Onyx® II
Model 9560 Bluetooth® Fingertip Pulse Oximeter
OEM Specification and Technical Information

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1 Change Log

This section provides a brief description of the changes incorporated into the release document.

- Addition of this section along with the Acronyms and Abbreviations section.
- Addition of Security Mode, Authentication and Encryption information in Specifications section.
- Added software revisions for which this document applies to section 4.2.1.
- Changed the discoverable time in section 4.3.1 from 2 minutes to 90 seconds.
- Added additional notes in section 4.3.1.
- Added section 4.3.2., Unpairing.
- Updated section 4.3.3 for clarity and completeness.
- Added response information to section 4.5.2.1., Setting the Date and Time.
- Added section 4.5.3., Retrieving the Model Number from the 9560.
- Added section 4.5.5., Retrieving the Revision Number in the 9560
- Added information regarding the serial number to section 4.5.6.3.
- General formatting changes and clarification.

2 Specifications

Oxygen Saturation Range (SpO_2)	0 % to 100 %
Pulse Rate Range	18 to 321 beats per minute (BPM)
Measurement Wavelengths and Output Power*	
Red:	660 nanometers @ 0.8 mW maximum average
Infrared (using Nonin PureLight® Sensor):	910 nanometers @ 1.2 mW maximum average
SpO_2 Accuracy (A_{rms})**	70 % to 100 %
Oxygen Saturation Accuracy:	± 2 digits
Low Perfusion Oxygen Saturation Accuracy:	± 2 digits
Pulse Rate Accuracy (A_{rms})**	
Pulse Rate Accuracy (20 – 250 BPM):	± 3 digits
Low Perfusion Pulse Rate Accuracy (40 – 240 BPM):	± 3 digits
Internal Power	
Battery:	Two 1.5 volt AAA batteries
Operating Life:	600 spot-checks (30 sec/spot-check) in a 6 month period.
Storage Life:	12 months
Weight	63 grams with batteries installed
Temperature	
Operating:	+5 °C to +40 °C (+41 °F to +104 °F)
Storage/Transportation:	-40 °C to +70 °C (-40 °F to +158 °F)***
Operating Altitude	Up to 12,192 meters (40,000 feet)
Hyperbaric Pressure	Up to 4 atmospheres
Humidity	
Operating:	10 % to 95 % relative humidity, non-condensing
Storage/Transportation:	10 % to 95 % relative humidity, non-condensing Allow to stabilize
Enclosure Degree of Ingress Protection	IP32

* This information is especially useful for clinicians performing photodynamic therapy.
** ±1 A_{rms} represents approximately 68% of measurements.
*** When the Model 9560 is transferred from a non-operating temperature/humidity condition, allow one hour of stabilization to operating temperature/humidity specifications prior to use.

Bluetooth Information

Bluetooth Compliance:	Version 2.0
Operating Frequency:	2.4 to 2.4835 GHz
Output Power:	<20dBm
Operating Range:	100 meter (328 ft) radius[1]
Network Topology:	Star
Operation:	Slave:
	Model 9560
Antenna Type:	L-shaped PWB whip-type antenna
Modulation Type:	Frequency Shift Keying
	Frequency Hopping Spread Spectrum
Bandwidth:	1 MHz
Bluetooth Profiles Supported:	Health Device Profile (HDP), Serial Port Profile (SPP)
Security Mode:	Mode 2 (service level enforced security)
Authentication and Encryption:	Enforced on all data channels (outgoing and incoming)
Encryption Key Size:	Up to 128 bits

Dimensions 3.23 cm (1.27 in.) x 6.40 cm (2.52 in.) x 3.78 cm (1.49 in.) (W x H x D)

Ruggedness

Shock:	IEC 60068-2-27
Vibration:	Sinusoidal – IEC 60068-2-6 Random – IEC 60068-2-64, IEC 60068-2-36 Bump – IEC 60068-2-29

Warranty 4 years from the date of purchase.

RoHS Compliance EU Directive 2002/95/EC

[1] Line of sight when connected to a class 1 device.

3 Acronyms and Abbreviations

ACK	Acknowledge
A_{rms}	Accuracy (root mean square)
ARTF	Artifact
ATR	Attempt To Reconnect
BAT	Battery
B-B	Beat to Beat
BCD	Binary Coded Decimal
BPM	Beats per Minute
C	Celsius
CHK	Checksum
cm	Centimeter
D	Depth
dBm	Decibel
DD	Day
DF	Data Format
E	Extended
ETX	End of Transmission
EU	European Union
F	Fahrenheit
ft	Feet
GHz	Gigahertz
GPRF	Yellow Perfusion
H	Height
HDP	Health Device Profile
hh	Hour
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
in.	Inches
ISO	International Standards Organization
LSB	Least Significant Byte
MCAP	Multi-Channel Adaption Protocol
MHz	Megahertz
MM	Month
mm	Minute
MSB	Most Significant Byte
mW	Milliwatts
NAK	Not Acknowledged
OOT	Out Of Track
PIN	Personal Identification Number
PR	Pulse Rate
PR-D	4-beat Pulse Rate Average
PWB	Printed Wiring Board
R	Reserved
RPRF	Red Perfusion
RS	Recommended Standard
SIG	Special Interest Group
SNSA	Sensor Alarm
SPA	Smart Point Measurement
SpO_2	Saturation Peripheral Oxygen
SpO_2-D	4-beat SpO_2 Average
SPP	Serial Port Profile
SREV	Oximeter Firmware Revision Level
ss	Second
STAT	Status
STX	Start of Transmission
TMR	Timer
W	Width
YPRF	Green Perfusion
YY	Year

4 Model 9560 Bluetooth® Profiles

The Health Device Profile (HDP) and the Serial Port Profile (SPP) are the two profiles available for a Bluetooth connection. If a successful HDP connection cannot be made, an SPP connection will be attempted.

