DA-2000
Defibrillator Analyzer

BC Biomedical
A Unit of BC Group International, Inc.

Contents

Introduction

Regular testing of defibrillators and pacemakers is critical in order to ensure safe and effective operation. The BC Biomedical DA2000 Defibrillator Analyzer accurately verifies the output characteristics of all defibrillators as well as testing the parameters of non-invasive pacemakers. The DA2000 is battery operated and completely portable. Simple-to-use menu soft keys allow quick access to tests.

The DA2000 measures the delivered energy in Joules (watt-seconds) from a defibrillator by simulating the human body's resistance. The analyzer then measures the flow of current through that resistance. The standard resistance used by the DA2000 is 50 ohms. Defibrillator energy is measured in one of two ranges: 0-100 Joules, or 0-1000 Joules.

The defibrillator pulse waveform can be replayed via the ECG jacks or paddle plates for viewing on a recorder, or on an oscilloscope for greater detail.

Synchronization time in milliseconds is measured by timing the firing delay from either the Q-wave (base) or R-wave (peak) simulated by the DA2000. The simulated waveform is present at both the ECG jacks and the paddle plates. Peak voltage and peak current (amps) of the defibrillator pulse can be measured. Overshoot voltage and current measurements of the defibrillator pulse are calculated and displayed.

The DA2000 also measures the defibrillator's charge time (the time it takes for a defibrillator to reach its maximum charge setting).

Waveforms, including ECG, arrhythmias, and performance, help verify monitor and recorder accuracy, and also test the automatic defibrillator's ability to recognize and fire.

All waveforms are present at the ECG jacks, the paddle plates and scope output. Utilities allow the setting of Serial RS-232 communication parameters to download results to printer, or computer. Display contrast can be adjusted to obtain the best view of the LCD display.

Upgrading the DA2000

A number of pre-configured DA2000 models are available. In addition, older models may be upgraded by contacting BC Biomedical. The following DA2000 models are available:

- **DA2000:**   Base unit. Features output energy, synchronization time, peak measurements, bi-directional RS-232.

- **DA2000W:**   "Waveform" version. Features output energy, sync time, peak measurements, overshoot, bi-directional RS-232, waveforms, charge time measurements, 28 programmable autosequences.

- **DA2000P:**   "Pacer" version. Output energy, sync time, peak measurements, overshoot, bi-directional RS-232, waveforms, charge time measurements, 28 programmable autosequences, pacer output measurements and pacer refractory period measurements.

Description
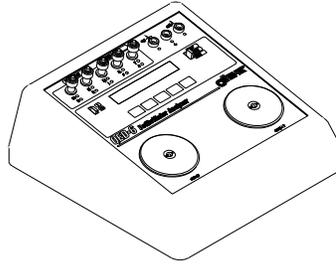
Figure 1.1. DA2000 Isometric View

Front Panel

The front panel of the DA2000 (*Figure 1.2*) includes the following operating features:

1. Universal ECG jacks that utilize AHA and International color coding, allowing for waveform output to monitor/recorder.

2. A "High Level ECG" Banana jack provides 1 Volt peak output of the selected waveform.

3. The "Common" Banana jack provides ground for the "High Level ECG" and "Defib Scope Out" jacks.
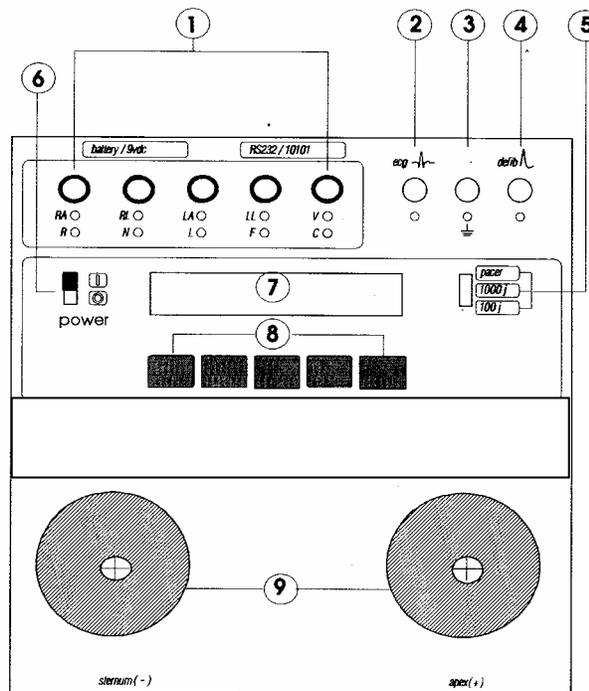
Figure 1.2. DA2000 Front Panel Layout

4. The "Defib Scope Out" Banana jack provides pulse output to an oscilloscope.

5. A range switch allows for defibrillator settings from 0 to **1000** Joules (high), for power below 0-**100** Joules (low) for increased accuracy, and a **PACER** range setting for pacer output measurements.

6. The **Power** switch enables the DA2000 (I = ON, O = OFF).

7. LCD display: 24 characters x 2 lines. The upper line of the LCD display provides messages and test results, while the bottom line displays menu choices.

8. Five "soft keys" can be used to select the desired function highlighted on the lower line of the display.

9. Two nickel-plated Defibrillator Paddle Plates are available for defibrillator paddle contact. All waveforms are present at the paddle plates simultaneously with the ECG jacks.

Back Panel

The Back Panel includes a battery holder that houses a 9-Volt alkaline battery, and a DC battery eliminator jack. An RS-232 D-9 pin Serial Port allows communications to a computer, serial printer or other test equipment.

Specifications

OUTPUT POWER MEASUREMENT

Load Resistance:	50 ohms +/- 1% non-inductive 160 watts
Range:	1000 J: 0-1000.0 Joules 100 J: 0-100.0 Joules
Resolution:	0.1 Joule
Max. Voltage:	1000 J: 5500 Volts 100 J: 1750 Volts
Max. Current:	1000 J: 110 Amps 100 J: 35 Amps
Measurement Trip Levels:	1000 J: 66 +/- 5 Volts 100 J: 20 +/- 5 Volts
Pulse Width:	1-50 ms

Accuracy:
1000 J Range:	+/- 2% of reading
100-1000 J:	+/- 2 Joules
100 J Range:	+/- 2% of reading
	+/- 0.1 Joule

SYNCHRONIZATION MEASUREMENTS

Range:	0-199.9 ms
Measurement:	From peak of R-wave From base of R-wave
Accuracy:	1% of fullscale or +/- 2 ms

ECG WAVEFORMS

QRS complex: Rates:	30, 60, 120, 180, 240 BPM
Rate Accuracy:	+/- 1% of setting
Amplitude:	Fixed at 1 mV Lead II (RA-LL) Fixed at 1.1 mV (Apex- Sternum)
Amplitude Accuracy:	+/- 2% (RA-LL) +/- 10% (Apex-Sternum)

PERFORMANCE WAVEFORMS

Pulse:	30, 60 BPM
	pulse width -60 ms
Triangle Wave:	2 Hz
Square Wave:	0.125 Hz, 2 Hz, 50% duty cycle
Sine Waves:	10, 40, 50, 60, 100 Hz
Time Base Accuracy:	+/- 1% of setting
Amplitude:	Fixed at 1 mV Lead II (RA-LL)
	(Triangle wave 2 mV Lead II (RA-LL)
	Fixed at 1.1 mV (Apex-Sternum)
Amplitude Accuracy:	+/- 2% (RA-LL)
	+/- 10% (apex-sternum)

