DNI NEVADA

Operating and Service Manual

Impulse 4000

Defibrillator and Transcutaneous Pacer Analyzer

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Impulse 4000 Defibrillator and Transcutaneous Pacer Analyzer

Operating and Service Manual

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DNI NEVADA INCORPORATED

To order this manual, use Part Number 9508-0242.

Revision History

Revision	Description	Date
A	Firmware Version 1.00	7/94
B	Firmware Version 1.02	9/96
C	Firmware Version 1.04	1/98

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Please note that only serialized products (products labeled with a distinct serial number) and accessories are eligible for partial refund and/or credit. Nonserialized parts and accessory items (cables, carrying cases, auxiliary modules, etc.) are not eligible for return or refund. In order to receive a partial refund/credit of a product purchase price on a serialized product, the product must not have been damaged by the customer or by the common carrier chosen by the customer to return the goods, and the product must be returned complete (meaning all manuals, cables, accessories, etc.) within 90 days of original purchase and in "as new" and resellable condition. The *Return Procedure* must be followed to assure prompt refund/credit.

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Return Procedure

Every product returned for refund/credit must be accompanied by a Return Material Authorization (RMA) number, to be obtained from our Order Processing Department. All items being returned must be sent freight prepaid to our factory location.

Certification

This instrument was thoroughly tested and inspected and found to meet DNI Nevada's manufacturing specifications when it was shipped from the factory. Calibration measurements are traceable to the National Institute of Standards and Technology (NIST). Devices for which there are no NIST calibration standards are measured against in-house performance standards using accepted test procedures.

Warranty

Warranty and Product Support

This instrument is warranted by DNI Nevada against defects in materials and workmanship for one full year from the date of original purchase. During the warranty period, we will repair or, at our option, replace at no charge a product that proves to be defective, provided you return the product, shipping prepaid, to DNI Nevada, Inc. This warranty does not apply if the product has been damaged by accident or misuse or as the result of service or modification by other than DNI Nevada. IN NO EVENT SHALL DNI NEVADA BE LIABLE FOR CONSEQUENTIAL DAMAGES.

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Warranty Disclaimer

Should you elect to have your instrument serviced and/or calibrated by someone other than DNI Nevada, please be advised that the original warranty covering your product becomes void when the tamper-resistant Quality Seal is removed or broken without proper factory authorization. We strongly recommend, therefore, that you send your instrument to DNI Nevada for factory service and calibration, especially during the original warranty period.

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WARNING

Unauthorized user modifications or application beyond the published specifications may result in electrical shock hazards or improper operation. DNI Nevada will not be responsible for any injuries sustained due to unauthorized equipment modifications.

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6 Technical Information

Abbreviations

NOTE: This column alphabetized

A	ampere
BPM	beats per minute
°C	degrees Celsius (centigrade)
°F	degrees Fahrenheit
DMM	digital multimeter
ECG	electrocardiograph or electrocardiogram
Hz	hertz
in	inch
J	joule
k	kilo– (10^3)
kHz	kilohertz
kΩ	kilohm
m	–meter
µ	micro– (10^{-6})
µA	microampere
µs	microsecond
m	milli– (10^{-3})
mA	milliampere
mm	millimeter
ms	millisecond
mV	millivolt
Ω	ohm
pacer	pacemaker
p–p	peak–to–peak
lb	pound
PPM	pulses per minute
PQRST	Refers to portion of the ECG waveform
s	second
V	volt

Chapter 1

General Information

SAFETY CONSIDERATIONS

General

This instrument and its related documentation must be reviewed for familiarization with safety markings and instructions before operation.

Safety Symbols

This is the instruction manual symbol; the instrument is marked with this symbol when it is necessary for you to refer to the instruction manual.

WARNING! The "***WARNING!***" sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a "***WARNING!***" sign until the indicated conditions are fully understood and met.

CAUTION: The "***CAUTION:***" sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the instrument. Do not proceed beyond a "***CAUTION:***" sign until the indicated conditions are fully understood and met.

Battery Charger

Use only the specified battery charger supplied by DNI Nevada with this instrument. Make sure the battery charger is rated for your power source. The power source should be compatible with the input voltage and current ratings printed on the battery charger.

Defibrillators

Defibrillators deliver high–voltage shocks to a patient in order to stop a life–threatening heart condition. The defibrillator pulse is potentially dangerous. Do not touch the Impulse 4000 paddle contacts or the defibrillator paddles when discharging (firing) a defibrillator. Always follow the device manufacturer's safety protocols of the defibrillator, such as holding both paddles correctly and pushing the buttons on both paddles simultaneously. Under no circumstances should you touch the conductive metal contacts on the defibrillator paddles. Never try to defeat the safety features of a defibrillator.

Automatic Defibrillators

Automatic defibrillators discharge automatically when they detect a life–threatening heart condition that requires defibrillation. The Impulse 4000 simulates a wide range of cardiac arrhythmias to test the defibrillator. If the Impulse 4000 has been set to output a ventricular fibrillation or a rapid ventricular tachycardia waveform, the automatic defibrillator will discharge after it detects the waveform and determines that defibrillation is necessary. The fully automatic defibrillator warns you that it is about to discharge.

Always heed the audible warnings of the automatic defibrillator. Make sure it is connected to the Impulse 4000 with the correct electrode adapters. Do not touch the Impulse 4000 paddle contacts or the defibrillator connections.

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SAFETY CONSIDERATIONS - *continued*

Automatic Defibrillators - *continued*

During automatic sequences of defibrillator tests, the Impulse 4000 outputs the ventricular fibrillation waveform automatically. Therefore, be aware of this fact and heed the defibrillator's audible warnings, so that you are ready for the pending defibrillator discharge.

Connecting the Defibrillator to the Impulse 4000

1. Select the proper Impulse 4000 electrode adapters (see the *Optional Accessories* section in Chapter 1) for the defibrillator to be tested. An electrode adapter consists of a connector to the defibrillator cable, a banana plug, and a plastic insulating cover. Ensure that the banana plug is in the center of the plastic cover.

2. Place the banana plug portion of the electrode adapter into the center of each of the Impulse 4000 defibrillator paddle contacts.

3. Fit the plastic cover so it completely covers the metal of each of the Impulse 4000 defibrillator paddle contacts.

4. Now plug each of the wires of the defibrillator cable onto the connector of each Impulse 4000 electrode adapter. There should not be any exposed metal conductors in the connection from the defibrillator to the Impulse 4000.

5. An alternate method of connection is to place the defibrillator paddles firmly on the Impulse 4000 paddle contacts.

CAUTION: Never use electrode paste on the defibrillator paddles when testing with the Impulse 4000 because it is not necessary and it will degrade the electrical connection.

Discharging the Defibrillator

The Impulse 4000 has several functions that measure defibrillator parameters when the defibrillator is discharged into its internal test load. To perform any of these tests, first turn on the Impulse 4000 power switch, and then select the appropriate function using the menus and function keys.

Always follow the manufacturer's instructions for the defibrillator that you are testing. Operate the defibrillator with the Impulse 4000 as follows:

WARNING! Defibrillators generate dangerous voltages between their paddles when discharged. Be very careful never to touch either paddle when the energy is discharged. Most defibrillators have a safety interlock which requires buttons on both paddles to be pushed simultaneously with separate hands to discharge the energy. Never try to defeat this safety interlock system.

CAUTION: Never use electrode paste on the defibrillator paddles or conductive disposable electrodes when testing with the Impulse 4000 because it is not necessary and it will degrade the electrical connection.

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SAFETY CONSIDERATIONS - *continued*

Discharging the Defibrillator - *continued*

NOTE: Certain defibrillators have an alternate connection path to the Impulse 4000 that requires the use of the electrode adapters. If this is the case, complete steps 1 through 4 in the preceding section, *CONNECTING THE DEFIBRILLATOR TO THE IMPULSE 4000.*

1. Turn the power on to the defibrillator, then set the defibrillator to the desired energy level.

   If testing cardioversion, turn on the synchronized mode of the defibrillator and connect the ECG monitor leads of the defibrillator to the Impulse 4000 ECG posts. Turn on the ECG monitor of the defibrillator and check that the ECG waveform is displayed and that the defibrillator is recognizing the simulated heartbeat waveform and synchronizing on it. A marker or visual indicator should be displayed on the defibrillator ECG monitor.

2. Charge the defibrillator to the preset energy level by pushing the charge button on the defibrillator. The defibrillator will indicate when it is charged.

3. Place the defibrillator paddles firmly on the Impulse 4000 paddle contacts. The apex (+) paddle should be on the right paddle contact and the sternum (-) paddle should be on the left.* Discharge the defibrillator by pushing both discharge buttons on the paddle handles simultaneously with separate hands.

   *NOTE: On most defibrillators this ensures a positive polarity of the signal at the real–time scope output. Reversing the paddles does not harm anything, even with grounded defibrillators, and still gives a correct energy reading. Reversing the paddles does reverse the real–time scope output polarity.

4. After you have discharged the defibrillator, remove the paddles. The Impulse 4000 displays the results.

Discharging the Automatic Defibrillator

From the ECG signal, the fully automatic defibrillator can detect that defibrillation is needed; then it will charge and discharge automatically. Automatic defibrillators do not use conventional apex and sternum paddles. Instead, they have a cable that connects to adhesive defibrillation electrode pads to facilitate safe and convenient use.

DNI Nevada has special electrode adapters available as optional accessories (see the *Optional Accessories* section in Chapter 1). These electrode adapters connect to the defibrillator's cable.

WARNING! Automatic defibrillators generate dangerous voltages at their outputs. Never touch the defibrillator cable contacts, or the connected electrode adapter metal parts whenever the defibrillator is turned on. Follow the defibrillator's warnings to "stand back" when it discharges.

1. Complete steps 1 through 4 in the earlier section *CONNECTING THE DEFIBRILLATOR TO THE IMPULSE 4000.*

2. If the automatic defibrillator incorporates an ECG monitor with 3– or 5–lead inputs, connect the ECG leads to the Impulse 4000 ECG posts.

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SAFETY CONSIDERATIONS - *continued*

Discharging the Automatic Defibrillator - *continued*

3. Select the appropriate function using the menus and function keys.
   - Use the "VFIB" function (see *Testing Semi– and Fully Automatic Defibrillators* in Chapter 3) for manual tests.
   - Use the "AUTO" function (see *AUTOSEQUENCE TEST* in Chapter 3) to *automatically* generate simulated ventricular fibrillation waveforms during energy tests.

   NOTE: Heed all defibrillator warnings, so that you are ready for the pending defibrillator discharge.
4. Turn on the automatic defibrillator. Follow the manufacturer's instructions. The automatic defibrillator detects the ventricular fibrillation waveform and determines that defibrillation is necessary, then it charges to the preset energy level. The automatic defibrillator issues a warning to stand back and then it discharges the energy.
5. The Impulse 4000 displays the test results.
6. Make sure to turn off the automatic defibrillator when you are done testing.

Internal Paddles

Some defibrillators have special defibrillation paddles for internal body use during open–heart surgery. These paddles are small and are placed directly on the heart. The Impulse 4000 has adapters for these internal paddles that are supplied as standard accessories. They are similar to the automatic defibrillator adapters in that they plug into the center of each of the Impulse 4000 paddle contacts and have plastic covers that go over the paddle contacts. They have a small curved contact surface on top that mates with the internal paddles. To test defibrillators with internal paddles, plug the two internal paddle adapters onto the Impulse 4000 paddle contacts, completely covering the conductive paddle contacts. Then proceed, as described previously, to discharge the defibrillator for an energy level measurement.

CAUTION: The internal defibrillation paddle adapter set (DNI Part # 5215–0198) is shipped with the Impulse 4000 Analyzer as a standard accessory. This adapter set tests the unsterilized cardiac contact plates of internally discharged defibrillators that are typically used during open–heart surgery. The set is shipped from the factory in an unsterilized condition and should not be used, as shipped, to test sterilized contact plates during an open–heart procedure.

The internal defibrillation paddle adapters can be gas sterilized using Ethylene Oxide (EtO) protocol. Both the metal and plastic parts of these adapters can withstand repeated sterilizations, but they should still be examined for damage such as cracking, discoloration, and warping both prior to and immediately following EtO sterilization. No extended product liability or implied warranty, beyond what is listed in the statement on the inside front cover of this manual, is intended by the manufacturer.

SAFETY INFORMATION

WARNING! Instructions for adjustments while covers are removed and for servicing of the Impulse 4000 are for use by trained service personnel only. To avoid dangerous electric shock, do not perform such adjustments or servicing unless qualified to do so.

INTRODUCTION AND FEATURES

Introduction

This manual is written for the biomedical equipment technician or clinical engineer responsible for testing defibrillator and transcutaneous pacemaker equipment. It explains the intended operation and service of the Impulse 4000 Defibrillator and Transcutaneous Pacemaker Analyzer.

The Impulse 4000 measures and reports specific defibrillator performance parameters and transcutaneous pacemaker performance parameters.

Features

The following is a list of the Impulse 4000 features:

- Measures energy output of defibrillators.
- Measures cardioversion delay time of defibrillators in the synchronized mode.
- Measures output parameters of transcutaneous pacemakers.
- Simulates the human body with an internal 50–Ω resistance.
- Provides the specific resistance loads and measurement algorithms necessary to test external transcutaneous pacemakers to manufacturer's specifications.
  NOTE: Requires the use of an adapter (pacemaker plug–in) module; this is an optional accessory.
- Automates testing by making 50 user–programmable autosequences available.
- Generates a wide variety of simulated ECG waveforms.
- Provides clinical training scenarios and interfaces to compatible training manikins such as the Armstrong Medical Defib Chris Clean or the Laerdal Defib–Anne.
- Connects to DNI Nevada's original medTester, medTester 5000, and medTester 5000B.
- Interfaces to a PC, terminal, or parallel printer.

Performs the following functions with defibrillators, transcutaneous pacemakers, and 12–lead ECG devices:

- DEFIBRILLATOR MEASUREMENTS. Output energy, peak output voltage and current, output pulse width, cardioversion delay time test, and charge time.
- TRANSCUTANEOUS PACEMAKER MEASUREMENTS. Peak current, pulse width, pulse rate, pulsed–refractory period, and sensed–refractory period.
- AUTOMATED TESTING PROTOCOLS. Capacity for 50 unique test sequences that inspect specific defibrillators and/or external transcutaneous pacemakers.
- ECG TEST/SIMULATION. Performance waveforms, normal sinus rhythm waveforms, arrhythmia simulations, and R–wave detector tests.
- INTERACTIVE TRAINING SCENARIOS. Simulated ECG waveform sequences that respond to defibrillator discharges and transcutaneous pacemaker inputs. Excellent for training medical personnel.

IMPULSE 4000 INSTRUMENT SPECIFICATIONS

Defibrillator Measurement

The Impulse 4000 Analyzer tests the operation of defibrillators with output waveforms such as Lown, Edmark, Truncated Exponential, or Trapezoidal. This instrument measures and digitally displays the energy, peak voltage, peak current, pulse width, and charge time of the applied defibrillator output pulse.

The Impulse 4000 is designed to operate up to the energy/voltage/current levels as specified below. The actual accuracy of the Impulse 4000 has been verified and tested at 360 joules using an Edmark waveform type defibrillator.

Modes of Operation:	Manual, Factory Preprogrammed Autosequence, User–Programmable Autosequence, and Remote Computer Control.	
Internal Defibrillation Test Load:	50 Ω, ±1%	
Energy Measurement Ranges:	High Range	
	Energy:	360.0 J maximum at specified accuracies NOTE: Readings are obtainable at energies up to 1000 J. Resolution: 0.1 J Accuracy: ±2% of reading for 100–360 J ±2 J for <100 J
	Peak Voltage:	6000 V maximum Resolution: 3 V Accuracy: ± (1% of reading + 10 V) NOTE: Accuracy specified is for energy levels ≤360 J.
	Peak Current:	120 A maximum Resolution: 0.1 A Accuracy: ±(1% of reading + 2 A) NOTE: Accuracy specified is for energy levels ≤360 J.
	Trigger Level:	100 V
	Test Pulse:	100 J ±5 J
	Real–Time Output:	1 V/1000 V Accuracy: ±5% peak–to–peak
	Playback:	1 mV/3000 V Lead II (Time Expansion Factor = 200:1)

Low Range

Energy: 50.0 J maximum
Resolution: 0.1 J
Accuracy: ±2% of reading for 20–50 J
±0.4 J for <20 J

Peak Voltage: 1200 V maximum
Resolution: 1 V
Accuracy: ±(1% of reading + 2 V)

Peak Current: 24 A maximum
Resolution: 0.1 A
Accuracy: ±(1% of reading + 0.1 A)

Trigger Level: 20 V

Test Pulse: 4 J ±0.2 J

Real–Time Output: 1 V/200 V
Accuracy: ±5% peak–to–peak

Playback: 1 mV/600 V Lead II
(Time Expansion Factor = 200:1)

Energy Measurement Time Window: 64 ms

Output Pulse Width Measurement: Measurement is 10% and 50% of the waveform peak; applies to voltage or current.
Resolution: 0.05 ms
Accuracy: ±0.2 ms

Automated Defibrillator Testing: Seven ventricular arrhythmias can be output across the 50–Ω test load to arm the automated defibrillator.
Selections: Ventricular Fibrillation 1 (coarse) and Ventricular Fibrillation 2 (fine).
Ventricular Tachycardia at 130, 175, 180, 185, and 220 BPM.

Cardioversion Delay Time: Measured from the peak of the simulated ECG R wave to the peak of the defibrillator output pulse.
Range: -120 to +380 ms from the R–wave peak.
Resolution: 1 ms
Accuracy: ±1 ms
ECG: Five selections—Normal Sinus Rhythm at 60, 80, and 120 BPM; Atrial Fibrillation 1 (coarse) and Atrial Fibrillation 2 (fine).

Charge Time: Measurement is initiated by pressing the function key and simultaneously charging the defibrillator. Charge time is displayed after the defibrillator output is applied across the internal 50–Ω test load.
Range: 1 to 99 s
Resolution: 1 s
Accuracy: ±1 s

Transcutaneous Pacemaker Measurement

The Impulse 4000 Analyzer is specifically designed to test the basic operation of external transcutaneous pacemakers.

NOTE 1: This particular type of pacemaker is used in both prehospital paramedic and hospital–based emergency cardiac applications to induce a productive heart rhythm in a patient with either asystole (no cardiac activity) or bradycardia (very low heart rate). The pacemaker pulse is typically delivered via a set of disposable electrode pads that are directly attached across the patient's chest.

NOTE 2: The Impulse 4000 Analyzer is not intended for use with either external transvenous or internal implantable pacemakers that use an indwelling invasive catheter to directly stimulate the heart. Refer to the specific device manufacturer for the recommended testing methods for these pacemakers.

The Impulse 4000 Analyzer measures monophasic external transcutaneous pacemaker pulse outputs such as rectilinear, trapezoidal, and truncated waveform types. This analyzer displays rate, peak output current, and pulse width of the applied pacemaker pulse. The Impulse 4000 Analyzer also has interactive testing capabilities for refractory period measurement and demand/asynchronous mode verification that are conducted without the use of additional test equipment.

NOTE: The Impulse 4000 also tests transcutaneous pacemakers using optional adapter (pacemaker plug–in) modules. These modules modify particular measurement techniques, add test load selections, and incorporate the proper electrode connectors to the standard Impulse 4000 as required by specific medical device manufacturers. Refer to Chapter 7 *Modules* or the current DNI Nevada price list for specific adapter (pacemaker plug–in) module availability.

Internal Pacemaker Test Load:	50 Ω, ±1%	
Current Amplitude Measurement:	Range:	4 to 250 mA
	Resolution:	0.2 mA
	Accuracy:	±(1% of reading + 2 mA)
Trigger Level:	4 mA	
Test Pulse Amplitude:	100 mA, ±5 mA	
Measurement Time Window:	100 ms (maximum)	
Pulse Width Measurement:	Pulse width is defined as the time between the initial upslope and the final downslope of the applied monophasic pacemaker pulse. This time is measured at 10% of the maximum amplitude of the applied pacemaker pulse leading–edge slope.	
	Resolution:	0.1 ms
	Accuracy:	±0.5 ms
Pulse Rate:	Range:	30 to 200 PPM
	Resolution:	1 PPM
	Accuracy:	±1 PPM

Refractory Tests:

These tests are performed in the pacemaker demand mode only.

Pulsed–Refractory Period (PRP)
This is the period of time that immediately follows the pacemaker pulse during which time the pacemaker does not sense cardiac activity.

Sensed–Refractory Period (SRP)
This is the period of time that immediately follows sensing of cardiac activity during which time the pacemaker does not sense further cardiac activity.

Measurement Range:	20 to 500 ms
Pacemaker Rate Range:	30 to 200 PPM
Measurement Points:	PRP: Leading edge of the pacemaker pulse to the peak of the first ECG R–wave complex.
	SRP: Between the peaks of the first and second ECG R–wave complex following the pacemaker pulse.
ECG Waveform Stimulus:	Havertriangle, 1 mV peak (Lead II), and 40–ms width.
Measurement Resolution:	1 ms
Measurement Accuracy:	±2 ms

Demand Test:

This is an interactive test that verifies the basic operation of the pacemaker in the demand mode. The applied pacemaker pulse rate is measured and two ECG heart rates are automatically computed that either inhibit or enable the pacemaker output.

