

Chapter 4

Test and Calibration

INTRODUCTION

WARNING! Read Chapters 1, 2, and 3 of this manual. Pay attention to all the WARNINGS. Failure to heed these WARNINGS can result in severe injury or death.

CAUTION: Read Chapters 1, 2, and 3 of this manual. Pay attention to all the CAUTIONS. Failure to heed these CAUTIONS can damage the instrument.

Read Chapters 1, 2, and 3 before beginning this chapter to familiarize yourself with the operation of the Impulse 4000.

FUNCTIONAL TEST

The following procedure checks the operation of the Impulse 4000.

Equipment Required for Functional Test

The following equipment is required to complete this test:

- Defibrillator with ECG monitor.
- Transcutaneous pacemaker with ECG monitor.

Functional Test Procedure

- From the MAIN MENU PAGE 1, press...
<F1> "DEFIB",
<F1> "NO",
<F1> "ENERGY",
<F2> "HIGH",
<right arrow> "SELECT", and finally
<F1> "TEST".
 - Check that the displayed energy is 100 J $\pm$ 5 J.
 - Check that the peak voltage "Vpk", peak current "Ipk", and 50% and 10% pulse width values, "t50" and "t10", are displayed.
- Press the <left arrow> "SELECT" key (to prepare for step #4).
- Discharge a defibrillator into the Impulse 4000. Check that all test parameters are displayed.
- Connect the ECG leads from the defibrillator to the Impulse 4000. Press <F1> "VFIB". Check that a ventricular fibrillation waveform is displayed on the defibrillator ECG monitor. Press <ESC> "ESCAPE" three times.
- From the MAIN MENU PAGE 1, press...
<F2> "PACER",
<F1> "NO",
<F1> "INT50 Ω " or <F2> "EXT", depending on the pacemaker connection, and
<F1> "PULSE".
 - Press <F5> "TEST" several times, once per second, then press <F1> "HOLD".
 - Check that the displayed pulse amplitude is 100 mA $\pm$ 5 mA.
 - Check that the pulse rate and pulse width are displayed, and press <F1> "REL".
- Connect a transcutaneous pacemaker to the Impulse 4000.
 - Turn on pacing.
 - Check that the pacemaker pulses are measured and that all test parameters are displayed.

CALIBRATION

Calibration is the procedure by which an instrument is adjusted to make its indicated values correspond as closely as possible to the actual values being measured. Sometimes calibration is accomplished by measuring a set of known values and adjusting the instrument accordingly. Verification is accomplished by comparing readings of the instrument with those of another instrument that serves as a reference or standard.

Recommendation

Calibration must be performed at the recommended interval to ensure that the instrument's measurements remain within its specifications. Consult DNI Nevada for the Impulse 4000's recommended calibration interval.

We recommend that you send your instrument to DNI Nevada for this service. When we receive your Impulse 4000, we will install any firmware updates, calibrate it, certify calibration, and return it to you promptly.

Our calibration measurements are traceable to the National Institute of Standards and Technology (NIST). A certificate of calibration and performance is sent with each instrument.

Calibration on Site

Before beginning this calibration procedure, it is important that you are aware of the Warranty Disclaimer (refer to page ii). According to this disclaimer, the warranty on the Impulse 4000 becomes void if the Quality Seal or the Calibration Tag is broken without proper factory authorization. For this reason, we recommend that you send your instrument to DNI Nevada for factory calibration.

Equipment Required for Calibration

The following equipment is required to perform the calibration.

- **Digital Multimeter (DMM)**—suggest Keithley 196*

Range	Resolution	Accuracy	Used in steps
1 A	0.1 mA	0.1%	2
20 V	1 mV	0.1%	4
10 V	0.1 mV	0.01%	8, 9, 10, 13, and 14
100 Ω	0.001 Ω	0.02%	19
1 V	0.01 mV	0.1%	20

*NOTE: Equivalent equipment is required to meet or exceed listed specifications.

- **DC Voltage Source**—suggest any stable DC power supply or batteries in this range.

4 V $\pm$ 1 V Use in steps 8, 9, 10, 13, and 14.

- **Resistor Set**—use in steps 8, 9, and 10.

