PERCUSSIONAIRE®
CORPORATION

Digital Multimeter

User Manual

LIT-MAN-DM REV E

Introduction

The Percussionaire® Digital Multimeter (PDM) is supplied in 6 versions:

Home IPV: *Impulsator®, Travel Air®*

EUR Therapy: *IPV®-1C, IPV®-2C,*

US IPV: *IPV®-1C, IPV®-2C*

TXP-2D: *TXP®-2D*

SBRO: *Sinusoidal & Transport Bronchotron®*

VDR: *VDR®-4*

The PDM has six different operating modes : POST, Wake, Active, Report, Sleep, and Fault.

1. The (POST) "Power-on self test "mode is active for 15 seconds after the batteries are installed and displays the System Information page (e.g. serial #, revision, etc.) and performs a Power-On Self-Test.

2. The **Wake** mode, is active for the first 15 seconds of use. If usage is stopped within 15 seconds, the PDM enters **Report** mode and displays the session duration of the last usage. A bar graph gives a visual indication of elapsed time, during the **Wake** mode phase.

3. In **Active** mode the PDM measures the pressure, computes the parameters and displays them on the display.

4. In **Report** mode, a page with the Session Timer and Total UsageTime are displayed, alternating with the System Information page.

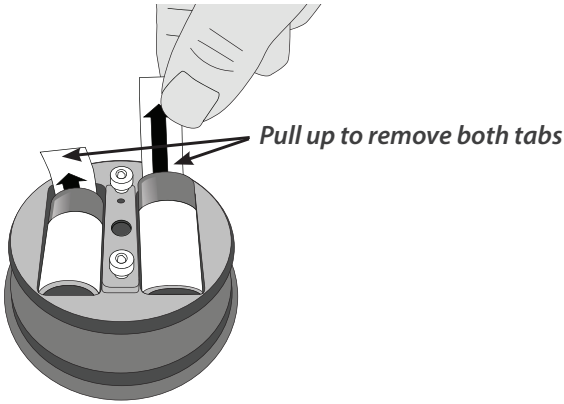
5. In **Sleep** mode, the LCD display is off, but the PDM continues to measure the pressure at the measuring port. If the PDM senses the preset startup pressure, it becomes active.

6. The **Fault** mode displays the Fault page.

A **Low Battery** indicator is displayed when battery capacity is estimated to be low

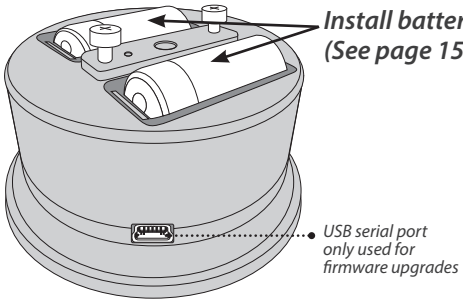
NOTE

The PDM has a USB serial port that is used for manufacturing, calibration, and firmware upload. It is not enabled during normal operation.



NOTE

To ensure correct atmospheric pressure calibration at start up, remove batteries, wait 30 seconds and re-install. Allow 15 seconds for power on self test. When screen goes blank, the multimeter can be installed into the Bronchotron device.



Side view of PDM

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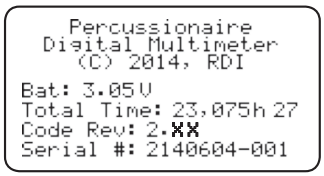
1 Power-On Self-Test (POST) Mode

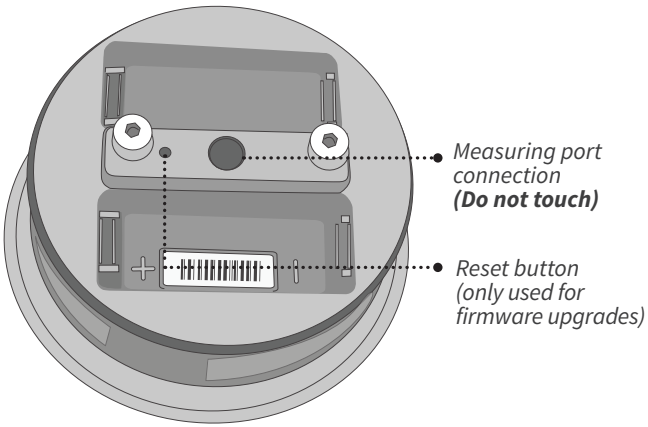
When batteries are installed in a system, the Percussionaire Digital Multimeter (PDM) software displays the software revision, battery voltage, total usage time and serial number for 15 seconds. This **Start-Up** mode allows the software to perform additional tests on the hardware that are part of the Power-On Self-Test (POST). If any errors are detected in the POST, the PDM enters the **Fault** mode. (See page 13, #6 Fault Mode.)
The POST checks require that the measurement port be left disconnected and exposed to the atmosphere for the entire duration.

