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Foreword

This service manual gives a detailed description of the **Duo** Portable Patient Monitor, including circuit descriptions, test and calibration procedures, and spare parts listings. This manual is intended as a guide for technically qualified personnel during repair, testing, or calibration procedures.

Warnings, Precautions And Notes

Please read and adhere to all warnings, precautions, and notes listed here and in the appropriate areas throughout this manual.

A **WARNING** is provided to alert the user to potential serious outcomes (death, injury, or serious adverse events) to the patient or the user.

A **CAUTION** is provided to alert the user to use special care necessary for the safe and effective use of the device. They may include actions to be taken to avoid effects on patients or users that may not be potentially life threatening or result in serious injury, but about which the user should be aware. Cautions are also provided to alert the user to adverse effects on this device of use or misuse and the care necessary to avoid such effects.

A **NOTE** is provided when additional general information is applicable.

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1.0 *Theory of Operation*

1.1 Introduction

The **Duo** is a compact, lightweight, portable patient monitor intended for monitoring the following vital signs: blood pressure, SpO_2 (optional), and pulse rate on adult and pediatric patients. The **Duo** monitor can be powered by either the internal rechargeable Lithium-Ion battery or external 100~240 volt 50/60 Hz AC.

1.2 Hardware Overview

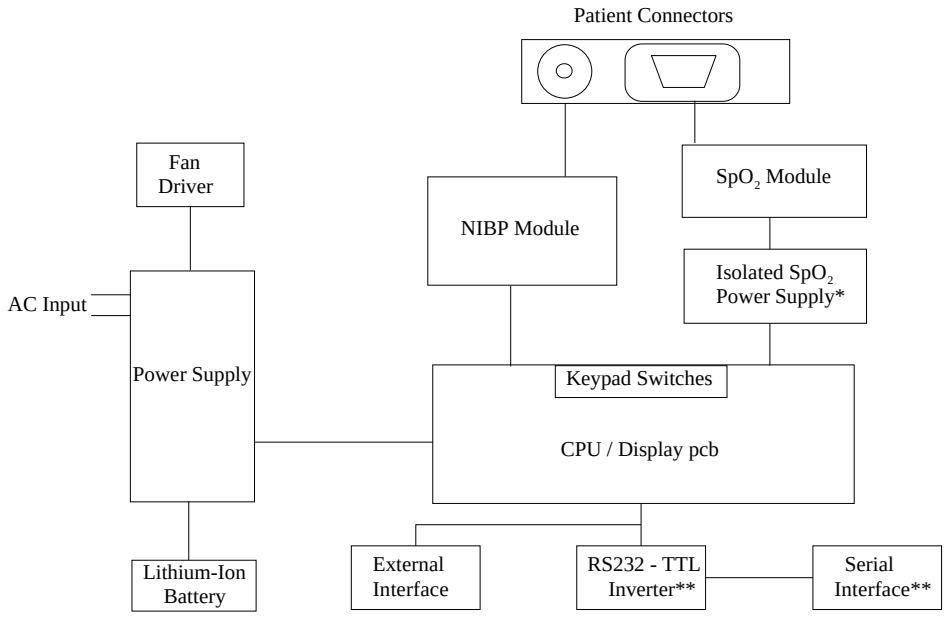

FIGURE 1-1 Interconnection Block diagram

* *The Isolated SpO_2 Power Supply is present with optional Masimo and Nellcor SpO_2 ONLY.*
** *The RS232 - TTL Inverter and Serial Interface Connector is used for software updates by Service*

1.2.1 Power Supply Board

Overview

The AC/DC converter transforms the AC input voltage (90 - 264 vac 50/60 Hz) to a DC voltage used to charge the internal Lithium-Ion battery and supply power to the +12 vdc and +3.3 vdc DC/DC converters. The battery charging circuit will actively charge the battery while the **Duo** is connected to an AC source. Battery charging takes place whether the monitor is on, off, or in use. The power supply will automatically switch to the internal battery if an AC source is not present.

NOTE: **The power supply board MUST be connected to a resistive load to operate properly and to avoid damage due to an over current condition.**

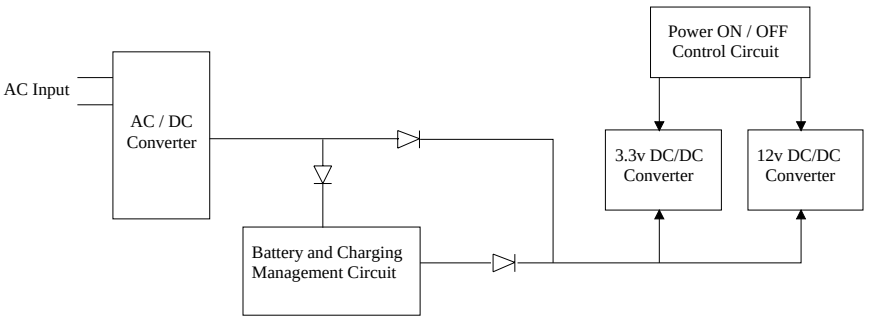

FIGURE 1-2 Power Supply Block Diagram

Power Supply Voltage Test Points:

Location	**Function**
Measure across C5	Primary Rectified Voltage (DC). Range: 105 - 374 volts.
C5 Negative Lead	Primary Ground.
Measure across Q1 pin1 and C5 Negative Lead	110k Hz Drive frequency.
Measure across C12	+10.5 vdc input for Fan Driver board.
C12 Negative Lead	Secondary Ground.
C47 Positive Lead	+5 vdc supply for Power On/Off Control.
C50 Positive Lead	+3.3 vdc output.
C68 Positive Lead	+12 vdc output.

1.2.2 Fan Driver Board Overview

The Fan Drive Board is active during the battery charging cycle. The Temperature Detector senses the temperature of the heat sink of the Secondary Rectifier diode and turns on the fan when the heat sink reaches a certain temperature.

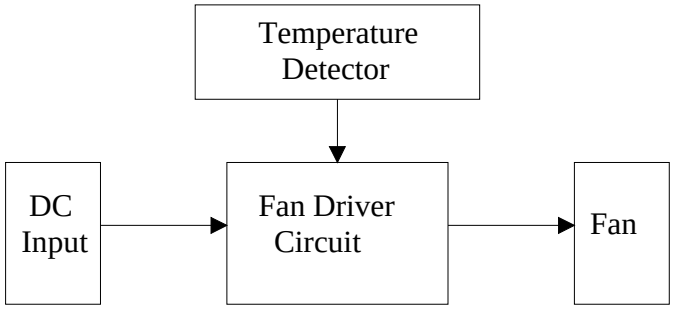

FIGURE 1-3 Fan Driver Block Diagram

Fan Driver Board Test Points

Location	Function
Measure across C202	+5 vdc Fan power.
C202 Negative Lead	Ground.
Measure between Q202 pin1 and Ground	Drive frequency when the Fan is activated.

1.2.3 CPU/Display Board Overview

The CPU/Display board controls the SpO_2 Module and NIBP Module through communications via UART devices. The CPU Board receives user commands from the Keypad. The power supply board provides +3.3 vdc and +12 vdc to the CPU board. These voltages are monitored by an A/D converter located on the CPU board. The CPU also controls an integral LED display array and indicator LEDs. The main processor has a built-in serial port that is used to load software. The processor also uses a FPGA to communicate with the NIBP Module, the optional SpO_2 module (SpO_2 presence is detected via a jumper on JP1) and to drive the LED arrays and indicators.

