Service Guide

SureSigns VS2+ and VSi

Vital Signs Monitors

Release B.01

English

PHILIPS

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First Edition

PHILIPS

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Vital Signs Monitors

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Notice

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Printing History

New editions of this document incorporate all material updated since the previous edition. Update packages may be issued between editions and contain replacement and additional pages to be merged by a revision date at the bottom of the page. Pages that are rearranged due to changes on a previous page are not considered revised.

The documentation printing date and part number indicate its current edition. The printing date changes when a new edition is printed. (Minor corrections and updates that are incorporated at reprint do not cause the date to change.) The document part number changes when extensive technical changes are incorporated.

First Edition . . . . . .March 2012

Conventions

This section describes the conventions used in this guide.

Text Formatting

The following typographical conventions are used in this guide.

Typeface	Usage	Example
Bold	System keys	Press the **Main Screen** key.
Special bold	User interface text	Open the **System Menu**.
Italic	Variables, document titles	• *<product name>-<hardware configuration>-<software version>*.cfg • *SureSigns VM Series Instructions for Use*

Decimal Points

Because the SureSigns monitor uses a period (.) to indicate a decimal point in decimal numbers (for example, 10.0), all decimal numbers in this guide use a period as a decimal point. Commas are not used as decimal points.

Notes, Cautions, and Warnings

This guide uses the following conventions for Notes, Cautions, and Warnings.

Note — A **Note** calls attention to an important point in the text.

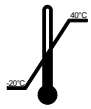
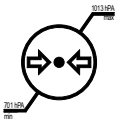
Caution **A Caution calls attention to a condition or possible situation that could damage or destroy the product or the user's work.**

Warning **A *Warning* calls attention to a condition or possible situation that could cause injury to the user and/or patient.**

Explanation of Symbols

The following symbols appear on the monitor and its packaging.

Symbol	Description	Symbol	Description
	Print key (VS2+ only)		Alarm Silence key
	Main Screen key		NBP key
	On/Standby key	SN	Serial number
	Up/Down key (VSi only)		Select Key (VSi only)
CE 0123	CE Marking	LOT	Batch code
Rx Only	Prescription Use Only (US Federal Law)		Date of manufacture
	Humidity limitation		Keep out of sun
	Fragile, handle with care		Keep upright
	Keep dry		Manufacturer's Name and Address
REF	Catalog number	STERILE	Sterile
	Electrostatic sensitive device handling		USB port
SpO_2	SpO_2 connector		Charging LED
	Temperature connector		AC power LED
	NBP connector	OPT	Option number

Symbol	Description	Symbol	Description
ICES-001	Canadian ISM requirement		Ethernet port
	Compliance with WEEE standard		CSA mark
100-240V ~ 50/60Hz 120VA  T 1.0 A 250V	Power label		Nurse call connector
	Caution, consult accompanying documents	**IPX1**	Ingress protection to vertically falling water drops
	Defibrillator Proof Type CF applied part		RF Interference
	EUFP (Environmentally-friendly use period — China)		Temperature limitation
	Atmospheric pressure limitation		Equipotential ground post
	CE marking and identifier for radio		Korean radio mark
IC ID	Industry Canada label for radio	**FCC ID**	FCC label for radio

Regulatory and Safety Specifications

Declaration

CE 0123

The SureSigns VS2+ and VSi vital signs monitors are Class IIb devices and comply with the requirements of the Council Directive 93/42/EEC of 14 June 1993 concerning medical devices and carry CE-marking accordingly.

CE !

The radio device used in the SureSigns VS2+ and VSi vital signs monitors are in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC (Radio Equipment and Telecommunications Terminal Equipment Directive).

Authorized EU Representative

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Germany

Rx Only

Caution **United States Federal Law restricts this device to sale by or on the order of a physician.**

Safety Standards

Parameter	Specification
VS2+: EN/IEC 60601-1, EN/IEC60601-1-2, EN/IEC 60601-2-30, EN/IEC 60601-2-49, ISO 9919	
VSi: EN/IEC 60601-1, EN/IEC60601-1-2, EN/IEC 60601-2-49, ISO 9919	
Protection Class	Class I, internally powered equipment, per IEC 60601-1
Degree of Protection	Type CF defibrillator-proof: per IEC 60601-1
Mode of Operation	Continuous
Protection Against Hazards of Ignition of Flammable Anaesthetic Mixtures	Equipment is not suitable for use in the presence of a flammable anaesthetic mixture with air or oxygen or nitrous oxide, per IEC 60601-1

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4. Troubleshooting

5. Repairing the Monitor

6. Replacement Parts and Assembly Drawings

A. Theory of Operation

B. Electromagnetic Compatibility

1 Overview

This guide includes information for both the SureSigns VS2+ and VSi vital signs monitors. Any differences are described where appropriate. The screen illustrations represent a fully configured SureSigns VS2+ monitor. The menus on your monitor may appear differently if you have a model with different options or a SureSigns VSi monitor.

Intended Audience

This guide is for biomedical engineers or technicians responsible for maintaining, troubleshooting, and repairing Philips patient monitoring systems.

Navigation Controls

The following table describes how to use the navigation controls on the VS2+ and VSi monitors:

Action	VS2+	VSi
Select	Rotate the wheel to highlight an item and press the wheel to select it.	Press the **Up/Down** key to highlight an item and then press the **Select** key to select it.
Scroll	Rotate the wheel to highlight the list and press the wheel. To scroll through the list, rotate the wheel. To select items in the list, press the wheel.	Press the **Up/Down** key to highlight the list and press the **Select** key. To scroll through the list, press the **Up/Down** key. To select items in the list, press the **Select** key.
Select or clear check boxes	Rotate the wheel to highlight the check box and press the wheel to select it.	Press the **Up/Down** key to highlight the check box and press the **Select** key to select it.
Enter text	Rotate the wheel to highlight the field and press the wheel. Rotate the wheel to select the text and press the wheel to save it.	Press the **Up/Down** key to highlight the field and press the **Select** key. Press the **Up/Down** key to select the text and press the **Select** key to save it.

SureSigns VS2+ and VSi Documentation

SureSigns VS2+ and VSi documentation includes:

- ***SureSigns VS2+ and VSi Installation and Configuration Guide***: Provides instructions for unpacking, installing, and connecting all hardware. Includes initial testing and configuration procedures. Also includes instructions for returning the monitor.
- ***SureSigns VS2+ Instructions for Use***: Provides information for day to day operation of the VS2+ monitor. Also includes safety information, monitor specifications, and a list of compatible accessories.
- ***SureSigns VSi Instructions for Use***: Provides information for day to day operation of the VSi monitor. Also includes safety information, monitor specifications, and a list of compatible accessories.

Note — For information about purchasing additional copies of the *SureSigns VS2+ or VSi Instructions for Use*, contact the Philips Customer Care Center.

- ***SureSigns VS2+ Quick Card***: Provides brief descriptions of commonly used VS2+ functions.
- ***SureSigns VSi Quick Card***: Provides brief descriptions of commonly used VSi functions.
- ***SureSigns VS2+ and VSi Service Guide***: Provides information for maintaining, testing, and troubleshooting the monitor. Includes assembly diagrams, spare parts lists, and troubleshooting information.
- ***SureSigns VS2+ and VSi Data Export Guide***: Provides detailed information about the syntax and structure of the HL7 messages that are exported from the VS2+ monitors and VSi monitors.
- ***SureSigns VS2+ and VSi Network Configuration Guide***: Provides instructions for configuring your VS2+ monitors and VSi monitors to connect to a network using a wired LAN connection, a wireless LAN connection, or an RS-232 serial adapter.

2
Performing Routine Maintenance

Recommended Frequency

Perform the maintenance procedures at the recommended frequency shown in the following table.

Caution **The frequency recommendations in the following table do not supersede local requirements. Always perform locally required testing in addition to the testing outlined here.**

Maintenance Procedure	Frequency
Routine Safety and Operational Checks	
• Visual Inspection of exterior for damage	Before use
• Inspection of labels for legibility	Before use
Cleaning and Disinfecting	According to your institution's policy or between each patient
Battery	
• Charging	As needed
• Reconditioning	Every six months

Routine Safety and Operational Checks

Philips recommends that you regularly:

- Visually inspect the monitor exterior for damage.
- Inspect the monitor labels for legibility.

  If the labels on the rear case are not legible, send the monitor for repair to replace the rear case. If the serial number label is not legible, return the monitor for label replacement.

Philips recommends that you perform certain tests and verification checks at least once a year and after each repair. For complete information about performing verification testing and checks, see Chapter 3, "Performance Verification Testing."

Cleaning and Disinfecting

To clean or disinfect your SureSigns monitor, use only the cleaning agents approved by Philips. For complete cleaning instructions, see the *Instructions for Use* for your monitor.

Maintaining the Battery

The rechargeable lithium ion battery used in the monitor is a *smart battery* with built-in circuitry that communicates battery status information to the monitor. Battery power lasts a minimum of 4.5 hours during continuous monitoring with no printing (VS2$^+$ only) and one NBP measurement every 15 minutes.

Observe these guidelines:

- If a battery shows damage or signs of leakage, replace it immediately.
- **Never** use a faulty battery in the monitor.
- **Never** dispose of the battery in a normal waste container.
- **Never** leave a battery inside the monitor if it is not used for a long period of time.
- **Never** store a battery that is more than 50% charged.

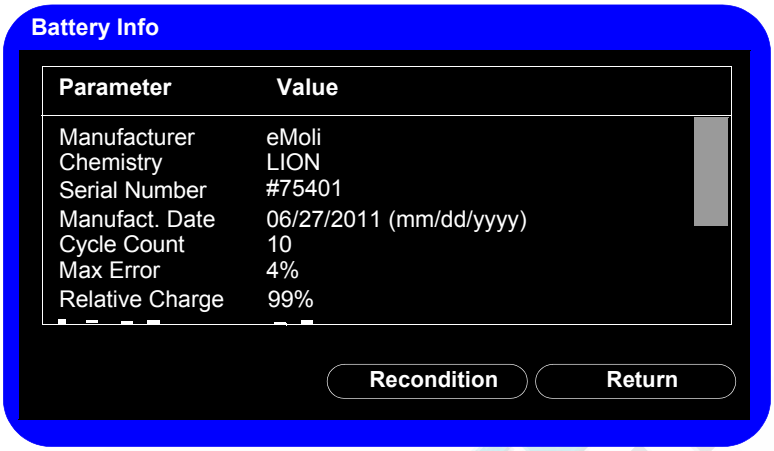
Note — For information about the battery status indicators, see the *SureSigns VSi Instructions for Use* or the *SureSigns VS2$^+$ Instructions for Use*.

Viewing Battery Information

As a battery ages, its capacity decreases and the battery status indicator becomes increasingly less accurate, relative to the total number of charges and discharges. The **Battery Info** menu displays battery parameters.

To view information about the battery:

Step	
1	Access the **System Admin Menu**. See “Accessing the System Admin Menu” on page 3-4.
2	Select the **Service** button.
3	Select the **Diagnostics** button.

Step	
4	In the **System Diagnostics** menu, select the **Battery Info** button. The **Battery Info** menu appears, showing the battery parameters. For example:  **Note —** *Ensure that the battery is connected if the following message appears:* **No data from battery. Please see Service Guide.** *For detailed information, see "Battery Messages and Alarms" on page 2-4.*
5	To view the entire list of parameters, select the list to activate scrolling.

The **Battery Info** menu provides detailed information about battery capacity and charging status, including:

- **Cycle Count**: The number of full charge and discharge cycles calculated by the battery.
- **Max Error**: The expected margin of error in the state of the charge calculation. The **Max Error** value is the difference between the **Relative Charge** value and the **Absolute Charge** value.
- **Relative Charge**: The predicted remaining battery capacity, expressed as a percentage of **Full Capacity**. The value in the **Relative Charge** field decreases as the battery ages. The battery **status** icon is a graphic representation of the **Relative Charge**.
- **Absolute Charge**: The predicted remaining battery capacity, expressed as a percentage of **Design Capacity**.
- **Full Capacity**: The predicted capacity of the battery when it is fully charged. The value in the **Full Capacity** field decreases as the battery ages. The difference between the value in the **Full Capacity** field and the value in the **Design Capacity** field is an indication of battery condition.
- **Design Capacity**: The capacity of a new battery.

Reconditioning the Battery

Reconditioning the battery reduces the **Max Error** value, and in turn, increases the accuracy of the **Relative Charge**. Philips recommends that you condition the battery by fully discharging and recharging it every six months.

Step	
1	Open the **Battery Info** menu. See "Viewing Battery Information" on page 2-2.

2	Select the **Recondition** button. The **Battery Reconditioning** menu appears. The reconditioning proceeds automatically and the battery is discharged and recharged twice. The screen displays status messages during the process. When the process is complete, a message, **Reconditioning Complete**, appears.
3	Select the **Return** button. The **Battery Info** menu appears. **Note —** *If the battery does not recharge after four reconditioning cycles, replace it.*

Replacing the Battery

Replace the battery if the following conditions occur:

- After reconditioning, if the monitor operates for less than one hour on a fully charged battery before the low battery alarm occurs.
- After reconditioning, if the **Max Error** value does not exceed 2%.
- If the battery does not recharge to full capacity after four reconditioning cycles.

For information about replacing the battery, see "Removing the Battery" on page 5-3.

Warning **Dispose of used batteries in an environmentally responsible manner. Do not dispose of the battery in normal waste containers. Consult your hospital administrator to find out about local arrangements.**

Battery Messages and Alarms

The condition of the battery is reported by messages, technical alarms, and error codes.

When the monitor is in standby mode, the **Battery service required** message appears if the following occurs:

- The **Max Error** value exceeds 8%.
- The **Full Capacity** value is half of the **Design Capacity** value.

Recondition the battery to clear the message. For information about the battery reconditioning procedure, see "Reconditioning the Battery" on page 2-3.

Technical Alarms

The following battery technical alarms appear in the monitor's message area:

- **Low Batt** — Remaining battery power is less than 30%.
- **Extreme Low Batt** — Remaining battery power is less than 21%.

Error Codes

An error code (for example, **257 System Error**, indicating Battery charger power failure) appears in the Error Log. To view the Error Log, see "Viewing, Exporting, and Printing (VS2+ Monitor Only) the Error Log" on page 4-36. For a complete list of error codes and actions to take, see Chapter 4, "Troubleshooting."

3
Performance Verification Testing

This chapter includes the following information:

- Testing and inspection guidelines
- Recommended frequency of performance tests
- Test procedures following monitor repair or during routine maintenance
- Calibration procedures

If the monitor fails any test, it must be repaired before it is returned to use.

Note — The procedures in this chapter assume knowledge of basic monitor operation. For information about using the monitor, see the *Instructions for Use* for your monitor.

Testing and Inspection Guidelines

The following table lists the tests that Philips requires you to complete after performing monitor installations, repairs, or software upgrades.

For information about routine maintenance, see Chapter 2, “Performing Routine Maintenance.”

For information about repair procedures, see Chapter 5, “Repairing the Monitor.”

After	Complete these tests
Upgrading the software	Power-on self test
Opening the monitor for any reason	• Power-on self test • Alarms Test • Pneumatic leakage test • All safety tests
Replacing any internal parts (except NBP module, SpO_2 board, Temperature module)	• Power-on self test • Pneumatic leakage test • All safety tests
Replacing the NBP module	• Power-on self test • NBP test • Pneumatic leakage test • All safety tests
Replacing the SpO_2 module	• Power-on self test • SpO_2 Test • Pneumatic leakage test • All safety tests

After	Complete these tests
Replacing the temperature module	• Power-on self test • Alarms Test • Temperature Test • Pneumatic leakage test • All safety tests
Replacing the wireless module	• Power-on self test • Alarms Test • Pneumatic leakage test • All safety tests

Recommended Frequency

Perform the test procedures at the recommended frequency outlined in the following table.

Caution **The frequency recommendations in the following table do not supersede local requirements. Always perform locally required testing in addition to the testing outlined in the table.**

Suggested Testing	Frequency
Preventive Maintenance	
NBP calibration	Once every two years.
Battery reconditioning	Once every six months.
Performance	
• Temperature accuracy • NBP accuracy test • SpO_2	Once every two years, or if you suspect the measurement is incorrect.
• Nurse call relay[1]	Before first use, and then once every two years.
Safety In accordance with IEC 60601-1	
• Enclosure leakage current • Ground integrity • Patient leakage currents	Once a year and after repairs where the monitor has been opened (front and back separated) or if the monitor has been damaged by impact.

1. When used as part of facility protocols.

Required Test Equipment

The following table lists the additional test equipment that you need to perform each of the tests in this chapter. Many of these tests also use the standard accessories that are shipped with the monitor.

To Perform This Test	You Need This Test Equipment
"Visual Test" on page 3-11	None
"Power-On Self Test" on page 3-11	None
"Alarms Test" on page 3-12	Temperature probe and well
"SpO_2 Test" on page 3-13	Adult SpO_2 sensor
"NBP Tests" on page 3-13	• Reference manometer (includes hand pump and valve), with an accuracy 0.2% • Expansion chamber (volume 250 ml ± 10%) • Appropriate tubing
"Temperature Test" on page 3-16	• Temperature well and probe • SureSigns temperature calibration key (part number 4535 640 33691)
"Safety Tests" on page 3-17	Multimeter
"Nurse Call Relay Test" on page 3-20	• Patient simulator • Ohmmeter • Phono connector

Test Recording

Authorized Philips personnel report test results back to Philips to add to the product development database. Hospital personnel, however, do not need to report results.

The following table describes what to record on the service record after you complete the tests in this chapter.

Note — P = pass, **F** = fail, **X** = measured value as defined in tests in this chapter.

Test	What to record
Visual	V:P or V:F
Power-On	PO:P or PO:F
NBP	NBP:P/X1/X2/X3 or NBP:F/X1/X2/X3
Safety	S(1): P/X1/X2 or S(1):F/X1/X2 S(2): P/X1 or S(2): F/X1 S(3): P/X1 or S(3): F/X1

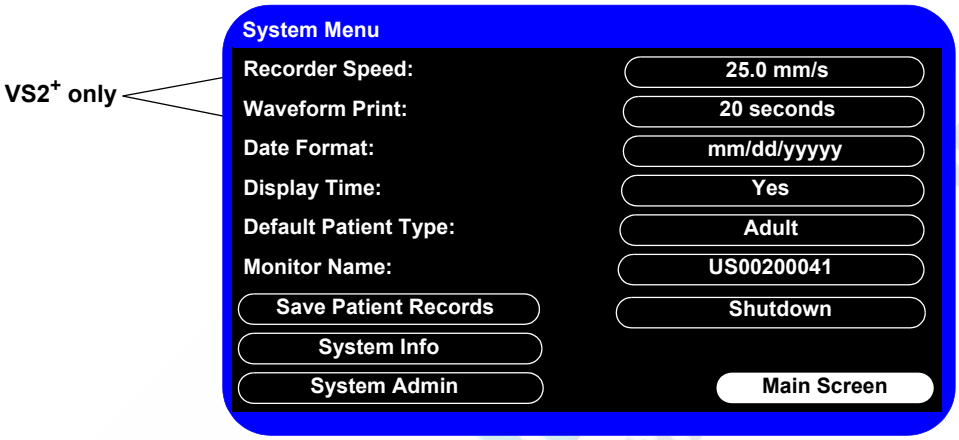
Accessing the System Menu

Use the **System Menu** to configure the monitor, view system information, shut down the monitor, and access the **System Admin Menu**. For more information about using the **System Menu** to configure the monitor, see the *Instructions for Use* for your monitor or the *SureSigns VS2+ and VSi Installation and Configuration Guide*.

To access the **System Menu**:

- Select the **System** button.

  The **System Menu** appears.

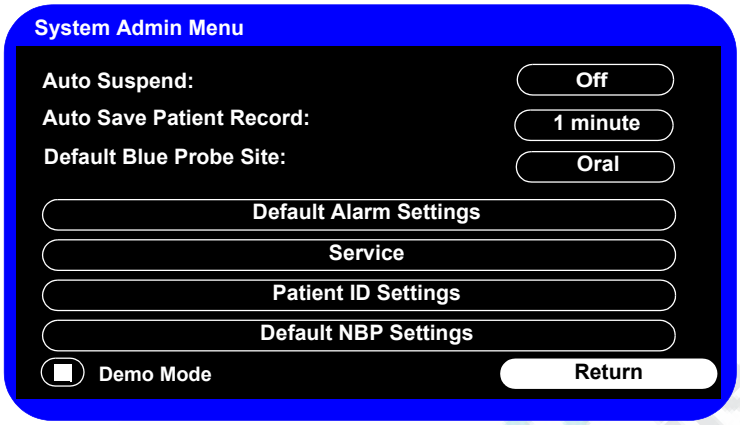


Accessing the System Admin Menu

Use the **System Admin Menu** to configure password-protected functions, including Demo mode, system diagnostics, and upgrading the software. For more information about using the **System Admin Menu** to configure the monitor, see the *SureSigns VS2+ and VSi Installation and Configuration Guide*.

To access the **System Admin Menu**:

Step	
1	In the **System Menu**, select the **System Admin** button.
2	In the window that appears, enter the Administrator password, **2-1-5**, as shown: 

Step	
3	Select the **OK** button. The **System Admin Menu** appears.  **Caution** **The System Admin Menu remains unlocked for 1 minute after you close it. This allows you to open the menu again without having to re-enter the password. Do not leave the monitor unattended during the *unlock* time.**

System Admin Menu Options

The following table describes the **System Admin Menu** options that are described in this guide. All other options on the menu are described in the *SureSigns VS2+ and VSi Installation and Configuration Guide*.

Option	Description
Demo Mode	Demo mode allows you to demonstrate the monitor without actually monitoring parameters. For more information, see "Enabling Demo Mode" on page 3-6.
Service	Allows access to the following functions: • **Diagnostics** — Opens the **System Diagnostics** menu. Monitoring is suspended while this menu is open. **Note —** *This button is unavailable when the monitor is running in Demo mode.* For more information, see "Performing Verification Tests" on page 3-9. • **Upgrade Software** — Opens the **Upgrade Software** menu. For more information, see "Upgrading the Software" on page 3-7.
Return	Returns the monitor to the **System Menu**.

Enabling Demo Mode

Warning **Do not connect a patient to a monitor running in Demo mode. Values represented in Demo mode do not represent measurements from a patient connected to the monitor, and may lead to incorrect diagnoses.**

Demo mode is used to demonstrate the monitor without monitoring parameters. Demo mode simulates all patient parameters and generates alarms when alarm settings are exceeded.

By default, the **Demo Mode** check box is cleared.

Caution **Entering Demo mode clears the patient data.**

To put the monitor in Demo mode:

Step	
1	Open the **System Admin Menu**. See “Accessing the System Admin Menu” on page 3-4.
2	Select the **Demo Mode** check box.
3	Select the **Return** button.
4	In the window that appears, select the **Yes** button. The monitor enters Demo mode and clears all patient data. A DEMO banner appears on the screen. 
5	To exit Demo mode, press the **On/Standby** key to turn off the monitor. The monitor clears all simulated patient data.

Upgrading the Software

Caution **Before you upgrade the software, you can back up the system settings by exporting the current configuration settings or by recording them on the worksheets provided in the *SureSigns VS2+ and VSi Installation and Configuration Guide*. For more information, see the *SureSigns VS2+ and VSi Installation and Configuration Guide*.**

Never downgrade the software to an earlier version. Doing so may cause hardware incompatibility and loss of system settings and patient records. The current software version is displayed on the start-up screen and the System Information window.

When you upgrade the software:

- **Charge the battery before upgrading the software.**
- **Never perform a software upgrade with the monitor connected to a patient.**
- **Disconnect any USB peripherals.**
- **Do not upgrade the software through a USB hub.**
- **If the USB port has a clamp in place, you may need to remove the clamp to ensure that the flash drive fits properly.**
- **If you upgrade from software version B.01.34 with Portuguese, Norwegian, Danish, Finnish, Russian, or Swedish configured, the language defaults to English and all system settings and patient data will be deleted from the monitor during the upgrade. To prevent loss of your patient data, ensure it has been exported to the EHR, print it, or save it to a USB drive for storage. Exported patient data, however, cannot be imported back into the monitor. For detailed information about saving patient data, see the *Instructions for Use* for your monitor.**

After the upgrade starts:

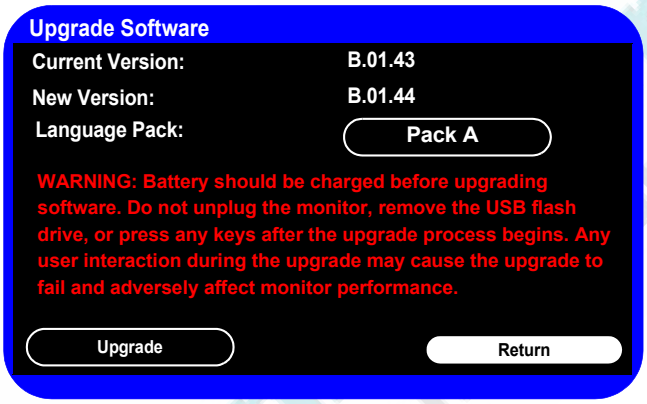
- **Do not unplug the monitor.**
- **Do not remove the USB flash drive.**
- **Do not press any keys.**

If the upgrade is inadvertently interrupted and the main board data is lost, replace the main board. For more information, see “Replacing the Main Board” on page 5-22.