DEFIB WAVEFORM PLAYBACK

**Time Base
Expansion:** 100:1 @25 mm/sec paper
speed; each division equals 40 ms

Amplitude Scaling
   Lead II (RA-LL):
   1000 J Range: 1 mV = 3000 Volts
   100 J Range: 1 mV = 900 Volts

ECG Output
   1000 J Range: 0.5 V = 3000 Volts
   100 J Range: 0.5 V = 900 Volts

ARRHYTHMIAS
Afib, Vfib, Atach, Vtach, Aflutter, RUN, PVC, R on T, Idioventricular

Rate Accuracy:	+/- 1%
Amplitude:	Fixed at 1 mV Lead II (RA-LL)
	Fixed at 1.1 mV (Apex-Sternum)
Amplitude Accuracy:	+/- 2 (RA-LL)
	+/- 10% (Apex-Sternum)

SCOPE OUTPUTS

ECG Hi-Level:	Fixed at 1 Volt
	Accuracy: +/- 2%
Defib Output:	Real Time
Pacer Range:	1V = 3.11 V
1000 J Range:	1V = 1450 V
100 J Range:	1V = 440 V
Amplitude Accuracy:	+/-2% of scale

EXTERNAL NON-INVASIVE PACER MEASUREMENTS

Load:	50 ohms +/- 1%
	(Apex-Sternum)
R-wave Amplitude:	1.1mV +/- 10% (Apex-Sternum)
	1 mV +/- 2% Lead II (RA-LL)
Pulse Width:	1-50 ms
Peak Voltage:	0-12.5 Volts
Peak Current:	4-250 mA < 4 mA = 0.0 mA
Rate:	25-400 ppm < 25 ppm = 0 ppm
Refractory Period:	
Sensed:	110-500 ms < 110 ms = 110 ms
Pulsed:	70-500 ms < 70 ms = 70 ms
Accuracy:	+/- 2% of fullscale for pulsewidth, peak voltage & current
	+/- 1% of fullscale for rate and refractory period measurements

CALIBRATION SCREEN

Load:	50 ohms +/- 1% (Apex-Sternum)
Amplitude scaling:	Apex (+) to Sternum (-)
Pacer Range:	318 counts/Volt
1000 J Range:	0.683 counts/Volt
100 J Range:	2.252 counts/Volt
Accuracy:	+/- 15 counts
Measurement Range:	Apex (+) to Sternum (-)
Pacer Range:	(0-12.86) = (0-4095)
1000 J Range:	(0-5995) = (0-4095)
100 J Range:	(0-1814) - (0-4095)
Zero Voltage Input:	0 +/- 2 counts

PEAK / OVERSHOOT

| **Voltage Accuracy:** | 1000 J Range: +/- 10 Volts |
| | 100 J Range: +/- 25 Volts |

Current Accuracy: +/- 1 Amp

RS-232 OUTPUT / COMPUTER CONTROL

Computer control allows the user to operate the
DA2000 remotely via a serial RS-232 interface.

Requires a BC Biomedical RS-232 cable and a
Bi-directional, D-9 connector.

Selectable Communications parameters:

Baud Rate:	300, 600, 1200, 2400, 9600
Parity:	None, Even, Odd
Stop Bits:	1 or 2
Data Bits:	7 or 8

Display: 2-line x 24-character LCD supertwist alphanumeric

Power: One 9-Volt Alkaline (DuracellMN1604 or equivalent);
12 hours continuous operation;
low battery indication;
120/240 Volts battery eliminator input.

Weight: 4.54 lbs

Dimensions: 26.67 x 24.13 x 10.16 cm

ENVIRONMENTAL OPERATING SPECS

**Storage
Temperature:**   -25 to 50°C

**Operating
Temperature:**   0 to 40°C

**Maximum
Humidity:**   90% Relative Humidity

Accessories

DESCRIPTION	SUPPLIED
• Carrying Case	(optional)
• User's Guide	1
• RS-232/Printer Cable Serial/Parallel	(optional)
• Printer (DPM 411-21)	(optional)
• Printer paper for DPM 411-21	(optional)
• Converter Data Serial-Parallel 110V	(optional)
• Power Supply for DPU-411-21 Printer (220 V)	(optional)
• Internal Paddle Adapters	2
• Automatic Paddle Adapters	(optional)
Hewlett Packard	
Marquette	
Laerdhal	
Physio Control	(Automatic Defibrillation)
Physio Control	(Pacer)
Zoll Cable Asby	
• 9 VDC 300 mA Adapter	(optional)

Use the following checklist when unpacking the DA2000 to check the instrument for shipping damage.

- ✔ Perform a visual inspection to ensure the front panel or case has not been damaged during shipping.

- ✔ Check the LCD display to ensure that it is intact. If the DA2000 has been damaged, call your BC Biomedical representative immediately.

- ✔ Place the DA2000 on a level surface and power up the instrument by turning the power switch to **I (ON).** Check the display. If the message, *Warning - Low Battery!!* appears, the instrument's battery requires replacement.

Operation Warnings

The operator must be familiar with, and follow the safety precautions listed detailed below, before using the DA2000 with a defibrillator:

- Inspect the defibrillator daily. Examine the paddles, lead wires, and power cord for cracks and frays.

- If the defibrillator is line powered, be sure that it is plugged into a grounded receptacle. Do not touch the electrical contact surfaces of the defibrillator paddles.

- Grip one paddle handle firmly in each hand. Apply to the DA2000 plates. Keep the paddles firmly depressed to prevent arcing that can cause injury to the operator and/or damage the DA2000 or defibrillator.

- Do not touch the contact plates on the DA2000 when the defibrillator paddles are being pressed onto the plates. Do not use any electrical paste or pads when testing a defibrillator with the DA2000.

Getting Acquainted

The DA2000 utilizes a 2-line x 24-character LCD display and "soft keys" to simplify operation (***Figure 2.1***).

The top line of the LCD display is used for test results and the bottom line provides menu choices. A menu selection is made by pressing the corresponding soft key. An audible "beep" verifies the selection.

Figure 2.2 provides an overview of the menus and functions that may be accessed from the DA2000 main menu.

For example, when the DA2000 is powered up, the following message appears briefly on the display, identifying the software version:

```
┌─────────────────────────────────┐
│          BC BIOMEDICAL           │
│    DA2000        Version: x.xx    │
└─────────────────────────────────┘
```

After a short delay, the display changes to the main menu:

```
┌─────────────────────────────────┐
│           Main Menu 1            │
│     ENRG SYNC PEAK WAVE more     │
└─────────────────────────────────┘
```

Pressing the blue soft key corresponding to **ENERG**, **SYNC**, **PEAK** or **WAVE** prompts a submenu of specific functions to appear; pressing **esc** in any of the sub-menus returns the display to the previous menu, and ultimately to the main menu.

Pressing **more** from Main Menu 1 toggles the display to Main Menu 2; pressing **more** from Main Menu 2 returns you to Main Menu 1.