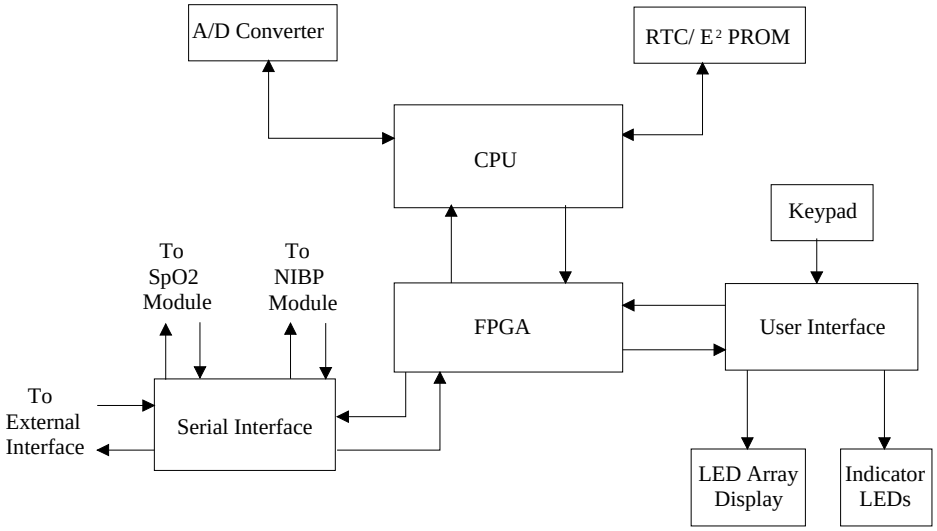

FIGURE 1-4 CPU/Display Board Block Diagram

CPU Board Test Points

Location	Function
VPP in	+12 vdc power supply
VDD in	+3.3 vdc power supply
BV	Battery voltage
5B in	+5 vdc power supply
ADV	+10.5 vdc ADV out
RST	CPU reset line
XT2	11.0592 MHz clock

1.2.4 NIBP Module Overview

The **Duo** monitor determines non-invasive blood pressure using the oscillometric method. The blood pressure cuff is inflated until the pressure in the cuff is sufficient to block blood flow in the brachial artery. As the cuff begins to deflate, blood beginning to flow through the artery will cause the artery to pulsate. These pulsations are transmitted through the blood pressure cuff and connecting hose to the pressure transducer in the NIBP module. The output of the pressure transducer is an analog pulsating signal. This signal is filtered by a high-pass filter and then amplified. The amplified analog signal is then converted to a digital signal. The digital signal is then processed to determine the systolic, diastolic, and mean pressures as well as heart rate.

1.2.5 SpO_2 Overview

Pulse oximetry (SpO_2) measurement is used to determine the oxygen saturation level of the patient's blood. The SpO_2 numeric display indicates the amount of hemoglobin that has bonded with oxygen molecules to form oxyhemoglobin. By analyzing the pulse in the fingertip using specified algorithm and consulting the clinical data table, we can obtain the SpO_2 value. The SpO_2 sensor consists of two LEDs (one red and one infrared) and a photodetector. The two LEDs are alternately lighted at a precise frequency. When the capillary vessels of the fingertip are filled, a certain amount of light from the LEDs is absorbed by blood in the capillaries. The remaining red and infrared light is then picked up by the photodetector. The photodetector detects the varying light intensity due to pulsations and transmits the changing light intensity in the form of changing electronic signals. The amount of light absorption is then compared to the known fixed LED output by the SpO_2 board. The pulse rate is counted and the SpO_2 value is determined by using an algorithm contained in the software on the SpO_2 board.

2.0 *Calibration and Performance Verification*

2.1 Introduction

The following procedures are provided to verify the proper operation of the **Duo** monitor. A menu driven interface is used to execute all verification tests. Performance tests should be performed at least once per year and after any preventive maintenance or repair has been performed.

2.2 Warnings and Guidelines

In the event that the instrument cover is removed, observe the following warnings and guidelines:

1. Do not short component leads together.
2. Perform all steps in the exact order they are given.
3. Use extreme care when reaching inside the opened instrument. Do not contact exposed metal parts that may become ''live''.
4. Read through each step in the procedure so it is understood prior to performing the step.

2.3 Test Equipment and Special Tools Required

- 0-300 mmHg Digital or Mercury manometer with bulb and valve
- 500 cc Test Chamber/Dummy Cuff. P/N 0138-00-0001-03
- DVM
- SpO_2 simulator
- NIBP simulator
- Safety Analyzer (Dempsey model 431 or equivalent)
- Oscilloscope
- Laptop or PC (software upgrade)

2.4 Calibration and System Checks

2.4.1 Device Appearance and Installation Checks

Inspect the **Duo** monitor to ensure that:

- The outer housing is clean and has no scratches or cracks
- When the device is gently shaken, there are no loose components
- All keys are smooth and free for operation
- Labels are complete, clean, and accurate
- All connectors/accessory modules are installed securely
  Ensure monitor is securely fastened to its rolling stand (if used)

2.4.2 Maintenance Functions/Non-Monitoring Modes

- When entering the maintenance functions/non-monitoring mode, the monitor will perform a self-test, however the verification of functional LEDs will not be displayed
- In the maintenance mode, the standby mode will not be active
- In the maintenance mode, the auto-shutoff will activate if no key is pressed for a period of 15 minutes.

2.4.3 Unit of Measure Mode

The unit of measure mode is used to change between mmHg and kPa. To access the Unit of Measure mode:

1. Turn the monitor off.
2. Simultaneously press and hold the **POWER** and **CLEAR** buttons.
3. Press the **CLEAR** button to cycle through the unit of measure choices.
4. Once the desired unit of measure is displayed, turn the **Duo** off to save that setting.

2.4.4 Software Version Mode

Use the following procedure to view the software version.

1. Ensure that the **Duo** is powered OFF.
2. Press and hold the **Patient Size** key.
3. While continuing to hold the **Patient Size** key, press and hold the **Power ON/OFF** key for two (2) seconds until the **Duo** beeps.
4. Release both keys.
5. After an additional 2-second delay, **Duo** will display "100" in the Pulse Rate tile and a number in the Information Codes tile.
6. Pressing the **Clear** key will cause the number displayed in the Pulse Rate tile to cycle through a sequence of four numbers indicating which software version is being displayed in the Information Codes tile as shown in the following table.

PULSE RATE TILE	INFORMATION CODES TILE SHOWS
100	Host Software Revision Level
200	NIBP Software Revision Level
300	SpO2 Software Revision Level

7. To return to normal operation, press the **Power ON/OFF** key for two (2) seconds to turn the **Duo** off.
8. You may then turn the **Duo** back on to resume normal operation.

