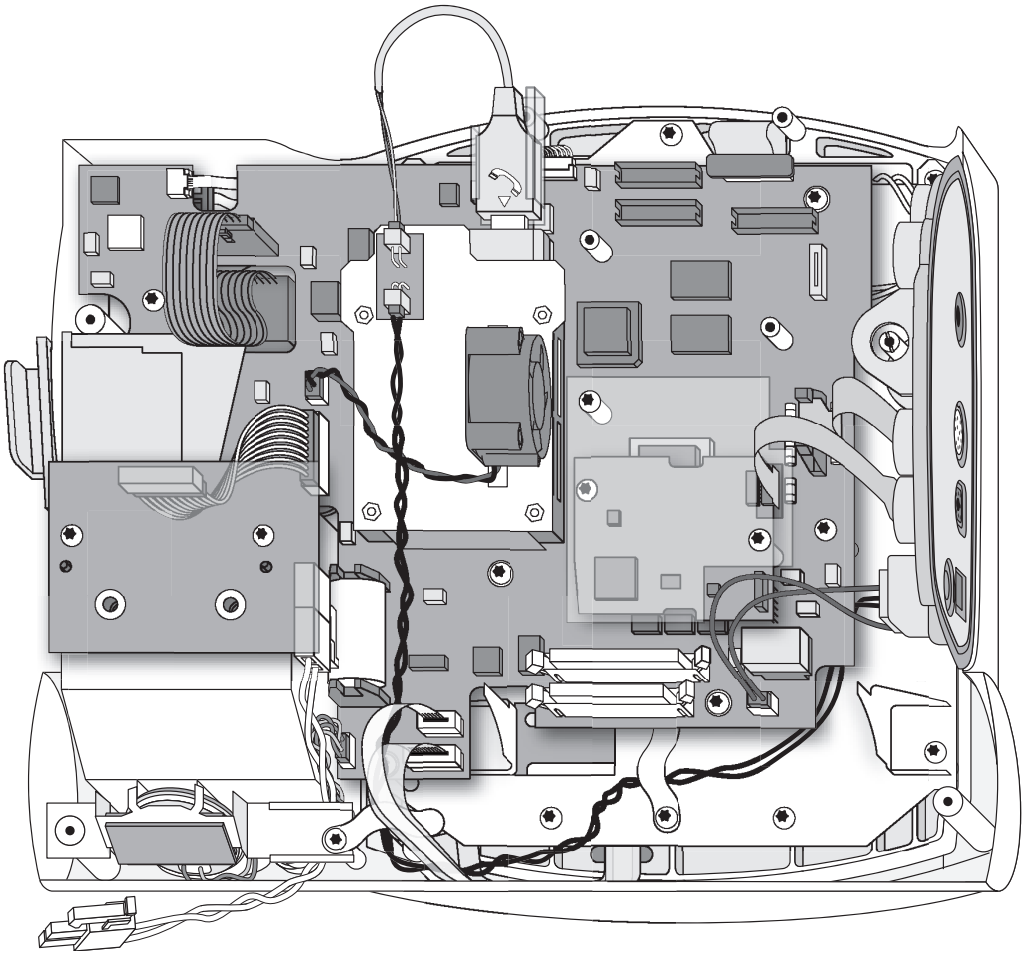
1. **Replace the front panel buttons.**
   See “Front Panel Buttons” on page 140.
2. **Replace the RFU Indicator.**
   See “Ready For Use Indicator” on page 138.

3. **Replace the Therapy switch.**
   See “Therapy Switch” on page 119.
4. **Replace the Display assembly.**
   See “Display Assembly” on page 135.
5. **Replace the Processor PCA and SpO_2 PCA together.**
   Leave the SpO2 PCA in place on the Processor PCA, then replace the Processor PCA in the Front Case. See “Processor PCA” on page 123.
6. **Replace the measurement module panel.**
   See “Measurement Module Panel” on page 117.
7. **Replace the Printer PCA.**
   See “Printer Connector PCA” on page 133.
8. **Replace the Speaker/Microphone Assembly.**
   See “Speaker and Microphone Assembly” on page 111.
9. **Close the case.**
   See “Closing the case” on page 176.
10. **Replace the Therapy Knob.**
    See “Therapy Knob” on page 90.
11. **Replace the printer.**
    See “Printer Assembly” on page 93.

12. **Affix the new labels.**

    See “Labels” on page 91 for information on removal and replacement procedures. See “Software Support Tool” on page 13 for information on where to affix product version labels.

Figure 60 Front case complete



After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

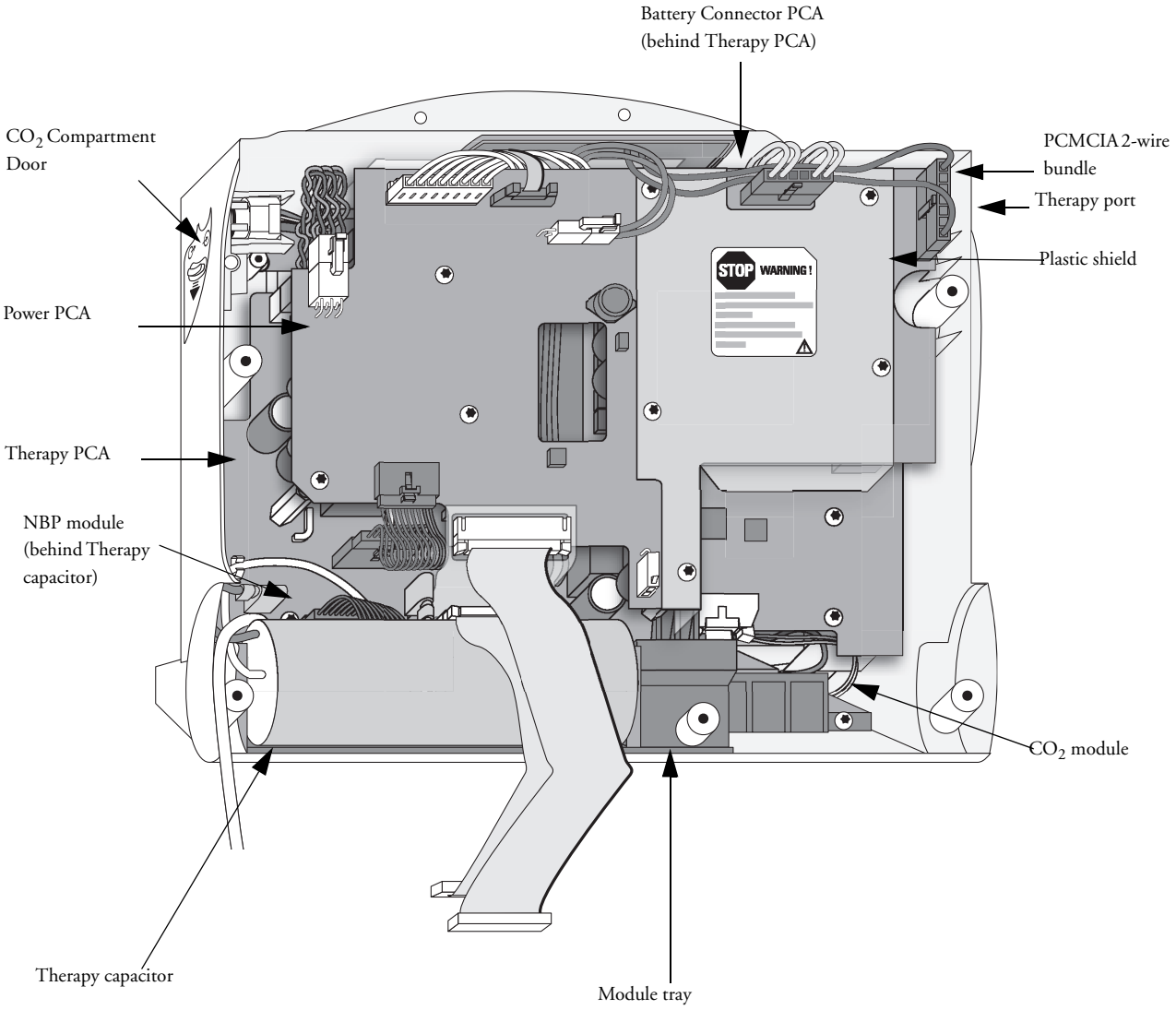
Internal Assemblies - Rear Case

This section is organized into the following topics:

Overview of Rear Case

Refer to Figure 61 to identify assemblies in the rear case.

Figure 61 Rear case overview



Therapy Capacitor

Preparation

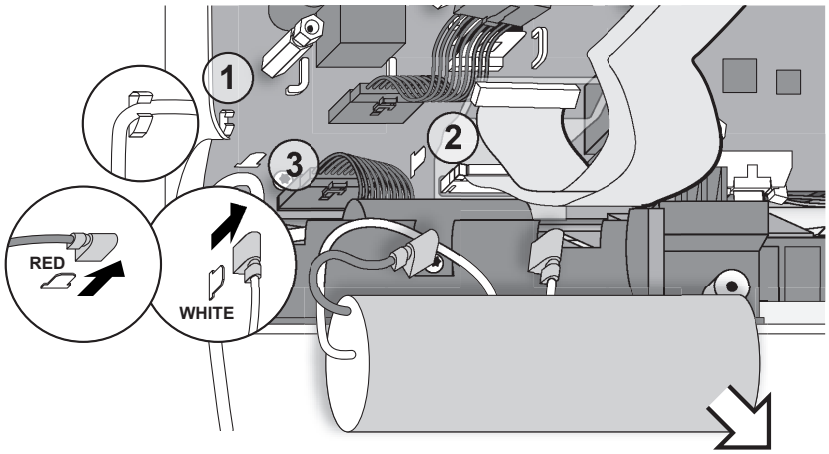
1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the rear case.**
   Lay the rear case on the work surface with the PCAs facing up and the Therapy port on the right.

WARNING Be sure the Therapy capacitor has been discharged before performing the following steps. See “Discharge the Therapy Capacitor” on page 105.

Removal

1. **Disconnect the Therapy capacitor.**
   a. Remove the white wire from the clip. **(1)**
   b. Disconnect the white wire from the Therapy PCA, using pliers, if necessary. **(2)**
   c. Disconnect the red wire from the Therapy PCA, using pliers, if necessary. **(3)**
2. **Remove the Therapy capacitor.**
   Slide the Therapy capacitor out of the tray.

Figure 62 Removing the Therapy Capacitor



Replacement

1. **Place the Therapy Capacitor into position.**
   a. The new capacitor comes with a shorting bar connecting the two terminals. Disconnect the shorting bar.
   b. Make sure the Therapy capacitor wires are parallel to the case and clear of the foam and that the red wire is on top.
   c. Place the side with the wires into the tray first and slide the Therapy capacitor into the tray.

2. **Connect the Therapy capacitor to the Therapy PCA.**
   a. Connect the red wire to the connector labelled red on the Therapy PCA, making sure that the orientation is the same as that shown in Figure 62.
   b. Loop the white wire through the clip and plug it into the connector labelled white on the Therapy PCA.
3. **Close the case.**
   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Power PCA

Preparation

1. **Open and separate the case.**

   See “Opening the case” on page 102.

2. **Position the rear case.**

   Lay the rear case on the work surface with the PCAs facing up and the Therapy port on the right.

Removal

1. **Disconnect all cables.**

   See Figure 63 and Table 26 on page 149. The connections may be removed in any order. The order in Table 26 begins with the left edge of the Power PCA, and then works around the rear case in a clockwise direction.

Figure 63 Power PCA Connections

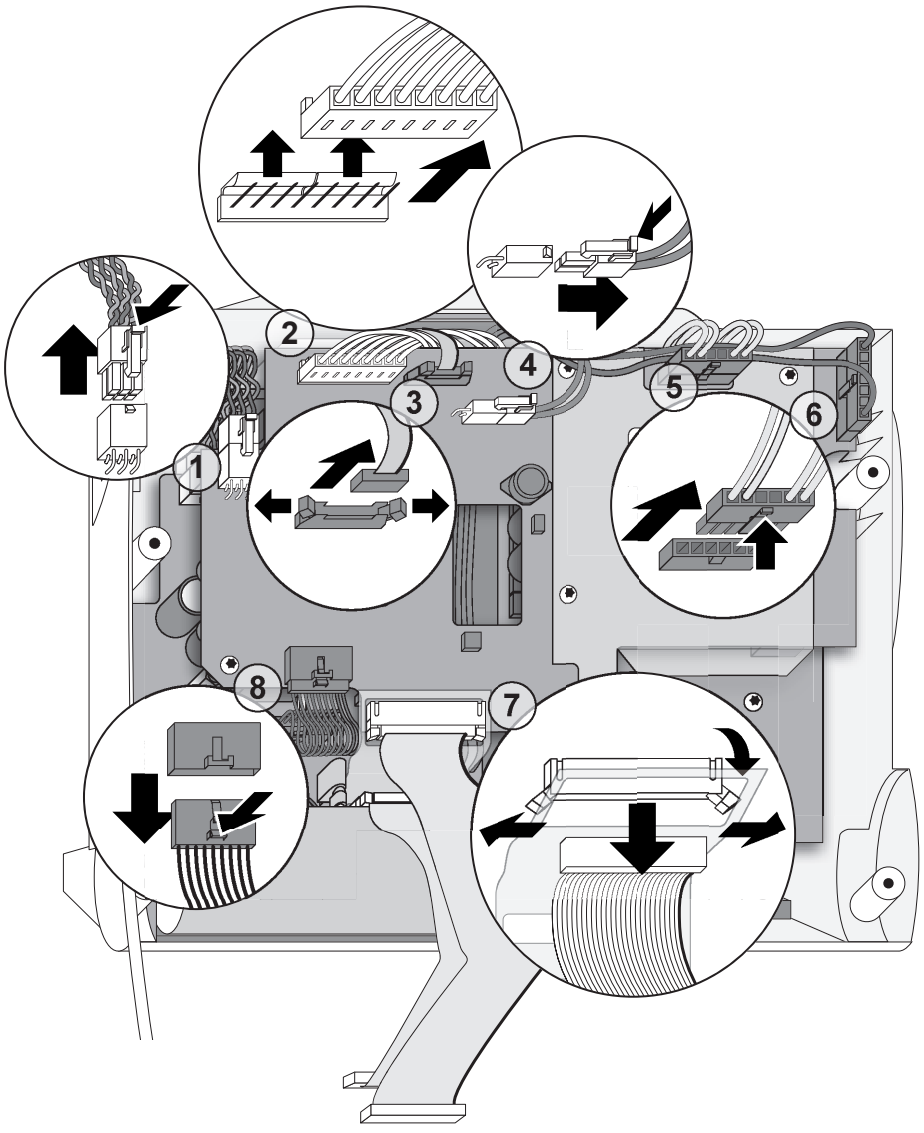


Table 26 Power PCA Connections

Ref. No.	Description	Connects To	Disconnect By
1	6-wire bundle	Therapy PCA	Push on latch to release, pull, wiggle.
2	8-wire bundle	Battery Connector PCA	Gently pull, wiggle. **Note**: Be careful not to break off the tabs.
3	small ribbon cable	Battery Connector PCA	Pull tabs apart, pull.
4	2-wire bundle	DC Power Connector	Push on latch to release, pull.
5	4 wire bundle	Therapy PCA	Push on latch to release, pull.
6	2-wire bundle	PCMCIA hole plug	Push on latch to release, pull.
7	ribbon cable plastic shield	Processor PCA	Release latches at edges of connector, pull. Close latches to remove plastic shield.
8	9-wire bundle	Therapy PCA	Push on latch to release, pull.

2. **Remove the large plastic shield.**

   Remove the 5 screws and plastic shield and place to the side. You will need to replace this when you install the new Power PCA.

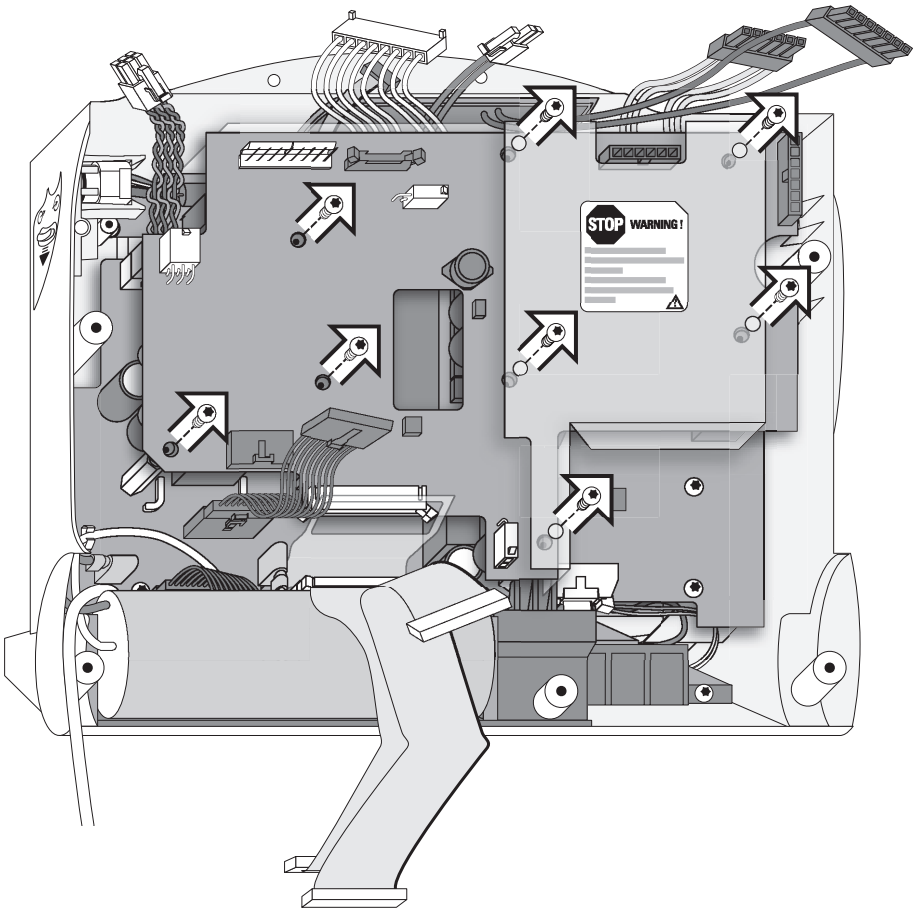
3. **Remove the screws.**

   Loosen and remove the 3 remaining T-10 screws.

4. **Remove the Power PCA.**

   Lift the Power PCA straight up out of the rear case.

Figure 64 Removing the Power PCA



Replacement

TIP It may be easier to connect cables #8 and #7 with the accompanying plastic shield before the Power PCA is placed in the case.

1. **Place the Power PCA into position.**

   Position the PCA in the rear case, lining up its holes with the threaded standoffs. Make sure no wires or cables are caught underneath the PCA.

2. **Replace the large plastic shield.**

3. **Replace the screws.**

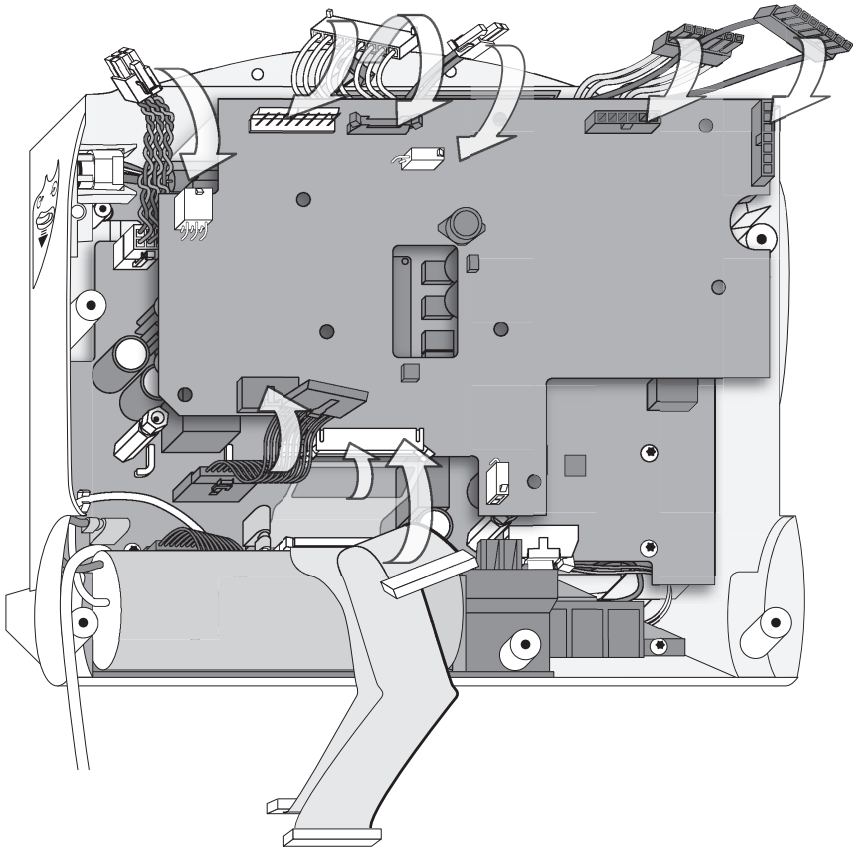
   Replace the 8 T-10 screws and tighten.

4. **Connect the Power PCA.**

   Refer to Figure 65 and Table 26. The connections may be replaced in any order. The order in Table 26 begins with the left edge of the Power PCA, and then works around the rear case in a clockwise direction.

NOTE Be sure to loop the PCMCIA 2-wire bundle (# 6 in Figure 63) underneath the Therapy PCA 4-wire bundle (# 5 in Figure 63).

Figure 65 Replacing the Power PCA



After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

NBP and CO_2 Module Tray

You need to remove the NBP and CO_2 module tray for several of the rear case assembly replacement procedures.

Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the rear case.**
   Lay the rear case on the work surface with the PCAs facing up and the Therapy port on the right.
3. **Remove the Therapy capacitor**
   See “Therapy Capacitor” on page 146.

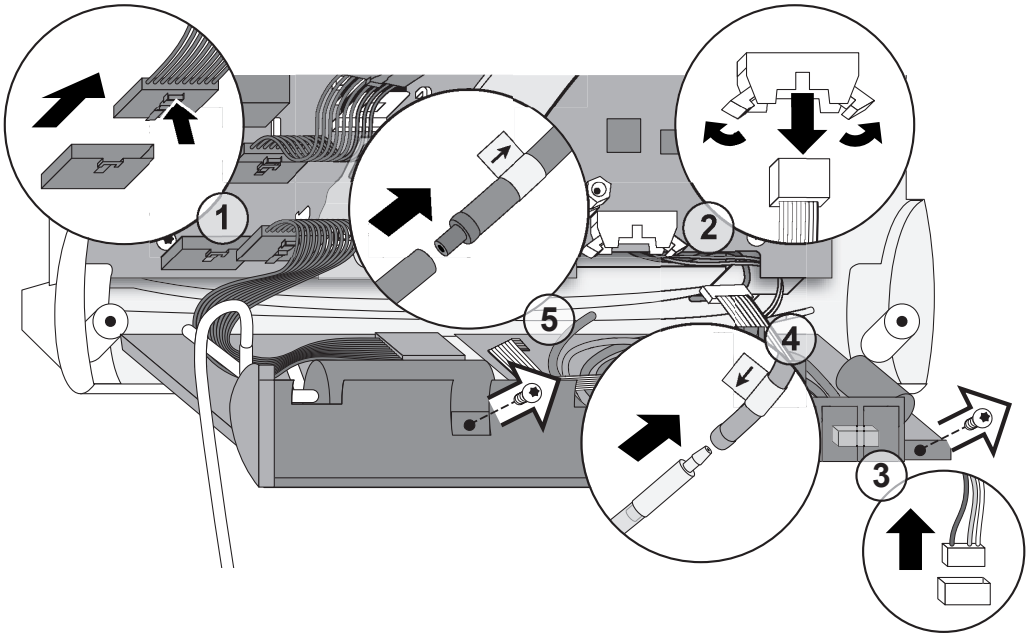
Removal

1. **Remove the 2 T-10 screws from the front of the tray.**

TIP You may find it easier to stand the device up with the PCAs facing you for the following procedures.

2. **Disconnect the NBP 10-wire bundle from the Therapy PCA. (1)**
3. **Disconnect the CO_2 ribbon cable from the Therapy PCA. (2)**
4. **Slide the tray out halfway.**
5. **Disconnect the CO_2 3-wire bundle. (3)**
6. **Disconnect the CO_2 intake tube from the CO_2 module. The intake tube has an arrow pointing towards the module and connects to the tube with the braided segment. (4)**
7. **Disconnect the CO_2 exhaust tube from the CO_2 module. The exhaust tube has an arrow pointing away from the module and connects to the tube *without* the braid. (5)**
8. **Slide the tray out of the case.**

Figure 66 Removing the NBP and CO_2 Module Tray



Replacement

TIP You may find it easier to slide the module tray in halfway until you connect the cables and tubes.

1. **Connect the CO_2 intake tube to CO_2 the module. The intake tube has an arrow pointing towards the module and connects to the tube with the braided segment.**
2. **Connect the CO_2 exhaust tube to the CO_2 module. The exhaust tube has an arrow pointing away from the module and connects to the tube *without* the braid.**
3. **Connect the CO_2 3-wire bundle to the CO_2 module connector. If you are installing the M3535-69181 CO_2 module, make sure that you connect the CO_2 3-wire bundle to the CO_2 module connector that is closest to the front of the device.**
4. **Connect the CO_2 ribbon cable to the Therapy PCA.**
5. **Connect NBP 10-wire bundle to the Therapy PCA.**
6. **Slide the tray the rest of the way into the rear case.**

NOTE Be careful not to pinch the wires or tubing between the Therapy PCA and the tray.

7. **Replace the 2 T-10 screws and tighten.**
8. **Replace the Therapy capacitor.**
   See “Therapy Capacitor” on page 146.
9. **Close the case.**
   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Therapy PCA

Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the rear case.**
   Lay the rear case on the work surface with the PCAs facing up and the Therapy port on the right.
3. **Remove the Power PCA.**
   See “Power PCA” on page 148.
4. **Remove the Therapy capacitor**
   See “Therapy Capacitor” on page 146.
5. **Remove the NBP and CO_2 module tray.**
   See “NBP and CO2 Module Tray” on page 152.

NOTE If the device does not have the NBP or CO_2 modules, simply unscrew the tray and slide it out.

Removal

1. **Disconnect all cables.**
   See Figure 67 and Table 27 on page 155. The connections may be removed in any order. The order in Table 27 begins with the top of the left edge of the Therapy PCA, and then works around the Rear Case in a clockwise direction.