ECG Waveform Stimulus:	Havertriangle, 1–mV peak (Lead II).
ECG Waveform Stimulus Rate Range:	1 to 250, in 1–BPM steps.

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Autosequence Test

The Impulse 4000 can store up to 50 autosequences with device–specific inspection protocols. These autosequences can include a wide range of defibrillator, pacemaker, and ECG tests. The first 26 autosequences are factory–initialized for selected device manufacturers' models. The first 18 of these selections comprise defibrillator–only devices, the next 8 comprise combination defibrillator/pacemaker devices, and the remaining 24 are exclusively reserved for your own customized protocols. If desired, you can program any of the 50 autosequences with your own customized protocols. However, the first 26 autosequences revert to factory values whenever the instrument is reinitialized and the rest of the autosequences are erased.

Defibrillator Tests

Defibrillator Energy Levels:	Up to 20 discrete energy levels with both ± test limits set in % steps. For low–level energy settings, a minimum test limit of ±0.7 J is factory preprogrammed.
Maximum Energy:	Records energy and charge time with ± test limits set in 1–J steps. A test can be repeated; only the results of the last test are saved.
Cardioversion:	Records up to three tests with both energy levels and delay time measurements. Energy has both ± test limits set in % steps.
ECG Performance Waveforms:	Series of ECG waveforms sequenced to test the basic operation of the ECG monitor and recorder functions. (Refer to the next section, *ECG Waveforms,* for details.)

Pacemaker Tests

Pulse Mode:	Up to 20 outputs with selectable amplitude and rate values. A ± test limit can be independently set for each of the parameters. This test is intended primarily for the continuous (asynchronous) mode of the transcutaneous pacemaker for basic amplitude and rate accuracy testing. For low–level amplitude settings, a minimum test limit of ± 5 mA is factory preprogrammed.
Asynchronous Pacemaker Test:	One discrete test for the continuous (asynchronous) pacemaker to ensure that the desired continuous pacemaker output selection is not disabled in the presence of a higher–rate ECG signal. The overdrive ECG signal can be set by the operator to a rate from 10% to 50% over the continuous pacemaker rate.
Demand Pacemaker Tests:	Five discrete rate tests. Interaction of the demand–mode pacemaker pulse and a user–programmable ECG base rate can be tested. Both the underdrive and the overdrive ECG rates can be set by the operator. Underdrive and overdrive rate ranges are 10% to 50% of the selected ECG base rate.
Refractory Tests:	Pulsed– and sensed–refractory tests are performed. A test can be repeated; only the results of the last test are saved.

ECG Waveforms

The Impulse 4000 Analyzer generates a true 12–lead ECG simulation with independent outputs for each signal lead.

Waveform Selections:

Manually Selectable Performance Waveforms

- Zero Output
- Square Wave: 2 Hz
- Pulse: 4 s
- Sine Waves: 0.05, 0.5, 1, 10, 25, 30, 40, 50, 60, 100, 125, and 150 Hz.
- Square Wave: 1 kHz
- Triangle Wave: 2 Hz

NOTE: Reference lead signal is 1–mV amplitude; selectable between I and II.

Automated ECG Performance Waveform Sequence

A series of the above–listed performance waveforms is output in the following sequence to facilitate the testing of ECG monitoring and recording devices:

Zero Output; Square Wave; Pulse; Sine Waves 1, 10, 30, 40, 50, 60, and 100 Hz, and 1 kHz (Square Wave); Triangle Wave; and Normal Sinus Rhythm rates 60, 30, 60, 120, 240, and 60 BPM.

NOTE: Reference lead signal is 1–mV amplitude; selectable between I and II.

Manually Selectable Normal Sinus Rhythms

30, 60, 80, 120, 160, 200, 240, and 300 BPM.

NOTE: Lead II signal is 1–mV amplitude.

ECG R–Wave Threshold Detection Test

Determines the minimum width and amplitude of the particular R wave that is detectable, i.e., those R waves that reach threshold.

ECG R Waves

Width: 8, 12, 20, 40, 60, 80, 100, 120, 140, 160, 180, and 200 ms.

Accuracy: ±1%

Amplitude: Lead II signal

0.05 to 0.50 mV in 0.05–mV steps.
0.50 to 5.50 mV in 0.25–mV steps.

Accuracy: ±5%

Arrhythmia Selections

NOTE: Lead II signal is 1-mV amplitude for all arrhythmia selections.

- Supraventricular: Atrial Fibrillation (1 & 2)
  Atrial Flutter
  Sinus Arrhythmia
  1° AV block
  2° AV block type I
  2° AV block type II
  3° AV block

- Ventricular: Premature Ventricular Contractions (PVC 1 and PVC 2)
  Multifocal PVCs
  Couplet (pair of PVCs)
  Bigeminy
  Trigeminy
  Run of 5 PVCs
  Run of 11 PVCs
  Ventricular
  Ventricular Tachycardia at 130, 175, 180, 185, and 220 BPM.
  Ventricular Fibrillation (1 & 2)
  Asystole (1 & 2)

- Transvenous Pacemaker:
  Continuous
  Demand (type 1 & 2)
  AV (Atrioventricular) Sequential
  Noncapture
  Nonfunctional

- Simulated Waveform Accuracy
  Amplitude: ±5% (reference lead)
  Rate: ±0.5%

- Transvenous Pacemaker Spike Simulation
  Amplitudes: -700, -500, -200, -100, -50, -20, -18, -16, -14, -12, -10, -8, -6, -4, -2, 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 50, 100, 200, 500, and 700 mV.
  Accuracy: ±(10% of setting +0.2 mV)
  Pulse Widths: 0.1, 0.2, 0.5, 1.0, and 2.0 ms.
  Accuracy: ±5%

Low–Level ECG Posts

- Ten binding posts that are compatible with disposable snap electrodes, 3.2– and 4–mm pins, and loose wires.
- The binding posts are as follows:
  1. RL (right leg)
  2. RA (right arm)
  3. LA (left arm)
  4. LL (left leg)
  5. V1 (chest)
  6. V2 (chest)
  7. V3 (chest)
  8. V4 (chest)
  9. V5 (chest)
  10. V6 (chest)
- A true 12–lead simulation with independent signals at each lead (RA + LA + LL = 0).
- Amplitude swing: ±2 mV maximum for each signal.
- Nominal levels for a Normal Sinus ECG R wave, baseline to peak:

Lead I	0.7 mV
Lead II	1.0 mV
Lead III	0.3 mV
V Leads	1.0 mV

- Defibrillator Paddle (50–Ω) Contacts are the same as the low–level Lead II amplitude signal.

High–Level Output

- A high–level version of the Lead II signal (LL–RA) proportional to the low–level signal at 1 V/mV.
- ¼–inch phone jack connection.

Manikin Interface

Compatible with training manikins such as Armstrong Medical Defib Chris Clean and the Laerdal Defib–Anne. Provides ECG signal and receives isolated defibrillator signal to sequence the ECG during training scenarios.

ECG Signal Output: Low–level Lead II signal.

Training Scenarios

The Impulse 4000 has several training scenarios that are interactive with defibrillators, transcutaneous pacemakers, and training manikins (listed in the preceding section). The Impulse 4000 outputs an ECG waveform and then responds to the discharge of a defibrillator or transcutaneous pacemaker thereby providing realistic training situations for medical personnel. The student can be presented with a new ECG selection, or defib/pacer conversion response by the instructor with the simple push of a button.

A printout of the student's responses, elapsed time, ECG waveform series, and formatted evaluation checklist can be output at the end of each training scenario. (Refer to the sample printout in *Using Training Scenarios* in Chapter 3.)

Defibrillator Training Scenarios:
- Emergency Ventricular Defibrillation (Sequence of waveforms that simulates a failing heart condition and subsequent revival if defibrillation is successful; also VFIB1, VFIB2, VTACH, and NORM–NSR 80.)
- Elective Cardioversion (AFIB1, AFIB2)

Transcutaneous Pacemaker Scenarios:
- Asystole
- Bradycardia
- Demand
- Noncapture

Calendar/Clock

Both the date and time are maintained with internal battery backup. These selections can be viewed on the display or printed on both the autosequence and training scenario test forms.

Data Interfaces

Printer Port: Parallel
Connector: IBM compatible DB25 female connector.

Serial Port: RS–232
Connector: IBM compatible DB25 male connector.

- Bi–directional port for controlling the instrument and outputting test results.
- CTS handshake for sending data.
- Baud rates are 300, 600, 1200, 2400, 4800, and 9600.

General Specifications for the Impulse 4000

PARAMETER	SPECIFICATION
Power Requirements:	Internal 12–V lead–acid battery provides a minimum of 20 hours' operation. Instrument will run from charger while charging a fully depleted battery. Battery is rechargeable from wall plug charger: • Use North American 115–volt CSA–approved battery charger with 115 VAC (±10%) @ 50–60 Hz. • Use European 230–volt with IEC square–power input jack battery charger with 230 VAC (±10%) @ 50–60 Hz.
Temperature Range:	Operating: 15° to 35°C (59° to 95°F). Storage: 0° to 50°C (32° to 122°F).
Relative Humidity:	95% maximum, noncondensing.
Display:	4–line x 40–character Supertwist Liquid Crystal Display.
Weight:	3.86 kg (8.5 lb).
Dimensions:	24.89 cm L x 26.92 cm W x 8.89 cm H (9.8" L x 10.6" W x 3.5" H).

Standard Accessories

	DNI Part #
Battery Charger	
Domestic (115 VAC) *or*	1201-0088
European (230 VAC)	1201-0089
Operating and Service Manual	9508-0242
Defibrillator Contact Plate Internal Paddle Adapter Set	5215-0198
Vinyl Carrying Case	9530-0050

Optional Accessories

Defibrillation–Only (50–Ω) Electrode Adapters

Cardiotronics—Molded Wing Type Connector	3010-0448
Physio–Control LIFEPAK series (set of two)	5215-0256
SpaceLabs–First Medic 610; Laerdal Heart Start 1000/2000/3000 (set of two)	5215-0278

External Transcutaneous Pacer–Only (50–Ω) Electrode Adapters

Physio–Control LIFEPAK series (set of two)	5215-0322
Zoll Medical—NTP Electrode System Compatible	3010-0450

Combination Defibrillator/External Transcutaneous Pacer (50–Ω) Electrode Adapters

Cardiotronics—Latching Type Connector	3010-0449
Hewlett Packard—Round Connector	3010-0447
Marquette Medical (all models; set of two)	5215-0258
Zoll Medical PD2200 Multi–Function Electrode System	3010-0378

Adapter (Pacemaker Plug–In) Modules	DNI Part #
TQA–2 Zoll Models PD1200 and PD1400; PD2200 Electrode System. (1000–Ω Load)	9513-0180
TQA–3 Zoll Models NTP2000 and NTP2100. (1000–Ω Load)	9513-0181
TQA–6 Medical Data Electronics (MDE) Model E300. (600– and 1000–Ω Loads, and Open Circuit)	9513-0179
TQA–7 Marquette Medical Model 1500. (300–Ω Load)	9513-0183
TQA–9 Physio–Control LIFEPAK series. (100–, 700–, 1000–, and 1500–Ω Loads)	9513-0178
TQA–11 Cardiotronics—Latching Type Connector. (100–Ω Load)	9513-0184
TQA–12 Hewlett Packard Code Master Series. (50– and 400–Ω Loads)	9513-0185

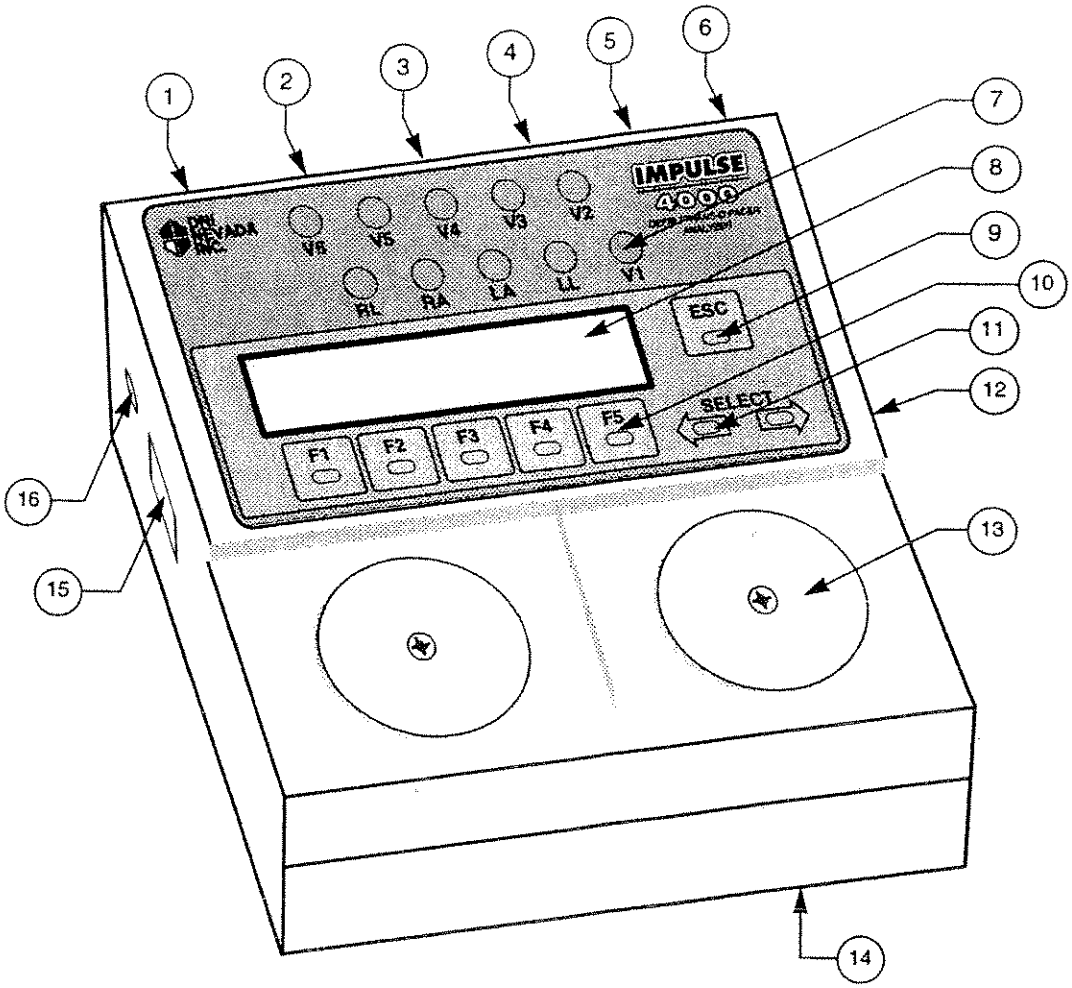
NOTE: Refer to the current DNI Nevada Price List for availability, part number information, and price.

Other Optional Accessories

Hard–sided carrying case	9530-0048
Bi–directional Serial Communication Cable, DB25 (female) to DB25 (female) connectors	3010-0250
Bi–directional Serial Communication Cable, DB9 (female) to DB25 (female) connectors	3010-0441
Use this cable for a medTester Bi–directional Serial Communication Cable, DB25 (female) to DB25 (female) connectors	3010-0467
Adapter Module Output Cable, 2.5–mm phone plug to BNC	3010-0442

NOTE: Refer to the current DNI Nevada Price List for availability, part number information, and price.

INSTRUMENT FAMILIARITY



1. Printer Port
2. RS–232 Serial Port
3. Handle
4. Manikin Port
5. High–Level ECG Output
6. Battery Charger Input
7. 10 ECG Lead–Binding Posts
8. Display
9. ESC: Escape Key
10. F1–F5: Function keys execute the function displayed above the key.
11. SELECT: Left and right arrow keys.
12. Power Switch
13. Defibrillator Paddle Contacts: "Apex" (right), "Sternum" (left).
14. EPROM cover located on the underside of the instrument.
15. Adapter Module Receptacle
16. Real–Time Output

Chapter 2

Installation

UNPACKING AND INSPECTION

Follow standard receiving practices upon receipt of the instrument. Check the shipping carton for damage. If damage is found, stop unpacking the instrument. Notify the carrier and ask for an agent to be present while the instrument is unpacked. There are no special unpacking instructions, but be careful not to damage the instrument when unpacking it. Inspect the instrument for physical damage such as bent or broken parts, dents, or scratches.

CLAIMS

Our routine method of shipment is via common carrier, FOB origin. Upon delivery, if physical damage is found, retain all packing materials in their original condition and contact the carrier immediately to file a claim.

If the instrument is delivered in good physical condition but does not operate within specifications, or if there are any other problems not caused by shipping damage, please contact DNI Nevada or your local sales representative.

WARRANTY REPAIR

The warranty statement for this product is at the front of this manual.

When shipping an instrument to DNI Nevada for repair, complete the Service Return Form and attach to the instrument. Completing this form will help to ensure timely repair of your instrument.

Use the original carton and packaging material for shipment. If they are not available, we recommend the following guide for repackaging:

a) Use a double–walled carton of sufficient strength for the weight being shipped.

b) Use heavy paper or cardboard to protect all instrument surfaces. Use a nonabrasive material around all projecting parts.

c) Use at least four inches of tightly packed, industrial–approved shock–absorbent material around the instrument.

CONNECTING THE PRINTER

You can connect any Centronics or IBM PC compatible parallel printer to the Impulse 4000. DNI Nevada recommends that you use a standard IBM PC compatible parallel printer cable.

Connect this cable to the "PRINTER PORT", a 25–pin (DB25) female connector, on the rear panel of the Impulse 4000.

RS–232 SERIAL PORT SETUP

The Impulse 4000 can be connected to the medTester via the RS–232 serial port. Test results can be sent to a computer using this port and it can also be used to control all test functions via a personal computer or compatible terminal device. DNI Nevada recommends that you use the appropriate cable as can be located in the *Other Optional Accessories* section in Chapter 1. The cable connects to the 25–pin (DB25) male connector, labeled "SERIAL PORT", on the rear panel of the Impulse 4000.

MANIKIN CONNECTION

The Impulse 4000 will output the selected ECG waveform to the defibrillator pick–up plates of either the Armstrong Medical Defib Chris Clean training manikin or the Laerdal Defib–Anne training manikin. Use the standard modular phone jack, labeled "MANIKIN", on the rear panel of the Impulse 4000.

HIGH–LEVEL ECG OUTPUT PORT

Use this port—a ¼–inch diameter phone jack, labeled "ECG HI LEVEL OUTPUT", on the rear panel of the Impulse 4000—to connect to an oscilloscope for monitoring waveforms.

Chapter 3

Operating Instructions

POWER–UP AND INITIALIZATION

The Impulse 4000 is battery operated. The power on/off switch is located on the right side of the Impulse 4000 case next to the ventilation slots. When you turn the instrument on, it displays the firmware version followed by the MAIN MENU PAGE 1 as shown below:

```
7/21/94              IMPULSE 4000              15:06:20
                   MAIN MENU PAGE 1:

DEFIB        PACER         ECG          PERF          AUTO>
```

<F1> <F2> <F3> <F4> <F5>

Press the "SELECT" right pointing arrow to view PAGE 2 of the MAIN MENU:

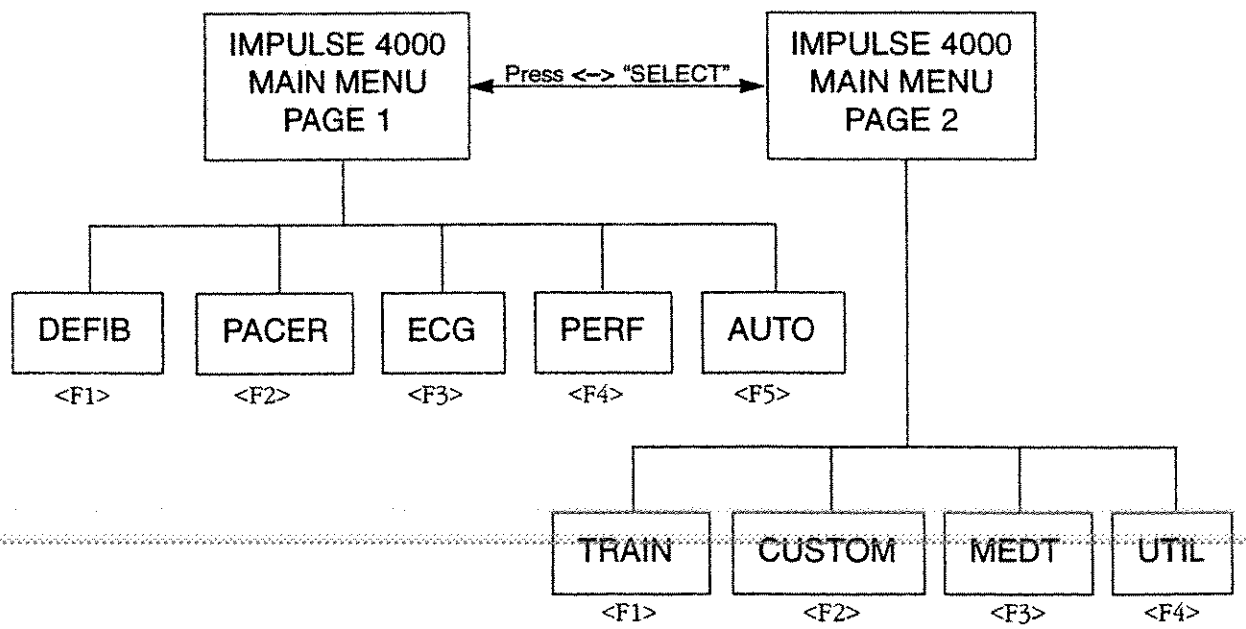
```
7/21/94              IMPULSE 4000              15:06:20
                   MAIN MENU PAGE 2:

<TRAIN       CUSTOM        MEDT         UTIL
```

<F1> <F2> <F3> <F4> <F5>

MAIN MENU STRUCTURE

Below is a brief outline of the Impulse 4000 main menu structure.



