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NICO100C

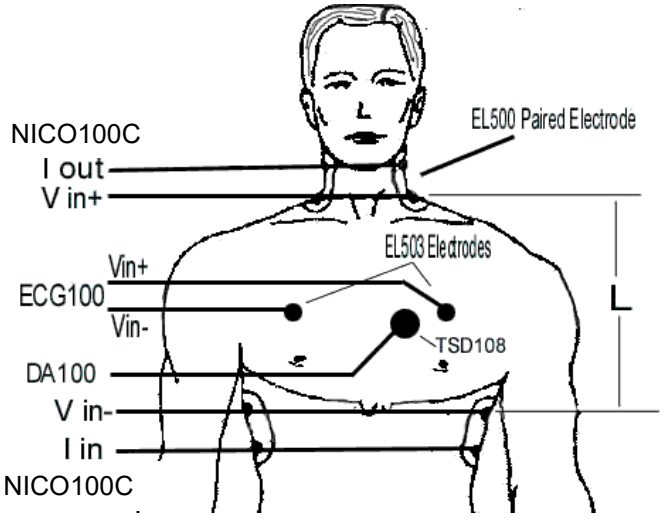
The NICO100C noninvasive cardiac output amplifier records the parameters associated with cardiac output measurements. It incorporates a precision high frequency current source, which injects a very small (400 µA) measurement current through the thoracic volume defined by the placement of a set of current source electrodes. A separate set of monitoring electrodes then measures the voltage developed across the thorax volume. Because the current is constant, the voltage measured is proportional to the impedance characteristics of the thorax.

The NICO100C simultaneously measures impedance magnitude (Zo; labeled "Z" on the module) and derivative (dZ(t)/dt; labeled "DZ" on the module). Zo and dZ(t)/dt can be recorded at four different measurement frequencies, from 12.5 kHz to 100 kHz; cardiac output measurements are usually performed at a measurement frequency of 50 kHz.

For operation, the NICO100C connects to four unshielded electrode leads terminating in 1.5 mm female Touchproof sockets.

The NICO100C is typically used with EL500 paired disposable electrodes but can function with spot or ring (tape) electrodes, reusable electrodes, or needle electrodes.

For injecting current and averaging voltage at four paired-electrode sites (often required for cardiac output measurements), use four CBL204 1.5 mm Touchproof "Y" electrode lead adapters and eight LEAD110 electrode leads with each NICO100C. In this situation, due to the anatomical shape of the thorax, the best placement for all eight electrodes is along the frontal plane (wider dimension). When directed through the thorax, the measurement current seeks the shortest and most conducting pathway. Consequently, the measurement current flows through the thoracic aorta and vena cava superior and inferior.



Use the CH SELECT switch bank to assign NICO100C output (Zo and dZ(t)/dt) channels as follows:

Bank	Magnitude (Zo)	Derivative (dZ(t)/dt)
1	Channel 1	Channel 9
2	Channel 2	Channel 10
3	Channel 3	Channel 11
4	Channel 4	Channel 12

If the particular NICO100C output is not used, the respective assigned channel cannot be used for another module's output; users should simply not record on the unwanted but assigned channel.

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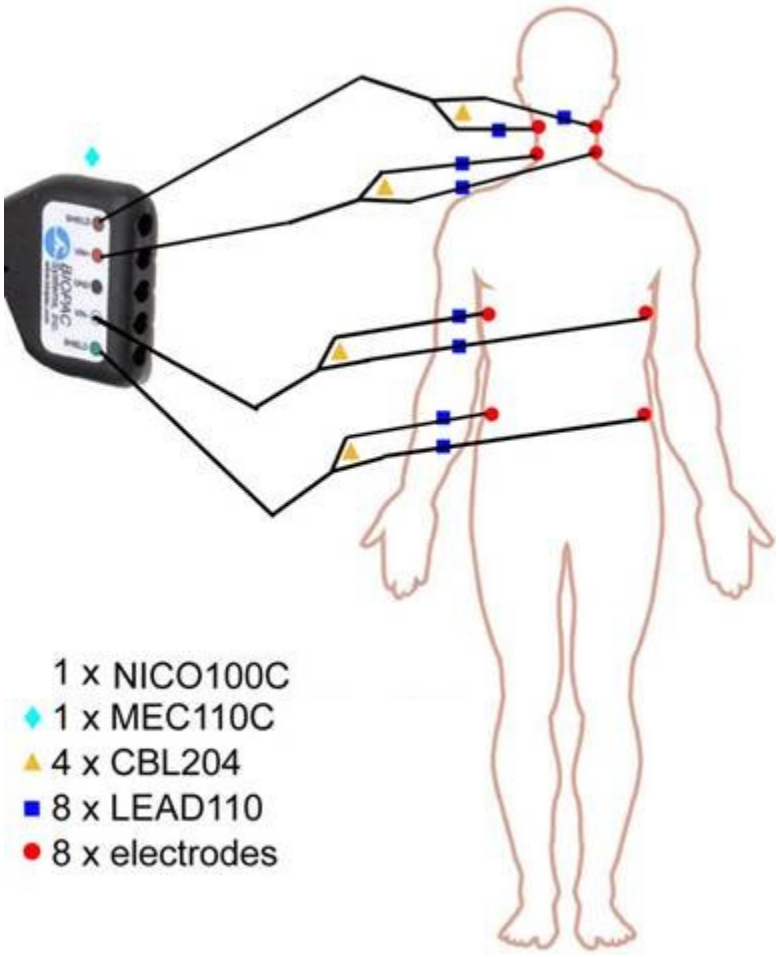
WHEN USING NICO100C WITH MEC110C MODULE EXTENSION CABLE:

Connect the four CBL204 1.5 mm Touchproof "Y" lead adapters to the following color inputs on the MEC110C.

