

ECG100C – ELECTROCARDIOGRAM AMPLIFIER MODULE

The electrocardiogram amplifier module (ECG100C) is a single channel, high gain, differential input, biopotential amplifier designed specifically for monitoring the heart’s electrical activity, and for use in the following applications:

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|---|---|
| Conventional electrocardiogram (12-lead ECG) | Chaos investigations (heart rate variability) |
| Einthoven’s triangle potential measurement (3-lead ECG) | Heart arrhythmia analysis |
| Transverse-plane ECG measurement (V1 through V6) | Exercise physiology studies |
| Vectorcardiogram measurement | |

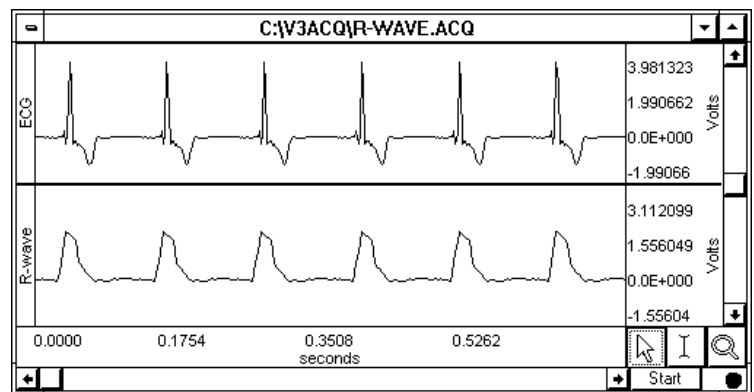
The ECG100C will connect directly to any of BIOPAC Systems, Inc.’s series of Ag-AgCl lead electrodes. The best choice for electrodes depends on the application, but typically the EL500 series (i.e., EL501, EL502, EL503) of adhesive/disposable snap electrodes are used in conjunction with the LEAD110/LEAD110S pinch lead. If reusable electrodes are required, the EL258 is typically used; when using EL258 electrodes, adhesive disks (ADD208) and electrode gel (GEL100) are also needed. Use two shielded electrodes (EL258S) for the signal inputs and one unshielded electrode (EL258S) for the ground.

The ECG100C has built in drive capability for use with shielded electrode leads. If high bandwidth (resolution) ECG measurements are required, then shielded electrode leads are recommended. When the interference filter is switched on, shielded leads are typically not necessary. The ECG100C is designed to pass the ECG signal (P, Q, R, S, T waves) with minimal distortion.

R-WAVE DETECTOR FUNCTION

The ECG100C has an additional R-wave detector function. When enabled, the output signal will produce a smoothed positive peak every time the R-wave is detected.

This graph illustrates ECG data recorded with the ECG100C. The top waveform is a raw ECG wave, and the bottom waveform is the same signal processed using the R-wave detector in the ECG100C module.



This function is extremely useful for rate calculations when a well-defined peak is desired.

Enabling the R-wave detector is useful for calculating BPM and IBI, as it tends to remove any components of the waveform that might be mistaken for peaks.

The R-wave detector circuitry consists of:

- 17 Hz band pass filter with Q = 5
- Full wave rectifier
- 10.0 Hz, three pole, low pass filter with Q = 0.707

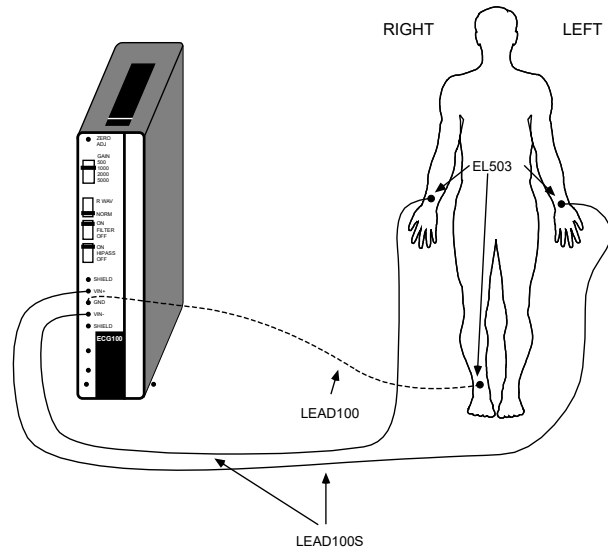
These settings are optimized for ECG data sampled at 250 Hz or faster. For data sampled at less than 250 Hz, the low pass filter might be set to 5 Hz.