TESTING A DEFIBRILLATOR

Defibrillator Testing Theory

Energy is defined as the integral over time of the instantaneous power output of a defibrillator. Power is equal to the voltage squared, then divided by the resistance.

$$E = \int p\ dt = \int V^2/R\ dt = \int V^2\ dt/R$$

The Impulse 4000 measures and stores the instantaneous voltage of the discharge pulse every 50 microseconds, 1280 times, for a total measurement time of 64 milliseconds. All of these instantaneous voltages are squared, summed, multiplied by 50 microseconds, and finally divided by the 50–Ω load resistance to yield an energy measurement in joules (J), also referred to as watt–seconds.

$$E = (\Sigma\ v^2) \bullet \Delta t/R = (\Sigma\ v^2) \bullet 50\ \mu s/50\ \Omega$$

Available Energy Ranges

The Impulse 4000 provides a low– and a high–energy range for thorough testing of the defibrillator output, as follows:

- Low energy = Less than or equal to 50 J.
- High energy = Up to 1000 J.

NOTE: Refer to the IMPULSE 4000 INSTRUMENT SPECIFICATIONS - *Defibrillator Measurement* section in Chapter 1 for more information.

Measuring Defibrillator Energy Output

WARNING! **Cardiac defibrillators generate potentially dangerous voltages which can be lethal if improperly handled by an untrained operator. Refer to the device manufacturer's operator or service manual for the specific device–inspection requirements. Additional safety information for testing cardiac defibrillators is included in the *SAFETY CONSIDERATIONS* section at the beginning of Chapter 1.**

To measure the defibrillator output energy:

1. If you are using electrode adapters, complete steps 1 through 4 in Chapter 1, SAFETY CONSIDERATIONS - *Connecting the Defibrillator to the Impulse 4000*.
2. Press <F1> "DEFIB" from the MAIN MENU PAGE 1.
3. If a printer is attached to the Impulse 4000, press <F5> to print a manual defibrillator test header. Press <F4> to send the header to the serial port. If no header is desired, press <F1> to continue.
4. Press <F1> "ENERGY".
5. Select either <F1> "LOW" for measurements up to 50 J or <F2> "HIGH" for measurements over 50 J. The top line of the display flashes "READY". The Impulse 4000 will accept a defibrillator output pulse for energy measurement.

6. Place the defibrillator paddles firmly on the Impulse 4000 defibrillator paddle contacts, and charge the defibrillator to the desired energy level. Alternately, ensure that the electrode adapters are connected properly as stated in Chapter 1, SAFETY CONSIDERATIONS - *Connecting the Defibrillator to the Impulse 4000.*

7. Discharge the defibrillator.

The Impulse 4000 displays the following measurement data:

```
DEFIB ENERGY:              READY   E = 98.1 J
   Vpk =    2025 V         Ipk =   40.5 A
   t50 =   1.60 mS         t10 =   2.65 mS
VFIB       VTACH      PLYBCK    SERIAL      PRINT>
```

<F1> <F2> <F3> <F4> <F5>

where:

E = Energy in joules.

Vpk = Peak voltage.

Ipk = Peak current in amperes.

t50 = Pulse width at 50 percent of the waveform peak in milliseconds.

t10 = Pulse width at 10 percent of the waveform peak in milliseconds.

Self–Test Feature

Press the "SELECT" right pointing arrow to view the next page of the display:

```
DEFIB ENERGY:              READY   E = 98.1 J
   Vpk =    2025 V         Ipk =   40.5 A
   t50 =   1.60 mS         t10 =   2.65 mS
<TEST
```

<F1>

Use <F1> "TEST" to periodically test the Impulse 4000 operation. When you press <F1> "TEST", the Impulse 4000 supplies a simulated defibrillator pulse to test its circuitry. There is an actual pulse generator circuit that feeds into the low–level measurement circuitry, after the high–voltage attenuator. Therefore, the circuitry and the firmware are tested completely. This is not an absolute calibration pulse, but just a general purpose self–test. When in the "LOW" range, the test pulse should measure 4 J ±0.2 J; and in the "HIGH" range, the test pulse should measure 100 J ±5 J.

Printing Measurement Data

The displayed measurement data can be sent to an attached serial printer or parallel printer.

- To send to a serial printer, press <F4> "SERIAL".
- To send to a parallel printer, press <F5> "PRINT".

Below is an example of a printed report with a header:

```
IMPULSE 4000              DNI NEVADA
DATE:  08/21/94           TIME:  11:34:54
OP CODE:_____________     CN:_____________
MANF:________________     MODEL:__________
SERIAL #_____________     LOC:____________

MANUAL DEFIB ENERGY TEST     RANGE: HI
E = 105.0 J               Ipk = 29.4 A
Vpk = 1472 V              t10 = 6.40 ms
t50 = 3.10 ms
ECG OUTPUT: vfib1
```

← Optional Header

Testing Semi- and Fully Automatic Defibrillators

Refer to the device manufacturer's operator or service manual for specific device–inspection requirements. The following ECG waveforms are available to activate the automatic defibrillator:

- VFIB – VFIB1 (coarse) and VFIB2 (fine).
- VTACH Rate – vt130, vt175, vt180, vt185, and vt220.

To test either semi- or fully automatic defibrillators:

1. Complete steps 1 through 3 in Chapter 1, SAFETY CONSIDERATIONS - *Discharging the Automatic Defibrillator.*
2. Press <F1> "DEFIB" from the MAIN MENU PAGE 1.
3. If a printer is attached to the Impulse 4000, press <F5> to print a manual defibrillator test header. Press <F4> to send the header to the serial port. If no header is desired, press <F1> to continue.
4. Press <F1> "ENERGY".
5. Select either <F1> "LOW" for measurements up to 50 J or <F2> "HIGH" for measurements over 50 J. The top line of the display flashes "READY". The Impulse 4000 will accept a defibrillator output pulse for energy measurement.
6. Press either <F1> "VFIB" (ventricular fibrillation) or <F2> "VTACH" (ventricular tachycardia) to generate the required stimulus ECG waveform for the advisory shock feature of the device. Press the key again to choose additional selections (coarse or fine VFIB or VTACH Rate). The display shows your choice.
7. Discharge the defibrillator. The Impulse 4000 displays the measurement data.

```
DEFIB ENERGY: vt185      READY     E = 98.5 J
   Vpk =    2022 V               Ipk =  40.4 A
   t50 =  1.60 mS                t10 =  2.60 mS
VFIB       VTACH       PLYBCK    SERIAL      PRINT>
```

<F1> <F2> <F3> <F4> <F5>

Viewing Waveform Output

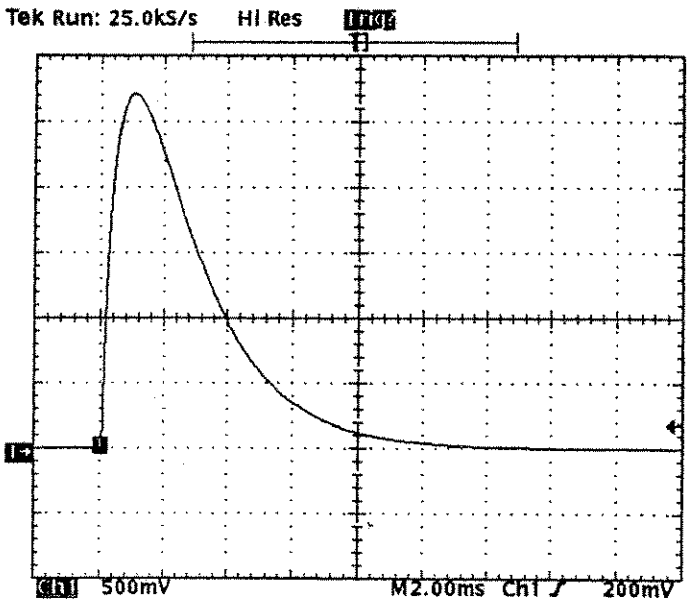
Real-Time Waveform Output

The attenuated defibrillator discharge pulse can be viewed on an oscilloscope using the Impulse 4000 real–time output. The ratios of displayed voltages to actual voltages are as follows:

Oscilloscope	*Defibrillator Voltage (displayed)*	*Defibrillator Voltage (actual)*
High range	1 V	1000 V
Low range	1 V	200 V

To view waveform output in real time:

Connect a BNC cable from the real–time output on the left side of the Impulse 4000 to the oscilloscope. A sample printout is shown below:



Waveform Output from an Oscilloscope

Time–Expanded Waveform Playback

The defibrillator discharge pulse can be viewed on a standard ECG monitor or recorder (e.g., strip chart) using time–expanded output. The expansion factor rescales at a ratio of 200:1. At typical 25 mm/s chart speed, 5 mm = 1 ms.

NOTE: Typically monitors have frequency response characteristics that can potentially distort the waveform. Because the low–end frequency (-3–db) response for the chart recorder and monitor is approximately 0.5 Hz or higher (in the monitoring quality mode), a certain amount of "droop" may be present in the playback waveform. For the highest fidelity reproduction, use an oscilloscope and directly couple (DC) the input.

Press <F3> "PLYBCK" to play back the waveform. First, the Impulse 4000 outputs a 1–mV marker pulse: 0.2 seconds wide in "HIGH" range or 0.1 seconds wide in "LOW" range. Then it plays back the waveform. The complete playback takes 13 seconds since there is a 200:1 ratio on the 64–ms data acquisition. Press <ESC> to terminate the playback if desired.

TESTING DEFIBRILLATOR CARDIOVERSION

Cardioversion Testing Theory, Measurement Technique and Parameters

The purpose of the cardioversion test is to determine the ability of the defibrillator to synchronize the discharge of its output pulse with the selected Impulse 4000 simulated ECG waveform.

Ideally, the peak of the defibrillator output pulse should coincide or immediately follow the peak of the ECG R wave within 30 milliseconds. Technical Reference: ANSI/AAMI DF2–1989 (Cardiac Defibrillators Devices Standard).

Cardioversion Delay Time

The Impulse 4000 can measure the cardioversion delay time of synchronized defibrillators. In this mode, the instrument outputs an ECG waveform (see the following section, *Selecting the Stimulus Waveform*) while it waits for a concurrent defibrillator pulse. When the defibrillator pulse comes, the delay time is computed from the R–wave peak of the last heartbeat to the onset of the defibrillator pulse. The ECG waveform is 1 mV on Lead II.

The Impulse 4000 measures the delay time from the peak of the simulated ECG R wave to the peak of the defibrillator output pulse. This measurement range is -120 to +380 ms. The values are negative if the defibrillator discharges prior to the peak of the simulated R wave, such as on the QR up–slope. The values are positive if the defibrillator discharges after the simulated R wave. If the delay time is outside of these limits, "NO SYNC" is displayed.

Selecting the Stimulus Waveform

The following ECG waveforms are simulated by the Impulse 4000 for performing the cardioversion test.

Waveform	Abbreviation
Normal Sinus @ 60 BPM	NSR60
Normal Sinus @ 80 BPM	NSR80
Normal Sinus @ 120 BPM	NSR120
Atrial Fibrillation (COARSE)	AFIB1
Atrial Fibrillation (FINE)	AFIB2

To select the ECG stimulus waveform:

1. Press <F1> "DEFIB" from the MAIN MENU PAGE 1.
2. If a printer is attached to the Impulse 4000, press <F5> to print a manual defibrillator test header. Press <F4> to send the header to the serial port. If no header is desired, press <F1> to continue.
3. Press <F2> "CARDIO".
4. To select the range, press <F1> "LOW" for measurements up to 50 J or <F2> "HIGH" for measurements over 50 J. The top line of the display flashes "READY". The Impulse 4000 will accept a defibrillator output pulse for cardioversion measurement.

   WARNING! Follow all instructions in the next section, *Conducting the Cardioversion Test*, before discharging the defibrillator.
5. Press <F1> "NSR" for a normal sinus rhythm selection or press <F2> "AFIB" for an atrial fibrillation selection.
   a. For NSR, press <F1> "NSR" until the desired heart rate is displayed.
   b. For AFIB, press <F2> "AFIB" to select coarse or fine atrial fibrillation.

Conducting the Cardioversion Test

WARNING! Cardiac defibrillators generate potentially dangerous voltages which can be lethal if improperly handled by an untrained operator. Refer to the device manufacturer's operator or service manual for the specific device–inspection requirements. Additional safety information for testing cardiac defibrillators is included in the *SAFETY CONSIDERATIONS* section at the beginning of Chapter 1.

1. If you are using electrode adapters, complete steps 1 through 4 in Chapter 1, SAFETY CONSIDERATIONS - *Connecting the Defibrillator to the Impulse 4000.*
2. Complete step 1 in Chapter 1, SAFETY CONSIDERATIONS - *Discharging the Defibrillator.*
3. Complete steps 1 through 5 in the preceding section, *Selecting the Stimulus Waveform.*
4. Select the "SYNCHRONIZED" mode of operation on the defibrillator.
5. Connect the ECG leads from the monitor/defibrillator to the Impulse 4000 binding posts.
6. Place the defibrillator paddles firmly on the Impulse 4000 defibrillator paddle contacts. Alternately, ensure that the electrode adapters are connected properly.
7. Charge the defibrillator to the desired energy level.
8. Press and hold the discharge pushbuttons on the defibrillator paddles and wait for the defibrillator to discharge.

   After the defibrillator discharges, the Impulse 4000 displays the following measurement data:

```
DEFIB CARDIO:    nsr60    READY     E = 145.6 J
 Vpk =    2477 V          Ipk =   49.5 A
 Delay time =   88 mS
 NSR        AFIB       PLYBCK     SERIAL      PRINT>
```

<F1> <F2> <F3> <F4> <F5>

where:

E = Energy in joules.

Vpk = Peak voltage.

Ipk = Peak current in amperes.

Delay time = Amount of time in ms; from -120 to +380.

NOTE: If the defibrillator discharges outside of the -120– to +380–ms timing window, the prompt "NO SYNC" displays. Verify that the "SYNCHRONIZED" mode of operation is selected on the defibrillator.

Self–Test Feature

Use <F1> "TEST", on page 2 of the DEFIB CARDIO menu, to periodically test the Impulse 4000 operation. First, press the <right arrow> "SELECT" key to change the display to PAGE 2 of the MAIN MENU. Then press <F1> "TEST". When you press <F1> "TEST", the Impulse 4000 supplies a simulated defibrillator pulse to test its circuitry. There is an actual pulse generator circuit that feeds into the low–level measurement circuitry, after the high–voltage attenuator. Therefore, the circuitry and the firmware are tested completely. This is not an absolute calibration pulse, but just a general purpose self–test. In the "LOW" range, the test pulse should measure 4 J ±0.2 J; and in the "HIGH" range, the test pulse should measure 100 J ±5 J.

Printing Measurement Data

Because the information is the same, refer to *Printing Measurement Data* in the previous section *TESTING A DEFIBRILLATOR.*

Viewing Waveform Output

Because the information is the same, refer to *Viewing Waveform Output* in the previous section *TESTING A DEFIBRILLATOR.*

TESTING DEFIBRILLATOR MAXIMUM ENERGY

Use the MAXE option to test the defibrillator's maximum energy output for either the low or high range. MAXE also measures the charging time of the defibrillator. The following ECG waveforms are available to activate the semi- and fully automatic defibrillator:

- VFIB – VFIB1 (coarse) and VFIB2 (fine).
- VTACH Rate – vt130, vt175, vt180, vt185, and vt220.

Conducting the Maximum Energy Test

To run the maximum energy test:

1. Complete steps 1 through 3 in Chapter 1, SAFETY CONSIDERATIONS - *Discharging the Automatic Defibrillator.*
2. Press <F1> "DEFIB" from the MAIN MENU PAGE 1.
3. If a printer is attached to the Impulse 4000, press <F5> to print a manual defibrillator test header. Press <F4> to send the header to the serial port. If no header is desired, press <F1> to continue.
4. Press <F3> "MAXE".
5. To select the range, press <F1> "LOW" for measurements up to 50 J or <F2> "HIGH" for measurements over 50 J.
6. For automatic defibrillators, press <F1> "VFIB" or <F2> "VTACH" repeatedly until the desired waveform is displayed. For example, press <F1> twice to select VFIB2 (fine).

   NOTE: The selected waveform doesn't affect an energy test for a nonautomatic defibrillator.
7. Press <F3> "START" and begin charging the defibrillator.

   The top line of the display flashes "READY". The Impulse 4000 will accept a defibrillator output pulse. Discharge the defibrillator. Test results display on the Impulse 4000 as shown in the sample below:

```
DEFIB MAXE     vfib2                    E =   97.5 J
  Charge Time =    1 S
Push F3 and start charging defib
VFIB       VTACH       START      SERIAL      PRINT>
```

<F1> <F2> <F3> <F4> <F5>

Self–Test Feature

The test pulse becomes available on <F5> after you press <F3> "START". When you press <F5> "TEST", the Impulse 4000 supplies a simulated defibrillator pulse and displays the data as shown above.

Printing Measurement Data

The displayed measurement data can be sent to an attached serial printer or parallel printer.

- To send to a serial printer, press <F4> "SERIAL".
- To send to a parallel printer, press <F5> "PRINT".

TESTING AN EXTERNAL TRANSCUTANEOUS PACEMAKER

The Impulse 4000 is specifically designed to test the basic operation of external transcutaneous pacemakers.

NOTE 1: This particular type of pacemaker is used in both prehospital paramedic and hospital–based emergency cardiac applications to induce a productive heart rhythm in a patient with either asystole (no cardiac activity) or bradycardia (very low heart rate). The pacemaker pulse is typically delivered via a set of disposable electrode pads that are directly attached across the patient's chest.

NOTE 2: The Impulse 4000 is not intended for use with either external transvenous or internal implantable pacemakers that use an indwelling invasive catheter to directly stimulate the heart. Refer to the specific device manufacturer for the recommended testing methods for these pacemakers.

The Impulse 4000 measures monophasic external transcutaneous pacemaker pulse outputs such as rectilinear, trapezoidal, and truncated waveform types. This instrument displays rate, peak output current, and pulse width of the applied pacemaker pulse. The Impulse 4000 also has interactive testing capabilities for refractory period measurement and demand/asynchronous mode verification that are conducted without the use of additional test equipment.

Test Load

The internal 50–Ω noninductive resistance provides a standard test load for the pacemaker that simulates the thoracic impedance of the adult chest.

Pulse Current Amplitude Measurement

The highest (or peak) current value, in either polarity, of the pacemaker pulse is directly computed by the Impulse 4000 and is displayed in milliamperes (mA).

NOTE: Some pacemaker manufacturers require different measurement techniques for their specific devices. Refer to the section *Adapter (Pacemaker Plug–In) Modules* for information or review the specific device specifications listed in the manufacturer's service manual.

Pulse Width Measurement

The width of the pacemaker pulse is measured at the 10%–point between the zero baseline and the highest peak current value. It is displayed in milliseconds (ms).

Pulse Rate Measurement

The rate is determined by measuring the elapsed time between the leading–edge points of consecutive pacemaker pulse waveforms. This rate is directly displayed in pulses per minute (PPM).

Refractory Period Measurement

Refractory tests are to be performed in the pacemaker "DEMAND" mode only. These tests verify the ability of the pacemaker to interact with cardiac activity while the pacemaker is operating in the "DEMAND" mode. The desired outcome of the "DEMAND" mode is to pace the heart during periods of asystole or extreme bradycardia, and not to interfere with the heart when it beats at a normal rhythm and rate.

While the pacemaker is in the "DEMAND" mode of operation, it acts as a backup to the heart's normal rhythm. If this normal rhythm rate falls below the selected pacemaker rate, the pacemaker's output is enabled and the heart is artificially paced. If the heart begins to beat at a normal rhythm and rate, the pacemaker's output becomes inhibited and discontinues pacing.