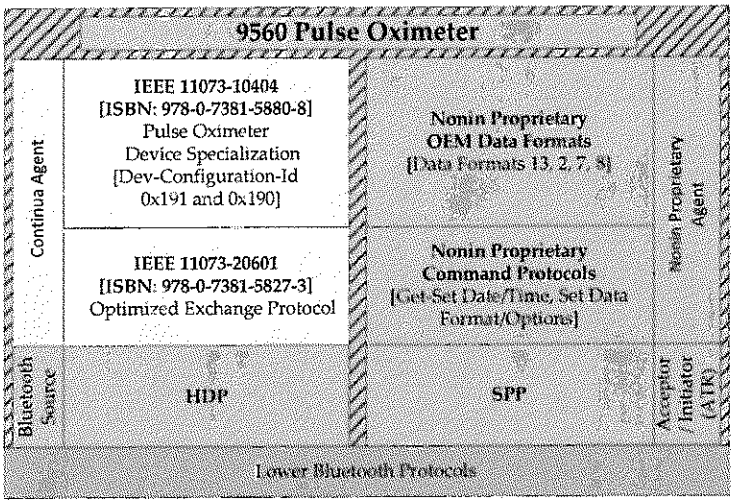

Figure 1: Bluetooth Profiles

4.1 Health Device Profile (HDP)

This Bluetooth profile defines a connection for qualified healthcare and fitness devices. These devices are called source and sink devices. Source devices include pulse oximeters (9560), weight scales, glucose meters, thermometers and blood pressure monitors. Sink devices include mobile phones, desktop and laptop computers, and health appliances.

For more information on the HDP specification, please refer to www.bluetooth.com for publically available HDP and MCAP specfications. Further information regarding testing can be obtained by joining the Bluetooth SIG at www.bluetooth.org.

Note: Selection of HDP is required to meet Continua Guidelines.

Further information regarding Continua Health Alliance and related specifications can be obtained by applying for membership at www.continuahealthalliance.org.

4.1.1 Communications Interface (HDP)

The Health Device Profile (HDP) operates with the ISO/IEEE 11073-20601 Personal Health Data Exchange Protocol. The device specialization for a Pulse Oximeter, ISO/IEEE 11073-10404, provides interoperability for the Model 9560 as a pulse oximeter when HDP is selected. Dev-Configuration-Id 0x191 (default) and 0x190 are supported.

For more information on the IEEE specifications, please consult www.ieee.org.

4.2 Serial Port Profile (SPP)

This Bluetooth profile defines an emulated serial port / RS-232 cable replacement between two Bluetooth devices. These devices are called acceptors and initiators. The 9560 can be configured to be either an acceptor or initiator. In the factory default, the 9560 is configured to be an initiator, using a feature called Attempt-To-Reconnect (ATR). The ATR feature can be disabled under certain conditions and once disabled the 9560 works as an acceptor.

4.2.1 Communications Interface (SPP)

The 9560 features a command protocol interface that enables the configuration of internal settings and the selection of predefined data format solutions.

Data Format Solutions:

- Data Format 13 (default) – provides easy spot-check measurements with the capability to store and forward measurements. This is the factory default for our standard offering. The 9560 acts as an initiator, however you can configure the 9560 to work as an acceptor only by disabling the ATR bit in DF13.
- Data Format 2 – provides real-time oximetry measurements with compressed waveform (8 bit waveform) every 1/3 of a second. The 9560 acts as acceptor only.
- Data Format 7 – provides real-time oximetry measurements with full resolution waveform (16 bit waveform) every 1/3 of a second. The 9560 acts as acceptor only.
- Data Format 8 – provides real-time oximetry measurements every second. The 9560 acts as acceptor only.

Note: The remainder of this document describes Nonin's proprietary protocols over the Serial Port Profile (SPP). The information below applies to software revision r147 or greater of the oximeter module and revision r6 or greater of the Bluetooth module.

4.3 Connection Details

Data Format 13, with ATR (attempt-to-reconnect) enabled, is the default data format for the 9560 device. See section 4.5.1, Selecting the Data Format, for instructions to change the data format. ATR assists the 9560 in being a true spot check device, where the system to which the 9560 is transferring information is an automatic connection. The system does not need to actively search for the 9560.

4.3.1 Pairing

In Bluetooth communications terms, the 9560 is a slave device (figure 2). To connect the 9560 to a master device, the master device must first associate with the 9560 and initiate the connection by inquiring for the 9560.

To be discoverable, the 9560 must be powered on with a finger inserted. The 9560 will be discoverable for 90 seconds with the finger inserted. During the master device's inquiry of the slave, the 9560 (as the slave) will provide a friendly name starting with "Nonin_Medical_Inc._" and followed by a six digit number, referred to as the PIN, to the master. The PIN is etched on the battery door and is the same as the last six digits of the serial number. The master device must follow the inquiry process by pairing.

To complete the pairing process the Bluetooth PIN must be provided by the master device. It is at this point that the master device can connect to the 9560.

Notes:

- If the 9560 is using DF13 with ATR enabled and is paired to a remote device, the 9560 will not be discoverable unless the remote device with which it is paired disables its Bluetooth or is out of range.
- While the 9560 is in a connection, it will not be discoverable regardless of the data format.
- The 9560 can only be paired with a single master at any given time.
- When using the 9560 as an acceptor, to allow the 9560 to properly turn-off, do not reconnect to the 9560 sooner than 15 seconds after a Bluetooth connection is dropped or lost.
- When using the 9560 as an initiator, do not actively poll/search for the 9560.
- If the pairing information is deleted from a device with which the 9560 has been paired, and the 9560 has not been paired with another device, the next time pairing is attempted using this device, a PIN of "0000" may need to be used if the normal 6 digit PIN does not work.
- Nonin Medical recommends the use of the following Bluetooth stacks: Toshiba, Microsoft or Widcomm

4.3.2 Unpairing

Steps to delete the pairing information on the 9560 or to make the 9560 forget its previously paired device.

1. Disable the Bluetooth stack on the device with which the 9560 has been previously paired.
2. Pair the 9560 with any other Bluetooth device, e.g. a phone or some other computer. Pairing with a new device will cause the 9560 to forget the previous one.
3. Start the Bluetooth stack on the device which with the 9560 was previously paired and delete any shortcuts for the 9560 and then unpair the 9560.
4. Confirm that the 9560 has "forgotten" by trying to connect to it. No incoming connection notification should be seen.

Note: If your device deletes the Bluetooth Security Link Key, make sure to follow our unpairing process to delete the link key on the 9560. If this is process is not followed, the 9560 will not be discoverable.

