

ProSim™ 8

Vital Signs Simulator

Users Manual

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Follow standard receiving practices upon receipt of the instrument. Check the shipping carton for damage. If damage is found, stop unpacking the instrument. Notify the carrier and ask for an agent to be present while the instrument is unpacked. There are no special unpacking instructions, but be careful not to damage the instrument when unpacking it. Inspect the instrument for physical damage such as bent or broken parts, dents, or scratches.

Technical Support

For application support or answers to technical questions, either email techservices@flukebiomedical.com or call 1-800-850-4608 or 1-440-248-9300. In Europe, email techsupport.emea@flukebiomedical.com or call +31-40-2965314.

Claims

Our routine method of shipment is via common carrier, FOB origin. Upon delivery, if physical damage is found, retain all packing materials in their original condition and contact the carrier immediately to file a claim. If the instrument is delivered in good physical condition but does not operate within specifications, or if there are any other problems not caused by shipping damage, please contact Fluke Biomedical or your local sales representative.

Returns and Repairs

Return Procedure

All items being returned (including all warranty-claim shipments) must be sent freight-prepaid to our factory location. When you return an instrument to Fluke Biomedical, we recommend using United Parcel Service, Federal Express, or Air Parcel Post. We also recommend that you insure your shipment for its actual replacement cost. Fluke Biomedical will not be responsible for lost shipments or instruments that are received in damaged condition due to improper packaging or handling.

Use the original carton and packaging material for shipment. If they are not available, we recommend the following guide for repackaging:

- Use a double-walled carton of sufficient strength for the weight being shipped.
- Use heavy paper or cardboard to protect all instrument surfaces. Use nonabrasive material around all projecting parts.
- Use at least four inches of tightly packed, industry-approved, shock-absorbent material around the instrument.

Returns for partial refund/credit:

Every product returned for refund/credit must be accompanied by a Return Material Authorization (RMA) number, obtained from our Order Entry Group at 1-440-498-2560.

Repair and calibration:

To find the nearest service center, go to www.flukebiomedical.com/service or

In the U.S.A. and Asia:

Cleveland Calibration Lab
Tel: 1-800-850-4608 x2564
Email: globalcal@flukebiomedical.com

In Europe, Middle East, and Africa:

Eindhoven Calibration Lab
Tel: +31-40-2675300
Email: ServiceDesk@fluke.com

To ensure the accuracy of the Product is maintained at a high level, Fluke Biomedical recommends the product be calibrated at least once every 12 months. Calibration must be done by qualified personnel. Contact your local Fluke Biomedical representative for calibration.

Certification

This instrument was thoroughly tested and inspected. It was found to meet Fluke Biomedical's manufacturing specifications when it was shipped from the factory. Calibration measurements are traceable to the National Institute of Standards and Technology (NIST). Devices for which there are no NIST calibration standards are measured against in-house performance standards using accepted test procedures.

WARNING

Unauthorized user modifications or application beyond the published specifications may result in electrical shock hazards or improper operation. Fluke Biomedical will not be responsible for any injuries sustained due to unauthorized equipment modifications.

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Manufacturing Location

The ProSim™ 8 Vital Signs Simulator is manufactured at Fluke Biomedical, 6920 Seaway Blvd., Everett, WA, U.S.A.

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Introduction

The Fluke Biomedical ProSim™ 8 Vital Signs Simulator (hereafter the Product) is a full-featured, compact, portable simulator, used to measure the performance of patient monitors.

The Product simulates:

- ECG Functions
- Respiration
- Invasive and Non-Invasive Blood Pressure
- Temperature
- Cardiac Output

When the term simulation is used in connection with ECG, respiration, temperature, IBP, NIBP, cardiac output, or SpO₂, the simulation type shown in Table 1 is used in this Product. Additionally, the Devices provide an optical signal to verify that the electronics within the pulse oximeter probe are functional.

Table 1. Simulation Types

Parameter	Simulation Type
ECG	Electrical
Respiration	Electrical
Temperature	Electrical
IBP	Electrical
NIBP	Pneumatic
Cardiac Output	Electrical
SpO ₂	Light Emission

Intended Use

The Product is intended to be used to test and verify the basic operation of patient monitoring devices or systems used to monitor various physiological parameters of a patient, including ECG, Respiration, Invasive blood pressure, Non-invasive blood pressure, Temperature, and Cardiac output. Additionally, the Devices provide an optical signal to verify that the electronics within the pulse oximeter probe are functional.

The intended user is a trained biomedical equipment technician who performs periodic preventative maintenance checks on patient monitors in service. Users can be associated with hospitals, clinics, original equipment manufacturers and independent service companies that repair and service medical equipment. The end user is an individual, trained in medical instrumentation technology.

This Product is intended to be used in the laboratory environment, outside of the patient care area, and is not intended for use on patients, or to test devices while connected to patients. This Product is not intended to be used to calibrate medical equipment. It is intended for over the counter use.

Safety Information

In this manual, a **Warning** identifies hazardous conditions and actions that could cause bodily harm or death. A **Caution** identifies conditions and actions that could damage the Product, the equipment under test, or cause permanent loss of data.

Warnings

To prevent personal injury, use the Product only as specified, or the protection supplied by the Product can be compromised.

To prevent possible electrical shock, fire, or personal injury:

- **Read all safety Information before you use the Product.**
- **Do not touch voltages >30 V ac rms, 42 V ac peak, or 60 V dc.**
- **Do not use the Product around explosive gas, vapor, or in damp or wet environments.**
- **Examine the case before you use the Product. Look for cracks or missing plastic. Carefully look at the insulation around the terminals.**
- **Do not use the Product if it is damaged.**
- **Disable the Product if it is damaged.**
- **Use this Product indoors only.**
- **Do not connect directly to mains.**
- **Use the correct terminals, function, and range for measurements.**
- **Do not use the Product if it operates incorrectly.**
- **Use only current probes, test leads, and adapters supplied with the Product.**
- **Remove all probes, test leads, and accessories that are not necessary for the measurement.**
- **Remove all probes, test leads, and accessories before the battery door is opened.**
- **The battery door must be closed and locked before you operate the Product.**

- **Replace the batteries when the low battery indicator shows to prevent incorrect measurements.**
- **Remove the batteries if the Product is not used for an extended period of time, or if stored in temperatures above 50 °C. If the batteries are not removed, battery leakage can damage the Product.**
- **Use only the mains power cord and connector approved for the voltage and plug configuration in your country and rated for the Product.**
- **Replace the mains power cord if the insulation is damaged or if the insulation shows signs of wear.**
- **Use only the external mains power supply included with the Product.**
- **Connect the battery charger to the mains power outlet before the Product.**
- **Do not put metal objects into connectors.**
- **Do not connect the Product to a patient or equipment connected to a patient. The Product is intended for equipment evaluation only and should never be used in diagnostics, treatment, or any other capacity where the Product would come in contact with a patient.**

Symbols

Table 2 describes symbols used in association with the Product.

Table 2. Symbols

Symbol	Description	Symbol	Description
	WARNING - RISK OF DANGER. Consult user documentation.		WARNING. HAZARDOUS VOLTAGE. Risk of electric shock.
	Magnetic Field		Input jack for the DC output of the AC-DC supply connector.
	Conforms to European Union directives.		Certified by CSA Group to North American safety standards.
	Conforms to relevant Australian EMC standards.		Complies with 47 CFR Part 15 requirements of the U.S. Federal Communications Commission.
	Conforms to relevant South Korean EMC Standards.	 Li-Ion	Spent Lithium batteries should be disposed of by a qualified recycler or hazardous materials handler per local regulations. Contact your authorized Fluke Service Center for recycling information.
	This product complies with the WEEE Directive marking requirements. The affixed label indicates that you must not discard this electrical/electronic product in domestic household waste. Product Category: With reference to the equipment types in the WEEE Directive Annex I, this product is classed as category 9 "Monitoring and Control Instrumentation" product. Do not dispose of this product as unsorted municipal waste.		

Unpack the Product

Carefully unpack all items from the box and check that you have these items:

- ProSim™ 8
- Getting Started Manual
- Carrying Case
- Power Cord
- AC/DC Power Supply
- USB Cable
- IBP Cable (unterminated)
- NIBP Cuff Mandrel set (adult and neonate)
- NIBP Cuff Adapters
- Ansur Demonstration Disk

After you unpack and inspect the Product, fully charge the battery before the first use. Afterwards, charge the battery when the Product shows the low battery message. See *Battery Maintenance*.

Accessories

Available Product accessories are shown in Tables 3 and 4.

Table 3. Standard Accessories

Item		Fluke Biomedical Part Number
ProSim™ 8 Getting Started Manual		3984515
AC/DC Power Supply		4219453
AC Power Cord	US	2201455
	Schuko	2201437
	UK	2201428
	Japan	2201419
	Australia	2201443
	Brazil	3930831
USB Cable		4034393
IBP Cable, unterminated		2392173
Carrying Case		4034597
Set of NIBP Cuff Adapters		2391882
Ansur Demonstration CD-ROM		2795488

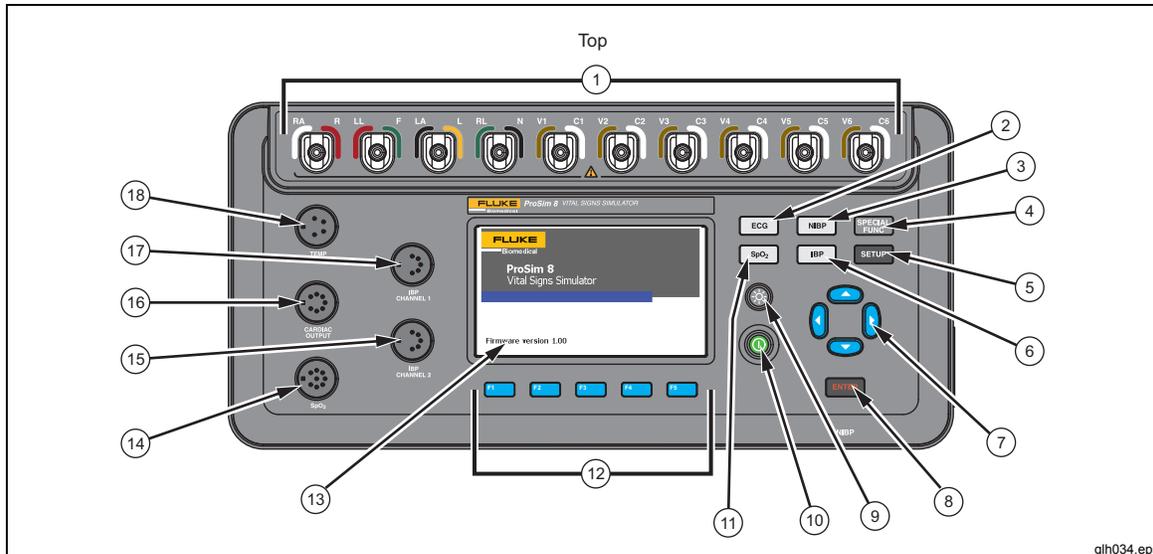
Table 4. Optional Accessories

Item	Fluke Biomedical Part Number
SpO ₂ Finger Module with cable	3985658
SpO ₂ Masimo RAINBOW cable	4034609
Battery pack	4021085
NIBP Test 500 mL rigid chamber	4034611
Simulation Cables: IBP Temperature	See your Fluke Biomedical Distributor
Cardiac Output Interface Box	2392199
Upgrade kit to ProSim™ 8	3987196
USB Wireless Dongle	3341333
Mini-DIN to DIN IBP Adapter	3408564
NIBP Mandrel Set	4308086

Instrument Familiarization

Table 5 is a list of Product top-panel controls and connections.

Table 5. Top-Panel Controls and Connections



gh034.eps

Item	Name	Description
①	ECG Posts	Connection posts for Device Under Test (DUT) ECG leads.
②	ECG Function	Accesses the ECG waveforms (adult, pediatric, and arrhythmias), and ECG test functions (performance waves, QRS detection, Tall T wave rejection, and R wave detection).
③	NIBP Button	Accesses the Non-Invasive Blood Pressure (NIBP) functions.
④	Special Functions	Accesses the temperature, respiration, cardiac output, fetal simulation, autosequences, and view memory functions.
⑤	SETUP Button	Accesses the setup controls.
⑥	IBP Button	Accesses the Invasive Blood Pressure (IBP) functions.
⑦	Navigation Buttons	Cursor control buttons for navigating menus and lists.
⑧	Enter Button	Sets the highlighted function.
⑨	Backlight Button	Turns the display backlight on and off.
⑩	Power Button	Turns the Product on and off.
⑪	SpO ₂ Button	Accesses the SpO ₂ functions.
⑫	Function Softkeys	Keys F1 through F5 are used to select from a number of selections that appear in the LCD display above each function softkey.
⑬	LCD Display	Color display.
⑭	SpO ₂ Connector	Connector to the SpO ₂ accessory.
⑮	IBP Channel 2 Connector	Connector to an IBP input of the patient monitor.
⑯	Cardiac Output Connector	Connector to the Cardiac input of the patient monitor.
⑰	IBP Channel 1 Connector	Connector to the IBP input of the patient monitor.
⑱	Temperature Connector	Connector to the Temperature input of the patient monitor.

Table 6 is a list of controls on the back, front, and side of the Product.

Table 6. Back, Front, and Side-Panel Connections

Item	Name	Description
①	AC/DC Supply Connector	Input jack for the DC output of the AC/DC supply connector.
②	Battery Charge LED	Battery charges when LED shows red. Green shows battery charge is complete.
③	Battery Latch	Locks the battery pack into the Product. Push down to remove the battery pack.
④	Mini B USB Device Port	Used to connect to a PC for remote control or download test results data to a PC.
⑤	USB A Controller Port	For external keyboard, barcode reader, or printer.
⑥	ECG BNC Connector	High-level output of ECG signal.
⑦	Air Port Connector	Pressure port for NIBP cuff and monitor.
⑧	Magnetic Holder for SpO ₂ Finger Module	Holds the SpO ₂ Optical Emitter and Detector finger module in two orientations.

Turn On the Product

Push **Ⓢ** on the front panel to turn on the Product. The screen shown in Figure 1 shows the Power-Up screen.



Figure 1. Power-Up Screen

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When the self test is complete and no errors are sensed, the Home screen in Figure 2 shows on the display.

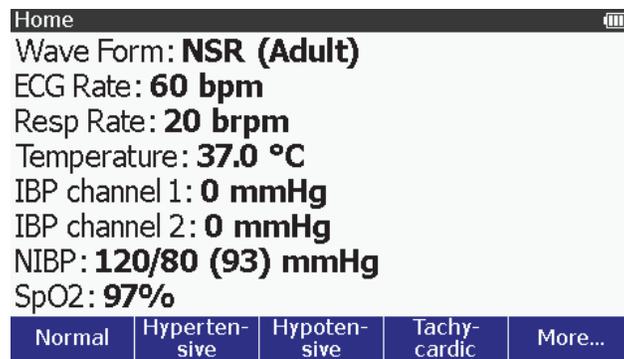


Figure 2. Home Screen

glh001.bmp

From the Home screen, you can use a number of pre-defined patient simulations to set all the simulation functions at one time. See *Pre-Defined Simulations* to learn more on how to use simulations. Waveform and ECG rate parameters are set through the ECG function. See *ECG Function* to learn more on how to set these variables. The respiration rate (Resp Rate), temperature parameter, cardiac output, and fetal simulation are set through the special functions menu. The two Invasive Blood Pressure (IBP) channels are set through the IBP function. The Non-Invasive Blood Pressure variables are set through the NIBP function. See *Invasive Blood Pressure Simulation and Tests* and *Non-Invasive Blood Pressure Simulation and Tests* to learn more on how to set IBP and NIBP variables. The SpO₂ variable is set through the SpO₂ function. See *Oximeter SpO₂ Optical Emitter and Detector* to learn more on how to set this variable.

Connect a PC to the Product

You can use a PC to store presets, auto sequences, and test results from the Product. You must use the ProSim Mini Plug-In on the PC to communicate with the Product.

Note

You must have Ansur Test Executive version 2.9.6 on your PC to communicate with the Product.

To connect the Product to a PC:

Connect a USB port on your PC or laptop to the Mini B USB device port of the Simulator.

Or

Plug in an XStick USB dongle to your PC USB port. See Figure 3.

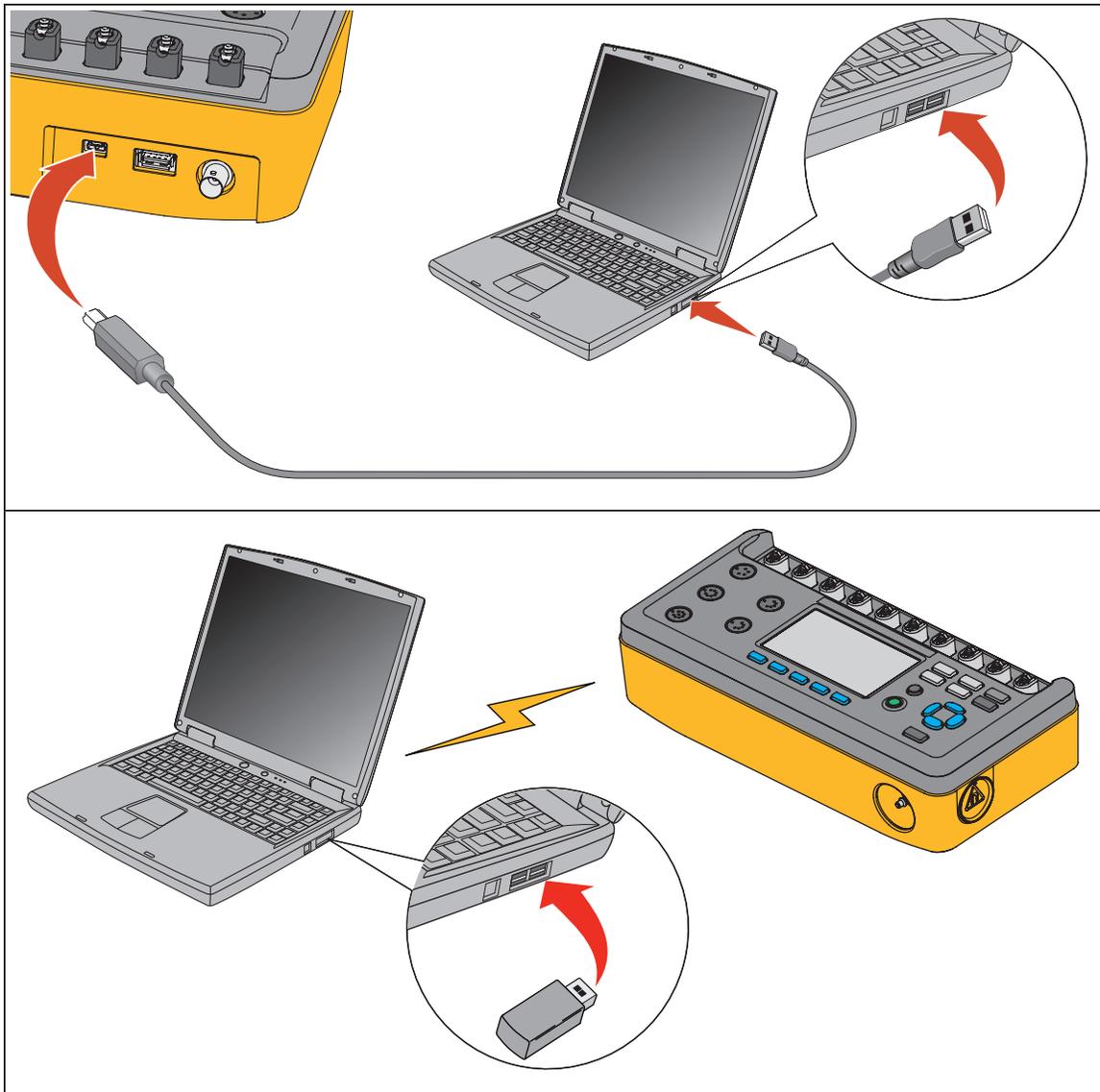


Figure 3. Laptop to PC Connection

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Pre-Defined Simulations

The pre-defined simulations are set through the softkeys along the bottom of the Home screen. See Figure 2. There are seven factory pre-defined simulations: normal, hypertensive, hypotensive, tachycardic, bradycardic, heart attack, and asystole. A **More** softkey shows on the display for more simulations. Table 7 lists the parameter values for each pre-defined simulation.

Table 7. Pre-Defined Patient Simulations

Simulation Name	Parameter	Pre-Set Value
Normal	Wave Form	NSR (Adult)
	ECG Rate	60 BPM
	Respiration Rate	20 brpm
	Temperature	37.0 °C
	IBP Channel 1	120/80 mmHg (Art)
	IBP Channel 2	28/15 mmHg (PA)
	NIBP	120/80 (93) mmHg
	SpO ₂	97 %
Hypertensive	Wave Form	NSR (Adult)
	ECG Rate	130 BPM
	Respiration Rate	40 brpm
	Temperature	37.0 °C
	IBP Channel 1	200/150 mmHg (Art)
	IBP Channel 2	45/25 mmHg (PA)
	NIBP	200/150 (166) mmHg
	SpO ₂	94 %
Hypotensive	Wave Form	NSR (Adult)
	ECG Rate	40 BPM
	Respiration Rate	15 brpm
	Temperature	37.0 °C
	IBP Channel 1	60/30 mmHg (Art)
	IBP Channel 2	15/10 mmHg (PA)
	NIBP	60/30 (40) mmHg
	SpO ₂	95 %
Tachycardia	Wave Form	NSR (Adult)
	ECG Rate	180 BPM
	Respiration Rate	50 brpm
	Temperature	40.0 °C
	IBP Channel 1	80/50 mmHg (Art)
	IBP Channel 2	25/10 mmHg (PA)
	NIBP	80/50 (60) mmHg
	SpO ₂	88 %

Table 7. Pre-Defined Patient Simulations (cont.)

Simulation Name	Parameter	Pre-Set Value
Bradycardic	Wave Form	NSR (Adult)
	ECG Rate	30 BPM
	Respiration Rate	15 brpm
	Temperature	35.0 °C
	IBP Channel 1	100/65 mmHg (Art)
	IBP Channel 2	25/10 mmHg (PA)
	NIBP	100/65 (77) mmHg
	SpO ₂	85 %
Ventricular Fibrillation	Wave Form	Atrial Fibrillation (Coarse)
	ECG Rate	No BPM
	Respiration Rate	70 brpm
	Temperature	34.0 °C
	IBP Channel 1	35/15 mmHg (Art)
	IBP Channel 2	35/0 mmHg (LV)
	NIBP	35/15 (22) mmHg
	SpO ₂	80 %
Asystole	Wave Form	Asystole
	ECG Rate	0 BPM
	Respiration Rate	0 brpm
	Temperature	33.0 °C
	IBP Channel 1	0 mmHg
	IBP Channel 2	0 mmHg
	NIBP	0/0 mmHg
	SpO ₂	50 %

After you set one of the pre-defined simulations, you can change the parameters of one or all of the vital signs. Changes are not kept in the Product. The pre-defined simulation parameters cannot be changed through the front panel.

There are seven custom pre-defined simulations in the Product. To set a custom simulation:

1. From the Home screen, push the **More** softkey.
2. Push the **Custom** softkey.

Four custom simulation names show above the first four softkeys. The names are **Custom1**, **Custom2**, **Custom3**, and **Custom4**. To show the next three names, push the **More** softkey.

3. Push the softkey for a custom pre-defined simulation.

All the vital sign simulation parameters are set to the values contained in the pre-defined simulation.

You can customize the seven factory simulations and seven custom simulations through the Ansur functionality.

ECG Function

The Product simulates normal heart signals (ECG) as well as heart signals for a variety of arrhythmias. Heart rate (beats per minute), signal amplitude, and ST segment elevation are all controlled by the Product through the user interface. Artifacts can also be simulated.

To measure the ECG performance of a monitor, connect the Product to the monitor as shown in Figure 4. You can connect a maximum of ten ECG leads to the Product.

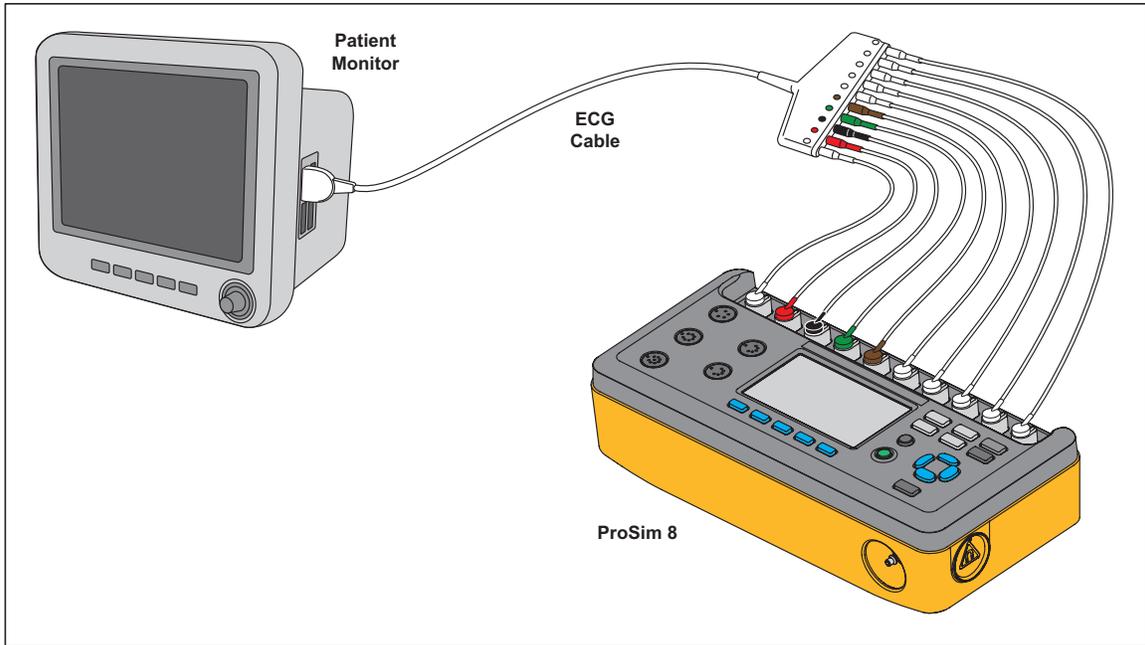


Figure 4. ECG Connections

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Set the ECG Parameters

Whenever the Product is turned on, the display shows the defaults for heart rate (60 BPM) with a patient type of Adult. Although not shown on the initial display, the signal amplitude is 1 mV. To set any of the ECG parameters, push **ECG**. The ECG screen shown in Figure 5 shows on the display.

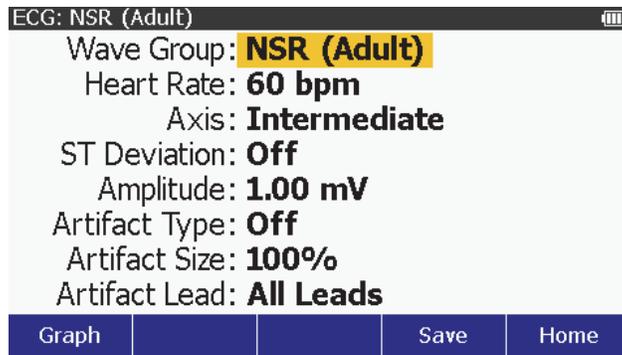


Figure 5. ECG Screen

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To change the ECG waveform:

1. Push  or  to move the highlight to the **Wave Group** value.
2. Push **ENTER**.
3. Push  or  to move the highlight to a waveform group name. Table 8 is a list of the wave groups available in the Product.