NOTE: **The Duo cannot be placed directly back into normal monitoring mode from Software Version Mode. It must first be powered OFF.**

2.5 Safety Test

2.5.1 Test Equipment

- Safety Analyzer (Dempsey model 431 or equivalent)

2.5.2 Case Leakage

1. Plug the line cord of the unit into the safety analyzer.
2. Connect the case ground lead of the analyzer to the equipotential lug of the **Duo** monitor.
3. Perform the leakage tests under the following conditions:
   a. Case grounded:
      Normal polarity
      Normal polarity with open neutral
      Reverse polarity
   b. Case ungrounded:

      Normal polarity
      Normal polarity with open neutral
      Reverse polarity
4. Verify the current reading is <100 uA under normal operating conditions; <300 uA under single fault conditions for 120 VAC and <500 uA under single fault conditions for 230 VAC.

2.6 NIBP Calibration

2.6.1 Test Equipment

- NIBP simulator
- NIBP test chamber/dummy cuff
- Manometer with bulb

2.6.2 Test Procedure

2.6.2.1 Transducer Accuracy

1. Connect the 500 cc Test Chamber and calibrated manometer via a ''T'' fitting to the NIBP fitting on the **Duo** monitor under test.
2. Ensure the **Duo** is not turned on. Simultaneously, press and hold the **POWER** and **NIBP START/STOP** buttons.

   When the monitor enters the NIBP Calibration Mode, message code 525 will be displayed in the Information Codes window. Release the buttons simultaneously.
3. Momentarily press the **NIBP START/STOP** button to start the NIBP calibration. Vent the Test Chamber and verify the **Duo** and the manometer read zero. Using the bulb, pressurize the test chamber to 50 mmHg and verify the **Duo** reading agrees with the manometer +/- 3 mmHg. Using the bulb, increase the pressure to 200 mmHg and verify the **Duo** reading agrees with the manometer +/- 3 mmHg.

2.6.2.2 Pneumatic Leak Test

1. Connect the 500 cc test chamber to the NIBP fitting on the **Duo** monitor under test.
2. From the NIBP Calibration Mode (code 525) momentarily press the **CLEAR** button on the **Duo** keypad. The **Duo** will then switch to the Pneumatic Test Mode and will display message code 550 in the Information Codes window.
3. Momentarily press the **NIBP START/STOP** button to start the leak test. The **Duo** under test will automatically pressurize the test chamber to approximately 180 mmHg.
4. After approximately 20 seconds, the **Duo** under test will vent the pressure in the test chamber and display a message code E06 (Pass) or E07 (Fail) in the systolic window.

2.6.2.3 Dynamic Repeatability Test

1. Restart unit and allow it to enter normal operating mode.
2. Use polyurethane tubing to connect the **Duo** monitor to a calibrated NIBP simulator and the 500 cc test chamber/dummy cuff via a ''T'' fitting.
3. Select Adult patient size for both the **Duo** under test and the NIBP simulator.
4. Select a target simulated blood pressure within the ''normal'' range on the simulator.
5. Take 10 successive NIBP readings and compare the systolic, diastolic, mean and heart rate readings for consistency. Readings should not deviate more than +/- 5 mmHg for the NIBP readings and +/- 2 bpm or 2%, whichever is greater for heart rate.

NOTE: **The actual measured values displayed on the Duo monitor may not compare with the selected target pressure on the simulator. This test is intended to confirm the REPEATABILITY, not accuracy, of dynamic NIBP readings. Accuracy can only be confirmed by performing the NIBP Calibration outlined in section 2.6 of this manual.**

2.7 SpO_2 Verification

2.7.1 Test Equipment

- SpO_2 simulator

2.7.2 Test Procedure

1. Connect the appropriate SpO_2 probe connector to the **Duo** monitor.
2. Connect the SpO_2 probe to the SpO_2 simulator.
3. Set the simulator target values to:

   SpO_2 = 98%
   Pulse Rate = 70
4. Verify that the displayed SpO_2 and pulse rate values on the **Duo** monitor are +/- 2% of the simulator target values.
5. Change the simulator values.
6. Verify the displayed values on the **Duo** monitor are equal to the simulator values +/- 2%.

3.0 *Parts*

3.1 Introduction

This section contains exploded views of the **Duo** monitor, internal modules, and parts list.