Note — Philips recommends using a SanDisk® or Kingston® USB flash drive for software upgrades.

To upgrade the software:

Step	
1	Connect the monitor to an AC power source and press the **On/Standby** key. **Note —** *Your monitor must be connected to AC power and have a fully charged battery before you upgrade the software.*
2	Insert the USB flash drive with the software upgrade into the USB port on the back of the monitor. **Note —** *The software upgrade folder must be located in the top directory of the USB flash drive (for example, F:\).*

2	Insert the USB flash drive with the software upgrade into the USB port on the back of the monitor. **Note —** *The software upgrade folder must be located in the top directory of the USB flash drive (for example, F:\).*
3	Access the **System Admin Menu**. For detailed information, see "Accessing the System Admin Menu" on page 3-4.
4	Select the **Service** button. The **Service Menu** appears.
5	Select the **Upgrade Software** button. The monitor searches for a valid software image on the USB flash drive and displays the updated image information in the **Upgrade Software** menu.  **Note —** *If the USB flash drive is not detected, ensure that the drive is completely inserted into the USB connector.*
6	Select the appropriate **Language Pack** to install. The following message appears:  **Note —** *If you upgrade the software using the same language pack that is currently installed, the current language is the default If you upgrade to a different language pack, the default language is English. If needed, reset the language using the* **System Admin Menu**. *For details on resetting the language, see the* ***SureSigns VS2+ and VSi Installation and Configuration Guide.***

7	Select the **Upgrade** button to start the upgrade. The **Upgrade in Progress** indicator increments during the upgrade process. When the upgrade is complete, the **Checking Memory CRC** and **Upgrade Successful** messages appear. When the software upgrade is complete, the monitor automatically shuts down and restarts.
8	Remove the USB flash drive.

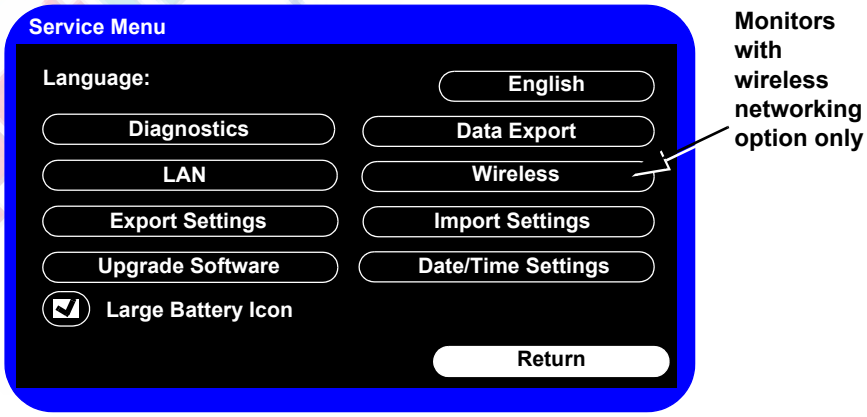
Performing Verification Tests

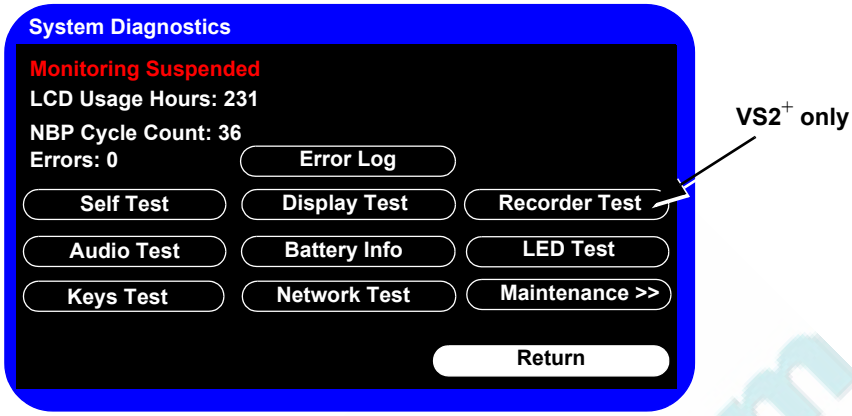
Some of the verification tests require using the **System Diagnostics** menu or the **Maintenance** options. When you open the **System Diagnostics** menu, monitoring is suspended.

Accessing the System Diagnostics Menu

Note — The **System Diagnostics** menu is not available in Demo mode.

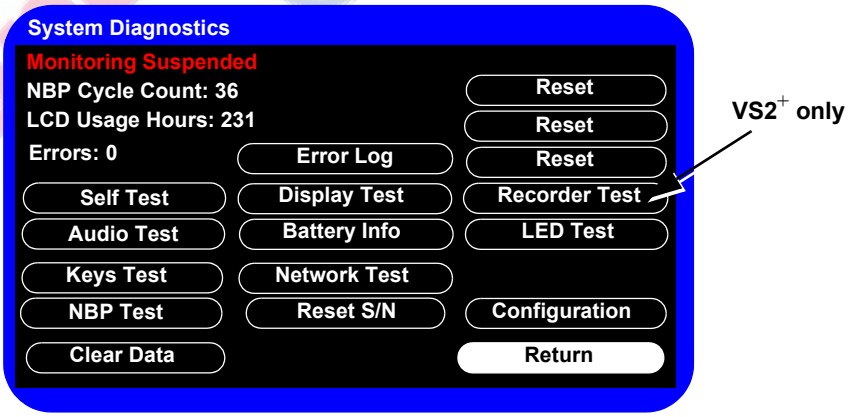
To access the **System Diagnostics** menu:

Step	
1	Access the **System Admin Menu**. For detailed information, see "Accessing the System Admin Menu" on page 3-4.
2	Select the **Service** button. The **Service Menu** appears.  **Note —** *For information about network settings, see the* ***SureSigns VS2+ and VSi Network Configuration Guide****.*

3	Select the **Diagnostics** button. The **System Diagnostics** menu appears. 

Accessing the Maintenance Options

To access the **Maintenance** options:

Step	
1	In the **System Diagnostics** menu, select the **Maintenance >>** button.
2	In the window that appears, enter the password, **1**-**2**-**9**, as shown: 
3	Select the **OK** button. The **Maintenance** options appear.  **Note —** *For information about the* **Network Test***, see the* ***SureSigns VS2+ and VSi Network Configuration Guide***.

Visual Test

To perform the visual test:

Step	
1	Inspect the system for obvious signs of damage such as cracks, cuts, or breakage.
2	Check all external cables and accessories for damage such as cuts, kinks, or wrong connections.
3	Ensure that all markings and labeling are legible. If the labels on the rear case are not legible, replace the rear case. If the serial number label is not legible, contact the Philips Customer Care Center or your local Philips representative to return the monitor for label replacement.
4	Check for any obstructions to mechanical parts. The expected test result is that the system has no obvious signs of damage or obstruction. **Note —** *Philips employees record this value as **V:P** or **V:F**.*

Power-On Self Test

To perform the power-on self test:

Step	
1	Connect the monitor to an AC power source.
2	Press the **On/Standby** key to power on the monitor.

3	Make sure that the monitor restarts successfully as described in the following sequence: • The screen displays color bars for about five seconds. • The LCD turns off for three seconds, and the Charging LED lights. **Note —** It can take up to 40 seconds for the Charging LED to light. • The Philips screen appears for one second, and a startup tone sounds. • The main screen appears. The expected result is that the monitor restarts and displays the main (or appropriate) screen. For detailed information about the start-up and power sequences, see "Start-up and Power Sequences" on page 4-3. If the LEDs do not function as expected, see "Power Problems" on page 4-6. If the display does not function as expected, see "Power Problems" on page 4-6 or "Display Problems" on page 4-7. If you do not hear a startup tone, or the monitor displays the **Speaker Malfunc** error message, see "Error Codes" on page 4-12. **Note —** *Philips employees record this value as **PO:P** or **PO:F**.*

Alarms Test

This test allows you to verify that the monitor alarms are working.

To test the monitor alarms:

Step	
1	With the monitor turned on, make sure that all alarms are enabled (the monitor is not in Audio Pause or Audio Off mode).
2	Block the NBP connector opening with your finger and press the **NBP** key.
3	Check that the **NBP Overpressure** message appears and an alarm tone sounds.
4	If you do not get the results in Step 3, see "Alarm Problems" on page 4-7.

SpO_2 Test

This test checks the performance of the SpO_2 measurement.

To perform this test, you need an Adult SpO_2 sensor. For information about compatible SpO_2 sensors, see the *Instructions for Use* for your monitor.

To perform the SpO_2 Test:

Step	
1	Connect a properly functioning adult SpO_2 sensor to the SpO_2 connector on the monitor. Ensure that the red LED in the sensor is lit.
2	Connect the other end of the sensor to your finger.
3	Verify that the SpO_2 value displayed on the monitor is between 95% and 100%. If it is not, try the test again with a patient simulator.
4	If you still do not get the results in Step 3, see "SpO_2 Measurement Problems" on page 4-9.

Caution **A functional tester cannot be used to assess the accuracy of a pulse oximeter monitor. However, if there is independent demonstration that a particular calibration curve is accurate for the combination of a pulse oximeter monitor and a pulse oximeter sensor, then a functional tester can measure the contribution of a monitor to the total error of a monitor/sensor system. The functional tester can then measure how accurately a particular pulse oximeter monitor is reproducing that calibration curve.**

NBP Tests

The NBP tests check the performance of the non-invasive blood pressure measurement. Perform each of the following procedures when checking the NBP module:

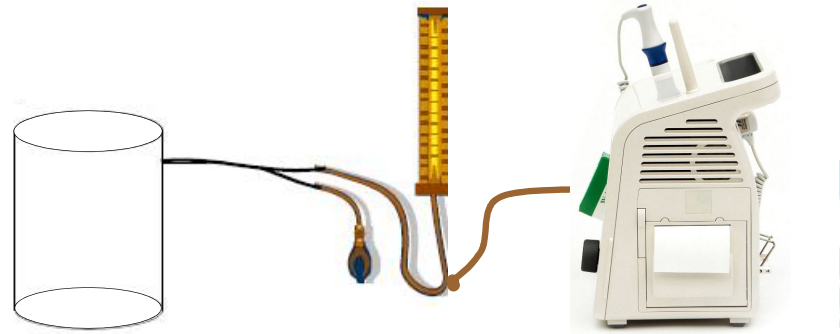
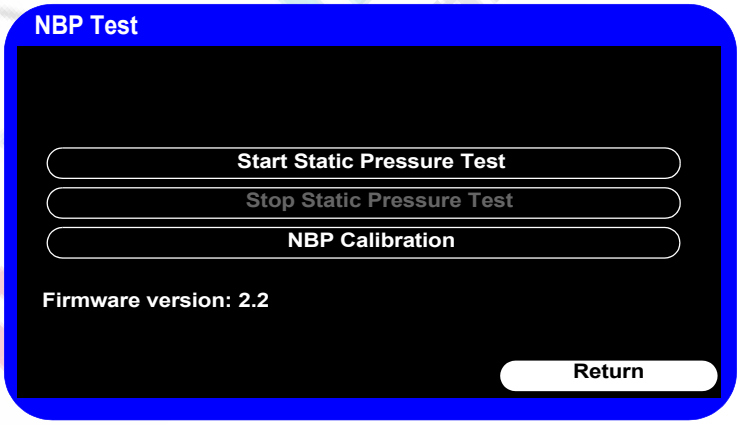
- NBP accuracy
- NBP calibration procedure (if required)
- NBP pneumatic leakage test

To perform this test, you need the following:

- Reference manometer (includes hand pump and valve), accuracy 0.2% of reading
- Expansion chamber (volume 500 ml ± 10%)
- Tubing

NBP Accuracy

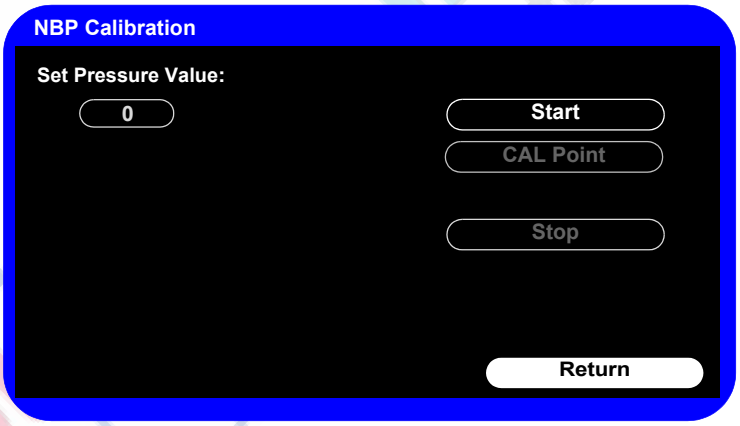
To test the NBP accuracy:

Step	
1	Connect the manometer and the pump with tubing to the NBP connector on the monitor.
2	Connect the tubing to the expansion chamber (250 ml cylinder).  **Expansion chamber** **Manometer** **SureSigns VS2+/VSi monitor**
3	Open the **Maintenance** options in the **System Diagnostics** menu. See “Accessing the Maintenance Options” on page 3-10.
4	Select **NBP Test**. The **NBP Test** menu appears. 
5	Select the **Start Static Pressure Test** button.
6	Squeeze the manometer pump and apply a pressure of 280 mmHg.
7	Wait 10 seconds for the pressure to stabilize. Note the pressure displayed in the **NBP Test** menu. The expected result is 280 mmHg ± 3 mmHg. **Note —** *Philips employees record this value as **X1**.*
8	Squeeze the manometer pump to apply a pressure of 150 mmHg.

9	Wait 10 seconds for the pressure to stabilize. Note the pressure displayed in the **NBP Test** menu. The expected result is 150 mmHg ± 3 mmHg. **Note —** *Philips employees record this value as **X2**.*
10	Select the **Stop Static Pressure Test** button.
11	If the difference between the manometer reading and displayed values is greater than 3 mmHg, calibrate the monitor (see "NBP Calibration Procedure" on page 3-15). If the results are as expected, continue with the "Pneumatic Leakage Test" on page 3-16.

NBP Calibration Procedure

To calibrate the NBP module:

Step	
1	In the **NBP Test** menu, select **NBP Calibration**. **Note —** *To stop the calibration at any time, select the* **Stop** *button.* The **NBP Calibration** menu appears.  **Note —** *If you are using a manual manometer, close the valve before continuing.*
2	Select the **Start** button to begin the calibration. The monitor inflates the expansion chamber and displays the following message: **Starting NBP calibration...**.
3	Wait until the following message appears: **Ready for calibration pressure point...**
4	Select the **Set Pressure Value** field.
5	Scroll through the list until the value matches the value displayed on the manometer and select it to confirm the change.
6	Select **CAL Point** to save the calibration point.
7	Wait until the following message appears: **NBP calibration successful**. If the test fails, select the **Stop** button to stop the test.
8	Select the **Return** button to exit the test.

9	To verify calibration, check the accuracy of the NBP. See “NBP Accuracy” on page 3-14.
10	If you do not get the expected results after several attempts, see “NBP Problems” on page 4-8.

Pneumatic Leakage Test

To check the pneumatic system and valve:

Step	
1	In the **NBP Test** menu, select the **Start Static Pressure Test** button.
2	Squeeze the manometer pump to apply a pressure of 280 mmHg.
3	Wait 10 seconds for the pressure to stabilize. Note the pressure value in the **NBP Test** menu. **Note —** *Philips employees record this value as **P1**.*
4	Wait 60 seconds for the pressure to stabilize. Note the pressure value in the **NBP Test** menu. **Note —** *Philips employees record this value as **P2**.*
5	Calculate and document the leakage test value. The expected leakage test value is ≤ 6 mmHg. **Note —** *Philips employees record this value as **X3** (where **X3** = **P1** - **P2**).*
6	Select the **Stop Static Pressure Test** button to stop the process.
7	If the leakage test value exceeds 6 mmHg, check the test setup cuff and tubing, and then test again. If the test still fails, check the pneumatic tubing inside the monitor. See “Removing the NBP Module” on page 5-15.
8	If you cannot eliminate the leak, see “NBP Problems” on page 4-8.

Temperature Test

This test uses a fixed temperature value to check the performance of the temperature measurement.

To perform this test, you need the following:

- SureSigns temperature probe
- SureSigns temperature calibration key (part # 4535 640 33691)

To test the performance of the predictive temperature measurement:

Step	
1	Connect the temperature probe to the monitor.
2	Open the **Temperature** menu and place the monitor in **Monitored** mode.

3	Remove the temperature probe and the probe well and disconnect the temperature probe connector from the monitor. **Note —** *A temperature probe error may be generated and an alarm may sound.*
4	Connect the SureSigns temperature calibration key to the temperature module.
5	Replace the temperature probe and the probe well. **Note —** *If temperature probe error was generated, the alarm stops.*
6	Remove the temperature probe from the probe well.
7	Wait for the monitor to display the static temperature value.
8	Check that the displayed temperature reads 36.3 ± 0.1°C (97.3 ± 0.2°F).
9	If the value is not within tolerance, see “Temperature Measurement Problems” on page 4-9.

Safety Tests

Use the following safety test procedures to verify safe service of the monitor. The setups used for these tests and the acceptable ranges of values are derived from local and international standards but may not be equivalent. These tests are not a substitute for local safety testing where it is required for a service event. If you are using the Metron Safety tester, perform the tests in accordance with your local regulations, for example, in Europe, use IEC 60601-1/IEC 60601-1-1 and in the United States, use UL 60601-1. The Metron Report should print results with the names listed below, together with other data.

Note — Safety tests meet the standards of, and are performed in accordance with IEC 60601-1, Clause 19 (EN 60601-1). The SureSigns VS2$^+$ and VSi vital signs monitors have been classified as Class I equipment.

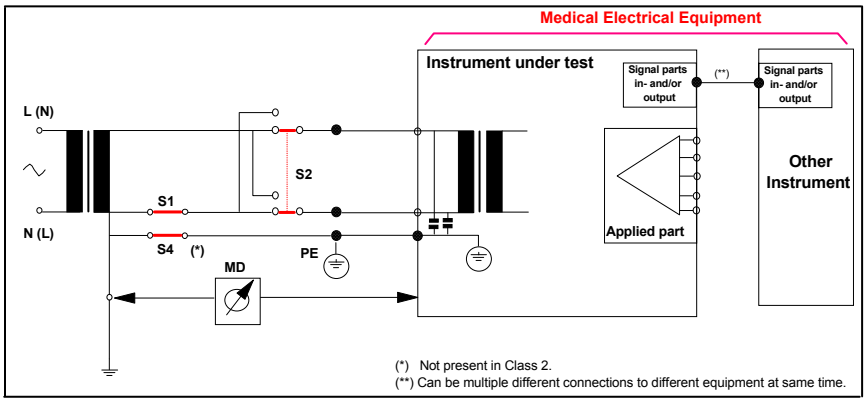
To perform these tests, you need a multimeter.

The monitor safety tests include:

- Enclosure leakage
- Ground integrity
- Patient leakage current with mains voltage

Enclosure Leakage

S(1) Part 1: Enclosure Leakage Current - NC (normal condition)



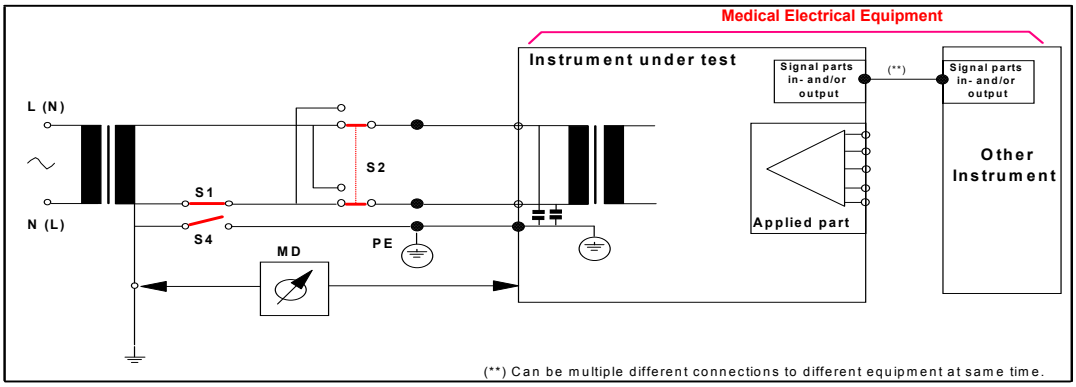
Expected Test Results

Normal condition maximum leakage current x1 ≤ 100µA.

This measures leakage current of exposed metal parts of Instrument under Test (IUT) and between parts of the system within the **patient environment**; normal and reversed polarity using S2.

Safety test according IEC 60601-1 / UL 60601-1.

S(1) Part 2: Enclosure Leakage Current - Single Fault (open earth)



Expected Test Results

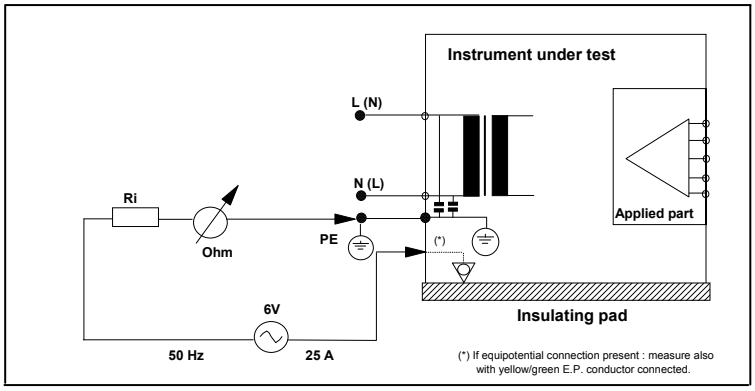
Single Fault maximum leakage current x2 ≤ 500µA (IEC 60601-1).

≤ 300µA (UL 60601-1)

This test measures the leakage current of exposed metal parts of Instrument under Test (IUT) with Protective Earth (PE) open circuit (S4 = open) and between parts of the system within the **patient environment**; normal and reversed polarity using S2.

Ground Integrity

S(2) Protective Earth Continuity



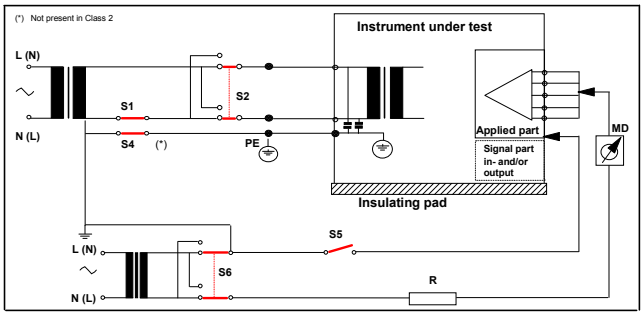
Expected Test Results

With mains cable, maximum impedance x ≤ 100 mOhms (IEC 60601-1 and UL 60601-1).

This test measures the impedance of the Protective Earth (PE) terminal to all exposed metal parts of Instrument under Test (IUT), which are for safety reasons connected to the Protective Earth (PE). Test current 25 Amp applied for 5 to 10 seconds.

Patient Leakage Current With Mains Voltage

S(3) Patient Leakage current - Single Fault Condition (S.F.C.) mains on applied part



Expected Test Results

Maximum leakage current, x ≤ 50 µA @ 250V (IEC60601-1 and UL 60601-1).

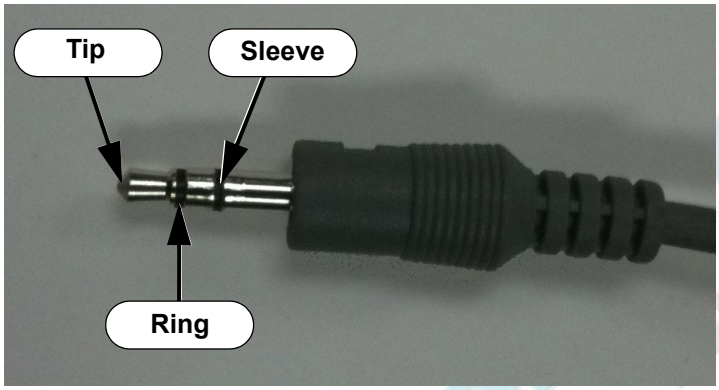
This test measures the patient leakage current from the applied part to earth caused by external main voltage on the applied part with switch S5 open and closed. Each polarity combination possible is tested using S2 and S6. This test is applicable for every measurement input.

Nurse Call Relay Test

If your facility uses the nurse call function on the monitor, perform the following procedure to test the nurse call alarm output relay.

The nurse call alarm output is a phone jack connector that is capable of both normally closed and normally open relay operation.

The nurse call connector jack has three contacts that connect with those on a phono connector as shown in the following illustration.