The pacemaker is constantly monitoring the patient's cardiac activity except during the intervals that the pacemaker pulse is output and during the blanking period immediately following the pacemaker pulse. The *Pulsed–Refractory Period (PRP)* is the period of time that immediately follows the pacemaker pulse during which time the pacemaker does not sense cardiac activity and its output is not inhibited. The Impulse 4000 interactively outputs the ECG R–wave complex following the pacemaker pulse and makes a series of adjustments to this coupling interval until the following pacemaker pulse is inhibited. The Impulse 4000 measures the PRP from the leading edge of the pacemaker pulse to the peak of the first ECG R–wave complex.

The *Sensed–Refractory Period (SRP)* is the period of time that immediately follows sensing of cardiac activity during which time the pacemaker does not sense further cardiac activity. The Impulse 4000 measures the SRP from the peak of the first ECG R–wave complex to the next ECG R–wave complex following the pacemaker pulse.

Demand Mode Interactive Testing

This is an interactive test that verifies the basic operation of the pacemaker in the "DEMAND" mode. The applied pacemaker pulse rate is measured and two ECG R–wave drive rates are automatically computed. The underdrive rate is 80 percent of the applied pacemaker pulse rate and the overdrive rate is 120 percent of the applied pacemaker pulse rate. These rates either enable (underdrive) or inhibit (overdrive) the pacemaker pulse rate when output by the Impulse 4000. If desired, you can adjust the ECG R–wave complex rate from 1 to 250 BPM in one–beat–per–minute steps.

Adapter (Pacemaker Plug-In) Modules - Optional

As an optional feature, DNI Nevada offers a series of adapter (pacemaker plug–in) modules for the Impulse 4000 designed to satisfy the testing requirements of specific manufacturers' models. These adapter (pacemaker plug–in) modules have the connector required to directly interface to the pacemaker's electrode cable, provide specified test loads, and also have an identification code that can modify the Impulse 4000 testing formats. While the standard pacemaker testing capabilities of this instrument satisfy general testing needs, some device manufacturers require different measurement techniques. The following manufacturers' models are some of the examples:

Zoll Medical Models PD1200, PD1400, NTP2000, and NTP2100
DNI Nevada Adapter (Pacemaker Plug–in) Modules TQA-2 and TQA-3

Output Current: Displayed reading (in mA) is an averaged value of samples taken every 50 microseconds across the entire rectilinear peak instead of a single maximum peak current value. Approximately 800 readings are averaged during this 40–millisecond time period.

Refractory Period: Pulsed–refractory period measurement is referenced from the trailing edge of the pacemaker pulse instead of the initial rising edge.

Medical Data Electronics Model E300
DNI Nevada Adapter (Pacemaker Plug–in) Module TQA-6

Output Current: Displayed reading (in mA) is the peak amplitude measurement of the trailing edge of the pacemaker pulse to the zero baseline instead of the maximum peak current value.

See the Adapter (Pacemaker Plug-In) Modules' listing in Chapter 1, *Optional Accessories* section, for specific information regarding the DNI Nevada Adapter Module model numbers and part numbers for each specific manufacturer's model.

NOTE: Refer to the current DNI Nevada Price List for the complete listing of available Adapter (Pacemaker Plug-In) Modules.

Connecting the Pacemaker to the Impulse 4000

WARNING! **Never touch the pacemaker connections when the pacemaker is turned on. The pacemaker must be turned off prior to changing any connections because the pacemaker generates a potentially dangerous voltage that can be lethal if improperly handled.**

Electrode adapters or an adapter (pacemaker plug-in) module (see above) can be used to connect the pacemaker to the Impulse 4000. It is preferable to use an adapter module because it is compatible with the pacemaker manufacturer's specifications.

1. If you are using electrode adapters, complete steps 1 through 4 in Chapter 1, SAFETY CONSIDERATIONS - *Connecting the Defibrillator to the Impulse 4000.*
2. If you are using an adapter module, turn off the Impulse 4000 and plug the adapter module into the "ADAPTER MODULE" receptacle on the left side of this instrument. Connect the adapter module cables to the pacemaker cables.

   NOTE: Readings will be identical if the connections are accidently reversed. If you want to reverse the polarity of the real–time output, reverse the connection.

Conducting the Manual Pacemaker Test

CAUTION: Do not discharge a defibrillator into the pacemaker adapter module inputs! This may result in damage to both the Impulse 4000 and the adapter module.

If this occurs, over–voltage protection circuitry in the Impulse 4000 displays an error message, and the adapter module produces an audible "beep". To reset the Impulse 4000, turn it off, disconnect the defibrillator leads, and then turn it on.

Measuring Pulse Parameters

1. Connect the pacemaker to the Impulse 4000 as explained in the preceding section.
2. Press <F2> "PACER" from the MAIN MENU PAGE 1.
3. If a printer is attached to the Impulse 4000, press <F5> to print a manual defibrillator test header. Press <F4> to send the header to the serial port. If no header is desired, press <F1> to continue.
4. Press <F1> "INT50 Ω" to select the internal 50–Ω resistance, or press <F2> "EXT" to select an external adapter module.
5. When <F2> "EXT" is selected, the name of the connected module is displayed. For modules with multiple loads, select the desired load.
6. Press <F1> "PULSE". Turn on the pacemaker and set the desired pacing rate and amplitude. Start sending pulses. The Impulse 4000 displays the following information:

```
PACER PULSE:                    Internal     50Ω
  Amp = 103.2 mA            Pulse rate = 105 PPM
  Pwd =  18.7 mS            ---Π---Π---Π---Π---Π-
HOLD                                         TEST
```

<F1> <F2> <F3> <F4> <F5>

where:

Amp = Amplitude in milliamperes (mA).

Pwd = Pulse width in milliseconds (ms).

Pulse rate = Pulse rate in pulses per minute (PPM).

---Π---Π-= Visual representation of the pulse rate (not calibrated), where "Π" is the pulse.

7. Incoming pulses are measured, the data is updated, and then the parameters are displayed. To print the test data or send it to the serial port, press <F1> "HOLD." This freezes the test data. Select <F4> "SERIAL" or <F5> "PRINT".
8. To release the hold and continue measuring incoming pulses, press <F1> "REL" (release).

Self–Test Feature

Press <F5> "TEST" to input a test pulse at approximately 100 mA.

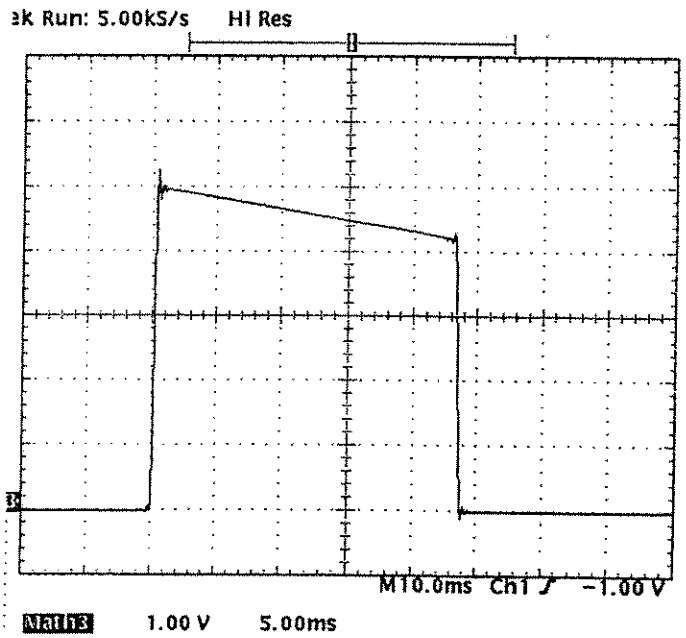
Viewing Real–Time Waveform Output

The pacemaker pulse waveforms can be viewed on an oscilloscope using this real–time output in a manner similar to viewing the defibrillator discharge pulse. The ratio of displayed voltage to actual pacemaker output current is as follows:

Pacemaker Voltage (displayed)	*Pacemaker Current (actual)*
1 V	40 mA

To view waveform output in real time:

1. Connect a BNC cable from the real–time output on the left side of the Impulse 4000 to the oscilloscope. A sample printout is shown below:



Waveform Output from an Oscilloscope

Measuring the Refractory Periods

Complete the following steps:

1. Connect the pacemaker output leads to the Impulse 4000 internal 50–Ω input using the optional electrode adapters or to the adapter (pacemaker plug–in) module if it is plugged into the left side of the Impulse 4000.

   NOTE 1: Refer to an earlier section in this chapter *Connecting the Pacemaker to the Impulse 4000* for more information.

   NOTE 2: To simplify the direct connection of the pacemaker output leads to the Impulse 4000, refer to the current DNI Nevada Price List for availability of optional electrode adapters and modules that are designed for specific manufacturers' models.

2. Connect the pacemaker's ECG cable to the Impulse 4000 top panel color–coded ECG binding posts.

3. On the pacemaker, select the pacemaker pulse rate and output level to be tested.

4. Press <F2> "PACER" from the MAIN MENU PAGE 1 on the Impulse 4000.

5. If a parallel printer is attached to the Impulse 4000, press <F5> to print a test form header. Press <F4> to send the test form header to the serial port. If no test form header is desired, press <F1> to continue.

6. Press <F1> "INT50 Ω" to select the internal 50–Ω top panel test load, or press <F2> "EXT" to select an adapter (pacemaker plug–in) module. If an adapter module is selected, it will be identified on the top line of the display. Some adapter modules have multiple test loads; if this is the case, select the desired value.

7. Press <F2> "RFRCTRY" to show the initial refractory test display:

```
PACER REFRACTORY:     Internal 50 Ω
set pacer to demand mode,
30..200 PPM, push START when ready
START
```

<F1> <F2> <F3> <F4> <F5>

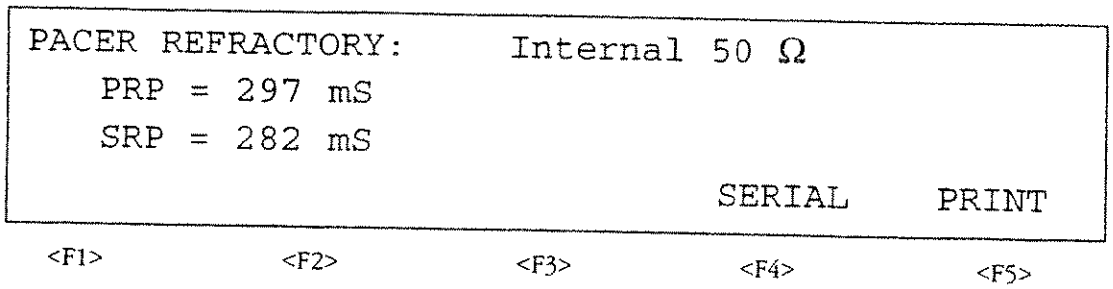
8. Place the pacemaker in the "DEMAND" mode of operation and activate the output.

9. When ready, press the Impulse 4000's <F1> "START" key.

   The Impulse 4000 calculates the rate of the applied pacemaker pulse and then outputs the 1.0–mV (Lead II) havertriangle waveform to conduct the PRP and the SRP measurements. If no pacemaker pulses are sensed, the Impulse 4000 halts the test and then shows <F1> "START" on the display. If this occurs, check all connections and controls as listed above and press <F1> "START" to restart the test.

   NOTE: At low pacemaker rates, these tests can take over 30 seconds to complete.

When the measurements are complete, the Impulse 4000 displays the following information:



The measurement can take up to 60 seconds to complete.

10. If a parallel printer is attached to the Impulse 4000, press <F5> to print a test form header. Press <F4> to send the test form header to the serial port. Press <ESC> once to return to "START".

Conducting a Demand Mode Test

Complete the following steps:

1. Connect the pacemaker output leads to the Impulse 4000 internal 50–Ω input using the optional electrode adapters or to the adapter module if it is plugged into the left side of the Impulse 4000.

   NOTE 1: Refer to an earlier section in this chapter *Connecting the Pacemaker to the Impulse 4000* for more information.

   NOTE 2: To simplify the direct connection of the pacemaker output leads to the Impulse 4000, refer to the current DNI Nevada Price List for availability of optional electrode adapters and modules that are designed for specific manufacturers' models.

2. Connect the pacemaker's ECG cable to the Impulse 4000's color–coded ECG binding posts located on the top panel.

3. On the pacemaker, select the pacemaker pulse rate and output level to be tested.

4. Press <F2> "PACER" from the MAIN MENU PAGE 1 on the Impulse 4000.

5. If a parallel printer is attached to the Impulse 4000, press <F5> to print a test form header. Press <F4> to send the test form header to the serial port. If no test form header is desired, press <F1> to continue.

6. Press <F1> "INT50 Ω" to select the internal 50–Ω top panel test load, or press <F2> "EXT" to select an adapter (pacemaker plug–in) module. If an adapter module is selected, it will be identified on the top line of the display. Some adapter modules have multiple test loads; if this is the case, select the desired value.

7. Press <F3> "DEMAND" to show the initial demand mode test display:

```
PACER DEMAND:          Internal 50 Ω
set pacer to demand mode,
30..200 PPM, push START when ready
START
```

<F1> <F2> <F3> <F4> <F5>

8. Place the pacemaker in the "DEMAND" mode of operation and activate output.

9. When ready, press the Impulse 4000's <F1> "START" key.

   The Impulse 4000 calculates the rate of the applied pacemaker pulse and then computes an underdrive ECG rate equal to 80 percent of the pacemaker rate. A 1.0–mV (Lead II) havertriangle waveform is output at this underdrive rate. Observe the tracing on the ECG monitor. Ensure that the havertriangle waveform is sensed by the pacemaker and that the selected pacemaker pulse train is not interrupted by this lower underdrive ECG rate. The demand mode display now shows:

```
PACER DEMAND:          Internal 50 Ω
   Under = 60 BPM      Testing for pulse...
    Over = 90 BPM       ---Π---Π---Π---Π---Π-
UNDER       OVER        UP        DOWN       HOLD
```

<F1> <F2> <F3> <F4> <F5>

NOTE: You may have to adjust the amplitude and lead settings on the ECG monitor to be able to properly view the signal.

If no pacemaker pulses are sensed, the Impulse 4000 halts the test and then shows <F1> "START" on the display. If this occurs, check all connections and controls as listed above. Press <F1> "START" to restart the test.

10. Press <F2> to output the overdrive ECG, which is equal to 120 percent of the applied pacemaker pulse. The 1.0–mV (Lead II) havertriangle waveform is now output at this higher overdrive rate. Observe the tracing on the ECG monitor and ensure that the havertriangle waveform is sensed by the pacemaker. Also, verify that the selected pacemaker pulse is inhibited by this higher overdrive ECG rate.

    NOTE: Make sure that the pacemaker is in the "DEMAND" mode of operation.

11. Both the underdrive and overdrive ECG rates can be adjusted in 1–BPM steps using the <F3> "UP" and the <F4> "DOWN" keys.

12. If you desire to print the measured pacemaker rate, the underdrive value, and the overdrive value, press <F5> "HOLD".

13. Press <F5> to output values to the parallel printer. Press <F4> to send the values to the serial port.

14. Press <F1> "REL" to release the held display, or press <ESC> once to return to "START".

GENERATING ECG WAVEFORMS

The Impulse 4000 generates a wide range of ECG waveforms for testing the cardiac vigilance capabilities of defibrillators and external transcutaneous pacemaker systems that incorporate monitoring, recording, and diagnostic features.

The ECG waveform signal is available on the

- ten ECG lead–binding posts *(Impulse 4000 top panel)*,
- through–the–paddles pickup *(Impulse 4000 top panel)*,
- high–level ECG output *(Impulse 4000 rear panel)*, and
- manikin connection *(Impulse 4000 rear panel)*.

Selecting the ECG Waveform

To generate the ECG waveform:

1. Press <F3> "ECG" from the MAIN MENU PAGE 1.
2. Select the ECG wave group:
   - <F1> "NORM" Normal Sinus Rhythm
   - <F2> "SVARR" Supraventricular Arrhythmias
   - <F3> "VENT1" Ventricular Arrhythmias - Series 1
   - <F4> "VENT2" Ventricular Arrhythmias - Series 2
   - <F5> "PACED" Transvenous Paced Group
3. As an example, select the <F1> "NORM" ECG wave group, and the Impulse 4000 displays:

```
NORMAL SINUS GROUP:
select wave:

 30          60          80          120          160>
```

<F1> <F2> <F3> <F4> <F5>

4. Press the "SELECT" right pointing arrow to view the next page of the display:

```
NORMAL SINUS GROUP:
select wave:

<200         240         300
```

<F1> <F2> <F3> <F4> <F5>

5. Use the *ECG Waveform Parameters Table* that follows in this section to help you select a waveform.
6. For example, select 200 BPM and the following displays:

```
NORMAL SINUS GROUP:
select wave:
Normal Sinus beats at 200 BPM
<200          240          300
```

<F1> <F2> <F3> <F4> <F5>

Transvenous Paced Feature

The ECG wave group *<F5> "PACED" Transvenous Paced Group* provides waveforms that are seen on a heart monitor when the patient has an implanted pacemaker.

1. To begin, press <F3> "ECG" from the MAIN MENU PAGE 1, then select <F5> "PACED". Menu selections of <F1> "WAVE", <F2> "ATRIAL", and <F3> "VENT" are displayed.
2. Press <F1> "WAVE" to view the possible paced ECG waveforms. Refer to the *ECG Waveform Parameters Table* that follows in this section for a description of the PACED wave group.
3. As an example, select <F2> "ASNC" (asynchronous pacemaker). Press <ESC> and the TRANSVENOUS PACED menu returns with "ASNC" ready to have its pacemaker parameters set.

The pacemaker parameters default to 100–mV amplitude and 1.0–ms width when the instrument is turned on. You can change the parameters and they remain changed until the instrument is turned off. All waveforms use the ventricular pacemaker parameters, and the AVSQ (atrioventricular sequential) waveform also uses the atrial pacemaker parameters. To set the pacemaker parameters, select <F2> "ATRIAL" or <F3> "VENT".

1. For example, complete steps 1 through 3 above, then select <F3> "VENT" to set up the ventricular pacemaker parameters for "ASNC". The following is displayed:

```
TRANSVENOUS PACED:  ASNC                    Vent
  amp = 100 mV       width = 1.0 mS

AMP        WIDTH      DOWN       UP         AUTO
```

<F1> <F2> <F3> <F4> <F5>

where:

ASNC = The selected waveform (NSR 80 is the default).

amp = Amplitude in millivolts (100 mV is the default; see specifications for list of values).

width = Pulse width in milliseconds (1.0 ms is the default; see specifications for list of values).

2. Select <F1> "AMP" and adjust the amplitude using <F3> "DOWN" and <F4> "UP".
3. Select <F2> "WIDTH" and adjust the pulse width using <F3> "DOWN" and <F4> "UP".
4. Press <F5> "AUTO" to initiate automatic incrementing or decrementing of the amplitude or width fields. This function steadily changes the selected parameter every 5 seconds. It is possible to test the monitor over a wide range of waveform amplitudes and widths using this function.