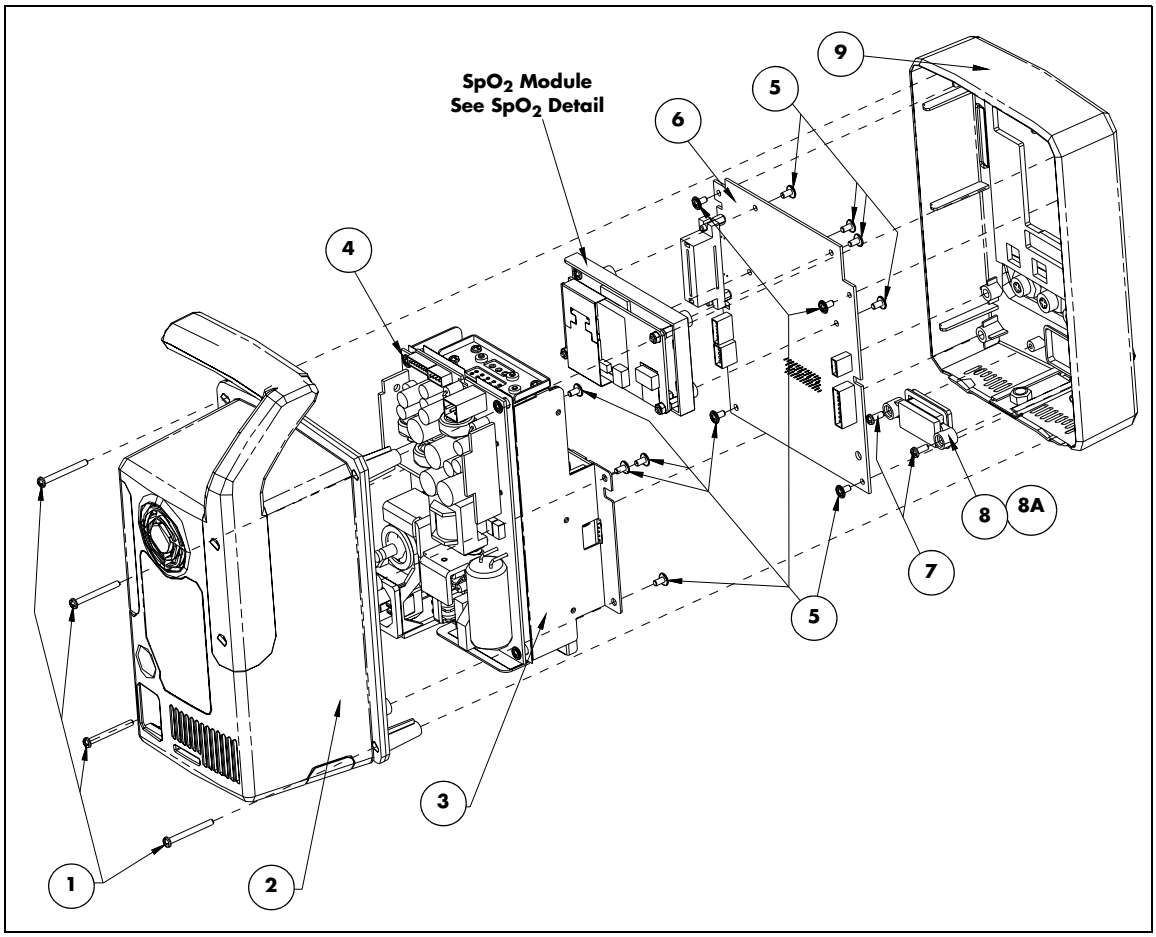

FIGURE 3-1 Duo Exploded View

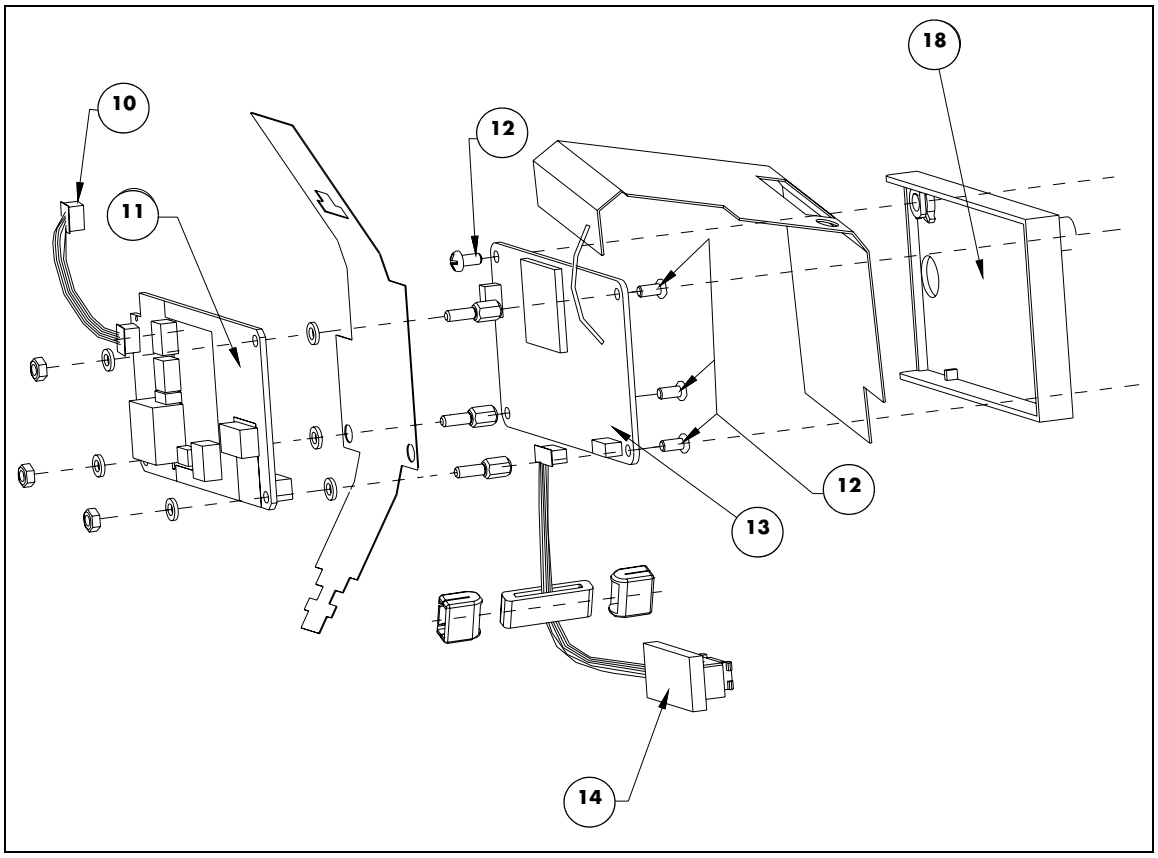

FIGURE 3-2 Masimo SpO_2 Detail

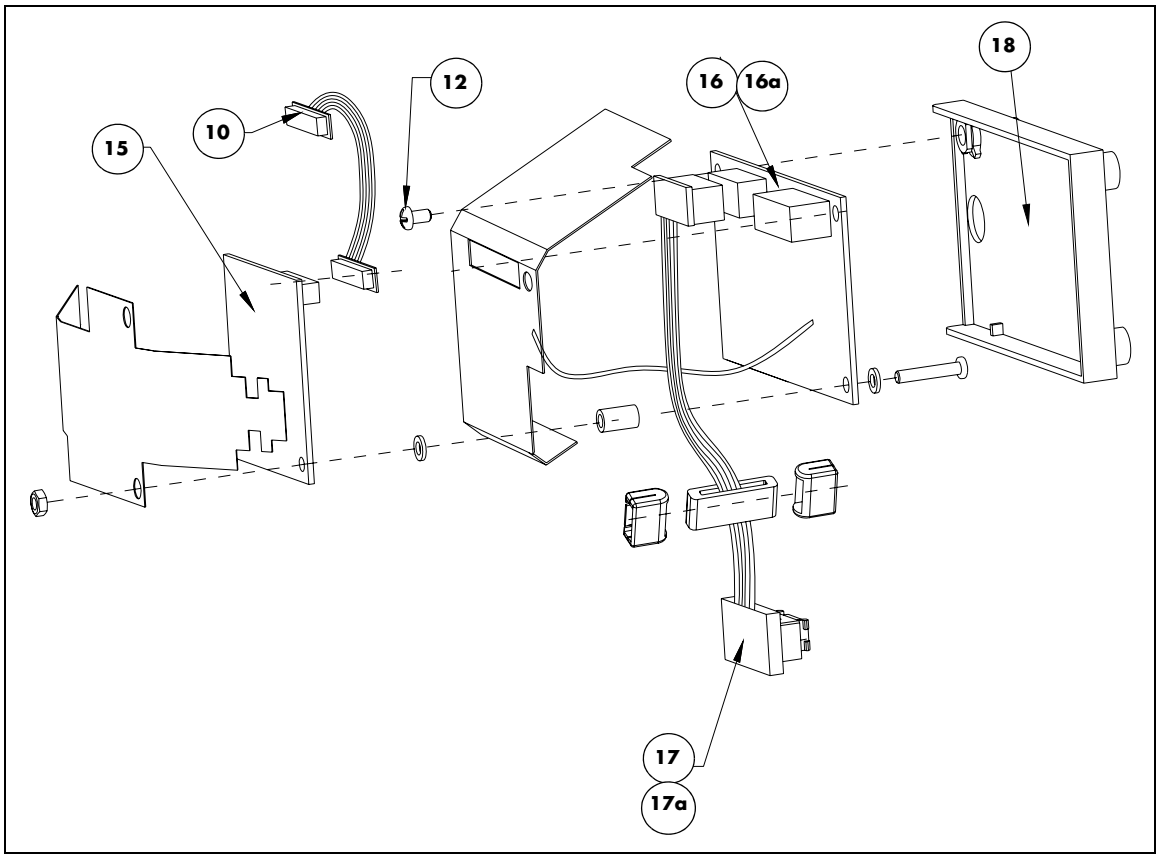

FIGURE 3-3 Nellcor SpO_2 Detail

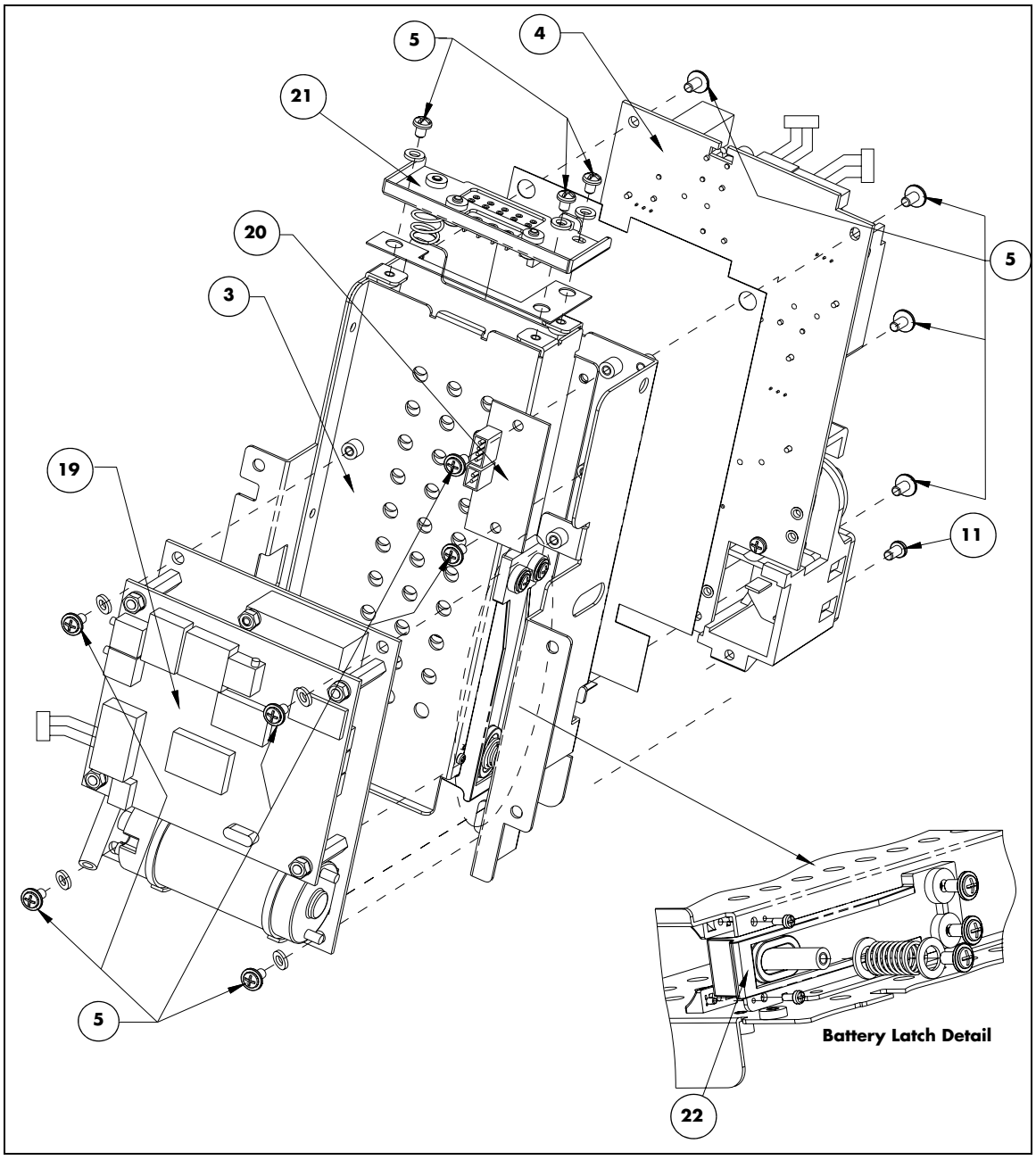

FIGURE 3-4 Main Frame

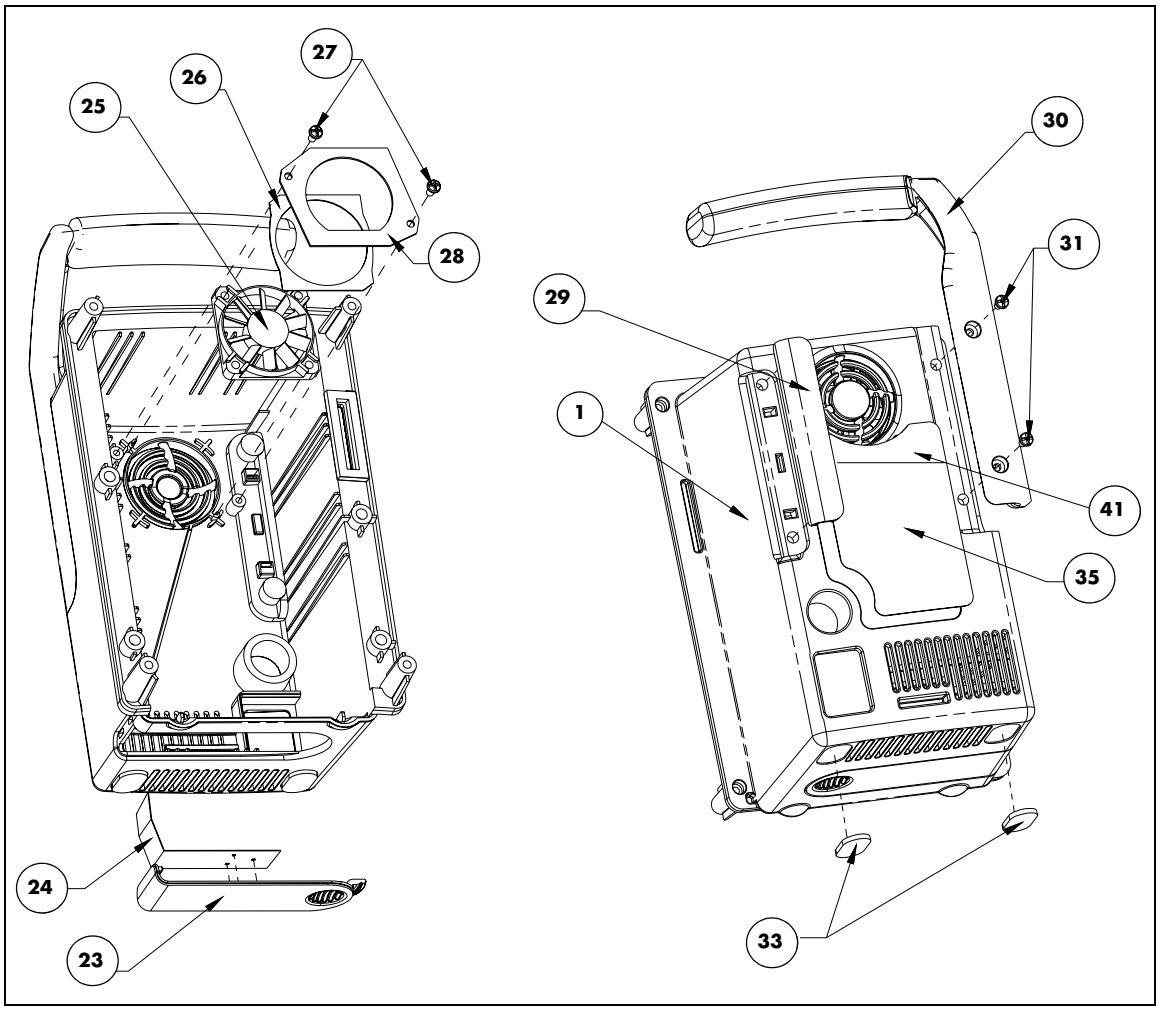

FIGURE 3-5 Rear Case Assembly

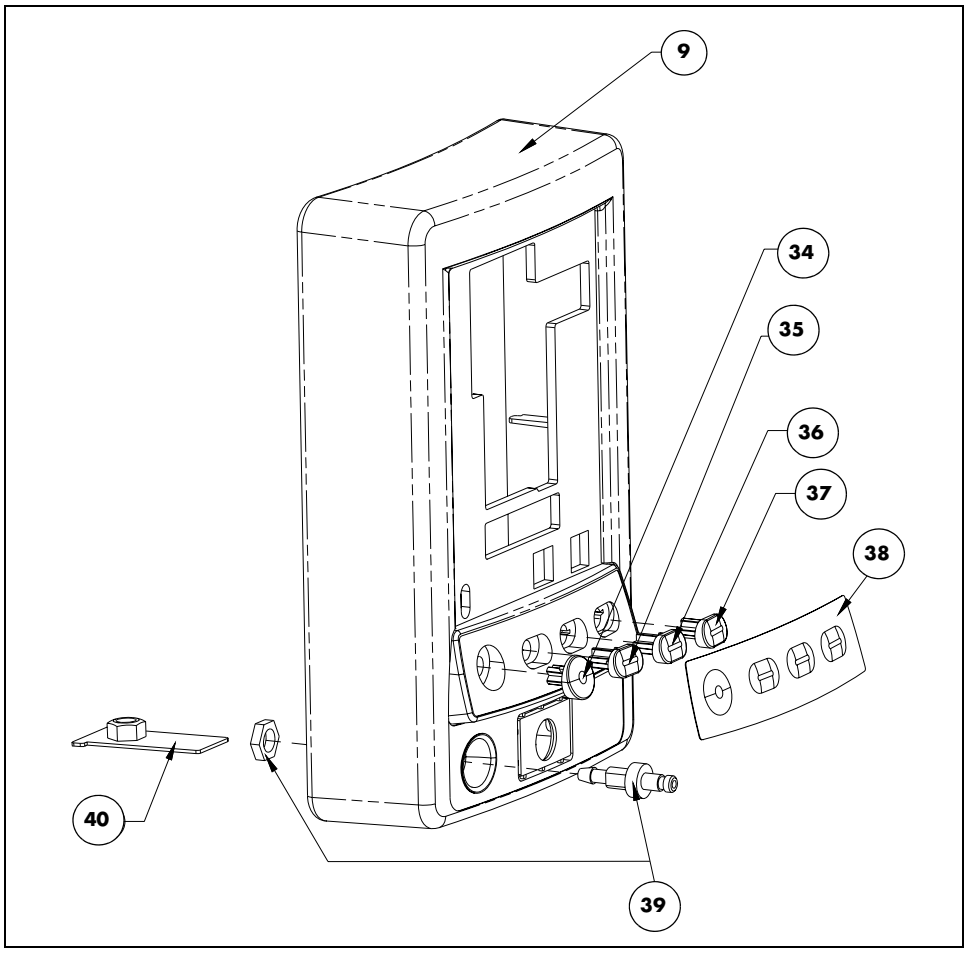

FIGURE 3-6 Front Case Assembly

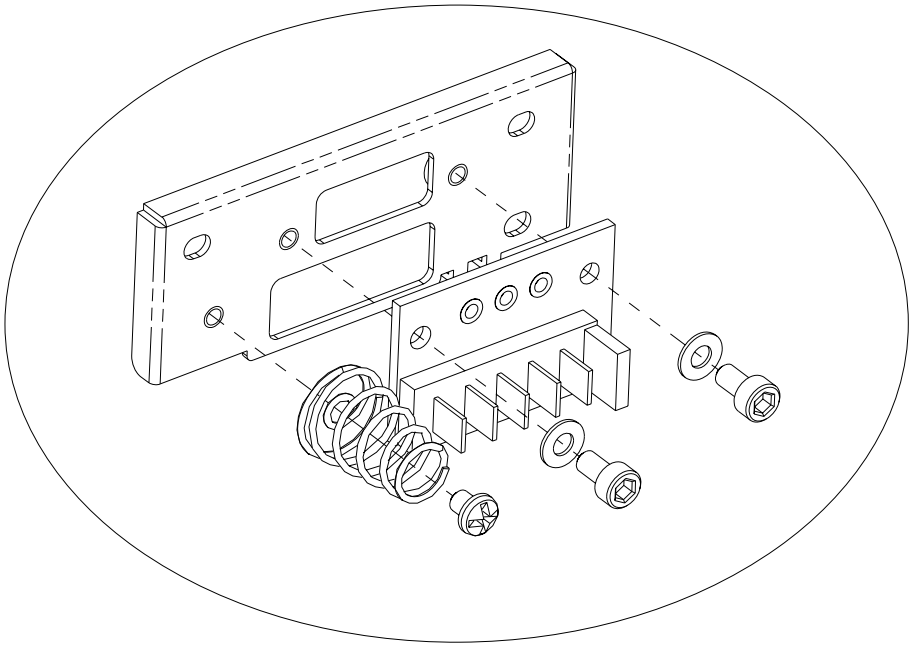

FIGURE 3-7 Battery Connector Assembly Detail

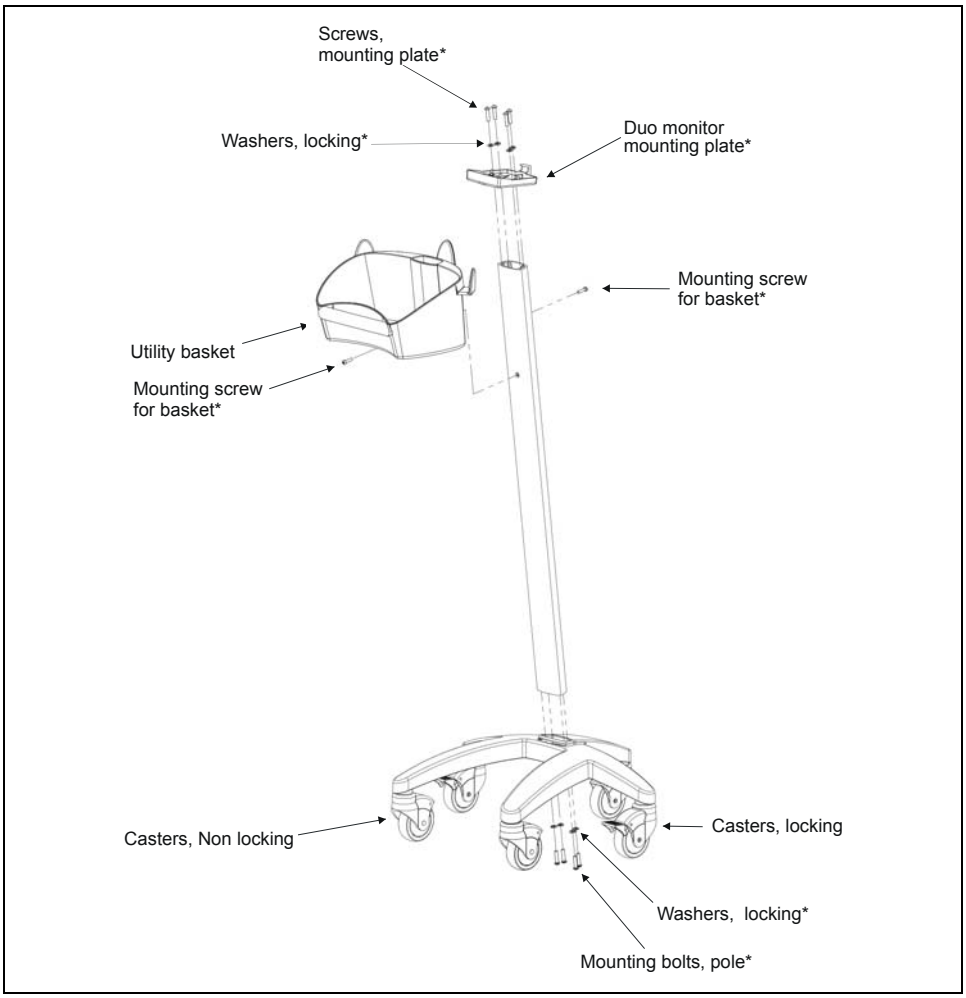

FIGURE 3-8 Duo Rolling Stand

Replacement Parts, Duo Rolling Stand

DESCRIPTION	PART NUMBER
Duo rolling stand, value	DUOROLLSTD
Duo monitor mounting kit	0406-00-0857-01
Casters, Non locking	0401-00-0045
Casters, Locking	0401-00-0046
Utility basket	0202-00-0166