NOTE

Do not install PDM until the POST test is complete and the screen is blank, indicating Sleep Mode.



System Information display



Rear view of PDM

2 Wake Mode

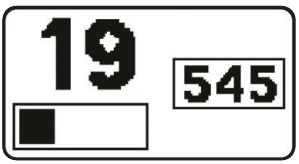
To wake up the PDM, ensure the ventilator pressure is greater than 2.5 cmH_2O or 2 hPa at the Phasitron® patient delivery port for more than 1 second.

PDM remains on for the first 15 seconds, showing bar-graph timer.

If usage is stopped within 12 seconds, the PDM enters **Report** mode.

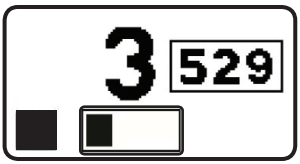
After 15 seconds, the current session continues counting from 16 seconds which turns into **Active** mode.

See below for PDM display screens in **Wake** mode



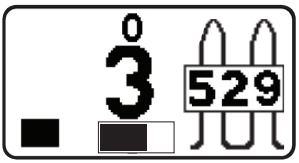
Home IPV: *Impulsator® and Travel Air® display*

EUR Therapy: *IPV®-1C, IPV®-2C*

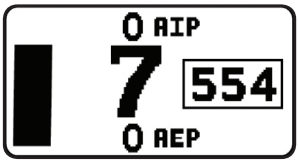


US IPV: *IPV®-1C, IPV®-2C*

TXP-2D: *TXP®-2D*



SBRO: *Sinusoidal & Transport Bronchotron®*



VDR: *VDR®-4*

NOTE

Display numbers are for reference only.

3 Active Mode

Model: *Home IPV*
Device: *Impulsator®, Travel Air®*
Display metrics: *Pulse Frequency Rate, Session Usage Time, Pulse Amplitude Pressure*

At 16 seconds the PDM enters **Active** mode. The timer bar will change to a numeric display, showing the current usage Session Timer. The display on the right shows the currently measured percussion rate/pulse frequency.

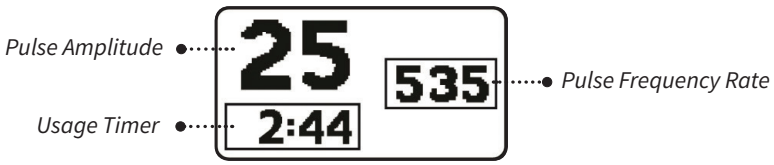
The PDM displays the usage Session Timer in minutes and seconds. The Session Timer is the total time of the current usage. The Session Timer can display a maximum of 59 minutes and 59 seconds.

If a usage has been stopped for more than 5 minutes, the Session Timer will reset and start over.

To display most recent usage duration time, the controller device can be turned on for more than 3 seconds but less than 12 seconds. This will put the PDM into **Report** mode. **Report** mode will then display the Session Timer of the most recent usage and the Total usage Time since new.

NOTE

To display most recent usage duration time, see Report Mode page 11.



Home IPV: *Impulsator® and Travel Air® display*

Model: *EUR Therapy*
Device: *IPV®-1C, IPV®-2C (Non USA)*
Display metrics: *Pulse Frequency Rate, Mean Airway Pressure, Session Usage Time, Pulse Amplitude Pressure.*

At 16 seconds the PDM enters **Active** mode. The timer bar will change numeric display, showing the current usage Session Timer. Above the timer reading is the display of the pulse amplitude. This is calculated from the pressure measurements at the moment of instantaneous peak and trough amplitude averaged over 5 seconds. The display on the right shows the currently measured percussion rate/pulse frequency.

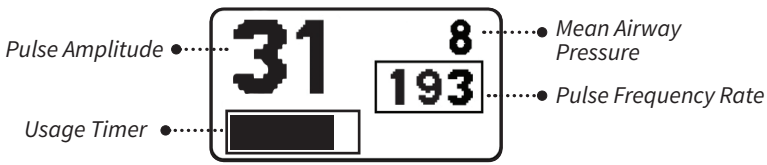
Mean Airway Pressure (MAP) averages pulse amplitude over 5 sec. At 100 samples per second, this is an average of 500 measurements.