4.3.3 Connection Details for Data Format 13

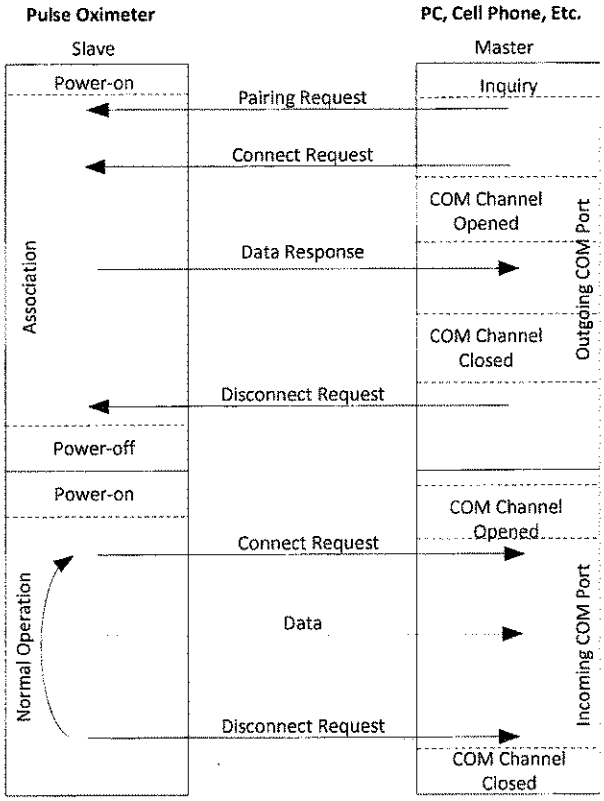

Figure 2: DF13 with ATR Enabled

If the 9560 is using DF#13 it can be configured to use the Attempt to Reconnect (ATR) feature. If ATR is enabled, during power-up, the 9560 will search for the last device it was paired with and attempt to pair with it. Note that the 9560 remembers the previous master device it was connected to and will not be discoverable unless that master device is turned off or not in range. During this process COM ports will be assigned. The master will then disconnect (refer to figure 2).The master device must have two COM ports available if DF#13 w/ Attempt to Reconnect (ATR) enabled is used.

The next power-on of the 9560 will result in a connection request to the master device with which it is paired on the first SPP server channel which is reported by the master device. The 9560 will connect as a preferred slave acting as a master. The receiving device must accept the connection after receiving the request. It is at

this point that a role switch within the Bluetooth lower protocol layers can occur to switch the 9560 back to being a slave and promote the receiving device to be the master.

If the original master which initiated the inquiry is not available, the 9560 will store the oximetry measurement into memory for transmission after the next power-on.

The 9560 will be discoverable during this process for 90 seconds. The Bluetooth service name will be whatever is associated with the first SPP server channel.

Depending on the Bluetooth stack or hardware used, the PIN may need to be re-entered. If PIN entry is required at each subsequent connection you may need to change your stack settings so the stack will retain the previous device's key.

This "connect-back" option can be disabled if the data format selection option is used. See ATR (Attempt to Reconnect) in section 4.5.1 Selecting the Data Format.

Note: If ATR is not enabled, a connection must be initiated from the remote device before communication can begin. The 9560 will not initiate a connection.

4.3.4 Connection Details for Data Formats 2, 7, 8 and 13 (with ATR Disabled)

For Data Formats 2, 7 and 8, the 9560 will not initiate the connection. If your system has only one COM port available, use of these alternate data formats is recommended. (The default Data Format 13 can be used, but ATR must be disabled using the Selecting the Data Format process below, section 4.5.1 Selecting the Data Format.) The master device must initiate the connection by occasionally polling for the 9560 (refer to figure 3) This is because the 9560 may pass in and out of range.

The 9560 will be available for connection to a new master once it has been disconnected from its current master. This disconnection may be due to a connection drop of any kind (i.e. out of range, master radio is shut off, or the connection is closed by the master).

After the connection is made, the 9560 will automatically send continuous data to the master.

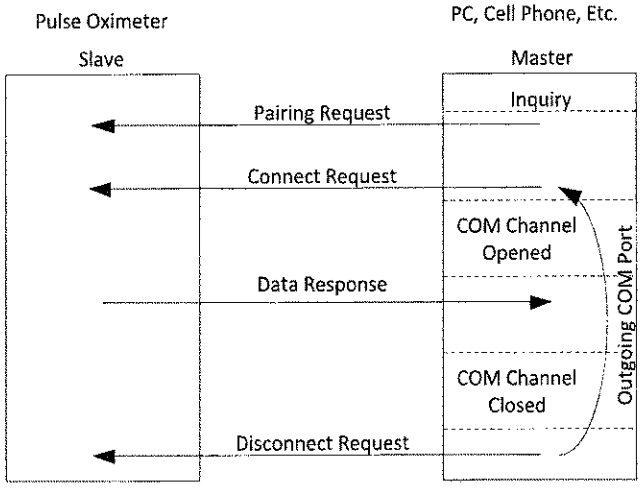

Figure 3: Data Formats 2, 7 and 8

Note: A Bluetooth connection indicator is not available on the 9560 product.

4.4 SmartPoint™ Algorithm

The SmartPoint algorithm provides a fast and accurate snapshot of the patient's SpO_2 and pulse rate and eliminates the guesswork in determining which oximetry values to use for analysis. The SmartPoint algorithm automatically determines when a high quality measurement is ready to be transmitted. Each measurement includes an indicator of quality.

The 9560 will typically acquire a SmartPoint measurement within 40 seconds from power-on. If the 9560 is unable to detect a high quality measurement due to such pulse conditions like low perfusion (weak pulse signal conditions) or artifact, the 9560 will send the current measurement and indicate in the packet that the measurement did not meet the criteria for SmartPoint quality.

4.5 Command Protocols

Once the Bluetooth connection is established, the 9560 receives and transmits data using the SPP protocol with the following settings:

Table 1: SPP Settings

Bits per Second	Data Bits	Parity	Stop Bits	Flow Control
9600 Minimum	8	None	1	None

Note: Throughout this document all values are in decimal unless otherwise noted. The decimal number must be converted to 8 bit hex for data transmission. A hex value will be described with this format: 0xZZ, where ZZ is the hex value with a range of 0x00 to 0xFF.