Menu Choice Line
Test Results Line

Sync Time-Peak   0.0 ms
BASE ENRG HEDR   esc

battery / 9vdc   RS232 / 10101   ecg ⫯⩘⫯   defib ⟋⎱

RA ○   ʀL ○   LA ○   LL ○   V ○
R ○   ʍ ○   L ○   F ○   C ○

pacer
1000 j
100 j

── Soft Keys ──

sternum (-)   apex(+)
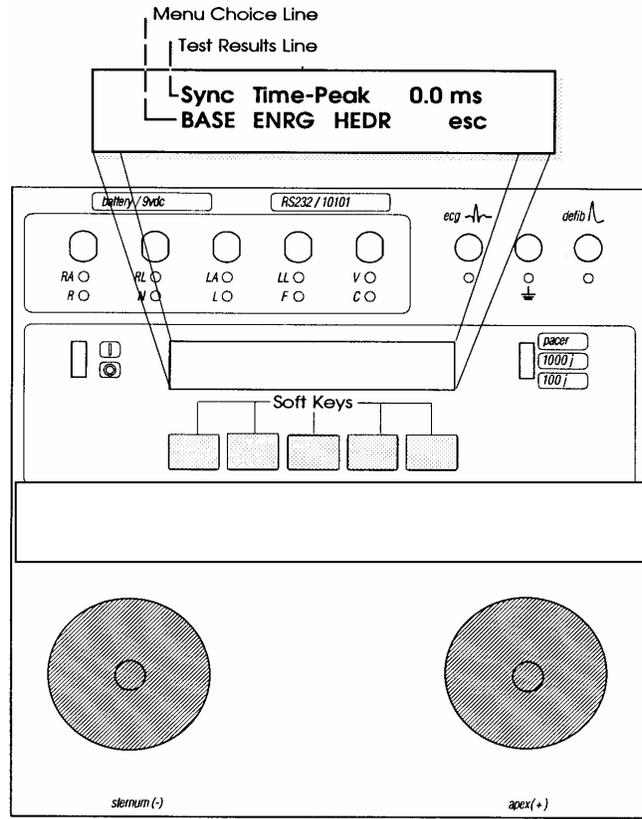
Figure 2.1. *DA2000 Front Panel Display*

DA2000 Menu Structure / Main Menu 1

Bio-Tek Instruments, Inc.
QED-6   Version x.xx

Main Menu 1
ENRG SYNC PEAK WAVE more

Main Menu 2
PACE AUTO CHRG UTIL more

Arrhythmia: Vfib
    +   -   esc

Vfib   RUN
Afib   RONT
ATACH   IDIO
PVC   AFLUT
         VTACH

Waveform Type:
ECG PERF ARRH   esc

ECG: 30 BPM
    +   -   esc

Performance: 2Hz sq
    +   -   esc

30 BPM
60 BPM
120 BPM
180 BPM
240 BPM

2 Hz Sq
.125 Hz Sq
10 Hz Sin
40 Hz Sin
50 Hz Sin
60 Hz Sin
100 Hz Sin
2 Hz Tri
30 BPS PLS
60 BPM PLS

Peak   --- V   ---A
OVER   esc

Over   --- V   ---A
PEAK   esc

Sync Rwave --- ms
ENRG Qwave   esc

Energy   0.0 J

ENERGY   --- Joules
VFIB VTACH PLAY HDR esc

Figure 2.2.1. DA2000 Menu Structure (Main Menu 1)

DA2000 Menu Structure / Main Menu 2

Main Menu 2
PACE AUTO CHRG UTIL more

Main Menu 1
ENRG SYNC PEAK WAVE more

Utilities:
R232 DISP CKSM CAL   esc

A/D Count = -0   esc

Checksum = XXXX   esc

CONTRAST X
+   -   esc

Charge Time: 00 sec
START   ENRG   esc

2400   N   8   1
BAUD   PAR   DATA   STOP esc

Autosequences:
PROG   RUN   DEFS   esc

ENERGY: 0.0 J

menu structure next page

Pacer Tests:
MEAS RFP HDR   esc

PRP --- ms at --- BPM
SRP --- ms   TEST   esc

--- mA   --- V   --- ms
--- BPM   PRINT   esc

Figure 2.2.2. *DA2000 Menu Structure (Main Menu 2)*

Main Menu 2: Autosequence Menu Structure

restore?   PROG #
<ALL> +   NO   OK   esc

Loading Defaults
Please wait

Autosequences:
PROG   RUN   DEFS   esc

RUN: PROG #
START   + -   esc

SET DEFIB AT _ J
DISCHARGE!   esc

Sequence: PROG 0
SEL   +   - NAME   esc

edit name: PROG#
+   -   -->   esc

Print Heading?   YES
SEL   STEP   esc

[1-10]
A-Z

YES/No

Defib Setting 1: OJ
+ -   NEXT STEP   esc

[0-500]

Limit: +/- 0 %
+ -   STEP esc

[0-25]

Charge Time?   YES
SEL   STEP   esc

[Yes/No]

Sync-Time?   YES
SEL   STEP   esc

[Yes/No]

Peak?   YES
SEL   STEP   esc

[Yes/No]

Overshoot?   YES
SEL   STEP   esc

[Yes/No]

ECG/Perf   30BPM   Pls
SEL   +   - STEP   esc

Pacer?   YES
SEL   STEP   esc

[Yes/No]

30 BPM	2 Hz Sq	Vfib	RUN
60 BPM	.125 Hz Sq	Afib	RonT
120 BPM	10 Hz Sin	Atach	IDIO
180 BPM	40 Hz Sin	PVC	AFLUT
240 BPM	50 Hz Sin		VTACH
	60 Hz Sin		
	100 Hz Sin		
	2 Hz Tri		
	30 BPS PLS		
	60 BPS PLS		

Figure 2.2.3*. DA2000 Autosequence Menu Structure
(Main Menu 2)*

Measuring Defibrillator Energy

1) Power up the defibrillator to be tested, and select the energy output following manufacturer's instructions.

2) Turn the DA2000 **ON**. Main Menu 1, as shown below, will appear on the display.

```
                    Main Menu 1
          ENRG  SYNC  PEAK  WAVE  more
```
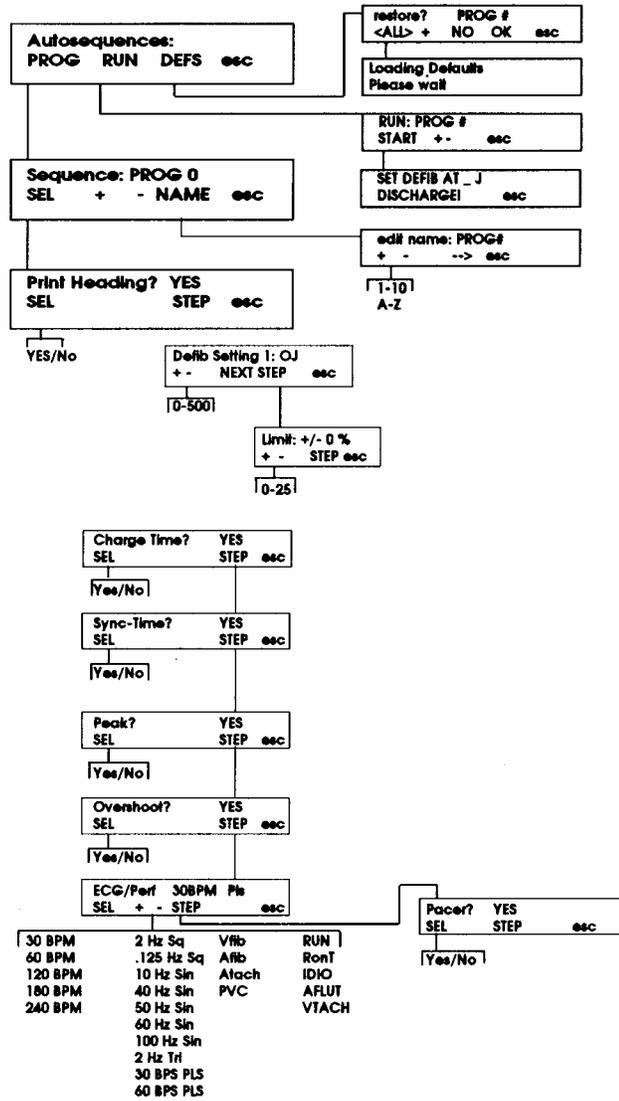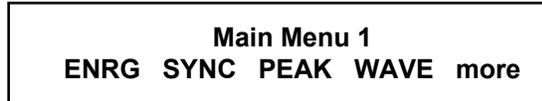
3) Press the soft key corresponding to **ENRG** to access the power menu shown below:

```
              Energy        ---J
          VFIB  VTACH  PLAY   HDR    esc
```