- Tip — Relay normally open, closed for alarm
- Ring — Relay normally closed, open for alarm
- Sleeve — Common

To perform this test, you need:

- A patient simulator
- An ohmmeter
- A 3.5 mm phono connector

To perform the nurse call relay test:

<table>
<tr><th>Step</th><th></th></tr>
<tr><td>1</td><td>Plug the phono connector into the Nurse Call connector on the back of the monitor.</td></tr>
<tr><td>2</td><td>Use the ohmmeter and simulator to verify relay operation as follows:
<table>
<tr><th>Condition</th><th>Phone Jack Connector Tip (Relay Normally Open)</th><th>Phone Jack Connector Ring (Relay Normally Closed)</th></tr>
<tr><td>Alarm</td><td>Closed</td><td>Open</td></tr>
<tr><td>No alarm</td><td>Open</td><td>Closed</td></tr>
</table></td></tr>
<tr><td>3</td><td>If you do not get the expected results, see Chapter 4, “Troubleshooting.”</td></tr>
</table>

4 Troubleshooting

Use the information in this chapter to diagnose and correct monitor problems. This chapter describes how to troubleshoot a monitor that is not operating correctly. Chapter 5, “Repairing the Monitor,” describes how to perform the recommended repairs.

You can repair the monitor in either of two ways:

- Spare parts, where you order replacement parts and you repair the monitor.
- Bench repair, where you return the monitor to a Philips authorized service center for repair.

The tools required to repair the monitor are listed in “Tools Required for Service” on page 5-2. If you open the case for a repair, you then must perform specific tests after reassembly. For detailed information about these tests, see Chapter 3, “Performance Verification Testing.”

The Philips Parts Center stocks board level assemblies and mechanical parts. Chapter 6, “Replacement Parts and Assembly Drawings,” lists these parts and assemblies. Service notes announce the availability of additional spare parts.

For information about returning the monitor for repair, see “Clearing Patient Data” on page 4-37 and the *SureSigns VS2+ and VSi Installation and Configuration Guide*.

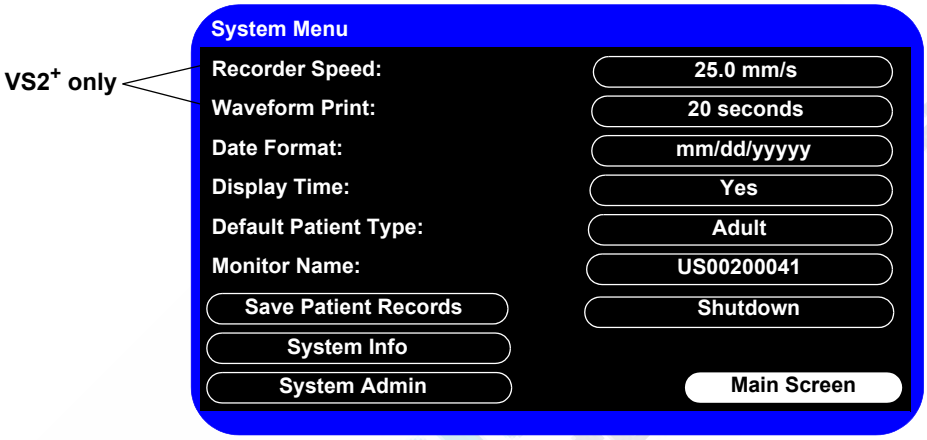
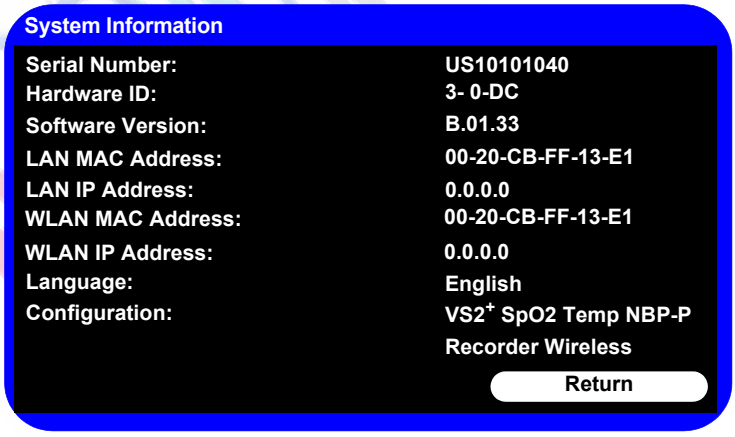
When You Cannot Correct a Problem

The information in this chapter is intended to help you resolve most problems that may occur with your monitor. If you still cannot isolate a problem after using the information in this chapter, call the Philips Customer Care Center or your local representative.

Viewing System Information

You can view monitor information, such as the hardware ID and the software version, in the **System Information** window.

To view the **System Information** window:

Step	
1	Select the **System** button. The **System Menu** appears with the current settings displayed. 
2	Select the **System Info** button. The **System Information** window appears.  **Notes** • *The serial number is also displayed on the back of the monitor.* • *The* **Hardware ID** *is the version of each of the following components: <Main board>* **- 0 -** *<FPGA ID>*

Diagnosing a Problem

Before you begin to troubleshoot a problem or open the monitor for repair, check the following basics:

1. Is the power turned on?
2. Is the battery adequately charged?
3. Is the power cord connected to the monitor and plugged into an AC outlet?
4. Is the display functioning?
5. Are the LEDs on the front panel lit as you expect?

Note — It may take several seconds for the AC Power LED to light or turn off after the power cord has been connected or disconnected.

If the monitor is not receiving power:

1. See “Start-up and Power Sequences” on page 4-3, and then follow the troubleshooting steps in “Power Problems” on page 4-6.
2. If the monitor has no display or an incorrect display, follow the troubleshooting steps in “Display Problems” on page 4-7.

When the monitor has power and a functioning display, you can use the information in this chapter to diagnose other monitor problems.

Start-up and Power Sequences

The following table describes the start-up and power on phases of the monitor and its components. If the monitor does not behave as described in the following table, see “Power Problems” on page 4-6.

For the monitor to start correctly, it must be powered correctly, as indicated by lit LEDs on the front panel.

The following table shows the start-up and power on sequences.

User Action	Expected Result
Plug the AC power cord or battery (or both) into an unpowered monitor.	The screen displays color bars for about five seconds. The LCD turns off for three seconds and the Charging LED lights (when a battery is available).
Press the **On/Standby** key.	The Philips screen appears and a tone sounds. The **Date/Time Menu** appears. After you acknowledge the **Date/Time Menu**, the main screen appears.

User Action	Expected Result
Press the **On/Standby** key on a monitor (with AC and/or battery) that is off.	The screen displays color bars for about five seconds. The LCD is off for three seconds and the Charging LED lights (when battery available). The Philips screen appears and a tone sounds. The main screen appears.
Software reset (system or user).	The screen displays color bars for about five seconds. The LCD turns off for three seconds and the Charging LED lights (when battery available). The Philips screen appears and a tone sounds. The main screen appears.
Plug AC into a monitor that is off (battery only). Press the **On/Standby** key.	The screen displays color bars for about five seconds. The LCD turns off for three seconds and the Charging LED lights (when battery available). The Philips screen appears and a tone sounds. The main screen appears.
Press the **On/Standby** key when the monitor is in Standby mode (AC and/or battery).	A tone sounds. The main screen appears.
Press the **On/Standby** key when the monitor is on (AC and/or battery).	The Philips screen appears and the LCD turns off.
Select the **Shutdown** button in the **System Menu**.	The Philips screen appears and the LCD turns off.

Troubleshooting Tables

Use the following tables to diagnose and fix monitor problems. The tables describe a monitor problem by symptom, list possible causes, and suggest actions. Check the first possible cause listed, and then perform the associated action to repair the problem. Perform all actions in the order that they appear in a table.

Monitor problems can be related to:

- Power
- Display
- Alarms
- Measurements, including:
  - NBP
  - Temperature
  - SpO_2
- Recorder ($VS2^+$ monitor only)
- Navigation wheel ($VS2^+$ monitor only) and keys
- Nurse Call
- USB hub

If you cannot resolve a problem by using the following troubleshooting tables, see “Running System Diagnostics” on page 4-29.

Power Problems

Symptom	Possible Cause	Action
The monitor does not power up with AC power, but does with battery power.	The power cord is unplugged.	Ensure that the power cord is plugged into an outlet.
	The power cord is broken.	Replace the power cord if necessary.
	A fuse is blown.	Replace the fuse. See “Replacing a Fuse” on page 5-18.
	The power supply cable malfunctioned.	Replace the DC-In cable. See “Removing the Power Supply” on page 5-34.
	The power supply malfunctioned.	Check the output voltage on the power supply. If it does not measure 15 V, replace the power supply. See “Removing the Power Supply” on page 5-34.
	The AC power connector malfunctioned.	Replace the AC connector. See “Removing the AC Power Connector” on page 5-44.
	The monitor keypad is worn.	Replace the front panel. See “Removing the LCD” on page 5-28.
	The main board malfunctioned.	Replace the main board. See “Replacing the Main Board” on page 5-22.
The monitor turns on with AC power, but does not with battery power.	The battery is not charged.	Charge the battery. For more information, see “Maintaining the Battery” on page 2-2.
	The battery connector is loose.	Reseat the battery cable.
	The battery is not connected to the main board.	Confirm that the battery is connected to the main board.
	The main board malfunctioned.	Replace the main board. See “Replacing the Main Board” on page 5-22.
The monitor does not turn on with either AC or battery power.	The power cord is unplugged and the battery is not installed or is not charged.	Ensure the monitor is connected to power and that a fully charged battery is installed. See “Installing the Battery” on page 5-5. Verify that the AC Power LED and the Charging LED are lit.
	The cables are disconnected.	Ensure that the power input module and battery cables are connected. See “Removing the Battery” on page 5-3.
	The main board malfunctioned.	Replace the main board. See “Replacing the Main Board” on page 5-22.
	The membrane switch assembly malfunctioned.	Replace the Front Panel assembly. See “Removing the LCD” on page 5-28.
Only one of the Battery Charging LED colors is displayed.	The membrane switch assembly malfunctioned.	Replace the Front Panel assembly. See “Removing the LCD” on page 5-28.
The following message is displayed: **Battery service required**	The **Max Error** value exceeds 8%. The **Full Capacity** value is half of the **Design Capacity** value.	Recondition the battery. See “Reconditioning the Battery” on page 2-3.

Display Problems

Symptom	Possible Cause	Action
The power is on, but the monitor screen is blank.	The monitor is in Standby mode.	Press the **On/Standby** key to end Standby mode.
	The main board malfunctioned.	Replace the main board. See "Replacing the Main Board" on page 5-22.
	The LCD is faulty.	Replace the LCD. See "Removing the LCD" on page 5-28.
The monitor displays random or distorted graphics with a white background.	The LCD cable is not attached correctly.	Open the monitor and reseat the LCD signal cable. See "Removing the LCD" on page 5-28.
	The LCD malfunctioned.	Replace the LCD. See "Removing the LCD" on page 5-28.
	The main board malfunctioned.	Replace the main board. See"Replacing the Main Board" on page 5-22.
The monitor turns on and the opening screen and/or color bar starts, but then freezes.	The main board malfunctioned.	Replace the main board. See "Replacing the Main Board" on page 5-22.

Alarm Problems

Symptom	Possible Cause	Action
A flashing red/white box with the message **AUDIO FAILED** appears on the screen.	The speaker malfunctioned.	Clear the error message by performing the speaker test or clearing the error log. See "Testing the Speaker" on page 4-31 or "Clearing Patient Data" on page 4-37.
	The connection to the speaker is faulty.	Ensure that the connection to the speaker is correct. Clear the error message by performing the speaker test or clearing the error log. See "Testing the Speaker" on page 4-31 or "Clearing Patient Data" on page 4-37.
	The speaker is faulty.	Replace the speaker. See "Replacing the Speaker" on page 5-15. Clear the error message by performing the speaker test. See "Testing the Speaker" on page 4-31.
Audible alarms do not sound.	The monitor is in Audio Pause mode or Audio Off mode.	Confirm that audio alarms are enabled.
	The connection to the speaker is faulty.	Ensure that the connection to the speaker is correct.
	The speaker is faulty.	Replace the speaker. See "Replacing the Speaker" on page 5-15.
	The main board malfunctioned.	Replace the main board. See "Replacing the Main Board" on page 5-22.

NBP Problems

Symptom	Possible Cause	Action
The NBP cuff does not inflate.	The tube or cuff is bent or twisted.	Straighten the tube or cuff.
	The tube or cuff is leaking air.	Replace the cuff and ensure that there is no air leakage in the tube.
	The NBP module malfunctioned.	Replace the NBP module. See “Removing the NBP Module” on page 5-15. Replace the main board. See “Replacing the Main Board” on page 5-22.
NBP measurements are not displayed.	Wrong cuff size or incorrect cuff placement.	Use the correct cuff size and ensure proper cuff placement.
	The tube is bent or twisted or there is air leakage in the air tube or cuff.	Ensure that the tube is straight and not kinked. Replace the cuff and ensure that there is no air leakage in the tube.
	A problem external to the monitor occurred.	Ensure that all external blood pressure reading requirements are met and that the patient is not moving excessively. For more information about taking NBP measurements, see the *Instructions for Use* for your monitor.
	The initial inflation pressure setting is incorrect.	Specify the correct initial inflation pressure. See the *SureSigns VS2$^+$ and VSi Installation and Configuration Guide*.
	An NBP module error occurred.	Replace the NBP module. See “Removing the NBP Module” on page 5-15. Replace the main board. See “Replacing the Main Board” on page 5-22.
NBP measurements are unreliable	Wrong cuff size, or incorrect cuff placement.	Use the correct cuff size and ensure proper cuff placement.
	An external problem occurred.	Ensure that all external blood pressure reading requirements are met and that the patient is not moving excessively.
	The initial inflation pressure setting is incorrect.	Specify the correct initial inflation pressure. See the *SureSigns VS2$^+$ and VSi Installation and Configuration Guide*.
	The calibration is unreliable.	Recalibrate the NBP module see “NBP Calibration Procedure” on page 3-15.
NBP initial pressure too high.	The cuff is too tight.	Ensure the cuff is fastened correctly.
	The initial inflation pressure setting is incorrect.	Specify the correct initial inflation pressure. See the *SureSigns VS2$^+$ and VSi Installation and Configuration Guide*.

Temperature Measurement Problems

Symptom	Possible Cause	Action
Temperature measurements are not displayed.	The probe is misplaced.	Ensure that the probe is properly placed in the measurement site.
	The probe cable is not connected.	Ensure that the probe is connected.
	The monitor has not completed the start-up sequence and the temperature module is not ready.	Insert the probe into the well and ensure that the monitor has completed the start-up sequence.
	The probe malfunctioned.	Replace the temperature probe.
	The temperature is over range.	Ensure that temperature readings are in the range of: 15°C – 45°C (59°F – 113°F). See "Temperature Test" on page 3-16.
	The temperature module malfunctioned.	Replace the temperature module. See "Removing the Temperature Module" on page 5-6.
	The main board malfunctioned.	Replace the main board. See "Replacing the Main Board" on page 5-22.
Temperature measurements are unreliable.	The probe malfunctioned.	Replace the temperature probe.
	The module is not calibrated.	Ensure that the temperature module is calibrated. See "Temperature Test" on page 3-16.
	The temperature module malfunctioned.	Replace the temperature module. See "Removing the Temperature Module" on page 5-6.

SpO_2 Measurement Problems

Symptom	Possible Cause	Action
SpO_2 measurements are not displayed.	The SpO_2 module is in the learning phase.	Wait until the module finishes the learning phase.
	The SpO_2 sensor malfunctioned.	Replace the SpO_2 sensor.
	The SpO_2 board malfunctioned.	Replace the SpO_2 board assembly. See "Removing the SpO_2 Board" on page 5-22.
	The main board malfunctioned.	Replace the main board. See "Replacing the Main Board" on page 5-22.
SpO_2 readings are unreliable.	A problem external to the monitor occurred. For example, excessive patient movement or incompatible sensor in use.	Ensure that all external SpO_2 reading requirements are met and that the patient is not moving excessively. For more information about taking SpO_2 measurements and compatible sensors, see the *Instructions for Use* for your monitor.
	Perfusion is low.	Reset the SpO_2 function. See "SpO_2 Test" on page 3-13.

Navigation Wheel (VS2+ Monitor Only) and Key Problems

Symptom	Possible Cause	Action
The monitor does not respond to the navigation wheel (VS2+ only) or front panel keys.	The main board has a faulty connection.	Ensure that all connectors to the main board are seated correctly.
	The monitor keypad or navigation wheel is broken.	Replace the front panel or navigation wheel. See "Removing the LCD" on page 5-28 and "Replacing the Main Board" on page 5-22.
	The main board malfunctioned.	Replace the main board. See "Replacing the Main Board" on page 5-22.
	The membrane switch assembly malfunctioned.	Replace the front panel assembly. See "Removing the LCD" on page 5-28.
Pressing a key does not access the expected function. For example, pressing the **Print** key initiates an NBP measurement.	The membrane switch assembly malfunctioned.	Replace the front panel assembly. See "Removing the LCD" on page 5-28.
A key is collapsed, or doesn't click when pressed.	The membrane switch assembly malfunctioned.	Replace the front panel assembly. See "Removing the LCD" on page 5-28.

Recorder Problems (VS2+ Monitor Only)

Symptom	Possible Cause	Action
The recorder paper is jamming.	The paper is not installed correctly.	Remove paper and reinstall correctly.
	The wrong type of paper is installed.	Install the recommended recorder paper.
	The recorder has a mechanical problem.	Replace the recorder module. See "Removing the Optional Recorder (VS2+ Only)" on page 5-9.
The recorder does not print.	An optional recorder is not installed.	Verify that a recorder is installed.
	The recorder is out of paper.	Install a new paper supply.
	The recorder door is open.	Open the recorder door, and then close it again.
	The system does not recognize the recorder.	Check the recorder's physical connections. See "Removing the Optional Recorder (VS2+ Only)" on page 5-9.
	The recorder module malfunctioned.	Replace the recorder module. See "Removing the Optional Recorder (VS2+ Only)" on page 5-9.
	The main board malfunctioned.	Replace the main board. See "Replacing the Main Board" on page 5-22.

Nurse Call Problems

Symptom	Possible Cause	Action
The nurse call function does not signal alarm conditions.	**Minimum Nurse Call Alarm Priority** is set too high.	Specify an appropriate **Minimum Nurse Call Alarm Priority** for your facility. For more information, see the *SureSigns VS2+ and VSi Installation and Configuration Guide*.
	Alarms have been silenced.	Press the **Alarm Silence** key to end the Audio Off mode or Audio Pause mode.
	The phono connector is loose or broken.	Ensure that the physical connection to the nurse call connector is correct.
	The communications board malfunctioned.	Replace the Communications board. See "Removing the Communications Board" on page 5-31.
	The main board malfunctioned.	Replace the main board. See "Replacing the Main Board" on page 5-22.

USB Hub Problems

Symptom	Possible Cause	Action
The USB hub does not work.	The USB hub is disconnected from the monitor.	Ensure that all USB plugs are firmly connected into their ports.
	The USB hub ports are blocked by dust or dirt.	Clean the USB hub. See the information that came with the USB hub for cleaning instructions.
	The USB hub is faulty.	Replace the USB hub.
	The Communications board is broken or not properly connected.	Confirm that the Communications board is properly connected to the main board. Replace the main board. See "Removing the Communications Board" on page 5-31.

Error Codes

When the monitor detects an error condition (depending on the type of error) an error message appears on the screen or an error code is written to the Error Log. An error code is an indication that the monitor has detected an error in operation and service might be required. An error code is a hexadecimal number that indicates the nature of the error.

Alarm Silence key

If an error occurs during monitoring, an audible alarm also sounds. Press the **Alarm Silence** key to end the audible alarm.

The following table lists the error codes that correspond to monitor malfunctions and actions to take when the error occurs. These errors are written to the Error Log. To access the error code log, see “Viewing, Exporting, and Printing (VS2+ Monitor Only) the Error Log” on page 4-36.

Code	Error Message	Possible Cause	Action
257	**System Error**	Battery charger power failure.	If the problem persists, replace the battery. See “Removing the Battery” on page 5-3. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22. If the problem persists, replace the AC power supply module. See “Removing the Power Supply” on page 5-17.
261	**System Error**	Battery is overcharged.	Run the monitor without AC power. If the problem persists, replace the battery. See “To remove the battery:” on page 5-3. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
264 *temp value*	**System Error**	Battery over temperature.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the battery. See “To remove the battery:” on page 5-3. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
817	**FPGA FIFO Overrun**	NBP software error.	Informational message. No action required.
818 (2)	**NBP Equip Malfunc (2)**	NBP power-on self test failed because the A/D converter is inoperative, or the pressure transducer offset is too large.	Replace the NBP module. See “Removing the NBP Module” on page 5-15. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.

Code	Error Message	Possible Cause	Action
818 (15)	**NBP Equip Malfunc (15)**	NBP abnormal, unrecoverable system errors with internal firmware.	Replace the main board. See “Replacing the Main Board” on page 5-22.
818 (25)	**NBP Equip Malfunc (25)**	NBP hardware has malfunctioned because there is no data.	Replace the NBP module. See “Removing the NBP Module” on page 5-15. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (101)	**NBP Equip Malfunc (101)**	Task overrun.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (102)	**NBP Equip Malfunc (102)**	Interrupt stack overwritten.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (103)	**NBP Equip Malfunc (103)**	User stack overwritten.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (104)	**NBP Equip Malfunc (104)**	Data validity check failed.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (106)	**NBP Equip Malfunc (106)**	Unable to write init flag data to non-volatile memory.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (107)	**NBP Equip Malfunc (107)**	Unable to verify init flag data written to non-volatile memory.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.

Code	Error Message	Possible Cause	Action
818 (109)	**NBP Equip Malfunc (109)**	Unable to write NBP configuration data to non-volatile memory.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (110)	**NBP Equip Malfunc (110)**	Unable to write NBP configuration data to non-volatile memory.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (111)	**NBP Equip Malfunc (111)**	Calibration data checksum error.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (112)	**NBP Equip Malfunc (112)**	Unable to write calibration data to non-volatile memory.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (113)	**NBP Equip Malfunc (113)**	Unable to verify calibration data written to non-volatile memory.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (114)	**NBP Equip Malfunc (114)**	Error log checksum error.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (115)	**NBP Equip Malfunc (115)**	Unable to write error log to non-volatile memory.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.

Code	Error Message	Possible Cause	Action
818 (116)	**NBP Equip Malfunc (116)**	Unable to verify error log data written to non-volatile memory.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
818 (117)	**NBP Equip Malfunc (117)**	Inflation cycle count and runtime data checksum error.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
818 (118)	**NBP Equip Malfunc (118)**	Unable to write inflation cycle count and runtime data to non-volatile memory.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
818 (119)	**NBP Equip Malfunc (119)**	Unable to verify inflation cycle count and runtime data written to non-volatile memory.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
818 (120)	**NBP Equip Malfunc (120)**	A new message will be sent to the host although the previous message is not finished.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
818 (121)	**NBP Equip Malfunc (121)**	Pressure value from second pressure sensor not available.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
818 (122)	**NBP Equip Malfunc (122)**	The 5-volt supply voltage value is too high or low.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.

Code	Error Message	Possible Cause	Action
818 (123)	**NBP Equip Malfunc (123)**	Error from the 5-volt regulator.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (124)	**NBP Equip Malfunc (124)**	The 12-volt supply voltage value is too high or low.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (128)	**NBP Equip Malfunc (128)**	Offset of pressure sensor 1 is out of range.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (129)	**NBP Equip Malfunc (129)**	Offset of pressure sensor 2 is out of range.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (130)	**NBP Equip Malfunc (130)**	Response of pressure sensor 2 to test signal is out of range.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (131)	**NBP Equip Malfunc (131)**	The difference between the two pressure channels is too large.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (132)	**NBP Equip Malfunc (132)**	One of the two valves was activated for too long.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the NBP module. See “Removing the NBP Module” on page 5-15.

Code	Error Message	Possible Cause	Action
818 (133)	**NBP Equip Malfunc (133)**	CRC mismatch in calibration data.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (134)	**NBP Equip Malfunc (134)**	CRC mismatch in error log data.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (135)	**NBP Equip Malfunc (135)**	CRC mismatch in inflation cycle count and runtime data.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (136)	**NBP Equip Malfunc (136)**	The pneumatic safety switch is defective.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22. If the problem persists, replace the NBP module. See “Removing the NBP Module” on page 5-15.
818 (137)	**NBP Equip Malfunc (137)**	Valve 2 is defective or blocked.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the NBP module. See “Removing the NBP Module” on page 5-15. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
818 (141)	**NBP Equip Malfunc (141)**	Inflation time for selected patient type exceeded.	Verify that the appropriate cuff size is being used for the selected patient type. If the problem persists, shut down (see “Shutting Down the System” on page 5-2) and restart the monitor.

Code	Error Message	Possible Cause	Action
818 (199)	**NBP Equip Malfunc (199)**	No data from NBP block.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
819	**NBP Equip Malfunc - Not Calibrated**	NBP not calibrated.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, recalibrate the NBP module. See "NBP Calibration Procedure" on page 3-15.
819 (127)	**NBP Equip Malfunc (127)**	NBP module is not calibrated.	Contact the Customer Care Center.
819 (138)	**NBP Hose Blocked (138)**	Problem in pneumatic system.	Verify that all internal NBP hoses are connected. If the problem persists, shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the NBP module. See "Removing the NBP Module" on page 5-15. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
819 (139)	**NBP Air Leak (139)**	Air leak or valve defect.	Verify that all internal NBP hoses are connected. If the problem persists, shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the NBP module. See "Removing the NBP Module" on page 5-15. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
833 (1)	**SpO2 Equip Malfunc (1)**	SpO_2 ROM checksum error.	Replace the SpO_2 board assembly. See "Removing the SpO_2 Board" on page 5-22.
833 (2)	**SpO2 Equip Malfunc (2)**	SpO_2 RAM test error.	Replace the SpO_2 board assembly. See "Removing the SpO_2 Board" on page 5-22.
833 (4)	**SpO2 Equip Malfunc (4)**	SpO_2 analog signal path self-test failed.	Replace the SpO_2 board assembly. See "Removing the SpO_2 Board" on page 5-22.