The PDM displays the usage Session Timer in minutes and seconds. The Session Timer is the total time of the current usage. The Session Timer can display a maximum of 59 minutes and 59 seconds.

If a usage has been stopped for more than 5 minutes, the Session Timer will reset and start over.

NOTE

To display most recent usage duration time, see Report Mode page 11.



EUR Therapy: *IPV®-1C, IPV®-2C, display*

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Model: *US IPV*
Device: *IPV®-1C, IPV®-2C (USA)*
Display metrics: *Pulse Frequency Rate, Pulse Amplitude Bar Graph, Mean Airway Pressure, Session Usage Time*

At 16 seconds the PDM enters **Active** mode. The display on the right shows the currently measured percussion rate.

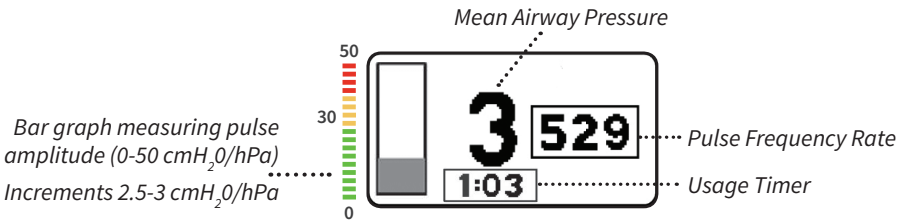
Mean Airway Pressure (MAP) averages pulse amplitude over 5 seconds. At 100 samples per second, this is an average of 500 measurements.

Pulsating Bar Graph on the left side displays pulse amplitude calculated as average peak Maximum Pressure sample in last 5 seconds, minus Minimum Pressure Sample in last 5 seconds. The Bar Graph is a visual representation better reflecting AIP and AEP values and represents an estimate of airway pressure. PEEP is represented by a solid bar at the base and AIP is represented by the pulsating peaks of the bar-graph display.

Pulsating grey color represents AIP.

NOTE

To display most recent usage duration time, see Report Mode page 11.



IPV®-1C and IPV®-2C display

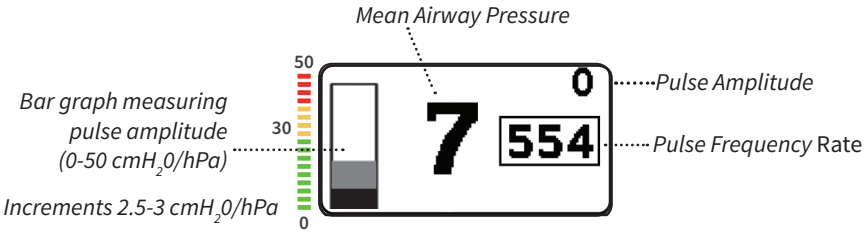
Model: *TXP*

Device: *TXP®-2D*

Display metrics: *Pulse Frequency Rate, Pulse Amplitude Pressure, Mean Airway Pressure, Pulse Amplitude BarGraph.*

Pulse amplitude reading is displayed at the top right, calculated at the instantaneous moment of peak and trough amplitude pressure.
Mean Airway Pressure (MAP) averages pulse amplitude over 5 seconds. At 100 samples per second, this is an average of 500 measurements.
Mechanical PEEP adjusted at the Phasitron can be observed on the bar graph allowing the clinician to dial the desired amount. As PEEP is added, it is displayed as a solid black area at the base of the bar graph. Each bar in the bar graph represents approx. 2.5 - 3 cmH_2O pressure.

Pulsating grey color represents AIP.
Solid black shows PEEP, only when adding PEEP with PEEP valve.



TXP®-2D display

Bar Graph on the left side displays pulse amplitude as calculated as average peak Maximum Pressure sample in last 5 seconds, minus Minimum Pressure Sample in last 5 seconds. Bar Graph is a visual representation better reflecting AIP and AEP type values and represents an estimate of the pressure in the lung, after resistance of ET tube, etc.