Table 8. ECG Wave Groups

Wave Group	
NSR (Adult)	Adult Normal Sinus Rhythm
NSR (Pediatric)	Child Normal Sinus Rhythm
Performance	Special waveforms for monitor tests. See <i>ECG Performance Tests</i> .
R-Wave Detection	
QRS Detection	
Tall T Wave Rejection	
Supraventricular	Arrhythmia waveforms. See <i>Simulate Arrhythmias</i> .
Premature	
Ventricular	
Conduction	
TV Paced	
ACLS	

4. When the **Waveform Group** value is highlighted, push **ENTER**.

To change the heart rate:

1. Push  or  to move the highlight on the display to the **Heart Rate** value.
2. Push **ENTER**.
3. Push  or  to adjust the heart rate. Each push of a key moves the heart rate one beat in the direction of the key pushed. The Product simulates a heart rate of 10 to 360 beats/minute (BPM) set in 1 BPM intervals.
4. Push **ENTER** to set the heart rate and go back to the ECG screen.

To change the axis:

1. Push  or  to move the highlight to the **Axis** value.
2. Push **ENTER**.
3. Push  or  to highlight **Intermediate**, **Horizontal**, or **Vertical**.
4. Push **ENTER**.

To set the ST Deviation:

1. Push \blacktriangle or \blacktriangledown to move the highlight to the **ST Deviation** value.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to adjust the deviation. Each push of a key moves the deviation 0.05 or 0.1 mV in the direction of the key pushed. The deviation range is ± 0.80 mV

Note

When the ST Deviation value is set to 0.00 mV, the value in the ECG screen shows as Off.

4. Push **ENTER** to set the deviation and go back to the ECG screen.

To set the ECG signal amplitude:

1. Push \blacktriangle or \blacktriangledown to move the highlight on the display to the **Amplitude** value.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to adjust the amplitude. Each push of a key increases or decreases the amplitude 0.05 mV between 0.05 mV and 0.50 mV and 0.25 mV above 0.50 mV to 5.00 mV in the direction of the key pushed.
4. Push **ENTER** to set the signal amplitude and go back to the ECG screen.

Table 9 shows the percentage of the signal amplitude value that is put on each ECG lead.

Table 9. ECG Lead Amplitudes

Waveform	I	II	III	V1	V2	V3	V4	V5	V6
Performance ^[1]	70 %	100 %	30 %	100 %	100 %	100 %	100 %	100 %	100 %
Normal Sinus	70 %	100 %	30 %	24 %	48 %	100 %	120 %	112 %	80 %
Normal Sinus, Horizontal Axis	100 %	30 %	-70 %	20 %	40 %	70 %	100 %	80 %	50 %
Normal Sinus, Vertical Axis	30 %	130 %	100 %	20 %	30 %	40 %	60 %	80 %	100 %
[1] Includes R-Wave Detection, QRS Detection, and Tall T-Wave Rejection waves.									

View the ECG Waveform

As you adjust the ECG signal, you can see the signal on the display. To see the ECG signal, from the ECG screen, push the **Graph** softkey. The ECG: Graph screen in Figure 6 shows on the display.



Figure 6. ECG Graph Screen

glh023.bmp

The ECG signal shows on the display in real time.

Push the **Back** softkey to go back to the ECG screen.

Simulate an ECG Artifact

The Product simulates a number of different ECG artifacts that can change the accuracy of an ECG indication. You can add several ECG artifact simulations to an ECG wave: line-frequency artifacts of 60 Hz (U.S. lines) and 50 Hz (European lines), as well as artifacts for muscle movement, wandering baseline, and respiration.

You can add an artifact to all simulated ECG signals. To add an artifact:

1. Push **ECG** to show the ECG screen in Figure 7 on the display.



Figure 7. ECG NSR Adult Screen

glh004.bmp

2. Push **▲** or **▼** to highlight the **Artifact Type** value.
3. Push **▲** or **▼** to highlight **50 Hz**, **60 Hz**, **Muscular**, **Baseline Wander**, or **Respiration**.
4. Push **ENTER** to enable the artifact and go back to the ECG screen.

To change the size of the artifact:

1. From the ECG screen, push  or  to highlight the **Artifact Size** value.
2. Push  or  to highlight **100%**, **50%**, or **25%**.
3. Push **ENTER** to set the artifact size and go back to the ECG screen.

You can add the artifact signal to one ECG lead or all leads. To change which lead the artifact is on:

1. From the ECG screen, push  or  to highlight the **Artifact Lead** value.
2. Push  or  to highlight **RA**, **LL**, **LA**, **V1 – V6**, or **All Leads** in the lead list.
3. Push **ENTER** to set the artifact lead and go back to the ECG screen.

Simulate Arrhythmias

All arrhythmia simulations are grouped into related wave groups. These arrhythmia wave groups are Supraventricular, Premature, Ventricular, Conduction, TV Paced, and ACLS. Table 10 shows all the arrhythmias the Product can simulate and identifies in which wave group they can be found. The table also identifies which model can simulate the arrhythmia.

Table 10. Arrhythmias by Wave Group

Arrhythmia	Wave Group
Asynchronous 75 BPM	TV Paced
Asystole	ACLS, Ventricular
Atr-Vent Sequential	TV Paced
Atrial Fibrillation	Supraventricular
Atrial Flutter	Supraventricular
Atrial PAC	Premature
Atrial Tach	Supraventricular
Atrial 80 BPM	TV Paced
Bigeminy	Ventricular
Bradycardia	ACLS
Demand Freq Sinus	TV Paced
Demand Occ Sinus	TV Paced
Freq Multi-focal PVCs	Ventricular
Ischemic Chest Pain	ACLS
Lt Bndl Branch Block	Conduction
MIs with LBBB	ACLS
MIs with RBBB	ACLS
Missed Beat at 80 BPM	Supraventricular
Missed Beat at 120 BPM	Supraventricular
Mono V Tach	Ventricular

Table 10. Arrhythmias by Wave Group (cont.)

Arrhythmia	Wave Group
Multi-focal PVCs	Premature
Myocardial Infarctions	ACLS
Narrow Complex Tach	ACLS
Nodal PNC	Premature
Nodal Rhythm	Supraventricular
Non-Capture	TV Paced
Non-Function	TV Paced
Paroxysmal ATach	Supraventricular
Poly V Tach	Ventricular
Poly V Tach (unstable)	ACLS
Pulseless Vent Tach	ACLS
Pulseless Elect Tach	ACLS
PVCs	Ventricular
PVC1 Left Vent	Premature
PVC1 LV Early	Premature
PVC1 LV R on T	Premature
PVC2 Right Vent	Premature
PVC2 RV Early	Premature
PVC2 RV R on T	Premature
Rt Bndl Branch Block	Conduction
Run of PVCs	Ventricular
Sinus Arrhythmia	Supraventricular
Stable Tachycardias	ACLS
Supra VTach	Supraventricular
Trigeminy	Ventricular
Unstable Tachycardias	ACLS
Ventricular Fibrillation	Ventricular
Wide Complex Tach	ACLS
1st Deg AV Block	Conduction
2nd Deg AV Block T1	Conduction
2nd Deg AV Block T2	Conduction
3rd Deg AV Block	Conduction

Supraventricular Arrhythmias

To set a supraventricular arrhythmia:

1. From the ECG screen, push  or  to highlight the **Wave Group** value.
2. Push .
3. Push  or  to highlight **Supraventricular** in the wave group list.
4. Push .
5. Push  or  to highlight the **Waveform** value.
6. Push .
7. Push  or  to highlight a waveform in the list.
8. Push  to set the arrhythmia waveform and go back to the ECG: Supraventricular screen.

You can adjust the amplitude of all supraventricular arrhythmia waveforms. See *Set the ECG Parameters*. ECG signal artifacts can also be added to each arrhythmia signal. See *Simulate an ECG Artifact*.

The atrial fibrillation arrhythmia has one variable not available on the other supraventricular arrhythmias. You can set the type variable to coarse or fine. To change the type variable with the atrial fibrillation waveform set:

1. Push  or  to highlight the **Type** value.
2. Push .
3. Push  or  to highlight **Coarse** or **Fine** from the list.
4. Push  to set the arrhythmia type and go back to the ECG: Supraventricular screen.

Premature Arrhythmias

The premature wave group arrhythmias simulate premature contraction of muscle at different nodes of the heart. To do a premature arrhythmia:

1. From the ECG screen, push  or  to highlight the **Wave Group** value.
2. Push .
3. Push  or  to highlight **Premature** in the wave group list.
4. Push .
5. Push  or  to highlight the **Waveform** value.
6. Push .
7. Push  or  to highlight a waveform in the list.
8. Push  to set the arrhythmia waveform and go back to the ECG: Supraventricular screen.

You can adjust the amplitude of all premature arrhythmia waveforms. See *Set the ECG Parameters*. ECG signal artifacts can also be added to each arrhythmia signal. See *Simulate an ECG Artifact*.

Ventricular Arrhythmias

Ventricular arrhythmias are arrhythmias in the lower chambers of the heart, or ventricles. To do a ventricular arrhythmia:

1. From the ECG screen, push  or  to highlight the **Wave Group** value.
2. Push **ENTER**.
3. Push  or  to highlight **Ventricular** in the wave group list.
4. Push **ENTER**.
5. Push  or  to highlight the **Waveform** value.
6. Push **ENTER**.
7. Push  or  to highlight a waveform in the list.
8. Push **ENTER** to set the arrhythmia waveform and go back to the ECG: Ventricular screen.

You can adjust the amplitude of all ventricular arrhythmia waveforms. See *Set the ECG Parameters*. You can also add ECG signal artifacts to each arrhythmia signal. See *Simulate an ECG Artifact*.

The ventricular fibrillation and poly V tach arrhythmias have a variable not available on the other ventricular arrhythmias. To change the type variable for the ventricular fibrillation and poly V tach waveform set:

1. Push  or  to highlight the **Type** value.
2. Push **ENTER**.
3. Push  or  to highlight **Coarse** or **Fine** from the list.
4. Push **ENTER** to set the arrhythmia type and go back to the ECG: Ventricular screen.

The mono v tach arrhythmia has a heart rate variable. To change the heart rate:

1. Push  or  to highlight the **Heart Rate** value.
2. Push **ENTER**.
3. Push  or  to adjust the heart rate. Each push of a key moves the heart rate one beat in the direction of the key pushed. You can set a heart rate of 120 beats/minute (BPM) to 300 BPM in 5 BPM intervals for this arrhythmia.
4. When the heart rate is set, push **ENTER** to set the arrhythmia heart rate and go back to the ECG: Ventricular screen.

The PVCs arrhythmia has a rate variable to set the number of PVCs in a minute. To change the rate of PVCs:

1. Push  or  to highlight the **Rate** value.
2. Push **ENTER**.
3. Push  or  to highlight **6/min**, **12/min**, or **24/min** in the list.
4. Push **ENTER** to set the arrhythmia rate and go back to the ECG: Ventricular screen.

The Run of PVCs arrhythmia has a number variable to set the number of PVCs in a run. To change the number of PVCs in a run:

1. Push  or  to highlight the **Number** value.
2. Push .
3. Push  or  to highlight **2 PVCs**, **5 PVCs**, or **11 PVCs**.
4. Push  to set the arrhythmia number and go back to the ECG: Ventricular screen.

Conduction Arrhythmias

Conduction arrhythmias are caused when conduction of electrical impulses are stopped or blocked from their usual pathways around the heart. To simulate a conduction arrhythmia:

1. From the ECG screen, push  or  to highlight the **Wave Group** value.
2. Push .
3. Push  or  to highlight **Conduction** in the wave group list.
4. Push .
5. Push  or  to highlight the **Waveform** value.
6. Push .
7. Push  or  to highlight a waveform in the list.
8. Push  to set the arrhythmia waveform and go back to the ECG: Conduction screen.

You can adjust the amplitude of all conduction arrhythmia waveforms. See *Set the ECG Parameters*. You can also add ECG signal artifacts to each arrhythmia signal. See *Simulate an ECG Artifact*.

Pacemaker Waveforms

The Product can simulate ECG waveforms with a number of artificial-pacemaker conditions. Table 11 shows the simulations in the waveform list of the Product with a description of each.

Table 11. Pacemaker Waveforms

Pacemaker Waveform Label	Waveform Description
Atrial 80 BPM	Atrial pacemaker wave at 80 BPM, with a pacer pulse at the start of each P wave.
Asynchronous 75 BPM	Asynchronous pacemaker wave with continuous ventricular-paced beats (75 BPM) and no P waves
Demand Freq Sinus	A “demand” pacemaker wave with frequent sinus beats (forty normal beats followed by twenty ventricular-paced beats, repeated)
Demand Occ Sinus	A “demand” pacemaker wave with occasional sinus beats (twenty normal beats followed by forty ventricular-paced beats, repeated)
Atr-Vent Sequential	AV-sequential-pacemaker wave with continuous paced beats, each with an atrial pulse and a P wave followed by a ventricular-paced pulse and QRS response
Non-Capture	Ventricular-paced beats, where one out of ten beats has no heart response.
Non-Function	Continuous pacer pulses at 75 BPM with no heart response.

To select a pacemaker waveform simulation:

1. From the ECG screen, push \blacktriangle or \blacktriangledown to highlight the **Wave Group** value.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to highlight **TV Paced** in the wave group list.
4. Push **ENTER**.
5. Push \blacktriangle or \blacktriangledown to highlight the **Waveform** value.
6. Push **ENTER**.
7. Push \blacktriangle or \blacktriangledown to highlight a waveform in the list.
8. Push **ENTER** to set the arrhythmia waveform and go back to the ECG: TV Paced screen.

You can adjust the amplitude of all TV Paced waveforms. See *Set the ECG Parameters*. You can also add ECG signal artifacts to each arrhythmia signal. See *Simulate an ECG Artifact*.

TV-Paced waveforms include the applicable pacer pulses. You can change the pacer pulses through the front panel. You can change all the ventricle pacemaker variables except for the Atrial 80 BPM waveform. The Atrial 80 BPM has an atrial pacemaker value. The Atr-Vent Sequential waveform has an atrial pacemaker value and a ventricle pacemaker value. To change the pacemaker values, push the **Atrial Settings** or **Vent. Settings** softkeys.

You can change the amplitude, width, and polarity of the pacemaker signal. To change the amplitude:

1. Push \blacktriangle or \blacktriangledown to highlight the **Amplitude** value.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to highlight an **Amplitude** value in the list. Below is a list of the pacemaker amplitude values.

0 mV	16 mV
2 mV	18 mV
4 mV	20 mV
6 mV	50 mV
8 mV	100 mV
10 mV	200 mV
12 mV	500 mV
14 mV	700 mV

4. Push **ENTER** to set the amplitude and go back to the TV Paced Settings screen.

To change the width value:

1. Push \blacktriangle or \blacktriangledown to highlight the **Width** value.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to highlight **0.1, 0.2, 0.5, 1.0, 1.5, or 2.0** mV in the list.
4. Push **ENTER** to set the width and go back to the TV Paced Settings screen.

To change the polarity:

1. Push  or  to highlight the **Polarity** value.
 2. Push .
 3. Push  or  to highlight **+** or **-** in the list.
 4. Push  to set the polarity and go back to the TV Paced Settings screen.
- Push the **Back** softkey to go back to the ECG: TV Paced screen.

Advance Cardiac Life Support (ACLS) Waveforms

The Product can simulate Advanced Cardiac Life Support (ACLS) waveforms.

To simulate an ACLS waveform:

1. From the ECG screen, push  or  to highlight the **Wave Group** value.
2. Push .
3. Push  or  to highlight **ACLS** in the wave group list.
4. Push .
5. Push  or  to highlight the **Waveform** value.
6. Push .
7. Push  or  to highlight a waveform in the list.
8. Push  to set the waveform and go back to the ECG: ACLS screen.

You can adjust the amplitude of all ACLS waveforms. See *Set the ECG Parameters*. You can also add ECG signal artifacts to each arrhythmia signal. See *Simulate an ECG Artifact*.

ECG Performance Tests

As well as physiological waveforms, the Product can supply signals to measure the performance of an ECG monitor. A set of performance waveforms are used to measure the frequency response (high and low), sensitivity, gain drift, internal calibration, stylus damping, paper speed, linearity, and sweep speed of an ECG monitor. Three more Product functions are used to measure R wave detection, QRS detection, and tall T wave rejection of an ECG monitor.

Set a Performance Wave

The waveforms in the performance wave group are sine, square, triangle, and pulse.

Note

When a performance wave is set on the Product, outputs for respiration, blood pressure, and temperature are disabled.

The four waveforms used for ECG performance tests are, sine, square, pulse, and triangle. You can adjust the rate and amplitude of these waveforms to preconfigured values. To output a performance wave:

1. Push  to show the ECG screen on the display.
2. Push  or  to highlight the **Wave Group** value.
3. Push .
4. Push  or  to highlight the **Performance** value in the wave group list.
5. Push  to show the ECG: Performance screen in Figure 8 on the display.

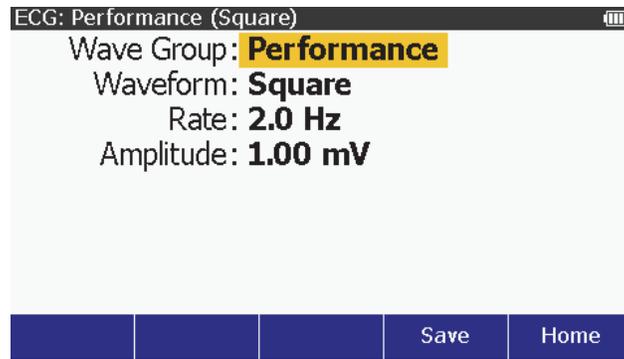


Figure 8. Performance Wave Screen

glh019.bmp

To change the waveform:

1. Push \uparrow or \downarrow to highlight the **Waveform** value.
2. Push **ENTER**.
3. Push \uparrow or \downarrow to highlight **Square**, **Sine**, **Triangle**, or **Pulse** in the list.
4. Push **ENTER** to set the performance waveform and go back to the ECG: Performance screen.

All waveforms have the same two variables: Rate and Amplitude.

To change the rate:

1. Push \uparrow or \downarrow to highlight the **Rate** value.
2. Push **ENTER**.
3. Push \uparrow or \downarrow to highlight a value in the rate list. Table 12 lists the rates for each type of wave.

Table 12. Performance Wave Rates

Performance Wave	Rates
Square and Triangle	0.125, 2.0, and 2.5 Hz
Sine	0.05, 0.5, 1, 2, 5, 10, 25, 30, 40, 50, 60, 100, and 150 Hz
Pulse	30 and 60 BPM

4. Push **ENTER** to set the rate and go back to the ECG: Performance screen.

To change the amplitude:

1. Push \uparrow or \downarrow to highlight the **Amplitude** value.
2. Push **ENTER**.
3. Push \uparrow or \downarrow to adjust the amplitude. Each push of a key increases or decreases the amplitude 0.05 mV between 0.05 mV and 1.00 mV and 0.25 mV above 1 mV to 5.00 mV in the direction of the key pushed.
4. Push **ENTER** to set the rate and go back to the ECG: Performance screen.

Set R Wave Detection Values

To sense a heartbeat, a monitor looks for R waves. The sensed R wave is used to calculate heart rate and other analysis. You adjust the R wave to find the range of values a heart monitor can sense a heartbeat. The R wave is a simple triangular pulse.

To output a signal for an R Wave detection test:

1. Push **ECG** to show the ECG screen on the display.
2. Push **▲** or **▼** to highlight the **Wave Group** value.
3. Push **ENTER**.
4. Push **▲** or **▼** to highlight the **R Wave Detection** value in the wave group list.
5. Push **ENTER** to show the ECG: R Wave Detection screen in Figure 9 on the display.

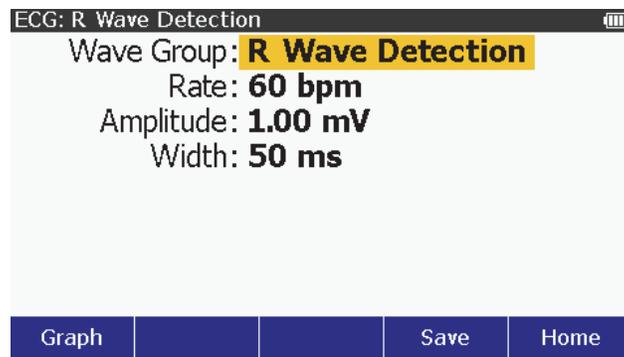


Figure 9. R Wave Detection Screen

glh020.bmp

You can change the rate, amplitude, and width of the R wave. To change the rate:

1. Push **▲** or **▼** to highlight the **Rate** value.
2. Push **ENTER**.
3. Push **▲** or **▼** to highlight **30, 60, 90, 120, 200, or 250 bpm** in the list.
4. Push **ENTER** to set the rate and go back to the ECG: R Wave Detection screen.

To change the R wave amplitude:

1. Push **▲** or **▼** to highlight the **Amplitude** value.
2. Push **ENTER**.
3. Push **▲** or **▼** to adjust the amplitude. Each push of a key increases or decreases the amplitude in the direction of the key pushed. The Product simulates a heart signal amplitude of 0.05 mV to 0.25 mV by 0.05 mV intervals and 0.05 mV to 5.00 mV that is set in 0.25 mV intervals.
4. When the amplitude is set, push **ENTER** to enter the value and go back to the R Wave Detection screen.

To change the width of the R Wave:

1. Push \uparrow or \downarrow to highlight the **Width** value.
2. Push **ENTER**.
3. Push \uparrow or \downarrow to adjust the width. Each push of a key increases or decreases the width 20 ms for each key push when the value is 20 ms or above and 2 ms when the value is 20 ms or less. The Product simulates an R Wave width of 8 ms to 200 ms.
4. When the amplitude is set, push **ENTER** to enter the value and go back to the R Wave Detection screen.

Set QRS Detection Test Values

The QRS Detection wave group supplies a signal that you can adjust the width of the QT interval. This QRS Detection wave includes the R and S waves with relative amplitudes as specified in EC-13. The R wave is 0.875 of the waveform amplitude and the S wave is negative at 0.125 of the waveform amplitude. The R wave up slope is 0.4375 of the waveform width. The R wave down slope is 0.5 of the waveform width. The S wave up slope is 0.0625 of the waveform width.

To generate a signal for an QRS detection test:

1. Push **ECG** to show the ECG screen on the display.
2. Push \uparrow or \downarrow to highlight the **Wave Group** value.
3. Push **ENTER**.
4. Push \uparrow or \downarrow to highlight the **QRS Detection** value in the wave group list.
5. Push **ENTER** to show the ECG: QRS Detection screen in Figure 10 on the display.

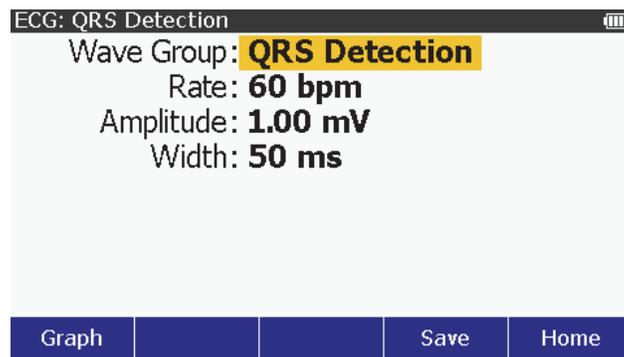


Figure 10. QRS Detection Screen

glh021.bmp

You can change the rate, amplitude, and width of the QRS wave.

To change the rate:

1. Push \uparrow or \downarrow to highlight the **Rate** value.
2. Push **ENTER**.
3. Push \uparrow or \downarrow to highlight **30, 60, 90, 120, 200, or 250 bpm** in the list.
4. Push **ENTER** to set the rate and go back to the ECG: QRS Detection screen.

To change the QRS Wave amplitude:

1. Push \blacktriangle or \blacktriangledown to highlight the **Amplitude** value.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to adjust the amplitude. Each push of a key increases or decreases the amplitude in the direction of the key pushed. The Product simulates a heart signal amplitude of 0.05 mV to 0.25 mV by 0.05 mV intervals and 0.50 mV to 5.00 mV that is set in 0.25 mV intervals.
4. Push **ENTER** to set the amplitude and go back to the ECG: QRS Detection screen.

To change the width of the QT interval:

1. Push \blacktriangle or \blacktriangledown to highlight the **Width** value.
5. Push **ENTER**.
6. Push \blacktriangle or \blacktriangledown to adjust the width. Each push of a key increases or decreases the width 10 ms for each key push when the value is 20 ms or above and 2 ms when the value is 20 ms or less. The Product simulates a QT width of 8 ms to 200 ms.
7. When the width is set, push **ENTER** to enter the value and go back to the ECG: QRS Detection screen.

Set Tall T Wave Rejection Test Values

An ECG monitor must sense and reject a large T wave when it calculates the heart rate. Use the Tall T Wave Rejection waveform for this test. This wave includes the QRS wave per EC-13 with a 100 ms width and QT interval of 350 ms. The T wave has a sinusoidal shape, 180 ms wide. You can adjust the amplitude to 0 % to 150 % of the overall waveform amplitude. The rate is set at 80 BPM. To output a tall T wave signal:

1. Push **ECG** to show the ECG screen on the display.
2. Push \blacktriangle or \blacktriangledown to highlight the **Wave Group** value.
3. Push **ENTER**.
4. Push \blacktriangle or \blacktriangledown to highlight the **Tall T Wave Rejection** value in the wave group list.
5. Push **ENTER** to show the ECG: Tall T Wave Rejection in Figure 11 on the display.



Figure 11. Tall T Wave Rejection Screen

glh022.bmp

You can change the amplitude of the T Wave. To change the amplitude:

6. Push **▲** or **▼** to highlight the **Amplitude** value.
7. Push **ENTER**.
8. Push **▲** or **▼** to increase or decrease the T Wave amplitude. The amplitude is set as a percentage of the voltage on the reference lead. The range is 0 % to 150 % in 10 % steps.
9. Push **ENTER** to enter the value and go back to the ECG: Tall T Wave Rejection screen.

Fetal Simulation

The Product simulates a mixed fetal and maternal electrocardiogram (ECG) that occurs during labor, as well as a selection of pressure waveforms made by uterine contractions. You can change the contraction period. There is also a manual contraction.

Note

The maternal heart rate is always a normal sinus rhythm at 80 beats/minute.

The Product does not provide simulations for all types of fetal heart rate tracings and contraction patterns. A few examples of simulations not provided are:

- Variable decelerations
- Sinusoidal pattern
- Reactive tracing
- Variations in FHR variability
- Tachysystole

Set Fetal Heart Values

The Product simulates the fetal/maternal ECG on its regular ECG leads. The maternal signal is a P-QRS-T wave at half the set ECG amplitude. The fetal signal is a narrow R wave at full amplitude. Fetal and maternal signals are summed to make a composite signal.

To do a fetal simulation:

1. Push **SPECIAL FUNC.**
2. Push **▲**, **▼**, **▶**, or **◀** to highlight **Fetal Simulation** and then push **ENTER** to show the Fetal ECG screen on the display. See Figure 12.

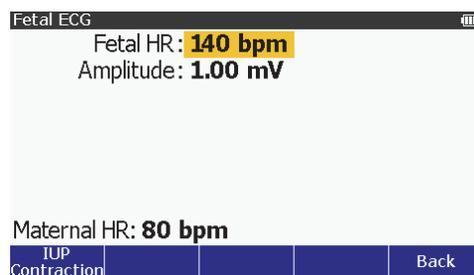


Figure 12. Fetal ECG Screen

glh025.bmp

Push the **Back** softkey to go back to the **Special Functions** screen.

To change the fetal heart rate:

1. Push  or  to highlight the **Fetal HR** value.
2. Push .
3. Push  or  to change the heart rate value in 1 BPM steps between 60 BPM and 240 BPM.

Note

When you hold down the direction key, the step size changes to 10 BPM until the key is released.

4. Push  to set the heart rate and go back to the Fetal ECG screen.

To change the amplitude of the fetal waveform:

1. Push  or  to highlight the **Amplitude** value.
2. Push  or  to adjust the amplitude. Each push of a key increases or decreases the amplitude in the direction of the key pushed. The Product simulates a fetal heart signal amplitude of 0.05 mV to 0.25 mV by 0.05 mV intervals and 0.50 mV to 5.00 mV that is set in 0.25 mV intervals.
3. Push  to set the amplitude and go back to the Fetal ECG screen.