Code	Error Message	Possible Cause	Action
833 (6)	**SpO2 Equip Malfunc (6)**	SpO_2 self-test timeout.	Reseat the SpO_2 board assembly. If the problem persists, replace the SpO_2 board. See "Removing the SpO_2 Board" on page 5-22.
833 (8)	**SpO2 Equip Malfunc (8)**	SpO_2 internal DSP communication error.	Replace the SpO_2 board assembly. See "Removing the SpO_2 Board" on page 5-22.
833 (10)	**SpO2 Equip Malfunc (10)**	SpO_2 host communication error.	Replace the SpO_2 board assembly. See "Removing the SpO_2 Board" on page 5-22. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
833 (20)	**SpO2 Equip Malfunc (20)**	SpO_2 hardware defect.	Replace the SpO_2 board assembly. See "Removing the SpO_2 Board" on page 5-22.
833 (40)	**SpO2 Equip Malfunc (40)**	SpO_2 non-volatile memory corrupted.	Replace the SpO_2 board assembly. See "Removing the SpO_2 Board" on page 5-22.
834	**SpO2 Sensor Malfunc**	Malfunction of the SpO_2 sensor or sensor cable.	Check the SpO_2 sensor and extension cable. If the problem persists, check the connector block cable connection on the SpO_2 board. If the problem persists, replace the SpO_2 board assembly. See "Removing the SpO_2 Board" on page 5-22.
835	**FPGA FIFO Overrun**	SpO_2 software error.	Informational message. No action required.
836	**SpO2 Communication Error**	SpO_2 communication error.	Informational message. No action required. If the message continues, replace the SpO_2 board assembly. See "Removing the SpO_2 Board" on page 5-22.
837	**SpO2 Error. The front end will now reset itself.**	No data from SpO_2.	Allow the monitor to reset. Replace the SpO_2 board assembly. See "Removing the SpO_2 Board" on page 5-22. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
865	**FPGA FIFO Overrun**	Temperature software error.	Informational message. No action required.

Code	Error Message	Possible Cause	Action
866 (21)	**Temp Probe Error (21)**	The probe is operating in temperature conditions above 112°F/43.3°C. Probe tip is defective: heater is too close to thermistor.	Replace the probe. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
866 (22)	**Temp Probe Error (22)**	Excessive heater energy. Heater is not working or it could have taken too long to predict.	Repeat the measurement. If the problem persists, replace the temperature probe.
866 (32)	**Temp Probe Error (32)**	Thermistor pulled away from the tip or heater broken.	Repeat the measurement. If the problem persists, replace the temperature probe.
866 (33)	**Temp Probe Error (33)**	Probe not responsive. Probe not characterized/calibrated.	Repeat the measurement. If the problem persists, replace the temperature probe.
866 (34)	**Temp Probe Error (34)**	Probe not characterized/calibrated.	Repeat the measurement. If the problem persists, replace the temperature probe.
866 (45)	**Temp Probe Error (45)**	Measurement below allowable temperature values and far below the low ambient limits.	Verify ambient temperature of 50°F. If conditions are valid and problem persists, replace the temperature probe. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
866 (46)	**Temp Probe Error (46)**	Measurement above allowable temperature values and far above the high ambient limits.	Verify ambient temperature of 50°F. If conditions are valid and problem persists, replace the temperature probe. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
866 (52)	**Temp Probe Error (52)**	Temperature probe not characterized/calibrated.	Replace the temperature probe. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
866 (63)	**Temp Probe Error (63)**	Probe well missing or not installed properly.	Reseat or replace the well. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
866 (70)	**Temp Probe Error (70)**	Problem reading the temperature probe EEPROM.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature probe.

Code	Error Message	Possible Cause	Action
866 (75)	**Temp Probe Error (75)**	Problem reading the temperature probe EEPROM correctly or the probe was not factory tested.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature probe.
866 (78)	**Temp Probe Error (78)**	Probe error.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
866 (79)	**Temp Probe Error (79)**	Module memory error.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6. If the problem persists, replace the main board. See "Replacing the Main Board" on page 5-22.
866 (80)	**Temp Probe Error (80)**	Software is trying to turn off the probe heater, but the heater feedback signal says it is still on.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature probe. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
866 (81)	**Temp Probe Error (81)**	Software is trying to turn on the probe heater, but the heater feedback signal says it is still off.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature probe. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.

Code	Error Message	Possible Cause	Action
867 (24)	**Temp Module Malfunc (24)**	Ambient temperature too high.	Verify that the venting slots of the temperature module are not blocked and are free of dust. Verify that the ambient temperature does not exceed operating specifications. If the problem persists, replace the temperature probe. If the problem persists, replace the temperature module. See “Removing the Temperature Module” on page 5-6.
867 (25)	**Temp Module Malfunc (25)**	Ambient temperature too low.	Verify that the ambient temperature does not exceed operating specifications. If the problem persists, replace the temperature probe. If the problem persists, replace the temperature module. See “Removing the Temperature Module” on page 5-6.
867 (27)	**Temp Module Malfunc (27)**	Battery or power supply voltage exceeds maximum value.	Replace the temperature module. See “Removing the Temperature Module” on page 5-6.
867 (28)	**Temp Module Malfunc (28)**	Battery or power supply voltage below minimum value.	Replace the Temperature Module. See “Removing the Temperature Module” on page 5-6. If the problem persists, replace the temperature module. See “Removing the Temperature Module” on page 5-6.
867 (47)	**Temp Module Malfunc (47)**	Internal calibration resistor (RCAL) on the board is damaged.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See “Removing the Temperature Module” on page 5-6.
867 (48)	**Temp Module Malfunc (48)**	Internal calibration resistor (RCAL) is damaged.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See “Removing the Temperature Module” on page 5-6.
867 (49)	**Temp Module Malfunc (49)**	Internal circuit validation resistor (PTB) is damaged.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See “Removing the Temperature Module” on page 5-6.

Code	Error Message	Possible Cause	Action
867 (50)	**Temp Module Malfunc (50)**	Internal circuit validation resistor (PTB) is damaged.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (51)	**Temp Module Malfunc (51)**	A/D measurement timed out and did not finish in the allowed time slot.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (59)	**Temp Module Malfunc (59)**	Battery or power supply voltage below maximum value.	Replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (60)	**Temp Module Malfunc (60)**	Battery or power supply voltage exceeds minimum value.	Replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (61)	**Temp Module Malfunc (61)**	Reference voltage circuit under voltage or unstable.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (62)	**Temp Module Malfunc (62)**	The module is not calibrated.	Replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (65)	**Temp Module Malfunc (65)**	Problem saving to the module's EEPROM.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (66)	**Temp Module Malfunc (66)**	The module's non-volatile calibration memory error detection mechanism detected an error.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (67)	**Temp Module Malfunc (67)**	Problem reading/writing to the module's EEPROM.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.

Code	Error Message	Possible Cause	Action
867 (68)	**Temp Module Malfunc (68)**	Problem reading/writing to the module's EEPROM.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (69)	**Temp Module Malfunc (69)**	Problem reading/writing to the module's EEPROM.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (74)	**Temp Module Malfunc (74)**	Internal error. Module is trying to initialize the EEPROM if it detects that it has not been initialized before.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (82)	**Temp Module Malfunc (82)**	Signal HTR_Q is on and signal HTRC is off, but still have voltage.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (83)	**Temp Module Malfunc (83)**	Signal HTR_Q is tri-stated with signal HTRC enabled, and has heater power.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (84)	**Temp Module Malfunc (84)**	Signal Q&C is turned on and the heater voltage is not high enough.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.
867 (85)	**Temp Module Malfunc (85)**	Heater hardware fail-safe should have turned off, but did not.	Shut down (see "Shutting Down the System" on page 5-2) and restart the monitor. If the problem persists, replace the temperature module. See "Removing the Temperature Module" on page 5-6.

Code	Error Message	Possible Cause	Action
868	**Temp Error. The front end will now reset itself.**	No data from temperature.	Allow the monitor to reset. Verify that the Temperature module is seated correctly and secured to the side of the monitor. Check the Temperature Adapter board connection cable. If the problem persists, replace the temperature module. See “Removing the Temperature Module” on page 5-6.
881	**Speaker Malfunc**	The speaker failed.	To clear the message, run the speaker test or clear the error log. See “Testing the Speaker” on page 4-31 or “Clearing Patient Data” on page 4-37. If the problem persists, replace the speaker. See “Replacing the Speaker” on page 5-15.
882	**Wireless Malfunc**	The wireless firmware cannot load.	Replace the wireless board. See “Removing the Wireless Board” on page 5-32.
1025	**System Error**	Could not load ResourceDLL.dll.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1026	**System Error**	Could not load data from flash.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1027	**System Error**	Could not start front end.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1028	**System Error**	Could not stop front end.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.

Code	Error Message	Possible Cause	Action
1029	**System Error**	Could not allocate enough memory.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1030	**System Error**	An error occurred when system shut down front end devices.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1031	**System Error**	The monitoring and watchdog thread could not initialize.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1032	**System Error**	Could not open audio files.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1033	**System Error**	Unspecified error.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1034	**System Error**	Failed to load product info.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1035	**System Error**	Cannot initialize front end manager.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.

Code	Error Message	Possible Cause	Action
1036	**System Error**	Failed to start work thread.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1037	**System Error**	Cannot start polling thread.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1042	**System Error**	Failed to start up network driver.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1043	**System Error**	Front end software error.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1044	**System Error**	Front end software error.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1045	**System Error**	Printing software error.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1047	**System Error**	Monitoring software error.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.

Code	Error Message	Possible Cause	Action
1048	**System Error**	An exception was detected in the alarming software.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1050	**System Error**	Failed to stop work thread.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1051	**System Error**	Cannot initialize NBP.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1052	**System Error**	Memory error.	Shut down (see “Shutting Down the System” on page 5-2) and restart the monitor. If the problem persists, replace the main board. See “Replacing the Main Board” on page 5-22.
1053	**System Error**	Loss of monitoring.	Informational message. No action required.

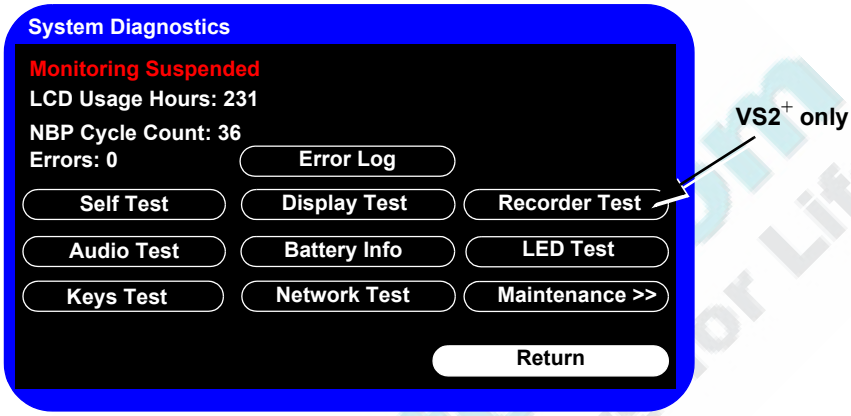
Running System Diagnostics

If you cannot identify a problem by using the troubleshooting tables on page 4-5 or the Error Code table on page 4-12, run the system diagnostics software.

To access the system diagnostics software:

- In the **Service Menu**, select the **Diagnostics** button. For information about opening the **Service Menu**, see "Accessing the System Admin Menu" on page 3-4.

  The **System Diagnostics** menu appears.



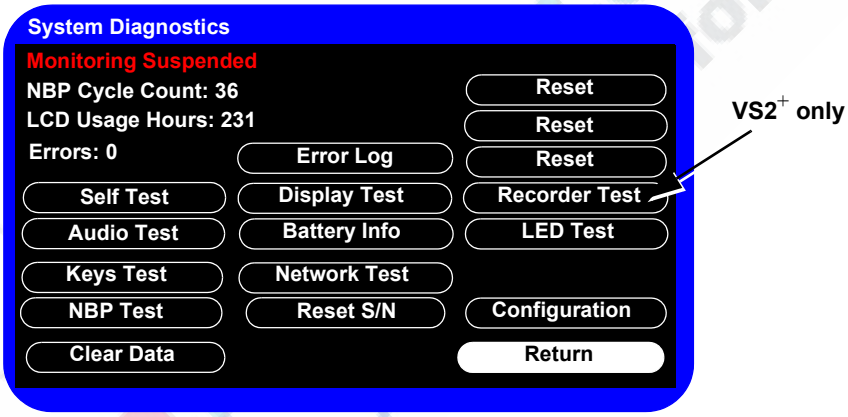
When the **System Diagnostics** menu is open:

- Patient monitoring stops
- The Charging LED turns off

Accessing the Maintenance Options

Note — You must enter a second password to access the **Maintenance** options. Only trained biomedical engineers or support persons should access the **Maintenance** options.

To access the **Maintenance** options:

Step	
1	In the **System Diagnostics** menu, select the **Maintenance >>** button.
2	In the window that appears, enter the password, **1**-**2**-**9**, as shown:  The complete **System Diagnostics** menu appears. 

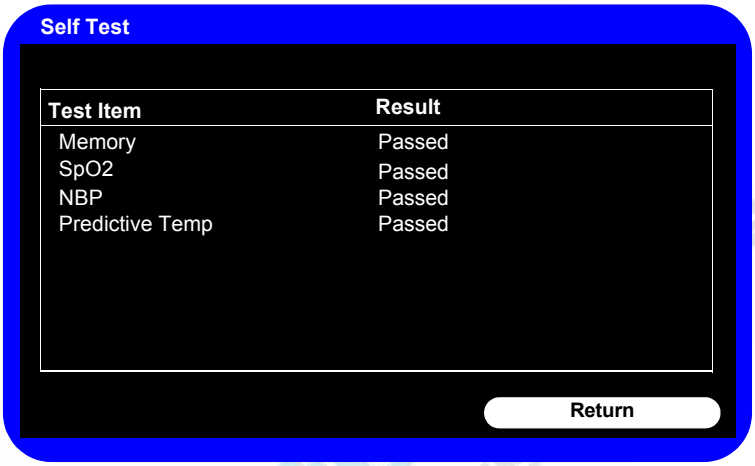
The following sections describe the diagnostic tests that you can run on the monitor. You can also run several verification tests from this menu. For more information about using the **Maintenance >>** menu to run verification tests, see Chapter 3, “Performance Verification Testing.”

Running the Self Test

Running the **Self Test** performs the resident self test, which includes a complete memory test and a front end test on all available modules, such as SpO_2, NBP, and Predictive Temperature. If the test cannot detect a specific module or if an error occurs, then that test fails.

Note — When the monitor is powered up from Standby mode, the monitor performs the front end tests in addition to the start-up sequence. When the monitor is powered up from Deep Sleep mode, the monitor performs the complete memory and front end tests.

To run the monitor resident self test:

Step	
1	In the **System Diagnostics** menu, select the **Self Test** button. The status of the self test is displayed. While the test is running, **In Progress** is displayed. If an option is not installed or configured, **Not Supported** is displayed as the **Result**. If a test fails, **FAILED** (in red text) is displayed as the **Result**. 
2	When all tests complete, select the **Return** button to return to the main screen. Detected errors are written to the error log with detailed error information and error codes.

Testing the Speaker

The audio test plays a sample sound on each of the different decibel (Db) levels.

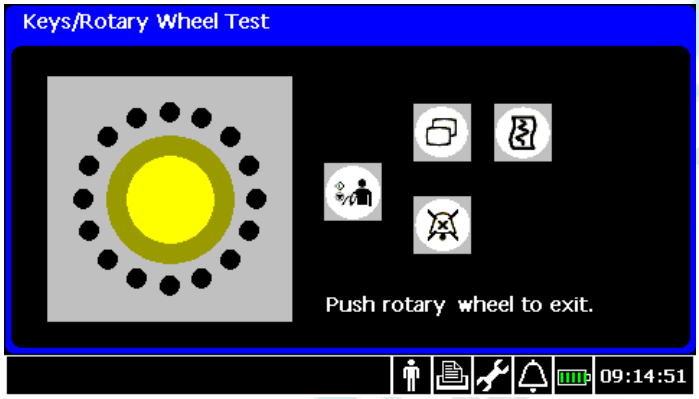
To perform the audio test:

Step	
1	In the **System Diagnostics** menu, select the **Audio Test** button to start the test. The following message is displayed: **Listen for three short tones**.
2	Verify that the monitor sounds three short tones at different Db levels. When the test completes, the **Audio Test** window closes.

Testing the Keys

The **Keys Test** verifies the functions of the system keys and, for the VS2+ monitor only, the wheel. If you do not get the expected results, see “Navigation Wheel (VS2+ Monitor Only) and Key Problems” on page 4-10.

To run the Keys test:

Step	
1	In the **System Diagnostics** menu, select the **Keys Test** button. The menu that appears depends on the monitor. On the SureSigns VS2+ monitor, the **Keys/Rotary Wheel Test** menu appears.  On the SureSigns VSi monitor, the **Keys Test** menu appears. 
2	To test a system key, press a key on the monitor. If the key you press on the monitor is working properly, the corresponding icon lights with a border for five seconds.
3	On the SureSigns VS2+ monitor, to test the navigation wheel, turn the wheel clockwise or counterclockwise. If the wheel is working properly, the black dots sequentially change to red in the direction that you turn the wheel.

4	On the SureSigns VS2+ monitor, to test the small movements of the navigation wheel, turn the wheel in small increments. If the wheel is working properly, the black dots change to red for each small movement.
5	To end the test, do one of the following: • On the SureSigns VS2+ monitor, press the wheel. • On the SureSigns VSi monitor, press the **Select** key.

Testing the Display

To test the display:

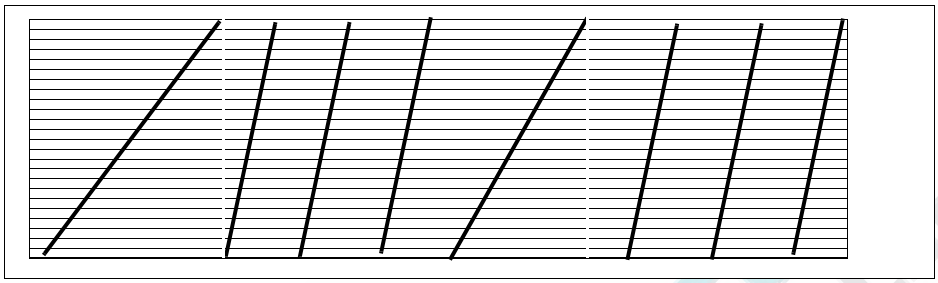
Step	
1	In the **System Diagnostics** menu, select the **Display Test** button. The display test draws a sequence of patterns on the monitor screen. Each pattern is displayed for five seconds. When the last pattern is drawn, the sequence starts again from the first pattern. The following table describes the test patterns that are displayed.

Pattern	Description of Screen
Vertical Bars	Alternating black and white vertical bars, starting with white. This description is displayed in red text across the top of the screen.
Vertical Bars (inverse)	Alternating black and white vertical bars, starting with black. This description is displayed in red text across the top of the screen.
Solid White	The screen background is white. **White** is displayed in black text that moves across the screen.
Solid Red	The screen background is red. **Red** is displayed in black text that moves across the screen.
Solid Green	The screen background is green. **Green** is displayed in black text that moves across the screen.
Solid Blue	The screen background is blue. **Blue** is displayed in black text that moves across the screen.

2	To end the test, do one of the following: • On the SureSigns VS2+monitor, press the wheel. • On the SureSigns VSi monitor, press the **Select** key.

Testing the Optional Recorder (VS2+ Monitor Only)

To test the optional recorder:

Step	
1	In the **System Diagnostics** menu, select the **Recorder Test** button to start the test. The recorder prints a test pattern similar to the following: 
2	Use the pattern to identify the recorder problem. For example, a faulty print head or motor.

Testing the Charging LED

To test the Charging LED:

- In the **System Diagnostics** menu, select the **LED Test** button.

  The expected LED behavior during the test is displayed. If the Charging LED is working properly, it does the following:

  – Lights in yellow for five seconds
  – Lights in green for five seconds
  – Flashes in yellow for five seconds
  – Flashes in green for five seconds

  The AC Power LED remains green during the test.

If the LEDs do not function as expected, see “Power Problems” on page 4-6.

Viewing and Resetting Tracked Parameters

The monitor tracks the usage of some of its parameters, which is useful in diagnosing problems with the monitor.

The monitor tracks the following parameters:

Parameter	Description
LCD Usage Hours	The number of hours that the LCD screen has been on.
NBP Cycle Count	The number of NBP measurements taken on the monitor.
Errors	The number of errors recorded by the monitor. For more information about tracked errors, see "Viewing, Exporting, and Printing (VS2+ Monitor Only) the Error Log" on page 4-36.

Resetting Parameters

Caution **You must always reset a tracked parameter after replacing the associated part.**

To reset a tracked parameter:

Step	
1	Access the **Maintenance** options.
2	Select the **Reset** button to the right of the parameter to reset. A confirmation window appears.
3	Select **Yes**.
4	To save the setting, press the **On/Standby** key and then restart the monitor.

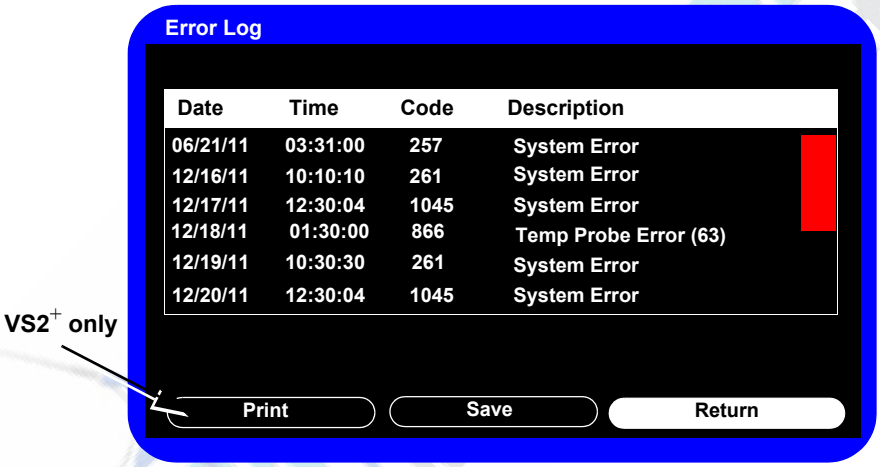
Viewing, Exporting, and Printing (VS2+ Monitor Only) the Error Log

When the monitor detects an error, it displays a message in the message area and saves the error to the error log. The log includes a timestamp that indicates when the error occurred.

To clear the error count and log, see “Resetting Parameters” on page 4-35.

For detailed information about errors and error codes, see “Error Codes” on page 4-12.

To view the error log:

Step	
1	In the **System Diagnostics** menu, select the **Error Log** button. The **Error Log** window opens. Each error log entry includes a timestamp, a unique error code, a description of the error, and an optional block of error information. 
2	To view the entire list of errors, select the list to activate scrolling.
3	To save the error log to a USB flash drive: • Insert a compatible USB flash drive into the USB port on the rear of the monitor. • In the **Error Log** window, select the **Save** button. The error log is saved to the USB flash drive as an .xls file.
4	On the VS2+ monitor only, to print the error log to the optional recorder: • In the **Error Log** window, select the **Print** button.

Clearing Patient Data

The **Clear Data** option clears all patient data in memory and the error log. It does not clear calibration and hardware configuration data. When you return a monitor for service, you must first clear the patient data.

To clear all patient data:

Step	
1	Open the **Maintenance** options of the **System Diagnostics** menu. See "Accessing the Maintenance Options" on page 3-10.
2	Select the **Clear Data** button. A confirmation window appears.
3	In the confirmation window, select **Yes**. The monitor clears the patient data and error log, and then restarts.

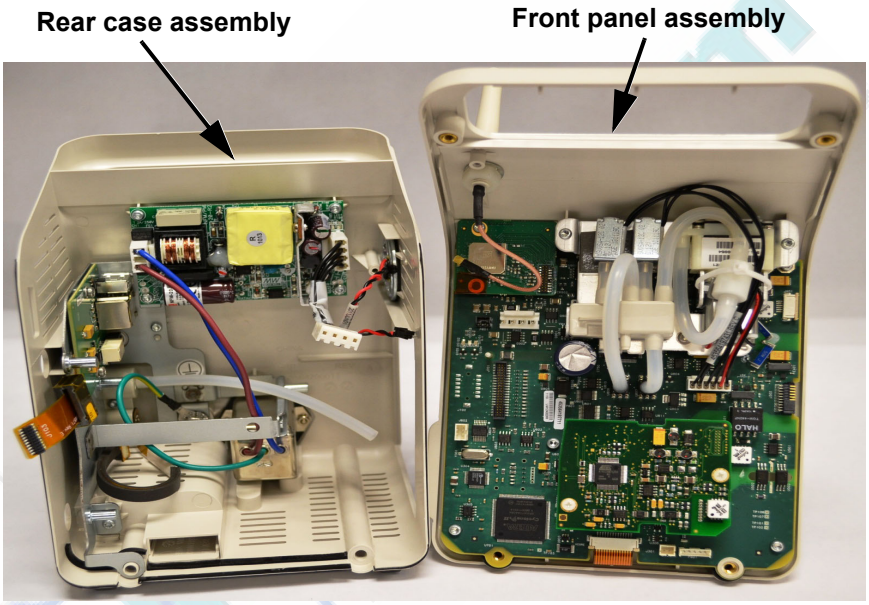
5
Repairing the Monitor

Disassembling the Monitor

This chapter contains the procedures for disassembling and assembling the monitor to replace or repair defective assemblies or components.