ECG Waveform Parameters Table

Waveform	Wave Group (Key)	Description	Rate
Normal Sinus Rhythm (NSR)	NORM	Normal heart beats.	30 BPM 60 BPM 80 BPM 120 BPM 160 BPM 200 BPM 240 BPM 300 BPM
Atrial Fibrillation (AFIB)	SVARR (AFIB1) (AFIB2)	Rapid, irregular atrial signal with no real P waves. Irregular ventricular rate. Select COARSE (AFIB1) or FINE (AFIB2).	N/A
Atrial Flutter	SVARR (AFLUT)	Large regular P waves. Ventricular response at 5:1 for 12 seconds, 13:1 for 6 seconds, 2:1 for 6 seconds, repeating.	Irregular
Sinus Arrhythmia	SVARR (SINAR)	Normal beats but triggered at irregular rate.	From 60 to 100 BPM
1° AV Block	SVARR (1AVB)	First–degree atrioventricular block. Normal beats except with long PR interval of 0.25 seconds.	80 BPM
2° AV Block Type I	SVARR (2AVBI)	Second–degree atrioventricular block, type I, Wenckebach. Increasing PR interval from 0.22 to 0.47 seconds followed by a P wave only with no QRS response, repeated. P waves at normal 80 BPM.	80 BPM
2° AV Block Type II	SVARR (2AVBII)	Second–degree atrioventricular block, type II. Waveform similar to right bundle branch block except PR interval is 0.25 seconds. Eighteen beats followed by two missed beats, repeated.	80 BPM
3° AV Block	SVARR (3AVB)	Third–degree atrioventricular block. Normal waveforms except with a P–wave rate of 80 BPM and a QRS rate of 30 BPM running independently of each other.	80 BPM (P wave) 30 BPM (QRS rate)
Premature Ventricular Contraction (PVC) Type 1	VENT1 (PVC1)	Normal rhythm except every tenth beat is a PVC. Left focus with marked left axis deviation and concordant positivity in the V leads.	

continued on the next page

NOTE: Normal heart rate amplitude = 1 mV

ECG Waveform Parameters Table (continued)

Waveform	Wave Group (Key)	Description	Rate
PVC Type 2	VENT1 (PVC2)	Normal rhythm except every tenth beat is a PVC. Right focus with left axis deviation and concordant negativity in the V leads.	
Multifocal PVCs	VENT1 (MF)	Normal rhythm except 2 of every 15 beats are PVCs. PVC type alternates between type 1 and type 2.	
Couplet of PVCs	VENT1 (COUP)	Two PVCs together in a series with 14 normal beats, repeated. Also called pair.	
Bigeminy	VENT1 (BIGEM)	Normal beat followed by a PVC, repeated.	
Trigeminy	VENT1 (TRIGEM)	Two normal beats followed by a PVC, repeated.	
Run of 5 PVCs	VENT1 (RUN5)	Five left–focus PVCs together in a series with eight normal beats, repeating continuously.	
Run of 11 PVCs	VENT1 (RUN11)	Ten left–focus PVCs followed by one right–focus PVC together in a series with eight normal beats, repeating continuously.	
Ventricular Rhythm 120	VENT2 (VENT)	Similar to left–focus PVCs at 120 BPM.	120 BPM
Ventricular Tachycardia	VENT2 (VT130) (VT175) (VT180) (VT185) (VT220)	Similar to left–focus PVCs at increased heart rates.	130 BPM 175 BPM 180 BPM 185 BPM 220 BPM
Ventricular Fibrillation	VENT2 (VFIB1) (VFIB2)	Irregular ventricular waveform. Coarse. Fine.	
Asystole	VENT2 (ASYS1) (ASYS2)	Irregular baseline. No beats (flat line).	

continued on the next page

NOTE: Normal heart rate amplitude = 1 mV

ECG Waveform Parameters Table (continued)

Waveform	Wave Group (Key)	Description	Rate
Transvenous Paced	PACED	Pacemaker waveforms. The AV sequential waveform uses both pacers. All others use the ventricular pacer which triggers a wide QRST similar to LBBB since the ventricular pacer is in the right ventricle. The pacemaker rate is 75 BPM.	
	(NSR)	Normal Sinus Rhythm.	80 BPM
	(ASNC)	Asynchronous at 75 BPM continuously paced.	75 BPM
	(DEM1)	Series of 40 paced beats and 20 normal beats. Pacer starts when normal beat is 20% late and stops when normal beat synchronizes to 80 BPM.	
	(DEM2)	Series of 20 paced beats and 40 normal beats. Pacer starts when normal beat is 20% late and stops when normal beat synchronizes to 80 BPM.	
	(AVSQ)	Atrioventricular sequential with dual pacer spikes. The first (atrial) spike triggers the P wave and the second (ventricular) spike triggers QRST; 0.15 seconds apart.	
	(NONC)	Asynchronous paced, except every tenth beat has no QRST response.	
	(NONF)	Nonfunction. Pacer spikes only. No QRST response.	

NOTE: Normal heart rate amplitude = 1 mV

GENERATING ECG PERFORMANCE WAVEFORMS

Use this menu option to perform gain, damping, frequency response, and linearity tests on the ECG section of the defibrillator and external transcutaneous pacemaker. Use the manual mode to output a single waveform, or use the automated mode to sequence a series of waveforms.

Manual Performance Mode

To output a single waveform:

1. Select <F4> "PERF" from the MAIN MENU PAGE 1.
2. Press <F1> "WAVES".
3. Press <F1> "MANUAL".
   NOTE: After you press <F1> "MANUAL", the message "Zero output" displays. When you select a waveform (as in the next step), its description displays.
4. Select the desired waveform:
   - <F1> SQUARE
   - <F2> PULSE
   - <F3> SINE*
   - <F4> TRIANGLE
   - <F5> ECG*

   NOTE 1: Refer to the *ECG Performance Waveform Parameters Table* that follows in this section for details about the waveforms.

   *NOTE 2: When you select <F3> "SINE" and <F5> "ECG", function keys <F4> "DOWN" and <F5> "UP" become available. Use these keys to manually step through the selections.

Automated Performance Sequence Mode

Use this option to output an automated series of ECG waveforms.

1. Select <F4> "PERF" from the MAIN MENU PAGE 1.
2. Press <F1> "WAVES".
3. Select <F2> "AUTO", then press <F5> "ADV" to begin.
   NOTE: The Impulse 4000 outputs waveforms as listed in the *ECG Performance Waveform Parameters Table* that follows in this section.

Reference Lead

Use this option to select the lead that is to be referenced at 1 mV. Your selection can be Lead I or Lead II and it is stored permanently in EEPROM nonvolatile memory. This selection is only available for ECG performance waveforms as described in this section. The factory default selection is Lead II.

When **Lead I** is referenced at 1.0 mV,	
Lead II is	1.5 mV
Lead III is	0.5 mV
V leads are	1.0 mV

When **Lead II** is referenced at 1.0 mV,	
Lead I is	0.7 mV
Lead III is	0.3 mV
V leads are	1.0 mV

1. Select <F4> "PERF" from the MAIN MENU PAGE 1.
2. Press <F1> "WAVES".
3. Select <F3> "LEAD", then press <F3> "I" or <F4> "II".
4. Press <F5> "STORE". Press <ESC> once to return to the "WAVES" menu and twice to return to the "PERF" menu.

ECG Performance Waveform Parameters Table

Waveform	Wave Group <Key>	Manual Performance Mode Amplitude refers to the reference lead signal	Automated Performance Sequence Mode
Square	SQUARE <F1>	2 Hz, 1–mV amplitude.	Outputs continuously; press <F5> "ADV" to advance.
Pulse	PULSE <F2>	4 s, 1–mV amplitude.	Outputs once for 4 seconds and then automatically advances.
Sine	SINE <F3>	The following are available, all at 1–mV amplitude: 0.05, 0.5, 1, 10, 25, 30, 40, 50, 60, 100, 125, and 150 Hz; and 1 kHz. (NOTE: 1 kHz is a square wave.)	Outputs the following sine waves, all at 1–mV amplitude, for 2 seconds each: 1, 10, 30, 40, 50, 60, and 100 Hz; and 1 kHz; then automatically advances.
Triangle	TRIANGLE <F4>	2 Hz, 1–mV amplitude.	Outputs continuously; press <F5> "ADV" to advance.
ECG (normal sinus rhythms)	ECG <F5>	The following are available, all at 1–mV amplitude: 30, 60, 120, and 240 BPM.	First, a 60–BPM waveform is output at 1–mV amplitude. This is output continuously to allow the monitor to settle down. To continue, press <F5> "ADV". Next, the following waveforms are output for 20 seconds each in the sequence shown: 30, 60, 120, 240, and 60 BPM. End of the automated performance sequence; returns to PERFORMANCE WAVE menu. Press <F2> "AUTO" to begin this sequence again. NOTE: Press <F5> "(ADV)" to skip segments of this sequence if necessary.

R–Wave Detector Testing

The Impulse 4000 generates an R wave that is used to determine the threshold of the ECG device. The R–wave waveform can be precisely adjusted in both amplitude and width to simulate the range of the normal sinus rhythm R–wave complex. R–wave amplitude refers to the Lead II signal.

Complete the following steps to generate an R wave:

1. Connect the ECG leads to the Impulse 4000.
2. Select <F4> "PERF" from the MAIN MENU PAGE 1.
3. Press <F2> "RDETECT".
4. Press <F1> "AMP" or <F2> "WIDTH". For settings, refer to the table below. Press <ESC> to change between the amplitude and width parameter settings.
5. Press <F3> "AUTO" and the Impulse 4000 will automatically change the values of the amplitude or width at 6–second intervals.

R–Wave Detector Tests

R–Wave Amplitude	0.05 to 0.50 mV in 0.05–mV steps 0.50 to 5.50 mV in 0.25–mV steps Menu Entry Default: +2.0 mV
R–Wave Width	8 and 12 ms 20 to 200 ms in 20–ms steps Menu Entry Default: 40 ms
Auto–Step Time Interval	6 s

AUTOSEQUENCE TEST

The Impulse 4000 can store up to 50 autosequences with device–specific inspection protocols. These autosequences can include a wide range of defibrillator, pacemaker, and ECG tests. The first 26 autosequences are factory–initialized for selected device manufacturers' models. The first 18 of these selections comprise defibrillator–only devices, the next 8 comprise combination defibrillator/pacemaker devices, and the remaining 24 are exclusively reserved for your own customized protocols. If desired, you can program any of the 50 autosequences with your own customized protocols. However, the first 26 autosequences revert to the factory default values whenever the instrument is reinitialized and the rest of the autosequences are erased.

Each autosequence is identified by an alphanumeric entry (maximum of six digits). In many cases, a similar designation is used for several autosequences. To help you identify the correct autosequence for the equipment under test, all the factory–initialized autosequences with pacemaker tests contain the suffix "P" or "PM". The "P" suffix is reserved for pacemaker tests using the internal 50–Ω test load. The "PM" suffix is reserved for pacemaker tests using a specific adapter (pacemaker plug–in) module.

For example,

- "LP10" is for the Physio–Control Model LIFEPAK 10© defibrillator tests only.
- "LP10P" adds a series of pacemaker tests using the internal 50–Ω test load.
- "LP10PM" upgrades the pacemaker tests with the factory–specified 700–Ω test load provided by the DNI Nevada Adapter Module TQA–9.

Running Autosequences

To run an autosequence:

1. Refer to the *Factory–Initialized Autosequence Tables* that follow in this section to determine the correct autosequence to run for the equipment under test. Use the defibrillator paddle contacts, disposable defibrillator/pacemaker electrode adapters, and/or the listed adapter module to conduct these tests. If desired, connect a printer/serial device to the Impulse 4000 for a hard copy record of the autosequence.

2. Select <F5> "AUTO" from the Impulse 4000's MAIN MENU PAGE 1.

3. Use the <right arrow> and <left arrow> "SELECT" keys to scroll through and locate the autosequence.

4. To begin, press the function key (<F1> through <F5>) beneath the desired autosequence.

5. Follow the displayed operating instructions to conduct the various test steps.

   NOTE 1: If any of the preprogrammed test limits are exceeded, you are prompted to either rerun that particular test step or continue with the autosequence. If you rerun the test and the test result is within limits, the Impulse 4000 stores the new test result. When you view or output the autosequence test record, a pound sign (#) marks the failed test steps.

   NOTE 2: The Impulse 4000 does not retain the autosequence test record if you either press the <ESC> key or turn it off.

continued on the next page

To run an autosequence (*continued*):

6. After you've conducted all the test steps, you can access the test record as follows:

   a. **View the autosequence test record.** Press <F1> "VIEW" to view the result of each test step. Press <F5> "ADV" to advance through the steps.

   b. **Print the autosequence test record.** Press <F5> "PRINT" to send the autosequence test record to a parallel printer.

   c. **Send the autosequence test record to a serial device.** Press <F4> "SERIAL" to send the autosequence test record to a serial device.

   NOTE : When you view or output the autosequence test record, a pound sign (#) marks the failed test steps.

7. Refer to the sample printouts that follow for information about the autosequence "HPXLPM". These printouts were generated by inspecting the Hewlett Packard Codemaster XL+ defibrillator/pacemaker with the Impulse 4000 using DNI Nevada Adapter Module TQA–12.

Sample Printouts for the Hewlett Packard Model Codemaster XL+ Defibrillator

Autosequence: "HPXLPM" Defibrillator/Pacemaker
Adapter Module: Model TQA-12

Program Sequence Printout

```
IMPULSE 4000              DNI NEVADA
DATE: 03/13/95        TIME: 02:24:43
SEQUENCE: HPXLPM  TYPE: DEFIB/PACER
ENERGY LEVEL TESTS
    1.          2 J
    2.          3 J
    3.          5 J
    4.          7 J
    5.         10 J
    6.         20 J
    7.         30 J
    8.         50 J
    9.         70 J
   10.        100 J
   11.        150 J
   12.        200 J
   13.        300 J
   14.        360 J
+LIMIT (%)     15
-LIMIT (%)     15

VFIB?          NO

MAX ENERGY?  YES
MAX LEVEL    360 J
MAX +LIMIT   385 J
MAX -LIMIT   335 J

CARDIO?        YES
ENERGY LEVEL TESTS
    1.         100 J
    2.         100 J
    3.         100 J
+LIMIT (%)     15
-LIMIT (%)     15

PERF WAVES?  YES
```

Test Results Printout

```
IMPULSE 4000              DNI NEVADA
DATE: 03/13/95        TIME: 02:23:57
SEQUENCE: HPXLPM  TYPE: DEFIB/PACER
OP CODE: MCB          CN: CN0005
MANF: HP              MODEL: Codemaster XL+
SERIAL #A123456    LOC: CCU
ENERGY LEVEL TESTS (+15/-15% or ±0.7J)
SET LEVEL        ENERGY
    (J)            (J)
     2             2.1
     3             3.1
     5             5.3
     7             7.1
    10            10.3
    20            20.8
    30            30.8
    50            51.1
    70            70.1
   100           100.0
   150           150.7
   200           201.8
   300           302.0
   360           362.6
MAX ENERGY       359.2 J   (385/335)
TIME TO CHARGE:    3 Seconds
CARDIOVERSION TESTS (+15/-15% or ±0.7J)
SET LEVEL        ENERGY      DELAY
    (J)            (J)       (mS)
   100           103.9        23
   100           104.8        23
   100           105.0        22

COMMENTS:_____
NEXT TEST DUE DATE:_____
```

Sample Printouts for the Hewlett Packard Model Codemaster XL+ Pacemaker

Autosequence: "HPXLPM" Defibrillator/Pacemaker
Adapter Module: Model TQA-12

Program Sequence Printout

```
IMPULSE 4000              DNI NEVADA
DATE: 03/13/95        TIME: 02:24:44
SEQUENCE: HPXLPM  TYPE: DEFIB/PACER
PACER MODULE: TQA-12 HP
PULSE MODE TESTS
  1.   400OHMS   40PPM    30mA
  2.   400OHMS   50PPM    30mA
  3.   400OHMS   60PPM    30mA
  4.   400OHMS   70PPM    30mA
  5.   400OHMS   80PPM    30mA
  6.   400OHMS   90PPM    30mA
  7.   400OHMS  100PPM    30mA
  8.   400OHMS  110PPM    30mA
  9.   400OHMS  120PPM    30mA
 10.   400OHMS  130PPM    30mA
 11.   400OHMS  140PPM    30mA
 12.   400OHMS  150PPM    30mA
 13.   400OHMS  160PPM    30mA
 14.   400OHMS  170PPM    30mA
 15.   400OHMS  180PPM    30mA
 16.   400OHMS   80PPM    60mA
 17.   400OHMS   80PPM   100mA
 18.   400OHMS   80PPM   140mA
 19.   400OHMS   80PPM   180mA
 20.   400OHMS   80PPM   200mA
+-LIMITS (%)          5      10

ASNC MODE?   YES
ASNC MODE TEST
  1.   400OHMS   80PPM      20%
DEMAND MODE?  YES
DEMAND MODE TESTS
  1.   400OHMS   80PPM
OVERDRIVE (%) 20
UNDERDRIVE (%) 20

REFRACTORY?   NO
```

Test Results Printout

```
IMPULSE 4000              DNI NEVADA
DATE: 03/13/95        TIME: 02:23:59
SEQUENCE: HPXLPM  TYPE: DEFIB/PACER
OP CODE: MCB          CN: CN0005
MANF: HP              MODEL: Codemaster XL+
SERIAL #A123456   LOC: CCU
PACER MODULE: TQA-12 HP
PULSE MODE TESTS (RATE ±5%)
   (AMPLITUDE ±10% OR ±5mA)
   LOAD      SET LEVEL     RATE     SET LEVEL      AMP
  (OHMS)       (PPM)      (PPM)       (mA)        (mA)
    400          40         40         30         29.6
    400          50         50         30         29.6
    400          60         60         30         29.6
    400          70         70         30         29.6
    400          80         80         30         29.6
    400          90         91         30         29.6
    400         100        100         30         29.6
    400         110        111         30         29.6
    400         120        121         30         29.6
    400         130        132         30         29.6
    400         140        141         30         29.6
    400         150        152         30         29.6
    400         160        162         30         29.6
    400         170        170         30         29.6
    400         180        181         30         29.6
    400          80         80         60         59.5
    400          80         80        100         99.8
    400          80         80        140        140.1
    400          80         80        180        181.0
    400          80         80        200        202.1
ASNC TESTPASSED(80PPM/96PPM)
DEMAND MODE TESTS   (20/20%)
     LOAD      SET LEVEL      RESULT
    (OHMS)        (PPM)
      400           80      PASSED
COMMENTS:_____
NEXT TEST DUE DATE:_____
```

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Factory-Initialized Autosequence Table - **Defibrillator**

Autosequence	Manufacturer/ Model	Energy Level Tests	+ Limit (%)	- Limit (%)	V-FIB On?	Max Energy?	Max + Limit	Max - Limit	Cardio Energy Level Tests	+ Limit (%)	- Limit (%)	Perf Waves?
LP4	Physio-Control LIFEPAK 4	10, 25, 50, 100, 200, 300, 400, 450	15	15	N	450	480	418	100, 100, 100	10	10	Y
LP5	Physio-Control LIFEPAK 5	20, 50, 100, 200, 300, 360	15	15	N	360	396	324	100, 100, 100	10	10	Y
LP6	Physio-Control LIFEPAK 6	5, 10, 20, 30, 50, 100, 200, 300, 400	15	15	N	400	428	372	100, 100, 100	10	10	Y
LP6S	Physio-Control LIFEPAK 6S	5, 10, 20, 30, 50, 100, 150, 200, 300, 360	15	15	N	360	385	335	100, 100, 100	10	10	Y
LP7	Physio-Control LIFEPAK 7	5, 10, 20, 30, 50, 100, 200, 300, 360	15	15	N	360	385	335	100, 100, 100	10	10	Y
LP8	Physio-Control LIFEPAK 8	2, 5, 9, 10, 20, 30, 50, 100, 150, 200, 300, 360	15	15	N	360	385	335	100, 100, 100	10	10	Y
M/D3	Datascope M/D3	5, 10, 20, 35, 50, 75, 100, 150, 200, 300, 400	15	15	N	400	440	360	100, 100, 100	10	10	Y
HP660	Hewlett Packard 78660A	5, 10, 20, 40, 60, 100, 150, 200, 250, 300, 360	15	15	N	360	400	330	100, 100, 100	10	10	Y
NK7K	Nihon Kohden 7000	3, 5, 10, 20, 30, 50, 70, 100, 150, 200, 300, 360	15	15	N	360	396	324	100, 100, 100	10	10	Y
HS2K	Laerdal Heart Start 2000	200, 200, 360, 200, 200, 360	15	15	Y	0	0	0	0, 0, 0	10	10	N
AOLOWN	American Optical	5, 10, 20, 30, 40, 50, 100, 150, 200, 300, 360	15	15	N	360	414	306	100, 100, 100	10	10	Y
M/D4	Datascope M/D4	1, 8, 40, 80, 160, 240, 320	15	15	N	320	384	256	100, 100, 100	10	10	Y
M/D2	Datascope M/D2	8, 20, 30, 40, 50, 100, 200, 300, 400	15	15	N	400	480	320	100, 100, 100	10	10	Y
M/D2J	Datascope M/D2J	5, 10, 20, 40, 75, 100, 200, 300, 400, 460	15	15	N	460	506	404	100, 100, 100	10	10	Y
HP670	Hewlett Packard 78670A	5, 10, 20, 30, 50, 70, 100, 150, 200, 300, 360	15	15	N	360	414	306	100, 100, 100	10	10	Y
HP431	Hewlett Packard 43100	2, 3, 5, 7, 10, 20, 30, 50, 70, 100, 150, 200, 300, 360	15	15	N	360	414	306	100, 100, 100	10	10	Y

*Factory-Initialized Autosequence Table - **Defibrillator** **continued***

Autosequence	Manufacturer/ Model	Energy Level Tests	+ Limit (%)	- Limit (%)	V-Fib On?	Max Energy?	Max + Limit	Max - Limit	Cardio Energy Level Tests	+ Limit (%)	- Limit (%)	Perf Waves?
ZOLL	Zoll PD2000	2, 3, 5, 7, 10, 20, 30, 50, 100, 150, 200, 300, 360	15	15	N	360	396	324	100, 100, 100	10	10	Y
LP10	Physio-Control LIFEPAK 10	5, 10, 20, 50, 100, 200, 300, 360	15	15	N	360	396	324	100, 100, 100	10	10	Y

Factory–Initialized Autosequence Table - Defibrillator Data for ***Defibrillator/Pacer***

Autosequence	Manufacturer/ Model	Energy Level Tests	+ Limit (%)	- Limit (%)	V-FIB On?	Max Energy?	Max + Limit	Max - Limit	Cardio Energy Level Tests	+ Limit (%)	- Limit (%)	Perf Waves?
LP8P	Physio-Control LIFEPAK 8P	2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 50, 100, 150, 200, 300, 360	15	15	Y	360	382	338	100, 100, 100	12	12	Y
LP9P	Physio-Control LIFEPAK 9P	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 50, 100, 200, 300, 360	15	15	Y	360	385	335	20, 50, 100	12	12	Y
LP9PM	Physio-Control LIFEPAK 9P Module	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 50, 100, 200, 300, 360	15	15	Y	360	385	335	20, 50, 100	12	12	Y

