MP System Hardware Guide

BIOPAC Systems, Inc.

The MP Hardware Guide describes how to connect and set up various signal conditioning and amplifier modules for use with the MP System, and includes sections that detail different applications and uses for the MP System.

✓ All specifications are subject to change without notice.

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Chapter 1 MP Systems

The MP System is a computer-based data acquisition system that performs many of the same functions as a chart recorder or other data viewing device, but is superior to such devices in that it transcends the physical limits commonly encountered (such as paper width or speed). The MP data acquisition unit (MP150 or MP100) is the heart of the MP System. The MP unit takes incoming signals and converts them into digital signals that can be processed with your computer.

MP Systems can be used for a wide array of applications, including:

Cardiovascular Hemodynamics	Evoked Response	Plethysmography
ECG: Cardiology	Exercise Physiology	Psychophysiology
EEG: Electroencephalogram	Interfacing with Existing Equipment	Pulmonary Function
EMG: Electromyogram	*In vitro* Pharmacology	Remote Monitoring
EOG / Eye Movement	Laser Doppler	Sleep Studies

Data collection generally involves taking incoming signals (usually analog) and sending them to the computer, where they are (a) displayed on the screen and (b) stored in the computer's memory (or on the hard disk). These signals can then be stored for future examination, much as a word processor stores a document or a statistics program saves a data file. Graphical and numerical representations of the data can also be produced for use with other programs.

- ❖ Application Notes are provided at www.biopac.com under Support; see page 19.
- ❖ ***Quick Start*** Templates are provided in the Samples folder to simplify setup; see page 21.

The MP System can be used on a Macintosh® or on a PC with Windows®. The System utilizes the same hardware, excepting hardware for computer interface. The software has the same "look and feel" on both the Macintosh® and the PC.

MP150 STARTER SYSTEM

MP150 System includes:

Data acquisition unit: MP150A-CE

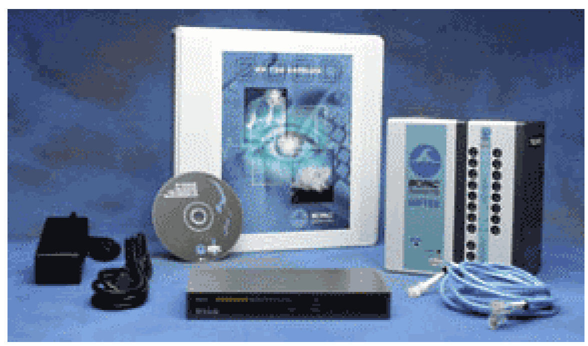
Universal interface module: UIM100C

Ethernet Switch (for user-supplied Ethernet card or adapter): ETHSW1

Transformer: AC150A

Cables: CBLETH1 (2)

Acq*Knowledge*® software:
ACKv3.7 for PC (Windows) *or*
ACKv3.7 for Mac available 3rd Quarter 2001



*MP150 Specifications are on page 14.

The **new MP150** high-speed data acquisition system utilizes the very latest in Ethernet technology. The MP150 is compliant with any Ethernet (DLC) ready PC or Macintosh. This next generation product takes full advantage of cutting edge technology. Access multiple MP150 devices located on a local area network and record data to any computer connected to the same LAN. Record multiple channels with variable sample rates to maximize storage efficiency. Record at speeds up to 400kHz (aggregate).

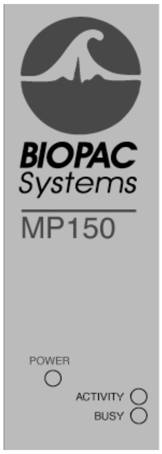
Recommended MP150 configuration:

For the best possible performance, connect the MP System solely to the computer's Ethernet port. For simultaneous connection of the network and the MP System, the ETHSW1 is required. If a computer has no Ethernet port, users need to install an industry standard PCI Ethernet card (Intel, 3COM, etc.). If a computer does not require simultaneous connection to the network, it's acceptable to use a standard crossover Ethernet cable to connect the MP System to a computer.

MP150 Symbology

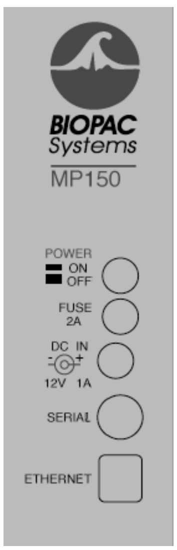
Front panel

See "Light Status" section for functionality details.



POWER	**Green light**	Indicates MP150 Power status.
ACTIVITY	**Amber light**	Indicates data traffic to or from MP150— *similar to Hard Disk activity light on any personal computer.*
BUSY	**Green light**	Indicates MP150 data acquisition.

Back panel



Power

ON Push in to power up the MP150

OFF Pop out to cut the flow of power to the MP150

IMPORTANT! The MP150 does not have a "Hardware Reset" switch like your personal computer does. To reset the MP150 for any reason, just click the power switch twice.

Fuse 2A 2 Amp fast-blow fuse holder; the maximum capacity of the fuse is 2 Amps.

- To remove the fuse, use a screwdriver to remove the fuse cover, which is located below the word **Fuse**.

DC Input Use the **DC Input** to connect a battery, AC/DC converter or other power supply to the MP150.

- The MP150 requires 12 VDC @ 2 Amps
- The receptacle can accept a "+" (positive) input in the center of the connector and a "–" (negative) input on the connector housing.

Serial port The MP150 can connect to the computer via a serial port, located just below the word **Serial** (this connection is not normally used).

- Uses a standard MINI DIN 8 connector.
- Should only be used to connect the MP150 to a PC (via USB1W) or Mac (via USB1M).

Ethernet The MP150 connects to the computer via a serial port, located just below the word **Ethernet**.

- Uses a standard RJ-Ethernet connector (10 base T).

Side panel

Module connections The two connector inputs are designed to connect directly to the UIM100C.

- **Analog signals** are transmitted through the 37-pin connector (upper right side)
- **Digital signals** are transmitted through the 25-pin connector (lower-right side)

Bottom

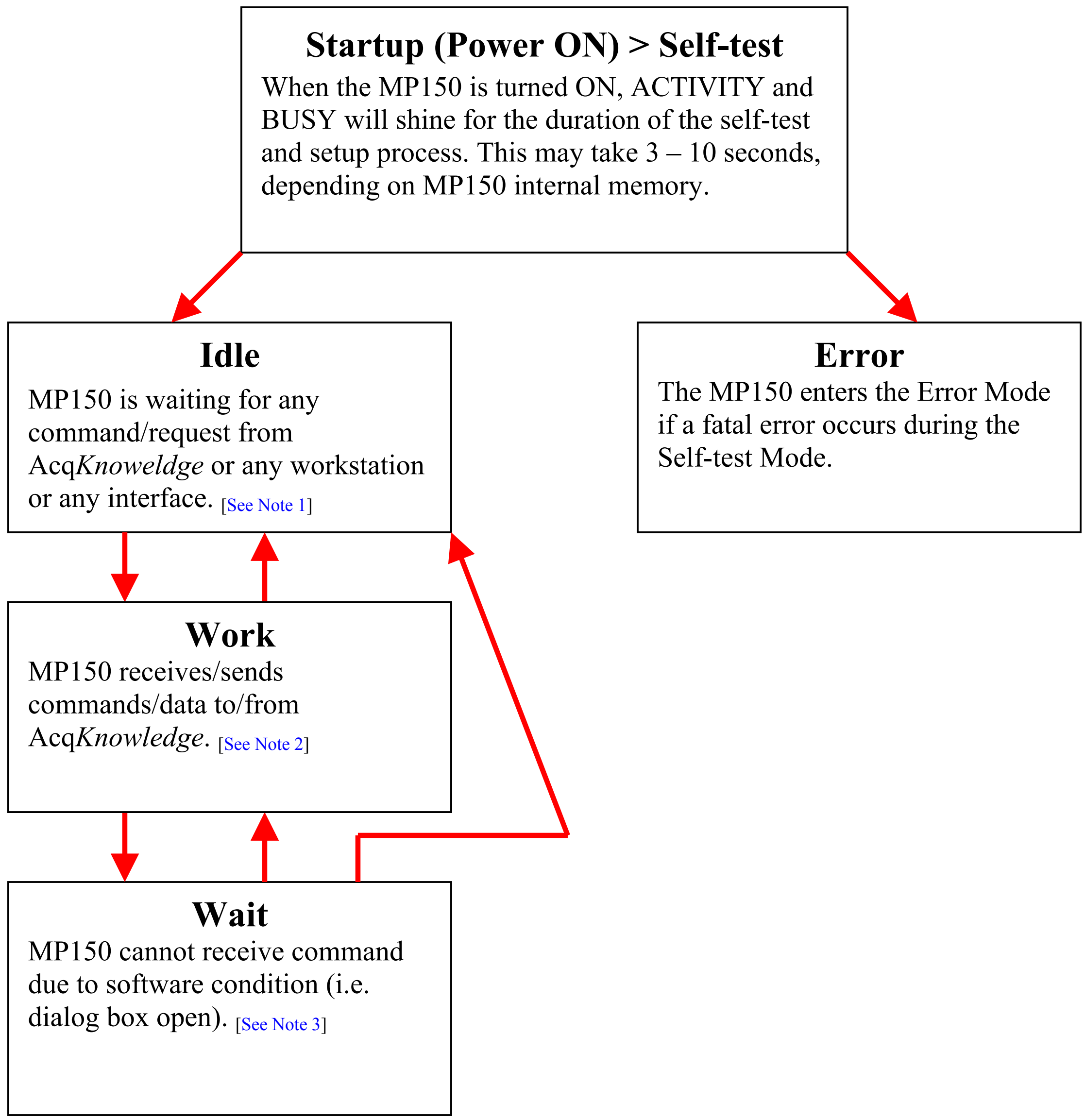
Firmware Rollback Switch

IMPORTANT! This is NOT A RESET SWITCH
The Firmware Rollback Switch is located on the bottom of the MP150 unit and is recessed to prevent accidental activation—it is NOT A RESET for the MP150 unit.

Warning! Activation of the Firmware Rollback Switch will cause the MP150 unit to operate under the previous version of firmware loaded into the unit. Refer to **Appendix F** of the **Acq*Knowledge* Software Guide** for procedural details.

ACTIVITY BUSY	MODE	DESCRIPTION
A Bright **B Bright**	Self-Test Work Error	ACTIVITY and BUSY be bright for the duration of the self-test and setup process. This may take 3 – 10 seconds, depending on MP150 internal memory. During data acquisition, ACTIVITY reflects command/data traffic (for acquisition speeds of 1000 Hz or more, ACTIVITY will be permanently bright or blink at a high frequency) and BUSY will be bright. It is normal for both lights to be on—this does not indicate a problem unless you receive an Error Message on the computer screen. ERROR: In rare cases, a serious problem may prevent a self-test and the lights may be erratic: both on, both off, or any other static combination.
A Bright **B Blink**	Error	The MP150 enters the Error Mode if a fatal error occurs during the Self-test Mode. In the Error Mode, ACTIVITY is bright and BUSY is blinking at a frequency of 5 Hz.
A Blink **B Bright**	Error	If the self-test fails or setup fails, the Error mode is initiated and ACTIVITY will blink at about 5 Hz rate and BUSY will remain bright.
A Blink **B Blink**	Idle-1	In Idle-1, ACTIVITY and BUSY alternate blinks with about 5 Hz frequency with an intermittent, very brief pause (the blink pattern is random). If the MP150 is not connected to a LAN or all other workstations are turned off, the MP150 will not receive any responses from the Ethernet. In this case, after three communication attempts, both lights will blink. In most cases this means 'MP150 not connected to LAN.' In rare cases, it may mean 'Another MP150 with the same serial number exists in the LAN.' (There is a second normal Idle status: In Idle-2, BUSY off ACTIVITY blinks.)
A Blink **B off**	Idle-2 Work	In Idle-2, ACTIVITY blinks from time to time (approx. 1 – 5 second interval) and BUSY is off. ACTIVITY blinks because the MP150 is checking the network connection. Also, it may receive test signals from another MP150 or from another workstation in the LAN, which may generate double or intermediate, random blinks. (There is a second normal idle status: In Idle-1, ACTIVITY and BUSY alternate blinks.) If running Acq*Knowledge* 3.7.x software and not collecting data, ACTIVITY reflects data traffic between the MP150 and the computer, and BUSY is off.
A off **B off**	Self-Test Wait Error	ACTIVITY and BUSY will go dark for less than 1 second at the end of the self-test before proceeding to the Idle mode. Under some conditions, such as when you have a dialog box open, Acq*Knowledge* cannot send commands to the MP150. When command flow from the workstation stops, the MP150 acts as if you have an open dialog and enters the Wait Mode to wait for a command from the workstation it is "locked" to—commands from any other work station will be ignored. When it receives a command, the MP150 return to the Work mode. After five minutes with no command communication, the MP150 will revert to the Idle mode. ERROR: In rare cases, a serious problem may prevent a self-test and the lights may be erratic: both on, both off, or a static combination.

MP150 STATUS LIGHT PATHS



NOTES

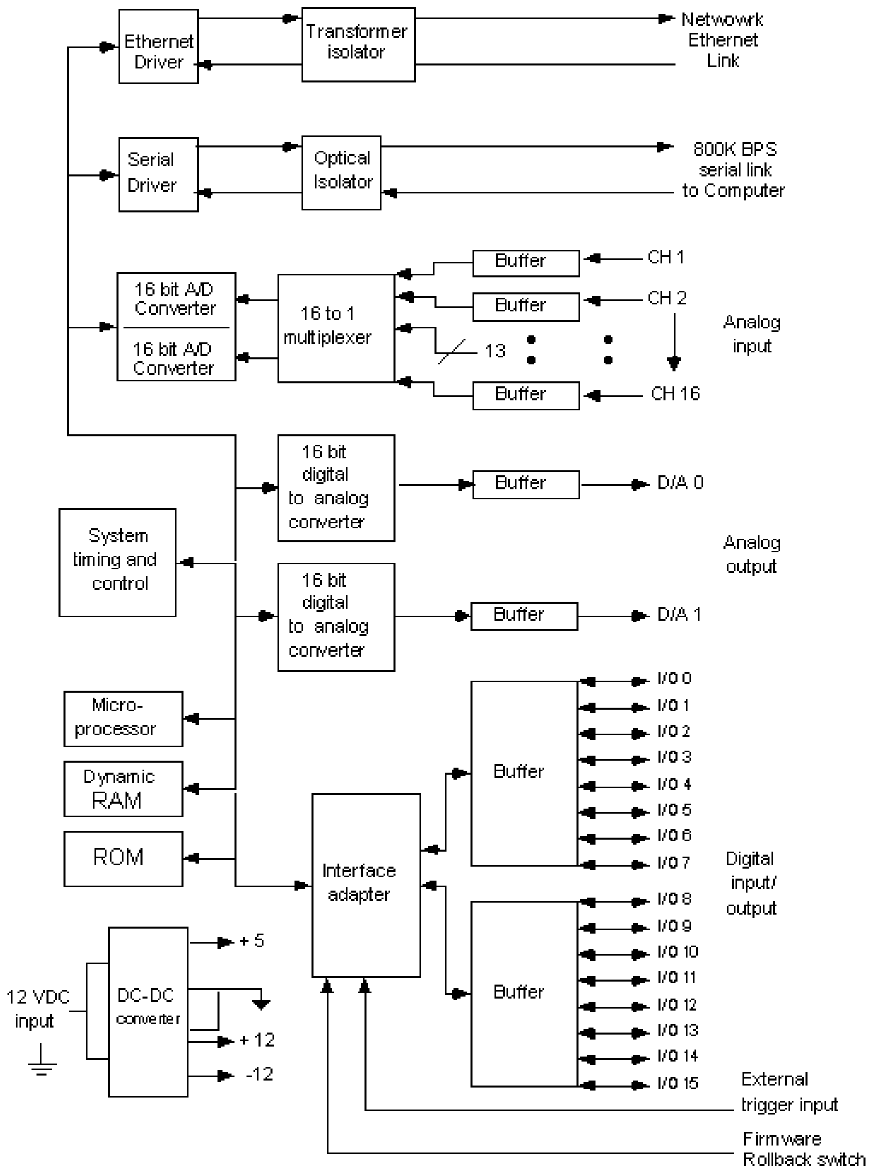
1. **IDLE**—Both light patterns are normal and indicate that the MP150 is waiting for a command—neither indicates a problem with the MP150. The light pattern depends on many factors, such as communication interface (Ethernet or Serial, direct or throw LAN/Switch/Hub), number of MP150 in LAN, number of active workstations in the LAN, and overall network traffic. The MP150 can randomly switch between Idle-1 and Idle-2 without indicating a problem—the primary consideration is if the MP150 can acquire data.

2. **WORK** — When the MP150 receives any command from any workstation, it locks on to that workstation and communicates with it exclusively. The MP150 "remembers" the active workstation and will ignore commands from any other workstation. The MP150 usually remains in the Working Mode until you quit the Acq*Knowledge* software.

3. **WAIT** — Under some conditions, such as when you have a dialog box open, Acq*Knowledge* cannot send commands to the MP150. When command flow from the workstation stops, the MP150 acts as if you have an open dialog and enters the Wait Mode to wait for a command from the workstation it is "locked" to—commands from any other work station will be ignored. When it receives a command, the MP150 enters the Work mode; if the MP150 does not receive a command within five minutes, it reverts to Idle.

MP150A-CE Data Acquisition Unit Block Diagram

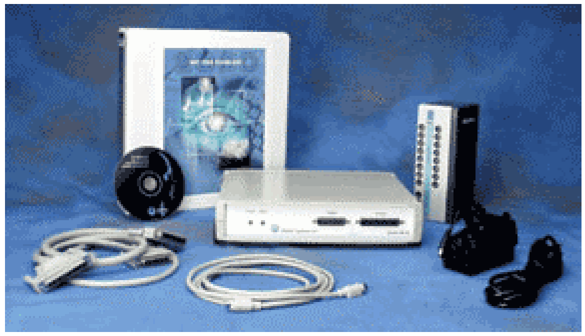
The MP150 has an internal microprocessor to control the data acquisition and communication with the computer. There are 16 analog input channels, two analog output channels, 16 digital channels that can be used for either input or output, and an external trigger input. The digital lines can be programmed as either inputs or outputs and function in 8 channel blocks. Block 1 (I/O lines 0 through 7) can be programmed as either all inputs or all outputs, independently of block 2 (I/O lines 8 through 15).



MP150A-CE block diagram

*MP150 Specifications are on page 14.

MP100 STARTER SYSTEM



*MP100 Specifications are on page 14.

The MP100 system offers USB-ready data acquisition and analysis. Record multiple channels with differing sample rates. Record at speeds up to 70 kHz or 16 kHz (aggregate to disk)

MP100 System includes:

Data acquisition unit: MP100A-CE

Universal interface module: UIM100C

USB adapter: USB1W (PC) *or* USB1M (Macintosh)

Transformer: AC100A

Cables: CBLSERA cable, CBLS100 cable set

Acq*Knowledge*® software: ACKv3.7 for Windows *or*
ACKv3.2.7 for Macintosh (ACKv3.7 for Mac available 2nd Qtr. 2001)

Recommended MP100 configuration:

For the best possible performance, connect the MP System to the computer's USB port, with no other USB traffic intensive devices (e.g. scanners, hard drives, cameras) running simultaneously. If a computer has no USB port, users need to install an industry standard PCI USB card.

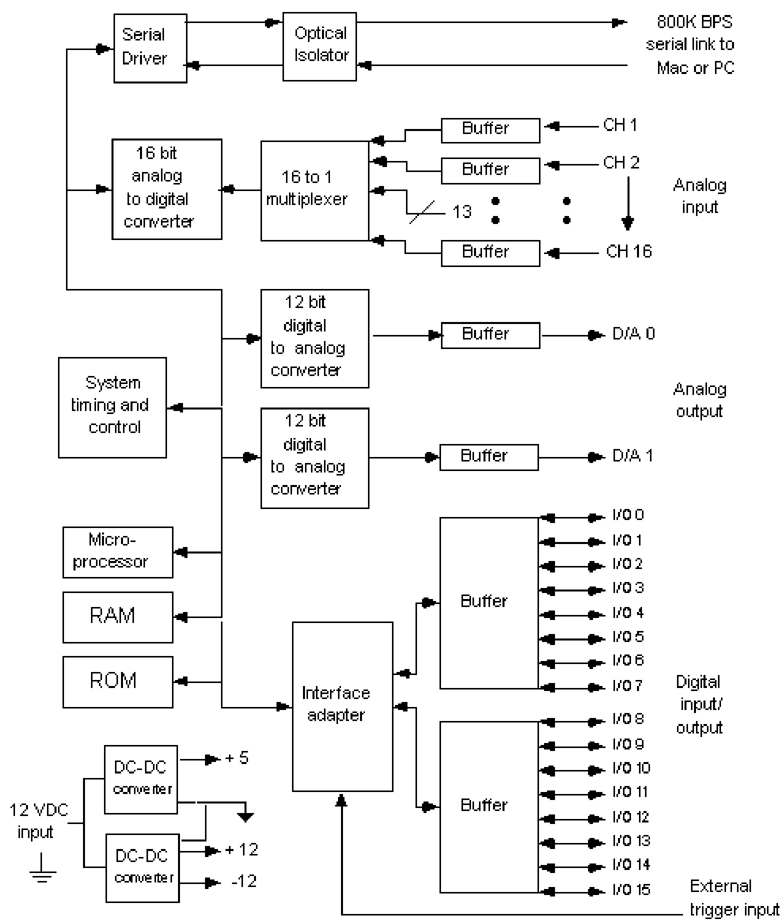
MP100 Symbology

Front panel		
POWER	Power status	**On** if MP100 is turned ON. **Off** if MP10 is turned OFF.
BUSY	MP100 acquisition status	**On** during acquisition or during the first 1-5 seconds after the MP100 is powered ON.
CABLE INPUTS	25-pin cable connection	Digital signals
	37-pin cable connection	Analog signals
Back panel		
Power switch	**On** powers up the MP100 **Off** cuts the flow of power to the MP100	
Fuse holder	Next to the power switch is a 2 Amp fast-blow fuse holder. To remove the fuse, use a screwdriver to remove the fuse cover, which is located below the word **Fuse**. The maximum capacity of the fuse is 2 Amps.	

Back panel	cont'd
DC Input	The **DC Input,** located between the fuse holder and the serial cable, is where a battery, AC/DC converter or other power supply connects to the MP100. The power supply requirements for the MP100 are 12 VDC @ 1 Amp, The receptacle is configured to accept a "+" (positive) input in the center of the connector and a "–" (negative) input on the connector housing.
Serial port	The MP100 connects to the computer via a serial port, located just below the word **Serial**. Uses a standard MINI DIN 8 connector. Should only be used to connect the MP100 to a PC or Macintosh.

MP100A-CE Data Acquisition Uni Block Diagram

The MP100 has an internal microprocessor to control the data acquisition and communication with the computer. There are 16 analog input channels, two analog output channels, 16 digital channels that can be used for either input or output, and an external trigger input. The digital lines can be programmed as either inputs or outputs and function in 8 channel blocks. Block 1 (I/O lines 0 through 7) can be programmed as either all inputs or all outputs, independently of block 2 (I/O lines 8 through 15).



MP100 block diagram

*MP100 Specifications follow.

MP System Specifications — for MP150 and MP100

MP150 and MP100 Data Acquisition Unit Specifications:

Analog Inputs		
Number of Channels:	16	
Input Voltage Range:	±10V	
A/D Resolution:	16 Bits	
Accuracy (% of FSR):	±0.003	
Input impedance:	1.0 MΩ	
Analog Outputs		
Number of Channels:	2	
Output Voltage Range:	±10V	
D/A Resolution:	MP150: 16 bits, MP100: 12 Bits	
Accuracy (% of FSR):	MP150: ±0.003, MP100: ±0.02	
Output Drive Current:	±5mA (max)	
Output Impedance:	100Ω	
Digital I/O		
Number of Channels:	16	
Voltage Levels:	TTL, CMOS	
Output Drive Current:	±20mA (max)	
External Trigger Input:	TTL, CMOS compatible	
Time Base		
Min Sample Rate:	2 samples/hour	
Trigger Options:	Internal, External or Signal Level	
Power		
Amplifier Module Isolation:	Provided by the MP unit	
CE Marking:	EC Low Voltage and EMC Directives	
Leakage current:	<8µA (Normal), <400µA (Single Fault)	
Fuse:	2A (fast blow)	
Device specific specs	***MP150A***	***MP100A***
Max Sample Rate		
MP Internal Memory:	200K samples/sec (400K aggregate)	70K samples/sec (70 K aggregate)
PC Memory/Disk:	200K samples/sec (400K aggregate)	11K samples/sec (16K aggregate)
Internal Buffer Size:	6M samples	16K samples
Serial Interface Type/Rate:	Ethernet: DLC type I (10M bits/sec) Serial: RS422 (800K bits/sec)	Serial: RS422 (800 Kbits/sec)
Transmission Type:	Ethernet	USB only (PC via USB1W or Macintosh via USB1M)
Maximum cable length:	100 meters (Ethernet cable)	7 meters (USB + SERIAL cable)
Power Requirements:	12VDC @ 2 amp (uses AC150A)	12 VDC @ 1amp (uses AC100A)
Dimensions:	10cm x 11cm x 19cm	7cm x 29cm x 25cm
Weight:	1.0 kg	1.8 kg
OS Compatibility		
Ethernet Interface		
PC	Windows 98, 98SE, 2000, NT 4.0	Not supported
Macintosh	System 8.6 or better	Not supported
USB Interface		
PC	Not supported	Windows 98, 98SE, 2000
Macintosh	Not supported	System 8.6 or better

Isolation

Designed to satisfy the following Medical Safety Test Standards affiliated with IEC601-1:

Creepage and Air Clearance
Dielectric Strength
Patient Leakage Current

Contact BIOPAC for additional details.

Signal conditioning module compatibility

$CO_2$100C	EGG100C	HLT100C	PPG100C
DA100C	EMG100C	LDF100C	RSP100C
EBI100C	EOG100C	MCE100C	SKT100C
ECG100C	ERS100C	$O_2$100C	STM100C
EEG100C	GSR100C	OXY100C	TEL100C

Cleaning procedures

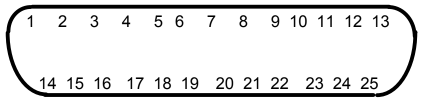
Be sure to unplug the power supply from the MP150/100 before cleaning. To clean the MP150/100, use a damp, soft cloth. Abrasive cleaners are not recommended as they might damage the housing. Do not immerse the MP150/100 or any of its components, as this can damage the system. Let the unit air-dry until it is safe to reconnect the power supply.

AC150/100A Power Supplies

The 12-volt in-line switching transformer connects the MP unit to the AC mains wall outlet. One transformer is included with each MP System; replacements can be ordered separately.

MP System Pin-outs — for MP150 and MP100

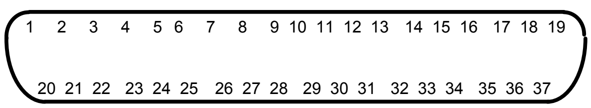
Digital DSUB 25 (male) Pin-outs



DIGITAL

Pin	Description	Pin	Description
1	I/O 0	**14**	I/O 4
2	I/O 1	**15**	I/O 5
3	I/O 2	**16**	I/O 6
4	I/O 3	**17**	I/O 7
5	GND D	**18**	GND A
6	GND D	**19**	Out 1
7	EXT T	**20**	Out 0
8	+5 VD	**21**	GND A
9	+5 VD	**22**	I/O 12
10	I/O 8	**23**	I/O 13
11	I/O 9	**24**	I/O 14
12	I/O 10	**25**	I/O 15
13	I/O 11		

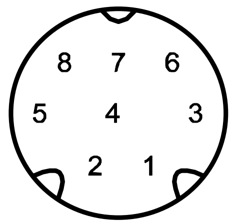
Analog DSUB 37 (male) Pin-outs



ANALOG

Pin	Description	Pin	Description
1	GND A	**20**	CH 1
2	GND A	**21**	CH 2
3	GND A	**22**	CH 3
4	GND A	**23**	CH 4
5	GND A	**24**	CH 5
6	GND A	**25**	CH 6
7	GND A	**26**	CH 7
8	GND A	**27**	CH 8
9	+12 V	**28**	+12 V
10	GND A	**29**	- 12 V
11	-12 V	**30**	CH 9
12	GND A	**31**	CH 10
13	GND A	**32**	CH 11
14	GND A	**33**	CH 12
15	GND A	**34**	CH 13
16	GND A	**35**	CH 14
17	GND A	**36**	CH 15
18	GND A	**37**	CH 16
19	GND A		

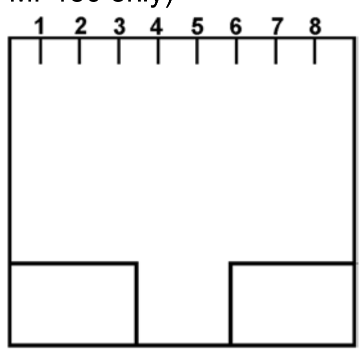
Serial MINI DIN 8 (female) Pin-outs



SERIAL

Pin	Description
1	No Connection
2	Clock (MP Output)
3	Rx+ (MP Input)
4	GND computer
5	Tx+ (MP Output)
6	Rx- (MP Input)
7	No Connection
8	Tx- (MP Output)

Ethernet connector Pin-outs (for model MP150 only)



Front View

Pin	Description
1	TXD+
2	TXD-
3	RXD+
4	No Connection
5	No Connection
6	RXD-
7	No Connection
8	No Connection

MP System Applications

Features

With proper hardware selection and setup, the MP System with Acq*Knowledge* software can be used for a wide array of application features. See the MP System Guide for descriptions of the following features. For additional support, or for help with an unlisted application, please contact the BIOPAC Technical Support Division — an Applications Specialist will be glad to help you.

- Active Electrodes
- Allergies
- Amplitude Histogram
- Anaerobic Threshold
- Animal studies
- Auditory Evoked Response (AER)
- Automate Acquisition Protocols
- Automated Data Analysis
- Automatic Data Reduction
- Autonomic Nervous System Studies
- Biomechanics Measurements
- Blood Flow / Blood Pressure /Blood Volume
- Body Composition Analysis
- Breath-By-Breath Respiratory Gas Analysis
- Cardiac Output
- Cardiology Research
- Cell Transport
- Cerebral Blood Flow
- Chaos Plots
- Common Interface Connections
- Connect to MP Systems
- Control Pumps and Valves
- Cross- and Auto-correlation
- Current Clamping
- Defibrillation & Electrocautery
- Dividing EEG into Specific Epochs
- ECG Analysis
- ECG Recordings, 12-Lead
- ECG Recordings, 6-Lead
- EEG Spectral Analysis
- Einthoven’s Triangle
- EMG and Force
- EMG Power Spectrum Analysis
- End-tidal CO2
- Episode Counting
- Ergonomics Evaluation
- Event-related Potentials
- Evoked Response
- Exercise Physiology
- External equipment, controlling
- Extra-cellular Spike Recording
- Facial EMG
- FFT & Histograms
- FFT for Frequency Analysis
- Field Potential Measurements
- Fine Wire EMG
- Forced Expiratory Flow & Volume
- Gait Analysis
- Gastric Myoelectric Activity
- Gastric Slow Wave Propagation
- Gastrointestinal Motility Analysis
- Hardware Flexibility
- Heart Rate Variability
- Heart Sounds
- Histogram Analysis
- Imaging Equipment, Interfacing
- Indirect Blood Pressure Recordings
- Integrated (RMS) EMG
- Interface with Existing Equipment
- Interface with Third-party transducer
- Invasive Electrode Measurements
- Ion-selective Micro-electrode Interfacing
- Iontophoresis
- Irritants & Inflammation
- Isolated Inputs & Outputs
- Isolated Lung Studies
- Isometric Contraction
- Isotonic Contraction
- Jewett Sequence
- Langendorff Heart Preparations
- Laser Doppler Flowmetry
- Left Cardiac Work
- Long-term Monitoring
- Lung Volume Measurement
- LVP
- Median & Mean Frequency Analysis
- Micro-electrode signal amplification
- Migrating Myoelectric Complex
- Motor Unit Action Potential
- Movement Analysis
- MRI Applications
- Multi-Channel Sleep Recording
- Nerve Conduction Studies
- Neurology Research
- Noninvasive Cardiac Output
- Noninvasive Electrode Measurements
- Nystagmus Investigation
- Oculomotor Research
- Off-line ECG Averaging
- On-line Analysis
- On-line ECG Analysis
- Orthostatic Testing
- Peripheral Blood Flow
- Peristaltic (Slow Wave) Propagation
- Planted Tissue
- Pressure Volume Loops
- Psychophysiology
- Pulsatile Tissue Studies
- Pulse Rate Measurement
- Pulse Transit Time
- Range of Motion
- Real-time EEG Filtering
- Real-time EEG Filtering
- Recurrent Patterns
- Regional Blood Flow
- Relative BP Measurement
- Remote Monitoring
- Respiration Monitoring
- Respiratory Exchange Ratio
- Rheumatology
- Saccadic Eye Movements
- Sexual Arousal Studies
- Signal Averaging
- Simultaneous Monitoring
- Single Channel Analysis
- Single-fiber EMG
- Software-controlled Stimulator
- Somatosensory Evoked Response
- Spectral Analysis
- Spike Counting
- SpO2 Analysis
- Stand Alone Amplifiers
- Standard Operating Procedures
- Startle Eye Blink Tests
- Startle Response
- Stimulator, software-controlled
- Systemic Vascular Resistance
- Template Analysis
- Tissue Bath Monitoring
- Tissue Conductance Measurement
- Tissue Magnitude & Phase Modeling
- Tissue Resistance & Reactance
- Ussing Chamber Measurements
- Ventricular Late Potentials
- Vestibular Function
- Video Capture, Synchronous
- Visual Attention
- Visual Evoked Response
- VO2 Consumption
- Volume/Flow Loop Relationships
- Working Heart Preparations

Application Notes

BIOPAC has prepared a wide variety of application notes as a useful source of information concerning certain operations and procedures. The notes are static pages that provide detailed technical information about either a product or application. A partial list of Application Notes follows.

You can view or print application notes directly from the "Support" section of the BIOPAC web site www.biopac.com.

APP NOTE	Application
#AH101	Transducer Calibration and Signal Re-Scaling
#AH102	Biopotential Amplifier Testing using CBLCAL
#AH103	Remote Monitoring System (TEL100C)
#AS105	Auditory Brainstem Response (ABR) Testing
#AS105b	ABR Testing for Jewett Sequence
#AS108	Data Reduction of Large Files
#AS109	3-, 6-, and 12-Lead ECG
#AH110	Amplifier Baseline (Offset) Adjustment
#AS111	Nerve Conduction Velocity
#AH114	TSD107A Pneumotach Transducer
#AH114b	TSD107B Pneumotach Transducer
#AS115	Hemodynamic Measurements — Part I
#AS116	Hemodynamic Measurements — Part II
#AS117	Pulse Transit Time and Velocity Calculation
#AS118	EMG Signal Analysis
#AS119	EMG Power Spectrum Analysis
#AS120	X/Y Loop Area Analysis
#AS121	Waveform Data Reduction
#AS122	Power Spectrum Analysis
#AH125	Pulse Oximeter Module Operation
#AH127	Precision Force Transducers
#AH128	Active Electrode Specifications and Usage
#AS129	Heart Rate Variability
#AH130	Blood Pressure Measurement
#AS131	Averaging Mode
#AH132	TSD105A Variable Force Transducer
#AH135	TSD117 Pneumotach Transducer
#AH136	BAT100 Instructions
#AH140	Angular Measurements with Goniometers
#AH141	Tri-Axial Accelerometer Calibration
#AS142	Acq*Knowledge* Rate Detector Algorithm
#AS143	Importing Acq*Knowledge* Data Into Excel

APP NOTE	Application
#AH144	Hand Dynamometer Calibration
#AH145	TSD101B Respiratory Effort Transducer
#AS148	Automated ECG Analysis
#AH149	O2100C Module
#AH150	O2100C Module — Sample application
#AH151	CO2100C Module
#AH152	CO2100C Module — Sample Application
#AH153	Physiological Sounds Microphone
#AH154	HLT100C High Level Transducer
#AS158	Analysis of Inspired and Expired Lung Volume
#AH159	TSD116 Series Hand Switch and Foot Switch
#AH160	Gas Analysis Module Response Time
#AS161	Automated Tissue Bath Analysis
#AH162	Stimulation Features
#AS168	Analysis of Intraventricular Pressure Wave Data (LVP Analysis)
#AS169	Speech Motor Control
#AH170	LDF100C Laser Doppler Flow Module
#AH175	Using the STMISOC Stimulus Isolator
#AS177	ECG Analysis using the Offline Averaging Mode
#AS183	VO_2 Measurement
#AH186	Psychological Assessment using the TSD115
#AH187	Electrodermal Response (EDR) using the GSR100 or TEL100
#AH190	Using the MCE100C Micro-electrode Amplifier
#AS191	Cardiac Output Measurement using the EBI100C and Acq*Knowledge*

AcqKnowledge QUICK STARTS

"Quick Start" template files were installed to the Sample folder of the BIOPAC Program folder. Use a Quick Start template to establish the hardware and software settings required for a particular application or as a good starting point for customized applications.

Q##	Application(s)	Feature
1	EEG	Real-time EEG Filtering
	Sleep Studies	Real-time EEG Filtering
2	EEG	Evoked Responses
3	EEG	Event-related Potentials
	Evoked Response	Event-related Potentials
4	Evoked Response	Nerve Conduction Studies
5	Evoked Response	Auditory Evoked response & Jewett Sequence
6	Evoked Response	Visual Evoked Response
7	Evoked Response	Somatosensory Evoked Response
9	Evoked Response	Extra-cellular Spike Recording
10	Pyschophysiology	Autonmic Nervous System Studies
12	Pyschophysiology	Sexual Arousal Studies
13	EBI	Cardiac Output
	Cardiovasc. Hemodynamics	Noninvasive Cardiac Output Measurement
	Exercise Physiology	Noninvasive Cardiac Output
15	EOG	Nystagmus Investigation
16	EOG	Saccadic Eye Movements
17	Plethsymography	Indirect Blood Pressure Recordings
19	Sleep Studies	Multiple-channel Sleep Recording
20	Sleep Studies	Cardiovasc. Hemodynamics
	ECG	On-line ECG Analysis
	ECG Analysis	On-line ECG Analysis
21	Sleep Studies	SpO_2 Analysis
22	ECG	Einthoven's Triangle & 6-lead ECG
23	ECG	12-lead ECG Recordings
24	ECG	Heart Sounds
25	Cardiovasc. Hemodynamics	On-line Analysis
26	Cardiovasc. Hemodynamics	Blood Pressure
27	Cardiovasc. Hemodynamics	Blood Flow
28	Cardiovasc. Hemodynamics	LVP
31	NIBP	Pyschophysiology
32	*In vitro* Pharmacology	Tissue Bath Monitoring
33	*In vitro* Pharmacology	Pulsatile Tissue Studies
34	*In vitro* Pharmacology	Langendorff & Working Heart Preparations
35	*In vitro* Pharmacology	Pulmonary Function
	Isolated Lung Studies	Animal Studies
38	Pulmonary Function	Lung Volume Measurement
39	Exercise Physiology	Respiratory Exchange Ratio
40	EMG	Integrated (RMS) EMG
41	EMG	EMG and Force
42	Biomechanics	Gait Analysis
43	Remote Monitoring	Biomechanics Measurements
44	Biomechanics	Range of Motion

Chapter 2 Interface Modules

UIM100C Universal Interface Module

HLT100C ***UIM100C***

The UIM100C Universal Interface Module is the interface between the MP150/100 and external devices. Typically, the UIM100C is used to input pre-amplified signals (usually greater than +/− 0.1 volt peak-peak) and/or digital signals to the MP150/100 acquisition unit. Other signals (e.g., those from electrodes or transducers) connect to various signal-conditioning modules.

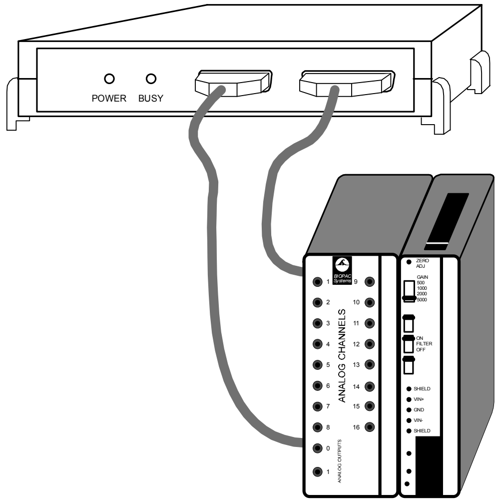
The Universal Interface Module (UIM100C) is designed to serve as a general-purpose interface to most types of laboratory equipment. The UIM100C consists of sixteen 3.5 mm mini-phone jack connectors for analog inputs, two 3.5 mm mini-phone jack connectors for analog outputs, and screw terminals for the 16 digital lines, external trigger, and supply voltages.

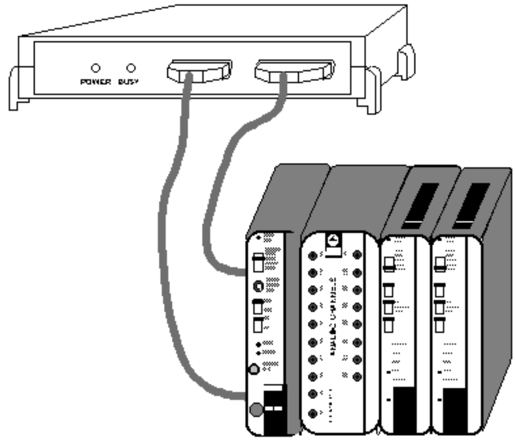
The UIM100C is typically used alone to connect polygraph and chart recorder analog outputs to the MP System. BIOPAC Systems, Inc. offers a series of cables that permit the UIM100C to connect directly to a number of standard analog signal connectors. Most chart recorders or polygraphs have analog signal outputs, which can be connected directly to the UIM100C.

The UIM100C allows access to 16 analog inputs and 2 analog outputs on one side, and 16 digital input/output lines, an external trigger, and supply voltages on the other side. The UIM100C is designed to be compatible with a variety of different input devices, including the BIOPAC series of signal conditioning amplifiers (such as the ECG100C).

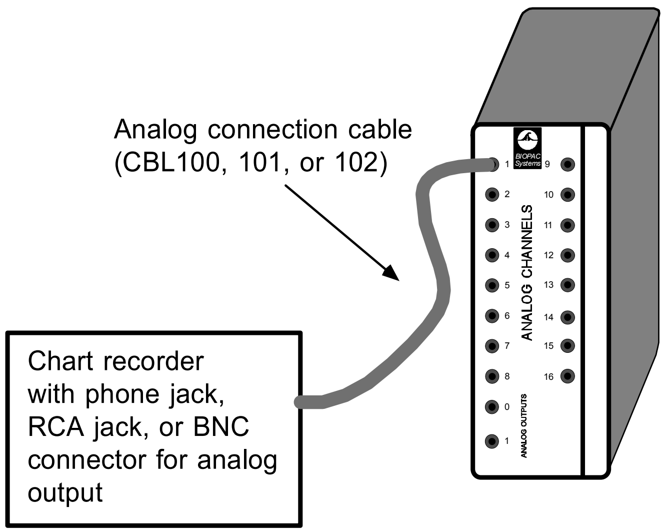
Connections between the UIM100C and the MP150/100 acquisition unit are made via two cables: one for analog signals (with a 37-pin connector) and one for digital signals (with a 25-pin connector). Use the 0.6-meter cables included with your system to connect the UIM100C to the acquisition unit.

When using the Universal Interface Module (UIM100C) with other 100-Series modules, the UIM100C is usually the first module cascaded in the chain. If using the STM100C, OXY100C or HLT100C, the module must be plugged in on the **left** of the UIM100C. Up to seventeen modules (including the UIM100C) can be snapped together, as illustrated in the following diagrams:





MP100 to UIM100C and amplifier moduleSTM100C and UIM100C and amplifier modules



Typical UIM100C to polygraph interface

When using the UIM100C, be careful not to short the “analog output” terminals together, and not to short across any of the connectors on the “Digital” (back) side of the module.

IMPORTANT USAGE NOTE

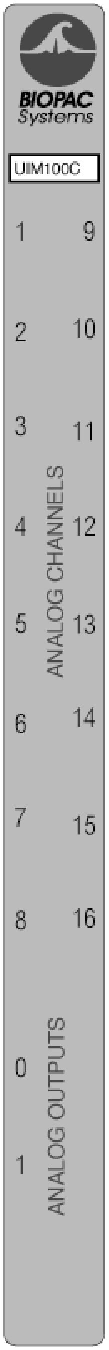
Mains powered external laboratory equipment should be connected to an MP System through signal isolators when the system also connects to electrodes attached to humans.

To couple external equipment to an MP System, use:

- For **analog** signals — **INISO** or **OUTISO** isolator (with **HLT100C**)
- For **digital** signals — **STP100** (with **UIM100C**)

Contact BIOPAC for details.

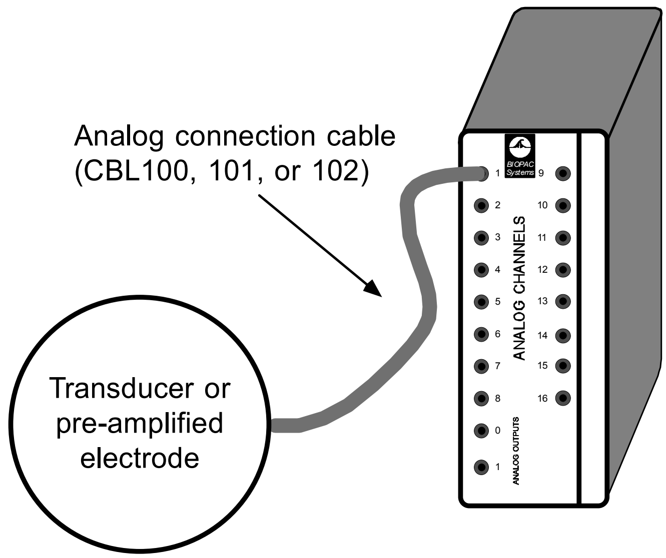
Analog connections



As noted, the UIM100C requires cables equipped with standard 3.5mm mini-phone plugs to connect to analog signal sources. This type of connector is commonly available with many different mating ends. BIOPAC Systems, Inc. carries several different types, including BNC and phone plugs. Since the MP150/100 analog inputs are single-ended, the tip of the mini-phone plug is the input and the base (shield) of the mini-phone plug is the ground (or common).

NOTE: Make sure the cable that you route into the UIM100C is a **<u>mono</u>** 3.5 mm phone plug.

To connect to existing equipment (such as polygraphs or chart recorders), run a cable from the analog output terminal of the external device to the UIM100C. Since there are so many different devices that can connect to the MP150/100 it's impossible to cover them all.

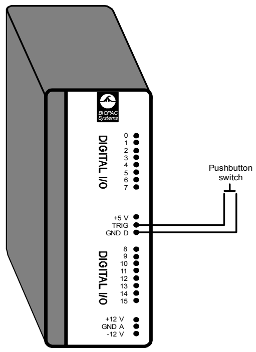


UIM100C connected to external analog signal source

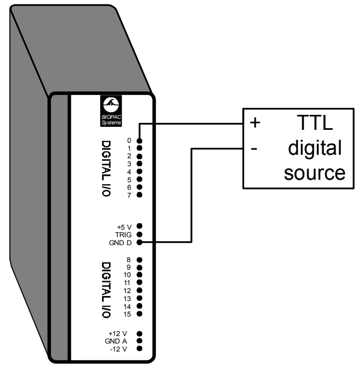
Please contact a BIOPAC Systems, Inc. applications engineer if you are not sure how to connect the MP System to your device or if you need a special cable.

Digital connections

A digital signal has only two voltage levels: 0 and +5 volts. Zero volts is a binary "0" and +5 volts is a binary "1." A **positive edge** is a 0 to 1 transition and a **negative edge** is a 1 to 0 transition. The MP150/100 digital I/O lines have internal pull-up resistors so that unconnected inputs will read "1."



Trigger connected to UIM100C

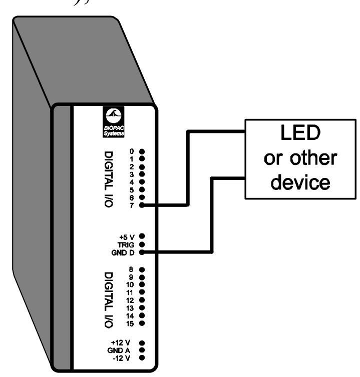


MP unit to digital source connection

The UIM100C allows access to 16 digital input/output lines through screw terminals which can accept either pin plugs or bare wires, as shown above. Be careful not to short the +5, +12V and −12V terminals together or to the GND A or GND D output terminal, or you may damage the MP150/100.

The 16 digital lines are divided into two blocks, I/O 0 through 7 and I/O 8 through 15. Each of these blocks can be programmed as either inputs or outputs. Do not connect a digital input source to a block that is programmed as an output.

It is also possible to connect an output device (such as an LED) to the digital side of the UIM100C. Leeds and similar devices can be connected so that they are "on" either when a signal output from the UIM100C reads 0 Volts or when a +5 Volt signal is being output. To connect an LED so that it defaults to "off" (i.e., the digital I/O reads 0), attach one lead of the output device to the GND D terminal on the UIM100C and connect the other lead to one of the digital I/O lines (I/O 7, for example). When configured this way, the device will be "off" when I/O 7 reads 0, and "on" when I/O 7 reads a digital "1"(i.e., +5 Volts). When connecting to an LED, be sure to use a current-limiting resistor (typically 330Ω) in series with the LED. Alternatively, you can connect one of the device leads to the +5V terminal on the UIM100C and leave the other lead connected to the digital line (e.g., I/O 7). With this setup, the device will be on whenever the I/O line (in this case digital I/O 7) reads 0, and on whenever the I/O reads a digital "1" (i.e., +5 Volts)



UIM100C Specifications

Analog I/O:	16 channels (front panel) – 3.5mm phone jacks
D/A Outputs:	2 channels (front panel) – 3.5mm phone jacks
Digital I/O:	16 channels (back panel) – screw terminals
External Trigger:	1 channel (back panel) – screw terminal
Isolated Power:	±12V, +5V @ 100 ma (back panel) – screw terminals
Weight:	520 grams
Dimensions:	7cm (wide) x 11cm (deep) x 19cm (high)

HLT100C High Level Transducer Interface Module

HLT100C ***UIM100C***

The HLT100C module is used to interface all high level output transducers to the MP System. The HLT100C module provides 16 input and 2 output channels. The HLT100C is similar in function to the UIM100C Universal Interface Module, but it also provides power to the transducer when making a connection.

High level output transducers and adapters connect to the HLT100C via standard 6 pin RJ11 type connectors. Transducers and adapters that presently require the HLT100C module are:

TSD109C/F	Tri-axial Accelerometers
TSD111	Heel/Toe Strike Transducer
TSD115	Variable Assessment Transducer
TSD150A/B	Active Electrodes
INISO	Input Signal Isolator
OUTISO	Output Signal Isolator

Alternatively, the HLT100C module can be used to connect mains powered external equipment to the MP System when the system also connects to electrodes attached to humans.

IMPORTANT USAGE NOTE

To provide the maximum in subject safety and isolation, use electrically isolated signal adapters to connect mains powered external equipment (i.e. chart recorders, oscilloscopes, etc.) to the MP System. Use the INISO adapter to connect to MP analog system inputs and the OUTISO adapter to connect to analog system outputs.

Hardware Setup

Connect the Digital and Analog cables from the MP150 directly to the HLT100C, then connect the UIM100C to the HLT100C. The HLT100C module must be connected on the left side of the UIM100C module. This allows the use of other amplifier modules with the UIM100C while the HLT100C is connected.

High level output transducers (e.g., TSD109 Tri-Axial Accelerometer) or active electrodes (e.g., TSD150A Active Electrode) connect via the 16 analog RJ11 jacks on the front of the HLT100C. Up to 16 analog channels can be used at the same time, as long as there are no other analog channels in use by the UIM100C module or by other BIOPAC modules.

NOTE: If active electrodes are used, it may be necessary to attach a single ground lead to the UIM100C via the GND A terminal on the back of the module.

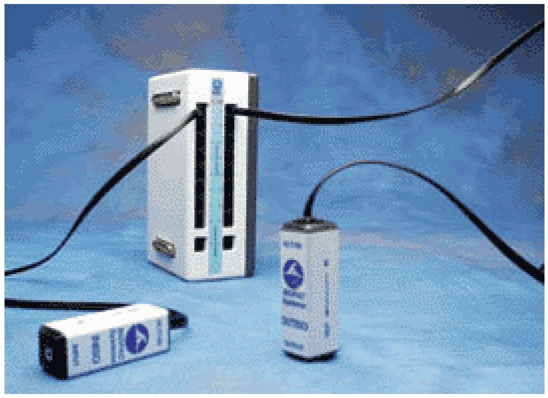
IMPORTANT!

If contention exists, the channel data will be corrupted. For example, if four channels [Ch.1-4] were in use by the UIM100C, then only 12 channels [Ch. 5-16] could be used by the HLT100C.

<u>HLT100C Specifications</u>

Transducer Inputs:	16 channels (front panel) – RJ11 jacks
System D/A Outputs:	2 channels (front panel) – RJ11 jacks
Isolated Power Access:	±12V, +5V @ 100 ma (via all RJ11 jacks)
Weight: 540 grams	
Dimensions:	7cm (wide) x 11cm (deep) x 19cm (high)

SIGNAL ISOLATORS



INISO and OUTISO shown with HLT100C

These analog signal isolators are used to connect mains powered external laboratory equipment to the MP System when it also connects to electrodes attached to humans. Each signal isolator comes with an RJ11 cable for connection to the HLT100C module.

- ❖ For digital (TTL compatible) isolation to the MP digital I/O ports, use the STP100 optical interface (see page 200).
- ❖ If the MP System does not electrically connect to human subjects, signal connections to external equipment can be made through the UIM100C module and the respective analog or digital connection cable.

INISO Input Signal Isolated Adapter

Use the INISO to connect external equipment outputs to MP analog input channels. The INISO plugs directly into any of the 16 input channels on the HLT100C module and incorporates a 3.5mm phone jack for signal input connections. Select the appropriate analog connection cable to connect to a external equipment's output.

OUTISO Output Signal Isolated Adapter

Use the OUTISO to connect MP analog signal outputs (amplifier and D/A) to external equipment inputs. The OUTISO plugs directly into any of the 16 signal output channels, plus the two D/A outputs, on the HLT100C module and incorporates a 3.5mm phone jack for signal output connections. The OUTISO is very useful when the biopotential amplifier output signal requires routing to external equipment while being sampled by the MP System. Select the appropriate analog connection cable to connect to a external equipment's input.

<u>INISO and OUTISO Specifications</u>

Isolator Type:	Analog	Isolation Voltage:	1500 VDC
Bandwidth:	DC to 50kHz	Isolation Capacitance:	30pF
Input/Output Range:	±10 volts	Connector:	3.5mm mono phone jack
Input Resistance:	200KΩ	Weight:	50 grams
Output Resistance:	120 Ω	Dimensions:	2.6cm (high) x 2.6cm (wide) x 7.6cm (long)
Output Current:	±5mA		
Offset Voltage:	±20mV (nominal)	Included Cable:	2.1 meter (straight through, M/M, 6 pin, RJ11)
Temperature Drift:	200 µV/°C (nominal)		
Noise:	2.5mV (rms)	Interface:	HLT100C—see page 26

TSD109 Series Tri-Axial Accelerometers

The Tri-Axial Accelerometers are high level output transducers with an amplifier built into the transducer, so no additional amplification is required. They connect directly to the **HLT100C** High Level Transducer module to provide three outputs, which measure acceleration in the X, Y, and Z direction simultaneously.

- The **TSD109C** (5g) is well suited for measuring slow movements
- The **TSD109F** (50G) is made to measure quick movements.

With the proper equipment and proper scaling parameters listed below, precise acceleration measurements can be obtained.

Equipment

MP Starter System

HLT100C High Level Transducer Module

TSD109C Tri-Axial Accelerometer- Output +/- 5G (400 mV/G)

TSD109F Tri-Axial Accelerometer- Output +/- 50G (40 mV/G)

Hardware Setup

Connect the HLT100C to the UIM100C Universal Interface Module. The TSD109 has 3 output connectors, 1 each for the X, Y, and Z axes. Each output connector must be connected to the appropriate HLT100C input channel. For example the X-axis to channel 1, the Y-axis to channel 2, and the Z-axis to channel 3.

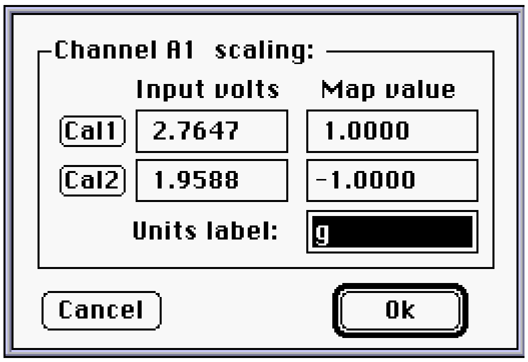
IMPORTANT

Make sure that the channel you choose is **not** already assigned to any other BIOPAC module; up to 5 Accelerometers can be used with a single MP System. **If contention exists, the channel data will be corrupted.**

TSD109 Calibration

Software Setup

1. Select **Setup Channels** under the MP menu and enable 3 analog channels, one for each axis. 2. Select **Scaling** (MPWSW) to generate the Scaling dialog.
3. In the **Map value** column, enter the scaling factors required, **1** and **-1**.
4. Enter "**g**" for the **Units label,** as shown.
5. Take the TSD109 and rest it in the upright position on the tabletop.
6. Calibrate the device by rotating it through 180 degrees and taking a calibration reading at each point.

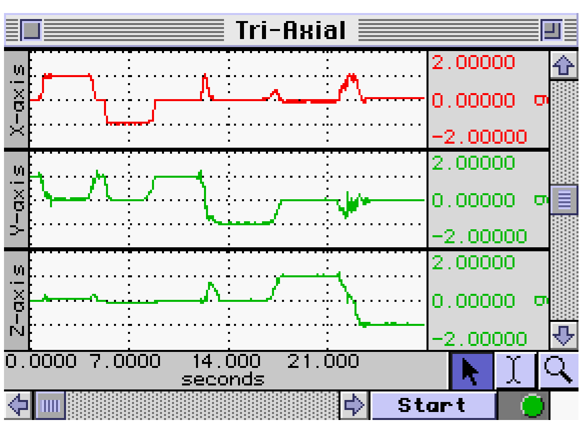


To calibrate the Y-axis, set the transducer face up on a flat surface (such as a table) and click CAL1. Rotate the transducer 180 degrees, so that it is upside down, and click the CAL2 button. This procedure must be followed for each axis. A label on the front of the transducer displays the X and Y axes. The Z-axis rotates from the end with the label and the end with the cable.

Testing Calibration

1. Start acquisition (for the test procedure, you should use a sample rate of 50 samples per second)
2. Rotate the TSD109 180° through each axis while continuing to acquire data.
3. Set the vertical scale to 1 and the midpoint to 0 for all channels.
4. Repeat the calibration procedure (by rotating the transducer 180°) through each axis.
5. Visually confirm the correct calibration.

This screen shot shows a TSD109 being rotated through each axis. Channel 1 (X-axis) shows the signal moving from 1g to -1g as the transducer is rotated. Likewise, Channel 2 (Y-axis) shows the same phenomenon as previously described. Finally, Channel 3 (Z-axis) has also been tested and the calibration confirmed.



TSD109 Series Specifications

Channels:	3 - (X, Y, Z axis)
Range (Output)	
TSD109C:	±5G (400 mV/G)
TSD109F:	±50G (40 mV/G)
Noise	
TSD109C:	325 µG/√Hz rms
TSD109F:	2.5 mG/√Hz rms
Bandwidth:	DC - 500 Hz (-3dB)
Nonlinearity:	0.2% of Full Scale
Transverse Axis Sensitivity:	±2%
Alignment Error:	±1°
Package:	Compliant silicone housing
Power:	+5V @ 9mA (via HLT100C)
Sterilizable:	Yes (contact BIOPAC for details)
Cable Length:	3 meters
Weight:	17 grams
Dimensions:	33mm long, 28mm wide (at base), 19mm high
Interface:	HLT100C—see page 26
TEL100C Compatibility:	SS26 (5G) and SS27 (50G)—see page 208

TSD110 Pneumogram Transducer

The multipurpose TSD110 pneumogram transducer can be used to:

- Noninvasively measure respiration — from a small mouse to a human.
- Measure small pressing forces (like pinching fingers together) for Parkinson's evaluations.
- Measure human smiling (with the sensor on the cheekbone).
- Measure pulse when placed close to the heart.
- Measure spacing and pressure between teeth coming together.

The TSD110 consists of a TSD160B differential pressure transducer, RX110 sensor, and tubing. Use TAPE1 or other single-sided adhesive to affix to the subject

TSD110 Tubing length: 1.6m
Sensor type: Self-inflating pressure pad
Sensor Pad Diameter: 20mm
Sensor Pad Thickness: 3.18mm
Sensor Tubing Diameter: 2.2mm
Sensor Tubing Length: 1m
Sensor Tubing ID: 1.6mm
Tubing Termination: Luer male
MRI Compatibility: Yes

RX110 Sensor The RX110 sensor can be used many times, but may eventually need to be replaced because it is a sensitive sensor and may become damaged with rough use.

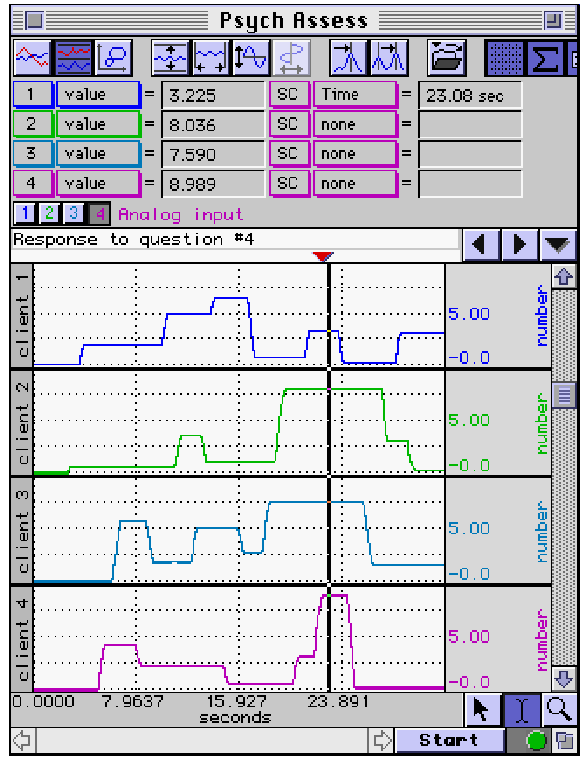
TSD111 Heel/Toe Strike Transducer

Each TSD111 heel/toe strike transducer incorporates two force sensitive resistor (FSR) sensors designed for attachment to the sole of a shoe. Typically, one FSR is placed (taped) under the heel and the other is placed under the toe. The FSRs indicate the precise moment of pressure placed on the heel and toe as the subject walks. The heel/toe strike data is encoded onto a single analog channel; the heel strike results in a [-1V] signal and the toe strike results in a [+1V] signal. If heel and toe strike timing is required for both feet, two TSD111 transducers are required. The TSD111 comes equipped with a 7.6-meter cable and is designed for direct connection to the HLT100C module.

<u>TSD111 Specifications</u>

Nominal Output Range:	-1 to +1 V
Nominal Contact Force:	200g to indicate heel/toe strike
Attachment:	tape (use TAPE1, TAPE2, or vinyl, electrical or duct tape)
FSR Active Area:	12.7mm (dia)
FSR Dimensions:	18.3mm (dia) x 0.36mm (thick) and 30cm pigtail lead
Cable Length:	7.6 meters
Interface:	HLT100C—see page 26
TEL100C compatibility:	SS28—see page 208

TSD115 Variable Assessment Transducer



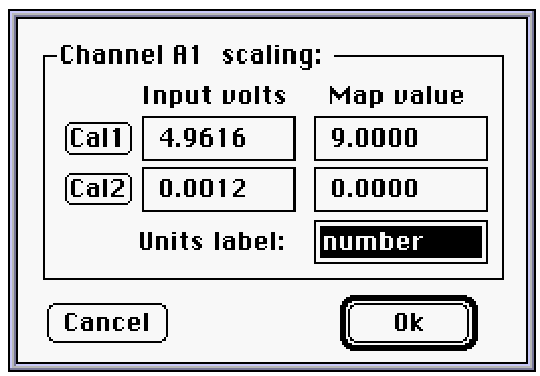
The TSD115 incorporates a slide control with graduated scale that allows the user to gauge their subjective response to a variety of different stimuli. Multiple TSD115 transducers can be used simultaneously allowing several people to answer the same question or otherwise respond to stimuli. The transducer is lightweight and fits easily into the subject's hand or lap. The TSD115 comes equipped with a 7.6-meter cable and is designed for direct connection to the HLT100C module.

This graph shows a measurement that identifies the responses (on a scale from 0 to 9) of the four clients to a particular question. In this case, at 23.08 seconds into the recording, the responses to question four were:

Client 1: 3.225 Client 3: 7.590

Client 2: 8.036 Client 4: 8.989

TSD115 Calibration



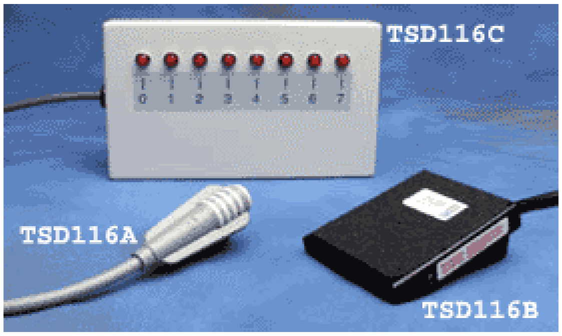
1. Generate the **Scaling** dialog for the first selected channel.
2. Slide the horizontal indicator all the way to the right side of the TSD115. (This reports the highest output for the TSD115, a value close to +5.0 volts.)
3. Click on the **Cal1** button to assign this value to "9." (This directs the system to collect the exact value output by the TSD115 when it's set to any specific indicator position.)
4. Slide the horizontal indicator all the way to the left on the TSD115. (This reports the lowest output for the TSD115, a value close to 0.0 volts.)
5. Click on the **Cal2** button to assign this value to "0."
6. Select the next channel and repeat this procedure for the remaining channels.