During an active connection, there are several commands which may be sent from the connected device to the 9560.

These commands include:

- Selecting the Data Format
- Setting/Retrieving the Date and Time in the 9560
- Retrieving the Serial Number from the 9560
- Retrieving the Revision Number in the 9560

Note: After a successful connection there is a 5-second window where uninterrupted communication can take place. After the initial 5 seconds, the use of these commands will interrupt continuous Data Formats 2, 7, and 8.

4.5.1 Selecting the Data Format

To select the data format the host on the master side must send the 9560 the following 8 byte command:

Table 2: Data Format Selection

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
Start(STX)	Op Code	Data Size	Data Type	Data Format	Options	Checksum	End (ETX)
0x02	0x70	0x04	0x02	0xZZ where ZZ is (0x02, 0x07, 0x08 or 0x0D)	Format Specific	0x76 + Data Format + Options	0x03

The Options field (byte 6) is only vaild when the Data Format field (byte 5) is set to 0x0D (Data Format 13), for all other data formats, please set this byte to 0x00.

For Data Format 13, Options are set as follows:

Table 3: DF13 Options

	Bit 7 (ATR)	Bit 6 Reserved	Bit 0 through Bit 5 Expansion Options
Byte 6 (DF13) Options	0 = Enabled (Default) 1 = Disabled	Set to 0	0 = Disabled (Default) 1 = Enabled (Append SN) 2 through 63 = reserved, do not use

Response: After receiving a data format command, the 9560 will respond with an ACK (0x06) for a supported format or NAK (0x15) for an unsupported format.

Alternatively for legacy devices, this can be a 6 byte selection if the Options are not required. Simply ignore columns containing Options byte (byte 6) and Checksum byte (byte 7) and adjust the Data Size byte to 0x02. In this case for Data Format 13, to set the ATR (Attempt to Reconnect) option to FALSE, set Byte 4 to 0x00 and byte 5 to 0x02.

Once the data format is changed, the 9560 will retain the new data format until it is changed to a different data format. Because the data format is retained in non-volatile memory, the data format will be retained after a battery change. If the data format is not changed the 9560 will default initially from the factory to data format 13 with the ATR option set to TRUE.

Example: To change the data format from the default of DF13 with no serial expansion option and ATR enabled to DF13 with the serial expansion option enabled and ATR enabled, send the following command:

02 70 04 02 0D 01 84 03

To change the device back to the default without the option, send the following command:

02 70 04 02 0D 00 83 03

4.5.2 Setting / Retrieving the Date and Time in the 9560

The host on the master side can set and retrieve the date and time from the 9560. The date and time must conform to the ranges defined below. The date and time will be lost when replacing the batteries.

Table 4: Date/Time Range

Name	Decimal Range
YY (year)	00-99
MM (month)	1-12
DD (day)	1-31*
hh (hour)	0-23
mm (minute)	0-59
ss (second)	0-59

*Depends on leap-year, and month for accurate range

4.5.2.1 Setting the Date and Time

To set the date and time in the 9560 the host on the master side must send the 9560 a 10 byte command:

Table 5: Set Date/Time

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10
Start(STX)	Op Code	Data Size	Year	Month	Day	Hour	Minute	Second	ETX
0x02	0x72	0x06	YY	MM	DD	hh	mm	ss	0x03

Example:

Date: 12-31-2050 & Time: 14:30:15 (Hours:Minutes:Seconds)

Table 6: Date/Time Example

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10
Start(STX)	Op Code	Data Size	Year	Month	Day	Hour	Minute	Second	ETX
0x02	0x72	0x06	0x32	0x0C	0x1F	0x0E	0x1E	0x0F	0x03

Response: The master device will receive a single byte response, either an ACK (0x06) or a NAK (0x15). An ACK indicates that the new date/time has been accepted. A NAK indicates that the 9560 has received an invalid date/time command or an invalid value for the date/time.

Responses are asynchronous and will be encapsulated within any active data stream.

Example:

For an ACK, the master will receive:

Table 7: Byte 1

Byte 1
ACK
0x06

4.5.2.2 Retrieving the Date and Time

To retrieve the date and time from the 9560, the host on the master side must send a 4 byte command:

Table 8: Retrieve Date/Time

Byte 1	Byte 2	Byte 3	Byte 4
Start(STX)	Op Code	Data Size	End (Etx)
0x02	0x72	0x00	0x03

Response: The 9560 sends the date and time as part of the following 10 bytes:

Table 9: Date/Time Response

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10
Start(STX)	Op Code	Data Size	Year	Month	Day	Hour	Minute	Second	ETX
0x02	0xF2	0x06	YY	MM	DD	hh	mm	ss	0x03

4.5.3 Retrieving the Model Number from the 9560

To retrieve the model number from the 9560, the host must send a 6 byte command:

Table 10: Retrieve Serial Number

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Start (STX)	Op Code	Data Size	ID Code	Checksum	End(ETX)
0x02	0x74	0x02	0x05	0x05	0x03

Response: The 9560 responds as described in the following 11 bytes:

Table 11: Model Number Response

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5 through Byte 9	Byte 10	Byte 11
Start (STX)	Op Code	Data Size	ID Code	Model Number	Checksum	ETX
0x02	0xF4	0x07	0x05	"9560" with null terminator ("\0")	Sum of Byte 4 through Byte 9	0x03

Note: The "Retrieve Model Number" command is only supported in firmware version 152 or later. The firmware revision is displayed when device is powered on.

4.5.4 Retrieving the Serial Number from the 9560

To retrieve the serial number from the 9560 (Rev 147 and later), the host on the master side must send a 6 byte command:

Table 12: Retrieve Serial Number

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Start (STX)	Op Code	Data Size	ID Code	Checksum	End(ETX)
0x02	0x74	0x02	0x02	0x02	0x03

Response: The 9560 sends the serial number as part of the following 15 bytes:

Table 13: Serial Number Response

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5 through Byte 13	Byte 14	Byte 15
Start (STX)	Op Code	Data Size	ID Code	Serial Number, MSB first	Checksum	ETX
0x02	0xF4	0x0B	0x02	9 digit Serial Number	Sum of Byte 4 through Byte 13	0x03

4.5.5 Retrieving the Revision Number in the 9560

The application of the master device can retrieve the software revision number of both the oximeter and the Bluetooth modules using the "Get Revision" command. This command can be used at any point during an active Bluetooth connection. Responses to this command are asynchronous and will be encapsulated within any active data stream.