Figure 67 Therapy PCA Connections

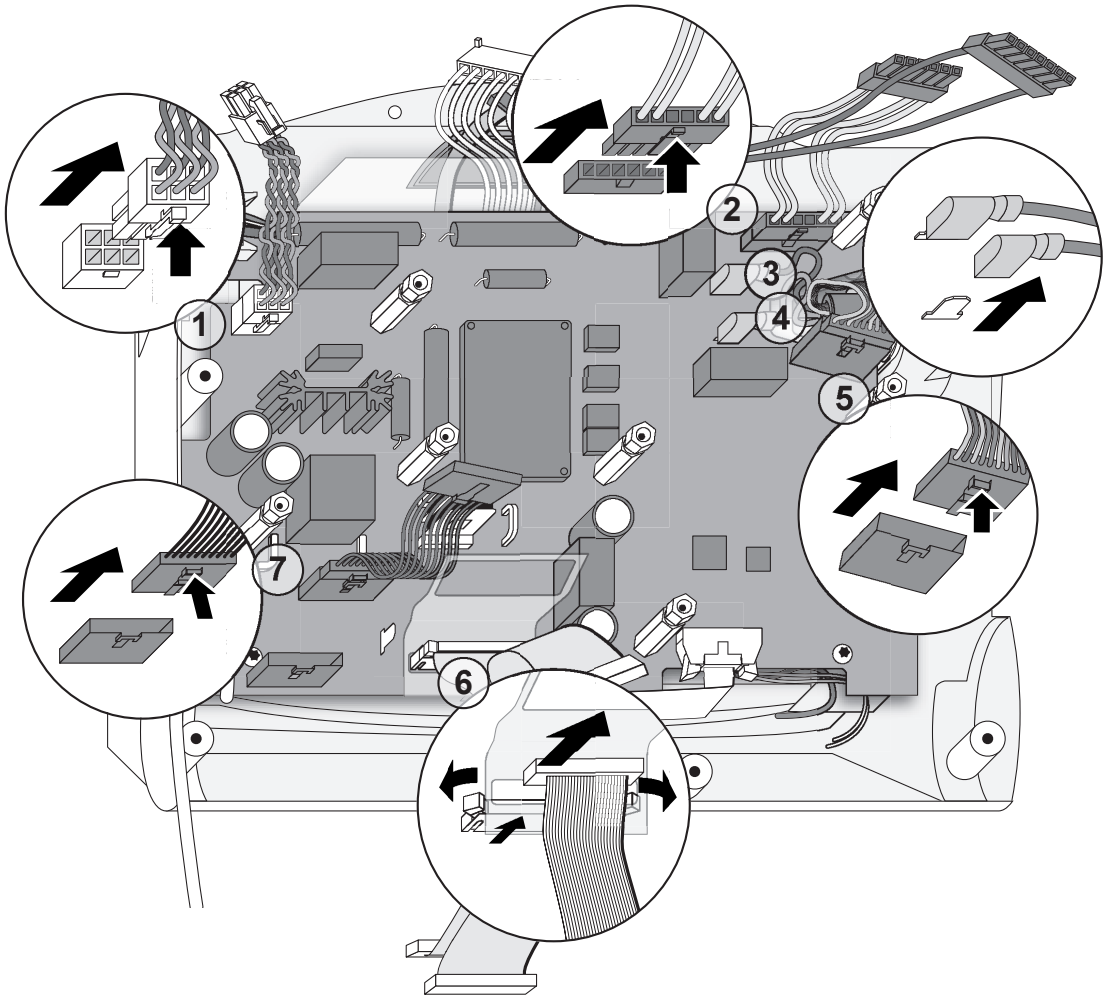
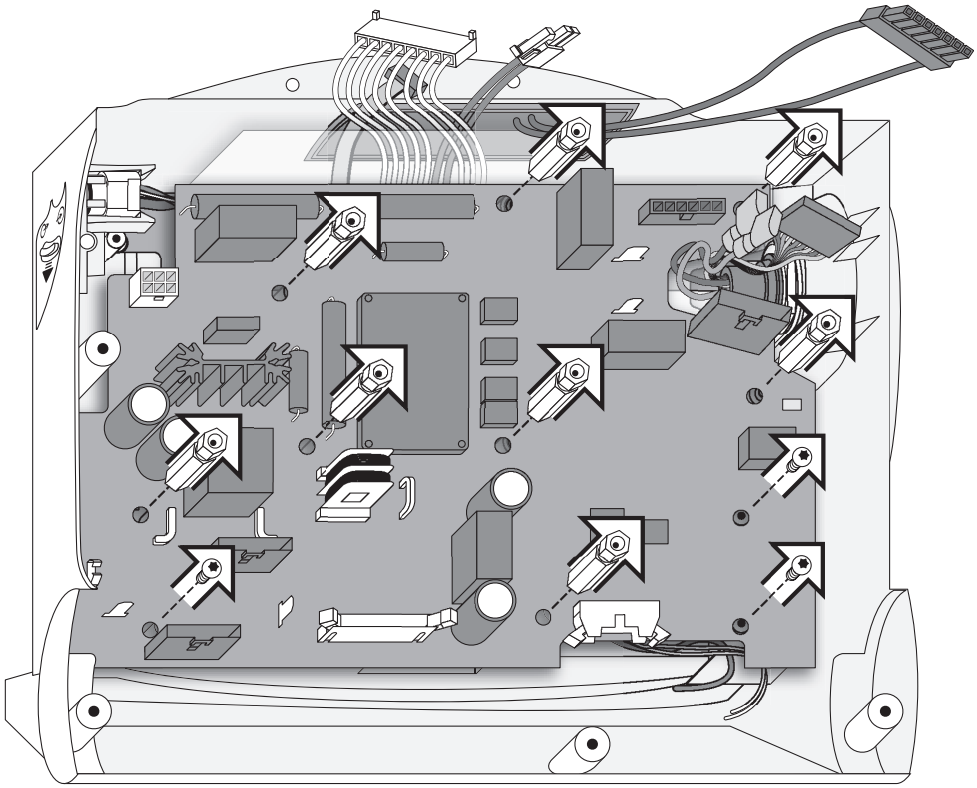


Table 27 Therapy PCA Connections

Ref. No.	Description	Connects To	Disconnect By
1	6-wire bundle	Power PCA	Push on latch to release, pull, wiggle.
2	4 wire bundle	Power PCA	Push on latch to release, pull, wiggle.
3	Large spade connector	Therapy port	Pull, wiggle, use pliers if needed.
4	Small spade connector	Therapy port	Pull, wiggle, use pliers if needed
5	9-wire bundle	Therapy port	Push on latch to release, pull.
6	Ribbon cable plastic shield	Processor PCA	Release latches at edges of connector, pull. Close latches to remove plastic shield.
7	10-wire bundle	NBP module	Push on latch to release, pull, wiggle.

2. **Remove the screws.**
   Loosen and remove the 3 T-10 screws.
3. **Remove the standoffs.**
   Loosen and remove the 8 (5/16-inch) hex standoffs.

Figure 68 Removing the Therapy PCA



4. **Remove the Therapy PCA.**
   Grasp the Therapy PCA by the black, square relays and lift the Therapy PCA straight up out of the rear case.

Replacement

1. **Place the Therapy PCA into position.**
   a. Position the PCA in the rear case, lining the PCA up on the Therapy port side first.
   b. Line up the PCA holes with the threaded case posts. Make sure there are no wires or cables caught underneath the PCA.
2. **Replace the screws.**
   Replace the 3 T-10 screws and tighten.

3. **Replace the standoffs.**

   Replace the 8 standoffs and tighten. Note that on each standoff, the two ends are different: the end with the groove should be up.

4. **Replace the NBP and CO_2 module tray.**

   See “NBP and CO2 Module Tray” on page 152.

5. **Connect the Therapy PCA.**

   Refer to Figure 67 on page 155 and Table 27 on page 155. The connections may be replaced in any order. The order in Table 27 begins with the left edge of the Therapy PCA, and then works around the Rear Case in a clockwise direction.

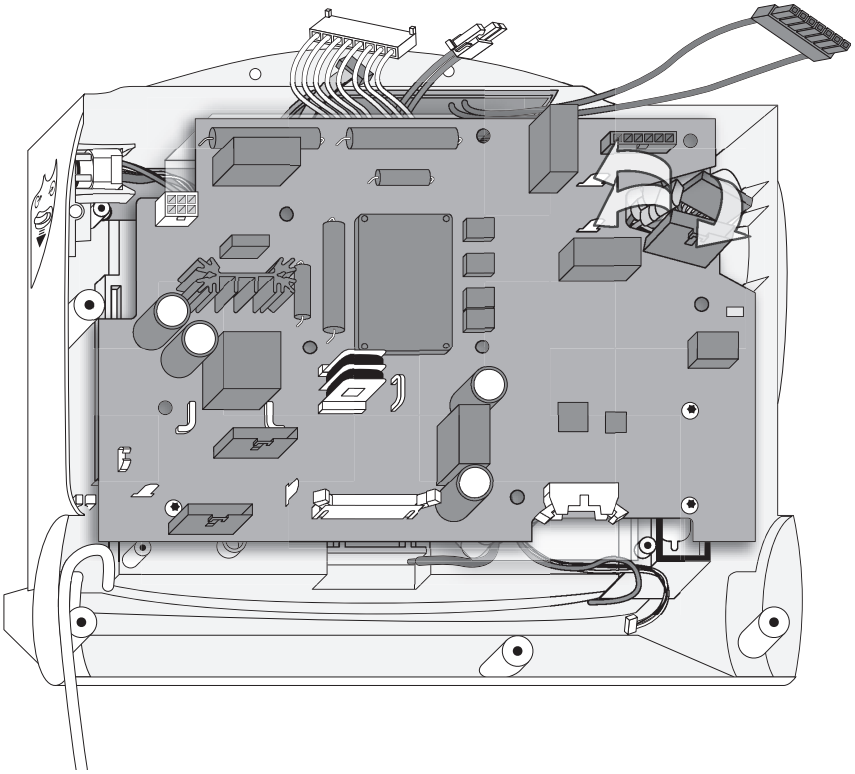
6. **Replace the Therapy capacitor.**

   See “Therapy Capacitor” on page 146.

7. **Replace the Power PCA.**

   See “Power PCA” on page 148.

Figure 69 Replacing the Therapy PCA



8. **Close the case.**

   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Therapy Port

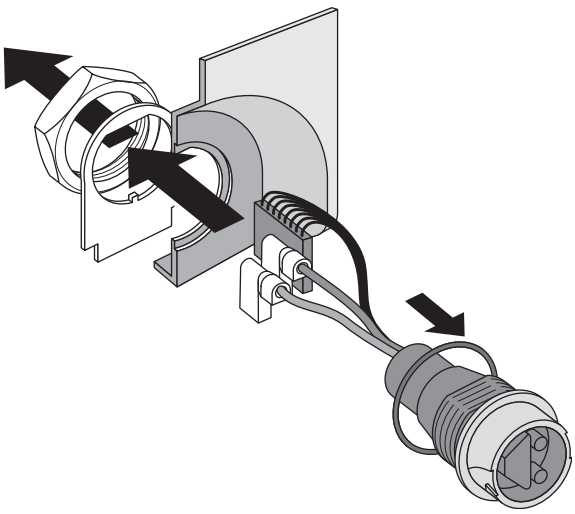
Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the rear case.**
   Lay the rear case on the work surface with the PCAs facing up and the Therapy port on the right.
3. **Remove the Power PCA.**
   See “Power PCA” on page 148.
4. **Remove the Therapy capacitor**
   See “Therapy Capacitor” on page 146.
5. **Remove the Therapy PCA.**
   See “Therapy PCA” on page 154.

Removal

1. **Remove the plastic shield.**
   Remove the plastic shield from the rear case and place it to the side. You will need to replace this when you finish replacing the Therapy port.
1. **Unscrew the nut.**
   Using a wrench, unscrew the large nut on the back of the Therapy port.
2. **Remove the hardware.**
   Remove the large nut and metal plate from the Therapy port. Guide the wires and connectors through the nut and plate. Turn the 9-pin connector so it passes through sideways.
3. **Remove the Therapy port.**
   Slide the Therapy port out of its hole in the case. Guide the wires and connectors through the hole.

Figure 70 Therapy port



Replacement

1. **Replace the Therapy port.**
   a. Install the O-ring onto the Therapy port.
   b. Slide the Therapy port into its hole in the case. Guide the wires and connectors through the hole.
2. **Replace the hardware.**
   a. Replace the metal plate and then the large nut onto the Therapy port.
   b. Guide the wires and connectors through the plate and the nut. Turn the 9-pin connector so it passes through end first.
3. **Tighten the nut.**
   a. Screw the large nut onto the back of the Therapy port. Be careful not to cross-thread the metal nut on the plastic connector.
   b. Tighten the nut against the metal plate.
4. **Replace the Therapy PCA.**
   See “Therapy PCA” on page 154.
5. **Replace the Therapy capacitor.**
   See “Therapy Capacitor” on page 146.
6. **Replace the Power PCA.**
   See “Power PCA” on page 148.
7. **Close the case.**
   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

NBP Module

The NBP and CO_2 modules are mounted onto a tray. To replace either module, you need to remove the tray first, then replace the individual module.

Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the rear case.**
   Lay the rear case on the work surface with the PCAs facing up and the Therapy port on the right.
3. **Remove the Therapy capacitor.**
   See “Therapy Capacitor” on page 146.
4. **Remove the NBP and CO_2 module tray.**
   See “NBP and CO2 Module Tray” on page 152.

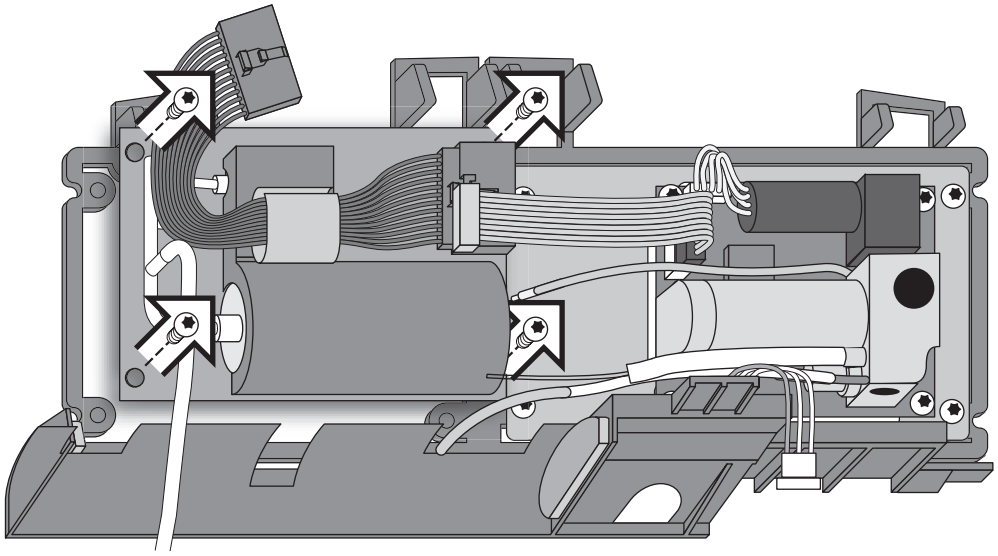
Removal

Remove the NBP module and shield.

a. Loosen and remove the 4 T-10 screws.

b. Lift the NBP module and shield straight up out of the module tray.

Figure 71 Removing the NBP Module



Replacement

1. **Place the NBP module and shield into position.**
   Position the NBP module and shield into the module tray.
2. **Replace the screws and tighten.**
3. **Replace the NBP and CO_2 module tray.**
   See “NBP and CO2 Module Tray” on page 152.

NOTE You connect the NBP tubing when you put the case halves together. See “Internal Assemblies - Front Case” on page 107.

4. **Replace the Therapy capacitor.**

   See “Therapy Capacitor” on page 146.

5. **Close the case.**

   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

CO_2 Module

There are two CO_2 module kits. Make sure that you order and install the correct module for your device.

CO_2 module kit number	Product Version
M3535-69103	B.xx devices
M3535-69181	A.xx devices

Check the product version label under battery compartment B or print the device info to determine the device's product version. See "Rear case labels" on page 15 or "Printing the Device Information" on page 16 for information on determining the devices's product version.

The NBP and CO_2 modules are mounted onto a tray. To replace either module, you need to remove the tray first, then replace the individual module.

NOTE If you are replacing the ***CO_2 module only***, start with "Preparation", continue with "Removing the CO_2 Module" on page 164, and "Replacing the CO_2 Module" on page 166 and finish with "After Repair".

If you are replacing the ***CO_2 module and intake receptacle and internal tubing***, start with "Preparation" and follow the instructions all the way through to the end.

Preparation

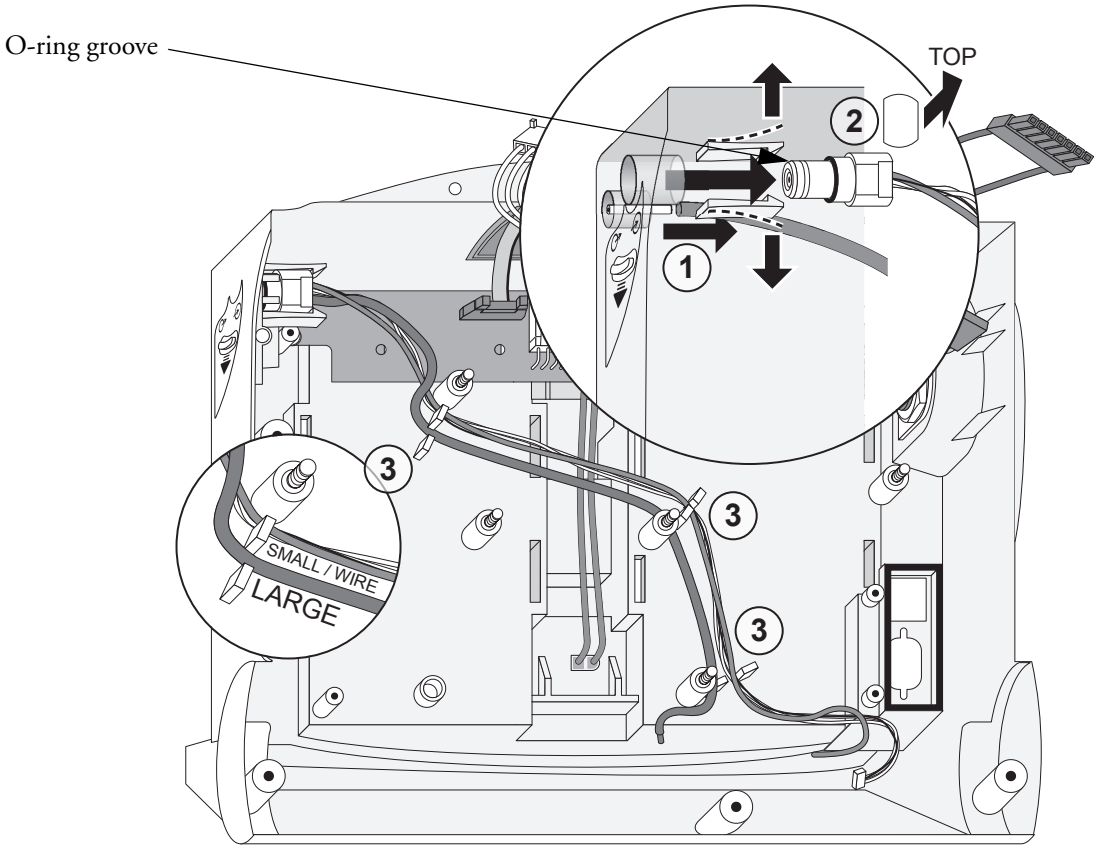
1. **Open and separate the case.**
   See "Opening the case" on page 102.
2. **Position the rear case.**
   Lay the rear case on the work surface with the PCAs facing up and the Therapy port on the right.
3. **Remove the Therapy capacitor**
   See "Therapy Capacitor" on page 146.
4. **Remove the NBP and CO_2 module tray.**
   See "NBP and CO2 Module Tray" on page 152.

Removing the CO_2 Tubing and Intake Receptacle

1. **Remove the Power PCA.**
   See "Power PCA" on page 148.
2. **Remove the Therapy PCA.**
   See "Therapy PCA" on page 154.
3. **Remove the plastic shield.**
   Remove the plastic shield from the rear case and place it to the side. You will need to replace this.
4. **Remove the CO_2 compartment door.**
   See "CO2 Compartment Door" on page 167.

5. **Disconnect the CO_2 exhaust tube. Figure 72(1)**
6. **Disconnect the CO_2 intake receptacle. Figure 72 (2)**
   Using your index fingers, open the two plastic snaps. From the outside of the case, push the receptacle out with your thumb.

Figure 72 Disconnecting the CO_2 Tubing and Intake Receptacle



Removing the CO_2 Module

1. **Remove the CO_2 module from the module tray.**
   a. For the M3535-69103 module, loosen and remove the 4 T-10 screws on the module plate. See Figure 73. For the M3535-69181 module, loosen and remove the 4 T-10 screws. See Figure 74.
   b. Lift the CO_2 Module straight up out of the tray.

Figure 73 Removing the CO_2 Module (M3535-69103)

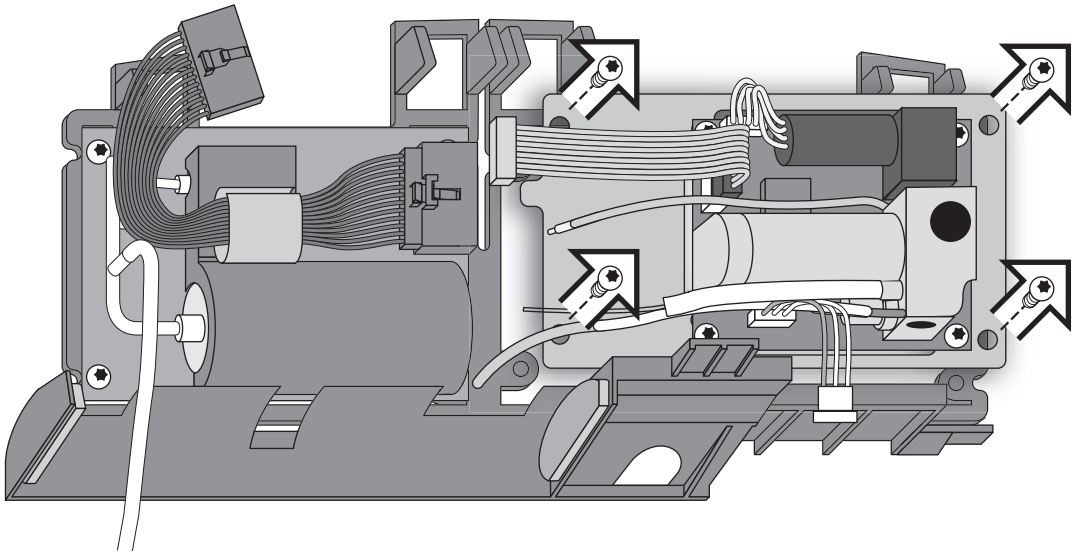
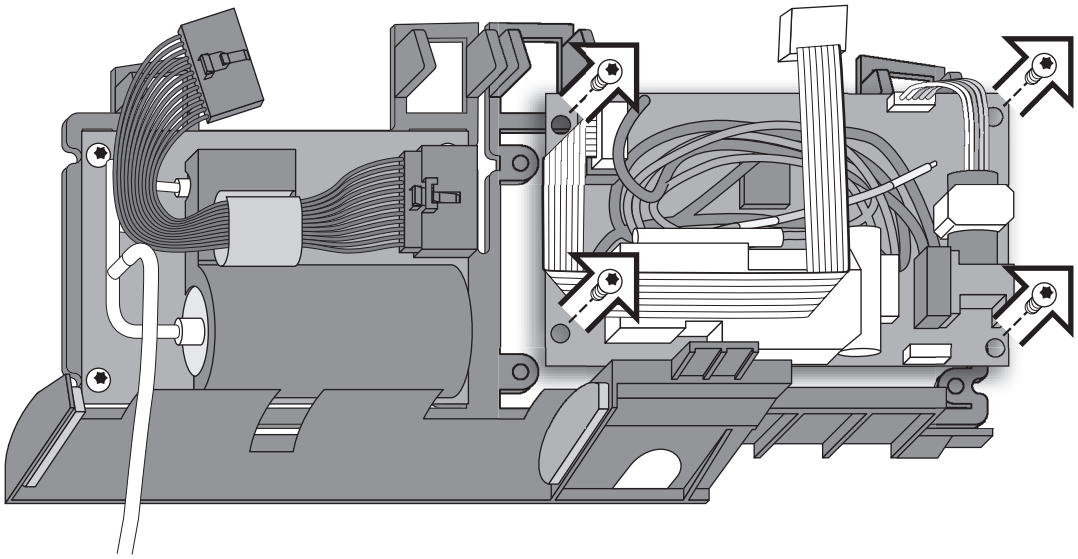


Figure 74 Removing the CO_2 Module (M3535-69181)



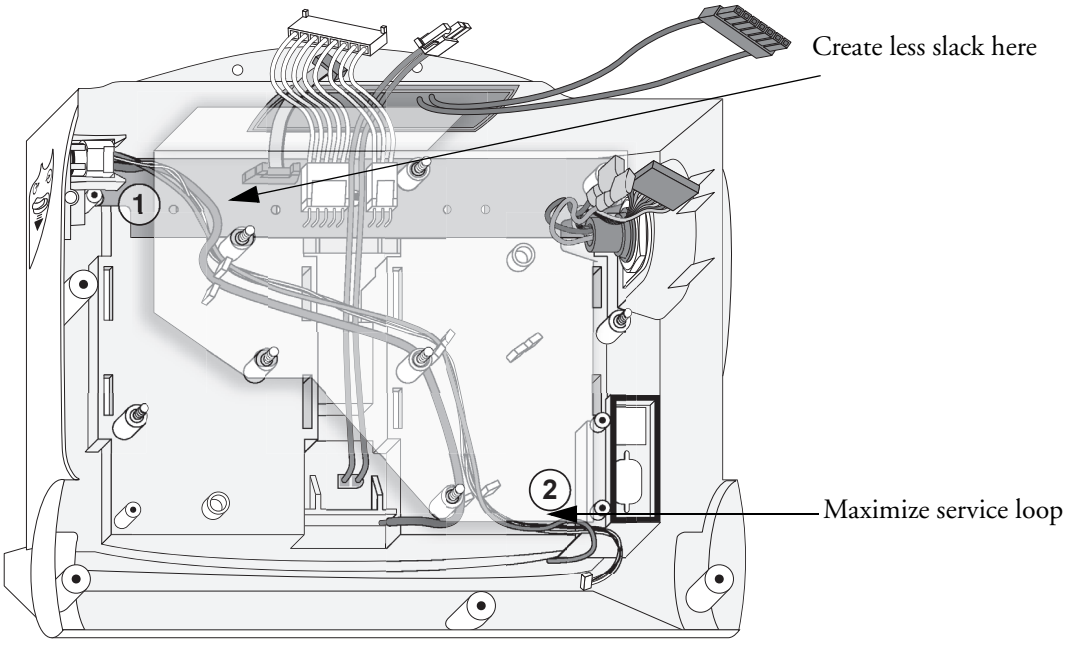
Replacing the CO_2 Tubing and Intake Receptacle

1. **Attach the O-ring to the first groove of the intake receptacle, as shown in Figure 72.**
2. **Connect the CO_2 exhaust tube and intake receptacle. See Figure 72.**
   a. Connect the exhaust tube to the CO_2 outlet port. **(1)**
   b. Make sure that the small face of the CO_2 intake receptacle is towards you and the large face is towards the rear case.
   c. Connect the CO_2 intake receptacle, making sure that it locks into the snaps in the rear case. **(2)**
3. **Route the tubing through the rear case according to the path shown in Figure 72. (3)**

NOTE Make sure you place the CO_2 intake receptacle wires under the tube when routing them through the case, as shown in Figure 75. Create less slack in area **(1)** to maximize the service loop in area **(2)**.

4. **Replace the CO_2 compartment door.**
   See "CO2 Compartment Door" on page 167.
5. **Replace the plastic shield.**

Figure 75 Rear Case Plastic Shield and Service Loop



6. **Replace the Therapy PCA.**
   See "Therapy PCA" on page 154.
7. **Replace the CO_2 module.**
   See "Replacing the CO_2 Module" below.
8. **Replace the Power PCA.**
   See "Power PCA" on page 148.

Replacing the CO_2 Module

1. **Place the CO_2 module into position.**
   For the M3535-69103 module, position the CO_2 module into the module tray with the tab located in the upper left side of the tray, as shown in Figure 73. For the M3535-69181 module, position the CO_2 module into the tray, as shown in Figure 74.
2. **Replace the screws and tighten.**
3. **Replace the NBP and CO_2 module tray.**
   See “NBP and CO2 Module Tray” on page 152.
4. **Replace the Therapy capacitor.**
   See “Therapy Capacitor” on page 146.
5. **Close the case.**
   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

CO_2 Compartment Door

Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the rear case.**
   Lay the rear case on the work surface with the PCAs facing up and the Therapy port on the right.

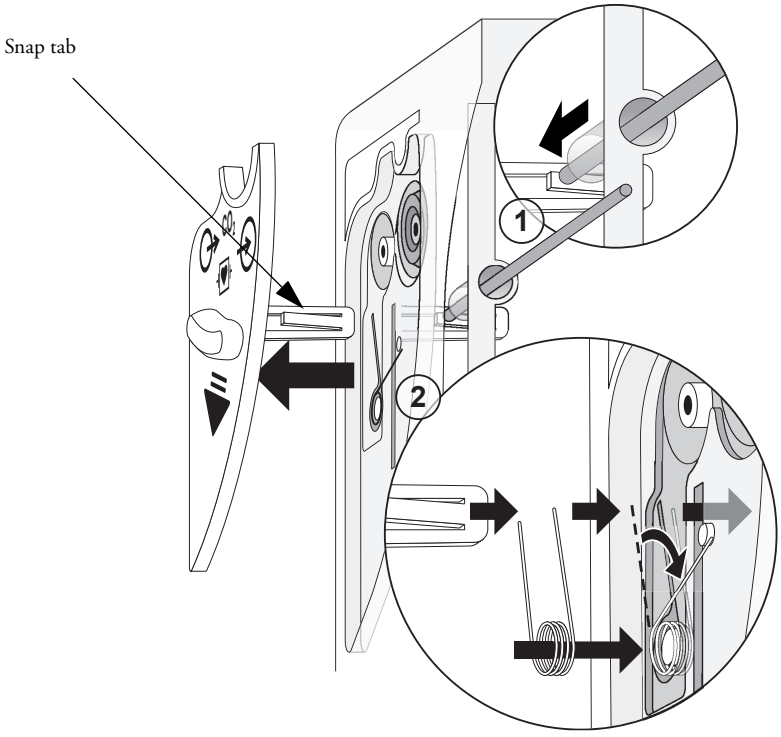
Removal

1. **Remove the door.**
   a. Look down the tapered hole and slide the door past until you see the snap tab. It is the bar in the middle when viewed through the tapered hole.
   b. Using a straightened paper clip, push on the snap tab to release the door. **(1)**
2. **Remove the spring.**

Replacement

1. **Place the spring into the recess and rotate the free end clockwise until it catches behind the post. Make sure that the spring is seated in the recess. (2)**
2. **Insert the door into the recess with the snap tab between the spring and the inlet/outlet ports. Make sure that the tab snaps into place.**

Figure 76 Replacing the CO_2 Compartment Door



3. **Close the case.**

   See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Battery Connector PCA

Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the rear case.**
   Lay the rear case on the work surface with the PCAs facing up and the Therapy port on the right.
3. **Remove the Power PCA.**
   See “Power PCA” on page 148.
4. **Remove the Therapy capacitor**
   See “Therapy Capacitor” on page 146.
5. **Remove the NBP and CO_2 module tray.**
   See “NBP and CO2 Module Tray” on page 152.