<u>TSD115 Specifications</u>

Scale Output Range: 0-5 V
Scale Resolution: Infinitely adjustable
Slide Control Length: 10 cm
Dimensions: 4cm (high) x 11cm (deep) x 19cm (wide)
Weight: 230 grams
Cable Length: 7.6 meters
Interface: HLT100C—see page 26

See also: Application Note #AH186 – Psychological Assessment (TSD115)

TSD116 Series Switches and Markers



The TSD116 series is used for externally triggering data acquisition, remote event marking, or psychophysiological response tests. The switches connect to the UIM100C digital I/O ports and can be monitored as input channels. The TSD116 series incorporate momentary ON operation (switch is ON only when pressed).

TSD116A — single channel hand switch

TSD116B — single channel foot switch

TSD116C — compact 8-channel digital marker

The TSD116C allows the user to independently mark events, or provide responses, on up to eight channels simultaneously. Because digital channels can be interleaved with analog channels, when using Acq*Knowledge*, it's easy to assign separate digital channels as event markers for individual analog input channels.

<u>TSD116 Series Specifications</u>

Switch Type:	Pushbutton: (ON) – OFF
Dimensions	
TSD116A:	19mm (dia) x 63mm (long)
TSD116B:	69mm (wide) x 90mm (long) x 26mm (high)
TSD116C:	19cm (wide) x 11cm (deep) x 4cm (high)
Cable Length	
TSD116A:	1.8 meters
TSD116B:	1.8 meters
TSD116C:	3 meters
Connector Type:	
TSD116A:	2mm pin plugs
TSD116B:	2mm pin plugs
TSD116C:	Stripped and tinned wires
MRI compatible:	TSD116A hand switch only (no ferrous parts)
Interface:	UIM100C
TEL100C Compatibility:	SS10 Hand switch—see page 208

TSD150 Series Active Electrode

TSD150 Active Electrodes are available in two configurations; the difference is the spacing between the stainless steel pads of the surface electrode. In both configurations, the surface electrode stainless stain pads have a diameter of 11.4 mm.

TSD150A wide — 35 mm **TSD150B** narrow — 20 mm

Each may be used as a surface electrode or as a fine wire electrode. Conversion of the surface to fine wire electrode is easily accomplished by replacing the stainless steel pads with screw-springs that connect to the internal amplifier.

Note: GROUND MUST BE USED — Unlike most active electrodes, BIOPAC System Inc.'s active electrodes have only two stainless steel disks attached to electrode case. The third disk, commonly centered between the two, is not necessary. In place of this third disk, a separate ground electrode is used. The LEAD110A is typically used as the ground electrode, and is inserted into the GND A terminal at the rear of the UIM100C. If one or more active electrodes are used on a single subject, only one Ground lead (LEAD110A) is required to act as Ground reference for all the active electrodes.

Conversion from Surface Electrode to Fine Wire Electrode System

To convert the active electrode from a surface electrode to a fine wire electrode system, the stainless steel pads of the surface electrode must be unscrewed from the active electrode case. To accomplish this task:

1) Grasp the stainless steel pads and rotate them counterclockwise until they are disconnected from the case.
2) Screw the screw-spring combinations (fine wire electrode attachment) into the holes left by the removal of the stainless steel pads.
3) Attach the active electrode case (using tape or an elastic strap) to the limb of the subject, near the insertion site of the fine wire electrodes.
4) Gently bend the springs and place one fine wire electrode in the gap formed by bending the spring. Allow the spring to return to its upright position.
5) Repeat this procedure for the other fine wire electrode.

Note: If the wire-spring contact does not provide a good EMG signal, it may be necessary to rub the fine wire electrode with an emery cloth to remove the insulation prior to placing the wire in the spring.

To convert the system back to a surface electrode system, simply unscrew the screw-spring combinations, place them in a secure place and re-screw the stainless steel electrode pads into the electrode case.

Operation

1) Attach the active electrode to the subject, with pads to the skin surface; use surgical tape (TAPE1) or an elastic strap. The active electrode requires good skin surface contact, so to obtain the best readings, you should select an area where skin surface is free of hair and/or lesions and abrade the skin slightly with the ELPAD.
2) Plug the active electrode into the desired channel (1-16) of the HLT100C module.

   IMPORTANT! Make sure that the channel you choose is **not** already assigned to any other BIOPAC module; up to 16 active electrodes can be used with a single MP System. **If contention exists, the channel data will be corrupted.**
3) After inserting the active electrode into the HLT100C module and attaching the active electrode to the subject, you will still need to attach a Ground electrode to the subject. The Ground electrode will act as reference for 1 to 16 active electrodes. The LEAD110A, 3-meter, unshielded electrode lead is recommended for this purpose. The LEAD110A will connect directly to any standard snap surface electrode (like the EL503). The surface electrode can be placed at any point on the subject, and performance is optimal when the electrode makes good contact with the skin surface.
4) The free end of the LEAD110A is inserted directly to the GND A terminal on the back of the UIM100C. To insert the LEAD110A into the GND A terminal, use a small screwdriver to back out the terminal locking screw, insert the LEAD110A 2 mm pin plug into the terminal opening and then tighten down the locking screw.
5) At this point, the active electrode is ready for data collection. Set up the active electrode **Scaling** in Acq*Knowledge*, by setting the MAP values to a factor of the default value divided by330. See the "MP System Guide" for more information on channel scaling. The recommended sampling rate for the MP System is 2000Hz on each active electrode channel.

TSD150 Calibration

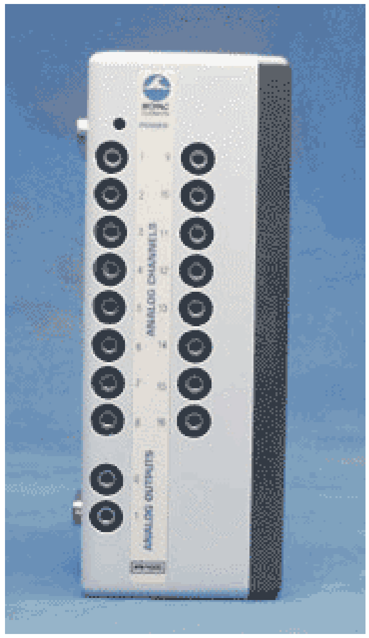
The TSD150 Series does not require calibration.

TSD150 Active Electrode Specifications

Recommended Sample Rate:	*Best*: 2000Hz, *Minimum*: 1000Hz
Gain:	350 (nominal)
Input Impedance:	100 MΩ
CMRR:	95 dB (Nominal)
3 dB Bandwidth:	12Hz - 500Hz
Cable:	3 meters, lightweight, shielded
Electrode Spacing	
TSD150A:	Wide — 35 mm
TSD150B:	Narrow — 20 mm
Stainless steel disk diameter:	11.4 mm
Fine Wire Attachment:	Screw springs
Ground Lead:	Requires LEAD110A for proper operation (one per subject)
Dimensions:	17.4mm wide x 51 mm long x 6.4 mm thick
Weight:	9.5 grams
Interface:	HLT100C—see page 26

See also: LEAD110A
TAPE1 / TAPE2

IPS100C Isolated Power Supply Module



The IPS100C is used to operate 100-series amplifier modules **independent** of an MP data acquisition unit. The IPS100C module couples the 100-series amplifier outputs directly to any **other** data acquisition system, oscilloscope or chart recorder. Amplifier modules snap onto the side of the IPS100C to receive the necessary isolated power and to direct the modules' output to the front panel of the IPS100C. The IPS100C allows users to operate up to 16 amplifiers on a stand-alone basis. The analog channel outputs are provided via 3.5mm phone jacks on the front panel. The IPS100C is generally used with animal or tissue preparations. When collecting data from electrodes attached to humans, use the HLT100C module with INISO and OUTISO adapters to couple signals to external equipment.

Includes In-line Transformer (AC100A) and USA or EURO power cord.

IMPORTANT USAGE NOTE

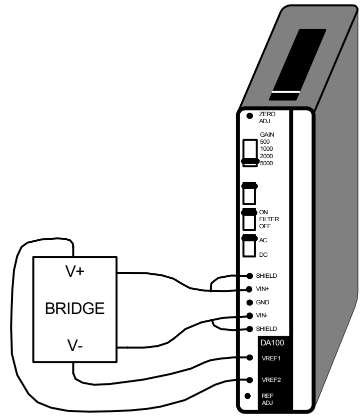
Do not use the IPS100C with an MP based system. For a fully isolated recording system using the IPS100C, couple signal inputs and outputs through the HLT100C module and INISO and OUTISO adapters, respectively. Contact BIOPAC for details.

IPS100C Specifications

Amplifier Output Access:	16 channels (front panel) – 3.5mm phone jacks
Isolated Power Access:	±12V, +5V @ 100 ma (back panel) – screw terminals
Weight:	610 grams
Dimensions:	7cm (wide) x 11cm (deep) x 19cm (high)
Power Source:	12VDC @ 1 amp (uses AC100A transformer)

Chapter 3 General Purpose Transducer Amplifier Module

DA100C - Differential Amplifier module



The differential amplifier module (DA100C) is a general purpose, single channel, differential amplifier. The DA100C is designed for use in the following measurement applications:

Blood pressure (hemodynamics)	Physiological sounds
Displacement (linear or angular)	Temperature
Muscle strain or force (pharmacology)	Humidity

The DA100C has one differential input linear amplifier with adjustable offset and gain. The DA100C is used to amplify low-level signals from a variety of sources. The DA100C has built-in excitation capability, so it can work directly with many different types of transducers, such as:

Pressure transducers	Piezo sensors
Strain gauges	Wheatstone bridges
Accelerometers	Photocells
Microphones	Thermistors
Electrogoniometers	

Compatible BIOPAC Transducers are:

TRANSDUCER	TYPE	TRANSDUCER	TYPE
TSD104A	Precision Pressure	TSD121C	Hand Dynamometer
TSD105A	Variable Range Force	TSD125 Series	Fixed Range Force
TSD107B	High Flow Pneumotach	TSD127	Low Flow Pneumotach
TSD108	Physiological Microphone	TSD130 Series	Goniometers & Torsiometers
TSD117	Medium Flow Pneumotach	TSD137 Series	Very Low Flow Pneumotach
TSD120	Noninvasive BP cuff	TSD160 Series	Differential Pressure

If the input signal is applied differentially between the VIN+ and VIN- inputs, the Input Signal Range can be centered on any voltage from -10 volts to +10 volts with respect to GND. If the signal is applied to a single input (with the other input grounded), then that signal can range over the selected Input Signal (pk- pk) with respect to GND.

The DA100C can be used to directly connect existing transducers. The DA100C can be outfitted with connector assemblies for easy interfacing to a variety of “off the shelf” pressure transducers, force gauges, and strain gauges.

These transducer connector interfaces (TCIs) have pin plugs on one side and the transducer mating connector on the other. The following TCIs are available. Or you can use the TCI Kit to make a custom adapter.

TCI100	Grass/Astromed transducers – 6 pin
TCI101	Beckman transducers – 5 pin
TCI102	World Precision Instrument transducers – 8 pin
TCI103	Lafayette Instrument transducers – 9 pin
TCI104	Honeywell transducers – 6 pin
TCI105	Modular phone jack connector – 4 pin
TCI106	Beckman transducers – 12 pin
TCI107	Nihon Koden transducers – 5 pin
TCI108	Narco transducers – 7 pin
TCI109	Fukuda transducers – 8 pin
TCI110	Gould transducers – 12 pin
TCI111	Liquid metal transducers – two 2mm sockets
TCI112	Hokansen transducers – 4 pin
TCI113	Hugo Sachs/Harvard Apparatus — 6 pin
TCIPPG1	Geer to PPG100C only — 7 pin

Voltage References

The DA100C has two adjustable voltage sources (VREF1 and VREF2) for activating passive sensors like pressure transducers, strain gauges, thermistors and photocells. The references can be set anywhere from -5.0 to +5.0 volts. GND is at 0 volts. VREF1 and VREF2 track each other with opposite polarity, thus a maximum differential of 10 volts is obtainable for driving external transducers. For example, if VREF1 is set to +1.0 v (with respect to GND), then VREF2 will automatically be set to –1.0 v.

The references can be adjusted using the **REF ADJ** potentiometer near the bottom of the module. The voltage references can handle up to 20 mA sourcing or sinking to each other or GND. Pay close attention to your sensor drive requirements so as to minimize overall current consumption.

Frequency Response Characteristics

Use the **10Hz LP** lowpass filter for connecting the DA100C to most pressure, force, and strain transducers (i.e., TSD104A, TSD105A, TSD120, TSD121C, TSD125 Series, and TSD130 Series).

Use the **300Hz LP** lowpass filter for connecting the DA100C to devices with higher frequency output signals (i.e., TSD107B, TSD108, TSD117).

Use the **5,000Hz LP** lowpass filter for connecting the DA100C to devices with the highest frequency signals, such as microphones and clamp signals (patch, voltage or current).

Modules are factory preset for 50 or 60Hz notch options, depending on the destination country.

See the sample frequency response plots beginning on page 215: 10Hz LP, 300Hz LP, 5000Hz LP

DA100C Calibration

A. Reference calibration

B. Amplifier gain calibration

C. Transducer calibration if applying physical variable

D. Transducer calibration if not applying physical variable

A. Reference Calibration

The **REFCAL** (see page 42) is used to check the reference voltage of the **DA100C**. The ref voltage is used to provide excitation to passive transducers.

B. Amplifier Gain Calibration

Use the CBLCAL/C.

C. Transducer Calibration if applying physical variable

1. Plug transducer it into the DA100C.
2. Set the gain switch on the DA100C to the desired level.
3. Apply the physical variable to the transducer on the low end of your expected range.
4. Press on Cal 1 in the scaling window in AcqKnowledge.
5. Apply the physical variable to the transducer on the high end of your expected range.
6. Press on Cal 2 in the scaling window in AcqKnowledge.
7. Review the Input Voltage differential (provided in the scaling window as a consequence of pressing cal 1/cal2) and adjust if necessary
   - ❖ If the Input Voltage differential is less than +/- 100 mV it may be appropriate to increase the gain setting on the DA100C.
   - ❖ If either Input Voltage signal is higher than 9.9V or less than –9.9V, then reduce the gain setting on the DA100C.

If you adjust the Gain switch setting on the DA100C, then you will need to repeat steps 3-7.

The **physical variable** for calibration varies based on the transducer type. See the appropriate transducer specification for details:

TRANSDUCER	TYPE	TRANSDUCER	TYPE
TSD104A	Precision Pressure	**TSD121C**	Hand Dynamometer
TSD105A	Variable Range Force	**TSD125 Series**	Fixed Range Force
TSD107B	High Flow Pneumotach	**TSD127**	Low Flow Pneumotach
TSD108	Physiological Microphone	**TSD130 Series**	Goniometers & Torsiometers
TSD117	Medium Flow Pneumotach	**TSD137 Series**	Very Low Flow Pneumotach
TSD120	Noninvasive BP cuff	**TSD160 Series**	Differential Pressure

D. Transducer Calibration if not applying physical variable

Use this procedure if you can't easily generate the required physical variable changes in order to calibrate the transducer.

1. Calculate the de-normalized calibration factor, VY.
   a) Note the factory calibration constant (generally listed as "Output" in the transducer specifications), expressed in the form of voltage/physical variable (V/P),
   b) Multiply V/P by the reference voltage (RV) of the DA100C (2V factory preset).
   c) Multiply the result [(V/P) * RV] by the Gain switch setting value on the DA100C.
2. Plug the transducer into the DA100C.
3. Press Cal 1 …this will generate VB in the Input Voltage box
4. Enter the ambient physical value in the Cal 1 Map/Scale window
5. Enter Cal 2 Input Voltage as VY+VB
6. Enter the ambient + delta physical value in the Cal 2 Map/Scale window

DA100C Specifications

Gain:	50, 200, 1000, 5000	
Output Range:	±10V (analog)	
Frequency Response		
Low Pass Filter:	10Hz, 300Hz, 5000Hz	
High Pass Filter:	DC, 0.05Hz	
Input Voltage (max):	±200mV (protected)	
Noise Voltage:	0.11µV rms - (0.05-10Hz)	
Temperature Drift:	0.3µV/°C	
Z (Differential input):	2MΩ	
CMRR:	90dB min	
CMIV—referenced to		
Amplifier ground:	±10V	
Mains ground:	±1500 VDC	
Voltage Reference:	-10 to +10V infinitely adjustable @ 20ma (max) (Factory preset to 2 volts excitation)	
Signal Source:	Variety of transducers	
Input Voltage Range	Gain	Vin (mV)
	50	±200
	200	±50
	1000	±10
	5000	±2
Weight:	350 grams	
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)	

REFCAL Reference Calibrator for the DA100C

The **REFCAL** is used to check the reference voltage of the **DA100C**. It connects to the DA100C and displays the reference voltage as an analog input signal. This makes it very easy to adjust the reference voltage of the DA100C to suit your transducer.

The REFCAL connects the VREF1 and VREF2 voltage reference outputs directly to the DA100C inputs via a precision attenuator of value (1/50). When using the REFCAL to set the DA100C references, the DA100C should be set to DC with a gain of 50.

The voltage output on the selected channel of the DA100C will be the voltage difference between VREF1 and VRREF2:

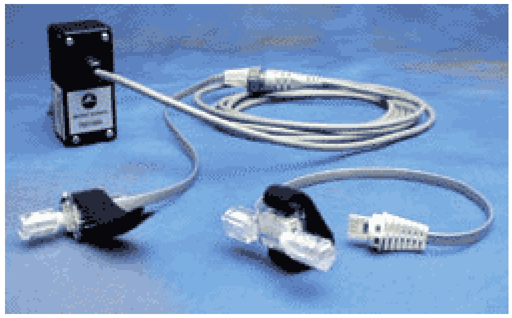
$$V_{OUT} = V_{REF1} - V_{REF2}$$

CBLCAL Calibration Cable for the DA100C

Use the CBLCAL to verify the signal calibration of the DA100C. This cable (1.8m) connects between the DA100C input and the UIM100C D/A output 0 or 1. To verify the DA100C's frequency response and gain settings, create a stimulus signal with Acq*Knowledge* and monitor the DA100C's output. The CBLCAL incorporates a precision 1/1000 signal attenuator.

See also: Application Note #AH102 — Biopotential Amplifier Testing using CBLCAL

TSD104A Blood pressure transducer *and* RX104A Replacement Element



The TSD104A is used to measure direct arterial or venous blood pressure in animals for research or teaching. It is designed to interface with the DA100C via a 3-meter cable (supplied). The RX104A is a replacement element for the TSD104A blood pressure transducer; it does not include the TCI connector and cable.

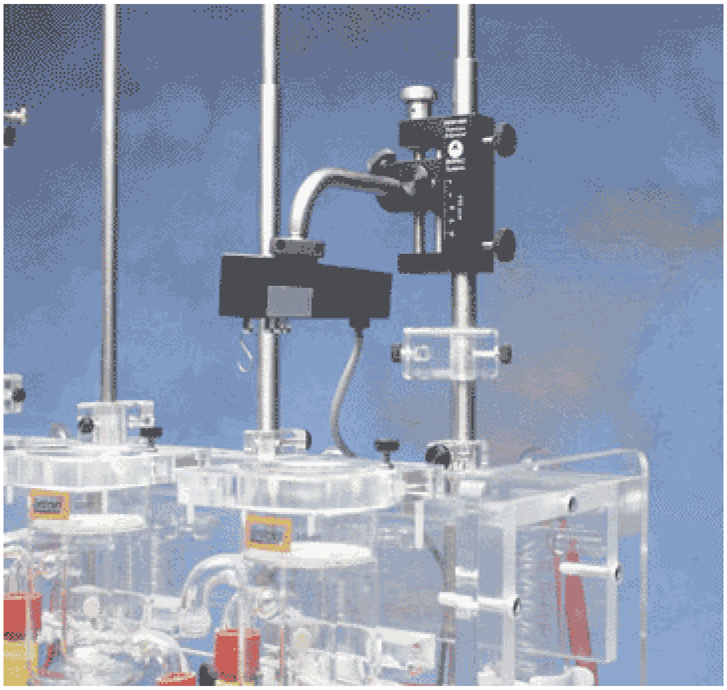
TSD104A SPECIFICATIONS

Operational pressure:	-50 mmHg to +300 mmHg
Overpressure:	-400 mmHg to +4,000 mmHg
Dynamic Response:	100Hz
Unbalance:	50 mmHg max
Connection ports:	Male Luer (2)
Eight-hour Drift:	1mmHg after 5 minute warm-up
Isolation:	≤ 5 µA leakage at 120 VAC/60Hz
Defibrillation:	Withstands 5 discharges of 400 joules in 5 minutes across a load
Operating temperature:	+15° C to +40° C
Storage Temperature:	-30° C to +60° C
Combined effects of sensitivity, linearity, and hysteresis:	1 mmHg (nominal)
Output:	5 µV/mmHg (normalized to 1V excitation)
MRI Compatible:	Yes — no ferrous parts
Weight:	11.5 grams
Transducer Dimensions:	67mm long x 25mm wide
Cable length:	3 meters
Interface:	DA100C

TSD104A Calibration

See DA100C Calibration options on page 40.

TSD105A Adjustable force transducer



TSD105A shown with HDW100A

Force transducers are devices capable of transforming a force into a proportional electrical signal. The TSD105A force transducer element is a cantilever beam load cell incorporating a thin-film strain gauge. Because the strain elements have been photolithographically etched directly on the strain beam, these transducers are rugged while maintaining low non-linearity and hysteresis. Drift with time and temperature is also minimized, because the strain elements track extremely well, due to the deposition method and the elements' close physical proximity. The TSD105A also incorporates impact and drop shock protection to insure against rough laboratory handling.

Forces are transmitted back to the beam via a lever arm to insure accurate force measurements. Changing the attachment point changes the full scale range of the force transducer from 50g to 1000g. The beam and lever arm are mounted in a sealed aluminum enclosure that includes a 3/8" diameter mounting rod for holding the transducer in a large variety of orientations. The TSD105A comes equipped with a 2-meter cable and plugs directly into the DA100C amplifier.

The TSD105A mounting rod can be screwed into the transducer body in three different locations, two on the top and one on the end surfaces of the transducer. The mounting rod can be placed in any angle relative to the transducer orientation. The TSD105A can be used in any axis and can be easily mounted in any standard measurement fixture, including pharmacological setups, muscle tissue baths and organ chambers.

The TSD105A has 5 different attachment points that determine the effective range of the force transducer. These ranges are 50g, 100g, 200g, 500g and 1,000g. The point closest to the end is the 50g attachment point, while the point closest to the middle is the 1,000g attachment point.

Two hooks are provided with the TSD105A. One with a .051" diameter wire and the other with a .032" diameter wire. The larger hook is intended for the 500g and 1000g ranges and the smaller hook is to be used for the 50g, 100g and 200g ranges.

TSD105A Calibration

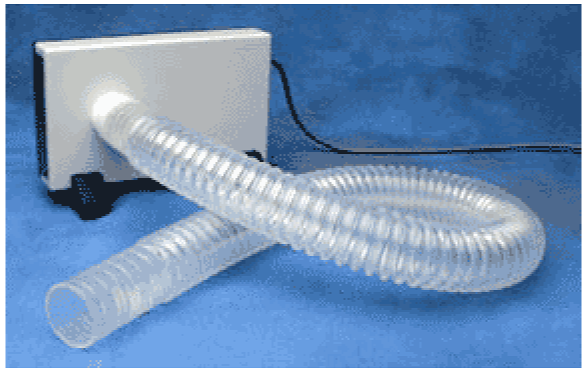
The TSD105A is easily calibrated using weights of known mass. Ideally, calibration should be performed with weights that encompass the range of the forces expected during measurement and should cover at least 20% of the full scale range of the transducer. When calibrating for maximum range on the force transducer, use weights that correspond to 10% and 90% of the full scale range for best overall performance.

See DA100C Calibration options on page 40.

TSD105A SPECIFICATIONS

Rated Output:	1mV/V (normalized to 1V excitation)
Ranges:	50, 100, 200, 500, 1000 grams
Noise (rms):	(Range/50)mg @ 10 volts excitation, 1Hz bandwidth
Nonlinearity:	<±0.025% FSR
Hysteresis:	<±0.05% FSR
Nonrepeatability:	<±0.05% FSR
30 minute creep:	<±0.05% FSR
Temperature Range:	-10°C to 70°C
Thermal Zero Shift:	<±0.03% FSR/°C
Thermal Range Shift:	<0.03% Reading/°C
Maximum Excitation:	10 VDC
Mounting Rod:	9.5mm (dia) – variable orientation
Weight:	300g (with mounting rod)
Length:	19mm (wide), 25mm (thick), 190mm (long)
Cable Length:	3 meters
Interface:	DA100C—see page 38

TSD107B High-flow Pneumotach transducer



The TSD107B is a highly linear, wide range, airflow transducer. Using the TSD107B and a DA100C amplifier with the MP System, you can perform a variety of tests relating to airflow and lung volume. With the equipment listed below and the proper software parameters, precise lung volume measurements can be obtained.

Equipment

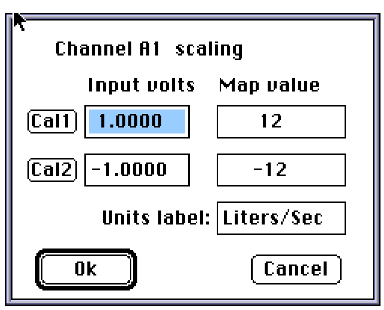
- MP System for data acquisition
- DA100C general purpose amplifier
- TSD107B pneumotach transducer

Hardware Setup

1. Select DA100C module for Channel 1.
2. Set Gain at 1000.
3. Set the high frequency response to 10Hz (300Hz in some cases).
4. Set the low frequency response to DC.
5. Set VREF1 to +1.0 Volts (default) with a Volt/ohm meter or with BIOPAC's REFCAL (VREF2 will track VREF1 with opposite polarity).
6. Plug the TCI connector into DA100C.
7. Insert the airflow tube between the bacterial filter and the airflow transducer.
8. Place the mouthpiece on the free end of the bacterial filter.

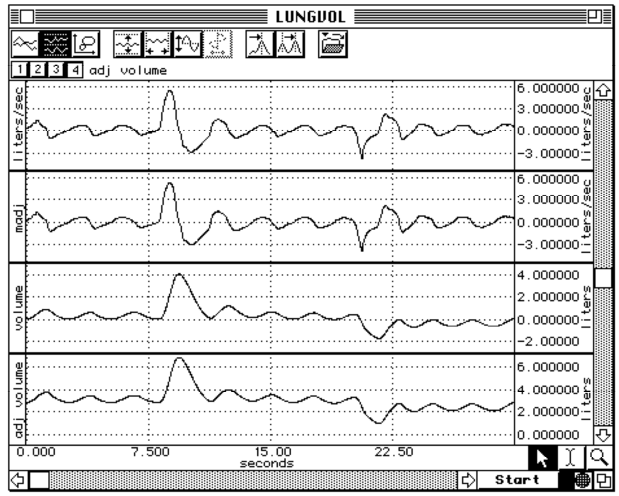
Software Setup

1. Under **Setup Channels** select channel 1 and click on the scaling button.
2. Complete the scaling dialog box as shown here:



3. Under **Setup Acquisition** set
   a) Storage: Disk
   b) Sample rate: 50 samples per second
   c) Acquisition length: 30 seconds.

Recording Procedure



1. Start breathing normally through the mouthpiece.
2. After several normal breaths, inspire as deeply as you can (just once) and then return to normal breathing for several seconds
3. Expire as completely as you can.
4. Return to normal breathing for the remainder of the recording.

The recorded wave should look something like the top wave in the following graph. Normal Tidal Volume can vary quite a bit, even over a 30-second period. Note that in Wave 4 - adj volume, the starting tidal volume is almost a liter, then, as the test progresses, the tidal volume drops to about 0.5 liters. This level of variation is somewhat expected, since respiratory effort has a strong voluntary component.

*Analysis — Acq*Knowledge

1. Duplicate the recorded data.
2. Subtract the mean value of the entire record from the duplicated data to create the Mean Adjusted Flow (madj). This procedure will simply remove any DC bias from the airflow signal.
3. Duplicate madj.
4. Integrate the duplicated madj channel. This process results in the third wave, which is the volume (in liters), which correlates to the air flow.
5. To correct for the proper residual volume in the lungs (estimated at about 1 liter), add a constant to the third wave to create a new adjusted volume (adj volume). The minimum point on this curve should be the estimated residual lung volume (1 liter).

TSD107B Calibration

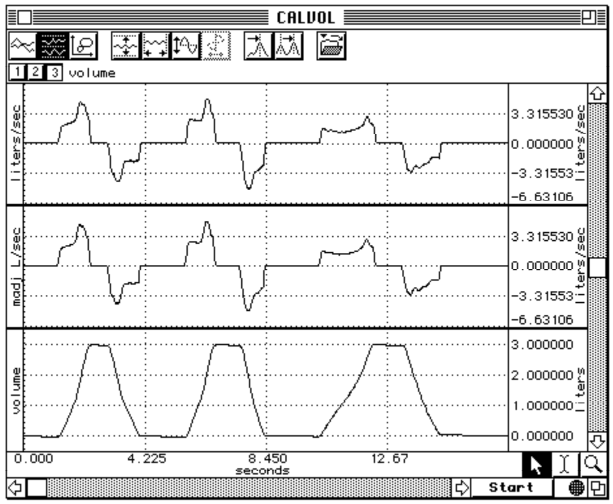
The TSD107B is factory calibrated to satisfy the scaling factor:

1 mVolt Δ output = 12.0 liters/sec flow rate

When connected to the DA100C with Gain =1,000, the calibration factor is:

1 Volt = 12.0 liters/sec

This graph illustrates how a calibration check is performed.



1. Insert a three-liter calibration syringe into the free end of the airflow tube.
2. Push three liters of air through the airflow transducer, first one direction, then the other.
3. Subtract the mean value of the first wave from the second wave, to correct for DC bias.
4. Integrate the second wave; the result will be placed in the third channel (volume).

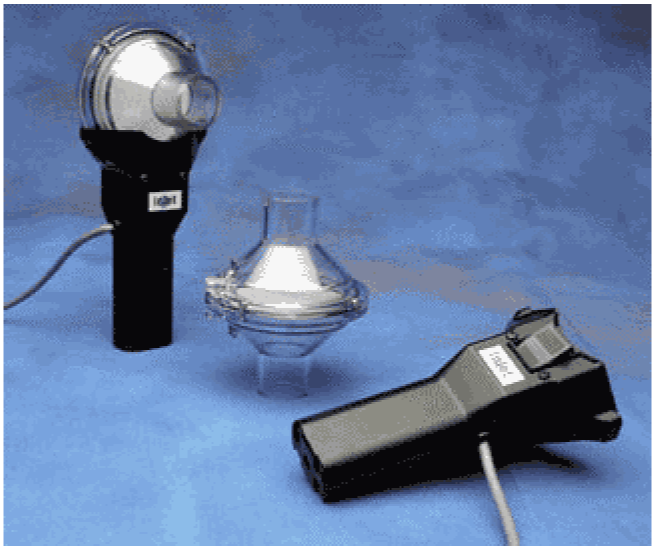
As air is forced back and forth through the transducer, you would expect that the volume would be from 0 to 3 liters. As air goes one way the volume climbs to 3 liters, and as that same air is then pulled the other direction through the transducer, the volume signal should head back to 0. As shown in the sample graph, the volume measurement is independent of the rate of flow, as you would expect for a linear airflow measurement transducer.

See DA100C Calibration options on page 40.

TSD107B Specifications

Pneumotach type:	Hans Rudolf® #4813 with integral differential pressure transducer
Voltage excitation:	+/- 5 volts (10 volts pk-pk) maximum
Nominal Output:	45 µV/[liters/sec] (normalized to 1V excitation)
Calibration factor:	90 micro-volts/(liters/second) - normalized to 2 VDC excitation
Calibrated flow range:	±800 Liters/min
Dead space volume:	87.8 ml
Back pressure:	2.8 cm H_2O/400 liters/min
Flow bore (Ports):	35mm OD
Weight:	690 grams
Dimensions:	4cm (deep) x 11cm (high) x 19cm (wide)
Cable:	3 meters
Interface:	DA100C—see page 38

TSD117 Medium-flow Pneumotach Transducer



The TSD117 can be used to measure respiratory flow over a wide range of subjects and conditions. The TSD117 includes an optically clear detachable flow head (RX117) for easy cleaning and inspection. As the detachable flow head is snapped into the TSD117 handle, the flow head plugs directly into an integral, precision low-differential pressure transducer. Accordingly, the TSD117 will output an electrical signal proportional to respiratory flow. The TSD117 plugs directly into the DA100C amplifier module. The RX117 detachable flow head can be cold sterilized, autoclaved (220° F max), or placed in a dishwasher.

- ❖ For air flow and lung volume measurements, use the TSD117 with the AFT2 mouthpiece and the AFT1 bacterial filter.
- ❖ For measurements of expired gases, use the TSD117 with the AFT22 non-rebreathing T valve with AFT10 facemask and the AFT15A or AFT15B mixing chambers.

All connections can be performed with AFT12 (22mm ID) tubing and AFT11 series couplers (page 141).

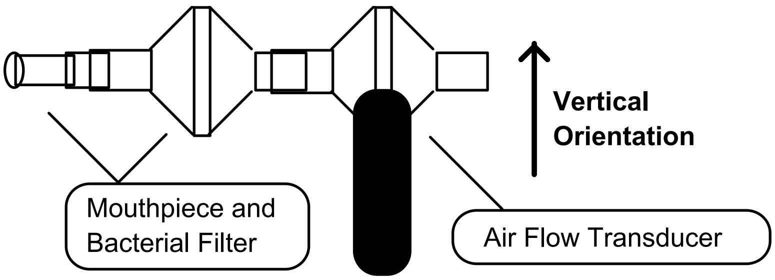
Please note the following:

a) The bacterial filter and mouthpiece are disposable and are "one per person" items. Please use a new disposable filter and mouthpiece each time a different person is to be breathing through the airflow transducer.

b) For more effective calibration, use a bacterial filter between the calibration syringe and the airflow transducer.

c) Either the bacterial filter and mouthpiece are inserted into the airflow transducer or the calibration syringe (with attached filter) is inserted into the airflow transducer.

Normal measurement connections:



For the most accurate lung volume recording, be sure to use a noseclip to prevent airflow through the nose. Also, be sure not to remove the airflow transducer assembly from your mouth during the recording. All air leaving or entering your lungs must pass through the airflow transducer during the lung volume measurement.

Use the following measurement procedure for determining lung volume:

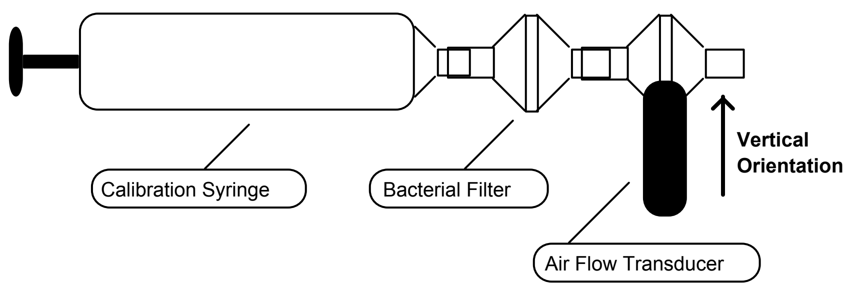
1. Breathe normally for 3 cycles (start on inspire)
2. Inspire as deeply as possible
3. Return to normal breathing for 3 cycles
4. Expire as deeply as possible
5. Return to normal breathing (end on expire)

Data Processing

When integrating the collected data to determine lung volume, it's important to integrate from the starting point of the first inspire, to the end point of the last expire. Before integration, you will need to determine the mean of the selected (air flow) data and then subtract the mean from the record. This process insures that the integral will have the same starting and ending point.

TSD117 Calibration

Calibration connections:



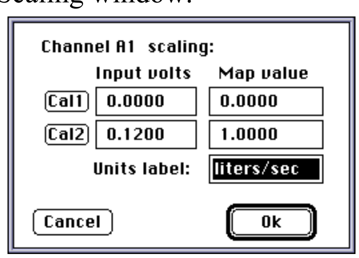
After the calibration process, please remove the calibration syringe and attach a new bacterial filter and mouthpiece to the airflow transducer.

It's very important that each individual use his/her own mouthpiece and bacterial filter.

Place the narrow end of the bacterial filter and mouthpiece assembly into either side of the airflow transducer. You are now ready to begin recording airflow data. For best results, hold the airflow transducer vertically.

Calibration Procedure Options

The TSD117 can be roughly calibrated without using the calibration syringe. Using the TSD117's nominal output of 60µV per liter/sec (normalized to 1 volt excitation), the following calibration factors can be entered in the Acq*Knowledge* Scaling window.



Scaling Factors for Rough Calibration of the TSD117

The following equation illustrates why 0.12 volts maps to 1.00 liter/sec :

$$\text{Calibration Constant} \bullet \text{Amp Gain} \bullet \text{Amp Excitation} = \text{Scale Factor}$$

thus

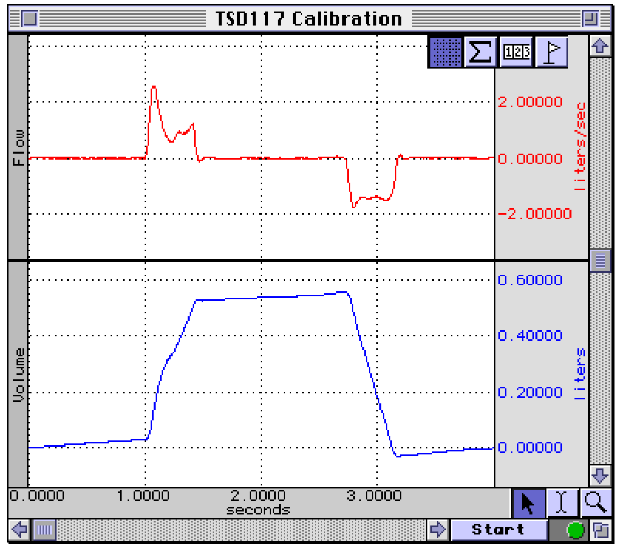
$$60\ \mu\text{V/[liter/sec]} \bullet 1000 \bullet 2\ \text{Volts} = 0.12\ \text{V / [liter/sec]}$$

Data can now be collected directly. Prior to analyzing the data, remember that there will always be some offset recorded in the case of zero flow. It's possible to largely trim this offset out, using the ZERO potentiometer on the DA100 amplifier, but some residual will always remain.

To remove residual offset after the flow data has been collected, select a portion of the baseline (zero flow reading) and calculate the mean value using the popup measurements. Subtract this mean value from the raw data to obtain a mean corrected flow signal.

Now, the integral of the mean can be calculated as shown in this graph →

In this case, a 600ml-calibration syringe was used to check the rough calibration of the TSD117 airflow transducer. The rough calibration indicates a syringe volume of about 550ml, so this method may only be expected to be accurate within ±10% of the real reading.



Flow Measurement and Volume Calculation

<u>To achieve a more exact calibration</u>, start with the above scaling factors and then boost or drop them slightly as indicated by the rough calibration. In this case, if the map value correlating to 0.12 volts were boosted about 10% to 1.10 (from 1.0 liters/sec), the resulting calibration would be fairly accurate.

Also see DA100C Calibration options on page 40.

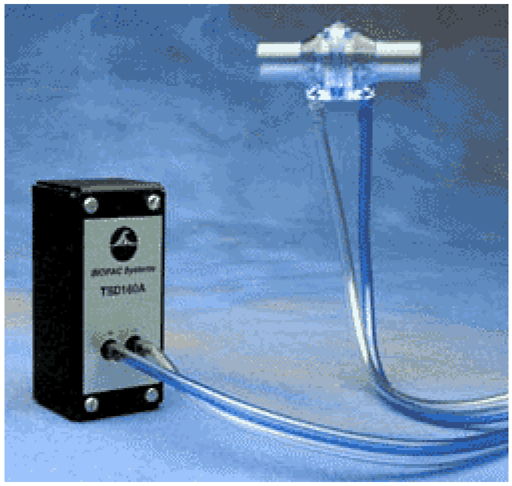
<u>TSD117 Technical Specifications</u>

Flow Rate:	±300 Liters/min highest linearity ≤ 5 Liters/sec)
Nominal Output:	60 µV/[liters/sec] (norma1ized to 1V excitation)
Dead space:	93ml
MRI Compatible:	Yes (no ferrous parts)
1/4" 25 TPI mounting nut:	standard camera mount
Flow Bore (Ports):	22mm (ID), 29mm (OD)
Flow Head Dimensions:	82.5mm (dia) x 101.5mm (long)
Flow Head Weight:	80 grams
Flow Head Construction:	Clear Polycarbonate
Handle Dimensions:	127mm (long) x 23mm (thick) x 35mm (wide)
Handle Weight:	85 grams
Handle Construction:	Black ABS
Cable Length:	3 meters, shielded
Interface:	DA100C—see page 38
TEL100C Compatibility:	SS11A—see page **Error! Bookmark not defined.**

RX117 Replacement Air Flow Head

The RX117 is a sterilizable air flow head for the TSD117 pneumotach transducer. Multiple RX117 heads help eliminate equipment downtime during cleaning procedures. To reduce the cost of disposable items, use the RX117 with the AFT8 sterilizable mouthpiece. (22mm ID/30mm OD)

TSD127 Pneumotach Air Flow Transducer (Low Flow)



The TSD127 can perform a variety of pulmonary measurements relating to air flow, lung volume and expired gas analysis. The transducer includes a detachable flow head (RX127) for easy cleaning and sterilization. The TSD127 is intended for animal use and consists of a low flow, pneumotach air flow head (RX127) coupled to a precision, highly sensitive, differential pressure transducer (TSD160A). The TSD127 will connect directly to a breathing circuit or plethysmogram chamber.

- ❖ For air flow and lung volume measurements, connect a short air flow cannula to the TSD127.
- ❖ For measurements of expired gases, use the TSD127 with the AFT22 non-rebreathing valve.

All connections can be performed with AFT11 series couplers (page 141).

TSD127 Calibration

Follow the procedure for TSD117 (see page 50) but move the calibration syringe plunger at a reduced velocity due to the higher sensitivity to flow of the TSD127.

Also see DA100C Calibration options on page 40.

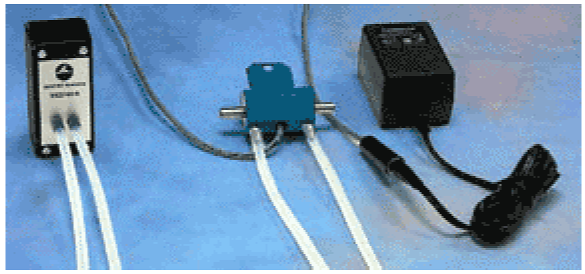
TSD127 Specifications

Range:	± 90 Liters/min
Nominal Output:	500 µV/[liters/sec] (normalized to 1V excitation)
Dead Space:	11cc
MRI Compatible:	Yes (no metal parts) – air flow head
Weight:	11 grams – air flow head
Dimensions:	5.7cm (long) – air flow head
Ports:	15mm OD / 11mm ID
Tubing Length:	1.8 meters (to DA100C)
Interface:	DA100C

RX127 Replacement Air Flow Head

The RX127 is a low air flow head for the TSD127 pneumotach transducer. Multiple RX127 heads help eliminate equipment downtime during cleaning procedures. (11mm ID/15mm OD)

TSD137 SERIES Pneumotach Air Flow Transducers (Very Low Flow)



The TSD137 series pneumotachs can be used to perform a variety of small animal pulmonary measurements relating to air flow, lung volume and expired gas analysis. The TSD137 series consists of a low flow, pneumotach air flow head (RX137A through RX137E) coupled to a precision, highly sensitive, differential pressure transducer (TSD160A). The TSD137 series pneumotachs will connect directly to a breathing circuit or plethysmogram chamber. For air flow and lung volume measurements, connect a short air flow cannula to the TSD137 series flow head. All of the TSD137 series pneumotachs come equipped with an internal heating element that can be optionally attached to the AC137A 6 volt power supply (see page 209).

TSD137 Calibration

Connect tubing and a flow restrictor between the calibration syringe and the TSD137 transducer, then follow the procedure for TSD117 (see page 50) but move the calibration syringe plunger at a reduced velocity due to the very high sensitivity to flow of the TSD137 series. Each of the TSD137 series comes factory calibrated to a known flow level, as indicated on the transducer.

Also see DA100C Calibration options on page 40.

TSD137 Series Specifications

Unit	Range (ml/sec)	Dead Space (cc)	Output	Flow Ports (µV/[ml/sec]) (OD-mm)	Animal Approx. Size	Approx. Weight
TSD137A	±12	0.1	25.7	7	Small Mouse	30 grams
TSD137B	±20	0.8	15.4	7	Mouse	50 grams
TSD137C	±60	0.9	5.78	7	Rat/Guinea Pig	350 grams
TSD137D	±150	2.0	2.10	10	Cat/Rabbit	750 grams
TSD137E	±350	4.0	0.924	11	Small Dog	5.5 kg

Nominal Output: Normalized to 1V excitation
Tubing Length: 1.8 meters (to TSD160A)
Interface: DA100C

RX137 Series Replacement Air Flow Heads

For TSD137 Series Pneumotachs

The RX137 series are low air flow heads for the TSD137 series pneumotach transducers. The RX137 heads can be mixed and matched with any of the TSD137 series pneumotachs. Switching one head for another when using a single TSD137 pneumotach can accommodate a wide range in flows. RX137 heads connect to the TSD160A differential pressure transducer via standard 3mm or 4mm ID tubing. Multiple RX137 heads help eliminate equipment downtime during cleaning procedures.

RX137 Series Specifications

Head	**Range** (ml/sec)	**Dead Space** (cc)	**Length** (mm)	**Flow Ports** **ID** (mm)	**OD**	**Weight** (grams)
RX137A	±12	0.1	75	1.35	7	100
RX137B	±20	0.8	75	6.00	7	90
RX137C	±60	0.9	75	6.00	7	90
RX137D	±150	2.0	75	9.00	10	100
RX137E	±350	4.0	60	10.00	11	60

TSD108 Physiological Sounds transducer

The TSD108 connects to the DA100C General Purpose Transducer Amplifier. The TSD108 can be used with the TSD120 Non-Invasive Blood Pressure Cuff or as a stand-alone device. If you use it with the TSD120, you can record Korotkoff sounds for easy determination of systolic and diastolic blood pressure (see page for 56 details). When used on its own, it can record a variety of acoustical signals, including heart sounds and sounds associated with ribbing or grinding (e.g., Bruxism. The acoustical transducer element is a Piezo-electric ceramic disk that is bonded to the interior of a circular metallic housing.

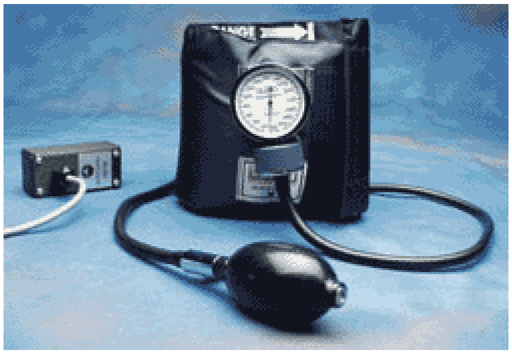
TSD108 Calibration

The TSD108 does not require calibration.

TSD108 Specifications

Frequency Response:	35Hz to 3500Hz
Housing:	Stainless Steel
MRI compatible:	Yes (no ferrous parts)
Sterilizable:	Yes (contact BIOPAC for details)
Noise:	5µV rms - (500-3500Hz)
Output:	2V (p-p) maximum
Weight:	9 grams
Dimensions:	29mm diameter, 6mm thick
Cable Length:	3 meters
Interface:	DA100C
TEL100C Compatibility:	SS17—see page 208

TSD120 Blood Pressure Cuff



TSD120

RX120A and RX120F cuff options

Blood Pressure Measurement

The most common form of indirect blood pressure measurement employs a pressure cuff, pump and pressure transducer. This complete assembly is commonly referred to as a *sphygmomanometer*.

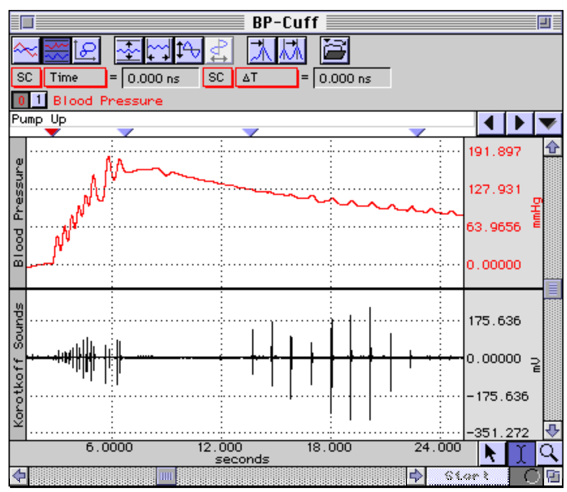
Typically, the cuff is wrapped around the upper arm and is inflated to a pressure exceeding that of the brachial artery. This amount of pressure collapses the artery and stops the flow of blood to the arm. The pressure of the cuff is slowly reduced as the pressure transducer monitors the pressure in the cuff. As the pressure drops, it will eventually match the systolic (peak) arterial pressure. At this point, the blood is able to “squirt” through the brachial artery. This squirting results in turbulence that creates the Korotkoff sounds. The Korotkoff sounds are detected using a **TSD108** physiological sounds transducer (see page 55). The cuff pressure continues to drop, and the pressure eventually matches the diastolic pressure of the artery. At that point, the Korotkoff sounds stop completely, because the blood is now flowing unrestricted through the artery.

The following graph illustrates a typical recording using the TSD120 and TSD108.

The TSD120 pressure signal was recorded via a DA100C amplifier set to DC, 10Hz LP and a gain of 200.

The TSD108 Korotkoff signal was recorded by a DA100C amplifier set to .05Hz HP, 300Hz LP and a gain of 50 to 200.

The signal for the TSD108 was further conditioned by the Acq*Knowledge* software.



Cuff Blood Pressure Versus Korotkoff Sounds

In a calculation channel, the TSD108 signal is bandpass filtered from 50 to 200Hz. Accordingly, the sampling rate for the entire recording needs to be about 600Hz, assuming the TSD108 transducer is used.

As the cuff is wrapped around the upper arm of the subject, be sure to place the TSD108 transducer **underneath** the blood pressure cuff, **directly over the brachial artery**. TSD108 placement is very important to get the best possible recordings of Korotkoff sounds. Finish wrapping the cuff around the upper arm and secure it with the Velcro® seal. Now, start inflating the cuff with the pump bulb.

The pressure trace shows the hand pump driving the cuff pressure up to about 150 mmHg. Then the cuff pressure is slowly released by adjusting the pump bulb deflation orifice. Notice that the Korotkoff sounds begin appearing when the cuff pressure drops to about 125 mmHg (bottom trace). As the pressure continues to drop, the Korotkoff sounds eventually disappear, at about 85 mmHg. The **systolic pressure** would be identified at 125 mmHg and the **diastolic pressure** would be 85 mmHg.

TSD120 Calibration

The TSD120's built-in pressure transducer will require an initial calibration prior to use. To calibrate the transducer, wrap the cuff into a roll and begin to inflate the cuff slowly with the pump bulb. You will notice the pressure change on the mechanical indicator. Set the cuff pressure to one lower pressure (typically 20 mmHg) and then one higher pressure (typically 100 mmHg). In this manner you can calibrate the pressure transducer using the standard procedure in the SCALING dialog (in Acq*Knowledge*). To use the cuff at a future date, simply save the calibration settings in a stored file.

Also see DA100C Calibration options on page 40.

TSD120 Blood Pressure Cuff Specifications

Pressure range:	20 mmHg to 300 mmHg
Manometer accuracy:	±3 mmHg
Output:	5 µV/mmHg (normalized to 1V excitation)
Cuff circumference range:	25.4 cm to 40.6 cm (as shipped with RX120D; cuff is switchable)
Cuff Dimensions:	14.5cm (wide) x 54cm (long)
Weight:	350 grams
Cable Length:	3 meters, shielded
Interface:	DA100C

RX120 SERIES Blood Pressure Cuffs for the TSD120

The RX120 series are optional blood pressure cuffs, of varying sizes, which can be quickly and easily swapped in and out of the TSD120 noninvasive blood pressure cuff transducer. Use a single TSD120 and substitute one cuff for another to accommodate a wide range in limb circumferences.

RX120 Specifications

Cuff	**Circumference Range** (cm)	**Width** (cm)	**Length** (cm)
RX120A	9.5-13.5	5.2	18.5
RX120B	13.0-19.0	7.5	26.1
RX120C	18.4-26.7	10.5	34.2
RX120D	25.4-40.6	14.5	54.0
RX120E	34.3-50.8	17.6	63.3
RX120F	40.6-66.0	21.0	82.5

TSD121C Hand Dynamometer

The multi-purpose hand dynamometer adds a new dimension to force measurements. This fully isometric transducer can be used in the traditional hand grip strength fashion, pulled apart by both hands (the Dynagrips option), or mounted against a wall and pulled. The hand dynamometer can be used in isolation, or combined with EMG recordings for in-depth studies of muscular activity. The isometric design improves experiment repeatability and accuracy. The hand dynamometer is designed to interface with the DA100C General Purpose Transducer Amplifier, and the TEL100C remote monitoring module. The hand dynamometer transducer is the same for each system, but they each use a different connector and a different part number. The equipment section provides you with a list of the appropriate part numbers and interfaces.

TSD121C Calibration

With the proper equipment and correct scaling techniques described below, precise force measurements can be obtained.

Equipment

TSD121C Hand Dynamometer

MP System and DA100C General Purpose Transduce Amplifier

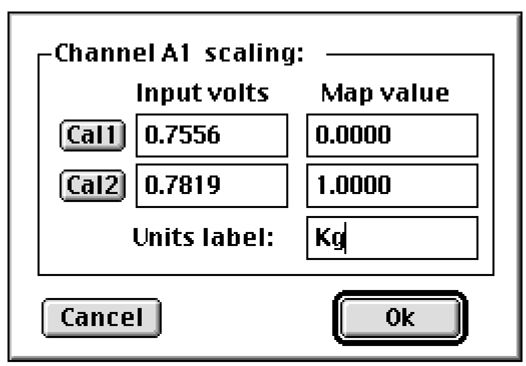
SS25 Simple Sensor Hand Dynamometer

MP System and TEL100C Remote Monitoring Module Set

Hardware Setup

Connect the TSD121C to the DA100C, or the SS25 to the TEL100C. When using this type of transducer, proper hand placement is at the uppermost portion of the foam grip, directly below the dynagrip connections.

Software Setup



1. Select **Setup Channels** under the MP menu and enable one analog channel; make sure to correlate this with the Analog Output Channel you selected on the DA100C module.
2. Select **Scaling**. A dialog similar to the one shown here will be generated.
3. In the **Map value** column, enter the scaling factors of 0 and 1, respectively. These represent 0 and 1 kilograms.
4. Enter “Kg” for the **Units label,** as shown.
5. Take the TSD121C and rest it on the table.
6. Click on the **Cal 1** button with the mouse to get a calibration reading.

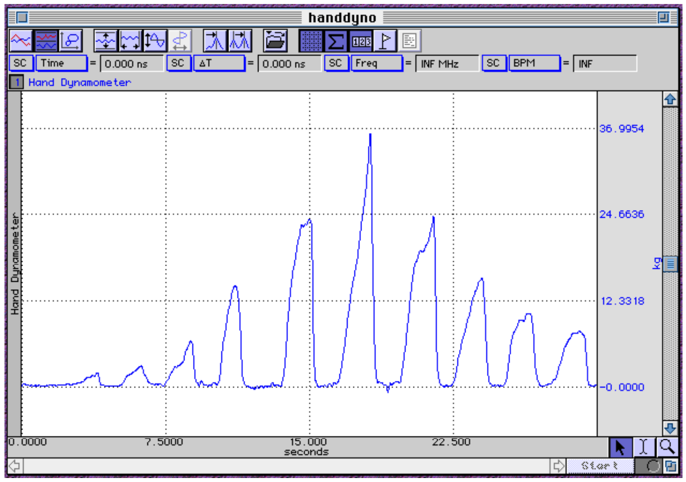
To obtain a value for the **Cal 2** box, add 13.15µV per volt of excitation to the value from the Cal 1 box. Currently, the DA100C is factory set to 2V (±1V) of excitation. If you have set your amplifier to another level of excitation, use the following equation wherein V = volts of excitation per 1 kg and G = gain setting on the DA100C or TEL100C module:

$$(13.15\mu V * G * V) + Cal\ 1 = Cal\ 2$$

Testing Calibration

To see if the calibration is correct for the MP System:

1. Start acquiring data.
2. Place the hand dynamometer on a flat surface.
3. Place a known weight on the uppermost portion of the grip.
4. Check the data — the weight should be reflected accurately in the data acquired.

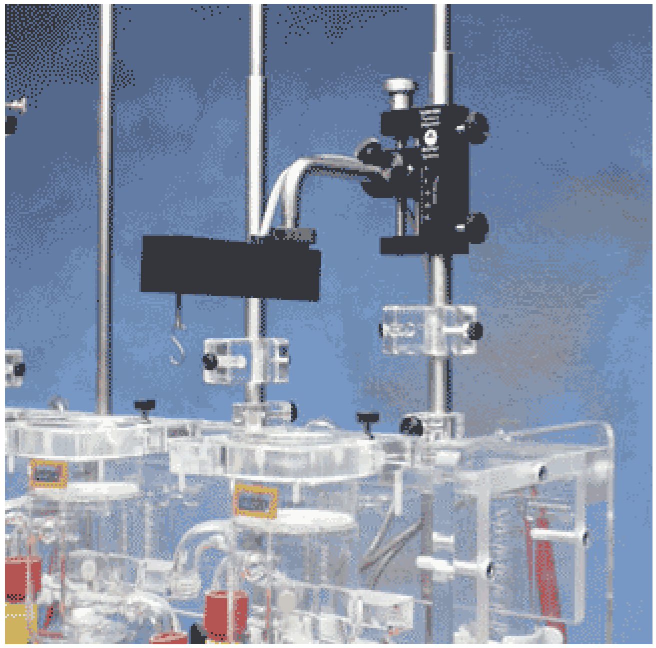


Sample Data

Also see DA100C Calibration options on page 40.

<u>TSD121C Specifications</u>

Isometric Range:	0-100 Kg
Nominal Output:	13.2 µV/kg (normalized to 1V excitation)
Weight:	315 grams
Dimensions:	185mm (long) x 42mm (wide) x 30mm (thick)
Cable Length:	3 meters
Interface:	DA100C—see page 38
TEL100C compatibility:	SS25—see page 208



TSD125 shown with HDW100A

Force transducers are devices capable of transforming a force into a proportional electrical signal. The TSD125 series force transducer elements are cantilever beam load cells incorporating thin-film strain gauges. Because the strain elements have been photolithographically etched directly on the strain beam, these transducers are rugged while maintaining low non-linearity and hysteresis. Drift with time and temperature is also minimized, because the strain elements track extremely well, due to the deposition method and the elements close physical proximity. Forces are transmitted back to the beam via a self-centering pull-pin to insure accurate force measurements. The cantilever beam is mounted in a sealed aluminum enclosure that includes a 3/8" diameter mounting rod for holding the transducer in a large variety of orientations.

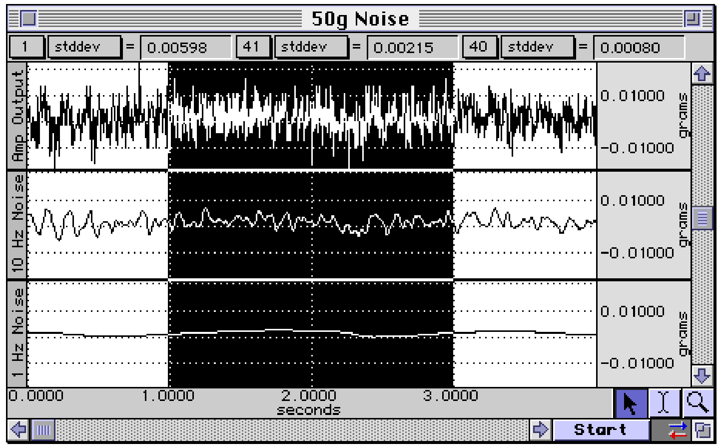
TSD125 Series Calibration

The following graphs illustrate actual data taken with the TSD125C (50 gram force transducer) and TSD125F (500 gram force transducer). The force transducers were connected directly to a DA100C amplifier with the excitation set to ±5 Volts. The DA100C gain was set to 1,000. The RMS noise output was determined by calculating the standard deviation of the amplified and calibrated signal over a period of time.

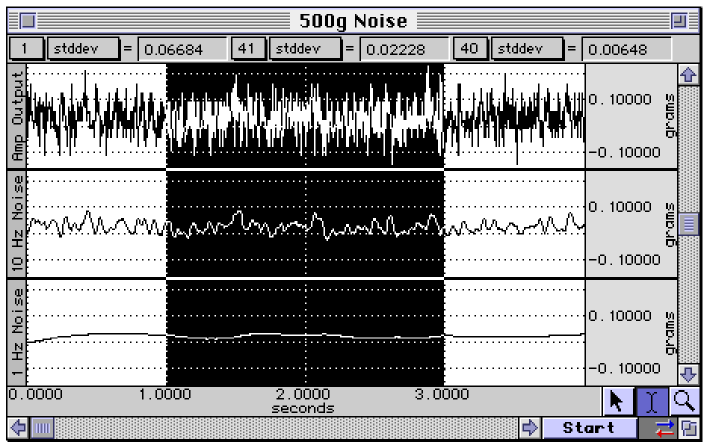
The RMS noise of each force transducer was determined in three different settings.

1) Channel 1 RMS Noise at DA100C output
2) Channel 41 RMS Noise after 10Hz Low Pass IIR real time filtering
3) Channel 40 RMS Noise after 1Hz Low Pass IIR real time filtering

RMS noise performance of TSD125F for different bandwidths



RMS noise performance of TSD125C for different bandwidths

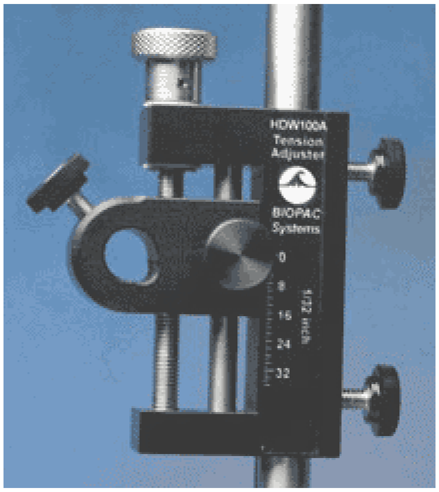


See DA100C Calibration options on page 40.

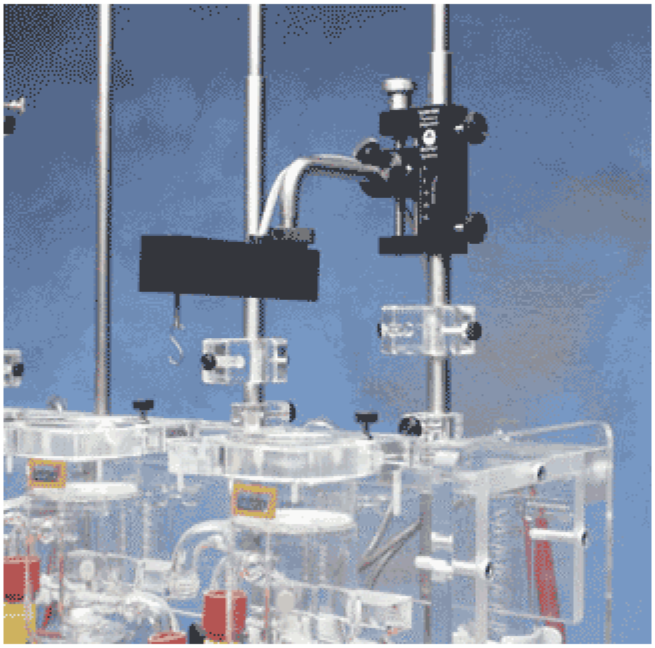
<u>TSD125 series Specifications</u>

Device	Full Scale Range (FSR)	Noise [10 volts Excitation] 1Hz	10Hz
TSD125C:	50 gram	2.5 mg	1 mg
TSD125D:	100 gram	5 mg	2 mg
TSD125E:	200 gram	10 mg	4 mg
TSD125F:	500 gram	25 mg	10 mg
Nonlinearity:	<±0.025% FSR		
Hysteresis:	<±0.05% FSR		
Nonrepeatability:	<±0.05% FSR		
30-Minute Creep:	<±0.05% FSR		
Temperature Range:	-10°C to 70°C		
Thermal Zero Shift:	<±0.03% FSR/°C		
Thermal Range Shift:	<0.03% Reading/°C		
Maximum Excitation:	10 VDC		
Full Scale Output:	1mV/V (normalized to 1V excitation)		
Weight:	250 grams		
Dimensions:	100mm (long) x 19mm (wide) x 25mm (high)		
Mounting Rod:	9.5mm (dia) – variable orientation		
Cable Length:	3 meters		
Interface:	DA100C—see page 38		

HDW100A Force Transducer Tension Adjuster



The HDW100A tension adjuster operates with the TSD105A and TSD125 series force transducers. The rugged design and stability of the mounting allow for fine position control. The position adjuster is located on the top for easy access and smooth operation. Vertical scales are provided for both metric and standard units. The HDW100A slides directly onto vertical rod laboratory stands and force transducers are clamped into the unit horizontally.