To get the software revision levels in the 9560 the host on the master side must send the 9560 the following 4 byte command:

Table 14: Get Revision Number

Byte 1	Byte 2	Byte 3	Byte 4
Start (STX)	Op Code	Data Size	End (ETX)
0x02	0x73	0x00	0x03

Response:

The 9560 sends the revision numbers as part of the following 6 bytes:

Table 15: Revision Number Response

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Start (STX)	Op Code	Data Size	Rev1 Oximeter Module	Rev2 Bluetooth Module	End (ETX)
0x02	0xF3	0x02	R1	R2	0x03

where R1 and R2 are the revision numbers of the oximeter module and the Bluetooth module respectively. Each revision is a binary number in a single byte. If the value for the Bluetooth module's revision is determined to be invalid, a value of zero will be sent.

4.5.6 Serial Data Format #13

Data format #13 attempts to send only one measurement when a SmartPoint measurement is available or after 40 seconds from power-on. The leftmost segments of the top 7-segment display flash while acquiring the measurement. The segments will stop flashing after a measurement is transmitted, or in the event that a wireless transmission is not possible, or when the measurement is stored into memory. The Bluetooth radio will deactivate 15 seconds after data has been transmitted or stored.

4.5.6.1 Packet Description

The data format #13 packet includes 6 bytes of header information, a minimum of 14 bytes of spot-check data, and 2 bytes of footer information. To determine the total length for the expandable Spot-check data, the host must capture the data length from bytes 5 and 6 of the header. With the minimum data length of 14, the data length defined in bytes 5 and 6 will be (0x00) (0x0E) (14 bytes decimal).

The spot-check data consists of the time of spot-check, SpO_2, Pulse Rate, and status.

Table 16: Spot Check Data

	Byte #	Data	Information	Format
Header	1	00	NULL start sync	Hex
	2	02	STX – start of packet	Hex
	3	00	Packet type MSB	Hex
	4	0D	Packet type LSB	Hex
	5	00	Data Length MSB (variable)	Hex
	6	0E	Data Length LSB (variable)	Hex
Expandable Spot-check Data [see notes]	7	20	Hundreds place of Year (default to 20)	BCD
	8	Year of Measurement	Year of Measurement (00-99)	BCD
	9	Month of Measurement	Month of Measurement (01-12)	BCD
	10	Day of Measurement	Day of Measurement (01-31 depending on the month)	BCD
	11	Hour of Measurement	Hour of Measurement (00-23)	BCD
	12	Minute of Measurement	Minute of Measurement (00-59)	BCD
	13	Second of Measurement	Second of Measurement (00-59)	BCD
	14	00	Hundredth of a second	BCD
	15	STATUS MSB	See STATUS specification below	Hex
	16	STATUS LSB	See STATUS specification below	Hex
	17	Pulse Rate MSB	See PR format below	Hex
	18	Pulse Rate LSB	See PR format below	Hex
	19	00 to FF	Reserved for future use	Hex
	20	SpO_2	See SpO_2 format below	Hex
Optional Data	XX*	See Optional Data	See Optional Data	N/A
Footer	21	Checksum LSB	LSB of sum of Spot-check Data	Hex
	22	03	ETX – end of transmission	Hex

Note:

* This data section is expandable and the length is defined during the data format selection process in Byte 5 and 6. The minimum length of the Spot-check Data section of the packet is 14 bytes (0x0E).

Table 17: Status MSB

Status (MSB)							
BIT7	**BIT6**	**BIT5**	**BIT4**	**BIT3**	**BIT2**	**BIT1**	**BIT0**
R	R	R	R	R	R	SPA	NOMS

Table 18: Status LSB

Status (LSB)							
BIT7	**BIT6**	**BIT5**	**BIT4**	**BIT3**	**BIT2**	**BIT1**	**BIT0**
R	R	R	MEM	R	R	R	LOW BAT

The following are all active high:

Table 19: Status Bits

SPA:	SmartPoint Algorithm	High Quality SmartPoint Measurement
NOMS:	No Measurement	No measurement for SpO_2 or Pulse Rate
MEM:	From Memory	Stored measurement from memory
LOW BAT:	Low Battery condition	Low Batteries. Replace batteries as soon as possible.
R:	Reserved	Reserved for future use

16-Bit PR Format:

Table 20: PR Format MSB

	7	6	5	4	3	2	1	0
PR MSB	R	R	R	R	R	R	R	PR8

Table 21: PR Format LSB

	7	6	5	4	3	2	1	0
PR LSB	PR7	PR6	PR5	PR4	PR3	PR2	PR1	PR0

8-Bit SpO_2 Format:

Table 22: SpO_2 Format

	7	6	5	4	3	2	1	0
SpO_2	R	SP6	SP5	SP4	SP3	SP2	SP1	SP0

When SpO_2 and PR cannot be computed, the system will send a missing data indicator. For missing data, the PR equals 511 and the SpO_2 equals 127. The missing data could be result of these conditions:

1. Device is positioned improperly on finger.
2. Device was removed from the finger prior to a reading.
3. Signal at the finger is not discernable. Warm the hand or choose a different finger.

4.5.6.2 *Memory Storage of Spot-Check Measurements*

The 9560 has memory capacity to store a minimum of 20 measurements. When a wireless connection is made the 9560 oximeter will forward the oldest stored measurements prior to sending the new measurement. After stored measurements are sent they are removed from memory.

Notes:

- If the finger is removed before 40 seconds and a SmartPoint measurement is not available, no data will be sent or stored in memory.
- Stored measurements will be lost after battery replacement.

4.5.6.3 *Optional Data*

The following data is available as expandable options (see section 4.5.1 Selecting the Data Format):

Note: This is optional data, the decision whether or not to include it needs to be selected by the configuring application.

Table 23: Optional Data

	Byte #	Data	Information	Format
Optional Data Serial Number Expansion Option	21	S9	Serial Number	ASCII
	22	S8	Serial Number	ASCII
	23	S7	Serial Number	ASCII
	24	S6	Serial Number	ASCII
	25	S5	Serial Number	ASCII
	26	S4	Serial Number	ASCII
	27	S3	Serial Number	ASCII
	28	S2	Serial Number	ASCII
	29	S1	Serial Number	ASCII

Serial Number is represented as (S9)(S8)(S7)(S6)(S5)(S4)(S3)(S2)(S1).