Simulate Intrauterine Pressure (IUP)

The simulated intrauterine-pressure (IUP) waveform shows a measurement read by an intra-amniotic catheter connected to a pressure transducer. The Product simulates the IUP on IBP channel 1, with a 5 $\mu\text{V/V/mmHg}$ or 40 $\mu\text{V/V/mmHg}$ sensitivity (as has been setup for blood pressure).

The Product sends waveforms to simulate intrauterine pressure during a contraction of the uterus in childbirth. Each IUP wave goes for 90 seconds with a bell-shaped pressure curve that increases from zero to 90 mmHg and goes back to zero. In an IUP-wave simulation, the fetal heart rate (which always begins at 140 BPM, regardless of the fetal ECG rate.) changes with the blood pressure. The fetal heart rate and blood pressure shows on the display.

The IUP period is adjustable to four preconfigured values: a manually started contraction, and contractions that start at 2, 3, or 5 minute intervals.

To do an Intrauterine pressure simulation, connect the fetal monitor to the Product as shown in Figure 13.

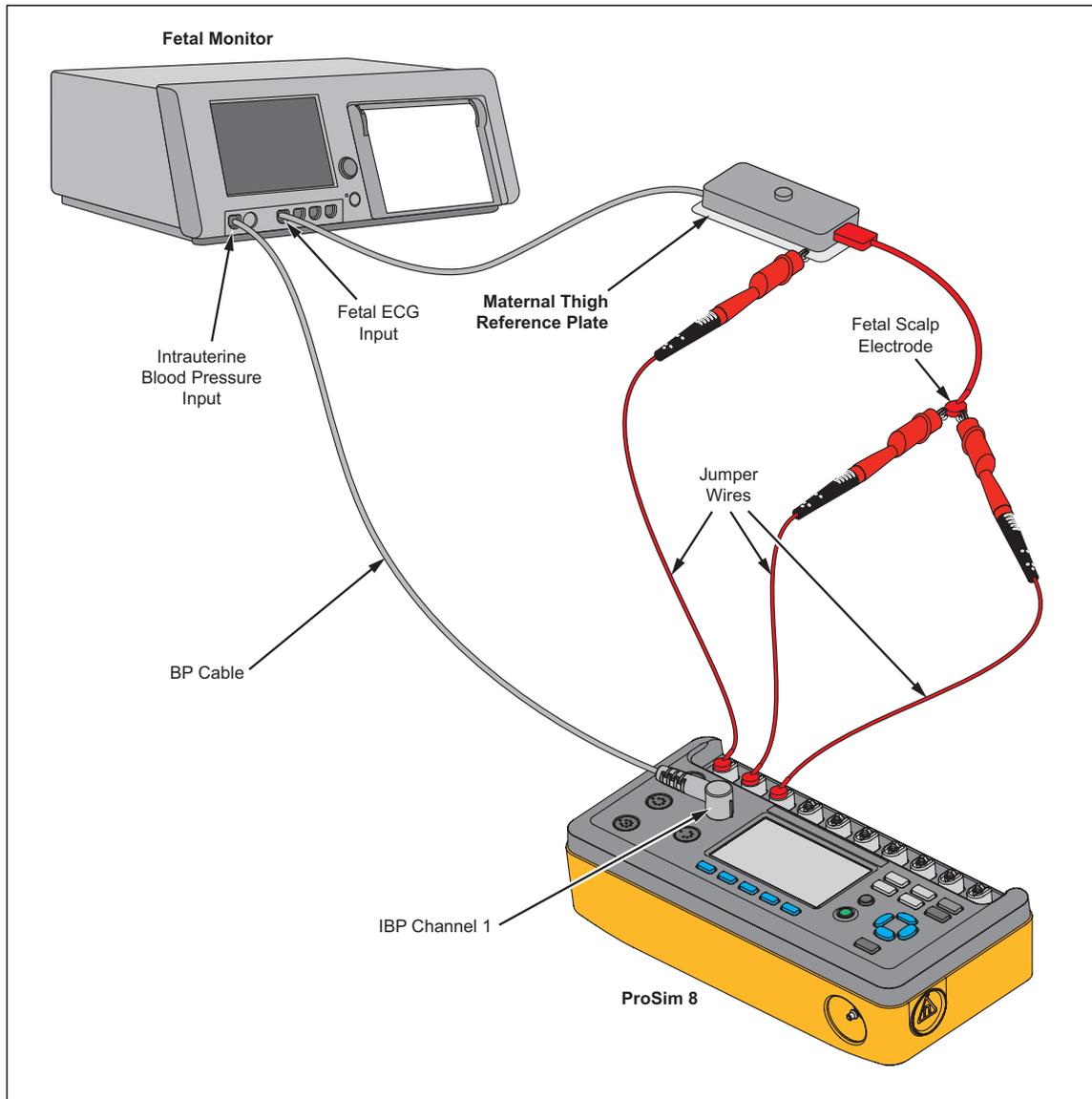


Figure 13. Fetal Monitor Connections for Intrauterine Pressure Simulation

gln058.eps

Note

The maternal thigh reference plate is an accessory provided by fetal monitor OEM, not by Fluke Biomedical, for internal FHR and FECG recording. The 3-lead leg plate employs a single skin electrode as a reference, positioned on the mother's thigh.

To simulate intrauterine pressure contractions push the **IUP Contraction** softkey to show the Fetal ECG: IUP screen on the display. See Figure 14.

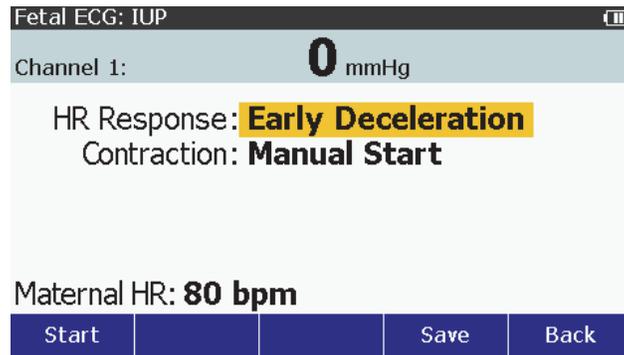


Figure 14. Intrauterine Pressure Contractions Screen

glh026.bmp

Set the Fetal Heart Rate Response

The Product simulates three types of preconfigured waveforms for a periodic fetal heart rate that is interactive with uterine contractions: early deceleration; late deceleration; or acceleration:

With early deceleration, the fetal heart rate follows the intrauterine pressure (no lag). The fetal heart rate starts at 140 BPM, slows to 100 BPM at intrauterine-pressure peak, and then goes back to 140 BPM as the IUP falls back to zero.

With late deceleration, the change in fetal heart rate starts when IUP pressure is at its peak and lags the change in intrauterine pressure by 45 seconds. The fetal heart rate starts at 140 BPM, slows to 100 BPM, and then goes back to 140 BPM.

With acceleration, the change in fetal heart rate lags the change in intrauterine pressure by 30 seconds. The fetal heart rate starts at 140 BPM, increases to 175 BPM, and then goes back 140 BPM.

To set the fetal heart rate response:

1. Push \uparrow or \downarrow to highlight the **HR Response** value.
2. Push **ENTER**.
3. Push \uparrow or \downarrow to highlight **Early Deceleration**, **Late Deceleration**, or **Acceleration**.
4. Push **ENTER** to set the response value and go back to the Fetal ECG: IUP screen.

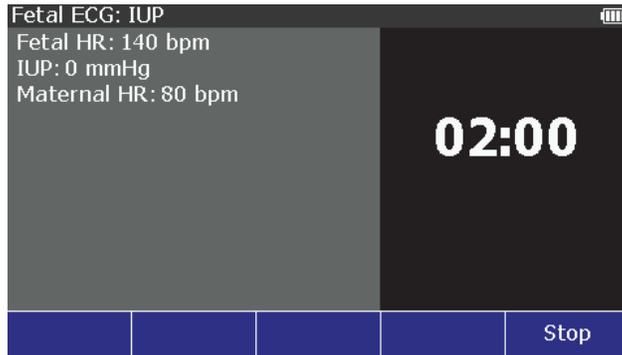
Set the Intrauterine Contraction Simulation

The IUP (Intrauterine Pressure) period is adjustable to four preconfigured values. These are contractions that start manually or at 2, 3, or 5 minute intervals.

To set the contractions:

1. Push \uparrow or \downarrow to highlight the **Contraction** value.
2. Push **ENTER**.
3. Push \uparrow or \downarrow to highlight **Manual Start**, **2**, **3**, or **5 minutes**.
4. Push **ENTER** to set the **Contraction** value and go back to the Fetal ECG: IUP screen.
5. To start a contraction, push the **Start** softkey. The screen below shows on

the display and updates with real-time simulation data. The time until the contraction ends is also shows on the display. See Figure 15.



glh027.bmp

Figure 15. Fetal ECG Intrauterine Pressure Screen

If the **Contraction** value is set to **Manual Start**, only one contraction cycle is simulated.

The timer shows the time until the contraction ends and the subsequent contraction starts.

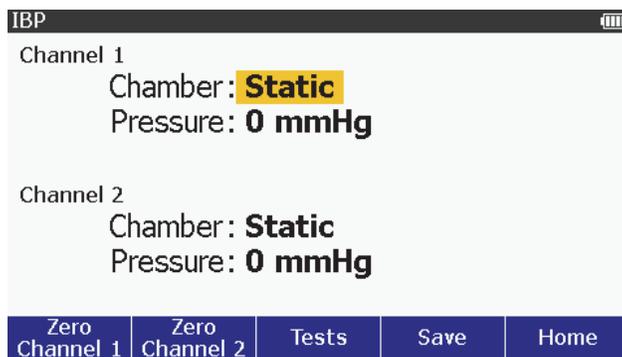
Push the **Stop** softkey to stop contractions and go back to the Fetal ECG: IUP screen.

Invasive Blood Pressure Simulation and Tests

The Product simulates blood pressure for Invasive blood pressure monitors. You can set each blood pressure variable through the front-panel controls. The Product also simulates Swan-Ganz and cardiac catheterization procedures.

Set the Invasive Blood Pressure Variables

The Product can simulate two invasive blood pressure transducers at one time. The blood pressure variables are set separately for each channel. To set these variables, push to show the IBP screen in Figure 16 on the display.



glh009.bmp

Figure 16. Invasive Blood Pressure Screen

To set the chamber:

1. Push  or  to highlight the **Chamber** value on **Channel 1** or **Channel 2**.
2. Push **ENTER**.
3. Push  or  to highlight a value in the chamber list. Below is a list of chamber values in the Product.

Static	Right Ventricle
Arterial	Pulmonary Artery
Radial Artery	PA Wedge
Left Ventricle	Right Atrium (CVP)
Left Atrium	

4. Push **ENTER** to set the chamber and go back to the IBP screen.

You must first zero the patient monitor when you connect to a new IBP transducer or patient simulator. To set a channel to 0 mmHg and Static chamber, push the **Zero Channel 1** or **Zero Channel 2** softkey. After you zero the product, do the zero function on the patient monitor.

To set the pressure:

1. Push  or  to highlight the **Pressure** value on **Channel 1** or **Channel 2**.
2. Push **ENTER**.

Systolic and diastolic pressures are set separately.

Note

If the chamber is set to static, only one pressure is set.

3. Push  or  to highlight the systolic or diastolic pressure value.
4. Push  or  to increase or decrease the pressure value in 1 mmHg steps. The range is -10 mmHg to +300 mmHg.

Note

When you hold down the direction key, the step size changes to 10 mmHg until the key is released.

5. Push **ENTER** to set the pressure and go back to the IBP screen.

When the **Chamber** parameter is set to a value other than **Static**, the **Artifact** parameter is added to the display as shown in Figure 17.

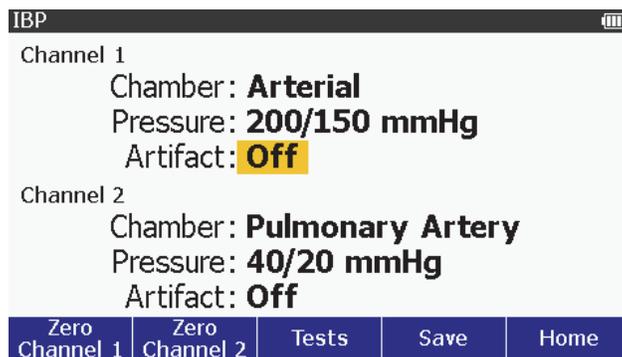


Figure 17. IBP with Chambers Screen

glih051.eps

To set the artifact:

Note

Artifact value is not available when the Chamber value is set to Static.

1. Push  or  to highlight the **Artifact** value on channel 1 or channel 2.
2. Push .
3. Push  or  to highlight **5%** or **10%** if the chamber parameter is set to **Arterial**, **Radial Artery**, or **Left Ventricle**. Highlight **5 mmHg** or **10 mmHg** for all other chamber values. Highlight **Off** to turn off the artifact function.

Note

The artifact values show in percent (%) or in mmHg. These units are set by the chamber value.

4. Push  to set the artifact value and go back to the IBP screen.
The IBP screen reappears on the display with the new artifact selection.

Simulate Invasive Blood Pressure Tests

The Product can simulate pressures that occur during a Swan-Ganz or Cardiac Catheterization procedure. Figure 18 shows a monitor connected to the two IBP channel jacks on the Product.

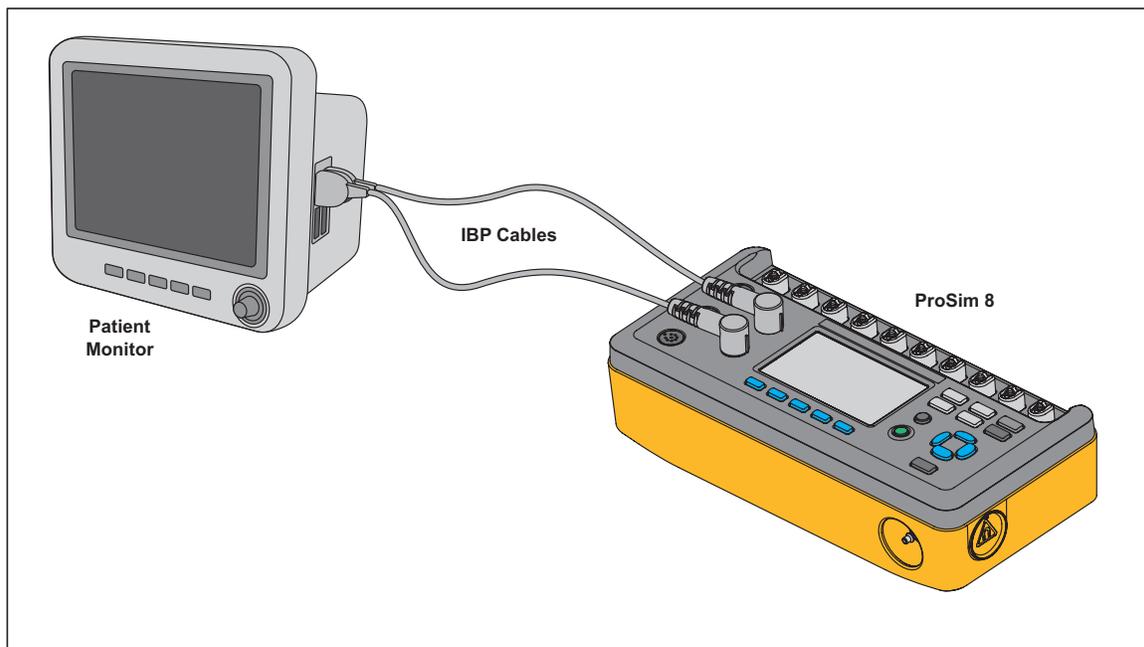


Figure 18. Invasive Blood Pressure Connections

gjh028.eps

Simulate a Swan-Ganz Procedure

To simulate IBP during a Swan-Ganz procedure:

1. Push the **Tests** softkey in the IBP screen.
2. Push \uparrow or \downarrow to highlight **Swan-Ganz – Channel 1** or **Swan-Ganz – Channel 2**.
3. Push **ENTER**. The details and steps in the procedure shown in Figure 19 are shown on the display.

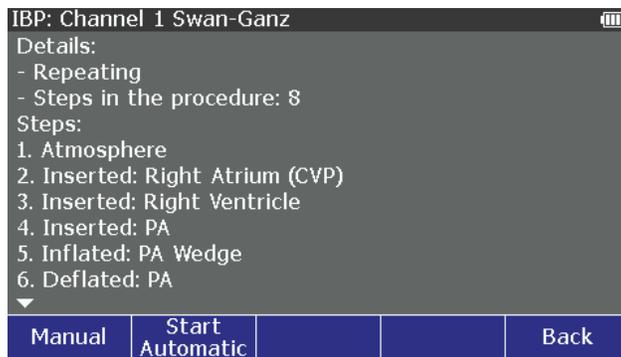


Figure 19. Initial Swan-Ganz Procedure Simulation Screen

glh012.bmp

You can do the Swan-Ganz procedure manually or automatically.

To step through the procedure manually, push the **Manual** softkey. Each procedure step shows on the display. To move to the subsequent step push the **Next** softkey.

After the first step, push the **Previous** softkey to go back a step. To stop the procedure, push the **Stop** softkey.

To do the steps automatically, push the **Start Automatic** softkey. The display in Figure 20 shows the Inserted (Right Atrium) step for the Swan-Ganz procedure.



Figure 20. Insert Step in Swan-Ganz Procedure Simulation

glh014.bmp

There is a 15 second period between steps. The remaining time for each step shows in the right part of the display. You can push the **Pause** softkey to stop the countdown to the subsequent step while the Product continues the patient simulation for that step. **Continue** replaces **Pause** when the procedure step is paused. Push **Continue** to continue the step.

You can go back a step when you push the **Previous** softkey. The Product simulates that step for a full 15 seconds before it does the subsequent step. When you push the **Previous** softkey while paused, the Product goes back a step, but stays paused and sets the time to 15 seconds.

When you push the **Stop** softkey, the procedure simulation is stopped and the initial test screen shown in Figure 19 shows on the display.

Simulate a Cardiac Catheterization Procedure

The Product simulates blood pressure measurements on both sides of a heart valve. The pressure difference, or gradient across the valve, is used to determine heart valve condition.

To simulate a Cardiac Catheterization procedure:

1. Push the **Tests** softkey in the IBP screen.
2. Push  or  to highlight **Cardiac Catheterization**.
3. Push . The valve selection shows on the display.

To change the valve value:

1. Push .
2. Push  or  to highlight **Aortic**, **Pulmonary**, or **Mitral**.
3. Push  to go back to the IBP: Cardiac Catheterization screen.

To start the procedure simulation:

1. Push the **Start** softkey.
All the procedure steps are done manually.
2. Push the **Insert** softkey for the next step.
3. You simulate an increase and decrease of simulated pressure when you push the **Increase Pressure** or **Decrease Pressure** softkeys.
4. Push the **Pullback** softkey to simulate the pressures when the catheter is pulled back.

Push the **Stop** softkey to stop the procedure and go back to the IBP: Cardiac Catheterization screen.

Aortic Valve Catheterization Simulation

The aortic valve controls flow from the left ventricle (LV) to the aorta (atrial pressure) and prevents flow in the reverse direction. Both IBP channels are set the Arterial 120/80. IBP channel 1 stays at arterial 120/80 for reference throughout the simulation.

1. Push the **Insert** softkey to simulate the insertion of IBP channel 2 catheter into the left ventricle at 120/0. Figure 21 shows the screen for the aortic valve catheterization simulation.

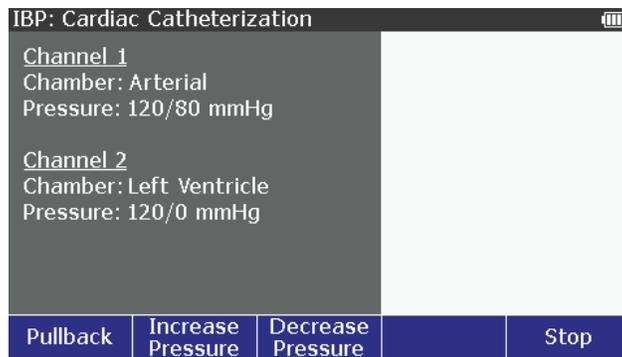


Figure 21. Aortic Valve Catheterization Simulation Screen

glh054.bmp

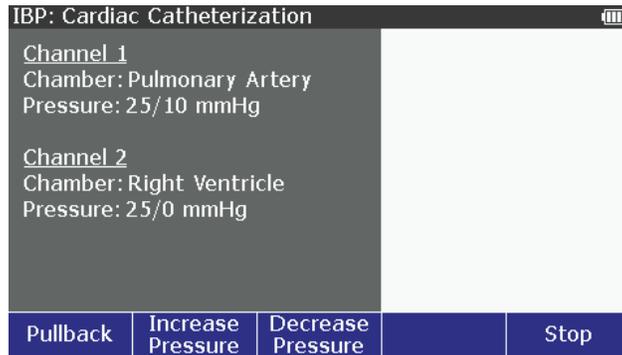
For a normal valve, when the heart beat starts, the LV pressure increases to 80 mmHg. Then, as the valve opens, both pressures increase to the systolic peak. Next, the pressures fall until the valve opens. The LV pressure goes back down, but the arterial stays at 80 mmHg.

2. Push the **Increase Pressure** or **Decrease Pressure** to simulate a bad aortic valve. There are six pressure values between 120 mmHg and 180 mmHg. Each push of the increase softkey sets the left ventricle pressure to 126 mmHg (+5 %), 132 mmHg (+10 %), 138 mmHg (+15 %), 144 mmHg (+20 %), and 180 mmHg (+50 %). Each push of the decrease softkey sets the pressure down from 180 mmHg to 120 mmHg with the same pressure steps.
3. Push the **Pullback** softkey to simulate the pull back of the IBP channel 2 catheter to the left ventricle.

Pulmonary Valve Catheterization Simulation

The pulmonary valve controls flow from the right ventricle (RV) to the pulmonary artery (PA) and prevents flow in the reverse direction. Both IBP channels are set to PA 25/10. IBP channel 1 stays at PA 25/10 for reference throughout the simulation.

1. Push the **Insert** softkey to simulate the insertion of the IBP channel 2 catheter into the right ventricle at 25/0.



glh055.bmp

Figure 22. Pulmonary Valve Catheterization Simulation Screen

For a normal valve, when the heart beat starts, the RV pressure increases to 10 mmHg. Then, as the valve opens, both pressures increase to the systolic peak. Next, the pressures fall until the valve opens. The RV pressure goes back down, but the pulmonary artery stays at 10 mmHg.

2. Push the **Increase Pressure** or **Decrease Pressure** to simulate a bad pulmonary valve. There are six pressure values between 25 mmHg and 38 mmHg. Each push of the increase softkey sets the left ventricle pressure to 26 mmHg (+5 %), 28 mmHg (+10 %), 29 mmHg (+15 %), 30 mmHg (+20 %), and 38 mmHg (+50 %). Each push of the decrease softkey sets the pressure down from 38 mmHg to 25 mmHg with the same pressure steps.
3. Push the **Pullback** softkey to simulate the pull back of the IBP channel 2 catheter to the right ventricle.

Mitral Valve Catheterization Simulation

The mitral valve controls flow from the left atrium (LA) to the left ventricle (LV) and prevents flow in the reverse direction. A mitral valve test is done indirectly with pressure measurements in the pulmonary artery (PA). There are two measurements: normal and wedged. A wedged measurement is done with an inflated balloon (PAW) in the pulmonary artery to measure the back pressure from the left ventricle through the left atrium and the lungs. At the start of the procedure, IBP channel 1 is set to LV 120/0 and channel 2 is set to pulmonary artery (PA) 25/10. IBP channel 1 stays at LV 120/0 for reference throughout the simulation.

1. Push the **Insert** softkey to simulate a change in IBP channel 2 catheter pressure to the pulmonary artery wedge pressure (PAW) of 10/2.

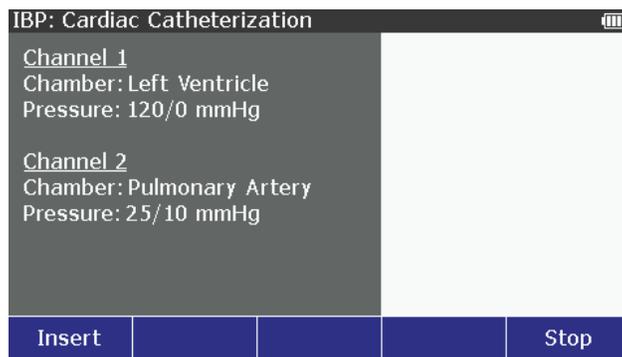


Figure 23. Mitral Valve Catheterization Simulation Screen

glh056.bmp

For a normal valve, the PAW pressure stays low because there is little back pressure from the left ventricle through the left atrium and the lungs.

2. Push the **Increase Pressure** or **Decrease Pressure** to simulate a bad mitral valve. There are six pressure values between 10/2 mmHg and 36/24 mmHg. Each push of the increase softkey sets the left ventricle pressure to 26/18, 29/19 mmHg, 31/21 mmHg, 34/22 mmHg, and 36/24 mmHg. Each push of the decrease softkey sets the pressure down from 36/24 mmHg to 10/2 mmHg with the same pressure steps.
3. Push the **Pullback** softkey to simulate the pulmonary artery wedge (PAW) balloon deflation. This changes IBP channel 2 back to the pulmonary artery.

Simulate Temperature

Temperatures simulated by the Product are compatible with Yellow Springs, Inc. (YSI) Series 400 and 700 probes. The type of cable connected to the temperature jack sets the type of temperature probe simulated. Connect the temperature input of the UUT to the Temperature jack as shown in Figure 24.

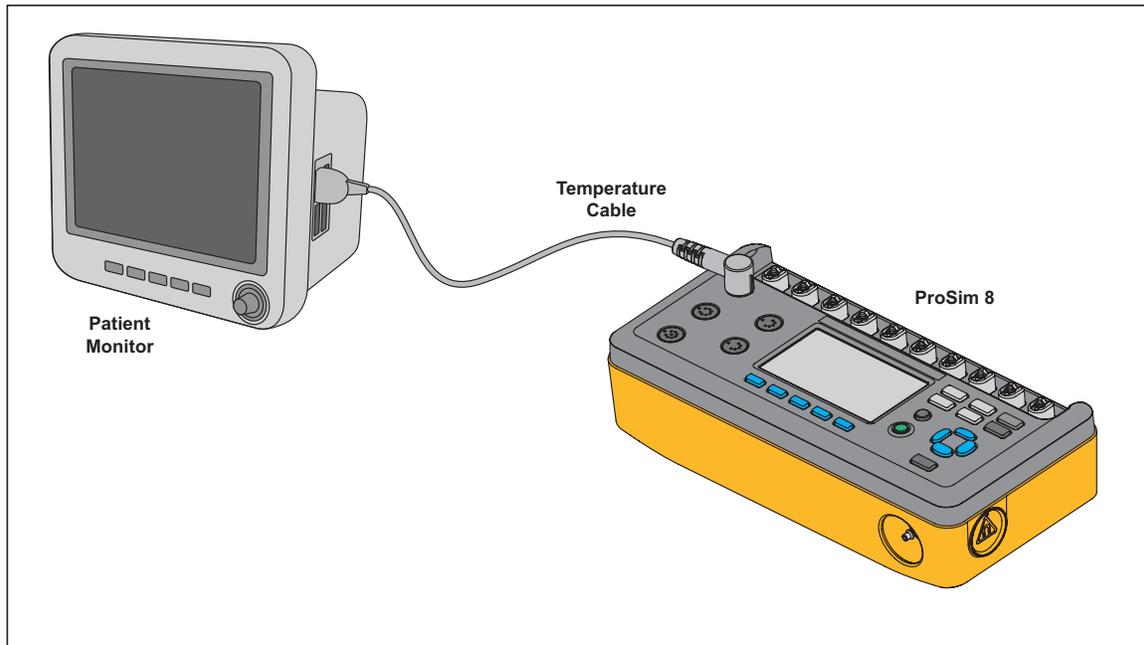


Figure 24. Temperature Simulation Connection

gln038.eps

To set the simulated temperature:

1. Push **SPECIAL FUNC.**
2. Push **▲**, **▼**, **▶**, or **◀** to highlight the **Temperature** selection then push **ENTER** to show the set temperature on the display.
3. Push **ENTER**.
4. Push **▲** or **▼** to change the temperature in 0.5 °C steps between 30.0 °C and 42.0 °C.