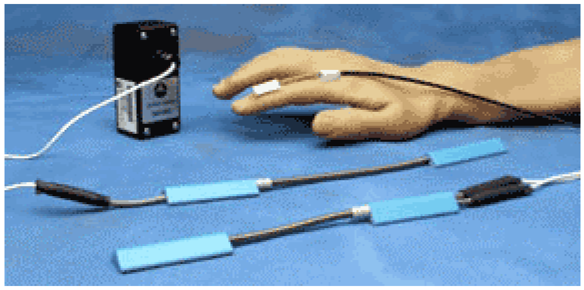


HDW100A and TSD125

<u>HDW100A Specifications</u>

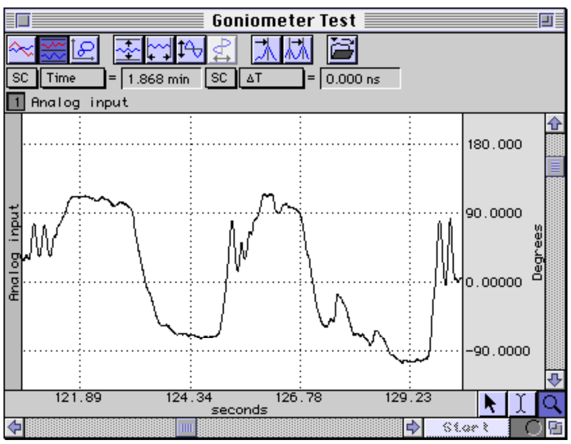
Travel Range:	25mm
Resolution:	0.0025mm per degree rotation
Stand Clamp:	13.25mm ID
Transducer Clamp	11mm ID
Weight:	140 grams
Dimensions:	93mm (high) x 19mm (thick) x 74mm (deep)

TSD 130 Series Goniometers & Torsiometers



The TSD130 Series are designed for the measurement of limb angular movement. Goniometers transform angular position into a proportional electrical signal. The TSD130 series goniometers incorporate gauge elements that measure bending strain along or around a particular axis.

The goniometers are unobtrusive and lightweight, and can be attached to the body surface using double-sided surgical tape (and can be further secured with single sided tape). The goniometers have a telescopic endblock that compensates for changes in distance between the two mounting points as the limb moves. The gauge mechanism allows for accurate measurement of polycentric joints. All sensors connect directly to the MP150/100 unit as part of an MP System. Activity data can be displayed and recorded, leaving the subject to move freely in the normal environment.



The bending strain is proportional to the sum total angular shift along the axis. Because the bending force is extremely small, the output signal is uniquely a proportional function of the angular shift.

In this example, the TSD130A was connected directly to a DA100C amplifier with the excitation set to ±5 Volts, the DA100C gain was set to 1,000, and Acq*Knowledge* was used to calibrate the signal to provide angular measurements from approximately +90° to -90°.

Twin axis goniometers — Dual output devices that can measure angular rotation about two orthogonal planes simultaneously. Goniometers provide outputs to simultaneously measure around two orthogonally rotational axes (e.g. wrist flexion/extension and radial/ulnar deviations).

TSD130A — use on the wrist or ankle.

TSD130B — use on the elbow, knee or shoulder.

Torsiometers — Measure angular twisting (as on the torso, spine or neck) as opposed to bending. Torsiometers measure rotation about a single axis (e.g. forearm pronation/supination).

TSD130C — use on the neck.

TSD130D — use along the torso or spine.

Single-axis goniometer — Measures the angle in one plane only; designed to measure finger joint movement.

TSD130E — use on the fingers, thumb or toes.

ATTACHMENT TO THE SUBJECT

Various combinations of display and recording instrumentation have been carefully developed fulfilling the requirements of specific research applications. Due to the wide range of applications, one method of attachment cannot be recommended. Experience has proven that standard medical adhesive tape is an excellent adhesion method in the majority of cases. Single-sided and double-sided medical tape (such as BIOPAC TAPE1 or TAPE2) should be used for the best results.

1) Attach pieces of double-sided tape to the underside of the goniometer endblocks.
2) Stick the tape to the subject and allow for the telescoping of the goniometer. The goniometer should be fully extended when the joint is fully flexed.
3) Press the two endblocks firmly onto the subject and ensure that the goniometer is lying over the top of the joint. When the joint is extended, the goniometer may present an "oxbow."
4) For additional security, pass a single wrap of single-sided medical tape around each endblock.
5) Secure the cable and connector leaving the goniometer with tape to ensure that they do not pull and detach the goniometer.

<u>For accurate results from long recordings</u>

Employ double-sided adhesive between the endblocks and skin, and place single-sided adhesive tape over the top of the endblocks. **No tape should come into contact with the spring**. You should also tape the connection lead down near the goniometer.

<u>For applications where quick or rapid movements are involved</u>

Fit a "sock" bandage over the whole sensor and interconnect lead. This does not apply to goniometer TSD130E, which has a different working mechanism.

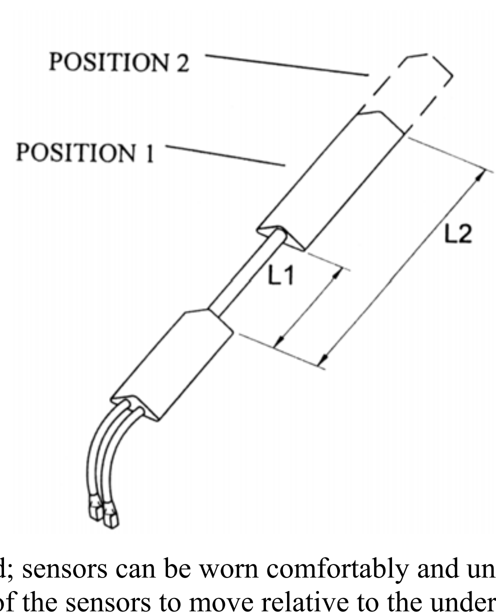
When the goniometer is mounted across the joint, the center of rotation of the sensor measuring element may not coincide with the center of rotation of the joint (for example, when measuring flexion /extension of the wrist). As the joint moves through a determined angle, the relative linear distance between the two mounting positions will change.

To compensate for this, all sensors are fitted with a telescopic endblock that permits changes in linear displacement between the two endblocks along axis ZZ without the measuring element becoming over-stretched or buckled.

In the free or unstretched position, the distance between the two endblocks is L1.

If a light force is applied, pushing the endblocks away from each other, this length will increase to a maximum of L2.

When the light force is removed, the distance between the two endblocks will automatically return to L1.

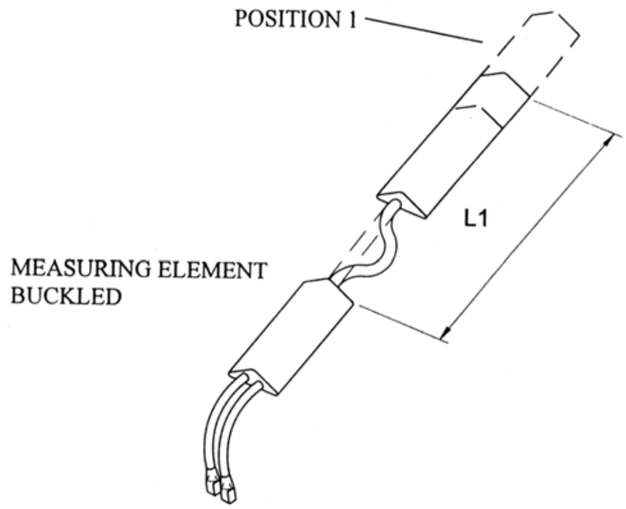


This creates several advantages: accuracy is improved; sensors can be worn comfortably and undetected under normal clothing; the tendency for the position of the sensors to move relative to the underlying skeletal structure is reduced.

If a light force is now applied, pushing the two endblocks linearly towards each other, the only way the distance L1 can decrease in length is if the measuring element buckles.

Buckling is detrimental to the accuracy of the TSD130A, TSD130B, TSD130C and TSD130D sensors, so attachment instructions are provided (on page 70) for the most commonly measured joints, to ensure that it does not occur in practice.

There is no universal rule governing which size of sensor is most suitable for a particular joint; this depends on the size of the subject.



In general, the sensor must be capable of reaching across the joint so that the two endblocks can be mounted where the least movement occurs between the skin and the underlying skeletal structure. In certain circumstances, more than one size of sensor will be appropriate.

WARNINGS

1. Take care to handle the goniometer and torsiometer sensors as instructed. Mishandling may result in inaccurate data, reduced equipment life, or even failure.
2. Observe the minimum bend radius value for each goniometer and torsiometer at all times, particularly when attaching and removing the sensors from the subject. Failure to do this will result in reduced equipment life or failure.
3. Never remove the goniometer from the subject by pulling on the measurement element and/or protective spring. Remove the endblocks individually and carefully, making sure not to exceed the minimum permissible bend radius, particularly where the measuring element enters the endblocks.
4. Take care when mounting goniometers to ensure that the measurement element always forms a “simple” bend shape. Accuracy will be reduced if an “oxbow” shape occurs in the element.
5. Do not bend the finger goniometer more than ±20° in the Y-Y Plane or reduced equipment life and/or failure may result.
6. Do not exceed rotations of ± 90° about ZZ. Exceeding the torsiometer range may result in a reduction of the life of the unit or failure.
7. Disconnect the transducers from the MP150/100 before cleaning or disinfecting goniometers and torsiometers.

CLEANING and DISINFECTION

***Important*:** When cleaning or disinfecting, the sensors must be disconnected from all instrumentation.

Cleaning: Clean by wiping the sensors with a damp cloth, or a cloth moistened with soapy water. No solvents, strong alkaline or acidic materials should be used to clean the sensors, or damage will result.

Disinfection: Disinfect the sensors by wiping the sensors with a cloth moistened with disinfectant.

MAINTENANCE & SERVICE

No periodic maintenance is required to ensure the correct functioning of the sensors.

The sensors contain no user serviceable components.

If the sensor fails, it should be returned to BIOPAC Systems, Inc.

→ **Please request a Return Merchandise Authorization** (RMA) number before you return the sensor and include a description of what has been observed and what instrumentation was in use at the time of sensor failure in the return package.

TSD130 Series Calibration

Each goniometer requires a DA100C amplifier per rotational axis. Accordingly, the twin axis goniometers will need two DA100C amplifiers to measure both rotational axes simultaneously. The recommended DA100C excitation voltage is ±5 VDC.

When using all goniometers and torsiometers**, the minimum value of bend radius must be observed at all times**, particularly when attaching and removing the sensors from the subject. Failure to do this will result in reduced unit life or failure.

The sensors have been designed to be as light as possible and the operating force to be a minimum. This permits free movement of the joint without influence by the sensors. The sensors measure the angle subtended between the endblocks. Use the software calibration features (Under **Setup Channels**) to calibrate any of the BIOPAC series goniometers.

See DA100C Calibration options on page 40.

TSD130 Specifications

Part:	**TSD130A**	**TSD130B**	**TSD130C**	**TSD130D**	**TSD130E**
Type:	Goniometer	Goniometer	Torsiometer	Torsiometer	Goniometer
Channels:	2	2	1	1	1
Range:	±180°	±180°	±90°	±90°	±180°
Max Length:	110mm	180mm	110mm	180mm	35mm
Min Length:	75mm	130mm	75mm	130mm	30mm
Cable(s):	2	2	1	1	1
Weight:	17g	19g	17g	19g	8g
Cable Length:		3 meters			
Nominal Output:		5 µV/degree (normalized to 1V excitation)			
Interface:		DA100C—see page 38			
TEL100C Compatibility:		SS20 thru SS24—see page 208			

OVERVIEW OF THE BIOPAC GONIOMETER SERIES

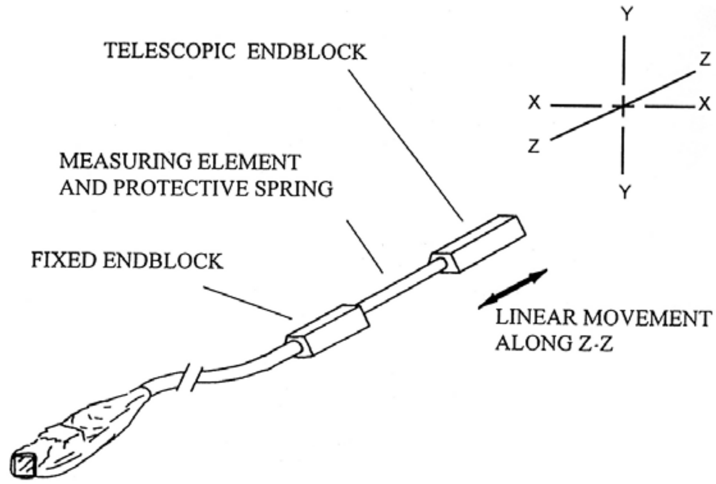
As with all measuring equipment, to correctly interpret the data, you should understand the working principles (i.e. what the sensor actually measures) before use. BIOPAC Systems, Inc. manufactures three types of sensors:

1.

The TSD130E single axis finger goniometer permits the measurement of angles in one plane.

Angles are measured when rotating one endblock relative to the other about axis X-X.

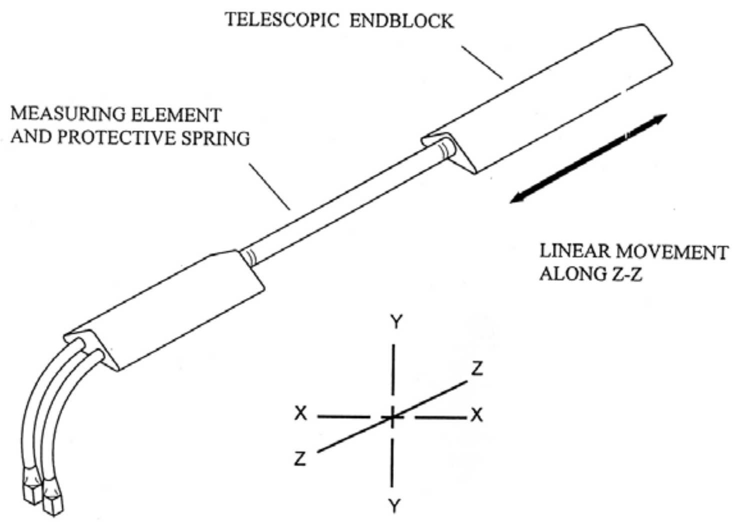
The goniometer is not designed to measure rotations about Y-Y. Any attempt to bend the unit in this way more than ± 20 from the neutral position will result in a reduction of the life of the unit or failure.



The goniometer does not measure rotations about axis Z-Z, though this movement is permitted without reduced life or damage occurring. This goniometer is designed primarily for the measurement of finger and toe flexion/extension.

2.

The TSD130A and TSD130B twin axis goniometers permit the simultaneous measurement of angles in two planes, e.g. wrist flexion / extension and radial / ulnar deviation. Rotation of one endblock relative to the other about axis X-X is measured using the gray plug. Similarly, rotation of one endblock relative to the other about axis Y-Y is measured using the blue marked plug.



Assuming the goniometer is mounted correctly (as outlined here), the outputs of the two channels are independent of linear displacements along axis Z-Z.

It should be noted that rotation of one endblock relative to the other around axis Z-Z cannot be measured.

All TSD130A and TSD130B series goniometers function in the same way, and differ only in size.

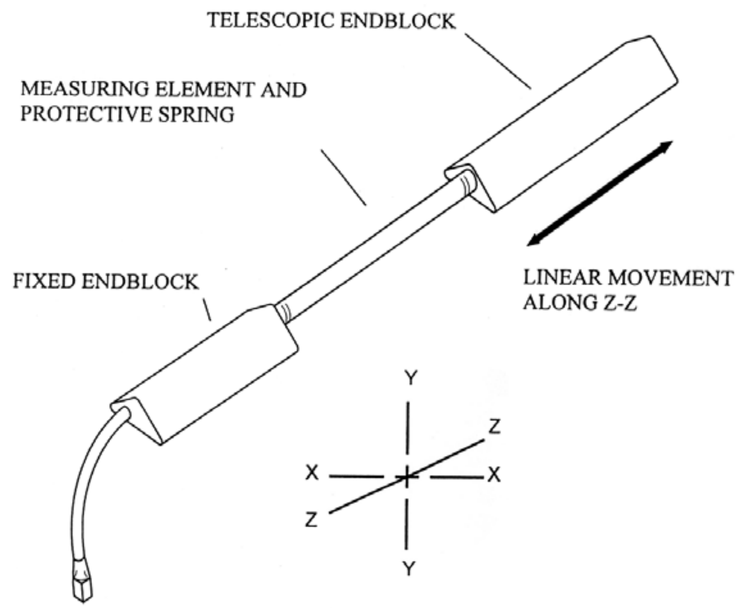
3.

The TSD130C and TSD130D single axis torsiometers permit the measurement of rotation in one plane, e.g. forearm pronation/supination.

Axial rotation of one endblock relative to the other along axis Z-Z is measured from the gray plug.

If the torsiometer is bent in planes X-X or Y-Y, the output remains constant.

All torsiometers function in the same way, and difference only in size.

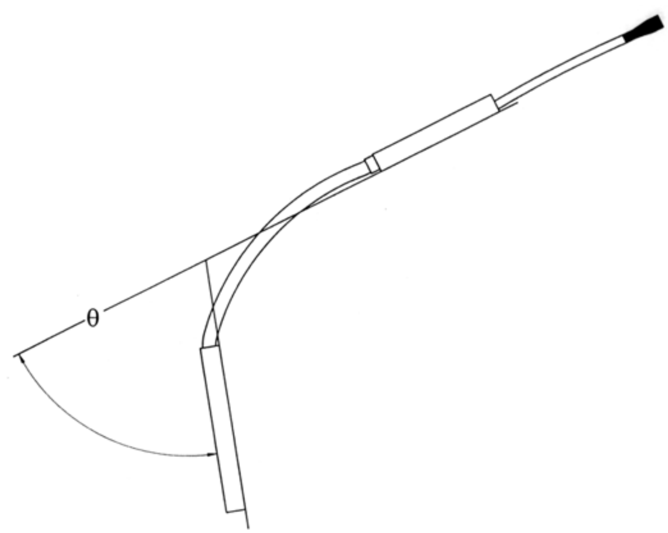


WARNING!

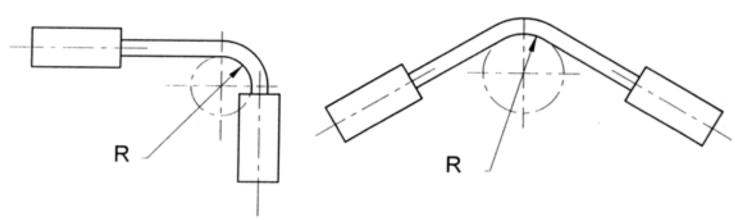
Torsiometers measure rotations about ZZ in the range ± 90°. Exceeding the range may result in a reduction of the life of the unit or failure.

The working mechanism is the same for all three types of sensors. There is a composite wire between the two endblocks that has a series of strain inside the protective spring gauges mounted around the circumference. As the angle between the two ends changes, the change in strain along the length of the wire is measured and this is equated to an angle. The design is such that only angular displacements are measured.

If the two ends move linearly relative to each other, within the limits of telescopic endblock, without changing the relative angles between them, then the outputs remain constant.

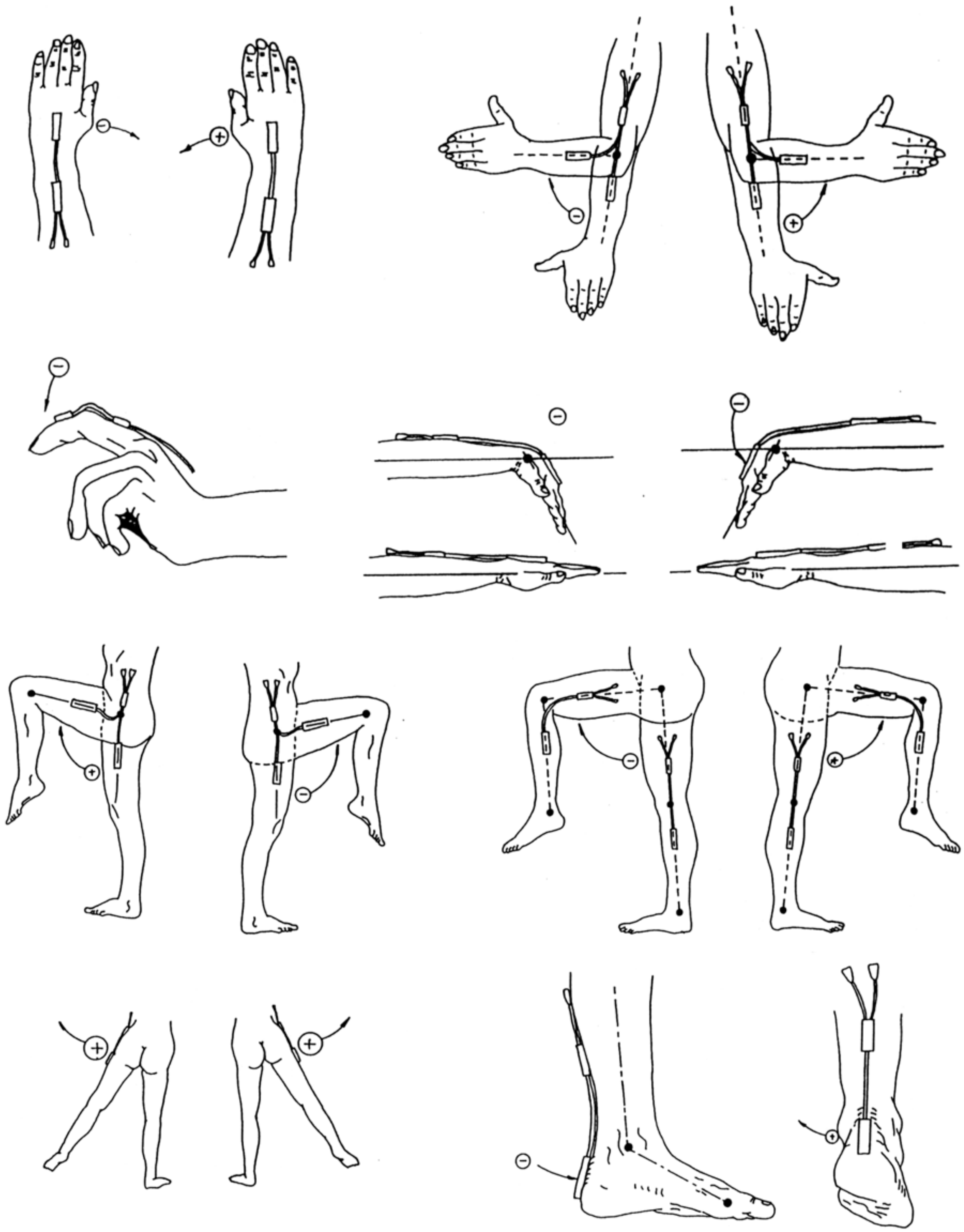


The amount of strain induced in the gauges is inversely proportional to the bend radius that the beam is bent around. If the stated minimum permissible bend radius is exceeded then unit life will be reduced or, in severe cases, failure may result.



SIGN CONVENTIONS

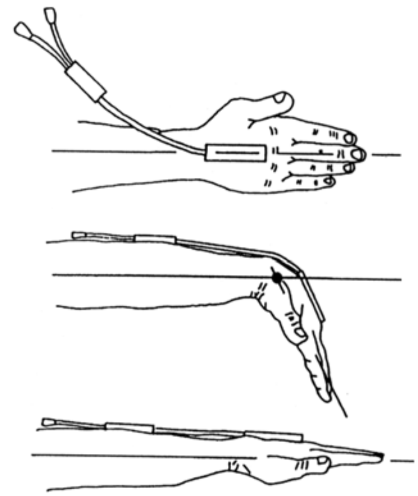
The sign convention for certain joints will differ, depending which side of the body the sensor is attached to. The following figures show sign conventions for the most common joints.



THE WRIST – TSD130A Goniometer

Attach the telescopic endblock to the back of the hand, with the center axis of the hand and endblock coincident (top of figure — viewed in the frontal plane).

While fully flexing the wrist (middle and bottom of figure), extend the goniometer to Position 2 (as shown on page 64) and attach the fixed endblock to the forearm so that when viewed from the dorsal plane, the axes of the forearm and endblock are coincident. The wrist may now be flexed or extended, abducted or adducted, with the goniometer freely sliding between Positions 1 and 2. Measurement of flexion/extension is obtained from the gray plug, and abduction/adduction is obtained from the blue plug.

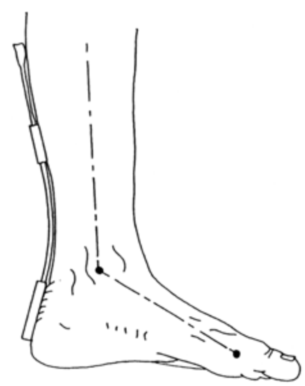


THE ARTICULAR COMPLEX OF THE FOOT – TSD130A Goniometer

Attach the telescopic endblock to the back of the heel.

Extend the ankle to the maximum extension anticipated during measurement, and attach the fixed endblock to the posterior of the leg, with the goniometer in Position 1 (maximum length, as shown on page 64) so that the axes of the leg endblock are coincident.

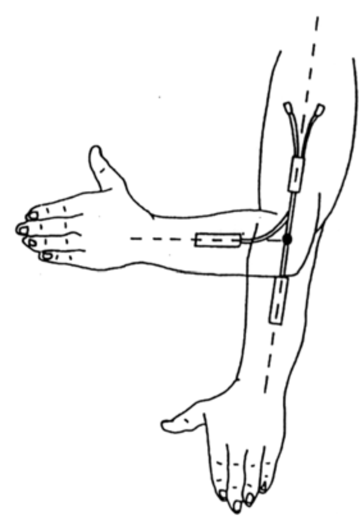
Flexion/extension of the ankle may now be monitored using the gray plug and pronation/supination using the blue marked plug.



THE ELBOW – TSD130B Goniometer

Attach the telescopic endblock to the forearm with the center axis of the endblock coincident with the center axis of the forearm. With the elbow fully extended, move the goniometer to Position 2 (maximum length, as shown on page 64) and attach the fixed endblocks to the upper arm, with the center of the endblock and the center axis of the upper arm coincident.

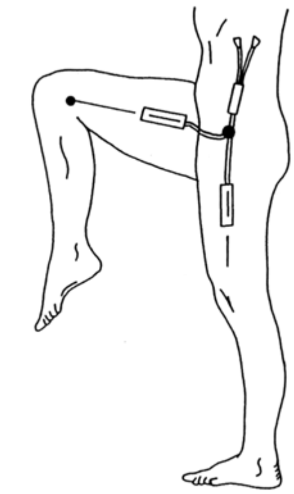
Now the elbow may be fully extended with the telescopic endblock freely sliding between Positions 1 and 2. Measurement of flexion/extension is obtained from the blue marked plug, and the gray plug is redundant. Note that the telescopic endblock is mounted on the half of the forearm nearest to the elbow joint. Movements of pronation and supination may be made and will affect the measurement of flexion/extension by a small amount.



THE HIP – TSD130B Goniometer

Attach the fixed endblock to the side of the trunk in the pelvic region. With the limb in the position of reference, extend the goniometer to Position 2 (maximum length, as shown on page 64) and attach the telescopic endblock to the thigh, so that axes of the thigh and endblock coincide (when viewed in the sagittal plane, as shown).

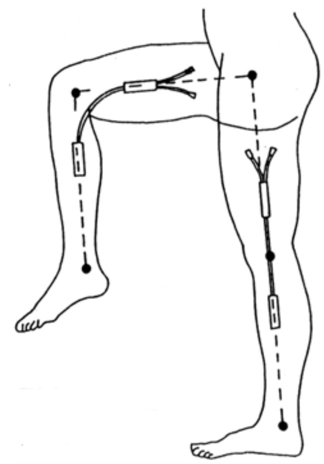
The thigh may now be flexed or extended, abducted or adducted, with the goniometer sliding freely between Positions 1 and 2. Measurements of flexion/extension are obtained from the blue marked, and abduction/adduction from the gray plug.



THE KNEE – TSD130B Goniometer

Mount the telescopic endblock laterally on the leg so the axes of the leg and endblock coincide, when viewed in the sagittal plane. With the leg fully extended in the position of reference, extend the goniometer to Position 2 (maximum length, as shown on page 64) and attach the fixed endblock to the thigh so the axes of the thigh and endblock coincide.

The knee may now be flexed or extended with the goniometer freely sliding between Positions 1 and 2. Measurements of flexion/extension may be monitored using the blue marked plug and varus/valgus may be monitored using the gray plug.



FOREARM PRONATION /SUPINATION – TSD130C or **TSD130D** Torsiometer

Attach the two endblocks of the torsiometer to the forearm, with the slider mechanism approximately midway between the two extremes.

Measurements of pronation/supination may now be made from the gray plug. Movements of wrist flexion/extension or radial/ulnar deviation will not effect the output.

FINGERS AND TOES – TSD130E Goniometer

The TSD130E goniometer is a single axis goniometer intended for use on fingers and toes. Angles are measured by rotating one endblock relative to the other about axis X-X (as shown on page 64).

The goniometer is not designed to measure rotations about Y-Y. **Any attempt to bend the unit in this way more than +/-20° from the neutral position will result in reduced unit life or failure**. The goniometer does not measure rotations about the axis Z-Z.

The unit is designed to fit over the joint to be measured and has extremely high flexibility to ensure the instrument does not interfere with normal joint movement. One endblock is attached either side of the joint.

Unlike the TSD130A and TSD130B series and "Z" series sensors, an "oxbow" shape is permitted in the measuring element. This is not detrimental to the results and does not reduce life of sensor. Care should be taken, however, **that the minimum bend radius is not exceeded**.

TSD 160 Series High Sensitivity Differential Pressure Transducers

The TSD160 series differential pressure transducers are designed for low range pressure monitoring. The transducers plug directly into the DA100C general-purpose differential amplifier. The differential pressure ports are located on the front of the transducers and are easily connected to breathing circuits, pneumotachs or plethysmograph boxes. These transducers are very useful for interfacing a variety of small animal pneumotachs or plethysmographs to the MP System. The transducers are extremely sensitive and come in three ranges to suit a number of different applications. RX137 heads connect to the TSD160A differential pressure transducer via standard 3mm or 4mm ID tubing.

<u>TSD160 Series Specifications</u>

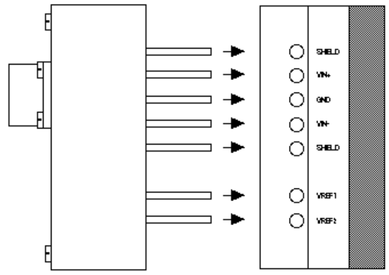
Part	**TSD160A**	**TSD160B**	**TSD160C**
Operational Pressure:	±2.5cm H_2O	±12.5cm H_2O	±25cm H_2O
Overpressure (max):	±250cm H_2O	±375cm H_2O	±375cm H_2O
Voltage Output (normalized to 1 volt excitation):	330 µV/cm H_2O	130 µV/cm H_2O	65 µV/cm H_2O
Warm-up Drift:	±50µV		
Stability:	±100µV		
Operating Temperature:	0 to +50 °C (compensated)		
Storage Temperature:	-40 to +125 °C		
Combined Linearity and Hysteresis Error:	±0.05%		
Dynamic Response:	100Hz		
Connection Ports:	Accepts 3mm to 4.5mm ID tubing		
Dimensions:	8.3cm (high) x 3.8cm (wide) x 3.2cm (deep)		
Weight:	76 grams		
Interface:	DA100C		

TSD160 Series Calibration

See DA100C Calibration options on page 40.

TCI Series Transducer Connector Interfaces

TCI interface options



TCI to DA100C Connection

The transducer connector interfaces (TCIs) adapt a variety of transducer types to the DA100C module. The front of the TCI contains the appropriate connector while the rear has seven 2 mm pin jacks which plug directly into the DA100C.Probes and transducers normally used with Grass, Beckman, World Precision Instruments and Lafayette Instrument's equipment can be used directly with the DA100C when used with the appropriate transducer connector interface.

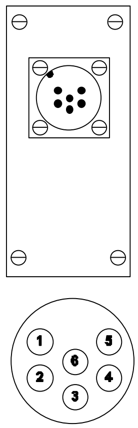
The TCIs match the DA100C to the transducer brands listed below. If no existing connector matches the required equipment, BIOPAC will build a special TCI for users, or users can use the TCIKIT to build their own. Please call or write BIOPAC with specific needs.

TCI100	Grass/Astromed transducers – 6 pin
TCI101	Beckman transducers – 5 pin
TCI102	World Precision Instrument transducers – 8 pin
TCI103	Lafayette Instrument transducers – 9 pin
TCI104	Honeywell transducers – 6 pin
TCI105	Modular phone jack connector – 4 pin
TCI106	Beckman transducers – 12 pin
TCI107	Nihon Koden transducers – 5 pin
TCI108	Narco transducers – 7 pin
TCI109	Fukuda transducers – 8 pin
TCI110	Gould transducers – 12 pin
TCI111	Liquid metal transducers – 2mm sockets (two)
TCI112	Hokansen transducers – 4 pin

TCIPPG1	PPG100C amplifier to Geer Photo-electric (IR) plethysmogram transducer – 7 pin

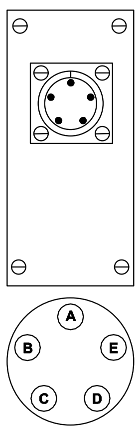
TCIKIT	Build a customized adapter to the DA100C — see page 80

TCI100 Grass transducer interface



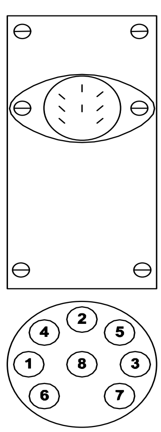
Pin	Signal
1	VREF2 (Set to -1V)
2	VIN-
3	VIN+
4	VREF1 (Set to +1V)
6	GND
Connector	ITT Cannon WK-F-32S
Typical VREF	±1V

TCI101 Beckman transducer interface



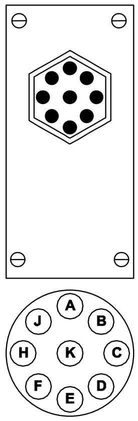
Pin	Signal
A	VIN-
B	VIN+
C	VREF1 (Set to +1V)
D	VREF2 (Set to -1V)
E	GND
Connector	ITT Cannon CA-3102-E-14S-5S
Typical VREF	±1V

TCI102 WPI transducer interface



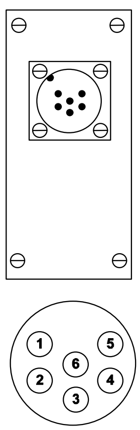
Pin	Signal
1	VREF1 (Set to +5V)
2	VIN+
3	VIN-
4	VREF2 (Set to -5V)
Connector	CUI Stack SDS-80J
Typical VREF	±5V

TCI103 Lafayette transducer interface



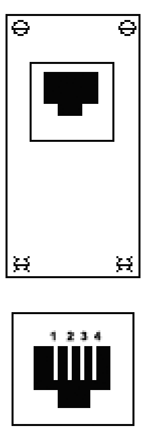
Pin	Signal
C	VREF2 (Set to -5 V)
E	GROUND
H	VIN+
K	VREF1 (Set to +5 V)
Connector	Amphenol 12F-013
Typical VREF	± 5V

TCI104 Honeywell transducer interface



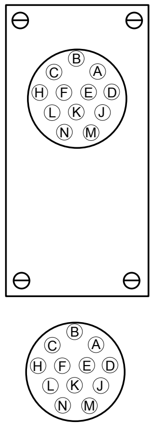
Pin	Signal
1	VREF2 (Set to -1 V)
2	VIN-
3	VIN+
4	VREF1 (Set to +1 V)
5	GND
Connector	ITT Cannon WK-F-32S
Typical VREF	±1V

TCI105 Phone plug (RJ-11) transducer interface



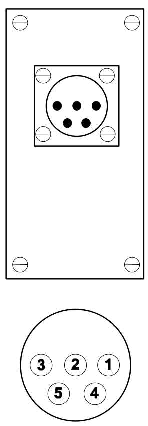
Pin	Signal
1	VREF1 (Set to +3 V)
2	VIN +
3	VIN -
4	VREF2 (Set to -3 V)
Connector	RJ-11 Phone plug
Typical VREF	±2 V DC

TCI106 Beckman (12-pin) transducer interface



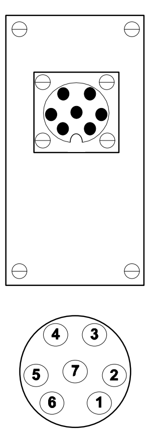
Pin	Signal
A	VIN +
B	VIN -
C	VREF2 (-1 V)
D	VREF1 (+1 V)
E	Ground
Connector	Amphenol 165-12
Typical VREF	±1 V

TCI107 Nihon Kohden transducer interface



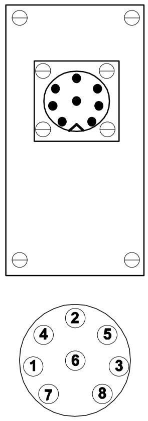
Pin	Signal
2	VIN+
3	VREF1 (+1 V)
4	VREF2 (-1 V)
5	VIN -
Connector	JAE SRC-02A13-5S
Typical VREF	±1 V

TCI108 Narco (7-pin) transducer interface



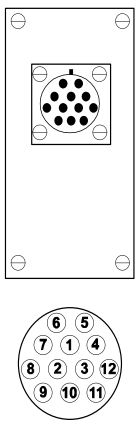
Pin	Signal
1	VIN+
2	VIN -
4	GND
5	(connect 1,600-ohm resistor between pins 5 and 7)
6	VREF1 (+1 V)
7	VREF2 (-1 V)
Connector	Amphenol 703-91T-3478-009
Typical VREF	±1 V

TCI109 Fukuda transducer interface



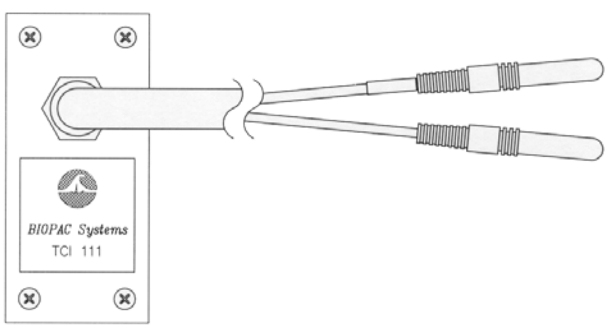
Pin	Signal
1	VIN+
3	VIN-
6	VREF2 (-1V)
7	VREF1 (+1V)
Connector	Hirshmann MAS 8100
Typical VREF	±1 V

TCI110 Gould transducer interface



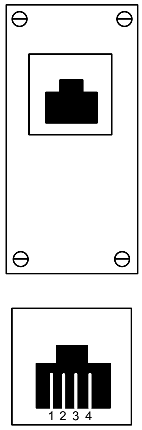
Pin	Signal
8	VREF2 (-1 V)
9	VREF1 (+1 V)
10	GND
11	VIN+
12	VIN-
Connector	Gould 288926
Typical VREF	±1 V

TCI111 Liquid metal transducer interface



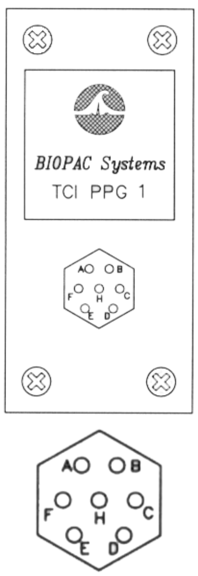
Connector:	Signal
A (top)	XDCR
B (bottom)	XDCR
Connector Type:	2 mm socket (accepts 2mm pin XDCRs)

TCI112 Hokansen transducer interface



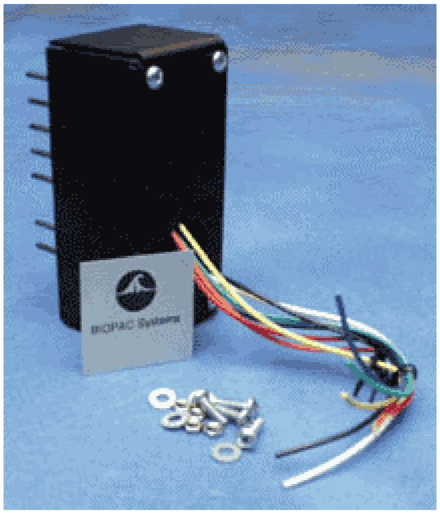
Pin	Signal
1	Iex $^{+}$
2	VIN $^{+}$
3	VIN $^{-}$
4	Iex $^{-}$
Connector	RJ-11 Phone plug
Typical Iex:	5 mA

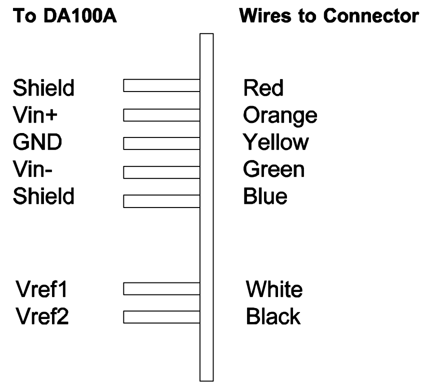
TCIPPG1 PPG—Geer transducer interface



Pin	Signal
A	not used
B	not used
C	not used
D	Ground
E	VIN +
F	+5 Vex
G	not used
Connector	Amphenol 7-pin

TCIKIT Custom Interface Kit





Build custom transducer connector interfaces for DA100C amplifier modules. The do-it-yourself **TCI Kit** includes housing, PC board with 7 attached PIN plugs (2mm) and instructions. The kits come partially assembled. Mount a connector to the housing and solder wires to the pins.

The TCI case has two connector holes on the front, 0.44" and 0.75" in diameter. These sizes should accommodate most connectors. The aluminum label is intended to cover up the unused hole. Color-coded wires have been soldered to each of the seven DA100C input pins. They are connected as shown above.

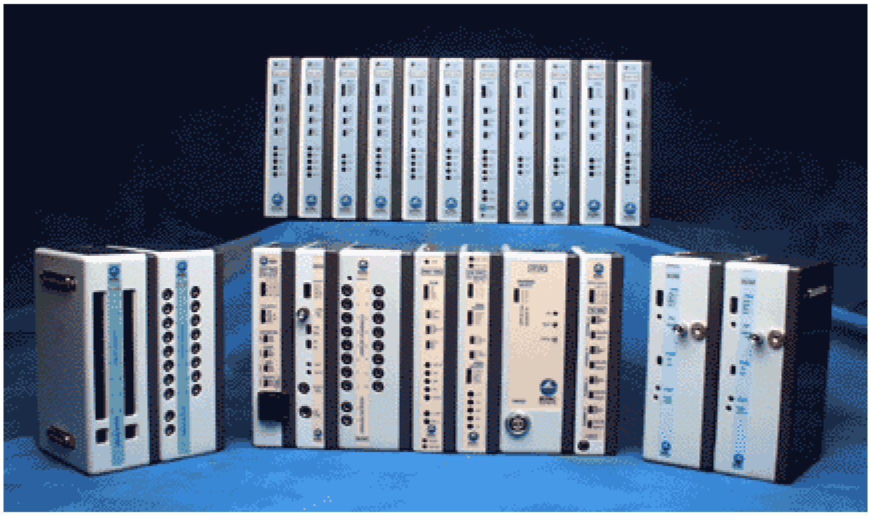
Adapting the TCI

The following instructions are for adapting the TCI for any particular connection. A "Bulkhead Mount" connector is the best type of connector to use.

1. Remove four screws from back of TCI so that the TCI PC board and case are separate.
2. Remove four connector-mounting screws from TCI case and set aside.
3. Check to see that your connector fits the TCI case. If not, the smaller (0.44") hole can be enlarged using a hole enlarging drill bit.
4. Clip off unused wires from the TCI PC board. Be very careful not to clip the ones you need.
5. Note that most connectors must be mounted from the outside of the case. This means that the wires should first be routed through the appropriate hole, then soldered to the connector.
6. Solder the appropriate wires to the connector.

   CAUTION! When you solder wires or components on the TCI PC board, be very careful not to desolder the pre-aligned pin plugs. You may not be able to get them straight if you inadvertently desolder them.
7. Bolt the connector to the case using the supplied 4-40 screws and nuts.
8. Bolt the TCI PC board to the TCI case.
9. Cover unused hole with supplied label.

Chapter 4 Biopotential / Transducer 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 (specifications start on page 81)
- **Transducer modules**: GSR100C; PPG100C; RSP100C; SKT100C (specifications start on page 102)

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.

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 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 *xxx*100C 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 of the 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 of the 100C series biopotential amplifiers incorporate a selectable interference filter. When the interference filter is on, 50/60Hz interfering signals are suppressed.

Filters All of the 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.

Line Freq Line Frequency is set using the recessed switch boxes on the back of the amplifier module (50 Hz = all switches down). See individual module sections for details.

Biopotential Modules

Biopotential amplifier modules: ECG; EEG; EGG, EMG; EOG; ERS.

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:

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

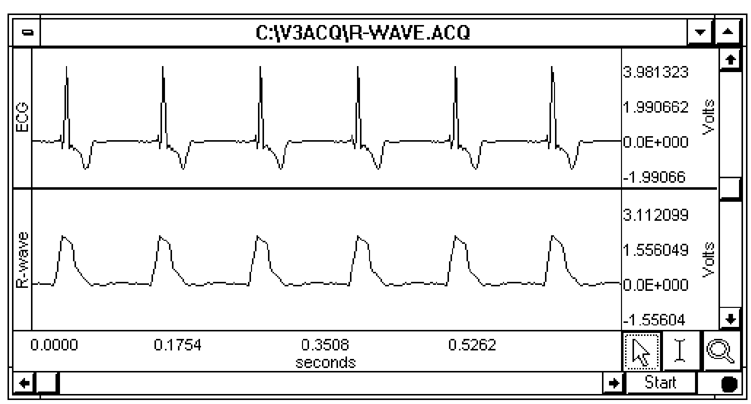
The ECG100C will connect directly to any of BIOPAC Systems, Inc.'s series of Ag-AgCl lead electrodes. The best choice for electrodes depends on the application, but typically the EL500 series (i.e., EL501, EL502, EL503) of adhesive/disposable snap electrodes are used in conjunction with the LEAD110/LEAD110S pinch lead. If reusable electrodes are required, the EL258 is typically used; when using EL258 electrodes, you will also need adhesive disks (ADD208) and electrode gel (GEL100). Use two shielded electrodes (EL208S) 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:

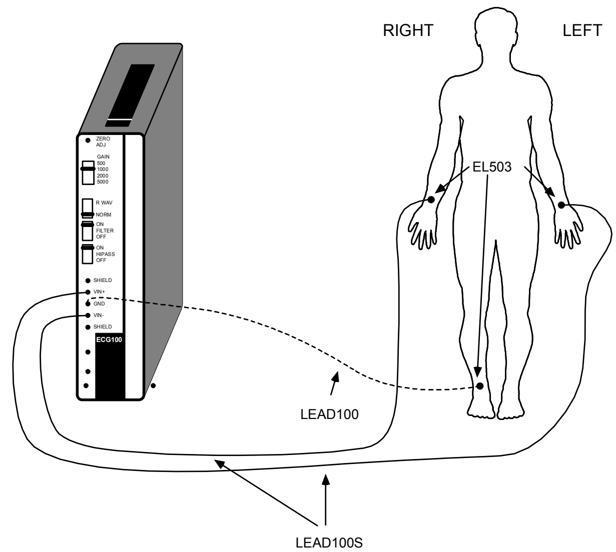
- 17Hz band pass filter with Q = 5
- Full wave rectifier
- 10.0Hz, three pole, low pass filter with Q = 0.707

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

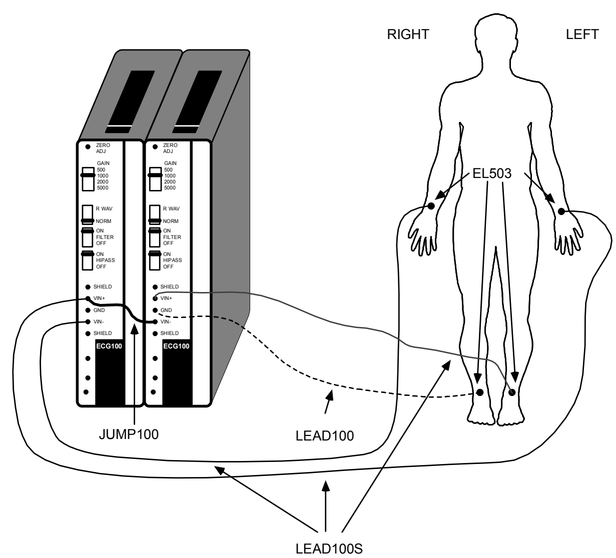
Recording a 12-lead ECG

- ❖ For full, simultaneous, 12-lead ECG recording, eight ECG100C amplifiers are required, along with a WT100C Wilson Terminal (see page 86). Two of the ECG100C are used to simultaneous 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 (page 86). 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].

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.



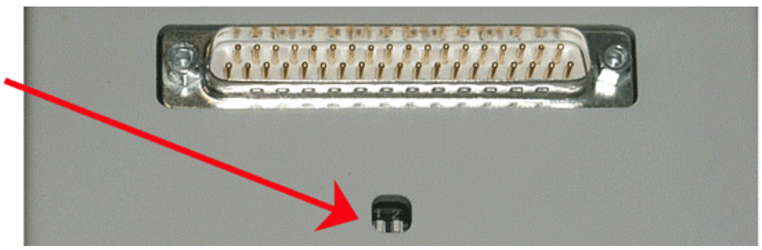
Frequency Response Characteristics

The ECG100C includes a high pass filter that is used to stabilize the ECG baseline. When the **HP** switch is set to 1.0Hz, 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.

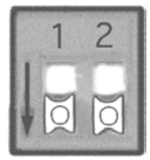
The 0.05Hz and 1Hz lower frequency response settings are single pole roll-off filters.

Modules are factory preset for 50Hz or 60Hz 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 60Hz in the United States and 50Hz in most of Europe; contact BIOPAC if you are unsure of your country's line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

Line Frequency switch bank is on the back of the amplifier

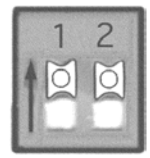


50Hz



Both switches DOWN

60Hz



Both switches UP

See the sample frequency response plots beginning on page 215: 35Hz LPN option (with 50Hz notch enabled), 100Hz LP option, and 35Hz LPN option (with 60Hz notch enabled)

ECG100C Calibration

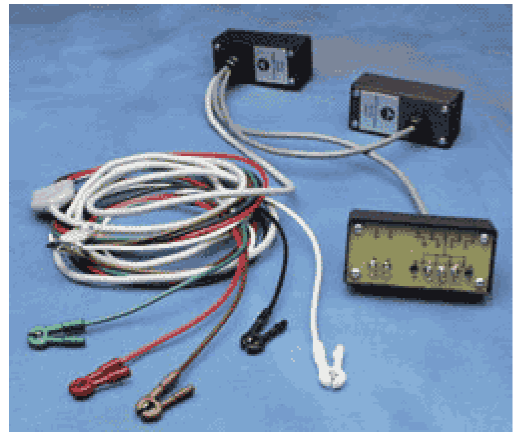
The ECG100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCALC.

<u>ECG100C Specifications</u>

Gain:	500, 1000, 2000, 5000	
Output Selection:	Normal, R-wave indicator	
Output Range:	±10V (analog)	
Frequency Response	Low Pass Filter:	35Hz, 150Hz
	High Pass Filter:	0.05Hz, 1.0Hz
Notch Filter:	50dB rejection @ 50/60Hz	
Noise Voltage:	0.1µV rms - (0.05-35Hz)	
Signal Source:	Electrodes (three electrode leads required)	
Z (input)	Differential:	2MΩ
	Common mode:	1000MΩ
CMRR:	110dB min (50/60Hz); see Shield Drive Operation on page 215	
CMIV--referenced to	Amplifier ground:	±10V
	Mains ground:	±1500 VDC
Input Voltage Range:	<u>Gain</u>	<u>Vin (mV)</u>
	500	±20
	1000	±10
	2000	±5
	5000	±2
Weight:	350 grams	
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)	

See also: JUMP100C and MEC series

TSD155C Multi-lead ECG Cable



To record 12-lead ECG with a movable chest lead, 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].

The TSD155C is used for performing a standard 12-lead ECG recording using only 3 ECG100C amplifiers.

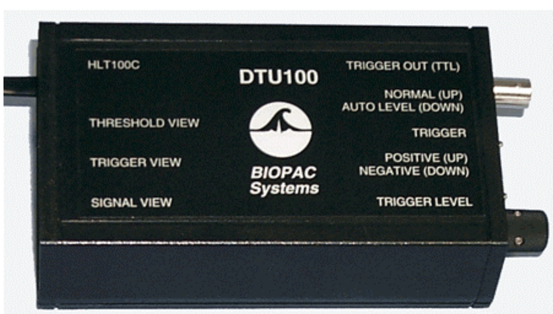
TEL100 Compatibility: SS29, page 208

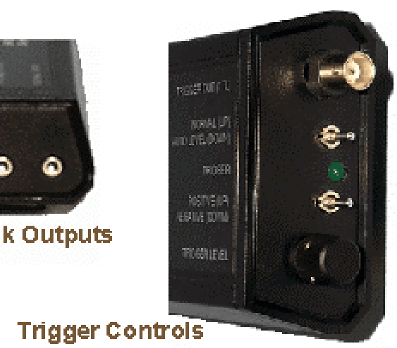
WT100C Wilson Terminal for the ECG100C

The WT100C is used to create a virtual reference electrode when measuring the transverse plane (i.e. precordial) ECG components [V1, V2, V3, V4, V5, and V6]. The virtual reference is created by the summation of the Right Arm (RA), Left Arm (LA) and Left Leg (LL) electrode leads. To measure all six transverse plane components, six ECG100C amplifiers are required. Use five of the JUMP100C jumper connectors to tie together the reference (Vin-) inputs of these amplifiers. This common reference connects to the virtual reference created by the WT100C.

DTU100 Digital Trigger Unit

Digital Trigger (MRI Trigger)





Use the DTU100 Digital Trigger Unit to trigger an MRI System with the occurrence of the R-wave present in animal (high frequency) ECG data. The DTU100 provides high-level (3000 v) isolation between the MP System and external equipment; the DTU100 is always used with the HLT100C module. This isolation is very important to maintain both subject safety and high quality signal recording. This external hardware module can accept data from any analog output associated with an MP System and convert that analog signal into a TTL compatible trigger suitable for synchronizing with external devices.

For the DTU100, "Analog output" means:

1) Analog output associated with any MP module (DA100C, ECG100C, etc) that is sending data to an MP System on Analog Input channels 1–16.
2) Analog output coming from the MP system via one of its D/A converters on Analog Output channel 0–1.

DTU100 CONTROLS

HLT100C The DTU100 is always used with the HLT100C module. Use the RJ-11 straight through cable provided by BIOPAC to plug the DTU100 into the HLT100C.

Feedback Views The DTU100 incorporates three feedback outputs that can be monitored on the MP System to properly set the threshold (trigger) level and required Trigger Out polarity for any type of analog input. Use a 3.5 mm mono phono cable (CBL100) to connect the respective line to an unused MP system input channel.

Threshold View Shows the Threshold (Trigger) Level

Trigger View Shows the Trigger Output as sent to the external equipment.

Signal View Shows the analog input signal as sent to the DTU100.

Trigger Out Connect a TTL line with BNC female connector between the DTU100 and your trigger device.

Normal/Auto Level The DTU100 incorporates an optional Automatic Level control circuit. The Automatic Level control circuit will expand or compress the analog input signal to fit inside of a ±5v range.

- Normal — use if the analog input signal is clearly defined.
- Auto Level — use if the analog input signal has a widely varying baseline or significant change in amplitude from one desired trigger point to the next; or you can try to improve signal definition.

Trigger The Trigger LED (green) lights up whenever the Trigger Out signal goes high.

Positive/Negative If analog data is above the threshold setting the DTU100 output can be set to either high (+5v) or low (0.0v). When analog data drops below the threshold value the output will be the opposite level.

Trigger Level Select a trigger level (or threshold) that will fire when analog data reaches that threshold.

SYNCHRONIZATION

To synchronize an MRI System with the occurrence of the R-wave, record animal (high frequency) ECG data on an ECG100C amplifier and direct the output to an analog input channel on the MP100/150 Unit.

a) Plug the DTU100 into channel 1 of the analog channels section of the HLT100C module.

b) Use CBL100 cables to connect the Threshold, Trigger and/or Signal View to unused inputs on the UIM100C, if required.

c) Connect the Trigger Out (TTL) line to the MRI system requiring synchronization to the R-wave of the ECG.

d) If the R-Wave is a clearly defined peak, run the DTU100 in Normal mode. If the R-wave is not always predominant, consider operating the DTU100 in Auto Level mode, or change the location of ECG leads on the subject to obtain a better-defined R-wave peak.

e) Adjust the Trigger Level potentiometer to obtain a Trigger Signal. Change the Trigger Out polarity to Positive or Negative as required for the MRI equipment. Verify proper operation by noting the periodic lighting of the green Trigger LED. This LED should light briefly whenever the R-wave is detected.

EEG100C - Electroencephalogram Amplifier module

The electroencephalogram amplifier module (EEG100C) is a single-channel, high-gain, differential input, biopotential amplifier designed specifically for monitoring the neuronal activity of the brain. The EEG100C is designed for use in the following applications:

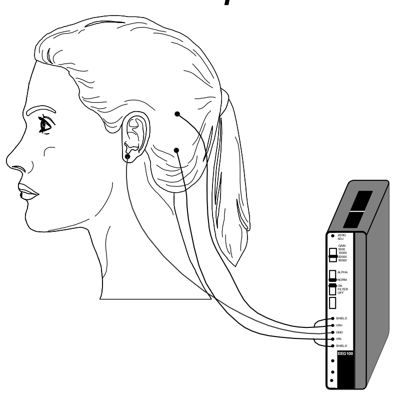
Conventional EEG (16 channel, unipolar or bipolar)	Sleep studies
Epilepsy investigations	Evoked responses
Tumor pathology studies	Cognition studies

The EEG100C will connect directly to any of BIOPAC Systems, Inc.'s series of Ag-AgCl lead electrodes. Typically, EL503 electrodes are recommended for evoked response measurements. Use two shielded electrodes (LEAD110S) for the signal inputs and one unshielded electrode (LEAD110) for ground. If hair is present, disposable electrodes don't work very well for scalp attachment, and you should use electrode gel (GEL100) and tape the electrode lightly in place or use a conductive adhesive paste (like Ten20® or Collodion HV®).

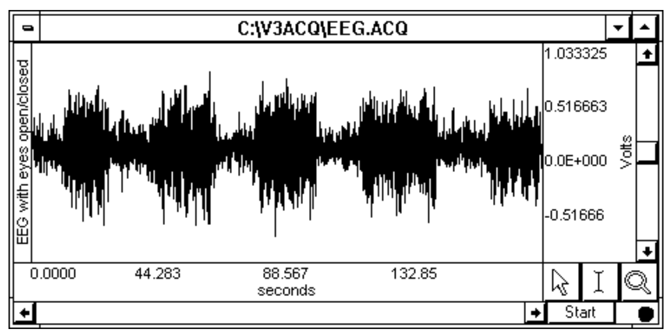
The EEG100C has built-in drive capability for use with shielded electrode leads. If high bandwidth (resolution) EEG measurements are required, then shielded electrode leads are recommended. When the interference filter is switched on, shielded leads are typically not necessary.

This module is designed to pass the EEG signal ranges (Delta, Theta, Alpha, Beta, and Gamma) with minimal distortion. In addition, the EEG100C has a built-in Alpha wave detector. When enabled, the output signal will produce a smoothed wave with peaks that indicate points of maximum Alpha activity. The Alpha wave detector consists of a highly selective, six pole, 8-13Hz bandpass filter, followed by a full wave rectifier, followed by a 6Hz, three pole, low pass filter.

Bipolar EEG electrode placement



Bipolar connection to the occipital lobe



EEG waveform with eyes closed then opened

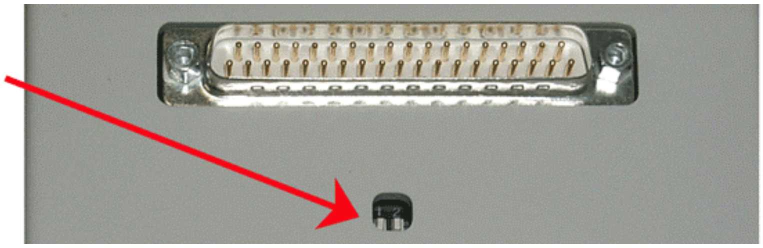
The illustration above shows a bipolar connection to the occipital lobe; to make a unipolar connection, relocate the VIN- electrode to the earlobe (where GND is attached). The graph indicates the change in the occipital EEG when eyes are closed and opened. The data is shown compressed, but can easily be expanded to show waveform differences in greater detail.

Frequency Response Characteristics

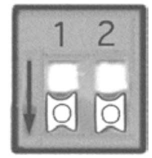
The 0.1Hz and 1Hz lower frequency response settings are single pole, roll-off filters.

Modules are factory preset for 50Hz or 60Hz 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 60Hz in the United States and 50Hz in most of Europe; contact BIOPAC if you are unsure of your country's line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

Line Frequency switch bank is on the back of the amplifier

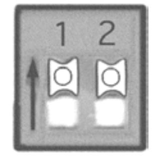


50Hz



Both switches DOWN

60Hz



Both switches UP

See the Frequency response Plots beginning on page 215: 35Hz LPN (with 50Hz notch enabled)
35Hz LPN (with 60Hz notch)
100Hz LP option

EEG100C Calibration

The EEG100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCALC.

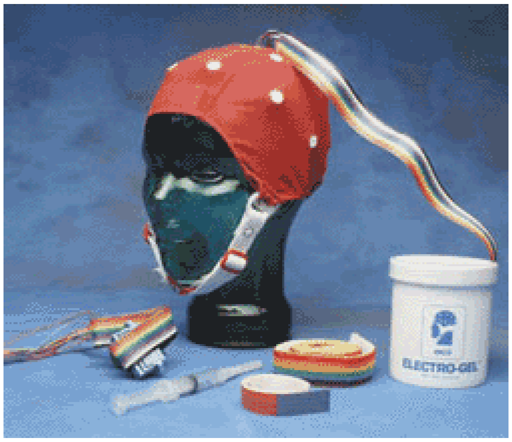
Hardware settings are based on line frequency, which varies by country. To confirm that line frequency is set correctly for your country, check the switches on the back panel of the amplifier.

<u>EEG100C Specifications</u>

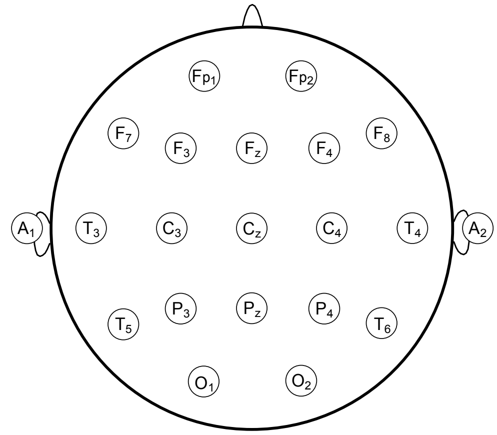
Gain:	5000, 10000, 20000, 50000	
Output Selection:	Normal, Alpha Wave indicator	
Output Range:	±10V (analog)	
Frequency Response		
Low Pass Filter:	35Hz, 100Hz	
High Pass Filter:	0.1Hz, 1.0 Hz	
Notch Filter:	50dB rejection @ 50/60Hz	
Noise Voltage:	0.1µV rms - (0.1–35Hz)	
Signal Source:	Electrodes (three electrode leads required)	
Z (input)		
Differential:	2MΩ	
Common mode:	1000MΩ	
CMRR:	110dB min (50/60Hz); see Shield Drive Operation on page 215	
CMIV—referenced to		
Amplifier ground:	±10V	
Mains ground:	±1500 VDC	
Input Voltage Range:	<u>Gain</u>	<u>Vin (mV)</u>
	5000	±2
	10000	±1
	20000	±0.5
	50000	±0.2
Weight:	350 grams	
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)	

See also: JUMP100C
MEC series

CAP100C Electrode Cap



Electrode cap (CAP100C)

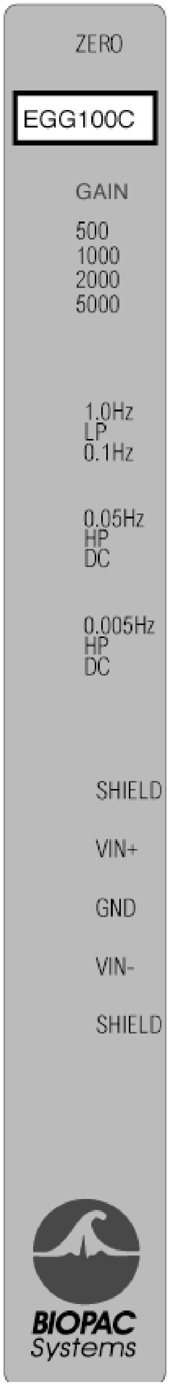


International 10-20 electrode montage

The CAP100C is a fabric cap with recessed tin electrodes attached to the Lycra-type fabric. The electrodes are pre-positioned in the International 10-20 montage (shown above). The standard (medium) electrode cap fits most subjects over age five; infant, small, and large caps are also available.

Leads from the electrode cap terminate in 2-mm pin plugs, which are typically connected to inputs on the **EEG100C**. Since leads are available for all electrodes, unipolar or bipolar montage recordings can be obtained. The electrode cap comes with two ground electrodes, and can also be used for evoked potential investigations (such as ABR).

EGG100C - Electrogastrogram Amplifier module



The EGG100C amplifies the electrical signal resulting from stomach and intestinal smooth muscle activity. The amplifier monitors the DC potential on the skin surrounding, or surface of, the intestine and stomach, which is indicative of the degree of slow wave contraction. The amplifier permits DC coupling to electrodes for signal amplification and presentation without discernible decay.