* *Included in Duo monitor mounting kit*

3.2 Parts Listing

REF. NUMBER	PART NUMBER	DESCRIPTION
1	0211-00-0146	Housing Screw (metric panhead)
2	0380-00-0475	Rear Housing
3	0441-00-0107	Chassis
4	0671-00-0045	Power Supply Board
5	0211-00-0145	Metric Panhead Screw
6	0671-00-0044	CPU/Display Board
7	0213-00-0032	Self Tapping Screw
8	0380-00-0472	Nellcor Connector Shroud
8A	0380-00-0473	Masimo Connector Shroud
9	0380-00-0476	Front Housing
10	0012-00-1595	SpO_2 Power Cable
11	0671-00-0246	Masimo Isolated Power Board
12	0211-00-0143	Screw
13	0671-00-0243	Masimo SpO_2 Board
14	0012-00-1474	Masimo Flex Cable
15	0671-00-0247	Nellcor Isolated Power Board
16	0671-00-0242	Nellcor SpO_2 Board
16a	0671-00-0066	Nell-3 SpO_2 Board
17	0012-00-1457	Nellcor Flex Cable
17a	0012-00-1661	Nellcor Flex Cable
18	0386-00-0308	SpO_2 Mounting Plate
19	0104-00-0037	NIBP Module
20	0671-00-0063	Fan Driver Board
21	0671-00-0043	Battery Connector Board
22	0380-00-0481	Battery Latch
23	0380-00-0474	Battery Door
24	0346-00-0052	Battery Door Tether
25	0012-00-1592	Fan with cable
26	0348-00-0216	Fan Gasket
27	0213-00-4014	Screw
28	0386-00-0310	Fan Mounting Plate
29	0380-00-0471	Filler Panel
30	0367-00-0084	Handle
31	0211-00-0147	Handle Screw (metric panhead)
32	0334-00-1603-03	Rear Label, Lower, S/N
33	0348-00-0202	Foot
34	0380-00-0480-01	Power Switch Plunger
35	0380-00-0480-02	Clear Switch Plunger
36	0380-00-0480-03	Patient Size Switch Plunger
37	0380-00-0480-04	Start NIBP Switch Plunger

N/S - Not Shown

REF. NUMBER	PART NUMBER	DESCRIPTION
38	0330-00-0052	Keypad Overlay
39	0103-00-0411	Pneumatic Fitting
40	0386-00-0309	Mounting Plate
41	See table below	Rear Label, Upper
N/S	See table below	Display Overlay
N/S	See table below	Connector Label

N/S - Not Shown

Display Overlay

LANGUAGE	OPTION	PART NUMBER
English	NIBP Only	0330-00-0053-01
English	NIBP/SpO_2	0330-00-0053-11

Upper Rear Label

LANGUAGE	PART NUMBER
English	0334-00-1641-01

Connector Label

DESCRIPTION	PART NUMBER
No SpO_2	0334-00-1602-01
Masimo SpO_2	0334-00-1602-02
Nellcor SpO_2	0334-00-1602-04

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4.0 *Repair Information*

4.1 Introduction

This chapter of the **Duo** Service Manual provides the necessary technical information needed to perform repairs on the instrument. The most important prerequisites for effective troubleshooting are a thorough understanding of the instrument functions as well as an understanding of the theory of operation.