Note

When you hold down the direction key, the step size changes to 1.0 °C until the key is released.

5. Push **ENTER** to set the temperature and go back to the Temperature screen.

Simulate Respiration

Respiration variables are set through the special functions. To set respiration:

1. Push **SPECIAL FUNC.**
2. Push **▲**, **▼**, **⏪**, or **⏩** to highlight **Respiration**.
3. Push **ENTER**. The Respiration screen in Figure 25, shows on the display.

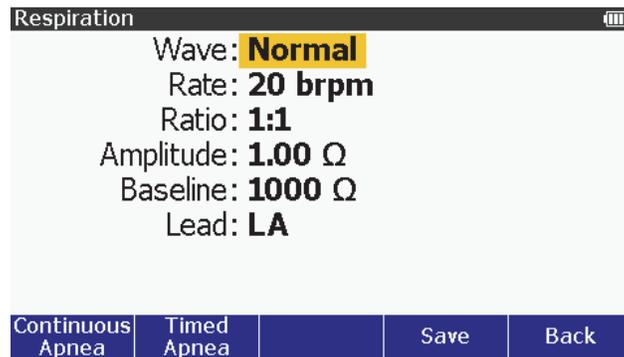


Figure 25. Respiration Screen

glh013.bmp

You can choose between a normal or ventilated respiration waveform and change the respiration rate. You can set the respiration signal to the left arm (LA) or left leg (LL) ECG lead. The baseline impedance between the leads and the amplitude of impedance variation (respiration amplitude) are set though the front panel as well. To set respiration between normal and ventilated:

1. Push **▲** or **▼** to highlight the **Wave** value.
2. Push **ENTER**.
3. Push **▲** or **▼** to highlight **Normal** or **Ventilated**.
4. Push **ENTER** to set the wave and go back to the Respiration screen.

To set the respiration rate:

1. Push **▲** or **▼** to highlight the **Rate** value.
2. Push **ENTER**.
3. Push **▲** or **▼** to increase or decrease the rate of respiration in 1 brpm steps between 10 and 150 brpm.
4. Push **ENTER** to set the respiration rate and go back to the Respiration screen.

To set the respiration ratio:

1. Push **▲** or **▼** to highlight the **Ratio** value.
2. Push **ENTER**.
3. Push **▲** or **▼** to highlight **1:1**, **1:2**, **1:3**, **1:4**, or **1:5**.
4. Push **ENTER** to set the respiration ratio and go back to the Respiration screen.

To set the respiration amplitude:

1. Push \blacktriangle or \blacktriangledown to highlight the **Amplitude** value.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to change the amplitude in 0.05 Ω steps between 0.00 Ω and 5.00 Ω .
4. Push **ENTER** to set the amplitude and go back to the Respiration screen.

To set the baseline resistance:

1. Push \blacktriangle or \blacktriangledown to highlight the **Baseline** value.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to highlight **500**, **1000**, **1500**, or **2000** Ω in the list.
4. Push **ENTER** to set the baseline impedance and go back to the **Respiration** screen. The baseline impedance is kept in memory and is non-volatile.

Note

Baseline value is kept in memory and is non-volatile.

To set the respiration lead:

1. Push \blacktriangle or \blacktriangledown to highlight the **Respiration** lead.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to highlight **LA** or **LL** in the list.
4. Push **ENTER** to set the respiration lead and go back to the Respiration screen. The respiration lead is kept in memory and is non-volatile.

Note

Respiration lead value is kept in memory and is non-volatile.

Set Apnea Simulation

You can simulate an apnea period manually or for a specified time period. To control an apnea period manually, push the **Continuous Apnea** softkey from the Respiration screen. The display shows a timer which shows the time since the apnea period started. The respiration simulation is stopped when the **Stop** softkey is pushed.

To do a timed apnea period:

1. Push the **Timed Apnea** softkey from the Respiration screen.
2. Push \blacktriangle or \blacktriangledown to highlight **12**, **22**, or **32 seconds**.
3. Push **ENTER**.

The display shows a timer that counts down the apnea period. When the timer counts down to zero, the apnea period ends and the display shows the Respiration screen. Push the **Stop** softkey to abort the apnea function.

Simulate Cardiac Output

The Cardiac Output function electronically simulates the dynamic temperature changes in the blood of the patient during a thermal dilution cardiac output measurement.

Thermal dilution cardiac output measurements are given by the heat interchange between the blood of the patient and a known volume of chilled saline put into the heart. Cardiac output is expressed in liters per minute (L/min) and ranges between 3 L/min and 7 L/min in normal adults.

Current cardiac output measurement devices can make sure you get the most accurate measurements. This includes an average of a series of measurements to prevent variations because of artifacts. This rejects measurements because of clinician technique or the underlying cardiovascular disease in a patient.

Note

Cardiac output measurement devices that use different techniques (such as Fick dye injection, Doppler ultrasonography and bioimpedance) are not addressed or intended for this Product.

To simulate cardiac output, a CI-3 module/jack is necessary and connects to the cardiac output jack of the Product. This module has connections for the cardiac output measurement under test and simulates the injectate temperature (IT) thermistors at 0 °C or 24 °C. Of the two connectors on the CI-3 module/cable, the smaller 3-pin connector is for catheter blood temperature (BT) and is standard on most monitors.

Note

This 3-pin catheter BT connector is compatible with the standard Baxter (Edwards) BT catheter and equivalent catheters available from other manufacturers such as Viggo-SpectraMed and Abbott (Sorenson).

The larger 4-pin connector supplies the simulated injectate temperature. The 10-turn 100 k Ω potentiometer enables adjustment of the injectate temperature to 0 °C or 24 °C.

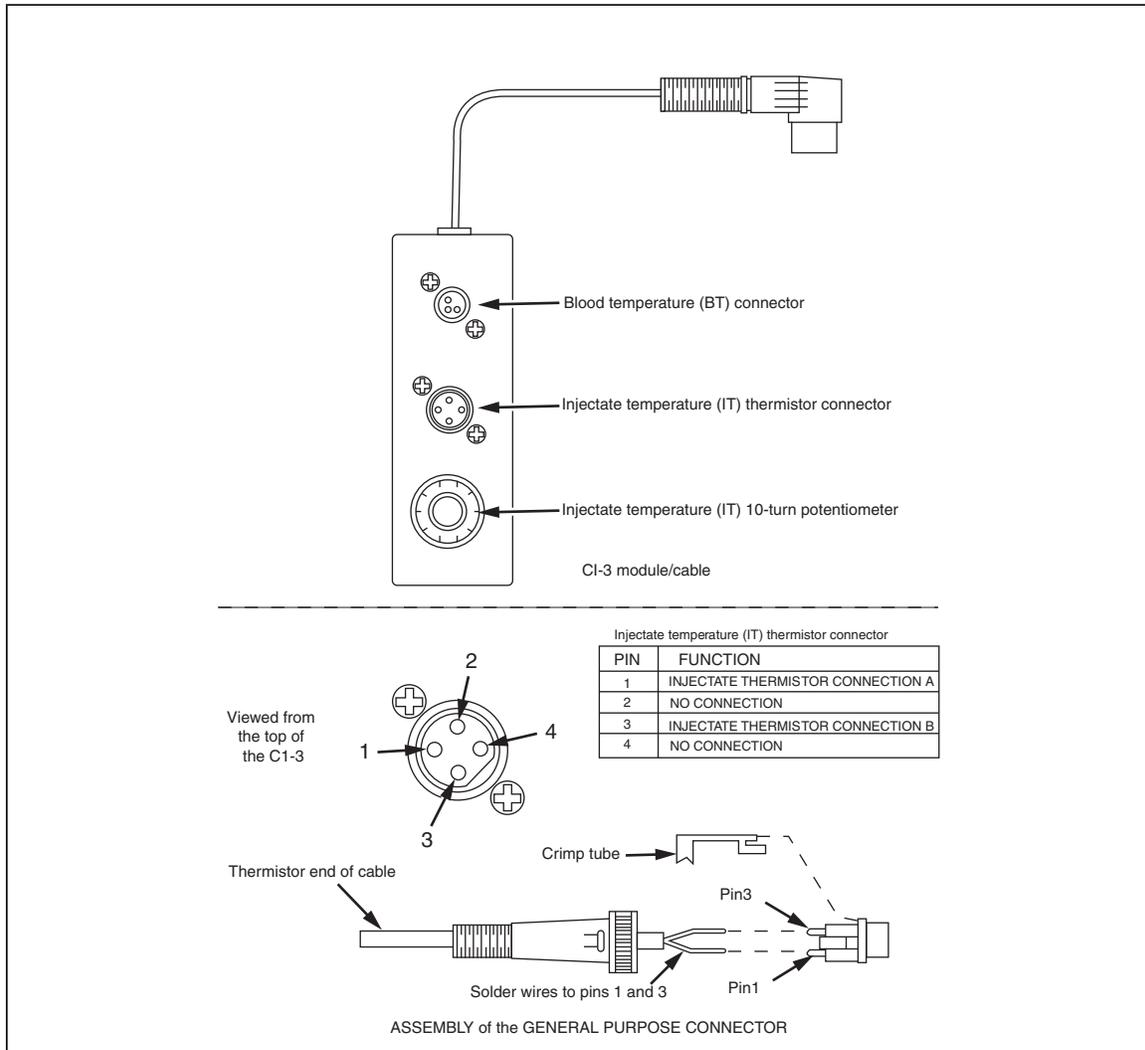
Although this 100 k Ω range of resistance has proven adequate to simulate the 0 °C or 24 °C temperature for most brands of cardiac output measurement devices, the 4-pin IT thermistors connector is not standard on all monitors. A general function connector that you can connect to the device under test (DUT) injectate cable is also supplied.

Figure 26 shows the general-purpose connector assembly. Note that the injectate temperature thermistor has to be cut off the EUT cable to install the general-purpose connector.

Note

A DUT cardiac output cable changed for this test must not be used in a clinical application.

If the DUT cardiac output cable includes an interconnection (or plug-in) for the injectate temperature bath probe assembly, change the plug-in cable only.



eic224.eps

Figure 26. Cardiac Output Injectate Cable Modification

Note

Fluke Biomedical offers optional adapter cables to connect the Product to specified brands of cardiac output measurement devices.

- *To examine Hewlett Packard Merlin systems, a cardiac output adapter and a temperature adapter are necessary.*
- *A special adapter is necessary for Gould/SpectraMed Models SP1445 and SP1465 cardiac output devices.*

Contact Fluke Biomedical for availability, price, and part number.

For cardiac output simulation, use the supplied CI-3 module/cable to connect the Product to the DUT. See Figure 27. If necessary, use the general-purpose connector.

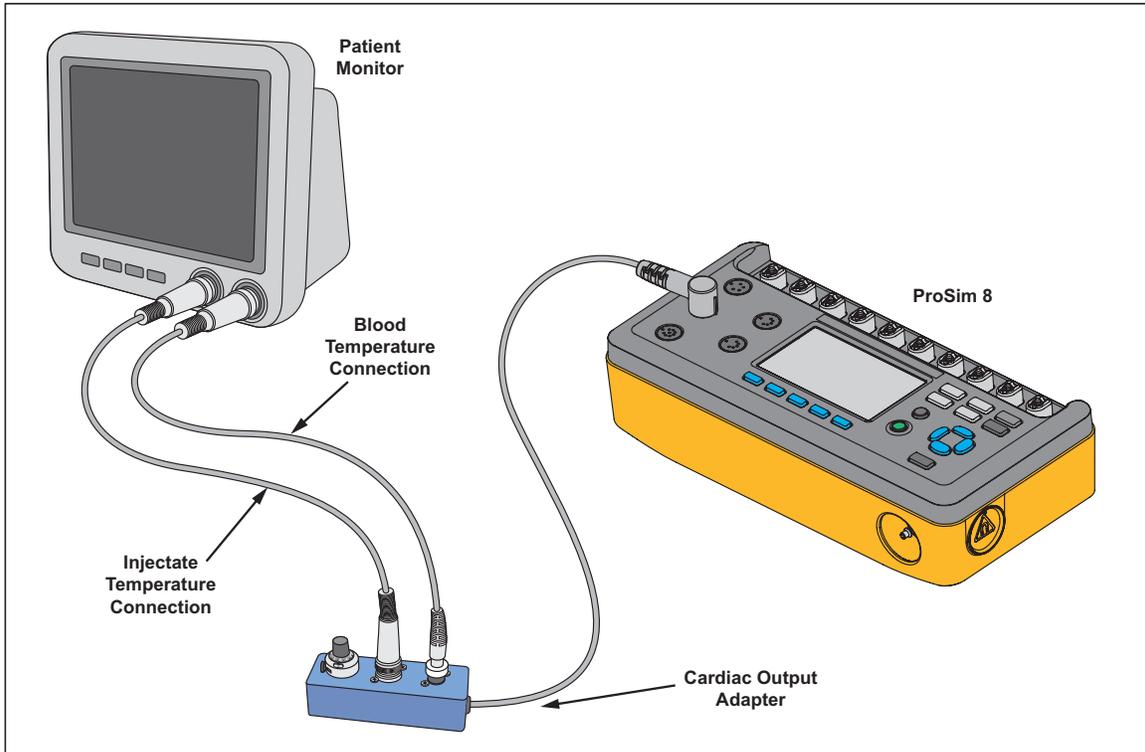


Figure 27. Cardiac Output Connections

glh057.eps

Setup the DUT for the simulated parameters that follow:

- Catheter Size: 7 F
- Injectate Volume: 10 cc
- Computational Constant: 0.542 or 0.595, based on the injectate temperature.

To set the Product for a cardiac output test:

1. Push **SPECIAL FUNC.**.
2. Push **▲**, **▼**, **⏪**, or **⏩** to highlight **Cardiac Output** and then push **ENTER** to show the cardiac output parameters on the display. See Figure 28.

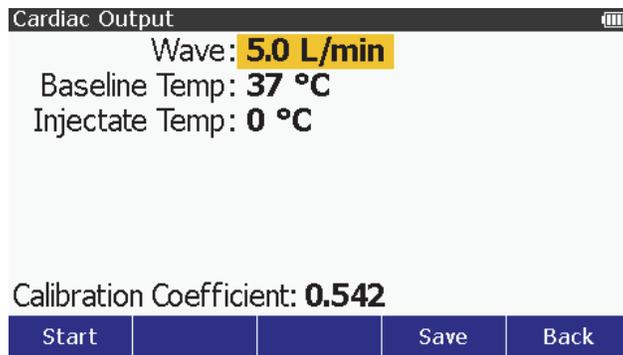


Figure 28. Cardiac Output Screen

glh017.bmp

Push the **Back** softkey to go back to the Special Functions screen,

Set the Cardiac Output Waveform

To set the cardiac output waveform:

1. In the Cardiac Output screen, use  or  to highlight the wave parameter.
2. Push **ENTER**.
3. Push  or  to highlight a waveform name in the list of waveforms.

Table 13 shows the cardiac output waveforms for the Product.

Table 13. Cardiac Output Waveforms

Waveform	Description
2.5 L/min	Normal waveform with accuracy of 2.5 L/min
5.0 L/min	Normal waveform with accuracy of 5.0 L/min
10.0 L/min	Normal waveform with accuracy of 10.0 L/min
Interrupted Injectable	Interrupted injection waveform
LR Shunt	Left to right ventricular shunt
Calibrated Pulse	Calibrated square wave pulse

4. Push **ENTER** to set the wave and go back to the Cardiac Output screen.

Set the Baseline Temperature

To set the baseline temperature:

1. In the cardiac output screen, if not already highlighted, use  or  to highlight the baseline temperature value.
2. Push **ENTER**.
3. Push  or  to highlight **36 °C**, **37 °C**, or **38 °C**.
4. Push **ENTER** to set the baseline temperature and go back to the Cardiac Output screen.

Set Injectate Temperature

To set the injectate temperature:

1. In the cardiac output screen, use  or  to highlight the injectate temperature value.
2. Push **ENTER**.
3. Push  or  to highlight **0 °C** or **24 °C**.
4. Push **ENTER** to set the temperature and go back to the Cardiac Output screen.

As you change the injectate temperature, the calibration coefficient necessary for the monitor shows on the display.

Start a Cardiac Output Simulation

After you set the parameters for a cardiac output simulation, push the **Start** softkey. The simulation completes automatically. To stop the simulation, push the **Stop** softkey.

Non-Invasive Blood Pressure Simulation and Tests

The Product simulates blood pressure for Non-Invasive blood pressure monitors. You can set each blood pressure variable through the front-panel controls. The Product also does leak, pressure source, and pressure relief tests. The manometer function sets the Product to measure static pressure and shows the pressure on the display.

Set the Non-Invasive Blood Pressure Variables

For non-invasive blood pressure tests, connect the Product to the BP cuff and monitor as shown in Figure 29.

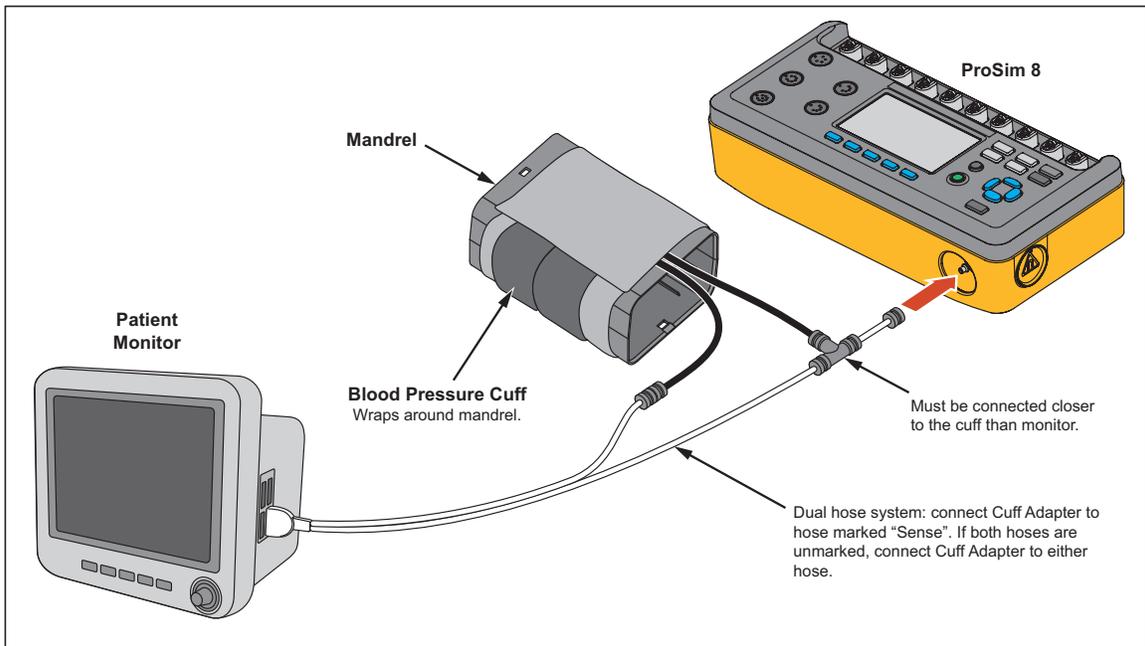


Figure 29. Non-Invasive Blood Pressure Test Connections

gln031.eps

Figure 30 shows the blood pressure cuff mandrel sizes.

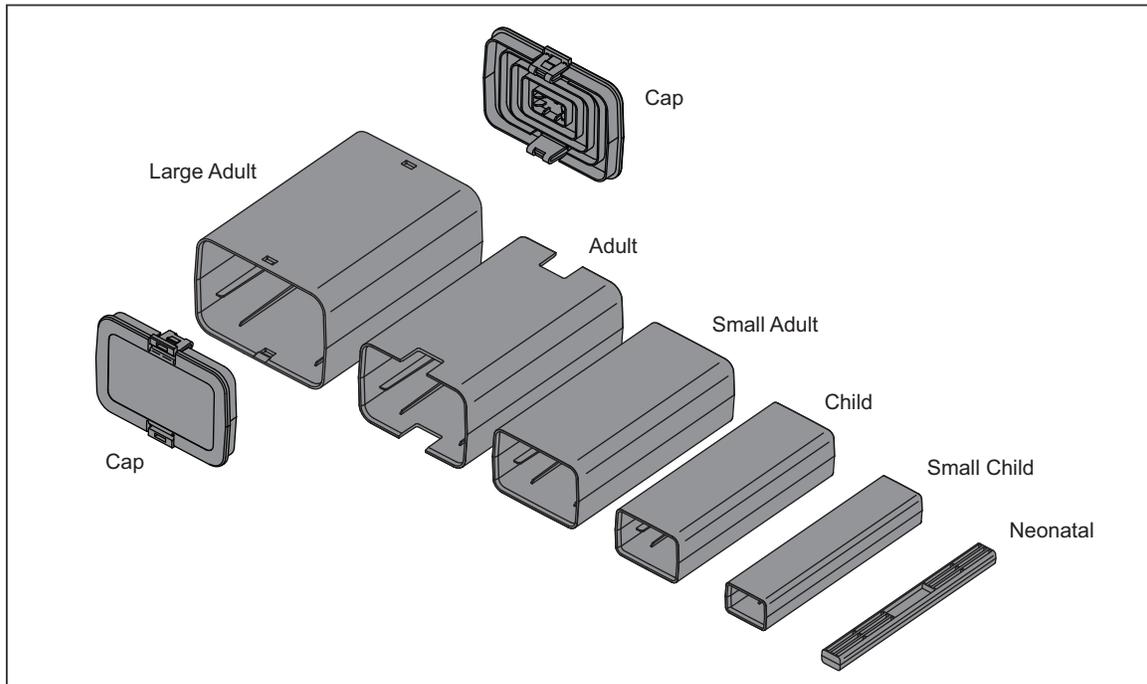


Figure 30. Blood Pressure Cuff Mandrel Sizes

fvc011.eps

To set the blood pressure simulation, push to show the NIBP screen in Figure 31 on the display.



Figure 31. Non-Invasive Blood Pressure Screen

glh003.bmp

Pressure, heart rate, pulse volume, brand, and wave are set through the front-panel controls to simulate different patient conditions. Arrhythmia waveforms are also simulated in the NIBP simulation (set through ECG). To set the Blood Pressure:

1. Push  or  to highlight the **Pressure** variable.
2. Push .
- Systolic and diastolic pressures are set separately.
3. Push  or  to highlight the systolic or diastolic pressure value.
4. Push  or  to increase or decrease the pressure value in 1 mmHg steps.

Note

When you hold down the direction key, the step size changes to 10 mmHg until the key is released.

5. Push  to set the pressure and go back to the NIBP screen.

Note

Heart Rate may not show in the NIBP screen if an arrhythmia or performance waveform is set.

To set the heart rate:

1. Push  or  to highlight the **Heart Rate** variable.
2. Push .
3. Push  or  to increase or decrease the heart rate in 1 BPM steps. The range is 30 BPM to 240 BPM.

Note

When you hold down the direction key, the step size changes to 10 BPM until the key is released.

4. Push  to set the heart rate and go back to the NIBP screen.

Note

*Arrhythmia may show on the display instead of **Heart Rate** when an arrhythmia or performance waveform is set under the ECG function. The Mono VTach waveform is the one exception. You can only change the heart beat to normal sinus rhythm in the NIBP screen.*

To set the heart beat waveform to normal sinus rhythm:

1. Push  or  to highlight the **Arrhythmia** variable.
2. Push .
3. Push  or  to increase or decrease the heart rate.
4. Push  to set the heart rate and go back to the NIBP screen.

To set the pulse volume:

1. Push \blacktriangle or \blacktriangledown to highlight the **Pulse Volume** variable.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to increase or decrease the pulse volume in 0.05 mL steps. The pulse volume range is 0.10 mL to 1.25 mL.
4. Push **ENTER** to set the pulse volume and go back to the NIBP screen.

You can set the wave variable to Adult or Neonatal simulation. When set, the pulse volume is set to the default for that simulation: 1.0 mL for Adult, 0.5 mL for Neonatal. Afterwards, you can change the pulse volume with its own control (see above). To set the wave variable:

1. Push \blacktriangle or \blacktriangledown to highlight the **Wave** variable.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to highlight **Adult** or **Neonatal**.
4. Push **ENTER** to set the wave and go back to the NIBP screen.

When the NIBP monitor starts the blood pressure measurement cycle, the Product keeps the measured parameters of the measurement cycle. If the NIBP screen shows on the display when the measurement cycle starts, a graph of pressure versus time shows on the display. See Figure 32.

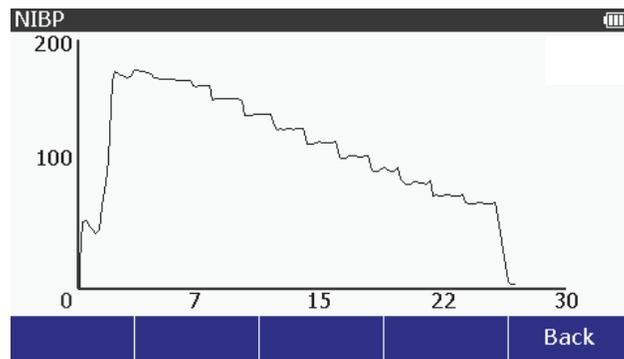


Figure 32. Blood Pressure Measurement Graph

glh005.bmp

Note

The Summary and Graph softkeys show in the NIBP screen after you do an NIBP simulation.

To see the measured parameters of the last blood pressure measurement cycle, push the **Summary** softkey in the NIBP screen. To see the graph of the last NIBP simulation, push the **Graph** softkey in the NIBP screen.

Adjust NIBP Pulse Envelope

To modify the shift of the blood pressure envelope in the Product with firmware 2.00:

1. Push **NIBP** to show the NIBP screen.
2. Push **▲** or **▼** to highlight **Envelope Shift**.
3. Push **ENTER**.
4. Push **▲** to shift the blood pressure envelope to the right, or push **▼** to shift the blood pressure envelope to the left.

The default value for a shift is zero, and the range is from -10 % to +10 %. In Figure 33, the top graph shows a blood pressure envelope with a negative shift, and the bottom graph shows a blood pressure envelope with a positive shift.

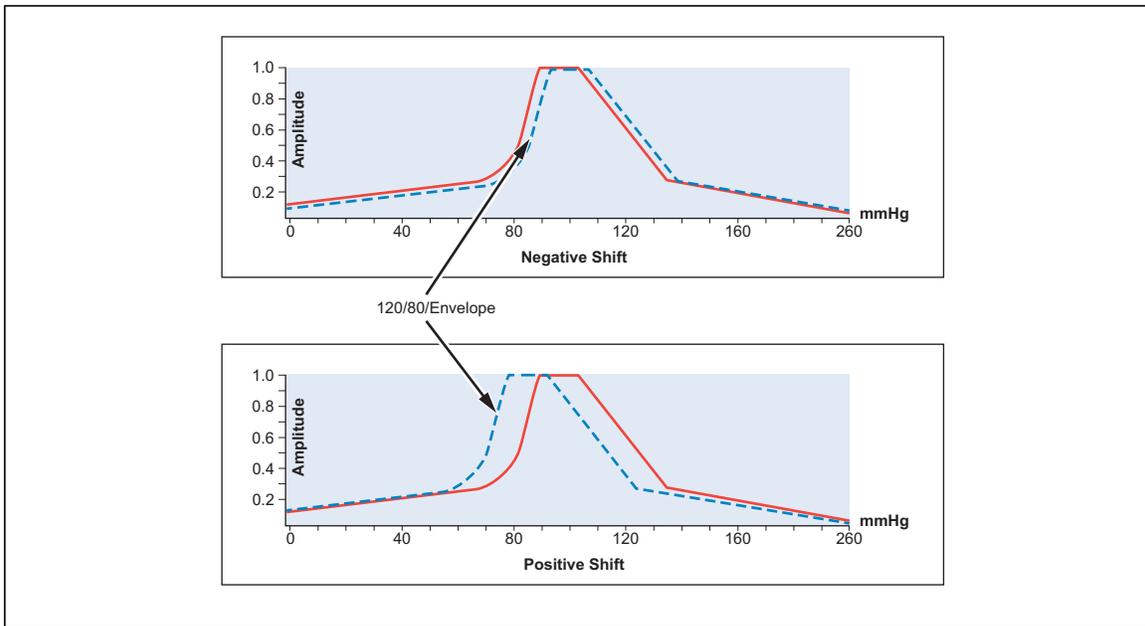


Figure 33. NIBP Blood Pressure Envelope Shifts

gjh059.eps

5. Push **ENTER** to go to the NIBP screen.

Do an NIBP Monitor Test

To do an accuracy test on an NIBP monitor:

1. Connect the NIBP monitor to the Product as shown in Figure 35.
2. Start an NIBP pressure cycle on the monitor. Refer to the monitor manual as necessary. After you start the blood pressure measurement cycle:
 - The blood pressure cuff inflates around the mandrel.
 - The Product starts the peripheral pulse simulation and shows the blood pressure measurement graph on the display.