The gastric slow wave (ECA) originates in the proximal stomach and propagates distally towards the pylorus. For recording, place multiple surface electrodes on the abdomen along the gastric axis and connect them to respective EGG100C amplifiers that have a common reference electrode placed near the xiphoid process. For consistent electrode-to-electrode spacing, use the EL500 dual electrodes with LEAD110 leads. For extremely tight electrode-to-electrode spacing, use the EL254 or EL258 reusable Ag-AgCl lead electrodes. The signals amplified at each electrode will be displayed on consecutive channels in Acq*Knowledge*.

Frequency Response Characteristics

Modules are factory preset for 50 or 60Hz notch options, depending on the destination country.

The 0.005Hz and 0.05Hz lower frequency response settings are single pole, roll-off filters.

See the Frequency Response Plots beginning on page 215: 0.1Hz LP, 1Hz LP.

EGG100C Calibration

The EGG100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCALC.

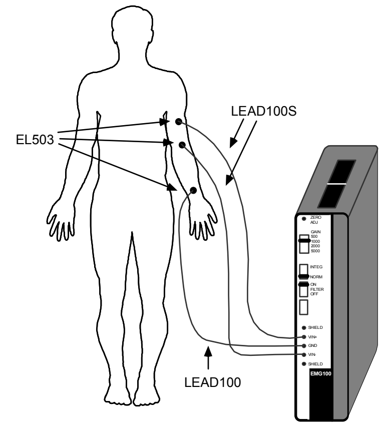
EGG100C Specifications

Gain & Input Voltage:	Gain	Vin (mV)
	500	±20
	1000	±10
	2000	±5
	5000	±2
Output Range:	±10V (analog)	
Frequency Response		
Low Pass Filter:	0.1Hz, 1Hz	
High Pass Filter:	DC, 0.005Hz, 0.05Hz	
Notch Filter:	50dB rejection @ 50/60Hz	
Noise Voltage:	0.1µV rms - (0.005-1.0Hz)	
Signal Source:	Electrodes (three electrode leads required)	
Z (input)		
Differential:	2MΩ	
Common mode:	1000MΩ	
CMRR:	110dB min (50/60Hz); see Shield Drive Operation on page 215	
CMIV—referenced to		
Amplifier ground:	±10V	
Mains ground:	±1500 VDC	
Weight:	350 grams	
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)	

EMG100C - Electromyogram Amplifier module

The electromyogram amplifier module (EMG100C) is a single-channel, high-gain, differential input, biopotential amplifier designed specifically for monitoring muscle and nerve response activity. The EMG100C is designed for use in the following applications:

- Conventional bipolar EMG measurement
- Biomechanics
- Nerve conduction measurement
- Muscular reflex studies
- Motor unit potential measurement

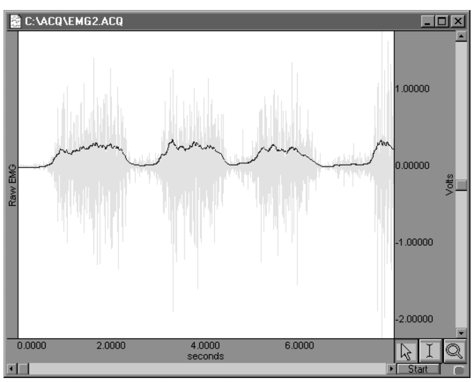


Electrode connections to the EMG100C to measure EMG activity from the arm biceps

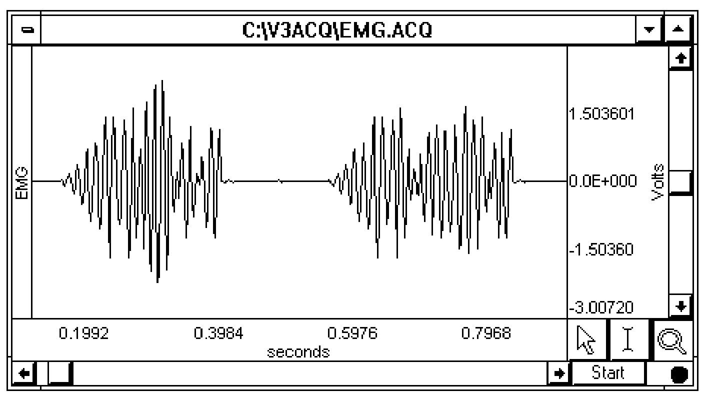
The EMG100C will connect directly to any of BIOPAC Systems, Inc.'s series of Ag-AgCl lead electrodes. The best choice for electrodes depends on the application, but typically, the EL503 adhesive/disposable snap electrodes are used in conjunction with the LEAD110S pinch lead. If reusable electrodes are required, the EL508S is typically used; when using EL508S electrodes, you also need adhesive disks (ADD208) and electrode gel (GEL100). Use two shielded electrodes (LEAD110S/EL503 or EL508S) for the signal inputs and one unshielded electrode (LEAD110/EL503 or EL508) for ground.

The EMG100C has built-in drive capability for use with shielded electrode leads. Shielded leads are typically required, as the EMG100C has a frequency response that extends through the 50/60Hz interference bands. The EMG100C is designed to pass EMG signals and signals associated with nerve responses.

The EMG100C incorporates a variety of filtering options to optimize the amplifier performance when recording from either surface or needle electrodes, and when recording from either muscle or nerves. For instance, when recording EMG (muscle) from surface electrodes, the 10Hz to 500Hz bandwidth setting could be used, but when recording nerve propagation times, the 100Hz to 5,000Hz bandwidth setting could be used.



This graph shows a typical raw EMG recording. Waveform peaks indicate points of peak muscle activity.



This graph shows raw EMG and integrated EMG.

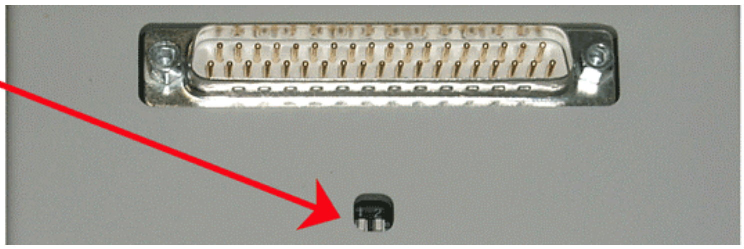
To integrate EMG in real-time, set up a calculation channel in Acq*Knowledge* using the **Integrate** function with **Rectify** checked **ON**. In this case, this waveform would be augmented by a smoothed curve following the positive envelope of the EMG signal.

Frequency Response Characteristics

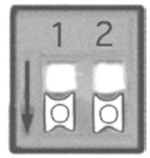
The 1Hz and 10Hz lower frequency response settings are single pole roll-off filters.

Modules are factory preset for 50Hz or 60Hz 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 60Hz in the United States and 50Hz in most of Europe; contact BIOPAC if you are unsure of your country's line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

Line Frequency switch bank is on the back of the amplifier

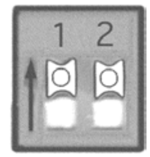


50Hz



Both switches DOWN

60Hz



Both switches UP

See the sample frequency response plots beginning on page 215:

100Hz HPN option (with 50Hz notch enabled) 500Hz LP option

100Hz HPN option (with 60Hz notch enabled) 5000Hz LP

EMG100C Calibration

The EMG100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCAL.

EMG100C SPECIFICATIONS

Gain:	500, 1000, 2000, 5000	
Output Range:	±10V (analog)	
Frequency Response		
Low Pass Filter:	500Hz, 5000Hz	
High Pass Filter:	1.0Hz, 10Hz, 100Hz	
Notch Filter:	50dB rejection @ 50/60Hz	
Noise Voltage:	0.2µV rms - (10-500Hz)	
Signal Source:	Electrodes (three electrode leads required)	
Z (input)		
Differential:	2MΩ	
Common mode:	1000MΩ	
CMRR:	110dB min (50/60Hz); see Shield Drive Operation on page 215	
CMIV--referenced to		
Amplifier ground:	±10V	
Mains ground:	± 1500 VDC	
Input Voltage Range	Gain	Vin (mV)
	500	±20
	1000	±10
	2000	±5
	5000	±2
Weight:	350 grams	
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)	

See also: JUMP100C
MEC series

EOG100C - Electrooculogram Amplifier module

The Electrooculogram amplifier module (EOG100C) is a single-channel, high-gain, differential input, biopotential amplifier designed for tracking eye movement. The EOG100C is designed for use in the following applications:

Sleep studies	Nystagmus testing	Vertigo investigations
Eye motion and tracking	REM activity analysis	Vestibular function studies

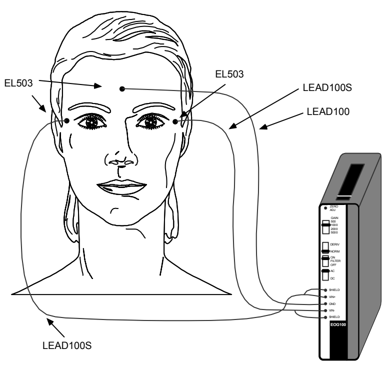
The EOG100C senses the corneal-retinal potential inherent in the eyeball. As the eyes move in the horizontal and vertical planes, these potentials are superimposed to generate a DC voltage variation in the region immediately surrounding the eye sockets.

The EOG100C will connect directly to any of BIOPAC's Ag-AgCl series lead electrodes. For most EOG applications, EL503 electrodes are used. Use two shielded electrode leads (LEAD110S) for the signal inputs and one unshielded electrode lead (LEAD110) for ground.

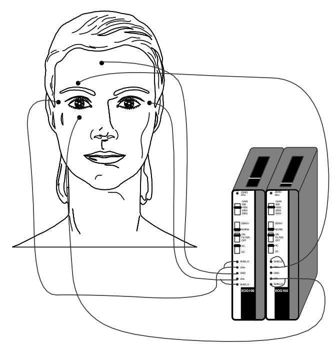
The EOG100C has built-in drive capability for use with shielded electrode leads. If high bandwidth (resolution) EOG measurements are required, then shielded electrode leads are recommended. When the interference filter is switched on, shielded leads are typically not necessary. The EOG100C is designed to pass the EOG signal to accommodate a large velocity range with minimal distortion.

This module includes an HP selection switch, which permits either absolute (DC) or relative (AC: 0.05Hz HP) eye motion measurements. When performing absolute eye motion measurement, the eye position signal will still decay, but the time constant will be significantly longer than when performing relative eye motion measurement.

The EOG100C also has an EOG derivative function. When enabled, the output signal will produce a wave that will be directly proportional to the velocity of eye movement. Eye velocity measurement is useful for performing Nystagmus testing. The derivative function is obtained through the use of a specially designed bandpass filter (center frequency of 30Hz, Q=0.8).



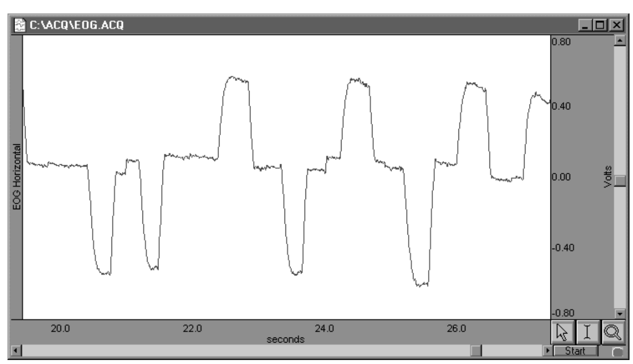
Setup to record horizontal eye movement



Setup for two EOG100C modules to record vertical and horizontal eye movement

To increase accuracy, use electrodes above and below each eye and parallel them with JUMP100C Jumper leads when connecting to the vertical track EOG100C module.

This graph shows a horizontal eye movement recording. The positive peaks indicate eyes looking left. The negative peaks indicate eyes looking right. The derivative of this waveform would indicate the speed of eye motion during this time.



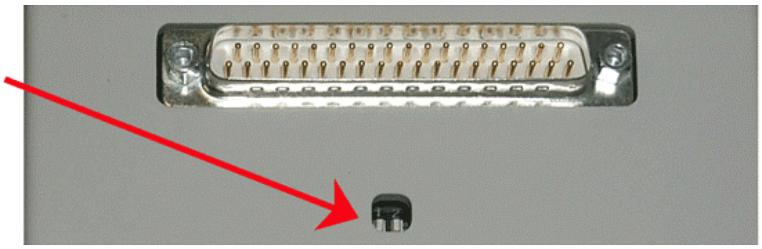
Typical EOG signal

Frequency Response Characteristics

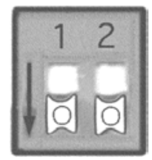
The 0.05Hz lower frequency response setting is a single pole roll-off filter.

Modules are factory preset for 50Hz or 60Hz 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 60Hz in the United States and 50Hz in most of Europe; contact BIOPAC if you are unsure of your country's line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

Line Frequency switch bank is on the back of the amplifier

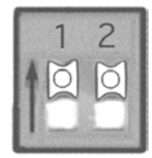


50Hz



Both switches DOWN

60Hz



Both switches UP

See the sample frequency response plots beginning on page 215:

35Hz LPN (with 50Hz notch)

35Hz LPN (with 60Hz notch)

100Hz LP

EOG100C Calibration

The EOG100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCALC.

EOG100C SPECIFICATIONS

Gain:	500, 1000, 2000, 5000	
Output Selection:	Normal, Derivative output	
Output Range:	±10V (analog)	
Frequenct Response		
Low Pass Filter:	35Hz, 100Hz	
High Pass Filter:	DC, 0.05Hz	
Notch Filter:	50dB rejection @ 50/60Hz	
Noise Voltage:	0.1μV rms - (0.05-35Hz)	
Signal Source:	Electrodes (three electrode leads required)	
Z (input)		
Differential:	2MΩ	
Common mode:	1000MΩ	
CMRR:	110dB min (50/60Hz); see Shield Drive Operation on page 215	
CMIV--referenced to		
Amplifier ground:	±10V	
Mains ground:	±1500 VDC	
Input Voltage Range	Gain	Vin (mV)
	500	±20
	1000	±10
	2000	±5
	5000	±2
Weight:	350 grams	
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)	

See also: JUMP100C and MEC series

ERS100C - Evoked Response Amplifier Module

The evoked response amplifier module (ERS100C) is a single channel, high gain, extremely low noise, differential input, biopotential amplifier designed to accurately amplify the very small potentials (< 200 nV) associated with evoked response measurement. The ERS100C is designed for use in the following applications:

Auditory brainstem response (ABR) testing	Visual evoked response testing
Nerve conduction velocity and latency recording	Somatosensory response testing

The ERS100C will connect directly to any of BIOPAC Systems, Inc.'s Ag-AgCl series of lead electrodes. Typically, the EL503 electrodes are recommended for evoked response measurements. Use two shielded electrodes (LEAD110S) for the signal inputs and one unshielded electrode (LEAD110) for the ground. If hair is present, disposable electrodes don't work very well for scalp attachment, and you should use electrode gel (GEL100) and tape the electrode lightly in place or use a conductive adhesive paste (like Ten20® or Collodion HV®).

The ERS100C has built-in drive capability for use with shielded electrode leads. Shielded leads are typically required, as the ERS100C has a frequency response that extends through the 50/60Hz interference bands. Furthermore, the ERS100C is used to amplify extremely low level signals that can be easily corrupted by interfering signals.

The ERS100C incorporates selectable gain and bandwidth options to perform a variety of evoked response testing. The ERS100C is typically used with two shielded electrodes for signal input and one unshielded electrode for ground. In nearly all cases of stimulus response testing, the ERS100C will be used in conjunction with the STM100C and the MP System.

- The STM100C is a general-purpose stimulator that can be used to present auditory, visual or mechanical stimulus signals.

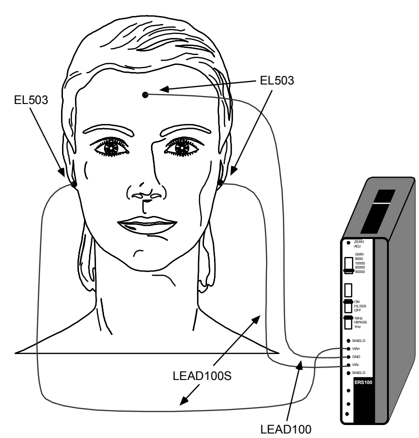
For most types of evoked response testing, the MP System will be operating in averaging mode. Typically, the stimulus output (usually a pulse) will be output through one of the analog channels (Out 0 or Out 1) or I/0 15 just prior to the data collection pass. Stimuli output on analog channels typically consists of pulses or tones, and stimulus output waveforms can easily be created and modified using the stimulator setup window, described in the MP System Guide section.

Auditory evoked potentials

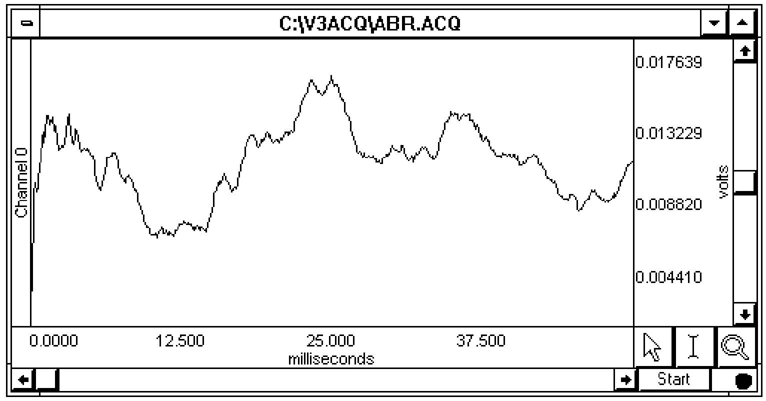
The ERS100C can record auditory evoked potentials, like the ABR,. Use the STM100C to present an auditory pulse or "click" to the auditory stimulator, such as the ER-3A Tubephone. Present the acoustical signal to the active ear using a calibrated auditory earphone like the OUT101 Tubephone.

To record the ABR:

1) Place the active (VIN+) electrode at the earlobe or mastoid.
2) Place the reference (VIN-) electrode at the vertex.
3) Place the ground electrode at the forehead.



The MP System collected the data in the "Averaging" mode.



2000 trial ABR test performed using the ERS100C with the STM100C and OUT101 (Tubephone)

Somatosensory response Somatosensory tests are used to characterize the perception of touch. Active electrodes are usually placed on an earlobe, and passive electrodes are placed on the contralateral earlobe. The ground electrode is placed on the forehead. In somatosensory response tests, the stimulation source is usually an electrical pulse or mechanical impulse applied at some point along the leg or arm.

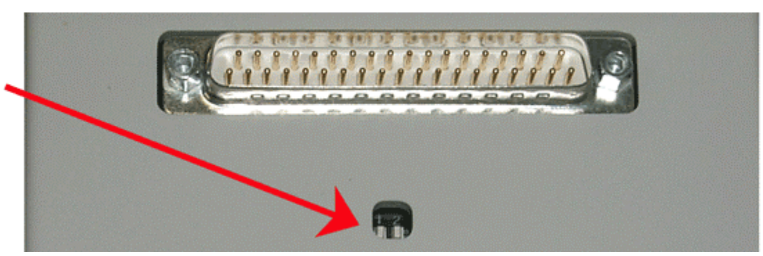
General nerve conduction velocity The ERS100C can also be used for general nerve conduction velocity tests, and will perform exceptionally well since the ultra low noise characteristics of the ERS100C are not required to obtain the best results and these tests don't require the extensive averaging required for auditory or visual evoked response measurements.

Frequency Response Characteristics

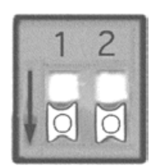
The 1Hz or 20Hz lower frequency response settings are single pole roll-off filters.

Modules are factory preset for 50Hz or 60Hz 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 60Hz in the United States and 50Hz in most of Europe; contact BIOPAC if you are unsure of your country's line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

Line Frequency switch bank is on the back of the amplifier

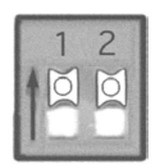


50 Hz



Both switches DOWN

60 Hz



Both switches UP

See the sample frequency response plots beginning on page 215: 100Hz HPN (with 50Hz notch)
100Hz HPN (with 60Hz notch)
3,000Hz LP
10kHz LP

ERS100C Calibration

The ERS100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCALC.

ERS100C SPECIFICATIONS

Gain:	5000, 10000, 20000, 50000
Output Range:	±10V (analog)
Frequencty Response	
Low Pass Filter:	3kHz, 10kHz
High Pass Filter:	1.0Hz, 20Hz, 100Hz
Notch Filter:	50dB rejection @ 50/60Hz
Noise Voltage:	0.5µV rms - (100-3000Hz)
Signal Source:	Electrodes (three electrode leads required)
Z (input)	
Differential:	2MΩ
Common mode:	1000MΩ
CMRR:	110dB min (50/60Hz); see Shield Drive Operation on page 215
CMIV--referenced to	
Amplifier ground:	±10V
Mains ground	±1500 VDC
Input Voltage Range	Gain — Vin (mV)
	5000 — ±2
	10000 — ±1
	20000 — ±0.5
	50000 — ±0.2
Weight:	350 grams
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)

CBLCAL/C Cable Calibrators for Biopotential Amplifiers

CBLCALC Calibration Cable for 100C-series Biopotential Amplifiers

CBLCAL Calibration Cable 100-B series Biopotential Amplifiers

Use CBLCAL/C to verify the calibration of the any of the Biopotential amplifiers. The cable (1.8m) connects between the amplifier input and the UIM100C D/A output 0 or 1. To verify the amplifier's frequency response and gain settings, create a stimulus signal using Acq*Knowledge* and monitor the output of the amplifier connected to the Calibration Cable. The Calibration Cable incorporates a precision 1/1000 signal attenuator.

Amplifier specification tests are performed at the factory before shipping, but a Calibration Cable can ensure users peace of mind by permitting precise frequency response and gain calibrations for exact measurements.

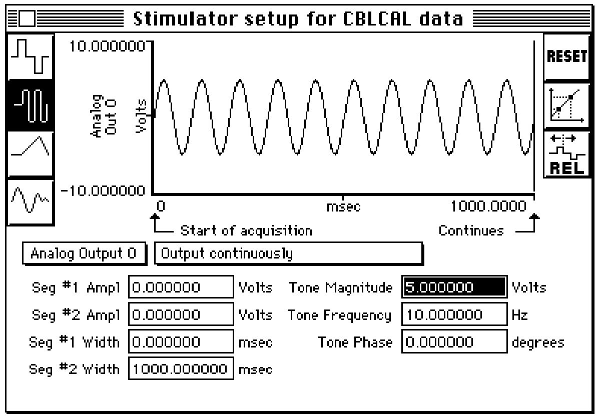
CBLCAL/C Calibration

Hardware Setup

1. Connect the MP150/100, UIM100C and biopotential amplifiers as normal.
2. Connect the CBLCAL/C between the selected amplifier and the UIM100C, inserting the single 3.5mm plug into the Analog Output "0" port on the UIM100C.
3. Connect the end containing several 2mm pins into the corresponding holes on the face of the biopotential amplifier.
4. Select a Gain setting of 1,000 for DA, ECG, EGG, EMG, and EOG, or 5,000 for EEG and ERS.
5. Turn all filters to the desired position.
6. Select an appropriate channel on the top of the amplifier being tested (usually channel one, as this is the default setup in the software).

Software Setup

1. Under **Channel Setup**, insure that the default is set to analog channel one (A1).
2. Under **Acquisition Setup**
   a) Choose a sampling rate of 2000Hz (or higher).
   b) Choose an acquisition period of at least 5 seconds.
   c) Choose Record Last mode.
3. Under **Stimulator Setup** (see figure below)

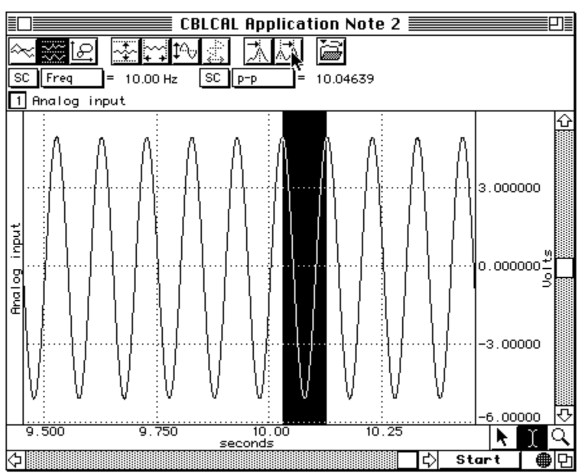


a) Select the sine wave for the shape of the output signal.
b) Set the "Seg. #1 Width' to zero. This means that the signal will be transmitted continuously starting at time-point zero.
c) Set "Seg. #2 Width" to 1,000 msec (one second). This is the length of the output signal.
d) Select "Analog Output: 0."
e) Select "Output continuously."
f) The most important settings are the signal magnitude and frequency. Set the magnitude to 5 Volts (i.e. 10V p-p) if the module gain setting is 1,000. If the lowest module gain setting available is 5,000, choose 1 Volt.
g) Set the frequency to 10Hz to check the gain calibration (on a sinusoidal signal, this setting is appropriate for all biopotential amplifiers).

Calibration Procedure

Acq*Knowledge* is now set-up to check for the proper calibration of biopotential amplifiers.

1. Start the acquisition. Theoretically, since you are in **record last** mode and are outputting a signal continuously, Acq*Knowledge* could acquire data forever.
2. Stop the acquisition when the waveform has stabilized.
3. Use the "I-beam" cursor to select the latter part of the record.
4. Perform all your calibration measurements on the latter part of the collected record.
   a) Scale the waveform into some semblance of the one in the following figure.



   b) Select the Pk-Pk (peak to peak) measurement to determine amplitude. The measured voltage depends on the voltage input and the gain setting on the amplifier. Use the following formula to determine this number.

      Measured Voltage =
      (Stimulator Input Voltage) * (1/1,000) * (Biopotential Amplifier Gain Setting)

If the amplifier gain setting is 1,000, it will cancel the CBLCAL/C attenuation (1/1,000). Therefore, the measured voltage will equal the stimulator input voltage. In this example, assuming a gain setting of 1,000 and a stimulator input of 10V (pk-pk), the expected signal will be very close to 10V (p-p).

c) It is important that you measure the amplitude of the acquired waveform correctly. Highlight several peaks with the "I-beam" cursor.

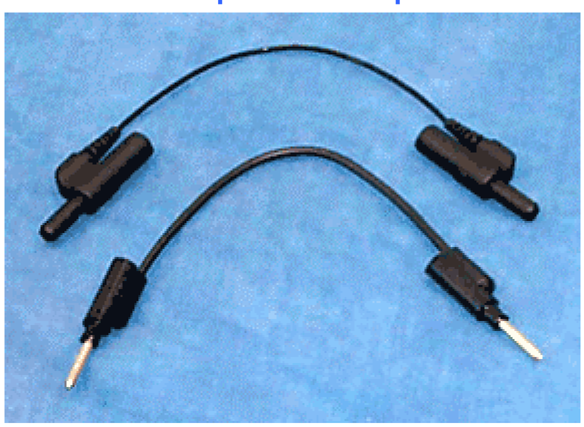
d) Click the "peak detection" icon at the top of the graph window twice. This will precisely highlight one of the many peak-to-peak amplitudes.

e) Open one of the pop-up measurement, windows and select "p-p" to measure the amplitude of the waveform. This result indicates the vertical distance of the waveform between the two selected peaks (see figure above).

f) To verify the consistency of the difference in peak-to peak values, click the "peak detection" icon again. This will move the cursor to the next available peak below.

g) Repeat this several times to verify the subsequent peak heights. If your measured peak-to-peak height is 10.04 Volts, then you can ascertain that your acquired signal is ±5.02 Volts. If you output a 5 Volt magnitude signal with the stimulator, then measuring 5.02 Volts (0-pk) is considered accurate for any biopotential amplifier (the analog output stimulator is accurate to within ± .5%). To best determine the accuracy of the amplifier, you should consider an average of measurements.

JUMP100/C Jumper Connectors for Biopotential Amplifiers



JUMP100 — for all connections between all 100B-series Biopotential amplifiers

JUMP100C — for all connections between all 100C-series Biopotential amplifiers

These jumper connectors (10 cm long) are used to create a common reference between Biopotential amplifier modules. Link one reference electrode to multiple amplifier inputs using one jumper connector per amplifier. Jumper connectors are required when connecting the same reference electrode lead to two or more amplifiers, as in multi-lead ECG or unipolar EEG measurements.

Transducer Modules

Transducer modules include: GSR; PPG; RSP; SKT.

GSR100C – Electrodermal Activity Amplifier Module

The GSR100C electrodermal activity amplifier module is a single channel, high gain, differential amplifier designed to measure skin conductance via the constant voltage technique. The GSR100C is designed for use in the following applications:

General eccrine activity measurement	Vestibular function analysis
Vertigo and motion sickness studies	Psychophysiological investigations

The GSR100C includes a selection switch for lower frequency response.

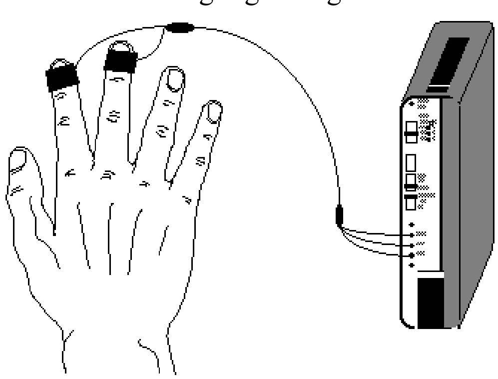
- To measure **absolute** skin conductance, set the lower frequency response to DC.
- To measure **relative** skin conductance changes, set the lower frequency response to 0.05Hz.

--IMPORTANT--

-----GROUNDING When using the GSR100C 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 GSR100C. If a biopotential ground is attached to the subject, then currents sourced from the GSR100C will be split to the biopotential amplifier ground lead, potentially resulting in measurement errors.

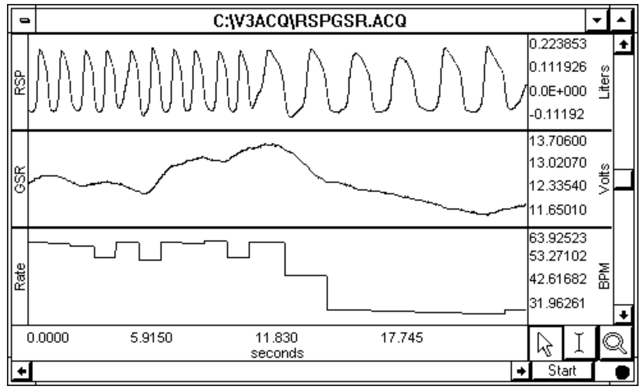
--IMPORTANT--

The GSR100C is typically used with TSD203 Ag-AgCl finger electrodes (page 105).



Skin conductance measurement using GSR100C and TSD203

The following graph shows the relationship between respiration rate and the electrodermal activity response (galvanic skin response). The left half of the graph marks the onset and completion of fast breathing (panting), and the subject begins to breathe normally at the time index corresponding to 12 seconds.



Electrodermal activity response, respiration and respiration rate waveforms

Frequency Response Characteristics

The 0.05Hz lower frequency response setting is a single pole roll-off filter.

Modules are factory preset for 50 or 60Hz notch options, depending on the destination country.

See the sample frequency response plots beginning on page 215: 1Hz LP
10Hz LP

GSR100C Calibration

To set up Acq*Knowledge* to record skin conductance directly, perform the following:

<u>Lower frequency response at DC</u>:

In the scaling window, set the input voltages so they map to the "DC " conductance ranges indicated by the sensitivity setting. For example, if the GSR100C is set to a Gain of 5 µmho/V, then 0V will map to 0 µmhos or infinite resistance and 1V will map to 5µmho or 200kohm.

<u>Lower frequency response at 0.05Hz</u>:

In the scaling window, set the input voltages so they map to the "0.05Hz" conductance ranges indicated by the sensitivity setting. For example if the GSR100C is set to a Gain of 5 µmho/V, then 0V will map to X µmhos and 1V will map to (X+5) µmhos. Where "X" is the mean conductance being recorded.

To verify the Gain setting of the GSR100C:

1. Calibrate Acq*Knowledge* as detailed above for lower frequency response at DC.
2. Place the lower frequency response to DC.
3. Set the Gain switch on the GSR100C to 5µmho/V.
4. Perform measurement with electrodes disconnected.
    - Acq*Knowledge* should produce a reading of 0 µmho.
5. Insulate a 100kohm resistor and place it from electrode pad to electrode pad (resistor must be insulated from fingers).
6. Perform measurement with electrode-resistor setup.
    - Acq*Knowledge* should produce a reading of 10 µmho.

GSR100C SPECIFICATIONS

Gain:	20, 10, 5, 2 micro-mhos/volt (i.e. micro-siemens/volt)
Output Range:	±10V (analog)
Frequency Response	
Low Pass Filter:	1Hz, 10Hz
High Pass Filter:	DC, 0.05Hz, 0.5Hz
Sensitivity:	0.7 nano-mhos - with MP System
Excitation:	Vex = 0.5VDC (Constant Voltage)
Signal Source:	TSD203
Weight:	350 grams
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)

Gain Settings			
Input conductance range			
DC	0.05Hz	*Minimum Resistance*	*Sensitivity*
0 to 200 µmho	±200 µmho	5,000 Ω	20 µmho/V
0 to 100 µmho	±100 µmho	10,000 Ω	10 µmho/V
0 to 50 µmho	±50 µmho	20,000 Ω	5 µmho/V
0 to 20 µmho	±20 µmho	50,000 Ω	2 µmho/V

TSD203 Electrodermal Response transducer

The TSD203 is a set of two Ag-AgCl electrodes, which incorporate molded housings designed for finger attachment. The TSD203 is used when measuring the electrodermal response. Each transducer includes a stretchable Velcro® strap for easy attachment.

When you use the TSD203 to measure electrodermal response, your choice of electrolyte is extremely important. A higher impedance electrolyte using hyposaturated electrolyte concentrations of Cl- (on the order of physiological levels) is necessary for effective monitoring of local eccrine activity.

Use GEL101 as an isotonic, hyposaturated, conductant with the TSD203 electrodermal response transducer (see page 129).

TSD203 Calibration

See the GSR100C transducer module.

PPG100C - Photoplethysmogram amplifier module

The photoplethysmogram amplifier module (PPG100C) is a single channel amplifier designed for indirect measurement of blood pressure or density. The PPG100C is designed for use in the following applications:

- General pulse rate determination
- Blood pressure analysis
- Exercise physiology studies
- Psychophysiological investigations

The PPG100C works with the TSD200 photoplethysmogram transducer (page 108). The peak measurement recorded by the PPG100C indicates the point of maximal blood density in the respective location. Indications of blood pressure can be inferred by comparing the point of R-wave onset in the ECG to the point of maximum blood density recorded by the PPG100C.

The PPG100C includes lower frequency response selection switches, which permits either absolute (DC) or relative (via 0.05 or 0.5Hz highpass filters) blood density measurements.

Frequency Response Characteristics

The 0.05Hz and 0.5Hz lower frequency response settings are single pole roll-off filters.

Modules are factory preset for 50 or 60Hz notch options, depending on the destination country.

See the sample frequency response plots beginning on page 215: 10Hz LP

PPG100C Calibration

None required.

PPG100C Specifications

Gain:	10, 20, 50, 100
Output Range:	±10V (analog)
Low Pass Filter:	3Hz, 10Hz
High Pass Filter:	DC, 0.05Hz, 0.5Hz
Noise Voltage:	0.5µV rms – amplifier contribution
Excitation:	6V
Signal Source:	TSD200 Pulse Transducer
Weight:	350 grams
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)

Excitation Voltage	6.0 Volts
Upper Frequency Response	10Hz
Lower Frequency Response	DC or 0.05Hz or 0.5Hz
Noise Voltage	0.5 µV (rms) - amplifier contribution

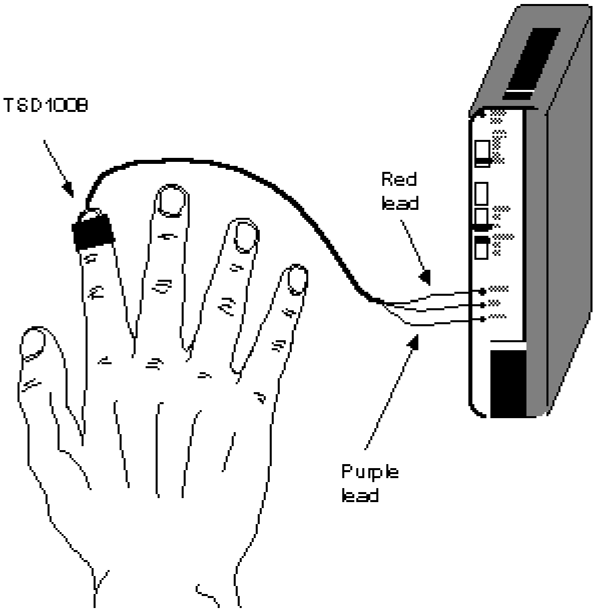
Gain Settings

Input Signal Range (pk-pk)	*Gain*
2000 mV	x 10
1000 mV	x 20
400 mV	x 50
200 mV	x 100

This illustration shows the proper connections to use the TSD200 with the PPG100C. The TSD200 can be placed on other body locations by employing ADD208 adhesive disks to hold the TSD200 in place.

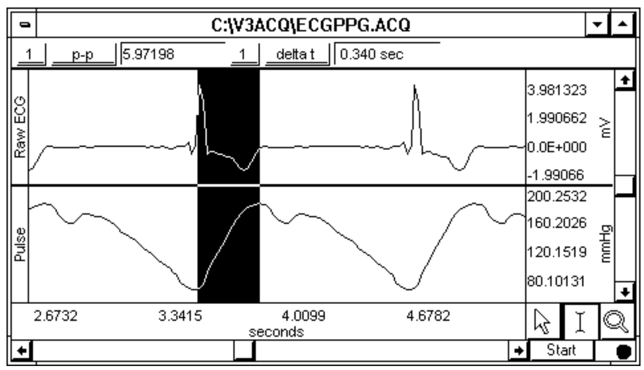
The TSD200 connects to the PPG100C as follows:

TSD200 Lead	PPG100C
Red lead	+VSUP
Black lead	GND
Purple or Blue lead	INPUT



Finger pulse measurement using the PPG100C and TSD200

This graph illustrates pulse plethysmogram data indicating blood density with respect to the acquired ECG. The distance between peaks on the two channels can provide indications of blood pressure, vascular resistance and compliance.



Pulse plethysmograph and ECG waveforms

TSD200 Photoplethysmogram transducer

The TSD200 consists of a matched infrared emitter and photo diode, which transmits changes in blood density (caused by varying blood pressure) in specific body locations. When the TSD200 is attached to the skin, the infrared light is modulated by blood pulsing through the tissue below. The modulated, reflected light results in small changes in the resistance of the photo resistor, which yields a proportional change in voltage output.

The TSD200 includes a shielded 2-meter cable and a stretchable Velcro® strap for easy attachment to the fingers, or it can be taped to other body parts. The TSD200 can also be placed on other body locations by employing ADD208 adhesive disks to hold the TSD200 in place.

Place the transducer around the finger and adjust the Velcro® closure to provide only slight tension. Blood density readings can vary considerably depending on transducer location and tension changes.

The TSD200 connects to the PPG100C as follows (see page 107—PPG100C for a diagram):

TSD200 Lead	PPG100C
Red lead	+VSUP
Black lead	GND
Purple or Blue lead	INPUT

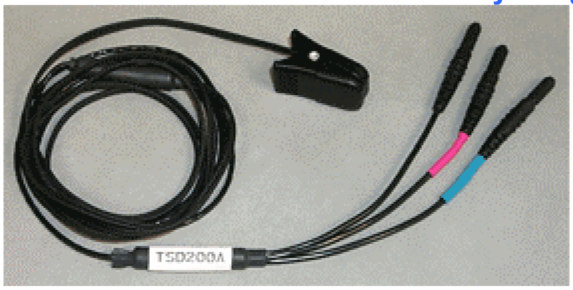
TSD200 Calibration

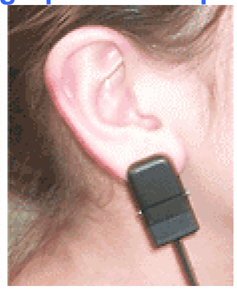
The TSD200 does not require calibration.

TSD200 Specifications

Emitter/Detector Wavelength	860nm ± 6 nm
Optical Low Pass Filter Cutoff Wavelength	800nm
Nominal Output	20 mV (p-p)
Power	6VDC Excitation @ 5 mA
MRI Compatible:	Yes (no ferrous parts)
Sterilizable:	Yes (Contact BIOPAC for details)
Weight:	4.5 grams
Dimensions	16mm (long) x 17mm (wide) x 8mm (high)
Attachment:	Velcro strap
Cable:	3 meters, shielded
Interface:	PPG100C
TEL100C Compatibility:	SS4—page 208

TSD200A Photoelectric Pulse Plethysmograph - Ear Clip





The photodetector operates via incident photons, from an IR transmitter, impacting an IR detector. The incident photons result in a proportional passage of electrons in the detector. The IR detector operates like a photon-controlled current source. The transducer incorporates an appropriate clipping range, with linearity insured for arbitrarily low levels of reflected light. For the expected magnitude of incident infrared light, the photodetector operates in a linear fashion. We have not encountered situations where the detector is operating non-linearly (near saturation).

The TSD200A transducer operates with the PPG100C amplifier to record the pulse pressure waveform. The TSD200A consists of a matched infrared emitter and photo diode, which transmits changes in infrared reflectance resulting from varying blood flow. The ergonomic housing design improves contact with the subject and helps reduce motion artifact. The TSD200A is primarily designed for ear attachment and comes with a shielded 3-meter cable.

TSD200A SPECIFICATIONS	
Emitter/Detector Wavelength:	860nm± 90nm
Optical Low Pass Filter	
Cutoff Wavelength:	800nm
Dimensions:	3cm (long) x 1.5cm (wide) x 1.5m (clip gap)
Transducer Weight:	4.5 grams
MRI Compatible:	Yes (no ferrous parts)
Sterilizable:	Yes (contact BIOPAC)
Nominal Output:	20 mV (p-p)
Power:	6VDC Excitation @ 5 mA
Cable Length:	3-meters (shielded)
Interface:	PPG100C
TEL100C compatibility:	SS4A (finger style)

RSP100C - Respiration Pneumogram amplifier module

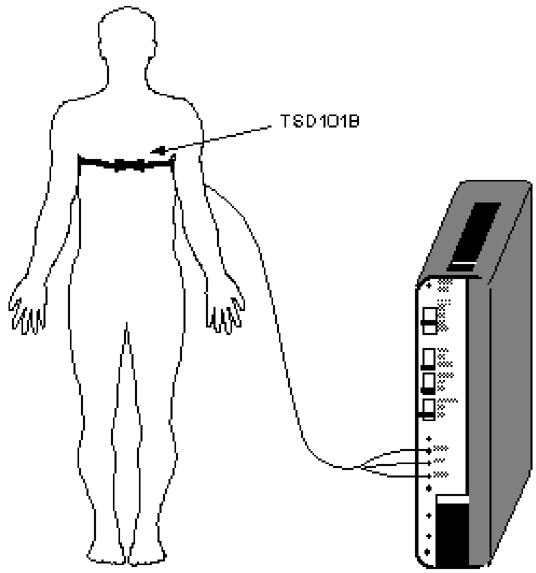
The RSP100C respiration pneumogram amplifier module is a single channel, differential amplifier designed specifically for recording respiration effort. The RSP100C is designed for use in the following applications:

- Allergic responses analysis
- Exercise physiology studies
- Psychophysiological investigations
- Respiration rate determination
- Sleep studies

The RSP100C works with the TSD201 respiration transducer (page 113) to measure abdominal or thoracic expansion and contraction.

The RSP100C includes a lower frequency response selection switch that permits either absolute (DC) or relative (via a 0.05 highpass filter) respiratory effort measurements.

The following illustration shows the placement and connections for recording thoracic respiration effort using the RSP100C and the TSD201 respiration transducer.



RSP100C Amplifier Module Settings

The RSP100C has three built-in filters and a number of different gain settings for the different uses of the transducer.

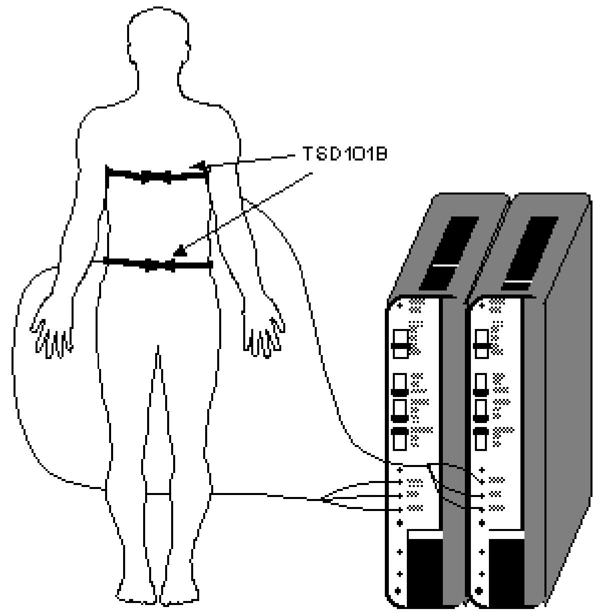
Type of Use	Gain Setting	Low Pass Filter	.5Hz Filter	.05Hz Filter
General	10	10Hz	DC	DC
Exercise Physiology	10	1Hz	.5Hz	.05Hz
Small Animal	20+	10Hz	.5Hz	.05Hz

General For most measurements with little or no subject movement. The most common setting is with all three filters at their bottom settings (10Hz, DC, and DC) and the gain set at 10. This allows any signals slower than 10Hz (cyclic rate) to pass, and is usually good for most measurements with little or no subject movement.

Exercise physiology The transducer produces the best signal at the lowest gain and with all three filter settings at their top position (1Hz, .5Hz, and .05Hz). This setting will allow only a signal between .5Hz and 1Hz to be transmitted, filtering out most of the signal interference due to extraneous chest and abdominal movement resulting from limb motion.

Smaller animals For measurements with very small changes in thoracic circumference. You'll need to increase the gain to magnify the signal. Increase the gain until you get a clear signal, but not so much that the signal is clipped.

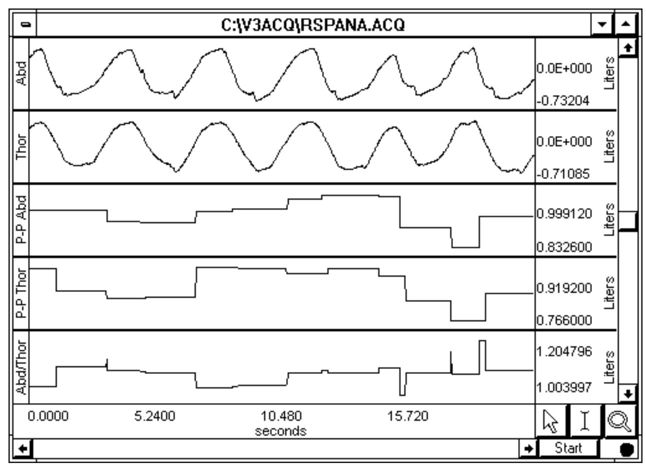
This illustration shows the placement and connections to record thoracic and abdominal respiration effort using two RSP100C amplifier modules and two TSD201 respiration transducers.



Connections for Thoracic and Abdominal Respiratory Effort Measurement

This graph shows the relationship between abdominal and thoracic expansion and contraction.

calculate the peak-to-peak values for both abdominal and thoracic respiration effort were calculated with Acq*Knowledge*, and then the two peak-to-peak values were compared in the lowest channel. When abdominal breathing effort changes with respect to thoracic breathing effort, the lowest channel will quantify the extent of the change.



Thoracic vs. Abdominal respiration effort data

Frequency Response Characteristics

The 0.05Hz lower frequency response setting is a single pole roll-off filter. The 0.5Hz lower frequency response setting is a two pole roll-off filter.

Modules are factory preset for 50 or 60Hz notch options, depending on the destination country.

See the sample frequency response plots beginning on page 215: 1Hz LP
10Hz LP

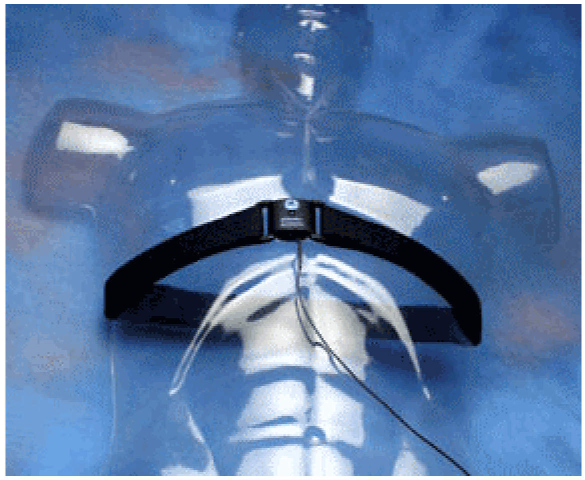
RSP100C Calibration

None required.

RSP100C SPECIFICATIONS

Gain:	10, 20, 50, 100
Output Range:	±10V (analog)
Frequency Response	
Low Pass Filter:	1Hz, 10Hz
High Pass Filter:	DC, 0.05Hz, 0.5Hz
Excitation Voltage	±0.5 Volts
Noise Voltage:	0.2μV rms – amplifier contribution
Signal Source:	TSD201
Weight:	350 grams
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)

TSD201 Respiration transducer



The TSD201 is a strain gauge transducer designed to measure respiratory-induced changes in thoracic or abdominal circumference, and can therefore be used to record respiratory effort. The TSD201 is essentially a resistive transducer and responds in a linear fashion to changes in elongation through its length, with resistance increasing as length increases.

The transducer is ideal for a variety of applications because it presents minimal resistance to movement and is extremely unobtrusive. Due to its unique construction, the TSD201 can measure extremely slow respiration patterns with no loss in signal amplitude while maintaining excellent linearity and minimal hysteresis.

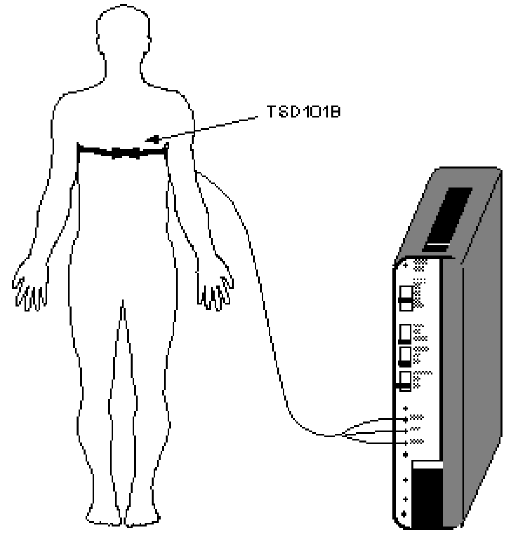
The TSD201 plugs directly into the RSP100C amplifier module (page 110). It includes a fully adjustable nylon strap to accommodate a large range of circumferences (9cm to 130 cm). To attach the nylon belt to the respiration transducer, thread the nylon strap through the corresponding slots so the strap clamps into place when tightened. Place the transducer around the body at the level of maximum respiratory expansion. This location will vary from the erect to supine positions (generally about 5 cm below the armpits).

Correct tension adjustment of the respiration transducer is important. For best sensitivity, the transducer must be just slightly tight at the point of minimum circumference (maximum expiration). To obtain proper tension, stretch the belt around the body and have the subject exhale. At maximum expiration, adjust the nylon strap so there is slight tension to hold the strap around the chest.

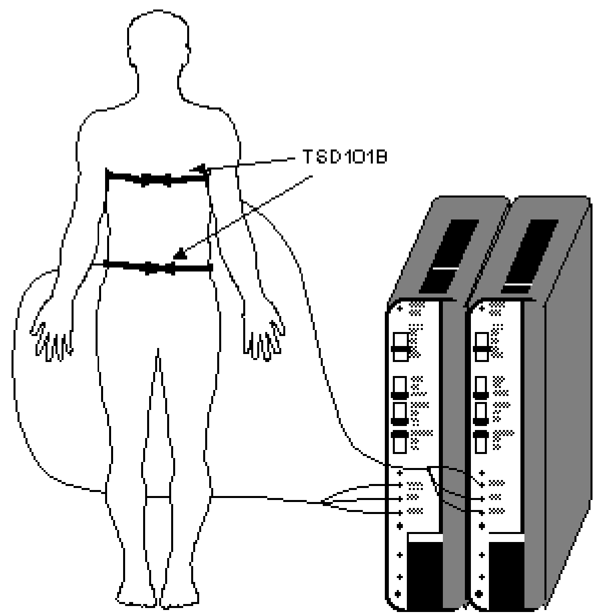
The transducer has three 2 mm pin plugs to connect to the amplifier. Insert the two blue lead transducer pin plugs into the two RSP100C inputs labeled XDCR. Either blue lead can be connected to either XDCR input. Insert the single black transducer lead into the GND input of the RSP100C. The respiration transducer is ready for measurement.

Sample Data for Subject at Rest

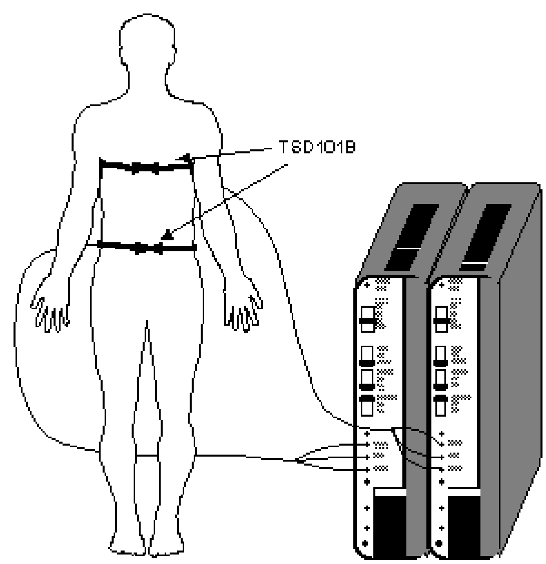
This illustration shows the placement and connections for recording thoracic respiration effort using the RSP100C and the TSD201 respiration transducer.



This illustration shows the placement and connections to record thoracic and abdominal respiration effort using two RSP100C amplifier modules and two TSD201 respiration transducers.



This illustration shows the placement and connections to record thoracic and abdominal respiration effort using two RSP100C amplifier modules and two TSD201 respiration transducers.



Connections for Thoracic and Abdominal Respiratory Effort Measurement

TSD201 Calibration

The TSD201 does not require calibration.

TSD201 Specifications

True DC Response:	Yes
Variable Resistance Output:	5-125 KΩ (increases as length increases)
Circumference Range:	15cm x 150cm (can be increased with a longer strap)
Attachment:	Velcro® strap (adjustable length)
MRI compatible:	Yes (no ferrous parts)
Sterilizable:	Yes (contact BIOPAC for details)
Sensor Weight:	18 grams
Sensor Dimensions:	66mm (long), 40mm (wide), 15mm (thick)
Cable Length:	3 meters
Interface:	RSP100C—see page 110
TEL100C compatibility:	SS5B—see page 208

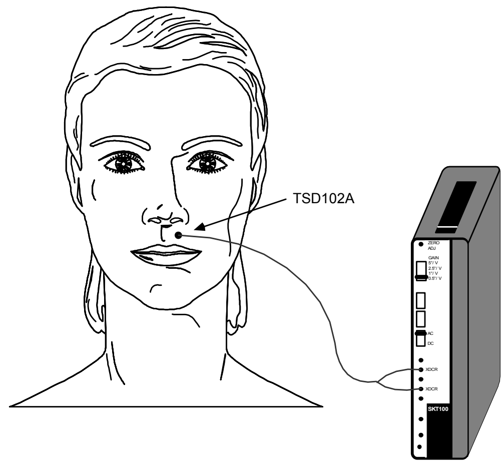
SKT100C - Skin temperature amplifier module

The SKT100C skin temperature amplifier module is a single channel, differential amplifier designed especially for skin and core temperature and respiration flow (rate) monitoring. The SKT100C is designed for use in the following applications:

General temperature measurement	Respiration rate determination
Psychophysiological investigations	Sleep studies

The SKT100C employs any of the BIOPAC TSD202 series thermistor transducers (page 119) to measure temperature. The SKT100C includes a lower frequency response selection switch that permits either absolute (DC) or relative (via a 0.05 highpass filter) temperature measurements.

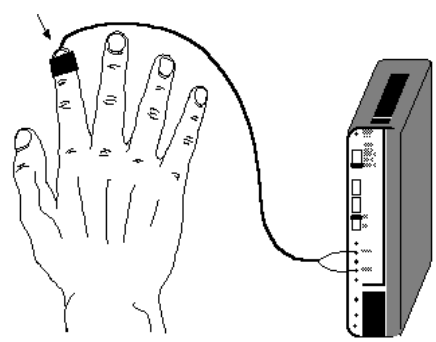
This illustration shows the connections and placement for **measuring respiration flow** using the SKT100C and the TSD202D surface temperature thermistor probe.



Respiration flow measurement using SKT100C and TSD202

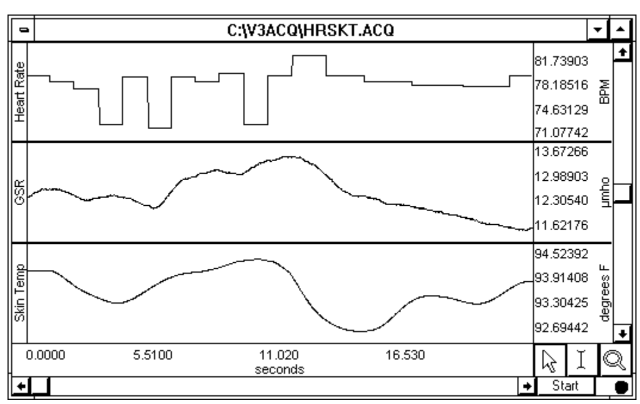
This illustration shows the connections and placement for **measuring index fingertip temperature** using the SKT100C and the TSD202D surface temperature thermistor probe.

The probe is secured to the finger using the Velcro® strap on the transducer.



Index finger temperature measurement with TSD202D

This graph shows the relationship between fingertip skin temperature, skin conductance and heart rate. This configuration of physiological measurements can be useful for psychological testing and evaluation.



SKT versus GSR versus Heart Rate Waveforms

Frequency Response Characteristics

The 0.05Hz lower frequency response setting is a single pole roll-off filter.

Modules are factory preset for 50 or 60Hz notch options, depending on the destination country.

See the sample frequency response plots beginning on page 215: 1Hz LP
10Hz LP

SKT100C Calibration

Temperature Measurements

To measure **absolute** temperature, set the lower frequency response to DC.

To measure **relative** temperature changes, set the lower frequency response to 0.05Hz.

To set up Acq*Knowledge* to record temperature directly, perform the following:

A. Lower frequency response at **DC**:
In the scaling window, set the input voltages so they map to the "DC " temperature ranges indicated by the sensitivity setting. In this case, 0V will always map to 90° F.

B. Lower frequency response at **0.05Hz**:
In the scaling window, set the input voltages so they map to the "0.05Hz" conductance ranges indicated by the sensitivity setting. In this case, 0V will map to the mean (average) temperature during the recording. Use this setting when temperature delta measurement is important, as when monitoring airflow (respiration rate).

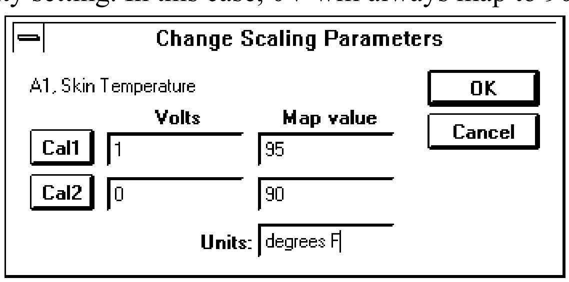
Skin Temperature Measurements

To measure **absolute** skin temperature, place the lower frequency response to DC.

To measure **relative** skin temperature changes or **respiration** rate (**airflow**), place the lower frequency response to 0.05hz.

To set up Acq*Knowledge* to record temperature directly, perform the following:

A. Lower frequency response to **DC**:
In the scaling window, set the input voltages so they map to the "DC on" temperature ranges indicated by the sensitivity setting. In this case, 0V will always map to 90° F.



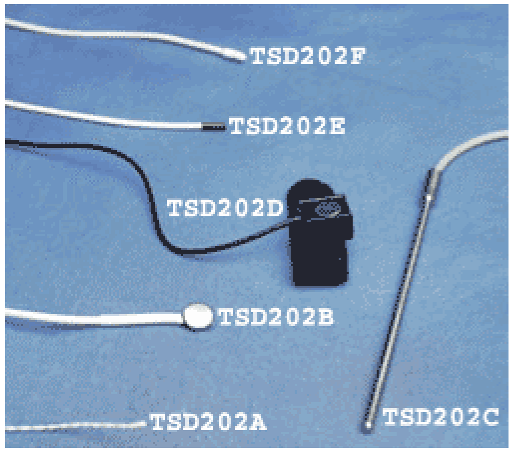
Scaling setup window set to correspond to 5°/V setting on SKT100C

B. Lower frequency response to **0.05Hz**:
In the scaling window, set the input voltages so they map to the "0.05HZ" temperature ranges indicated by the sensitivity setting. In this case, 0V will map to the mean (average) temperature measured during the recording.

SKT100C Specifications

Gain:	5, 2, 1, 0.5 °F/Volt— can also calibrate in °C		
Output Range:	±10V (analog)		
Low Pass Filter:	1Hz, 10Hz		
High Pass Filter:	DC, 0.05Hz, 0.5Hz		
Sensitivity:	180 micro °F (100 micro °C)— with MP System		
Signal Source:	TSD202 Series Temperature Probe		
Weight:	350 grams		
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)		
Input Signal Range:	Gain	Range (°F)	Range (°C)
	5	40-140	5-60
	2	70-110	22-43
	1	80-100	27-37
	0.5	85-95	30-35

TSD202 Series Temperature Transducers



TSD202 SERIES

TSD202A The TSD202A employs a fast response thermistor, and is appropriate for use in locations where temperature changes rapidly, as with the temperature changes of inspired/expired breath. The TSD202A is useful for measuring skin temperature (in small areas) or airflow rate resulting from respiration, and is not designed for liquid immersion. For measuring skin (surface) temperature, simply tape the TSD202A to the location of interest. For measuring respiration rates, by monitoring airflow, place the TSD202A next to the mouth or nose so that inspired or exhaled air will intercept the tip of the TSD202A transducer.

RX202A Replacement Fast-response Temperature Sensor

TSD202B The TSD202B is a "Banjo" style surface probe useful for measuring surface temperature. The "Banjo" design allows efficient skin temperature measurements on a variety of body locations. The TSD202B is not designed for liquid immersion. For measuring skin (surface) temperature, simply tape the TSD202B to the location of interest.

TSD202C The TSD202C encases the internal thermistor in a stainless steel, waterproof housing, and is designed for liquid immersion and other temperature measurement applications where ruggedness is required and fast response is not critical.

TSD202D The TSD202D is a modified TSD202B, with a housing that conforms to curved skin surfaces and includes a stretchy Velcro® strap for easy attachment to the fingers or toes. The "Banjo" design allows efficient skin temperature measurements. The TSD202D is not designed for liquid immersion. For measuring skin (surface) temperature, simply tape the TSD202D to the location of interest. Insert the two blue lead transducer pin plugs into the two SKT100C inputs labeled XDCR. Either blue lead can be connected to either XDCR input.

TSD202E The TSD202E is a general-purpose waterproof thermistor.

TSD202F The TSD202F is a small, flexible waterproof thermistor.

TSD202 SERIES SPECIFICATIONS

Nominal Resistance:	2252Ω@ 25°C
Maximum operating temperature:	60°C (when used with SKT100C)
Accuracy and Interchangeability:	±0.2°C interchangeability over the range of 31°C - 45°C
Sterilizable:	Yes (Contact BIOPAC for details)
MRI Compatible:	Yes (no ferrous parts)
Response Time	
TSD202 A:	0.6 sec
TSD202 B:	1.1 sec
TSD202 C:	3.6 sec
TSD202 D:	1.1 sec
TSD202 E:	0.9 sec
TSD202 F:	1.1 sec
Size	
TSD202 A:	1.7 mm (diameter) *x* 5 mm (long)
TSD202 B:	9.8 mm (diameter) *x* 3.3 mm (high)
TSD202 C:	4 mm (diameter) *x* 115 mm (long)
TSD202 D:	16 mm (long) *x* 17 mm (wide) *x* 8 mm (high)
TSD202 E:	9.8mm (long) x 3.3mm(diameter)
TSD202 F:	9.8mm (long) x 3.3mm(diameter)
Cable length:	3 meters
Interface:	SKT100C—116
Compatibility:	YSI® series 400 (biomedical standard) temperature probes
TEL100 Compatibility:	SS6—208

Electrodes: Reusable and Disposable

Application Instructions for all electrodes:

In selecting the application site, care should be taken that:

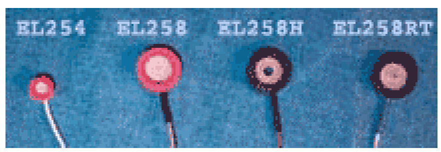
a) Electrode site is dry and free of excessive hair.
b) Electrode is not placed over scar tissue or on an area of established erythema or lesion.
c) Skin is properly prepared. (Prepare the skin at the electrode site. Use the ELPAD to lightly abrade the skin surface. Use a brisk dry rub to prepare the application site. Avoid excessive abrasion of the skin surface.)

EL120 Contact Posts

The EL120 electrode has contact posts designed to improve contact through fur or hair. The 12 posts create a 10 mm contact area. The posts are 2mm deep to push through the fur/hair to provide good contact with the skin surface. Silver-silver chloride (Ag-AgCl) electrodes provide accurate and clear transmission of surface biopotentials and are useful for recording all surface biopotentials on animals and human EEG. Shipped in packs of 10.

Note: It is not necessary to use an EL120 for your ground; you can use a generic electrode for ground. Requires one LEAD120 per electrode (see page 125).