RECORDING A 12-LEAD ECG

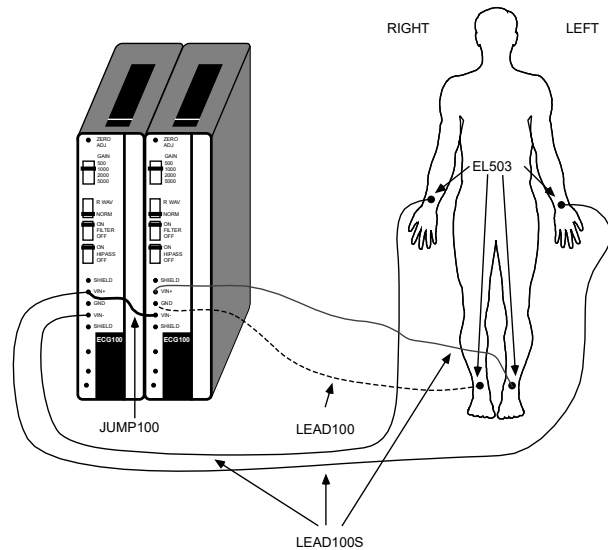
- For full, simultaneous, 12-lead ECG recording, eight ECG100C amplifiers are required, along with a WT100C Wilson Terminal. Two of the ECG100C are used to simultaneously record Leads I, II, III, aVR, aVL and aVF, while the remaining six ECG100C are used to generate the six precordial leads.
- To perform a standard 12-lead ECG recording using only three ECG100C amplifiers, use the TSD155C. The TSD155C multi-lead ECG cable is 3 meters long and incorporates a built-in Wilson Terminal for simultaneous recording of Leads I, II, III, aVR, aVL, aVF and one (movable) precordial lead [V1, V2, V3, V4, V5 or V6].

CONNECTIONS

This figure shows the electrode connections to the ECG100C for the measurement of **Lead I**. Signals from this electrode montage can be used to calculate BPM (or IBI) and general-purpose ECG applications.



This figure shows the electrode connections to two ECG100C modules for recording a standard **two lead ECG** (Lead I and Lead III). Although only two channels are directly acquired, Lead II can be computed (either on-line or after the fact) by summing Lead I and Lead III. For this setup, the GND input on Lead I is internally connected to the GND input on Lead III, and the VIN+ on Lead I is connected to the VIN- on Lead III via a JUMP100C jumper lead.



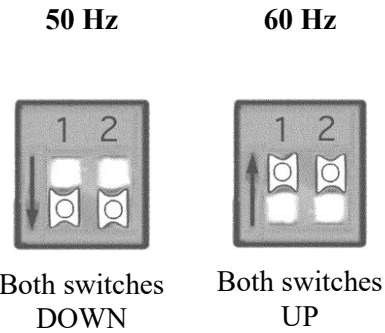
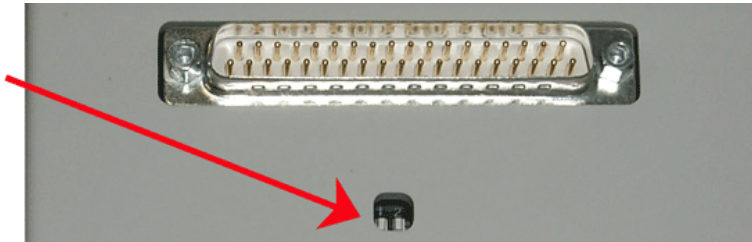
FREQUENCY RESPONSE CHARACTERISTICS

The ECG100C includes a high pass filter that is used to stabilize the ECG baseline. When the **HP** switch is set to 1.0 Hz, P and T wave amplitudes will be reduced somewhat, but the QRS wave will be virtually unchanged. The HP switch is usually ON when using the ECG100C for rate measurements only or when monitoring the ECG of an active subject.

