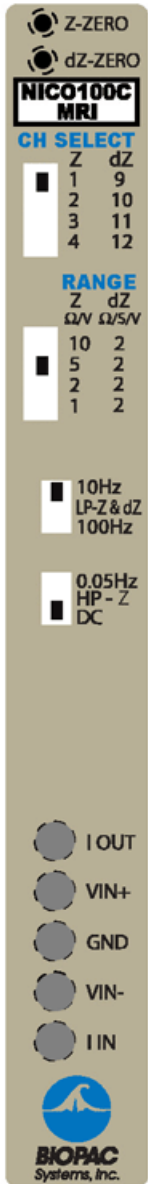


NICO100C-MRI



The NICO100C-MRI noninvasive cardiac output amplifier records the parameters associated with cardiac output measurements while subjects are undergoing fMRI or MRI scanning procedures. The NICO100C-MRI incorporates a precision high frequency current source, which injects a small (4 ma rms) 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-MRI simultaneously measures impedance magnitude (Z_o ; labeled “Z” on the module) and derivative ($dZ(t)/dt$; labeled “DZ” on the module). Z_o and $dZ(t)/dt$ are recorded at a stimulation frequency of 50 kHz.

For operation, the NICO100C-MRI typically connects to the MECMRI-NICO Cable/Filter set. This set incorporates a shorter (2 meter), control room, cable (MECMRI-2) that connects the NICO100C-MRI to the patch-panel-attached MRIRFIF-3 Pi filter. The other side of this filter pokes through the patch panel to the chamber room where a longer (8 meter), chamber room, cable (MECMRI-1) connects between the patch panel filter and the subject electrode leads (four CBL204-MRI “Y” electrode lead adapters that connect to eight LEAD108B and/or LEAD108C carbon composition unshielded electrode leads terminating in 1.5 mm Touchproof sockets).

The NICO100C-MRI is typically used with EL508 disposable carbon composition (MRI conditional to 7T) electrodes but can function with other electrode types too.

For injecting current and averaging voltage at four paired-electrode sites (often required for cardiac output measurements), use four CBL204-MRI 1.5 mm Touchproof “Y” electrode lead adapters and eight LEAD108B and/or LEAD108C electrode leads with each NICO100C-MRI. One electrode lead is attached to each 508 electrode, with electrode lead pairs coupled together using the CBL204-MRI 1.5 mm Touchproof “Y” electrode lead adapter.

IMPORTANT: BIOPAC recommends that the shortest electrode leads possible are used for fMRI or MRI.

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-MRI output (Z_o and $dZ(t)/dt$) channels as follows:

| Bank | Magnitude (Z_o) | 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-MRI 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.

MRI Cabling

When using NICO100C-MRI the MECMRI-NICO Cable/Filter Set is recommended. This cable set is identical to MECMRI-BIOP but incorporates a different five-line Pi filter set (MRIRFIF-3).

Grounding

When using the NICO100C-MRI 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-MRI. If a biopotential

ground is attached to the subject, then currents sourced from the NICO100C-MRI will be split to the biopotential amplifier ground lead, potentially resulting in measurement errors.

Derivative Polarity – NICO100C vs. EBI100C

The NICO100C-MRI module incorporates an internal, hardware-based, derivative function, which outputs $dZ(t)/dt$ simultaneously with Z_o (impedance magnitude).

When used with *AcqKnowledge*, this internal derivative function outputs the inverted mathematically accurate $dZ(t)/dt$ signal so that it displays a positive-going peak, coincident with negative slopes indicated in Z_o , as per academic research convention. The $dZ(t)/dt$ polarity can be inverted to record as a negative-going pulse, if required, by simply inverting the scaling in the associated analog input channel DZ in *AcqKnowledge*.

The EBI100C does not include an internal, hardware-based, derivative function for the Z (impedance magnitude) channel. An *AcqKnowledge* 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-MRI Specifications

| | |
|--|---|
| Number of Channels: | 2 – Magnitude (Z_o) and $dZ(t)/dt$ |
| Operational Frequencies: | 50 kHz |
| Current Output: | 4 mA (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) |
| Maximum Over-Voltage for Differential Input: | ± 25 V |
| CMIV, referenced to: | Amplifier ground: ± 10 V Mains ground: ± 1500 VDC |
| Signal Source: | Electrodes (requires 8 LEAD108B and/or LEAD108C electrode leads) |
| 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: 0.0025 (Ω) rms @ 10 Hz bandwidth |

dZ(t)/dt: 0.005 (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)
 Hardware Interface: MECMRI-NICO to MP160/150 System

Possible NICO100C-MRI Lead Configurations

| Setup Type | Amplifier | MEC | Lead | Adapter | Electrode |
|--|-----------------------------|-----------------|-------------------|----------------|-----------|
| Simulated Equipotential <i>Absolute measures</i> | NICO100D <i>optimal</i> | | LEAD132 | | 4 x EL500 |
| | NICO100D <i>optimal</i> | MEC104D | LEAD132 | | 4 x EL500 |
| | NICO100D | | LEAD131 | | 4 x EL503 |
| | NICO100D | MEC104D | LEAD131 | | 4 x EL503 |
| | NICO100C | 1 x MEC110C | 8 x LEAD110 | 4 x CBL204 | 4 x EL500 |
| | NICO100C | | 8 x LEAD110A | 4 x CBL204 | 4 x EL500 |
| | NICO100C-MRI <i>optimal</i> | 1 x MECMRI-NICO | 8 x LEAD108C | 4 x CBL204-MRI | 4 x EL508 |
| | BN-NICO <i>optimal</i> | | 2 x BN-EL50-LEAD4 | | 4 x EL500 |
| Fully Equipotential <i>Absolute measures</i> Uses ICG strip conductor, circumferential, cardiographic electrode tape (ICG Tape) | NICO100C <i>optimal</i> | 1 x MEC110C | 4 x LEAD140 | | ICG Tape |
| | BN-NICO <i>optimal</i> | | 2 x BN-EL50-LEAD2 | | ICG Tape |
| Non-Equipotential <i>Relative measures</i> Suitable for establishing timing relationships between waves | NICO100D | | LEAD131 | | 2 x EL500 |
| | NICO100D | MEC104D | LEAD131 | | 2 x EL500 |
| | NICO100C | 1 x MEC110C | 4 x LEAD110 | | 2 x EL500 |
| | NICO100C | | 4 x LEAD110A | | 2 x EL500 |
| | NICO100C | | 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 |