EL250 Series — Reusable Ag-AgCl electrodes



Small Reusable		*General-purpose*	
EL254	unshielded	**EL258**	unshielded
EL254RT	radio-translucent, unshielded	**EL258H**	low-profile, unshielded, 2mm hole
EL254S	shielded	**EL258RT**	radio-translucent, unshielded
		EL258S	shielded

Silver-silver chloride (Ag-AgCl) electrodes provide accurate and clear transmission of surface biopotentials. Reusable electrodes are permanently connected to robust and pliable lead wires (1mm OD). The lead wires terminate in standard Touchproof connectors for interfacing to 100C-series Biopotential modules or MEC Series modular extension cables. Unshielded electrodes terminate in a single Touchproof connector. Shielded electrodes terminate in two Touchproof connectors;one connects to the Ag-AgCl disk and the other connects to the lead wire shield.

The EL258 series is suitable for most applications (i.e., ECG, EEG, EGG, EMG, EOG and ERS recordings). Use EL254 series lead electrodes when closely spaced biopotentials are required. Generally, for each Biopotential amplifier module, two EL254S or EL258S and one EL254 or EL258 are required.

For best signal performance use shielded electrodes (EL254S or EL258S) as recording electrodes and unshielded electrodes (EL254 or EL258) as ground or reference electrodes.

H: Gel Hole For ease of setup, use the EL258H for both recording and reference electrodes (useful for EEG monitoring). Inject gel in the center hole after an EL258H electrode is attached.

RT: MRI When recording from subjects in MRI or X-ray based environments use the EL254RT or EL258RT for the recording and reference electrodes. These electrodes are non-ferrous and employ carbon fiber lead wire for superior radio-translucent performance. For radio-translucent requirements, use three of the EL254RT or EL258RT with each Biopotential module.

Applying EL250 Series Electrodes:

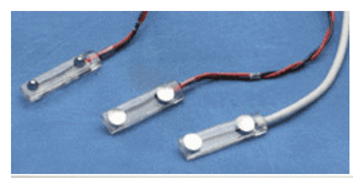
1. Remove an appropriate size adhesive collar (ADD204 or ADD208, page 129) from its waxed paper strip and carefully apply the washer to the electrode so the center hole of the washer is directly over the electrode cavity. Use ADD204 adhesive collars with the EL254 series and use ADD208 adhesive collars with the EL258 series.
2. Fill the cavity with electrode gel (GEL100). No air bubbles should be present in the cavity.
3. Remove the white backing from the washer to expose the second adhesive side.
4. Place electrode on prepared skin area and smooth the washer into place.
5. Apply a few drops of electrode gel to fingertip and rub the exposed side of the adhesive collar (around the electrode) to rid its surface of adhesive quality.

Storing EL250 Series Electrodes

1. Store electrodes in clean, dry area.
2. After use, clean electrode with cold to tepid water
    a) DO NOT use hot water.
    b) Cotton swabs are suggested.
    c) Let the electrode dry completely before storing it.
3. DO NOT allow the electrodes to come in contact with each other during storage (adverse reaction could take place).
4. Electrodes may form a brown coating if they have not been used regularly. To remove the coating, gently polish the surface of the electrode element with non-metallic material or wipe it with mild ammonium hydroxide. Rinse with water and store the electrode in a clean, dry container.

<u>EL250 Specifications</u>

Part	EL254	EL254RT	EL254S	EL258	EL258H	EL258RT	EL258S
Outer diameter	7.2mm	7.2mm	7.2mm	12.5mm	12.5mm	12.5mm	12.5mm
Recording dia.	4mm	4mm	4mm	8mm	8mm	8mm	8mm
Height	6mm	6mm	6mm	6mm	4mm	6mm	6mm
Lead length	1 meter	1.5 meter	1 meter	1 meter	1 meter	1.5 meter	1 meter

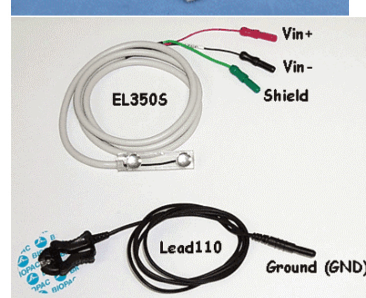


EL350 Series — Bar lead electrodes

EL350 Concave bar lead electrode, use for stimulating or recording

EL350S Concave bar lead electrode, shielded, use for recording

EL351 Convex bar lead electrode, use for stimulating

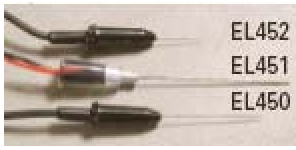


All bar electrodes are MRI compatible and consist of two tin electrodes placed 30mm apart in a watertight acrylic bar. The bar configuration permits easy electrode placement without disturbing electrode-to-electrode spacing. Bar electrodes are recommended for use when applying a stimulus or recording a signal, or during nerve conduction, somatosensory or muscle twitch recordings. When using bar electrodes for signal recording, a single ground lead (LEAD110 with EL503) is required. When using the EL350S the "Shield" line should be placed into one of the two shield connectors on any biopotential amplifier. A ground lead is still required when using the EL350S.

<u>EL350 Series Specifications</u>

Electrode Spacing:	30mm
Lead length:	61 cm
MRI Compatible:	Yes (non-ferrous)
Interface:	Leads terminate in standard Touchproof connectors, which connect to any 100C-series Biopotential amplifier or stimulus isolation adapter (STMISOC/D/E). CBL201 required for connection to 100A/100B-series amplifiers.

EL450 Series — Needle electrodes



These needle electrodes are fully insulated, with a clear Teflon® overcoat, except for the conductive needle tip. EL450 and EL452 are unipolar and the EL451 is a concentric bipolar electrode. Needle electrodes are equipped with a flexible lead terminating in standard Touchproof connectors. Use needle electrodes for stimulation or recording in animal subjects and tissue preparations. Needle electrodes are shipped non-sterile, so pre-sterilization is required.

- ❖ For general-purpose recording (e.g. ECG), use a pair of EL450 or EL452 electrodes and one EL452 uncoated ground electrode.
- ❖ When recording from a single site (e.g. studies of individual muscle fibers), use one EL451 and one EL452 uncoated ground electrode.
- ❖ For stimulation, use a pair of EL450 or EL452 electrodes.
- ❖ To record a biopotential signal (such as ECG), abrade the Teflon® off the needle to maximize the contact area.

EL450 Specifications

Type:	28-gauge stainless steel, needle electrodes		
Dimensions	Needle	Diameter	Cable
EL450:	2.5 cm	300 µm	61 cm
EL451:	3.7 cm	460 µm	61 cm
EL452:	1.5cm	300µm	61cm
MRI Compatible:	Yes (non-ferrous)		

EL500 Series — Disposable electrodes

EL504

EL508

The EL500 Series snap electrodes, designed for one use only, provide the same signal transmission as BIOPAC's reusable electrodes, with added convenience and hygiene. Each peel-and-stick disposable electrode is pre-gelled and requires no additional electrode gel or adhesive.

Remove an electrode from the waxed paper strip and position it in the desired location, then snap on LEAD110 or LEAD110S leads (see page 150).

EL500 Specifications

Type: Disposable Ag-AgCl
Fastener: Snap fastener for attachment to LEAD110, LEAD110S or LEAD130
Gel: Hypoallergenic gel
Contact area: 10mm (except EL507 = 1 cm)

EL500 Paired (Dual) Electrodes	foam	41mm x 82mm x 1.5mm
EL501 Small Stress Test Electrodes	foam	38mm diameter
EL502 Long-term Recording Electrodes	tape	41mm diameter
EL503 General-purpose Electrodes	vinyl tape	35mm diameter
EL504 Cloth Electrodes—Facial EMG	cloth	2.5cm sq
EL506 Strip Electrode—Bioimpedance	cloth	25cm (can be cut)
EL507 GSR Snap Electrodes	foam	2.5cm x 4.5cm, 1cm contact area Wet Gel: 0% NaCl and .05% ionic materials
EL508 MRI-Compatible, radiotranslucent	vinyl tape	1cm diameter contact area on 38mm diameter backing; requires LEAD108, see page 125

ELSTM2 Animal Stim. Needle Electrode

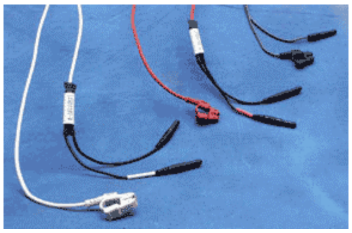
ELECTRODE LEADS

LEAD108 — MRI-compatible/Radiotranslucent Lead for EL508

LEAD108 is used with EL508 MRI-compatible, radiotranslucent electrodes.

Construction: Carbon fiber leadwire and electrode snap
Leadwire Length: LEAD108 is 1.8m, LEAD108A is 3.6m
Leadwire Diameter: 1.5 mm
Leadwire Resistance: 156 Ohms/meter

LEAD110 Series — Electrode leads



The LEAD110 Series, for use with disposable and other snap connector electrodes, are pinch leads for easy connection between the EL500-series snap electrodes and any BIOPAC biopotential amplifier or the GND terminal on the back of the UIM100C. Leads terminate in standard 2mm pin plug for connection to BIOPAC modules or to a Modular Extension Cable (MEC series).

LEAD	TYPE	LENGTH	USAGE NOTE
LEAD110	Unshielded	1 meter	Works best as a ground electrode
LEAD110A	Unshielded	3 meter	Works best with ground or reference electrodes
LEAD110S-R	Shielded; red	1 meter	Use with recording electrodes for minimal noise interference. The white lead plug is for the electrode contact; the black lead pin plug is for the lead shield.
LEAD110S-W	Shielded; white	1 meter	Use with recording electrodes for minimal noise interference. The white lead plug is for the electrode contact; the black lead pin plug is for the lead shield.

See also: TSD155C Multi-lead ECG Cable, page 86
WT100C Wilson Terminal (virtual reference), page 86

LEAD120 Lead for EL120

This 1-meter lead with Touchproof connector works exclusively with the reusable EL120 electrode (shown on page 121). Snap the electrode into place and then plug the lead in with the Touchproof connector. Available in white (LEAD120-W) or red (LEAD120-R).

LEAD130 Shielded Lead Assembly

LEAD130 Shielded Lead Assembly is for use with the EBI100C Electrical Bioimpedance Module or the NICO100C Noninvasive Cardiac Output Module. The shielded lead assembly terminates with an adapter that plugs into the front of the amplifier module and includes four leads:

White = I+ **Red** = Vin+ **Green** = Vin- **Black** = I- (GND)

Important Usage Notes:

- If using multiple biopotential modules, do not connect the ground (GND) for the other modules — establish one ground per subject.
- If using a GSR100C Electrodermal Response Amplifier with the EBI100C or the NICO100C, please note that the I- connection will shunt current from the GSR100C current source. Accordingly, GSR100C measurement values will be shifted somewhat high in absolute conductance, and should be used as relative measures only.

See also: EBI100C Electrical Bioimpedance Module, page 150.
NICO100C Noninvasive Cardiac Output Module, page 154.
EL506 Bioimpedance Strip Electrode and EL500 Series Disposable Electrodes, page 123.

LEAD140 Series Clip Leads

LEAD140 Series clip leads have a 1m black cable and a Touchproof connector, and require the SS1LA interface.

LEAD140 Alligator clip with teeth, 40mm: Use this fully-insulated, unshielded lead to connect fine wire electrodes, including irregular surfaces. Not MRI-compatible: ferrous metal in the clip.

LEAD141 Alligator clip with smooth (flat) clamp, 40mm:: Use this fully-insulated, unshielded lead to connect to fine wire electrodes without damage, including arbitrarily small electrode wires. Not MRI-compatible: ferrous metal in the clip.

LEAD142 Retractable clip lead with copper extension contacts, 3.5mm: Use this unshielded lead to connect to fine wire electrodes up to 1mm diameter. Extension LengthMRI-compatible: non-ferrous copper alloy in clip.

MICROMANIPULATOR

This manual micromanipulator is a reliable, durable, and economical solution for high-precision experiments.

- Vernier scales allow readings to 0.1 mm
- X-axis fine control allows readings to 10 µm
- Includes tilting base
- Includes standard 12 mm clamp
- Includes 14 cm electrode holder
- All control knobs project to the rear, so units can be tightly grouped.

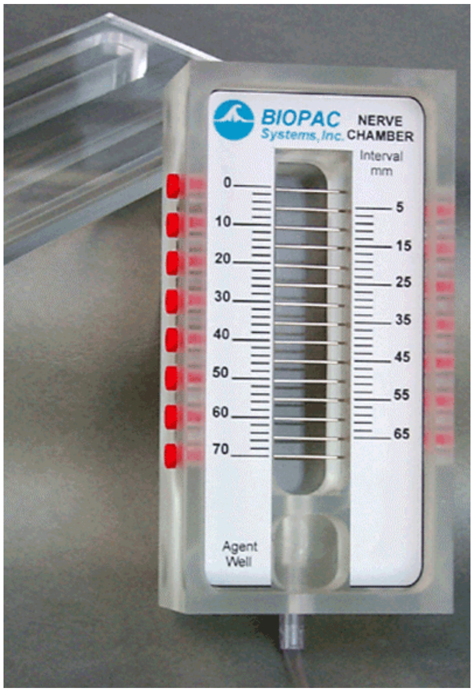
	Travel Range	Resolution
X-axis fine	10 mm	0.01 mm
X-axis	35 mm	0.1 mm
Y-axis	25 mm	0.1 mm
Z-axis	25 mm	0.1 mm

Specify left- or right-handed unit when ordering.

MANIPULATOR-R Right-handed

MANIPULATOR-L Left-handed

NERVE CHAMBERS



NERVE1 Specifications	
Pins:	15, stainless steel
Spacing:	5mm
Sockets:	accept 2mm pin plugs
Reservoir:	holds 35mL (or use drain/valve)
Agent well:	1.4cm x 2cm x 2cm (h x w x l)
Dimensions:	4.5cm x 7cm x 14cm (h x w l)
Lid:	50mm thick

This acrylic, desktop Nerve Chamber has 15 stainless steel pins for recording and stimulating a variety of different nerve preparations. Each stainless steel pin is spaced 5mm apart to provide a variety of recording and stimulating configurations. The sockets accept 2mm pin plugs.

NERVE1 The **unique design** of the NERVE1 chamber includes:

- **Deep Reservoir** (35mL) for containing Ringers or other solutions
- **Drain (with valve & hose)** to facilitate extended viability of your preparation
- **Agent Well** for adding compounds (such as ether or dry ice)
- **Lid** to enclose the preparation when the protocol requires it.

NERVE2 This basic nerve chamber option does not include agent well, drain, or lid.

Related components:

- STM100C Stimulator Module
- STMISO Series Stimulator Modules
- MCE100C Micro-electrode Amplifier
- ERS100C Evoked Response Amplifier
- EMG100C Electromyogram Amplifier

To connect the Nerve Chamber to MP-series Biopotential amplifiers (MCE100C, ERS100C, or EMG100C), use three JUMP100 connectors and three CBL200 adapter cables. Optionally, for additional lead length, use one MEC110C extension cable.

1. Plug the three JUMP100s into the desired points of the Nerve Chamber.
2. Connect the free ends of the JUMP100s to the mating ends of the CBL200s.
3. Then connect the free ends of the CBL200s to the Biopotential amplifier inputs. For additional lead length, plug the MEC110C into the Biopotential amplifier and plug the free ends of the CBL200s into the free end of the MEC110C.

To connect the Nerve Chamber to the STM100C Stimulator, use one CBL106 and one CBL102.

1. Plug the red and black leads (2mm pins) of the CBL106 into the desired points of the Nerve Chamber.
2. Connect the free end (Female BNC) of the CBL106 to the mating end (Male BNC) of the CBL102.
3. Then insert the free end of the CBL102 (3.5mm phone plug) into the 50 Ohm output of the STM100C.

Note: If the STM100C Stimulator is used with a Biopotential amplifier on the same nerve - which is nearly always the case - make sure that the black lead of the CBL106 (stimulation negative) is connected to the same pin as the ground lead going to the Biopotential amplifier. This is easy to do because the design of the JUMP100 allows stacking connections.

Electrode Accessories

TAPE Adhesive

You will need adhesive tape for attaching Active Electrodes and other devices. Use your preferred tape or BIOPAC's adhesive tape:

TAPE1 single-sided adhesive

TAPE2 double-sided adhesive

GEL Electrode Gels

GEL100 This non-irritating, hypo-allergenic gel is used as a conductant with the EL200 series reusable electrodes.

GEL101 This non-irritating, isotonic gel is primarily used as a conductant for the TSD203 electrodermal response electrodes. Each tube contains 4 ounces of gel.

ADD200 Adhesive Disks

The ADD200 series of adhesive disks are two-sided adhesive collars used to hold reusable electrodes in place.

ADD204 19mm outside diameter, use with EL254 and EL254S

ADD208 22mm outside diameter, use with EL258 and EL258S

ELPAD Abrasive Pads

Before applying electrodes, abrade the skin lightly with an ELPAD to remove non-conductive skin cells and sensitize skin for optimal adhesion.

Chapter 5 Gas Concentration Measurement Modules

O2100C and CO2100C

BIOPAC offers two fast-response analyzers for gas analysis. Each module measures partial pressure (of O_2 or CO_2, respectively) and thus module output is proportional to the pressure in the sample cell. Gas sampled must be free of liquids or any condensable vapors and should be filtered to 5 microns or better.

O2100C Records quickly varying oxygen concentration levels. ***See setup on page 134***

Ideal for monitoring time-averaged O_2 levels using mixing chambers or real-time O_2 levels for breath-by-breath measurements.

Employs an analysis technique based on the parametric oxygen measurement principle.

CO2100C Records quickly varying carbon dioxide concentration levels. ***See setup on page 136***

Ideal for monitoring time-averaged CO_2 levels using mixing chambers or real-time CO_2 levels for breath-by-breath measurements.

Employs a single beam infrared, single wavelength, measurement technique.

Both modules are equipped with a variable speed pump to adjust the flow over a wide range of sampling conditions. Sampling line connections for input and output flow are readily accessible on the front panel of either module.

Each module can interface with the AFT15A and AFT15B mixing chambers (via the AFT20 gas sampling interface kit), the AFT21 and AFT22 non-rebreathing T valves or the AFT25 mask with integral non-rebreathing T valve.

Technical Use Notes

1. Snap the module together with the UIM100C (or other BIOPAC modules).
2. Select an unused channel on the channel selector switch on top of the module.
   - If two or more BIOPAC modules are set to the same channel, the outputs will conflict, resulting in erroneous readings.
3. Turn the MP150/MP100 unit on and start the Acq*Knowledge* software.
   - Please consult the "Acq*Knowledge* Software Guide" for information about Acq*Knowledge*.
4. Plug the adapter into the main power and insert the adapter plug into the back of the module.
   - The module is supplied with a 12 vdc @ 1 amp wall adapter**—do not use other wall adapters with a gas analysis module.**
   - The green POWER LED should light up. If it doesn't, check the adapter main power and the connection to the O2100C module and then, if necessary, check the FUSE on the back of the O2100C module. [The FUSE ratings are: Instrumentation Type, Fast Blow @ 2 amps.]
   - The O2100C module has a warm-up time of approximately 5 minutes. Output readings during this warm-up period will be very erratic.
5. Check for pump operation by turning the PUMP switch ON (after the green POWER LED comes on).
   - You should hear a humming from the box, indicating that the pump is working. Generally, you will never have to adjust the PUMP SPEED control.
   - The PUMP will start fast, then slow down and stabilize on a speed after a few seconds. This is a perfectly normal process, designed to overcome the pump's initial mechanical hysteresis.
   - If the pump does not come on or comes on for a brief period and then shuts off, the PUMP SPEED control is set to a very low value (i.e., zero speed). To change the pump speed, keep the PUMP switch in the ON position and use a small straight blade screwdriver to turn the recessed potentiometer in the PUMP SPEED control. Turn trim POT clockwise to increase PUMP speed or Counter-clockwise to decrease PUMP speed
6. Adjust the GAIN switch on the front of the module after proper startup.

Module	**Gain**	**1V output = % gas concentration**	**Voltage output range**
O_2	**100% / V**	100% O_2	0 to 1 volt
O_2	**50% / V**	50% O_2	0 to 2 volts
O_2	**20% / V**	20% O_2	0 to 5 volts
O_2	**10% / V**	10% O_2	0 to 10 volts
CO_2	**10% / V**	10% CO_2	0 to 1 volt
CO_2	**5% / V**	5% CO_2	0 to 2 volts
CO_2	**2% / V**	2% CO_2	0 to 5 volts
CO_2	**1% / V**	1% CO_2	0 to 10 volts

O_2 example: If the **100% / V** setting is used, then 20.93% oxygen (atmospheric level) will be output as 0.2093 volts or 209.3 mV. Generally, you should have no trouble if you leave the GAIN at the setting of 100% oxygen per volt (top position).

CO_2 example: if the **10% / V** setting is used, then 4% carbon dioxide (approximate concentration in expired breath) will be output as 0.40 volts or 400 mV. Generally, you should have no trouble if you leave the GAIN at the setting of 10% carbon dioxide per volt (top position).

Gas Sampling Setup

1. Stabilize the measurement setup prior to sampling any gases.
   Pump speed, filters and sampling lines all affect the oxygen measurement of the module. Everything should be stable prior to attempting module calibration.
2. Attach a 5 micron filter (or better) on the sample input port prior to sampling any gases.
   The sample input port is a male Luer fitting on the front of the module. The module incorporates an internal particulate filter, however the addition of this external filter will extend the life of the internal filter and otherwise improve the long-term performance of the module. Always use a 5 micron hydrophobic sampling filter (or better) at the sampling input of the module. One is included with each module and each Gas Sampling Interface Kit (AFT20). The 5-micron hydrophobic filter will help to protect the module from airborne particulate matter and other contaminants.
3. Screw a 10/32 Luer adapter into the bulkhead fitting and attach the venting line to the Luer adapter to vent undesirable gases away from the site of the module.
   The sample output port is adjacent to the sample input port (on the right, facing the front panel of the module) and is a bulkhead fitting with a 10/32 internal thread.

Important

Sample dry gases only. All water vapor needs to be removed from the sampling stream prior to being monitored by the module. To dry the sampling stream, use water vapor permeable tubing (i.e. NAFION®). The AFT20 Gas Sampling Interface Kit includes all the items necessary (including NAFION® tubing) to efficiently connect the module to the sampling chamber.

Calibration

Each gas concentration module comes factory-calibrated to ± 1% concentration accuracy. If you run at increased flow rates, the calibration may veer further from ±1% accuracy. Generally, **you should perform a gas calibration prior to all exacting measurements**. This may also be required if you are running at increased pump speeds and thus increased flow rate. Initial (Factory) oxygen accuracy calibration is usually inadequate for varying setup protocols. Proper calibration of the module should be performed after the specific measurement setup is in place.

Choose the calibration gases to bracket your expected measurements. For example

- When performing End Tidal O_2 measurements, you can use normal air as the first calibration gas because you know the oxygen concentration is 20.93%. For the second gas, it might be best to use a calibration gas of 16% oxygen and 84% nitrogen. In this case, your measurements will be most accurate for the range of 16.00% to 20.93% oxygen.
- When performing End Tidal CO_2 measurements, you can use normal air as the first calibration gas because you know the carbon dioxide concentration is 0.04%. For the second gas, it might be best to use a calibration gas of 4% carbon dioxide and 96% nitrogen. In this case, your measurements will be most accurate for the range of 0.04% to 4% carbon dioxide.

Exact calibration is typically performed in Acq*Knowledge*, using the **Scaling** function under **Setup Channels**, once the measurement setup is in place.

1. Set up your measurement so that all gas sampling lines are in place between the module and the sampling chamber.
2. Adjust the PUMP SPEED control (if required) on the module.
3. Run the module and click on the CAL1 button when the first calibration gas is introduced into the sampling chamber.
4. Introduce a second calibration gas into the chamber and click on CAL2 when the second calibration gas is introduced into the sampling chamber.

Note: Do not change the pump speed, the sampling filter or the sampling line length/configuration during or after a calibration. Changing any of these elements may reduce the accuracy of the calibration.

Pump Speed Control

The pump speed is factory preset to result in a sampling flow rate of approximately 100 ml/min, when used with the AFT20 Gas Sampling Interface Kit. The time delay between change of oxygen concentration at the sampling end of the Gas Sampling Interface Kit (AFT20) to measurement at the module is approximately 2.4 seconds. This is because the pump will move 100 ml/min and the internal volume of the Gas Sampling Interface Kit is about 4.0 ml.

$$\text{Volume in ml} = (\pi) \bullet (\text{radius in cm})^2 \bullet (\text{length in cm})$$

The Gas Sampling Interface Kit volume is calculated using:

PVC Sample Line:	72" long at 0.060" ID	Volume = 3.336 ml
NAFION® Dryer:	12" long at 0.050" ID	Volume = 0.386 ml
Misc. Tubing/Junctions:	6" long at 0.060" ID	Volume = 0.278 ml

If the sample rate is 100 ml/min, then the pump will pull 4 ml in 2.4 seconds:

$$(60 \text{ min/sec}) \bullet (4 \text{ ml}) / (100 \text{ ml/min}) = 2.4 \text{ sec}$$

To check the flow rate, breathe into the free end of the sampling line at the moment you mark the recording (using the marker function in Acq*Knowledge*). You should see no change in the oxygen concentration level until after 2.4 seconds. Please note that you can change the pump speed to a relatively fast level. It's quite possible to exceed the maximum acceptable flow rate to the module, depending on the sampling line type and conditions. You won't harm the module by setting a fast flow rate, but erroneous readings may occur.

<u>To achieve the best results:</u>

O2100C: Run the pump speed so the flow rate to the module does not exceed 150 ml/min.

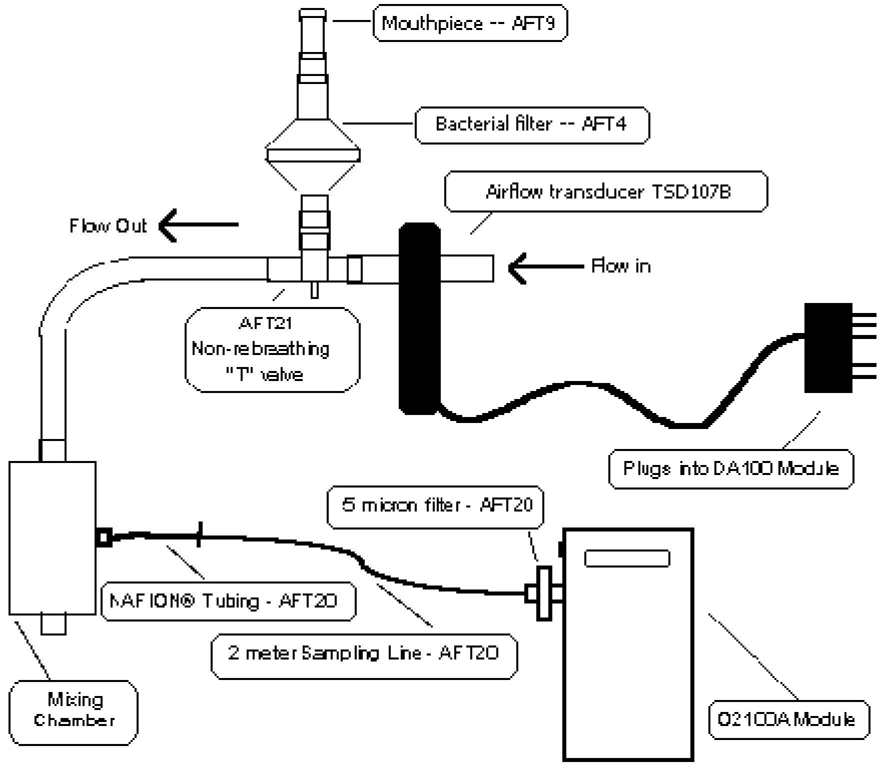
- Between 50 and 100 ml/min, the O2100C module output will be relatively insensitive to flow changes.
- Above 100 ml/min, module output will become increasingly sensitive to flow rate.
- Up to 150 ml/min, the output signal will increase; past 150 ml/min, the signal may oscillate, decrease, or become erratic.
- Response times can often be boosted 50% over the nominal response times of 500ms at 100 ml/min. This particular increase is not exactly specified, as it is somewhat module dependent.
- Run at flow rates between 100 ml/min and 150 ml/min to improve the response time of the O2100C module.

CO2100C: Run the pump speed so the flow rate to the module does not exceed 200 ml/min.

- Between 50 and 200 ml/min, the CO2100C module output will be relatively insensitive to flow changes.
- Above 100 ml/min, module output will become increasingly sensitive to flow rate.
- Above 200 ml/min, the CO2100C module output may become erratic.
- Response times can often be boosted 10% over the nominal response times of 100ms at 100 ml/min. This particular increase is not exactly specified, as it is somewhat module dependent.

O2100C Oxygen Measurement Module

Typical connection for the O2100Cmodule to a mixing chamber, AFT21 and TSD107B:



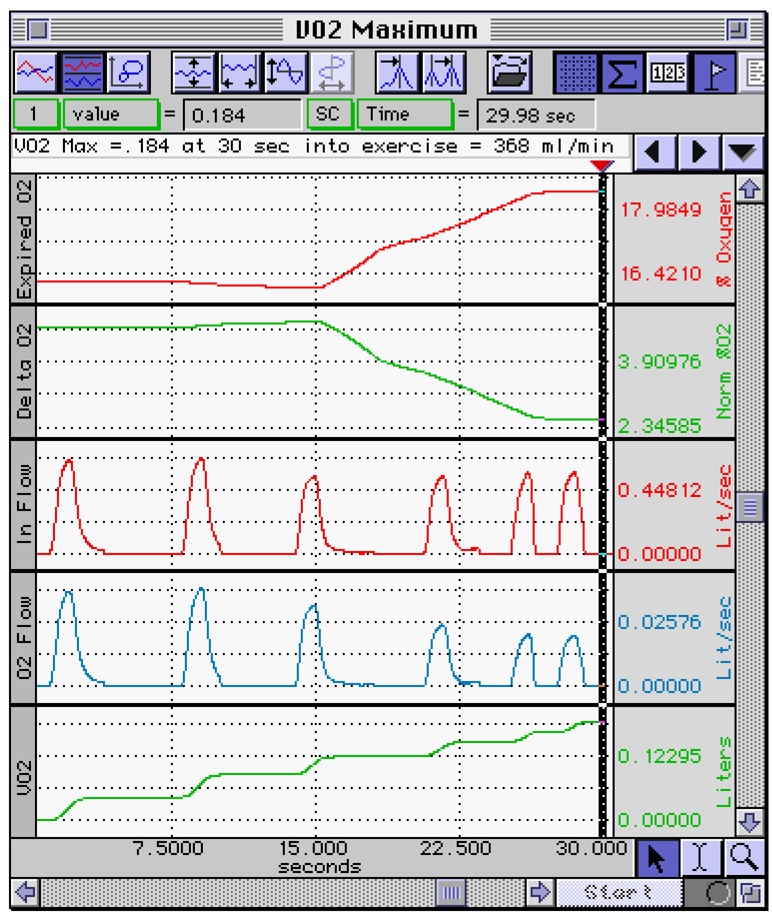
The subject breathes through the mouthpiece (AFT9) that attaches to the non-rebreathing "T" valve (AFT21) via a bacteria filter (AFT4). When the subject inspires, air is drawn into the AFT21, through the TSD107B, as shown by the "Flow In" arrow. When the subject expires, air is forced out through the mixing chamber, as shown by the "Flow Out" arrow.

Assuming the O2100C module is connected to the sampling port of the mixing chamber (via the AFT20 Gas Sampling Interface Kit), the O2100C module will sense the changes in oxygen concentration that occur as the subject breathes.

If the TSD107B is placed in the "Flow In" line, the total volume of expired air can be calculated on a breath-by-breath basis. Because both the oxygen concentration and total volume of expired air are known, it is possible to determine the precise amount of oxygen consumed by the subject during the course of breathing.

The following graph illustrates data collected using this procedure.

Acq*Knowledge* calculated and derived the waveforms in real-time.



Waveform descriptions (as referenced from the top down):

Waveform 1 Concentration of O_2

This waveform is the O2100Cmodule output. The O2100Cmodule samples the O_2 concentration directly from the mixing chamber.

Waveform 2 - V O_2

This waveform is the O_2 concentration in the mixing chamber subtracted from the O_2 concentration in the ambient environment (O_2 = 20.93%). This waveform is the O_2 concentration consumed.

Waveform 3 - V O_2

This waveform is the total inspired O_2 flow.

Waveform 4 - O_2 Flow

This waveform is the mathematical result of multiplying the expired airflow signal measured by the TSD107B by the consumed oxygen concentration (waveform 2). Accordingly, this waveform is the oxygen flow consumed by the subject. Note how the flow signal drops as the normalized oxygen concentration level drops.

Waveform 5 - V O_2

This waveform is the integral of the oxygen flow consumed by the subject. The integral of the oxygen flow is the amount of oxygen consumed up to a particular point in time. In this case, V O_2 equaled 184 ml after 30 seconds of exercise, which extends to an estimate of 368 ml/min oxygen consumption.

O2100CSpecifications

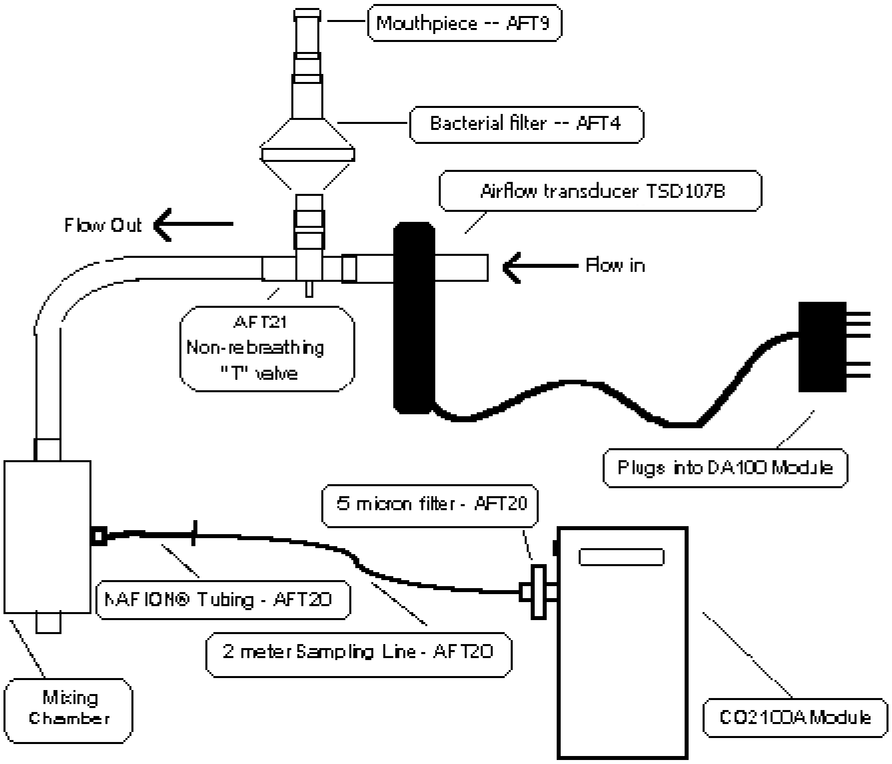
Range:	0-100% O_2
Gain:	10, 20, 50, 100 (%O_2/Volt)
Output Range:	0-10 volts
Repeatability:	±0.1% O_2
Resolution:	0.1% O_2
Linearity:	±0.2% O_2
Zero Stability:	±0.01% O_2/hr
Response Time	
@50 ml/min:	1000msec (T10-T90)
@ 100 ml/min:	500msec (T10-T90) — factory preset
@ 200 ml/min:	160msec (T10-T90)
Flow Range:	50-200 ml/min (50-150 ml/min recommended)
Temp Range:	5-50°C
Zero Drift:	±0.05% O_2/°C
Span Drift	±0.25% O_2/°C
Sampling Port:	Male Luer
Weight:	990 grams
Dimensions:	7cm (wide) x 11cm (deep) x 19cm (high)
Power Source:	12VDC @ 1 amp (uses AC100A transformer)

Note:
The module measures the partial pressure of O_2 so the module output is proportional to the pressure in the sample cell. Gas sampled must be free of any liquid or condensable vapors. Gas should be filtered to 5 microns or better. The module utilizes Servomex, Inc. technology for O_2 concentration signal processing.

See also: AFT Series Air Flow & Gas Analysis Accessories, page 139.
Application Note # AH149 — O2100C Module
Application Note # # AH150 — O2100C Module: Sample application

CO2100C Carbon Dioxide Measurement Module

Typical connection for the CO2100C module to a mixing chamber, AFT21 and TSD107B:

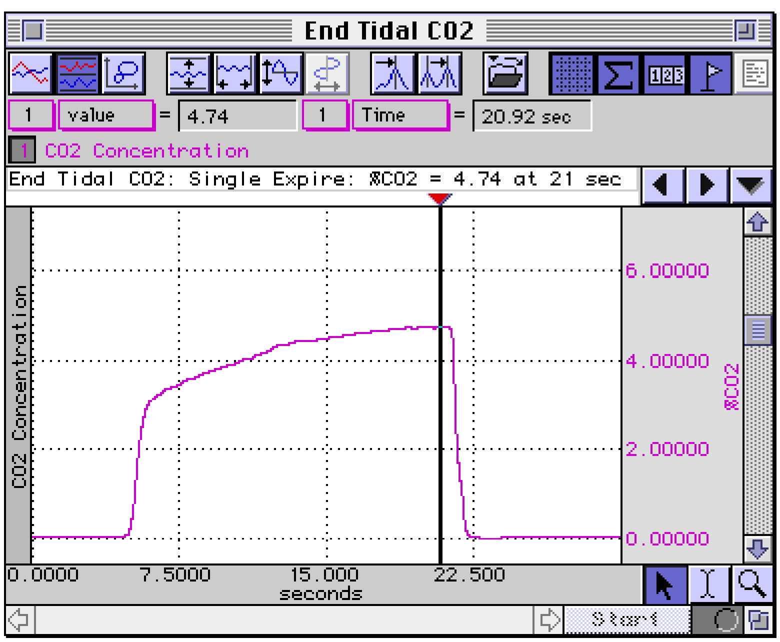


The subject breathes through the mouthpiece (AFT9), which attaches to the non-rebreathing “T” valve (AFT21) via a bacteria filter (AFT4).

When the subject inspires, air is drawn into the AFT21 through the TSD107B (see “**Flow In**” arrow).

When the subject expires, air is forced out through the mixing chamber (see “**Flow Out**” arrow).

This waveform above shows the output of the CO2100C module recorded during a subject’s single expiration. Note that the CO_2 concentration peaks out just prior to the Subject’s inspiration



It would be possible to monitor the total flow (via the TSD107B) and then multiply the flow by the concentration change. The result would be the precise amount of carbon dioxide expired by the subject.

CO2100C Specifications

CO_2 Range:	0-10% CO_2
Gain	1, 2, 5, 10 (%CO_2/Volt)
Output Range:	0-10 volts
Repeatability:	0.03% CO_2
Resolution:	0.1% CO_2
Linearity:	0.1% CO_2
Zero Stability:	0.1% CO_2/24 hours
Response Time:	
@ 50 ml/min	130msec (T10-T90)
@ 100 ml/min	100msec (T10-T90) — factory preset
@ 200 ml/min	90msec (T10-T90)
Flow Range:	50-200 ml/min
Temp Range:	10-45°C
Zero Drift:	0.01% CO_2/°C
Span Drift:	0.02% CO_2/°C
Warm Up Time:	5 minutes @ 25°C
Sampling Port:	Male Luer
Weight:	740 grams
Dimensions:	7cm (wide) x 11cm (deep) x 19cm (high)
Power Source:	12VDC @ 1 amp (uses AC100A transformer)

Note:
The module measures the partial pressure of CO_2 so the module output is a function of the pressure in the sample cell. Gas sampled must be free of any liquid or condensable vapors. Gas should be filtered to 5 microns or better. The module utilizes Servomex, Inc. technology for CO_2 concentration signal processing.

See also: AFT Series Air Flow & Gas Analysis Accessories, page 139.
Application Note # AH151 — CO2100C Module
Application Note # AH152 — CO2100C Module: Sample Application

Gas-System2-RA/B CO2 & O2 Gas Analysis System

Modular assembly makes complete cleaning easy!
See page 218 for cleaning details

Gas-System2 modules measure expired O_2 and CO_2 concentrations. When the subject inspires, air is drawn into the Gas-System2 through the TSD107B airflow transducer. The TSD107B is placed on the inspiration side to eliminate any effects associated with expired air humidity. When the subject expires, air is directed to the Gas-System2 module. The Gas-System2 is designed to work with saturated expired air.

Obtain real-time Oxygen Consumption (VO_2) and Respiratory Exchange Ratio (RER) measurements using the MP System with a Gas-System2 module and some airflow accessories. The Gas-System2 connects directly to the MP System via the UIM100C and requires two channels.

See the **AFT series** of accessories for airflow and gas analysis (page 139)

The non-rebreathing "T" valve directs only expired air to the Gas-System2. Because only expired air is directed to the module, the system acts to average respiratory outflows. This averaging effect causes the CO_2 and O_2 concentrations to vary in accordance to the mean values resident in a few expired breaths.

Two chamber sizes are available for the Gas-System2. Each chamber assembly includes the chamber casing and rod. The chambers work exactly the same way and are interchangeable on the module base. Use the smaller chamber size for small children/medium sized animals.

5-liter chamber — included in the **GAS-SYSTEM2-RA**; order chamber only as **RX-GASA**

1-liter chamber — included in the **GAS-SYSTEM2-RB**; order chamber only as **RX-GASB**

The Gas-System2 also includes **AFT7** tubing, **AFT11E** Coupler, **AFT22** Non-rebreathing T-Valve, and a power supply.

Gas-System2 Specs

O_2 sensor:	Warm-up: 10 minutes. Response time 10-90%: 30 sec. Accuracy: ±1% FSR*. Zirconia solid electrolyte with a 0.1-25% sensing range and an estimated 5-year lifetime. It runs hot, which helps to burn off humidity.
CO_2 sensor:	Warm-up: 2 minutes. Response time 10-90%: 45 sec. Accuracy: ±3% FSR*. Uses a humidity-repellant (hydroponic) membrane and has a sensing range of 0-5%. It uses non-dispersive infrared diffusion with single-beam IR and a self-calibrating algorithm. It also runs hot, which helps to burn off humidity.
Calibration:	Gas-System2 sensors are factory calibrated prior to shipping.
Power Supply:	5 V DC @ 1.6 amp (AC200) wall adapter for serial numbers ending 0-199 12 V DC @ 1 amp (AC100A) wall adapter for serial numbers ending 200 or greater

*FSR = Full Scale Reading

GASCAL Calibration Gas

GASREG REGULATOR

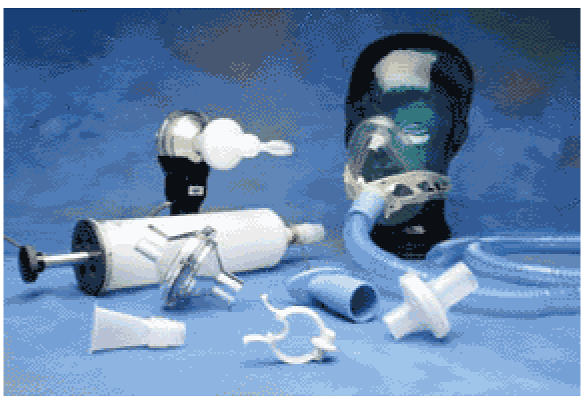
Calibration Gas Specs	
Composition:	4% Carbon Dioxide, 16% Oxygen, balance Nitrogen
Cylinder Type:	ED
Valve Connection:	CGA-973
Accuracy:	+/-0.03% absolute
Stability Guarantee:	3 years
Cylinder Pressure:	2200 psig
Gas Volume:	560 liters

Use the single stage, non-corrosive, general-purpose GASREG regulator with the GASCAL Calibration Gas Cylinder. Single-stage pressure regulators reduce the cylinder pressure to the delivery or outlet pressure in one step, and are generally good for short duration applications.

GASCAL Cylinder Recycling Program available.

- Call 1-800-457-0809 to receive instructions for returning a cylinder; delivery paid by sender and recycling covered by manufacturer.

AFT Series Air Flow & Gas Analysis Accessories



AFT1 **Disposable Bacterial Filter**
22mm ID/OD; designed to remove airborne bacteria; for use between the TSD117 and the AFT2.

AFT2 **Disposable Mouthpiece**
22mm OD; connects to the TSD117 via the AFT1.

AFT3 **Disposable Noseclip**
Gently squeezes the nostrils shut.

AFT4 **Disposable Bacterial Filter**
Designed to remove airborne bacteria; for use with the TSD107B, connects between the AFT7 and the AFT9. (35mm ID/35mm OD)

AFT6 **Calibration Syringe**
0.6 Liter Calibration syringe. *See also*: AFT26 2.0 liter Calibration Syringe

AFT7 **Smooth Bore Tubing**
1 meter length, 35mm ID; connects to the TSD107B.

AFT8 **Autoclavable Mouthpiece**
30mm ID; interfaces with the TSD117 and reduces the cost of disposable parts.

RX117 Replacement Sterilizable Airflow Head
22mm ID/30mm OD; autoclavable transducer head for the TSD117; can be used with the AFT8 to reduce the cost of disposable items.

AFT 9 **Reusable Mouthpiece**
35mm ID; designed to connect to the TSD107B with the AFT7 via the AFT4. (Also connects to the AFT21 Non-rebreathing T Valve.)

AFT10 **Disposable Adult Facemask**
These mouthpieces connect to 22mm breathing circuits. Connects directly to the AFT1, AFT22 non-rebreathing T valve or TSD117 air flow transducer (via AFT11B coupler). Includes hook-ring to secure AFT10S adjustable head strap. (22mm ID/25mm OD)

AFT10S **Adjustable Head Strap**
This fully adjustable latex head strap holds the AFT10 disposable facemask securely to the subject's head. Use one or more straps to securely fasten the mask.

***** See the AFT part guides on pages 141, 144, and 144 for common applications. *****

AFT11 Couplers

AFT11A Flexible

AFT11B Rigid

AFT11C Rigid

AFT11D Flexible

AFT11E Flexible

These couplers are very useful for connecting up a variety of air flow port IDs and ODs to transducers, tubing and calibration syringes. Pick the AFT11 Series coupler that matches the port sizes you want to interface.

AFT11 Series Coupler Guide

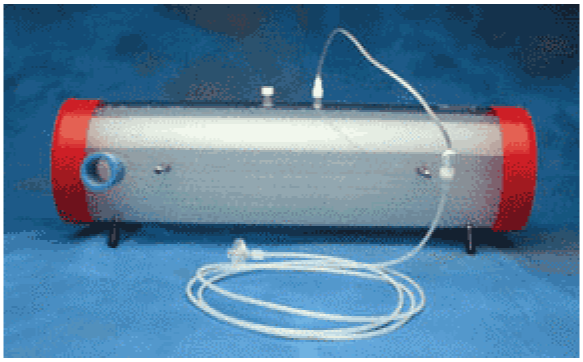
Item 1		Item 2		Coupler
15mm	OD	22 mm	ID	AFT11B
20mm	OD	22 mm	ID	AFT11B
22 mm	ID	15mm	OD	AFT11B
		20mm	OD	AFT11B
		22mm	ID	AFT11B
22mm	OD	22mm	OD	AFT11C
		25 mm	ID	AFT11C
22-25mm	OD	22mm	OD	AFT11E
		25 mm	ID	AFT11E
25mm	ID	25 mm	ID	AFT11C
25-30 mm	OD	25-30mm	OD	AFT11A
		28-35mm	ID	AFT11A
28-35 mm	ID	25-30mm	OD	AFT11A
		35mm	ID	AFT11A
35mm	ID	28-35mm	ID	AFT11A
		38mm	ID	AFT11E
35-38mm	ID	22-25 mm	OD	AFT11E
35-38mm	OD	35-38 mm	OD	AFT11D

AFT12 Tubing (22mm)

For use in 22mm breathing circuits. (1.8 meter length, 22mm ID)

***** See the AFT part guide on page 144 for additional applications. *****

AFT15 Mixing Chambers



AFT15A/B mixing chambers incorporate dual baffles and flexible connection ports capable of interfacing with 35mm or 22mm breathing circuits.

Two female Luer connection ports are provided between the baffles for the simultaneous monitoring of O_2 and CO_2 concentrations.

AFT15A shown with AFT20 (not included)

AFT15A — 5 Liter

Use for demanding expired gas analysis measurements (e.g. VO_2 or RER measurements).

Dimensions: 13cm (dia) x 47cm (long) Coupling Ports: 35mm OD, 25mm ID

AFT15B — 8 Liter

Use for very high volume and rate expired gas analysis measurements (e.g. VO_2 or RER measurements).

Dimensions: 13cm (dia) x 73cm (long) Coupling Ports: 35mm OD, 25mm ID

AFT 20 Gas sampling Interface kit

Use to interface the CO2100Cand the O2100C modules with the TSD107B or TSD117 Airflow Transducer breathing circuits.

Includes: 1.8 meters of 1.5mm diameter polyethylene tubing with M/F Luer connector; 30cm Nafion® water vapor permeable tubing with M/F Luer connector; 5 micron filter with M/F Luer connector; M/F Luer to female Luer "Y" connector.

Typically, the AFT20 connects the CO2100C or O2100C directly to the sampling port of a mixing chamber. The AFT20 also permits sampling connections to the Non-rebreathing "T" Valves (AFT21 or AFT22).

AFT21 Non-Rebreathing "T" Valve: Female, 35mm

High performance, very low dead space, low air flow resistance valve, suitable for high air flow applications (e.g. exercise physiology). The non-rebreathing "T" valve incorporates a Female Luer connector gas sampling port for interfacing with the AFT20. All ports are 35mmOD, 30mm ID.

Includes: 35mm OD coupler

Requires: AFT4, AFT7, and AFT9 for proper operation.

AFT22 (top left), **AFT21** (top right) and **AFT21** (bottom)

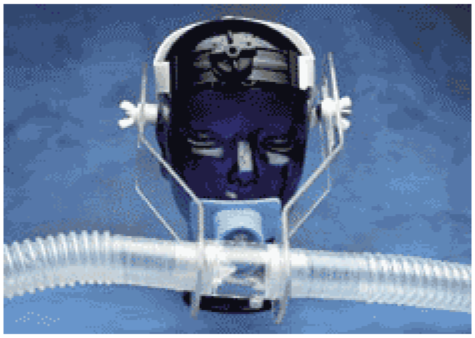
AFT22 Non-Rebreathing "T" Valve: Male, 22mm

Very low dead space valve, suitable for low to medium air flow applications. The non-rebreathing "T" valve incorporates a Male Luer connector gas sampling port for interfacing with the AFT20. All ports are 22mmOD; the common port incorporates a 15mm ID connection.

Includes: 22mm OD coupler *Requires*: AFT1 and AFT2 for proper operation.

***** See the AFT part guides on pages 141 and 144 for common applications. *****

AFT24

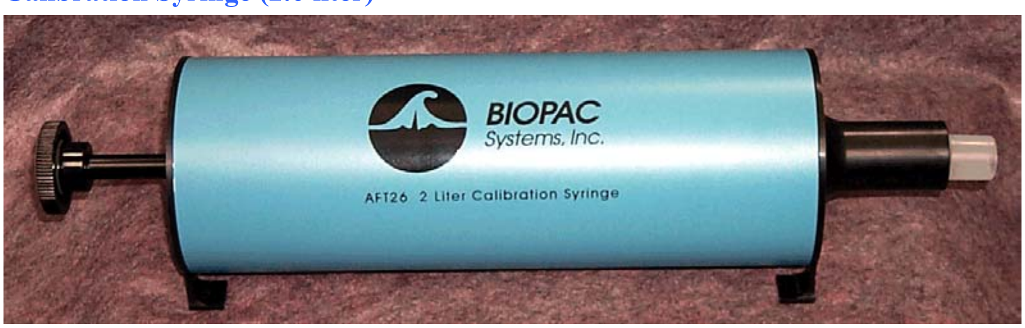


The AFT24 head support is used when breathing directly into the AFT21 non-rebreathing T valve for exercise physiology measurements. The AFT21 is secured directly in front of the subject and minimizes the strain associated with the weight of valves and tubing.

AFT25 Facemask with Valve

This adult facemask with integral non-rebreathing T valve is a high performance, very low dead space, low air flow resistance mask and valve; suitable for high air flow applications (e.g. exercise physiology). The AFT25 incorporates two gas sampling ports (female Luer) for interfacing with the AFT20 Gas Sampling Kit. All ports are 35mm OD, 28mm ID.

AFT26 Calibration Syringe (2.0 liter)



The increased size and accuracy of this 2.0 liter calibration syringe provide a wider calibration range than the AFT6 for advanced studies. The AFT26 Calibration Syringe is certified to have a 2-liter volume that meets or exceeds an accuracy ± 1% of the total displacement volume.

Part Summary for Typical Air Flow / Gas Analysis Applications

Pulmonary Function

Part #	High Flow *Exercising human*	Med. Flow *Resting human*	Low Flow *Child, Pig, Dog*	Very Low Flow *Small Animals*
AFT2 Mouthpiece		X		
AFT3 Noseclip	X	X		
AFT6 Calibration Syringe	X	X	X	
AFT7 Tubing	X (2)			
AFT9 Mouthpiece	X			
AFT21 T Valve	X			
AFT24 Head Support	X (optional)			
AC137 In-line Transformer				
DA100C Amplifier	X (2)	X	X	X
TSD107B Pneumotach (High)	X (2)			X
TSD117 Pneumotach (Med.)		X		
TSD127 Pneumotach (Low)			X	
TSD137 A-E Pneumotachs (Very Low)				X (by size)

Part Options: AFT25 = AFT21 + AFT9 + AFT3 + optional AFT24
AFT2 + AFT3 = AFT0 + AFT11B

Exercise Physiology

Part #	Mixed Expiratory Gases		Breath-by-Breath		
	High Flow *Exercising human*	Med. Flow *Resting human*	High Flow *Exercising human*	Med. Flow *Resting human*	Low Flow *Dog*
AFT6 Calibration Syringe	X	X	X	X	X
AFT7 Tubing	X (2)		X		
AFT10 Facemask		X		X	
AFT10S Head Strap		X		X	
AFT11 Series Couplers		X (3)*		X	X (2)**
AFT12 Tubing		X (2)		X	
AFT15A Mixing Chamber	X	X			
AFT20 Interface Kit	X (2)	X (2)	X (2)	X	X (2)
AFT22 T Valve		X		X	X
AFT25 Facemask w/Valve	X		X		
DA100C Amplifier	X	X	X	X	X
CO2100C CO2 Module	X	X	X	X	X
O2100C O2 Module	X	X	X	X	X
TSD107B Pneumotach (High)	X		X		
TSD117 Pneumotach (Med.)		X		X	
TSD127 Pneumotach (Low)					X

Part Options: AFT25 = AFT21 + AFT9 + AFT3 + optional AFT24
AFT10 + AFT10S = AFT2 + AFT3 + AFT11C

* use 2 AFT11B and 1 AFT11C
** use 1 AFT11B and 1 AFT11C

***** See the AFT part guide on page 141 for additional applications. *****

Chapter 6 Specialty Modules

NIBP100A

MPMS100

OXY100C Pulse Oximeter Module

The OXY100C Pulse Oximeter Module is primarily used to measure the blood oxygen saturation level in a non-invasive fashion. The OXY100C transmits two wavelengths of light (660 and 940 nanometers) via LEDs through a pulsating vascular bed (typically a finger or an earlobe) to a receiving photodiode. Compared to unsaturated blood, oxygen saturated blood absorbs different fractions of light at different wavelengths. Accordingly, the ratio of light absorbed can be used to calculate the ratio of oxygenated hemoglobin to total hemoglobin.
This ratio is expressed as the O_2 Saturation Level and will vary between 0% and 100%.

The Pulse Oximeter Module connects directly to the MP150 via the UIM100C. Up to four OXY100C modules can be used with a single MP System. The Pulse Oximeter Transducer (TSD123) connects to the OXY100C via a 3-meter extension cable (included with the OXY100C).

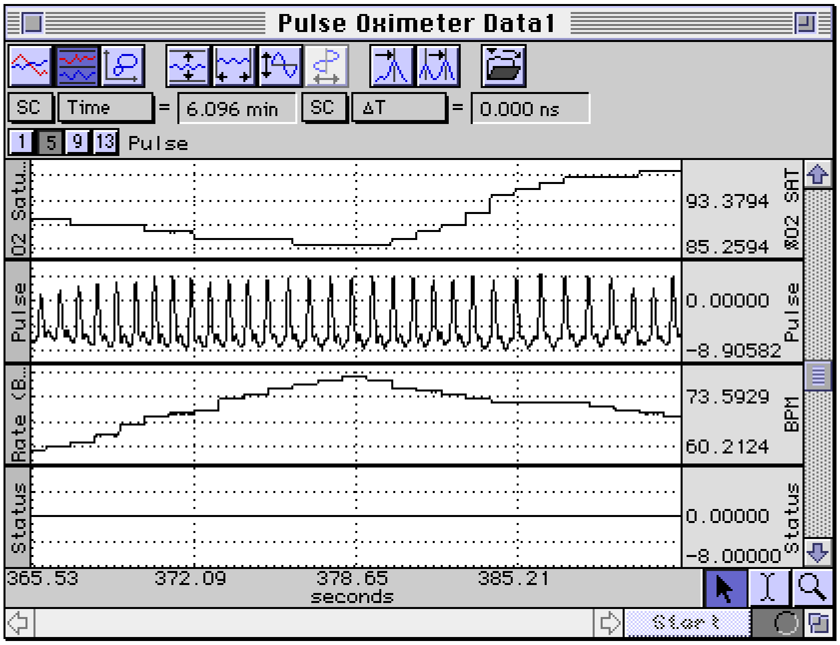
The OXY100C outputs four signals simultaneously. Output signals can be optionally directed to a number of different MP System input channels as determined with the **BANK SELECT**:

CH	SIGNAL	Bank 1	Bank 2	Bank 3	Bank 4
A	O_2 Saturation	Channel 1	Channel 2	Channel 3	Channel 4
B	Pulse Waveform	Channel 5	Channel 6	Channel 7	Channel 8
C	Pulse Rate	Channel 9	Channel 10	Channel 11	Channel 12
D	Module Status	Channel 13	Channel 14	Channel 15	Channel 16

There is an **ON/OFF** switch for each signal output channel on the OXY100C. Set the switch for each signal output channel to sample all, some or none of the signals. When any Signal Channel Enable switch is OFF (bottom position), the corresponding MP150 channel can be used by another input device.

The OXY100C includes Calibration features that permit easy scaling of all these signals when using the OXY100C with the MP System.

The graph on the following page shows sample output.



O_2 Saturation
(beat-by-beat, CH 1)

Pulse Waveform
(beat-by-beat, CH 5)

Pulse Rate
(continuous, CH 9)

Module Status
(dynamic, CH13)

OXY100C Calibration

When you initially set up the OXY100C with an MP System:

1. Snap the OXY100C into the side of the UIM100C.
2. Connect the Analog cables directly from the MP150 to the OXY100C Analog mating connectors.
3. Connect the Digital cables directly from the MP150 to the OXY100C Digital mating connectors.
4. When the cable connections are secure, power up the MP150.
5. On the OXY100C module, place the four-position **Bank Select** switch to the first bank (top position).
   In this position, the OXY100C output signals will be directed as follows:

O_2 Saturation	Channel 1
Pulse Waveform	Channel 5
Pulse Rate	Channel 9
Module Status	Channel 13

   If you are using multiple OXY100C modules with a single MP System, then be sure to place additional OXY100C modules on unique banks. Furthermore, please check that any OXY100C output does not reside on the same channel used by any other amplifier module.
6. On the OXY100C module, slide the four-position **Calibration** switch to the **OFF** position (bottom).
7. On the OXY100C module, set all the **Signal Channel Enables** to **ON** (top position).
8. Using the **Input Channels Setup** in Acq*Knowledge*, label the OXY100C signal outputs as follows:

Channel	Label
A1	02 Saturation
A5	Pulse
A9	Rate (BPM)
A13	Status
9. It's best to calibrate the OXY100C once, then **Save As>Graph Template** to save the respective scale values.

Scale Setting

1. **Determine the highest frequency component** of all the waveforms sampled. To properly sample the signals from the OXY100C, the sample rate of the MP150 (set from Acq*Knowledge*) will need to be double the rate of the highest frequency component resident in the input data.

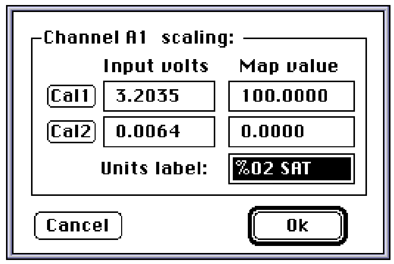
   If you are just using the OXY100C, the maximum sampling rate will normally be 50Hz or less.

   If you are not sampling the Pulse Waveform signal, the maximum sampling rate drops to double what the expected pulse rate maximum would be.

   The fastest pulse rate detectable by the OXY100C is 250 BPM, so the safe sampling rate minimum would be: 2 x [250 BPM]/[60 sec/min] or 8.33Hz

2. **Establish the Calibration Scaling for each channel**

O_2 Saturation (Channel 1) scaling



a) Slide the OXY100C Calibration switch on the OXY100C module to the CAL LO position.

b) Click on the Cal2 button in the Channel A1 scaling dialog box.

c) Slide the OXY100C Calibration switch to the CAL HI position.

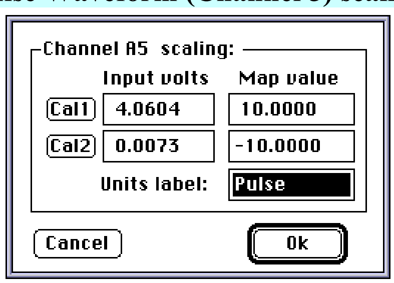
d) Click on the Cal1 button in the Channel A1 scaling dialog box.

e) Enter the Map values: Cal1 = 100.00, Cal2 = 0.00

f) Enter the Units label: %O2 SAT

Ideally, the nominal Cal1/Input volts value should be exactly 3.200. The nominal Cal2/Input volts value should be exactly 0.00. In practice, there will be very slight deviations from these expected values. The minimum O_2 Saturation level detectable by the OXY100C is 0.00%. The maximum O_2 Saturation level detectable is 100%. In the range from 80% to 100% the O_2 Saturation level is ±2% accurate. From 0% to 79%, the O_2 Saturation level is unspecified.

Pulse Waveform (Channel 5) scaling



a) Slide the OXY100C Calibration switch on the OXY100C module to the CAL LO position.

b) Click on the Cal2 button in the Channel A5 scaling dialog box.

c) Slide the OXY100C Calibration switch to the CAL HI position.

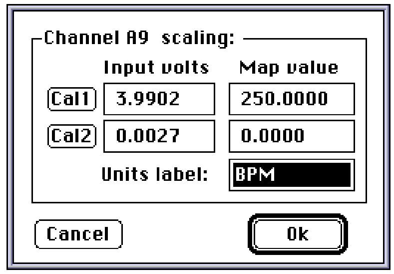
d) Click on the Cal1 button in the Channel A5 scaling dialog box.

e) Enter the Map values: Cal1 = 10.00, Cal2 = -10.00.

f) Enter the Units label: Pulse

Ideally, the nominal **Cal1/Input** volts value should be exactly 4.064. The nominal **Cal2/Input volts** value should be exactly 0.00. In practice, there will be very slight deviations from these expected values. The Pulse Waveform output from the OXY100C is functionally equivalent to a standard plethysmographic waveform, such as obtained with the PPG100C and TSD200.

Pulse Rate (Channel 9) scaling

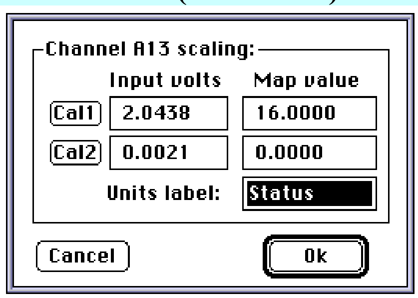


a) Slide the OXY100C Calibration switch on the OXY100C module to the CAL LO position.
b) Click on the Cal2 button in the Channel A9 scaling dialog box.
c) Slide the OXY100C Calibration switch to the CAL HI position.
d) Click on the Cal1 button in the Channel A9 scaling dialog box.
e) Enter the Map values: Cal1 = 250.00, Cal2 = 0.00.
f) Enter the Units label: BPM.

Ideally, the nominal **Cal1/Input volts** value should be exactly 4.00. The nominal **Cal2/Input volts** value should be exactly 0.00. In practice, there will be very slight deviations from these expected values.

The minimum BPM detectable by the OXY100C is 30. The maximum BPM detectable is 250. The BPM accuracy in the range of 30-250 BPM is ±1%. The BPM settles to ±1% of the final reading less than 15 seconds after the sensor is properly applied.

Module Status (Channel 13) scaling



1. Slide the OXY100C Calibration switch on the OXY100C module to the CAL LO position.
2. Click on the Cal2 button in the Channel A13 scaling dialog box.
3. Slide the OXY100C Calibration switch to the CAL HI position.
4. Click on the Cal1 button in the Channel A13 scaling dialog box.
5. Enter the Map values: Cal1 = 16.00, Cal2 = 0.00.
6. Enter the Units label: Status.

Ideally, the nominal **Cal1/Input volts** value should be exactly 2.048. The nominal **Cal2/Input volts** value should be exactly 0.00. In practice, there will be very slight deviations from these expected values.

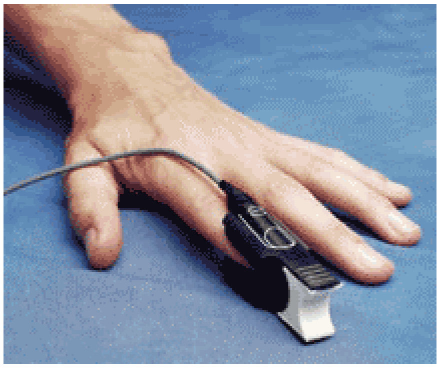
The Module Status levels are:

0.0 = Proper operation

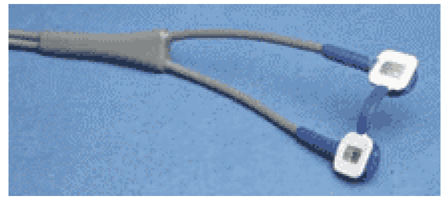
1.0 = Probe off finger

10 = Probe disconnected from OXY100C

TSD 123 Series SpO_2 Transducers for OXY100C



TSD123A



TSD123B

TSD123A SpO_2 Finger Transducer

The TSD123A Blood Oxygen Saturation Finger transducer connects to the OXY100C Pulse Oximeter module and is ideal for short term SpO_2 monitoring.