The monitor has two main assemblies:

- Rear case assembly
- Front panel assembly



For more information about replaceable parts, see Chapter 6, “Replacement Parts and Assembly Drawings.”

Warning **Before you attempt to open or disassemble the monitor, disconnect the AC power from the monitor and remove the battery. Remove any cables from the measurement modules, and the nurse call and network connections.**

After any monitor repair, you must perform the recommended Performance and Safety tests before putting the monitor into operation. Failure to perform these tests might result in erroneous monitor readings. For more information about performing safety and performance tests, see Chapter 3, “Performance Verification Testing.”

Caution **Observe ESD (electrostatic discharge) precautions when working inside the monitor.**

Tools Required for Service

The following tools and equipment are required to disassemble, repair, and re-assemble the monitor:

- Small Phillips screwdriver
- Torx T10, T20 screwdrivers
- Medium flathead screwdriver
- 10 mm wrench
- 6 mm wrench
- Needle-nose pliers
- ESD mat and wrist strap

Shutting Down the System

Perform a hard shutdown whenever you need to power down the monitor for repair. This ensures that all patient and system data is saved in memory.

To perform a hard shutdown:

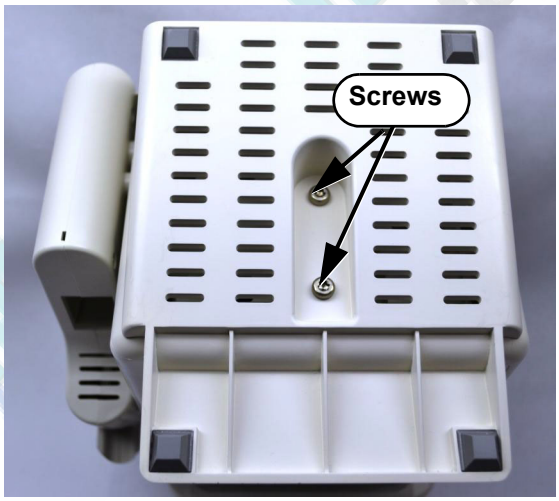
Step	
1	Select the **System** button. The **System Menu** appears.
2	Select the **Shutdown** button.
3	In the window that appears, select the **Yes** button. The monitor shuts down.

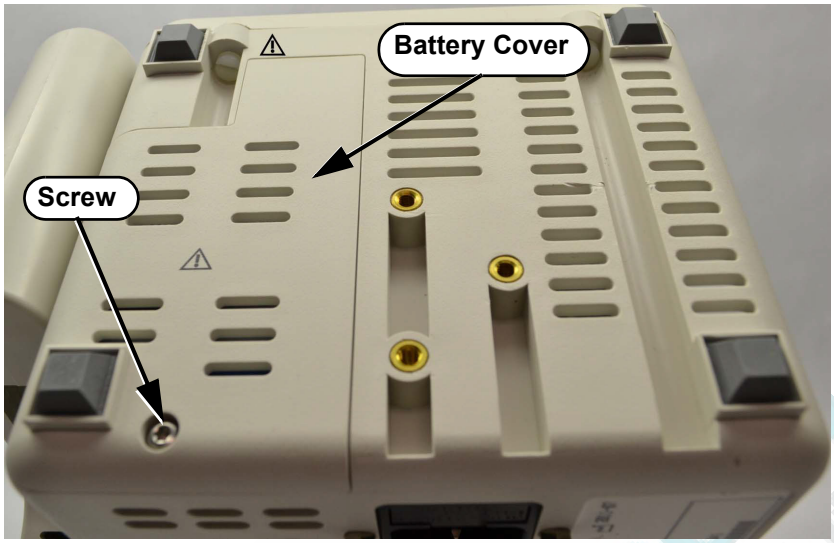
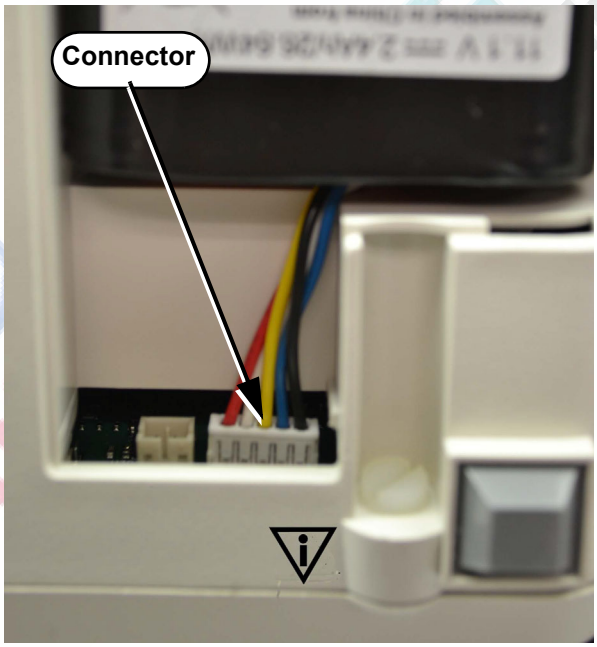
Removing the Battery

Warning **Dispose of used batteries in an environmentally responsible manner. Do not dispose of the battery in normal waste containers. Consult your hospital administrator to find out about local arrangements.**

Caution **Before you remove the battery, perform a hard shutdown.**

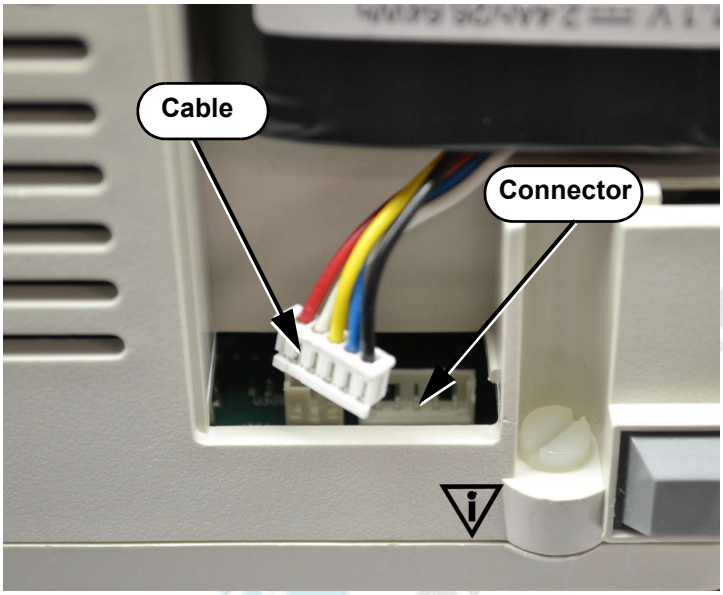
To remove the battery:

Step	
1	Perform a hard shutdown (see “Shutting Down the System” on page 5-2) and disconnect the power cord from the rear of the monitor.
2	If your monitor has a tabletop base, remove it by removing the two Torx T20 screws from the bottom of the base. 

3	Remove the Torx T10 screw from the battery cover on the bottom of the monitor. 
4	Disconnect the battery cable from the connector and remove the battery from the monitor. 

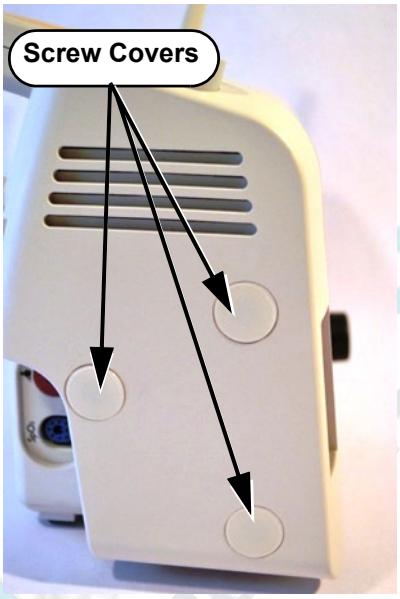
Installing the Battery

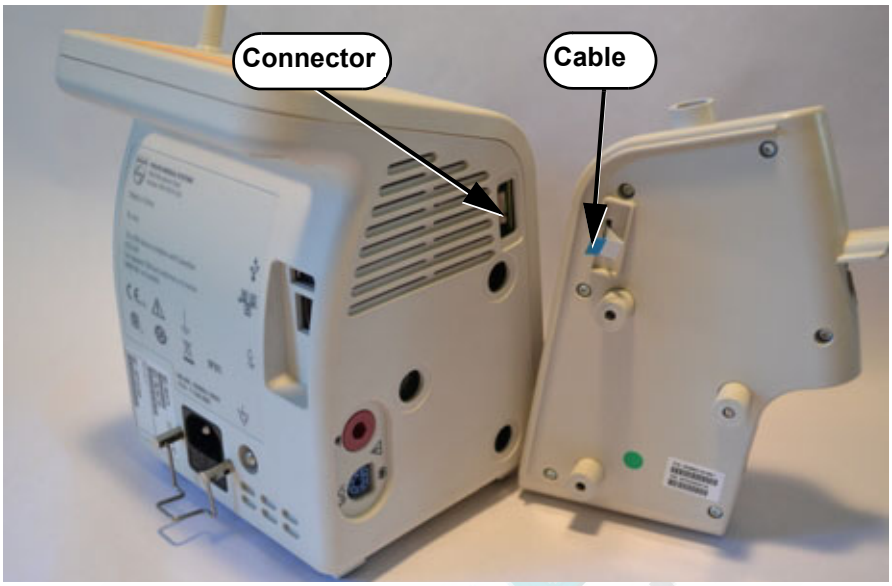
To install the battery:

Step	
1	Connect the battery cable. Ensure that the cable is attached securely to the connector. 
2	Insert the battery into the compartment with the cable closest to the case.
3	Replace the battery cover and the Torx T10 screw.
4	Confirm that the battery is installed correctly by observing that the Charging LED is lit.

Removing the Temperature Module

To remove the temperature module:

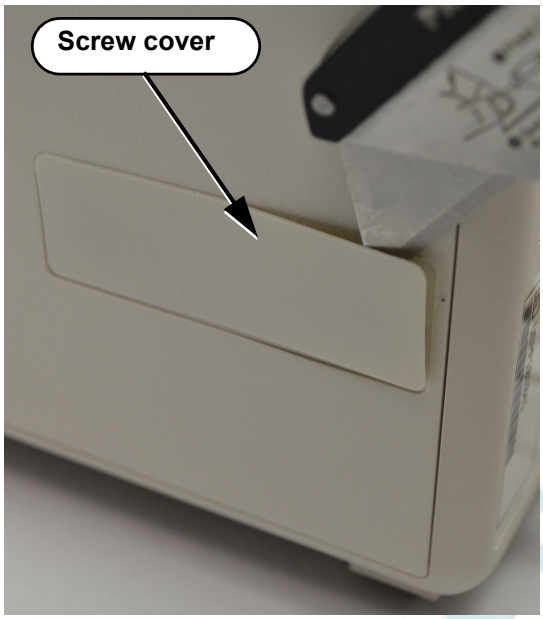
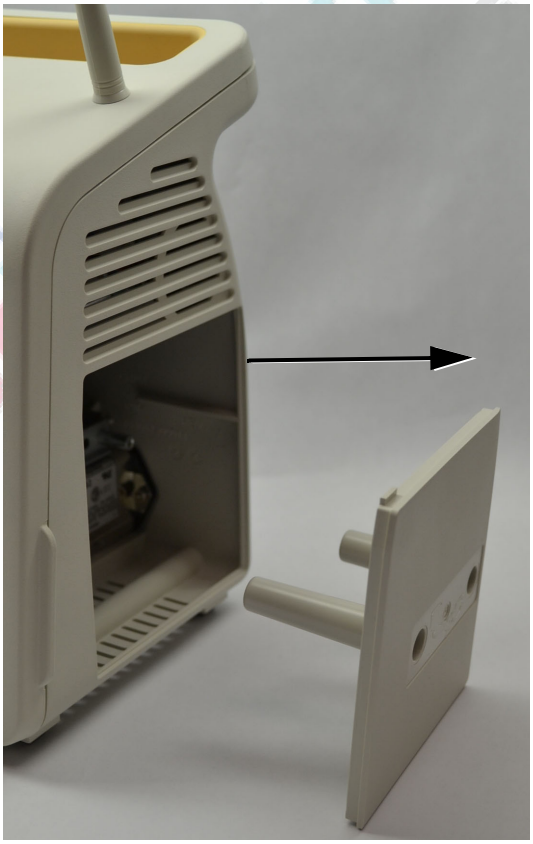
Step	
1	Remove the temperature probe and well.
2	Remove the adhesive covers from the screw holes by inserting a sharp, pointed tool under the edge of the covers. 
3	Remove the three Torx T20 screws from the temperature module.

4	Slowly and gently pull the temperature module away from the monitor and disconnect the cable from the connector on the main board.  **Caution** **After you replace the temperature module, perform the temperature accuracy test. For more information, see "Temperature Test" on page 3-16.**

Removing the Recorder Faceplate

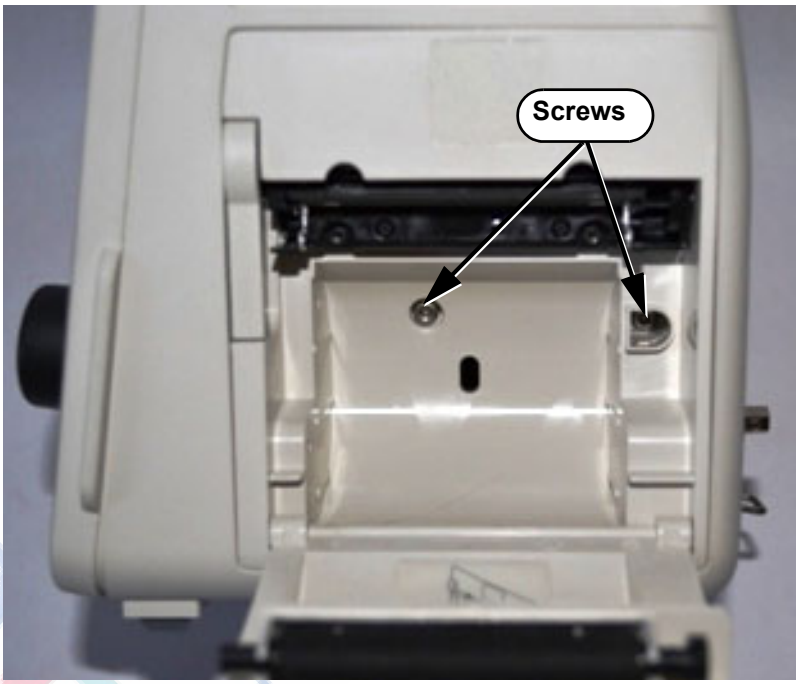
For monitors without an optional recorder, remove the faceplate as follows:

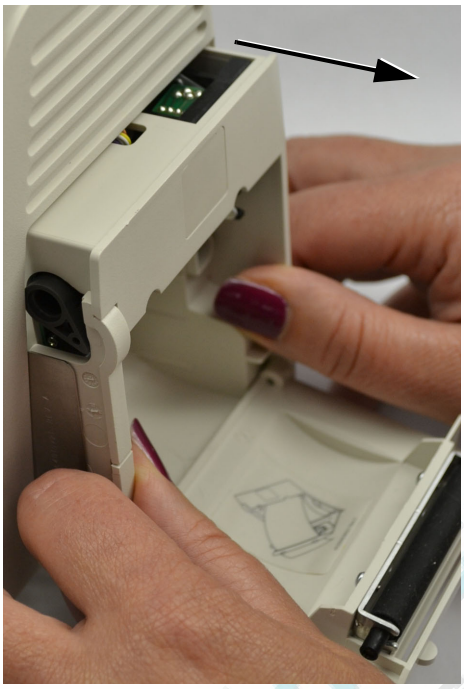
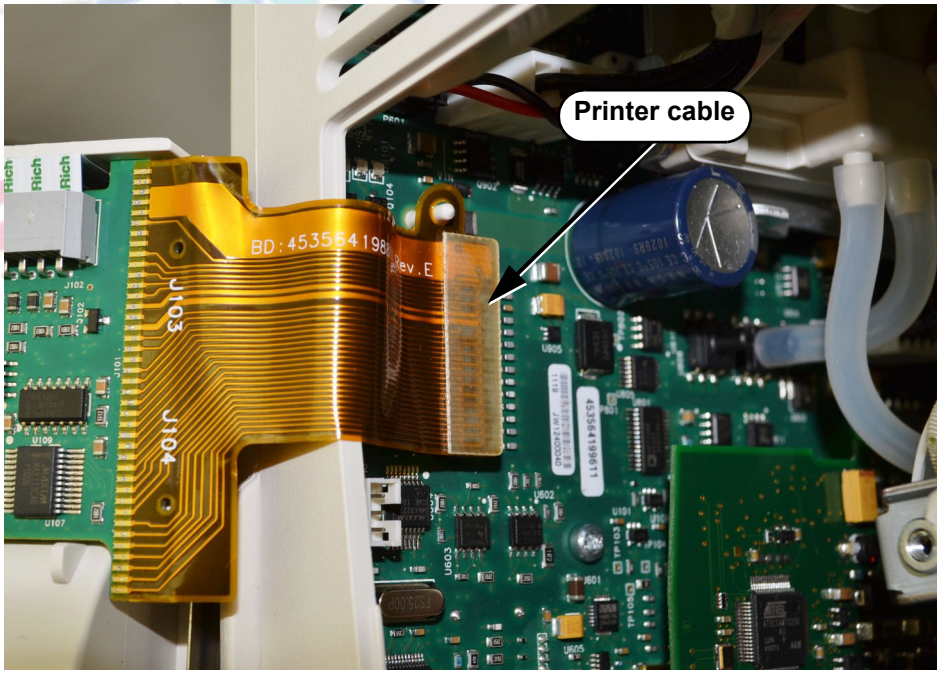
Step	
1	Remove the battery. See "Removing the Battery" on page 5-3.

2	Remove the plastic adhesive screw cover by inserting a sharp tool under it and lifting it up. 
3	Remove the two Torx T10 screws and pull the faceplate straight away from the monitor. 

Removing the Optional Recorder (VS2+ Only)

To remove the optional recorder:

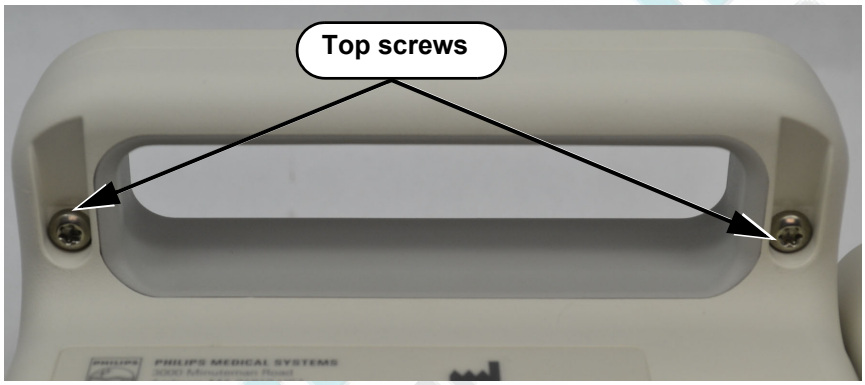
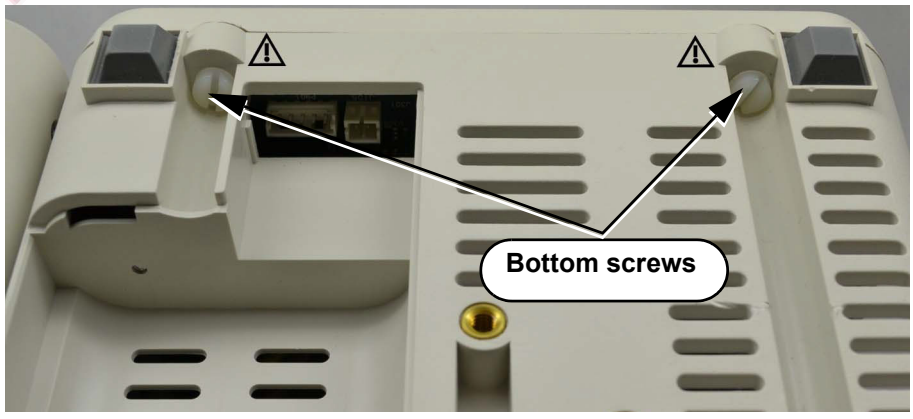
Step	
1	Remove the battery. See “Removing the Battery” on page 5-3.
2	Open the recorder door and remove the paper roll.
3	Loosen (do not remove) the two Torx T10 screws holding the recorder to the monitor case. 

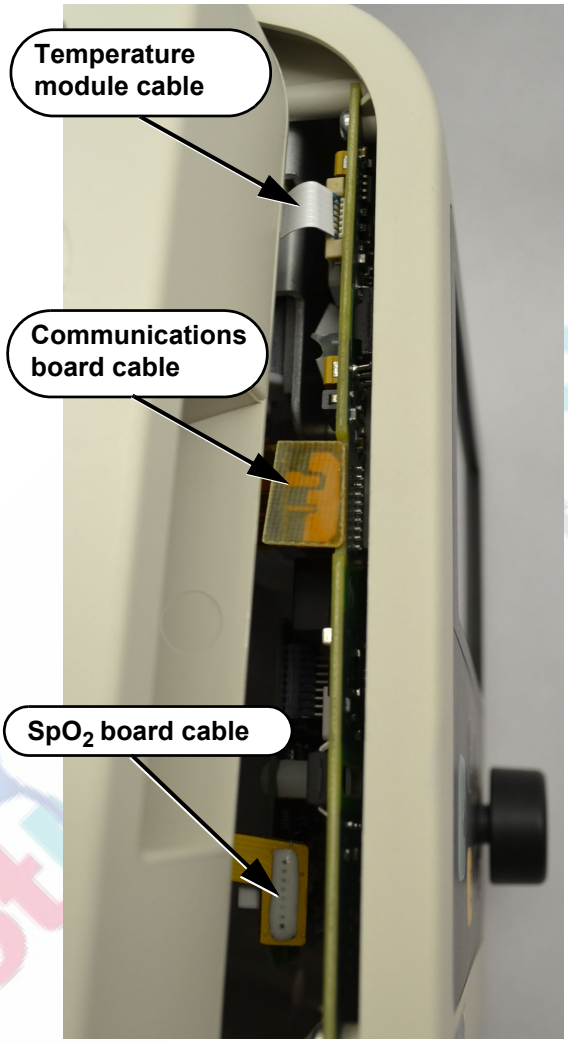
4	Place your thumbs on either side of the recorder case and being careful not to pull the ribbon cable from the connector, slowly pull the recorder straight out of the monitor.  **Caution** **When you reassemble the recorder or faceplate, do not overtighten the screws.**
5	Rotate the recorder to the side to expose the printer cable connection and disconnect the printer cable from the main board. 

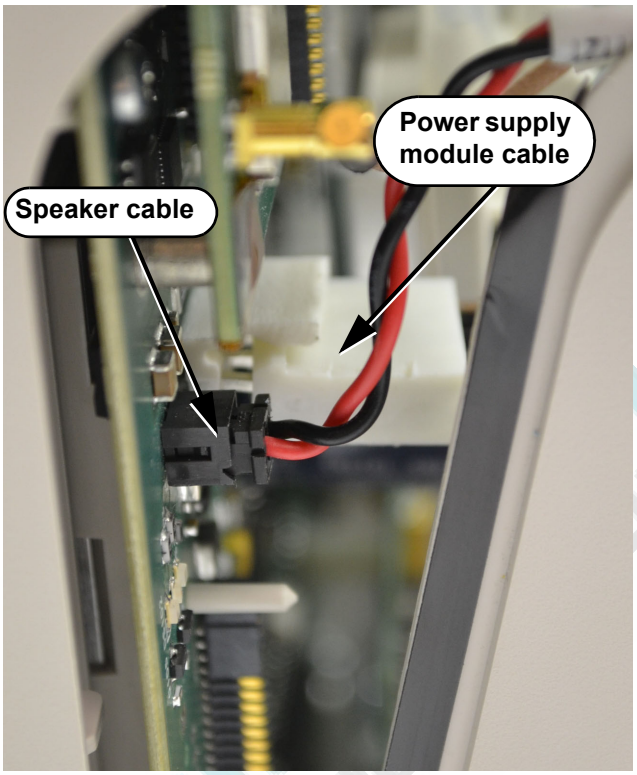
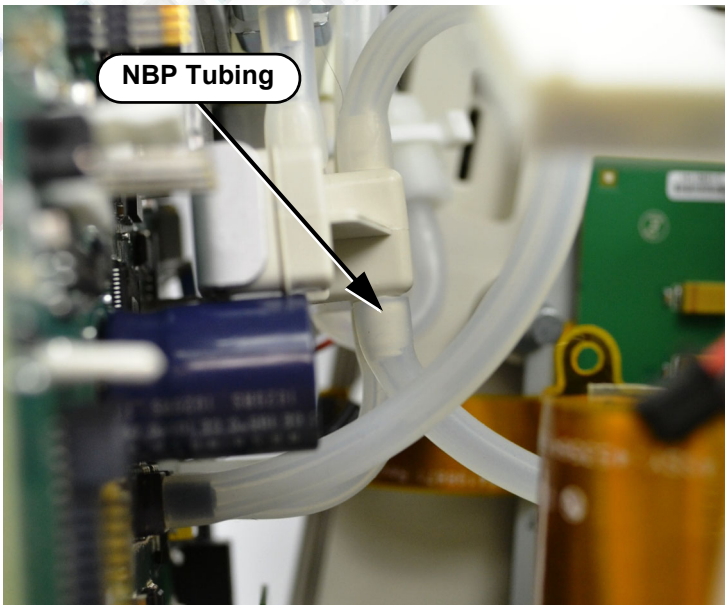
Removing the Front Panel

To open the monitor to install internal replacement parts, you must first separate the front panel assembly from the rear case assembly.

