User's Reference Manual

HP Viridia Telemetry System

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First Edition

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the instrument is used in accordance with the instructions for use.

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Intended Use

The HP Viridia Telemetry System (M2600A) is a comprehensive ambulatory system solution for the intermediate care unit. The foundation of the solution is a transmitter that can capture and transmit ECG signals and SpO_2 values which are then processed and displayed on the HP OmniCare Component Central Monitor. The central monitor generates alarms and recordings, thus notifying clinicians of changes in patients' conditions. The Telemetry System communicates with other devices via the HP Viridia monitoring network (SDN). The HP Viridia Wave Viewer is intended for use at the patient's side for assistance in ECG electrode and SpO_2 sensor positioning.

Patient Population

The HP Viridia Telemetry System provides monitoring for adult and pediatric patients.

Environment

The HP Viridia Telemetry System is designed for use in health care facilities by trained health care professionals. It is not for home use.

United States law restricts this device to sale by or on the order of a physician.

Caution

This device provides ST level change information; the clinical significance of the ST level change information should be determined by a physician.

System Safety Standards

The HP Viridia Telemetry System (except the HP Viridia Wave Viewer) complies with the following international safety requirements for medical electrical equipment:

- UL2601-1
- CSA 22.2 601.1
- IEC 601-1
- IEC 606-1-1
- AAMI Voluntary Performance Standards for Cardiac Monitors: Sections 3.1.2.1.c, 3.2.6.1.a-c, 3.2.6.2, 3.2.6.3, 3.2.7, 3.2.8.3, 3.2.8.4, 3.2.8.7, 3.2.9.2, 3.2.9.3, and 3.1.4.1

The system is protected against the effects of defibrillation and electrosurgery.

The HP Viridia Wave Viewer complies with UL General Safety requirements.

Conventions Used in This Manual

Warning 

A "warning" calls attention to the user of imminent hazard to people if proper procedures are not followed.

Caution 

A "caution" calls attention to a condition or possible situation that could cause injury to the user.

Note 

Notes contain additional information on HP Viridia Telemetry System usage.

Warnings

The following warnings apply to the HP Viridia Telemetry System.

General System

Warning

- **DO NOT TOUCH THE PATIENT, BED, OR INSTRUMENT DURING DEFIBRILLATION.**
- **A possible explosive hazard exists if the system is used in the presence of flammable anesthetics.**
- **Do not use a 3-wire to 2-wire adapter with this instrument.**
- **Removal of the secondary grounding wire from the rear of the product voids the IEC approval.**
- **Power modules for analog output, antennas, and palmtop personal computers (wave viewer) must not be installed or used within an 8' radius of the patient.**

ECG Monitoring

Warning

- **If you are using a 3-wire cable (or the 5-wire cable with the M1400A/B transmitter), Hewlett-Packard recommends you do not use `Change Label` except to select the correct labels which reflect the physical placement of the electrodes. This will ensure that the monitored lead and the label match, and prevent any possible confusion.**
- **Hewlett-Packard recommends you do not turn telemetry off when a patient leaves the area. Instead, acknowledge the INOP when the patient leaves the telemetered range. Monitoring will resume automatically when the patient returns. However, if you do turn telemetry monitoring off, you *must* remember to turn it back on when the patient returns to the area.**

- The *Exercise* bandwidth should not be used on ECG-CH1 for paced patients. The pace pulse may be sufficiently distorted and be inadvertently detected as a QRS complex which could lead to missed detection of cardiac arrest.
- The *Exercise* bandwidth should not be used when arrhythmia monitoring is turned on.
- Do not touch the patient, bed or instrument during defibrillation.
- Pacemakers can be susceptible to radio frequency (RF) interference which may temporarily impair their performance.

  The output power of telemetry transmitters and other sources of radio frequency energy, when used in the proximity of a pacemaker, may be sufficient to interfere with the pacemaker's performance. Due to the shielding effects of the body, internal pacemakers are somewhat less vulnerable than external pacemakers. However, caution should be exercised when monitoring any paced patient.

  Consult the pacemaker manufacturer for information on the RF susceptibility of their products and the use of their products with the telemetry transmitters.

  In order to minimize the possiblity of interference, position electrodes, electrode wires, and transmitter as far away from the pacemaker as possible.
- During complete heart block or pacemaker failure to pace/capture, tall P-waves (greater than 1/8 of the average R-wave height) may be erroneously counted by the monitor, resulting in missed detection of cardiac arrest.
- The monitor may continue to count pacemaker pulses or pace pulse repolarization tails, resulting in a false

heart rate during cardiac arrest or some arrhythmias. Keep pacemaker patients under close observation.

- Failure on the part of the responsible individual hospital or institution employing the use of this equipment to implement a satisfactory maintenance schedule may cause undue equipment failure and possible health hazards.
- If you are cleaning the transmitter or receiver mainframe with a flammable liquid, prevent fire by providing adequate ventilation, and avoid smoking.

  Disconnect the power from the the receiver mainframe to prevent electrical shock and accidental turn-on.

SpO_2 Transducer Application

Warning

- Failure to apply the transducer properly may cause incorrect measurement of SpO_2.
- Specific attention must be given to sensor site inspection for changes in skin quality, proper optical path alignment and attachment. Check the application site at regular intervals and change the site if any compromise in skin quality should occur.
- Using a transducer during MR imaging can cause severe burns. To minimize this risk, ensure that the cable is positioned so that no inductive loops are formed. If the transducer does not appear to be operating properly, remove it immediately from the patient.
- Using a transducer in the presence of bright lights may result in inaccurate measurements. In such cases, cover the site with opaque material.
- Injected dyes, such as methylene blue, or intravascular dyshemoglobins, such as methemoglobin, may lead to inaccurate measurements.

- Performance may be compromised by excessive motion. This can lead to inaccurate SpO_2 readings.
- Avoid placing the SpO_2 transducer on any extremity with an arterial catheter, or intravascular venous infusion line.
- Do not use disposable transducers on patients who exhibit allergic reactions to the adhesive.

For Specific SpO_2 Transducers

Warning

- When the specified *NELLCOR*® transducers are used, the application must be consistent with the manufacturer's own guidelines.
- HP Reusable Adult Finger Transducer (M1191A): Failure to apply the transducer properly may cause incorrect measurement of SpO_2. For example, not pushing the transducer far enough over the finger can result in inaccurate SpO_2 readings. Pushing the transducer too far, so that the finger protrudes from the transducer, can pinch the finger, resulting in inaccurately low SpO_2 readings.
- HP Reusable Pediatric Finger Transducer (M1192A): Failure to apply the transducer properly may reduce the accuracy of the SpO_2 measurement.
- HP Reusable Clip Transducer (M1194A): Failure to apply the clip transducer properly may reduce the accuracy of the SpO_2 measurement.

SpO_2 Monitoring

Warning

- Prolonged, continuous monitoring may increase the risk of changes in skin characteristics, such as irritation, reddening, blistering or pressure necrosis, particularly on patients with impaired perfusion and varying or

immature skin morphology. Specific attention must be given to sensor site inspection for changes in skin quality, proper optical path alignment and attachment. Check the application site at regular intervals and change the site if any compromise in skin quality should occur. More frequent checking may be required due to an individual patient's condition.

- **Setting the high SpO_2 alarm limit to 100% is equivalent to switching off the high alarm limit. Therefore the upper alarm limit for oxygen saturation must be carefully selected in accordance with accepted clinical practices.**
- **Pulse oximetry can overestimate the SpO_2 value in the presence of Hb-CO, Met-Hb or dye dilution chemicals.**

Cautions

The following cautions apply to the HP Viridia Telemetry System.

HP M2604A and M1401A Receiver Mainframes

The following cautions can be found on the HP M2604A Receiver Mainframe.

Caution

- CAUTION-
  SHOCK HAZARD
  DO NOT REMOVE COVERS
  SERVICE BY QUALIFIED PERSONNEL
- CAUTION
  METRIC & INCH HARDWARE
  CONSULT SERVICE MANUAL
- This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

- CAUTION
  REMOVAL OR INSERTION
  OF RECEIVER MODULES
  WITH POWER ON MAY
  CAUSE DAMAGE TO
  INSTRUMENT

HP M1407A Power Supply

The following caution can be found on the HP M1407A Power Supply.

Caution 

CAUTION
INDOOR USE ONLY
TO REDUCE THE RISK OF FIRE OR
ELECTRICAL
SHOCK, CONNECT DIRECTLY TO A
GROUNDING RECEPTABLE (3-PRONG)

Contents

1

Introducing the HP Viridia Telemetry System

This chapter describes the individual parts of the HP Viridia Telemetry System, including transmitters, receiver modules, receiver mainframe, and antenna system. The wave viewer is described in Chapter 4.