The transducer, with the OXY100C, provides continuous readings for SpO_2, pulse rate, Pulse Waveform, and Module Status. The transducer comes with a 1-meter cable, which plugs into the (3m) extension cable included with the OXY100C.

TSD 123B Universal Adhesive SpO_2 Transducer

The Universal Adhesive TSD123B Blood Oxygen Saturation Transducer connects to the OXY100C Pulse Oximeter module, and comes with a 1-meter cable, which plugs into the (3m) extension cable included with the OXY100C. Adhesive patches can be used to connect to the TSD123B to fingers, ears, and toes. The transducer fits into a special window cut into the adhesive patch, which allows the transducer to be located on almost any part of the body and is ideal for long-term monitoring.

The TSD123B, with the OXY100C, provides continuous readings for SpO_2, Pulse rate, Pulse Waveform, and Module Status.

TSD123A/B Calibration

See the OXY100 transducer.

<u>TSD123 Series Specifications</u>

Optical Transmission:	Red (660nm) and IR (940nm)
MRI Compatible:	Yes (no ferrous parts)
Weight:	TSD123A: 23 grams, TSD123B: 6 grams
Dimensions:	TSD123A: 62mm (long) x 23mm (wide) x 26mm (high)
	TSD123B: 12mm (long) x 12mm (wide) x 12mm (high)
Sterilizable:	Yes (contact BIOPAC for details)
Cable Length:	1 meter
Interface:	OXY100C—see page 145

EBI100C Electrical Bio-Impedance Amplifier

> ***See also***
> **Application Note #AH-196**
> Cardiac Output Measurement
> **www.biopac.com**
> and
> **Applications** (Appendix) in the "Acq*Knowledge* Software Guide"

The EBI100C records the parameters associated with cardiac output measurements, thoracic impedance changes as a function of respiration or any kind of biological impedance monitoring.

The EBI100C incorporates a precision high frequency current source, which injects a very small (100µA) 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.

The EBI100C simultaneously measures impedance **magnitude** and **phase**. Impedance can be recorded at four different measurement frequencies, from 12.5kHz to 100kHz; cardiac output measurements are usually performed at a measurement frequency of 50 kHz.

For operation, the EBI100C connects to four unshielded electrode leads terminating in Touchproof sockets. The EBI100C is typically used with EL500 paired disposable electrodes, but can function with spot or ring electrodes, reusable electrodes, or needle electrodes.

The **CH SELECT** switch has four bank settings, which assign EBI100C output (i.e. Magnitude or Phase) channels as follows:

Bank	Magnitude (MAG)	Phase (PHS)
1	Channel 1	Channel 9
2	Channel 2	Channel 10
3	Channel 3	Channel 11
4	Channel 4	Channel 12

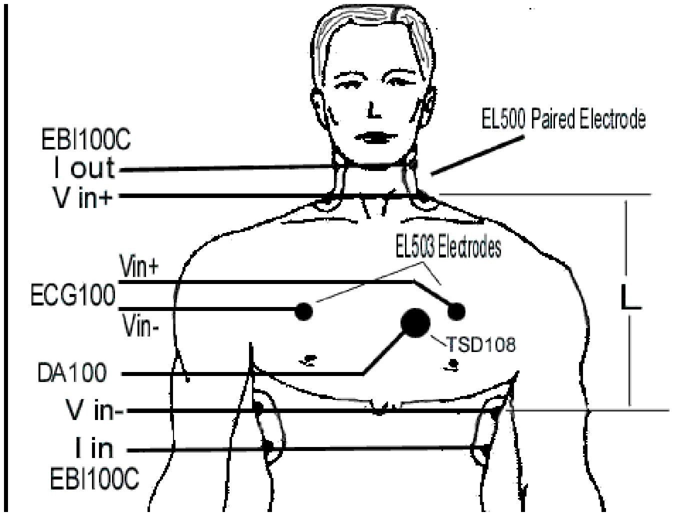
If the particular EBI100C output is not used, the respective assigned channel cannot be used for another module's output; users should simply not record on the unwanted, but assigned channel.

Grounding

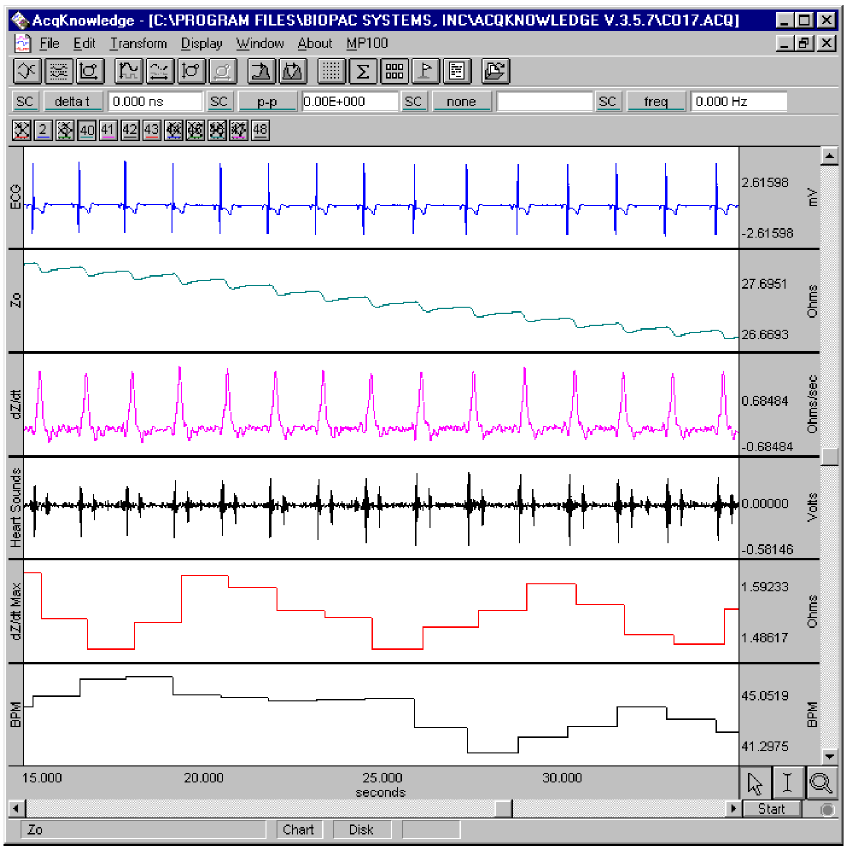
When using the EBI100C amplifier with other biopotential amplifiers attached to the same subject, it's not necessary to attach the ground lead from the biopotential amplifier(s) to the subject. The subject is already appropriately referenced to the subject via the attachment to the EBI100C. If a biopotential ground is attached to the subject, then currents sourced from the EBI100C will be split to the biopotential amplifier ground lead, potentially resulting in measurement errors.

Typical Configuration for Cardiac Output Measurements

For injecting current and averaging voltage at four paired-electrode sites (required for **cardiac output measurements**), use four CBL204 Touchproof "Y" electrode lead adapters (see page 212) and eight LEAD110 electrode leads with each EBI100C.



Sample Data



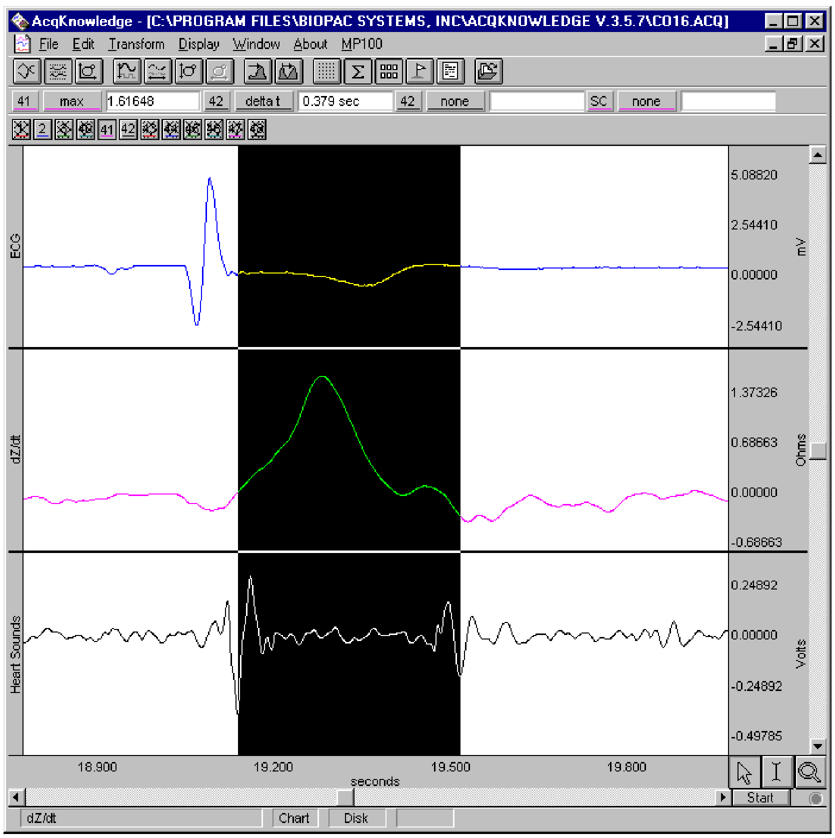
Note that dZ/dt maximum is determined on a cycle-by-cycle basis from the raw dZ/dt waveform.

Similarly, the heart rate in BPM is derived from the raw ECG waveform in Channel 1.

This graph illustrates the procedure for measuring Left Ventricular Ejection Time (T).

The Acq*Knowledge* cursor was swept to bridge from peak to peak in the filtered (40-60 Hz) Heart Sounds channel.

The delta t (0.379 seconds) indicates the time from aortic valve opening to closing.



Applications

Cardiac Output can be determined, non-invasively, by employing electrical bio-impedance measurement techniques. Electrical bio-impedance is simply the characteristic impedance of a volume of tissue and fluid. In the case of Cardiac Output measures, the relevant tissue includes the heart and the immediate surrounding volume of the thorax, and the relevant fluid is blood. The electrical impedance of the thorax can be thought of as composed of two types of impedance's:

1. **Zo** (the base impedance) corresponds to non-time varying tissues, such as muscle, bone and fat.
2. **dZ/dt** is the magnitude of the largest impedance change during systole (Ω /sec).

BIOPAC Application Note #AH-196 Cardiac Output Measurements, implements the following equation, but other equations/modifications can be incorporated.

$$SV = r \cdot (L^2/Zo^2) \cdot T \cdot dZ/dt$$

Where: SV = Stroke volume (ml)
r = Resistivity of blood (Ω · cm)
L = Length between inner band electrodes (cm)

Frequency Response Plots

The 0.05Hz lower frequency response setting is a single pole roll-off filter.

See the sample frequency response plots beginning on page 215: 10Hz LP, 100Hz LP

EBI100C Calibration

For Cardiac Output Measurements

1. Set the EBI100C to a Frequency of 50kHz and a Magnitude Gain range of 5 ohms/volt.
2. Introduce a 20 ohm resistor between the I Out / Vin+ combination terminal to the I In / Vin- combination terminal.
3. Press the Cal1 button…
4. Introduce a 40 ohm resistor between the I Out / Vin+ combination terminal to the I In / Vin- combination terminal.
5. Press the Cal2 button…

EBI100C Specifications

Number of Channels:	2 – Magnitude (MAG) and Phase (PHS)
Operational Frequencies:	12.5, 25, 50, 100kHz
Current Output:	100µA (rms)— constant sinusoidal current
Outputs:	MAG of Impedance (0-1000Ω) PHS of Impedance (0-90°)
Output Range:	±10V (analog)
MAG Gain Range:	100, 20, 5, 1 Ω/volt
MAG LP Filter:	10Hz, 100Hz
MAG HP Filter:	DC, 0.05Hz
MAG Sensitivity:	0.0015 Ω @ 10Hz bandwidth
PHS Gain:	90°/10 volts
PHS LP Filter:	100Hz
PHS HP Filter:	DC coupled
PHS Sensitivity:	0.0025 degrees @ 10Hz bandwidth
CMIV -- referenced to	
Amplifier ground:	±10V
Mains ground:	±1500 VDC
Signal Source:	Electrodes (four electrode leads required)
Weight:	370 grams
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)

NICO100C

The NICO100C is designed to specifically record the parameters associated with cardiac output measurements. It incorporates a precision high frequency current source, which injects a very small (400µA) 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/dt; labeled "DZ" on the module). Zo and dZ/dt can be recorded at four different measurement frequencies, from 12.5kHz to 100kHz; 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 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 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/dt) channels as follows:

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

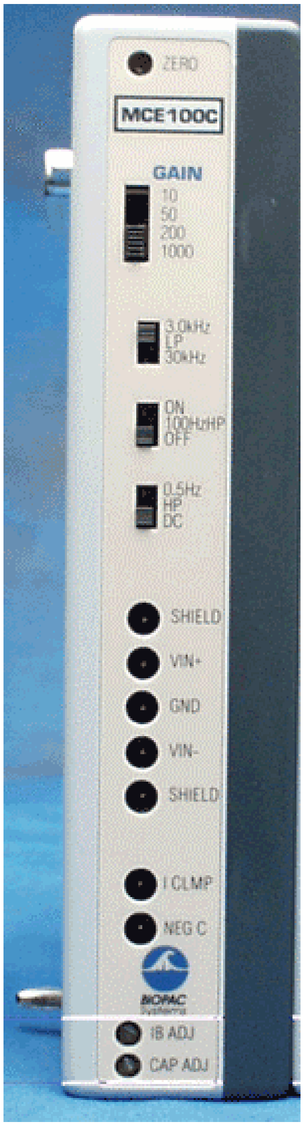
If the particular NICO100C output is not used, the respective assigned channel cannot be used for another module's output; users should simply not record on the unwanted, but assigned channel.

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.

NICO100C Specifications

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

MCE100C Micro-electrode Amplifier



The MCE100C is an extremely high input impedance, low noise differential amplifier that accurately amplifies signals derived from micro-electrodes. A number of selectable options make the module useful for general-purpose recording of cortical, muscle and nerve action/resting potentials or cellular recordings with the optional use of input capacity compensation and a current clamp.

Cable shield drives for input signals can be configured for voltage following (for reduced input capacitance) or simply grounded (for low feedback noise).

See also
Application Note #AH-190
Using the MCE100C
Micro-electrode Amplifier
www.biopac.com
and
Applications (Appendix)
in the "Acq*Knowledge*
Software Guide"

The MCE100C includes manual controls for input capacity compensation (±100pF) and clamp current zeroing (I bias). It also incorporates an external voltage control to vary the clamp current proportionally to the control voltage (100mV/nA). An MP150A D/A output channel can drive this external voltage control to change clamp currents automatically during recording. The MCE100C also includes a clamp current monitor output so the clamp current can easily be recorded by another MP150 input channel.

For general-purpose recording, without input capacity compensation or a current clamp, use standard shielded or unshielded electrode leads terminating in Touchproof sockets.

Add simple input capacity compensation and current clamp control by connecting the respective signal ports to the [Vin+] input of the MCE100C using the JUMP100C jumper connectors.

For the best performance and shielding, use the MCEKITC (page 157) to interface a micro-electrode lead cable to the MCE100C.

IMPORTANT USAGE NOTE

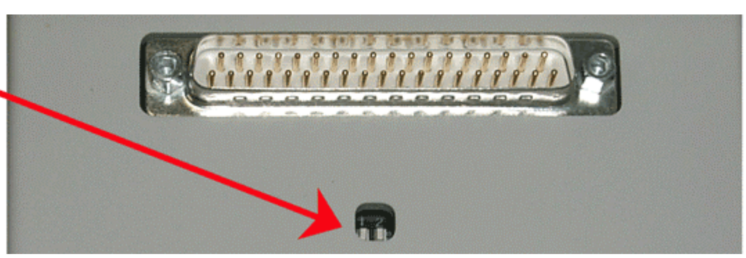
Although the MCE100C will function with an MP100A System, an MP150A system is recommended due to the module's wide operational bandwidth. Contact BIOPAC for details.

Frequency Response Plots

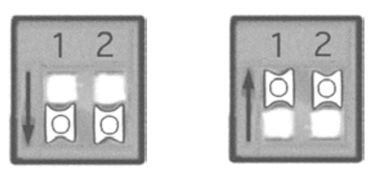
The 0.05Hz lower frequency response setting is a single pole roll-off filter.

Modules are factory preset for 50Hz or 60Hz 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 60Hz in the United States and 50Hz in most of Europe; contact BIOPAC if you are unsure of your country's line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

Line Frequency switch bank is on the back of the amplifier



50 Hz **60 Hz**



Both switches DOWN

Both switches UP

See the sample frequency response plots beginning on page 215: 100Hz HPN (with 50Hz notch)
100Hz HPN (with 60Hz notch)
3kHz LP
30kHz LP

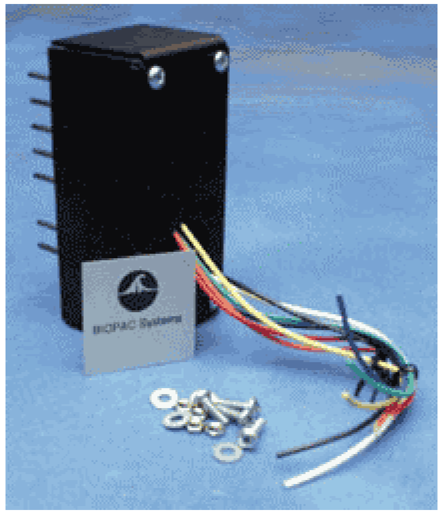
MCE100C Calibration

No calibration required. Use the CBLCALC to verify accuracy.

MCE100C Specifications

Gain & Input Voltage:	Gain	Vin (mV)
	10	±1000
	50	±200
	200	±50
	1000	±10
Output Range:	±10V (analog)	
Frequency response		
Low Pass Filter:	3kHz, 30kHz	
High Pass Filter:	DC, 0.5Hz, 100Hz	
CMRR:	92dB typical; see Shield Drive Operation on page 215	
CMIV – referenced to		
Isolated ground:	±10V	
Mains ground:	±1500 VDC	
Notch Filter:	50dB rejection (50/60Hz)	
Noise Voltage:	2.1µV rms - (DC-3000Hz)	
Noise Current:	0.1 fA/√Hz	
Z (input)		
Differential:	10 E15 Ω	
Common mode:	10 E15 Ω	
Cap Comp (Neg):	Input capacitance compensation (0-100pF) – manual control	
I Clamp (I bias):	Adjustable (±100nA) – voltage control	
I Clamp Control:	Input - 3.5mm phone jack (100mV/nA)	
I Clamp Monitor:	Output - 3.5mm phone jack (100mV/nA)	
Signal Source:	Micro-electrodes	
Weight:	350 grams	
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)	

MCEKITC Connector Kit for MCE100C Micro-electrode Amplifier



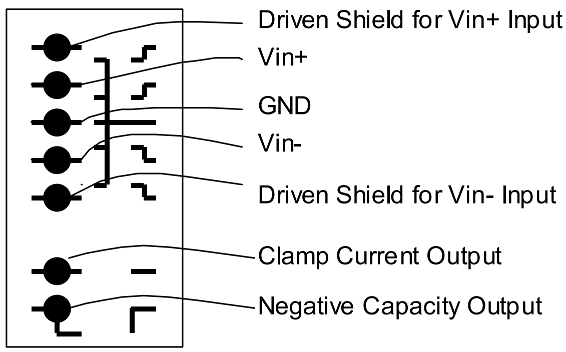
Build a customized adapter to a micro-electrode shielded cable. Cable shields can be tied to voltage follower drive or simply grounded. Input capacity compensation and clamp current options can be independently added to or removed from a cable configuration. The MCEKITC comes with seven attached Touchproof sockets (1.5mm) and instructions.

The MCEKITC is a junction box assembly that plugs directly into the front panel of the MCE100C amplifier. The MCEKITC comes equipped with an assortment of wire and coaxial cable to customize the MCE100C for a variety of micro-electrode lead connectors. The MCEKITC construction allows you to mount the appropriate interface connector to the housing and solder wires to the respective socket pins.

The MCEKITC is required when either of the last two MCE100C operational modes (5,6) are used with micro-electrodes. The following table illustrates the configuration desired. The amplifier configuration is determined via the MCEKITC. The MCEKITC connects to the MCE100C and modifies the MCE100C appropriately. See the respective figure to determine the correct MCEKITC configuration for your application.

INPUT TYPE	SHIELD	CURRENT CLAMP	NEGATIVE CAPACITY	MCEKITC FIGURE
Differential	Grounded	No	No	A
Differential	Driven	No	No	B
Single-ended	Grounded	No	No	C
Single-ended	Grounded	No	Yes	D
Single-ended	Grounded	Yes	Yes	E
Single-ended	Driven	Yes	Yes	F

MCEKITC LEGEND



MCEKITC CONFIGURATIONS

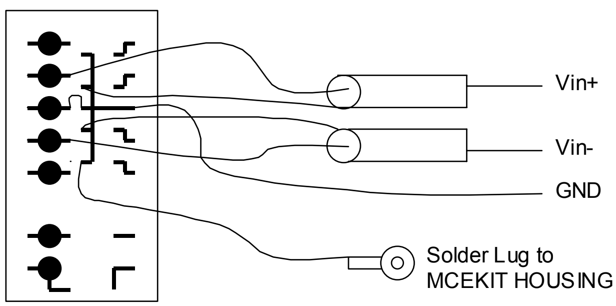


FIGURE A

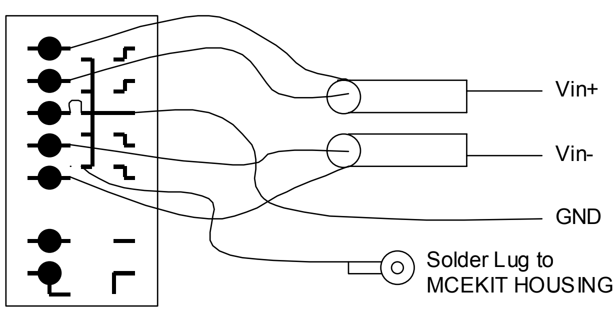


FIGURE B

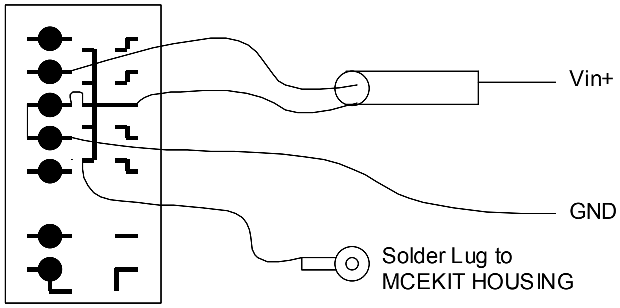


FIGURE C

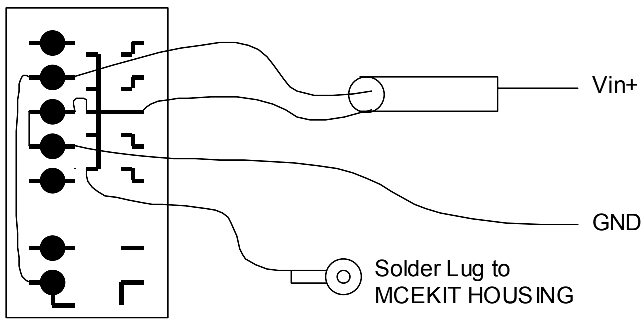


FIGURE D

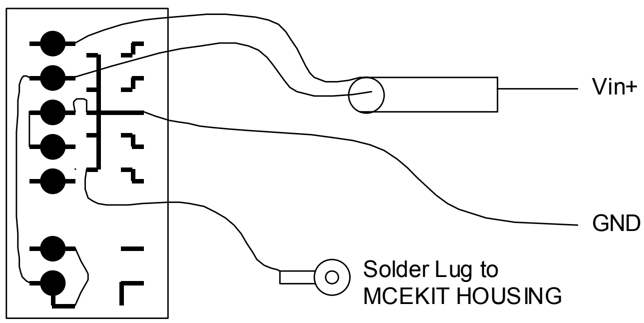


FIGURE E

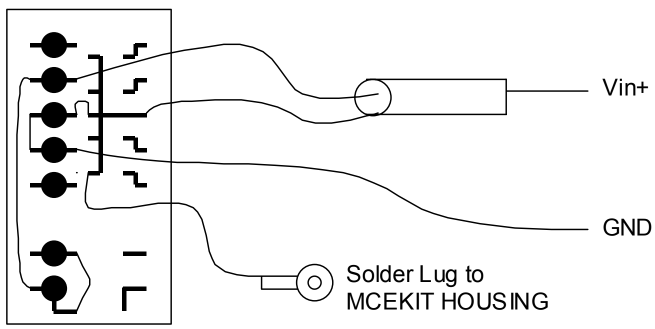
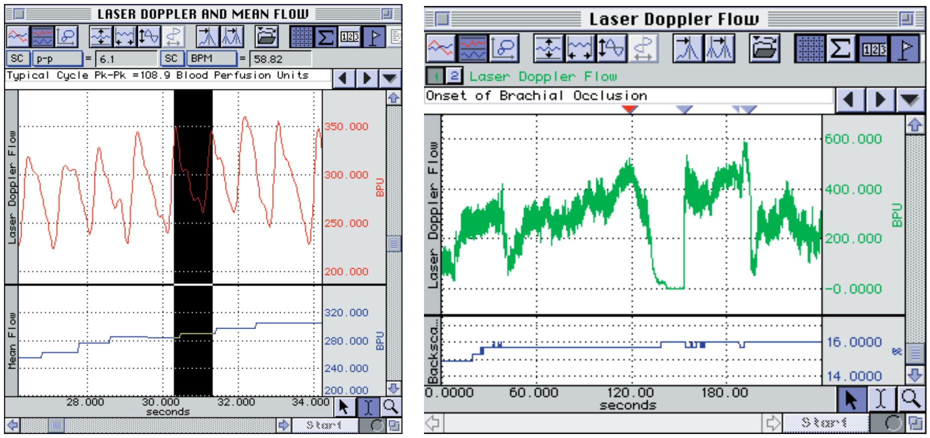


FIGURE F

Laser Doppler Flowmetry



Sample blood perfusion data acquired with the LDF100C

Laser Doppler Flowmetry (or simply "LDF") is an established and reliable method for the measurement of blood perfusion in microvascular research. Most LDF applications are concerned with monitoring the competence of regional (microvascular) blood supply following trauma, degenerative and pathological disease, surgical intervention and drug therapy.

LDF measurements are performed with the Laser Doppler Flowmetry module (LDF100C) and a wide range of fiber-optic based probes (TSD140 series) in order to access the tissue. Probes include small and lightweight probes for (non-invasive) skin and tissue surface measurements and needle type probes for direct (invasive) measurements within tissue, such as muscle and organ. Double-sided adhesive rings (ADD200 series) can be used to attach surface type probes to tissue; one size of ring fits both standard and miniature surface probes

LDF Calibration requires a calibration kit (LDFCAL), which includes a Motility Standard and positioning device to hold a probe in the solution during calibration. The Motility Standard comprises a carefully controlled solution of microspheres undergoing Brownian motion , which provides a standard calibration value of 1000 BPU ±5% at 21°C.

The Laser Doppler Flowmetry section covers

- LDF100C laser Doppler flowmetry module & specifications
- TSD140 series laser Doppler probes & specifications
- LDFCAL Calibration Kit
- LDF Setup (module & probes)
- LDF Calibration Procedure
- LDF Troubleshooting
- Storage & Maintenance
- LDF — Basic Principles

Unpacking LDF Components

1. Inspect the packaging for damage before unpacking the component(s).
   - If the outer packaging or carton is wet or damaged in any way, immediately notify the shipping agent and file a claim. It is the receiver's duty to notify the specific carrier's local office. In the event of any damage, please save the shipping carton as evidence.
2. Unpack the component(s) and check the part(s) against the enclosed packing slip.
3. Remove the packaging and check for signs of obvious damage or defect either to the main body of the LDF100C module or the TSD140 series laser Doppler probes.
   - Contact BIOPAC Systems, Inc. for replacement of any damaged component.

IMPORTANT
It is essential that you fully understand the **Warnings** and **Cautions** before using the LDF100C.

LDF100C Laser Doppler Flowmetry Module

> **IMPORTANT**
> It is essential that you fully understand the **Warnings** and **Cautions** before using the LDF100C.

The LDF100C is a laser Doppler microvascular perfusion module that is capable of monitoring red blood cell (erythrocyte) perfusion in the microcirculation of a tissue. This module uses a Laser Doppler Flowmetry technique.

- Microvascular blood perfusion is indicated on the Acq*Knowledge* software display in relative units called Blood Perfusion Units (BPU).
- In common with all LDF devices, quantitative measurements of tissue blood perfusion in absolute units (e.g. ml/min/g of tissue) are not possible with the LDF100C.

The LDF100C laser Doppler microvascular perfusion module works by illuminating tissue with low power laser light using a probe (TSD140 series) containing optical fiber light guides. Laser light from one fiber is scattered within the tissue and some is scattered back to the probe. Another optical fiber collects the backscattered light from the tissue and returns it to the module. Most of the light is scattered by tissue that is not moving but a small percentage of the returned light is scattered by moving red blood cells. The light returned to the module undergoes signal processing to extract the signal related to the moving red blood cells. The LDF100C is not designed for the diagnosis, mitigation or treatment of disease in humans.

CONTROLS, INDICATORS AND SYMBOLS

Interface: Connect the LDF100 directly to the UIM100C as part of an MP system for data acquisition.

Channel Select Switch: Choose a channel setting that will not conflict with other modules to display Flow and Backscatter as follows:

Flow	Backscatter
CH 1	CH 5
CH 2	CH 6
CH 3	CH 7
CH 4	CH 8

If the particular output (i.e. Flow or Backscatter) is not used, the respective assigned channel cannot be used for another module's output. The user should simply not record on the unwanted, but assigned channel.

Cal Button: For calibrating new or existing probes (intentionally recessed).

Reset Button: For re-initializing the LDF100C module without unplugging the power supply to the module.

Status LED: Color changes to indicate status: Green = Power ON, Amber = Laser ON, and Flashing Red/Amber = Warnings.

Probe Connector: Combined fiber optic and electrical connector. Use only TSD140 series probes.

Power plug: Mini-Din socket on the back panel; use to connect the AC101 power adapter that is included with each LDF100C module.

1. Place the LDF100C module on a flat surface close to the point of measurement; note that the standard probe cable length is 3m. Press the **RESET** button to initialize the LDF100C module without unplugging the power. Initialization will be followed by a double beep and a Green LED status indication. Allow the module to warm up for 10 minutes with a probe attached before taking any measurements.

See also: **TSD140** series probes, page 163 · LDF Warnings & Cautions, page 169
LDFCAL calibration standard, page 167 · LDF Troubleshooting, 172
LDF Calibration, page 167-168 · LDF Principles (overview), page 176

LDF100C Specifications

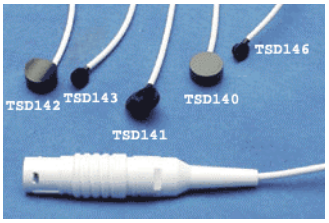
Primary Measure:	Microvascular blood flow (Relative RBC Flux)
Mode of operation:	Continuous Laser Doppler flowmetry
Units:	LDF: Blood Perfusion Units (**BPU**); Tissue Remittance (**BS**)
Analog output range:	**BPU**: 0-5V analog (0 – 9999) and **BS**: 0-5V analog (0-100%)
Analog output resolution:	**BPU**: 0.01 (60 µV) and **BS**: 0.002% (60 µV)
Laser Type:	Semiconductor laser diode — Peltier temperature stabilized
Laser Class:	1 (EN 60825-1:1994; 21 CFR 1040-10)
Laser Wavelength:	830±10 nm
Laser Power (at probe):	< 0.5 mW at end of a probe
Processing sampling rate:	48 kHz (16 bit)
Processing Bandwidth:	22 kHz
Output update rate:	750 Hz
Dynamic Range:	116dB
Doppler Update Rate:	187.5Hz
Linearity:	Up to 0.35% of full scale moving scatterers by volume.
Response time:	< 100 msec
Stability of reading:	5% of full scale (measured using the Motility Standard solution)
Zeroing:	Automatic
Calibration:	Flow: User set via Motility Standard of 1000 BPU ±5% @ 21°C (LDFCAL) Flux: Factory set using a motility standard (i.e. known concentration solution of latex spheres undergoing Brownian motion)
Operating humidity:	0 – 70% (non condensing humidity)
Operating temperature:	10 – 35°C
Storage temperature:	5 – 50°C
Signal Source:	TSD140 Series Laser Doppler Probe
Probe identification:	Automatic; calibration factors automatically stored
Power source:	±12, +5 VDC @ 1 amp (uses AC101A transformer)
Technology:	Oxford Optronix, Ltd. technology for laser Doppler signal processing
Weight:	790 grams
Dimensions (H × W × D):	19cm x 7cm x 11cm

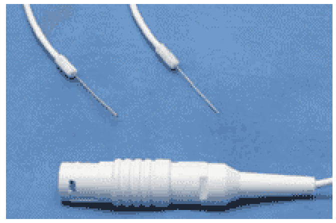
TSD140 Series Probes

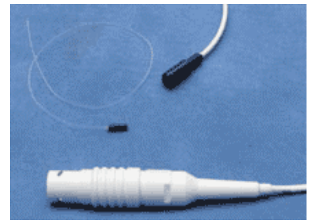
The TSD140 series offers a wide range of laser Doppler probes that interface with the LDF100C module. Probes are designed to allow the local monitoring of blood perfusion from almost any tissue type. All probes contain optical fibers, which are used to direct low power laser light to and from the tissue. All probes are MRI compatible (no ferrous parts). Three types of probes (surface, needle, and disposable) and a driver are stocked for the LDF100C; other probes styles are available. Standard cable length for all probes is 3m. Single fiber probes have an overall length of 30-100cm and require the use of TSD148; they can be cut to any length with a sharp, hot knife.

✓ Probe cable lengths between 1m and 8m and needle and pencil probes with shaft lengths of between 10mm to 70mm may be custom ordered. Contact BIOPAC Systems, Inc. for more information.

PROBE OPTIONS







SURFACE	Designed for skin and exposed tissue blood flow monitoring. Ideal for noninvasive measurements from skin or organ surfaces. The signal delivery fiber intersects the probe body at a right angle, making the probes easy to secure to the skin or tissue surface. Made from black Delrin®.
TSD140	Cutaneous blood flow anywhere on the skin surface.
TSD141	These thin and lightweight surface probes apply negligible pressure to the underlying tissue. Their low-profile geometry allows them to be placed under compression bandages, which is useful in chronic wound healing studies.
TSD142	Micro-vascular skin blood flow in the digits (i.e., Raynaud's disease).
TSD143	Small animal work, including post-operative monitoring such as reconstructive surgery (suturable).
TSD146	Small animal work and general clinical tissue surface monitoring (this is a non-suturable version of the TSD143).
NEEDLE	Designed for invasive and endoscopic blood flow monitoring of tissue. Needle probes can be used both for noninvasive monitoring from the surface of tissues (by positioning the tip in contact/close proximity to the tissue) or for invasive placement and monitoring from regions within tissues. The signal delivery fiber terminates straight into the top of the needle, making the probes easy to insert into tissue. Made from medical grade stainless steel.
TSD144	Microvascular blood flow measurements. Typically positioned using a micromanipulator clamp over soft tissues such as brain and muscle.
TSD145	Micro-vessel or micro-vascular blood flow within skin, muscle, tumor and organ tissues. Fine probe diameters facilitate blood flow measurements from only a small number of capillaries.
DISPOSABLE	Designed for safe, continuous, invasive microvascular blood flow monitoring. Composed of a polymethyl methacrylate core and a tough fluorinated polymer cladding. Incorporate a coupling bead to interface with the TSD148 single fiber driver for connection to the LDF100C module.
TSD147A	Blood flow measurements under the skin (use a standard 22G ID cannula to insert directly into tissue).
TSD147B	Cortical blood flow measurements on the surface of the brain during surgery (single fiber is bonded for right-angle delivery through a flexible PharmElast® strip).
DRIVER	
TSD148	This is a precision-machined coupling system for interfacing the TSD147 series single fiber probes to the LDF100C. The TSD148 consists of a compact laser driver housed in a non-metallic Delrin® housing (MRI compatible), terminated with a 2-meter cable for connection to the LDF100C module.

HANDLING TSD140 SERIES PROBES

! Caution TSD140 series probes must be handled with care. Failure to do this may result in breakage of the internal optical fibers, scratching the polished probe ends or separation of the cable from the probe ends or connectors.

! Caution Do not use a worn or damaged probe.

The optical fibers used in the TSD140 series probes are glass and have a diameter of 125 µm. The fibers are flexible and can be bent; however, it is recommended that they are not subjected to bends with a radius less than 30mm.

The connectors on TSD140 series probes must be kept clean and free from dust. Connectors should be inspected before each use. Dust can be removed from the connectors using a good quality 'air-duster.'

You may check the integrity of TSD140 series probes by holding the probe end to a source of bright diffuse light (e.g. a lamp) and inspecting the connector end. Two bright spots of light of equal intensity should be visible from the pins within the connector.

APPLYING PROBES TO THE SUBJECT

Surface Surface probes may be attached to tissue using double-sided adhesive rings (such as ADD204 or ADD208). Alternatively, the miniature suturable probe can be sutured directly into position.

Needle Needle probes can be secured in a micromanipulator assembly or stand and placed above the tissue. Depending on the tissue, fine needle probes may be introduced directly into tissue after first ensuring an appropriate superficial incision has been made. Alternatively, a suitable introducer or catheter should be used. All needle style probes can optionally be secured in a micromanipulator assembly or stand.

- Bear in mind that all needle probes have a blunt end and may cause some degree of tissue trauma when inserted directly into tissue without using a suitable introducer.

Single fiber The insertable probe can be inserted into tissue using a standard 2G ID cannula. The surface probe can be attached to tissue (such as brain) using a flexible PharmElast™ strip. These probes can be cut to the desired length with a hot, sharp knife. The single fiber probes require the TSD148 driver.

Pencil Due to their larger diameter, standard pencil probes (which can be custom ordered) should be introduced using a suitable introducer or catheter when used invasively.

It is important to control the relative movements of the tissue (induced by breathing, etc.) with respect to the probe to reduce artifact in the perfusion signal. Allowing the supported probe to lightly come into contact with the surface of the tissue can reduce these artifacts. Under some conditions it may be best to hold the probe in position by hand.

It is essential to ensure that the pressure on the tissue is minimal, otherwise local occlusion of the microvasculature may result.

Avoid direct illumination of the measurement site from external lighting sources and direct sunlight. Excessive ambient lighting at the probe site can disturb the blood perfusion reading. If erroneous readings due to excessive ambient lighting levels are suspected, cover the attached probe and measurement area with a light piece of opaque material.

2. The probe can be placed in or on tissue at any stage, either prior to or following connection to the LDF100C.
3. The probe can be exchanged for another at any stage without the need to first switch off the LDF100C.
4. The probe does not need to be disconnected from the LDF100C prior to turning off the LDF100C.

SOFTWARE SCALING

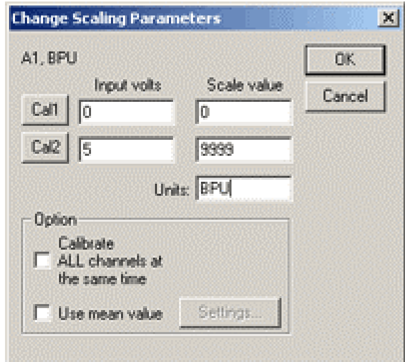
You need to setup Acq*Knowledge* to scale the input values to the correct units for LDF measurements. Access the Change Scaling Parameters dialog under MP menu>Setup Channels>Scaling, and then set the parameters for BPU (Channel A1) and Backscatter (Channel A5) as follows:

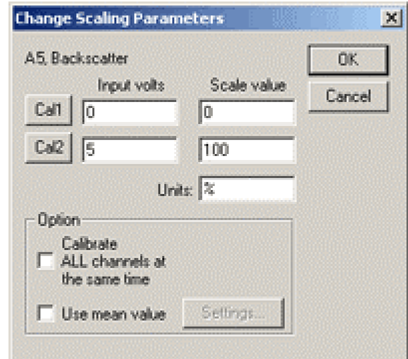
BPU (A1)

	Input	Scale	Units
Cal1	0	0	BPU
Cal2	5	9999	

Backscatter (A5)

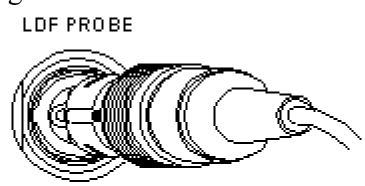
	Input	Scale	Units
Cal1	0	0	%
Cal2	5	9999	





CONNECTING PROBES TO THE LDF100C

Very carefully remove the probe from its protective case and check that the Probe Connector is clean and free from dust. The TSD140 series probes plug into the front of the LDF100C module, which contains the laser source, sensitive photo-detection and signal processing circuitry. All probes are standardized using a reference Motility Standard (LDFCAL) consisting of latex microspheres undergoing Brownian motion.



1. Select a TSD140 series probe.
2. Plug the TSD140 probe into the "PROBE" connector located on the front panel of the LDF100C, taking care to orient the connector plug with respect to the socket. Align the probe and push the connector firmly home into the socket until a click is heard.
3. Assuming the LDF100C module is powered ON, the LED status indicator will be illuminated in Amber. (When the probe is not inserted, the indicator will illuminate Green only.)
   - If there is no probe connected the **`No Probe`** beep sequence will be emitted.
   - If the connected probe has not previously been calibrated then the **`Calibrate Probe`** beep sequence will be emitted. Please refer to the probe calibration section on page 168.
4. After a short delay, the module will enter Trend Mode, and the Acq*Knowledge* software display should show blood perfusion values as **`XXXX BPU`** (where XXXX is a number in the range 0-9999 units) and backscatter as **%** (a percentage).

   ! Caution Since the LDF100C is a light-based measurement system, it is not unusual for random values to appear on the software display while probes are not attached to tissue.

5. With the probe connected, allow the module to warm up for a period of at least 10 minutes before making any measurements or performing a calibration.

Disconnect

To disconnect the probe plug from the front panel socket, gently pull the connector by the ribbed part of the connector.

! Caution Attempting to remove the connector by any other part of the probe (for example, by pulling the cable sleeving) will cause irreparable damage to the probe.

PROBE IDENTIFICATION

The LDF100C system incorporates proprietary Simple Sensor technology that enables the module to recognize a previously calibrated probe and to automatically apply the necessary probe calibration coefficients. This alleviates the need to re-calibrate a probe every time a different probe is plugged in to the module. The module 'recognizes' a specific probe every time the probe is plugged in.

New Probe

If a new (or unrecognized) probe is connected to the LDF100C module, then the module's Flow & Backscatter outputs will return to 5.1 volts shortly after the RESET button is pressed. To take measurements, the probe must either be removed and a recognized probe connected or the new probe must be calibrated (see following section on calibrating probes). The status LED will be amber when a probe — recognized or unrecognized — is connected to the LDF100C.

Temperature out of range (Double beep every 5 seconds)

If the internal temperature of the LDF100C module rises above the maximum operating temperature range of the device, then the module will emit a double beep every 5 seconds. If this occurs, the instrument should be moved to cooler environment for proper operation. With the temperature out of range, output signals will continue to be generated but may no longer be within the calibrated tolerance of the system and should be interpreted with caution. If the environmental temperature is below 25°C and this message occurs repeatedly soon after power-on, then a fault may have occurred and you should contact BIOPAC Systems, Inc. for further advice.

TSD140 SERIES PROBE SPECIFICATIONS

Part #		Suturable	Body Dimensions	Angle of Laser Delivery & Collectio	Skin & Tissue Monitoring
TSD140	Standard surface	no	8mm (high) x 17mm (dia)	Right angle to probe body	yes
TSD141	Low-profile surface	no	6mm (high) x 17mm (dia)	Right angle to probe body	yes
TSD142	Digit surface	no	10mm (high) x 17mm (dia)	Right angle to probe body	yes
TSD143	Suturable Miniature surface	yes	5mm (high) x 10mm (dia)	Right angle to probe body	yes
TSD144	needle	no	25mm (long) x 1mm (dia)	Straight	Invasive and endoscopic
TSD145	Micro-needle	no	25mm (long) x 480µm (dia)	Straight	Invasive and endoscopic
TSD146	Miniature surface	no	5mm (high) x 5mm (dia)	Right angle to probe body	yes
TSD147A*	Disposable, insertable single fiber	no	30cm (long) x 0.5mm (dia)	Straight	Insert via 22G ID cannula
TSD147AL*	Disposable, insertable single fiber	no	100cm (long) x 0.5mm (dia)	Straight	Insert via 22G ID cannula
TSD147B*	Surface single fiber	no	33cm (long) x 0.5mm (dia)	Right-angle delivery	Yes (via PharmElast™ strip)
Part #	**Style**	**Used with**	**Body Dimensions**	**Connection Type**	**Cable Length**
TSD148	Single fiber Driver	TSD147A TSD147AL TSD147B	28mm (long) x 8mm (dia)	In-line single fiber connector	2 meters

***Requires the TSD148 Single Fiber Driver for operation with the LDF100C.**

QUICK SET UP AND USE GUIDE

*For detailed set up and use guidelines, see section 5 on page

1. Place the LDF100C module on a flat surface close to the point of measurement.
2. Connect the AC100A to the LDF100C and plug the AC101 into a properly grounded AC Mains socket.
3. Allow **at least ten minutes** for the instrument to warm up before making any measurements.
4. Select a probe with which you would like to make measurements and connect it respecting the correct orientation. If no probe is connected to the LDF100C module, the Flow and Backscatter outputs will be held at 0 volts. The status LED will be green when no probe is connected.

If the **`Calibrate Probe`** beep sequence is emitted, proceed to the Calibration section for instructions on how to calibrate it. If the Acq*Knowledge* software displays a value between 0 and 9999 then it is ready to begin making measurements. A recognized and calibrated probe, when held free in the air, will cause the module's Flow and Backscatter outputs to be held near 0 volts (under 0.5 v). The status indicator will be amber with a calibrated and recognized probe is connected to the module.

LDF CALIBRATION

LDF100C CALIBRATION

When probes are ordered at the same time as the LDF100C, BIOPAC will calibrate the LDF100C to the ordered probes with a "Motility Standard" before shipping the items. The LDF100C is a stable instrument and should not, under normal circumstances, require re-calibration with calibrated probes. The module is designed to automatically recognize, configure and apply the correct calibration coefficients when calibrated probes are connected.

Calibration is required if probes (additional or replacement) are shipped separately from the initial LDF100C order. Probes must be calibrated with the LDFCAL Motility Standard from BIOPAC Systems, Inc. When the LDFCAL is used, the LDF100C will automatically configure and calibrate itself for new probes.

LDFCAL CALIBRATION KIT

The LDFCAL Calibration Kit consists of a Motility Standard and a positioning device. The Motility Standard is a solution of latex spheres at a controlled concentration. The Brownian motion of the latex spheres provides the standard calibration value, which is 1000 BPU ±5% @ 21°C. The positioning device is used to hold the probe in the solution.

! Caution The Motility Standard has a limited life. The expiration date is indicated on the label. The solution must not be used beyond this date, as it will produce misleading values due to the aggregation of the latex spheres.

! Caution Do not use the Motility Standard in ambient temperatures below 15°C or above 25°C.

! Caution Store the Motility Standard within the temperature range 3 – 25°C. Do not freeze the solution.

! Caution Never attempt to re-fill the bottle with spilt solution. Errors may arise as a result of contamination.

! Caution Do not dilute the Motility Standard.

TSD140 Series Calibration

! Caution Every probe is supplied with a probe identification number on its cable. Calibration errors may occur if you use probes with the same probe identification number. Please contact BIOPAC for advice.

The LDF100C system incorporates proprietary Simple Sensor technology that enables the module to recognize a previously calibrated probe and to automatically apply the necessary probe calibration coefficients. This alleviates the need to re-calibrate a probe every time a different probe is plugged in to the module. The module 'recognizes' a specific probe every time the probe is plugged in.

The LDF100C will automatically configure and calibrate itself for new probes. To perform this operation, you will require the special calibration kit — BIOPAC Systems part LDFCAL — which includes a dedicated solution of latex spheres at a controlled concentration. It is also advisable to have a stable worktop (i.e., free from any vibration) and a clamp to hold the probe reliably in the calibration solution.

The instrument procedure for performing a calibration is described in the next section.

! Caution When probes are purchased with a module, they will be pre-calibrated at the factory with the module. TSD140 series probes ordered subsequently require a first-time calibration with the LDF100C module with which they are to be used. Please refer to the Probe Calibration section for details.

Probes purchased at the same time as a module will be calibrated at the factory. If a probe has previously been calibrated then there is generally no need to re-calibrate that probe. However, when additional probes are purchased they will require a first-time calibration. When the calibration procedure ends, the calibration data is automatically stored in the module. The calibration data is automatically retrieved every time that particular probe is connected to the module.

Calibration Procedure

To perform a new probe calibration, you will require a Calibration Kit (LDFCAL), which contains a Motility Standard and a positioning device.

! Caution The Motility Standard has a limited life. The expiration date is indicated on the label. The solution must not be used beyond this date, as it will produce misleading values due to the aggregation of the latex spheres.

! Caution Do not use the Motility Standard in ambient temperatures below 15°C or above 25°C.

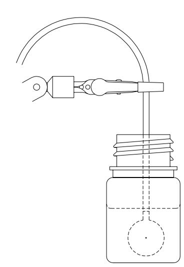
! Caution Store the Motility Standard within the temperature range 3 – 25°C. Do not freeze the solution.

! Caution Never attempt to re-fill the bottle with spilt solution. Errors may arise as a result of contamination.

! Caution Do not dilute the Motility Standard.

! Caution It is essential that the calibration procedure be performed on a stable and vibration-free surface. This is very important, any movement or vibration during the calibration procedure, however slight, is likely to result in erroneous calibration data.

1. Connect the TSD140 series probe that will be calibrated into the front panel of the LDF100C module.
2. Gently swirl the bottle to disperse the contents before use — DO NOT SHAKE THE BOTTLE!
3. Open the bottle and allow the contents to settle for one minute before proceeding.
4. Carefully position the TSD140 series probe into the solution.



   - *To best achieve this…* Hold the probe cable within the jaws of the clamp; place the cable far enough back in the jaws of the clamp to hold the probe firmly but not too tightly. Do not clamp the probe too tightly! Carefully lower the active area of the probe into the center of the solution, with the probe's measuring surface the maximum distance from all edges of the bottle. It is important to keep the active surface of the probe as far as possible from the edge of the bottle. Support the probe in such a way that it does not swing or move while in the solution.

5. Press the **Cal** button on the LDF100C once.
    - The module will emit one long beep.
    - The Status LED indicator will flash Red/Amber.
    - **IMPORTANT! Any vibration or movement will invalidate the calibration procedure.**
    - Press the "Reset" button to abandon the calibration routine.
6. After a period of time, the calibration procedure will end.
    - The module will emit a quick double beep.
    - The Status LED indicator will return to continuous Amber.
    - If the calibration procedure fails, the LDF100C will emit a second, long beep followed by several quick beeps.
7. Check calibration status. *Note* – Calibration may take up to 30 seconds.
    - Successful Calibration: the **`Calibration OK`** beep sequence (an audible double beep) will be emitted. The module will then enter Trend mode and a blood perfusion value of approximately 1000 +/- 50 BPU will be displayed in the Acq*Knowledge* software.
    - Failed Calibration: the **`Calibration Failed`** beep sequence will be emitted. The number of audible beeps is the same as 'X'. Refer to the Trouble-Shooting & Maintenance section for further information.

The parameters are automatically stored and recalled when that particular probe is subsequently connected.

LDF SAFETY

This section contains important safety information related to the general use of the LDF100C laser Doppler perfusion module. Important safety information also appears throughout the LDF100C and TSD140 series sections as Warnings and Cautions.

! Warning	A warning indicates the possibility of injury to the operator
! Caution	A caution indicates a condition that may lead to equipment damage and/or malfunction.

LDF100C incorporates semiconductor laser diode devices operating in continuous mode and emitting invisible laser radiation at a nominal operating wavelength of 830 nm. The maximum output power at the probe tip is less than 0.5 mW. Laser light emitted from the optical fiber is highly divergent. Although the characteristics of the laser radiation place the LDF100C device within the "Class 1" classification users should avoid directing the laser radiation onto the eye. Applying the probe to any tissue **OTHER THAN THE EYE** is harmless, even over prolonged time periods.

Warnings

! Warning	**Never** apply an LDF100C probe directly to the eye. The laser beam may cause permanent damage to the retina.
! Warning	**Do not** attempt to use the LDF100C if it is damaged or does not operate as described in this manual. There is a risk of electrical shock or other injury. The module must be returned to BIOPAC for repair.

Cautions for the Module

! Caution **Do not** attempt to operate the LDF100C in the vicinity of imaging or therapeutic equipment that emits ionizing radiation or produces a strong magnetic field as the performance of the module may be affected. Extra long probes are available that allow the LDF100C module to be operated at a safe distance from such equipment.

! Caution **Do not** attempt to autoclave, pressure sterilize, or expose to radiation, any part of the module.

! Caution **Do not** attempt repairs to the LDF100C module or TSD140 series probes. Only BIOPAC trained personnel should undertake repairs.

! Caution **Do not** use the LDF100C in the presence of strong or changing ambient lighting levels as this may result in erroneous measurements and artifacts.

! Caution **Do not** use probes, cables and other accessories unless supplied by BIOPAC, otherwise serious damage may result.

! Caution **Do not** mishandle the module; use extreme care at all times.

! Caution **Do not** use the module in the presence of flammable anesthetics, which represent an explosive hazard.

Cautions for the Probes

! Caution **Do not** drop, pull, stretch or apply mechanical shock to a TSD140 series probe. Permanent damage to the probe may result.

! Caution **Do not** apply tension to the probe cable. Permanent damage to the probe may result.

! Caution **Do not** soak or immerse the probe in any corrosive liquid solution. Permanent damage to the probe may result.

! Caution **Do not** mishandle. Handle the probes with great care to avoid breaking the optical fibers, scratching the polished ends or separating the probe ends or connectors from the fibers.

MAINTENANCE

User Responsibility Never use a defective product. Replace parts that are missing, broken, worn or damaged in any way immediately. This product (or its components) should be repaired only by BIOPAC Systems, Inc. trained engineers. Any exceptions to this recommendation must be made using written instructions supplied by BIOPAC Systems, Inc. If service is not provided by BIOPAC Systems, Inc. (or its appointed agents) then the user of this product will have the sole responsibility for any losses incurred as a result of unauthorized maintenance, improper repair, alterations or damage.

LDF100C

! Warning Only BIOPAC technical staff should remove the cover of the LDF100C module. There are no user-serviceable parts inside.

Inspect the module regularly for signs of wear and tear.

TSD140 Series Probes

Inspect TSD140 series probes regularly to check the integrity of the internal optical fibers.

- A simple check is to hold the probe end to a source of bright diffuse light (e.g. a lamp) while visually inspecting the connector end. Two bright spots of light of equal intensity should be visible from the two large pins within the connector.

Storage & Cleaning

LDF100C Storage & Cleaning

When not in use, the LDF100C module should ideally be stored at room temperature, although it may be stored between 5°C to 50°C. When returning from extremes of temperature, it is important to allow the module to stabilize at room temperature before use.

To clean the surface of the module: wipe lightly with a dry, lint-free cloth. Or wipe lightly with a soft cloth dampened with a commercial, nonabrasive cleaner, or use a low-pressure air line to blow dust free, or carefully clean with a suitable vacuum cleaner.

To disinfect the module, wipe the surface with a soft cloth dampened with a solution of 70% alcohol in water.

! Warning Do not spray, pour or spill any liquid on the LDF100C module, its accessories, connectors, switches or openings.

TSD140 Series Probes Storage & Cleaning

When not in use, TSD140 series probes for the LDF100C should be stored in the probe box with the optical fiber coiled neatly. Following sterilization, probes should be stored unopened in the packaging in which they were sterilized.

Cleaning

Probes are cleaned prior to packing and shipment. It is recommended that the probe end on all new probes be wiped with a soft cloth, preferably one that does not shed fibers, dampened with a solution of 70% alcohol in water.

Probes should be cleaned immediately after use as it is easier to remove soiling and particulate matter before it dries onto surfaces.

Visually inspect the probe end, cable and connector.

- If there is no visible soiling, wipe the probe end and cable with a soft cloth dampened with a solution of 70% alcohol in water. Allow the alcohol to dry completely before using the probe.
- If there is visible soiling, clean the probe with warm water containing a mild detergent. To ensure that all soiling and particulate matter is removed, keep the probe beneath the surface of the cleaning solution and rub it carefully with a soft cloth or brush. Avoid immersing the probe connector in the cleaning solution. Rinse the probe end and cable in clean water. Wipe the probe end and cable with an absorbent cloth and leave the probe to dry completely.

Disinfection

To disinfect TSD140 series probes, immerse the probe end and cable (for the disinfectant manufacturer's recommended immersion times) in:

- 2% glutaraldehyde (Cidex)
- 70% alcohol in water

Sterilization

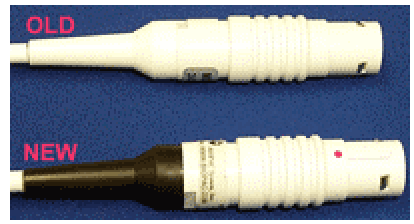
Some of the TSD140 series dedicated perfusion probes may be sterilized by moist heat (steam). They are capable of withstanding an autoclave cycle of 134°C for 3 minutes. With care a TSD140 series probe can be expected to survive between 10 – 20 sterilization cycles.

! Caution TSD140 series probes must be cleaned prior to sterilization.

! Caution It is the responsibility of the user to validate the sterility of TSD140 series probes after sterilization.

The TSD140 series probe should be packaged to maintain sterility after processing. The packaging material used should be appropriate for sterilization by steam, e.g. a tray within a pouch. The dimensions of the base of the tray should not be smaller than 15cm x10cm for a standard length probe.

1. Place the probe in the tray in a neat coil.
    - Starting at the connector end, tape the connector to the base of the tray using autoclave tape. Coil the probe onto the tray and lay the probe end in the center of the coil. Autoclave tape may be used to secure the cable to the tray. Do not use tape on the probe end. Do not rest the connector on the cable as it is heavy and may distort the cable.
2. Seal the tray into a pouch designed to withstand sterilization by steam.
3. Use only a validated autoclave to sterilize the TSD140 series probes.
    - Probes can be immersed in a non-corrosive sterilizing solution, such as 2% Glutaraldehyde (Cidex) or in a low-temperature, ethylene-oxide gas sterilization chamber. The maximum temperature to which **older** style probes can be exposed is 60 °C.



Troubleshooting

! Warning Only BIOPAC technical staff should remove the cover of the LDF100C module. There are no user-serviceable parts inside.

! Caution Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

If you experience a problem using the LDF100C and are unable to correct it, contact BIOPAC.

Beep & LED Guide

Beep	LED	Indicates
Double beep	Green LED	Initialization
--	Amber	No probe
--	Amber	Calibrate probe
Double beep every 5 seconds	Amber	Temp out of range
1 long beep	Flash Red/Amber	Calibration in process
Quick double beep	Continuous Amber	Calibration ended & successful
Quick double beep followed by a second, long beep followed by several quick beeps (the number of beeps indicates the error condition)	Continuous Amber	Calibration ended & failed 1, 2, 3, 4 Beeps Incorrect probe position or malfunctioning probe. Reposition the probe in the Motility Standard and repeat calibration procedure. Repeat up to five times if necessary. 5 or 6 Beeps Vibration or probe/cable movement. Ensure Motility Standard is on a vibration free surface and that probe and cable movement is eliminated. Repeat calibration procedure.

REDUCING SIGNAL ARTIFACT

! Caution Certain environmental conditions and probe application and positioning errors can affect laser Doppler blood perfusion readings.

Irrespective of the probe used, it is important to reduce the possibility of signal artifact, noise and signal dropout in the blood perfusion reading. The presence of motion artifact noise in the blood perfusion signal is often due to relative movements of the tissue (e.g. induced by breathing) with respect to the probe and/or probe cable movements. To minimize artifact, allow the probe to come into contact with the tissue such that the probe and tissue 'move together' and ensure that the cables do not move. It may be helpful to secure the probe cable to the table with adhesive tape at intervals.

It is also essential to ensure that undue probe pressure is not applied to the tissue, otherwise local occlusion of the microvasculature may result in a corresponding reduced blood perfusion reading.

Excessive ambient lighting at the probe measurement site can also disturb the blood perfusion reading. Avoid direct illumination of the measurement site from external lighting sources and direct sunlight. If erroneous readings due to excessive ambient lighting levels are suspected, cover the attached probe and measurement area with a light piece of opaque material.

In summary, avoid the following situations:

- Probe movement relative to the tissue.
- Movement of the probe cables.
- Strong ambient lighting sources such as surgical lights, fluorescent lights and direct sunlight.
- Changing ambient lighting.

Loss of signal due to excessive tissue occlusion could occur for the following reasons:

- Excessive probe pressure on the tissue.
- The formation of a hematoma (blood clot) within the tissue.

ELECTRO-MAGNETIC INTERFERENCE

! Caution With the proliferation of radio-frequency transmitting equipment and other sources of electrical noise in research environments (e.g. mobile phones, electrical appliances), high levels of such interference due to close proximity or strength of a source may result in disruption of performance of this device.

Erratic readings, cessation of operation or other incorrect functioning may indicate electro-magnetic interference to the module. If this occurs, survey the location of use to determine the source of the disruption and take actions to eliminate it:

- Turn equipment off in the vicinity of the module to isolate the equipment generating the electromagnetic interference.
- Relocate the other device(s).
- Increase the separation between the interfering equipment and the LDF100C module.

For further information and assistance contact BIOPAC.

Possible errors & Suggestions

A. *There is no response to the Power On button and the Power On LED indicator fails to light green.*

The power adapter may not be properly connect to the LDF100C or to the Mains outlet, or it may not be functioning. Check all connections and if possible, try another adapter with the same specs.

B. *There is no double beep upon power on and/or the initial beep does not occur.*

If the power on indicator is not lit, the power supply may not be working. Notify institution service personnel to check and if necessary, replace with the same type and rating of adapter.

If the power on indicator is lit, the module has failed the power on self-test. Do not use the module. Contact BIOPAC.

C. *There is a continuous sound upon power on.*

The module has failed the power-on self-test. Do not use the module. Contact BIOPAC.

D. *The `Temp. Out of Range` beep sequence is emitted (an audible beep every 5 seconds).*

If the internal temperature of the LDF100C module rises above the maximum permitted internal operating temperature range then the **`Temp. Out of Range`** sequence will be generated. If this occurs, the instrument should be moved to cooler environment for proper operation. Output signals (analog voltage outputs and serial data) will continue to be generated but the Trend values will not. Data generated during this condition may no longer be within the calibrated tolerance of the system and should be interpreted with caution.

If the environmental ambient temperature is below 25°C and this error occurs repeatedly soon after power-on, then a fault may have occurred and you should contact BIOPAC for further advice.

E. *The `No Probe` beep sequence is emitted even though there is a probe connected.*

This is likely a problem with the probe. If you have a spare probe available, replace the probe connected to the module with the spare probe. It may be possible to determine which probe is faulty.

If you are unable to resolve the problem, contact BIOPAC.

F. *The `Calibrate Probe` beep sequence is emitted.*

Probe calibration is required. Follow the instructions for probe calibration given in section 4.12.

G. *Pressing the CAL button for probe calibration does not emit a double beep to indicate a probe calibration is under way.*

The calibration process has failed to start. Try pressing the CAL button again. If there is still no response, contact BIOPAC.

H. *The `Error` beep sequence (varying number of beeps) is emitted.*

Probe calibration has failed. There are 6 series of error beeps used to indicate the reason for calibration failure. The most common beep sequences are **4 beeps** and **6 beeps**. Beep sequences are explained below:

# of Error Beeps	Probable cause	Remedial action
1, 2, 3, 4	Incorrect probe position in CAL solution or improperly seated probe connection or malfunctioning probe.	Reposition the probe in the Motility Standard and/or replug the probe into the LDF100C, and then repeat calibration procedure. Repeat up to five times if necessary.
5, 6	Laser is not up to temperature or excessive vibration has occurred.	Ensure Motility Standard is on a vibration free surface and that probe and cable movement is eliminated. Repeat calibration procedure.

I. The BPU trend values are erratic.

The probe may have become detached, check and replace if required.

Tissue movement may be excessive.

The probe cable is moving. Re-route the cable and/or secure that cable at intervals using adhesive tape.

There is local electro-magnetic interference (see page 173).

J. The analog output signal is zero.

There may be a cable problem. Check that the cable attached to the analog output connector(s) is correctly configured. Notify institution service personnel and request that they check that i) the cable is correct and ii) the output signal(s) are available on the pins of the connector(s).

If the problem cannot be resolved, contact BIOPAC.

OBTAINING TECHNICAL ASSISTANCE

For technical information and assistance or to order additional probes and accessories, please contact BIOPAC. When calling BIOPAC for technical support, it is helpful if you have the serial number of the LDF100C module and/or TSD140 series probes and the version of Acq*Knowledge* software.

- The serial number of the LDF100C module can be found on the back panel.
- Probe serial numbers can be found on the cable label.
- The Acq*Knowledge* software version appears under the **About** menu in the software.

RETURNING LDF COMPONENTS

Contact BIOPAC for shipping instructions including a Returned Materials Authorization (RMA) number and a RMA Declaration (including decontamination of equipment) form.

Pack the module in its original shipping carton. If the original carton is not available, wrap the module securely using bubble wrap and pack it in a strong box surrounded by polystyrene chips and/or suitable foam inserts.