Note

The graph shows on the display automatically only when the blood pressure measurement cycle starts when the NIBP screen shows on the display.

- The Product starts blood pressure simulation when the pressure is 10 mmHg. Heart beat simulation starts when the pressure equals the diastolic pressure set into the Product.
 - The Product stops the simulation when the pressure is 2 mmHg or below.
 - The NIBP monitor interprets and shows the measured blood pressure values and heart rate when the test stops.
3. Push the **Summary** softkey to show the blood pressure measurements in Figure 34 on the display.

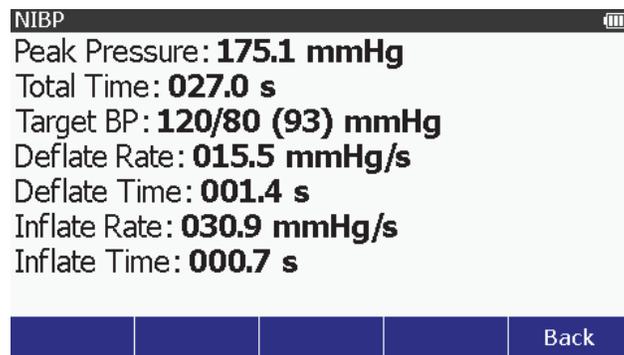


Figure 34. NIBP Summary Screen

glh053.bmp

4. Compare the NIBP monitor values with the target values shown in the Product display.

Do a Pressure Leak Test

The leak test measures leaks in a non-invasive blood pressure monitor, the hoses connected to the monitor, and the pressure cuff.

Note

Before you do a pressure leak test on a monitor, do the pressure leak test without the monitor to identify the leak rate of the Product. Use this leak rate to offset the rate of the full system with the monitor connected.

Note

Put the NIBP monitor in “calibrate” or “service” mode to close the vent valve, so the Product can inflate the pneumatic system. Refer to the service manual for the NIBP monitor.

Connect the Product to the monitor and cuff as shown in Figure 35.

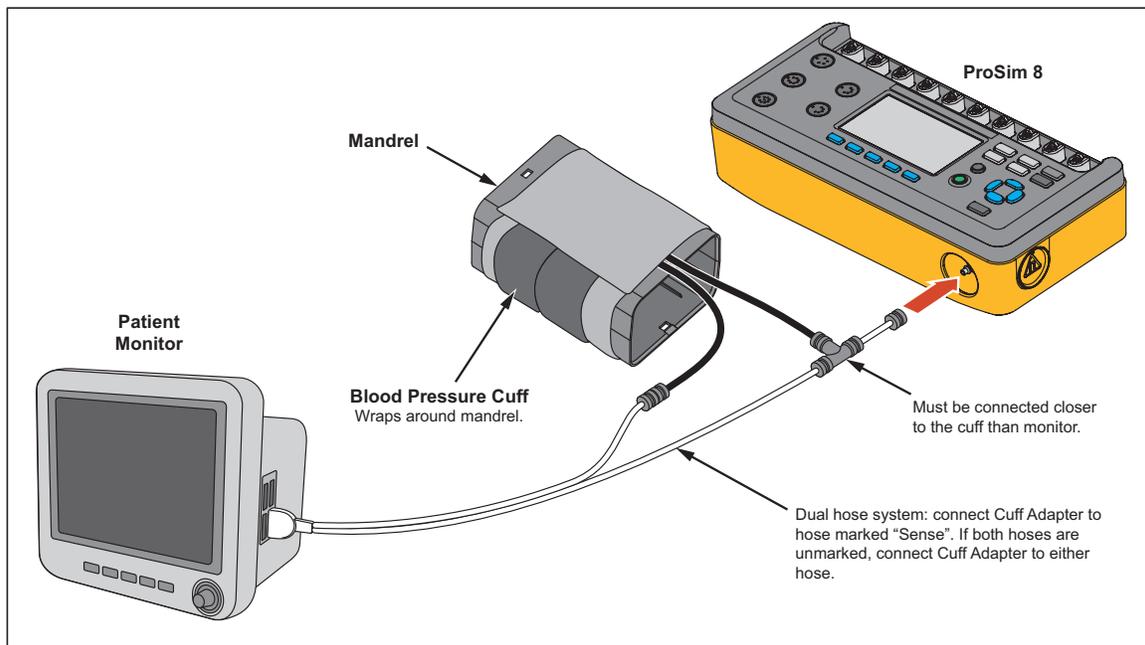


Figure 35. Pressure Leak Test Connections

glh008.bmp

Note

If the NIBP device has an internal system leak test or one that vents the cuff inflation pneumatic circuit to the atmosphere when idle, do not use the Leak Test. Rather, do a Manometer check to test for internal system leaks. Refer to the NIBP monitor operators manual for the recommended test protocol.

To perform a leak test:

1. Push **NIBP** to show the NIBP screen.
2. Push the **Tests** softkey.
3. Push **▲** or **▼** to highlight **Leak Test**.
4. Push **ENTER** to show the NIBP: Leak Test screen in Figure 36 on the display.

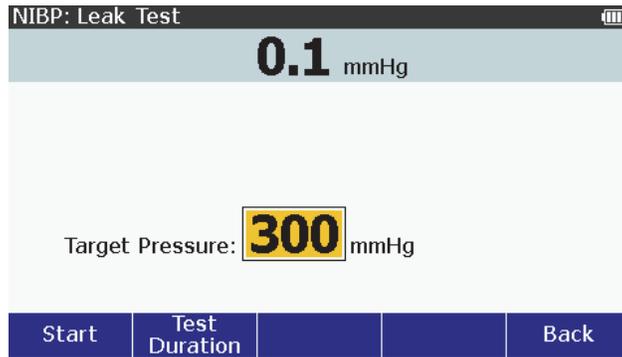


Figure 36. Leak Test Screen

glh024.bmp

The default target pressure is 300 mmHg. You can set the target pressure between 20 mmHg and 400 mmHg. To change the target pressure, push **▲** or **▼** to increase or decrease the pressure value in 1 mmHg steps.

Note

When you hold down the direction key, the step size changes to 10 mmHg until the key is released.

5. Push the **Start** softkey to start the leak test.

The Product pressurizes the pneumatic system to the target pressure. While the Product pumps air into the pneumatic system, the pressure and a graph of the pressure shows on the display. See Figure 37.

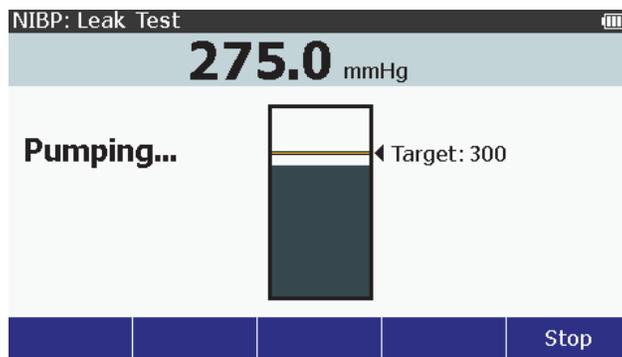


Figure 37. Leak Test Pumping Screen

glh006.bmp

The pump stops when the measured pressure is the same as the target pressure. The Product waits for a time to let the pressure to become stable. Then the Product starts to measure and monitor the pressure for the test period.

When the test is done, the test results show on the display. An example pressure test result is shown in Figure 38.

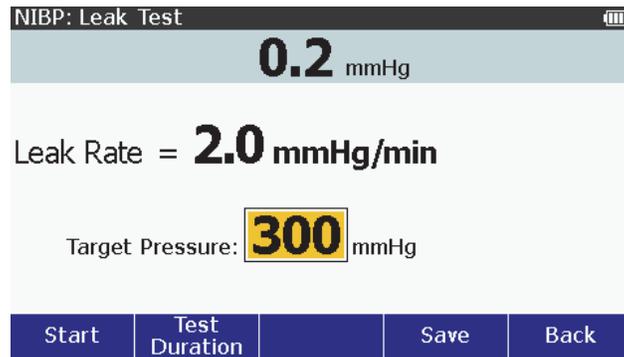


Figure 38. Example Leak Test Result Screen

glh007.bmp

To set how long to run the test:

1. Push the **Test Duration** softkey.
2. Push \uparrow or \downarrow to adjust the time between 30 seconds and 5 minutes in 30 second steps. The default time is 1 minute.
3. Push **ENTER** to set the test duration and go back to the NIBP: Leak Test screen.

Do a Pressure Relief Test

The pressure relief test pressurizes a pneumatic system until the Product senses a drop in pressure, as occurs when the relief valve opens. Or the test stops if the pressure gets to the target pressure and no relief is sensed.

Note

Put the NIBP monitor in “calibrate” or “service” mode to close the vent valve, so the Product can inflate the pneumatic system. Refer to the service manual for the NIBP monitor.

To test the relief valve:

1. From the NIBP screen, push the **Tests** softkey.
2. Push \uparrow or \downarrow to highlight **Pressure Relief Test**.
3. Push **ENTER**.
4. Push \uparrow or \downarrow to increase or decrease the target pressure between 100 mmHg and 400 mmHg in 1 mmHg steps.

Note

When you hold down the direction key, the step size changes to 10 mmHg until the key is released.

5. Push the **Start** softkey to begin the test.

The Product pressurizes the pneumatic system to the target pressure with the pressure measurement and a graph of the pressure shown on the display. See Figure 37. When the Product senses the pressure valve has opened, the test stops and the results show on the display. See Figure 39. It is recommended you do three pressure relief tests in case the relief valve is intermittent.

If there is no drop in pressure and the pressure climbs to the target pressure, the pump stops and **Not Tripped** shows in the display.

Note

Some NIPB monitors do not let you access a “Service” mode. If you cannot close the vent valve, the system cannot be pressurized by an external pump. It is possible to start a blood pressure measurement with the monitor (this closes the valve), then start the Pressure Relief tests, so that two pumps inflate the system. The results can change, but the monitor usually opens a relief valve at some high pressure.

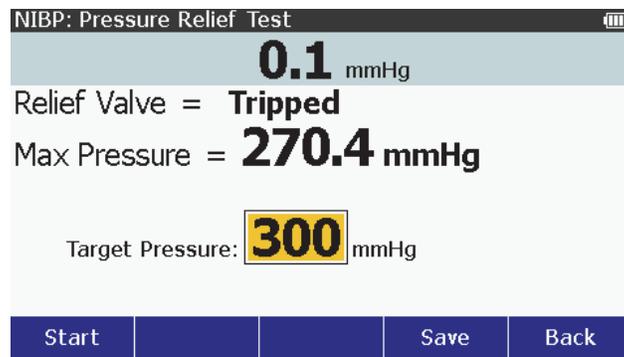


Figure 39. Pressure Relief Valve Test Results Screen

glh008.bmp

See *Save Test Results* to learn more on how to save your test results data.

Do a Pressure Source Test

The pressure source test is used to pressurize a pneumatic system while it measures the pressure. You can use the pressure source test for static calibration of non-invasive blood pressure measurement systems, sphygmomanometer checks, and other devices that measure pressure.

To do a pressure source test:

1. Connect the pressure port to pressure system as shown in Figure 40.

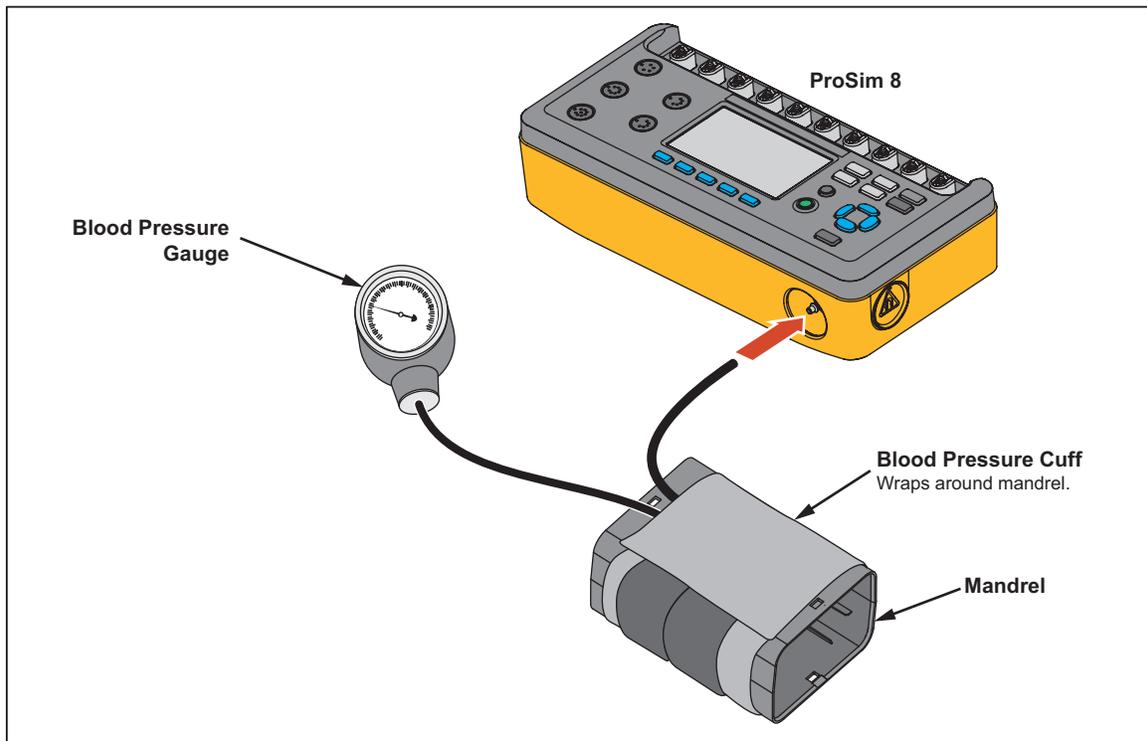


Figure 40. Pressure Source Connection

gln051.eps

2. From the NIBP screen, push the **Tests** softkey.
3. Push \uparrow or \downarrow to highlight **Pressure Source**.
4. Push **ENTER**.
5. Push \uparrow or \downarrow to increase or decrease the target pressure between 20 mmHg and 400 mmHg in 1 mmHg steps.

Note

When you hold down the direction key, the step size changes to 10 mmHg until the key is released.

6. Push the **Start** softkey to begin the test.

The Product pressurizes the pneumatic system to the target pressure. While the Product pumps air into the pneumatic system, the pressure measurement and a graph of the pressure shows on the display. See Figure 41.

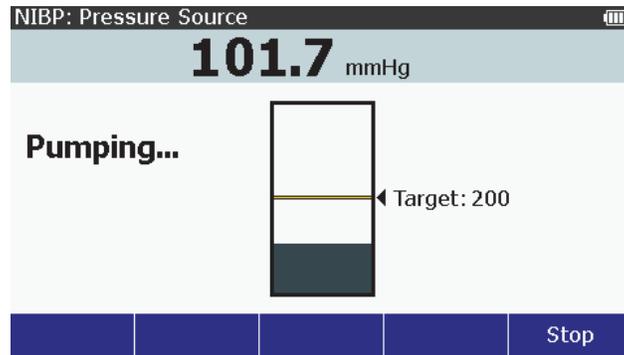


Figure 41. Pressure Source Pumping Screen

glh010.bmp

7. Push the **Stop** softkey to stop the test.

A **Vent** softkey shows on the display. The pressure remains at the level it was when the **Stop** softkey was pushed.

8. Either push the **Vent** softkey to vent the pressure system or change the pressure and push the **Start** softkey to do another test.

Check a Manometer

The manometer function sets the Product up as a pressure gauge to measure pressure supplied by an external source.

To measure pressure:

1. Connect the pressure port to a pneumatic system as shown in Figure 42.

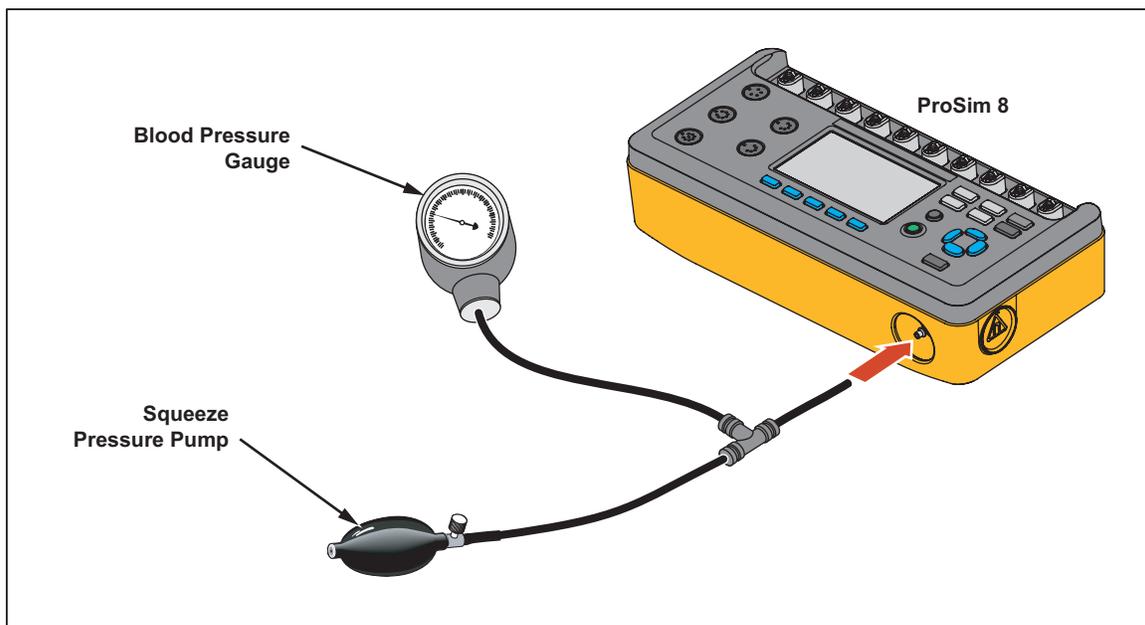


Figure 42. Manometer Connections

glh050.eps

2. From the NIBP screen, push the **Tests** softkey.

3. Push  or  to highlight **Manometer**.
4. Push **ENTER**.

The NIBP: Manometer screen in Figure 43 shows on the display.

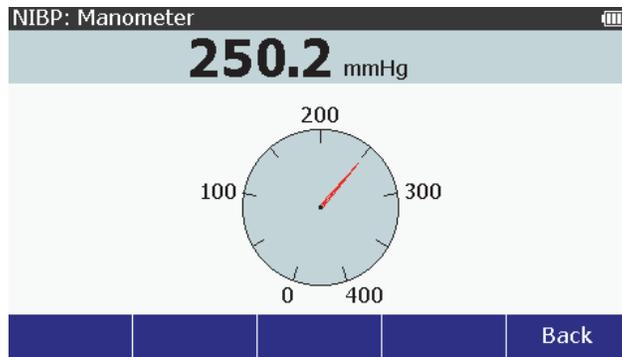


Figure 43. Manometer Screen

glh011.bmp

As the external generator increases the pressure, the digital and analog pressure values on the display show the current pressure.

Zero Pressure

To zero the pressure in the Product with firmware 2.00:

1. Disconnect tubes from the ProSim NIBP port.
2. From the NIBP screen, push the **Tests** softkey.
3. Push  or  to highlight **Manometer**.
4. Push **ENTER**.
5. Push **Zero Pressure**.

Oximeter SpO₂ Optical Emitter and Detector

The subject device provides Oximeter SpO₂ optical emitter and detector capability, which is solely intended to generate an optical signal to verify that the electronics within the pulse oximeter probe are functional. The subject device presents pulse oximeter equipment with a signal having a predictable value of ratio so that the operator can observe the resulting displayed value of SpO₂, and compare it to the expected value derived from the calibration curve for that particular pulse oximeter equipment.

⚠ Warning

The pulse oximeter component of the device is not intended to validate the SpO₂ accuracy of pulse oximeter equipment.

The pulse oximeter component of this device is not intended to confirm the SpO₂ accuracy of the calibration curve of the pulse oximeter monitor or to assess the optical characteristics of representative pulse oximeter probes to determine their proper calibration.

Not all functional testers and pulse oximeter equipment are compatible. Functional testers can vary in pulse methods, pulse contours, and amplitude. A functional tester might not accurately reproduce the calibration of the pulse oximeter equipment and can yield different results between pulse oximeter equipment.

Note

When the Type value is set to Masimo Rainbow, more SpO₂ parameters show on the display than other types of sensors. See Test a Masimo Rainbow SpO₂ to learn about these parameters.

To set oximeter SpO₂ optical emitter and detector parameters, push SpO₂ to show the screen in Figure 44 on the display.

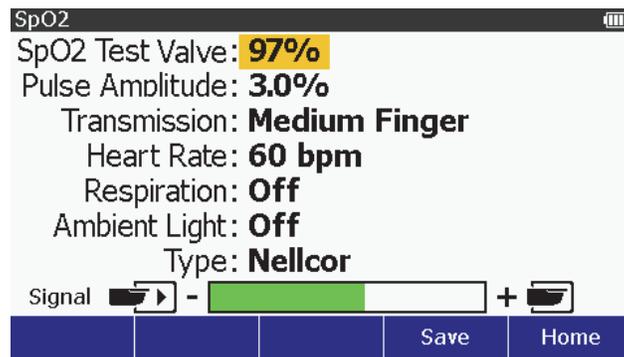


Figure 44. Oximeter SpO₂ Optical Emitter and Detector Screen

glh018.bmp

Connect the SpO₂ artificial finger to the SpO₂ jack on the front panel as shown in Figure 45.

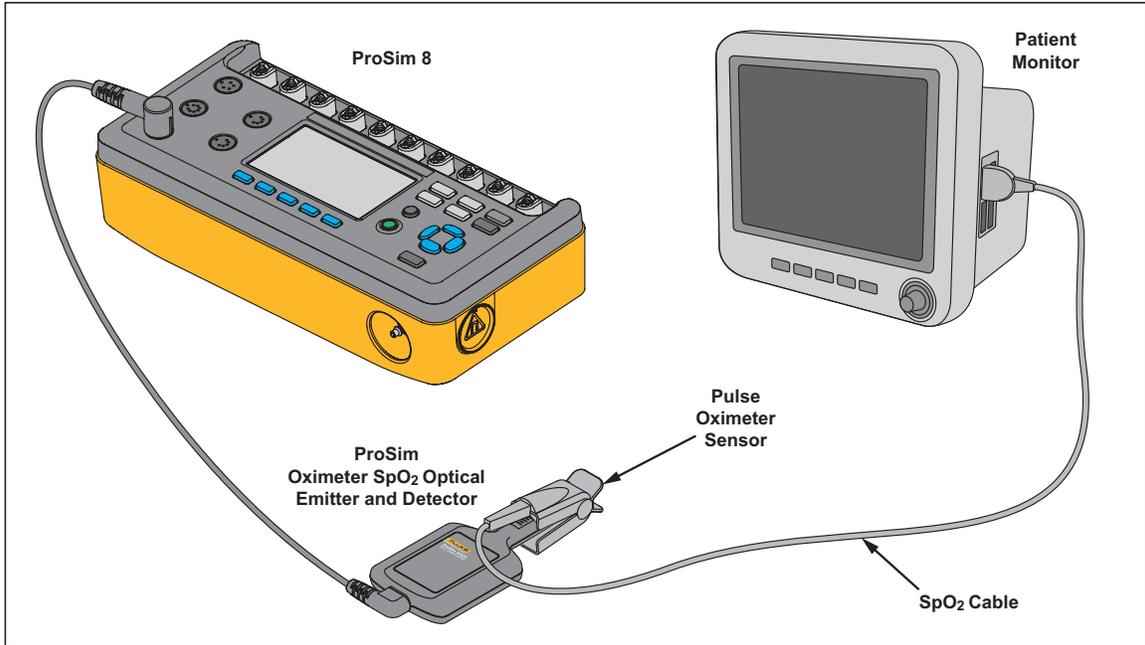


Figure 45. Oximeter SpO₂ Optical Emitter and Detector Connections

gln029.eps

Note

When you put the oximeter sensor on the artificial finger, make sure the red LEDs (light emitting diodes) are on the bottom.

Put the SpO₂ sensor on the artificial finger as shown in Figure 46. Place the sensor with the LEDs on the bottom of the artificial finger. While you put the sensor on the artificial finger, monitor the signal indicator along the bottom of the Product display. Adjust the sensor on the finger for maximum signal strength.

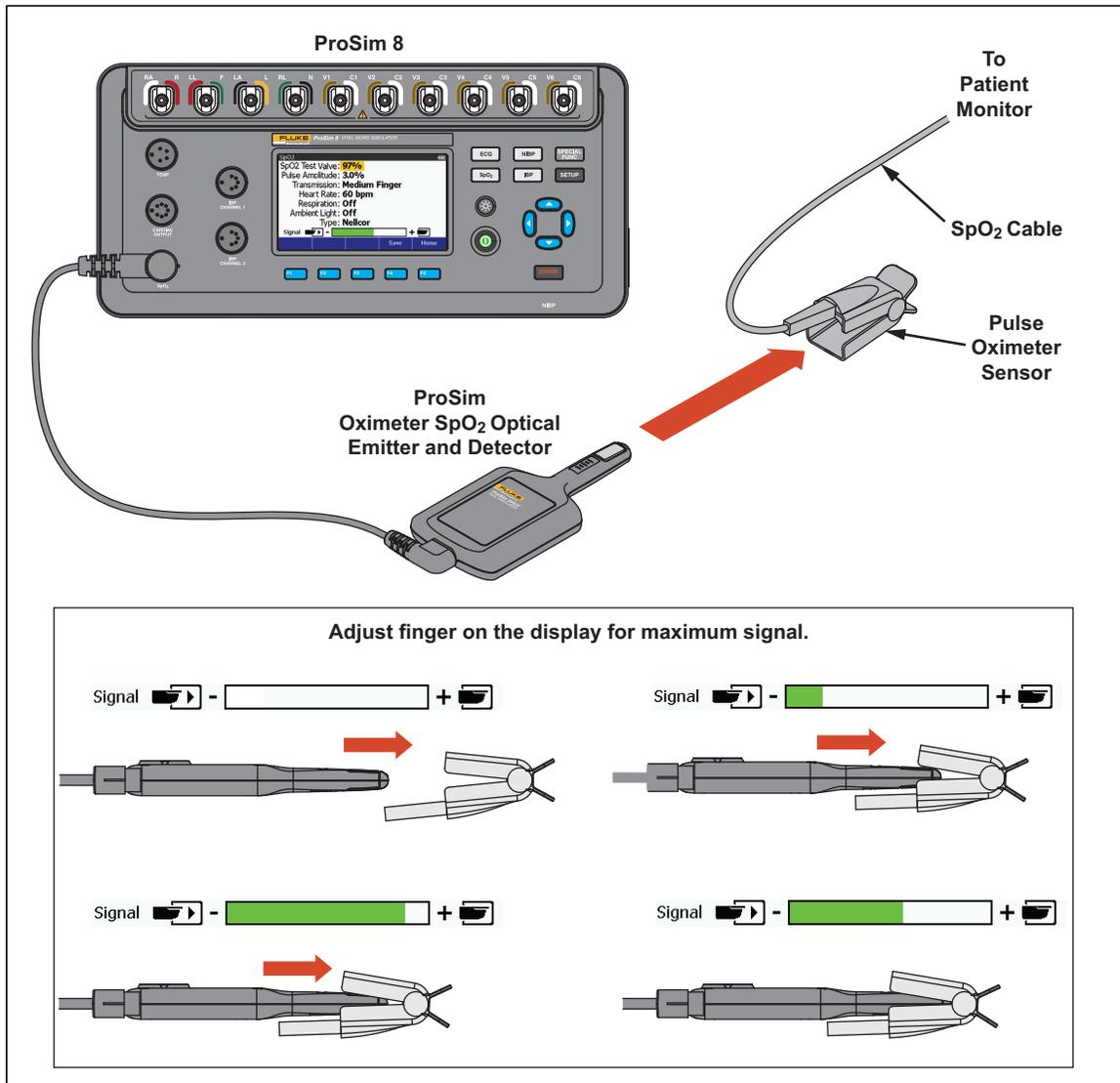


Figure 46. SpO₂ Sensor Placement

gln048.eps

Attach the artificial finger to the magnetic holder on the right side of the Product as shown in Figure 47.

