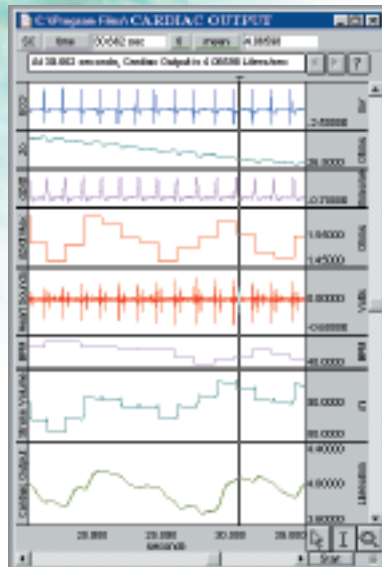


Record the parameters associated with cardiac output measurements, thoracic impedance changes as a function of respiration, or any kind of biological impedance monitoring. The EB1100C incorporates a precision high frequency current source, which injects a very small (100 $\mu$ A) current through the measurement tissue volume defined by the placement of a set of current source electrodes. A separate set of monitoring electrodes then measures the voltage developed across the tissue volume. Because the current is constant, the voltage measured is proportional to the characteristics of the biological impedance of the tissue volume.

## FEATURES

- CARDIAC OUTPUT VIA IMPEDANCE CARDIOGRAPHY
- SYSTEMIC VASCULAR RESISTANCE
- LEFT CARDIAC WORK
- PERIPHERAL BLOOD FLOW
- TISSUE MAGNITUDE & PHASE MODELING
- PULSE RATE MEASUREMENT
- TISSUE RESISTANCE & REACTANCE MEASUREMENT
- BODY COMPOSITION ANALYSIS
- RESPIRATION MONITORING



- $Z(t)$
- $dZ/dt$
- $dZ/dt$  maximum
- BPM
- LVET
- Stroke volume
- Cardiac output

### CARDIAC OUTPUT **Q13**

To determine Cardiac Output noninvasively, employ electrical bioimpedance measurement techniques with the EB1100C. With pairs of EL500 electrodes attached to the neck and torso, the EB1100C can isolate the base  $Z(t)$  and delta impedance ( $dZ/dt$ ) values, which vary as the heart pumps blood. In real time,  $dZ/dt$  magnitude and heart rate can be determined on a cycle-by-cycle basis. Simultaneously, the DA100C and the TSD108

can identify aortic valve opening and closing times. Use the Equation Generator to combine data from these various sources to compute Stroke Volume and Cardiac Output on-line. One possible equation for determining Stroke Volume is (from Nyboer, 1970):

$$\Delta V = \rho \cdot (L^2/Z_0^2) \cdot T \cdot (dZ_{\min}/dt)$$

where

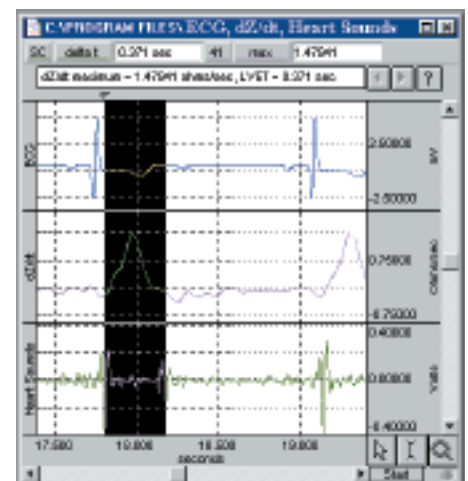
$\Delta V$  = Stroke Volume

$\rho$  = Resistivity of Blood

$T$  = LVET

$L$  = Length Between Recording Electrodes

$dZ_{\min}/dt$  = Magnitude of Largest Impedance Change During Systole

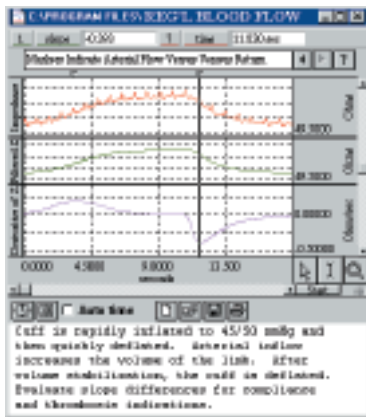


## SYSTEMIC VASCULAR RESISTANCE & LEFT CARDIAC WORK

By recording cyclic Stroke Volume (SV) along with the blood pressure waveform using the NIBP100, and computing mean arterial pressure (MAP) using AcqKnowledge, it's possible to derive Systemic Vascular Resistance (SVR) and Left Cardiac Work (LCW). Divide MAP by SV to obtain a parameter proportional to SVR. Multiply MAP by SV to obtain a parameter proportional to LCW.