A probe should be returned in the probe storage box. If returning a probe on its own, wrap the probe storage box in bubble wrap and pack it in a strong box.

Use a recognized courier company for the return of the module and probes.

Warranty

BIOPAC warrants that this device is free from defects in both materials and workmanship.

THE ABOVE WARRANTIES ARE IN LIEU OF ALL WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The user shall determine suitability for use of this device for any procedure. BIOPAC shall not be liable for incidental or consequential loss or damages of any kind.

Principles of Laser Doppler Flowmetry

This section address the following issues:

A. What the LDF100C Measures
B. About Blood Perfusion
C. Blood Perfusion and the BPU
D. What the Backscatter Signal (BS) Represents
E. The Meaning of Zero BPU
F. What Volume of Tissue the LDF100C Measures
G. Motion Artifact Noise
H. Signal Processing
I. Bandwidth Consideration

What the LDF100C Measures

The LDF100C is a laser Doppler blood perfusion module whose primary purpose is to measure real-time microvascular red blood cell (or erythrocyte) **perfusion** in tissue.

- Perfusion is sometimes also referred to as *microvascular blood flow* or *red blood cell flux*.

Laser Doppler flowmetry (LDF) offers a continuous measurement of blood cell perfusion in the microcirculatory beds of skin tissue and other tissues without influencing the blood perfusion. LDF is established as an effective and reliable method for the measurement of blood perfusion in the microcirculation in both routine clinical medicine and microvascular research. This has been achieved largely because LDF satisfies the need for a continuous, non-invasive and real-time measurement of blood perfusion in the microvasculature.

The LDF100C laser Doppler perfusion module employs a technique called laser Doppler Flowmetry (LDF) and works by illuminating the tissue under observation with low power laser light from a probe containing optical fiber light guides. Laser light from one fiber is scattered within the tissue and some is scattered back to the probe. Another optical fiber collects the backscattered light from the tissue and returns it to the module. Most of the light is scattered by tissue that is not moving but a small percentage of the returned light is scattered by moving red blood cells. The light returned to the module undergoes signal processing to extract the signal related to the moving red blood cells. Microvascular blood perfusion is indicated in the Acq*Knowledge* software display in relative units called Blood Perfusion Units (BPU).

The LDF technique offers substantial advantages over other methods in the measurement of microvascular blood perfusion. Studies have shown that it is both highly sensitive and responsive to local blood perfusion and is also versatile and easy to use for continuous monitoring. The LDF100C is potentially noninvasive (since the TSD140 series probe is not actually required to touch the surface of the tissue) and in no way harms or disturbs the normal physiological state of the microcirculation. Furthermore, the small dimensions of the TSD140 series probes enable the LDF100C to be employed in experimental environments not readily accessible using other techniques.

Measurements obtained by LDF are intrinsically of a <u>relative</u> nature. Although such measurements are proportional to perfusion, the factor of proportionality will be different for different tissues, so an absolute, quantitative index of perfusion (e.g. number of blood cells moving through 1 g of tissue per second) cannot be derived using LDF.

Attempts to introduce a calibration standard for laser Doppler measurements rest on the assumption that microcirculatory blood perfusion is essentially homogeneous for all tissue structures over the human body. This assumption is seriously flawed since the regional complexity of the microvasculature, its global variability over the human body, and the complex nature of light scattering in tissue make LDF suitable for characterizing only relative changes in blood perfusion. So, although the laser Doppler technique can be absolutely calibrated using an *in vitro* model, the complex and variable geometry of the vascular tree precludes absolute calibration in *in vivo* applications.

Broadly, LDF can provide useful information about the microcirculation for:

a) Clinical and/or surgical management of microvascular diseases.
b) Continuous monitoring of patients with peripheral vascular disorders.
c) Evaluation of vaso-active drugs on the microcirculation.
d) Increasing knowledge of the basal physiology and pathophysiology of the microcirculation in both animal and human tissue.

About Blood Perfusion

The skin is the body's largest and most accessible organ and blood flow in the skin performs an essential role in the regulation of the metabolic, hemodynamic and thermal state of the individual. Nonetheless, the measurement of cutaneous microcirculatory blood perfusion has until quite recently proved a formidable task.

By far the largest proportion of the body's dermal vasculature is involved in regulating body temperature and controlling systemic blood pressure. A smaller but significant proportion of the bulk skin blood perfusion also fulfils the skin's metabolic requirements. It is the upper dermis (i.e., the first 1.5 - 4.0 mm of tissue, depending on the site) that is chiefly responsible for providing a nutritional supply of blood to the avascular epidermis, the integrity of which is essential for the well-being of the individual. The degree of blood cell perfusion in this region of the microvascular tree, over both long and short time periods, can provide a reliable indicator of peripheral vascular disease or injury. Reduction or even complete occlusion of blood perfusion in the microcirculatory blood vessels can often be attributed to a variety of cutaneous vascularisation disorders.

There are many situations where the measurement of blood cell perfusion in the cutaneous microcirculatory beds is required. Examples include Peripheral Vascular Diseases where accurate assessment of reduced peripheral blood perfusion is necessary in order to decide upon the type of procedure (where it is important to be able to recognize the failure of a free flap transfer early on for the best chance of success in a subsequent operation).

Obviously, the need for a continuous and versatile method of measuring skin blood perfusion is paramount, not only for gaining knowledge about the pathophysiology of tissue, but also for the assessment and management of ischaemic tissue disorders. A method of measuring tissue blood perfusion is also useful for evaluating the effectiveness that a treatment (such as the application of a vaso-active drug) may have on the microcirculation.

Blood Perfusion and the BPU

Laser Doppler signals from the tissue are recorded in BPU (Blood Perfusion Units), which is a relative unit scale defined using a carefully controlled motility standard comprising a suspension of latex spheres undergoing Brownian motion. The primary function of the LDF100C is to produce a blood perfusion output signal that is proportional to the red blood cell perfusion (or flux). This represents the transport of blood cells through microvasculature and is defined as:

Microvascular Perfusion (Red Blood Cell Flux) = Number of blood cells moving in the tissue sampling volume x Mean velocity of these cells

Microvascular blood perfusion therefore, is the product of mean blood cell velocity and mean blood cell number concentration present in the small measuring volume of tissue under illumination from the probe. For the LDF100C, microvascular blood perfusion is indicated on the Acq*Knowledge* software display in relative units called Blood Perfusion Units (BPU).

All LDF100C devices have been calibrated with a constant, known motility standard so that, for a given perfusion situation, all TSD140 series probes will read the same value of blood perfusion expressed in blood perfusion units (BPU). It should be noted, however, that the blood perfusion value (BPU) is not an intrinsic physiological definition of blood perfusion. As previously explained, the notion of a universal physiological standard, valid for all types of tissue, is scientifically unconceivable. This means that even though the Blood Perfusion Unit (BPU) can be traced to a physical standard (and will therefore facilitate compatible measurements from all LDF100C probes and all LDF100C modules), the measurement expressed in BPU must be considered as strictly relative.

What the Backscatter Signal (BS) Represents

Simultaneous with the BPU output, the LDF100C module produces a backscatter signal (BS), which is expressed as a percentage of the laser light remitted (or "back scattered") from the tissue from the total amount of laser light incident on the tissue. BS is sent as an analog voltage output based on the Channel Select setting on the front panel of the LDF100C module.

Backscatter is generally used to determine if the probe is working correctly, and it can also be used to check that the contact between the probe and tissue remains constant throughout the measurement. For example, assuming significant respiratory movement, the distance between the probe tip and tissue may change, resulting in a modulation of BS. Ideally, the probe should be reattached or moved so that the BSC signal remains constant.

Low BS	The intensity of light output from the probe (i.e., BS) may be low if the probe is damaged. In highly perfused tissues, the BS will be low due to increased photon absorption. Situations where the BS signal is close to zero may indicate that the probe has come into contact with whole blood; this could cause the BPU reading to saturate since the system is no longer monitoring microvascular perfusion. *Note*: The laser Doppler signal is automatically zeroed if the backscatter signal falls below 1%.
Stepped BS	The BS will show a step change if the probe is knocked during a measurement.

The Meaning of Zero BPU

The zero (0000) reading of the LDF100C has been obtained by calibrating the system against a special static scattering material where no movements occur. In such cases the back-scattered light processed by the LDF100C contains no Doppler shifted frequency components and a true zero is obtained. A zero reading therefore indicates zero motion both in the measuring volume under examination and artifactual motion arising from relative movements between the probe and the measuring volume. During *in vivo* measurements, rarely is an absolute zero obtained. Even during total occlusion of tissue blood perfusion, there is often some small, residual motion of blood cells trapped in the vessels, as well as some small muscle and tissue movement in the measuring volume. Even after surgical removal of tissue, localized cell movement and Brownian motion may still occur in the severed blood vessels.

The LDF100C digital signal processing software allows the zeroing of the laser Doppler signal when there is insufficient light returning from the tissue to the probe. In the default condition (power ON), the cutoff threshold is set to 1%. This means that the laser Doppler signal is automatically zeroed if the backscatter signal falls below 1%.

What Volume of Tissue the LDF100C Measures

LDF defines a perfusion parameter from information contained in the optical spectrum of light remitted from the tissue. The actual measurement sampling volume or depth can only be determined by identifying precisely which blood vessels and erythrocytes have interacted with the remitted light, which in turn, is principally dependant on two parameters; namely the optical scattering and optical absorption coefficients of the tissue under observation. Since both of these coefficients are entirely dependent on the site of observation and perfusion of the microvasculature at the time of measurement, it is impossible to determine the actual sampling volume/depth at any tissue site.

Generally speaking however, we have estimated that for well-perfused tissue such as muscle, the mean sampling depth is in the region 0.5-1.0 mm with a concomitant sampling volume in the region 0.3-0.5 mm^3. For cutaneous measurements, the sampling depth is likely to be in the range 1.0 – 1.5 mm. These estimates have been obtained heuristically through many years of experience and are based on both *in vitro* observations and mathematical modeling of photon diffusion through 'imaginary tissues’ using Monte Carlo techniques[1].

Principally, LDF makes use of the fact that when a coherent, low-powered laser illuminates tissue, light is scattered in static structures as well as in moving blood cells within the microcirculatory beds. Photons, scattered by the moving blood cells, are spectrally broadened according to the Doppler effect. A maximum Doppler frequency shift is achieved when the particle is moving in a direction parallel to the incident beam of light and the light scattered back from the particle is detected in a direction opposite to its origin. For example, a Doppler shift of about 4 kHz is obtained when laser light (l = 830 nm) is back-scattered from a particle in water moving at 1 mm/s parallel to the light beam. Due to the diffused nature of light passing through tissue, the angles between the blood cell velocity vectors and the beam propagation vectors can be considered randomized. A continuous range of Doppler frequency shifts up to the maximum can therefore be expected. Spectral broadening of the incident light laser can be attributed to either single or multiple photon scattering events in moving blood cells, which in turn, generate single or successive Doppler shifts. Photons scattered by static structures alone do not undergo Doppler frequency shifting.

The maximal fractional frequency change $\delta\omega/\omega_0$ for infrared light (830 nm) scattered off a particle moving with a velocity of 1 mm/s is approximately 6.7×10^{-12}. It is necessary to employ the technique of “optical beating” in order to detect such small frequency shifts. This is the heterodyning or time-dependent interference of two optical beams in which the two signals are added on the surface of a non-linear detector. The output of the detector contains a fluctuating component related to the difference or beat frequency between the frequency-shifted and non-shifted beams. If the optical frequencies of the two interfering beams are close, then the optical beating produced from the difference term will be in the low (audio) frequency range. In general, spectral broadening in tissue is caused by more than one scattering event (i.e. multiple scattering) which produces successive Doppler shifts in the same photon. Additionally, other photons are scattered in static tissues alone and therefore do not undergo frequency shifts. Using the technique of heterodyne mixing in the detection of backscattered light from the tissue, it is possible to obtain a spectrum of ‘beat’ frequencies, the magnitude and frequency of which are related to the velocity and fractional volume of moving red blood cells in the illuminated volume of tissue.

A portion of the back-scattered light from the tissue is brought to the surface of a sensitive photodetector. The photocurrent signal obtained from the detector contains the beat frequency spectrum produced from the heterodyne and/or homodyne mixing of the frequency shifted and non-shifted light. The frequency and magnitude of the alternating component of the photocurrent (i.e., the power spectral density) is related to the mean velocity and number concentration of blood cells present in the measuring volume. Contributions to the photocurrent arise from both **heterodyne** detection — which requires the presence of both shifted and non-shifted laser light, and **homodyne** detection — which results from the self-mixing of the frequency-shifted light only.

Theoretical studies indicate that heterodyne mixing dominates if the scattering is from tissues that have fairly low levels of blood perfusion. On the other hand, for highly-perfused tissues, homodyne mixing processes become more predominant as the incidence of multiple photon scattering increases.

Since the laser Doppler flowmeter operates on the basis of characterizing a change (or shift) in frequency from a reference, it is important that the reference source is both highly stable and of single frequency. This is the reason why lasers, which are both monochromatic and highly stable, are employed in preference to other light sources. The temporal coherence property of laser light is an essential requirement for the heterodyne and/or homodyne mixing process between the Doppler shifted light and the reference beam.

Although the laser Doppler flowmeter can be absolutely calibrated using an *in vitro* model, the complex and variable geometry of the vascular tree precludes absolute calibration in *in vivo* applications. The localized nature of the perfusion signal, coupled with the gross variability of the microvasculature, prohibits meaningful comparisons of absolute blood perfusion measurements across different individuals. This must also be borne in mind when comparing readings from different sites within the same individual. LDF is strictly site-specific, and ideally should be limited to monitoring dynamic responses to physiological stimuli at a single site.

However, appropriate electronic processing of the photocurrent signal can enable estimations of the microvascular perfusion present in the specific measuring volume under illumination from the laser Doppler probe.

Motion Artifact Noise

Laser Doppler studies can reveal changes in the blood perfusion signal that are often unrelated to actual physiological changes in blood perfusion. These artifacts in the blood perfusion signal can often be attributed to the movement of the optical fibers in the beam delivery/collection system and are noticeable in situations where the subject moves or twitches. This type of artifact may be worse in situations where the probe moves with respect to the tissue. Using a probe that is connected to, rather than clamped over, the tissue can therefore minimize this effect (for example, using standard right angle or suturable probes).

Spurious motion artifact may occur when a ventilator or other mechanical device is employed. Under these conditions, controlling vibration reaching the measurement site and the LDF100C should minimize artifact. This may be achieved by placing the ventilator on a separate table and on a vibration-absorbing medium.

Some laser Doppler instruments employ motion artifact rejection systems and filters to limit the contribution of artifact to the flow signal. However, problems can arise when the fiber movements are small and/or continuous — as is often the case in neonatal monitoring. When the fiber movements are small, the system finds it difficult to distinguish between genuine changes in blood perfusion and motion artifact. On the other hand, continuous fiber movement of large enough amplitude to trigger the rejection filter could lead to a situation where the blood perfusion output is corrupt for a considerable period.

Signal Processing

The feasibility of using a laser Doppler flowmeter measurement of blood perfusion in the microcirculation rests, to a large extent, on the linearity of the flowmeter output to changes in blood cell perfusion (or flux). The signal-processing unit transfers the blood perfusion related photocurrent signal into a level that is uniquely related to the perfusion of blood cells present in the volume of tissue under observation. Ideally, a signal processor should provide an accurate and continuous estimate of the perfusion parameter and correct for noise sources (such as shot noise and amplifier noise). The linearity of the flowmeter response is exclusively determined by the nature of the signal-processing algorithm.

Frequency weighting essentially introduces a velocity-dependent multiplier into the signal processing, which enables estimates of blood cell perfusion to be made. Different methods of obtaining a reliable blood perfusion index using frequency-weighted estimates of the laser Doppler photocurrent signal have been proposed. Results from *in vitro* studies indicate that frequency weighted algorithms are responsive to both changes in mean blood cell velocity and concentration, whereas the non-weighted algorithms respond to concentration changes only. The LDF100C uses a processing algorithm that responds linearly over a wide range of blood cell concentrations (up to 0.35% p.c.v.) and exceeds the normal physiological range expected in most tissues.

Bandwidth Considerations

The linearity of velocity responses for the frequency-weighted algorithms is critically dependent on the cut-off frequency of the signal processing bandwidth. Since the high frequency components of the photocurrent signal are generally a result of high average blood cell velocities, large cut-off frequencies must be adopted to avoid gross under-estimations in the perfusion output. The LDF100C operates continuously over an extended bandwidth region of 22 kHz (considerably greater than most other laser Doppler flow meters) and avoids the misleading practice of defaulting to lower bandwidth settings on initial switch-on.

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[1] The Monte Carlo method, as first proposed by Metropolis and Ulam, uses a stochastic model to simulate physical processes. N. Metropolis and S. Ulam, “The Monte Carlo method,” *J. Am. Statistical Association*, vol. 44, pp. 315-341, 1949.

NIBP100A Noninvasive, Continual BP Measurement System

The NIBP100A Measurement System consists of

1) Monitor
2) Pressure sensor with attached cable and wrist module
3) Wrist Guide
4) V-line interface
5) Power cord
6) Operator's Manual.

The noninvasive NIBP100A provides continual blood pressure measurement with accuracy comparable to an indwelling radial artery catheter.

The NIBP100A is an accurate, continual, and noninvasive solution to blood pressure monitoring. Using a patented method of measuring radial artery pressure waveforms, the NIBP100A system calculates accurate systolic, diastolic and mean pressures. The system displays pulse rate, pressure waveforms, trending, and alarm and clock settings.

The NIBP100A is easy to use. Just position the wrist sensor and make one keystroke to begin measuring arterial blood pressure. Within 15 heartbeats, the initial measurement and waveform will be displayed, and the display will be continually updated every 10-15 heartbeats. Very slight changes in blood pressure down to 40mmHg systolic are measured.

Subjects experience minimal sensation while wearing the wrist sensor. Operation is very smooth and quiet. The wrist sensor fits adults of any size, can be worn on either wrist, and is completely latex-free. The NIBP100A can be used to monitor obese subjects, subjects with low cardiac output, hypothermia or abnormal heart rhythm.

The NIBP100A also provides improved ability to obtain measurements from subjects undertaking light exercise or psych analysis conditions. The NIBP100A quickly rejects most artifact caused by arm movement and automatically initiates a new measurement when the wrist is at rest. It takes somewhere between 10 and 15 heartbeats to obtain and display a new measurement.

In addition, the NIBP100A system provides trend lines and historical data on the graphics screen. The historical data may also be output to a standard serial port or printer.

Additional features include:

- **Artifact rejection** — As with an arterial line, the arterial waveform highlights artifact rejection. The system can identify and eliminate some noise and motion artifact.
- **Automatic pressure zeroing** — The system continually reads the sensor offset and automatically performs the calculations required to zero the offset pressure.
- **Alarms** — The NIBP100A has audible and visual alarms for systolic, diastolic and mean pressures, and pulse rate can be set to individual parameters or preset default values. Additional alarms will alert the user of any abnormal condition or system failure.

It's important to note…

The NIBP100A does not provide true beat-by-beat blood pressure measurement, but rather an average representation of the blood pressure waveform over a 10 to 15 beat interval. The output signal is designed in such a manner that it "simulates" a continuous blood pressure recording, even though the instrument employs averaging measurement techniques.

Sensor Replacement

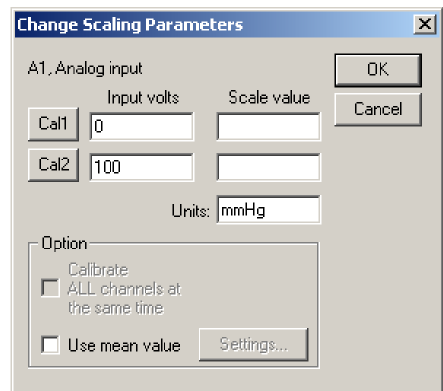
The sensor in the NIBP100A requires replacement every six months. The sensor has an internal processor that monitors the age of the sensor. The sensor starts counting after the first few uses and then automatically stops on the 6-month anniversary. **BIOPAC replacement sensor: RXNIBPA** (pg. 182).

Setup

You can record data from the NIBP100A through an MP System if you use the TCI105 interface to create a compatible input for the pressure transducer. The NIBP100A will output a signal similar to the one that would actually be recorded by a direct arterial connection to a pressure transducer. In effect, the output from the NIBP100A simulates a direct connection arterial pressure transducer. The TCI105/DA100C combination amplifies the signal for delivery to the MP System. This configuration provides partial isolation.

1. Connect the DA100C to the MP System.
2. Set the DA100C to DC and 300 Hz.
3. Plug the TCI105 into the front of the DA100C.
4. Connect the V-Line Interface phone plug from the NIBP100A to the TCI105.

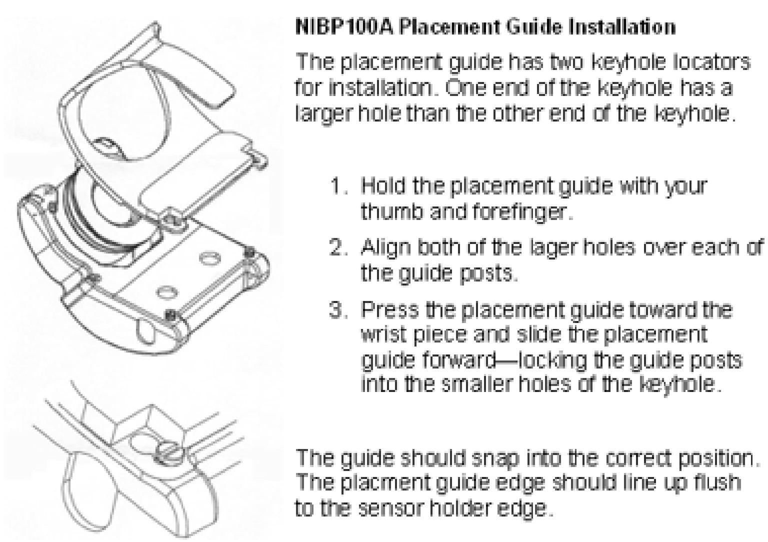
Calibration



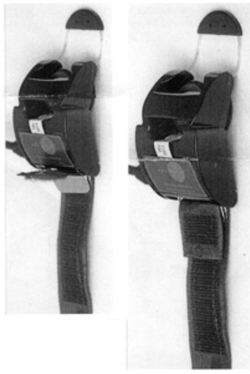
There are no complicated set-up or calibration requirements. Just set the Scaling options for 0 and 100 mmHg to establish the recording range.

1. Select **MP menu > Setup channels**.
2. Select the channel for the NIBP100A and click on **Scaling**…
3. **<u>Cal 1</u>**: Enter 0 for Input volts. Use the SETUP key on the NIBP100A to toggle the CYCLE TIME screen. Click Cal 1 to establish the zero Scale value, just as you would vent an arterial line transducer to atmosphere.
4. **<u>Cal 2</u>**: Enter 100 for Input volts. Use the SETUP key on the NIBP100A to toggle the ALARMS screen. Wait 30 seconds and then click Cal 2 to establish the Scale value; the dialog will update to display the established Cal 2 Scale Value.
5. **<u>Units</u>**: Enter mmHg for Units.
6. Click **OK** to close out of the scaling dialog and then close the Setup Channels dialog.

Placement Guide Installation



Wrist Strap Installation



1. Position the hook and loop piece side upwards.
2. Thread the single one-inch Velcro® loop end piece through the strap loop guide.
3. Pull just to the end of the strap loop guide, align the Velcro® loop end to the hook piece, and press into position.

NIBP100A Specifications

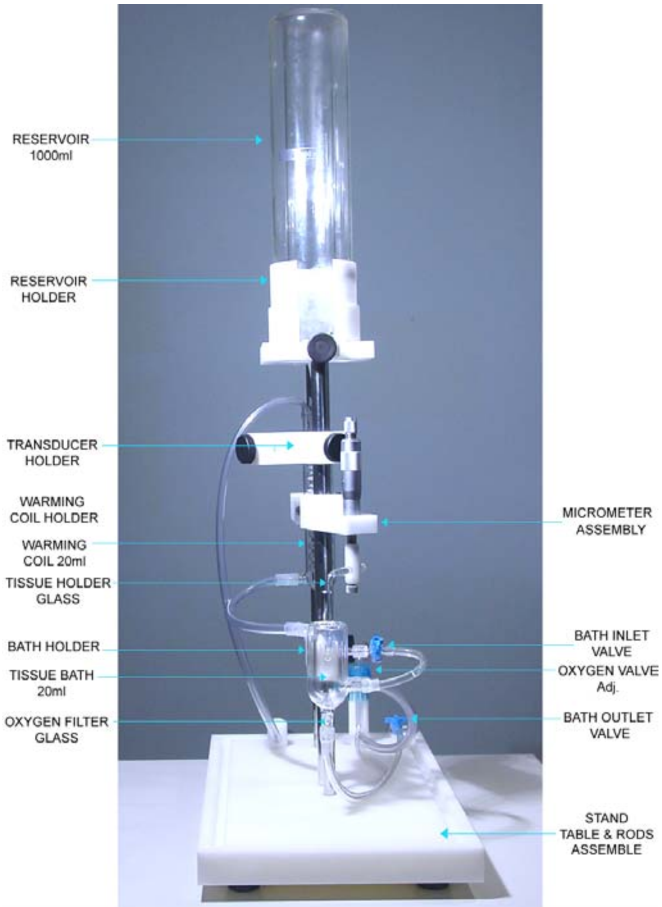
Physical Description:	
Case:	Aluminum
Size:	5" (h) x 4.5" (w) x 8.5" (l)
Weight:	4.5 lbs with power cord and wrist module
Displays:	
LCD	128 x 240 pixel LCD with Cold Cathode Fluorescent backlight; 2.5" (h) x 4.5" (w)
LED:	Three (3) high intensity light emitting diodes; 75" (h) x 1.5" (w)
Electrical:	
Ratings:	100-240 VAC, 50/60 Hz, 0.25 - 0.5A max
Current Leakage:	IEC60601, UL2601-1
Equipment Interface/Data Port:	RS232 (EIA-2332 serial port); 25 pin connector
Performance Range:	Min/Max Accuracy
Systolic:	40mmHg-240mmHg±5mmHg/SD 8mmHg
Mean:	30mmHg-200mmHg±5mmHg/SD 8mmHg
Diastolic:	20mmHg-180mmHg±5mmHg/SD 8mmHg
Pulse:	40 bpm - 200 bpm± 5 bpm or 10%
Trend:	Updated tabular and graphical trends following each reading, up to approximately 900 readings.
Microprocessor Design:	Texas Instruments TM320 digital signal processor (DSP); high-performance CMOS 32-bit floating-point device. Clock speed of 33MHz/min provides reliable, high-speed DSP.
Audible Alarm:	Piezo buzzer, typically 85 decibels.
Safety Classifications:	Classified to U.S. and Canadian safety standards with respect to electric shock, fire and mechanical hazards only in accordance with UL2601-1 and IEC 60601-2-30.
Sensor Cable:	15' (for connection between subject and monitor)
Interface:	DA100C with TCI105

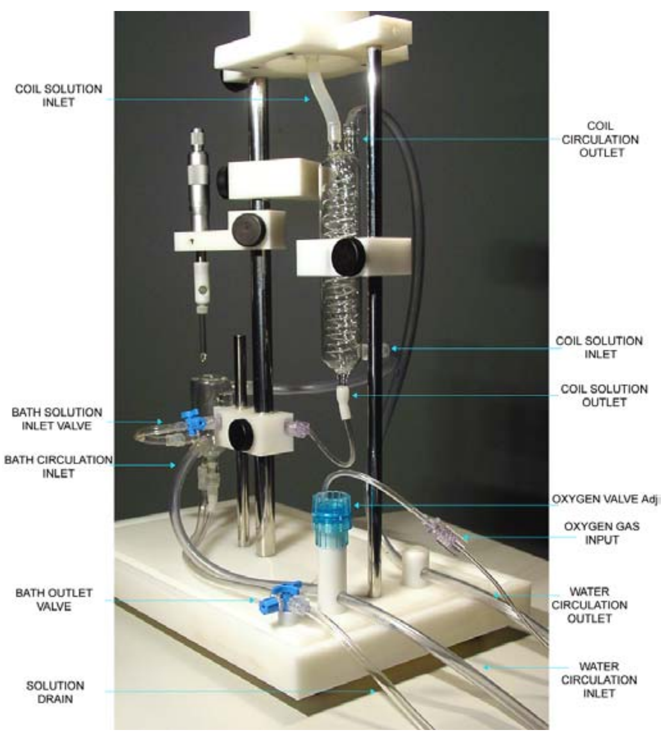
RXNIBPA Replacement Sensor for NIBP100A

The sensor in the NIBP100A requires replacement every 6 months. The sensor has an internal processor that monitors the age of the sensor. The sensor starts counting after the first use and then automatically stops on the 6-month anniversary. The RXNIBPA replacement sensor snaps into the wrist module.

> *Note*: **Limited Warranty on RXNIBPA Sensors**
> BIOPAC Systems, Inc. warrants the RXNIBPA sensor to be free from defects in material and workmanship for **three (3) months** following the delivery of the sensor to the original purchaser.

Tissue Bath 1, 2, 4, 8 Tissue Bath Stations





The Tissue Bath Station is completely modular, which enables you to purchase it in multiples of one unit. The System includes all of the glassware, tubing, reservoir, tissue hooks and mounting accessories, force transducer and micrometer tension adjuster.

The ergonomic design of the station allows you to lower the tissue bath away from the tissue holder so that mounting of the tissue preparation is very easy. The taps for filling and draining the bath are mounted on the tubing to avoid the risk of accidental bath breakage. The entire station is mounted on a convenient base stand, which creates a sturdy platform for your experiment. The unique design makes it easy to add or remove stations to provide the optimal solution for your requirements.

When you order a system, you must specify the size of the tissue bath and heating coil.

Each **Tissue Bath** station includes:

1	Reservoir
1	Reservoir Holder
1	Transducer Holder
1	Warming Coil Holder
1	Warming Coil (specify 5ml, 10ml, 20ml, or 30ml size)
1	Tissue Holder (glass; left)
1	Tissue Holder (stainless steel; right)
2	Triangle Tissue Holder (stainless steel)
2	Tissue Clip (stainless steel)
1	Bath Holder
1	Tissue Bath (specify 5ml, 10ml, 20ml, or 30ml size)
1	Oxygen Filter (glass)
1	Micrometer Assembly
1	Mount Accessories Kit
1	Base Station with Support Rods
1	TSD125 Force Transducer (specify TSD125 model C, D, E or F)

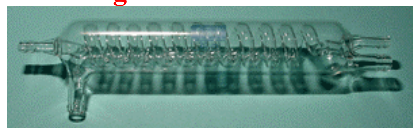
See also: BIOPAC Circulators, page**Error! Bookmark not defined.**, or you can use an existing system.

RX Tissue Bath Accessories / Reorder Parts

Tissue Holders

Tissue Clips

Warming Coil



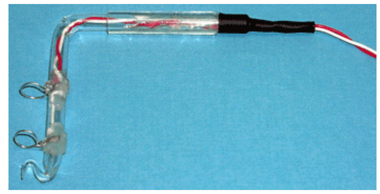
Oxygen Filter

Tissue Bath

Reservoir

Mount Accessories

Field Stimulation Electrode



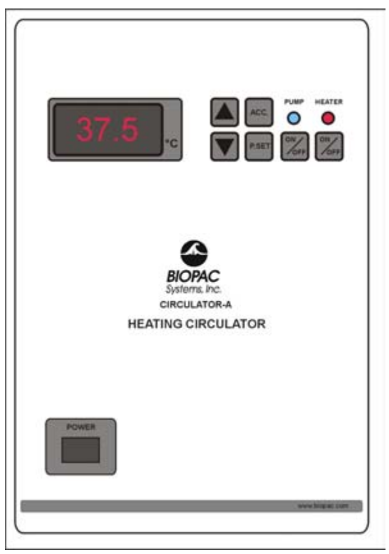
RXHOLDER-S	Tissue Holder (stainless steel)	**RXCOIL**	Warming Coil
RXHOLDER-G	Tissue Holder (glass)	**RXO2FILTER**	Oxygen Filter (glass)
RXHOLDER-T	Triangle Tissue Holder (stainless)	**RXBATH**	Tissue Bath
RXCLIP	Tissue Clip (stainless steel)	**RXRESERV**	Reservoir 1000ml
RXCLIP-TRI	Triangle Tissue Clip for Rings (stainless steel)	**RXMOUNT**	Mount Accessories Kit
		STIMHOLDER	Field Stimulation Electrode

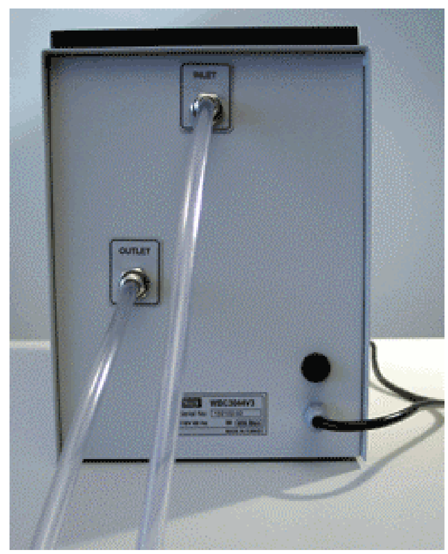
Circulator A/B Heating Circulators

Heating circulators are used with Tissue Bath Stations and include a digital temperature display and the following controls:

- **Preset**
- **Temperature**
- **Power**
- **Heater**
- **Circulation**

Inlet and **Outlet** ports are on the back, along with the power cord.

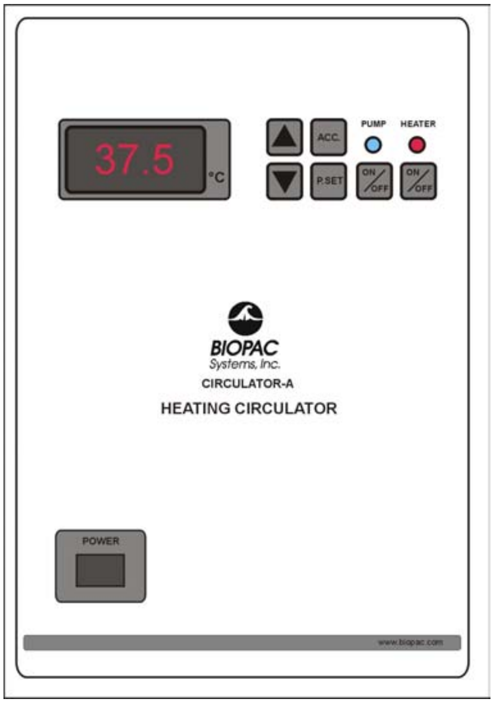


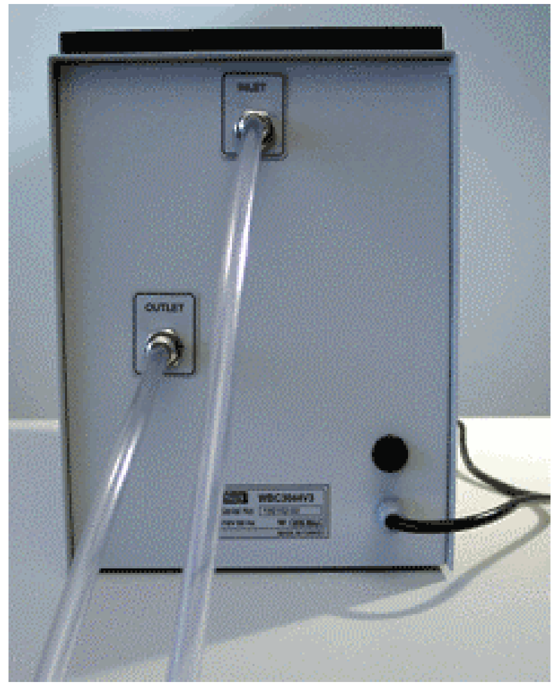


Circulator A:
110 V, 60 Hz

Circulator B:
220 V, 50 Hz

See the ***Setup and Usage Guide*** on page 185.





BIOPAC Heating Circulators will maintain water temperature at a preset value in the range 30^0C to 45^0C and circulate the water through tissue baths.

Heating circulators include a digital temperature display and the following controls:

- **Preset**
- **Temperature**
- **Power**
- **Heater**
- **Circulation**

Inlet and **Outlet** ports are on the back, along with the power cord.

Circulator A:
110 V, 60 H

Circulator B:
220 V, 50 H

Calibration

Although the offset value for the temperature sensor is factory-calibrated, the user can calibrate the controller's internal temperature sensor. To calibrate the sensor:

1. Install a calibrated reference thermometer in the bath.
2. Adjust the offset value to zero.
3. Adjust the preset value to an appropriate temperature.
4. Once the bath reaches the preset value and stabilizes, calculate the offset value by noting the difference between the reference thermometer value and the preset value.
5. Enter this value as an offset.

Error Codes

Display	
Lo	Water in the bath is not enough or the bath is empty.
Sen	Microprocessor cannot communicate with the temperature sensor.

CIRCULATOR SETUP & USAGE GUIDELINES

1. Connect a hose from the INLET on the back of the circulator to the tissue bath OUTPUT.
   - For more than one tissue bath, connect the tissue baths serially.
2. Connect a hose from the OUTLET on the back of the circulator to the tissue bath INPUT.
3. Fill the stainless steel water bath with 4.5 liters of water.
   - You hear a buzzer sound warning if there is not enough water in the bath when you power on the Circulator. See *Error Codes* above.
4. Place the glass lid on the bath to close.
5. Plug the power cord from the back of the Circulator to a power source.
6. Press the **POWER** key to turn on the circulator.
7. To see the preset temperature value, press the **P.SET** key.
   - To change the preset temperature value, hold down the P.SET key and, at the same time, repeatedly press the UP or DOWN arrow keys to increase or decrease the preset value.
8. To see the acceleration value of the Circulator, press the **ACC** key.
   - To change the preset acceleration value, hold down the ACC key and, at the same time, repeatedly press the UP or DOWN arrow keys to increase or decrease the preset value. The higher values for acceleration indicate more rapid heating.
9. To see the offset temperature value, press the ACC and P.SET keys at the same time.
   - This is a factory-calibrated value. To calibrate the temperature sensor, see *Calibration* above.
   - All preset values are written to non-volatile memory.
10. Press the **PUMP ON/OFF** key to start the circulation pump.
    - Check that the **blue** Pump Status LED is ON. The pump should begin circulating water.
11. Check that the water goes out of the circulator and flows through the waterway of the tissue bath(s).
    - With initial setup, some air may remain in the circulator pump. See *Troubleshooting* below.
12. Press the **P.SET** button and confirm the set value of the desired temperature.
13. Press the **HEATER ON/OFF** key to turn on the heater.
    - Check that the **red** Heater Status LED is ON.
    - Check that the Heater Display LED is on to confirm that the heater inside the bath is working.
    - Circulator will maintain the preset temperature of water in the bath; variations of +/-0.2^{0}C are acceptable.
14. Check the water level periodically and add water to the bath if the level drops below 4 liters.
    - **Caution**: Over time, the water level inside the bath may decrease. Do not operate the circulator with less than 4 liters of water in the bath.
15. To turn the PUMP and HEATER on and off individually, press their respective ON/OFF keys.
16. To stop operation, press ON/OFF keys.
    - Power down equipment in the following order: PUMP, HEATER, POWER.

TROUBLE SHOOTING

- **There is no water circulation or very little.**
    1. Check the hose connections and be sure they are connected to the correct positions.
    2. Check that the hoses are not bent or twisted (which might impede the flow of water).
    3. Confirm that there is at least 4 liters of water in the bath.
- **There is some air in the waterway.**

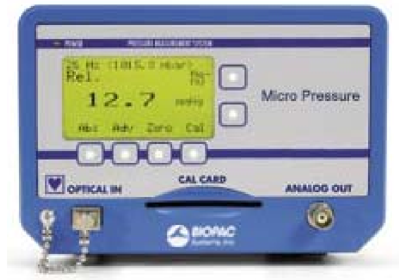
    To remove the air:

    1. Press the PUMP ON/OFF key to **OFF** stop the circulator pump.
    2. Disconnect the hose from the INPUT of tissue bath. (Leave other end connected to the Circulator OUTLET.)
    3. Put the end of the hose in a bucket to catch the water flow.
    4. Press the PUMP ON/OFF to **ON** to start the circulator pump.
    5. Operate the circulator pump for a few 1-2 second cycles.
    6. Press the PUMP ON/OFF key to **OFF** stop the circulator pump.
    7. Reconnect the hose to the INPUT of the tissue bath.
    8. Press the PUMP ON/OFF to **ON** to start the circulator pump and continue with normal operation.

TECHNICAL SPECIFICATIONS

Temperature Range:	30^0C to 44^0C
Reading Sensitivity:	0.1^0C
Display:	3 digit (LED Display)
Water Bath Volume:	4.5 liters (Stainless Steel)
Circulation Flow:	2 liter/min.
Heater Resistance:	1000 Watt
Circulation Pump:	110V 100W Plastic Head
Supply Voltage:	
CIRCULATA:	110 Volt 60 Hz (1000 Watt)
CIRCULATB:	220V 50 Hz (1100 Watt)
Inlet/Outlet	OD 8.5mm, ID 6.3mm Tubing
Temperature Offset Range:	0^0C to 1.2^0C
Acceleration Levels:	0 to 5

MPMS100 Micro Pressure Measurement System



MPMS100 Control Unit

The **Micro Pressure Measurement System** from BIOPAC is the complete solution for demanding pressure measurements using advanced optoelectronic technology—and is the premier choice for a variety of pressure measurements where accurate data, high speed, or small size are key features.

Typical application areas are: cardiovascular blood pressure, intracranial pressure, intervertebral disc pressure, pediatric intensive care respiratory monitoring, muscle pressure, and pressure in the bladder or in the urinary tract.

Intelligent electronics in conjunction with fiber optics produce accurate data at high speed, making instantaneous pressure change analysis possible.

The electromagnetic immunity inherent in the technology makes pressure measurement trouble-free, even in environments with high electromagnetic field strength—such as in MRI applications.

Control Unit with TSD170 series transducer

The system consists of a **Control Unit** and a **Micro Pressure Transducer** (see TSD170 series, separate purchase).

- The Ø 0.42 mm optical transducer is very stable, has a low temperature coefficient, and is easy to use. The transducer is biocompatible, has intrinsic electrical isolation, and can be made radio opaque. The micro dimensions of the transducer tip ensure a well-defined measurement location and minimal influence on the measurement environment.

MPMS100 Control Unit

The Control Unit is based on advanced optoelectronic technology. All settings can be made on the front panel. Analog output and serial RS232 make connection with a BIOPAC MP Unit easy. Measurement data can be monitored in real time and stored for further data analysis.

Control Unit Specifications

Resolution: 12 bit	Internal Barometer Precision: ± 0.5 mbar
Numerical Resolution: 0.1 mbar	Inputs/Outputs: Power, RS-232, Analog out, Optical in
Measurement Frequency:	Analog Output: 0-10V
Analog 100-5000 Hz	Power Requirement: 85-264 V AC, 47-63 Hz
Digital 1- 200 Hz	Operating Temperature: 15 - 35° C
Measurement Modes:	Dimensions: 170 x 115 x 240 mm
Absolute, or Relative	Weight: 2.2 kg

TSD170 Series Micro Pressure Transducer

TSD170 Series Micro Pressure Transducer

The Micro Pressure Transducer fits the MPMS100 Micro Pressure Measurement System.

The optical transducer is very stable, has a low temperature coefficient, and is easy to use. The transducer is biocompatible, has intrinsic electrical isolation, and can be made radio opaque. The micro dimensions of the transducer tip ensure a well-defined measurement location and minimal influence on the measurement environment.

The transducer consists of a silicon sensor element, 0.42 mm in diameter, bonded to an optical fiber 0.25 mm to 0.40 mm diameter. Each transducer is delivered calibrated to minimize the need for customer calibration. This simplifies the use of the system and reduces the risk of human errors.

Control Unit with TSD170 series transducer

The system consists of a **Control Unit** (see MPMS100, separate purchase) and a **Micro Pressure Transducer**.

- The Control Unit is based on advanced optoelectronic technology. All settings can be made on the front panel. Analog output and serial RS232 make connection with a BIOPAC MP Unit easy. Measurement data can be monitored in real time and stored for further data analysis.

TSD170 Series Transducers Control Unit

TSD170 Micro Pressure Transducer

TSD171 Micro Pressure Transducer, radio opaque (MRI-compatible)

Transducer Specifications	*Other pressure ranges available upon request.*
Sensor ø: 0.42 mm	Accuracy;
Fiber ø: 0.25 to 0.40 mm	-50 to 250 mbar: ±0.5 mbar plus ± 2% of reading
Calibration: Factory calibrated	250 to 350 mbar: ± 4% of reading
Measurement Media: Gases and fluids	5 bar: ± 10 mbar plus ± 2% of reading
Minimum Bend Radius: 10 mm	10 bar: ± 15 mbar plus ± 2% of reading
Long-term Stability: < 0.5% of range	17 bar: ± 20 mbar plus ± 2% of reading
Storage Temperature: -40 to + 80° C	Temperature Coefficient:
Standard Length: 4 m (for MRI: 10 m)	-50 to 250 mbar: < 0.2 mbar/° C (20-45°C)
	250 to 350 mbar: < 0.2 mbar/° C (20-45°C)
	5 bar: < 3.5 mbar/° C (20-45°C)
	10 bar: < 7 mbar/° C (20-45°C
	17 bar: < 14 mbar/° C (20-45°C)

STM100C Stimulator module

The STM100C is a single channel stimulation amplifier that was designed for use in the following applications:

Stimulus and Response Testing

Auditory brainstem response testing

Visual evoked response testing

Somatosensory response testing

Nerve conduction velocity and latency recording

Biofeedback Procedures

Auditory, visual or mechanical feedback from biophysical signals

The STM100C incorporates manual and automatic attenuation and polarity controls. Automatic attenuation can be effected in 1-dB steps over a 128-dB range. The STM100C has dual stimulus outputs. The **50 Ω Output** can be AC or DC coupled. The **Ext Stim** output is a very low-impedance, high-power, AC coupled output that can be used to drive headphones, speakers and other low impedance devices like lights and solenoids.

The STM100C can amplify and condition signals from four possible sources:

Analog (D/A) Output 0

Analog (D/A) Output 1

Pulse (Digital I/O 15)

Analog Input CH 16

IMPORTANT!

A) The STM100C is placed on the **opposite side** of the UIM100C, compared to other 100C-series amplifier modules.

B) You must check the "**Stim 100**" option in the Manual Control dialog box (accessed via the MP menu). See the "MP System Guide" for Manual Control details

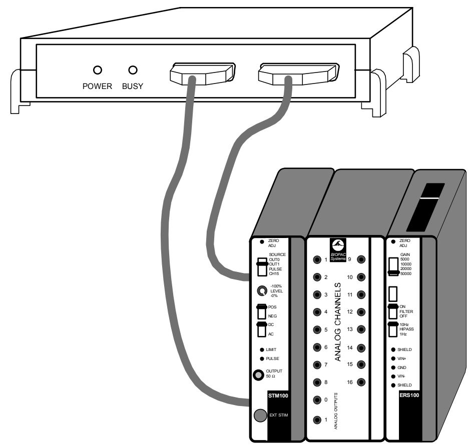
C) The STM100C always requires connection of both analog and digital cables to the MP150/100. The MP150 analog and digital cables first plug into the STM100C, then the UIM100C snaps onto the free side of the STM100C. Other amplifier modules, like the ERS100C, snap onto the UIM100C.

The following diagram illustrates proper connection of the STM100C to the MP150/100 and other modules.

Stimulus response testing

In nearly all cases of stimulus response testing, the **STM100C** will be used in conjunction with the **ERS100C** and the **MP System**. The ERS100C is a very low noise biopotential amplifier, with sufficient bandwidth ranges to accommodate the variety of evoked potential testing.

For most types of evoked response testing, the MP150/100 will be operating in averaging mode. Typically, the stimulus output waveform is generated in the stimulator setup window and ported through either analog output 0 or analog output 1, and the output device (such as the OUT101 Tubephone) is connected to the external stimulus jack on the STM100C. This allows for complex pulses, tones, ramp waves and arbitrary shaped analog waveforms to be used as stimulus signals.



STM100C connection to MP device, UIM100C and ERS100C

See the *MP System Guide* for details.

Alternatively, a single variable-length digital pulse can be output on I/O 15. The analog output options offer greater flexibility and are generally easier to use, but I/O 15 allows for greater resolution (1 µsec vs 22 µsec for analog output options). In either case, the stimulus signal is output just prior to each data collection pass in the averaging sequence.

IMPORTANT!

Make sure that the settings on the STM100C match those in the stimulator setup windows (i.e., the output channel in the stimulator window matches the output channel selected on the STM100C).

Auditory evoked potentials Auditory evoked potentials, like the **ABR** can be implemented using the STM100C. The STM100C is used to present the auditory pulse or "click" to an auditory stimulator, like the *Tubephone* (OUT101). The OUT101 or headphones (OUT100) plug directly into the EXT STIM jack on the STM100C. "Clicks" can be either rarefaction or condensation (positive or negative pulses). "Click" attenuation can be controlled manually or via the computer in 1-dB steps over a 128-dB range.

Somatosensory response tests These tests are very similar to ABR and VEP tests, except the stimulation source is usually an electrical pulse or mechanical impulse applied at some point along the leg or arm. Somatosensory tests are used to characterize the perception of touch. By connecting a solenoid to the EXT STIM output of the STM100C, a mechanical pulse can be generated for peripheral nervous system stimulation.

General nerve conduction velocity tests General nerve conduction velocity tests are evoked potential tests, but they generally do not require extensive signal averaging like the ABR or EP tests. The STM100C can perform this type of test, however the STM100C output is limited to a 20-Volt pk-pk signal. In the case of ***in vitro*** or ***in vivo*** experimentation, the 20-Volt range of the STM100C is typically adequate. For surface electrode stimulators, higher voltage is often required.

→ For higher voltage outputs, use the STMISOD or STMISOE (with the STM100C) to boost the voltage stimulus signal to 100V or 200V, respectively.

Biofeedback procedures

The STM100C can be used to condition and amplify the signals coming from any biopotential or transducer amplifier. The source amplifier must have its output switched to CH 16 (last channel), and the STM100C SOURCE switch needs to be placed on CH 16 as well. With the headphones or speaker plugged into the EXT STIM jack, biopotential signals like EMG can be heard directly. The EXT STIM output can also be used to drive visual indicators directly, so rhythmic or pulsatile signals (like ECG or respiration) can be easily observed. Mechanical actuators like relays and solenoids can be directly connected to the STM100C.

STM100C Calibration

None required.

STM100C Specifications

Stimulus Output Voltage:	20 Volts (p-p) maximum (100/200 volts using STMISOD/E)	
Current Output Drives:		
50 Ω Output:	±100mA (3.5mm phone jack)	
Ext. Stim. Output:	±1.0 amp (¼" phone jack)	
Ext. Stim Z (out):	Less than 0.1 Ω	
Input Sources:	D/A0, D/A1, PULSE (DIG I/O 15), CH 16 (Analog)	
Polarity Control:	Manual or digital control (DIG I/O 7, H-POS, L-NEG)	
Attenuation Control:	Manual or digital control	
Attenuation Control Range:	128dB (Digital I/O 0-6, LSB-MSB)	
Attenuation Step Resolution:	1dB	
LED Indicators:	Pulse, Current Limit	
Uniphasic Pulse Width:	10µs (min) with 5µs resolution	
Biphasic Pulse Width:	MP150: 20µs (min)	MP100: 50µs (min)
Biphasic Pulse Resolution:	MP150: 10µs	MP100: 25µs
Arbitrary Wave Resolution:	MP150: 10µs	MP100: 25µs
Weight:	380 grams	
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)	

STMISO Stimulus isolation adapters (C/D/E)

See also: *Stimulator Setup* notes in Acq*Knowledge* Software Guide

BIOPAC offers three stimulus isolation adapters:

STMISOC	constant current or constant voltage (5X / 10X) stimulation; see below.
STMISOD	multiplies STM100C voltage by 5; see page 196.
STMISOE	multiplies STM100C voltage by 10; see page 196.

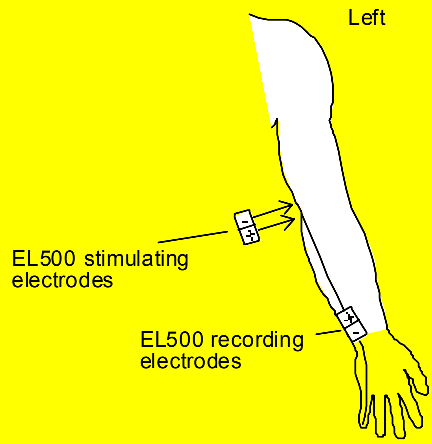
IMPORTANT SAFETY NOTES!

When using the STMISOC, STMISOD, or STMISOE, it is possible to generate voltages as high as 200 v p-p. These voltages are potentially dangerous, especially if the stimulator's high voltage outputs are connected across the subject's heart. Across the heart means that the heart is potentially in the electrical path from lead to lead. This situation occurs when the stimulation electrodes are placed on opposite sides of the subject's body.

NEVER PLACE STIMULATION ELECTRODES ON OPPPOSITE SIDES OF THE SUBJECT'S BODY!

Always use the stimulator with the leads placed in relatively close proximity to each other and relatively far from the heart, and with the leads placed only on the **SAME** side of the body. The figure to the right illustrates correct connection techniques when using the STMISOC/D/E.

Example of correct stimulation electrode placement:



STMISO SAFETY

The harmonized, international regulatory standard relating to the safety of nerve and muscle stimulators is **IEC 601-2-10**. Certain stimulation equipment is excluded from this standard, such as stimulators intended for cardiac defibrillation; however, for the purposes of defining relevant safety metrics for BIOPAC's STMISO series stimulation units, this standard is quite relevant.

BIOPAC's STMISO series stimulation units are designed in such a manner that the power available to stimulate the subject is limited. This limitation of power is achieved through the use of stimulus isolation transformers which have physical constraints (due to their size and construction) which absolutely —in accordance to known physical laws — constrain the maximum transferable power to be no more than a specific level.

Section **51.104** of the IEC 601-2-10 standard clearly specifies the **limitation of output power** for a variety of wave types.

* For stimulus pulse outputs, the maximum energy per pulse shall not exceed 300mJ, when applied to a load resistance of 500 ohms,
* For stimulus pulse outputs, the maximum output voltage shall not exceed a peak value of 500V, when measured under open circuit conditions.

All BIOPAC STMISO units employ stimulus isolation transformers that limit the output pulse width to 2ms maximum, under 500 ohm load conditions. In addition, the highest available output voltage is 200V pk-pk (STMISOC or STMISOE) under open circuit conditions.

For the pulse energy calculation for STMISOC and STMISOE:

Joules = Watts x Seconds
Watts (instantaneous maximum) = (200V x 200V) / 500 ohms = 80
Joules = 80 W x 0.002 seconds = 0.16 Joules = 160mJ

Accordingly, the highest possible energy output using the STMISOC or STMISOE is **160mJ**.

The remaining stimulus isolation unit, STMISOD, has a maximum voltage output of 100V. In this case, the maximum energy output is:

Watts (instantaneous maximum) = (100V x 100V) / 500 ohms = 20
Joules = 20 W x 0.002 seconds = 0.04 Joules = 40mJ

In all cases the maximum available energy, from the STMISO series stimulus isolation units, is limited to be considerably **less than the 300mJ maximum** as specified by IEC 601-2-10.

CAUTIONS FOR USE!

Even the safest stimulation units, if used incorrectly, can cause serious harm. The following points illustrate fundamental rules for using stimulus isolation units to stimulate subjects.

1) **NEVER APPLY THE STIMULUS SIGNAL IN SUCH A MANNER AS TO CAUSE CURRENT TO FLOW THROUGH THE HEART**.

   Primarily considered, this rule implies that stimulation leads should never be split apart so as to be able to touch opposing sides of the body surrounding the heart.

   For example: NEVER CONNECT THE STIMULUS ISOLATION UNIT SO THAT ONE LEAD TOUCHES THE LEFT ARM AND THE OTHER LEAD TOUCHES THE RIGHT ARM.

   Both stimulus leads [(+) and (-)], should be applied to the SAME side (left or right) of the subject's body. Furthermore, always stimulate AWAY from the heart. Stimulation probes (such as BIOPAC's EL350 or the EL351), which constrain the distance from the positive stimulation output to the negative stimulation output, should always be used for skin surface stimulation of nerve or muscle.

   The EL350 or the EL351 stimulation probes fix the distance between stimulation outputs to 35mm. It is not recommended that this distance be increased for skin surface stimulation of nerve or muscle. An increase in this distance simply allows stimulation currents to circulate over a larger area, which is usually not necessary for nerve or muscle stimulation scenarios.

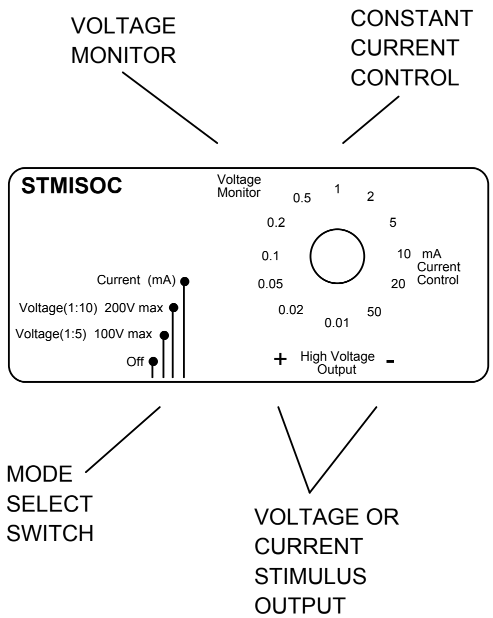
   level. The control for the STMISO series stimulus isolation units is located on the STM100C stimulation module. Set the control knob to the 0% level, prior to the onset of the stimulation protocol. During the protocol, increase the stimulus intensity by SLOWLY turning the control knob towards the 100% level. Stop increasing the intensity at the first sign of subject discomfort.

IMPORTANT NOTES!

A) It takes as little as **15 micro-amps** directed across the heart to instigate ventricular fibrillation. This situation can be readily achieved by using sub-surface stimulation needle electrodes that insert directly into the heart. It is considerably more difficult to achieve ventricular fibrillation on the same heart using surface electrodes, but it is possible to do so, evidenced by the performance of cardiac defibrillation units used in hospitals or by paramedics.

B) **Qualified experienced professionals** should supervise any protocols where electrical stimulation is applied to human subjects. Electrical stimulation protocols are not simple. Please contact BIOPAC Systems for any questions regarding the use of BIOPAC's stimulation units or accessories.

STMISOC Constant voltage or constant current stimulus isolation adapter



To use the STMISOC, you need an MP System with, minimally, one STM100C Stimulator module.

Plug the STMISOC directly into the EXT STIM jack on the STM100C module.

Use two LEAD110 electrode leads to connect the stimulus output to the subject. The LEAD110 electrode leads are required because they have the proper plug type for the new safety lead standard used on the STMISOC module. (1.6mm pin connectors)

In the Voltage mode, the STMISOC can be used with bipolar stimulation and with different waveform types (square, sine, triangle).

See Safety Notes on pages 193-194.

STMISOC Mode	Signal output if LEVEL control is set to 100%
OFF	No signal will be output from the STMISOC.
Voltage (1:5) 100V Max	Signal output will be 5x the values shown in the Stimulator Setup dialog (acts like a STMISOD).
Voltage (1:10) 200V Max	Signal output will be 10x the values shown in the Stimulator Setup dialog (acts like a STMISOE).
Current	Signal output will be positive constant current output; set signal value with the Current Control rotary switch. It's important to output **positive pulses** only. Pulses should have a height of at least 10v because pulse height output determines the voltage compliance of the current stimulation signal. The compliance of the current stimulation signal is determined by multiplying the pulse voltage amplitude by 10. For a 10v pulse the compliance would be 100v. This means that the STMISOC can output a current of up to 100V/R load. If R load = 5 k ohms, in this case the maximum output current would be 100v/5k = 20ma. The maximum pulse height can be as much as 20v, so it's possible to have a compliance as high as 200v.

The **Voltage Monitor Output** provides a proportional output of the exact voltage used to stimulate the subject. Use a CBL100 to connect the Voltage Monitor Output to an unused channel on the UIM100C. If the Current mode is selected, the Voltage Monitor Output will be disabled. The Voltage Monitor output provides output as follows:

Voltage (1:5) 100V Max setting: 1/10 proportional output

Voltage (1:10) 200V Max setting: 1/20 proportional output

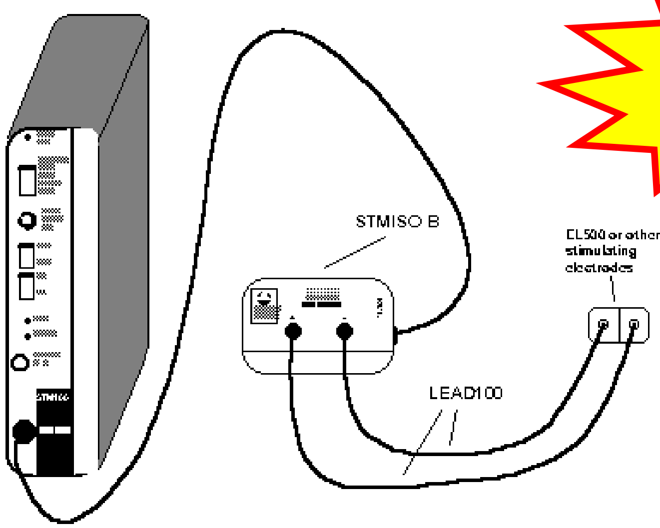
For example, if the mode is set to Voltage (1:10) 200V Max setting, then the Voltage Monitor Output will output a voltage that is 1/20 of the actual stimulation voltage.

STMISOC Specifications

Stimulus Pulse Width:	50µsec to 2msec (voltage and current)
Stimulus Sine Wave Range:	100Hz to 5kHz (voltage only)
Step Up Voltage Ratio:	Selectable: (1:5) or (1:10)
Maximum Output Voltage:	(1:5) mode 100v (p-p); (1:10) mode 200v (p-p) into 5k ± load
Constant Current Range:	0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 50.0 ma (unipolar only)
Current Source Compliance:	200V maximum
Current stimulation mode:	Positive current only
Isolation Capacitance:	150 pf
Isolation Voltage:	1500 VDC (from amplifier ground)
Cable Length:	1.8 meters
Weight:	190 grams
Dimensions:	10cm (wide) x 5cm (deep) x 4.5cm (high)
Interface:	STM100C—see page 180
Off mode	Turns off Voltage or Current stimulation to subject.
Voltage Monitor output	
Output via	3.5mm mono phono jack
(1:5) mode	1:10 of stimulation voltage
(1:10) mode	1:20 of stimulation voltage
Current mode	disabled
OFF	Reports a signal of approximately 50% of the voltage indicated in the stimulator setup window.

STMISOD/STMISOE

See Safety Notes on pages 193-194.



STMISOD/E setup for EL500 electrodes

The STMISOD/E plugs into the STM100C external stimulus output to provide an isolated voltage stimulus for response studies requiring a voltage stimulus (nerve conduction, somatosensory, etc.).

STMISOD adapter	boosts the voltage of the STM100C by a multiple of **5x** to provide a stimulus of up to ±50V (or 100V pk-pk).
STMISOE adapter	boosts the voltage of the STM100C by a multiple of **10x** to provide a stimulus of up to ±100V (or 200V pk-pk).

The front of the STMISOD/E has two 1.6mm pin plugs that accept any of BIOPAC's "safe lead" electrode leads, including bar electrodes, needle electrodes, and reusable electrodes.

The STMISOD/E has 1.6mm "safe lead" pin plug outputs so you can connect most needle or stimulating electrodes. For voltage stimulus applications, the EL500 bar electrode or the EL500 electrodes with two of the LEAD110 electrode leads are recommended.

The STMISOD/E comes with an attached 2-meter cable that has a 1/4" phone plug on the end that connects to the EXT STIM output on the STM100C.

STMISOD/E Calibration

See Safety Notes on pages 193-194.

To use the STMISOD/E, simply set up the stimulator in the software as you normally would, and hook the STMISOD/E adapter as shown in the figure above. Then, hook the stimulating electrodes of your choice to the two 1.6mm “safe lead” pin plugs.

The STMISOD/E provides an additional barrier of galvanic isolation between the MP150 and the stimulating electrodes. When using the STMISOD/E to create a pulsed voltage stimulus output, the pulse width must be between 10 µsec and 300 µsec.

If the pulse is narrower than 10 µsec, the STMISOD/E will not reproduce the pulse well, due to rise-time constraints.

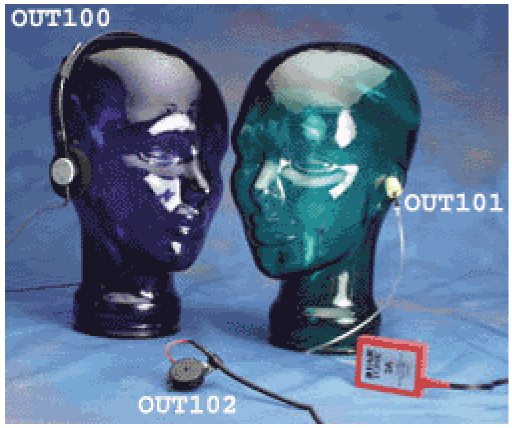
If the pulse is greater than 300 µsec, the pulse output will sag after 300 µsec, due to lower frequency response limits.

When using the STMISOD/E for voltage stimulus applications, turn the level control to 0% on the STM100C, then, after stimulation has begun, turn the level control up slowly. This approach will help you determine the appropriate voltage level for stimulating the subject.