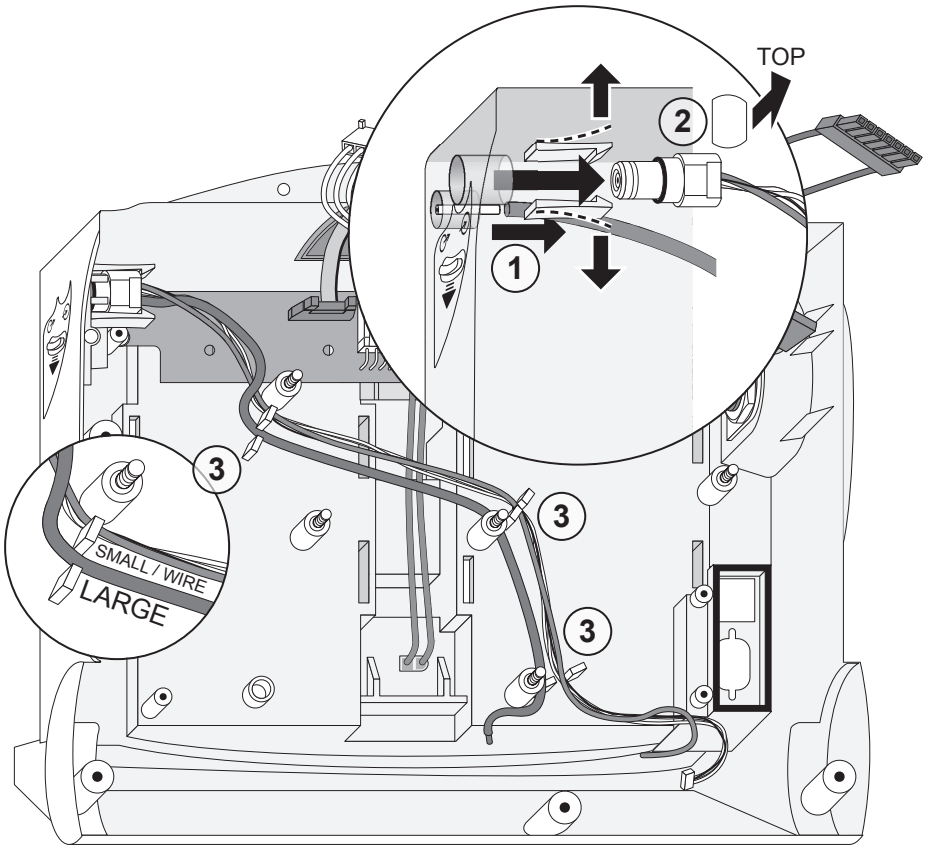
NOTE If the device does not have the NBP or CO_2 modules, simply unscrew the tray and slide it out.

6. **Remove the Therapy PCA.**
   See “Therapy PCA” on page 154.
7. **Remove the plastic shield.**
   Remove the plastic shield from the rear case and place it to the side. You will need to replace this.
8. **Remove the CO_2 compartment door.**
   See “CO2 Compartment Door” on page 167.

9. **Disconnect the CO_2 exhaust tube. (1)**
10. **Disconnect the CO_2 intake receptacle. (2)**

    Using your index fingers, open the two plastic snaps. From the outside of the case, push the receptacle out with your thumb.

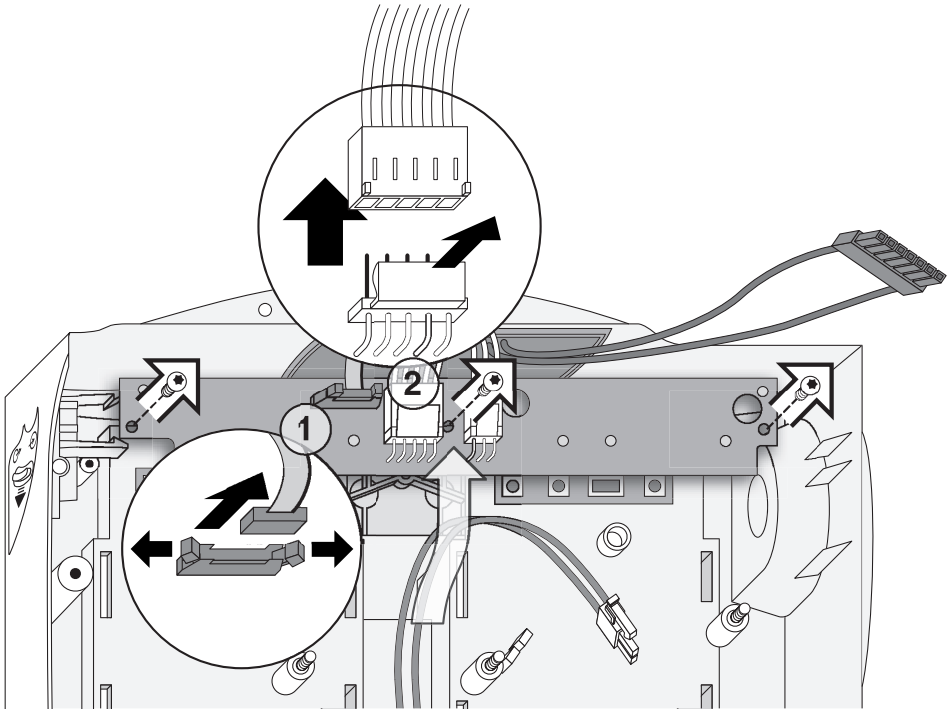
Figure 77 Disconnecting the CO_2 Tubing and Intake Receptacle



Removal

1. **Disconnect the small ribbon cable from the Battery connector PCA. (1)**
2. **Remove the screws.**
   Loosen and remove the 3 T-10 screws.
3. **Disconnect the 8-wire bundle from the Battery Connector PCA. (2)**
4. **Remove the Battery Connector PCA.**
   Gently grasp the white 8-wire bundle connector and pull up while tilting the PCA towards you. Use your other hand to wiggle and lift the PCA out from under the Therapy port and rear case.

Figure 78 Removing the Battery Connector PCA



Replacement

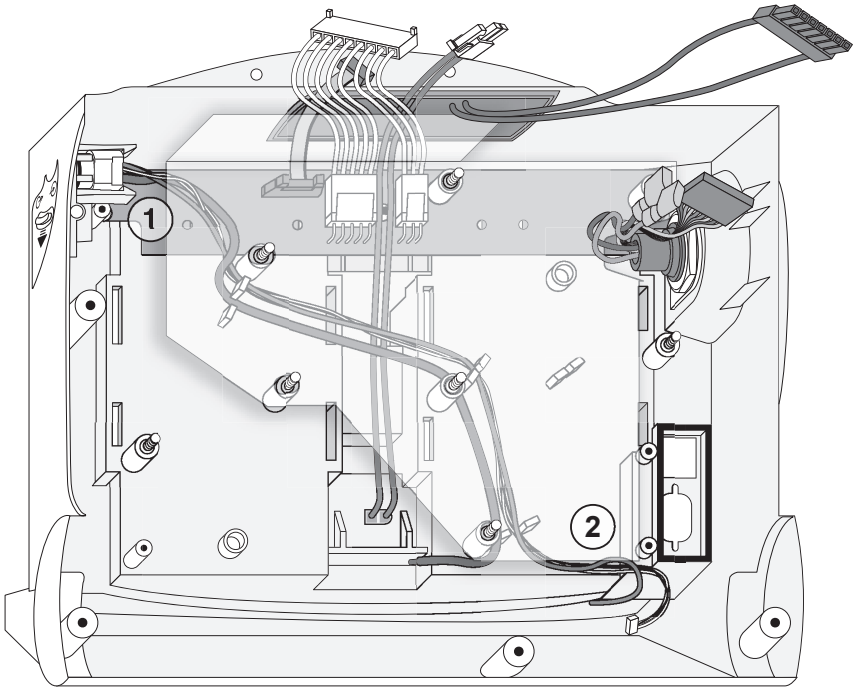
1. **Place the Battery Connector PCA into position.**
   a. Hold the PCA by the white 8-wire bundle connector and slide the end nearest the CO_2 compartment door under the plastic posts.
   b. Tilt the PCA towards you and wiggle it to position the PCA into the rear case, lining up its holes with the posts in the rear case. Guide it down over the case posts.
2. **Replace the screws.**
   Install the 3 T-10 screws and tighten.

3. **Connect the CO_2 exhaust tube and intake receptacle. See Figure 77.**
   a. Connect the exhaust tube to the CO_2 outlet port.
   b. Make sure that the small face of the CO_2 intake receptacle is towards you and the large face is towards the rear case.
   c. Connect the CO_2 intake receptacle, making sure that it locks into the snaps in the rear case.
4. **Route the tubing through the rear case according to the path shown in Figure 77. (3)**

NOTE Make sure you place the CO_2 intake receptacle wires under the tube when routing them through the case, as shown in Figure 79. Create less slack in area **(1)** to maximize the service loop in area **(2)**.

5. **Connect the small ribbon cable.**
6. **Replace the plastic shield.**

Figure 79 Rear Case Plastic Shield and Service Loop



7. **Replace the CO_2 compartment door.**
   See “CO2 Compartment Door” on page 167.
8. **Replace the Therapy PCA.**
   See “Therapy PCA” on page 154.
9. **Replace the NBP and CO_2 module tray.**
   See “NBP and CO2 Module Tray” on page 152.
10. **Replace the Therapy capacitor**
    See “Therapy Capacitor” on page 146.

11. **Replace the Power PCA.**

    See “Power PCA” on page 148.

12. **Close the case.**

    See “Closing the case” on page 176.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Rear Case Assembly

The rear case replacement involves moving existing parts from the old case to the new and replacing the labels.

Preparation

1. **Open and separate the case.**
   See “Opening the case” on page 102.
2. **Position the rear case.**
   Lay the rear case on the work surface with the PCAs facing up and the Therapy port on the right.

Removal

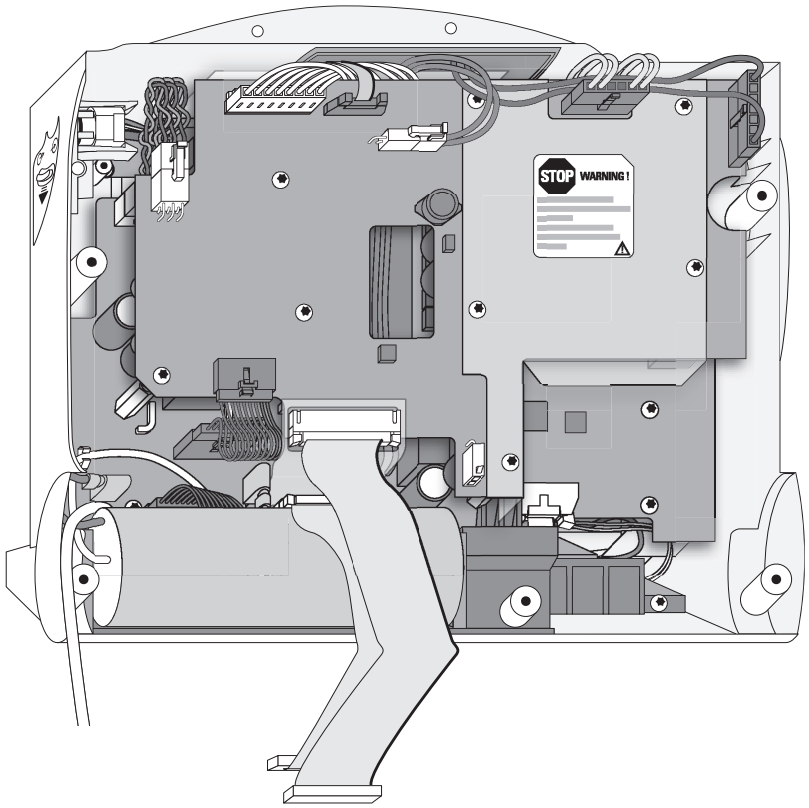
1. **Remove the Therapy capacitor**
   See “Therapy Capacitor” on page 146.
2. **Remove the Power PCA.**
   See “Power PCA” on page 148.
3. **Remove the NBP and CO_2 module tray.**
   See “NBP and CO2 Module Tray” on page 152.
4. **Remove the Therapy PCA.**
   See “Therapy PCA” on page 154.
5. **Remove the Therapy port.**
   See “Therapy Port” on page 158.
6. **Remove the CO_2 tubing and intake receptacle.**
   See “Removing the CO_2 Tubing and Intake Receptacle” on page 162.
7. **Remove the CO_2 compartment door.**
   See “CO2 Compartment Door” on page 167.
8. **Remove the Battery Connector PCA.**
   See “Battery Connector PCA” on page 169.

Replacement

1. **Replace the Battery Connector PCA.**
   See “Battery Connector PCA” on page 169.
2. **Replace the CO_2 compartment door.**
   See “CO2 Compartment Door” on page 167.
3. **Replace the CO_2 tubing and intake receptacle.**
   See “Replacing the CO_2 Tubing and Intake Receptacle” on page 165.
4. **Replace the Therapy port.**
   See “Therapy Port” on page 158.
5. **Replace the Therapy PCA.**
   See “Therapy PCA” on page 154.

6. **Replace the NBP and CO_2 module tray.**
   See “NBP and CO2 Module Tray” on page 152.
7. **Replace the Power PCA.**
   See “Power PCA” on page 148.
8. **Replace the Therapy capacitor.**
   See “Therapy Capacitor” on page 146.

Figure 80 Rear Case Complete



9. **Close the case.**
   See “Closing the case” on page 176.
10. **Affix the new labels to the back of the case.**
    See “Labels” on page 91.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

Closing the case

1. **Recheck the connections.**

   Make sure all connections are fully seated and latched.

2. **Get the device ready for assembly.**

   a. Place the device on a smooth, flat surface in a clamshell orientation.

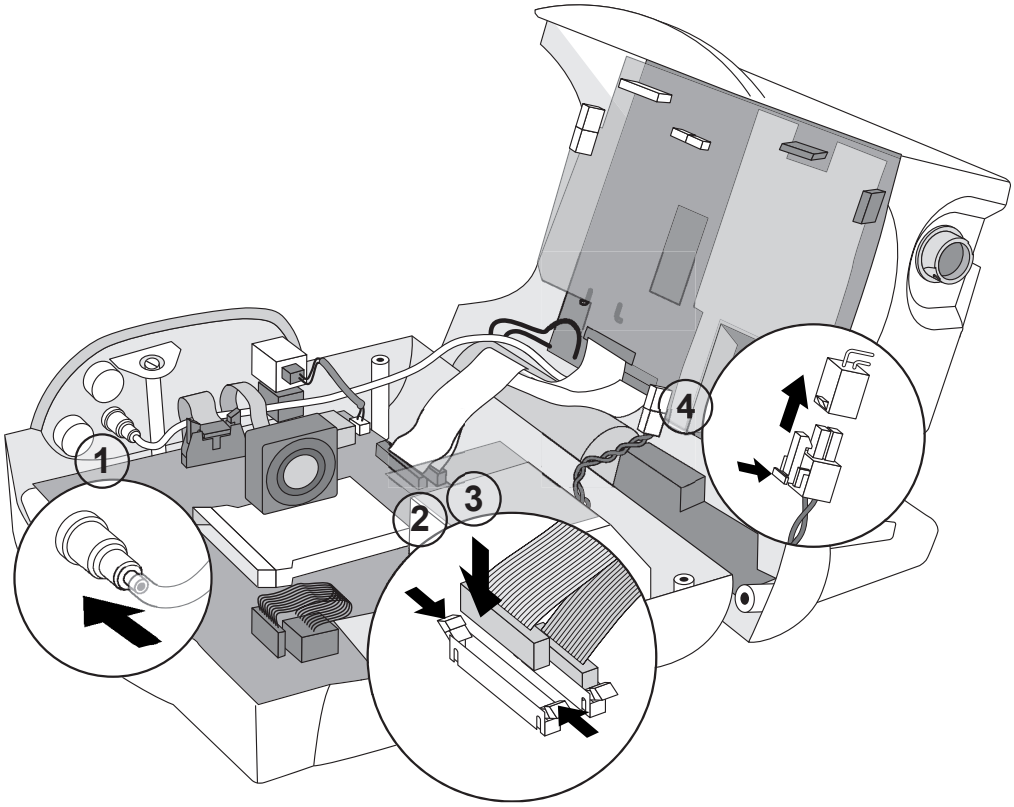
3. **Connect the front to rear case wires and cables.**

   a. Connect the NBP tubing to the measurement module panel. Route the tubing as shown in Figure 81. **(1)**

   b. Connect the two ribbon cables to the Processor PCA by pushing in the connectors and closing the latches. **(2,3)**

   c. Connect the 2-wire bundle from the Printer to the Power PCA. **(4)**

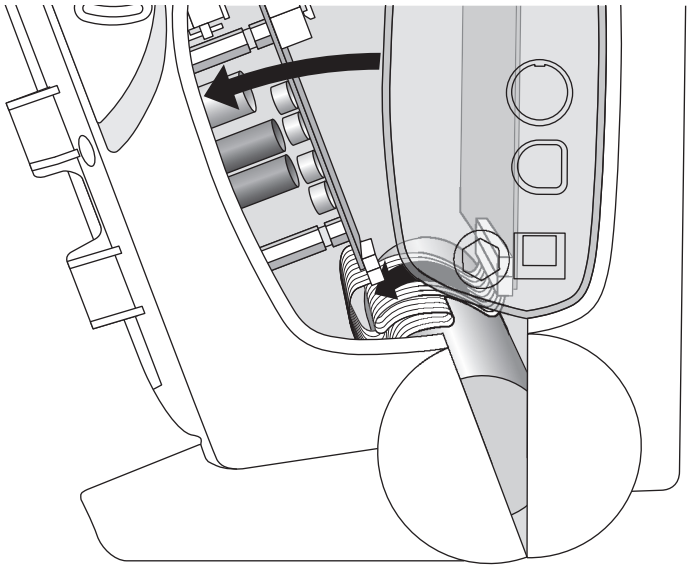
Figure 81 Front to Rear Case Connections



4. **Fit the case halves together.**
   a. Lift up the front case and align with rear case.
   b. Fold the ribbon cables down over the Therapy capacitor and under the Power PCA connectors.

NOTE It is ***very important*** to fold the ribbon cables down to ensure that the case halves fit together properly.

Figure 82 Folded Ribbon Cables



5. **Place the device on its back and ensure that the case halves line up all around the device. Work the halves together gently as the case gasket is delicate.**
6. **Replace the case screws.**
   a. Replace and secure the seven T-15 screws.
7. **Replace the paddle tray or handle and cap plate.**
   See “Paddle Tray” on page 95 or “Handle and Cap Plate” on page 100.
8. **Replace the bedrail hook mount, if present.**
   See “Bedrail Hook Mount” on page 89.

After Repair

Run Performance Verification and Safety testing as described in the "Performance Verification" chapter.

5

Performance Verification

This chapter describes how to verify the performance of the HeartStart MRx monitor/defibrillator after repairs are complete

Overview

This chapter is organized into the following sections:

Required Testing Levels

The Performance Verification and Safety Tests in this chapter are intended to verify proper operation of the HeartStart MRx following repair. The level of testing required corresponds to the type of repair performed, and is divided into 3 categories:

- External repairs/replacements
- Printer replacement
- Internal repairs

External Repairs/Replacements

External repairs/replacements are those involving the repair or replacement of one or more of the following items. The key point is that **the case has not been opened**.

- Accessory pouches
- Internal paddles and/or adapter cable
- Pads adapter cable
- ECG cable
- SpO_2 cable
- NBP cuff or interconnect tubing
- AC or DC power modules
- AC power cord
- Therapy Knob
- Paddle tray
- Paddle tray 50 ohm load resistor

The following tests are required after an External Repair or Replacement **when the case has not been opened**:

- Perform the Visual Inspection (“Visual Inspection” on page 191)
- Run the Operational Check (“Operational Check” on page 192)
- Print and Verify the Status log (“Service Mode Tests” on page 192)
- (Therapy Knob only) Run the Controls test (see “Controls Test” on page 193)
- (Paddle tray and Paddle tray 50 ohm load resistor only) Run the Paddle Safety Check (see “Paddles Safety Check” on page 207)

Printer Replacement

The printer is accessible for replacement from the exterior of the device, without opening the case. If the printer was replaced, **and the case was not opened**, the following tests are required:

- Perform the Visual Inspection (see "Visual Inspection" on page 191)
- Run the Operational Check (see "Operational Check" on page 192)
- Run the Printer Test (see "Printer Test" on page 194)
- Print and Verify the Status Log (see "Service Mode Tests" on page 192)

Internal Repairs

If **the case was opened** (regardless of what else the repair involved), **all** of the Performance Verification and Safety tests **must** be performed:

- Run the Performance Verification and Safety tests (see "Test and Inspection Matrix" on page 184 and "Performance Verification Procedures" on page 190).

Verification Test Equipment

Table 28 lists the equipment needed to perform the Performance Verification and Safety tests, and provides specifications for commercially available analyzers and simulators. Test equipment is called out within each test procedure when needed.

Table 28 Verification Test Equipment

Equipment	Specification
ECG Simulator - Leads	
Leads simulated	3, 5, or 10 (if 12-lead option installed)
Amplitude accuracy	± 2%
Rate accuracy	± 2%
ECG Simulator - Pads/Paddles	
Amplitude accuracy	± 2%
Rate accuracy	± 2%
Defibrillator Analyzer	
Waveform compatibility	Meets all specs below using biphasic truncated exponential waveform.
Load resistance	50 Ω ±1% (non-inductive)
Maximum energy	≥ 200 joules
Maximum voltage	≥ 2500 V
Maximum current	≥50 A
Energy measurement accuracy	<20 J: ≤ ±0.4 joules ≥20 J: ≤ ±2% of reading
Cardioversion measurement range	–150 to +150 ms
Test Load	
Load resistance	50 Ω ±1% (non-inductive)
Pacer tester	
Load impedance:	≤400 Ω
Current measurement accuracy	10 mA–50 mA: ≤±2 mA 50 mA–200 mA: ≤±4%
Rate measurement accuracy	30–180 ppm: ≤±0.5%
Waveform duration measurement accuracy	30–180 ppm: ±1ms
NBP Tester	
Pressure range	>280 mmHg
Pressure measurement accuracy	± 1mmHg

Table 28 Verification Test Equipment (Continued)

Equipment	Specification
CO_2 Tester	
Flowmeter	± 0.1 ml/min
5% calibration gas	5% CO_2 ± .0000001% balance N_2
10% calibration gas	10% CO_2 ± .0000001% balance N_2
Pressure regulator	N/A
Tubing set	N/A
Safety Tester	
Leakage current measurement range	0 - 5000 uA
Leakage current measurement accuracy	± 1%

Test and Inspection Matrix

Table 29 summarizes Performance Verification tests and inspections for the HeartStart MRx.

Table 29 Test and Inspection Matrix

Test Group Name	Test or Inspection to Perform	Expected Test Results	Data to Record x = p (pass) or f(fail)
Visual Inspection (V)	Inspect the device, accessories, cables, etc. for signs of wear, damage, corrosion, or missing items, as described on page 191.	If no unusual damage, no corrosion, no missing items, then Visual Inspection passes.	V:*x* Example V:p
Service Mode Tests			
Operational Check (OC)	Run the Operational Check (page 192).	If "Pass" reported on all tests applicable to the device configuration and options, then Operational Check passes.	*OC:x* Example OC:p
Status log (SL)	Check the status log after the Operational Check (page 55).	If no errors, then status log passes. (Assuming the log has been cleared after the last successful Operational Check.)	*SL:x* Example SL:p
Controls test (C)	Run test to check buttons, Therapy Knob and soft keys (page 193).	If all keys respond as expected, then Controls test passes.	*C:x* Example C:p
Printer (Pr)	Run printer test (page 194).	If print quality is adequate; no stray marks or lines and print speed: 25 mm ± 5% (1.25mm). If print speed configured for 25 mm. OR print speed: 50 mm ± 5% (2.5mm). If print speed configured for 50 mm. then Printer test passes.	*Pr:x* Example Pr:p
NBP Cal Check (NC)	Run the NBP Calibration check (page 196).	If all data passes within limits, then NBP calibration check passes.	*NC:x* Example N:p
CO_2 Cal Check (CO)	Run the CO_2 Calibration check (page 197).	If all data passes within limits, then CO_2 calibration check passes.	*CO:x* Example CO:p

Table 29 Test and Inspection Matrix (Continued)

Test Group Name	Test or Inspection to Perform	Expected Test Results	Data to Record x = p (pass) or f(fail)
Functional Checks			
In normal Operating Mode, perform the following functional checks:			
SpO_2 (Sp)	Using the SpO_2 sensor, perform SpO_2 check (page 201).	If pleth wave is clear, pulse rate is displayed, and saturation reads between 95% -100% then SpO_2 check passes.	*SP:x* Example Sp:p
NBP Measurement	Take a blood pressure measurement on yourself or another person (page 201).	If you are able to complete a measurement, the NBP check passes.	*NM:x* Example: NM:p
ECG (E)	Using an ECG simulator, perform Leads ECG and Pads cable ECG test (page 201)	If all data within limits; all checks pass: • Waveform clear on display • HR correct on display and matches defib analyzer at 2 data points: 30 and 200 bpm • HR alarm works • Leads off indicators perform as expected • Cycles through different views. then ECG test passes.	*E:x* Example E:p

Table 29 Test and Inspection Matrix (Continued)

Test Group Name	Test or Inspection to Perform	Expected Test Results	Data to Record x = p (pass) or f(fail)
Pacing Test (P)	Using a defibrillator analyzer, perform the Pacing test (page 205). (70 ppm) 30 mA (180 ppm) 160 mA	All data within limits, all checks pass: 30 mA ± 5 mA 160 mA ± 16mA then Pacing test passes.	*P:x* Example P:p
Synchronized Cardioversion (SC)	Using an ECG simulator and defibrillator analyzer, perform the Synchronized cardioversion test (page 206).	If all data within limits, all checks pass: • Sync markers appear on the display, at the peak or on the falling side of the QRS complex • Shock delivered on next QRS • Shock delivered 6J ± 2J • If applicable, strip prints with the correct information on it • Delay between the peak of the QRS and the delivered shock is ≤ 30 ms • If clinicians use an external monitor as the ECG source, verify that the external monitor and the HeartStart MRx combination will deliver a synchronized shock within 60 ms of the peak of the R-wave. then Synchronized cardioversion test passes.	*SC:x* Example SC:p

Table 29 Test and Inspection Matrix (Continued)

Test Group Name	Test or Inspection to Perform	Expected Test Results	Data to Record x = p (pass) or f(fail)
Defibrillator Test - AC Power (DA) (if AC Power used in normal operation)	Using only AC power and a defibrillator analyzer, run the Defibrillator Test (AC Power at 200 Joules) (page 203): Measured by Defibrillator Analyzer: Delivered energy Displayed by MRx: Energy setting Delivered energy	If all data within limits, all checks pass: 200 ± 30J 200 ± 0J Actual delivered energy ± 15% then Defibrillator Measurement test passes	*DA:x* Example DA:p
Defibrillator Test - Battery Power (DB)	Using only battery power, run the Defibrillator Test (at 200 Joules) (page 203): Measured by Defibrillator Analyzer Delivered energy Displayed by MRx Energy setting Delivered energy	If all data within limits, all checks pass: 200 ± 30 J 200 ± 0J Actual delivered energy ± 15% then Defibrillator Measurement test passes.	*DB:x* Example DB:p
Defibrillator Disarm Test (D)	Run the Defibrillator Disarm Test (page 204).	• Verify that the monitor/ defibrillator disarmed • Verify that the charge tone stopped then the Defibrillator Disarm test passes.	*D:x* Example D:p
Paddles Safety Check (Pa)	Perform Paddles Safety Check (page 207).	If PCI flashes as expected, then Paddles test passes.	*Pa:x* Example Pa:p

Table 29 Test and Inspection Matrix (Continued)

Test Group Name	Test or Inspection to Perform	Expected Test Results	Data to Record x = p (pass) or f(fail)
Safety Tests Using a Safety Analyzer			
Note: All leakage current tests include both Normal and Reverse Polarity Conditions. Report worst case values.			
AC Mains (S1)	Earth Leakage Current NC (Normal Condition) - aaa (page 208). Earth Leakage Current SF (Single Fault -open neutral) - bbbb (page 208).	If Normal Condition Maximum leakage current: < 300 uA (UL, 120 VAC) < 500 uA (IEC, 240 VAC) If Single Fault Maximum leakage current: < 1000 uA then Earth Leakage Safety test passes	*S1:x/aaa/bbbb* Example:S1:p/125/800
Chassis Leakage (S2)	Use ECG Out (Sync) jack as ground NC (Normal Condition) - cc (page 208) Single Fault condition - dd (page 208)	If Normal Condition Maximum leakage current: < 100 uA then Chassis Leakage test passes. If Single Fault Maximum leakage current: < 300 uA (UL) < 500 uA (IEC)	*S2:x/cc/dd* Example: S2:p/99/299
Patient Lead Leakage (S3)	**ECG Patient Cable** (page 209). Source (Normal Condition) - eee Source (Single Fault condition - open earth, open neutral) - fff With Mains on applied part (Single Fault condition) - ggg	If readings are as expected: < 10 uA < 50 uA < 50 uA then ECG Patient Cable Leakage Safety test passes.	*S3: x/eee/fff/ggg/hhh/iii/jjj* Example: S3:p/9/49/49/100/500/5000

Table 29 Test and Inspection Matrix (Continued)

Test Group Name	Test or Inspection to Perform	Expected Test Results	Data to Record x = p (pass) or f(fail)
	Pads Cable (page 209). Source (Normal Condition) - hhh Source (Single Fault Condition - open earth, open neutral) - iii With Mains on applied part (Single Fault condition) - jjj	< 100 uA < 500 uA < 5000 uA then Patient Lead Leakage Safety test passes	

Note: When recording test results, separate results within a test by slashes; separate tests by a semicolon (;); and use no empty spaces. For example:

V:x;OC:x;SL:x;C:x;Pr:x;NC:x;CO:x;Sp:x;E:x;NM:xP:x;SC:x;DA:x;DB:x;D:x;Pa:x;
S1:p/aaa/bbbb;S2:p/cc/dd;S3:p/eee/fff/ggg/hhh/iii/jjj

V:p;OC:p;SL:p;C:p;Pr:p;NC:p;CO:p;Sp:p;E:p;NM:pP:p;SC:p;DA:p;DB:p;D:p;Pa:p;
S1:p/125/800; S2:p/99/299;S3:p/9/49/49/100/500/5000

Performance Verification Procedures

This section gives instructions for performing inspections and running Performance Verification and Safety tests on the HeartStart MRx. If desired, you can make copies of the Test and Inspection Matrix (page 184) and use it to record results.