Model: *SBRO*

Device: *Sinusoidal & Transport Bronchotron®*

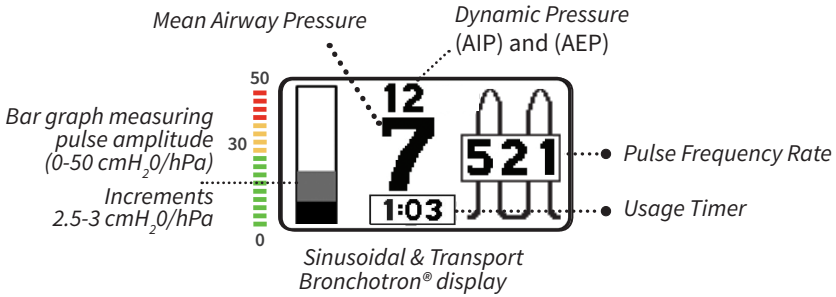
Display metrics: Pulse Frequency Rate, *Mean Airway Pressure, Dynamic Pressure (AIP) and (AEP), Usage Timer, Pulse Amplitude Bar Graph.*

Mean Airway Pressure (MAP) averages pulse amplitude over 5 sec. At 100 samples per second, this is an average of 500 measurements. Above the MAP is a Dynamic Pressure which changes between Average Inspiratory Pressure (AIP) and Average Expiratory Pressure (AEP) as the Bronchotron cycles. Range: 0 – 99 cmH_2O/hPa.

NOTE

PDM display Represents an estimate of pressure in the lung (after resistance of ET tube etc.).

- *100 measurements per second at Phasitron®. Time duration of the average depends on time duration of pulsatile flow or O/CPAP.*



Pulsating grey color represents AIP.

Solid black shows PEEP, only when adding peep with PEEP valve.

Pulsating Bar Graph on the left side displays pulse amplitude and calculated as average peak Maximum Pressure sample in last 5 seconds, minus Minimum Pressure Sample in last 5 seconds. Bar Graph is a visual representation better reflecting AIP values and represents an estimate of airway pressure. PEEP is represented by a solid bar at the base and AIP is represented by the pulsating peaks of the bar-graph display.

Model: *VDR*

Device: *VDR®-4*

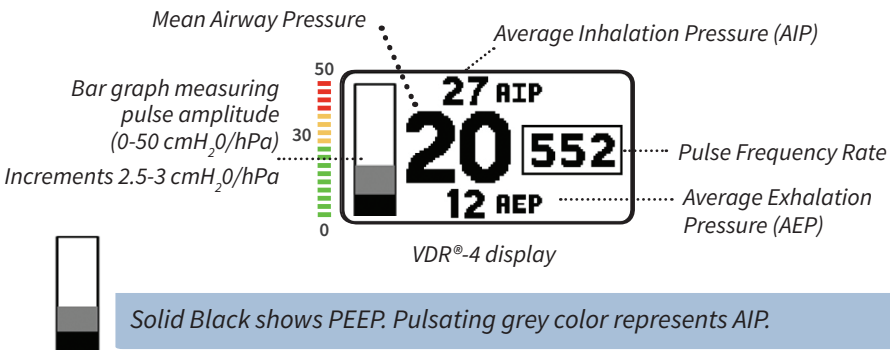
Display metrics: *Pulse Frequency Rate, Mean Airway Pressure, Average Inhalation Pressure, Average Exhalation Pressure, Pulse Amplitude Bar Graph.*

Mean Airway Pressure (MAP) averages pulse amplitude over 5 sec. At 100 samples per second, this is an average of 500 measurements.
Average Inhalation Pressure (AIP) is the average pressure of the Inspiratory Phase over a set period of ***I*** time. Range: 0 – 99 cmH_2O/hPa.
Average Exhalation Pressure (AEP) is the average pressure during the expiratory phase over a set period of ***E*** time. Range: 0 - 99 cmH_2O/hPa.

NOTE

PDM display Represents an estimate of pressure in the lung (after resistance of ET tube etc).

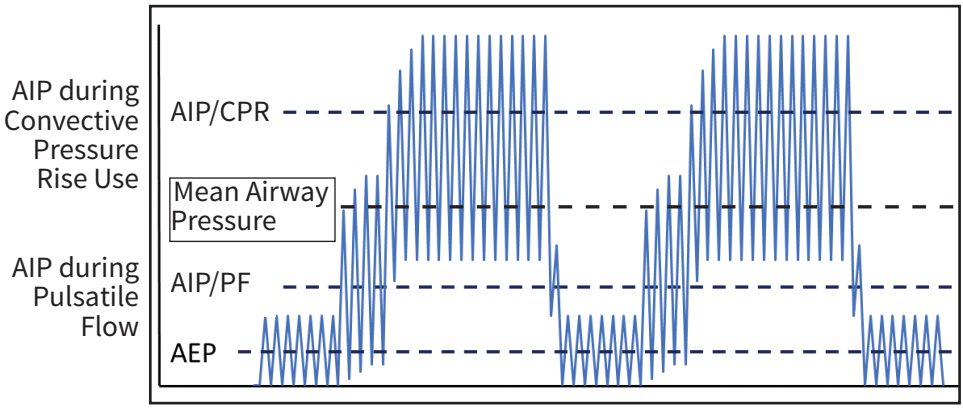
• 100 measurements per second at Phasitron®. Time duration of the average depends on time duration of pulsatile flow or O/CPAP.