<u>STMISOD/E Specifications</u>

Stimulus Pulse Width:	50µsec to 2msec (voltage only)
Stimulus Sine Wave Range:	100Hz to 5kHz (voltage only)
Step Up Voltage Ratio:	STMISOD (1:5)
	STMISOE (1:10)
Maximum Output Voltage:	STMISOD 100V (p-p) into 5k ohm load
	STMISOE 200V (p-p) into 5k ohm load
Isolation Capacitance:	120pf
Isolation Voltage:	1500 VDC (from amplifier ground)
Cable Length:	1.8 meters
Weight:	140 grams
Dimensions:	6.5cm (wide) x 5cm (deep) x 4.8cm (high)
Interface:	STM100C—see page 180

OUT Series for the STM100C



OUT100 Mono headphones

The OUT100 is a monaural, wide response, high efficiency headphone compatible with the STM100C. It's typically used with the STM100C in applications where audio feedback is required while monitoring a specific physiological signal; the most common application for the OUT100 is the audio monitoring of EMG as data is being recorded. The OUT100 weighs 3 ounces and includes a 1.8-meter cord.

OUT101 Tubephone

The OUT101 is a single channel tubephone compatible with the STM100C. It has a response that can be matched to audiometric headphones (TDH-39, TDH-49, and/or TDH-50). Because the OUT101 uses a flexible plastic tube to couple the sound energy to the eardrum, two advantages result when comparing to conventional audiometric headphones:

1) Significant ambient noise reduction is obtained, which is useful for testing performed outside of a standard audiometric test booth.
2) The tube itself creates a 1 ms delay in the auditory signal, so electrical artifact can be easily separated from true response in auditory evoked response applications.

The OUT101 is typically used with the STM100C in auditory evoked response applications like the ABR. It measures 3.8 cm x 5 cm x 1 cm, and has a clip attached to secure to fabric or fixtures. Each Tubephone set includes one plastic tubephone, 50 foam ear inserts, and a 2-meter cable.

OUT102 Piezo Audio Transducer

The OUT102 piezo transducer is typically connected directly to the STM100C stimulator module. When the stimulator module output rises above 1.5 volts, the piezo indicator will emit a constant audible signal (3.0 kHz @ 80dB). Accordingly, the device is very useful for providing an audible stimulus, or alarm, when a physiological signal passes a certain threshold. As such, the OUT102 makes an excellent audible BPM indicator for ECG, blood pressure or respiration signals. The device can also be used to indicate when temperature or other slowly moving variable (e.g. electrodermal response) passes a certain threshold. The threshold for the OUT102 is determined by adjusting the amplitude control on the STM100C module. The specific Biopotential or Transducer amplifier signal monitored can be recorded while simultaneously directed through the STM100C module. The OUT102 also connects directly to the UIM100C digital I/O ports for operation with Control Channel outputs. The OUT102 measures 2.5cm (dia) x 1cm (high) and comes equipped with a 1.8m cable terminated in a 3.5mm phone plug. An adapter is included for connecting the OUT102 to the UIM100C digital I/O ports.

OUT Series Calibration

The OUT series does not require calibration.

TSD122 Stroboscope

The TSD122 Stroboscope connects directly to the UIM100C or STM100C for Visual Evoked Response applications. This battery-operated device will provide 360,000 flashes between charges. The unit will go from zero to a maximum of 12,000 flashes per minute. It has external TTL synchronization and Trigger facilities for interfacing with the MP System and other equipment.

The TSD122 can also be used to trigger the MP System, via the External Trigger terminal block (on the back of the UIM100C).

<u>TSD122 Specifications</u>

Display:	Digital LCD
Battery:	Built-in, rechargeable
Battery Life:	60 hours at 100 strobes/sec (360,000 strobes between charges)
Flash duration:	30µsec
Flash energy:	180mJoule
External TTL:	Sync/Trigger
Weight:	1.1 kg
Body Dimensions:	9.3cm (wide) 9 cm (high) x 23cm (long)
Reflector Housing:	12.2cm (dia)
Handle:	10.8cm (long)
I/O Ports:	TTL (Sync input and output) - 3.5mm phone jacks
Cables:	CBL102 and CBL106
Interface:	UIM100C—see page 22
	STM100C (triggered)—see page 180

STP100W Stimulus Presentation System (SuperLab™)

See
on page 201.

The STP100W is a stand-alone system that measures subject responses to visual or auditory stimuli. It can present visual stimuli on a computer screen, or auditory stimuli via headphones or speakers, and simultaneously (1ms resolution) send trigger signals to an MP System on a different computer for data synchronization and collection purposes.

The SuperLab™ Pro software can change the placement of visual stimuli on the screen or change the screen's background color. It offers a variety of input and timing options, and will provide feedback based on the subject's response or reaction time. Different trigger channels can be paired to different visual or auditory stimuli to perform sophisticated evoked response averaging tests (e.g. P300).

The STP100W system includes:

SuperLab™ Pro Software (Windows 95/98)

STP100 Optical Interface (w/3-meter ribbon cable)

- ✓ Measures physiological responses to stimuli
- ✓ Permits up to eight synchronization signals (input or output) between the STP100W and the MP System

Digital I/O Card (PCI slot required)

Support Pack for Digital I/O Card (Windows 95/98)

Pushbutton Keycap Color Change Kit

Six Pushbutton Response Box

- ✓ Performs accurate (1 ms resolution) reaction time measurements

Second PC required— The synchronization signal(s) coming from the STP100W can be directed to an MP System running on a Macintosh or PC, but it's not possible to run the STP100W on the same computer as the MP System. The STP100W requires that the SuperLab™ software and a Digital I/O card (PCI slot required) be placed on a PC running Windows 95 or 98, with an available ISA card slot.

STP100 Isolated Digital Interface for the UIM100C

See SuperLab Setup on page 201.

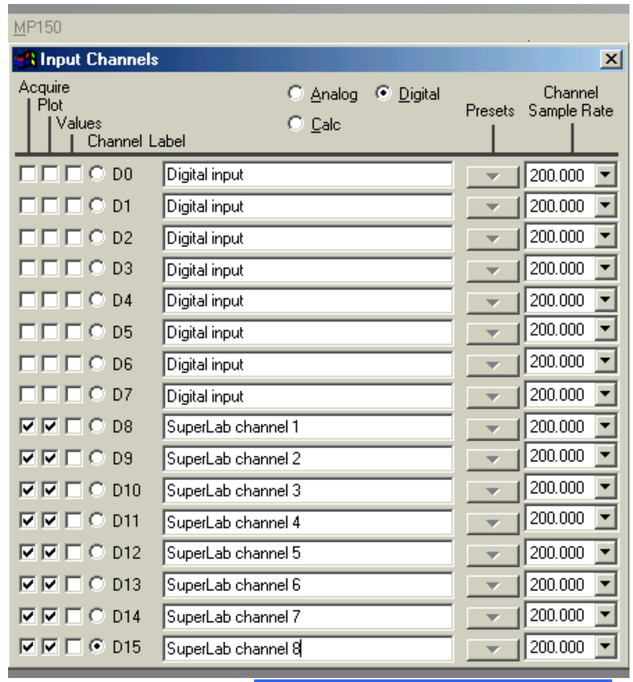
If you already have the SuperLab™ and the Digital I/O card with the Support Pack, you can interface to the MP System using the STP100 optical interface. The STP100 interface connects between the SuperLab™ Digital I/O card and the UIM100C module. The STP100 module can also be used to connect digital signals (TTL compatible) from any mains powered external equipment to the MP System when the system also connects to electrodes attached to humans. The STP100 provides 8 lines for digital data inputs and 8 lines for digital data outputs. All lines are optically isolated to 1500 VDC protection. The STP100 module comes equipped with a 3-meter ribbon cable (37 pin F/F) for easy system interfacing.

Instructions:

1. Connect the STP100 module to the digital I/0 connectors on the back of the UIM100 module.
2. Use the 3-meter ribbon cable to connect the STP100 module (computer I/O 37-pin connector) to the digital I/O card in the PC.
3. Connect Port A (inputs; pins 30-37) on the digital I/O card to digital I/O lines 0-7 on the MP unit.
4. Connect Port B (outputs; pins 3-10) on the digital I/O card to digital I/O lines 8-15 on the MP unit.
5. To externally trigger the MP Unit acquisition, send a signal from Port B (line 0) on the digital I/O card, which connects to digital I/O line 8 on the Mp unit. This lien also connects to the MP unit external trigger.
6. If certain UIM100 digital lines require routing to other devices, unscrew the offending 2mm pin from the STP100 to permit access to the respective UIM100 digital I.10 line.
7. For digital I/O card debugging purposes, pins 19 and 21 are GND and pins 18 and 20 are +5v.

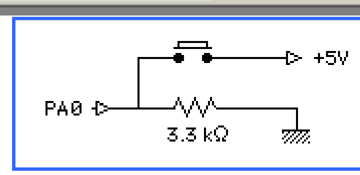
SuperLab Set up

See the **STP100 SuperLab Interface** on page 200.



1. Connect the **SuperLab** output card via the STP100 to the UIM100C and the BIOPAC MP100 or MP150 System.
2. Create your presentation using the appropriate digital outputs from the **SuperLab** PC to the MP150.
   - See the **SuperLab Manual** for instructions on how to create your presentation.
3. Setup digital channels 8-15 (as used in your presentation) using the MP150>Setup Channels>Digital dialog.
   - The **SuperLab** stimulus output synchronization signals will be output on digital lines 8 through 15. In order to record the changes and use the stimulus for analysis purposes, you must have the appropriate channels turned on (Acquire).

✓ **SuperLab** employs a digital I/O PCI card that uses Port A for input and Port B for output (Port C is unused). For input, lines must be "pulled low" (connected to ground by a resistor). The diagram on the right illustrates how this is done for line A0 (pin 37). The same diagram applies for lines A1 to A7. The resistor's value may range from 2.2 kilo-ohm to 5 kilo-ohm.



Cedrus highly recommends that all lines on Port A are pulled low even if you will not be using all 8 input lines. ***Better yet***: connect unused lines directly to ground.

To add other digital inputs and outputs to the system, simply remove the 2mm pin plugs from the STP100 Interface Module. The 2mm pins are screwed in and can be removed and added to mirror your particular application.

Application example — P300 visual evoked response test

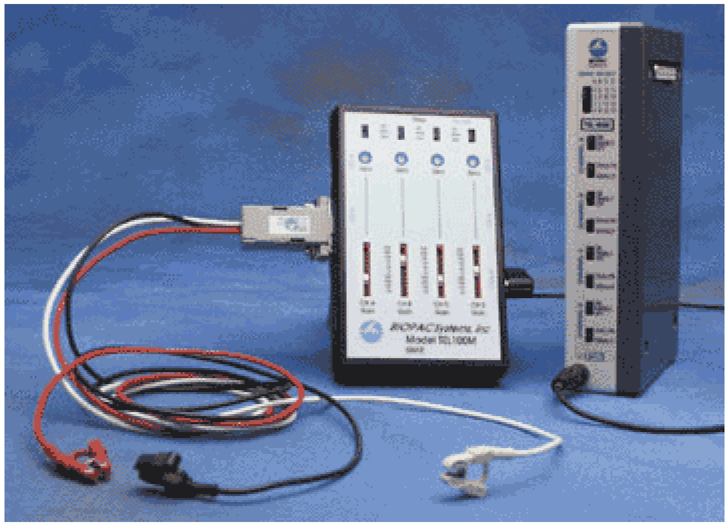
To set up the STP100W with an MP System to perform a P300 visual evoked response test:

1. Connect two **SuperLab** outputs to the respective MP System digital inputs.
   - These **SuperLab** outputs are assigned to respective images that will be presented to the subject during the recording session. Typically, image presentation occurs within a statistical framework, i.e., *Image 1* is presented 20% of the time and *Image 2* is presented 80%. The **SuperLab** outputs will be tightly (1 ms) synchronized to the respective image presentation.
2. Set the MP System up to record EEG and the two **SuperLab** outputs, which should be directed to the MP System digital inputs.
3. After the recording session has been completed, use Acq*Knowledge* to perform specific averaging on the collected EEG data.
   a) Use the digital input corresponding to **SuperLab** output 1 as a "Control Channel" in the Find Peak Averaging Setup; all the responses resulting from *Image 1* presentation will be averaged together to create the composite response for *Image 1* presentation.
   b) Repeat the above procedure with the "Control Channel" assigned to **SuperLab** Output 2 to create the composite response for *Image 2* presentation.

for this kind of measurement, see the Acq*Knowledge* Software Guide.pdf.

Chapter 8 Remote Monitoring

TEL100C Remote Monitoring System



The TEL100C is a remote monitoring system designed for use with an existing MP System. In addition, the TEL100C System can be used with existing BIOPAC amplifiers (e.g., ECG100C, RSP100C) and/or other TEL100C Systems. Up to four TEL100C Systems can be connected to a single MP System, and a single TEL100C System can be used with as many as 15 existing amplifiers or direct analog inputs.

Each TEL100C System consists of four major components (as shown above):

- TEL100M-C transmitter with 4 channel inputs
- TEL100D-C receiver
- CBL117 cable which connects the TEL100M-C to the TEL100D-C, and
- Up to four "Simple Sensor" electrode/transducer assemblies (which must be purchased separately).

TEL100D-C

The TEL100D-C is a four-channel receiver module that is compatible with all other MP150/100 modules. The TEL100D-C includes filtering and channel select controls.

- Select the **bank** (A, B, C and D) you want the channels assigned to. Make sure no other 100C series amplifiers are assigned to those same channels.

- If certain channels in a particular bank are already being used (and can't be moved), then turn the telemetry channel off, via the "**Enable ON/OFF**" switch on the front panel of the TEL100D-C.

Up to four TEL100D-C units can be connected to a single MP150, allowing for up to 16 channels of transmitted data originating from up to four separate TEL100M-C units. For every TEL100M-C, a TEL100D-C must be available to receive its data signals.

TEL100M-C

Each TEL100M-C is a miniature four-channel remote amplifier/transmitter that connects directly to the TEL100D-C via a lightweight coaxial transmission cable. The TEL100M-C does the work of four 100C series amplifiers and includes filtering, offset and gain control for each of its four channels.

All BIOPAC SS series transducers and electrodes will function directly with the TEL100M-C. Excitation voltages are available on each channel input to provide power for "Simple Sensor" transducer assemblies (such as RSP, GSR, PPG and SKT).

The TEL100M-C requires one 9V alkaline battery for operation. A low battery indicator light will flash when the battery requires replacing. Expected battery life is approximately 24 hours of continuous operation.

The TEL100C module set is a modulation/demodulation system.

- The modulation process occurs in the TEL100M-C.
- The demodulation process occurs in the TEL100D-C.

The TEL100M-C amplifies and filters the four input channels. After amplification the channel signals are time division multiplexed (TDM) into a single transmission channel and are sent through the CBL117 (coaxial cable) to the TEL100D-C (see diagram on page 204). The TDM process intrinsically samples the four input channels at a rate of 2000Hz / per channel. This sampling process occurs in the TEL100M-C module and is independent of the MP System.

Prior to the TDM process, the four input channels are low-pass filtered to 500Hz. The TDM process always samples at 2000Hz for each channel and each channel's maximum bandwidth is 500Hz. Accordingly, the sampling process does not affect the user or the rate at which the MP150 samples data. The TEL100M-C transmits an analog signal.

The TEL100D-C demodulates the transmission from the TEL100M-C and incorporates user-selectable 30Hz low-pass **filters** for removing noise or 50/60Hz interference from the four input channels. Filters can be independently assigned **on** or **off** for each channel.

The TEL100D-C produces a ±10 volt range analog output for each channel, and then these analog outputs are sampled by the MP150.

- The analog outputs are also available via the front panel of the UIM100C, if you want to direct the outputs to an alternate recording system in conjunction with the MP System.

The TEL100C module set has an upper frequency limit of 500Hz for each channel. The TEL100C is not recommended for physiological measurements requiring higher frequency measurements (e.g. certain evoked response applications). However, a wide range of physiological activity can be monitored with the TEL100C, including ECG, EOG, EEG, GSR, SKT, PPG, RSP and surface EMG.

- Specialized signal processing of physiologic variables (like RMS filtered EMG, or QRS detection) are performed on the computer via calculation channels.

Up to four TEL100C module sets can be connected to a single MP System, providing a maximum of 16 transmitted channels. The TEL100C module set behaves the same as four alternate 100 series modules.

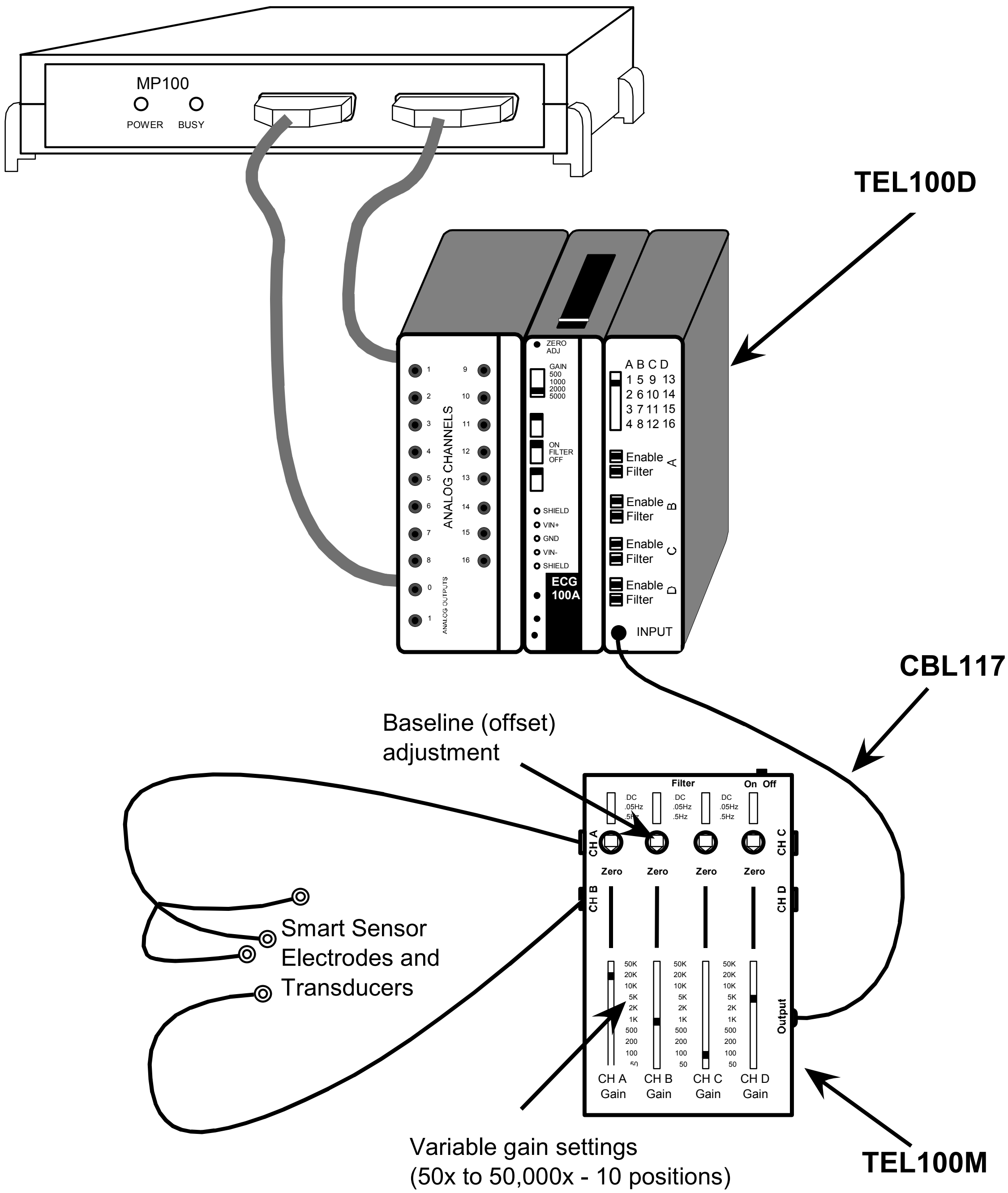
The 2000Hz sampling rate of the TEL100C module set is independent of the MP System sampling rate.

- If a TEL100Channel is low-pass filtered at 30Hz, it would be appropriate for the MP System to sample that channel at 100Hz.

The TEL100C module set can be used independently from the MP System. The recommended configuration requires the UIM100C in addition to the TEL100C. You must supply ±12 volts to the appropriate terminals on the back panel of the UIM100C. The TEL100Channels are then accessed on the front panel of the UIM100C. Up to four TEL100C units can be used with a single UIM100C.

For studies that employ surface electrodes (e.g., ECG, EMG), gain settings from 500 to 5000 are typically appropriate. Similar settings are also appropriate for measurements with the RSP and PPG Simple Sensors. Moreover, non-electrode measurements (temperature, pulse, respiration and so forth) are typically performed with the **hipass** switch on the TEL100M-C set to DC (or 0.05Hz to remove baseline drift), and the **filter** switch on the TEL100D-C in the ON position.

No special software is required to use the TEL100C module set. The TEL100C operates on the same Acq*Knowledge* software platform as the MP150. The TEL100C module set behaves equivalently to any four 100 series modules. All the surface electrode measurements (ECG, EEG, EMG and EOG) terminate in an SS2 Simple Sensor shielded electrode lead assembly. See the section on Simple Sensors (page 208) for information about the termination of other physiological variables.



TEL100C - MP System setup

CBL117 This 10-meter cable connects the TEL100D-C receiver to the TEL100M-C transmitter and is included in the TEL100C remote monitoring module set. The lightweight coaxial cable minimizes hindrance caused by multiple heavy cables. For increased operating distance, use CBL118.

CBL118 This 60-meter cable connects the TEL100D-C receiver to the TEL100M-C transmitter and is designed as an extension option for the TEL100C remote monitoring module set. The lightweight coaxial cable minimizes hindrance caused by multiple heavy cables.

TEL100C Calibration

To begin using the TEL100C system:

1. Plug the TEL100D-C into the side of the UIM100C
2. Select the bank you want the channels (A, B, C and D) assigned to. Make sure no other 100C series amplifiers are assigned to those same channels. If certain channels in a particular bank are already being used (and can't be moved), then turn the telemetry channel off, via the "Enable" switch on the front panel of the TEL100D-C.
3. Plug the CBL117 into the TEL100M-C and the TEL100D-C.
4. When recording in Acq*Knowledge*, turn on the TEL100M-C, by flipping the power switch from right to left. The LED on the TEL100M-C should blink once then stay off. If the LED continues to blink, the 9V battery needs to be replaced (use 9 Volt alkaline batteries).
5. If bank 1 is selected on the TEL100D-C, then the TEL100Channels A, B, C and D will be assigned to MP150/100 channels 1, 5, 9 and 13 respectively. When using Acq*Knowledge*, select these channels when viewing data assigned to bank 1. The following documentation assumes that bank 1 is the selected bank.
6. To determine correct operation, rotate the zero balance for channel A on the TEL100M-C. Channel 1 in Acq*Knowledge* should indicate a moving baseline that changes as the zero is adjusted. Set the zero balance for channels A, B, C and D, so that the Acq*Knowledge* screen trace is centered. Plug the desired Simple Sensor into the TEL100M-C.

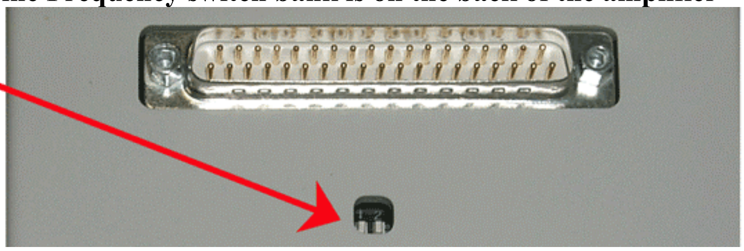
For GSR measurements, the following **Gain** settings correspond to µmhos per Volt. Similarly, for temperature measurements, the **Gain** settings listed correspond to ºF per Volt. Using the **rescaling** feature in Acq*Knowledge*, these settings can be used to calibrate the signal.

Gain	GSR (SS3A) µmhos/V	SKT (SS6) ºF/V
50	200	100
100	100	50
200	50	25
500	20	10
1,000	10	5
2,000	5	2.5
5,000	2	1
10,000	1	0.5
20,000	.5	0.25
50,000	.2	0.1

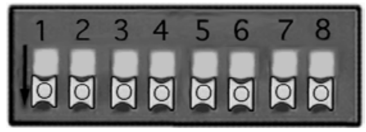
As with the SKT100C amplifier, temperature data collected with the TEL100C is centered around 90º F. Supposing data was acquired using a gain setting of 500, a reading of 0 Volts would correspond to 90ºF, whereas a signal of +2 Volts (read on the MP150) would correlate to a temperature of 110ºF. These values could then be used to rescale the incoming signal from raw voltages to degrees Fahrenheit.

Modules are factory preset for 50Hz or 60Hz 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 60Hz in the United States and 50Hz in most of Europe; contact BIOPAC if you are unsure of your country's line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

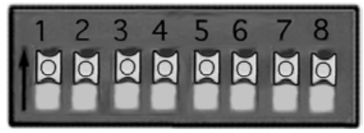
Line Frequency switch bank is on the back of the amplifier



(The TEL100 has an 8-switch bank vs. 2-switch bank shown)



50 Hz = All 8 switches DOWN



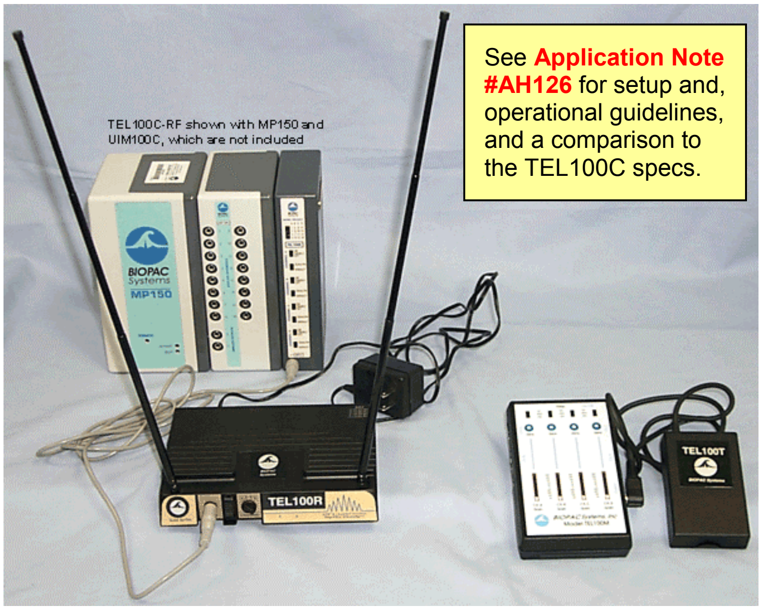
60 Hz = All 8 switches UP

TEL100C System Specifications

Number of Channels:	4	
Sampling Rate:	2000Hz (per channel) [Transparent to user]	
Frequency response	(independent bandwidth settings per channel)	
Low Pass Filter:	30Hz, 500Hz	
High Pass Filter:	DC, 0.05Hz and 0.5Hz	
Channel Gain Control:	x50, x100, x200, x500, x1000, x2000, x5000, x10000, x20000, x50000	
Output Range:	±9V (analog)	
Offset Control:	Yes	
Input Impedance:	2 MΩ (differential)	
CMRR:	110dB min (50/60Hz); see Shield Drive Operation on page 215	
CMII:	11 MΩ (DC), >1000 MΩ (50/60Hz)	
CMIV:	±7V (referenced to amplifier ground) ±1500 VDC (referenced to mains ground)	
Noise Voltage:	0.1μV rms (0.05-30Hz)	
Transducer Excitation:	±5V (10V pk) @ 10ma (max)	
Signal/Crosstalk Ratio:	(0.05-500Hz) 65dB min	
Signal/Noise Ratio:	(0.05-30Hz) 75dB min, (0.05-500Hz) 65dB min	
Encoding:	TDM-DSB/LC	
Signal transmission range:	≤ 60 meters via coaxial cable	
TEL100M Power Source:	9V alkaline battery (24 hrs nominal)	
Dimensions	Size	Weight
TEL100D-C:	4 cm *x* 11 cm *x* 19 cm	400 g
TEL100M-C:	9 cm *x* 15 cm *x* 3.3 cm	308 g

See also: SS Series Simple Sensor Transducers, page 208.

TEL100C-RF Wireless Remote Monitoring System



Each **TEL100C-RF system** includes:

- 1 - TEL100D-C receiver module
- 1 - TEL100M-C portable 4-channel amplifier/transmitter
- 1 - TEL100-RFL radio frequency link (wireless set includes TEL100T transmitter and TEL100R receiver)
- 1 - CBL119 2-meter connection cable (RCA-M to 1/4-M mono)

The TEL100C-RF will work with your current MP System and any other standard 100-series amplifiers.

Use with BIOPAC SS series Simple Sensor transducers and electrodes.

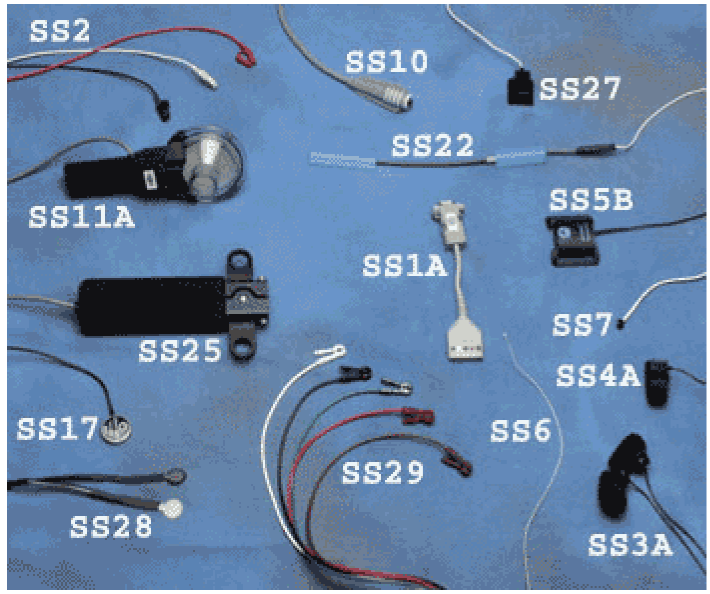
The TEL100C-RF system offers a completely wireless transmission scheme to record data while subjects are mobile and/or physically distant (75-150 meters) from the recording system. The TEL100C-RF system includes a portable amplifier/transmitter, which converts up to four channels of data into a modulated data stream. This data stream is transmitted to the receiver module, and then the receiver demodulates the data and sends it to the MP System for recording and analysis. Up to four TEL100C-RF module sets can be used with a single MP System, allowing up to 16 channels of transmitted data originating from up to four distinct locations. Each channel incorporates a switchable, non-distorting 50/60 Hz interference filter. Gain and bandwidth can be adjusted independently for each channel.

TEL100C-RF SPECIFICATIONS

Number of Channels:	4	
Channel Bandwidth:	500 Hz or 35 HzLPN (low pass filters)	
Notch Filters:	50 or 60 Hz (user selectable - side panel); Independent bandwidth per channel	
Sampling Rate:	2000 Hz (per channel)	
Encoding:	TDM-DSB/LC-FM	
Channel Gain Control:	10 levels: 50, 100, 200, 500, 1000, 2000, 5000, 10000, 20000, 50000	
Input Signal Level:	Max: ±50 mV	
Offset Control:	Yes	
AC/DC Coupling:	DC, 0.05 Hz and 0.5 Hz	
Transducer Excitation:	±5 V @ 20 ma (total max current - four channels)	
Transmit Frequency Options:	Four channels (selected group ranging from 170 to 216 MHz)	
Transmit Frequency Stability:	±0.005% (crystal controlled)	
RF Power Out:	50 mW (max allowed by FCC)	
Transmission Range:	75 meters (nominal), 150 meters (line-of-sight)	
Signal/Crosstalk Ratio:	35 dB (nominal)	
Signal/Noise Ratio:	0.05-35 Hz: 40 dB (nominal); 0.05-500 Hz: 35 dB (nominal)	
Pk-Pk Noise:	Voltage (Shorted Inputs): 0.28 µV (0.1-10 Hz); Current: 10 pA (0.1-10 Hz)	
Biopotential Amplifiers (in TEL100M-C):		
CMRR (1 kOhm source imbalance):	110 dB min. (DC-60Hz); see Shield Drive Operation on page 215	
Input Impedance:	Differential 2 Mohm; Common 11 MOhm (DC), >1000MOhm (60 Hz)	
Component Dimensions and Weight:		
TEL100D-C:	4.3" x 7.5" x 1.6"	14 oz.
TEL100M-	C: 3.5" x 5.6" x 1.2"	11 oz. with battery
TEL100T:	2.5" x 4.0" x 1.0"	6 oz. with battery
TEL100R:	4.5" x 7.0" x 1.3"	22 oz.

Simple Sensor (SS) Electrodes and Transducers for the TEL100C

Simple Sensor (SS) electrodes and transducers are explicitly designed to connect to the **TEL100M-C** transmitter, and most come with a 1.2 meter cable. SS assemblies include specific circuitry to adapt various physiological variables to the TEL100M-C.



Any SS electrode or transducer can be plugged into any TEL100M-C input. The "smart" configuration of each electrode and transducer assembly communicates its specific signal type. Certain transducers (such as SS26 and SS27 Accelerometers) will reduce the overall recording life of the 9-Volt battery, but it is generally possible to record biopotentials and other signals for up to 24 hours.

Simple Sensors take the place of BIOPAC's traditional electrodes and transducers in that they are only compatible with the TEL100M-C amplifier. All the surface electrode measurements (ECG, EEG, EMG and EOG) terminate in an SS2 (Simple Sensor shielded electrode lead assembly).

The Simple Sensor connector varies from the transducer connector, but functionality is the same. The following physiological variables terminate as shown—see the corresponding transducer section for information about each Simple Sensor

SS #	Description	Corresponding Transducer	
SS1A	Unshielded Touchproof Electrode Adapter (10 cm)		
SS2	Shielded Electrode Lead Assembly (1 meter)		
SS3A	Electrodermal Response Transducer	*see* TSD203	page 105
SS4A	Pulse Plethysmogram Transducer	*see* TSD200	page 108
SS5B	Respiratory Effort Transducer	*see* TSD201	page 113
SS6	Fast Response Temperature Probe	*see* TSD202A	page 119
SS7	Skin Surface Temperature Probe	*see* TSD202B	page 119
SS10	Hand Switch	*see* TSD116A	page 34
SS11A	Air Flow Transducer (medium)	*see* TSD117	page 49
SS17	Physiological Sounds Microphone	*see* TSD108	page 55
SS20	Twin-Axis Goniometer (110mm) — requires 2 channels	*see* TSD130A	page 63
SS21	Twin-Axis Goniometer (180mm) — requires 2 channels	*see* TSD130B	page 63
SS22	Single Axis Torsiometer (110mm)	*see* TSD130C	page 63
SS23	Single Axis Torsiometer (180mm)	*see* TSD130D	page 63
SS24	Finger Goniometer (35mm)	*see* TSD130E	page 63
SS25	Hand Dynamometer	*see* TSD121C	page 58
SS26	Tri-Axial Accelerometer (5G) — requires 3 channels	*see* TSD109C	page 29
SS27	Tri-Axial Accelerometer (50G) — requires 3 channels	*see* TSD109F	page 29
SS28	Heel/Toe Strike Transducer	*see* TSD111	page 32
SS29	Multi-lead ECG Cable — requires 3 channels	*see* TSD155C	page 86

Simple Sensor Calibration

Refer to the corresponding transducer section.

Chapter 9 Power & Cables

IN-LINE POWER TRANSFORMERS

All AC series in-line power transformers are CE marked for the EC Low Voltage Directive and EMC Directive, and all have UL and TUV approval. The units have standard IEC power input plugs and operate over mains power ratings of 100-240 VAC, 50-60Hz. Each includes a USA or EURO power cord.

AC100A	+12 volt, 1 amp	Connects the MP100 System, IPS100C, CO2100C or O2100C to the AC mains wall outlet. One transformer is included with each MP100 Starter System, IPS100C, CO2100C or O2100C module.
AC101A	±12 volt, +5 volt, 1 amp	Connects the LDF100C to the AC mains wall outlet. One transformer is included with each LDF100C module.
AC137A	+6 volt, 1.5 amp	Powers the heating element for any of the TSD137 series pneumotachs.
AC150A	+12 volt, 2.5 amp	Connects the MP System to the AC mains wall outlet. One transformer is included with each MP150 Starter system.

See also: IPS100C Isolated Power Supply, page 37

BAT100 Rechargeable battery pack

BAT100 with Recharger

The BAT100 is a sealed lead-acid rechargeable battery pack and recharger designed to operate with the MP System. The battery pack comes in a handy carrying case equipped with a shoulder strap. The fully charged battery pack will operate an MP System for 12 hours minimum. The battery pack can be recharged only when disconnected from the MP System. The BAT100 includes all necessary cables.

Using the BAT100 to operate an MP System: Connect the charged battery to the MP unit via the 1.2-meter BAT100-to-MP unit power cable. The red LED on the battery cable should light, indicating that power is being supplied to the MP unit. Turn on the MP unit if it is not already on. The power LED should light and you may operate your MP System as you normally would.

Recharging/Storage: Turn off the BAT100 and MP units if you have not already done so. Remove the power cable from the BAT100. Connect the BAT100 to the recharger unit via the recharger's attached cable. Plug the charger's power cable into a mains outlet. Full recharging of a completely discharged BAT100 takes 16-24 hours. A shorter recharging period of 3 hours or more will allow you to "top off" a partially discharged battery or provide enough charge for shorter operating sessions. Leaving the battery charger and BAT100 connected and charging for slightly longer periods than the full recharging time or charging a partially discharged battery for several hours or overnight will not adversely affect the performance of the BAT100. Do not leave the battery charger plugged into the BAT100 for a significant time after the BAT100 is fully charged. To optimize performance, allow the battery pack to fully discharge prior to recharging.

Connections: The socket on the pack and the charger connector are both standard "cigarette lighter" connections. The tip of the receptacle core is positive and the shell is negative.

<u>BAT100 Battery pack Specifications</u>

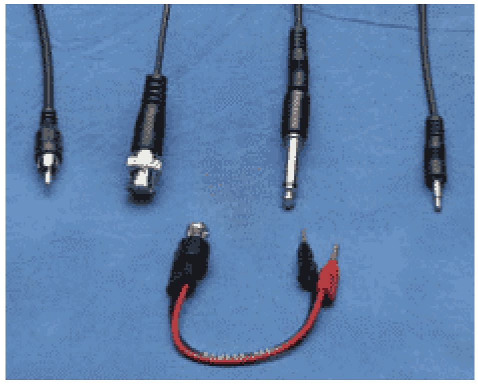
<u>Battery Pack</u>

Output Capacity:	12V @ 13 amp-hours unregulated
Operating Time:	MP100 with 4 modules: 24-48 hours nominal (12 hours min) MP150 with 4 modules: 16 hours nominal
Charge Time:	15 hours
Recharge Cycles:	500 (typical)
Weight:	5.6kg
Dimensions:	22cm (high) x 8cm (wide) x 24cm (deep)
Temperature Range:	Operation: -60°C to 60°C, Recharge: -20°C to 50°C
Shelf life:	Recharge every 6 months if stored/unused

<u>Recharger</u>

Output:	12V @ 1.0 amps
Input:	120/240 VAC @ 50/60 Hz (USA or EURO power cord)
Weight:	1.8 kg
Dimensions:	8cm (high) x 13cm (wide) x 15cm (long)

CBL100 Series Analog Connection Cables



CBL100 series

The CBL100 Series analog connection cables are used to connect your stand-alone equipment to the MP System. Analog outputs (from chart recorders, force plates, pre-amplifiers, oscilloscopes, etc.) can be connected to the UIM100C module or other MP System modules. Select the cable number with the plug corresponding to the output jack of your equipment. Use one cable per recording channel.

CBL100 2m; 3.5mm mono phone plug to 3.5mm mono phone plug

CBL101 2m; 3.5mm mono phone plug to male RCA

CBL102 2m; 3.5mm mono phone plug to male BNC

CBL105 2m; 3.5mm mono phone plug to 6.35mm (¼") mono phone plug

CBL106 10cm; 2mm pin plugs to female BNC
The CBL106 is a multi-purpose adapter that can be used to:
Connect BNC terminated equipment to the DA100C
Connect a BNC cable to the digital I/O lines on the UIM100C
Connect the STM100C to nerve conduction chambers (via the CBL101)

CBL107 10m, 3.5mm mono plug to 3.5mm mono phone plug

CBL108 60cm, 3.5mm mono plug to 3.5mm mono phone plug

CBL117 10m RCA male plug to RCA male R/A plug for TEL100C

CBL118 60m RCA male plug to RCA male R/A plug for TEL100C

CBL200 Series   Lead Connector Conversion Cables

See the guide to *External Device Interfaces* on page 213 for connections to common devices

CBL200	10cm, 2mm pin to 1.5mm socket	Converts a 2mm pin electrode or transducer lead to a Touchproof socket (1.5mm ID), for connection to any of the 100C-series Biopotential or Transducer amplifiers or STMISO series modules. One CBL200 is required for each Touchproof socket.
CBL201	10cm, 1.5mm socket to 2mm pin	Converts a Touchproof (1.5mm ID) socket electrode or transducer lead to an old-style 2mm pin, for connection to any of the 100B-series Biopotential or Transducer amplifier modules. Also used to connect a ground electrode lead (e.g. LEAD110A) to the UIM100C module (required when using the TSD150 active electrodes). One CBL201 is required for each Touchproof socket.
CBL202	2mm Male pins to 6.3mm (¼″) mono phone jack	Adapts transducers with a 6.3mm (¼″) mono phone plug to the DA100C.
CBL203	1.5mm Female to 6.3mm (¼″) mono phone jack	Adapts temperature transducers with a 6.3mm (¼″) mono phone plug to the SKT100C.
CBL204	25cm, Touchproof "Y" adapter	Connects connecting multiple electrode sites to a single amplifier input or stimulator output. The CBL204 plugs into any 100C-series Biopotential amplifier input or STMISO series output and provides two sockets to connect to electrode leads terminating in Touchproof sockets. Multiple CBL204s can be plugged together to reference 3 or more electrode leads to the same input or output.

Custom cables are available from BIOPAC for connectors not listed.

External Device Interfaces to an MP System using UIM100C			
Company	**Device**	**Connector Type**	**BIOPAC cable**
AMTI	MSA-6: Force Plate Amp (Use AMTI cable 5405C) MCA: Force Plate Amp (Use AMTI cable 5405C)	BNC female	CBL102
Axon	All Amplifiers	BNC female	CBL102
Buxco	MAX II	3.5 mm mini-phone jack	CBL100
Data Sciences International	Physio Tel Receiver with ART Analog Adapter	BNC female	CBL102
Gould	6600 Series	BNC female	CBL102
Grass	Model 7 (J6)	3.5 mm mini-phone jack	CBL100
	P55, P122, and P511 Series	BNC female	CBL102
Harvard	HSE PLUGSYS AH 69-0026 Dissolved Oxygen Meter	BNC female	CBL102
	AH 60-2994-2999 Research Grade Isometric Transducers AH 6-03000/3001 Research Grade Isotonic Transducers	4 mm double banana jack	CBL102 with CBL106
Kent	TRN(001-012) Amplifiers	BNC female	CBL102
Kissler	Force Plates	BNC female	CBL102
Millar	TCB600: Transducer Control Unit	¼" phone jack	CBL105
	TC-510 (Specify Grass Cable interface #850-3028)	6-pin	TCI100 (to DA100C)
Sonometrics	Sonomicrometer Systems with Optional Adapter	BNC female	CBL102
Transonic	T106, T206, T106U, T206U: Animal Research Flowmeters T110: Lab Tubing Flowmeter BLF21D/21: Laser Doppler Meters	BNC female	CBL102
Triton	CBI System System 6	¼" phone jack	CBL105
Tucker Davis	All Digital BioAmp Systems	BNC female	CBL102
WPI	705: Electro 705 Electrometer 721: Cyto 721 Electrometer 767: Intra 767 Electrometer 773: Duo 773 Electrometer DAM50: Bio-amplifier DBA Series Digital Biological Amps DVC-1000: Voltage Current Clamp EVC-4000-(1-4): Voltage Clamp FD223: Dual Electrometer ISO2: Dissolved Oxygen Meter & Electrode ISODAM: Low Noise Preamplifier ISO-DAM8A-(1-8): Bio-amplifier System NOMK2: ISO-NO Mark II Nitric Oxide Meter TRN001, TRN002, TRN011, TRN012: Isometric Transducers VF-4: 4-Channel Buffer Amplifier	BNC female	CBL102
	DAM60, DAM70, DAM80: Bio-amplifiers	3.5 mm mini-phone jack	CBL100

Interfaces are available for a variety of connectors…if you don't see what you need, call to discuss custom options.

MEC Series Module Extension Cables

MEC100C and MEC110C

These module extension cables are used to increase the distance between subject and recording system, allowing increased subject movement and comfort. Each extension cable attaches to one amplifier; electrodes and transducers plug into the extension cable's molded plastic input plug. The 3-meter extension includes a clip for attaching to a subject's belt loop or clothing.

The MEC series extension cables contain no ferrous parts (less the removable clothing clip). The MEC100C is designed for Transducer amplifiers. The MEC110C and MEC111C are designed for Biopotential amplifiers. Use the MEC100C or MEC110C to increase the lead length to the amplifier. The MEC111C is required for the protection of a system and Biopotential amplifiers when electrocautery or defibrillation equipment is used while recording data.

COMMON EXTENSIONS

MEC100C	100C-series Transducer amplifiers to Touchproof inputs
MEC110C	100C-series Biopotential amplifiers to Touchproof inputs
MEC111C	100C-series Biopotential amplifiers to Touchproof inputs—Protected

LESS COMMON EXTENSIONS

MEC100	DA100C or 100B-series Biopotential or Transducer amplifiers to 2mm socket inputs
MEC110	100B-series Biopotential or Transducer amplifiers to Touchproof inputs
MEC111	100B-series Biopotential amplifiers to Touchproof inputs—Protected

APPENDIX

Shield Drive Operation

- ECG100C
- EEG100C,
- EGG100C
- EMG100C
- EOG100C
- ERS100C
- MCE100C
- TEL100M

The shield drive for BIOPAC biopotential front-end differential amplifiers is developed as the arithmetic mean of the voltages sensed on the positive and negative differential inputs with respect to Ground. Given that interfering noise sources (usually 50Hz / 60Hz) nearly always appear as high level voltage signals of similar value on the positive and negative differential inputs, creating a shield drive for the positive and negative input leads will act to increase the amplifier's Common Mode Rejection Ratio (CMRR) via capacitance reduction of the differential input to its respective shield. Because the shield drive is introduced identically to the differential inputs, additive noise from the shield drive will have a tendency to cancel out due to the operation of the differential amplifier front end.

Generally, it's helpful to have an active shield drive for interfering noise reduction. However, in special cases, it may be worthwhile to ground the shields of the differential inputs or to dispense with shielding altogether. Any BIOPAC biopotential front-end differential amplifier can be user-adapted to satisfy these special cases; please contact BIOPAC Systems, Inc. for details.

Amplifier Frequency Response Characteristics

The following frequency response plots illustrate the frequency response selections available on the indicated amplifier modules. LP is low pass, HP is high pass, and the N suffix indicates the notch setting. Modules are factory preset for 50 or 60Hz notch options, depending on the destination country.

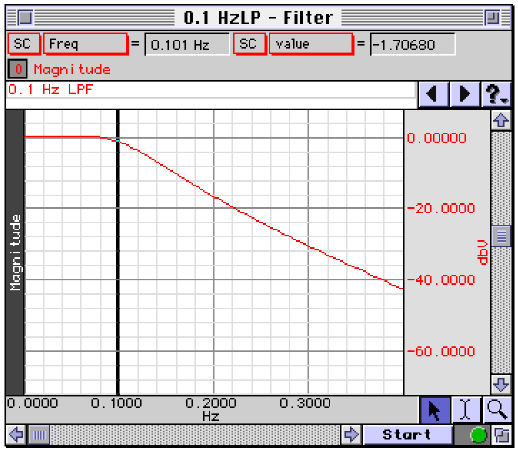
Setting	Modules
0.1Hz LP	EGG100C
1Hz LP	EGG100C, GSR100C, SKT100C
3Hz LP	PPG100C, RSP100C
10Hz LP	DA100C, EBI100C, GSR100C, PPG100C, RSP100C, SKT100C
35Hz LPN (with 50Hz notch)	ECG100C, EEG100C, EOG100C
35Hz LPN (with 60Hz notch)	ECG100C, EEG100C, EOG100C
100Hz LP	EBI100C, ECG100C, EEG100C, EOG100C
100Hz HPN (with 50Hz notch)	EMG100C, ERS100C, MCE100C
100Hz HPN (with 60Hz notch)	EMG100C, ERS100C, MCE100C
300Hz LP	DA100C
500Hz LP	EMG100C
3,000Hz LP	ERS100C, MCE100C
5000Hz LP	DA100C, EMG100C
10kHz LP	ERS100C
30kHz LP	MCE100C

Sample plots follow…

Sample Frequency Response Plots

0.1Hz LP

EGG100C

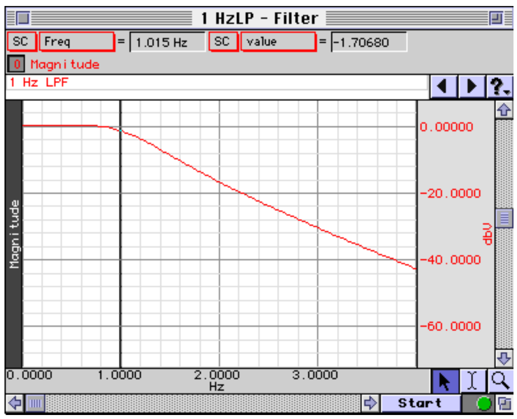


1Hz LP

EGG100C

GSR100C

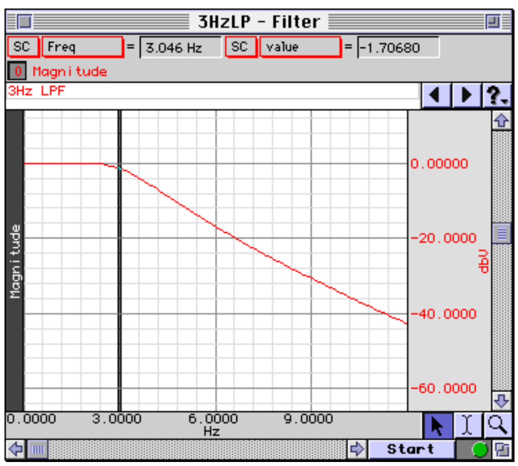
SKT100C



3Hz LP

PPG100C

RSP100C



10Hz LP

DA100C

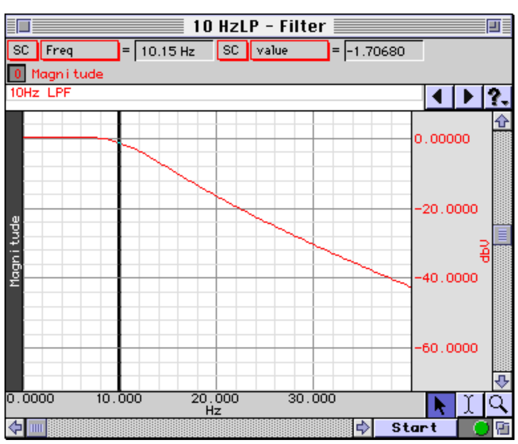
EBI100C

GSR100C

PPG100C

RSP100C

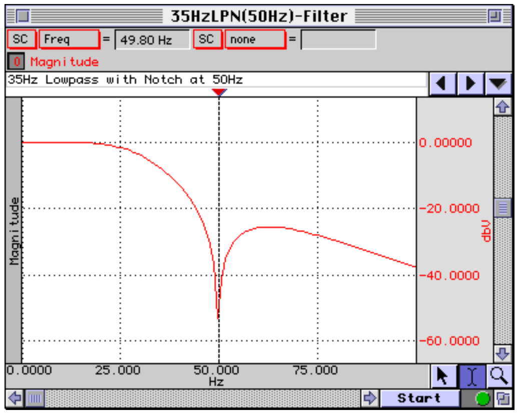
SKT100C



Sample Frequency Response Plots

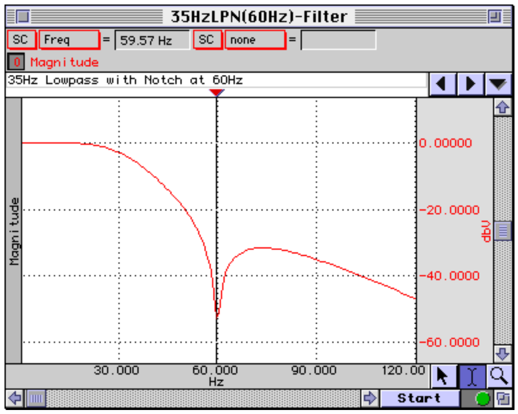
35Hz LPN
(with 50Hz notch enabled)

ECG100C
EEG100C
EOG100C



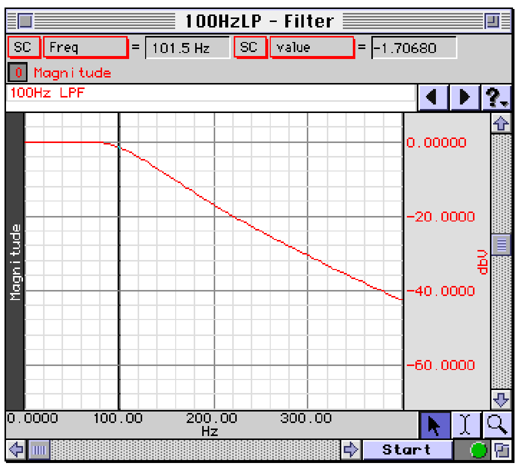
35Hz LPN
(with 60Hz notch enabled)

ECG100C
EEG100C
EOG100C



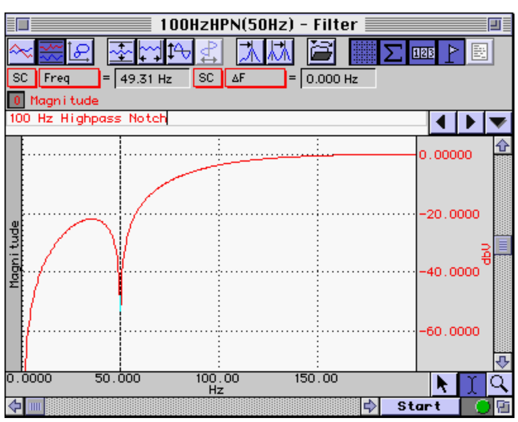
100Hz LP

EBI100C
ECG100C
EEG100C
EOG100C



100Hz HPN
(with 50Hz notch enabled)

EMG100C
ERS100C
MCE100C



Sample Frequency Response Plots

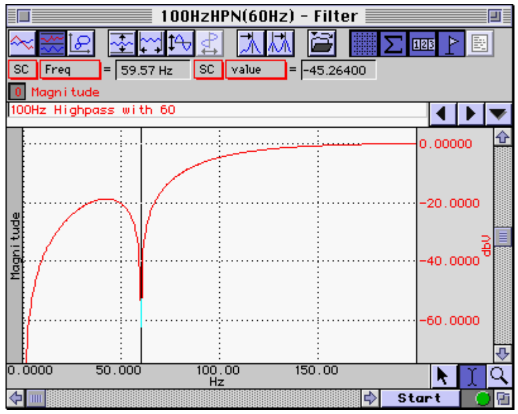
100Hz HPN
(with 60Hz notch enabled)

MCE100C

EMG100C

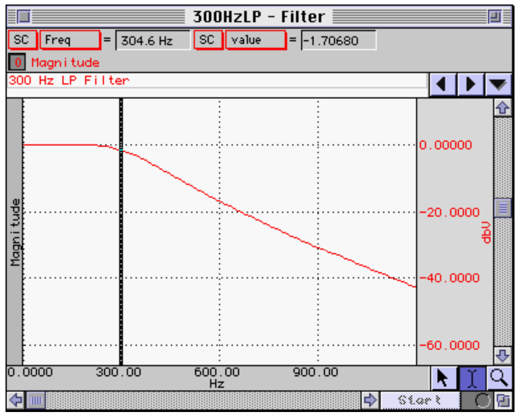
ERS100C

MCE100C



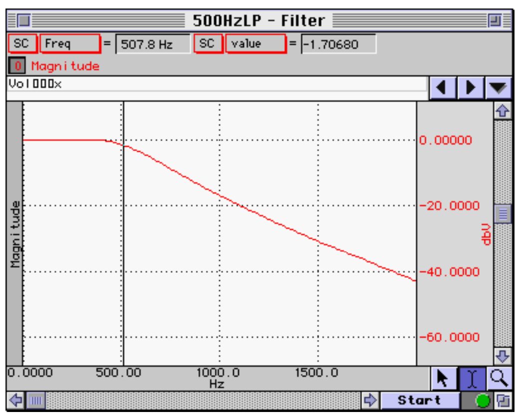
300Hz LP

DA100C



500Hz LP

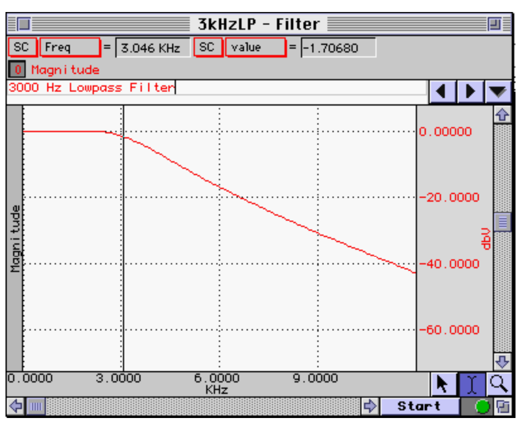
EMG100C



3,000Hz LP

ERS100C

MCE100C

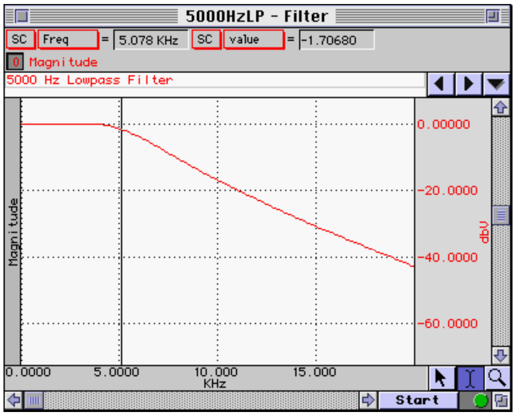


Sample Frequency Response Plots

5000Hz LP

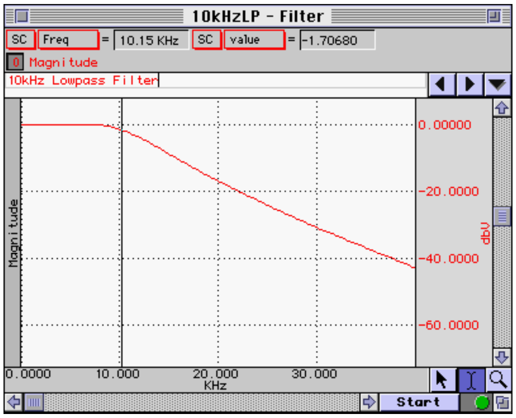
DA100C

EMG100C



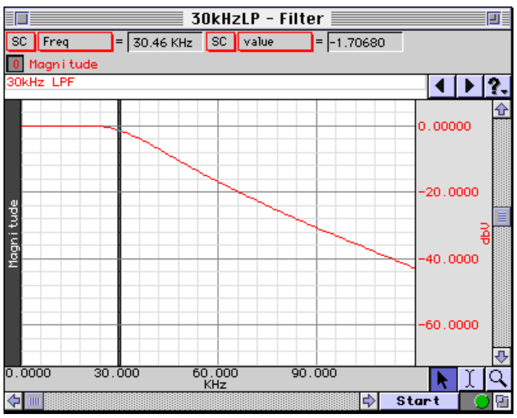
10kHz LP

ERS100C



30kHz LP

MCE100C

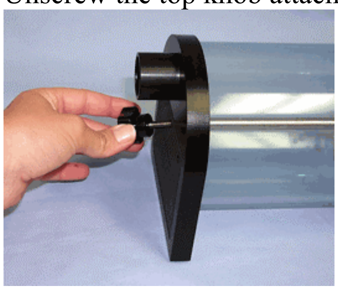


Cleaning the BIOPAC Gas-System2

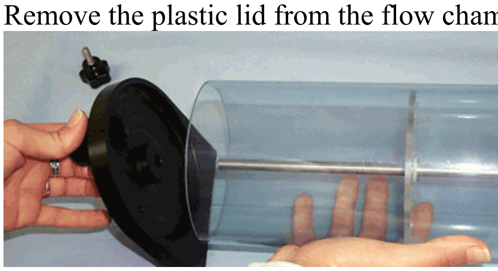
Gas-System2
See page 132 for specs.

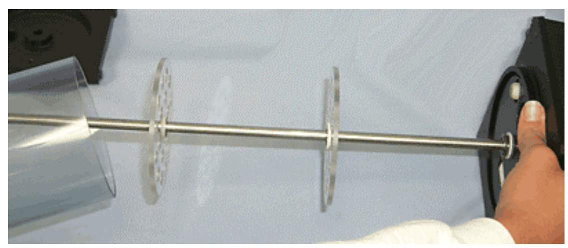
> ***Note***: Never clean the sensor base of the device. The two sensors, a screen and a copper-colored gas detector, are highly sensitive.

1) Unscrew the top knob attachment.

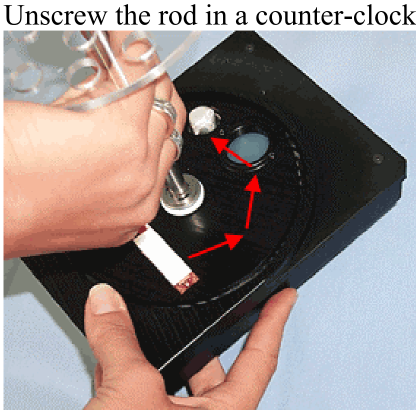


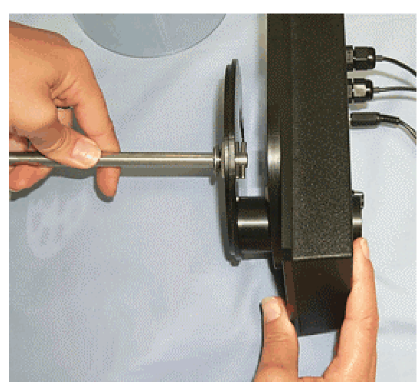
2) Remove the plastic lid from the flow chamber.





3) Gently pull the clear cylinder off the sensor base.
4) Detach the metal standing rod and its lower base attachment by holding the third of the standing rod nearest the base of the module and unscrewing the rod in a counter-clockwise motion.
   a. Depress the rod by applying pressure at the base – this unlocks the rod's position and allows movement.
   b. Unscrew the rod in a counter-clockwise motion.





5) Remove the chamber stand (gently pull back the chamber stand from the electronics base).

6) Clean the flow chamber with one of two methods:

   a. Use a soft cloth and Cidex Plus Sterilizing and Disinfecting Solution cleanser. Spray a light mist of Cidex cleanser on the parts of the device to be cleaned, and wipe the pieces with a dry rag. It is important never to get Cidex near the sensors of the device.

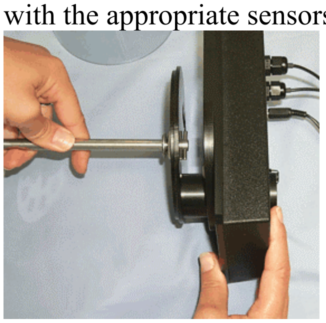
      - Other cleansers should not be substituted for Cidex – non-Cidex cleansers might damage or abrade the flow chamber pieces.

   b. Heating the components in an autoclave sterilizing oven.

7) After cleaning reattach the platformed-standing rod to the electronics base.

   a. Align the exhaust tube at the bottom of the rod stand with the exhaust port on the electronics base and insert securely.

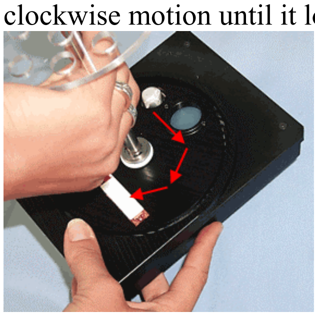
   b. Gently ease the rod stand back into its appropriate position on the electronics base. The sensors are very delicate so you need to slowly lower the plastic base of the standing rod to the electronics base to make sure that the openings in the standing rod base correspond with the appropriate sensors.



8) Locate the latch opening for the security screw and align it with the screw, and then press the base of the standing rod to the sensor base.

   a. Revolve the rod until the lower screw drops into its opening. When the screw meets its opening, it should drop into the hole.

   b. Depress the rod by applying pressure on the lower third of the piece and rotate it in a clockwise motion until it locks into position.



9) Ease the clear cylinder back onto the device and lay its lower edge in the track on the electronics base.

10) Re-attach the plastic top to the clear cylinder.

11) Lock the plastic top into place by screwing in the security knob.

MRI-compatibility Statement

BIOPAC defines **"radiotranslucent"** products as products that have no metal at all in the applied part.

- These are **best suited** for MRI applications.

BIOPAC defines **"MRI-compatible"** products as products that have no ferrous metal in the applied part. They may include non-ferrous metal, but are not significantly mechanically influenced by a magnetic field.

- They **may be suitable** for MRI applications.

Safety Issues

Caution is required when employing electrode leads and electrodes in an MRI environment. Under certain conditions, single fault and otherwise, low impedance conduction through the subject represents a potential hazard due to currents that may be induced in loops placed in the time-varying MRI field gradients and RF fields, and due to body movement in the static MRI field. Low impedance conduction can result in significant heating at the electrode/skin junction, because this point is often the part of the signal path with the highest impedance. Sufficient heating at the electrode/skin juction could result in burns.

- For more information, read Methodological Issues in EEG-correlated Functional MRI Experiments (Lemieux L, Allen PJ, Krakow K, Symms MR, Fish DR; International Journal of Bioelectromagnetism 1999; 1: 87-95).

Important Note

BIOPAC Systems, Inc. products (including instruments, components, accessories, electrodes and electrode leads) are designed for educational and research applications. BIOPAC does not condone the use of its products for clinical medical applications. Products provided by BIOPAC are not intended for the diagnosis, mitigation, treatment, cure or prevention of disease.

Return to… Gas-System2

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