To remove the front panel:

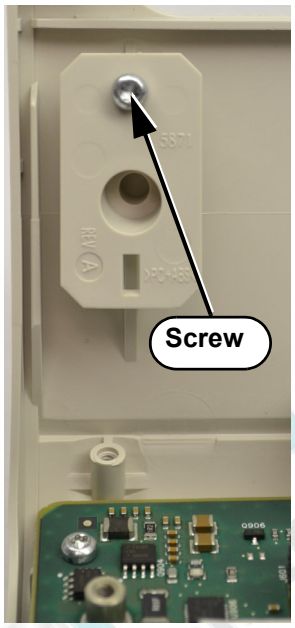
Step	
1	Remove the battery from the monitor. See “Removing the Battery” on page 5-3.
2	Remove the recorder faceplate or recorder. See “Removing the Recorder Faceplate” on page 5-7 or “Removing the Optional Recorder (VS2+ Only)” on page 5-9.
3	Remove the two Torx T20 screws from the top of the monitor. 
4	Remove the two nylon flathead screws from the bottom of the monitor. ***Warning*** **When you reassemble the monitor be sure to install the nylon screws in the bottom of the monitor. Installing metal screws in the bottom of the monitor can cause an electrical hazard.** **As shown in the illustration below, the nylon screws are associated with the symbol:** ⚠. 

5	Gently pull the front panel up and over the handle, and while holding the two parts close together, disconnect the cables in the following order: 1. Temperature module cable 2. Communications board cable 3. SpO_2 board cable 

6	On the opposite side of the monitor, disconnect the speaker cable and the power supply module cable. 
7	Disconnect the NBP tubing from the bottom left connector on the NBP module. 
8	Carefully and slowly pull the front panel away from the rear case.

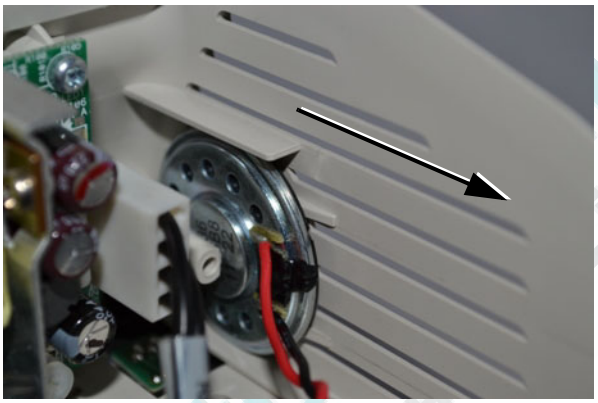
Reassembling the Monitor

To reassemble the monitor:

Step	
1	If you are replacing the front panel on a monitor with the wireless option, you must first remove the antenna hole cover from the replacement front panel by doing the following: • Remove the Torx T10 screw from the cover.  • Remove the cover from the antenna hole and reinstall the antenna.
2	Reconnect the cables that run between the front panel and rear case.
3	Snap the front panel and rear case together and install the two Torx T20 screws in the handle.
4	Install and hand-tighten the two nylon screws in the bottom of the case. ***Warning*** **Be sure to install the nylon screws in the bottom of the case. Installing metal screws in the bottom of the case can cause an electrical hazard.** **Caution** **Only hand-tighten the nylon screws.**
5	Replace the power cord and turn on the monitor.
6	If the monitor starts up properly, perform the required performance tests. See Chapter 3, “Performance Verification Testing.”

Replacing the Speaker

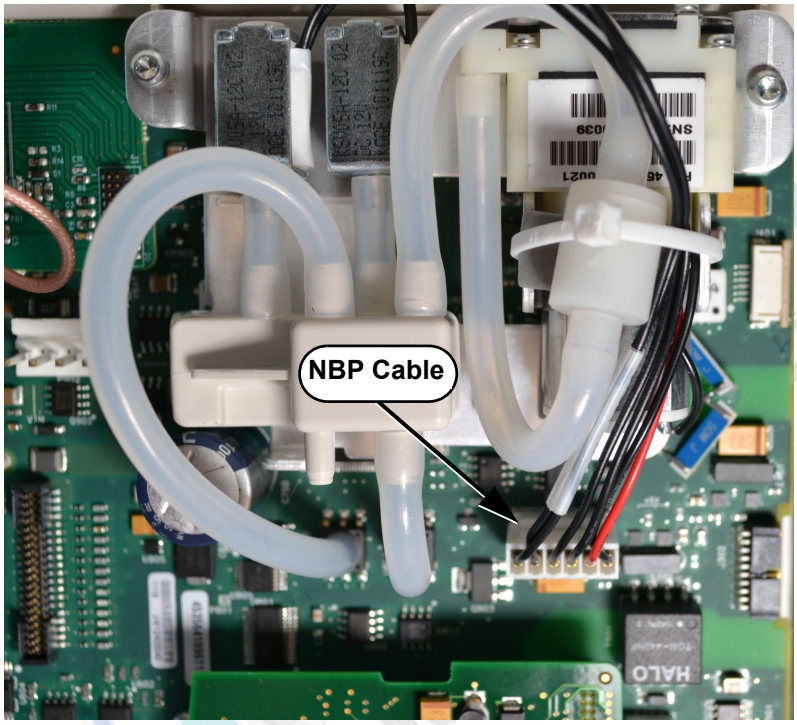
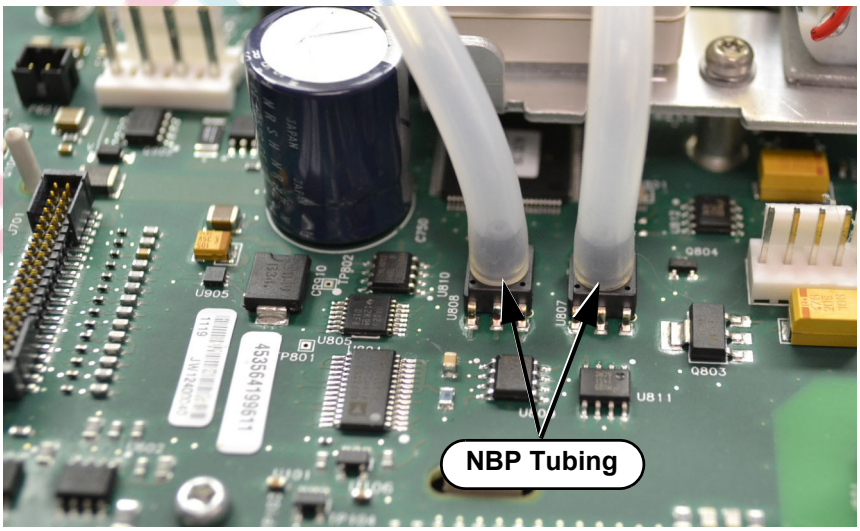
To replace the speaker:

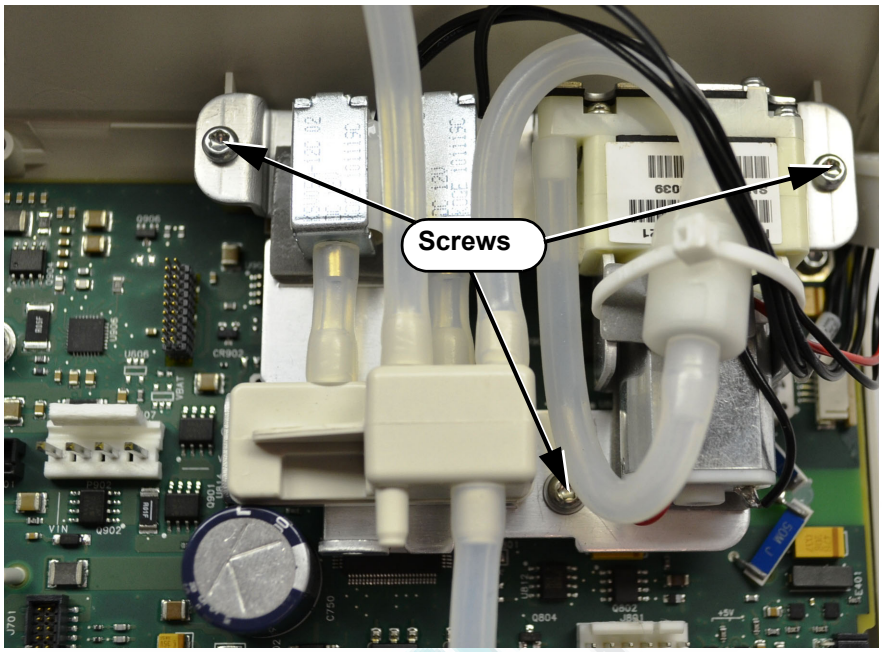
Step	
1	Separate the front panel from the rear case assembly to disconnect the speaker cable. See “Removing the Front Panel” on page 5-11.
2	Remove the speaker by gently lifting it over the ridge and sliding it out of the rear case. 
3	Slide the speaker back into the rear case, connect the cable, and reassemble the monitor.
4	After you reassemble the monitor, ensure that the speaker works. Verify that a tone sounds when you power on the monitor and test the alarms. See the “Testing the Speaker” on page 4-31.

Removing the NBP Module

Caution **After you replace the NBP module, you must reset the NBP cycle count and run the NBP test. For information about resetting the NBP cycle count, see “Viewing and Resetting Tracked Parameters” on page 4-35. For information about running the NBP test, see “NBP Tests” on page 3-13.**

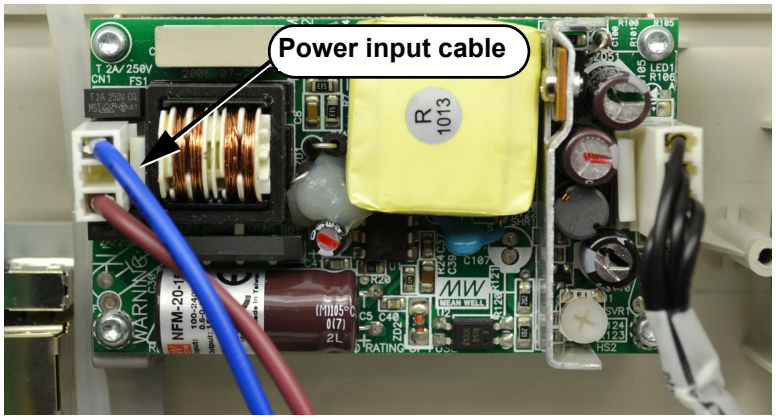
To remove the NBP module:

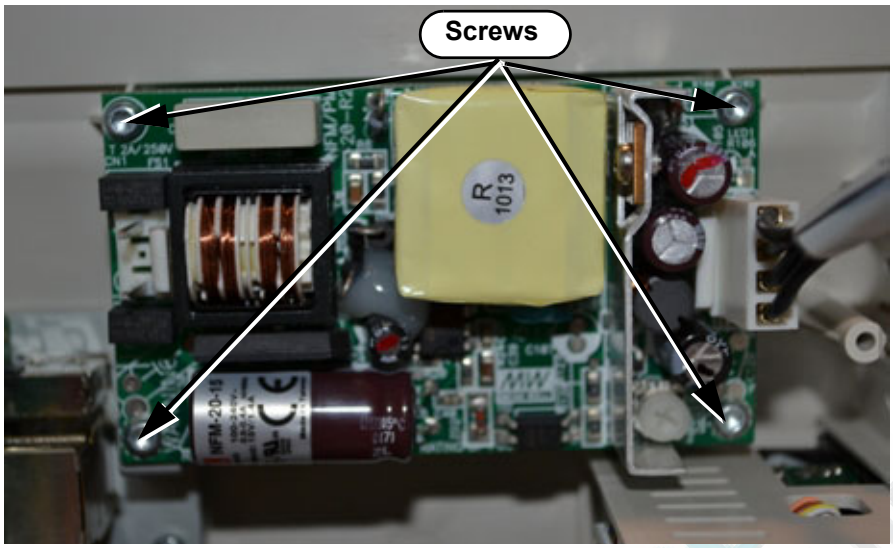
Step	
1	Separate the front panel from the rear case assembly. See “Removing the Front Panel” on page 5-11.
2	Disconnect the NBP cable from the main board. 
3	Disconnect the NBP tubing from the main board. 

4	Remove the three Torx T10 screws from the metal bracket attaching the NBP module assembly to the main board. 
5	Remove the assembly from the front case.

Removing the Power Supply

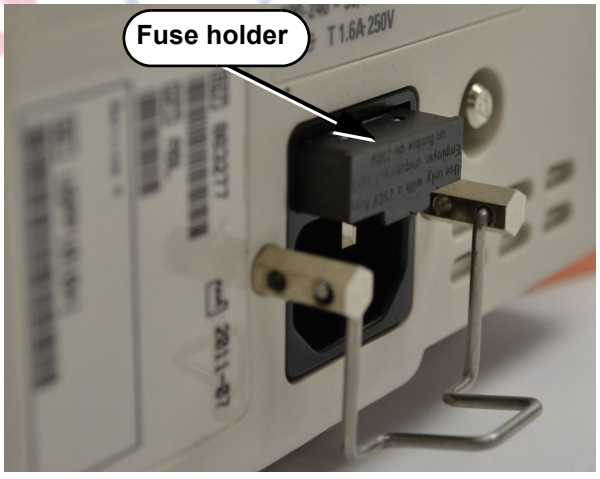
To remove the power supply:

Step	
1	Separate the front panel from the rear case assembly. See “Removing the Front Panel” on page 5-11.
2	Disconnect the power input assembly cable. 

3	Remove the four Torx T10 screws and remove the power supply from the rear case. 

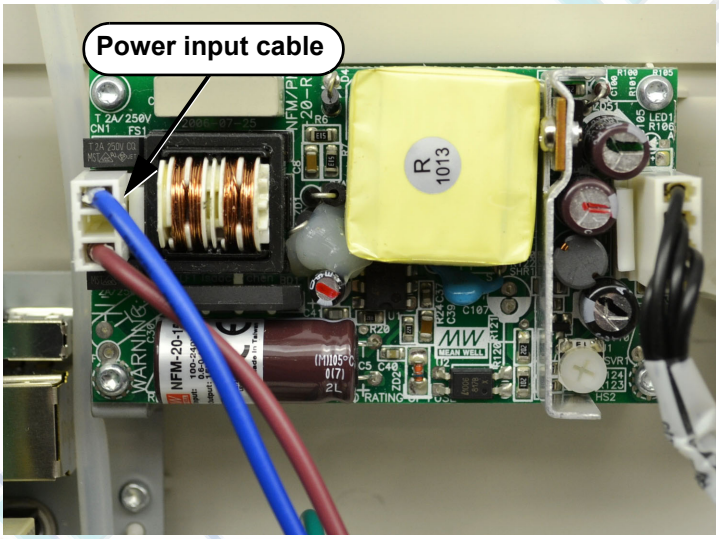
Replacing a Fuse

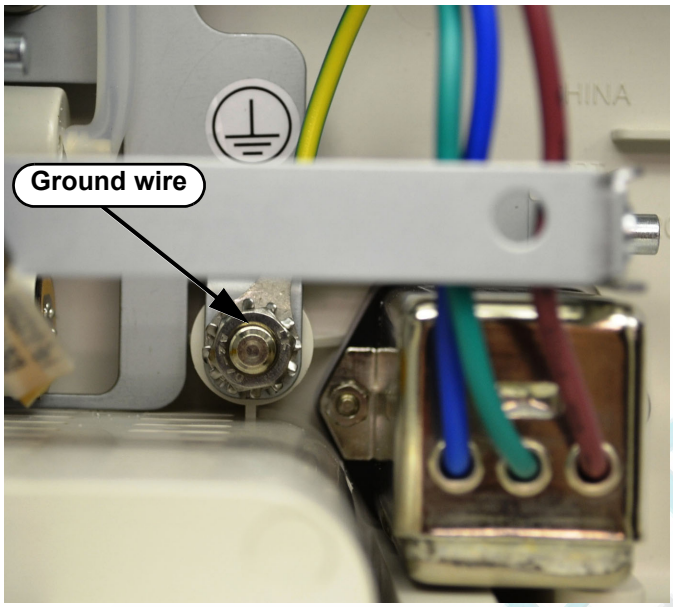
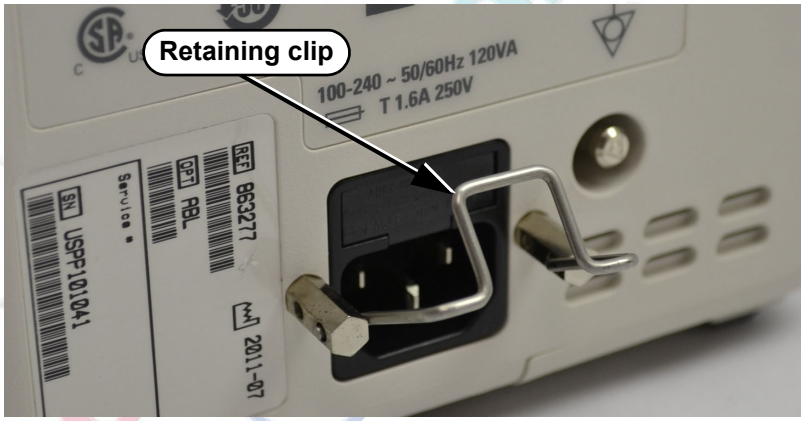
To replace a fuse in the AC power connector:

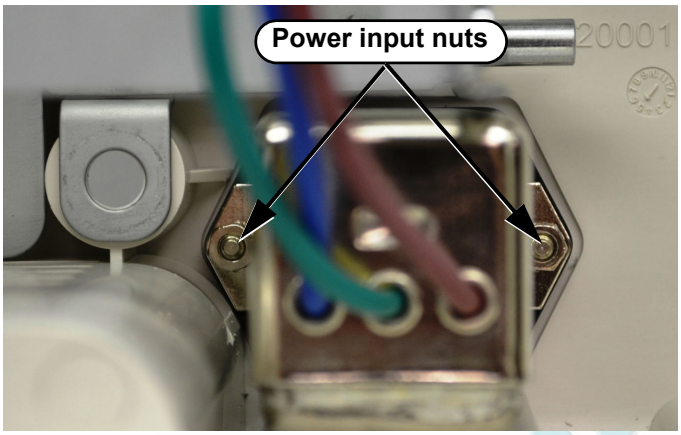
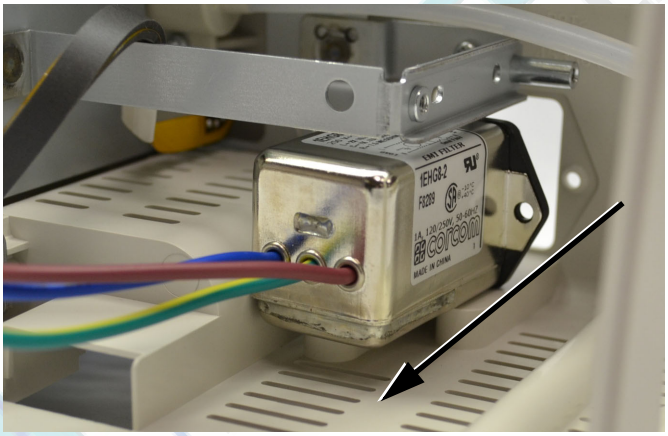
Step	
1	Remove the AC power cord from the rear of the monitor.
2	Remove the battery from the monitor. See “Removing the Battery” on page 5-3.
3	Use a small flathead screwdriver to pry the fuse holder out of the AC power connector. 
4	Replace the fuse(s), and then push the fuse holder back into the power connector until it snaps into place.

Removing the AC Power Connector

To remove the AC power connector:

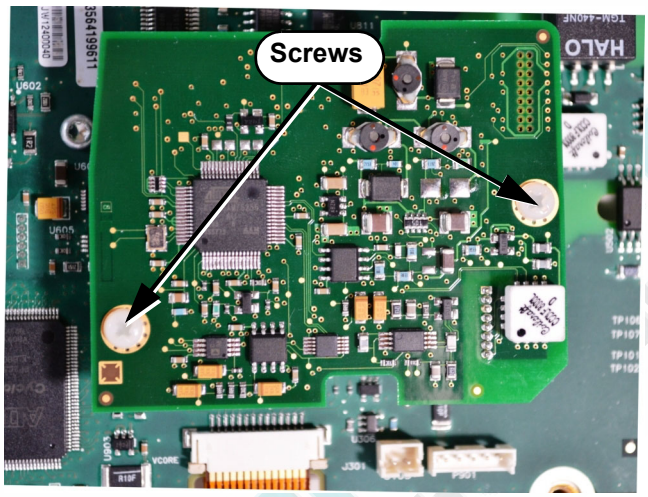
Step	
1	Separate the front panel from the rear case assembly. See “Removing the Front Panel” on page 5-11.
2	On the VS2+ with the recorder option, remove the recorder. See “Removing the Optional Recorder (VS2+ Only)” on page 5-9.
3	Remove the cable tie that secures the power input cables to the chassis.
4	Disconnect the power input cable from the power supply assembly. 

5	Disconnect the ground wire. 
6	Squeeze the power cord retaining clip and remove it from the bolts. 

7	Remove the bolts by using a 6 mm wrench to hold the nut while unscrewing the bolt from the front. 
8	Remove the AC power input assembly from the inside of the rear case. 

Removing the SpO_2 Board

To remove the SpO_2 board:

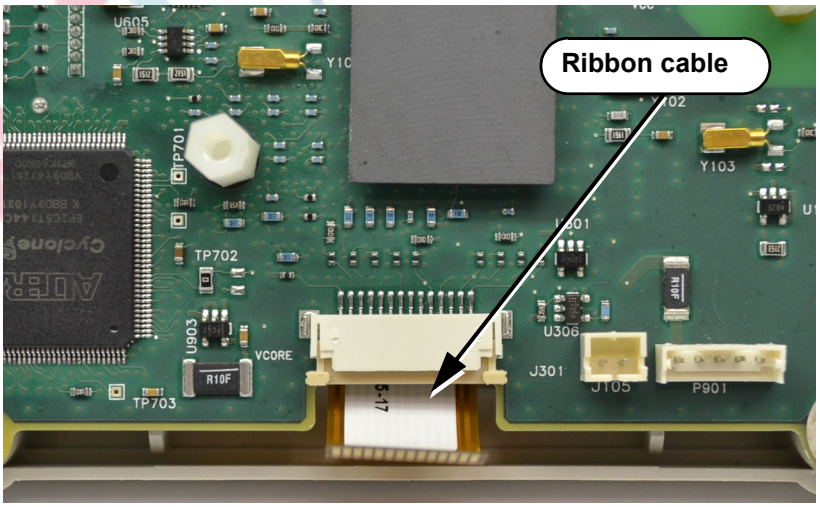
Step	
1	Separate the front panel from the rear case assembly. See “Removing the Front Panel” on page 5-11.
2	Remove the two white plastic Phillips screws on the SpO_2 board assembly. 
3	Lift the SpO_2 board assembly straight up and off of the standoff pegs and away from the connectors on the main board.