The Performance Verification procedures are divided into two levels:

- **Visual Inspection** - examining for damage, wear, contamination
- **Performance Verification and Safety tests**- consist of the following tests and checks:
  - Service Mode tests (including Operational Check), which consist of running the device in Service Mode, applying signals, measuring, observing behavior, and recording results.
  - Functional checks, which consist of running the device in its normal operating mode, applying signals, measuring, observing behavior, and recording results.
  - Safety tests, which consist of connecting the MRx to a safety analyzer and measuring results.

The Performance Tests are sequenced to check more basic functions first, and then build on that to check more complex functions. We recommend you perform these tests in this sequence.

Visual Inspection

A thorough visual inspection of the device should include at least the checks described below.

Check Cables, Supplies and Accessories

1. **Are they the right ones?**

   Sometimes a problem can be resolved simply by using the cables and supplies with which the device was designed to operate.

   – Are they the correct Philips models recommended for use with the HeartStart MRx, or are they some other brand?

2. **Are they all present?**

   The device should have:

   – An undamaged, fully charged Philips battery.

   – A new, dry roll of Philips printer paper. Printer paper may jam if paper is wet. Also, the printer may be damaged if wet paper is allowed to dry while in contact with the printhead elements.

   – Cables and sensors which are approved by Philips and known to be good. Also make sure that all external cables are fully inserted in their receptacles.

   – A new, empty Philips data card.

3. **Are the consumables fresh?**

   Check the ECG electrodes and multifunction electrode pads for freshness (date code or expiration date) and condition.

PASS: Accessories and supplies are those specified by Philips. Electrodes and pads are within their expiration date and appear usable. For single-use items, packaging is unopened and shows no tears or punctures. No corrosion is visible on connector sockets, electrodes, or pads.

Check Monitor/Defibrillator

1. **Inspect the device on all sides, looking for:**

   – Signs of mechanical damage to the case, switches, speaker cover, display, or printer.

   – Loose or missing hardware.

   – Evidence of liquid spill. Open the printer door and clean out any accumulation using gloves and an approved cleaner. Also check for residue in the patient connectors on either side of the device (ECG, SpO_2, ECG Out, CO_2 , therapy port).

   – Residue on the thermal printhead.

   – Printer roller wear.

   – Damage to connector pins, or corrosion on the pins, or debris in the connectors.

2. **Inspect the paddles, power cord, battery, cables, and sensors for signs of the following:**

   – Wear or damage to paddles, cables, and adapters.

   – Wear or damage to patient cables and associated strain reliefs.

   – Wear or damage to power cord and associated strain relief.

PASS: Only normal wear, no damage serious enough to inhibit performance. No corrosion visible.

Service Mode Tests

The following tests are available from Service Mode:

- Operational Check.
- NBP and CO_2 calibration checks.
- Controls test.
- Printer test.

Service Mode also allows you to view and print the status log; check and enter device information, such as serial number and options; and upgrade the software and set the device's language.

CAUTION Be sure that the monitor/defibrillator is not connected to a patient when performing any functions in Service Mode.

Operational Check

Operational Checks should be performed at regular intervals to supplement the hourly, daily, and weekly Automated Tests executed by the MRx. Automated Tests provide adequate assurance that the device is in a functional state of readiness. Operational Checks supplement the Automated Tests by verifying therapy cables, the ECG cable, paddles, audio, and display functionality, along with replicating the Weekly test. Operational Checks also notify you if the battery, NBP module, or CO_2 module need calibration.

Always run an Operational Check and check the Status log after a repair.

Run the Operational Check:

1 Attach a Pads or Paddles therapy cable.

2 Attach an ECG cable.

3 Insert a battery charged to at least 20%.

4 Access Service Mode (see "Accessing Service Mode" on page 10.)

5 From the Service Mode Main menu, select **Operational Check** and press the Menu Select button.

NOTE You can run Operational Check from the Other menu in Monitor Mode or from the Service Mode Main menu - the Operational Check is the same in both modes. When you exit the Operational Check from Service Mode, you are returned to Monitor Mode.

6 When a response is required, use the Navigation buttons to select your answer and the Menu Select button to confirm your choice. Table 4 on page 41 shows the tests, in the order in which they are performed, explains the prompts that may appear, and describes the actions you should take (if any).

Check the Status Log

Select **Status Log** from the Service Mode Main menu. The Status log includes entries for all errors logged during normal operating mode, Automated tests, Service tests and Configuration Mode, and Operational Checks. See "Status Log Errors" on page 55 for more information.

TIP Remember to clear the Status log after a successful Operational Check.

Controls Test

These instructions describe how to test the operation of the front panel controls.

If all results pass, the device passes that portion of the test. Return to the Service Mode Main screen by pressing the **[Main Service]** softkey.

If there is any failure, begin troubleshooting and repairing the device as needed. See "Troubleshooting" on page 33.

Test the Buttons and Soft Keys

1. **Select Controls from the Service Mode Main menu and press the Menu Select button.**

   A list of the front panel buttons, soft keys, and the Therapy Knob are displayed on the screen.

2. **Press each button and soft key and check the screen.**

   The screen shows "Pass" when each button and soft key press is detected.

Test Therapy Knob

3. **Test the Therapy Knob.**

   Test the Therapy Knob by turning it to each of the available settings, and verifying that the value next to "Therapy Knob" on the display matches the knob position. Turning the Therapy Knob to "Off" turns the device off.

Figure 83 Controls Test Service Screen

Printer Test

The printer test checks printer parameters, and prints test patterns to check the print head and the paper drive mechanism. Perform the printer test at the configured speed of either 25 mm/sec or 50 mm/sec.

Start the Printer Test

1. **Select Printer from the Service Mode Main menu and press the Menu Select button.**
   The printer prints a series of test patterns.
2. **Stop the printout.**
   Once the patterns have printed, press the **Print** button to stop the printout.

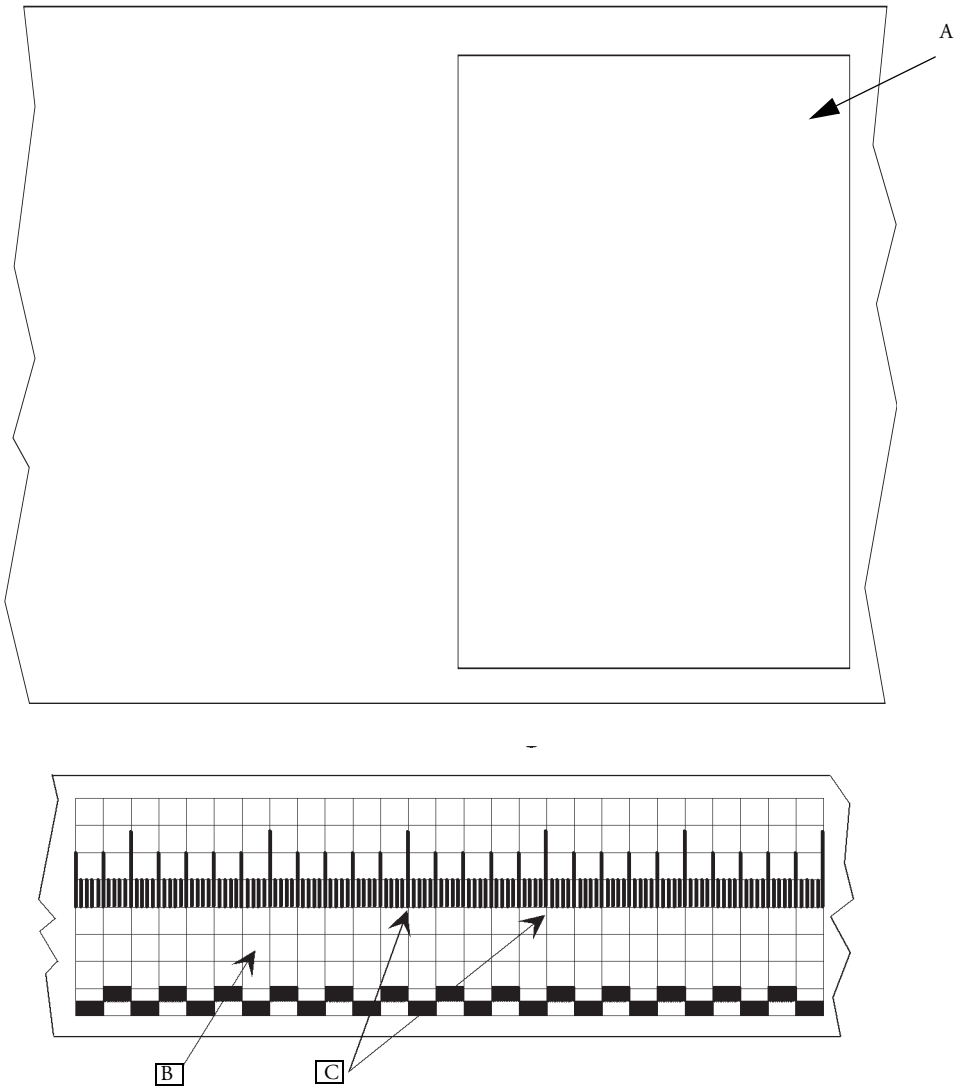
Inspect the Test Patterns

3. **Check the print quality. Verify that the test patterns on the strip are as indicated in Figure 84.**
   a. Area "A" contains printouts of all characters and symbols. Verify that they are readable.
   b. Check Area "B" for stray marks or lines.
   c. Check for white lines (printhead elements stuck off) or black lines (printhead elements stuck on).

Measure the Print Speed

4. **Verify the print speed.**
   Measure between the long tick marks (area "C") to verify paper speed. Distance should be:
   – 25 mm ± 5% (± 1.25 mm) if print speed is configured for 25 mm/sec.
   – 50 mm ± 5% (± 2.5 mm) if print speed is configured for 50mm/sec.

Figure 84 Printer Test Output



NBP Calibration Check

This check only needs to be performed if NBP is installed. See “Maintenance Tools and Equipment” on page 18 for information on equipment needed to run the test.

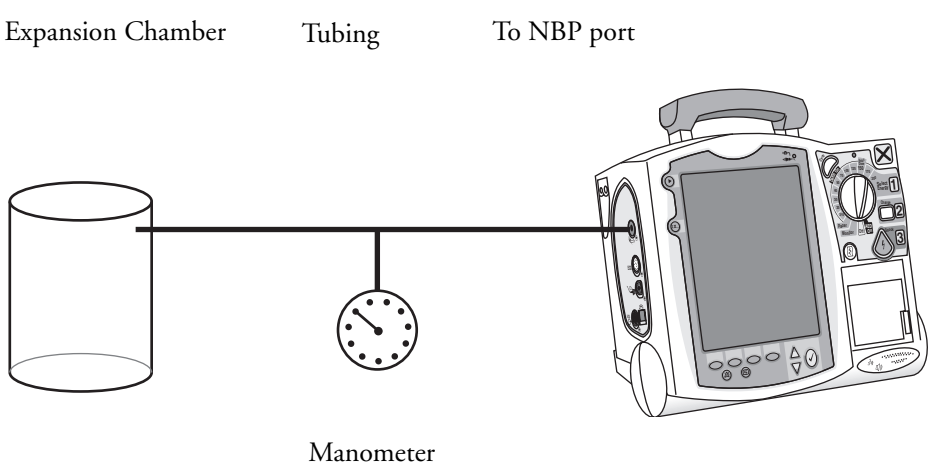
NBP Safety Timeout

Do not keep the cuff pressurized for more than 3 minutes. The NBP module times out if the pressure is greater than 5mmHg for 180 seconds. The valve opens and the pressure drops. To reset the module, exit Service Mode and press the **[Start NBP]** soft key. The inop “Cuff not deflated” is displayed. Access the NBP Service screen again to start the calibration.

Setup

1. **Connect the NBP tubing to the NBP port on the monitor/defibrillator, and connect the test manometer and expansion chamber to the tubing.**

Figure 85 NBP Test Setup



2. **Start the test.**
   a. Access the Service Mode Main menu as described in “Accessing Service Mode” on page 10.
   b. Select **NBP** from the Service Mode Main menu.

Check

3. **Pressurize the expansion chamber to approximately 280 mmHg.**
4. **When the pressure stabilizes, compare the displayed pressure reading to the pressure indicated by the manometer.**
5. **If the difference between the manometer and the displayed pressure is >± 2mmHg, perform the steps in “Calibrate the NBP Measurement” on page 22.**

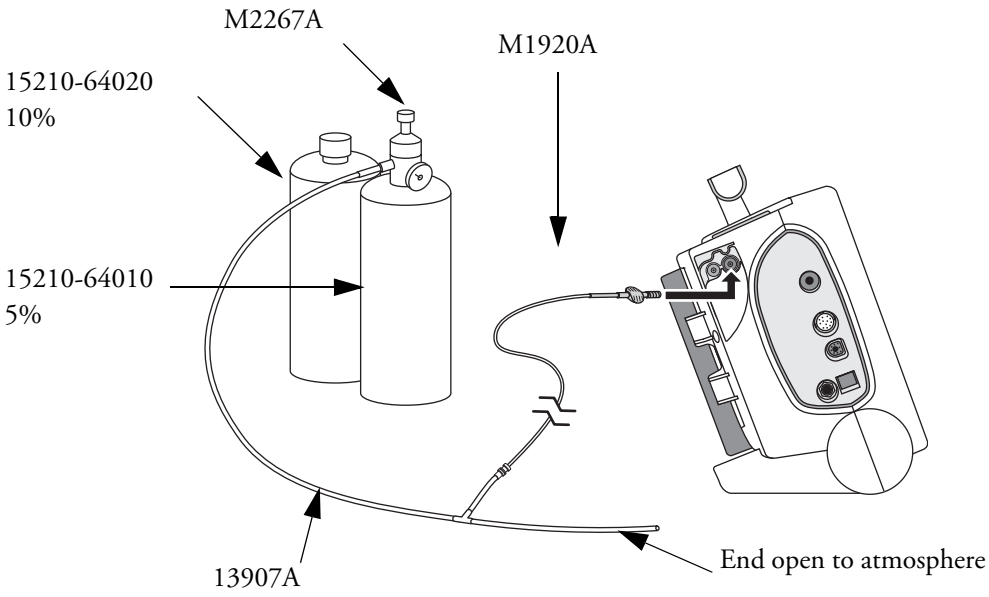
CO_2 Calibration Check

This check only needs to be performed if CO_2 is installed. The monitor/defibrillator must be operating for at least 20 minutes prior to starting this test with the FilterLine connected to the CO_2 Inlet port. See "Maintenance Tools and Equipment" on page 18 for information on equipment needed to run the test.

Setup

1. **Set up the calibration gas as shown in Figure 86.**
   a. Connect the 5% calibration gas to the CO_2 Inlet port.
   b. Turn on the gas.

Figure 86 CO_2 Noise and Calibration Check Setup



2. **Start the test.**
   a. Access the Service Mode Main menu as described in "Accessing Service Mode" on page 10.
   b. Select **CO_2** from the Service Mode Main menu.
   c. From the CO_2 Service menu, select **Calibration Check**.

Check

This tests the accuracy of the CO_2 measurement and, if needed, adjusts the measurement to meet specifications.

5% Calibration Check

1. **Wait until the displayed CO_2 value is stable.**

2. **Calculate the expected CO_2 reading, which will depend on both the gas concentration you are using (typically 5.0%) and the ambient pressure. Calculate as follows:**

   [concentration of cal gas] X [ambient pressure] = expected CO_2 value

   For example:

   [0.05] X [736 mmHg] = 36.8 mmHg

3. **Calculate the allowable tolerance, which is ±5% of the expected reading. Calculate as follows:**

   [±0.05] X [expected CO_2 value]] = ±[tolerance] mmHg

   example:

   [±0.05] X [36.8 mmHg] = ±1.8 mmHg

   In this example, the reading displayed with 5% cal gas must be 36.8 mmHg ±1.8 mmHg, or between 35.0 mmHg and 38.6 mmHg.

4. **Compare the displayed CO_2 value to the allowable range of values.**
   If the displayed value falls within the allowable range, proceed to the 10% Calibration Check section below.
   If the displayed value does not fall within the allowable range, the CO_2 measurement module needs to be calibrated. Perform the steps under "CO_2 Calibration" on page 30, then begin again at step 1.

10% Calibration Check

1. **Disconnect the 5% gas (and regulator, if needed) and connect the 10% gas.**
2. **Turn on the gas.**
3. **Wait until the displayed CO_2 value is stable.**
4. **Calculate the expected CO_2 reading, which will depend on both the gas concentration you are using (typically 10.0%) and the ambient pressure. Calculate as follows:**

   [concentration of cal gas] X [ambient pressure] = expected CO_2 value

   example:

   [0.10] X [736 mmHg] = 73.6 mmHg

5. **Calculate the allowable tolerance, which is ±7% of the expected reading. Calculate as follows:**

   [±0.07] X [expected CO_2 value]]= ±[tolerance] mmHg

   example:

   [±0.07] X [73.6 mmHg] = ±5.2 mmHg

   In this example, the reading displayed with 10% cal gas must be 73.6 mmHg ±5.2 mmHg, or between 68.4 mmHg and 78.8 mmHg.

6. **Compare the displayed CO_2 value to the allowable range of values.**

   If the displayed value falls within the allowable range, the device has passed its accuracy test.

   If the displayed value does not fall within the allowable range, the CO_2 measurement module needs to be calibrated. Perform the steps under "CO_2 Calibration" on page 30, then begin again at step 1.

7. **Return to the main CO_2 Service screen by pressing the `[Done]` soft key.**

Functional Checks

The functional checks exercise the basic functions of the monitor/defibrillator. They are intended as a broad check of the device's performance and are used in conjunction with the Service Mode and Safety tests to verify the performance of the device.

Functional checks are performed with the device in a normal clinical operating mode - not in Service Mode.

If all elements of a test pass, record that test as a PASS. If there is any failure, begin troubleshooting and repairing as needed.

SpO2 Check

This check only needs to be performed if SpO2 is installed.

1. **Connect the sensor.**
   Attach the SpO_2 sensor to your finger and to the MRx.
2. **Check SpO_2.**
   a. Turn the Therapy Knob to **Monitor**.
   b. The pleth wave should be clear.
   c. The SpO_2 value displayed should be in the range of 95-100%. If the value is less than 95%, check that your finger is fully inserted into the sensor and properly positioned.
   d. The pulse rate should be displayed.

NBP Check

Perform a blood pressure check on yourself or another person. Make sure the measurement completes.

ECG Check

This section describes how to check the operation of the ECG functions. Each of the ECG checks assumes the device and the simulator are still set up as they were at the end of the previous ECG check.

Setup

1. **Set up the simulator.**
   a. Connect a Therapy cable and ECG cable to the MRx.
   b. Connect the ECG simulator to both the Therapy cable and the 3- or 5-lead ECG cable.
   c. Set the simulator for normal sinus rhythm (NSR), 1mV amplitude, and 30 bpm.
2. **Set up the MRx.**
   Turn the Therapy Knob to **Monitor**.

Check ECG Display, HR, Leads Off

1. **Check the waveform.**
   Verify that the waveform displays clearly. Using the Lead Select button, verify that the display shows a clear waveform for all Leads and Pads.
2. **Check the Heart Rate (HR).**
   Verify that the Heart Rate (HR) displayed is correct.
3. **Check the alarms.**
   a. Verify that the heart rate alarm is sounding (assuming that 30 bpm is below the configured lower limit).
   b. Set the simulator to 60 bpm.
   c. Verify that the heart rate alarm stops.

4. **Check Leads Off.**
   a. Using the Lead Select button, select Pads (or Paddles).
   b. Disconnect the ECG simulator from the Therapy cable and verify that the display shows a dashed line in place of the waveform and that the device sounds an alert and displays the Pads Off message
   c. If you are testing a 3-lead cable, use the Lead Select button to select Lead II.

NOTE If you are testing anything other than a 3-lead ECG cable, make sure an ECG waveform appears in Wave Sectors 1 and 2.

   d. If you are testing a 5-lead cable, select the V or V/C lead (depending on the electrode configuration).
   e. Disconnect each of the ECG electrodes from the simulator one at a time, and verify that the display shows a dashed line in place of the waveform when that electrode is disconnected. Verify that the device sounds an alert and displays the Leads Off message.

5. **Repeat the above test, setting the simulator for normal sinus rhythm (NSR), 1mV amplitude, at 200 bpm.**
6. **Verify that the heart rate alarm sounds (assuming that 200 bpm is above the configured upper limit).**

Check ECG printing

1. **Reconnect the simulator.**
   Connect the simulator to the device as described in the Setup section.
2. **Print a strip.**
   a. Press the Print button to print a strip.
   b. Verify that it shows a normal ECG with a clean baseline.
   c. Verify that the date, time, and configuration information printed at the top of the strip is correct.
   d. Press the Print button again to stop printing.

Defibrillator Measurement Test

These instructions describe how to test the defibrillation functions. The test sequence causes the MRx to:

- Charge and deliver a shock when powered by AC power alone.
- Charge and deliver a shock when powered by battery alone.
- Charge and disarm when the **`[Disarm]`** softkey is pressed.

If all results are as described, the device passes that portion of the test.

If there is any failure, begin troubleshooting and repairing the device as needed. See “Troubleshooting” on page 33.

Defibrillator Test (AC Power At 200 J)

These instructions describe how to test the defibrillation function when powered only by AC power (no battery installed).

Setup

1. **Turn the MRx off and remove the batteries.**
2. **Install the AC power module, and plug its mains power cord into an outlet.**
3. **Connect the Pads cable to the MRx.**
4. **Connect the defibrillator analyzer to the Pads cable.**
5. **Set the analyzer to measure delivered energy.**

Test the Charge/Shock Functions

1. **Charge and Deliver a 200J shock.**
   a. Turn the MRx's Therapy Knob to **200J**.
   b. Press the Charge button to charge the MRx.
   c. Press the Shock button to deliver the shock to the defibrillator analyzer.
   d. If the device is not configured to print on the Charge command, press the Print button.
2. **Check the analyzer readings.**
   The delivered energy should be 200J ± 30J.
3. **Check the printed strip from the MRx.**
   The selected energy should be 200J. The delivered energy should be 200J ± 30J and will be printed on the strip if the device is configured to print on shock.
4. **Repeat the test using paddles, pressing the Shock button on the paddles in Step 1c.**

Defibrillator Test (Battery Power At 200 J)

These instructions describe how to test the defibrillation function when powered only by a battery (charged to at least 20%), with no AC power connected.

Setup

1. **Insert a battery charged to at least 20% and disconnect the AC Power cord.**
2. **Connect the defibrillator analyzer to the Pads cable.**
3. **Connect the Pads cable to the MRx.**
4. **Connect the defibrillator analyzer to the Pads cable.**
5. **Set the analyzer to measure delivered energy.**

Test the Charge/Shock Functions

1. **Charge and deliver a 200J shock.**
   a. Turn the monitor/defibrillator's Therapy Knob to **200J**.
   b. Press the Charge button to charge the MRx.
   c. Press the Shock button to deliver the shock to the defibrillator analyzer.
   d. If the device is not configured to print on the Charge command, press the Print button.
2. **Check the analyzer readings.**
   The delivered energy should be 200J ± 15%.
3. **Check the printed strip from the MRx.**
   The energy setting should be 200J. The delivered energy should be 200J ± 15% and will be printed on the strip if the device is configured to print on shock.
4. **Repeat the test using paddles, pressing the Shock button on the paddles in Step 1c.**

Defibrillator Disarm Test

These instructions describe how to test the disarm function.

Setup

1. **Insert a battery charged to at least 20% and disconnect the AC power cord.**
2. **Connect the Pads cable to the MRx.**
3. **Connect the defibrillator analyzer to the Pads cable.**
4. **Set the analyzer to measure delivered energy. If needed, reset the analyzer's display to read 0.**

Test the Disarm Softkey

1. **Charge to 200J.**
   a. Turn the MRx's Therapy Knob to **200J**.
   b. Press the Charge button to charge the MRx.
2. **Press the `[Disarm]` softkey.**
   The MRx should disarm itself by discharging into an internal load resistor.
3. **Check the results.**
   Verify that the "Defib Disarmed" message appears on the MRx. Verify that the charge tone stopped.
4. **Check the analyzer readings.**
   Read the delivered energy indicated by the defibrillator analyzer. It should be 0J or be blank.

Pacer Test

These instructions describe how to test the pacing function. Only run this test if the Pacing option is installed on the monitor/defibrillator.

If all results are as described, the device passes the test. If there is any failure, begin troubleshooting and repairing the device as needed. See “Troubleshooting” on page 33.

Setup

1. **Insert a battery charged to at least 20% and disconnect the AC power cord.**
2. **Connect the Pads cable to the MRx.**
3. **Connect the defibrillator analyzer to the Pads cable.**
4. **Turn the Therapy Knob on the MRx to Pacer.**
5. **Set Pacer mode to Fixed.**

Test Pacing

1. **Generate a fixed pacing waveform on the MRx for 70 ppm@30mA.**
   c. Press the **[Pacer Rate]** soft key and use the Navigation buttons to set the rate to **70 ppm**.
   d. Press the **[Pacer Output]** soft key and use the Navigation buttons to set the rate to **30mA**.
   e. Press the **[Start Pacing]** soft key.
2. **Check the default output on the defibrillator analyzer.**
   a. The output should read 70 ppm and 30mA ± 5mA.
3. **Test the maximum output by generating a fixed pacing waveform on the MRx for 180 ppm @160 mA.**
   a. Press the **[Pacer Rate]** soft key and use the Navigation buttons to increase the rate to 180 ppm.
   b. Press the **[Pacer Output]** soft key and use the Navigation buttons to increase the output to 160 mA.
4. **Check the output on the defibrillator analyzer. The output should read 180 ppm and 160 mA ± 16 mA.**

Synchronized Cardioversion Test

This section describes how to check the synchronized cardioversion function.

WARNING Whenever possible, we recommend that clinicians perform synchronized cardioversion procedures while directly monitoring the patient through the HeartStart MRx's electrodes or lead inputs.

If clinicians use an external monitor as the ECG source, you **must** verify that the external monitor and the HeartStart MRx combination will deliver a synchronized shock within 60 ms of the peak of the R-wave. Use a 1 mV QRS complex with a QRS width of 40 ms. This performance cannot be guaranteed with all commercially available monitors.