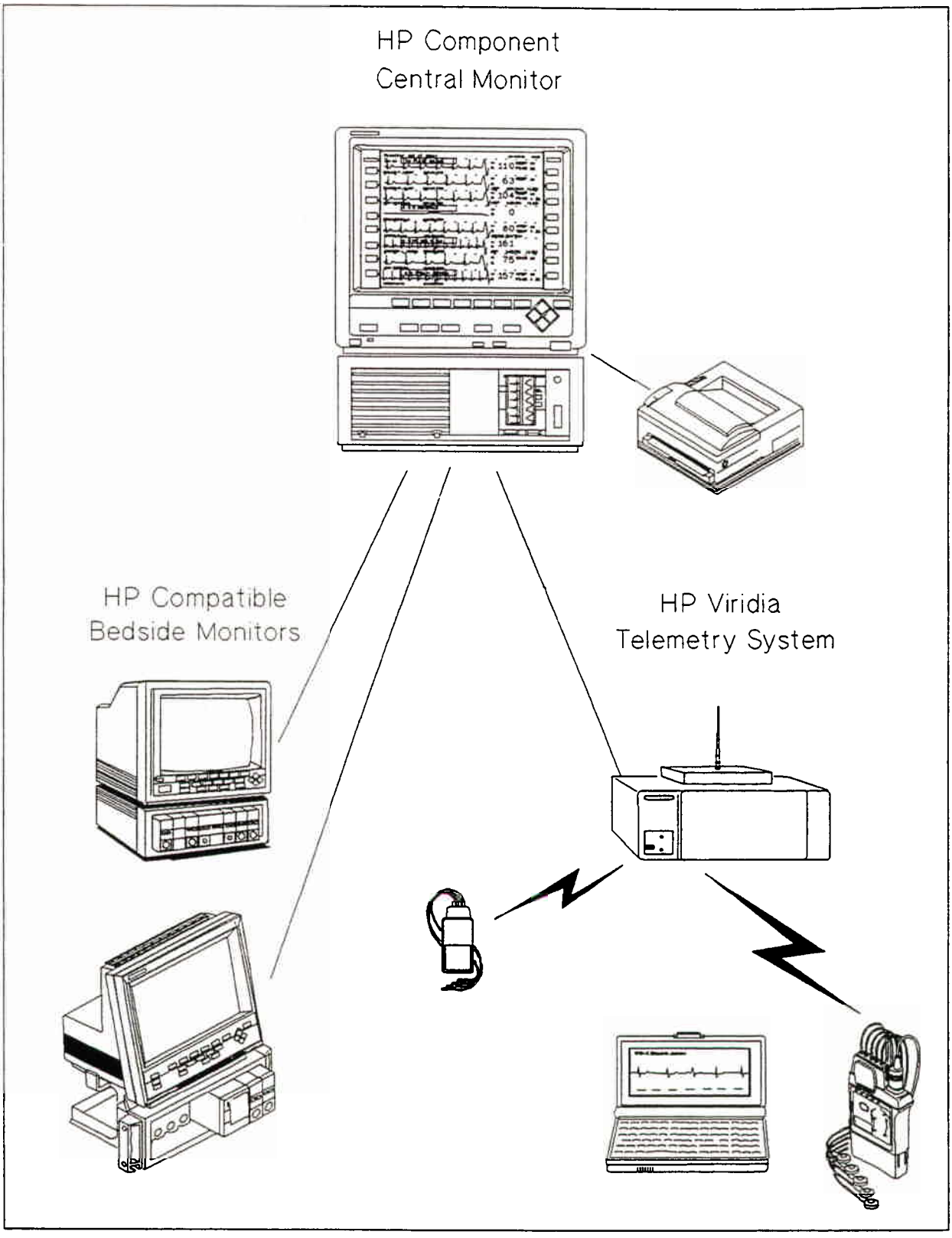
System Introduction

The HP Viridia Telemetry System provides remote monitoring of ECG (and optional ST segment) and integrated SpO_2.

The HP Viridia Telemetry System consists of:

- a transmitter for each patient
- a receiver for each transmitter
- a receiver mainframe housing up to eight receivers
- an antenna system

If the Central Monitor includes the Patient Locator Interface option, patient location information tracked by Fisher Berkeley's SmartLink^{TM} system of infrared badges and receivers can be displayed at central. For information on this capability, refer to Appendix B of the *HP OmniCare Component Central Monitor User's Reference Manual*.


HP Component
Central Monitor
HP Compatible
Bedside Monitors
HP Viridia
Telemetry System

Transmitter

The following transmitters can be used with the HP Viridia Telemetry System:

- HP Viridia Transmitter (ECG/SpO_2 or ECG only)
- HP M1400A/B Transmitter (ECG only)

Note

See Chapter 1 in the *User's Guide* for illustrations of the transmitters, information about the transmitter button, and directions for removing and inserting the battery and connecting and disconnecting the ECG lead set and SpO_2 sensor.

ECG Signal Processing

The transmitter acquires the patient's ECG signal, amplifies and digitizes it, detects pace pulses, then sends the signal via an Ultra High Frequency (UHF) radio channel to a receiver in the receiver mainframe.

Depending on the lead set used, the transmitter transmits up to three ECG leads. Up to seven leads are displayed on the Central Monitor. The clinician can make adjustments to only two channels of the signal, ECG-CH1 and ECG-CH2. ECG-CH1 is always the cardiotach ECG, that is, it is used by the monitor to count the heart rate.

Note

See Chapter 2 in this manual for more information on monitoring ECG.

Warning 

Pacemakers can be susceptible to radio frequency (RF) interference from devices such as telemetry transmitters. See "Monitoring Paced Patients" in Chapter 2 for additional information.

Integrated SpO_2 Processing

Algorithm processing for integrated SpO_2 occurs in the HP Viridia transmitter. Measurements can be made on a continuous basis, periodically at 1-minute or 5-minute intervals, or manually on demand. Adjustments to the sample rate are made at the HP Wave Viewer.

See Chapter 3 in this manual for more information on setting up and monitoring SpO_2, and SpO_2 transducers. The compatible SpO_2 sensors are listed in Appendix A, "Specifications and Ordering Information."

Transmitter Button

The transmitter button can be configured to produce an ECG recording, set off the nurse call alarm, do both, or neither.

Batteries

The battery compartment is capable of accommodating most standard 8.4 volt or 9 volt batteries. The life expectancy of the battery depends on the transmitter configuration and the type of battery used.

HP recommends that the battery be removed when the transmitter is not in use.

Warning 

The battery must be removed if a transmitter will be stored for an extended period of time.

Battery Life Expectancy

Battery Type	ECG Only	ECG & SpO_2 Continuous	ECG & SpO_2 Intermittent
Lithium	3 days 6 hours	16 hours	1.5 - 2.5 days
Alkaline[1]	1 day 8 hours	8 hours	1 day

1 Tested with DURACELL battery

If you have a transmitter with SpO_2 that is not in use, HP recommends setting the SpO_2 measurement mode to manual at the wave viewer to conserve battery power.

The message **BATTERY WEAK** appears in the patient's sector to warn when the battery has approximately 15 minutes left (HP Viridia transmitter) or one hour left (M1400A/B transmitter).

Note

If you are making a STAT SpO_2 measurement or changing the SpO_2 sample rate out of Manual when the **BATTERY WEAK** message appears, it may be necessary to replace the battery immediately in order to continue monitoring.

Automatic Shutoff

Automatic Shutoff enables an HP Viridia transmitter to stop broadcasting if there is no signal from any electrode for 10 minutes. This saves battery life and prevents interference with other powered transmitters in close proximity. Automatic Shutdown can be configured to off. When configured off, batteries must be removed when the tranmitters are not in use to prevent RF interference.

Automatic Shutoff is not availabale on M1400A/B transmitters.

Lead Sets

The HP Viridia transmitter uses M259X series 3- and 5-lead cables. When a combiner shield is added to leadsets from bedside monitors, such as the HP OmniCare CMS, bedside lead sets can also be used with the HP Viridia transmitter. Use of the combiner shield provides for optimal telemetry performance. The M1400A/B transmitter uses M14XX series 3-, 4-, or 5-lead cables.

Leads Off Lights

The chest diagram on the front of the HP Viridia transmitter has a light for each electrode which illuminates if the corresponding electrode becomes unattached. In a LEADS OFF situation, this indicator will help you identify quickly which leads are off and re-attach them. If the reference lead is off, after you correct the situation you may find other lights illuminated as well.

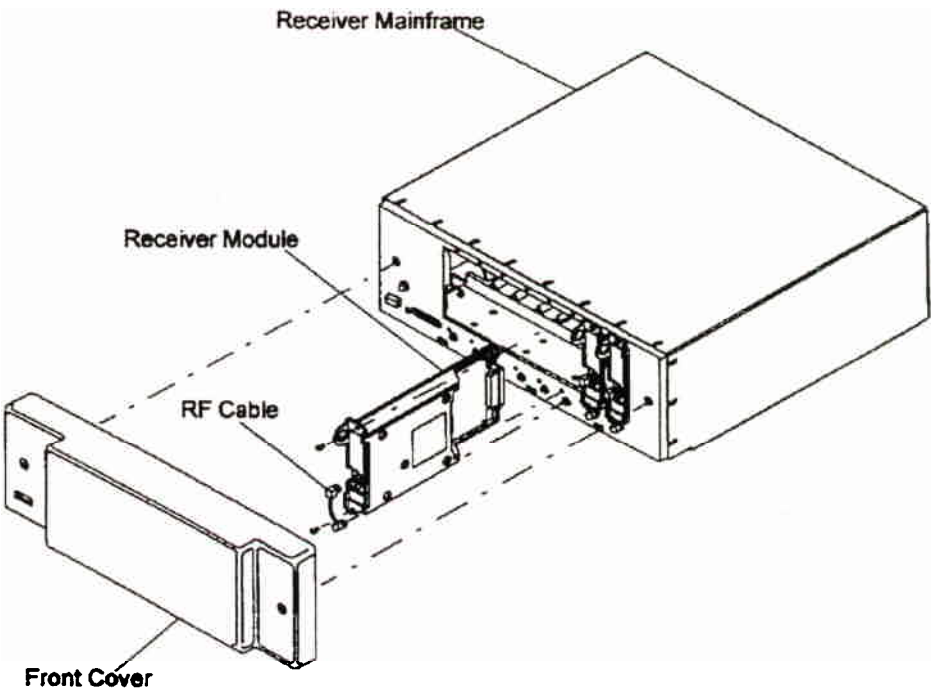
A second function of the Leads Off lights is to indicate the battery status. When you insert a battery into the transmitter, all five lights flash once. This indicates that the battery has adequate power for monitoring.

Transmitter Durability

The HP Viridia Transmitter is water-resistant. The M1400A/B Transmitter is resistant to water. However if either type of transmitter is exposed to liquids, remove the battery and dry the battery compartment thoroughly before monitoring.