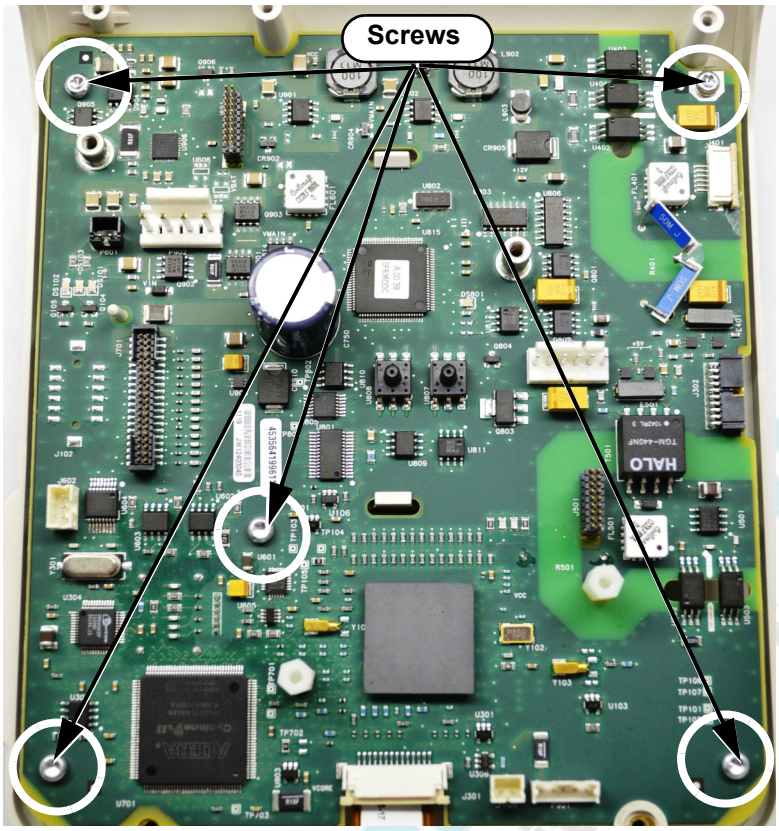
Replacing the Main Board

Caution **To save your current configuration settings, export them before you replace the main board. For more information, see the *SureSigns VS2+ and VSi Installation and Configuration Guide*.**

After you replace the main board, you must reset the monitor serial number and reconfigure the system. For information about resetting the serial number, see “Resetting the Serial Number” on page 5-25. For information about importing previous configuration settings, see the *SureSigns VS2+ and VSi Installation and Configuration Guide*.

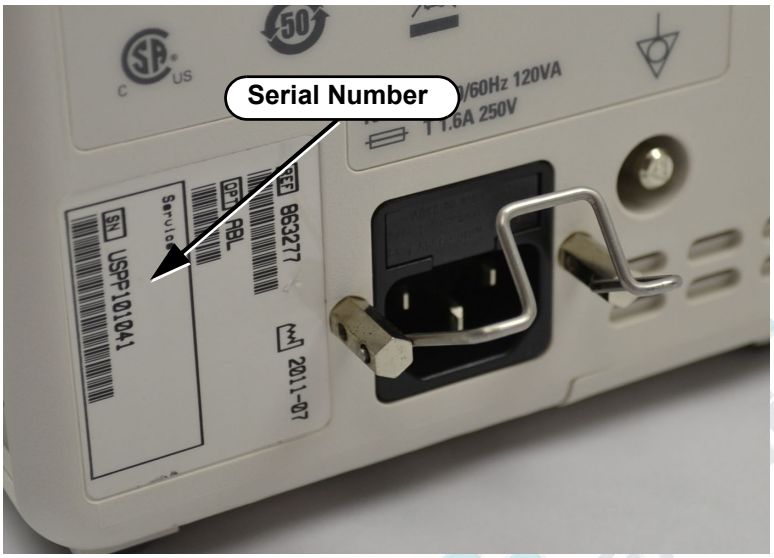
To remove the main board:

Step	
1	Separate the front panel from the rear case assembly. See “Removing the Front Panel” on page 5-11.
2	On the SureSigns VS2+ monitor, remove the navigation wheel by pulling the wheel off of the stem. 
3	Remove the NBP module. See “Removing the NBP Module” on page 5-15.
4	Remove the SpO_2 board. See “Removing the SpO_2 Board” on page 5-22.
5	On monitors with the wireless option installed, remove the wireless board. See “Removing the Wireless Board” on page 5-32.
6	Disconnect the ribbon cable from the main board. 

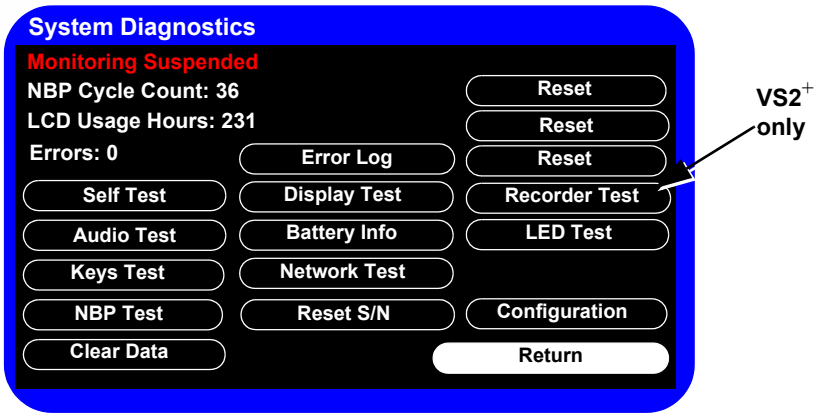
7	Remove the five Torx T10 screws from the main board. 
8	Remove the main board from the front panel.
9	After you replace the main board and reassemble the monitor, you must perform the following procedures before use: • “Resetting the Serial Number” on page 5-25. • “Setting the System Configuration” on page 5-27.

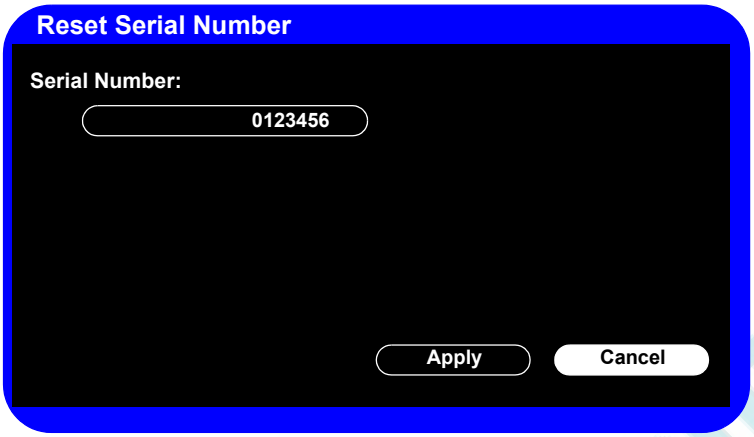
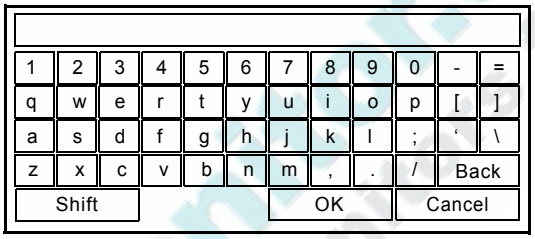
Resetting the Serial Number

When you replace the main board, you must reset the monitor's serial number. The serial number appears in a label (marked SN) on the back of the monitor as shown below.



To reset the serial number:

Step	
1	Access the **System Diagnostics** menu. For detailed information, see "Running System Diagnostics" on page 4-29.
2	Select the **Maintenance >>** button.
3	In the window that appears, enter the password, **1**-**2**-**9**, as shown: 
4	The complete **System Diagnostics** menu, including the **Maintenance** options, appears. 

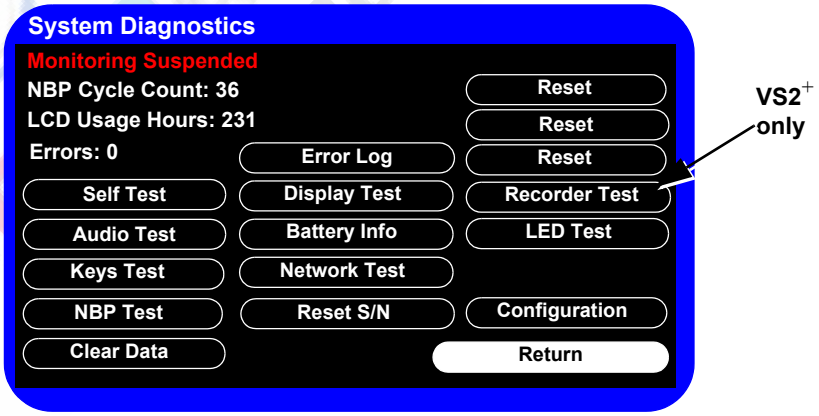
5	Select the **Reset S/N** button. The **Reset Serial Number** menu appears. 
6	Select the **Serial Number** button. A keyboard appears. 
7	Enter the serial number (from the label on the back of the monitor), and then select the **OK** button to save the change.
8	Select the **Apply** button.
9	In the window that appears, select the **OK** button. The monitor restarts.

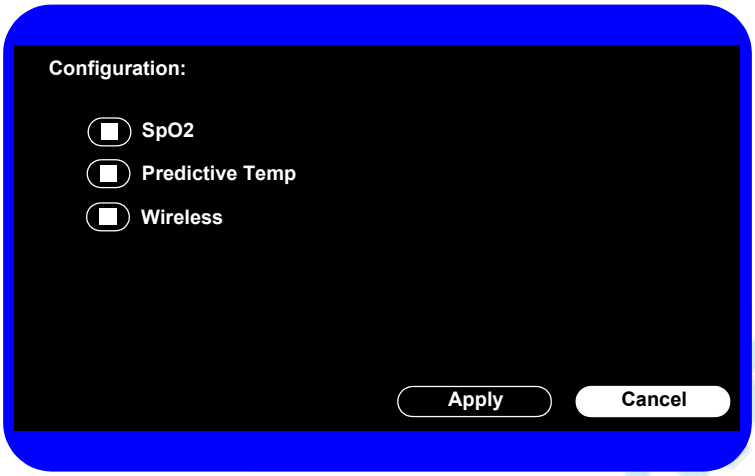
Setting the System Configuration

When the monitor performs a self test, it first checks its system configuration. If you replace the main board, you must reprogram the system configuration.

Caution **The system configuration settings must match the hardware installed on the monitor. Incorrect settings may result in system malfunction alarm messages and the monitor not starting up. If this happens, correct the system configuration settings.**

To reset the system configuration:

Step	
1	Access the **System Diagnostics** menu. For detailed information, see "Running System Diagnostics" on page 4-29.
2	Select the **Maintenance >>** button.
3	In the window that appears, enter the password, **1-2-9**, as shown: 
4	Select the **OK** button. The complete **System Diagnostics** menu, including the **Maintenance** options, appears. 

5	In the **System Diagnostics** menu, select the **Configuration** button. The **Configuration** menu appears: 
6	Select each option to be used. **Note —** *For detailed information about the* **Wireless** *settings, see the* ***SureSigns VS2+ and VSi Network Configuration Guide****.*
7	Select the **Apply** button.
8	In the window that appears, select the **OK** button. The monitor restarts.

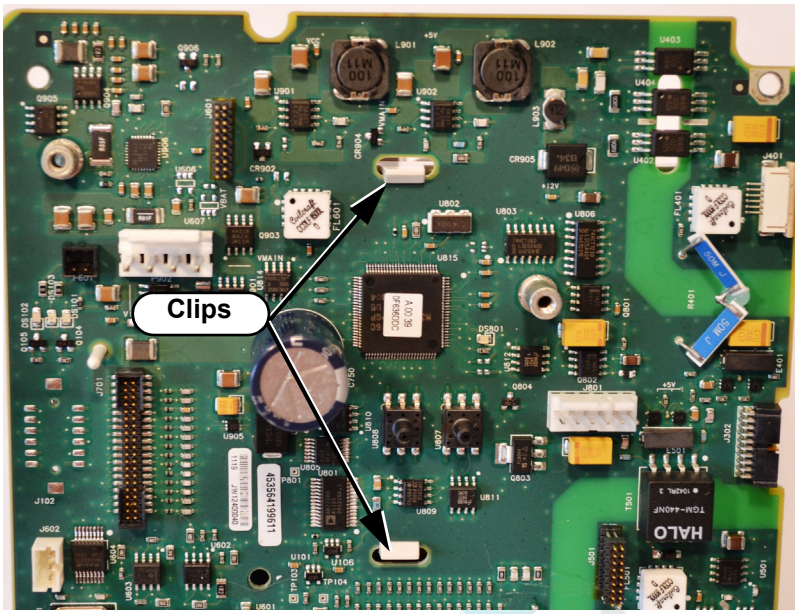
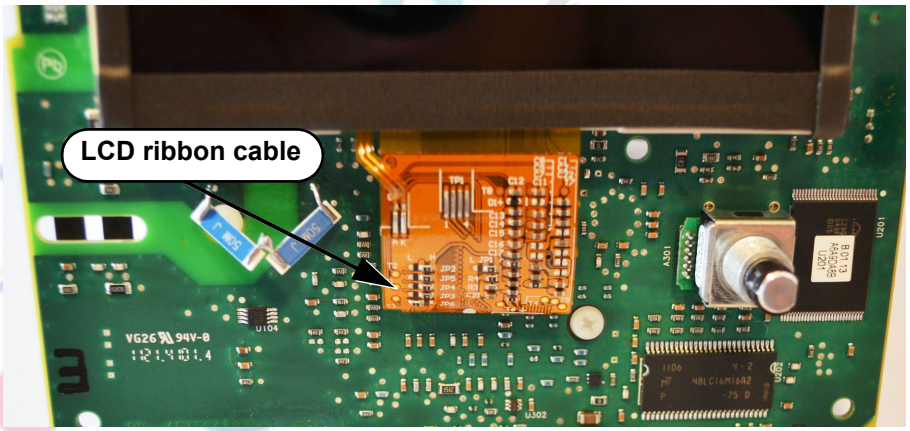
Removing the LCD

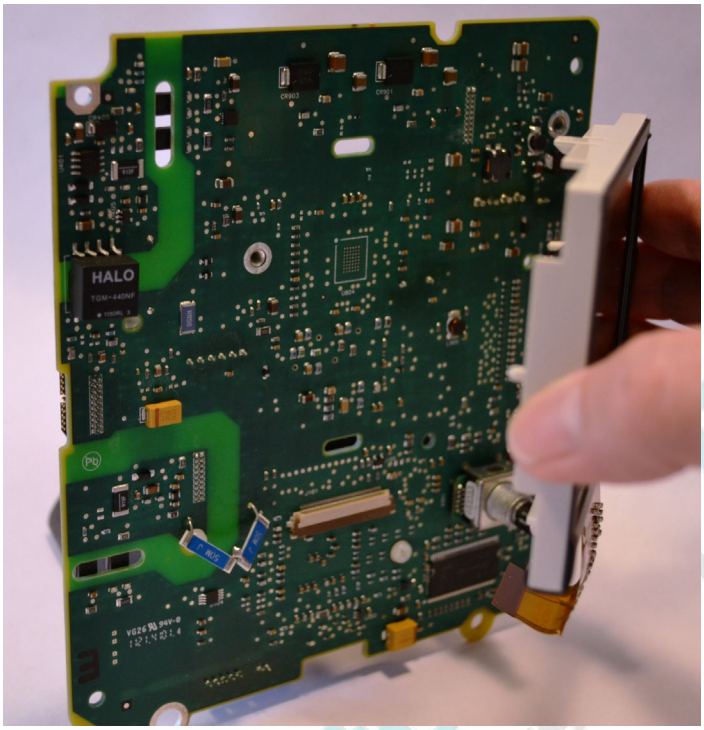
Caution

- **Perform this procedure in a dust-free environment to avoid damage to the LCD display.**
- **After you replace the LCD, you must reset the LCD Usage Hours. For more information about resetting the LCD Usage Hours, see “Viewing and Resetting Tracked Parameters” on page 4-35.**

To remove the LCD:

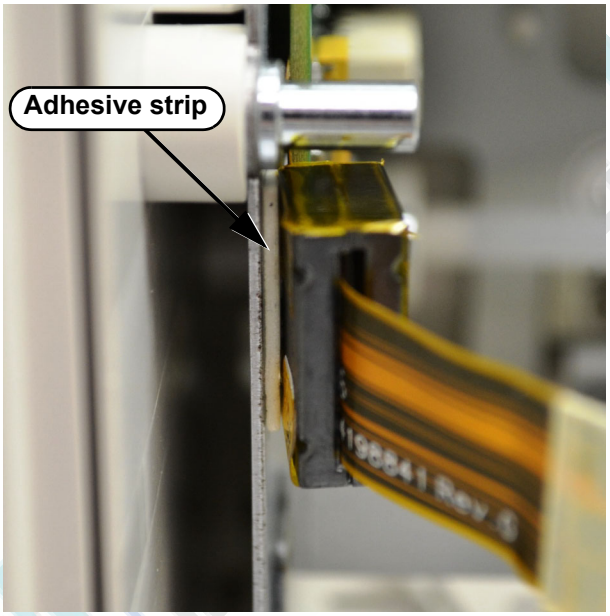
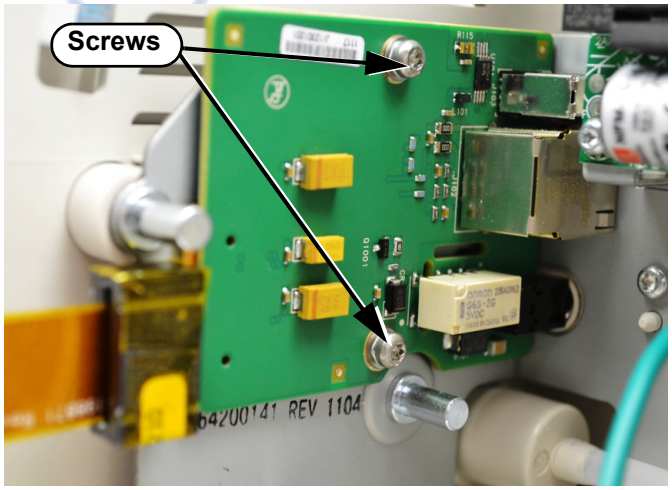
Step	
1	Separate the front panel from the rear case assembly. See “Removing the Front Panel” on page 5-11.
2	Remove the main board. See “Replacing the Main Board” on page 5-22.

3	Disengage the two clips that attach the LCD module to the main board. 
4	Disconnect the LCD ribbon cable from the main board. 

5	Remove the LCD from the front panel. 

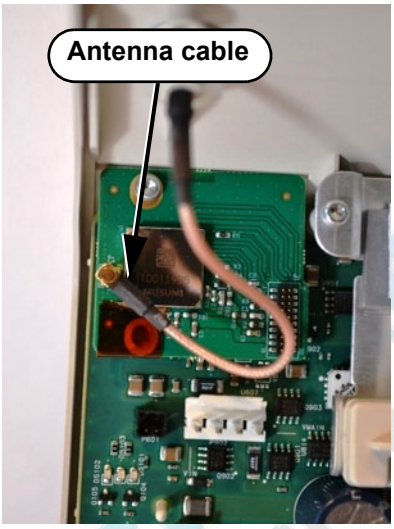
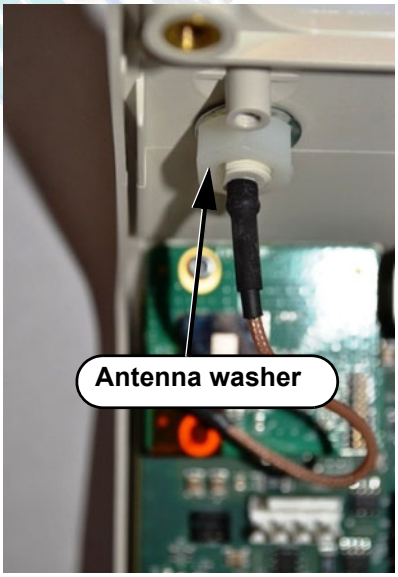
Removing the Communications Board

To remove the communications board:

Step	
1	Separate the front and rear monitor case assemblies. See “Removing the Front Panel” on page 5-11.
2	Remove the cable from the chassis by inserting a sharp tool under the adhesive strip and removing it. 
3	Remove the two Torx T10 screws and washers holding the communications board to the chassis assembly. 
4	Lift the board out of the rear case.

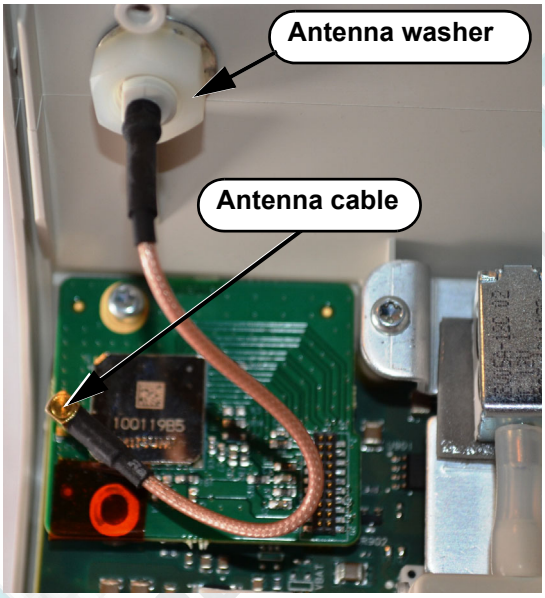
Removing the Wireless Board

To replace the wireless board:

Step	
1	Separate the front panel from the rear case assembly. See “Removing the Front Panel” on page 5-11.
2	Pull the antenna cable upward to disconnect it from the wireless board. 
3	Loosen the antenna washer and then remove the antenna from the front case. 
4	Remove the Torx T10 screw from the wireless board and remove the board from the front panel.

Removing the Antenna

To remove the antenna:

Step	
1	Separate the front panel from the rear case assembly. See “Removing the Front Panel” on page 5-11.
2	Disconnect the antenna cable from the wireless board and remove the washer. 
3	Unscrew the antenna and remove it from the front panel.

6 Replacement Parts and Assembly Drawings

Spare Parts

The following table lists the SureSigns VS2$^+$ and VSi spare parts, their Philips part numbers, and in which of the following figures they appear. See “Assembly Drawings” on page 6-3 for the referenced figures.

Note — For clarity, some screws and connector lines do not appear in the drawings.

Description	Part Number	Figure	Item
Antenna	4535 642 70421	6-1	5
Battery (lithium ion)	989 803 174881	6-2	19
Battery compartment cover	4535 642 00031	6-2	18
Communications (I/O) board	4535 641 70121	6-2	15
Cover (faceplate, without recorder)	4535 642 70081	6-2	10
Front panel without LCD, VSi	4535 642 70161	6-1	6
Front panel without LCD, VS2$^+$	4535 642 70171	6-1	6
LCD assembly	4535 642 70091	6-1	4
Main board, VSi	4535 642 70081	6-1	3
Main board, VS2$^+$	4535 642 70151	6-1	3
NBP module	4535 642 70111	6-1	1
Power supply module	4535 642 70131	6-2	14
Power input module	4535 642 70141	6-2	16
Rear case, NBP only	4535 642 70181	Not shown	
Rear case, NBP, SpO_2	4535 642 70191	6-2	12
Recorder assembly	4535 642 70221	6-2	11
RS-232 serial adapter (includes USB hub, insulator sheath, and USB clamp)	9898 031 59601	Not shown	
Roll Stand	9898 031 44001	Not shown	

Description	Part Number	Figure	Item
Small parts kit:	4535 642 70201	Not shown	
– Rubber feet (4)		Not shown	
– Battery compartment cover (1)		6-2	18
– Navigation wheel (1)		6-1	7
– VSi Product label (1)		Not shown	
– VS2^{+} Product label (1)		Not shown	
– Recorder faceplate (1)		6-1	10
– M3 x 8 mm machine screws (2)		Not shown	
– M4 x 7 mm machine screws (4)		Not shown	
– Captive screw (recorder) (1)		Not shown	
– M3 x 8 mm self-forming screws (8)		Not shown	
– M3 x 6 mm nylon screws (4)		Not shown	
– M3 x 12.7 mm stand-off pegs (2)		6-2	8
– M4 x 7 mm nylon screws, slotted (4)		Not shown	
– O-ring, 0.5 in. (4)		Not shown	
– Fuse, T 1.0A, 250V (2)		Not shown	
– Power cord retainer clip (1)		Not shown	
Speaker	4535 642 93611	6-2	13
SpO_2 board	4535 640 20531	6-1	9
Temperature calibration key	4535 640 33691	Not shown	
Temperature module	4535 642 70211	6-2	17
USB Hub	4535 640 39661	Not shown	
Wall mount	9898 031 44011	Not shown	
Wireless board	4535 642 70101	6-1	2

Assembly Drawings

See “Spare Parts” on page 6-1 for the part numbers referenced in the following figures.