I OUT (Shield)	BROWN
VIN +	RED
VIN -	WHITE
I IN (Shield)	GREEN

The diagram below shows the eight LEAD110 electrode positions for impedance cardiography or cardiac output.



The black port (GND) on the MEC110C is typically ignored in this application. (See Grounding note below.)

GROUNDING

When using the NICO100C amplifier with other biopotential amplifiers attached to the same subject, it's not necessary to attach the ground lead from the biopotential amplifier(s) to the subject. The subject is already appropriately referenced to the subject via the attachment to the NICO100C. If a biopotential ground is attached to the subject, then currents sourced from the NICO100C will be split to the biopotential amplifier ground lead, potentially resulting in measurement errors.

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Derivative Polarity – NICO100C vs. EBI100C

The NICO100C module incorporates an internal, hardware-based, derivative function, which outputs dZ(t)/dt simultaneously with Z (impedance magnitude). When used with Acq*Knowledge*, this internal derivative function also inverts the polarity of the dZ(t)/dt signal so that it displays a positive-going peak, coincident with negative slopes indicated in Z, as per academic research convention.

The EBI100C does not include an internal, hardware-based, derivative function for the Z (impedance magnitude) channel. An Acq*Knowledge* calculation channel can be used to determine dZ(t)/dt, if required. Channel scaling can be employed to specify the dZ(t)/dt polarity desired.

USAGE STATEMENT

Bioimpedance methods to perform stroke volume and cardiac output measurements via application of electrodes on the neck and torso are considered by BIOPAC to be research and educational tools. Historically, there have been numerous research efforts to measure stroke volumes and cardiac outputs using bioimpedance techniques. The performance of these systems is subject to evolving algorithms. New bioimpedance methods, such as TransRadial Electrical bioimpedance Velocimetry (TREV) are examples that show new promise in this area. Additionally, machine learning strategies are beginning to accommodate the variabilities of bioimpedance methods due to electrode type, placement, body position, movement artifacts, and electrical signal filtering. Research is ongoing as bioimpedance techniques offer profound non-invasive advantages compared to thermodilution and similar "gold-standard" historical methods for measuring stroke volume and cardiac output. BIOPAC is committed to continue to offer educational and research solutions for the application of bioimpedance methods to measure cardiovascular parameters despite the present "state of the art" showing these measures to be generally more useful for determining relative changes versus absolute values.

NICO100C SPECIFICATIONS

Number of Channels:	2 – Magnitude (Zo) and dZ(t)/dt	
Operational Frequencies:	12.5, 25, 50, 100 kHz	
Current Output:	400 µA (rms)—constant sinusoidal current	
Outputs:	MAG of Impedance: 0-100 Ω	dZ(t)/dt of Impedance: 2 (Ω/sec)/v
Output Range:	±10 V (analog)	
CMIV, referenced to…	Amplifier ground: ±10 V	Mains ground: ±1500 VDC
Signal Source:	Electrodes (requires 4 electrode leads)	
Maximum Over-Voltage for Differential Input:	±25 V	
Gain Range:	MAG: 10, 5, 2, 1 Ω/V	dZ(t)/dt: 2 (Ω/sec)/v constant (independent of MAG Gain)
LP Filter:	MAG: 10 Hz, 100 Hz	dZ(t)/dt: 100 Hz
HP Filter:	MAG: DC, 0.05 Hz	dZ(t)/dt: DC coupled
Sensitivity:	MAG: 0.0015 Ω rms @ 10 Hz bandwidth	dZ(t)/dt: 0.002 (Ω/sec) rms @ 10 Hz bandwidth
Weight:	370 g	
Dimensions:	4 cm (wide) x 11 cm (deep) x 19 cm (high)	
Input Connectors:	Five 1.5 mm male Touchproof sockets (Output, Vin+, Ground, Vin-, Input)	

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Possible NICO Lead Configurations

Setup Type	Amplifier	MEC	Lead	Adapter	Electrode
Simulated Equipotential *Absolute measures*	NICO100**D** *optimal*		LEAD132		4 x EL500
	NICO100**D** *optimal*	MEC104D	LEAD132		4 x EL500
	NICO100**D**		LEAD131		4 x EL503
	NICO100**D**	MEC104D	LEAD131		4 x EL503
	NIC0100C	1 x MEC110C	8 x LEAD110	4 x CBL204	4 x EL500
	NIC0100C		8 x LEAD110A	4 x CBL204	4 x EL500
	NICO100C-MRI *optimal*	1 x MECMRI-NICO	8 x LEAD108C	4 x CBL204-MRI	4 x EL508
	BN-NICO *optimal*		2 x BN-EL50-LEAD4		4 x EL500
Fully Equipotential *Absolute measures* Uses ICG strip conductor, circumferential, cardiographic electrode tape (ICG Tape)	NIC0100C *optimal*	1 x MEC110C	4 x LEAD140		ICG Tape
	BN-NICO *optimal*		2 x BN-EL50-LEAD2		ICG Tape
Non-Equipotential *Relative measures* Suitable for establishing timing relationships between waves	NICO100**D**		LEAD131		2 x EL500
	NICO100**D**	MEC104D	LEAD131		2 x EL500
	NIC0100C	1 x MEC110C	4 x LEAD110		2 x EL500
	NIC0100C		4 x LEAD110A		2 x EL500
	NIC0100C		1 x LEAD130		2 x EL500
	NICO100C-MRI	1 x MECMRI-NICO	4 x LEAD108C		4 x EL508
	BN-NICO		2 x BN-EL45-LEAD2		2 x EL500