Factory-Initialized Autosequence Table - Pacer Data for ***Defibrillator/Pacer***

Autosequence	Manufacturer/ Model	Input Load	Pulse Mode Tests	+ Limit (%)	- Limit (%)	Asnc Mode Test	Overdrive (%)	Demand Mode Test	Overdrive (%)	Underdrive (%)	Refractory
LP8P	Physio-Control LIFEPAK 8P	Int 50Ω	50Ω, 40 PPM, 200mA 50Ω, 50 PPM, 200mA 50Ω, 60 PPM, 200mA 50Ω, 70 PPM, 200mA 50Ω, 80 PPM, 200mA 50Ω, 90 PPM, 200mA	10	10	50Ω, 70 PPM	20	50Ω, 50 PPM	20	20	N
LP9P	Physio-Control LIFEPAK 9P	Int 50Ω	50Ω, 60 PPM, 55mA 50Ω,150 PPM, 55mA 50Ω,170 PPM, 55mA 50Ω,160 PPM, 55mA 50Ω,140 PPM, 55mA 50Ω,130 PPM, 55mA 50Ω,120 PPM, 55mA 50Ω,110 PPM, 55mA 50Ω,100 PPM, 55mA 50Ω, 90 PPM, 55mA 50Ω, 80 PPM, 55mA 50Ω, 70 PPM, 55mA 50Ω, 60 PPM, 55mA 50Ω, 50 PPM, 55mA 50Ω, 40 PPM, 55mA 50Ω, 60 PPM, 200mA 50Ω, 60 PPM, 150mA 50Ω, 60 PPM, 100mA 50Ω, 60 PPM, 130mA	10	10	50Ω, 60 PPM	20	50Ω, 50 PPM	20	20	N
LP9PM	Physio-Control LIFEPAK 9P Module	TQA-9	700Ω, 60 PPM, 55mA 700Ω,150 PPM, 55mA 700Ω,170 PPM, 55mA 700Ω,160 PPM, 55mA 700Ω,140 PPM, 55mA 700Ω,130 PPM, 55mA 700Ω,120 PPM, 55mA 700Ω,110 PPM, 55mA 700Ω,100 PPM, 55mA 700Ω, 90 PPM, 55mA 700Ω, 80 PPM, 55mA 700Ω, 70 PPM, 55mA 700Ω, 60 PPM, 55mA 700Ω, 50 PPM, 55mA 700Ω, 40 PPM, 55mA 700Ω, 60 PPM, 200mA 700Ω, 60 PPM, 150mA 700Ω, 60 PPM, 100mA 700Ω, 60 PPM, 130mA	10	10	100Ω, 60 PPM	20	700Ω, 50 PPM	20	20	N

Factory-Initialized Autosequence Table - Defibrillator Data for ***Defibrillator/Pacer*** ***continued***

Autosequence	Manufacturer/ Model	Energy Level Tests	+ Limit (%)	- Limit (%)	V-FIB On?	Max Energy?	Max + Limit	Max - Limit	Cardio Energy Level Tests	+ Limit (%)	- Limit (%)	Perf Waves?
LP10P	Physio-Control LIFEPAK 10P	5, 10, 20, 50, 100, 200, 300, 360	15	15	Y	360	396	324	100, 100, 100	12	12	Y
LP10PM	Physio-Control LIFEPAK 10P Module	5, 10, 20, 50, 100, 200, 300, 360	15	15	Y	360	396	324	100, 100, 100	12	12	Y

Factory-Initialized Autosequence Table - Pacer Data for ***Defibrillator/Pacer*** ***continued***

Autosequence	Manufacturer/ Model	Input Load	Pulse Mode Tests	+ Limit (%)	- Limit (%)	Asnc Mode Test	Overdrive (%)	Demand Mode Test	Overdrive (%)	Underdrive (%)	Refractory
LP10P	Physio-Control LIFEPAK 10P	Int 50Ω	50Ω, 40 PPM, 40mA 50Ω, 50 PPM, 40mA 50Ω, 60 PPM, 40mA 50Ω, 70 PPM, 40mA 50Ω, 80 PPM, 40mA 50Ω, 90 PPM, 40mA 50Ω,100 PPM, 40mA 50Ω,110 PPM, 40mA 50Ω,120 PPM, 40mA 50Ω,130 PPM, 40mA 50Ω,140 PPM, 40mA 50Ω,150 PPM, 40mA 50Ω,160 PPM, 40mA 50Ω,170 PPM, 40mA 50Ω, 80 PPM, 60mA 50Ω, 80 PPM, 80mA 50Ω, 80 PPM,100mA 50Ω, 80 PPM,140mA 50Ω, 80 PPM,180mA 50Ω, 80 PPM,200mA	10	10	50Ω, 80 PPM	20	50Ω, 50 PPM	20	20	N
LP10PM	Physio-Control LIFEPAK 10P Module	TQA-9	700Ω, 40 PPM, 40mA 700Ω, 50 PPM, 40mA 700Ω, 60 PPM, 40mA 700Ω, 70 PPM, 40mA 700Ω, 80 PPM, 40mA 700Ω, 90 PPM, 40mA 700Ω,100 PPM, 40mA 700Ω,110 PPM, 40mA 700Ω,120 PPM, 40mA 700Ω,130 PPM, 40mA 700Ω,140 PPM, 40mA 700Ω,150 PPM, 40mA 700Ω,160 PPM, 40mA 700Ω,170 PPM, 40mA 700Ω, 80 PPM, 60mA 700Ω, 80 PPM, 80mA 700Ω, 80 PPM,100mA 700Ω, 80 PPM,140mA 700Ω, 80 PPM,180mA 700Ω, 80 PPM,200mA	10	10	100Ω, 80 PPM	20	700Ω, 80 PPM	20	20	N

Factory-Initialized Autosequence Table - Defibrillator Data for ***Defibrillator/Pacer*** ***continued***

Autosequence	Manufacturer/ Model	Energy Level Tests	+ Limit (%)	- Limit (%)	V-FIB On?	Max Energy?	Max + Limit	Max - Limit	Cardio Energy Level Tests	+ Limit (%)	- Limit (%)	Perf Waves?
1500PM	Marquette Model 1500 Module	5, 10, 20, 50, 100, 200, 300, 360	15	15	Y	360	385	335	100, 100, 100	12	12	Y
HPXLPM	Hewlett Packard Code Master Series	2, 3, 5, 7, 10, 20, 30, 50, 70, 100, 150, 200, 300, 360	15	15	Y	360	385	335	100, 100, 100	12	12	Y

Factory-Initialized Autosequence Table - Pacer Data for ***Defibrillator/Pacer*** ***continued***

Autosequence	Manufacturer/ Model	Input Load	Pulse Mode Tests	+ Limit (%)	- Limit (%)	Asnc Mode Test	Overdrive (%)	Demand Mode Test	Overdrive (%)	Underdrive (%)	Refractory
1500PM	Marquette Model 1500 Module	TQA-7	300Ω,40 PPM, 30mA 300Ω,50 PPM, 30mA 300Ω,60 PPM, 30mA 300Ω,65 PPM, 30mA 300Ω,70 PPM, 30mA 300Ω,75 PPM, 30mA 300Ω,80 PPM, 30mA 300Ω,90 PPM, 30mA 300Ω,100 PPM,30mA 300Ω,110 PPM,30mA 300Ω,120 PPM,30mA 300Ω,130 PPM,30mA 300Ω,140 PPM,30mA 300Ω,150 PPM,30mA 300Ω,160 PPM,30mA 300Ω,180 PPM,30mA 300Ω,80 PPM, 50mA 300Ω,80 PPM,100mA 300Ω,80 PPM,150mA 300Ω,80 PPM,200mA	10	10	300Ω, 80 PPM	20	300Ω, 80 PPM	20	20	N
HPXLPM	Hewlett Packard Code Master Series	TQA-12	400Ω, 40 PPM, 30mA 400Ω, 50 PPM, 30mA 400Ω, 60 PPM, 30mA 400Ω, 70 PPM, 30mA 400Ω, 80 PPM, 30mA 400Ω, 90 PPM, 30mA 400Ω,100 PPM, 30mA 400Ω,110 PPM, 30mA 400Ω,120 PPM, 30mA 400Ω,130 PPM, 30mA 400Ω,140 PPM, 30mA 400Ω,150 PPM, 30mA 400Ω,160 PPM, 30mA 400Ω,170 PPM, 30mA 400Ω,180 PPM, 30mA 400Ω, 80 PPM, 60mA 400Ω, 80 PPM,100mA 400Ω, 80 PPM,140mA 400Ω, 80 PPM,180mA 400Ω, 80 PPM,200mA	10	10	400Ω, 80 PPM	20	400Ω, 80 PPM	20	20	N

Factory-Initialized Autosequence Table - Defibrillator Data for ***Defibrillator/Pacer*** ***continued***

Autosequence	Manufacturer/ Model	Energy Level Tests	+ Limit (%)	- Limit (%)	V-FIB On?	Max Energy?	Max + Limit	Max - Limit	Cardio Energy Level Tests	+ Limit (%)	- Limit (%)	Perf Waves?
MD300M	Medical Data Electronics (MDE) Series 300 Module	2, 3, 5, 10, 20, 30, 50, 100, 150, 200, 300, 360	15	15	Y	360	400	320	10, 50, 100	15	15	Y

Factory-Initialized Autosequence Table - Pacer Data for ***Defibrillator/Pacer*** ***continued***

Autosequence	Manufacturer/ Model	Input Load	Pulse Mode Tests	+ Limit (%)	- Limit (%)	Asnc Mode Test	Overdrive (%)	Demand Mode Test	Overdrive (%)	Underdrive (%)	Refractory
MD300M	Medical Data Electronics (MDE) Series 300 Module	TQA-6	600Ω,40 PPM, 60mA 600Ω,60 PPM, 60mA 600Ω,70 PPM, 60mA 600Ω,75 PPM, 60mA 600Ω,80 PPM, 60mA 600Ω,90 PPM, 60mA 600Ω,100 PPM,60mA 600Ω,120 PPM,60mA 600Ω,140 PPM,60mA 600Ω,160 PPM,60mA 600Ω,100 PPM,60mA 600Ω,100 PPM,90mA 600Ω,100 PPM,120mA 1000Ω,60 PPM,120mA	10	10	600Ω, 100 PPM	40	600Ω, 80 PPM	20	20	N

Programming Custom Autosequences

The CUSTOM option from the MAIN MENU PAGE 2 makes it easy to program your own autosequences. You can change a factory–initialized autosequence or create a new autosequence for a defibrillator–only, defibrillator/pacemaker combination, or pacemaker–only model.

Reset changed autosequences to factory default settings using <F3> "INIT".

NOTE 1: Factory default defibrillator energy limits changed from 10% to 15% with firmware version 1.01. If the limits on your Impulse 4000 are not 15% and you want them to be 15%, reinitialize your instrument to factory default values as explained below.

1. Select <F2> "CUSTOM" from the MAIN MENU PAGE 2.
2. Press <F3> "INIT".
3. Press <F1> "YES".

NOTE 2: Reinitialization affects all 50 autosequences; the first 26 revert to the factory default values and the rest are erased.

View autosequence steps using <F2> "VIEW" and print autosequence steps using <F5> "PRINT".

You will be prompted for different information depending on whether you are making a defibrillator or pacemaker autosequence. For combination defibrillator/pacemaker models, the Impulse 4000 prompts first for defibrillator information, then pacemaker information. Before making an autosequence, it is suggested that the parameter entries be planned using the *Autosequence Test Options Table* that follows in this chapter.

To make a custom autosequence:

1. Select <F2> "CUSTOM" from the MAIN MENU PAGE 2.

2. Press <F1> "MAKE" to begin making the autosequence.

3. Select the autosequence to make using the <left arrow> and <right arrow> "SELECT" keys.
   NOTE: Blank autosequences begin at AS#27.

4. The Impulse 4000 prompts for the autosequence name. Assign the autosequence a name up to six characters.
   a. Use the <F3> "DOWN" and <F4> "UP" keys to change the character displayed. Letters are followed by symbols, then numerals.
   b. Use the <left arrow> and <right arrow> "SELECT" keys to move left and right in the name.
   c. When finished, press <F5> "ENTER".

5. Select the type of instrument this autosequence is for

   Defibrillator–Only . . . . . <F1> "DEFIB"
   Defibrillator/Pacemaker Combination . . . . . <F2> "DFB/PCR"
   Pacemaker . . . . . <F3> "PACER"

Making Defibrillator Autosequences

1. Complete steps 1 through 4 in the previous section *Programming Custom Autosequences*, and select <F1> "DEFIB".

2. **Energy Level Tests**. Select up to 20 separate energy levels to test in sequence: "Step 1", "Step 2", "Step 3", and so on.
   a. For each step, set the energy level from 1 to 500 J. Use the <F4> "UP" and <F3> "DOWN" keys to increase and decrease the energy level (press continuously to advance rapidly).
   b. To move to the next step, press <F2> "NEXT", or press <F1> "PREV" to return to a previous step.
   c. When you have programmed all energy levels to test, press <F5> "END".
   d. Next, select the upper (+) and lower (–) level limits as a percentage: for example, +10%, –10%. This programs the Impulse 4000 to flag any output that is outside these limits.
   e. Use <F2> "–LIM" to select a lower limit and <F1> "+LIM" to select an upper limit. Both limit ranges are 0% to 99%.
   f. Use the <F4> "UP" and <F3> "DOWN" keys to increase and decrease the energy level limits.
   g. When you are done setting both upper and lower limits, press <F5> "ENTER".

3. **V-FIB for Energy Tests**. Press <F1> "YES" to have a ventricular fibrillation ECG waveform output for energy level tests and maximum energy tests. Or press <F2> "NO" to output the previous pulse playback waveform.

4. **Max Energy Test**. Press <F1> "YES" to perform a maximum energy test or <F2> "NO" to bypass the maximum energy test. If you answer "YES," you can enter maximum energy high and low test limits from 1 to 999 J.

5. **Cardio Energy Level Tests**. Press <F1> "YES" to perform cardioversion tests or <F2> "NO" to bypass the cardioversion test. If you are performing cardioversion tests, you will be prompted for the information in (a) and (b) below:
   a. Enter up to three cardioversion energy levels to test; from 1 to 500 J. Press <F5> "END" when done.
   b. Select the cardioversion energy level limits. Use <F2> "–LIM" to select a lower limit and <F1> "+LIM" to select an upper limit. Use the <F4> "UP" and <F3> "DOWN" keys to increase and decrease the energy level limits. Press <F5> "ENTER" when done. Both limit ranges are 0% to 99%.

7. **Performance Waveforms**. Press <F1> "YES" to run performance waveforms or <F2> "NO" to bypass them.

8. **Saving the Custom Autosequence**. Press <F1> "YES" to save your custom autosequence, or <F2> "NO" to exit without saving.

9. The Impulse 4000 displays "END MAKE" and returns to the custom autosequence menu.

Making Defibrillator/Pacer Autosequences

1. Complete steps 1 through 4 in the section *Programming Custom Autosequences*, and select <F2> "DFB/PCR".

2. Use the instructions above, *Making Defibrillator Autosequences*.

3. Use the instructions that follow next, *Making Pacer Autosequences*.

NOTE: The Defibrillator/Pacer autosequence includes first, all steps from the Defibrillator Autosequence series and then, second, all steps from the Pacer Autosequence series.

Making Pacer Autosequences

1. Complete steps 1 through 4 in the section *Programming Custom Autosequences*, and select <F3> "PACER".

2. **Pacer Test (Input) Load**. Select the external adapter (pacemaker plug-in) module you are using. Select "INTERNAL" if you are not using a module.

3. **Pulse Mode Tests**. Select up to 20 pulse–mode pacemaker rates to test in sequence: "Step 1", "Step 2", "Step 3", and so on.
   a. For each step, set the rate from 30 to 200 PPM (in 1–PPM increments). Use the <F4> "UP" and <F3> "DOWN" keys to increase and decrease the rate (press continuously to advance rapidly).
   b. Press <F2> "NEXT" (moves the cursor). Set the amplitude from 10 to 250 mA (in 1–mA increments). Press <F2> "NEXT" (begins next step). Press <F1> "PREV" to return to a previous step and/or parameter.
      NOTE: If you are using a module that has more than one load, use the "UP" and "DOWN" keys to select the required load for the test. Use the "NEXT" key to move the cursor to the rate parameter.
   c. When you have programmed all rates and amplitudes, press <F5> "END".
   d. Select the rate and amplitude limits as percentages: for example, Rate Limit (%) = 5 (press <F1> "RATE")*, Amp Limit (%) = 5 (press <F2> "AMP")*. This programs the Impulse 4000 to flag any output that is outside these limits. The limit range is 0% to 99% (in 1% increments) and applies to all steps in this mode. When both limits are set, press <F5> "ENTER".
      *NOTE: Use the <F4> "UP" and <F3> "DOWN" keys to increase and decrease the limits.

4. **Async Mode Test**. Press <F1> "YES" to enter the asynchronous mode test parameters for the pacemaker or <F2> "NO" to bypass them.
   a. Use <F1> "RATE" to select rate limits from 30 to 200 PPM (in 1–PPM increments). Use the <F4> "UP" and <F3> "DOWN" keys to increase and decrease the rate.
   b. Use" <F2> "OVER to select the overdrive limits from 10% to 50% (in 1% increments). Use the <F4> "UP" and <F3> "DOWN" keys to increase and decrease the overdrive limits.
   c. When both parameters are set, press <F5> "ENTER".

5. **Demand Mode Test**. Press <F1> "YES" to perform demand mode pacemaker tests or <F2> "NO" to bypass them. If you answer "YES," you can enter demand mode pacemaker rates for up to 20 steps.
   a. For each step, set the rate from 30 to 200 PPM (in 1–PPM increments). Use the <F4> "UP" and <F3> "DOWN" keys to increase and decrease the rate.
   b. To begin the next step, press <F2> "NEXT", or press <F1> "PREV" to return to a previous step.
      NOTE: If you are using a module that has more than one load, use the "UP" and "DOWN" keys to select the required load for the test. Use the "NEXT" key to move the cursor to the rate parameter.
   c. When you have programmed all rates necessary for your test, press <F5> "END".
   d. Select the demand mode pacer drive limits as percentages: for example, Overdrive (%) = 10 (press <F1> "OVER")*, Underdrive (%) = 10 (press <F2> "UNDER")*. This programs the Impulse 4000 to flag any output that is outside these limits. The limit range is 10% to 50% and applies to all steps in this mode. When done with both limits, press <F5> "ENTER".
      *NOTE: Use the <F4> "UP" and <F3> "DOWN" keys to increase and decrease the limits.

6. **Refractory Tests**. Press <F1> "YES" to perform the refractory mode pacemaker tests: pulsed–refractory period and sensed–refractory period (compatible with pacemaker rate ranges of 30 to 100 PPM), or <F2> "NO" to bypass them.

7. **Saving the Custom Autosequence**. Press <F1> "YES" to save the custom autosequence, or <F2> "NO" to exit without saving.

8. The Impulse 4000 displays "END MAKE" and returns to the custom autosequence menu.

Viewing Autosequences

View steps in any existing autosequence.

1. Select <F2> "CUSTOM" from the MAIN MENU PAGE 2.
2. Press <F2> "VIEW".
3. Select the autosequence you wish to view by pressing the corresponding function key. Use the <left arrow> and <right arrow> "SELECT" keys to see all autosequence selections. The Impulse 4000 displays the autosequence name and type.
4. Press <F5> "ADV" to advance to the next step in the autosequence.

Printing Autosequences

Print the steps in any existing autosequence using a parallel printer.

1. Select <F2> "CUSTOM" from the MAIN MENU PAGE 2.
2. Press <F5> "PRINT".
3. Select the autosequence you wish to print by pressing the corresponding function key. Use the <left arrow> and <right arrow> "SELECT" keys to see all autosequence selections. The Impulse 4000 displays the autosequence name and prints the selected autosequence.

Print the steps in any existing autosequence using a serial printer.

1. Select <F2> "CUSTOM" from the MAIN MENU PAGE 2.
2. Press <F4> "SERIAL".
3. Select the autosequence you wish to print by pressing the corresponding function key. Use the <left arrow> and <right arrow> "SELECT" keys to see all autosequence selections. The Impulse 4000 displays the autosequence name and prints the selected autosequence.

Initializing Autosequences

Initialize all existing autosequences to factory default values.

NOTE 1: Initialization affects all 50 autosequences; the first 26 revert to factory default values and the rest are erased.

NOTE 2: All user–programmed autosequences are erased.

To initialize autosequences:

1. Select <F2> "CUSTOM" from the MAIN MENU PAGE 2.
2. Press <F3> "INIT".
3. Press <F1> "YES" to overwrite current autosequence definitions with factory default values.
4. Press <F2> "NO" to bypass initialization.