The 0.05 Hz and 1.0 Hz lower frequency response high pass filter settings are single pole roll-off filters.

Modules can be set for 50 Hz or 60 Hz notch options to match the wall-power line frequency of the destination country. The proper setting reduces noise from interfering signals when the notch filter is engaged. Generally, wall-power line frequency is 60 Hz in the United States and 50 Hz in most of Europe and China; if necessary contact BIOPAC to determine the correct line frequency. To reset the line frequency setting, adjust the bank of switches on the left panel of the amplifier module.

Line Frequency switch bank is on the left panel of biopotential and transducer amplifiers



See also: Sample frequency response plots: 35 Hz LPN option (with 50 Hz notch enabled), 150 Hz LP option, and 35 Hz LPN option (with 60 Hz notch enabled)

ECG100C CALIBRATION

The ECG100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCALC.

ECG100C SPECIFICATIONS

- Gain: 500, 1000, 2000, 5000
- Output Selection: Normal, R-wave indicator
- Output Range: ±10 V (analog)
- Frequency Response Maximum Bandwidth: (.05 Hz – 150 Hz)
 - Low Pass Filter: 35 Hz, 150 Hz
 - High Pass Filter: 0.05 Hz, 1.0 Hz
- Notch Filter: 50 dB rejection @ 50 Hz or 60 Hz
- Noise Voltage: 0.1 µV rms – (0.05-35 Hz)
- Signal Source: Electrodes (three electrode leads required)
- Z (input) Differential: 2 MΩ
 - Common mode: 1000 MΩ
- CMRR: 110 dB min (50/60 Hz); see also: [Shield Drive Operation](#)
- CMIV–referenced to Amplifier ground: ±10 V
 - Mains ground: ±1500 VDC
- Input Voltage Range:

Gain	V _{in} (mV)
500	±20
1000	±10
2000	±5
5000	±2
- Maximum Over-Voltage for Differential Input: ±25 V
- Weight: 350 grams
- Dimensions: 4 cm (wide) x 11 cm (deep) x 19 cm (high)
- Input Connectors: Five 1.5 mm male Touchproof sockets (Vin+, Ground, Vin-, 2 of shield)

See also: JUMP100C and MEC series

AMPLIFIER MODULES



100C series modules

The 100C series biopotential/transducer amplifier modules are single channel, differential input, linear amplifiers with adjustable offset and gain. These modules are used to amplify smaller voltage signals coming from raw electrodes and transducers (typically less than ± 0.01 volt). In addition to amplifying signals, most of the 100C series modules include selectable signal conditioning ability so that data may be filtered or transformed as it is being collected.

- **Biopotential modules:** ECG100C, EEG100C, EGG100C, EMG100C, EOG100C, ERS100C
- **Transducer modules:** EDA100C; PPG100C; RSP100C; SKT100C
- **MRI Smart modules**—advanced signal processing circuitry removes spurious MRI artifact from the source physiological data: ECG100C-MRI; EDA100C-MRI; EEG100C-MRI; EMG100C-MRI; PPG100C-MRI.

Modules can be cascaded by snapping the modules together. Up to sixteen 100C series modules can be connected to the MP System at any one time.

- Click to view a [Biopotential Module System Diagram with MP150](#)
- Click to view a [Transducer Module System Diagram with MP150](#)
- Click to view an [MRI Smart Module System Diagram with MP150](#)

IMPORTANT

When cascading modules, it is important to remember that **no two amplifiers may be set to the same channel**. If two connected amplifier modules are left on the same channel, then contention will result and both amplifier outputs will give erroneous readings.