If the transmitter needs cleaning, follow the instructions in Chapter 8, "Cleaning and Disinfection."

Receiver Module

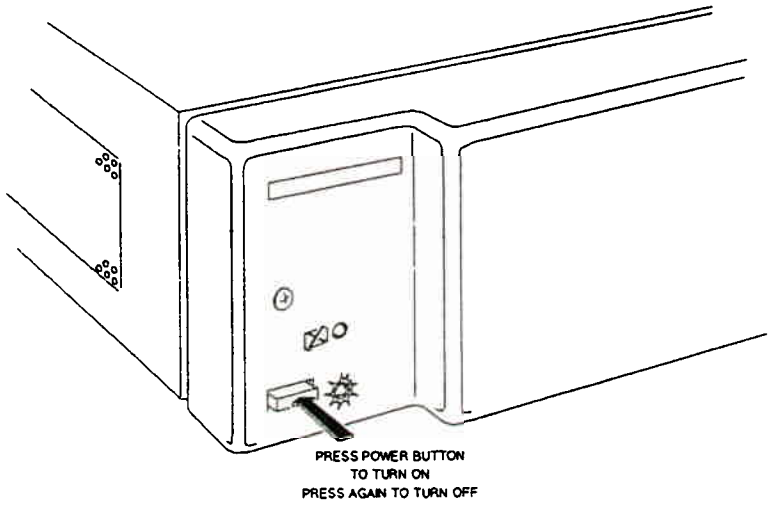


The HP receiver modules are housed in the receiver mainframe. Each receiver module is dedicated to a specific transmitter by an internal identity code. This prevents another patient's waveform from being erroneously transmitted and displayed. The receiver acquires the ECG and SpO_2 signals from the transmitter and sends them to the receiver mainframe.

Receiver Mainframe

The HP M2604A Receiver Mainframe houses up to eight receiver modules. For each receiver, the receiver mainframe calculates the heart rate, and sends the waveform, alarms, inoperative messages (INOPS), and status messages over the HP Viridia monitoring network (SDN) to the central monitor for display and recording. If SpO_2 is available, the transmitter processes the data and sends it to the central monitor via the network as well.

Turning the Receiver Mainframe On or Off



The receiver mainframe must be turned on for individual transmitters and receivers to work. To turn the receiver mainframe on, press the button on the lower left corner of the front of the mainframe. A green light illuminates to signify the mainframe and all the receivers are on.

If the receiver mainframe is turned off, the light and all receiver modules are off.

Receiver Mainframe Malfunction Light

A red light on the front panel of the mainframe illuminates when either the mainframe or one of the receivers has malfunctioned. Depending on the problem, you may see the message, NO DATA FROM BED, in single or multiple patient sectors. Contact service.

When the mainframe is first turned on, the red light flashes. If no problems are detected, the flashing stops and the light turns off.

Channel Frequencies

The frequency of the HP Viridia transmitter and receiver are programmable, thus enabling changes in frequency if interference is detected. In case of interference, contact service.

Retaining Telemetry Settings

If power to the receiver mainframe is interrupted or turned off, your settings such as alarm limits, bandwidth and size may be affected.

- If the receiver mainframe is turned off for less than three hours, your settings should still be in effect.
- If the mainframe is turned off for more than three hours, your settings revert to default, that is, to the configured settings at installation.

Antenna System

The telemetry antenna system is custom designed for your unit to ensure adequate coverage, therefore the telemetry signal can only be received where there are receiving antennas. After it is received by the antenna system, it is sent to the receiver which recovers the patient's ECG and optional SpO_2. This information is then sent to a monitoring display.

2

ECG Monitoring

This chapter provides information on how to obtain the best ECG signal for effective telemetry monitoring.

Topics include:

- Optimizing Your System's Performance
- How to Get the Best Signal
- Lead Selection
- Electrode Placement
- Characteristics of a Good ECG Signal

Optimizing Your System's Performance

While telemetry monitoring offers many advantages, it can be a challenge. The reliability and quality of the signal transmission through the air and hospital walls is governed by a number of variables which can be difficult to control. A telemetry system cannot be as dependable as a hardwired bedside monitor that transmits its signal through a wire.

The effect of interference on the telemetry system ranges from a momentary loss of ECG to complete inoperability, depending on the situation. The strength, frequency, and proximity of the source of interference to transmitters or the antenna system are factors that determine the degreee of severity. In cases where the source of interference is known - for example, computers, cellular phones, other radio equipment, motorized

equipment - removing the source of interference will increase the system's dependability.

Warning

Telemetry should not be used for primary monitoring in applications where the momentary loss of the ECG is unacceptable.

In this section, we'll investigate some of the problems affecting ECG signal clarity and when possible, show you how you can greatly enhance performance.

Understanding the Telemetry Signal

As discussed in Chapter 1, the HP Viridia Telemetry System consists of a transmitter and receiver for each patient, a receiver mainframe and an antenna system.

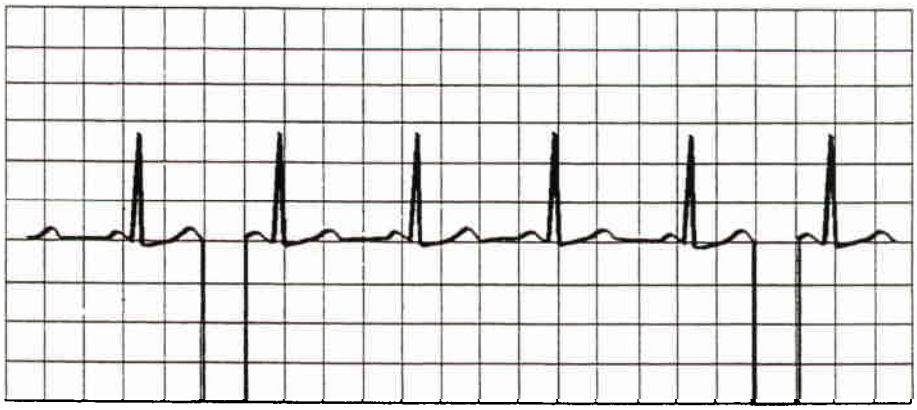
The transmitter is worn by the patient. It acquires the patient's physiological data, amplifies and digitizes it, detects ECG pace pulses and broadcasts this information via radio waves to the antenna system. Since the signal passes through the air, it is susceptible to interference from many sources.

Antenna System

The telemetry antenna system is custom designed for your unit to ensure adequate coverage, therefore the telemetry signal can only be received where there are receiving antennas. After it is received by the antenna system, the signal is sent to the receiver, which recovers the patient's ECG and SpO_2. This information is then sent to the central monitor.

Frequent Signal Strength and RF INOPS

Dropouts result from a weak signal strength or RF interference. The signal is "dropped down" for a minimum of 200 ms to indicate to the clinical user that it is a non-physiological event. If dropouts are frequent enough to affect the heart rate count, the `TEL CANNOT ANALYZE` INOP occurs. The following recording strip is an example of dropouts.



If frequent dropouts are occurring, there are some steps you can take to improve performance.

Signal Strength

The antenna system is custom designed for your unit, so reliable signal reception is only possible where there are receiving antennas. When the signal is too low, the following INOPS occur:

- TEL CANNOT ANALYZE
- WEAK SIGNAL
- NO SIGNAL

To correct, first check the location of the patient. If not in the coverage area, do one of the following.

- Return the patient to the specified antenna coverage area.
- Turn the patient's telemetry off.

Warning

Hewlett Packard recommends that you do not turn telemetry off when a patient leaves the area. Instead, acknowledge the INOP when the patient leaves the telemetered range. Monitoring will resume automatically

when the patient returns. However, if you *do* turn the telemetry off, you *must* remember to turn it back on when the patient returns to your unit.

If the patient is in the coverage area and is stationary, try the following.

- Move the location of the transmitter or patient about six inches.

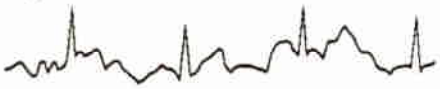
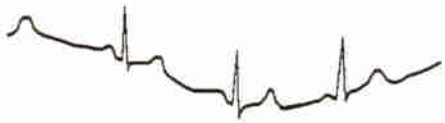
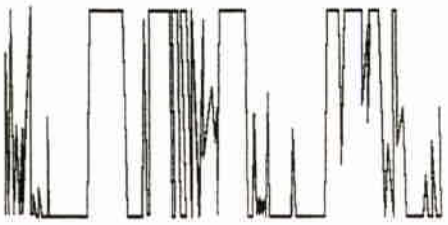
Radio Frequency Interference

Radio frequency (RF) interference is caused by anything that intrudes into the transmitted electrical signal, such as paging transmitters and walkie-talkies. We are all familiar with electrical interference in our homes and cars when it causes "snow" on the television and static on the radio station. These same types of interference can occur with the transmitted telemetry signal. Even though the HP Viridia Telemetry System is designed to resist these effects, interference can occasionally be seen in the form of "dropouts". To improve performance, the source of the interference must be identified and eliminated.

Getting the Best ECG Signal for Telemetry Monitoring

Muscle and Movement Artifact

Muscle and movement artifact differ from radio frequency interference since you can prevent much of the occurrence. Noise on the ECG signal can be caused by many sources, such as interference from other electrical equipment, muscle artifact and respiration variation. It is up to the clinician to use certain techniques to minimize these types of noise. Use the following table to help you troubleshoot the most common sources of ECG noise.