If the serial number is included in the payload, the data length defined in bytes 5 and 6 of the header will change to 0x17 (i.e. 23 bytes decimal). The 23 bytes includes 14 bytes of data and 9 bytes of the serial number.

4.5.7 Serial Data Format #2

This data format provides continuous data transmission of a 5 byte data packet sent 75 times per second. The data packet includes real-time data including: 8-bit waveform value, six different output options for the SpO_2 value, four different averaging options for the pulse rate values, and options formatted for both recording and display purposes, as well as status information for the measurement and status of the battery.

4.5.7.1 Packet Description

A frame consists of 5 bytes; a packet consists of 25 frames. Three packets (75 frames) are transmitted each second.

Table 24: Packet Description

Packet	Frame				
	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
1	01	STATUS	PLETH	PR MSB	CHK
2	01	STATUS	PLETH	PR LSB	CHK
3	01	STATUS	PLETH	SpO_2	CHK
4	01	STATUS	PLETH	SREV	CHK
5	01	STATUS	PLETH	reserved	CHK
6	01	STATUS	PLETH	TMR MSB	CHK
7	01	STATUS	PLETH	TMR LSB	CHK
8	01	STATUS	PLETH	STAT2	CHK
9	01	STATUS	PLETH	SpO_2-D	CHK
10	01	STATUS	PLETH	SpO_2 Fast	CHK
11	01	STATUS	PLETH	SpO_2 B-B	CHK
12	01	STATUS	PLETH	reserved	CHK
13	01	STATUS	PLETH	reserved	CHK
14	01	STATUS	PLETH	E-PR MSB	CHK
15	01	STATUS	PLETH	E-PR LSB	CHK
16	01	STATUS	PLETH	E-SpO_2	CHK
17	01	STATUS	PLETH	E-SpO_2-D	CHK
18	01	STATUS	PLETH	reserved	CHK
19	01	STATUS	PLETH	reserved	CHK
20	01	STATUS	PLETH	PR-D MSB	CHK
21	01	STATUS	PLETH	PR-D LSB	CHK
22	01	STATUS	PLETH	E-PR-D MSB	CHK
23	01	STATUS	PLETH	E-PR-D LSB	CHK
24	01	STATUS	PLETH	reserved	CHK
25	01	STATUS	PLETH	reserved	CHK

Notes:

- Byte number 1 in each frame is set to a value of 1.
- Reserved bytes are undefined (range of 0 to 255).

4.5.7.2 Byte 1 – START BYTE

Always set to a 01 value.

4.5.7.3 Byte 2 – STATUS BYTE

This byte provides status information at a rate of 1/75 of second.

Range: 0x80 to 0xFF

Table 25: Status Byte

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
1	R	ARTF	OOT	SNSA	YPRF		SYNC
					RPRF	GPRF	
*Note: Bit 7 is always set.							

The following are all active high:

Table 26: Status Bits

R:	Reserved	Reserved for future use
ARTF:	Artifact – short term	Indicates artifact condition of each pulse (occurs only during pulse)
OOT:	Out Of Track	An absence of consecutive good pulse signals.
SNSA:	Sensor Alarm	Device is providing unusable data for analysis (set when the finger is removed)
RPRF:	*Red Perfusion	Amplitude representation of low/poor signal quality (occurs only during pulse).
YPRF:	*Yellow Perfusion	Amplitude representation of low/marginal signal quality (occurs only during pulse).
GPRF:	*Green Perfusion	Amplitude representation of high signal quality (occurs only during pulse).
SYNC:	Frame Sync	1 on Frame 1 (0 on frames 2 through 25).

* The oximeter reports each pulse by setting/clearing the RPRF and GPRF bits for a period of 12 frames (160 ms). The table below describes the condition and state of the pulse perfusion bits.

Table 27: RPRF and GPRF Bit Definition

Condition	RPRF Bit 2 of Status Byte	GPRF Bit 1 of Status Byte
Green – high pulse signal	0	1
Yellow – low/marginal pulse signal	1	1
Red – low/no pulse signal	1	0

4.5.7.4 Byte 3 – PLETH BYTE

This byte consists of an 8 bit plethsmographic waveform (pulse waveform). The pulse oximeter infra-red signal is filtered and then compressed into an 8 bit value. The compression provides good detail for low to large pulse signals. For uncompressed waveform refer to Data Format 7.

Range: 0x00 to 0xFF

4.5.7.5 Byte 4 – FLOAT BYTE

This byte is used for SpO_2, pulse rate, and information that can be processed at a rate of 1/3 of second.

Range: 00 to 127

SREV:	Oximeter Firmware Revision Level
TMR:	1/3 Second Timer, LSB=least significant 7 bits, MSB=most significant 7 bits
STAT2:	Status Byte 2 (occurs 1 of 25) - description given below

Table 28: Byte 4 Definition

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
Depends on Frame Number							
*Note: Bit 7 is always set.							

The following are all active high:

LOW BAT:	Low Batteries. Replace batteries as soon as possible.
SPA:	High Quality SmartPoint Measurement
R:	Reserved (range - 0 or 1), for future use

Standard Mode - Formatted for Recording Purposes:

These values are formatted for recording purposes and are updated every 1/3 of second. When the finger is removed from the device these values will be formatted with the missing data value. The following output options are available in standard mode:

PR:	4-beat Pulse Rate Average
E-PR:	8-beat Pulse Rate Extended Average
SpO_2:	4-beat SpO_2 Average
E-SpO_2:	8-beat SpO_2 Extended Average
SpO_2 Fast:	4-beat Average optimized for fast responding
SpO_2 B-B:	Beat to Beat value – No Average

When SpO_2 and PR cannot be computed, the system will send a missing data indicator. For missing data, the PR equals 511 and the SpO_2 equals 127.