Quantity	Description	DNI Part #	Fluke #
2	634- Ω , 0.1% resistor	0316-0240	7178386
2	3.16-k Ω , 0.1% resistor	0316-0241	340588
2	316-k Ω , 0.1% resistor	0316-0242	2178402
3	2-pin Molex connector	2710-0014	641667
6	Molex pins	2716-0027	376368

NOTE: Several steps depend on the completion of the previous step; therefore, complete the steps in the order shown.

Calibration Setup

1. Turn off the Impulse 4000.
2. Remove all cables connected to the Impulse 4000 including the battery charger.
3. Remove the two screws on the top cover, three screws on the front panel, two screws on the back panel, and two screws on the side panel (top, center).

NOTE: This action breaks the Quality Seal and voids the factory calibration and warranty if factory authorization is not obtained.

4. Lift the top cover and rest it on the bottom case assembly. Ensure that the rear panel of the top half does not rest on the power switch.

Calibration Procedure

1. Connect a short jumper between TB6—pins 1 and 2. This is the calibration-enable test block. You can use a screwdriver tip to short the pins together until the calibration mode has been entered.
2. Turn on the Impulse 4000.
3. Select <F4> "UTIL" from the MAIN MENU PAGE 2.
4. Press <F5> "CAL".
5. ENTERING CALIBRATION ROUTINE.
 - a) Press <F1> to enter the calibration routine with raw calibration constants.
 - b) Press <F2> to enter the calibration routine with existing constants.

6. **CAL 1: BATTERY CHARGING CURRENT OFFSET.** Unplug the battery charger but keep the battery connected. Press <F5> "ADV" to continue.

NOTE: Throughout the calibration of the Impulse 4000, two functions keys are used.

- The <F4> SKIP key moves the Impulse 4000 to the next calibration step. It does not affect the calibration constants previously stored.
- The <F5> ADVANCE key instructs the Impulse 4000 to take the new values (either entered manually or acquired automatically) and store them in the EEPROM at the end of the calibration procedure.

At the end of calibration you are prompted to save the new calibration constants. In some calibration steps, the Impulse 4000 acquires the new calibration constants automatically. In these cases, there is no input required from you. Some calibration steps require you to enter data. In all cases, read the value to enter from the DMM. Use the <F1> "DOWN" and <F2> "UP" keys to change the value the Impulse 4000 displays.

7. **CAL 2: BATTERY CHARGER CURRENT AMPLITUDE.** Plug in the battery charger. Remove the POSITIVE lead from the battery (yellow wire). Connect the DMM (in DC current mode) in series with the lead and the battery. Read the value on the DMM. Use the Impulse 4000's <F1> "DOWN" and <F2> "UP" keys to adjust the displayed "mA" value to match the DMM reading. The range is from 200 to 400 mA.

NOTE: If the battery is fully charged, then the measured current is quite small and thus is outside the adjustment range. Disconnect the battery at J2 and connect a 50- Ω , 5-watt resistor across J2. This creates a load for the Battery Charging Circuit to use during calibration. Press <F5> "ADV" to continue.