PROBLEM	CAUSE	REMEDY
60-Cycle (AC) Interference 	Poor electrode placement. Possible non-grounded instrument near patient.	Reapply electrodes. Disconnect electrical appliances near patient (one at a time) by pulling wall plugs, to determine faulty grounding. Have engineering check grounding.
Muscle Artifact 	Tense, uncomfortable patient. Poor electrode placement. Tremors. Diaphoresis.	Make sure patient is comfortable. Check that electrodes are applied on flat, non-muscular areas of the torso; dry the skin and reapply electrodes if necessary.
Irregular Baseline 	Poor electrical contact. Respiratory interference. Faulty electrodes. Dry electrodes.	Reapply electrodes, using proper technique. Move electrodes away from areas with greatest movement during respiration.
Baseline Wander 	Movement of the patient. Improperly applied electrodes. Respiratory interference.	Make sure patient is comfortable. Reapply electrodes. Check that patient cable is not pulling on electrodes. Move electrodes away from areas with greatest movement during respiration.
Poor Electrode Contact 	Loose electrodes. Defective cables.	Change all electrodes, using good skin prep. Replace cables.

More About Bandwidths

The telemetry system contains between two and five bandwidths, depending on the type of transmitter used. Each is appropriate for specific applications. You can select a different bandwidth for each monitored lead. ECG-CH1, the cardiotach lead, should always be monitored in a bandwidth with sufficient noise suppression, such as monitoring.

A selected bandwidth allows a specific range of electrical frequencies of the ECG signal to be displayed.

For the HP Viridia Transmitter

Choices are:

- Monitor: 0.5 - 40 Hz (selectable), 0.05 to 40 Hz if ST monitoring
- Exercise: 5.0 - 40 Hz (selectable)

Monitor This bandwidth is the most commonly used. It is the bandwidth of choice for most monitoring including arrhythmia monitoring.

Exercise This bandwidth allows a narrower range of electrical frequencies to be displayed and has the greater noise suppression. This bandwidth is most appropriate in areas where the patient is exercising and the ECG will not be analyzed except for an accurate heart rate count.

Warning

The *Exercise* bandwidth should not be used on ECG-CH1 for paced patients. The pace pulse may be sufficiently distorted and be inadvertently detected as a QRS complex which could lead to missed detection of cardiac arrest.

The *Exercise* bandwidth should not be used when arrhythmia monitoring is turned on.

For the M1400A/B Transmitter

Choices are:

- Monitor: 0.5 - 40 Hz
- Exercise: 5.0 - 40 Hz
- Diagnostic: 0.05 - 100 Hz
- Paced : 0.5 - 100 Hz
- ST: 0.05 - 40 Hz

Monitor This bandwidth is the most commonly used. It has greater noise suppression than Diagnostic but less than Exercise. It is the bandwidth of choice for most monitoring including arrhythmia monitoring. Assigning arrhythmia monitoring automatically changes the bandwidth to Monitor, unless the bandwidth selection is ST. Unassigning arrhythmia does not change the selected bandwidth.

Exercise This bandwidth allows the narrowest range of electrical frequencies to be displayed and has the greatest noise suppression. This bandwidth is most appropriate in areas where the patient is exercising and the ECG will not be analyzed except for an accurate heart rate count.

Warning

- **The *Exercise* bandwidth should not be used on ECG-CH1 for paced patients. The pace pulse may be sufficiently distorted and be inadvertently detected as a QRS complex which could lead to missed detection of cardiac arrest.**
- **The *Exercise* bandwidth should not be used when arrhythmia monitoring is turned on.**

Diagnostic	This bandwidth allows the widest range of electrical frequencies to be shown. Sometimes certain frequencies can be present as noise on the waveform since the Diagnostic bandwidth has the least noise suppression. The Diagnostic bandwidth is usually only selected when diagnostic measurements are done, or the clinician needs to closely examine the ECG complexes momentarily. Use of this bandwidth can make the system more susceptible to false alarms.
Paced	This bandwidth is recommended for paced patients. When the paced mode is selected, the monitor automatically selects the Paced bandwidth for both monitored leads. If you choose, you can then select a different bandwidth.
ST	This bandwidth is used when ST analysis is needed.

Note

If arrhythmia is assigned, the bandwidth is automatically set to Monitoring (or ST, if ST is On) whether Pacemaker setting is On or Off. If arrhythmia is unassigned, but ST is On, the bandwidth is automatically set to Diag.

Heart Rate Limit Adjustment

Heart rate limits should be set according to clinical protocol, and be appropriate for the patient. The telemetry system's heart rate counter (the cardiotach) uses the upper heart rate limit to correctly count the rate. If this limit is set too high, it is possible the monitor could miscount. Specifically, if you are getting double-counting, the algorithm may be counting T waves. To avoid problems in counting, Hewlett-Packard

recommends setting the high heart rate limit no more than 10 to 20 beats above the patient's heart rate.

Monitoring Paced Patients

You must select the paced mode when monitoring patient's with pacemakers. The purpose of the paced mode is to detect a pace pulse correctly, and not count it as a QRS. If using the M1400A/B transmitter, when the paced mode is designated, the paced bandwidth is automatically selected. If desired, you can manually select another bandwidth.

Warning

The monitor may continue to count pacemaker pulses or pace pulse repolarization tails, resulting in a false heart rate during cardiac arrest or some arrhythmias. Keep pacemaker patients under close observation, especially if you have not designated paced mode for patients having a pacemaker.

During complete heart block or pacemaker failure to pace/capture, tall P-waves (greater than 1/8 of the average R-wave height) may be erroneously counted by the monitor, resulting in missed detection of cardiac arrest.

Warning

Pacemakers can be susceptible to radio frequency (RF) interference which may temporarily impair their performance.

The output power of telemetry transmitters and other sources of radio frequency energy, when used in the proximity of a pacemaker, may be sufficient to interfere with the pacemaker's performance. Due to the shielding effects of the body, internal pacemakers are somewhat less vulnerable than external pacemakers. However, caution should be exercised when monitoring any paced patient.

Consult the pacemaker manufacturer for information on the RF susceptibility of their products and the use of their products with the telemetry transmitters.

In order to minimize the possiblity of interference, position electrodes, electrode wires, and transmitter as far away from the pacemaker as possible.

Monitoring Paced Patients with Arrhythmia

If your paced patient is arrhythmia monitored, all heart rate processing is done with arrhythmia software. You can select paced mode through arrhythmia functions or in the Admit Task Window.

Upon assigning arrhythmia monitoring, the monitor bandwidth is automatically selected. This is the optimal bandwidth for arrhythmia monitoring, and remains if arrhythmia is unassigned. If using the M1400A or M1400B transmitter, you can manually select a different bandwidth.

When you unassign arrhythmia, the paced mode is automatically selected for *all* patients, paced or not, on a bedside monitor. For telemetry patients, the system reverts to the pacemaker status the user selected prior to arrhythmia assignment. This is a safety feature to ensure proper pace pulse detection and rejection in the event you inadvertently neglect to assign the telemetry paced mode. Then if your patient is not paced, you should select NO for the paced mode. If desired, a bandwidth other than monitor can also be selected.

Optimizing Pace Pulse Detection with the HP Viridia Transmitter

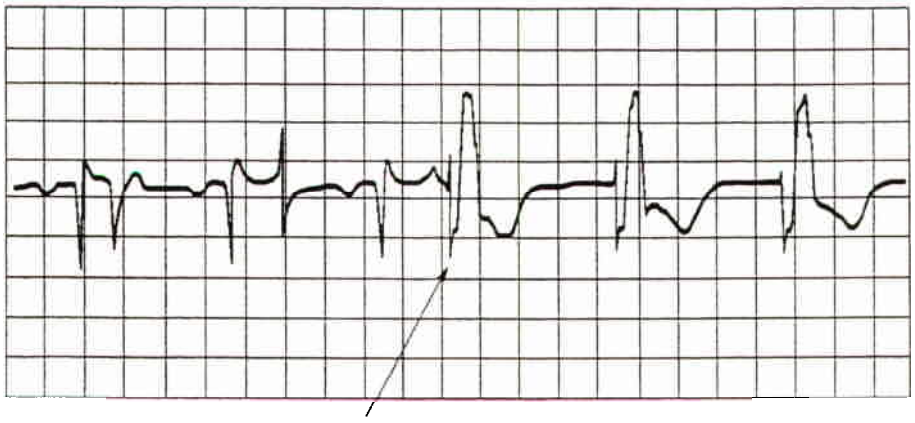
The HP Viridia transmitter obtains a high fidelity waveform, then deemphasizes pacemaker repolarization tails, thus facilitating discrimination between the R-wave and the tail.

To optimize pace pulse detection:

- Use a 5-wire leadset if possible. This also enables a wider set of leads from which to select.
- Select leads so that:
  - R-wave is monophasic and between 1 and 2 mv.
  - R-waves are taller than pace pulses.
  - Pace pulses have no visible repolarization tails (see next section)
- If you are using a 3-wire leadset, either change to a 5-wire cable or reposition the electrodes to find a suitable lead. Remember to set the lead label accordingly.

Pace Pulse Repolarization Tails

Some unipolar pacemakers display pace pulses with repolarization tails. These tails may be counted as QRSs in the event of cardiac arrest or other arrhythmias.



PACE PULSE REPOLARIZATION TAIL (NOTE WIDTH)

If you note a visible repolarization tail:

1. Choose a lead that decreases the size of the repolarization tail.

2. In the rare situation where you cannot reduce the size, the DIAG (diagnostic) bandwidth should be used (M1400A/B transmitter only).

Preparing the Patient

Monitoring patients who are ambulating and exercising can be a challenge to the monitor and the clinical staff. Certain applications are very helpful in preventing noise caused from improper skin preparation and electrode placement.

Preparing the Patient for Telemetry Monitoring

The skin is a poor conductor of electricity, therefore preparation of the skin is important to ensure good electrode contact and a clear ECG signal.

1. Shave hair from electrode sites.
2. Wash sites thoroughly (preferably with soap and water).
3. Rinse well to remove all soap residue.
4. Dry briskly to increase capillary blood flow to the tissues and remove skin cells and oils.