Display Mode - Formatted for Display Purposes:

These values are formatted for display purposes and are updated every 1.5 seconds. When the device is removed from the finger, the last SpO_2 and Pulse Rate reading will be reported for 10 seconds before changing to the missing data value. During this 10 second period the sensor alarm bit (SNSA) is set, indicating that the finger has been removed. This feature is useful for spot-check measurements. The following output options are available in Display Mode:

PR-D:	4-beat Pulse Rate Average
E-PR-D:	8-beat Pulse Rate Extended Average
SpO_2-D:	4-beat SpO_2 Average
E-SpO_2-D:	8-beat SpO_2 Extended Average

When SpO_2 and PR cannot be computed, the system will send a missing data indicator. For missing data, the PR equals 511 and the SpO_2 equals 127.

PR Format:

Table 29: PR Format - MSB

	7	6	5	4	3	2	1	0
PR MSB	0	R	R	R	R	R	PR8	PR7

Table 30: PR Format - LSB

	7	6	5	4	3	2	1	0
PR LSB	0	PR6	PR5	PR4	PR3	PR2	PR1	PR0

SpO_2 Format:

Table 31: SpO_2 Format

	7	6	5	4	3	2	1	0
SpO_2	0	SP6	SP5	SP4	SP3	SP2	SP1	SP0

R = Reserved (range 0 or 1)

4.5.7.6 Byte 5 – CHK

This byte is used for the checksum of bytes 1 through 4.

Range: 00 to 255

CHK: Checksum = (Byte 1) + (Byte 2) + (Byte 3) + (Byte 4) modulo 256

4.5.8 Serial Data Format #7

This data format provides the same information as Data Format 2, except that the waveform value provides the full resolution of 16 bits instead of 8 bits.

4.5.8.1 Packet Description

A frame consists of 5 bytes; a packet consists of 25 frames. Three packets (75 frames) are transmitted each second.

Table 32: Packet Description

Packet	Frame				
	Byte 1	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**
1	STATUS	PLETH MSB	PLETH LSB	PR MSB	CHK
2	STATUS	PLETH MSB	PLETH LSB	PR LSB	CHK
3	STATUS	PLETH MSB	PLETH LSB	SpO_2	CHK
4	STATUS	PLETH MSB	PLETH LSB	SREV	CHK
5	STATUS	PLETH MSB	PLETH LSB	reserved	CHK
6	STATUS	PLETH MSB	PLETH LSB	TMR MSB	CHK
7	STATUS	PLETH MSB	PLETH LSB	TMR LSB	CHK
8	STATUS	PLETH MSB	PLETH LSB	STAT2	CHK
9	STATUS	PLETH MSB	PLETH LSB	SpO_2-D	CHK
10	STATUS	PLETH MSB	PLETH LSB	SpO_2 Fast	CHK
11	STATUS	PLETH MSB	PLETH LSB	SpO_2 B-B	CHK
12	STATUS	PLETH MSB	PLETH LSB	reserved	CHK
13	STATUS	PLETH MSB	PLETH LSB	reserved	CHK
14	STATUS	PLETH MSB	PLETH LSB	E-PR MSB	CHK
15	STATUS	PLETH MSB	PLETH LSB	E-PR LSB	CHK
16	STATUS	PLETH MSB	PLETH LSB	E-SpO_2	CHK
17	STATUS	PLETH MSB	PLETH LSB	E-SpO_2-D	CHK
18	STATUS	PLETH MSB	PLETH LSB	reserved	CHK
19	STATUS	PLETH MSB	PLETH LSB	reserved	CHK
20	STATUS	PLETH MSB	PLETH LSB	PR-D MSB	CHK
21	STATUS	PLETH MSB	PLETH LSB	PR-D LSB	CHK
22	STATUS	PLETH MSB	PLETH LSB	E-PR-D MSB	CHK
23	STATUS	PLETH MSB	PLETH LSB	E-PR-D LSB	CHK
24	STATUS	PLETH MSB	PLETH LSB	reserved	CHK
25	STATUS	PLETH MSB	PLETH LSB	reserved	CHK

Notes:

- Byte number 1 in each frame is greater than 0x7F.
- Reserved bytes are undefined (range of 0 to 255).

4.5.8.2 Byte 1 – STATUS BYTE

This byte provides status information at a rate of 1/75th of a second.

Range: 128 to 255

Table 33: Byte 1 Definition

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
1	R	ARTF	OOT	SNSF	YPRF		SYNC
					RPRF	GPRF	
***Note**: Bit 7 is always set.							

The following are all active high:

Table 34: Status Bits

R:	Reserved	Reserved for future use.
ARTF:	Artifact	Indicates artifact condition of each pulse (occurs only during pulse).
OOT:	Out Of Track	An absence of consecutive good pulse signals.
SNSA:	Sensor Alarm	Device is providing unusable data for analysis (set when the finger is removed).
RPRF:	*Red Perfusion	Amplitude representation of low/no pulse signal (occurs only during pulse).
YPRF:	*Yellow Perfusion	Amplitude representation of low/marginal signal quality (occurs only during pulse).
GPRF:	*Green Perfusion	Amplitude representation of high signal quality (occurs only during pulse).
SYNC:	Frame Sync	= 1 to Frame 1 (=0 on frames 2 through 25).

* The oximeter reports each pulse by setting/clearing the RPRF and GPRF bits for a period of 12 frames (160 ms). The table below describes the condition and state of the pulse perfusion bits.

Table 35: RPRF/GPRF Bit Description

Condition	RPRF Bit 2 of Status Byte	GPRF Bit 1 of Status Byte
Green – high pulse signal	0	1
Yellow – low/marginal pulse signal	1	1
Red – low/no pulse signal	1	0

4.5.8.3 Byte 2 & 3 – PLETH BYTE

These two bytes consist of a 16 bit plethsmographic waveform (pulse waveform).

Range: 0x00 to 0xFFFF (MSB:LSB)

Byte 2 = MSB Pulse Waveform

Byte 3 = LSB Pulse Waveform

Pulse waveform value = (Byte 2 decimal value * 256) + Byte 3 decimal value

4.5.8.4 Byte 4 – FLOAT BYTE

This byte is used for SpO_2, Pulse Rate, and information that can be processed at a rate of 1/3 of a second.