Amplifier offset Set by the zero adjust control trim potentiometer near the top of the module.

The offset control can be used to adjust the zero point or “baseline” of a signal.

Gain Switch The four-position slide Gain switch controls sensitivity. Lower gain settings will amplify the signal to a lesser extent than higher gain settings. If the signal plotted on the screen appears to be very small for a given channel, increase the Gain for that particular channel. Conversely, if the signal seems to be “cropped” at +10 Volts or -10 Volts, decrease the Gain.

Connections Transducers and electrodes connect to the amplifiers using 1.5 mm female Touchproof connectors.

- Electrodes** The biopotential amplifier modules use a three-electrode arrangement (VIN+, GND, VIN-). Although certain applications may require different arrangements of electrodes and/or transducers, some generalizations about electrode and transducer connections can be made. Electrodes measure the electrical activity at the surface of the skin, and since electricity flows from – to +, measuring the flow of a signal requires that there be (at least) one “-” electrode and (at least) one “+” electrode. An additional electrode, a “ground” (or earth) electrode is used to control for the general level of electrical activity in the body.
- Leads** Typically, electrode leads are used to connect individual electrodes to the xxx100C amplifier. Most electrode leads are shielded, which means they introduce less noise than an unshielded lead. A shielded electrode lead has an extra jack on one end that plugs into the SHIELD input on the amplifier modules. A standard electrode lead configuration consists of two LEAD110S electrode leads (one connected to the VIN + input and one to the VIN – input on the amplifier) and a single LEAD110 (connected to the GND input on a biopotential amplifier).
- Transducers** Transducers, on the other hand, are not designed to measure electrical activity directly and usually involve simpler connections. The transducers discussed in this manual translate physical changes (in temperature, for instance) into electrical signals. Connections for individual transducers are discussed in each section.
- Channel** The active channel is selected using the channel select switch on the top of the module. The channel select switch can direct the amplifier output to one of sixteen possible MP System input channels. *Remember to make sure that each amplifier module is set to a unique channel.*
- Zero Adjust** On input signals, a limited range in baseline level (DC offset) can be “zeroed out” using the zero adjust potentiometer. Typically, the zero adjust will not have to be used (as it is preset at the factory). However, some of the 100C series modules can measure DC signals and, in certain circumstances, signal “zeroing” may be required.
- Setup** All 100C Series biopotential or transducer amplifiers incorporate specific gain, coupling and filtering options that are appropriate for the biopotential type or transducer signal that requires measurement. Generally, when an electrode or transducer is inserted into the corresponding 100C series module, the amplifier will immediately produce a useful output, with no user adjustments necessary.
- Certain functionality is added to each module to optimize its performance with its intended signal measurement. For example, all 100C series biopotential amplifiers incorporate a selectable interference filter. When the interference filter is on, 50/60 Hz interfering signals are suppressed.
- Filters** All 100C series amplifiers are constructed with filters that have a high degree of phase linearity. This means the 100C series modules will filter signals with as little distortion as possible. These modules also incorporate protection circuitry to limit input current in the event of input signal overload. Notch and bandstop filters have the potential to cause distortion, especially in the form of “ringing” in the data stream; biopotential hardware notch filters are implemented in conjunction with LP or HP functions to minimize distortion.
- Line Freq** Line Frequency is set using the recessed switch boxes on the left panel of the amplifier module (50 Hz = all switches down). It is important to select the correct line frequency for your geographical region. Typically, U.S. line frequency is 60 Hz; Europe and China 50 Hz. Contact BIOPAC for additional line frequency information. All MP biopotential amplifier modules which contain a 50/60 Hz notch filter only engage the filter when the pass filter is also ON:
- ECG100C, EEG100C, EOG100C amplifiers: the 50/60 Hz notch is only engaged when the 35 Hz LPN low pass notch filter switch is set to ON.
 - EMG100C, ERS100C amplifiers: the 50/60 HZ notch is only engaged when the 100 Hz HPN high pass notch filter switch is set to ON.
- See individual module sections for details.