Applying the Electrodes

1. Use only silver/silver chloride electrodes.
2. Check the electrode for fresh, moist gel.
3. Attach the wire to the electrode first.
4. Follow the color-coded diagram on the transmitter for standard lead placement.
5. Select electrode sites where movement or respiration does not impede the signal.
6. For diaphoretic patients, apply skin drying substances only over the area where the electrode adhesive contacts, leaving the gel area free.

Note

- Check electrode expiration dates before using.
- Check electrodes every 24-48 hours.
- Electrode gel is sensitive to air and tends to become dry. Once opened, use as soon as possible.

Selecting a Lead

The system supports two types of transmitters, each with several lead cables. How your telemetry system operates is dependent on the type of transmitter and the type of cable used.

If you are not receiving a good ECG waveform and the electrodes are securely placed, you should try changing the lead in which you are monitoring.

Note

For all transmitters and cables, ECG-CH1 is always the cardiotach lead, that is, the lead the monitor uses to count the heart rate. ECG-CH1 cannot be turned off.

The HP Viridia Transmitter

The HP Viridia Transmitter supports 3- and 5-wire lead sets. The 3-wire lead set enables monitoring of one fixed lead of ECG on channel 1 (CH1).

HP Viridia Transmitter, 3-Wire Lead Set/Standard Electrode Placement

The default configuration is no lead selection at the transmitter. If you use standard lead placement, you will monitor Lead II. To monitor a different lead, you must change electrode positions on the patient's chest. Be sure the lead label at central matches the lead placement. The label chosen will appear in the patient sector and on recordings and reports. You can use the lead placement diagrams on the wave viewer to guide you in electrode positioning.

Lead Select at transmitter: OFF (default)

Lead Selection: Not available at central monitor or wave viewer.

Lead Labelling: Available at central monitor. The broadcasted lead is Lead II. If a different lead is desired, then you **must** use a non-standard electrode placement

and then change the label at central to correspond to the placement.

Label Choices: I, II, III, MCL

Warning

If you are using a 3-wire placement, Hewlett-Packard recommends you do not use `Change Label` except to select the correct labels which reflects the physical placement of the electrodes. This will ensure that the monitored lead and the label match, and prevent any possible confusion.

Viridia Transmitter, 3-Wire Lead Set/Standard Electrode Placement

If lead selection is configured on, lead selection is enabled at the wave viewer. The lead selected at the wave viewer is sent to central. Lead selection at central is disabled.

Lead Select at transmitter: ON

Lead Selection: Available at wave viewer. Not available at central monitor.

Lead Choices: I, II, III

Viridia Transmitter, 5-Wire Lead Set/Standard Electrode Placement

The 5-wire lead set enables monitoring of two leads, ECG-CH1 and ECG-CH2. If the electrodes are in standard position, the user can change the monitored lead at the central monitor without moving the electrodes on the patient.

Lead Selection: Available at central monitor.

Lead Choices:

ECG-CH1	I, II, III, aVL, aVR, aVF, MCL, V
ECG-CH2	I, II, III, aVL, aVR, aVF, MCL, V, Off

The HP M1400A/B Transmitter

The HP M1400A/B transmitter supports 3-, 4-, and 5-wire lead sets.

M1400A/B Transmitter and 4-Wire Lead Set

The 4-wire lead set enables monitoring of two leads, ECG-CH1 and ECG-CH2. If the electrodes are in standard position, the user can change the monitored lead at the central monitor without moving the electrodes on the patient.

Choices are:

ECG-CH1	I, II, III, aVL, aVR, aVF
ECG-CH2	I, II, III, aVL, aVR, aVF, Off

Warning

The above lead selections are *only* correct if you follow the diagram on the transmitter, or use the standard 4-lead placement in this chapter.

M1400A/B Transmitter and 3-Wire Lead Set

There is *no* lead selection. If you are using a 3-wire lead set, when you place electrodes in the standard position, you monitor Lead II. If you choose to reposition the electrodes on the patient's chest, you must change the label to I, III, or MCL in order for the correct label to appear in the patient sector and on recordings and reports.

ECG-CH2 *must* be turned off if you are using the 3-wire lead set to eliminate the `LEADS OFF (MCL)` message.

Warning

If you are using a 3-wire lead set, Hewlett-Packard recommends you do not use `Change Label` except to select the correct labels which reflects the physical placement of the electrodes. This will ensure that the monitored lead and the label match, and prevent any possible confusion.

M1400A/B Transmitter and 5-Wire Lead Set

If you are using a 5-wire lead set, the default leads are displayed and the operation of the leftmost softkey depends on whether your system is configured for lead swap OFF or lead swap ON.

Lead Swap OFF

The default settings for the 5-wire lead set, when you place electrodes in the standard position, are Leads II and MCL. If you choose to reposition the electrodes on the patient's chest, you can change the label of ECG-CH1 to I, III, or MCL, or change the label of ECG-CH2 to I, II, III, MCL or the generic ECG.

Warning

If you are using a 5-wire lead set, Hewlett-Packard recommends you do not use `Change Label` except to select the correct labels which reflects the physical placement of the electrodes. This will ensure that the monitored lead and the label match, and prevent any possible confusion.

Lead Swap ON

When electrodes are in the standard position, you can monitor Leads II and MCL with the 5-wire cable. You can assign either of the two configured leads as ECG-CH1 (the cardiotach lead) without moving electrodes. Changing the lead labels is not possible, but you can configure ECG-CH1 and ECG-CH2 from the list of ECG labels available: ECG-CH1 - I, II, III, MCL; and ECG-CH2 - I, II, III, MCL, ECG, OFF.

Note

The factory default settings are Lead Swap OFF and ECG-CH2 OFF.

Lead Placement for Telemetry Monitoring

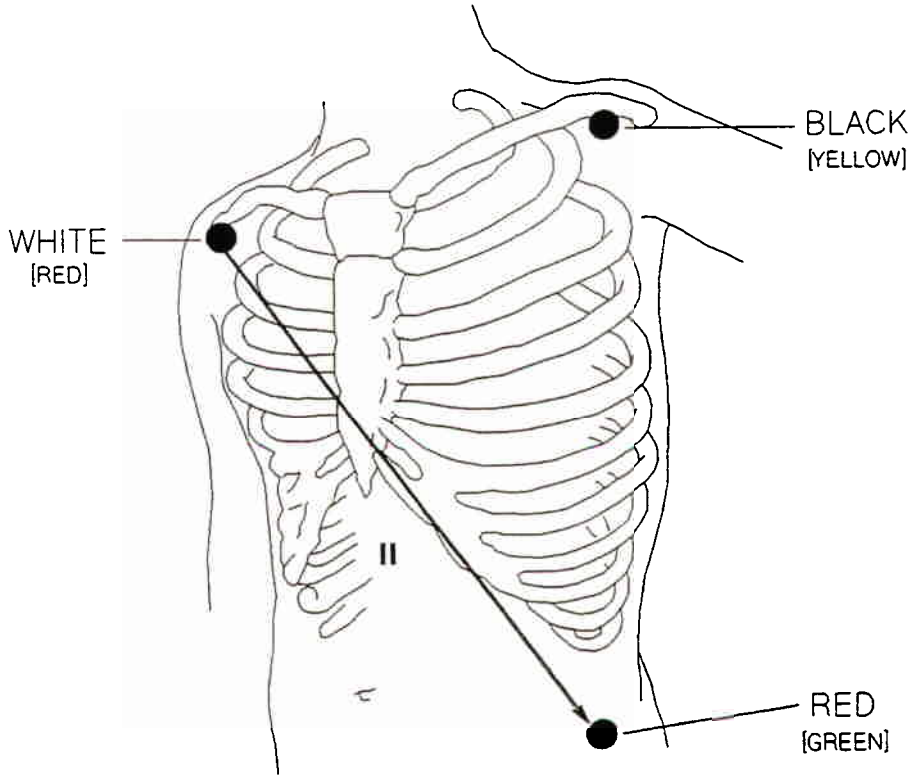
Note

To ensure patient safety, all leads must be attached to the patient.

Electrode labels and colors are given for U.S norms. International colors are shown in brackets.

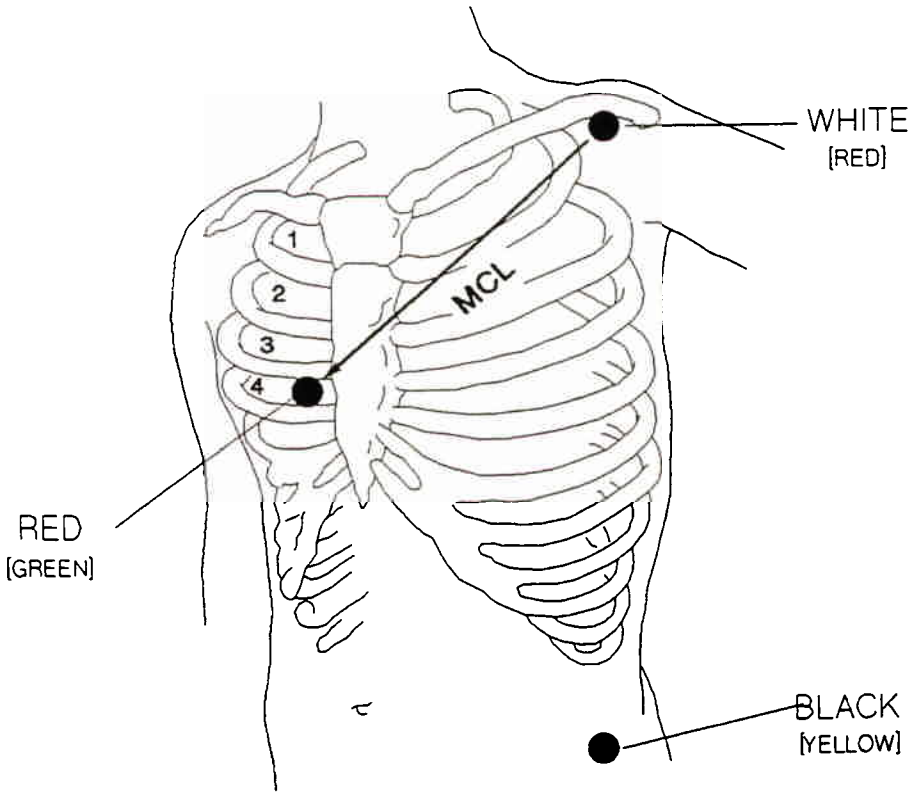
3-wire Lead Set

Standard Placement: enables monitoring of Lead II.