If the range switch is set to **Pacer**, the following message will appear momentarily:

```
                   ATTENTION
                Select DEFIB Range
```

4) Select the DA2000's 1000 Joule range (high) for defibrillator outputs over 100 Joules, or select the 100 Joule range (low) for outputs under 100 Joules. Select the high range for unknown defibrillator output power.

Simultaneously press the two defibrillator paddles onto the contact electrode plates on the front of the DA2000.

Initiate a discharge from the defibrillator.
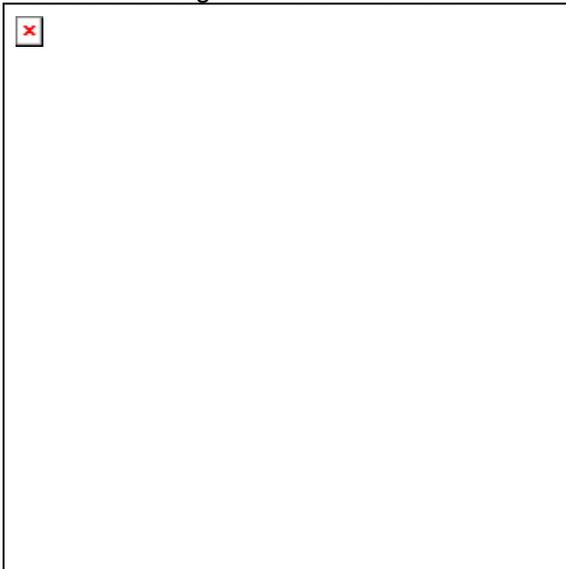
Observe the output settings and the actual readings displayed on the DA2000, and record them if desired.

Note: **The DA2000 will continue to display the reading until the next defibrillator pulse is fired.**

To test automatic defibrillators for their ability to recognize ventricular fibrillation and/or ventricular tachycardia, and automatically fire:

1)   Attach the optional automatic defibrillator paddle adapters to the DA2000.

2)   Connect the ECG patient leads to the DA2000 as shown in **Figure 2.5**.

3)   Press the soft key corresponding to **VFIB** (refer to **Figures 2.2.1** and **2.2.2** for an overview of the menu functions). A ventricular fibrillation waveform will be simulated by the DA2000 through the ECG jacks and paddle plates. Once a discharge is complete, the DA2000 will output a 90 BPM Normal Sinus Rhythm.

4)   Press the soft key corresponding to **VTACH**. A ventricular tachycardia will be simulated by the DA2000 through the ECG jacks and paddle plates. Once the discharge is complete, the DA2000 will output a 90 BPM Normal Sinus Rhythm.
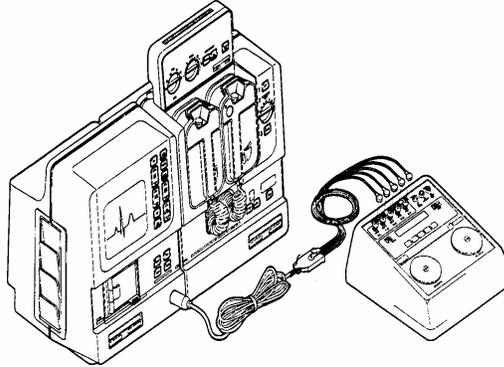

Figure 2.5 *ECG Lead Configuration*

Defib Pulse Playback

The DA2000 allows the user to play the defibrillator pulse waveform for the purpose of analysis. Playback is accomplished using a strip recorder or defibrillator monitor through the ECG jacks or scope output. The waveform can also be inspected on an oscilloscope through the high-level ECG outputs. To play back the defibrillator pulse:

1)   Follow Steps 1-4 in the section titled *Measuring Defibrillator Energy*.

2)   Connect the ECG patient leads to the DA2000 as shown in **Figure 2.5**.

3)   After the defibrillator discharge, press the soft key labeled **PLAY**. The last defibrillator pulse will be replayed each time **PLAY** is pressed. Refer to the specifications section for playback scaling on a chart recorder.

Oscilloscope Viewing of Output

The DA2000 provides 2 banana jacks for real-time oscilloscope viewing. An oscilloscope with storage capability should be used. To view the output on the oscilloscope:

1)   Connect the oscilloscope to the DA2000 using a banana plug and a scope probe. Using a scope probe ensures signal integrity.

2)   Attach the ground from the scope probe to the "common" black jack on the DA2000. Attach the scope probe's positive lead to the defib output.

3)   Set the oscilloscope trigger on "external" and connect a lead between the input of the oscilloscope and the external trigger input.

4) Set the time scale on the oscilloscope to 1 ms/division and adjust to the desired expansion after observing the waveform output.

5) Set the gain on the oscilloscope to 0.2 V/division and adjust to the desired level after observing the waveform.

6) Activate the storage control on the oscilloscope.

7) For most applications, set the oscilloscope input coupling control to "AC" mode.

Note: If the defibrillator under test uses a discharge waveform with sizable DC components (trapezoidal or pulsatile discharge), improved output waveform fidelity can be obtained by placing the oscilloscope in the DC-coupling mode.

8) Follow steps 1-6 in the section titled *Measuring Defibrillator Energy*. The waveform is 1/1450 when in the 1000 Joule range, and 1/440 in the 100 Joule range of the input voltage through 50 ohms. The actual magnitude of the discharge voltage can be obtained by using the following equation:

$$V_{discharge} = V_{scope}(1450) \text{ High range}$$

$$V_{discharge} = V_{scope}(440) \quad \text{Low range}$$

9) Observe that the waveform appears on the oscilloscope. Repeatedly discharge the defibrillator while adjusting the time and the gain to the optimal scale for observing the waveform.

10) If the waveform does not appear on the oscilloscope, readjust the trigger levels on the oscilloscope and repeat steps 7, 8 and 9.

Measuring Synchronization

The DA2000 measures the synchronization time (cardioversion delay time) of synchronized defibrillators. A 90 BPM ECG waveform is output through the ECG jacks and the paddle plates. During normal operation, the defibrillator recognizes and responds to this trigger by discharging within a certain amount of time.

The DA2000 is capable of measuring up to 199.9 ms in delay time from either the peak or the base edge of the "R" wave. Typical acceptable delay times are within 60 ms from the peak of the "R" wave. To measure synchronization:

1) Turn the defibrillator to be tested to "ON" and select the desired energy output in accordance with the manufacturer's instructions.