Setup

1. **Set up the defibrillator analyzer.**
   a. Connect the ECG cable and the Pads cable to the HeartStart MRx.
   b. Connect the ECG cable to the analyzer.
   c. Connect the Pads cable to the analyzer.
   d. Set the analyzer to take a synchronized measurement, 1mV amplitude, at some nominal rate (e.g., 60 bpm).
2. **Set up the MRx.**
   a. Turn the Therapy Knob to **1-10 joules**.
   b. Press the Sync button. Check that a Sync message appears in the upper right corner of Wave Sector 1.

Check Display, Shock, Print

1. **Check the displayed waveform.**
   Verify that sync markers appear on the display, at or near the peak of the QRS complex. Adjust the size of the displayed ECG as needed to view it more clearly.

TIP To adjust the size of the displayed ECG, access the following menus: Main, Waves, Wave1, II, II size.

2. **Check shock delivery.**
   a. Select an energy of 6J. Press the Charge button then press and hold the Shock button until the shock is delivered (at next QRS).
   b. Verify on the defibrillator analyzer that the shock was delivered, and was 6J ± 2J.
   c. If the device is configured to do so, verify that it prints a strip with the correct information on it (waveform, text, shock).
   d. Verify on the defibrillator analyzer that the delay between the peak of the QRS and the delivered shock was ≤ 30 ms.

Paddles Safety Check

This section describes how to test the paddles to ensure they are connected correctly. This test checks the PCI (Patient Contact Indicator) function of the paddles. The PCI measurement is used to detect Pads Off and Paddles Off, and to illuminate the PCI LEDs on PCI-equipped paddle sets. If all results are as described, the device passes that portion of the test.

1. **Connect a set of external paddles to the device.**
   a. Make sure the metal surfaces of the paddles are clean and dry. Also make sure the slide-on adult paddle adapters are clean, shiny, and making good contact to the paddle surface.
   b. Put the paddles in the paddle tray.
2. **Turn the Therapy Knob to Monitor.**
3. **Verify that the PCI is not lit.**
4. **Take one paddle out of the paddle tray.**
5. **Verify that one red LED of the PCI flashes.**
6. **Take both paddles from the paddle tray and hold them firmly together, face to face (metal-to-metal).**
   Be sure the paddles are clean and are making good contact with one another.
7. **Verify that all LEDs on the PCI are lit.**

Safety Tests

This section discusses tests of the MRx's electrical safety. The Philips Safety test designation for each test is provided for reference of Philips service personnel.

Test Notes

- Use the procedures called out by the manufacturer of the safety analyzer in use.
- Only test the AC Mains (line) voltage used in the customer's facility - there is no need to test both 120 VAC and 240 VAC.
- Test both Normal and Reverse Polarity line connections for each test, and record the worst case value.
- If a chassis reference point is needed for the testing, connect to the inside metal shaft on the ECG Out (Sync) jack. (This is ***not*** earth ground.)
- The HeartStart MRx does not have an earth ground node that could be used for leakage testing purposes. The only accessible earth ground node is at the AC inlet on the AC power module.
- Only perform the AC Mains test if the device has an AC power module.

AC Mains

Leakage through earth (ground) wire of AC power cord.

1 Normal Condition (both AC line connections intact)
   – Should be ≤ 300 uA (UL, 120 VAC).
   – Should be ≤ 500 uA (IEC 240 VAC).
   – Record as "aaa".

2 Single Fault Condition (one AC line connection open)
   – Should be ≤1000 uA.
   – Record as "bbbb".

Chassis (Enclosure) Leakage

Use ECG Out (Sync) jack to measure enclosure leakage current. (This is ***not*** earth ground.)

1 Normal Condition
   – Should be <100 uA
   – Record as "cc".

2 Single Fault condition
   – Should be <300 uA (UL)
   – Should be <500 uA (IEC)
   – Record as "dd".

Patient Lead Leakage

Leakage out of (Source) or into (Sink) patient-connected inputs (Applied Parts).

1 ECG leads (IEC Type CF)

Source

a. Normal Condition (both AC line connections and earth ground intact)
Should be ≤ 10 uA.
Record as “eee”.

b. Single Fault Condition (separately open neutral and open earth, each in turn)
Should be ≤ 50 uA.
Record as “fff”.

Sink

a. Single Fault Condition is with AC Mains voltage on Applied Parts
(both AC line connections and earth ground intact)
Should be ≤ 50 uA.
Record as “ggg”.

2 External Paddles/pads (IEC type BF)

Source

a. Normal Condition (both AC line connections and earth ground intact)
Should be ≤ 100 uA.
Record as “hhh”.

b. Single Fault Condition (separately open neutral and open earth, each in turn)
Should be ≤ 500 uA.
Record as “iii”.

Sink

a. Single Fault Condition (with AC Mains voltage on Applied Parts)
(both AC line connections and earth ground intact)
Should be ≤ 5000 uA.
Record as “jjj”.

6

Parts and Accessories

This chapter provides information on ordering replacement parts, supplies, and accessories for the HeartStart MRx monitor/defibrillator. Information on Key Component tracking is also provided.

Overview

This chapter is organized into the following sections:

Parts and Accessories Notes

The tables in this chapter list two part numbers: one is the 12NC number and the other is the 5x5 number. Use the 12NC number when ordering replacement parts and kits. Use the 5x5 part identifier number when calling the Response Center.

The following notes contain some important information relating to replacement parts.

Ordering Replacement Parts

To order replacement parts:

- In the US, call 888-561-5018.
- Outside the US, contact your local Philips Medical Systems office.

Ordering Supplies and Accessories

To order accessories and supplies:

- Visit our Medical Systems website at: www.medical.philips.com/cms and follow the links to Supplies
- In the US, call 800-225-0230.
- Outside the US, contact your local Philips Medical Systems Sales Office, or your authorized Philips Medical Systems Dealer or Distributor.

Key Component Tracking

Replacement assemblies marked with an asterisk (*) contain one or more Key Components. Key Components require detailed tracking, by recording the Key Component part number and either the Key Component's date code or its serial number. This data must be recorded for both the failed assembly and the replacement assembly.

Philips Medical Systems service personnel must record this information on the Customer Service Order (CSO).

The Key Components that are part of the replacement assemblies are listed in Table 40 on page 229.

Replacement Parts

The tables of replacement parts are organized as follows:

Electrical Assemblies

The following tables list all the electrical field-replaceable assemblies.

Processor PCA

The replacement Processor PCA includes the clock battery backup, the battery cable's tie wrap, ProGold wipes for the battery terminals and connectors, and the fan assembly. All Processor PCAs are American English, part number 453563478461 (M3535-68101). Order the appropriate Software Support Tool to set the Processor PCA to the correct language.

NOTE The Processor PCA is a Key Component that requires tracking. See Table 40 on on page 229.

Table 30 Software Support Tool

Description	12NC	5x5
American English	453563484001	M3535-87900
Commonwealth English	453563484011	M3535-87901
French	453563484021	M3535-87902
Spanish	453563484031	M3535-87903
German	453563484041	M3535-87904
Dutch	453563484051	M3535-87905
Italian	453563484061	M3535-87906
Swedish	453563484071	M3535-87907
Norwegian	453563484081	M3535-87908
Finnish	453563484091	M3535-87909
Danish	453563484101	M3535-87910
Portuguese	453563484111	M3535-87911
Japanese	453563484701	M3535-87913
Traditional Chinese	453563484711	M3535-87914
Simplified Chinese	453563484721	M3535-87915
Korean	453563484731	M3535-87916
Traditional Cantonese Chinese	453564004351	M3535-87917
Russian	453564011791	M3535-87918
Blank card for SoftServer use	453563484121	M3535-87912

Other Replacement PCAs

These PCAs come with specific parts, as noted.

Table 31 Replacement PCAs

Description	12NC	5x5
SpO_2 PCA	453563476681	M3535-69100
Power PCA *	453563478491	M3535-68109
Therapy PCA *	453563478481	M3535-68108
Battery Connector PCA *	453563476861 Includes battery power signal cable and battery power cable	M3535-69120
Printer Connector PCA	453563476781	M3535-69115

Items marked with an asterisk (*) are Key Components which require tracking. See Table 40 on on page 229.

Other Electrical Assemblies

These assemblies come with specific parts, as noted.

Table 32 Other Electrical Assemblies

Description	12NC	5x5
AC power module *	453563481151	M3535-69171
NBP module	453563476761	M3535-69104
CO_2 module	453564016141 (for A.01 and A.02 devices) 453563476731 (for A.03 and B.xx devices)	M3535-69181 (for A.xx devices) M3535-69103 (for B.xx devices)
RFU indicator	453563476691	M3535-69110
Display assembly *	453563476721 Includes Inverter PCA and cable, Display cable	M3535-69102
Fan assembly	453563476771	M3535-69114
Speaker/microphone assembly	453563476971	M3535-69129
Printer assembly (50 mm)	453563476831	M3535-69117
Printer assembly (75 mm)	453564014851	M3535-69180
Therapy switch *	453563345471 Also order Knob, 453563476791	M4735-68564 M3535-69116
Therapy Capacitor assembly *	453563338331	M3500-69564
PCMCIA Hole Plug assembly (with wires)	453563478421	M3535-69148
50 ohm load resistor assembly	453563478431	M3535-69149

Items marked with an asterisk (*) are Key Components which require tracking. See Table 40 on on page 229.

Individual Electrical Parts

Description	12NC	5x5
Clock (lithium) battery replacement kit	453563377901 Includes battery, ProGold wipes, and cable tie wrap.	M3500-69565
Internal memory card	453563498891	M3535-69178

External Electrical Components

These components are visible outside of the case and the user interacts with them.

Table 33 External Components

Description	12NC	5x5
Therapy Port *	453563338311	M3500-69562
Measurement module panel	453563476801 ECG, ECG Out, RJ11	M3535-69105
	453563476811 ECG, ECG Out, RJ11, SpO_2	M3535-69106
	453563476821 ECG, ECG Out, RJ11, SpO_2, NBP	M3535-69107

Items marked with an asterisk (*) are Key Components which require tracking. See Table 40 on on page 229.

Internal Cables

The following table lists the orderable cables.

Table 34 Internal Cables

Description	12NC	5x5	Connects	
Display cable	453563478281	M3535-69134	Processor PCA	Display assembly
Case Interconnect cable	453563478411	M3535-69147	Processor PCA	Power PCA Therapy PCA Contains the following cables: Therapy PCA cable Processor Power cable
Battery - Power Signal cable	453563478301	M3535-69136	Power PCA	Battery PCA
Battery Power cable	453563478381	M3535-69144	Power PCA	Battery PCA
Therapy-Power High Current cable	453563478351	M3535-69141	Power PCA	Therapy PCA
Therapy-Power Power Signals cable	453563478361	M3535-69142	Power PCA	Therapy PCA
Therapy-Power High-Voltage cable	453563478371	M3535-69143	Power PCA	Therapy PCA
Printer Power cable	453563478401	M3535-69146	Power PCA	Printer PCA
Printer Data cable	453563478391	M3535-69145	Processor PCA	Printer PCA
RJ11 Cable	453563478311	M3535-69137	small PCA on PCMCIA aluminum plate	Measurement module panel
CO_2 module cable	453563478321	M3535-69138	Therapy PCA	CO_2 module
NBP module cable	453563478331	M3535-69139	Therapy PCA	NBP module
DC cable	453563478441	M3535-69150	Power PCA	N/A
PCMCIA Hole plug with wires	453563478421	M3535-69148	Power PCA	N/A
50 ohm load resistor assembly	453563478431	M3535-69149	Paddle pockets	N/A

Paddles

For the convenience of Philips field personnel, a selected subset of the external paddles have been made available through normal parts ordering channels. These numbers are for the use of Philips personnel only. Customers and non-Philips repair personnel should refer to “Supplies and Accessories” on page 224.

Table 35 Paddles

Description	12NC	5x5
Paddle assembly - standard *	453563476981 Includes labels	M3535-69130
Paddle assembly - water resistant *	453563476991 Includes labels	M3535-69131

Items marked with an asterisk (*) are Key Components which require tracking. See Table 40 on on page 229.

Mechanical Assemblies

These assemblies come with specific parts, as noted.

Replacement Mechanical Assemblies

Table 36 Replacement Mechanical Assemblies

Description	12NC	5x5
Front Case assembly	453563476961	M3535-69128 (also order localized Instruction label set)
Rear Case assembly	453563476891	M3535-69121
Bedrail Hook mount	453563476901	M3535-69122
Handle assembly - grey	453563476911 To order colored handles, see Table 39.	M3535-69123
CO_2 Door Kit	453563476741	M3535-69112
CO_2 Recess Blank-off Kit	453563476751	M3535-69113
Paddle Tray assembly	453563477001 Includes color ID labels	M3535-69132
Handle and Cap Plate assembly	453563477011	M3535-69133

Individual Mechanical Parts

Table 37 Mechanical Parts

Description	12NC	5x5
Front panel buttons	453563476711	M3535-69111
Therapy Knob	453563476791	M3535-69116
External Data Card holder	453563476851	M3535-69119
Plastic shields	453563496431 contains plastic shields for SpO_2 PCA, ribbon cable, Power PCA, rear case.	M3535-69177

Labels

There are 4 groups of labels that are available to order for the HeartStart MRx: the Instruction label set, the Hazardous Shock Warning label set, the Branding label set, and Speaker label. The Connector label set, the Product Version label and the Primary label are only available as part of field replacement kits. Each set of labels is one sheet containing all the labels in that set.

Instruction Label Sets

There is one Instruction Label set for each language. This set includes labels for:

- AC power compartment
- Battery compartments
- DC In port
- Network port
- Therapy port
- Therapy Knob
- Service Warning
- Warning labels (for Paddle tray, top of device)
- Instruction labels 1 and 2 (for each side of the Paddle tray)
- Color ID labels for Paddle tray

NOTE Each Instruction label set includes a label for devices with pacing and a label for devices without pacing. You ***must*** ensure that you place the correct label on the device.

Table 38 Instruction Label Sets

Language	12NC	5x5
English	453563478961	M3535-69156
French	453563478971	M3535-69157
German	453563478981	M3535-69158
Dutch	453563478991	M3535-69159
Spanish	453563479001	M3535-69160
Italian	453563479011	M3535-69161
Swedish	453563479021	M3535-69162
Japanese	453563479031	M3535-69163
Norwegian	453563479041	M3535-69164
Finnish	453563479051	M3535-69165
Simplified Chinese	453563479061	M3535-69166
Traditional Chinese	453563479071	M3535-69167
Portuguese	453563479081	M3535-69168
Korean	453563479091	M3535-69169
Danish	453563484691	M3535-69173

Hazardous Shock Warning Label Set

The Hazardous Shock Warning Label set (12NC - 453563492751; 5x5 - M3535-69176) is affixed to the Power PCA and under the Paddle tray or cap plate.

Branding Label Set

The branding label (12NC - 453563478941; 5x5 - M3535-69154) is affixed to the front of the device, directly below the center of the display.

Speaker Label Set

The speaker label (12NC - 453564000881; 5x5 - M3535-69179) is affixed to the speaker.

Connector Label Set

This label set is only available as part of the rear case field replacement kit.

Supplies and Accessories

Approved supplies and accessories for the HeartStart MRx are listed in the following table

Table 39 Supplies

Part Number	Description
Upgrades	
M3530A	SpO_2 Upgrade
M3531A	NBP Upgrade
M3532A	$EtCO_2$ Upgrade
M3533A	Pacing Upgrade
M3534A	12-Lead Upgrade Option B02 - 12-lead acquisition Option B03 - 12-lead transmission Option B04 - 75 mm printer
M4760A	Handle and Cap Plate Upgrade
M5527A	External Paddles with Paddle Tray Option C01 - Standard Paddles Option C02 - Water Resistant Paddles
M4765A	Hardware Upgrade Option B01 - Version B hardware that supports 12-lead transmission
Paper	
40457C	50 mm Chemical Thermal Paper, gray grid -1 box (10 rolls)
40457D	50 mm Chemical Thermal Paper, gray grid-1 box (80 rolls)
989803138171	75 mm Chemical Thermal Paper, Gray Grid (10 rolls)
989803138181	75 mm Chemical Thermal Paper, Gray Grid (80 rolls)
Color Handle (includes handle and label)	
M5521A	Green
M5522A	Blue
M5523A	Yellow
M5524A	Rose
M5525A	Gray
Case	
M3541A	Carrying Case

Table 39 Supplies (Continued)

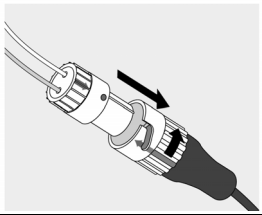
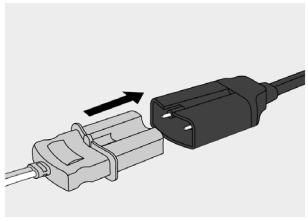
Part Number	Description
Defibrillation Pads, Pads Cables and Test Load (white twist lock connector)	
M3501A	Adult Defib Multifunction Pads, AAMI
M3502A	Adult Defib Multifunction Pads, IEC
M3503A	Pediatric Defib Multifunction Pads, IEC
M3504A	Pediatric Defib Multifunction pads, AAMI
M3507A *	Defib Hands-free Pads Cable, barrel style
M1781A	50 ohm defibrillator test load, barrel connector (M3507A)
05-10200	HeartStart Pads Adapter, barrel connector. Connects to M3507A pads connector cable
Defibrillation Pads, Pads Cables, Adapters and Test Load (gray flat connector)	
M3713A	Adult Plus Multifunction Pads
M3716A	Adult Radiolucent Multifunction Pads
M3717A	Pediatric Plus Multifunction Pads
M3718A	Adult Radiotransparent/Reduced Skin Irritation Multifunction Pads
M3719A	Pediatric Radiotransparent/Reduced Skin Irritation Multifunction Pads
M3508A *	Hands-free Pads Cable, plug style
M3725A	50 ohm defibrillator test load, plug connector (M3508A)

Table 39 Supplies (Continued)

Part Number	Description
	External Paddles
M3542A *	Standard External Paddles
M3543A *	Water Resistant External Paddles
M4745A *	Sterilizable External Paddles
Internal Reusable Switched Paddles	
M4741A *	7.5 cm Switched Internal Paddles
M4742A *	6.0 cm Switched Internal Paddles
M4743A *	4.5 cm Switched Internal Paddles
M4744A *	2.8 cm Switched Internal Paddles
Internal Reusable Switchless Paddles	
M1741A	7.5 cm Switchless Internal Paddles
M1742A *	6.0 cm Switchless Internal Paddles
M1743A *	4.5 cm Switchless Internal Paddles
M1744A *	2.8 cm Switchless Internal Paddles
M4740A *	Internal Paddles Adapter Cable
Internal Disposable Switched Paddles	
989803127121 *	Large Disposable Switched Internal Paddles
989803127131 *	Medium Disposable Switched Internal Paddles
989803127141 *	Small Disposable Switched Internal Paddles
Internal Disposable Switchless Paddles	
989803127151 *	Large Disposable Switchless Internal Paddles
989803127161 *	Medium Disposable Switchless Internal Paddles
989803127171 *	Small Disposable Switchless Internal Paddles
ECG Cables	
M1500A	3-lead ECG Trunk Cable (AAMI)
M1605A	3-lead ECG Set with Snaps (AAMI)
M1510A	3-lead ECG Trunk Cable (IEC)
M1615A	3-lead ECG Set with Snaps (IEC)
M1520A	5-lead ECG Trunk Cable (AAMI)
M1625A	5-lead ECG Set with Snaps (AAMI)
M1530A	5-lead ECG Trunk Cable (IEC)
M1635A	5-lead ECG Set with Snaps (IEC)
M3525A	10-lead ECG Trunk Cable, 12-pin Connector (for 3-Lead and 12-Lead use)
M3526A	3-wire Lead Set with Snap (AAMI)
M3527A	Add 7-wire Lead Set for 12-Lead use (AAMI)
M3528A	3-wire Lead Set with Snap (IEC)
M3529A	Add 7-wire Lead Set for 12-Lead use (IEC)
M5530A	Combiner Plug for 3-wire Lead Set for use with M3526A/M3528A

Table 39 Supplies (Continued)

Part Number	Description
M1949A	10-lead ECG Patient Trunk Cable, 12-pin connector (for 5-Lead and 12-Lead use)
M1968A	10-electrode Cable Set, extremities, grabber (use with M1976A) (AAMI)
M1976A	10-electrode Cable Set, chest, grabber (use with M1968A) (AAMI)
M1971A	10-electrode Cable Set, extremities, grabber (use with M1978A) (IEC)
M1978A	10-electrode Cable set, chest, grabber (use with M1971A) (IEC)
Sync Cable	
M1783A	12-pin Sync Cable (8 feet)
M5526A	12-pin Sync Cable (25 feet)
Monitoring Electrodes	
M2202A	High-Tack Foam ECG Electrodes - 5 electrodes/pack (60 packs/case)
Intubated Circuits	
M1920A	Filter Line Set - Adult/Pediatric (25 sets per case)
M1921A	Filter Line H Set - Adult/Pediatric (25 sets per case)
M1923A	Filter Line H Set - Infant/Neonatal (yellow coded, 25 sets per case)
Non-Intubated Dual Purpose Circuits (CO_2 + O_2)	
M2520A	Smart CapnoLine - Pediatric CO_2 + O_2
M2522A	Smart CapnoLine - Adult CO_2 + O_2
Non-Intubated Single Purpose Circuits (CO_2)	
M2524A	Smart CapnoLine - Pediatric CO_2
M2626A	Smart CapnoLine - Adult CO_2
NBP Interconnect Tubing	
M1598B	Adult Pressure Interconnect Cable 1.5 M (5 ft)
M1599B	Adult Pressure Interconnect Cable 3 M (10 ft)
Reusable Blood Pressure Cuffs	
40400A	Reusable NBP Cuff Kit, 3 sizes (Pediatric, Adult, Large adult)
40400B	Reusable NBP Cuff Kit, 5 sizes (Infant, Pediatric, Adult, Large adult, Thigh)
40401A	Traditional Reusable Cuff - Infant
40401B	Traditional Reusable Cuff - Pediatric
40401C	Traditional Reusable Cuff - Adult
40401D	Traditional Reusable Cuff - Large adult
40401E	Traditional Reusable Cuff - Thigh
M4552A	Antimicrobial Coated Reusable Cuff - Infant
M4553A	Antimicrobial Coated Reusable Cuff - Pediatric
M4554A	Antimicrobial Coated Reusable Cuff - Small Adult
M4555A	Antimicrobial Coated Reusable Cuff - Adult
M4557A	Antimicrobial Coated Reusable Cuff - Large Adult
M4559A	Antimicrobial Coated Reusable Cuff - Thigh
M1572A	Multi-Patient Comfort Cuffs - Pediatric

Table 39 Supplies (Continued)

Part Number	Description
M1573A	Multi-Patient Comfort Cuffs - Small Adult
M1574A	Multi-Patient Comfort Cuffs - Adult
M1575A	Multi-Patient Comfort Cuffs - Large Adult
Disposable Blood Pressure Cuffs	
M4572A	Soft Single-Patient Disposable Cuff - Infant
M4573A	Soft Single-Patient Disposable Cuff - Pediatric
M4574A	Soft Single-Patient Disposable Cuff - Small Adult
M4575A	Soft Single-Patient Disposable Cuff - Adult
M4576A	Soft Single-Patient Disposable Cuff - Adult X-Long
M4577A	Soft Single-Patient Disposable Cuff - Large Adult
M4578A	Soft Single-Patient Disposable Cuff - Large Adult X-Long
M4579A	Soft Single-Patient Disposable Cuff - Thigh
Reusable SpO_2 Sensors	
M1191A	Reusable SpO_2 Sensor - Adult finger
M1192A	Reusable SpO_2 Sensor - Pediatric/Small Adult
M1193A	Reusable SpO_2 Sensor - Adult thumb
M1194A	Reusable SpO_2 Sensor - Adult ear clip
M1195A	Reusable SpO_2 Sensor - Infant
SpO_2 Extension Cable and Adapter Cable	
M1941A	SpO_2 Extension Cable 2 m (6.5 ft)
M1943A	Nellcor SpO_2 Sensor Adapter Cable, 1.1 m (3.6 ft) (use with M1903/4B)
Data Card	
M3545A	Data Card and Tray
M3544A	Data Card Tray
Power	
M3538A *	Lithium Ion Battery
M3539A *	AC Power Module
M5529A	DC Power Module
M5528A	DC Power Module mounting bracket
989803135301	2-Bay Battery Support System for Lithium Ion Batteries
989803135331	4-Bay Battery Support System for Lithium Ion Batteries
989803135341	4-Bay Battery Support System for Sealed Lead Acid and Lithium Ion Batteries

Items marked with an asterisk (*) are Key Components which require tracking. See Table 40 on on page 229.

Key Components

Key Components require tracking, as indicated in the following table. Record the part number and either the date code or serial number for both the failed component and the replacement competent.

Table 40 Key Components

Replacement Assembly Kits		Key Component		
Description	**Part Number**	**Description**	**Part Number**	**Tracking Method**
Electrical Assemblies				
Processor PCA	M3535-68101 (453563478461)	Processor PCA	M3535-60200	Serial Number
Power PCA	M3535-68109 (453563478491)	Power PCA	M3535-60140	Serial Number
Other Replacement PCAs				
Therapy PCA	M3535-68108 (453563478481)	Therapy PCA	M3535-60110	Serial Number
Battery PCA	M3535-69120 (453563476861)	Battery Connector PCA	M3535-60130	Date Code
Other Electrical Assemblies				
Display Assembly	M3535-69102 (453563478471)	TFT Display Switch Assembly Inverter PCA	M3535-60996 M3535-60987 M3535-60997	Serial Number Date Code Serial Number
Therapy Capacitor Assembly	M3500-69564 (453563338331)	Therapy Capacitor	010879-0005	Serial Number ***and*** Date Code
Therapy Switch Assembly	M4735-66564 (453563345221)	Switch Assembly	M4735-60018	Date Code
Ports				
Therapy Port	M3500-69562 (453563338311)	Therapy Port	M3500-62601	Date Code

Table 40 Key Components (Continued)

Replacement Assembly Kits		Key Component		
Description	**Part Number**	**Description**	**Part Number**	**Tracking Method**
Supplies & Accessories				
External Defibrillation Paddles				
External Paddle Assembly (Standard)	M3535-69130 (453563476981)	External Paddles (Standard)	M3542-61999	Serial Number ***and*** Date Code
External Paddle Assembly (Water Resistant)	M3535-69131 (453563476991)	External Paddles (Water Resistant)	M3543-61999	Date Code
Internal Defibrillation Paddles				
7.5 cm Switchless Internal Paddles	M1741A	7.5 cm Switchless Internal Paddles	M1741A	Date Code
6.0 cm Switchless Internal Paddles	M1742A	6.0 cm Switchless Internal Paddles	M1742A	Date Code
4.5 cm Switchless Internal Paddles	M1743A	4.5 cm Switchless Internal Paddles	M1743A	Date Code
2.8 cm Switchless Internal Paddles	M1744A	2.8 cm Switchless Internal Paddles	M1744A	Date Code
7.5 cm Switched Internal Paddles	M4741A	7.5 cm Switched Internal Paddles	M4741A	Two Date Codes - paddles, connector
6.0 cm Switched Internal Paddles	M4742A	6.0 cm Switched Internal Paddles	M4742A	Two Date Codes - paddles, connector
4.5 cm Switched Internal Paddles	M4743A	4.5 cm Switched Internal Paddles	M4743A	Two Date Codes - paddles, connector
2.8 cm Switched Internal Paddles	M4744A	2.8 cm Switched Internal Paddles	M4744A	Two Date Codes - paddles, connector
Internal Paddles Adapter Cable	M4740A	Internal Paddles Adapter Cable	M4740-61601	Date Code
Internal Disposable Defibrillation Paddles				
Large Disposable Switched Internal Paddles	989803127121	Large Disposable Switched Internal Paddles	989803127121	Lot/Batch Number
Medium Disposable Switched Internal Paddles	989803127131	Medium Disposable Switched Internal Paddles	989803127131	Lot/Batch Number
Small Disposable Switched Internal Paddles	989803127141	Small Disposable Switched Internal Paddles	989803127141	Lot/Batch Number

Table 40 Key Components (Continued)

Replacement Assembly Kits		Key Component		
Description	**Part Number**	**Description**	**Part Number**	**Tracking Method**
Large Disposable Switchless Internal Paddles	989803127151	Large Disposable Switchless Internal Paddles	989803127151	Lot/Batch Number
Medium Disposable Switchless Internal Paddles	989803127161	Medium Disposable Switchless Internal Paddles	989803127161	Lot/Batch Number
Small Disposable Switchless Internal Paddles	989803127171	Small Disposable Switchless Internal Paddles	989803127171	Lot/Batch Number
Pads Cables				
Defib Pads Cable, barrel connector	M3507A	Defib Pads Cable, barrel connector	M3507-60007	Date Code
Defib Pads Cable, plug connector	M3508A	Defib Pads Cable, plug connector	M3508-60008	Date Code
Battery/AC Power Module				
Lithium Ion Battery Module	M3538A	Lithium Ion Battery	M3535-60994	Date Code
AC Power Module Assembly	M3535-69171 453563481151	AC Power Module	M3535-60995	Date Code

7

Theory of Operation

This chapter provides functional descriptions of the components contained in the HeartStart MRx. These descriptions are at the functional-block level. This chapter also provides system level interconnection and signal and data flow schematics.