- White(RA) electrode - place directly below the clavicle and near the right shoulder.
- Black(LA) electrode - place directly below the clavicle and near the left shoulder.
- Red(LL) electrode - place in left lower abdomen.

Marriott Configuration: enables monitoring of MCL_1. This lead configuration is not available for 3-wire lead sets with Lead Select ON (HP Viridia transmitters only).

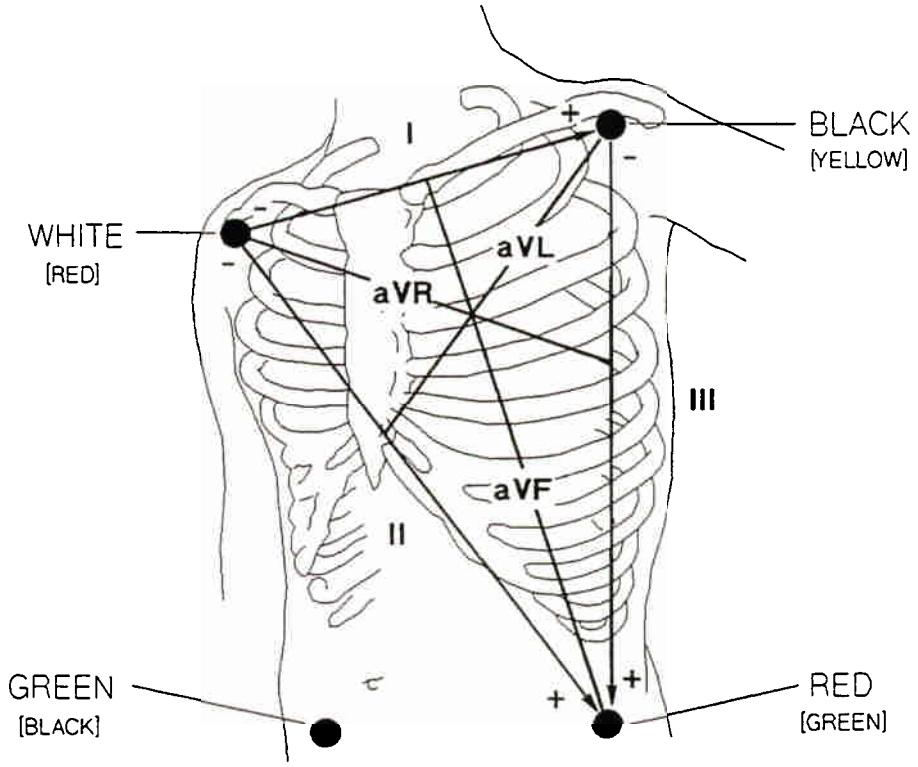


If you choose to monitor MCL_1 with a 3-wire lead set, this is the electrode placement that is required.

- White(RA) electrode - place directly below the clavicle and near the left shoulder.
- Red(LL) electrode - place on the 4th intercostal space at the right sternal border.
- Black(LA) electrode - place in left lower abdomen.

4-Wire Lead Set (M1400A/B transmitter only)

Standard Placement: enables monitoring of up to two leads of ECG, and lead selection of Leads I, II, III and aVL, aVR and aVF.



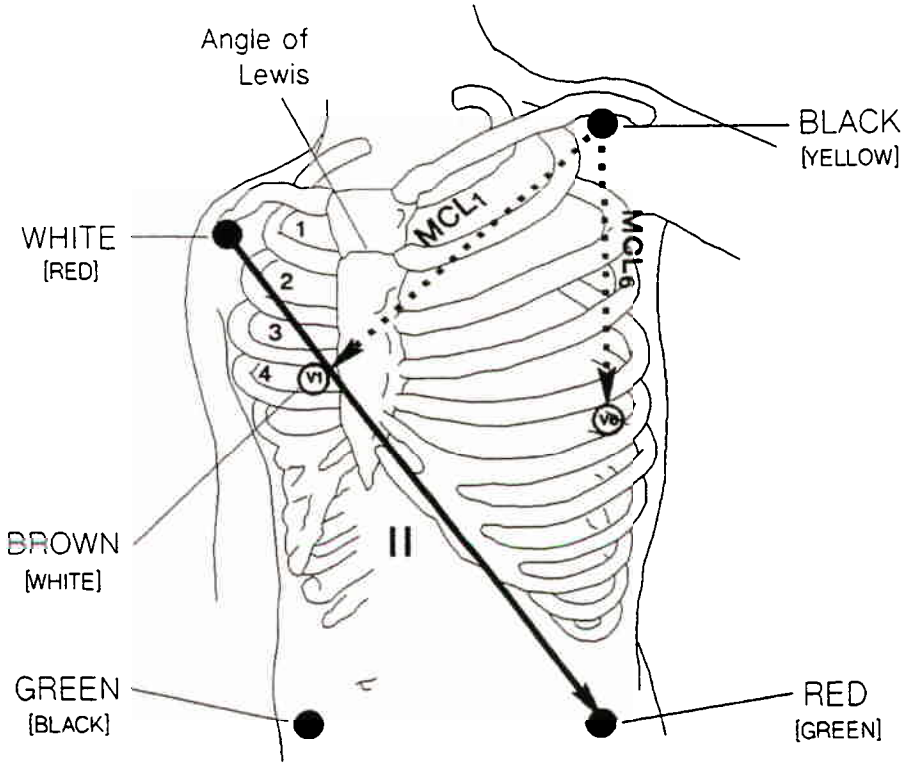
- White(RA) electrode - place directly below the clavicle and near the right shoulder.
- Black(LA) electrode - place directly below the clavicle and near the left shoulder.
- Green(REF) electrode - place in right lower abdomen.
- Red(LL) electrode - place in left lower abdomen.

5-Wire Patient Lead Set

Note

HP M1400A/B transmitters: Standard Placement enables monitoring of Leads II and MCL_1 or MCL_6. The telemetry system produces bipolar leads only (for example, MCL_1, not V_1).

HP Viridia Transmitter: Standard Placement enables monitoring of limb and precordial leads.



- White(RA) electrode - place directly below the clavicle and near the right shoulder.

- Black(LA) electrode - place directly below the clavicle and near the left shoulder.
- Green(REF) electrode - place in right lower abdomen.
- Red(LL) electrode - place in left lower abdomen.
- Brown(V) electrode - place on the chest as illustrated:

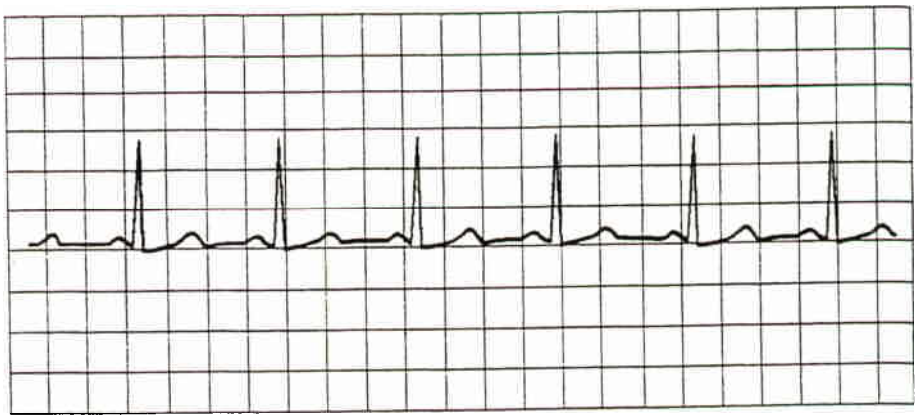
  For MCL_1, on the 4th intercostal space at the right sternal border.

  For MCL_6, V6 on the left midaxillary line, horizontal with V4 electrode.

Note

For accurate V lead electrode placement and monitoring it is important to locate the 4th intercostal space. The 4th intercostal space is determined by first locating the 1st intercostal space. Because patients vary with respect to body shape, it is difficult to palpate the 1st intercostal space with accuracy. Thus, locate the 2nd intercostal space by first palpating the little bony prominence, called the **Angle of Lewis**, where the body of the sternum joins the manubrium. This rise in the sternum identifies where the second rib is attached, and the space just below it is the second intercostal space. Palpate and count down the chest until you locate the 4th intercostal space.

Characteristics of a Good ECG Signal



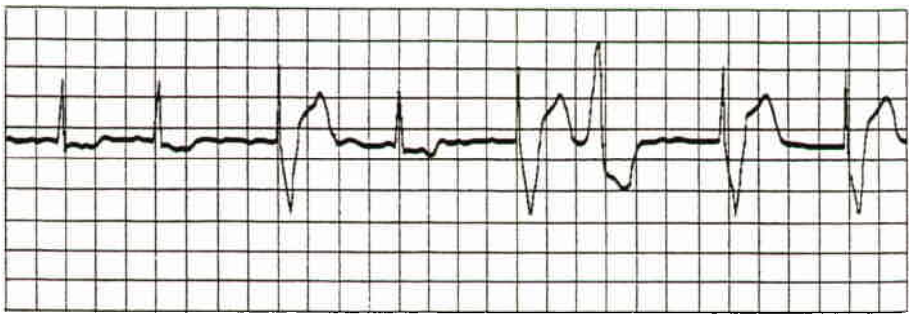
The QRS is:

- completely above or below the baseline.
- 2-3 times the size of the P and T wave.
- free from artifact and baseline wander.