2) Connect the ECG patient leads to the DA2000 as shown in *Figure 2.5*.

3) Power up the DA2000 by sliding the power switch to the **ON** position (forward).

4) The DA2000 will display Main Menu 1, as shown below:

```
┌──────────────────────────────────────┐
│              Main Menu 1               │
│     ENRG  SYNC  PEAK  WAVE  more       │
│                                        │
└──────────────────────────────────────┘
```

5) Press the soft key corresponding to **SYNC** to enter the sync menu shown below:

```
┌──────────────────────────────────────┐
│           Sync Rwave   --- ms          │
│        ENGR Qwave  --- ms      esc     │
│                                        │
└──────────────────────────────────────┘
```

Sync time measurements are performed as shown:
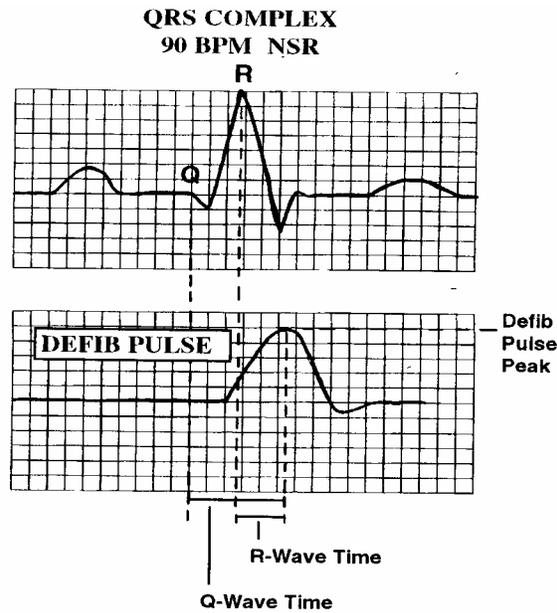
6) Select the 1000 Joules range on the DA2000 for defibrillator outputs over 100 Joules or select the 100 Joule range for outputs under 100 Joules. Select the 1000 Joule range for unknown defibrillator output power.

7) Place the defibrillator in synchronous mode.

8) Simultaneously press both defibrillator paddles to the contact plates of the DA2000.

9) Initiate a discharge from the defibrillator.

10) Press the soft key corresponding to **ENRG** to view the energy readings. The reading will appear as shown below**.**

Note: The LCD will display the reading for about 2 seconds.

Energy	0.0 J

Generating Waveforms

The DA2000 generates a series of waveforms designed to verify the accuracy of ECG machine/monitors. These waveforms, available for simulation via ECG jacks or paddle plates, are calibrated for lead II at 1 mV:

ECG	Performance	Arrhythmia
30 BPM	30 BPM Pulse	Atrial Fibrillation
60 BPM	60 BPM Pulse	Atrial Flutter
120 BPM	2 Hz Triangle (2 mV)	Atrial Tachy
180 BPM	0.125 Hz Square (50% d.c.)	Idioventricular
240 BPM	2.0 Hz Square (50% d.c.)	PVC
	10 Hz Sine	R on T
	40 Hz Sine	Run
	50 Hz Sine	Ventricular Fib.
	60 Hz Sine	Ventricular Tachy
	100 Hz Sine	

Procedure

1) Turn the defibrillator to be tested to **ON**.

2) Connect the ECG patient leads to the DA2000 as shown in *Figure 2.5*.

3) Power up the DA2000 by sliding the power switch to **ON** (forward).

4) Main Menu 1 will appear on the DA2000 display.

> **Main Menu**
> **ENRG SYNC PEAK WAVE more**

5) Press the soft key corresponding to **WAVE** to access the waveform menu:

> **Waveform Type:**
> **ECG   PERF   ARRH   esc**

6) Press the soft key corresponding to the desired wave simulation:

- **ECG**   for ECG waveforms (menu shown below)
- **PERF**   for performance waveforms
- **ARRH**   for arrhythmia waveform

> **ECG: 30 BPM**
> **UP   DOWN   esc**

7) To select the next available waveform, press the soft key corresponding to **+** (up).

   To select the previous waveform, press the soft key corresponding to **-** (down).

8) Observe the waveform on the monitor under test.

Note: The waveform selected will continuously play until another is selected, or until the soft key corresponding to esc is pressed.

Testing High Level Out

All waveforms available through the ECG jacks are simultaneously output through the **High Level** jacks. This offers the user a 1-Volt peak signal for testing purposes.

To test **High Level** signal:

1) Using an oscilloscope and a scope probe, measure the output waveform on the high level output.

Note: Use a scope probe to guarantee signal integrity.

2) Refer to *Generating Waveforms*, page 2-16.

Measuring Peak Voltage, Current and Overshoot

To measure the peak voltage and current of the defibrillator pulse:

1) Power up the defibrillator to be tested, and select the energy output following manufacturer's instructions.

2) Power up the DA2000. Main Menu 1, as shown below, will appear on the display.

```
┌─────────────────────────────────┐
│          Main Menu 1            │
│   ENRG SYNC PEAK WAVE more      │
└─────────────────────────────────┘
```

3) Press the soft key corresponding to PEAK to access the current and voltage menu:

```
┌─────────────────────────────────┐
│         Peak:   --- V   ---A    │
│   OVER                     esc  │
└─────────────────────────────────┘
```

Pressing the soft key that corresponds to **PEAK/OVER** toggles the measurement between Peak current and voltage, and Over current and voltage.

4) On the DA2000, select the 1000 Joule range for defibrillator outputs over 100 Joules, or select the low range (100J) for outputs under 100 Joules. Select the high range for unknown defibrillator output power.

5) Simultaneously press the two defibrillator paddles onto the contact electrode plates on the front of the DA2000.

6) Initiate a discharge from the defibrillator.

7) Observe the LCD on the DA2000 and record the   defibrillator voltage and current.

NOTE: The LCD will continue to display the reading until the next defibrillator pulse is fired.

Charge Time (DA2000W, H)

1) From Main Menu 1, press **more** to access Main Menu 2. The following display will appear.

```
┌─────────────────────────────────────────┐
│              MAIN MENU 2                 │
│       PACE AUTO CHRG UTIL more           │
│                                          │
└─────────────────────────────────────────┘
```

2) From Main Menu 2, press the soft key below CHRG. The following screen will appear.

```
┌─────────────────────────────────────────┐
│       Charge Time:    00      sec        │
│    START            ENRG          esc    │
└─────────────────────────────────────────┘
```

3) Select the DA2000's 1000 Joule range (high) for defibrillator outputs over 100 Joules, or select the 100 Joule range (low) for outputs under 100 Joules. Select the high range for unknown defibrillator output power.

4) Press the two defibrillator paddles onto the contact electrode plates on the front of the DA2000.

5) Press the soft key corresponding to **START**, and initiate the defibrillator's charge cycle.

   As soon as the defibrillator reaches full charge, discharge it. Note the time (in seconds) on the display. The maximum for the DA2000 is 60 seconds. After 60 seconds is reached, the DA2000 displays **OVER**.