Overview

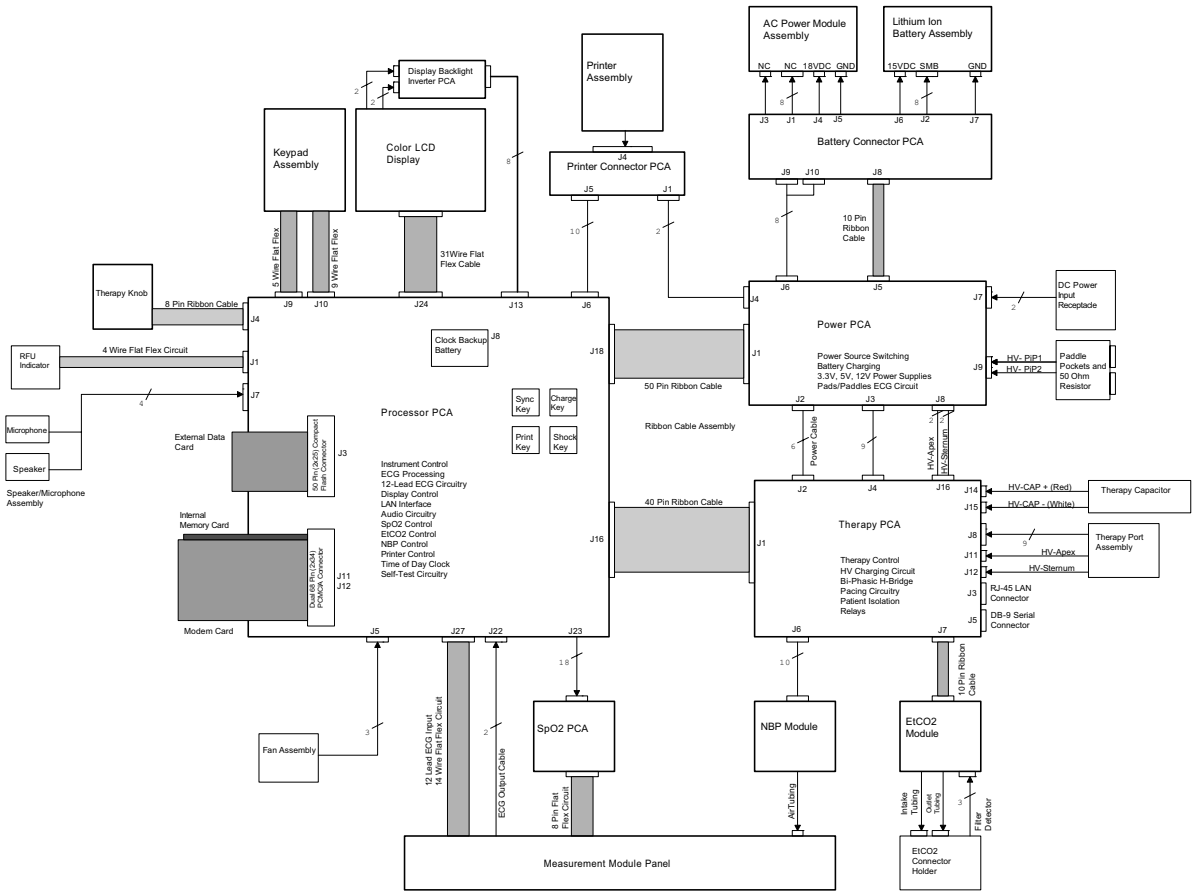
This chapter is organized into the following sections:

Schematic Diagrams

The following diagrams show the system level interconnection and signal and data flow schematics.

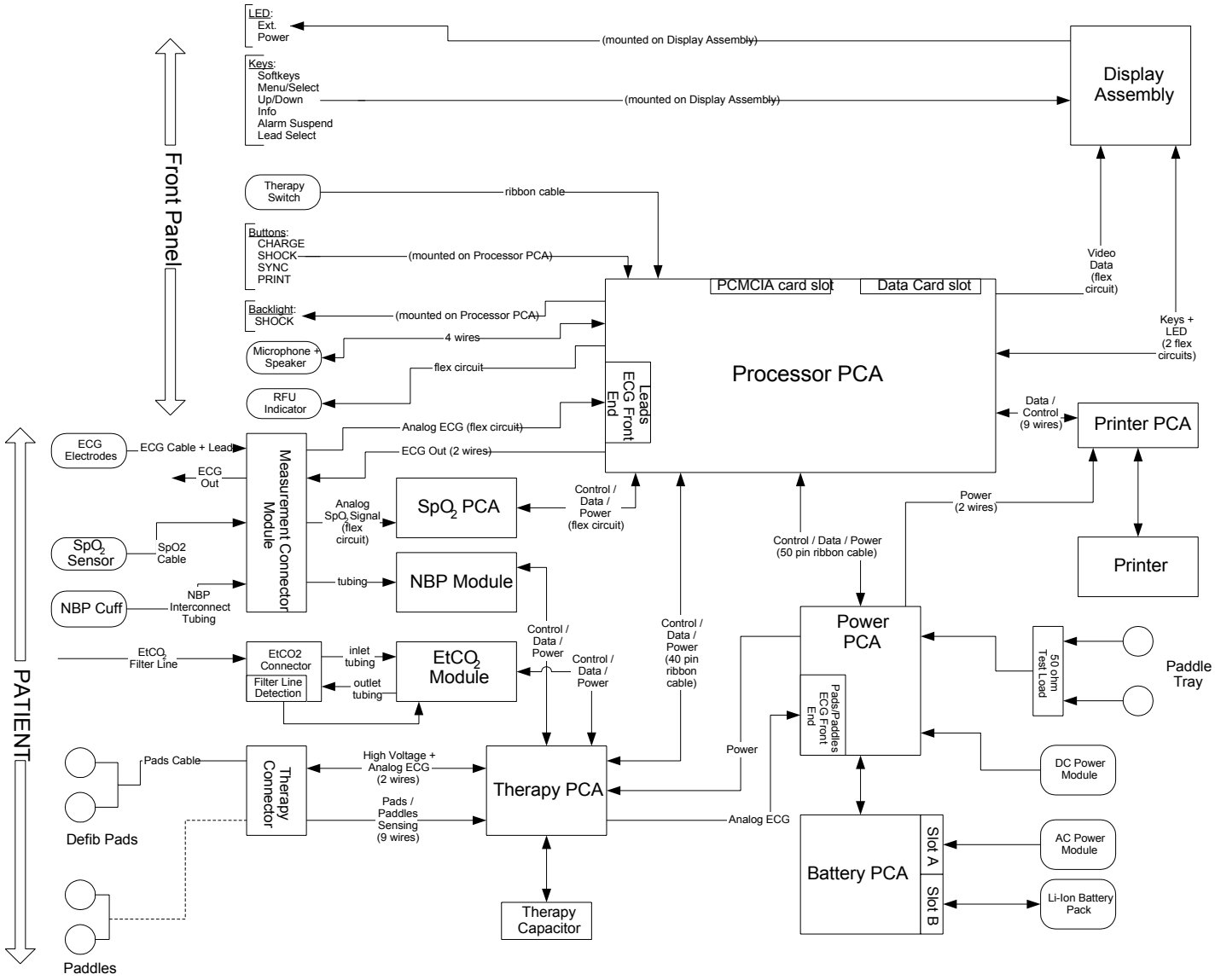
System Level Interconnections

Figure 87 System Interconnection Schematic



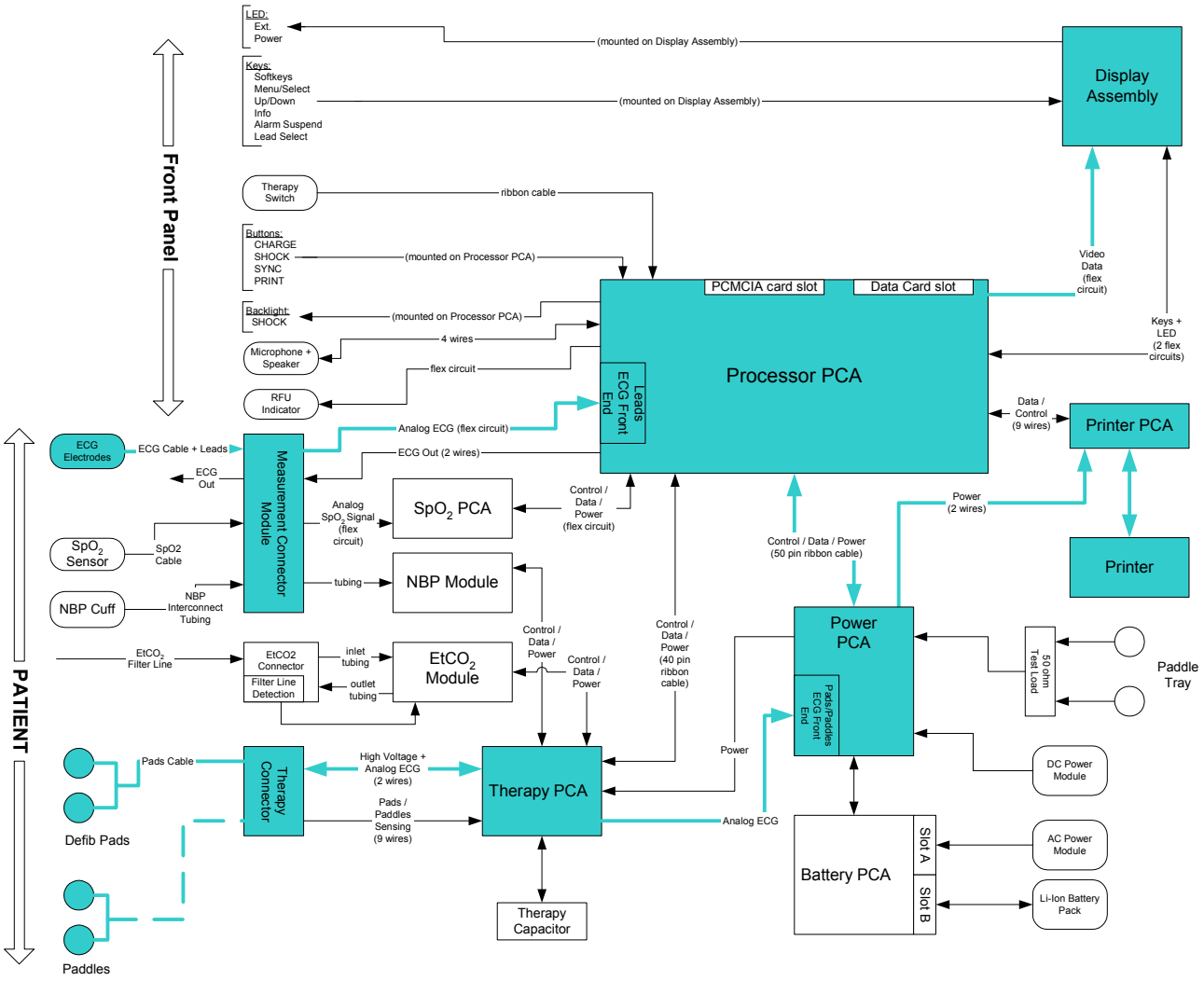
Signal and Data Flow

Figure 88 Signal and Data Flow Schematic



ECG Signal Flow

Figure 89 ECG Signal Flow



Functional Descriptions

The following sections provide descriptions of the functions handled by each component.

Processor PCA

The Processor PCA performs the following functions:

- Overall system control.
- High-level control of all modules and subsystems.
- Control of power up and power down sequences.
- Storage of configuration selections made by the user.
- Storage of operating software, including data for generating display formats and graphics.
- All user interface functions, including:
  - Generation and control of tones and audio prompts and detecting of front panel button presses.
  - Generation and formatting of information for the display and printer.
  - Control of indicator LEDs for Shock button backlight and External Power.
- Storage of information on the data card.
- Supervision of defibrillation functions on the Therapy PCA, including:
  - Initiating a capacitor charge sequence.
  - Secondary monitoring of capacitor voltage.
  - Initiating a shock delivery sequence.
  - Controlling therapy isolation and internal paddles relays.
- Control of pacing functions on the Therapy PCA, including:
  - Initiation of each pace pulse.
  - Monitoring pacing current delivered.
  - Controlling enabling of pacing and pacing isolation relays.
- Control of the ECG front ends on the Processor PCA (Leads ECG) and Power PCA (Paddles/Pads ECG).
- All ECG processing including filtering, beat detection, and rhythm analysis.
- Setting various alarm limits (HR, SpO_2 , etc.), and generating alarms when those limits are violated.
- Interconnection site for ECG leads cable, ECG out cable and SpO_2 PCA.
- ECG analog front end for ECG from 3- , 5-, and 12-lead (10 wire) cables.
- SpO_2 logic and patient isolation.
- Measurement of device temperature.
- Monitoring of overall system health, and control of the RFU indicator.

Therapy PCA

The Therapy PCA has responsibility for the following functions:

- Charging the capacitor to the correct energy level and keeping the capacitor charged to the correct level, as directed by the Processor PCA.
- Delivering defibrillator shocks and controlling the waveform as directed by the Processor PCA.
- Disarming (discharging) the capacitor.
- Internal load to absorb disarmed energy.
- Generation of pacing waveforms as directed by the Processor PCA.
- Electrical interface to the NBP module, CO_2 module, RS232 serial port, and LAN port.
- Sensing the paddle ID resistor (to identify the type of paddles/pads connected).

Power PCA

The Power PCA performs the following functions:

- Supplies 3.3V, 5V, and 12V system power.
- Charges batteries.
- Analog front end for ECG from the pads/paddles.
- Impedance measurement for the Patient Contact Indicator (PCI) function.
- Monitoring the overall system power, including detecting installed batteries or the presence of external power and selecting power sources.

Battery Connector PCA

The Battery Connector PCA provides the contacts with which the batteries and AC power module mate. It is an interconnection PCA only, and has no active circuitry.

Power/Batteries

The HeartStart MRx can be configured with two batteries and no AC supply or with one battery and one AC supply. The device transitions between power sources as sources are added and removed without interrupting any operation as long as at least one source of power is always present.

AC Power Module Assembly

The AC power module has a standard power connector and operates between 100-240VAC at 50 or 60 Hz. The AC power module plugs into battery compartment B and can power the device and charge the battery that is in battery compartment A.

Battery

The batteries used in the HeartStart MRx utilize lithium ion chemistry. Lithium ion batteries feature very high energy density, allowing the use of smaller and lighter batteries to achieve the same power levels as in nickel cadmium batteries. In addition, lithium ion batteries are more environmentally friendly than nickel cadmium or lead acid batteries, and do not suffer from the “memory effect” that plagues nickel cadmium chemistries.

Each battery pack includes built-in protective circuitry to prevent damage from overcharging, excessive discharge current, and other types of electrical abuse. It contains circuitry to monitor the amount of charge available in the battery. This information is communicated to the Processor PCA (via the Battery Connector PCA and the Power PCA) which provides battery status information on the display. In addition each battery pack has on-board temperature sensing which is monitored by the Power PCA for battery charging purposes.

WARNING Never crush, penetrate or attempt to open these or any lithium ion batteries. Never incinerate these or any lithium ion batteries. High case temperatures resulting from abuse of the battery could cause physical injury. Rupture of the battery pack may cause venting and flame.

CAUTION Due to their high energy density, these batteries can deliver significant power. Use care when working with or testing these or any lithium ion batteries. Do not short circuit the terminals.

NOTE When the battery is removed from the HeartStart MRx, it disconnects power to the output terminal. Thus, it is not possible to test the battery with a voltmeter.

Display Assembly

The Display assembly contains the:

- LCD display — 640 by 480 pixel, color flat panel display illuminated by cold cathode florescent lamps.
- Backlight Inverter — The power for the display backlight is provided by a Backlight Inverter PCA.

LCD Display

All display functions are handled by the Processor PCA. Display formats, graphics, waveforms, numeric values and messages are all generated and formatted by the Processor PCA, using either data it has or data it receives from other parts of the device.

The LCD display accepts this digital data from the Processor and maps it into pixels on the display.

Backlight Inverter

The display also contains a backlight, which is powered by the Backlight Inverter PCA. The Backlight Inverter PCA converts DC current from the system power supply to high voltage alternating current. The Backlight Inverter PCA is part of the Display assembly.

Indicators

The External Power LED is controlled by the Power PCA via a driver located on the Processor PCA. The External Power LED is part of the Display assembly, and is connected into the Processor PCA via flex circuits.

The Shock button backlight LEDs are mounted on the Processor PCA directly behind the Shock button and are controlled by the Processor PCA.The Shock button backlight illuminates only when that button is active. When using pads or switchless internal paddles, the Shock button is active and lit when the device is charged and ready to deliver a shock. When using external or switched internal paddles, the Shock button is disabled and not lit - the Shock buttons on the paddles are active instead.

RFU Indicator

Displays the status of the device with an hourglass indicating the device is ready for use and a solid red "X" indicating a critical failure. This indicator is visible even when the device is off.

Front Panel Buttons

The Charge, Shock, Print and Sync buttons are mounted in the front case. They operate by actuating four small switches mounted on the Processor PCA directly behind each button.

All of the buttons around the display (Navigation, Menu Select, etc.) and the soft keys are part of a membrane keypad. They are connected to the Processor PCA by flex circuits.

Presses from all buttons and soft keys are detected and processed by the Processor PCA. The Processor PCA then interacts with the other parts of the system as needed to respond to the soft key or button press.

Therapy Knob

The Therapy Knob selects operation in either AED Mode or Manual DefibMode.

In Manual Defib Mode, energy selection is made by rotating the Therapy Knob to the appropriate position. The Therapy Knob operates an optical rotary switch. The signals pass through the switch's ribbon cable and then on to the Processor PCA. The Processor PCA then interacts with the other parts of the system as needed to respond to the setting of the Therapy Knob.

Paddle Indicators and Controls

External and switched internal paddles have a Shock button located on the paddles. Additionally, external paddles have a Charge button on the right-hand paddle. When the paddles are connected to the monitor/defibrillator, the paddle Shock button is active and the Shock button on the monitor/defibrillator is disabled. External paddles have a Patient Contact Indicator (PCI) located on the Sternum paddle. The contact quality is indicated on the PCI using red, orange, and green LEDs. Once proper contact has been made, the PCI illuminates a green LED.

Printer Assembly and Printer Connector PCA

The Printer assembly provides hard copy output of text, waveforms, event data, etc. The printer module receives print commands from the Processor PCA and drives the printhead and paper motor accordingly. It senses when the paper is out, or the door is left open.

The Printer Connector PCA provides:

- Printhead power from the Power PCA
- Serial communications and logic power from the Processor PCA to the printer module.

The Printer Connector PCA is an interconnection PCA only, and has no active circuitry.

Printing

All printing of data is handled by the Processor PCA. Waveforms, graphics, numeric values, and messages are all generated and formatted by the Processor PCA, using either data it has or data it receives from other parts of the device. This data is then passed to the Printer Connector PCA in serial digital messages, via a10-wire bundle, and then on to the printer.

Contrast

The printing contrast is controlled automatically by the printer itself. The printer module senses printhead supply voltage, temperature and impedance, and adjusts drive voltage to the printhead (and thus contrast) based on these readings.

Out of Paper/Door Open

The printer also incorporates an optical sensor that detects when there is no paper left, or when the printer door is open. The information is passed to the Processor PCA in serial digital messages via the Printer Connector PCA and the10-wire bundle, and the Processor PCA generates the appropriate screen message and tones to alert the user.

ECG Monitoring Functions

There are two separate ECG front ends: one for signals coming in on the paddles or pads cable, and one for signals coming in on the 3- ,5-, or 10-lead ECG cable.

Leads ECG

The ECG signal picked up by the ECG monitoring electrodes is carried by the ECG cable to the ECG port, and then to the Processor PCA. There it is amplified, filtered, and digitized.

The Processor PCA then performs digital signal processing on the ECG data, and is responsible for:

- Formatting and presenting the ECG to the display and to the printer.
- Counting heart rate and generating heart rate alarms.
- Reporting on the status of the patient connection, and alerting the user to measurement problems.
- Arrhythmia analysis and alarms.

Pads/Paddles ECG

The ECG signal picked up by the paddles or disposable defibrillation pads is carried by the cable to the Therapy port via the Therapy PCA, and then to the Power PCA. There it is amplified, filtered, digitized and passed across a patient isolation barrier before being passed to the Processor PCA via a large ribbon cable.

The Processor PCA then performs digital signal processing on the ECG data, and is responsible for:

- ECG waveform analysis and Shock Advisory (in AED Mode).
- Formatting and presenting the ECG to the display and to the printer.
- Counting heart rate and generating heart rate alarms.
- Reporting on the status of the patient connection.

Patient impedance functions

The HeartStart MRx measures patient impedance in two ways: an impedance measurement before the shock, and a impedance measurement during the shock.

Before the Shock

The HeartStart MRx makes a small-signal AC impedance measurement (at 32 kHz) in the steady state situation before a shock is delivered. This measurement is used to detect Pads Off and Paddles Off. It is also used for the Patient Contact Indicator (PCI) function, in which the quality of the contact the paddles are making with the patient is indicated on an LED bar graph on the Sternum paddle.

During the Shock

The HeartStart MRx also makes an impedance measurement during shock delivery. This impedance is derived from measurements of voltage and current, and is reported on the printed event summary. The device uses the value of the impedance to adjust the phase durations of the biphasic waveform and to provide the optimal waveform delivery. This information is also used to abort the shock.

Since one measurement is a small-signal AC measurement of impedance and the other is a high-voltage/high-current measurement of impedance, it is normal and expected for the two measurements to produce slightly different numerical results.

Defibrillation

The following sections describe the defibrillation functions.

Charging

There are three basic events that can initiate a charging cycle:

- In AED Mode, when the Processor PCA shock advisory analysis algorithm determines from the pads ECG waveform that a shock is needed.
- In Manual Defib Mode with either pads or paddles, when the front panel Charge button is pressed, the button press is then detected and processed by the Processor PCA.
- In Manual Defib Mode with external paddles only, when the Apex paddle Charge button is pressed, the button press is transferred from the button to the Therapy PCA via the paddles cable. The Therapy PCA transfers the button press to the Processor PCA via a large ribbon cable. The button press is then detected and processed by the Processor PCA.

In all cases, the charging cycle is initiated by the Processor PCA. It directs the Therapy PCA to charge the Therapy capacitor to a specified level. A controller on the Therapy PCA is responsible for all aspects of charging the Therapy capacitor to the specified level. However, the Processor PCA also monitors the voltage on the capacitor through a separate measurement circuit on the Therapy PCA and aborts the operation if the capacitor voltage is not consistent with the specified level.

When the Therapy PCA detects that the selected energy (voltage) level has been reached, it stops charging. It then continues to monitor the voltage on the capacitor, and as the voltage bleeds down, it resumes charging to top up the charge to the correct level.

Should a decision be made to change the selected energy to a lower value, the user would turn the Therapy Knob to the desired setting. At the lower energy setting, the Processor PCA directs the Therapy PCA to charge to the new level. The Therapy PCA then disarms (completely discharges) the capacitor and charges up to the new (lower) level. At a higher energy setting, the Therapy PCA charges the capacitor until the new level is reached.

If the requested charge is not used within the configured timeframe (30, 60, or 90 seconds), the Processor PCA automatically directs the Therapy PCA to disarm the capacitor as a safety precaution.

Delivering a shock

The discharging cycle (delivering a shock) is initiated by any of the following three events:

- Pressing the front panel Shock button when using pads or switchless internal paddles. (The button is disabled when using external paddles or switched internal paddles). This button press is then detected and processed by the Processor PCA.
- Simultaneously pressing the Shock buttons on both the external Sternum and Apex paddles. These button presses are transferred from the buttons to the Therapy PCA via the paddles cable. The Therapy PCA transfers the button press to the Processor PCA via a large ribbon cable. The button press is then detected and processed by the Processor PCA.
- Pressing the Shock button on the switched internal paddles. This button press is transferred from the button to the Therapy PCA via the paddles cable. The Therapy PCA transfers the button press to the Processor PCA via a large ribbon cable. The button press is then detected and processed by the Processor PCA.

In any case, the Processor PCA directs the Therapy PCA to deliver the shock. Patient resistance is derived from the current and voltage delivered during the initial portions of the waveform, and the biphasic waveform timing is then adjusted as needed to deliver the correct energy.

The Therapy PCA aborts delivery of the shock if any of the followings situation occur:

- During the impedance measurement, the impedance is outside of operating limits (too high or too low).
- At any time during delivery of the shock, it detects an open circuit (voltage too high for that point in the waveform) or a short circuit (current too high for that point in the waveform).

Should any of these conditions be detected, the Therapy PCA terminates delivery of the waveform and disarms the capacitor. The problem is reported to the Processor PCA, which displays and/or prints the appropriate messages.

Another safety feature is the presence of an identification resistor in the pads and paddles cables. If the device does not sense that resistance, it gives a Cable Off message and does not charge the capacitor.

Delivering synchronized cardioversion

Synchronized cardioversion operates the same as delivering a shock, except that the shock must be synchronized to the R wave of the ECG. The Processor PCA is responsible for detecting the R wave and placing markers on the printed strip and on the display to indicate the timing of the proposed cardioversion shock.

A synchronized shock can be delivered in either of two ways:

- First, when using pads, by pressing and holding the Shock button until the next time an R wave is detected.
- Second, by simultaneously pressing and holding the Shock buttons on both the Sternum and Apex paddles until the next time an R wave is detected.

When both events occur (either type of button press **and** detection of an R wave) the Processor PCA directs the Therapy PCA to deliver the shock.

Transcutaneous Pacing

Pacing is initiated and controlled by pressing front panel buttons. These button presses are transferred from the buttons to the Processor PCA via a flex circuit. The button presses are detected and processed by the Processor PCA.

The Processor PCA directs the Therapy PCA to deliver the pacing pulses at the rate and output current selected by the user. The Therapy PCA controls the output current and the wave shape and the Processor PCA controls when each pace pulse occurs depending on the selected rate and the demand mode setting. The pacing pulses are delivered via the pads cable to the multifunction electrode pads. The pacing current delivered is reported back to the Processor PCA, which sends the information to the display and activates any printouts or screen messages as needed.

Audio

The HeartStart MRx has two types of audio output: tones, and voice prompts. Both are generated and controlled by the Processor PCA, which also amplifies the signals and passes them directly to the speaker via a wire pair.

Audio input is routed from the microphone to the Processor PCA over a separate wire pair, in the same connector as the speaker wires. The audio is filtered, digitized, and processed on the Processor PCA.

Data Storage

The HeartStart MRx has the capability of storing the following information:

- Patient data - acquired during an event.
- Configuration data - set up by the user to define specific settings related to the behavior of the device.
- Support data - generated by the device to support the maintenance and service of the device.
- Device data - set up by the manufacturer to define installed options, serial numbers, etc.

External Data Card

In addition to storing data in internal memory, the HeartStart MRx supports an external Compact Flash data card. You can copy patient data, such as ECG waveform and shock advisories, from internal memory to the external data card. The data card is read by the HearStart Event Review Pro for post-event analysis or by a compatible Compact Flash card reader.

Clock Backup Battery

The Clock Backup Battery (lithium battery located on the Processor PCA) provides standby power to maintain the system time and date during times when the main battery is either absent or discharged and no external power is supplied.

NBP Module

The NBP module handles the following functions:

- Inflation and deflation of the NBP cuff.
- Measurement of pressure in cuff.
- Detection of pressure waveform, and extraction of the systolic and diastolic values from that waveform.
- Calculation of mean pressure from waveform, systolic, and diastolic data.

SpO_2 PCA

The SpO_2 PCA serves as the interface to the SpO_2 sensor, including:

- Generation and control of voltages to drive the LEDs in the sensor.
- Receiving and processing the signals from the SpO_2 sensor.
- Derivation of the SpO_2 waveform, SpO_2 value, and pulse rate.
- Providing the digital SpO_2 value to the Processor PCA.

The SpO_2 signal from the sensor is carried by the external SpO_2 cable to the SpO_2 port, and then to the SpO_2 PCA. There it is analyzed to derive SpO_2 saturation level, pulse rate, and the waveform. This information is then passed to the Processor PCA via a flex circuit. (Power for the SpO_2 PCA and sensor is provided by the Processor PCA via this same flex circuit.) The Processor PCA provides patient isolation, and the power supply for SpO_2.

The Processor PCA is then responsible for:

- Formatting and presenting the O_2 saturation level, pulse rate and waveform to the display.
- Generating O_2 saturation level alarms.
- Reporting on the status of the sensor and its connections, and alerting the user to measurement problems.