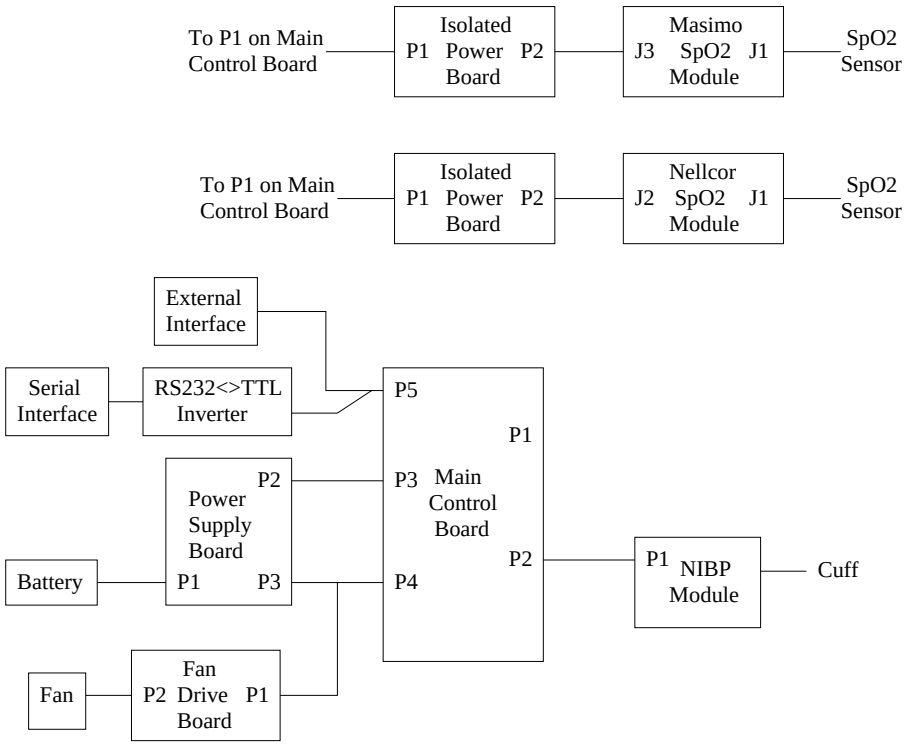

FIGURE 4-1 Module Interconnection

4.2 Troubleshooting Guide

Error Codes and Solutions

MESSAGE/ PROBLEM	REASON	SOLUTION
E01	NIBP Self Test Error	NIBP Module hardware failure
E02	NIBP Communications Error	Communications with NIBP Module have failed
E03	Loose Cuff	Cuff is not properly wrapped or no cuff is present
E04	Air Leak	Cuff, hose or connector is damaged, internal leak
E05	Air Pressure Failure	Stable pressure value is not available (e.g. hoses are pinched or occluded)
E06	Successful Pneumatic Test	Indicates NIBP pneumatic test was successful
E07	Pneumatic Test Failed/ Pneumatic Leak	Leak detected during the pneumatic test
E08	Weak Signal	Cuff is too loose or patient pulse is too weak
E09	Range Exceeded	NIBP value exceeds the upper measurement limit
E10	Excessive Motion Signal Saturated	Monitor is detecting too much motion and/or noise to obtain a reading
E11	Over Pressure	Pressure has exceeded the specified upper safety limit
E12	NIBP System Failure	Operation of blood pressure pump system has failed
E13	NIBP Time Out	Measuring time has exceeded 120 seconds
E14	NIBP Illegally Reset	Unexpected NIBP reset
E15	NIBP Reset Failed	NIBP reset failed
E16	NIBP Communications CRC Error	NIBP Serial Communication CRC failure
E17	NIBP Patient Size Change Error	Attempt to change Patient Size failed
E20	Masimo SpO_2 Interference	Noise detected on the pulse signal prevents pulse discrimination
E21	Masimo SpO_2 Low Perfusion	Patient perfusion is low
E22	Masimo SpO_2 Too Much Light	There is too much ambient room light for the sensor to function properly
E23	Masimo SpO_2 Unrecognized Sensor	The monitor does not recognize the sensor
E24	Masimo SpO_2 Communication Error	The monitor and the SpO_2 module are not communicating
E25	Masimo SpO_2 Board Fault	The Masimo SET board has failed to operate properly
E26	Masimo SpO_2 Sensor Fault	Defective sensor
E28	Masimo SpO_2 Timeout	SpO_2 data has been determined continuously for more than 2 minutes, so SpO_2 data has timed out from the display
E29	Masimo SpO_2 Low Signal IQ	The SpO_2 signal quality is poor

Error Codes and Solutions (Continued)

MESSAGE/ PROBLEM	REASON	SOLUTION
E34	Masimo SpO_2 Pulse Rate Exceeded	Pulse Rate value exceeds the measurement range
E34	Nellcor SpO_2 PR Exceeded	Pulse Rate value exceeds the measurement range
E40	Nellcor SpO_2 Interference	Noise is detected on the pulse signal, preventing pulse discrimination from the noise. The interference may be due to motion, excess infrared light or electrical/optical interference. The message is removed when the noise is removed
E41	Nellcor SpO_2 Check Sensor	The Nellcor module senses an unstable or illegal sensor. This may be due to a poor connection or a bad sensor. The user is required to reconnect the same sensor or connect a new sensor. The message will be removed once the Nellcor module clears the error
E42	Nellcor SpO_2 Communication Error	The front end module is having problems communicating (i.e.: framing errors or bad checksums) with the Nellcor module
E43	Nellcor SpO_2 Weak Pulse	A pulse rate can not be determined and all other measurement conditions are normal. The message is removed when a pulse is detected
E44	Nellcor SpO_2Weak Signal	Noise is detected but a pulse rate can not be discriminated. The message is removed when a pulse is detected
E45	Nellcor SpO_2 Board Fault	The SpO_2 board has malfunctioned
E46	Nellcor SpO_2 Motion	Motion is detected. The message is removed when No Pulse status is detected or when motion ceases
E47	Nellcor SpO_2 Timeout	SpO_2 data has been determined continuously for more than 2 minutes, so SpO_2 data has timed out from the display
E501	Unit Battery Voltage Low	Battery voltage is low
E504	Unit Keyboard Error 1	Error with front panel keypad board
E505	Monitor Shut Off Failure	Monitor cannot be turned off normally
E506	SpO_2 Module Not Recognized	Monitor cannot communicate with SpO_2 module during self-test

Monitor Failures

MESSAGE/ PROBLEM	REASON	SOLUTION
No display after power-on, power indicator does not light.	Bad line fuse	Replace fuse
	Bad power supply	Replace power supply
	Bad CPU/Display board	Replace CPU/Display board
NIBP or SpO_2 will not function.	CPU/Display board or module failure.	Isolate and replace defective board/module

Module Failures

MESSAGE/ PROBLEM	REASON	SOLUTION
NIBP cuff cannot be inflated.	Pinched or leaking hose or cuff	Check hose and cuff. Replace as needed
Intermittently won't take an NIBP reading.	Loose cuff or patient movement	Keep the patient quiet. Reapply cuff
NIBP readings inappropriately high or low for patient condition.	Incorrect cuff size. Incorrectly applied cuff	Use appropriate size cuff. Ensure correct cuff application
	NIBP module is out of calibration	Calibrate/replace NIBP module
No SpO_2 reading	SpO_2 sensor or cable damaged or disconnected	Check sensor placement and connection. Replace if damaged
	Sensor not on patient	
SpO_2 value is inaccurate	SpO_2 sensor or cable damaged or disconnected	Check sensor placement and connection. Replace if damaged
	Sensor not on patient	
	Coloring agent (dye) has been injected into patient	Retry after the coloring agent has dissipated
	Patient movement	Keep patient quiet
	Patient is cold	Warm patient and retry
	Patient is wearing nail polish	Remove nail polish

4.3 Disassembly Instructions

Before disassembling the unit, perform the following:

- Turn off the unit and remove the line cord
- Remove all cables and hoses
- Remove the battery
- Perform all maintenance on a properly grounded work station.

4.3.1 Tools Needed

- Phillips Screwdriver
- 5 mm nutdriver

4.3.2 Front Housing Removal

1. Remove four (4) 3 x 30 mm Phillips panhead machine screws from the corners of the Rear Housing.
2. Carefully separate the front and rear housings and disconnect the cables from the CPU/Display PCB connectors P02, P03 and P07. Disconnect the NIBP tubing from the front housing pressure fitting.

4.3.3 SpO_2 Interface Board Removal

1. Disconnect the cable from P01 on the CPU/Display pcb.
2. Remove three (3) 5mm hexnuts from their stand-offs on the SpO_2 pcb.
3. Lift the SpO_2 Interface pcb from the stand-offs.

4.3.4 SpO_2 Board Removal

1. Remove three (3) 5mm hex stand-offs from the SpO_2 Board.
2. Remove one (1) 3 x 6 mm Phillips panhead machine screw from the SpO_2 Board.
3. Lift the SpO_2 Board from the mounting bracket.

4.3.5 CPU/Display Board Removal

1. Remove four (4) 3 x 6 mm Phillips panhead machine screws from the corners of the CPU/Display Board.
2. Lift the CPU/Display Board from the Front Housing.

4.3.6 NIBP Module Removal

1. Remove four (4) 3 x 6 mm Phillips panhead machine screws from the corners of the NIBP module frame.
2. Lift the NIBP module from the battery housing frame.

4.3.7 Power Supply Removal

1. Remove the battery cable from P1 on the power supply PCB.
2. Remove four (4) 3 x 6 mm Phillips panhead machine screws from the corners of the power supply PCB.
3. Remove one (1) 3 x 6 mm Phillips panhead machine screw from the line power entry connector.
4. Slide the Power Supply pcb towards the bottom (open end) of the battery housing frame until it can go no farther.
5. Lift the power supply PCB from the battery housing frame. Use care to avoid breaking the positioning tab from the line power entry connector.