Pacer (Non-Invasive) Testing

1) From Main Menu 1, press **more** to access Main Menu 2. The following display will appear.

```
MAIN MENU 2
PACE AUTO CHRG UTIL more
```

2) Ensure that the front panel range switch is set to pacer. Otherwise the unit will beep and display the following message:

```
Attention!
Select PACER range
```

3) From Main Menu 2, press the softkey labeled **PACE**. The following display will appear:

```
PACER TESTS
MEAS RFP HEDR esc
```

4) Connect the output from the pacer to the DA2000 shown in *Figure 2.6*.

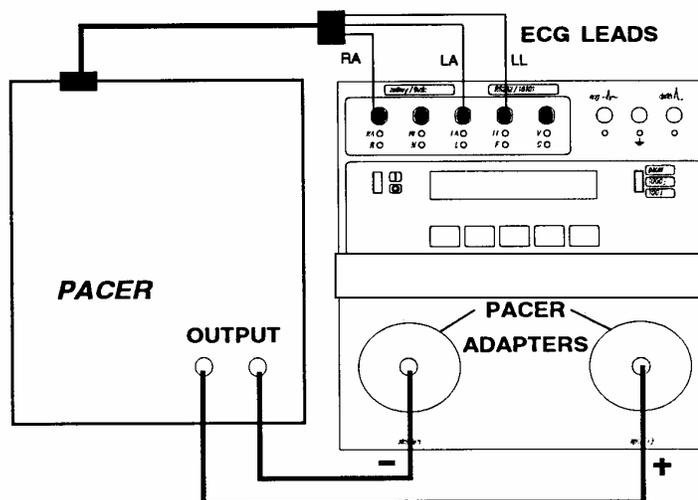**Note:** **The Pacer can be in either demand or non-demand mode.**

Figure 2.6. Connecting Pacer Output to DA2000

5) Select **MEAS** from the pacer tests menu. The following display will appear:

```
---MA   ---V    ---MS
---BPM          PRINT  esc
```

--- indicates no pacer pulses received.

6) Set the pacer at various current and heart rate settings. The results will be displayed. Press **PRINT** for a hard copy.

Note: Pacer voltage and current are displayed as Average voltage and current. If a printer is connected to the DA2000, the printout will also document peak voltage and current. If computer control is being utilized, no peak values are available. All voltage measurements are referenced to the internal 50 ohms load.

Pacer Refractory Period Testing

1) Set Pacer in Demand Mode

2) From Main Menu 2, press the soft key corresponding to **PACE** to get to the Pacer Tests menu:

```
Pacer Test:
MEAS RFP HDR esc
```

3) Press **RFP** from the pacer tests menu to select refractory period testing. Refer to ***Figure 2.6*** for setup. The following menu appears.

```
PRP ---- ms at ---- PPM
SRP ---- ms   TEST  esc
```

----- indicates results received from pacer.

PRP   Pulsed refractory period (refer to theory of operations for definition of PRP & SRP)

SRP   sensed refractory period

BPM   pacing rate at which the test was performed

4) Press **TEST** to start testing. The dashed lines will flash, indicating the test is in progress and pulses are detected. When the refractory period is determined, the results will be displayed.

Note: At slow rates it may take 1-3 minutes to determine the refractory tests. The test will be quicker at higher pacing rates. The results will automatically be output via the RS-232 port. Do not alter the pacing rate during refractory measurements or incorrect data may be recorded.

Autosequencing (DA2000P)

The DA2000P can store in memory up to 28 automatic sequences to fully test defibrillator performance according to protocol. Standard defaults for Programs 0-27 for the DA2000P are:

Print Heading:	Yes
Energy Measurements:	10 J
	100 J
	200 J
	300 J
	360 J
Energy Limits +/-	5%
Charge Time:	Yes
Sync Time:	Yes
Peak:	No
Overshoot:	No
ECG performance:	30 BPM
	120 BPM
	240 BPM
	2 Hz Sq
	.125 Hz Sq
	10 Hz Sin
	40 Hz Sin
	50 Hz Sin
	60 Hz Sin
	100 Hz Sin
	2 Hz Tri
	60 BPM PLS
	Vfib
Pacer:	No

Programming an Automatic Test Sequence

From Main Menu 2

1) Press the soft key corresponding to **AUTO** to access the Autosequences menu.

```
┌─────────────────────────────────────┐
│          Autosequences:             │
│   PROG      RUN       DEFS  esc     │
└─────────────────────────────────────┘
```

2) Press the **PROG** soft key to access the individual programs to be modified.

```
┌─────────────────────────────────────┐
│        Sequence:      PROG 1        │
│   SEL       + -       NAME    esc   │
└─────────────────────────────────────┘
```

    Select the program to be modified by pressing the
+ or **-** soft keys to increment/decrement program numbers. Available programs are 0-28.
Pressing **NAME** allows the program name to be modified.

3) Press the **SEL** soft key to confirm the program selected for modification. You will be asked if you wish to attach a header to the data to be output after the test sequence has been run.

    Press **SEL** to toggle between Yes and No.

```
┌─────────────────────────────────────┐
│        Print Heading?  Yes          │
│   SEL     STEP            esc       │
└─────────────────────────────────────┘
```

4) Press STEP to advance to the next check item.

```
┌─────────────────────────────────────┐
│        Defib Setting 1:  10J        │
│    +     -      NEXT STEP     esc   │
└─────────────────────────────────────┘
```

Press **+** or **-** to increment or decrement the Defib setting.

Press **NEXT** for the next Defib setting.

5) Press STEP to advance to the next check item:

```
┌─────────────────────────────────────┐
│         LIMIT:    +/-5%             │
│    +     -         STEP      esc    │
└─────────────────────────────────────┘
```

    Press **+** or **-** to increment/decrement the accuracy limit.

6) Press **STEP** to advance to the next check item.

```
┌─────────────────────────────────────┐
│        Charge Time?      YES        │
│    SEL          STEP      esc       │
└─────────────────────────────────────┘
```

    Press **SEL** to select **Yes** or **No**.

7) Press **STEP** to advance to the next check item.

```
┌─────────────────────────────────────┐
│        Sync Time?        YES        │
│    SEL             STEP      esc    │
└─────────────────────────────────────┘
```

Press **SEL** to select **Yes** or **No**.

8) Press **STEP** to advance to the next check item.

```
                   Peak?            No
           SEL               STEP      esc


```

Press **SEL** to select **Yes** or **No**. Selecting **Yes** includes Peak Voltage and Peak Current measurements.

9) Press **STEP** to advance to the next check item.

```
                 Overshoot?    No
           SEL               STEP      esc

```

Press **SEL** to select **Yes** or **No**.

10) Press STEP to advance to the next check item.

```
                 ECG/Perf: *        30 BPM
           SEL   +  -        STEP      esc

```

Press **SEL** to program/deprogram a waveform. An * indicates the item is programmed.

Press **+** or **-** to advance to the next waveform.

11) Press **STEP** to advance to the next check item.

```
                  Pacer?           No
           SEL               STEP      esc

```

Press **SEL** to select **Yes** or **No**.

12) Press **STEP** to return to the program menu.

```
                Sequence:        PROG1
           SEL +  -          NAME      esc

```

13) Press **esc** to save changes.

Note: **The changes will be saved until the program is modified again, or the DA2000 is reset to factory defaults.**

Running an Automatic Test Sequence

From Main Menu 2:

1) Press the soft key corresponding to **AUTO** to access the autosequence programs.

```
                        Autosequences:
                PROG      RUN    DEFS  esc
```

2) Press the soft key corresponding to **RUN** to select an autosequence program, which are numbered 0-27.

```
                        RUN:   PROG0
                START        +   -           esc
```

3) Choose a Program number by pressing the soft key corresponding to **+** or **-** to increment/decrement the program numbers.