Solid Black shows PEEP. Pulsating grey color represents AIP.

Pulsating Bar Graph on the left side displays pulse amplitude and calculated as average peak Maximum Pressure sample in last 5 seconds, minus Minimum Pressure Sample in last 5 seconds. Bar Graph is a visual representation better reflecting AIP and AEP values and represents an estimate of airway pressure. PEEP is represented by a solid bar at the base and AIP is represented by the pulsating peaks of the Bar-graph display.

VDR®-4 Waveform viewed on Monitron II

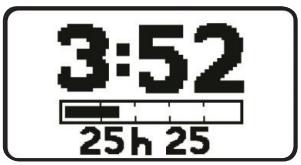


To activate/set Convective Pressure (CPR) Rise on VDR4; first set Pulsatile Flowrate and note the AIP, this is the baseline. Then Slowly add Convective Pressure Rise while monitoring the increase in AIP to the desired level of CPR. AIP now reflects the Convective Pressure Rise addition including the Pulsatile Flow Control, and the Baseline reflects your AIP during the first 0.7 second of the convective breath set by the Pulsatile Flow Control before the CPR turns on.

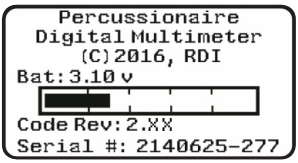
4 Report Mode

The Session Timer and the Total Usage Time **(A)** are displayed for two seconds, followed by the System Information page **(B)** for 2 seconds alternating. Alternating page display continues for 5 minutes or until usage resumes and the PDM enters **Active** mode. During the 5 minute period, a horizontal bar graph indicates the time by moving from left to right at a fixed rate. After 5 minutes of no usage, the system information page is no longer displayed and the time display flashes (2 seconds on, 2 seconds off) **(C)** for an additional 25 minutes. The PDM enters **Sleep** mode after 25 minutes.

(A)



(B)

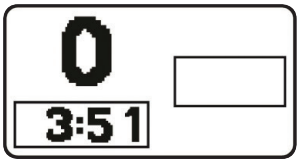


(C)

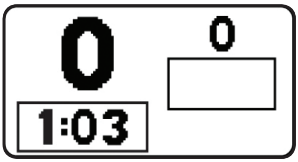
Below: display screens when the ventilator is Switched off.

NOTE

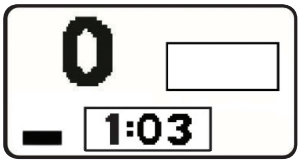
When the Percussionaire® ventilator is turned off, the measurements will drop to zeros after a few seconds.



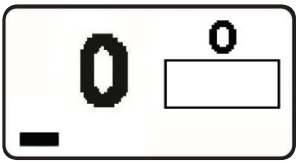
Home IPV: *Impulsator® and Travel Air® display*



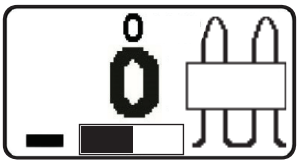
EUR Therapy: *IPV®-1C and IPV®-2C display*



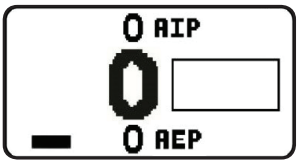
US IPV: *IPV®-1C and IPV®-2C display*



TXP-2D: *TXP®-2D display*



SBRO: *Sinusoidal & Transport Bronchotron® display*



VDR: *VDR®-4 display*

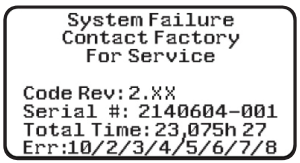
5 Sleep Mode

In **Sleep** mode, the LCD is off but the microcontroller continues to sample and calculate the pressure at the measuring port 5 times a second. Over any 3 second period, if the pressure is greater than 2.5 cmH_2O or 2 hPa at the Phasitron® patient delivery port, for more than 1 second, the PDM enters the **Wake** mode.