## PERIPHERAL BLOOD FLOW

When used in conjunction with an occluding cuff, electrical bioimpedance measurements on limbs can assess arterial blood flow and venous thrombosis. To prevent venous outflow without significantly changing arterial inflow, rapidly inflate the TSD120 cuff to 40-50 mmHg. The blood inflow causes an increase in the volume of the limb. To measure the arterial flow rate, use the slope of the initial impedance change. The volume change that occurs after the impedance change reaches a plateau is a measure of the compliance of the venous system. Once the volume has stabilized, quickly deflate the cuff. For thrombosis to exist in the veins, the time constant of the outflow lengthens. The percentage outflow drop can be measured directly, at any time, once the cuff pressure is released.



## TISSUE MAGNITUDE & PHASE MODELING

The EBI100C measures tissue impedance magnitude and phase simultaneously at any of four operational frequencies (12.5, 25, 50 and 100kHz). Accordingly, the EBI100C can be used to develop an electrical model of the tissue measured. Real and imaginary parts of the tissue impedance can be determined over this range of frequencies, which points to specific electrical circuit elements (resistors, capacitors and inductors) that can be assembled to electrically model the actual tissue impedance characteristics.

## PULSE RATE MEASUREMENT

The EBI100C easily measures the change in thoracic impedance that occurs as the heart beats. As blood is forced out of the aorta during ventricular ejection, the impedance through the torso drops momentarily. The derivative of this waveform ( $dZ/dt$ ) can be processed to record pulse rate (BPM) on a cycle-by-cycle basis in real time. The  $dZ/dt$  waveform is directly related to the aortic ejection velocity.

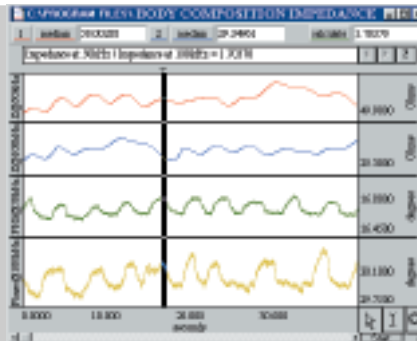
## TISSUE RESISTANCE & REACTANCE MEASUREMENT

Tissue resistance is mathematically described as the real part of the tissue impedance and tissue reactance is defined as the imaginary part of the tissue impedance. To determine these parameters, measure the impedance magnitude and phase using the EBI100C. Use the AcqKnowledge Equation Generator to multiply the magnitude by the cosine of the phase to obtain the tissue resistance and by the sine of the phase to obtain the tissue reactance. Invert the resistance value to obtain tissue conductance.

## BODY COMPOSITION ANALYSIS

Although there is no direct theoretical relationship between whole body resistance and/or reactance and adiposity, empirical relationships exist to relate total body water and fat free mass to impedance, weight, height, gender and age. In effect, lean body impedance is a function of the specific resistivity of the lean tissue, together with its cross-sectional area and its length. When investigating body composition, the EBI100C can be used to perform multi-frequency measurements of different body parts to obtain the segment's resistive and reactive components using standard tetrapolar electrode placement.

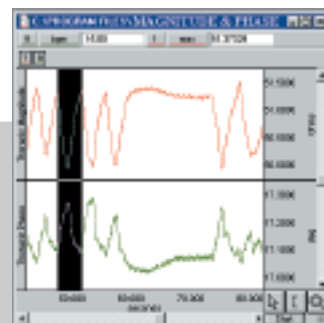
- Body water estimation
- Fat free mass
- Extra/intracellular water ratio
- Resistivity of bone, fat and muscle



## RESPIRATION MONITORING

For bioimpedances measured across the thorax using the EBI100C, a small impedance change is observed with each inspiration and expiration. For respiration monitoring, electrodes are placed across the mid-thorax along the mid-axillary line. Filtering can be employed in AcqKnowledge to minimize motion artifacts. Because the EBI100C measures the thoracic impedance directly, the module can measure arbitrarily low breathing rates. When initially calibrated against a pneumotach, the EBI100C can also be used to estimate ventilation.

- General respiration monitoring
- Apnea investigations



**EBI100C** 60  
Electrical Bioimpedance Amplifier

**ECG100C** 56  
Electrocardiogram Amplifier

**DA100C** 54  
General-purpose Transducer Amplifier

**TSD108** 70  
Physiological Sounds Microphone

**TSD120** 72  
Noninvasive Blood Pressure Cuff Trans.

**RX120 SERIES** 73  
Blood Pressure Cuffs (for the TSD120)

**HLT100C** 53  
High Level Transducer Module

**INISO** 53  
Input Signal Isolated Adapter

**OUTISO** 53  
Output Signal Isolated Adapter

**NIBP100A** 68  
Noninvasive Arterial Blood Pressure Monitor

**EL SERIES** 83  
Electrodes

**LEAD SERIES** 83  
Electrode Leads

**CBL204** 86  
Touchproof "Y" Electrode Lead Adapter