4) Press the **START** soft key to start the selected program.

Note: If the range switch is not already set to the appropriate range (100 J for settings under 100 Joules, or 1000 J for settings over 199 J) and Pacer for PACE tests, the DA2000 will sound an audible alarm and a warning message will appear until the condition is corrected.

The DA2000 will prompt the user through the complete autosequence program. Data output (if requested) to a printer or computer will occur after the test sequence has been run.

Resetting the DA2000 for Factory Defaults

From Main Menu 2:

1) Press the soft key corresponding to **AUTO** to enter the Autosequences Menu.

```
                        Autosequences:
                PROG      RUN    DEFS  esc
```

2) Press the **DEFS** (defaults) soft key to access the Restore menu.

```
                        restore?    PROG1
                (ALL)  +   No     OK    esc
```

3) Press **OK** to restore **PROG1** to factory defaults. Press **NO** or **esc** to back up one menu level. Press **(ALL)** to restore all 28 factory default programs.

Serial Port

The DA 2000 provides a Male D9 (9 pin) Serial Port, located on the back side of the unit, for the transfer of data to a computer or printer. The Data Computer Equipment (DCE) wiring configuration is shown below.

PIN	FUNCTION
1	Unused
2	RX
3	TX
4	DTR
5	Unused
6	Unused
7	Unused
8	Serial
9	232 Ground

BC Biomedical Serial Cable (optional accessory)

Use the BC Biomedical serial cable to transfer data from the DA 2000 serial port to any IBM (or compatible) computer or printer. The Data Terminal Equipment (DTE) wiring configuration is:

PIN	FUNCTION
1	Unused
2	TX
3	RX
4	RTS
5	CTS
6	DSR
7	232 Ground
8 - 25	Unused

Printing

All test reports received by the DA 2000 may be printed via the RS-232 port. A serial printer, or a serial-to-parallel converter and a parallel printer is required. You will also need BC Biomedical's serial cable and null modem device. For more information and/or part numbers for these items, refer to the *Accessories* list in **Section 1** of this manual.

- To print a Report header from the **ENRG** (Energy) menu:

    1) At Main Menu 1, press the **ENRG** soft key

    2) At the Energy Menu press the soft key corresponding to **HDR**. The header will be forwarded via the serial port to the target device (computer or serial printer).

- To print a Report Header from the **PACE** (Pacer) menu:

    1) At Main Menu 1, press the **more** soft key to access Main Menu 2.

    2) At Main Menu 2, press the **PACE** soft key.

    3) At the Pacer Menu, press the soft key corresponding to **HDR**. The header will be forwarded via the serial port to the target device (computer or serial printer). An example of the header is shown in *Figure 3.1*.

- An example of a standard printout (manual operation) with a header is shown in ***Figure 3.1***. During manual operation, results are output to the printer (or computer) immediately after each test is performed.
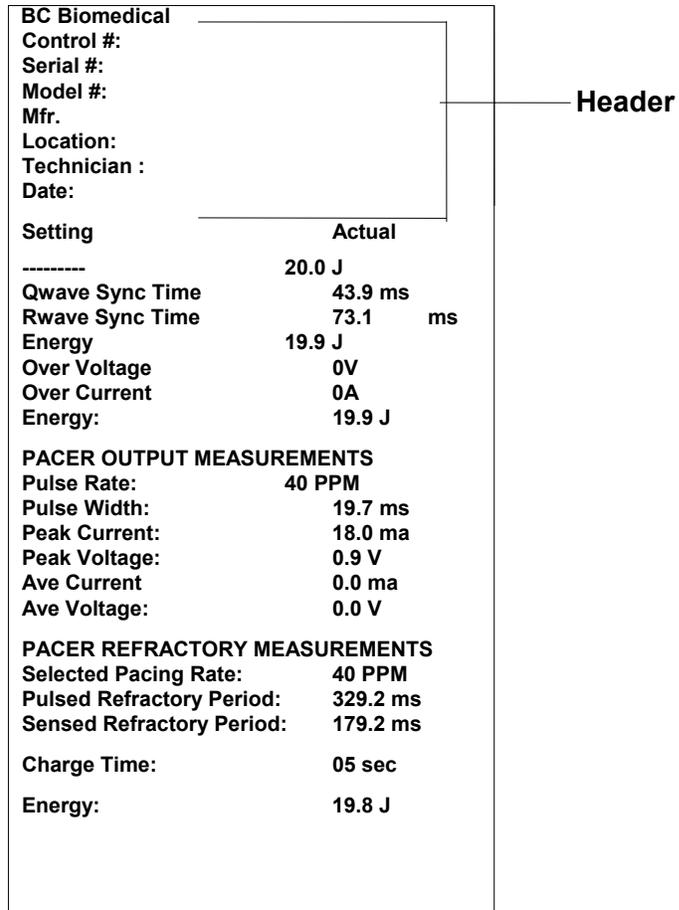
```
BC Biomedical
Control #:
Serial #:
Model #:
Mfr.                                              ──────  Header
Location:
Technician :
Date:

Setting                      Actual

---------               20.0 J
Qwave Sync Time              43.9 ms
Rwave Sync Time              73.1          ms
Energy                   19.9 J
Over Voltage                 0V
Over Current                 0A
Energy:                      19.9 J

PACER OUTPUT MEASUREMENTS
Pulse Rate:              40 PPM
Pulse Width:                 19.7 ms
Peak Current:                18.0 ma
Peak Voltage:                0.9 V
Ave Current                  0.0 ma
Ave Voltage:                 0.0 V

PACER REFRACTORY MEASUREMENTS
Selected Pacing Rate:        40 PPM
Pulsed Refractory Period:    329.2 ms
Sensed Refractory Period:    179.2 ms

Charge Time:                 05 sec

Energy:                      19.8 J
```

Figure 3.1 *Manual Output with Header*

- An example of a standard printout (automatic sequence) with a header is shown in ***Figure 3.2.*** In autosequencing mode, all results are output to the printer (or computer) after the sequence is complete.

```
BC Biomedical
Control #:
Serial #:
Model #:
Mfr.
Location:
Technician:
Date:

PROGRAM NAME:  PROG 5

Setting                Actual Limit +/- 5%

10 J                      10.3 J
100 J            10.3 J
200 J            199.0 J
300 J            300.0 J
360 J            360.0 J

Charge Time: 5 sec 198.3 J

Qwave Sync Time    21.0
Rwave Sync Time    50.0

Peak Voltage:        2270 V
Peak Current:          45 A

OVER Voltage:           2 V
OVER Current:           2A

ECG/Performance Waves
30 BPM
120 BPM
240 BPM
2 Hz Sq
.125 Hz Sq
10 Hz Sin
40 Hz Sin
50 Hz Sin
60 Hz Sin
100 Hz Sin
2 Hz Tri
60 BPM Pls
Vfib


PACER OUTPUT MEASUREMENTS
Pulse Rate:               40 PPM
Pulse Width:             0.0 ms
Peak Current:            0.0 ma
Peak Voltage:            0.0 V
Ave Current:             0.0 ma
Ave Voltage:             0.0 V


PACER REFRACTORY MEASUREMENTS
Selected Pacing Rate:     40 PPM
Pulsed Refractory Period:            329.2 ms
Sensed Refractory Period:   195.4 ms
```

Figure 3.2: *Automatic Sequence Output with Header*

The Utilities Menu

The Utilities function provides control over serial data flow parameters and LCD display values.