Blank screen, indicating PDM sleep mode.

6 Fault Mode

The PDM displays an error message on the LCD stating “Contact Factory for Service” and stays in this mode until both batteries are removed. The displayed information includes the software revision, PDM serial number, the Total Usage Time and an error code for the exclusive use of the factory.



Pressure faults are triggered by a continuous pressure of more than 150 cmH_2O for more than 5 seconds during **Wake** and **Active** modes.

In all other modes, the software continuously monitors the hardware for errors, as well as verifying that each data sample has a valid value. If an error is detected, the software logs the error and reboots the processor, which would cause it to recover from a transient error. After reboot, the processor returns to the same mode it was in before the reboot. If more than one error is detected in any 10 second period, it is considered a fatal error and the software enters **Fault** mode.

NOTE

If system failure screen is displayed, remove batteries for 30 seconds. Replace batteries (note that positive terminals face same direction) and wait 30 seconds until the screen turns off. If POST check runs correctly, PDM may be used. If system failure screen recurs, contact Percussionaire Corporation for factory service.

Fault Logging

The software keeps track of several types of hardware and data faults. All faults are logged in the microcontroller's memory and are retained even if the batteries are removed. If multiple faults happen within 10 seconds of each other, the PDM stops normal operation and enters **Fault** mode. In this mode, a subset of the collected fault information is displayed on the LCD. This data is intended for manufacturing and repair use only.

The user can exit the **Fault** mode by removing and replacing the batteries. This resumes normal operation of the PDM, but does not erase the faults stored in memory or fix the problem that caused the fault.

Fault Detection

The PDM has both hardware and software ***fault detection***. This is a dedicated hardware "watchdog" that runs on an independent clock source and can continue to operate even if the ***main*** microprocessor's clock fails or the ***micro-controller*** pauses in any way. The *Independent* ***fault detection*** is reset each time a valid pressure reading (free of hardware and software errors) is obtained.

In addition to the hardware ***fault detection***, the software also implements a ***fault-detection*** watchdog. This "watchdog" detects if a software task fails to complete within the specified time, logs an error and resets the processor.

Changing Batteries:

Press on the Multimeter's bezel and twist counter clockwise approximately 20 degrees.

1. Gently pull on the Multimeter to remove it from the housing.
2. Remove the two old batteries.
3. Install the two new batteries. Note that the positive terminals face the same direction. Wait 30 seconds until screen turns off.
4. Install the Multimeter back into the housing and twist clockwise until the stop is felt.
5. See instructions section 1 on page 3 **POST** mode, to verify display operation.

NOTE

Clean Multimeter when visibly soiled, or according to facility protocols. Do not spray any type of cleaner on to the Multimeter. We recommend cleaning the glass with a product or chemical approved for cleaning glass only. When cleaning outer bezel, use a moiste cloth with warm soapy water. Use of cleaning methods not outlined in these instructions will cause damage to the multimeter.

Specifications

Size	2.87 inch diameter, 73mm
Mass	165g (0.36 lb)
Storage and transport	*Temp., 10° C to 25° C (50° F to 77° F) Humidity <93%* non-condensing
Display	128 x 64 pixel FSTN chip-on-glass LCD with reflector
Fault detection	Independent *Hardware and Software* Watchdogs
Serial Port	USB (Manufacturing, firmware upgrade Use Only)
Thermal	-40°C to +60°C
Rate Range	0-999 pulses per minute
Pressure Range	0-150 cmH_2O/hPa
Pressure Resolution	1 cmH_2O/hPa
Pressure Accuracy	Greater of ±0.5% of reading or 1 cmH_2O/hPa
Battery Type	CR123A 3.0V 1500 mAH x 2, Percussionaire® Corp.Part # B13350
Battery Duration	3,250 Operational hours at 35°C
Battery Shelf Life	3.5 Years at 35°C, followed by 325 Hours of operation (assuming a self-discharge rate of 5% per year)

NOTE

The cell used in this device may present a risk of fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C (212°F) or incinerate. Replace cell with type recognized CR123A only, or Percussionaire® Part # B13350. Use of another cell may present a risk of fire or explosion. Dispose of in accordance with appropriate regulations, country, local, and state laws.

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P.O. Box 817
Sandpoint, Idaho 83864

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Percussionaire® Corporation reserves the right to make changes without notice in design, specifications, and models.

First Printing, 2015

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