Autosequence Test Options Table

DEFIBRILLATOR	
Energy Levels	1 to 20 steps. 0 to 500 J. Must enter a value other than zero to move to next step.
Energy Level Limits	+ Limit: 0% to 99%. – Limit: 0% to 99%.
V-FIB for Energy Tests?	YES: Outputs ventricular fibrillation ECG waveform for energy level tests and maximum energy test. NO: No ECG waveform.
Perform Max Energy Test?	YES: Performs maximum energy test. NO: Bypasses maximum energy test.
Max Energy Test Limits	Sets high and low limits. 0 to 999 J.
Perform Cardio-version Test?	YES: Performs cardioversion test. NO: Bypasses cardioversion test.
Cardio Energy Levels	1 to 3 steps. 0 to 500 J. Must enter a value other than zero to move to next step.
Cardio Energy Level Limits	+ Limit: 0% to 99%. – Limit: 0% to 99%.
Run Performance Waveforms?	YES: Outputs ECG sequence. NO: Bypasses ECG sequence.
OK to Save?	YES: Saves autosequence. NO: Discards autosequence.

PACER	
Pacer Test Load	Internal 50 Ω or External Pacer Module (TQA-##).
Pulse Mode Rate & Amplitude	1 to 20 steps. Load: Module dependent. Rate: 30 to 200 PPM. Amplitude: MIN - 10 mA, MAX - 250 mA.
Rate & Amplitude Limits	Rate Limit: 0% to 99%. Amplitude Limit: 0% to 99%.
Perform Async Mode Tests?	YES: Performs asynchronous mode pacer tests; prompts for rates shown below. NO: Bypasses async mode pacer tests.
Asnc Mode Rate & Overdrive	One step. Rate: 30 to 200 PPM. Overdrive: 10% to 50%.
Perform Demand Mode Pacer Tests?	YES: Performs demand mode pacer tests; prompts for rates shown below. NO: Bypasses demand mode pacer tests.
Demand Mode Pacer Rates	1 to 5 steps. Rate: 30 to 200 PPM.
Demand Mode Drive Limits	Overdrive: 10% to 50%. Underdrive: 10% to 50%.
Refrac-tory Mode Tests?	YES: Performs refractory mode tests: Pulsed–Refractory Period and Sensed–Refractory Period. NO: Bypasses refractory mode tests.
OK to Save?	YES: Saves autosequence. NO: Discards autosequence.

TRAINING

The Impulse 4000 has several training scenarios that are interactive with the defibrillator, transcutaneous pacemaker, and manikins such as the Armstrong Medical Defib Chris Clean™ and the Laerdal Defib–Anne™.

This instrument outputs ECG waveforms that simulate real–life situations.

Three types of interactive—real–life—training scenarios are available:

- Emergency Ventricular Defibrillation
- Elective Cardioversion
- Transcutaneous Pacemaker

The Impulse 4000 outputs a simulated ECG waveform that, in turn, responds to

- a defibrillator discharge at the Impulse 4000 defibrillator paddle contacts.
- a defibrillator discharge at the defibrillator pick–up plates of the connected manikin.
- an input of a transcutaneous pacemaker pulse via the electrode adapters at the Impulse 4000 defibrillator paddle contacts or the connected adapter (pacemaker plug-in) module; refer to the *Optional Accessories* section in Chapter 1.

Using Training Scenarios

The training scenarios may require use of Impulse 4000 accessories such as the defibrillator electrode adapters, pacemaker adapters, and adapter (pacemaker plug–in) modules.

For more information, refer to these sections in this manual: *Connecting the Defibrillator to the Impulse 4000* in Chapter 1 (SAFETY CONSIDERATIONS section); *Connecting the Pacemaker to the Impulse 4000* and *Adapter (Pacemaker Plug-In) Modules* in Chapter 3 (TESTING AN EXTERNAL TRANSCUTANEOUS PACEMAKER section); or the current DNI Nevada Price List.

Common features are programmed in the training scenarios. These features appear on the Impulse 4000 display as follows: "NEXT", "INHIBIT", "CONVERT", "END", and "ESCAPE".

Explanations of common training scenario features follow:

- <F1> "NEXT" - Returns to the waveform selection menu within the training scenario.

- <F2> "INHIBIT" - Allows the instructor to introduce randomness, or a real–life nonconversion simulation into a training scenario. When the inhibit feature is used, the Impulse 4000 senses the defibrillator pulse or pacemaker pulse and does not respond to it.

  For example: The instructor can press the inhibit button in several successive defibrillator training scenarios, each time requesting the student to increase the energy level. At the instructor's discretion, the <F2> "INHIBIT" key can be pressed again to turn the inhibit feature off. When the inhibit feature is turned off, the Impulse 4000 responds to the defibrillator input (conversion is not inhibited).

  Also, if the instructor notices that the student is making an error, he or she can stop the test by pressing <F2> "INHIBIT".

continued on the next page

Explanations of common training scenario features follow (*continued*):

- <F3> "CONVERT" - Provides a simulated defibrillator pulse. If a defibrillator is not available, use this feature to show students ECG waveforms and the effect that an applied "energy pulse" has on a waveform.

  NOTE: A properly timed "energy pulse" for recovery (conversion) is ouput in the elective cardioversion scenario.

- <F5> "END" - Ends a particular training session. At this time, press <F4> "SERIAL" to transmit the training session data via the serial port or <F5> "PRINT" to print the results of the training session.

  NOTE: An improper defibrillation automatically ends a training session.

  Below is a sample printout:

```
IMPULSE 4000                DNI NEVADA
DATE: 03/16/94              TIME: 13:08:45
DEFIB SKILLS                      EMERGENCY
STUDENT:_____________________________________
INSTRUCTOR:__________________________________
DEVICE MAN:_____________ MODEL:_____________
SERIAL #:____________________________________

       TIME   ACTIVITY
       00:00  NSR 80 BPM
       00:00  Failure Sequence Initiated
       00:13  VFIB1
       01:43  Defib Pulse - E = 109.6 J
       01:43  Converted
       02:00  NSR 80 BPM

EVALUATION:                  PASS      FAIL
Verbal Skills                ____      ____
Equipment Skills             ____      ____
Safety Procedures            ____      ____
Protocol/Format              ____      ____
Overall Assessment           ____      ____
CPR/Ventilations             ____      ____
CPR/Compressions             ____      ____

COMMENTS:____________________________________
_____________________________________________
_____________________________________________
DEFIB Student:_______________________________
Re-Certification Date:_______________________
```

- <ESC> "ESCAPE" - Returns to training scenario selection. Repeatedly pressing <ESC> returns to previous menus.

Interactive Defibrillator Training

The Impulse 4000 is well-suited for use as a defibrillator training tool. Both types of interactive defibrillator training scenarios, Emergency Ventricular Defibrillation and Elective Cardioversion, are covered in this section. Ensure that the proper connections have been made; refer to *Connecting the Defibrillator to the Impulse 4000* in Chapter 1 (SAFETY CONSIDERATIONS section).

Emergency Ventricular Defibrillation

To enter this mode:

- Select <F1> "TRAIN" from the MAIN MENU PAGE 2.
- Press <F1> "DEFIB", then press <F1> "EMRG".

Use emergency ventricular defibrillation when the patient's heart is in a failing condition. Press <F1> "FAIL", then <F1> "START" and the Impulse 4000 outputs a sequence of ECG waveforms that simulates a failing heart condition and subsequent revival if defibrillation succeeds. The failure sequence is NSR80, PVC1, NSR80, PVC1, VFIB1. Defibrillation must occur during the VFIB1 period (two minutes) for it to succeed.

Student Training Aid. The remaining function keys on the "DEFIB EMRG" menu offer these simulations: "VFIB1", "VFIB2", "VTACH", and "NORM" (NSR 80).

- When you press <F2> "VFIB1", <F3> "VFIB2", or *<F4> "VTACH" and then press <F1> "START", the selected ECG waveform runs for two minutes and then changes to an asystole waveform. If the student does not defibrillate correctly during the two-minute period, the message "IMPROPER DEFIBRILLATION" displays and the training session terminates.
  *NOTE: After you press <F4> "VTACH", the simulations "VT130", "VT175", "VT180", "VT185", and "VT220" are offered.
- When you press <F5> "NORM" and then press <F1> "START", a normal sinus rhythm of 80 BPM outputs continuously. Defibrillation at this time gives the message "IMPROPER DEFIBRILLATION" and the training session terminates.

Elective Cardioversion

To enter this mode:

- Select <F1> "TRAIN" from the MAIN MENU PAGE 2.
- Press <F1> "DEFIB", then press <F2> "CARDIO".

Use elective cardioversion when a synchronized defibrillation is required to change or convert a patient's irregular heartbeat to a regular heartbeat. Select <F1> "AFIB1" (coarse) or <F2> "AFIB2" (fine). The common training scenario features operate as explained previously in *Using Training Scenarios*. The features explained below are specific to the elective cardioversion mode:

- <F3> "CONVERT" - Outputs a properly timed "energy pulse", within the delay time range, for recovery (conversion).
- <F4> "NO-SYNC" - Outputs a poorly timed "energy pulse", outside the delay time range, that results in a ventricular fibrillation (VFIB) waveform.

The cardioversion delay time range is -120 to +120 ms from the R-wave peak. Outside of this range, synchronization does not occur and a ventricular fibrillation (VFIB) outputs.

Interactive Transcutaneous Pacemaker Training

The Impulse 4000 is an effective training tool for instructing clinical staff in the basic use and operation of the transcutaneous pacemaker.

Four different transcutaneous pacemaker training scenarios output. These scenarios simulate typical patient ECGs that require intervention by a transcutaneous pacemaker. Run these scenarios with or without a transcutaneous pacemaker connected to the Impulse 4000. Connect a transcutaneous pacemaker to the Impulse 4000, and you can interact with the operation of the pacemaker.

NOTE: During the pacemaker scenarios, the ECG signal is available on the chest electrode plates of the attached training manikin for monitoring purposes only. If you connect the pacemaker to the manikin chest electrode plates, the Impulse 4000 and the pacemaker can't interact.

For best monitoring results, connect the pacemaker electrodes to either the 50–Ω internal test load or to the adapter (pacemaker plug–in) module, and then monitor the ECG signal using the pacemaker's 3– or 5–lead patient cable connected to the Impulse 4000's top panel ECG lead binding posts.

The Impulse 4000 connections explained above and a manikin attached to the Impulse 4000 interact in the defibrillation scenarios only.

1. Connecting the transcutaneous pacemaker to the Impulse 4000.

   Follow the instructions in the *Connecting the Pacemaker to the Impulse 4000* section, which is located earlier in this chapter.

   NOTE: You can attach a printer or serial device to the Impulse 4000 to document the training scenario.

2. Beginning the pacemaker training scenario.

   - Press the <right arrow> "SELECT" key from the MAIN MENU PAGE 1.
   - Press <F1> "TRAIN" from the MAIN MENU PAGE 2.
   - Press <F2> "PACER".

3. Preparing to run pacemaker training scenarios with or without a pacemaker.

   a. Prepare to run the scenario interactively with a pacemaker.

      - Press <F1> "ACTUAL".
      - Press either <F1> "INT50" for the internal 50–Ω test load or <F2> "EXT" for the first (lowest resistance) test load selection of the adapter module.
      - Connect the pacemaker electrodes and the ECG patient cable to the Impulse 4000.

   b. Press <F2> "SIMULATE" to prepare to run the scenario without a pacemaker.

      NOTE: If a transcutaneous pacemaker is not available and you choose <F2> "SIMULATE", you need a basic cardiac monitor (or equivalent device) to view the ECG waveform generated by the Impulse 4000.

4. Interacting with the pacemaker operation.

   - In the "ACTUAL" mode, press <F2> "INHIBIT" to cancel (inhibit) the effect of the incoming pacemaker pulse.
   - In the "SIMULATE" mode, press <F3> "CAPTURE" to mimic a paced beat.

5. Running scenarios.

   a. Press a below–listed function key and then press **<F1>"START"**:

   <F1> "ASYS" ASYSTOLE—Flat line ECG waveform.

   <F2> "BRADY" BRADYCARDIA—Normal sinus rhythm ECG @ 30 BPM.

   <F3> "DEMAND" Normal sinus rhythm ECG @ 80 BPM that degrades to asystole on the 20th beat and then restarts to a normal sinus rhythm after 40 seconds. Set up the pacemaker in the "DEMAND" mode at a rate less than 80 PPM.

   NOTE: Whenever the Impulse 4000 senses a pacemaker pulse while it is outputting a normal sinus rhythm ECG waveform, the message "PACER/PATIENT CONFLICT" flashes on its display.

   This flashing message makes you aware that the pacemaker is improperly set for the simulated patient condition.

   The Impulse 4000 outputs an 80–BPM normal sinus rhythm ECG waveform that degrades to an asystole waveform after 19 beats and then restarts after 40 seconds. The pacemaker must be set in the "DEMAND" mode at a pacemaker rate less than 80 PPM to properly convert the asystole waveform and sense the restart of the 80–BPM normal sinus rhythm ECG waveform.

   <F4> "NONC" NONCAPTURE—Asystole. Upon capture, every 10th ventricular paced beat is dropped.

   b. During the scenario, you can use the function keys as explained below:

   1) **Change scenarios.** Press <F1> "NEXT" and then select another scenario.

   2) **Stop a scenario.** Press <F5> "END" to stop a scenario.

   3) **Print the scenario data.** Press <F5> "END" and then press <F5> "PRINT". Ensure that a parallel printer is attached to the Impulse 4000. The Impulse 4000 outputs the elapsed time indicated in its upper right display.

   4) **Send the scenario data to the serial data port**. Press <F5> "END" and then press <F4> "SERIAL". The Impulse 4000 outputs the elapsed time indicated in its upper right display.

   5) **Return to the earlier "ACTUAL SIMULATE" display**. Press <ESC> "ESCAPE" once.

NOTE: An automatic time–out terminates a scenario if you do not initiate intervention during any elapsed 10–minute interval. Additionally, if the maximum number of 200 events or a total scenario–elapsed time of 1 hour 40 minutes is exceeded, the scenario also terminates.

The prompt "Maximum training time exceeded" displays and you have the option to either immediately abort the selection or output the scenario log/data to an attached printer or serial device.

MEDTESTER INTERFACE

The Impulse 4000 is designed to interface with the original medTester (one that can run an autosequence) or the medTester 5000B. When the medTester runs a defibrillator autosequence, it uses the Impulse 4000. Both the Impulse 4000 and the medTester are switched to a 2400–baud rate by this feature. When this feature is exited, the previous baud rates resume.

Using the Impulse 4000 with the medTester

This feature enables the sending of data obtained from an Impulse 4000 after a defibrillator discharge to the medTester.

Connect an RS–232 interface cable (DNI Part # 3010-0250) from the Impulse 4000 to the medTester's COM2. Turn both instruments on.

From the medTester "DEFIB" menu, select "CASO", "LOAD", then "IMPULSE". *The medTester baud rate is automatically set to 2400 upon entering this mode.* Escape to any medTester defibrillator autosequence. Operate the autosequence until the medTester display indicates "ready" and the medTester is waiting to accept defibrillator energy information.

Select <F3> "MEDT" from the MAIN MENU PAGE 2 of the Impulse 4000 and "MEDTESTER INTERFACE: READY" displays. Also, "TEST" appears above the <F5> key. At this point, there is an ECG NSR 60 waveform present at the ECG jacks of the Impulse 4000 (a mode similar to CARDIOVERSION). *The Impulse 4000 baud rate is automatically set to 2400 upon entering this mode.*

Use <F3> and <F4> to change the waveform from NSR 60 to VFIB or from VFIB to NSR 60. Use <F1> and <F2> to select the range. The autosequence starts out in the low range then a prompt occurs to switch to the high range.

- NSR 60 - For a nonautomatic defibrillator; a delay time reading.
- VFIB - For an automatic defibrillator; no delay time reading. In VFIB "YYY" is transmitted for the delay time.

Press <F5> for a test pulse.

Discharge the defibrillator into the Impulse 4000 when both the Impulse 4000 and the medTester displays indicate "ready". The Impulse 4000 then sends data to the medTester containing the defibrillator energy and cardio delay time. The Impulse 4000 displays the delay time in milliseconds (mS) and the energy (E=) in joules (J).

Press <ESC> to return to MAIN MENU PAGE 2; reverts the baud rate to its previous setting.

UTILITIES

Options in this section affect operating the Impulse 4000 but not taking measurements. Press <F4> "UTIL" from the MAIN MENU PAGE 2 to access the UTILITIES menu.

Available options:

- <F1> VIEW
- <F2> CLOCK
- <F3> BATT
- <F4> BAUD
- <F5> CAL
- <F1> DIAG (UTILITIES MENU PAGE 2)

View Angle

Changes the viewing angle (contrast) of the Impulse 4000's display. The Impulse 4000 is shipped from DNI Nevada with the display viewing angle set at five. The adjustment range varies from zero (dimmest) to seven (brightest).

Set the view angle as follows:

1. Select <F4> "UTIL" from the MAIN MENU PAGE 2.
2. Press <F1> "VIEW".
3. Use the <F3> "DOWN" and <F4> "UP" keys to adjust the angle between zero and seven.
4. Press <F5> "STORE" to save the setting in nonvolatile memory (EEPROM).
5. Press <ESC> to exit this option.

   NOTE: If you exit this option without storing your setting, the view angle remains at the previous setting.

Clock

Sets the day and time of the real–time clock.

NOTE: The clock runs on 24–hour time, i.e., military time.

Set the clock as follows:

1. Select <F4> "UTIL" from the MAIN MENU PAGE 2.
2. Press <F2> "CLOCK".
3. Use the <F1> "left arrow" and the <F2> "right arrow" to select the digit you want to change. The asterisk moves to the digit you select.
4. Use the <F3> "DOWN" and <F4> "UP" keys to increase or decrease the value of the digit. The clock stops counting while you change the digit.
5. Press <F5> "START" and the clock resumes counting.
6. Press <ESC> to exit this option.

   NOTE: If you exit without pressing <F5> "START" (step 5), the time reverts to the previously set time.

Battery

Displays the battery status.

View the battery status as follows:

1. Select <F4> "UTIL" from the MAIN MENU PAGE 2.
2. Press <F3> "BATT". The table below describes the various displayed messages.

Battery Status Table

Impulse 4000 Battery	***Wall Plug Charger*** *115–volt or 230–volt*	***Message*** *displayed on the Impulse 4000*
Fully charged	Not plugged in	Battery voltage: 12.4 V to 13.7 V ±0.15 V Not charging
Not fully charged	Plugged in	Battery voltage: ##.# V Charging at: ## mA
Lowly charged NOTE: At battery voltages below 10.5 V, the Impulse 4000 doesn't operate as specified.	Not plugged in	Battery voltage: 10.5 V Not charging
Almost depleted of charge	Not plugged in	BATTERY DEAD CHARGE BEFORE USING
Depleted of charge	Not plugged in	No message displayed
Turned off (Impulse 4000 isn't powered up)	Plugged in	No message displayed (Impulse 4000 battery is charging)

The internal 12–V lead–acid battery provides a minimum of 20 hours of operation. The instrument will run from the charger while it is charging a fully depleted battery.

The battery charger limits the charging voltage to 13.7 V ±0.15 V. As the battery charges, the charging current decreases. The battery is fully charged when the charging current decreases to 50 mA or less. The amount of time required to fully charge the battery varies. Generally, 12 hours is adequate to recharge a depleted battery.

To optimize battery life

1. Operate the Impulse 4000 without the charger for a maximum of 10 hours, which is 50 percent of capacity.
2. Plug in the charger and fully recharge the Impulse 4000.
3. Again, operate the Impulse 4000 without the charger for a maximum of 10 hours.
4. Plug in the charger and fully recharge the Impulse 4000. Repeat this cycle of use.

NOTE: Operating the Impulse 4000 with the charger plugged in full–time does not hurt the instrument.

Baud Rate

Matches the Impulse 4000's baud rate to a serial communication device. Refer to the *Serial Port Operation* section later in this chapter.

Set the baud rate as follows:

1. Select <F4> "UTIL" from the MAIN MENU PAGE 2.
2. Press <F4> "BAUD".
3. Use the <F3> "DOWN" and <F4> "UP" keys to adjust the value.
4. Press <F5> "OK" to save the baud rate for the current instrument usage. The baud rate is always reset at power-up to 2400.

NOTE: There is a remote command—"BAUD"—for changing the baud rate via the serial port. See the *SERIAL PORT OPERATION* section later in this chapter.

Calibration

Refer to *Chapter 4 - Test and Calibration* for more information on this option.

Start calibration as follows:

1. Select <F4> "UTIL" from the MAIN MENU PAGE 2.
2. Press <F5> "CAL".

Diagnostics

Checks the Impulse 4000's internal functions.

Begin the diagnostic option as follows:

1. Select <F4> "UTIL" from the MAIN MENU PAGE 2.
2. Press <F1> "DIAG", UTILITIES PAGE 2.
3. A brief summary of the Impulse 4000's diagnostic capabilities follows:

- <F1> "MEM" Checks the ROM (press <F1>) using a checksum method.
  Tests the RAM (press <F2>) and the EEPROM (press <F3>) by writing and then reading back from every byte in these memories. Ensures the RAM and the EEPROM are working.
- <F2> "MODTST" Tests the adapter module (when it's plugged in the Impulse 4000) by switching the loads in the module.
  To check that the load is switched correctly, attach an ohmmeter to the inputs and measure the resistance .
- <F3> "VWCAL" View of calibration constants.
- <F4> "PRINTER" Initiates printout.
- <F5> "PACEIN" For DNI Nevada's use only.