To access the Utilities menu:

1) Power up the DA 2000. Main Menu 1 will appear on the display:

> **Main Menu 1**
> **ENRG SYNC PEAK WAVE more**

2) Press the soft key corresponding to **more** to access Main Menu 2:

> **Main Menu 2**
> **PACE AUTO CHRG UTIL more**

3) Press the soft key corresponding to **UTIL** to access the   Utilities Menu:

> **Utilities:**
> **R232 DISP CKSM CAL   esc**

Adjusting RS-232 Parameters

Parameters for RS-232 data transfer (baud rate, parity setting, data bit and stop setting) may be set within the RS-232 menu. To set RS-232 parameters:

1) Press the soft key corresponding to **R232** to enter the RS-232 menu:

> **XXXX X   X   X**
> **BAUD PAR DATA STOP esc**

2) Press the soft key that corresponds to the parameter to be changed. Repeated pressing of the soft key will cycle through the setting options.

   The following settings are recommended:

   BAUD rate: 300, 600, 1200, 2400, 9600
   PARity: N, E, O
   DATA Bits: 8, 7
   Stop Bits: 1,2

   The DA 2000 factory default setting is 2400, N, 8, 1.

   1. When **esc** is pressed, the last displayed parameters are stored in memory and retained when power is off.

Adjusting Display Contrast

Display contrast on the DA 2000 may be adjusted to optimize viewing of menus and test data. To set display contrast:

1) From Main Menu 2, press the soft key corresponding to **UTIL**.

2) At the Utilities menu, press the soft key corresponding to **DISP** to access the display contrast menu.

```
┌─────────────────────────────────────────┐
│              Contrast:  X                │
│      +     -                    esc      │
└─────────────────────────────────────────┘
```

3) Press the **-** (down) soft key to lower the numerical value and **increase the contrast**.

   Press the **+** soft key (up) to increase the numerical value and **decrease the contrast.**

   The default is **5**. When **esc** is pressed, the last display value is stored in memory while power is off.

Computer Control Commands

The DA 2000's RS-232 bi-directional interface allows communications with a PC. The computer may be used to send the commands to the DA 2000.

The information that is sent to the computer is identical to the data sent to the printer. *The null modem supplied with the BC Biomedical serial cable is not required when data is being transferred to a computer.*

During operation, the DA 2000 senses if an RS-232 cable or printer is attached, and sends data to the appropriate device. If neither is attached, test data appears on the display.

Communications Protocol

Refer to *Adjusting RS-232 Parameters*, page 3-6, to prepare the DA 2000 for serial communications with an attached computer.

The computer and DA 2000 should share the same Baud Rate, Parity, Data and Stop Bits. For example, if the DA 2000 has been set up for a baud rate of **2400**, **No** Parity, **8** Data bits and **1** Stop bit, the COM port on the computer should be set to operate at these settings.

Initializing Computer Control

▪ To initialize computer control of the DA 2000, send an "**[**" (open bracket) command from the computer.

▪ To release the DA 2000 from computer control, send a Quit Com session command **[Q]** from the computer.

Computer Control Commands

DA 2000 Functions	Computer Control Commands ( )
Quit COM session	(Q)
Return last result	(R)
Version of DA 2000	(VER)
ECG 30	(W01)
ECG 60	(W02)
ECG 120	(W03)
ECG 180	(W04)
ECG 240	(W05)
Pulse 30 BPM	(W06)
Pulse 60 BPM	(W07)
Square wave 0.125 Hz	(W08)
Square wave 2 Hz	(W09)
Sin 10	(W10)
Sin 40	(W11)
Sin 50	(W12)
Sin 60	(W13)
Sin 100	(W14)
Triangle 2 Hz	(W15)
AFIB	(W16)

Computer Control Commands

DA 2000 Functions	Commands ( )
AFLUT	(W17)
ATACH	(W18)
PVC 1	(W19)
RUN	(W20)
R on T	(W21)
IDIO	(W22)
VTACH	(W23)
VFIB	(W24)
Stop Waveform Output	(WSP)
Energy with VFIB	(NRG)
Energy with VTACH	(EVT)
Print a Header	(HDR)
Sync-Time BASE	(STB)
Sync-Time PEAK	(STP)
Peak Current	(PVT)
OVER Voltage	(OVT)
OVER Current	(OCR)
PACER Beats/Minute	(BPM)
PACER Volts	(PAV)
PACER Current	(PAC)
PACER Pulse Width	(PAW)
PACER Pulsed Refractory	(PRP)
PACER Sensed Refractory	(SRP)
Charge Time	(CRG)

This section provides a brief troubleshooting guide to help you pinpoint potential problems with the DA2000, and if necessary, obtain service or technical assistance from BC Group.

Warranty

BC Group warrants the DA2000 to the original purchaser for a period of one year from the original purchase date. The warranty covers normal use and service, as well as defective material or workmanship. If the customer ships the DA2000 Defibrillator Analyzer to BC Group, postage prepaid, and BC Group determines the defect to be in materials or manufacturing, BC Group shall opt to repair or replace the unit without cost to the customer.

This warranty is void if the DA2000 is visibly damaged by accident, misuse, or repaired or altered by persons not authorized by BC Group, or its serial number defaced or removed.

BC Group reserves the right to discontinue the DA2000 at any time, or change specifications, price or design without notice and without incurring any obligation. BC Group guarantees availability of service parts for 5 years after the manufacture of the unit has been discontinued.

Parts shall include materials, charts, instructions, diagrams, and accessories furnished with the unit. The purchaser assumes all liability for any damages or bodily injury which may result from the use or misuse of the unit by the purchaser, his employees, agents or customers.

Storage and Shipping

The DA2000 should be stored between 25º C and 40º C with a relative humidity of 50%. The optional carry case is recommended for storage. It is recommended that the storage environment be free from vibration.

Troubleshooting

The chart on the following page provides basic troubleshoot   ing information for the DA2000. Problems other than those described in this section should be referred to   the BC Group's Service Department at (800) 242-8428.

Description	Cause	Action
"Warning - low battery!!" indication on display	Low battery	Replace battery
Two beeps/sec. on power up	Defective RAM or incorrectly inserted RAM	Call factory
Four beeps/sec. on power up	Incorrectly inserted EPROM, misprogrammed EPROM or defective EPROM	Call factory
Infrequent resets during operation	Hi EMI fields produced by defib units	Reset power on QED-6 and continue operation.

Returning the DA2000 for Service

If repairs are required, the DA2000 s   hould be returned to the factory.

Before returning the instrument, contact   BC Group's Service Department to obtain a   Return Material Authorization Number   . Record the RMA number in a prominent   place on the outside of the packing box, and refer to the number in any correspondence with BC Group Service.

Pack the instrument carefully, using the original packing   materials, and insure for full value. If the original packing materials have been discarded or are unusable, call   BC Group for replacement packing or instructions. Failure to pack the instrument pr   operly could void your warranty.

Return the instrument to:

BC Group International, Inc.
3081 Elm Point Industrial Dr
St. Charles, MO 63301
Attn: Service Department
TEL: 800-242-8428
314-638-3800
FAX: 314-638-3200