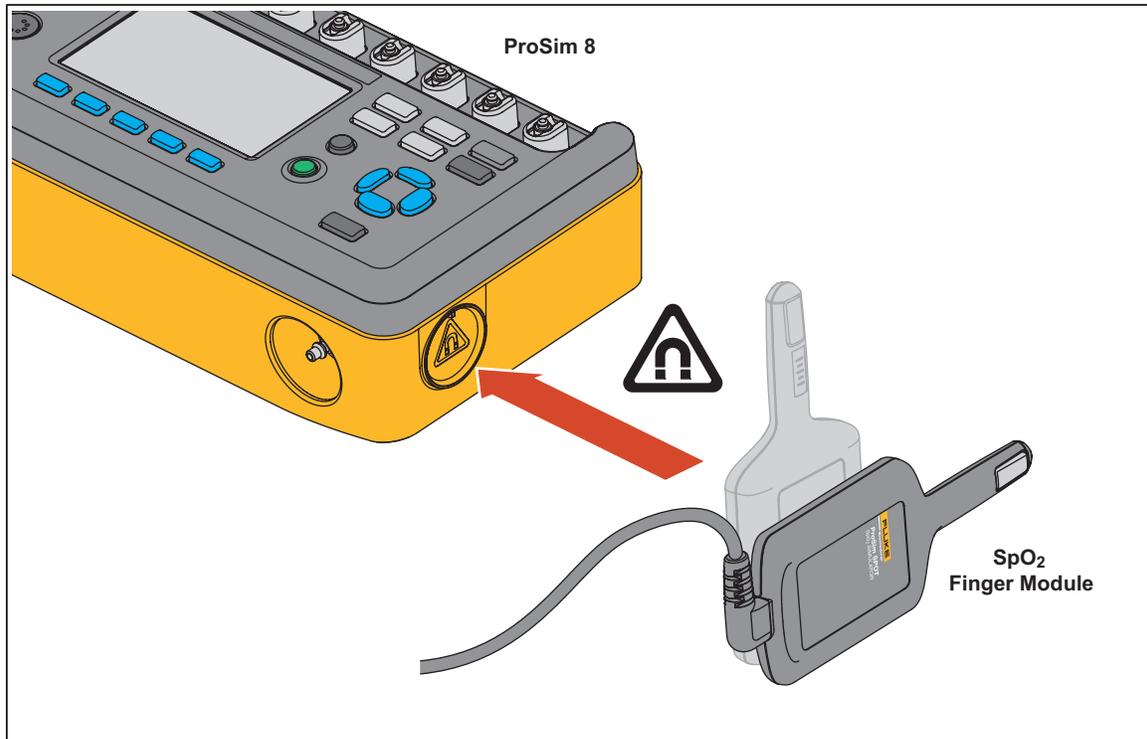


Figure 47. Magnetic Holder for SpO₂ Artificial Finger

Set the SpO₂ Parameters

You can raise or lower the degree of oxygen saturation. To change the SpO₂ value:

1. Push \uparrow or \downarrow to highlight the **SpO₂** value.
2. Push **ENTER**.
3. Push \uparrow or \downarrow to increase or decrease the **SpO₂** value in 1 % steps between 30 % and 100 %.
4. Push **ENTER** to set that **SpO₂** value and go back to the SpO₂ screen.

To change the pulse amplitude value:

1. Push \uparrow or \downarrow to highlight the **Pulse Amplitude** value.
2. Push **ENTER**.
3. Push \uparrow or \downarrow to change the pulse amplitude value between 0 % and 20 %. Each push of a key changes the value 0.01 % between 0 % and 1 % in the direction of the key pushed. The value changes 0.1 % between 1 % and 10 %. The value changes 1 % between 10 % and 20 %.
4. Push **ENTER** to set the pulse amplitude value and go back to the SpO₂ screen.

To change the transmission value:

1. From the SpO2 screen, push  or  to highlight the **Transmission** value.
2. Push .
3. Push  or  to highlight **Dark, Thick Finger, Medium Finger, Light, Thin Finger, and Neonatal Foot**.
4. Push  to set that transmission value and go back to the SpO2 screen.

You can change the simulated heart rate of the Product from the SpO2 screen.
To change the heart rate:

1. Push  or  to highlight the **Heart Rate** value.
2. Push .
3. Push  or  to adjust the heart rate. Each push of a key moves the heart rate one beat in the direction of the key pushed. The range is 10 BPM to 300 BPM.
4. Push  to go back to the SpO2 screen.

To change SpO2 respiration:

1. From the SpO2 screen, push the  or  to highlight the **Respiration** value.
2. Push .
3. Push  or  to highlight **1%, 2%, 3%, 4%, 5%** or **off**.
4. Push  to set the respiration and go back to the SpO2 screen.

You can test SpO2 under different ambient light conditions. To change the ambient light value:

1. From the SpO2 screen, push the  or  to highlight the **Ambient Light** value.
2. Push .
3. Push  or  to highlight an ambient light value. Below is the list of ambient light values in the Product.

Sunlight	Indoor – 4 kHz
Indoor – DC	Indoor – 5 kHz
Indoor – 50 Hz	Indoor – 6 kHz
Indoor – 60 Hz	Indoor – 7 kHz
Indoor – 1 kHz	Indoor – 8 kHz
Indoor – 2 kHz	Indoor – 9 kHz
Indoor – 3 kHz	Indoor – 10 kHz

4. Push  to go back to the SpO2 screen with the new ambient light value.

The manufacturer must be known before you do a pulse oximeter test, optically through an artificial finger. For Masimo, you need to know if the sensor is a 2 wavelength or Rainbow sensor. You can configure the Product for the make of pulse oximeter(s) used for the test. You change variables for each of the pulse oximeters through the type variable. To change the oximeter sensor type:

1. From the SpO₂ screen, push the \blacktriangle or \blacktriangledown to highlight the **Type** value.
2. Push **ENTER**.
3. Push \blacktriangle or \blacktriangledown to highlight a type value in the list. Below is the list of types in the Product.

Nellcor	Philips
Masimo	Hihon Khoden
Masimo Rainbow	Mindray
Nonin	BCI
GE/Ohmeda	

4. Push **ENTER** to set the type value and go back to the SpO₂ screen.

To test other manufacturer types of oximeters, you must download R-Curve data into the Product through the USB Port. Oximeter R-Curve design and data download is done through the Ansur functionality.

Test a Masimo Rainbow SpO₂

When you set the SpO₂ type parameter to Masimo Rainbow, you must connect the Product to the monitor with the optional SpO₂ Masimo Rainbow cable. See Table 4 for a part number. The SpO₂ screen shows three more parameters than what shows for other types of sensors: SpMet, SpCO, and SpHb.

SpMet, SpCO, and SpHb cannot be set through the Product. The special Masimo Rainbow cable sets them based on the measured SpO₂ percent. At 100 %, SpMet = 0 %, SpCO = 0 %, and SpHb = 25 g/dl. A -1 % change in SpO₂ changes SpMet +0.3 %, SpCO by +0.7 %, and SpHb by -0.5 %. SpHb does not change for values of SpO₂ above 90 %.

Note

The Product tests Masimo Rainbow technology with an optional adapter supplied by Masimo that allows the ProSim two-wavelength to test the Rainbow multiple wavelength system.

Note

Since a special Masimo testing sensor is required to connect the Product to Masimo Rainbow Oximeter, the Product only validates performance of Oximeter, not the Masimo Rainbow sensor (the SpHb, SpCO and SpMet values from the Masimo technology are generated based on the SpO₂ value provided to the test sensor and are not able to be changed independently).

Perform an Oximeter Limits Test

Most oximeters have alarms that you can set for the parameters it measures. You can use the Product to trip the alarm as a test. Connect the Oximeter to the Product as shown in Figure 45.

Oxygen Limits Test

You do a sensitivity test on an oximeter through SpO₂ value adjustments. To do an oxygen limits test:

1. Set the oxygen alarm limit value(s) on the oximeter.
2. From the SpO₂ screen, push  or  to highlight the **SpO₂** value.
3. Push .
4. Push  to increase the oxygen saturation until the oximeter alarm sounds.
5. Push  to decrease the oxygen saturation until the oximeter alarm sounds.

Pulse Rate Test

You can simulate different patient conditions while you monitor the effect of different pulse rates on the SpO₂ measurement. To do a pulse rate test:

1. Set the pulse rate alarm limit value(s) on the oximeter.
2. From the SpO₂ screen, push  or  to highlight the **Heart Rate** value.
3. Push .
4. Push  to increase the heart rate until the alarm sounds.
5. Push  to decrease the heart rate until the alarm sounds.

You can decrease the heart rate to 0 BPM to simulate asystole or no pulse.

Pulse Amplitude Test

You can increase or decrease the peak-to-peak amplitude of the blood pressure wave tested by the Product. You can decrease the amplitude to find where the oximeter fails to sense a pulse. To do a pulse amplitude test:

1. From the SpO₂ screen, push  or  to highlight the **Pulse Amplitude** value.
2. Push .
3. Push  to decrease the pulse amplitude value until the oximeter no longer shows a pulse or the oximeter alarm sounds.

Autosequences

Autosequences are a series of steps that change the output of the Product automatically. For example, to do a temperature test on a monitor, you must change the temperature of the temperature simulation a number of times for a specified time period. To do this manually, you can go to the temperature function, push  and then push  or  to change the temperature and then push  again. After some time period, you do these same steps for the subsequent temperature change. The Temperature autosequence does these changes for you automatically. Each step of the temperature autosequence sets the temperature and after the allotted time period, it does the subsequent step.

Table 14 is a list of autosequences that are built into the Product.

Table 14. Autosequences

Autosequence	Sequence Steps	Run Time
Monitor Testing	ECG 200 BPM, IBP1 (Arterial, 200/150), IBP2 (PA, 45/25), SpO ₂ 100 %, NIBP 200/150, Respiration 80 brpm and Temperature 42 °C	01:30
	ECG 80 BPM, IBP1 (Arterial, 120/80), IBP2 (PA, 28/15), SpO ₂ 97 %, NIBP 120/80, Respiration 20 brpm and Temperature 37 °C	01:30
	ECG 30 BPM, IBP1 (Arterial, 60/30), IBP2 (PA, 20/10), SpO ₂ 85 %, NIBP 60/30, Respiration 10 brpm and Temperature 32 °C	01:30
	STOP	Total Time 04:30
Medical Training	ECG 80 BPM, IBP1 120/80 (Art), IBP2 120/0 (LV), SpO ₂ 98 %, NIBP 120/80, Respiration 20 brpm, and Temperature 37 °C	01:00
	ECG 120 BPM, IBP1 250/150 (Art), IBP2 200/0 (LV), SpO ₂ 85 %, NIBP 200/150, Respiration 60 brpm, and Temperature 40 °C	01:00
	ECG 30 BPM, IBP1 60/30 (Art), IBP2 60/0 (LV), SpO ₂ 50 %, NIBP 60/30, Respiration 10 brpm, and Temperature 34 °C	01:00
	REPEAT	Total Time 03:00
Oximeter Testing	SpO ₂ 100 %, Pulse Amplitude 20 %, Transmissivity: normal adult, heart rate 60 BPM	00:45
	SpO ₂ 95 %, Pulse Amplitude 15 %, Transmissivity: normal adult, heart rate 60 BPM	00:45
	SpO ₂ 90 %, Pulse Amplitude 10 %, Transmissivity: dark/thick adult, heart rate 120 BPM	00:45
	SpO ₂ 85 %, Pulse Amplitude 7 %, Transmissivity: dark/thick adult, heart rate 30 BPM	00:45
	SpO ₂ 84 %, Pulse Amplitude 5 %, Transmissivity: normal adult, heart rate 60 BPM	00:45
	SpO ₂ 83 %, Pulse Amplitude 4 %, Transmissivity: normal adult, heart rate 60 BPM	00:45
	SpO ₂ 82 %, Pulse Amplitude 3 %, Transmissivity: dark/thick adult, heart rate 120 BPM	00:45
	SpO ₂ 81 %, Pulse Amplitude 2 %, Transmissivity: dark/thick adult, heart rate 30 BPM	00:45
	SpO ₂ 80 %, Pulse Amplitude 1 %, Transmissivity: normal adult, heart rate 60 BPM	00:45
	SpO ₂ 79 %, Pulse Amplitude 0.5 %, Transmissivity: normal adult, heart rate 60 BPM	00:45
	STOP	Total time 07:30

Table 14. Autosequences (cont.)

Autosequence	Sequence Steps	Run Time
Cardiac Failure	NSR (Adult) 80 BPM	00:45
	Premature PVC1 Left Vent	00:30
	Ventricular Mono VTach	00:30
	Ventricular Ventricular Fibrillation	00:30
	Ventricular Asystole	00:25
	STOP	Total Time 02:30
Arrhythmia Sequences	NSR (Adult) 80 BPM	00:20
	NSR (Adult) 120 BPM	00:20
	Supraventricular Supra VTach	00:20
	Ventricular Bigeminy	00:20
	TV Paced Asynchornous 75 BPM	00:15
	Ventricular Asystole	00:15
	Conduction Lt Bndl Branch Block	00:15
	Ventricular Run of PVCs	00:30
	Supraventricular Atrial Fibrillation	00:15
	Ventricular Ventricular Fibrillation	00:15
REPEAT	Total Time 03:05	
Exercise	NSR (Adult) 50 BPM	00:30
	NSR (Adult) 90 BPM	00:30
	NSR (Adult) 120 BPM	00:30
	NSR (Adult) 150 BPM	00:30
	NSR (Adult) 90 BPM	00:30
	NSR (Adult) 70 BPM	00:30
	REPEAT	Total Time 03:00
Respiration Sequence	Respiration 110 brpm	00:30
	Respiration 60 brpm	00:30
	Respiration 20 brpm	00:30
	Respiration 0 brpm	00:12
	REPEAT	Total Time 01:42

Table 14. Autosequences (cont.)

Autosequence	Sequence Steps	Run Time
NIBP Sequence	Waveform: Square; Rate: 2.0 Hz; Amplitude: 1.0 mV	00:05
	Waveform: Sine; Rate: 0.05 Hz; Amplitude: 1.0 mV	00:05
	Waveform: Sine; Rate: 0.5 Hz; Amplitude: 1.0 mV	00:05
	Waveform: Sine; Rate: 1 Hz; Amplitude: 1.0 mV	00:05
	Waveform; Sine; Rate: 10 Hz; Amplitude: 1.0 mV	00:05
	Waveform: Sine; Rate: 50 Hz; Amplitude: 1.0 mV	00:05
	Waveform: Sine; Rate: 60 Hz; Amplitude: 1.0 mV	00:05
	Waveform: Sine; Rate: 100 Hz; Amplitude: 1.0 mV	00:05
	Waveform: Sine; Rate: 150 Hz; Amplitude: 1.0 mV	00:05
	Waveform: Triangle; Rate: 0.125 Hz; Amplitude: 1.0 mV	00:05
	Waveform: Triangle; Rate: 2.0 Hz; Amplitude: 1.0 mV	00:05
	Waveform: Pulse; Rate: 60 BPM; Amplitude: 1.0 mV	00:05
	REPEAT	Total time 01:10
IBP Sequence	IBP 1: 120/80 mmHg (Art), 2: 120/0 mmHg (LV)	01:00
	IBP 1: 25/0 mmHg (RV), 2: 120/80 mmHg (Art)	01:00
	IBP 1: 25/10 mmHg (PA), 2: 10/2 mmHg (PAW)	01:00
	REPEAT	Total Time 03:00
Temperature Sequence	Temperature 30.0 °C	00:20
	Temperature 34.0 °C	00:20
	Temperature 37.0 °C	00:20
	Temperature 42.0 °C	00:20
	STOP	Total Time 01:20

View the Steps of an Autosequence

To view an autosequence:

1. Push .
2. Push , , , or  to highlight **Autosequences**.
3. Push .
4. Push  or  to highlight an autosequence in the list. See Table 14.
5. Push .

The screen shown in Figure 48 is the Temperature Sequence in the autosequence list.

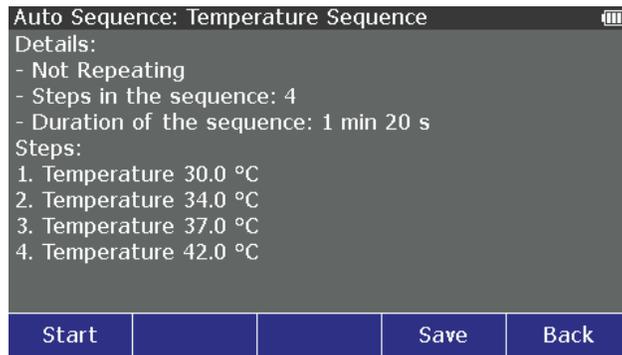


Figure 48. Autosequence Start Screen

glh032.eps

The details of the autosequence show the sequence does each of the four steps and stops. Although this example does not repeat, some autosequences do. The screen also shows the four-step sequence takes 1 minute and 20 seconds to complete.

Each sequence step shows on the display. When there are more steps than can show in one display screen, push  or  to go to the next or previous screen.

Do an Autosequence

To do an autosequence:

1. Push .
2. Push , , , or  to highlight **Autosequences**.
3. Push .
4. Push  or  to highlight an autosequence in the list.
5. Push the **Start** softkey. The autosequence screen in Figure 49 shows on the display.

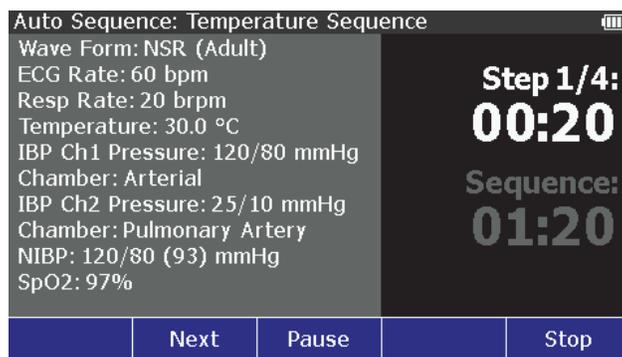


Figure 49. Autosequence Step Screen

glh033.bmp

The autosequence screen shows all the simulation parameters which are updated as the Product steps through the sequence. The right part of the screen shows which step the sequence is on and how much time is left to complete the step. The length of time left to complete all steps of the autosequence also shows on the display.

Push the **Next** softkey to abort the step and move to the subsequent step. When the autosequence has moved to step two, a **Previous** softkey shows on the display. Push the **Pause** softkey to pause the step. A **Continue** softkey shows on the display when the auto sequence is paused. Push the **Continue** softkey to continue the step for the time left when the step was paused.

To abort the autosequence, push the **Stop** softkey and go back to the Autosequence screen.

You cannot change a pre-defined autosequence or rename it. But, you can use the Ansur functionality to copy an autosequence, make changes, and then put it into the Product as a new custom autosequence. You can change each step of the new autosequence and add more steps as necessary.

Save and View Test Results

You can save the data of test results to and recall them from the Product. Test results are organized in memory first by operator ID, then by a test record ID, and then individual test results. Figure 50 shows the memory organization of test results data.

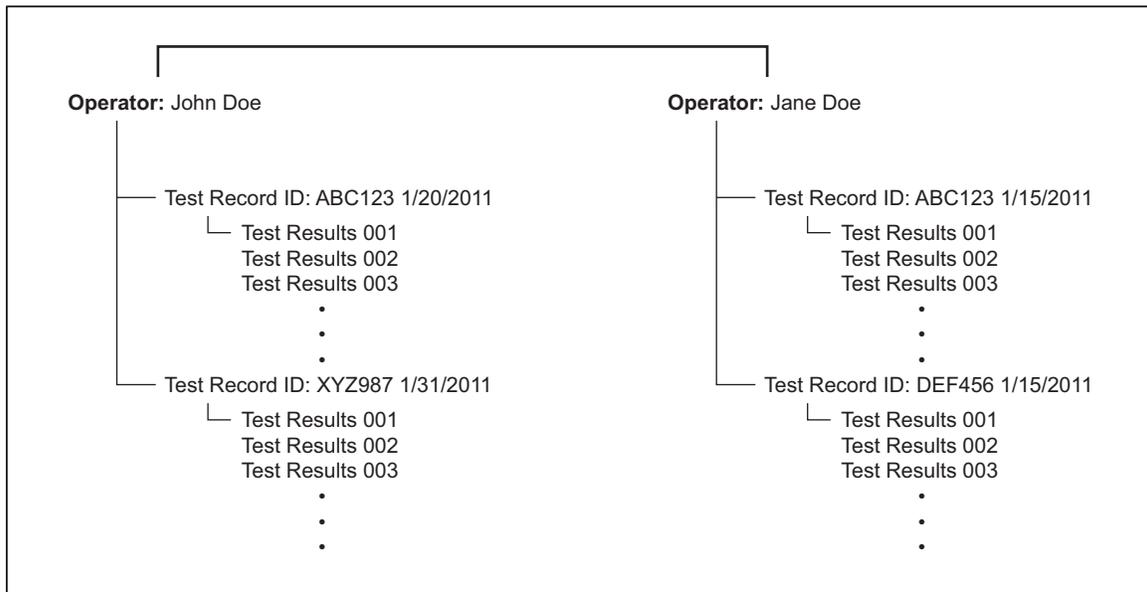


Figure 50. Memory Organization of Test Results

gln044.eps

Make an Operator ID

Test results are kept in memory by an operator ID. To make a new operator ID:

1. Push **SETUP**.
2. Push **▲** or **▼** to highlight **Test Record ID** in the list.
3. Push **ENTER** to open the Test ID screen shown in Figure 51.

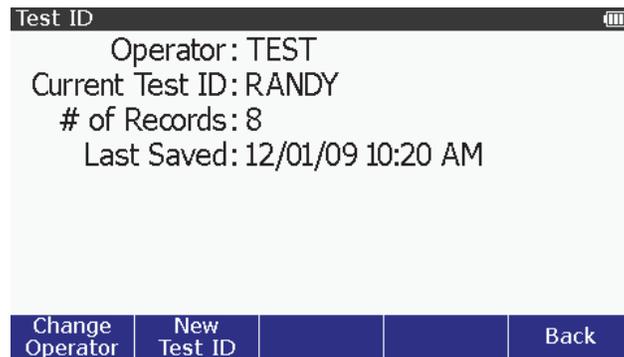


Figure 51. Operator ID Screen

glh036.bmp

4. Push the **Change Operator** softkey to open the Change Operator screen shown in Figure 52.

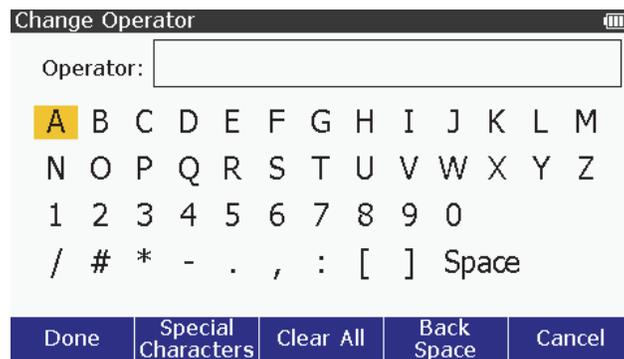


Figure 52. Change Operator ID Screen

glh037.bmp

5. Push **←**, **→**, **▲**, and **▼** to highlight a character for the operator ID.
6. Push **ENTER** to add the highlighted character to the operator ID.
7. Do steps 5 and 6 for each character in the operator ID. You can have the maximum number of characters that fit in the test ID field on the display. If you use more of the narrow characters like I and 1, you can have more characters in the operator ID than when wider characters are used.
8. Push the **Done** softkey when you have all the characters in the operator ID.

Note

If this is a new operator ID, the ID won't exist until you save the first test result.

Do these same steps when you change the operator ID to an ID that is already in memory. After you type the ID in as it already is in memory, all saved results data are added to that operator ID.

Make a Test ID

As shown in Figure 50, test results data is related to a Test Record ID. This test record ID could identify the device under test. Some examples could be its model number, its serial number, or its asset number. After you input the new Test ID, all results data saved after that point is kept with that test ID until you change the test ID.

Note

When you type in a new test ID, the test ID that was open before is closed and you cannot add more test results data to that test ID. You can use the same test ID name as one that is already in memory, but a date and time stamp will always be appended to the name and its own test ID.

To make a test ID:

Note

*These instructions use the setup function to make a test ID. You can also make a test ID when a **Save** softkey label shows on the display. The **New Test ID** softkey always shows on the display when you push the **Save** softkey.*

1. Push **SETUP**.
2. Push **▲** or **▼** to highlight **Test Record ID** in the list.
3. Push **ENTER** to open the Test ID screen.
4. Push the **New Test ID** softkey.
5. Push **←**, **→**, **▲**, and **▼** to highlight a character for the test ID.
6. Push **ENTER** to add the highlighted character to the test ID.
7. Do steps 5 and 6 for each character in the test ID. You can have the maximum number of characters that fit in the test ID field on the display. If you use more of the narrow characters like **I** and **1**, you can have more characters in the test ID than when wider characters are used.

Additional characters are available when you push the **Special Characters** softkey. To go back to the normal characters, push the **Back** softkey.

Note

*If you make a mistake, push the **Back Space** softkey to remove the last character added. A **Clear All** softkey removes all characters in the test ID field of the display.*

8. Push the **Done** softkey when you have all the characters in the test ID.

Save Test Results

Note

Before you save test results, make sure the operator ID and test ID are set correctly.

Each function of the Product lets you save test results data through a **Save** softkey. To save test results:

Note

*If the **Save** softkey label does not show on the display, it means you cannot save data at this point.*

1. Push the **Save** softkey to show the Save screen. The screen in Figure 53 is the save screen for the temperature simulation function.

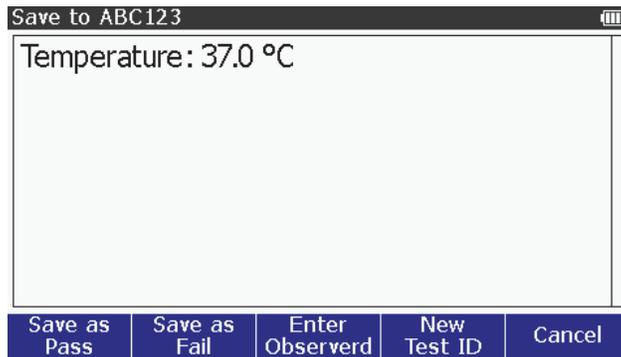


Figure 53. Save Screen

glh039.bmp

Note

*The next step is valid only when the **Enter Observed** softkey shows on the display.*

2. To add measurements shown in the UUT display to the test results record, push the **Enter Observed** softkey.

Note

*If there is more than one simulation parameter, you have to highlight a parameter and push **ENTER** before the next step.*

3. Push **▲** or **▼** to set the parameter to the value observed on the UUT.
4. Push **ENTER** to set the observed value and show the save screen shown below on the display.