Note

If you are not receiving a good ECG waveform and the electrodes are securely placed, you should try changing the lead in which you are monitoring.

Characteristics of a Good ECG for Arrhythmia Monitoring



The QRS is:

- tall and narrow, and ectopics are wider and differently shaped.
- free from artifact and baseline wander.
- the same size as other QRSs (stable amplitude).
- larger than the P wave, T wave and pace pulses.
- large enough to fill at least 1/2 the sector without clipping.

Tips for ECG Telemetry Monitoring

Do

- Take time to properly prepare the patient's skin before applying electrodes (see "Patient Preparation" in this chapter).
- Position the electrodes following the diagram on the transmitter.
- Check the waveform at wave viewer to verify correct electrode positioning.
- Support the transmitter and if needed, tape the lead wires to the chest to prevent traction on the electrodes.
- Use appropriate bandwidths.
- Respond promptly to INOP conditions to prevent loss of monitoring.
- Teach the patient how and when to press the transmitter button.
- M1400A/B transmitter: Remove the battery when the transmitter is stored.
- HP Viridia transmitter: If configured, the transmitter automatically shuts off if all leads are off for more than 10 minutes. If not configured for automatic shutoff, remove the battery when the transmitter is stored.

Don't

- Place electrodes on areas subject to movement.
- Mix electrode brands.
- Use alcohol or other solvents to cleanse the skin.
- Apply skin drying substances to area under the electrode gel.
- Immerse the transmitter for cleaning longer than 5 minutes. See Chapter 8, "Cleaning and Disinfection".

3

SpO_2 Monitoring

Introduction to SpO_2 Monitoring

This chapter provides an introduction to the SpO_2 measurement and its application. The information under "Optimizing Your System's Performance" in Chapter 2 also applies when monitoring SpO_2.

Topics include:

- What does SpO_2 Measure?
- Measurement Limitations
- SpO_2 Transducers - Selection and Application

What does SpO_2 Measure?

The SpO_2 parameter measures the arterial oxygen saturation. That is, the percentage of oxygenated hemoglobin in relation to the total hemoglobin.

If, for example, a total of 97% of the hemoglobin molecules in the red blood cells of the *arterial* blood combine with oxygen, then the blood has an oxygen saturation of 97%. The SpO_2 numeric on the monitor will read 97%. The SpO_2 numeric indicates the percentage of hemoglobin molecules which have combined with oxygen molecules to form oxyhemoglobin.

- The oxygen saturation is measured using the pulse oximetry method. This is a continuous, noninvasive method of measuring the arterial hemoglobin oxygen saturation. It measures how much light, sent from light sources on one side of the transducer, travels

through patient tissue (such as a finger or an ear), to a receiver on the other side.

- The amount of light getting through depends on many factors, most of which are constant, such as tissue or venous blood). However one of the factors, the blood flow in the arterioles, varies with time - because it is pulsatile.

  This measurement principle is used to derive the SpO_2 measurement. The numeric that is displayed at the central monitor is the Oxygen saturation of the arterial blood - the measurement of light absorption during a pulsation.

Warnings

- **When the specified *NELLCOR*® transducers are used, the application must be consistent with the manufacturer's own guidelines.**
- **Prolonged, continuous monitoring may increase the risk of changes in skin characteristics, such as irritation, reddening, blistering or pressure necrosis, particularly on patients with impaired perfusion and varying or immature skin morphology. Specific attention must be given to sensor site inspection for changes in skin quality, proper optical path alignment and attachment. Check the application site at regular intervals and change the site if any compromise in skin quality should occur. More frequent checking may be required due to an individual patient's condition.**
- **Setting the high SpO_2 alarm limit to 100% is equivalent to switching off the high alarm limit. Therefore the upper alarm limit for oxygen saturation must be carefully selected in accordance with accepted clinical practices.**
- **Pulse oximetry can overestimate the SpO_2 value in the presence of Hb-CO, Met-Hb or dye dilution chemicals.**

Note

The SpO_2 alarm delay built into the system is ten seconds. That means that the monitor generates an alarm if the averaged numeric value on the display stays beyond the alarm limit for more than 10 seconds.

Measurement Limitations

Refer to this section on problem situations if you have difficulty getting a signal or obtaining accurate measurements.

1. Distortion, such as ambient light, motion, perfusion or incorrect sensor placement may affect the accuracy of the derived measurements.
2. The measurement depends on the pulsatile nature of blood flow in the arteries and arterioles; with the following conditions arterial blood flow may be reduced to a level at which accurate measurements cannot be made:
   - shock
   - hypothermia
   - use of vasoconstrictive drugs
   - anemia
3. The measurement also depends on the absorption of particular light wavelengths by the oxyhemoglobin and reduced hemoglobin. If other substances are present which absorb the same wavelengths, they will cause a falsely high,or falsely low SpO_2 value to be measured. For example:
   - carboxyhemoglobin
   - methemoglobin
   - methylene blue
   - indocyanine green *
   - indiocarmine *

* These chemicals are used in dye dilution cardiac output calculations.

4. Very high levels of ambient light can also affect the measurement; an SpO_2 `INTERFERENCE.` message will appear on the display. The measurement quality can be improved by covering the transducer with suitable non see-through material.

SpO_2 Transducers

Transducers and Accessories

Disposable Transducers

These should be used once only and then discarded. However, they can be relocated to a different patient-site if the first location does not give the desired results. Disposable transducers must not be reused on different patients.

Reusable Transducers

These can be reused on different patients after being cleaned and disinfected. See instructions in the section "Care and Cleaning" in this chapter. Reusable sensors should be changed to another site regularly.

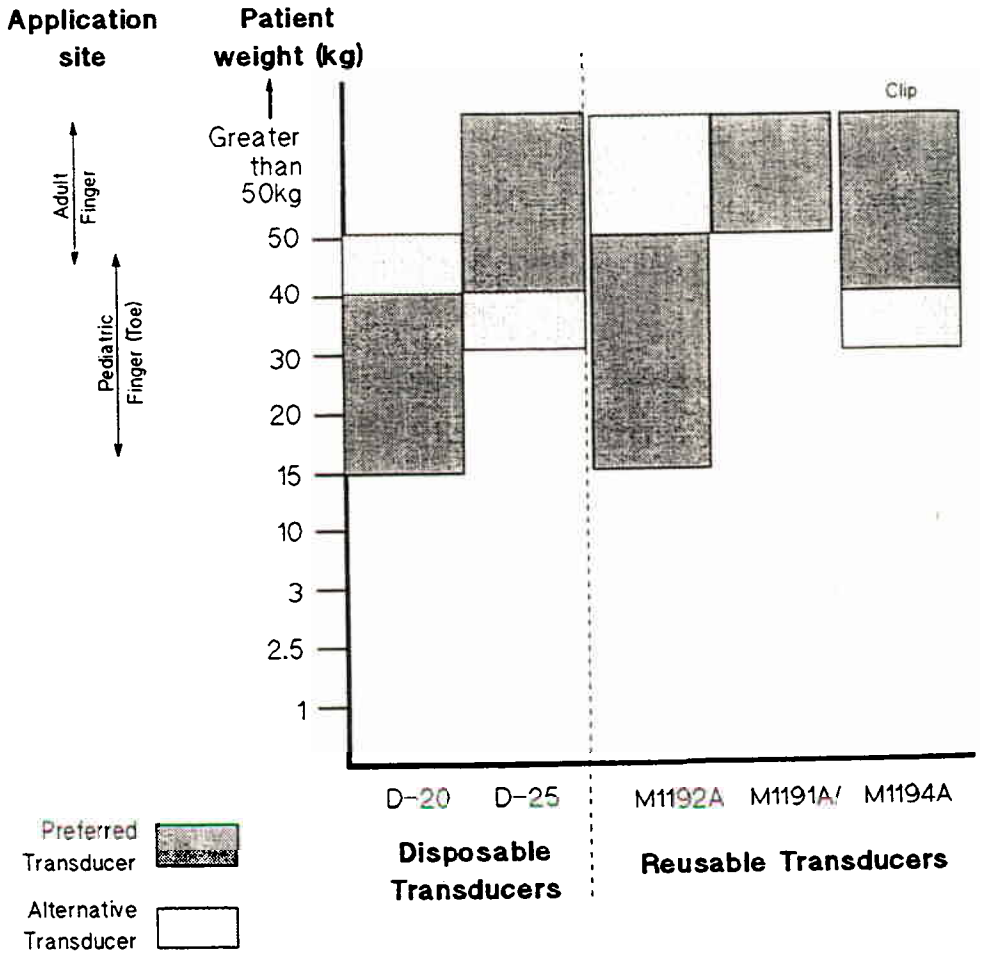
Description	*NELLCOR*® Label	HP Part No.	Qty.
HP Reusable Transducers			
Adult finger		M1191A	1
Pediatric/Small Adult finger		M1192A	1
Adult/Pediatric ear clip		M1194A	1
Disposable Transducers			
Adult digit	Oxisensor II™ D-25	M1904A/B	24
Pediatric finger/toe	Oxisensor II™ D-20	M1903A/B	24
Accessories			
Adaptor cable for disposable transducers		M1943A	1
Wristbands for M1191A transducer		M1627A	10

OXISENSOR II™ is a trademark of *NELLCOR*® Incorporated.

Disposable transducers are not available as HP parts in the USA or Canada. Contact *NELLCOR*® Incorporated.

Transducer Selection

Use the following chart as a guideline to select the most appropriate transducer for your patient. (Note: In the following chart, N-25 and I-20 transducers cannot be used with the HP Viridia Telemetry System.)
Find the patient's weight on the vertical axis, and draw a horizontal line across the chart. Each shaded area that the line passes through represents a transducer which can be used on this patient.
Areas of dark shading indicate that the transducer is the *most appropriate* one in that weight range.
Areas of light shading indicate that the transducer *may* be used in this weight range, even though it is not the most appropriate transducer.