Range: 0x00 to 0x7F

SREV:	Oximeter Firmware Revision Level
TMR:	1/3 Second Timer, LSB=least significant 7 bits, MSB=most significant 7 bits
STAT2:	Status Byte 2 (occurs 1 of 25) - description given below

Table 36: Byte 4 Bit Definition

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
0	R	SPA	R	R	R	R	LOW BAT

The following are all active high:

LOW BAT:	Low Batteries. Replace batteries as soon as possible.
SPA:	High quality SmartPoint Measurement
R:	Reserved (range - 0 or 1), for future use

Standard Mode - Formatted for Recording Purposes:

These values are formatted for recording purposes and are updated every 1/3 of second. When the finger is removed from the device these values will be formatted with the missing data value. The following output options are available in standard mode:

PR:	4-beat Pulse Rate Average
E-PR:	8-beat Pulse Rate Extended Average
SpO_2:	4-beat SpO_2 Average
E- SpO_2:	8-beat SpO_2 Extended Average
SpO_2 Fast:	4-beat Average optimized for fast responding
SpO_2 B-B:	Beat to Beat value – No Average

When SpO_2 and PR cannot be computed, the system will send a missing data indicator. For missing data, the PR equals 511 and the SpO_2 equals 127.

Display Mode - Formatted for Display Purposes:

These values are formatted for display purposes and are updated every 1.5 seconds. When the device is removed from the finger the last SpO_2 and Pulse Rate reading will be reported for 10 seconds before changing to the missing data value. During this 10 second period the sensor alarm bit (SNSA) is set, indicating that the finger has been removed. This feature is useful for spot-check measurements. The following output options are available in Display Mode:

PR-D:	4-beat Pulse Rate Average
E-PR-D:	8-beat Pulse Rate Extended Average
SpO_2-D:	4-beat SpO_2 Average
E- SpO_2-D:	8-beat SpO_2 Extended Average

When SpO_2 and PR cannot be computed, the system will send a missing data indicator. For missing data, the PR equals 511 and the SpO_2 equals 127.

PR Format:

Table 37: PR Format - MSB

	7	6	5	4	3	2	1	0
PR MSB	0	R	R	R	R	R	PR8	PR7

Table 38: PR Format - LSB

	7	6	5	4	3	2	1	0
PR LSB	0	PR6	PR5	PR4	PR3	PR2	PR1	PR0

SpO_2 Format:

Table 39: SpO_2 Format

	7	6	5	4	3	2	1	0
SpO_2	0	SP6	SP5	SP4	SP3	SP2	SP1	SP0

R = Reserved (range- 0 or 1)

4.5.8.5 Byte 5 – CHK

This byte is used for the checksum of bytes 1 through 4.

Range: 00 to 255

CHK: Checksum = (Byte 1) + (Byte 2) + (Byte 3) + (Byte 4) modulo 256

4.5.9 Serial Data Format #8

This data format provides continuous data transmission of a 4 byte data packet sent once per second. The data packet includes real-time data including: SpO_2 and pulse rate formatted for display, status of the measurement, and status of the battery.

4.5.9.1 Packet Description

Four bytes of data are transmitted once per second.

Table 40: Status Byte

Byte 1 - Status							
BIT7	**BIT6**	**BIT5**	**BIT4**	**BIT3**	**BIT2**	**BIT1**	**BIT0**
1	R	OOT	LPRF	MPRF	ARTF	PR8	PR7
***Note**: Bit 7 is always set							

Table 41: Pulse Rate

Byte 2 - Pulse Rate (PR-D)							
BIT7	**BIT6**	**BIT5**	**BIT4**	**BIT3**	**BIT2**	**BIT1**	**BIT0**
0	PR6	PR5	PR4	PR3	PR2	PR1	PR0
***Note**: Bit 7 is always clear							

Table 42: SpO_2-D

Byte 3 - SpO_2-D							
BIT7	**BIT6**	**BIT5**	**BIT4**	**BIT3**	**BIT2**	**BIT1**	**BIT0**
0	SP6	SP5	SP4	SP3	SP2	SP1	SP0
***Note**: Bit 7 is always clear							

Table 43: Status 2

Byte 4 - Status2							
BIT7	**BIT6**	**BIT5**	**BIT4**	**BIT3**	**BIT2**	**BIT1**	**BIT0**
0	R	SPA	R	SNSA	R	R	LOW BAT
***Note**: Bit 7 is always clear							

The following are all active high:

Table 44: Bit Definition

ARTF:	Artifact	Indicated artifact condition on each pulse
OOT:	Out Of Track	An absence of consecutive good pulse signals.
LPRF:	Low Perfusion	Amplitude representation of low/no signal quality (holds for entire duration).
MPRF:	Marginal Perfusion	Amplitude representation of low/marginal signal quality (holds for entire duration).
SNSA:	Sensor Alarm	Device is providing unusable data for analysis (set when the finger is removed)
SPA:	SmartPoint Algorithm	High quality SmartPoint measurement
LOW BAT:	Low Battery condition	Low Batteries. Replace batteries as soon as possible.
PR8 – PR0:	Pulse Rate (PR-D)	4-beat Pulse Rate average formatted for display
SP6 – SP0:	SpO_2 (SpO_2-D)	4-beat SpO_2 average formatted for display
R	Reserved (range – 0 or 1)	Reserved for future use.

The SpO_2 and pulse rate values are formatted for display purposes and are updated every 1.5 seconds. When the device is removed from the finger the last SpO_2 and Pulse Rate reading will be reported for 10 seconds before changing to the missing data value. During this 10-second period, the sensor alarm bit (SNSA) is set, indicating that the finger has been removed. This feature is useful for spot-check measurements. The following output options are available in Display Mode:

PR-D: 4-beat Pulse Rate Average

SpO_2-D: 4-beat SpO_2 Average

When SpO_2 and PR cannot be computed, the system will send a missing data indicator. For missing data, the PR equals 511 and the SpO_2 equals 127.

5 Indications for Use

The Nonin Model 9560 Finger Pulse Oximeter is a small, lightweight, portable, wireless device indicated for use in measuring and displaying functional oxygen saturation of arterial hemoglobin (%SpO_2) and pulse rate of patients who are well or poorly perfused. It is intended for spot-checking of adult and pediatric patients on fingers (other than the thumb) between 0.3 – 1.0 inch (0.8 – 2.5 cm) thick.

Refer to the Model 9560 Instructions for Use (IFU) for additional warnings, cautions, and information.