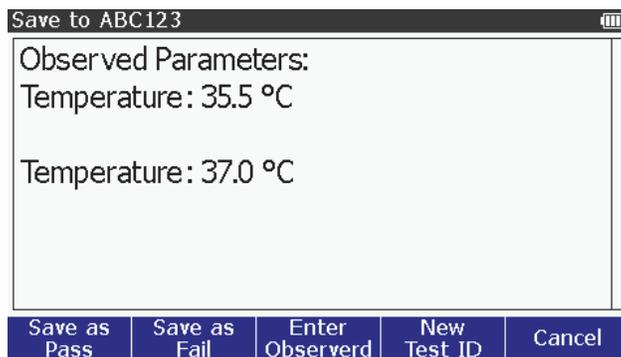


Figure 54. Observed Results Screen

glh049.bmp

Note

*If the observed value is incorrect at this point, you can push the **Enter Observed** softkey and change the observed parameter.*

5. Test results are saved with a Pass or Fail prefix in their label. Push the **Save as Pass** or the **Save as Fail** softkey. The save screen in Figure 55 shows on the display.

Save to ABC123 

Saving...

001: Temperature, Pass.



Figure 55. Saving Screen

glh040.bmp

The three-digit number is the test result ID. Within the test ID, each saved test results is assigned a number in sequence. When the save operation completes, the display goes back to the screen for the function you just saved. In the case of this example, the display goes back to the temperature screen.

View Test Results

To view the test results in memory:

1. Push .
2. Push , , , and  to highlight **View Memory**.
3. Push .

Note

If no test results data is saved to memory, an error message shows on the display when you push .

4. Push  or  to highlight an operator.
5. Push .

Note

If there is only one operator, the operator list does not show on the display and the Product skips steps 4 and 5.

6. The list of test IDs shows on the display. Figure 56 shows an example list of test IDs.

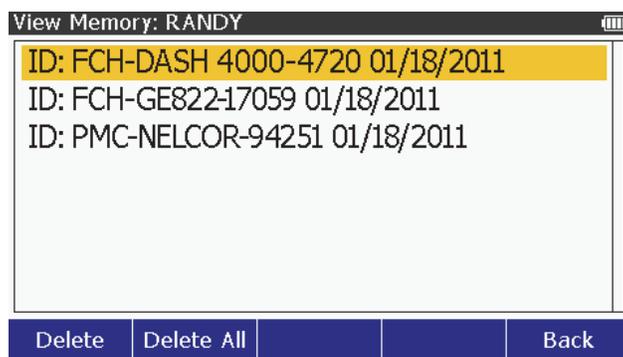


Figure 56. Test ID Screen

glh041.bmp

7. Push  or  to highlight a test ID record.

- Push **ENTER** to show the test results data saved for the test ID. See Figure 57.

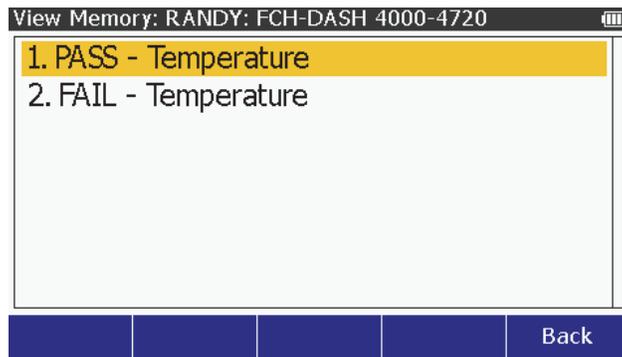


Figure 57. Test Results Screen

glh042.bmp

- Push **▲** or **▼** to highlight a test results file.
- Push **ENTER** to show the test results data shown in Figure 58.



Figure 58. Test Results Data Screen

glh043.bmp

Print Test Results

With a PCL5 compatible printer connected to the USB A Controller Port, you can print a test results record.

Note

*A compatible printer must be connected to the Product before the **Print** softkey appears in the view screen of a test results record.*

- Do the steps in *View Test Results* to show a test results record on the display.
- Push the **Print** softkey.

The data in the test results record that show on the display is transmitted through the printer port.

Delete Saved Data

Removal of data from memory is done through the View Memory feature. You can only delete test ID records. When the test ID record is deleted, all saved test results data connected to that test ID is deleted from memory. To remove a test ID record:

1. Push **SPECIAL FUNC.**
2. Push **←**, **→**, **▲**, and **▼** to highlight **View Memory**.
3. Push **ENTER**.
4. Push **▲** or **▼** to highlight an operator.
5. Push **ENTER**.

Note

If there is only one operator, the operator list does not show on the display and the Product skips steps 4 and 5.

6. Push **▲** or **▼** to highlight a test ID record.
7. Push the **Delete** softkey to delete the test ID record.

A Confirm Delete screen shows on the display with a “Delete Record?” message. When you push the **Yes** softkey, the test ID record is deleted from memory and the display goes back to the View Memory screen. Push the **No** softkey to abort the delete.

Use the **Delete All** softkey to delete all the test ID records associated with the operator. A Confirm Delete screen shows in the screen with a “Delete ALL records for this operator?” message.

Setup Features

The Product has several functions that are accessed through the **SETUP** key. Push **SETUP** to show the setup variables shown below on the display.

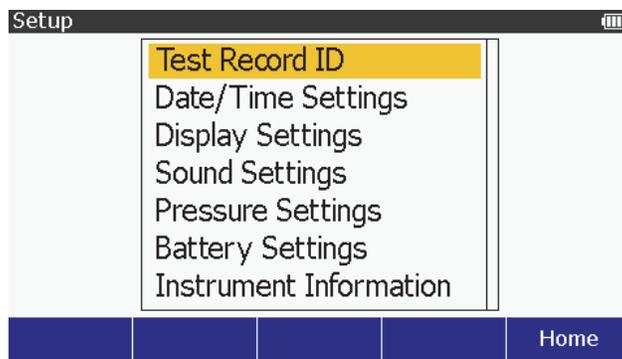


Figure 59. Setup Screen

glh016.bmp

The setup parameters are kept in memory and are non-volatile.

Set the Time and Date

You can set the date, time, and the format in which they show on the display. From the Setup screen, push  or  to highlight **Date/Time Settings** and then push . To go back to the Setup screen, push the **Back** softkey.

To set the date:

1. Push  or  to highlight the **Date** value.
2. Push .
3. Push  or  to move to the **Month, Day, or Year**.
4. Push  or  to increase or decrease the value.
5. Push  to set the date and go back to the Date/Time Settings screen.

To set the time:

1. Push  or  to highlight the **Time** value.
2. Push .
3. Push  or  to move to the **Hour, Minute, or Second** value.
4. Push  or  to increase or decrease the value.
5. Push  to set the time and go back to the Date/Time Settings screen.

To set the date format:

1. Push  or  to highlight the **Date Format** value.
2. Push .
3. Push  or  to highlight the **Date Format** value.
4. Push  to set the date and go back to the Date/Time Settings screen.

To set the time format:

1. Push  or  to highlight the **Time Format** value.
2. Push .
3. Push  or  to highlight the **Time Format** value.
4. Push  to set the format and go back to the Date/Time Settings screen.

Set the Backlight Intensity

The backlight on the Product has two intensity levels: Low and High. You can set each intensity separately. From the Setup screen, push  or  to highlight **Display Settings** and push . To go back to the Setup screen, push the **Back** softkey.

To set the backlight intensity:

1. Push .
2. Push  or  to highlight a **Backlight** value.
3. Push  or  to increase or decrease the backlight intensity.
4. Push  to set the backlight intensity and go back to the Display Settings screen.

Set the Beeper

You can turn on and off the beeper and set its volume. From the Setup screen, push  or  to highlight **Sound Settings** and push . To go back to the Setup screen, push the **Back** softkey.

5. Push .
6. Push .
7. Push  or  to highlight **On** or **Off**.

When the beeper is set to on, two more variables appear in the Sound Settings screen.

To set the beeper type:

1. Push  or  to highlight the **Beep Type** value.
2. Push .
3. Push  or  to highlight the **Beeper Type** value.

You can set the beeper to beep at each key press or to beep only when an error occurs.

4. Push  to go back to the Sound Settings screen.

To set the beeper volume:

1. Push  or  to highlight the **Volume** value.
2. Push .
3. Push  or  to highlight the **Volume** value.
4. Push  to set the volume and go back to the Sound Settings screen.

Set the Pressure Units and IBP Sensitivity

The units of measure for pressure (IBP and NIBP) values and IBP sensitivity to simulate are set through the pressure Settings. From the Setup screen, push  or  to highlight **IBP Settings** in the setup list and push . To go back to the Setup screen, push the **Back** softkey.

To set the IBP sensitivity:

1. Push  or  to highlight the **IBP Sensitivity** value.
2. Push .
3. Push  or  to highlight a **Sensitivity** value.
4. Push  to set the sensitivity and go back to the Pressure Settings screen.

To set the Pressure units:

1. Push  or  to highlight the **Units** value.
2. Push .
3. Push  or  to highlight **mmHg** or **kPa**.
4. Push  to set the units and go back to the IBP Settings screen.

Set Battery Settings

To help save battery life, you can set the Product to power down (Auto power off) when no buttons are sensed as pushed for a set period of time. You can also set whether or not the battery charges in the Product. From the Setup screen, push  or  to highlight **Battery Settings** and push . To go back to the Setup screen, push the **Back** softkey.

To set auto power off:

1. Push  or  to highlight the **Auto Power Off** value.
2. Push .
3. Push  or  to highlight an **Auto Power Off** value: 10, 30, or 60 minutes.
4. Push  to set auto power and go back to the Battery Settings screen.

To set the battery charger:

1. Push  or  to highlight the **Charge Battery** value.
2. Push .
3. Push  or  to highlight **Yes** or **No**.
4. Push  to set the charger value and go back to the Battery Settings screen.

Note

A 1-minute warning message shows on the display before the Product turns off.

Set the Display Language

You can setup the Product to show text and messages on the display in different languages. To set the language, push  or  to highlight **Instrument Information** in the Setup screen and push . To go back to the Setup screen, push the **Back** softkey.

The language already set in the Product, shows on the display. To change the language:

1. Push .
2. Push  or  to highlight a language in the list. Below is a list of the display languages.

English	Spanish
French	Japanese
Italian	Chinese
German	

3. Push .

Control the Product Remotely

Ansur test automation systems uses a solutions-based procedure for medical device tests. Ansur helps you make standard work through test templates and/or sequences that use your written test procedure. All test results are then integrated into one test report that you can print or archive. Ansur manages your test procedures through manual and visual automated test sequences.

The software works hand-in-hand with Fluke Biomedical analyzers and simulators, that integrates:

- Visual inspections
- Preventive maintenance
- Work procedures
- Performance tests
- Safety tests

Ansur software uses plug-in modules to interface with a wide array of Fluke Biomedical instruments. The plug-in module is a software interface to the Ansur test program. Plug-ins supply test elements used by Ansur Executive that use the same user interface for all analyzers and simulators supported by an Ansur plug-in.

When you purchase a new Fluke Biomedical analyzer or simulator, you can update your existing Ansur software by installing a new plug-in. Each plug-in module allows you to work only with the options and capabilities you need for the instrument you are testing.

Maintenance

The Product is a calibrated measurement instrument. Try to prevent mechanical abuse that could change the calibrated values. The Product has no internal user-serviceable parts.

Warnings

For safe operation and maintenance of the Product:

- **Repair the Product before use if the battery leaks.**
- **Use only Fluke Biomedical approved power adapters to charge the battery.**

To prevent possible electrical shock, fire, or personal injury:

- **Batteries contain hazardous chemicals that can cause burns or explode. If exposure to chemicals occurs, clean with water and get medical aid.**
- **Do not disassemble the battery.**

- Do not disassemble or crush battery cells and battery packs.
- Do not put battery cells and battery packs near heat or fire. Do not put in sunlight.
- Do not short the battery terminals together.
- Do not keep cells or batteries in a container where the terminals can be shorted.
- Remove the input signals before you clean the Product.
- Use only specified replacement parts.
- Have an approved technician repair the Product.

Clean the Product

⚠ Caution

Do not pour fluid onto the Product surface; fluid seepage into the electrical circuitry may cause the Product to fail.

⚠ Caution

Do not use spray cleaners on the Product; such action may force the cleaning fluid into the Product and damage electronic components.

Clean the Product occasionally with a damp cloth and mild detergent. Try to prevent the entrance of liquids.

Clean the adapter cables with the same precautions. Examine them for damage and deterioration of the insulation. Examine the connections for integrity. Keep the transducer adapter clean and dry.

Battery Maintenance

For peak battery performance, charge the Product to maximum charge once a month. If the Product is not to be used for more than a month, keep it connected to the charger.

Note

To get the specified performance, use the specified battery charger that comes with this Product.

When the battery gets low, a low battery message shows on the display.

When the battery discharges to 3 % of full charge, a different message shows and the NIBP function is disabled.

Charge the Battery

The battery charge level shows in the upper right corner of the display.



Shows when the ac/dc power supply is connected



Shows the battery level when the Product operates on the battery

You can charge the battery while it is in or out of the Product. The charge rate is slower when the Product is energized and the battery charger is on. To charge the battery:

1. Connect the ac/dc power supply to the power connector on the battery pack. See Figure 60.
2. Connect the ac/dc power supply to a power source.

Note

When the battery pack is installed in the Product, ensure the battery charger is enabled. See Set Battery Settings to enable and disable the battery charger.

The battery charge LED on the battery pack shows red or green when the battery charges. When the LED is green, the battery is charged.

When you have two or more battery packs, you can charge one battery externally while you use the other to energize the Product.

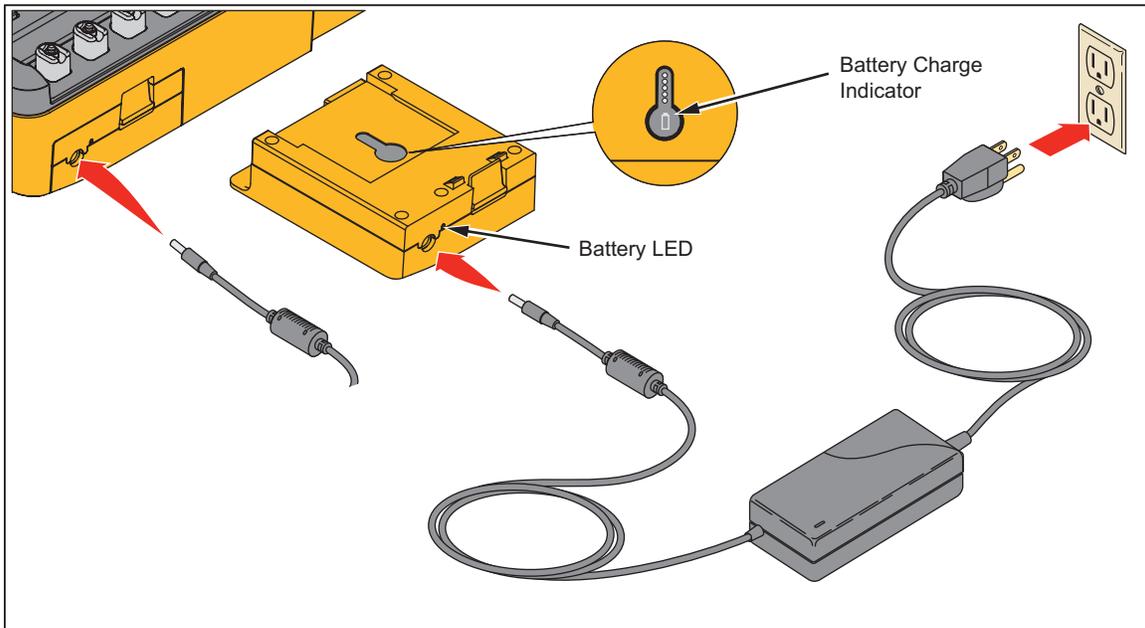


Figure 60. External Battery Charging Connections

gjh047.eps

When the battery pack is removed from the Product, push the button below the charge level indicators to see the battery charge level. See Figure 60.

Battery Removal

The battery pack is easy to remove and replace. To remove the battery pack:

1. Push down on the battery pack latch as shown in Figure 61.
2. Remove the battery pack from the Product.

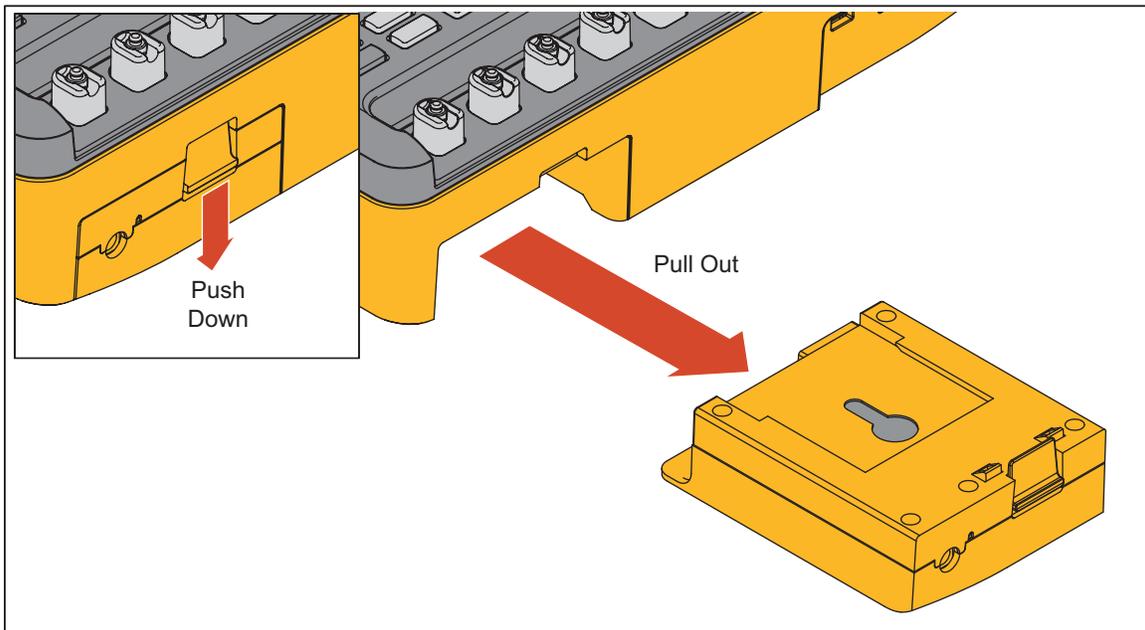


Figure 61. Battery Removal

gln046.eps

To put the battery pack into the Product, align the battery pack with the guides on the Product and push it into the Product until the latch locks.

The ProSim 8 battery is not compatible with the ProSim 4.

General Specifications

Temperature

Operating	10 °C to 40 °C (50 °F to 104 °F)
Storage	-20 °C to +60 °C (-4 °F to +140 °F)

Humidity..... 10 % to 90 % non-condensing

Altitude..... 3000 meters (9843 ft)

Size (L x W x H) 30.22 cm x 14.48 cm x 8.64 cm (11.9 in x 5.7 in x 3.4 in)

Display LCD Color Display

Communication

USB Device Upstream Port Mini-B connector for control by a computer

USB Host Controller Port..... Type A, 5 V output, 0.5 A max load. Connector for keyboard, barcode reader, and printer

Wireless IEEE 802.15.4 for control by a computer

USB Device Virtual COM Port Settings

Baud Rate..... 115 200 bps

Data bits..... 8 data bits

Stop Bits 1 stop bit

Flow Control..... Hardware (RTS/CTS)

Power Lithium-Ion rechargeable, 7.2 V, 31 Wh battery, 4300 mAh

Battery Charger..... 100 V to 240 V, 50/60 Hz input, 15 V/2.0 A output. For best performance, the battery charger should be connected to a properly grounded ac receptacle

Battery Life 9 hours (minimum), 100 NIBP cycles typical

Weight..... 1.81 kg (4 lb)

Wireless Radio

Frequency Range 2412 MHz to 2462 MHz

Output Power..... <1 mW

Safety IEC 61010-1: Overvoltage Category II, Pollution Degree 2

Electromagnetic Compatibility (EMC)

International IEC 61326-1: Portable Electromagnetic Environment
CISPR 11: Group 1, Class A

Group 1: Equipment has intentionally generated and/or uses conductively-coupled radio frequency energy that is necessary for the internal function of the equipment itself.

Class A: Equipment is suitable for use in all establishments other than domestic and those directly connected to a low-voltage power supply network that supplies buildings used for domestic purposes. There may be potential difficulties in ensuring electromagnetic compatibility in other environments due to conducted and radiated disturbances.

Emissions that exceed the levels required by CISPR 11 can occur when the equipment is connected to a test object. The equipment may not meet the immunity requirements of this standard when test leads and/or test probes are connected.

Korea (KCC) Class A Equipment (Industrial Broadcasting & Communication Equipment)

Class A: Equipment meets requirements for industrial electromagnetic wave equipment and the seller or user should take notice of it. This equipment is intended for use in business environments and not to be used in homes.

USA (FCC)..... 47 CFR 15 Intentional Radiators: This device complies with part 15 of the FCC Rules.

Operation is subject to the following two conditions:

(1) This device may not cause harmful interference.

(2) This device must accept any interference received, including interference that may cause undesired operation. (15.19).

Changes or modifications not expressly approved by Fluke could void the user's authority to operate the equipment. (15.21)

Detailed Specifications

Normal-Sinus-Rhythm Waveform

ECG Reference	The ECG amplitudes specified are for Lead II (calibration), from the baseline to the peak of the R wave. All other leads are proportional.
Normal Sinus Rhythm	12-lead configuration with independent outputs referenced to right leg (RL). Output to 10 Universal ECG Jacks, color-coded to AHA and IEC Standards.
High-Level Output	0.5 V/mV $\pm 5\%$ of the ECG amplitude setting available on a BNC connector.
Amplitude	0.05 mV to 0.5 mV (0.05 mV steps); 0.5 mV to 5.0 mV (0.25 mV steps). Other leads are proportional to Lead II (reference lead) in percentage per:
Lead I	70
Lead II	100
Lead III	30
Lead V1	24
Lead V2	48
Lead V3	100
Lead V4	120
Lead V5	112
Lead V6	80
Amplitude Accuracy	$\pm 2\%$ of setting + 0.05 mV)
ECG Rate	10 BPM to 360 BPM in 1 BPM steps
Rate Accuracy	$\pm 1\%$ of setting
ECG Waveform Selection	Adult (80 ms) or pediatric (40 ms) QRS duration
ST-Segment Elevation	Adult mode only. -0.8 mV to +0.8 mV (0.1 mV steps) Additional steps: +0.05 mV and -0.05 mV
Power-On Default	60 BPM, 1.0 mV, adult QRS and ST-segment elevation of 0 mV

Pacemaker Waveform

Pacer-Pulse

Amplitude

0 mV (off), ± 2 mV, ± 4 mV, ± 6 mV, ± 8 mV, ± 10 mV, ± 12 mV, ± 14 mV, ± 16 mV, ± 18 mV, ± 20 mV, ± 50 mV, ± 100 mV, ± 200 mV, ± 500 mV, and ± 700 mV for lead II (reference lead)

Accuracy

Reference lead II

$\pm 5\%$ setting + 0.2 mV)

All other leads

$\pm 10\%$ setting + 0.4 mV)

Pacer-Pulse Width

0.1 ms, 0.2 ms, 0.5 ms, 1.0 ms, and 2.0 ms $\pm 5\%$

Paced Arrhythmias

Atrial 80 BPM
Asynchronous 75 BPM
Demand with frequent sinus beats
Demand with occasional sinus beats
Atrio-Ventricular sequential
Noncapture (one time)
Nonfunction

Power-On Default.....

Amplitude 10 mV, width 1.0 ms, atrial waveform

Arrhythmia

Baseline NSR	80 BPM
PVC Focus	Left focus, standard timing (except where specified)
Supraventricular Arrhythmia	Atrial fibrillation (coarse or fine); atrial flutter; sinus arrhythmia; missed beat (one time); atrial tachycardia; paroxysmal atrial tachycardia; nodal rhythm; and supraventricular tachycardia.
Premature Arrhythmia	Premature atrial contraction (PAC); premature nodal contraction (PNC); PVC1 left ventricular; PVC1 left ventricular, early; PVC1 left ventricular, R on T; PVC2 right ventricular; PVC2 right ventricular, early; PVC2 right ventricular, R on T; and multifocal PVCs
Ventricular Arrhythmia	PVCs 6 per minute, 12 per minute, or 24 per minute; frequent multifocal PVCs; bigeminy; trigeminy; multiple PVCs (one-time run of 2 PVCs, 5 PVCs, or 11 PVCs); mono-ventricular tachycardia (120 BPM to 300 BPM in 5 BPM steps); poly-ventricular tachycardia (5 types); ventricular fibrillation (coarse or fine); and Asystole
Conduction Defect	First-, second-, or third-degree heart block; and right- or left-bundle-branch block
Advanced Cardiac Life Support	
Shockable Pulseless Arrest Rhythms	Ventricular fibrillation (coarse), ventricular fibrillation (fine), unstable polymorphic ventricular tachycardia
Non Shockable Pulseless Arrest Rhythms	Asystole
Symptomatic Bradycardia	Sinus Bradycardia (<60 BPM) 2 nd Degree AV Block, Mobitz Type I 2 nd Degree AV Block, Mobitz Type II Complete/3 rd Degree AV Block Right Bundle Branch Block Left Bundle Branch Block
Symptomatic Tachycardia	
Regular Narrow-complex Tachycardias (QRS <0.12 seconds)	
Sinus Tachycardia	>150 BPM
Supraventricular Tachycardia	SVT
Regular Wide-complex Tachycardias (QRS ≥0.12 seconds)	
Sinus Tachycardia	>150 BPM
Supraventricular Tachycardia	SVT with aberrancy
Irregular Tachycardia	Atrial Fibrillation (Coarse and fine), Atrial Flutter, unstable monomorphic ventricular tachycardia (120 BPM to 300 BPM), Torsade De Pointes/Polymorphic ventricular tachycardia (long QT interval)

ECG-Performance-Testing

Amplitude (peak-to-peak)	0.05 mV to 0.5 mV (0.05 mV steps) 0.5 mV to 5.0 mV (0.25 mV steps) Other leads are proportional to Lead II (reference lead) in percentage per:
Lead I	70
Lead II	100
Lead III	30
Lead V1 through V6	100
Pulse Wave	30 BPM, 60 BPM, with 60 ms pulse width
Square Wave	0.125 Hz, 2.0 Hz, 2.5 Hz
Triangle Wave	0.125 Hz, 2.0 Hz, 2.5 Hz
Sine Wave	0.05 Hz, 0.5 Hz, 1 Hz, 2 Hz, 5 Hz, 10 Hz, 25 Hz, 30 Hz, 40 Hz, 50 Hz, 60 Hz, 100 Hz, and 150 Hz

R-wave Detection

Waveform.....	Triangular pulse
Rate	30 BPM, 60 BPM, 80 BPM, 120 BPM, 200 BPM, and 250 BPM
Width.....	8 ms to 20 ms in 2 ms steps, and 20 ms to 200 ms in 10 ms steps
Width Accuracy.....	$\pm(1\% \text{ of setting} + 1 \text{ ms})$

QRS Detection

Widths.....	8 ms to 20 ms in 2 ms steps and 20 ms to 200 ms in 10 ms steps
Width Accuracy.....	$\pm(1\% \text{ of setting} + 1 \text{ ms})$
Rate	30 BPM, 60 BPM, 80 BPM, 120 BPM, 200 BPM, and 250 BPM
R-Wave up slope.....	0.875 amplitude, 0.4375 x width
R-Wave down slope.....	Full amplitude, 0.5 x width
S-Wave up slope.....	0.125 amplitude, 0.0625 x width

Tall T-Wave Rejection

Waveform	
QT Interval.....	350 ms
T-Wave width.....	180 ms
T-Wave Shape.....	$\frac{1}{2}$ sinewave
Amplitude.....	0 % to 150 % reference lead amplitude in 10 % steps
Rate	80 BPM