Figure 6-1 Front Panel Assembly

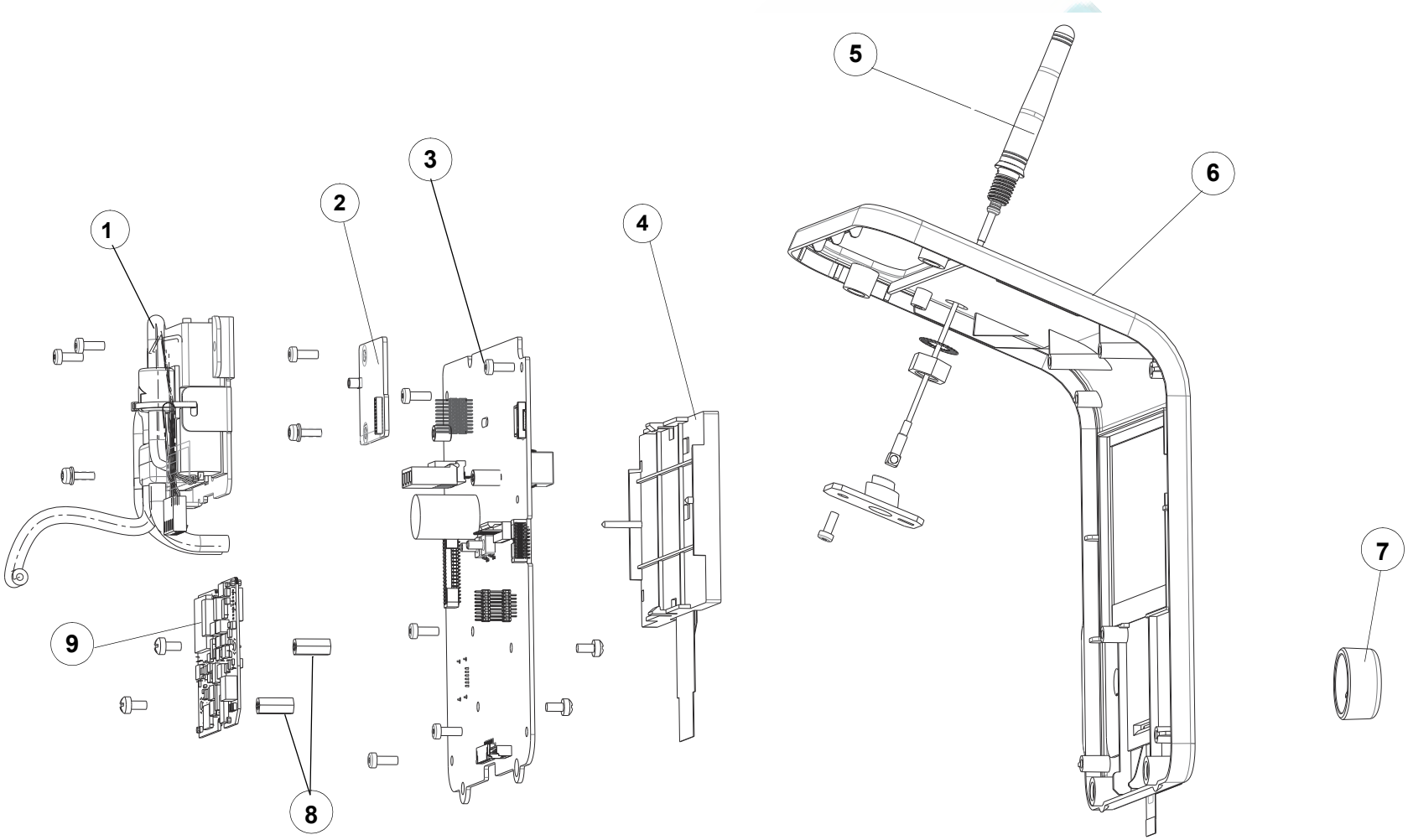
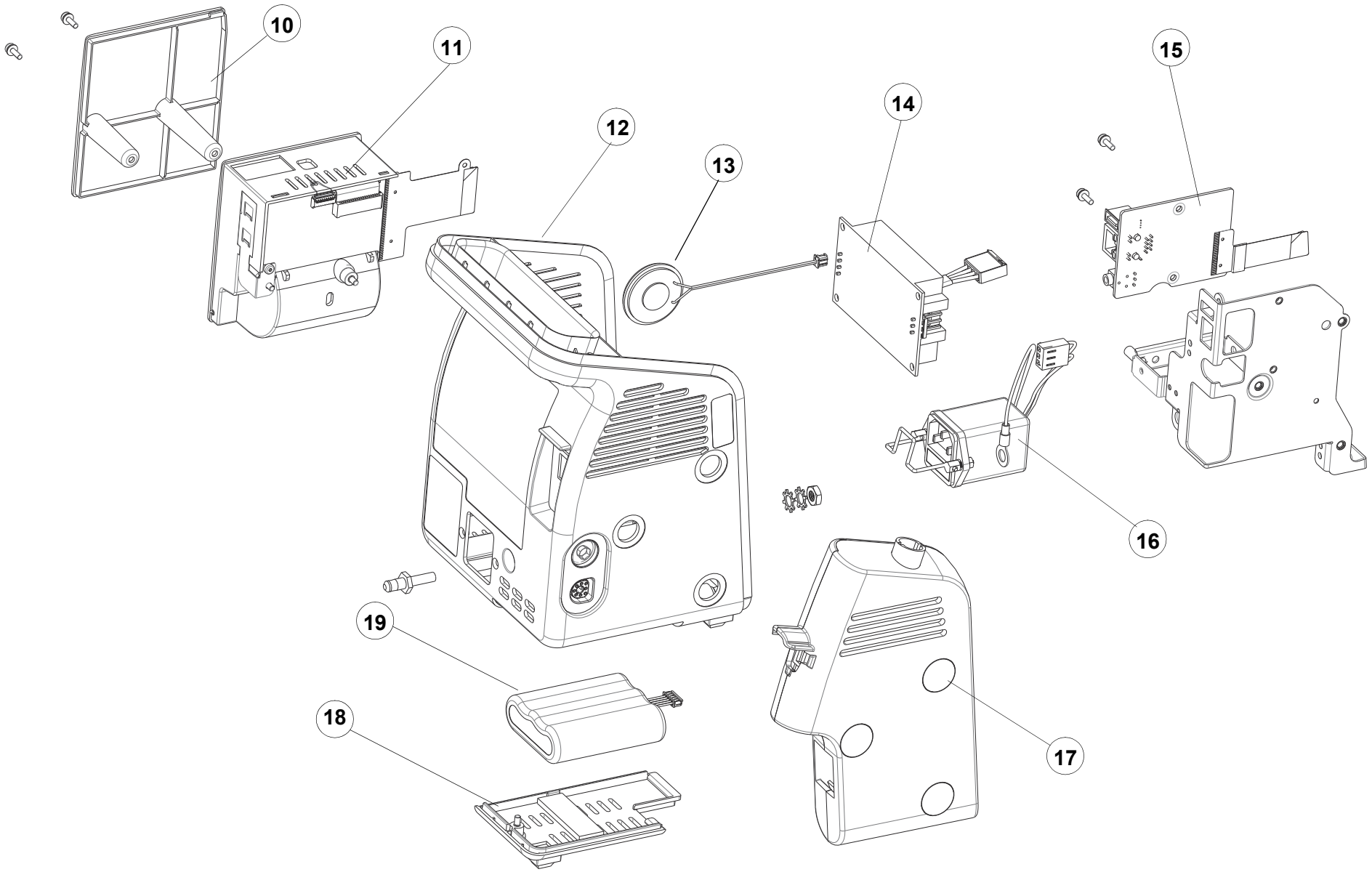


Figure 6-2 Rear Case Assembly



Power Cords

The following table lists the power cord part number and description.

Description	Part Number
Power cord (900), 2 m United Kingdom	8120-1351
Power cord (901), 2 m Australia, New Zealand	8120-4475
Power cord (902), 2 m Europe	8120-1689
Power cord (903), 2.4 m North America	8120-5429
Power cord (906), 2 m Switzerland	8120-2104
Power cord (912), 2 m Denmark	8120-2956
Power cord (917), 2 m India, South Africa	8120-4211
Power cord (919), 2 m Israel	8120-5182
Power cord (920), 2 m Argentina	8120-6869
Power cord (921), 4.5 m Chile	8120-6980

A
Theory of Operation

This section contains a system overview of the SureSigns VS2$^+$ and SureSigns VSi vital signs monitors, including a high-level block diagram. The block diagram shows major components of the monitor, including the power supply, an isolated front end, the NBP control, SpO_2 processing, and a microcontroller.

The monitor is a full function monitor for use on adult, pediatric, and neonatal patients. The measurements performed by the system include:

- Blood pressure
- Blood oxygen saturation
- Temperature

In addition to monitoring and displaying the status of physiological parameters, the monitor performs various microprocessor-programmed analytical functions, including:

- Creating visual and audible alarm signals when settings are violated

  Note — The SureSigns VSi monitor signals technical alarms only.

- Creating and displaying warning messages when conditions are detected that would degrade or prevent valid measurements
- On the SureSigns VS2$^+$ monitor only, providing input to an optional recorder for printout of current waveforms or tabular data

The monitor operates from either an AC power source or battery power. The monitor charges the battery when powered by an AC line.

Block Diagram Components

The monitor contains several major blocks, including:

- Main board
- Communications board

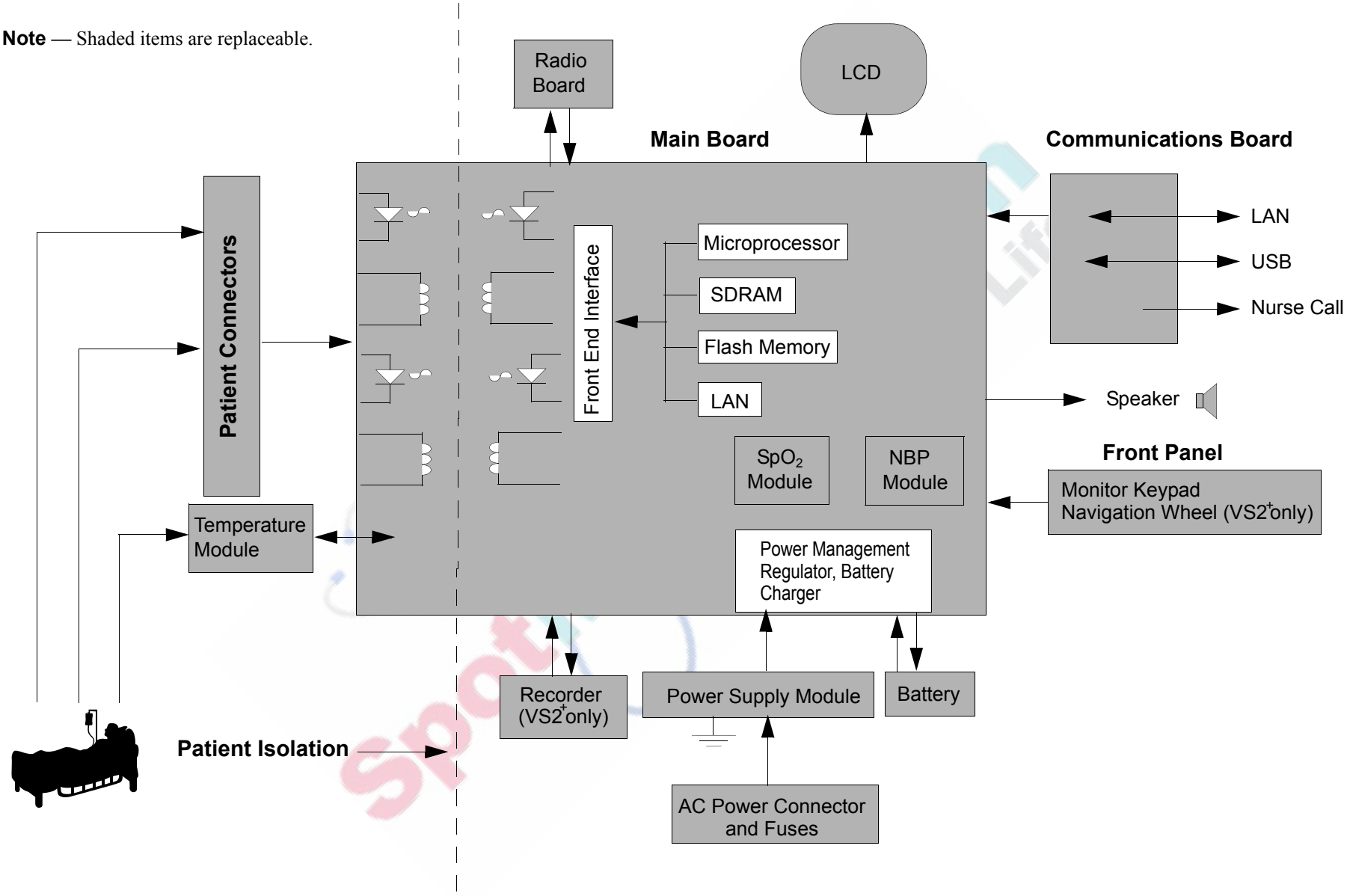
The monitor may contain optional modules.

The following sections briefly describe many of the functional units in the block diagram.

Note — Shaded items in the diagram indicate parts that are replaceable. For more information, see Chapter 5, “Repairing the Monitor.”

VS2+ and VSi Block Diagram

Note — Shaded items are replaceable.



Main Board

The main board contains the following components:

- ARM9 microprocessor
  - 16 MB flash memory
  - 32 MB SDRAM
- LAN controller — 10/100T
- Power management circuit
- NBP control circuitry
- USB – 2.0 compliant
- LCD drivers
- Front end interface circuitry
- Audio Codec
- Connectors
  - DC power input (wire to AC/DC module)
  - Speaker
  - LCD
  - LCD backlight
  - B2B: SpO2 Interface board
  - B2B: Main board
  - B2B: Recorder
  - Wireless board

Communications Board

The communications board contains the following connectors:

- Nurse call alarm
- USB
- LAN

NBP Assembly and Circuitry

The NBP assembly and circuitry contain these elements:

- Pump
- Valves (2-valve system of dump and safety valve)
- Manifold
- Filter
- Pressure measurement and control circuitry

Pressure data is converted to digital format and conveyed to the processor. The NBP pump uses an oscillometric method that employs stepwise pressure deflation. The measurement software eliminates most ambient noise and motion interference.

Applications are neonatal, pediatric, and adult patients. The following table includes the blood pressure ranges.

Application	Systolic	Diastolic	Mean
Adult	30 mmHg – 270 mmHg	10 mmHg – 245 mmHg	20 mmHg – 255 mmHg
Pediatric	30 mmHg – 180 mmHg	10 mmHg – 150 mmHg	20 mmHg – 160 mmHg
Neonatal	30 mmHg – 130 mmHg	10 mmHg – 100 mmHg	20 mmHg – 120 mmHg

The accuracy is ±5 mmHg, with standard deviation no greater than 8 mmHg.

NBP processing uses an oscillometric technique to provide needed measurements at selected intervals. This technique uses an inflatable sphygmomanometer cuff similar to those used by clinicians in routine measurements. At the default initial inflation pressure, a motorized pump inflates the cuff to approximately 160 mmHg (adult mode) initially, at which point the pressure effectively stops the flow of blood. Then, under monitor control, the pressure in the cuff is gradually reduced, while a pressure transducer detects the pressure and transmits the parameter signal to the NBP input circuitry. As the pressure is reduced, blood flows in the previously occluded artery, and changes the measurements made by the transducer. The point at which oscillation increases sharply is defined as systolic pressure. As the cuff continues to deflate, the oscillation amplitude increases to a maximum, and then decreases. The peak oscillation amplitude is defined as the mean arterial pressure. The point at which the system detects a rapid decrease in oscillation is defined as the diastolic pressure.

Power Supply Module

The monitor contains a medical grade power supply module and circuitry that converts AC lines (100 V to 240 V) to DC (15 V). Power consumption is < 25 W.

Power Management

The power management module contains:

- Li + battery
  - 10.8 V to11.1 V
  - 2200 mAH
- Smart battery charger
- DC/DC converter

The power management circuitry charges a Li-Ion battery through a *smart* battery charger. Both the battery and the AC/DC power module can power the system through several DC/DC converters that provide various voltage outputs required by various chips. Isolation transformers provide the power to the front ends floating area.

Speaker

The speaker is driven by an amplifier and Audio CODEC that interfaces to the microprocessor. The speaker provides the monitor's audio during alarm conditions. The microprocessor outputs different audio tones specified by different alarm priorities and conditions.

Nurse Call Contacts

The nurse call alarm contacts are available through a 3.5 mm, miniature insulated phone jack on the back of the monitor. The alarm contacts close (open) for any alarm condition detected by the monitor.

The alarm contacts are the three switching signals associated with a single pole, double throw relay as follows:

- Normally open contact (NO)
- Common contact
- Normally closed contact (NC)

Contact Rating of: 1A @ 25 VAC, 60 VDC

Isolation of 1.5 KV

Front Panel Assembly

The front panel assembly contains these elements:

- LCD
  - 4.3" WVGA display
  - 480 pixels x 272 lines
- Monitor keypad
- Navigation wheel (VS2$^+$ Only)

Navigation Wheel (VS2$^+$ Only)

The navigation wheel is a rotating, push-switch wheel. The associated wheel circuitry generates a pulse when pressed and generates a digitally encoded pair of quadrature signals whose relative magnitudes and polarities represent the angular position of the wheel. These outputs are connected to the microprocessor where they are interpreted as required for the functions involved. Successive angular positions determine the direction of wheel rotation. In addition to the functions performed in conjunction with the keypad, the wheel operates in conjunction with the display to select menus and lists of parameter variables.

Recorder (VS2$^+$ Only)

The recorder contains the following features:

- Digital thermal head array assembly
- Printing width
  - 48 mm on 58 mm paper
  - Resolution:
    Time axis = 16 dots/mm at the speed of ≤ 25 mm/sec, 8 dots/mm at 50 mm/sec
    Voltage axis = 8 dots/mm
- Motor (paper drive) and driver circuitry
- Paper out/door open detector
- Selectable print speed: 6.25, 12.5, 25, 50 mm/s

The print head control logic is implemented on the main board.

SpO_2 Module

The SpO_2 module measures oxygen saturation in the blood using an optical spectrophotometry technique. The technique is based on the differences in the absorption of red and infrared light by oxygenated and deoxygenated Hemoglobin.

A pulse oximeter passes red and infrared light into an arteriolar bed and measures changes in light absorption during the pulsatile cycle. The light sources are red and infrared light emitting diodes (LEDs). A photo diode provides detection.

To identify the oxygen saturation of arterial hemoglobin, the monitor uses the pulsatile nature of arterial flow. During systole, a new pulse of arterial blood enters the vacuolar bed, and both blood volume and light absorption increase. During diastole, blood volume and light absorption reach their lowest point. The measurement is based on the difference between maximum and minimum absorption, focusing on the pulsatile arterial blood. In addition to the oximetry function, the measurement can also provide the pulse rate.

Temperature module

The temperature module is a fully integrated microprocessor-based thermistor thermometer that takes oral, axillary, and rectal temperatures for all patient populations. The module provides two types of temperature measurement:

- Predictive
- Monitored

Predictive Measurements

In Predictive mode, the monitor measures the patient's temperature for approximately four seconds for oral measurements and approximately 16 seconds for axillary and rectal measurements. The monitor then displays the final measurement.

If the monitor cannot get a reading after one minute, it automatically switches to Monitored mode.

Monitored Measurements

In Monitored mode, the monitor measures the patient's temperature continuously and displays the temperature in the numeric pane as long as the probe is in contact with the patient. You use Monitored mode when a situation prevents accurate predictive measurement.

Note — Temperature measurements taken in Monitored mode are not saved to a patient record.

Wireless Module

The wireless module includes a radio board and an antenna. The module provides wireless connectivity for the monitor. The radio board interfaces with the main board through a 20-pin connector. The antenna interfaces with the radio board through a MMCX (micro-miniature coaxial) connector. The module supports all 802.11a, 802.11b, and 802.11g data rates and automatically adjusts data rates and operational modes based on various environmental factors.

B
Electromagnetic Compatibility

This appendix lists the tests and compliance levels that make the SureSigns VS2+ and VSi vital signs monitors suitable for use in the specified electromagnetic environment according to EN/IEC 60601-1-2:2001.

Medical electrical equipment can either generate or receive electromagnetic interference. This product has been evaluated for electromagnetic compatibility (EMC) with the appropriate accessories according to EN/IEC 60601-1-2:2001, the international standard for EMC for medical electrical equipment. This IEC standard has been adopted in the European Union as the European Norm, EN/IEC 60601-1-2:2001.

Radio frequency (RF) interference from nearby transmitting devices can degrade performance of the product. Electromagnetic compatibility with surrounding devices should be assessed prior to using the product.

Fixed, portable, and mobile radio frequency communications equipment can also affect the performance of medical equipment. See your service provider for assistance with the minimum recommended separation distance between RF communications equipment and the product.

The cables, sensors/transducers, and other accessories for which compliance is claimed are listed earlier in the *Instructions for Use*.

Warning

- **Use of accessories, transducers, and cables other than those specified may result in increased emissions and/or decreased immunity of the SureSigns VS2+ and VSi vital signs monitors.**
- **The SureSigns VS2+ and VSi vital signs monitors should not be used adjacent to or stacked with other equipment. If adjacent or stacked use is necessary, the monitor should be observed to verify normal operation in the configuration in which it is used.**

Reducing Electromagnetic Interference

The SureSigns VS2+ and VSi vital signs monitors and associated accessories can be susceptible to interference from other RF energy sources and continuous, repetitive, power line bursts. Examples of other sources of RF interference are other medical electrical devices, cellular products, information technology equipment, and radio/television transmission. If interference is encountered, as demonstrated dramatic variations in physiological parameter measurement values, attempt to locate the source. Assess the following:

- Is the interference due to misplaced or poorly applied sensors? If so, re-apply sensors correctly according to directions in the product's *Instructions for Use*.
- 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 electrical equipment?
- Do parameter measurement values change dramatically when the AC line cord is unplugged?

Once the source is located, attempt to attenuate the interference by distancing the product from the source as much as possible. If assistance is needed, contact your local service representative.

Emissions and Immunity

The SureSigns VS2$^+$ and VSi vital signs monitors are designed and evaluated to comply with the emissions and immunity requirements of international and national EMC standards. See Table B-1 through Table B-4 for detailed information regarding declaration and guidance.

The EMC standards state that manufacturers of patient-coupled equipment must specify immunity levels for their systems. See Table B-2 and Table B-3 for this detailed immunity information. See Table B-4 for recommended minimum separation distances between portable and mobile communications equipment and the product.

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 system performance 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 can vary with the manufacturer.

Guidance and Manufacturer's Declaration

The SureSigns VS2$^+$ and VSi vital signs monitors are intended for use in the electromagnetic environment specified in the following tables. The customer or the user of the product should assure that it is used in such an environment.

Table B-1 Electromagnetic Emissions

	Compliance	Electromagnetic Environment Guidance
RF emissions CISPR 11	Group 1	The SureSigns VS2$^+$ and VSi vital signs monitors use RF energy only for their internal function. Therefore, RF emissions are very low and not likely to cause any interference in nearby electronic equipment.
RF emissions CISPR 11	Class A	The SureSigns VS2$^+$ and VSi vital signs monitors are suitable for use in all establishments other than domestic establishments and those directly connected to a low voltage power supply network which supplies building used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Class A	
Voltage fluctuations/flicker emissions IEC 61000-3-3	Complies	

Table B-2 Electromagnetic Immunity (ESD, EFT, Surge, Dips and Magnetic Field)

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	± 1 kV differential mode ± 2 kV common mode	± 1 kV ± 2 kV	In the event of reduced performance, it may be necessary to operate the patient monitor from a filtered power connection or battery power (no electrical connection to the AC mains while monitoring).
Surge IEC 61000-4-5	± 1 kV differential mode ± 2 kV common mode	± 1 kV ± 2 kV	Mains power quality should be that of a typical commercial and/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 40% U_T 70% U_T < 5% U_T	
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.
Note — *U_T is the AC mains voltage prior to application of the test level.*			

Table B-3 Electromagnetic Immunity (RF Radiated and Conducted)

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 SureSigns VS2+ or VSi vital signs monitors, 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 0.15 to 80 MHz Outside ISM bands	3 V rms	Recommended Separation Distance $d = \left[\frac{3.5}{3}\right]\sqrt{P}$; 0.150 to 80 MHz
Radiated RF IEC 61000-4-3	3 V/m 80 to 2500 MHz	3 V/m	$d = \left[\frac{3.5}{3}\right]\sqrt{P}$; 80 to 800 MHz $d = \left[\frac{7}{3}\right]\sqrt{P}$; 800 to 2500 MHz where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer 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: 

[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 SureSigns VS2+ and VSi vital signs monitors are used exceeds the applicable RF compliance level above, the SureSigns VS2+ and VSi vital signs monitors should be observed to verify normal operation. If abnormal performance is observed, additional measures are necessary, such as re-orienting or relocating the SureSigns VS2+ and VSi vital signs monitors.

[b] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m. Respiration measurement may be subject to interference at 900 - 1100 kHz and 70 - 80 MHz at less than 3 V/M field strength.

Recommended Separation Distances

The SureSigns VS2$^+$ and VSi vital signs monitors are intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the product can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the product as recommended below, according to the maximum output power of the communications equipment.

Table B-4 Recommended Separation Distances Between Portable and Mobile RF Communication Equipment and the SureSigns VS2$^+$ and VSi Vital Signs Monitors

	150 kHz to 80 MHz	80 MHz to 800 MHz	800 MHz to 2.5 GHz
Equation	$d = \left[\frac{3.5}{3}\right]\sqrt{P}$	$d = \left[\frac{3.5}{3}\right]\sqrt{P}$	$d = \left[\frac{7}{3}\right]\sqrt{P}$
Rated Maximum Output Power of Transmitter (Watts)	**Separation Distance (d)(meters)**	**Separation Distance(d) (meters)**	**Separation Distance(d) (meters)**
0.01	0.12	0.12	0.23
0.1	0.37	0.37	0.74
1	1.17	1.17	2.33
10	3.69	3.69	7.38
100	11.67	11.67	23.33

For transmitters rated at a maximum output power not listed above, the separation distance *d* can be estimated, in meters, using the equation in the corresponding column, where *P* is the maximum output power rating of the transmitter in watts according to the transmitter's manufacturer.

These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

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