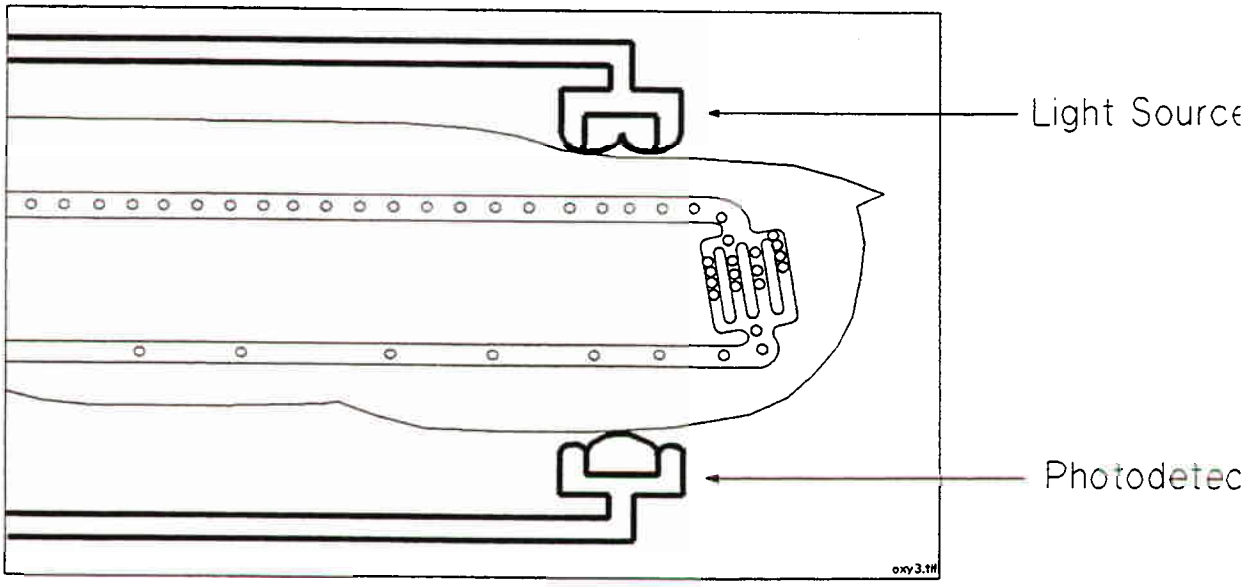


Transducer Application

A minimum pulsatile flow must be present at the application site of your patient to obtain measurements.

Select an appropriate transducer and apply the transducer properly to avoid incorrect measurements. Use one of the preferred application sites for your transducer. Selecting the most suitable transducer and application site will help you to ensure that:

- the light emitter and the photodetector are **directly** opposite each other and that **all** the light from the emitter passes through the patient's tissues,
- the application site is of the correct thickness for light to pass through. If the application site is too thick or too thin, an SpO_2 **NON-PULSATILE** INOP will occur. You should then select another site as appropriate.
- Applying a small amount of pressure at the application site can improve the measurement.



Positioning of the Light Emitters and Photodetector

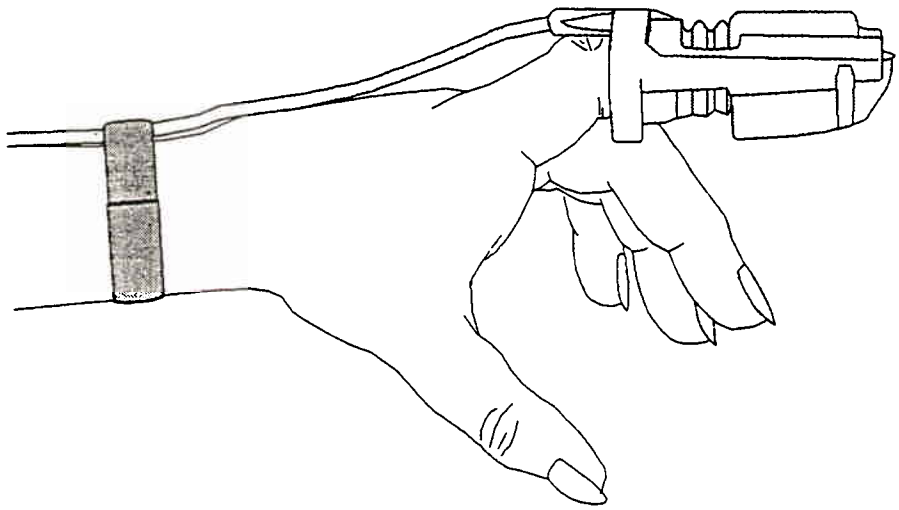
Inspect the application site every 2 to 3 hours to ensure skin integrity and correct optical alignment. If skin integrity changes, move the transducer to another site.

Warning

- **Failure to apply the transducer properly may cause incorrect measurement of SpO_2.**
- **Specific attention must be given to sensor site inspection for changes in skin quality, proper optical path alignment and attachment. Check the application site at regular intervals and change the site if any compromise in skin quality should occur.**
- **Using a transducer during MR imaging can cause severe burns. To minimize this risk, ensure that the cable is positioned so that no inductive loops are formed. If the transducer does not appear to be operating properly, remove it immediately from the patient.**
- **Using a transducer in the presence of bright lights may result in inaccurate measurements. In such cases, cover the site with opaque material.**
- **Injected dyes such as methylene blue or intravascular dyshemoglobins, such as methemoglobin may lead to inaccurate measurements.**
- **Performance may be compromised by excessive motion. This can lead to inaccurate SpO_2 readings.**
- **Avoid placing the SpO_2 transducer on any extremity with an arterial catheter, or intravascular venous infusion line.**
- **Do not use disposable transducers on patients who exhibit allergic reactions to the adhesive.**

Application of the HP Reusable Adult Finger Transducer (M1191A)

Push the transducer over the fingertip in such a way that the fingertip touches but does not protrude from the end of the transducer. The fingernail must be *uppermost* and the cable must lie on the *back* of the hand. This ensures that the light sources cover the base of the fingernail giving the best measurement results. The cable can be held in place by the accompanying wristband.



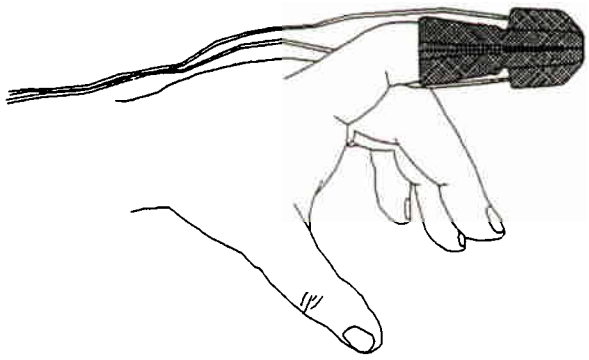
Adult Finger Tranducer

Warning

Failure to apply the transducer properly may cause incorrect measurement of SpO_2. For example, not pushing the transducer far enough over the finger can result in inaccurate SpO_2 readings. Pushing the transducer too far, so that the finger protrudes from the transducer, can pinch the finger, resulting in inaccurately low SpO_2 readings.

Application of the HP Reusable Small Adult/Pediatric Finger Transducer (M1192A)

Push the transducer over the fingertip in such a way tha the fingertip touches but does not protrude from the enc of the transducer.

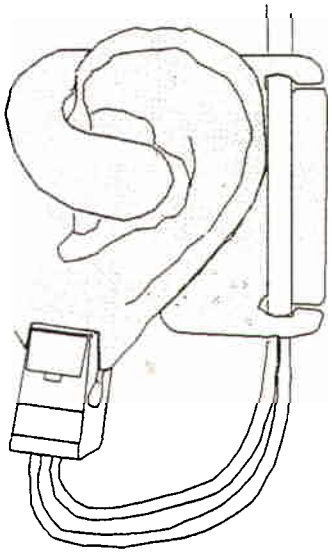


Small Adult/Pediatric Finger Transducer

Warning **Failure to apply the transducer properly may reduce the accuracy of the SpO_2 measurement.**

Application of the HP Reusable Ear Clip Transducer (M1194A)

Clip the probe onto the fleshy part of the ear lobe as shown in the diagram below. The plastic fixing mechanism helps to minimize artifact generated by patient motion. Do not position the probe on cartilage or where it presses against the head.



Ear Clip Transducer

The clip transducer can be used as an alternative if the adult finger transducer does not provide satisfactory results. The preferred application site is the ear lobe, although other application sites with higher perfusion (such as the nostril) can be used. Due to the physiologically lower perfusion in the ear lobe, you should be aware of the reduced accuracy of the measurement and more frequent INOPs.

Warning **Failure to apply the clip transducer properly may reduce the accuracy of the SpO_2 measurement.**

Preparation and Application of Disposable Transducers

See the Directions for Use supplied by *NELLCOR®* Incorporated for instructions on preparation and application of disposable transducers.

Warning 

When the specified *NELLCOR®* transducers are used, the application must be consistent with the manufacturer's own guidelines.

Optimizing Transducer Performance

To get the best results from your SpO_2 reusable transducer:

- Always handle the transducer and cable with care. The soft finger sleeve houses a sensitive electronic device that can be damaged by harsh treatment. Always protect the cable from sharp-edged objects.
- Use the wristband that is supplied with your M1191A transducer. By keeping the cable between the finger transducer and the wristband fairly loose, you will maintain good monitoring conditions.

Normal wear and tear associated with patient movement and regular transducer cleaning naturally mean that your transducer will have a limited lifetime. However, provided you handle the transducer and its cable with care, you can expect useful service from it for up to two years. Harsh treatment will drastically reduce the lifetime of the transducer. Moreover, HP's warranty agreement shall not apply to defects arising from improper use.