Rate Accuracy $\pm 1\%$ of setting

Amplitude Accuracy $\pm(2\% \text{ of setting} + 0.05 \text{ mV})$

ECG Artifact

Type.....	50 Hz, 60 Hz, muscular, baseline wander, respiration
Size.....	25 %, 50 %, 100 % of the normal sinus R-Wave for each lead
Lead Select.....	All, RA, LL, LA, V1, V2, V3, V4, V5, V6

Fetal / Maternal-ECG

Fetal Heart Rate (Fixed)	60 BPM to 240 BPM in 1 BPM steps
Fetal Heart Rate (IUP)	140 BPM at beginning, then varies with pressure
Intrauterine-Pressure Waveforms	Early deceleration, late deceleration, and acceleration
Wave Duration	90 seconds, bell-shaped pressure curve, from 0 mmHg to 90 mmHg and returning to 0 mmHg
IUP Period	2 minutes, 3 minutes, or 5 minutes; and manual
Default Settings	FHR 140 BPM, early deceleration wave, manual

Invasive Blood Pressure

Channels	2, each independently settable with identical parameters and are individually electrically isolated from all other signals
Input/output Impedance	300 $\Omega \pm 10\%$
Exciter Input Range	2.0 V to 16.0 V peak
Exciter-Input Frequency Range	DC to 5000 Hz
Transducer Sensitivity	5 $\mu\text{V/V/mmHg}$ (default) or 40 $\mu\text{V/V/mmHg}$
Pressure Accuracy	$\pm(1\% \text{ of setting} + 1 \text{ mmHg})$ Accuracy guaranteed for DC excitation only
Static Pressure	-10 mmHg to +300 mmHg in 1 mmHg steps
Pressure Units	mmHg or Kpa

Dynamic Waveforms

Types (default pressures).....	Arterial (120/80) Radial artery (120/80) Left ventricle (120/00) Right ventricle (25/00) Pulmonary artery (25/10) Pulmonary-artery wedge (10/2) Right atrium (central venous or CVP) (15/10)
Pressure Variability.....	Systolic and diastolic pressures are independently variable in 1 mmHg steps.
Swan-Ganz Sequence	Right atrium, right ventricle (RV), pulmonary artery (PA), pulmonary artery wedge (PAW)

Cardiac Catheterization

Chambers.....	Aortic, Pulmonary valve, and Mitral valve
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Respiration Artifact

Arterial, radial artery, and left ventricle.....	5 % to 10 % multiplication
Other.....	5 mmHg or 10 mmHg

BP Output	Circular DIN 5-Pin
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Power-On Default	0 mmHg
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Respiration

Rate	0 BrPM (OFF), 10 BrPM to 150 BrPM in 1 BrPM steps
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Waves	Normal or ventilated
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Ratio (inspiration:expiration)

Normal.....	1:1, 1:2, 1:3, 1:4, 1:5
Ventilated.....	1:1

Impedance Variations ($\Delta \Omega$)	0.00 Ω to 1.00 Ω in 0.05 Ω steps and 1.00 Ω to 5.00 Ω in 0.25 Ω steps
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Delta Accuracy	\pm (5 % of setting + 0.1 Ω)
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Baseline	500 Ω , 1000 Ω (default), 1500 Ω , 2000 Ω , Leads I, II, III
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Baseline Accuracy	\pm 5 %
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Respiration Lead	LA or LL (default)
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Apnea Selection	12 seconds, 22 seconds, or 32 seconds (one-time events), or continuous (Apnea ON = respiration OFF)
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Power-On Default	20 BrPM, delta 1.0 Ω
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Temperature

Temperature	30.0 $^{\circ}$ C to 42.0 $^{\circ}$ C in 0.5 $^{\circ}$ C steps
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Accuracy	\pm 0.4 $^{\circ}$ C
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Compatibility	Yellow Springs, Inc. (YSI) Series 400 and 700
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Output	Circular DIN 4-pin
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Cardiac Output

Catheter Type	Baxter Edwards, 93a-131-7f
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Calibration Coefficient	0.542 (0 $^{\circ}$ C injectate), 0.595 (24 $^{\circ}$ C injectate)
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Blood Temperature	36 $^{\circ}$ C (98.6 $^{\circ}$ F) to 38 $^{\circ}$ C (100.4 $^{\circ}$ F) \pm 0.2 $^{\circ}$ C in 1 $^{\circ}$ C steps
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Injectate Volume	10 cc
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Injectate Temperature	0 $^{\circ}$ C or 24 $^{\circ}$ C
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Cardiac Output	2.5 liters per minute, 5 liters per minute, 10 liters per minute \pm 7.5 %
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Faulty-Injectate Curve	Waveform for simulation available
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Left-to-Right-Shunt Curve	Waveform for simulation available
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Calibrated Pulse	1.5 $^{\circ}$ C for 1 second
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Connector	Circular DIN 7 pin
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Power-On Default	5 liters per minute, 0 $^{\circ}$ C injectate, 37 $^{\circ}$ C blood temperature
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Non-Invasive Blood Pressure

Pressure Units mmHg or kPa

Manometer (Pressure Meter)

Range 0 mmHg to 400 mmHg
Resolution 0.1 mmHg
Accuracy $\pm(0.5\% \text{ reading} + 0.5 \text{ mmHg})$

Pressure Source

Target Pressure Range 15 mmHg to 400 mmHg
Resolution 1 mmHg

NIBP Simulations

Pulse 2 mmHg max into 500 ml NIBP system
Volume of air moved 1.25 ml max
Simulations Systolic/diastolic (MAP)
Adult 60/30 (40), 80/50 (60), 100/65 (77); 120/80 (93); 150/100 (117); and 200/150 (167) and 255/195 (215)
Neonatal 35/15 (22); 60/30 (40); 80/50 (60); 100/65 (77); 120/80 (93) and 150/100 (117)
Pressure variability Systolic and diastolic pressures are variable by 1 mmHg
Repeatability Within ± 2 mmHg (at maximum pulse size independent of device under test)
Synchronization
Normal Sinus heart rates 30 BPM to 240 BPM
Maximum rate at 1 ml 240 BPM achievable with pulses up to 1 ml
Maximum rate at 1.25 ml 180 BPM
Arrhythmias Premature atrial contraction (PAC), Premature ventricular contraction (PVC), atrial fibrillation, and missed beat.

Leak Test

Target Pressure 20 mmHg to 400 mmHg
Elapsed time 0:30 minutes:seconds to 5:00 minutes:seconds in 30 second steps
Range 0 mmHg/minute to 200 mmHg/minute
Internal Leak rate < 2 mmHg/min into 500 ml rigid volume
Pressure Relief Test Range 100 mmHg to 400 mmHg

Oximeter SpO₂ Optical Emitter and Detector (optional)

% O₂

Range 30 % to 100 %
Resolution 1 %
Accuracy
With oximeter manufacturer's R-curve
Saturation within UUT specific range $\pm(1 \text{ count} + \text{specified accuracy of the UUT})$
Saturation outside UUT specific range monotonic with unspecified accuracy
With Fluke Biomedical R-curves
91 % to 100 % $\pm(3 \text{ counts} + \text{specified accuracy of the UUT})$
81 % to 90 % $\pm(5 \text{ counts} + \text{specified accuracy of the UUT})$
71 % to 80 % $\pm(7 \text{ counts} + \text{specified accuracy of the UUT})$
Below 71 % monotonic with unspecified accuracy

Heart Rate

Range 30 BPM to 300 BPM in 1 BPM steps. Oximeter SpO₂ Optical Emitter and Detector is synchronized with ECG rate delayed by 150 ms.
Accuracy $\pm 1\%$ of setting

Transmission (Ratio of detector current to LED current, expressed in parts per million (ppm))

Range	0 ppm to 300.00 ppm
Resolution	0.01 ppm
Accuracy	+50 %/-30 % for compatible monitors, unspecified for others. Selected by finger size and color: Dark, thick finger, medium finger, light, thin finger, neonatal foot.

Pulse Amplitude

Range	0 % to 20.00 %
Resolution	0.01 %

Artifact

Respiration

Range	0 % to 5 % of transmission
Resolution	1 %
Rate	all ProSim respiration simulation settings

Ambient Light

Range	0X to 5X transmitted light
Resolution	1X
Frequency	DC, 50 Hz, 60 Hz, and 1 kHz to 10 kHz in 1 kHz steps

Masimo Rainbow Technology Masimo Rainbow technology with an optional adapter supplied by Masimo that allows the ProSim two wavelength to test the Rainbow multiple wavelength system

Compatible Manufacturer Products

With manufacturer R-curve	Nellcor, Masimo, Nonin, and Nihon Kohden
With Fluke Biomedical R-curve	Mindray, GE-Ohmeda, Philips/HP, and BCI

Pre-Defined Simulations

- Normal
- Hypertensive
- Hypotensive
- Tachycardic
- Bradycardic
- Ventricular Fibrillation
- Asystole

Autosequences (default)

- Monitor testing sequence
- Medical training sequence
- Oximeter testing sequence
- Cardiac failure sequence
- Arrhythmia sequence
- Exercise sequence
- Respiration sequence
- Performance Wave Test
- IBP testing sequence
- Temperature sequence

Appendix A

Glossary

Introduction

The words in this glossary are common words used in this manual that may need further explanation. Words in italics are words that are defined in this glossary.

AAMI

Acronym for the Association for the Advancement of Medical Instrumentation. A group of physicians, biomedical and clinical engineers, nurses, manufacturers, and government representatives who set industry guidelines for the performance and safety of biomedical instrumentation.

AC component

The *pulse* factors of the blood measured by oximetry.

Ampere

A unit of steady electrical current which, when flowing in straight parallel wires of infinite length and negligible cross section, separated by a distance of one *meter* in free space, produces a force between the wires of 2×10^{-7} newtons per meter of length.

Aorta

The main trunk of the systemic arteries, carrying blood from the left side of the heart to the arteries of all limbs and organs except the lungs.

Apnea

Apnea is described as the cessation of breathing. In general there are three types of apnea: central (often seen in infants, when there is no diaphragm movement and no air flow); obstructive (where an object, such as food, is lodged in the trachea); and mixed (where central apnea is followed immediately by obstructive apnea).

Artery

Any of a branching system of muscular tubes that carry blood away from the heart.

Artifact

An abnormal signal or structure produced by an external medium, such as a muscle or electrical wiring. Artifacts are sometimes referred to as noise.

An *ECG* artifact can be caused by depolarization or contraction of the muscle which depends on an electrical charge. These electrical charges can be detected by an electrocardiogram. The electrical charges associated with the contractions of the heart will be clear only if there is not interference by auxiliary signals from other muscle movement. Electrical signals from power lines or local (in-wall) circuitry represent another kind of artifact (also called noise) that can be picked up by an ECG device. These sources can cause minute electric currents through capacitive coupling or resistive contacts. On an ECG readout, such electrical artifacts can cause a serious safety condition. Even a relatively tiny current of 60 *hertz* (Hz) can be fatal. Therefore, whenever line frequency in an electrocardiogram is noted, the cause of the signal should be determined at once

Asynchronous

Signals sent to a computer at irregular intervals. Data is transmitted at irregular intervals by preceding each character with a start bit and following it with a stop bit. Asynchronous transmission allows a character to be sent at random after the preceding character has been sent, without regard to any timing device.

Asystole (Cardiac Standstill)

No *ECG* activity whatsoever. Ventricular asystole is a critical condition characterized by the absence of a heartbeat either in the *ventricles* or in the entire heart. This condition, also referred to as *cardiac* standstill, is usually accompanied by loss of consciousness, *apnea*, and—if not treated immediately—death.

Atrial Fibrillation

A rapid, irregular atrial signal, coarse or fine, with no real P waves; an irregular ventricular rate. Coarse and fine atrial fibrillation occurs when the electrical signals in the atria are chaotic, and multiple, ectopic pacemakers are firing erratically. Some impulses may conduct through to the *AV node* to stimulate the *ventricles*, causing a quite-irregular and often-rapid ventricular rate. On the *ECG* there is an absence of P waves, with an irregular R-R interval. Atrial-fibrillation *waveforms* are irregularly shaped and usually rounded. The amplitude of the atrial signal is higher for coarse, and lower for fine, fibrillation.

Atrial Flutter

A repeating sequence of large, irregular P waves at 300 *BPM*; an irregular ventricular response. Atrial flutter occurs when a single, ectopic, atrial pacemaker that is non-SA (usually low, near the *AV node*) fires repeatedly and (usually) regularly, producing large, pointed P waves at an approximate rate of 400 *BPM* (between 240 *BPM* and 480 *BPM*). Not all of the atrial impulses conduct through to the *ventricles*. On the *ECG* readout the *waveform* generally exhibits a “saw tooth” appearance. This type of arrhythmia can reduce *cardiac* output by as much as 25 %, due in many cases to the lack of an atrial “kick” and the accompanying failure of the ventricles to fill completely with blood prior to ventricle contraction.

Atrial Tachycardia (AT)

Normal rhythm at a faster-than-normal rate of 160 *BPM*.

Atrial tachycardia occurs when an ectopic, atrial pacemaker (non-SA) fires repeatedly at a rate between 150 BPM and 250 BPM. AT may cause *cardiac* output to drop significantly (in some cases by as much as 25 %), due to the inability of the *ventricles* to fill completely during the typically short diastole. This condition may result from an atrioventricular blockage or digitalis toxicity.

Atrium

(1) One of the two upper chambers of the heart. (2) Any chamber allowing entrance to another structure or organ.

AV Junction

A junction consisting of the AV node and the *bundle of His*. Conducts the electrical impulse sent from the *SA node* from the atria into the ventricles.

AV Node

Also called the atrioventricular node. Located in the right *atrium* near the septum. Conducts the electrical impulse in the heart to the *bundle of His*, which passes it on to the left- and right-bundle branches.

Baud

A unit of measurement that denotes the number of discrete signal elements, such as bits, that can be transmitted per second. Bits-persecond (bps) means the number of binary digits transmitted in one second.

Bigeminy

Two sequences: a PVC followed by a normal beat, or a PVC followed by two normal beats. Bigeminy—also called a fixed coupling or bigeminal rhythm—is a type of PVC in which a beat with a normal *QRS complex* alternates with a PVC; in other words, every other beat is premature. In *trigeminy*, which is similar to bigeminy, a PVC appears after every two normal QRS complexes.

Blood Pressure

The pressure of the blood within the arteries, primarily maintained by contraction of the left *ventricle*.

BPM

Beats per minute. SEE pulse.

Bundle-Branch Block

Blockage in the right- or left-bundle branches, with beats exhibiting a wide QRS and a PR interval of 160 ms. Bundle-branch blockage—also referred to as intraventricular conduction defect, BBB or IVCD—is a form of *heart block* in which there is a conduction delay or failure from one of the branches of the *bundle of His* (which start about a centimeter below the bundle of His) to the *Purkinje network*. The blockage may be complete or incomplete, transient, intermittent, or permanent. In most cases, the electrical impulse travels through the normal bundle branch to stimulate one *ventricle* and then passes through the *cardiac* septum to stimulate the other, resulting in one ventricle's depolarizing later than the other. (Both anatomically and functionally, the septum separates the heart into its left and right halves.)

Bundle Of HIS

A collection of nerves (about 1 cm in length) that lies just below the *AV node* in the heart. Part of the heart's electrical conduction system. With the AV node, forms the *AV junction*. Below the bundle, the nerves divide into left and right branches.

Computational Constant

Pertaining to cardiac output. Sometimes called calibration coefficient.

Cardiac

Of, near, or pertaining to the heart.

Cardiovascular

Of, pertaining to, or involving the heart and the blood vessels.

Capillary

One of the minute blood vessels that connect the arteries and veins.

DC component

See R-Value

ECG

An electrocardiogram (ECG) records the electrical signals of the muscles of the heart—the depolarization and repolarization of the *myocardium*. Wires from an ECG machine are connected to small plastic or metal cables called leads, or electrodes. Put on the chest, the wrists of the right and left arms, and the left leg at the ankle, these electrodes transmit signals to a recorder. The recorder makes lines in the shape of waves on graph paper in the ECG machine, follow the heart's electrical activity (rate) and its rhythm (beat). Each contraction of a normal heart causes a normal sinus rhythm (NSR) *waveform*, also referred to as the P QRS T waveform.

Frequent Multifocal PVCs

A sequence that includes a left-focus PVC followed by normal beats, alternating with a right-focus PVC followed by normal beats. Frequent *multifocal PVCs* are initiated by a number of different ectopic pacemakers in the *ventricles*, with events occurring at least five times per minute, and usually more often.

Gram

A metric unit of mass and weight, equal to one-thousandth of a *kilogram*, about 0.035 ounces.

Heart Block: First, Second, and Third Degree

Three heart-block simulations, running as repeating sequences. A heart block is a condition wherein the signal generated by the *SA node* is delayed or is blocked (partially or completely) in its journey to the *ventricles*. Because this condition typically occurs at the AV (atrioventricular) junction, a more precise term for heart block is atrioventricular block. When the conduction time from the atria to the ventricles becomes delayed (usually resulting in a P-R interval greater than 0.20 seconds), it is referred to as a first-degree block. When impulses from the atria occasionally do not reach the ventricles, the block is considered partial or incomplete and is referred to as a second-degree block. Finally, when no impulses whatsoever are able to enter the ventricles from the atria, the heart block is complete and is referred to as a third-degree block. As a consequence of a third-degree block, the atria and the ventricles beat at their own separate rates.

Hemoglobin

The oxygen-bearing, iron-containing conjugated protein in vertebrate red blood cells, consisting of about 6 per cent **heme** and 94 per cent **globin**.

Hertz

A unit of frequency equal to one cycle per second. Used to measure electrical current and light, especially ultraviolet radiation (as in fluorescent light).

Impedance

A measure of the total opposition to current in a circuit.

Infrared

Of, pertaining to, or being electromagnetic radiation having *wavelengths* greater than those of visible light and shorter than those of microwaves.

Joule

A unit of energy, equal to the work done when a current of one ampere is passed through a *resistance* of one *ohm* for one second.

Kilogram

The fundamental unit of mass in the International System, about 2.2046 pounds.

LCD

Liquid crystal display. A digital display consisting of a liquid crystal material between sheets of glass that becomes readable in the presence of an applied voltage.

Meter

The fundamental unit of length, equivalent to 39.37 inches, in the metric system.

Millivolt

One-thousandth of a *volt*.

Missed Beat

A single missing beat, with the heart rate returning to normal. Missed beats, often present in first-degree *heart block*, are symptomatic of other conditions as well.

Multifocal PVCs

A sequence that includes a left-focus PVC, followed by two normal beats, followed by a right-focus PVC, followed by a normal rhythm at 80 *BPM*. Multifocal *PVCs* are *premature ventricular contractions* that originate in different ectopic-pacemaker sites throughout the *ventricles*. These *PVCs*, which exhibit different size and shape elements, are characterized by the absence of a P wave (due to the lack of any atrial-pacemaker activity).

Multiple PVCs: Paired PVCs; Run 5 PVCs; Run 11 PVCs

Three series of multiple *PVCs* run as one-time (nonrepeating) events. The term multiple *PVCs* refers to any condition where two or more *PVCs* occur in a row. Standard *PVCs* of this type include a pair of *PVCs* (also known as a couplet), a run of five *PVCs* in a row, and a run of eleven *PVCs* in a row.

Myocardium

The thick muscular layer of the heart, located between the endocardium at the inside and the epicardium at the outside walls of the heart.

Nanometer

One-billionth (10^{-9}) of a *meter*.

Nanosecond

One billionth (10^{-9}) of a second (one thousand-millionth of a second). Electricity travels approximately one foot per nanosecond.

Nodal Rhythm

Normal rhythm, but with a P wave that originates in the *AV node*, and a P-R interval that is very short. Nodal rhythm, also referred to as junctional rhythm or junctional escape, is a condition where the predominant pacemaker is the AV node rather than the *SA node*.

Noninvasive

Not tending to spread; especially, not tending to invade healthy tissue.

Ohm

A unit of electrical *resistance* equal to that of a conductor in which a current of one ampere is produced by a potential of one *volt* across its terminals.

PAP

Pulmonary arterial pressure.

Patient Leads

Cables that connect a patient directly with the monitor. Sometimes called applied parts.

Paroxysmal Atrial Tachycardia (PAT)

Normal rhythm at alternating rates. When *atrial tachycardia* occurs as a seizure-like spasmodic event, it is called paroxysmal atrial tachycardia or PAT. PATs typically start and stop suddenly, initiated by a *premature atrial contraction* (PAC). PAT spasms may last for only a few seconds or for minutes or hours. A patient may experience ATs and PATs over the course of many years.

PCWP

Pulmonary *capillary* wedge pressure. Also known as PAW.

Premature Atrial Contraction (PAC)

A beat that is 25 % premature but otherwise normal. Any part of the heart can depolarize earlier than it should; the accompanying heartbeat is called extrasystole. This type of depolarization is called a premature contraction; a premature contraction that originates in the *SA node* is referred to as a PAC. An isolated PAC is relatively unimportant. However, frequent PACs are a concern, because they could be the precursor of more serious and potentially life-threatening conditions, including *atrial flutter*, *atrial fibrillation*, and *atrial tachycardia*.

Premature Nodal Contraction (PNC)

A nodal beat that is 25 % premature, followed by a *nodal rhythm* at 80 *BPM*. A premature nodal contraction—also called a premature junctional contraction, a PNC, or a PJC—is an extra beat that occurs as a result of an electrical impulse sent from the atrioventricular (junctional) node. The P-R interval is shorter than normal. PNCs, which may occur in isolation or in groups, can appear sporadically for no obvious reason in an otherwise-healthy person.

Premature Ventricular Contractions

Six PVC-type selections of focus and timing:

- a left-focus premature ventricular beat with standard timing, 20 % premature;
- a left-focus premature ventricular beat with early timing, 33 % premature;
- a left-focus premature ventricular beat with very early timing, 65 % premature, which starts during the T wave of the previous beat;
- a right-focus premature ventricular beat with standard timing, 20 % premature;
- a right-focus premature ventricular beat with early timing, 33 % premature; or
- a right-focus premature ventricular beat with very early timing, 65 % premature, which starts during the T wave of the previous beat.

A premature ventricular contraction or PVC is an extra beat consisting of an abnormally wide and unusual *QRS complex* originating in an ectopic pacemaker in the *ventricles*. Early ventricular *PVCs* occur close to the preceding beat. Moreover, R-on-T *PVCs*, which are characterized by a beat that falls on the T wave of the preceding QRS-T complex, are especially inauspicious because of their potential to cause *ventricular tachycardia* or *ventricular fibrillation*.

Pulse

The rhythmical throbbing of arteries produced by regular contractions of the heart.

Pulse Oximeter

A *non-invasive*, arterial, oxygen-saturation monitor that measures the ratio of two principle forms of *hemoglobin* in the blood.

Purkinje Network

The dense collection of Purkinje fibers, which are dispersed throughout the *myocardium* and which represent the terminal portion of the heart's electrical conduction system.

PVCS

Premature ventricular contractions.

PVCS: 6, 12, or 24 Per Minute

PVCs scattered among normal beats AT 80 *BPM*, so that *PVCs* take place 6, 12, or 24 times every minute. *Premature ventricular contractions* may occur independently (even in healthy individuals), as well as in groups and/or for a number of times every minute.

QRS Complex

The part of the P-QRS-T wave that records ventricular depolarization and contraction.

R-Value

The non-pulsating components of tissue, specifically the tissue bed, the *venous* blood, the *capillary* blood, and nonpulsatile arterial blood. Also referred to as the DC component.

Resistance

The opposition to electric current that is characteristic of a medium, substance, or circuit element.

SA Node

The dominant pacemaker site in the heart, responsible for setting the heart rate. Positioned in the right *atrium* near the inlet of the superior vena cava.

SaO₂

Abbreviation for saturated oxygen, SaO₂ is the ratio of the concentration of oxyhemoglobin (cHbO₂) to the concentration of the two principle types of blood *hemoglobin*: saturated hemoglobin (HbO₂) plus reduced hemoglobin (Hb).

Serial Port

An *asynchronous* COMmunication port/address to which a peripheral—such as a printer or a mouse—is connected to a computer or other device. SEE RS-232.

Sinus Arrhythmia

Beats that are normal, but triggered at an irregular rate, from 60 *BPM* to 100 *BPM*.

Sinus arrhythmia occurs when the *SA node* paces the heart irregularly. Typically, the heartbeat increases with each intake of breath and decreases with each exhalation (a condition most commonly found in young children and the elderly).

SpO₂

The type of saturated oxygen measured with a *pulse oximeter*.

Supraventricular Tachycardia

Normal rhythm at a faster-than-normal rate of 200 *BPM*. Supraventricular tachycardia is a combination of a junctional tachycardia (that is, an *atrial tachycardia* occurring in the AV or junctional node) and an atrial tachycardia. Therefore, supraventricular tachycardia encompasses multifocal, ectopic, atrial pacemakers in and around the *AV node* above the *bundle of His*.

Swan-Ganz

A soft, balloon-tipped catheter used for measuring *blood pressure* and *cardiac* output. The catheter is guided by blood flow into the pulmonary *artery*. A monitor near the tip of the catheter detects *PAP*, *PCWP*, and *thermodilution*.

Swan-Ganz Procedure

After insertion of a Swan-Ganz catheter into a vein (usually the basilic vein of the forearm), the catheter is gently guided by the flow of the blood into the pulmonary *artery*. A monitor attached to the distal lumen port supplies a reading of pulmonary-artery pressure (*PAP*). Pulmonary-capillary-wedge pressure (*PCWP*) is determined by inflating the balloon, which becomes wedged; when this wedge blocks blood flow, it provides a reading of the pressure in the left side of the heart.

Thermodilution

The measuring of temperature change, enabled by the injection of a cold or room-temperature solution (such as saline) into the right *atrium* by means of a *Swan-Ganz* procedure.

Trigeminy

A PVC appears after every two normal *QRS complexes*.

Venous

(1) Of or pertaining to a vein or veins. (2) Returning to the heart through the great veins.

Ventricle

A small anatomical cavity or chamber, as of the brain or heart, especially (1) the chamber on the left side of the heart that receives arterial blood from the left *atrium* and contracts to drive it into the *aorta*, and (2) the chamber on the right side of the heart that receives *venous* blood from the right atrium and drives it into the pulmonary *artery*.

Ventricular Fibrillation

An irregular ventricular *waveform*, coarse or fine. Coarse and fine ventricular fibrillations occur when the electrical signals in the *ventricles* are chaotic, and multiple, ectopic, ventricular pacemakers are firing erratically. There are no real P waves and no clear R-R interval. Ventricular fibrillation waveforms are irregularly shaped. Ventricular fibrillation is a life-threatening condition; usually in such situations a defibrillator is applied immediately to return the heart to its normal rhythm.

Ventricular Tachycardia

A faster-than-normal rhythm of beats (160 *BPM*) originating in the *ventricles*, similar to type-1 (left-focus) *PVCs*. Ventricular tachycardia is a life-threatening arrhythmia in which one or multiple, ectopic, ventricular pacemakers in the bundle branches, *Purkinje network*, or ventricular *myocardium* are firing in a heart beating more frequently than 110 times a minute. In some cases the heart will be beating at a rate above 240 *BPM*. Ventricular tachycardia usually occurs in cases of extreme *cardiac* disease and often initiates or degenerates into *ventricular fibrillation*. This type of tachycardia can reduce cardiac output by as much as 25 % due, in many cases, to the lack of an atrial “kick” and therefore the lack of a complete filling of the ventricles with blood prior to ventricle contraction.

Volt

The International System unit of electric potential and electromotive force, equal to the difference of electric potential between two points on a conducting wire carrying a constant current of one ampere when the power dissipated between the points is one watt.

Waveform

(1) The mathematical representation of a wave, especially a graph of deviation at a fixed point (baseline) versus time. (2) On an *ECG* tracing or output, the size, shape, and distance (in milliseconds) of a P-QRS-T complex.

Wavelength

In a periodic wave, the distance between two points of corresponding phase in consecutive cycles.