SERIAL PORT OPERATION

The Impulse 4000 serial port is compatible with the RS–232 Standard: EIA RS–232–C, and the IBM PC connector configuration. It uses a 25–pin (DB25) male D–sub connector. The port is wired as Data Terminal Equipment (DTE). The connector signals are as follows:

- Pin 1 - Chassis ground connection (sometimes used for shielding)
- Pin 2 - Transmit data connection (from the Impulse 4000)
- Pin 3 - Receive data connection (to the Impulse 4000)
- Pin 5 - Clear to send connection (CTS)
- Pin 7 - Signal ground connection

Test results can be downloaded to a computer or other serial device using the Impulse 4000 serial port. The use of this port provides a way to remotely control the instrument and obtain test data.

A standard null-modem cable with female connectors is required to connect the Impulse 4000 to a personal computer (wired as DTE with a male connector). The appropriate cable is available from DNI Nevada and its part number can be found in the *Other Optional Accessories* section in Chapter 1. This cable connects the Impulse 4000 to the medTester. When using the cable, notice that pins 1, 2, 3, and 7 are connected but not pin 5.

The clear–to–send (CTS) line is not usually used when the Impulse 4000 is connected to a personal computer or a serial terminal; therefore, it is best to leave this line disconnected.

There are instances when a serial printer or other device needs to interrupt the flow of data it is receiving. This occurs to prevent a loss of data during operations such as a carriage return [CR] or a line feed [LF]. When the interruptions are necessary, connect the CTS line to the Data Terminal Ready (DTR) line of the attached device. Then assert the CTS line high using the attached device's DTR line; otherwise, the Impulse 4000 will not send data.

The CTS line is a hardware function of the Impulse 4000 and is not programmable. When it is left disconnected, the line is pulled high by a resistor. If connected, the line must be asserted high by the attached device to allow the Impulse 4000 to send data. If a user mistakenly connects the CTS line and does not assert it high, the Impulse 4000 will not respond to any inputs.

Baud Rate

The Impulse 4000 can be queried as to what baud rates it accepts using

- QBAUD

The Impulse 4000 responds with

- 300,600,1200,2400,4800,9600

To set the baud rate, send

- BAUD=baudrate

Where "baudrate" is one of the baud rates listed in the above response, the Impulse 4000 responds with

- OK

The baud rate of the Impulse 4000 is now changed. The controller should wait approximately 0.5 seconds before attempting communication at the new baud rate. Communication should be started with [CR][LF] to clear the buffers. *At power-up, the Impulse 4000 operates at 2400 baud.*

The baud rate can also be changed from the control panel using the BAUD menu. From the MAIN MENU PAGE 2, press <F4> "UTIL", then <F4> "BAUD". Choose the baud rate using the <F3> "DOWN" and <F4> "UP" keys. Then press <F5> "OK" to set the baud rate. Escape to previous menus using the <ESC> "ESCAPE" key.

XON/XOFF

The Impulse 4000 supports XON/XOFF handshaking for both transmitting and receiving data. Initially, the Impulse 4000 transmits characters to a connected device. If a connected device sends the XOFF character (13 hexadecimal) to the Impulse 4000, it stops sending data. When the connected device sends an XON character (11 hexadecimal), the Impulse 4000 resumes sending data. In this way the connected device controls the incoming stream of data.

When receiving data, the Impulse 4000 monitors the receive buffer. When this buffer is almost filled, the Impulse 4000 sends an XOFF character to the connected device telling it to stop sending data. When the Impulse 4000 has processed the buffer data, it sends an XON character to the connected device indicating that it can resume sending data.

Serial Printing of Test Data

After the Impulse 4000 performs measurements, the results (test record) can be sent out the serial port to a serial printer. Simply select the "SERIAL" function key to send the test data. This menu selection is located within the Defibrillator Manual Tests (DEFIB) menus, the Pacemaker Manual Tests (PACER) menus, and at the end of an autosequence—after you've conducted all test steps. To send the existing steps in an autosequence to a serial printer, select the "SERIAL" function key in the CUSTOM AUTOSEQUENCES menu.

Remote Commands

Introduction

Use the remote commands to control the Impulse 4000 from a personal computer or other serial device, to make measurements, and to obtain test results.

Primary commands are valid when the instrument is in the MAIN MENU or in the REMOTE MAIN MODE. When a valid command is received from the MAIN MENU, the instrument enters the REMOTE MAIN MODE. In this mode, and in any remote submodes, the remote commands are displayed and the keys on the top panel are deactivated.

The "LOC" command is a special command that leaves whichever remote mode the instrument is in and returns to local control at the MAIN MENU.

The "EXIT" command is a special command that is valid in any of the remote submodes and which exits that submode and returns to the REMOTE MAIN MODE.

Commands that are listed more than once are defined only at the first occurrence.

At power-up, the global variables are set to the default. When entering a mode, the variables for that mode are set to the default. The default setting is the one listed first unless otherwise stated. The global variable setup commands are valid in the MAIN MENU and also in the modes where they are listed. Other measurement commands are only valid in the specific mode they are listed in.

Command Syntax

Commands can be sent in upper or lower case. All command strings must be terminated with a carriage return [CR] and/or a line feed [LF], i.e., [command][CR][LF]. Spaces are ignored.

Commands shown with "=" are setup commands that require at least one parameter to be included with the command. Multiple parameters, if required, are separated by commas. All possible parameter choices are shown. Unless otherwise stated, the default parameters are listed first.

Responses to Commands

The instrument responds to all commands. Commands that do not return any other message or data return "OK".

After receiving a command, the instrument ignores all other incoming characters until it has responded to the one at hand. Some commands take a while to complete. These are noted.

The null command, which has no characters and consists only of terminating characters, returns "?".

All responses are in upper case and are followed by a [CR] and [LF]. Where a command returns more than one item, they are separated by commas. The items are returned in the order listed.

Commands can return character strings, integers, or floating point numbers.

Measurement readings are returned as floating point numbers. The readings are in scientific notation and include a unit of measurement.

Readings are in the following format:

[+/-][reading][E][+/-][exponent][unit]

- The leading + sign is not transmitted.
- The reading is up to four digits with or without a decimal point.
- The E indicates that an exponent follows.
- The exponent has either a plus or minus sign and is 0, 3, 6, or 9.
- The units of measurement have the following abbreviations:

  V = volt

  A = ampere

  S = second

  J = joule

  PM = per minute

Error Responses

If an error is detected, an error response is returned in the following format:

- ERR=XX, description

The possible error responses are as follows:

- ERR=00,NO COMMANDS ALLOWED NOW
  The instrument is in a mode in which commands are not allowed.

- ERR=01,UNKNOWN COMMAND
  The received command was not recognized.

- ERR=02,ILLEGAL COMMAND
  The command was understood, but it is not allowed at this time.

- ERR=03,ILLEGAL PARAMETER
  A parameter sent with a command was not the right type, was out of range, was not understood, or the right number of parameters were not sent.

- ERR=20,OVERLOAD
  The adapter module has been overloaded because a defibrillator has been discharged into it. This is a terminal condition that causes the instrument to go into a dead-end state. This message is unique in that it is not a response to a command, but is sent immediately when an overload is detected. The Impulse 4000 displays "!!! MODULE OVERLOAD !!!" and the adapter module produces an audible "beep". To reset the Impulse 4000, turn the instrument off, disconnect the defibrillator leads, wait 5 seconds, and then turn the instrument back on.

Special Commands

- LOC
  Leaves any remote mode and returns to local key control at the MAIN MENU. Returns "OK".

- EXIT
  Exits any of the remote submodes and returns to the REMOTE MAIN MODE. Returns "OK".

Instrument Identification Commands

- IDENT
  Asks for the instrument identification, then returns a string which contains the instrument name, firmware version level, and any installed options. The IDENT string is in the following format: [model],[version],[options].

  Where model is "IMPULSE4000", version is a character string (for example, "VER 1.02"), and options is a character string listing the options.

- QADAPTER
  Asks for the adapter module identification, then returns an integer 0 through 255 that identifies the installed adapter module. This number corresponds to the TQA number on the adapter module.

Global Variable Setup Commands

- DEFRANGE=range
  Sets the defibrillator measurement range. Use "HIGH" for high range or "LOW" for low range. Returns "OK".

- PACELOAD=load
  Sets the pacemaker load using one of the following commands:

INT	Internal 50 Ω.
ADAP0	Adapter, open circuit.
ADAP1	Adapter, load 1.
ADAP2	Adapter, load 2.
ADAP3	Adapter, load 3.
ADAP4	Adapter, load 4.

  Returns "OK".

  NOTE: If running a transcutaneous interactive waveform, the waveform must be restarted with a new ECG wave command when the pacemaker load is changed with this command.

- PACEIN=enable
  Enables or disables the incoming pacemaker pulse from affecting the ECG waveform when running one of the transcutaneous interactive waves (TQXXX).

ON	Pulse affects the waveform.
OFF	Pulse doesn't affect the waveform.

  Returns "OK".

For the next two commands the width and amplitude parameters are as follows:

Width: A number that represents the width in milliseconds. It must be from the following list, exactly as shown: 0.1, 0.2, 0.5, 1.0, 2.0. The default value is 1.0.

Amplitude: A number that represents the amplitude in millivolts. It must be from the following list, exactly as shown: -700, -500, -200, -100, -50, -20, -18, -16, -14, -12, -10, -8, -6, -4, -2, 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 50, 100, 200, 500, 700. The default value is 100.

- ATRPACE=width,amplitude
  Sets the width and amplitude of the atrial pacemaker spike in transvenous paced ECG waveforms. Returns "OK".

- VENTPACE=width,amplitude
  Sets the width and amplitude of the ventricular pacemaker spike in transvenous paced ECG waveforms. Returns "OK".

General Purpose Command

The following command is valid during measurement modes to query the status of measurement data in that mode:

- QDATA
  Asks if the measurement data is available. Valid during all measurement modes. Returns one of the following:

NODATA	No data is available.
NEWDATA	Data is available. Reading the data with the "XXXDATA" command, for that mode, resets the status to "OLDDATA".
OLDDATA	Data has been read by the "XXXDATA" command. It can be read again if desired.

Defibrillator Measurement Commands

• ENERGYMODE is a command that enters the energy mode and enables measuring a defibrillator pulse when ready. The following commands are enabled and then "OK" is returned.

- DEFRANGE (See definition in a previous section *Global Variable Setup Commands.*)
- DEFIBWAVE=ECG waveform
  Sets the ECG waveform for a defibrillator test as follows:

NONE	No waveform.
VFB1	Ventricular fibrillation 1, coarse.
VFB2	Ventricular fibrillation 2, fine.
VTC130	Ventricular tachycardia 130 BPM.
VTC175	Ventricular tachycardia 175 BPM.
VTC180	Ventricular tachycardia 180 BPM.
VTC185	Ventricular tachycardia 185 BPM.
VTC220	Ventricular tachycardia 220 BPM.

  Returns "OK".
- QDATA (See definition in the preceding section *General Purpose Command.*)
- ENERGYDATA
  Asks for the energy mode defibrillator pulse data. Returns all the following if the data is available:

Defibrillator energy	J
Peak voltage	V
Peak current	A
50% pulse width	S
10% pulse width	S

  If no data is available, "NODATA" is returned.
- CHKENERGY (medTester checklist command)
  Returns the defibrillator energy reading: "DEFIB ENERGY=ddd.d J"
  NOTE: Does not change NEWDATA to OLDDATA.
- PLAYBACK
  Starts the energy playback waveform. This waveform takes 13 seconds to complete.
  Returns "OK" when complete.
- EXIT (See definition in a previous section *Special Commands.*)

• MAXEMODE is a command that enters the maxe mode and enables measuring the defibrillator maximum energy and charge time. The following commands are enabled and then "OK" is returned.

- DEFRANGE
- DEFIBWAVE
- QDATA
- MAXESTART
  Starts the charge time test. Should be sent at the same time that the defibrillator is set to start charging. Returns "OK".
- MAXEDATA
  Asks for the maxe mode defibrillator pulse data. Returns all the following if good data is available:

Defibrillator energy	J
Peak voltage	V
Peak current	A
Charge time	S

  If no data is available, "NODATA" is returned. If a defibrillator pulse arrives and the MAXESTART command has not started the test yet, "NOSTART" is returned. If the charge time was greater than the maximum of 99 seconds, "CT>99S" is returned.
- CHKENERGY (medTester checklist command)
- PLAYBACK
- EXIT

• CARDIOMODE is a command that enters the cardio mode and enables measuring defibrillator cardioversion delay time. The following commands are enabled and then "OK" is returned.

- DEFRANGE
- CARDIOWAVE=ECG waveform
  Sets the ECG waveform for a defibrillator cardioversion test as follows:

NSB60	Normal sinus rhythm 60 BPM.
NSB80	Normal sinus rhythm 80 BPM.
NSB120	Normal sinus rhythm 120 BPM.
AF1	Atrial fibrillation 1, coarse.
AF2	Atrial fibrillation 2, fine.

  Returns "OK".
- QDATA
- CARDIODATA
  Asks for the cardio mode defibrillator pulse data. Returns all of the following if the data is available:

Defibrillator energy	J
Peak voltage	V
Peak current	A
Cardio delay time	S

  If the cardio delay time is outside the measurement range or -120 to +380 ms, "NO-SYNC" is returned for this field instead of the data. If no data is available, "NODATA" is returned.

- CARDIOMODE *continued*
  - CHKENERGY (medTester checklist command)
  - CHKCARDIO (medTester checklist command)
    Returns the cardioversion delay time: "DEFIB CARDIO=ddd mS".
    NOTE: Does not change NEWDATA to OLDDATA.
  - PLAYBACK
  - EXIT

Pacemaker Measurement Commands

- PACEPMODE is a command that enters the pacep mode and enables measuring pacemaker pulse parameters.

NOTE: Complete data is not available until at least two pulses have been received. Two pulses are required to establish the pacing rate. The following commands are enabled and then "OK" is returned.

- QADAPTER
- PACELOAD
- HOLD=hold
  Sets or releases a hold on the current data during which the instrument will not look at additional incoming pulses. The hold parameter can be

RESUME	Resume measuring pulses.
HOLD	Hold current data.

  Returns "OK".
- QDATA
- PACEPDATA
  Asks for the pacep mode pacemaker pulse data. Returns all the following if data is available:

Peak current	A
Pulse width	S
Pulse rate	PM

  If no data is available, "NODATA" is returned.
- CHKPACEP (medTester checklist command)
  Returns the pacemaker pulse amplitude and pacing rate:
  "PACER PULSE=ddd.d mA, ddd PPM".
  NOTE: Does not change NEWDATA to OLDDATA.
- EXIT

- PACEREFRACT is a command that measures the pacemaker pulsed– and sensed–refractory periods, and the pacing rate.
  - If no pacemaker pulse is detected within 10 seconds, "NO PACER" is returned.
  - If the pacing rate is less than the minimum, "PACERATE TOO LOW" is returned.
  - If the pacing rate is greater than the maximum, "PACERATE TOO HIGH" is returned.
  - If the pacing rate is within the range (30 to 100 PPM) and the refractory periods are able to be measured, all of the following are returned:

Pacing rate	PM
Pulsed–refractory period	S
Sensed–refractory period	S

    NOTE: The entire measurement can take up to 60 seconds to complete.

Waveform Commands

- PERFLEAD=lead
  Sets the performance waveform reference lead to I or II.
  Returns "OK".

  NOTE: When you run waveforms from the serial commands, performance waveforms (as listed below) are affected by the reference lead selection; ECG waveforms (as listed below) aren't affected by the reference lead selection.

The following waveform commands simply turn on the specified waveform. They do not enter a special mode. All of these commands return "OK".

NOTE: The "W0##" commands are alternatives (secondary commands) to the commands they follow, and are compatible with the medTester.

Performance Waveforms			
• ZERO			Zero output.
• SQU	or	W001	2–Hz square wave.
• PUL	or	W002	4–second pulse.
• SIN0.05			0.05–Hz sine wave.
• SIN0.5	or	W014	0.5–Hz sine wave.
• SIN1			1–Hz sine wave.
• SIN10	or	W003	10–Hz sine wave.
• SIN25			25–Hz sine wave.
• SIN30			30–Hz sine wave.
• SIN40	or	W004	40–Hz sine wave.
• SIN50			50–Hz sine wave.
• SIN60	or	W005	60–Hz sine wave.
• SIN100	or	W006	100–Hz sine wave.
• SIN125			125–Hz sine wave.
• SIN150			150–Hz sine wave.
• SQ1K		W007	1–kHz square wave.
• TRI		W008	2–Hz triangle wave.

ECG Waveforms		
• NSB30	W010	Normal sinus rhythm at 30 BPM.
• NSB60	W011	Normal sinus rhythm at 60 BPM.
• NSB80		Normal sinus rhythm at 80 BPM.
• NSB120	W012	Normal sinus rhythm at 120 BPM.
• NSB160		Normal sinus rhythm at 160 BPM.
• NSB200		Normal sinus rhythm at 200 BPM.
• NSB240	W013	Normal sinus rhythm at 240 BPM.
• NSB300		Normal sinus rhythm at 300 BPM.

ECG Waveforms continued

• AF1	W015	Atrial fibrillation 1, coarse.
• AF2		Atrial fibrillation 2, fine.
• AFL		Atrial flutter.
• SINA		Sinus arrhythmia.
• 1DB		1st degree AV block.
• 2DB1	W016	2nd degree AV block, type 1, Wenckebach.
• 2DB2	W017	2nd degree AV block, type 2.
• 3DB		3rd degree AV block.
• PVC1	W020	PVC type 1.
• PVC2	W021	PVC type 2.
• MF	W022	Multifocal PVCs.
• PAIR	W024	A pair or couplet of PVCs.
• BIG		Bigeminy.
• TRG		Trigeminy.
• RUN5	W025	Run of 5 PVCs.
• RUN11	W026	Run of 11 PVCs.
• VNT		Ventricular rhythm 120 BPM.
• VTC130		Ventricular tachycardia 130 BPM.
• VTC175		Ventricular tachycardia 175 BPM.
• VTC180	W028	Ventricular tachycardia 180 BPM.
• VTC185		Ventricular tachycardia 185 BPM.
• VTC220		Ventricular tachycardia 220 BPM.
• VFB1	W029	Ventricular fibrillation 1, coarse.
• VFB2		Ventricular fibrillation 2, fine.
• ASY1		Asystole 1, some movement.
• ASY2	W030	Asystole 2, flat.
• ASN		Asynchronous, continuous, transvenous paced.
• DM1		Demand 1, mostly paced, transvenous paced.
• DM2		Demand 2, mostly normal, transvenous paced.
• AVS		Atrioventricular sequential, transvenous paced.
• NCA		Noncapture, transvenous paced.
• NFU		Nonfunctional, transvenous paced.
• TQASYS		Asystole, transcutaneous paced.
• TQBRAD		Bradycardia, transcutaneous paced.
• TQDEM		Demand, transcutaneous paced.
• TQNC		Noncapture, transcutaneous paced.

- THRESH=width,amplitude
  Turns on the R–wave threshold detection waveform with the specified width and amplitude parameters as indicated below:

  Width: A number that is the width in milliseconds. It must be from the following list, exactly as shown: 8, 12, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200.

  Amplitude: Referenced to Lead II. A number that represents the amplitude in millivolts. It must be from the following list, exactly as shown: 0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.75, 1.00, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75, 3.00, 3.25, 3.50, 3.75, 4.00, 4.25, 4.50, 4.75, 5.00, 5.25, 5.50.

  Returns "OK".

Utilities and Diagnostics

- QBAUD
  Asks for all possible baud rates that the instrument can operate in. Returns all the possible baud rates separated by commas, exactly as follows:
  300,600,1200,2400,4800,9600

- BAUD=baudrate
  Sets the baud rate that is a number from the following list exactly as shown:
  300, 600, 1200, 2400, 4800, 9600.
  Returns "OK".

- SETCLOCK=month,day,year,hour,minute,second
  Sets the real–time clock. Note that time is always in a 24–hour format.

month	An integer 1 through 12.
day	An integer 1 through 31.
year	An integer 0 through 99.
hour	An integer 0 through 23.
minute	An integer 0 through 59.
second	An integer 0 through 59.

  Returns "OK".

- QCLOCK
  Asks for the date and time from the real–time clock. Returns the following as integers: month, day, year, hour, minute, and second.

- ROMCHECK
  Calculates the ROM checksum and checks to see if it is equal to the stored checksum. All checksums are four–digit hexadecimal numbers. Returns one of the following:

GOOD	The checksum does match the stored checksum.
BAD	The checksum doesn't match the stored checksum.

- RAMTEST
  Performs a RAM test. Returns one of the following:

GOOD	The RAM tests good.
BAD	The RAM tests bad.

- EEPROMTEST
  Performs an EEPROM test. Note that this test can take up to 60 seconds. Returns one of the following:

GOOD	The EEPROM tests good.
BAD	The EEPROM tests bad.