8. **CAL 3: BATTERY VOLTAGE OFFSET.** No setup. Press <F5> "ADV" to continue. Disconnect the DMM. Reconnect the battery lead.
9. **CAL 4: BATTERY VOLTAGE AMPLITUDE.**
CAUTION: Do not short TB1—pins 1 and 2—together. They are connected to the battery directly. This could blow a trace off the printed circuit board.
With mini-hooks, connect the DMM in the voltage mode to TB1—pin 1 (*ground*) and pin 2 (+12 V *battery*). Adjust the display to match the DMM reading. The range is from 10.40 to 15.50 V. Press <F5> "ADV" to continue. Remove the DMM leads.
10. **CAL 5: DIFF AMP DEFIB HI OFFSET.** Remove the cable on the J5 connector. This is reconnected in the *Post Calibration Procedure*. Press <F5> "ADV" to continue.
11. **CAL 6: DIFF AMP DEFIB LO OFFSET.** Press <F5> "ADV" to continue.
12. **CAL 7: DIFF AMP PACER OFFSET.** Press <F5> "ADV" to continue.
13. **CAL 8: DIFF AMP DEFIB HI AMPLITUDE.** This calibration step requires two 634- Ω , 0.1% resistors. These resistors are connected in series (one for each lead) with a voltage source. Connect the voltage source (set to approximately 4.00 V) to J5—pin 1 (*right-positive*) and pin 2 (*middle-negative*). Connect the DMM across the voltage source (not across J5). Adjust the display value to match the DMM reading. The range is from 3.000 to 5.000 V. Press <F5> "ADV" to continue. Remove the two 634- Ω resistors.
14. **CAL 9: DIFF AMP DEFIB LO AMPLITUDE.** This calibration step requires two 3.16-k Ω , 0.1% resistors. These resistors are connected in series (one for each lead) with a voltage source. Connect the voltage source (set to approximately 4.00 V) to J5—pin 1 (*right-positive*) and pin 2 (*middle-negative*). Connect the DMM across the voltage source (not across J5). Adjust the display value to match the DMM reading. The range is from 3.000 to 5.000 V. Press <F5> "ADV" to continue. Remove the two 3.16-k Ω resistors.
15. **CAL 10: DIFF AMP PACER AMPLITUDE.** This calibration step requires two 316-k Ω , 0.1% resistors. These resistors are connected in series (one for each lead) with a voltage source. Connect the voltage source (set to approximately 4.00 V) to J5—pin 1 (*right-positive*) and pin 2 (*middle-negative*). Connect the DMM across the voltage source (not across J5). Adjust the display value to match the DMM reading. The range is from 3.000 to 5.000 V. Press <F5> "ADV" to continue. Remove the two 316-k Ω resistors.
16. **CAL 11: EXT PACER HI OFFSET.** Short TB3—pin 2 to pin 1 (*ground*)—with a short clip lead. Press <F5> "ADV" to continue.
17. **CAL 12: EXT PACER LO OFFSET.** Short TB3—pin 3 to pin 1 (*ground*). Press <F5> "ADV" to continue.
18. **CAL 13: EXT PACER HI AMPLITUDE.** Connect a 4.000-V voltage source to TB3—pin 2 and pin 1 (*ground*). Connect a DMM (in voltage mode) across the voltage source. Adjust the display to match the DMM reading. Range is from 3.000 to 5.000 V. Press <F5> "ADV" to continue. Remove the voltage source.
19. **CAL 14: EXT PACER LO AMPLITUDE.** Connect a 4.000-V voltage source to TB3—pin 3 and pin 1 (*ground*). Connect a DMM (in voltage mode) across the voltage source. Adjust the display to match the DMM reading. Range is from 3.000 to 5.000 V. Press <F5> "ADV" to continue. Remove the voltage source.

20. **CAL 15: TEST PULSE DEFIB OFFSET.** No setup. Press <F5> "ADV" to continue.
21. **CAL 16: TEST PULSE PACER OFFSET.** No setup. Press <F5> "ADV" to continue.
22. **CAL 17: TEST PULSE DEFIB AMPLITUDE.** No setup. Press <F5> "ADV" to continue.
23. **CAL 18: TEST PULSE PACER AMPLITUDE.** No setup. Press <F5> "ADV" to continue.
24. **CAL 19: LOAD RESISTOR MEASUREMENT.** With the DMM in four-terminal Ω mode, measure the load resistor across the "Apex" (*RIGHT*) and "Sternum" (*LEFT*) paddles. Do not use the two-terminal technique because it is not accurate enough for this calibration step. Adjust the display to match the DMM reading. Press <F5> "ADV" to continue. Disconnect the DMM.
25. **CAL 20: PACO DAC OFFSET.** Connect a voltmeter across the ECG posts LL (+) and RA (-). Adjust the voltage by pressing the <F1> "DOWN" and <F2> "UP" keys until the smallest voltage possible is measured by the voltmeter. The voltage should be less than 0.5 mV. Press <F5> "ADV" to continue.
26. **LEAVING CAL ROUTINE**
SAVE NEW CAL CONST
 - a) Enter "YES" to save all changes that were made during the calibration procedure.
 - b) Enter "NO" to abort all changes made during the calibration procedure, and exit the calibration procedure with the previous calibration constants intact.

Post Calibration Procedure

1. Reconnect the cable from the load assembly to the J5 connector.
2. Ensure that the battery leads are connected.
3. Reassemble the instrument. Install the nine screws on the top, front, back, and side panels.