CO_2 Module

The CO_2 module performs the following functions:

- Pumping the gas sample from the sidestream port into the measurement cell.
- Controlling the light source and the detector inside the measurement cell.
- Sensing the CO_2 level.
- Generating the CO_2 value and waveform.
- Sensing whether a FilterLine is plugged into the device.
- Providing digital data to the Processor PCA.

8

Specifications and Safety

This chapter describes the specifications and safety features of the HeartStart MRx monitor/defibrillator.

Specifications

General

Dimensions with pads 31.5 cm (W) x 21.0 cm (D) x 29.5 cm (H); (12.4 in. x 8.3 in. x 11.7 in.)

Dimensions with paddles 34.0 cm (W) x 21.0 cm (D) x 34.5 cm (H); (13.4 in. x 8.3 in. x 13.6 in.)

Weight Less than 13.2 lbs. including pads, pads cable, battery, and full roll of paper. Incremental weight of external standard paddles and paddle tray is less than 2.5 lbs. Additional battery weighs less than 1.6 lbs.

Defibrillator

Waveform Biphasic Truncated Exponential. Waveform parameters adjusted as a function of patient impedance.

Shock Delivery Via multifunction electrode pads or paddles.

Delivered Energy Accuracy

Selected Energy	Nominal Delivered Energy vs. Patient Impedance							Accuracy
	Load Impedance (ohms)							
	25	50	75	100	125	150	175	
1J	1.2	1.3	1.2	1.1	1.0	0.9	0.8	±2J
2J	1.8	2.0	2.0	1.9	1.7	1.6	1.5	±2J
3J	2.8	3.0	3.0	3.1	3.0	2.9	2.7	±2J
4J	3.7	4.0	4.0	4.1	4.2	4.2	4.0	±2J
5J	4.6	5.0	5.1	5.1	5.2	5.2	5.0	±2J
6J	5.5	6.0	6.1	6.2	6.3	6.3	6.1	±2J
7J	6.4	7.0	7.1	7.2	7.3	7.3	7.1	±2J
8J	7.4	8.0	8.1	8.2	8.4	8.3	8.1	±2J
9J	8.3	9.0	9.1	9.3	9.4	9.4	9.1	±2J
10J	9.2	10	10	10	10	10	10	±2J
15J	14	15	15	15	16	16	15	±15%
20J	18	20	20	21	21	21	20	±15%
30J	28	30	30	31	31	31	30	±15%
50J	46	50	51	51	52	52	50	±15%
70J	64	70	71	72	73	73	71	±15%
100J	92	100	101	103	104	104	101	±15%
120J	110	120	121	123	125	125	121	±15%
150J	138	150	152	154	157	156	151	±15%
170J	156	170	172	175	177	177	172	±15%
200J	184	200	202	206	209	209	202	±15%

Charge Time:

- Less than 5 seconds to 200 Joules with a new, fully charged Lithium Ion battery pack at 25°C.
- Less than 15 seconds when operating without a battery, using the M3539A AC power module alone at 90-100% rated mains voltage.
- Less than 15 seconds with a new, fully charged Lithium Ion battery pack at 25°C, depleted by up to 15 200 Joule discharges.
- Less than 25 seconds from initial power on, with a new, fully charged Lithium Ion battery pack at 25°C, depleted by up to 15 200 Joule discharges.
- Less than 25 seconds from initial power on when operating without a battery, using the M3539A AC power module alone at 90-100% rated mains voltage.
- Less than 30 seconds from initiation of rhythm analysis (AED Mode) with a new, fully charged Lithium Ion battery pack at 25°C, depleted by up to 15 200 Joule discharges.
- Less than 30 seconds from initiation of rhythm analysis (AED Mode) when operating without a battery, using the M3539A AC power module alone at 90-100% rated mains voltage.

- Less than 40 seconds from initial power on (AED Mode) with a new, fully charged Lithium Ion battery pack at 25°C, depleted by up to 15 200 Joule discharges.
- Less than 40 seconds from initial power on (AED Mode) when operating without a battery, using the M3539A AC power module alone at 90-100% rated mains voltage.

Patient Impedance Range:

- Minimum: 25 Ohm (external defibrillation); 15 Ohm (internal defibrillation)
- Maximum: 180 Ohm

Note: Actual functional range may exceed the above values.

Manual Defib Mode

Manual Output Energy (Selected): 1-10, 15, 20, 30, 50, 70, 100, 120, 150, 170, 200 Joules; maximum energy limited to 50J with internal paddles

Controls: On/Off Therapy Knob, Charge, Shock, Sync, Print, Mark Event, ECG Lead Select, Alarm Pause, Event Review, Disarm

Energy Selection: Front panel Therapy Knob

Charge Control: Front panel button, button on external paddles

Shock Control: Front panel button, buttons on external or switched internal paddles

Synchronized Control: Front panel SYNC button

Indicators: Text Prompts, Audio Alerts, QRS Beeper, Battery Status, Ready For Use, External Power, Sync Mode

Armed Indicators: Charging tone, charge done tone, flashing shock button, and energy level indicated on display

AED Mode

AED Energy Profile: 150 Joules nominal into a 50 ohm test load

Text and Voice Prompts: Extensive text/audible messages guide user through configured protocol.

AED Controls: On/off, Shock

Indicators: Monitor display messages and prompts, voice prompts, battery status, Ready For Use, external power

Armed Indicators: Charging tone, charged tone, flashing shock button, and energy level indicated on display

ECG Analysis: Evaluates patient ECG and signal quality to determine if a shock is appropriate and evaluates connection impedance for proper defibrillation pad contact

Shockable Rhythms: Ventricular fibrillation and certain ventricular tachycardias, including ventricular flutter and polymorphic ventricular tachycardia

Shock Advisory Algorithm Sensitivity and Specificity: Meets AAMI DF-39

Table 41 AED ECG Analsysis Performance

Rhythm Class	ECG Test Sample Size[a]	Nominal Specifications
Shockable Rhythm Ventricular Fibrillation	600	Meets AAMI DF39 requirement and AHA recommendation[b] (sensitivity > 90%) for adult defibrillation
Shockable Rhythm Ventricular Tachycardia	300	Meets AAMI DF39 requirement and AHA recommendation[b] (sensitivity > 75%) for adult defibrillation
Non-shockable Rhythm Normal Sinus Rhythm	250	Meets AAMI DF39 requirement (specificity > 95%) and AHA recommendation[b] (specificity > 99%) for adult defibrillation
Non-shockable Rhythm Asystole	500	Meets AAMI DF39 requirements and AHA recommendation[b] (specificity > 95%) for adult defibrillation
Non-shockable Rhythm All other non-shockable rhythms	600	Meets AAMI DF39 requirements and AHA recommendation[b] (specificity > 95%) for adult defibrillation

a. From Philips Medical Systems ECG rhythm databases.

b. American Heart Association (AHA) AED Task Force, Subcommittee on AED Safety & Efficacy. Automatic External Defibrillators for Public Access Use: Recommendations for Specifying and Reporting Arrhythmia Analysis Algorithm Performance, Incorporation of New Waveforms, and Enhancing Safety. American Heart Association (AHA) AED Task Force, Subcommittee on AED Safety & Efficacy. *Circulation* 1997;95:1677-1682.

ECG and Arrhythmia Monitoring

Inputs: Up to four (4) ECG waves may be viewed on display and up to two (2) waves printed simultaneously. Lead I, II, or III is obtained through the 3-wire ECG cable and separate monitoring electrodes. With a 5-lead ECG cable, leads aVR, aVL, aVF, and V can also be obtained. Pads ECG is obtained through 2 multifunction electrode pads.

Lead Fault: LEAD OFF message and dashed line appear on the display if an electrode or lead becomes disconnected.

Pad Fault: Dashed line appears on the display if a pad becomes disconnected.

Heart Rate Display: Digital readout on display from 15 to 300 bpm, with an accuracy of ± 10%

Heart Rate/Arrhythmia Alarms: HR, Asystole, VFIB/VTACH, VTACH, Extreme Tachy, Extreme Brady, PVC rate, Pacer Not Capture, Pacer Not Pacing

Hands Free Defibrillation Patient Cable Length:

- M3508A - 2.2 m (7 ft.)
- M3507A - 2.2 m (7 ft.)

ECG Cable Length: 2.7 m (9 ft.)

Common Mode Rejection: Greater than 90 dB measured per AAMI standard for cardiac monitors (EC 13)

ECG Size: 2.5, 5, 10, 20, 40 mm/mV, autogain

Frequency Response:

- AC Line Filter - 60 Hz or 50 Hz
- Pads ECG for Display: Monitor - (.15-40 Hz) or EMS (1-30 Hz)
- Pads ECG for Printer - Monitor (.15-40 Hz) or EMS (1-30 Hz)
- Leads ECG for Display - Monitor (.15-40 Hz) or EMS (1-30 Hz)
- Leads ECG for Printer - Diagnostic (.05-150 Hz) or Monitor (.15-40 Hz) or EMS (1-30 Hz)

Patient Isolation (defibrillation proof):

- ECG: Type CF
- SpO_2 : Type CF
- $EtCO_2$: Type CF
- NBP: Type CF
- External Defib: Type BF
- Internal Defib: Type CF

Other Considerations: The HeartStart MRx is suitable for use in the presence of electrosurgery. Burn hazard protection is provided via a 1K current limiting resistor contained in each ECG lead wire.

Display

Size: 128 mm x 171 mm

Type: TFT Color LCD

Resolution: 640 x 480 pixels (VGA)

Sweep Speed: 25mm/s nominal (stationary trace; sweeping erase bar) for ECG and SpO_2 ; 6.25 mm/sec for CO_2

Wave Viewing Time: 5 seconds (ECG)

Battery

Type: 6.0 Ah, 14.8 V, rechargeable, Lithium Ion

Dimensions: 165 mm (H) x 95 mm (W) x 42 mm (D); (6.5 in. x 3.8 in. x 1.6 in)

Weight: Less than 1.6 lb. (0.73 kg)

Charge Time with instrument off: Approximately 3 hours to 100%. Approximately 2 hours to 80%, indicated by indicator. Charging the battery at temperatures above 45°C may degrade battery life.

Capacity: At least 5 hours of monitoring with ECG, SpO_2 , and CO_2 monitored continuously and NBP measured every 15 minutes, or at least 50 full-energy discharges (with a new, fully charged battery, operating at room temperature, 25°C).

Battery Indicators: Battery gauge on battery, capacity indicator on display; flashing RFU indicator, chirp, and LOW BATTERY message appears on display for low battery condition*

*When LOW BATTERY message first appears, there is still enough energy remaining for at least 10 minutes of monitoring time and six maximum energy discharges (with a new battery at room temperature, 25°C).

Battery Storage: Storing the battery for extended periods at temperatures above 40°C will reduce battery capacity and degrade battery life.

Thermal Array Printer

Continuous ECG Strip: The Print key starts and stops the strip. The printer can be configured to run real time or with a 10-second delay. The strip prints the primary ECG lead with event annotations and measurements.

Auto Printing: The printer can be configured to automatically print on Mark Events, Charge, Shock, and Alarm. When an alarm condition occurs, the unit prints the Primary ECG wave and the alarming wave, if configured.

Reports: The following can be printed:

- Event Summary (short, medium, and long)
- 12-Lead
- Operational Check
- Configuration
- Status Log
- Device Information

Speed: 25 or 50 mm/s with an accuracy of ±5%

Amplitude Accuracy: ±5% or ± 40 uV, whichever is greater

Paper Size:

- 50 mm (W) x 30 m (100 ft.) (L)
- 75 mm (W) x 30 m (100 ft.) (L)

Noninvasive Pacing

Waveform: Monophasic Truncated Exponential

Current Pulse Amplitude: 10 mA to 175 mA (5 mA resolution); accuracy 10% or 5 mA, whichever is greater

Pulse Width: 40 ms with ±10% accuracy

Rate: 30 ppm to 180 ppm (10 ppm increments); accuracy ± 1.5%

Modes: Demand or Fixed Rate

Refractory Period: 340 msec (30 to 80 ppm); 240 msec (90 to 180 ppm)

SpO_2 Pulse Oximetry

Range:

- SpO_2 : 0-100%
- Pulse Rate: 30 to 300 bpm

Resolution: 1%

Display Update Period: 1 sec typical numeric update rate

SpO_2 Accuracy with:

- M1191A sensor - 1 standard deviation 70% to 100%, ± 2.5%
- M1192A sensor - 1 standard deviation 70% to 100%, ± 2.5%
- M1193A sensor - 1 standard deviation 70% to 100%, ± 2.5%
- M1194A sensor - 1 standard deviation 70% to 100%, ± 4.0%
- M1195A sensor - 1 standard deviation 70% to 100%, ± 4.0%
- NELLCOR sensors - 1 standard deviation 80% to 100%, ± 3.0%

Pulse Rate Accuracy: 2% or 1 bpm (whichever is greater)

Alarm Range:

- Low Limit: 50 to 99% (Adult/Pediatric)
- High Limit: 51 to 100% (Adult/Pediatric)

Alarm Delay: 10 seconds

NBP

Pressure Range:

- Systolic: 40-260 mmHg
- Diastolic: 20-200 mmHg

Initial Pressure: 160 mmHg Adult; 120 mmHg Pediatric

Maximum Pressure: 280 mmHg

Overpressure Safety Limits: Maximum of 300 mmHg

Cuff Inflation Time: 50 second maximum (pediatric or adult)

Accuracy: ±3mmHg

Alarm Range:

- Systolic high limit: 35-270 (Adult), 35-180 (Pediatric)
- Systolic low limit: 30-265 (Adult), 30-175 (Pediatric)
- Diastolic high limit: 15-245 (Adult), 15-150 (Pediatric
- Diastolic low limit: 10-240 (Adult), 10-145 (Pediatric)
- Mean high limit: 25-255 (Adult), 25-160 (Pediatric)
- Mean low limit: 20-250 (Adult), 20-155 (Pediatric)

Rated Life: 50,000 measurement cycles (36/day for 2.3 years)

Auto Mode Repetition Time: 1, 2.5, 5, 10, 15, 30, 60, or 120 minutes

Measurement Time: Auto/manual mode: 30 seconds (average) @ HR>60 bpm, 170 seconds maximum)

Interconnect Tube Length:

- M1598B Connect tubing 1.5 m
- M1599B Connect tubing 3.0 m

$EtCO_2$

Range: 0 to 99 mmHg

Resolution: 1 mmHg (0.1kPa)

Accuracy: For values between 0 and 38 mmHg: ±2 mmHg. For values between 39 and 99 mmHg: ±5% of reading + 0.08% for every 1 mmHg (above 40 mmHg). Values read at sea level after ≥20 min warm up.

The accuracy specification is maintained to within 4% for the following gas mixtures (all values are in Vol. %).

CO_2	N_2	O_2	N_2O	H_2O	Anesthetic Agents
0 to 13	0 to 97.5	0 to 100	0 to 80	dry to saturated	According to EN864

Rise Time: 190 ms maximum @ 10ml/min

Delay Time: 2.7 seconds typical

System Response Time: 2.9 seconds typical

Sample Flow Rate: Nominally 50 ml/min, ±7.5 ml/min

Microstream CO_2 Humidity Correction Factor: BTPS (Body Temperature and Pressure, Saturated - 37°C, 750mmHg, 100% humidity or 47mmHg) is the humidity correction factor for the Microstream CO_2 readings. The formula for the correction calculation is:

$$P_{BTPS} = FCO_2 \times (Pb-47)$$

$$\sim FCO_2 \times 0.94$$

Where FCO2 = fractional concentration of CO_2 in dry gas.

$F_{CO2} = \%CO_2/100$

Pb = ambient pressure

Alarm Range:

- Low Limit: 10 to 94 mmHg (Adult/Pediatric)
- High Limit: 20 to 95 mmHg (Adult/Pediatric)

AwRR

Range: 0 to 150 rpm

Resolution: 1 rpm

Accuracy:

- 0 to 40 rpm ±1 rpm
- 41 to 70 rpm ±2 rpm
- 71 to 100 rpm ±3 rpm
- 101 to 150 rpm ± 5 rpm

Alarm Range:

- Low Limit: 0 to 95 rpm (Adult/Pediatric)
- High Limit: 10 to 100 rpm (Adult/Pediatric)

Apnea Alarm: 10-40 seconds, in increments of 5

Calibration Gas for CO_2 Measurement System

Ingredients: 5% Carbon Dioxide, 21% Oxygen, 74% Nitrogen

Cylinder Size: BD

Method of Preparation: Gravimetric

Blend Tolerance: 0.03%

Accuracy: 0.03% absolute

Moisture: 10 PPM Maximum

Expiration Period: 2 years

Pressure: 144 PSIG, Volume: 10L

12-Lead ECG

Inputs: With a 10-lead cable, leads I, II, III, aVR, aVL, aVF, V/C1-V/C6 can be obtained. All 12-Lead ECG waves can be viewed on the display simultaneously. All 12 leads can be printed on the strip chart printer in 3x4 format.

Patient Data Storage

Internal Event Summary: The internal Event Summary stores up to 8 hours of continuous ECG waveforms and events per Event Summary, with a maximum capacity of 60 Event Summaries or 62 megabytes of patient data, whichever comes first.

Data Card Event Summary: The Data Card stores up to 8 hours of continuous ECG waveforms and events per Event Summary, with a maximum capacity of 60 Event Summaries or 62 megabytes of patient data, whichever comes first.

Environmental (M3535A)

Temperature: 0°C to 45°C operating, -20° to 70°C storage

- Charging the battery at temperatures above 45°C may degrade battery life
- Storing the battery for extended periods at temperatures above 40°C will reduce battery capacity and degrade battery life

Humidity: Up to 95% Relative Humidity

- Printer paper may jam if paper is wet
- Thermal Printer may be damaged if wet paper is allowed to dry while in contact with printer elements

Altitude:

- Operating: 0 to 15,000 ft (0 to 4,500 m)
- Storage: 0 to 15,000 ft (0 to 4,500 m)

Shock:

- Operating: Half-sine waveform, duration < 3 ms, acceleration > 145 g, 1 time on all six faces
- Storage: Trapezoidal waveform, acceleration ≥ 30 g, velocity change=742 cm/s ±10% on all six faces

Vibration:

- Operating: Random vibration, 0.30 Grms, 5-500 Hz for ≥10 minutes/axis PSD=0.0002 g^2/Hz from 5 to 350 Hz, -6 dB/octave slope from 350 to 500 Hz
- Storage:

  Random vibration, 2.41 Grms, 5-500 Hz for ≥10 minutes/axis PSD=0.02 g^2/Hz from 5 to 100 Hz, -6 dB/octave slope from 100 to 137 Hz, 0 dB/octave slope from 137 to 350 Hz, -6 dB/octave slope from 350 to 500 Hz.

  Swept sine vibration, (0.75 g [0 to peak] 5 to 500 Hz) resonant search, 1 octave/minute sweep rate, 5 minute resonant dwell at 4 resonances per axis.

Water/Solids Resistance:

- Water Resistance: Meets EN60601-2-4. Water testing performed with cables connected to the device.
- Solids Resistance: IP2X.

EMC: Complies with the requirements of standard EN 60601-1-2:2001.

Safety: Complies with the requirements of applicable safety standards.

Other Considerations:

- The HeartStart MRx is not suitable for use in the presence of concentrated oxygen or a flammable anesthetic mixture with air, oxygen, or nitrous oxide.
- Hazards arising from software errors were minimized by the product's compliance with the software requirements contained in EN 60601-1-4:1996.

Mode of Operation: Continuous

AC Line Powered: 100 - 240 VAC, 50 - 60 Hz, 1 - 0.46 A (Class 1)

Battery Powered: 14.8 V Rechargeable, Lithium Ion

DC Powered:

- Input: 11-32 VDC, 11 A
- Output: 18 V, 5 A, 90 W

Environmental (M3536A)

Temperature: 0°C to 45°C operating, -20° to 70°C storage

- Charging the battery at temperatures above 45°C may degrade battery life
- Storing the battery for extended periods at temperatures above 40°C will reduce battery capacity and degrade battery life

Humidity: Up to 95% Relative Humidity

- Printer paper may jam if paper is wet
- Thermal Printer may be damaged if wet paper is allowed to dry while in contact with printer elements

Altitude:

- Operating: 0 to 15,000 ft (0 to 4,500 m)
- Storage: 0 to 15,000 ft (0 to 4,500 m)

Shock:

- Operating: Half-sine waveform, duration < 3 ms, acceleration > 145 g, 1 time on all six faces
- Non-operating Shipping: Trapezoidal waveform, acceleration ≥ 30 g, velocity change=742 cm/s ±10% on all six faces
- Bump: EN60068-2-29 Bump (Half-sine, 40 g peak, 6 msec duration, 1,000 bumps x 3 axes)
- Free Fall: IEC 68-2-32 Free Fall. Drops on all faces onto a steel surface (excluding bed rail hook)
  - 30 in. (76.2 cm) with carrying case
  - 16 in. (40.6 cm) without carrying case

Vibration:

- Operating: MIL STD 810E 514.4 Category 6 Helicopter, General Storage, UH60
- Non-Operating:
  - IEC 68-2-6 Vibration (sinusoidal) (10-57 Hz± 0.15mm; 58-150 Hz, 2g; 20 sweeps x 3 axes)
  - IEC 68-2-64 Vibration, broad-band random (10-20 Hz, 0.05 g^2/Hz; 20-150 Hz, -3 dB/octave; 150 Hz, 0.0065 g^2/Hz; 1.5 hours x 3 axes)

Solids/Water Resistance: IP24. Water testing performed with cables connected to the device.

EMC: Complies with the requirements of standard EN 60601-1-2:2001.

Safety: Complies with the requirements of applicable safety standards.

Other Considerations:

- The HeartStart MRx is not suitable for use in the presence of concentrated oxygen or a flammable anesthetic mixture with air, oxygen, or nitrous oxide.
- Hazards arising from software errors were minimized by the product's compliance with the software requirements contained in EN 60601-1-4:1996.

Mode of Operation: Continuous

AC Line Powered: 100 - 240 VAC, 50 - 60 Hz, 1 - 0.46 A (Class 1)

Battery Powered: 14.8 V Rechargeable, Lithium Ion

DC Powered:

- Input: 11-32 VDC, 11 A
- Output: 18 V, 5 A, 90 W

Symbol Definitions

Table 42 lists the meaning of each symbol shown on the HeartStart MRx and the M3538A battery.

Table 42 Monitor/Defibrillator and Battery Symbols

Symbol	Definition
	Defibrillation Shock.
	Attention - See operating instructions in Instructions for Use.
	Input.
	Output.
	Meets IEC type BF leakage current requirements and is defibrillator protected. (Patient Applied Part is isolated and defib-proof suitable for direct patient contact except the heart or major arteries.)
	Meets IEC type CF leakage current requirements and is defibrillator protected. (Patient Applied Part is isolated and defib-proof suitable for direct patient contact except the heart or major arteries.)
	Alarms are active.
	Alarms are paused.

Table 42 Monitor/Defibrillator and Battery Symbols (Continued)

Symbol	Definition
	Alarms are disabled.
	Recyclable material.
IP24	Protected against ingress of solid foreign objects >12.5mm in diameter. Protected against access to hazardous parts with a finger. Protected against splashing water.
IP2X	Protected against ingress of solid foreign objects >12.5mm in diameter. Protected against access to hazardous parts with a finger.

Table 43 lists the meaning of the symbols appearing on the shipping carton.

Table 43 HeartStart MRx Shipping Carton Symbols

	Atmospheric pressure range.
	Temperature range
	Relative humidity range.
	Recyclable paper product.
	Fragile.
	Right side up.
	Do not get wet.

Safety Considerations

The following general warnings and cautions apply to use of the HeartStart MRx. Additional warning and cautions specific to a particular feature are provided in the appropriate section.

General

WARNING Remove all power sources (AC, battery, DC) before opening the device. Failure to do so may allow the device to charge without warning and could result in serious injury or death.

WARNING HeartStart MRx service should only be performed by qualified service personnel, in accordance with the *HeartStart MRx MRx Service Manual*.

WARNING The HeartStart MRx MRx is not intended to be deployed in settings or situations that promote use by untrained personnel. Operation by untrained personnel can result in injury or death.

WARNING Use only 3-wire AC power cords with 3-pronged grounded plugs.

WARNING Never operate the HeartStart MRx MRx in standing water. Do not immerse, or pour fluids on, any portion of the HeartStart MRx MRx.

WARNING Do not use the HeartStart MRx MRx in a flammable or oxygen-rich atmosphere. This can cause an explosion hazard.

WARNING Operating the HeartStart MRx MRx or its accessories in conditions outside the environmental specifications can result in device or accessory malfunction. The HeartStart MRx should be allowed to stabilize within the operating temperature range for 30 minutes prior to operation.

WARNING Electric shock hazards exist internally. Do not remove assembly screws. Refer servicing to qualified personnel.

WARNING Where the integrity of the external protective earth conductor is in doubt, the device shall be operated from its internal power source.

WARNING To break connection with main power remove plug from wall outlet.

CAUTION Do not discharge the defibrillator with the paddles shorted together.

CAUTION Conductive parts of electrodes and associated connectors for applied parts, including the neutral electrode, should not contact other conductive parts including earth.

CAUTION Following electrosurgery interference, the equipment returns to the previous operating mode within 10 seconds without loss of stored data. Measurement accuracy may be temporarily decreased while performing electrosurgery or defibrillation. This does not affect patient or equipment safety. Do not expose the equipment to x-ray or strong magnetic fields (MRI).

CAUTION Be aware of patient cables, including ECG monitoring equipment when used with high frequency surgical equipment.

NOTE This device and its accessories are not intended for home use.

NOTE The HeartStart MRx can be operated with only AC/DC power, only 14V M3538A Lithium Ion Battery, or AC/DC power and M3538A battery simultaneously.

NOTE For operation in the U.S., the AC power cord must have the proper NEMA type plug.

NOTE The HeartStart MRx MRx does not require the practice of any special ElectroStatic Discharge (ESD) precautionary procedures.

Defibrillation

WARNING Keep hands and feet clear of paddle electrode edges. Use your thumbs to depress the shock buttons on the paddle handle.

WARNING Do not allow multifunction electrode pads to touch each other or to touch other ECG monitoring electrodes, lead wires, dressings, etc. Contact with metal objects may cause electrical arcing and patient skin burns during defibrillation and may divert current away from the heart.

Battery

WARNING Properly dispose of or recycle depleted batteries according to local regulations. Do not puncture, disassemble, or incinerate batteries.

WARNING Built in safety circuits can not protect against handling abuse. Adhere to all warnings and cautions in handing and using lithium ion batteries.

WARNING Do not expose batteries to temperatures greater than 60°C (140°F). Excess temperatures may result in battery damage.

WARNING Keep batteries away from flame and other heat sources.

WARNING Do not short circuit the battery. Avoid placing batteries around metal objects that may short circuit the battery.

WARNING Avoid getting batteries wet or using batteries in high humidity environments.

WARNING Do not crush, dent or allow any deformation of the batteries.

WARNING Do not disassemble or open batteries. Do no attempt to alter or bypass the safety circuit.

WARNING Do not use or connect the battery to batteries of other chemistries.

WARNING Avoid extreme shock and vibration to the battery.

WARNING Avoid electrostatic discharge to the battery.

WARNING Avoid extreme shock and vibration to the battery

WARNING Do not use or connect the battery to batteries of other chemistries.

Electromagnetic Compatibility

When using the HeartStart MRx, electromagnetic compatibility with surrounding devices should be assessed.

A medical device can either generate or receive electromagnetic interference. Testing for electromagnetic compatibility EMC with and without the appropriate accessories has been performed according to the international standard for EMC for medical devices (IEC 60601-1-2). This IEC standard has been adopted in Europe as the European Norm (EN 60601-1-2).

The EMC standards describe tests for both emitted and received interference. Emission tests deal with interference generated by the device being tested.

WARNING Radio frequency (RF) interference from nearby transmitting devices may degrade performance of the HeartStart MRx. Electromagnetic compatibility with surrounding devices should be assessed prior to using the defibrillator.

Fixed, portable, and mobile radio frequency communications equipment can affect the performance of medical equipment. See Table 48 for the minimum recommended separation distance between RF communications equipment and the HeartStart MRx.

Reducing Electromagnetic Interference

The HeartStart MRx and associated accessories may be susceptible to interference from other RF energy sources and continuous, repetitive, power line bursts. Examples of other sources of RF interference are medical devices, cellular products, information technology equipment and radio/television transmission. Should interference be encountered, as demonstrated by artifact on the ECG or dramatic variations in parameter measurement values, attempt to locate the source. Assess:

- Is the interference intermittent or constant?
- Does the interference occur only in certain locations?
- Does the interference occur only when in close proximity to certain medical devices?
- Do parameter measurement values change dramatically when the AC line cord is unplugged?

Once the source is located, attempt to attenuate the EMC coupling path by distancing the monitor/defibrillator from the source as much as possible. If assistance is needed, call your local service representative.

Restrictions for Use

Artifact on the ECG and parameter waveforms caused by electromagnetic interference should be evaluated by a physician or physician authorized personnel to determine if it will negatively impact patient diagnosis or treatment.

Emissions and Immunity

The HeartStart MRx is designed and tested to comply with the radiated and conducted emissions requirement of international and national standards IEC 60601-1-2:2001 and EN 60601-1-2:2002. See Tables 44 through 48 for detailed information regarding declaration and guidance.

WARNING The use of accessories, transducers and cables other than those specified may result in increased emissions or decreased immunity of the HeartStart MRx.

The list of cables, transducers, and other accessories with which Philips claims compliance with the emissions and immunity requirements of IEC standard 60601-1-2 are listed in the Supplies and Accessories section of "Parts and Accessories" on page 211.

The local area network (LAN) connector of the HeartStart MRx is marked with the  label. The pins of connectors marked with this warning symbol should not be touched or connections made to until the following precaution is taken:

Discharge yourself to a conductive metal surface which is connected to earth ground before making connections or touching the marked connector.

All staff using the HeartStart MRx should be instructed on these precautionary measures in order to avoid damage to this sensitive medical equipment.

The EMC standards state that manufacturers of patient-coupled equipment must specify immunity levels for their systems. See Tables 44 through 47 for this detailed immunity information. See Table 48 for recommended minimum separation distances between portable and mobile communications equipment and the HeartStart MRx.

Immunity is defined in the standard as the ability of a system to perform without degradation in the presence of an electromagnetic disturbance. Degradation in ECG quality is a qualitative assessment which can be subjective.

Caution should, therefore, be taken in comparing immunity levels of different devices. The criteria used for degradation is not specified by the standard and may vary with the manufacturer.

NOTE For additional information about compliance with the EMC standards and the Declaration of Conformity Statement, please see the Philips Medical web site at http://powerstation.medical.philips.com. Select the Business Data Viewer Tab, and then select the Declaration of Conformity link listed under Regulatory.

Guidance and Manufacturer's Declaration

The HeartStart MRx is intended for use in the electromagnetic environment specified in the tables below. The customer or the user of the HeartStart MRx should assure that it is used in such an environment.

Table 44 Electromagnetic Emissions

For devices with serial numbers US001XXXXX

Emissions Test	Compliance	Electromagnetic Environment - Guidance
RF emissions CISPR 11	Group 1	The HeartStart MRx uses RF energy only for its internal function. Therefore, its RF emissions are very low and not likely to cause interference in nearby electronic equipment.
RF emissions CISPR 11	Class A	The HeartStart MRx is suitable for use in all establishments, other than domestic establishments or those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes. It may be used in domestic establishments if it is under the supervision of healthcare professional.[1]
Harmonic emissions IEC 61000-3-2	Class A	
Voltage fluctuations/flicker emissions IEC 61000-3-3	Complies	

[1] International standard IEC 60601-1-2 (dated April 1993) allows for equipment to be operated in domestic locations if it is under the supervision of a healthcare professional. Note that national authorities may apply whatever measures they consider necessary to protect radio communications. This allowance will no longer apply to medical equipment being sold or put into service after 1 November 2004.

For devices with serial numbers US002XXXXX

Emissions Test	Compliance	Electromagnetic Environment - Guidance
RF emissions CISPR 11	Group 1	The HeartStart MRx uses RF energy only for its internal function. Therefore, its RF emissions are very low and not likely to cause interference in nearby electronic equipment.
RF emissions CISPR 11	Class B	The HeartStart MRx is suitable for use in all establishments, including domestic establishments or those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Class A	
Voltage fluctuations/flicker emissions IEC 61000-3-3	Complies	

Table 45 Electromagnetic Immunity - General

Immunity Test	IEC 60601 Test Level	Compliance Level	Electromagnetic Environment - Guidance
Electrostatic discharge (ESD) IEC 61000-4-2	± 6 kV contact ± 8 kV air	± 6 kV contact ± 8 kV air	Floors should be wood, concrete, or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.
Electrical fast transient/burst IEC 61000-4-4	± 2 kV for power supply lines ±1 kV for input/ output lines	± 2 kV for power supply lines ±1 kV for input/ output lines	Mains power quality should be that of a typical commercial or hospital environment.
Surge IEC 61000-4-5	± 1 kV differential mode ± 2 kV common mode	± 1 kV differential mode ± 2 kV common mode	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions, and voltage variations on power supply input lines IEC 61000-4-11	< 5% U_T (> 95% dip in U_T) for 0,5 cycle 40% U_T (60% dip in U_T) for 5 cycles 70% U_T (30% dip in U_T) for 25 cycles < 5% U_T (> 95% dip in U_T) for 5 sec	< 5% U_T (> 95% dip in U_T) for 0,5 cycle 40% U_T (60% dip in U_T) for 5 cycles 70% U_T (30% dip in U_T) for 25 cycles < 5% U_T (> 95% dip in U_T) for 5 sec	Mains power quality should be that of a typical commercial or hospital environment.
Power frequency (50/60 Hz) magnetic field IEC 61000-4-8	3 A/m	3 A/m	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.
U_T is the AC mains voltage prior to application of the test level.			

Table 46 Electromagnetic Immunity - Life Supporting Functions

Immunity Test	IEC 60601 Test Level	Compliance Level	Electromagnetic Environment - Guidance
			Portable and mobile RF communications equipment should be used no closer to any part of the HeartStart MRx, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter.
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz outside ISM bands[a]	3 Vrms	**Recommended Separation Distance** $d = 1.2\sqrt{P}$
	10 Vrms 150 kHz to 80 MHz in ISM bands[a]	10 Vrms	**Recommended Separation Distance** $d = 1.2\sqrt{P}$

Table 46 Electromagnetic Immunity - Life Supporting Functions (Continued)

Immunity Test	IEC 60601 Test Level	Compliance Level	Electromagnetic Environment - Guidance
Radiated RF IEC 61000-4-3	10 V/m 80 MHz to 2.5 GHz	10 V/m	$d = 1.2\sqrt{P}$ 80 MHz to 800 MHz $d = 2.3\sqrt{P}$ 800 MHz to 2.5 GHz where *P* is the maximum output power rating of the transmitter in watts (W) according to the transmitter's specified output power and *d* is the recommended separation distance in meters (m).[b] Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey,[c] should be less than the compliance level in each frequency range.[d] Interference may occur in the vicinity of equipment marked with the following symbol: 
At 80 MHz and 800 MHz, the higher frequency range applies. These guidelines my not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.			

[a] The ISM (industrial, scientific, and medical) bands between 150 kHz and 80 MHz are 6.765 MHz to 6.795 MHz; 13.553 MHz to 13.567 MHz and 26.957 MHz to 27.283 MHz; and 40.66 MHz to 40.70 MHz.

[b] The compliance levels in the ISM frequency bands between 150 kHz and 80 MHz and in the frequency range 80 MHz to 2.5 GHz are intended to decrease the likelihood that mobile/portable communications equipment could cause interference if it is inadvertently brought into patient areas. For this reason, an additional factor of 10/3 is used in calculating the recommended separation distance for transmitters in these frequency ranges.

[c] Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the HeartStart MRx is used exceeds the applicable RF compliance level above, the HeartStart MRx should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as re-orienting or relocating the HeartStart MRx.

[d] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.

Table 47 Electromagnetic Immunity - Nonlife Supporting Functions

Immunity Test	IEC 60601 Test Level	Compliance Level	Electromagnetic Environment - Guidance
			Portable and mobile RF communications equipment should be used no closer to any part of the HeartStart MRx, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter.
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz	3 Vrms	**Recommended Separation Distance** $d = 1.2\sqrt{P}$
Radiated RF IEC 61000-4-3	3 V/m 80 MHz to 2.5 GHz	3 V/m	$d = 1.2\sqrt{P}$ 80 MHz to 800 MH $d = 2.3\sqrt{P}$ 800 MHz to 2.5 GHz where *P* is the maximum output power rating of the transmitter in watts (W) according to the transmitter's specified output power and *d* is the recommended separation distance in meters (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey,[a] should be less than the compliance level in each frequency range.[b] Interference may occur in the vicinity of equipment marked with the following symbol: 
At 80 MHz and 800 MHz, the higher frequency range applies. These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.			
[a] Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the HeartStart MRx is used exceeds the applicable RF compliance level above, the HeartStart MRx should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as re-orienting or relocating the HeartStart MRx. [b] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.			

Recommended Separation Distances

The HeartStart MRx is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the HeartStart MRx can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the HeartStart MRx as recommended below, according to the maximum output power of the communications equipment.

Table 48 Recommended Separation Distances

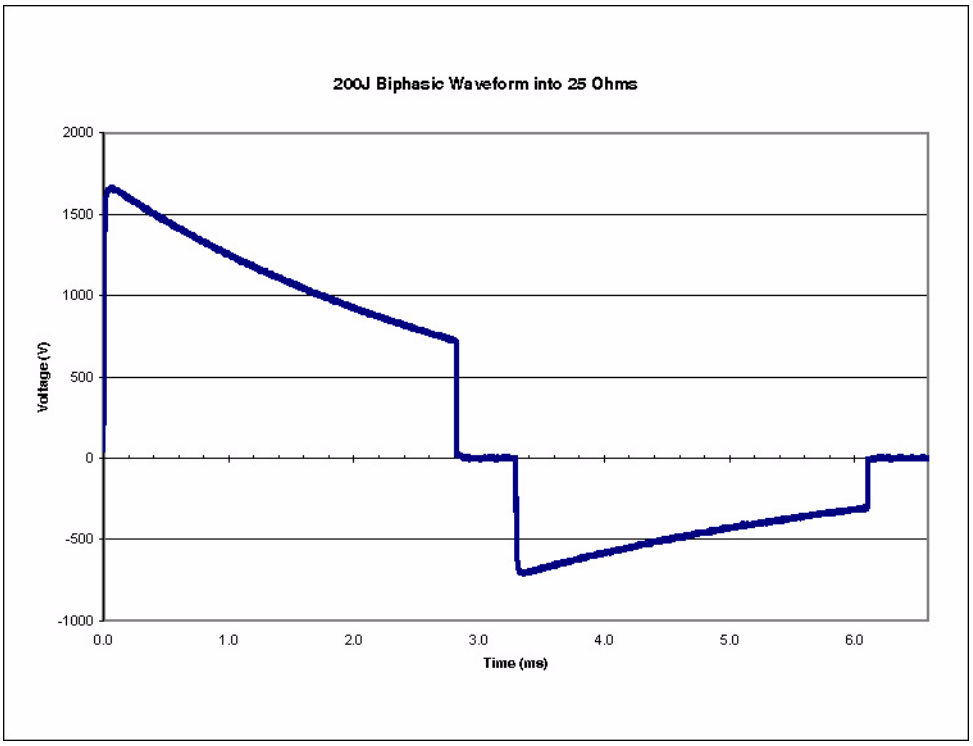
	Separation Distance According to Frequency of Transmitter (m)	
Rated Maximum Output Power of Transmitter (W)	**150 kHZ to 800 MHz** $d = 1.2\sqrt{P}$	**800 MHz to 2.5 GHz** $d = 2.3\sqrt{P}$
0.01	0.1 m	0.2 m
0.1	0.4 m	0.7 m
1	1.2 m	2.3 m
10	4 m	7 m
100	12 m	23 m

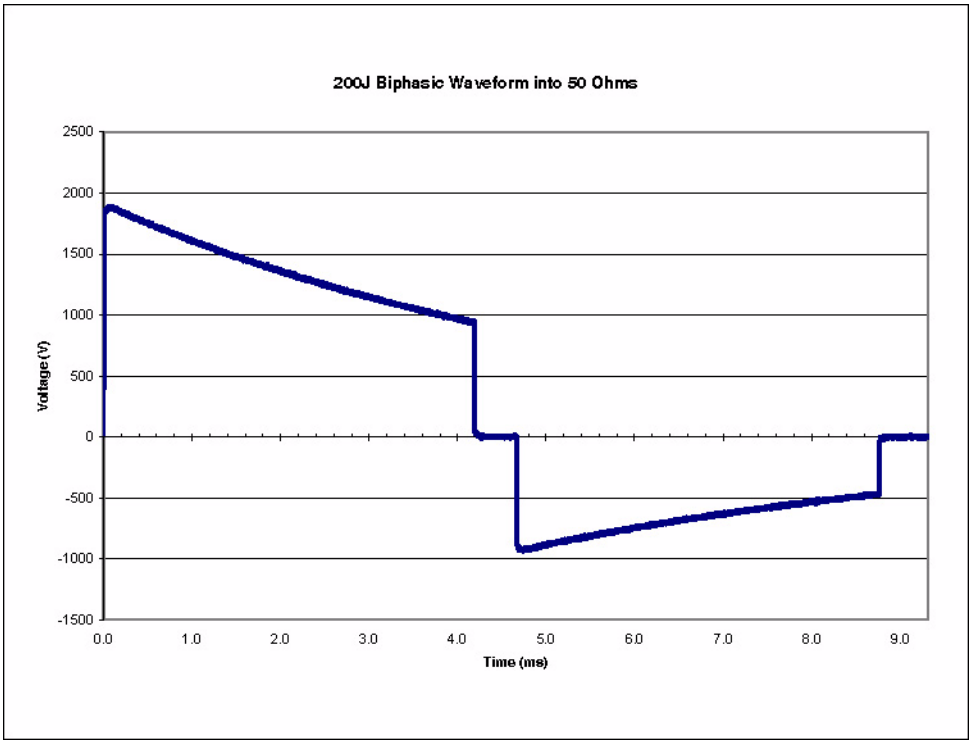
For transmitters rated at a maximum output power not listed above, the recommended separation distance *d* in meters (m) can be determined using the equation applicable to the frequency of the transmitter, where *P* is the maximum output power rating of the transmitter in watts (W) according to the transmitter's manufacturer.

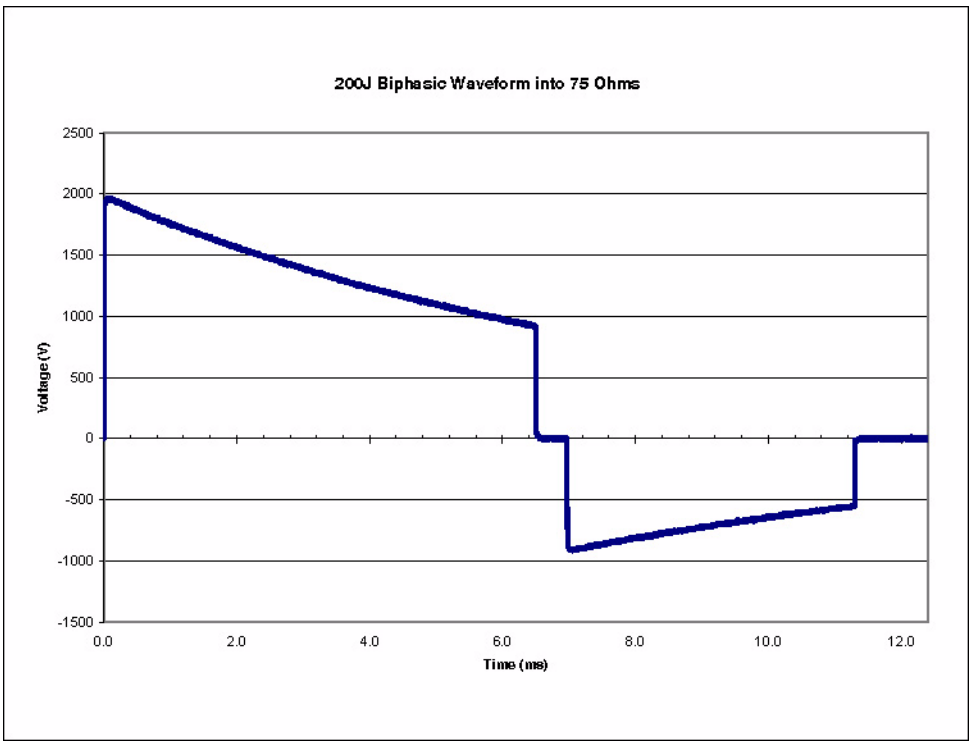
At 80 MHz and 800 MHz, the higher frequency range applies.

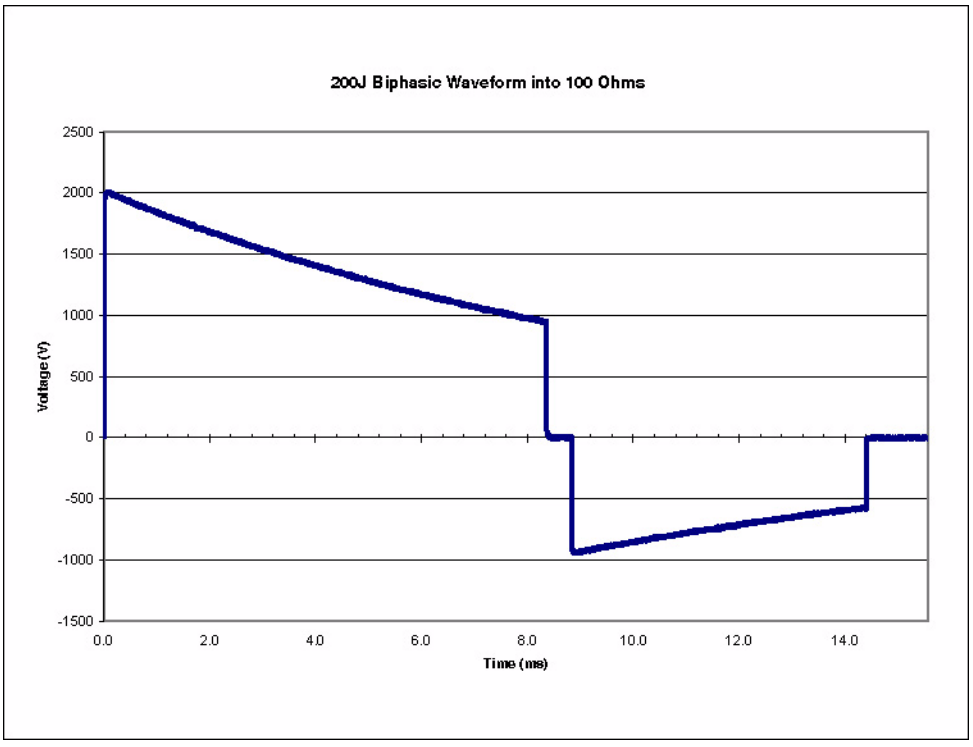
These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

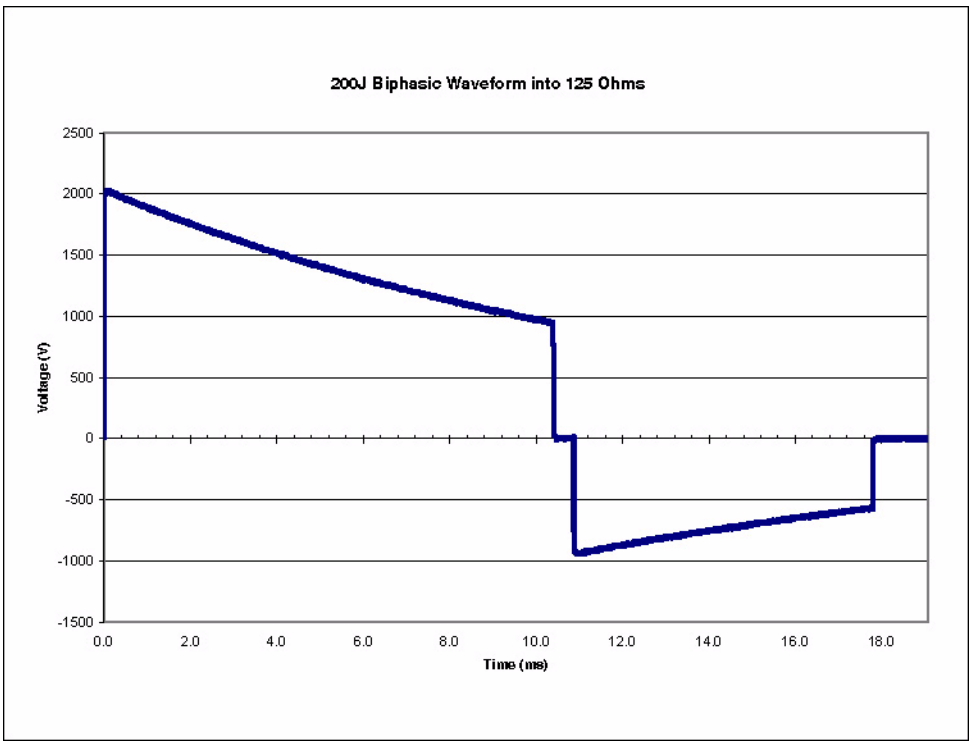
Waveforms

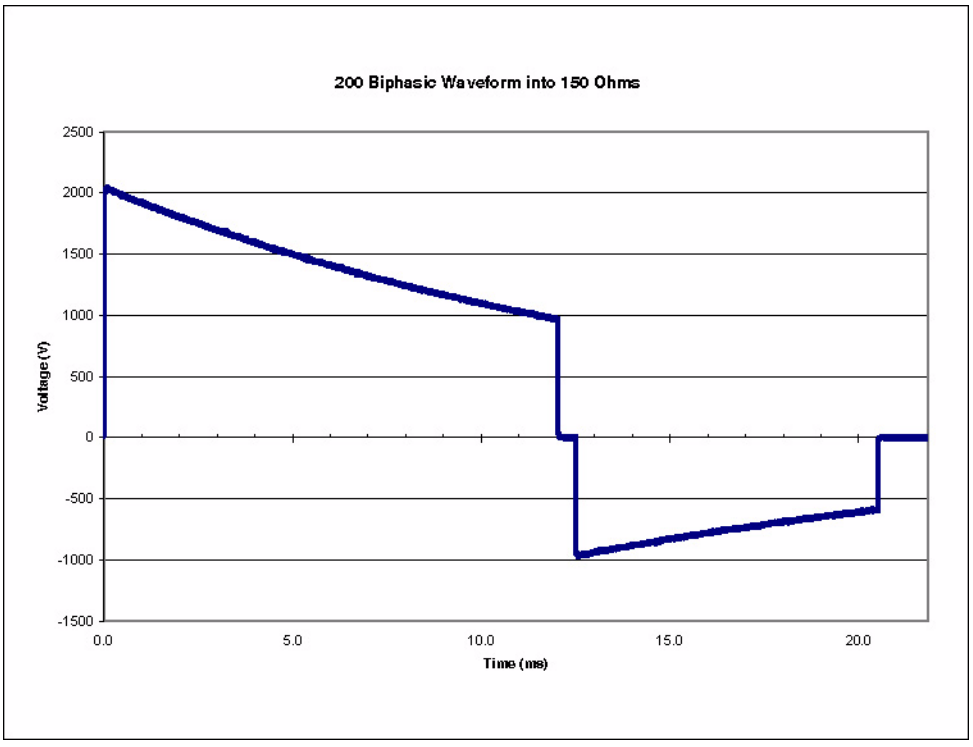

200J Biphasic Waveform into 25 Ohms
2000
1500
1000
500
0
-500
-1000
Voltage (V)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Time (ms)

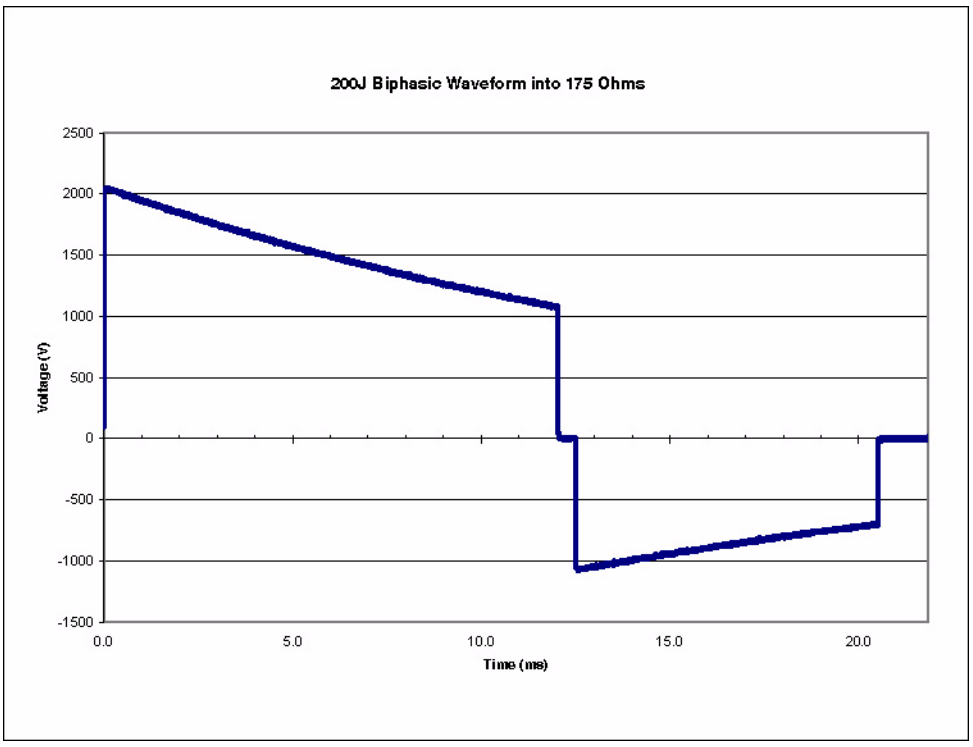

200J Biphasic Waveform into 50 Ohms
2500
2000
1500
1000
500
0
-500
-1000
-1500
Voltage (V)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Time (ms)

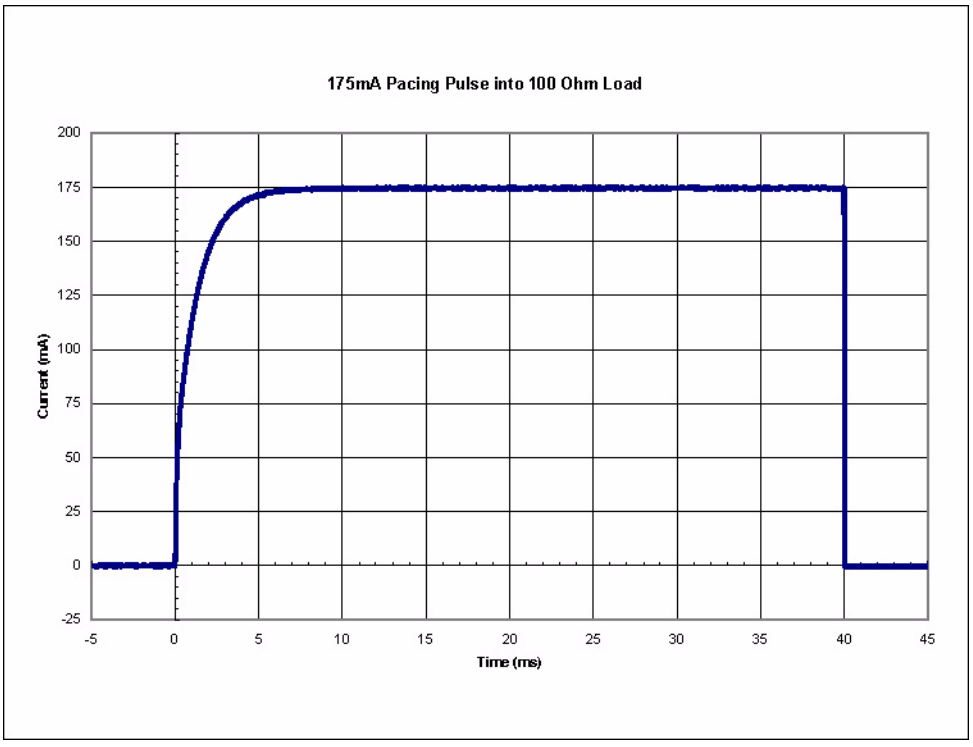

200J Biphasic Waveform into 75 Ohms
2500
2000
1500
1000
500
0
-500
-1000
-1500
Voltage (V)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Time (ms)


200J Biphasic Waveform into 100 Ohms
2500
2000
1500
1000
500
0
-500
-1000
-1500
Voltage (V)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
Time (ms)


200J Biphasic Waveform into 125 Ohms
2500
2000
1500
1000
500
0
-500
-1000
-1500
Voltage (V)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
Time (ms)


200 Biphasic Waveform into 150 Ohms
2500
2000
1500
1000
500
0
-500
-1000
-1500
Voltage (V)
0.0
5.0
10.0
15.0
20.0
Time (ms)


200J Biphasic Waveform into 175 Ohms
2500
2000
1500
1000
500
0
-500
-1000
-1500
Voltage (V)
0.0
5.0
10.0
15.0
20.0
Time (ms)


175mA Pacing Pulse into 100 Ohm Load
200
175
150
125
100
75
50
25
0
-25
Current (mA)
-5
0
5
10
15
20
25
30
35
40
45
Time (ms)

Index

N

O

P

R

S

T

U

V

W