

MRI RESEARCH

For the Life Sciences

CATALOG



MRI Solutions for Human and Animal Studies

- Physiological Data Acquisition Systems
- AcqKnowledge Software—automation & specialized MRI tools
- **New!** Remote Monitor
- **New!** MRI Smart Amplifiers
- Transducers, Electrodes, and Accessories
- Human-safe Isolated RF Cable/Filter Systems



BIOPAC
Systems, Inc.

Registered to ISO 9001:2000



BIOPAC — High-Quality Data for

BIOPAC provides physiological data acquisition and analysis systems specifically for human and small animal MRI life science research applications.

BIOPAC offers data acquisition systems, MRI Smart Amplifiers, transducers, stimulus options, electrodes, and leads with advanced software tools for safe data collection, subject monitoring, and clean physiological signals in the MRI environment.

MP Systems and amplifiers are placed in the MRI Control Room, and specialized cable systems optimize data quality with isolated and RF filtered interfacing between the subject/MRI Chamber and the Control Room. Filter leakage currents and dielectric isolation satisfy IEC60601-1.

Systems include AcqKnowledge software with rich display and monitoring features, plus automation and scoring routines to provide a flexible solution for life science research.

New MRI Smart Amplifiers incorporate advanced signal processing circuitry which removes spurious MRI artifact from the source physiological data.

Use the new BIOPAC Remote Monitor feature for a simplified view of subject data across an IP network on another computer or a mobile device. The monitor displays trend data



and current data values. It's a convenient way to view the data on other computers in the MRI suite.

Each MP System includes all the necessary hardware and software required to turn any computer into a powerful data acquisition workstation specifically designed for life science applications.

The MP System will reduce your equipment setup time and increase the quality of your physiological data. The MP System gives you publication results with minimum effort.

BIOPAC's range of amplifiers further enhances your ability to create a system to suit your application requirements. Amplifiers snap together and pull apart for simple substitutions. The system is small and easily transported from the lab to the MRI Control Room.

To put together a system for your specific needs, start with one of our Starter Systems, then add the amplifier modules, transducers, isolated RF cable/filter systems, and electrodes to match your research design.

Amplifier & Transducer Options:

- Biopotentials: ECG, EEG, EGG, EMG, EOG
- Airflow & Gas Analysis
- Blood Pressure—Human and Animal
- Differential Pressure
- Electrodermal Activity (EDA)
- Gating Units (digital trigger)
- Force
- Laser Doppler Flow
- Micro Pressure Measurement
- Pulse
- Respiration
- Stimulation
- Subject Feedback
- Temperature

Additional amplifiers & transducers available for non-MRI applications.

Isolated RF Filtered Cable Systems

MRI Cable/Filter systems include the cables and isolated RF filtering necessary to safely connect from the subject in the MRI chamber room to the amplifier in the MRI control room. Systems are available for biopotential and transducer amplifiers, general and high-level transducer amplifiers, stimulus isolation, and more!

Electrodes & Leads

Reusable and disposable radiotranslucent or MRI-compatible electrodes and leads provide high quality signals. Gels and accessories also available.

MP150 Data Acquisition & AcqKnowledge®

Combine the sophistication and performance of BIOPAC data acquisition hardware with the power and flexibility of AcqKnowledge software to customize your acquisition and analysis system for life science research in the MRI.



MP150 data acquisition provides:

- High resolution — 16 bit
- High speed — up to 400 kHz aggregate
- Variable sample rates (analog & calculation channels)
- 16 analog inputs and 2 independent analog outputs
- Digital I/O lines (receive/send TTL triggers)
- 16 online calculation channels
- Ethernet connectivity — fast & efficient
- Safety

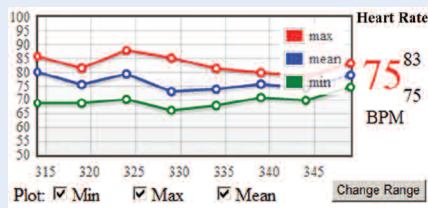
AcqKnowledge® SOFTWARE

The AcqKnowledge software included with each MP System is a highly interactive user-friendly application with intuitive controls that lets you instantly view, measure, analyze, and transform data. Perform complex data acquisition, triggering and analyses using simple pull-down menus and dialogs — no need to learn a programming language or new protocol.

- **Acquisition Features** — variable sample rates, pause mode, and stimulation design and control. Online analysis settings, filters and transformations provide real-time recording feedback.

Software runs on Windows OS or Mac OS X.

- **New! Remote Monitor** — Simplified user interface to view subject data on another machine – bedside monitor display. Track the welfare of the subject with alarms to warn when signals fall out of range. The system will work on any device that has access to the same IP based network as the MP150.



- **Display Features** — multiple display modes, advanced grid system, journal facility for note taking, textual event markers, and measurement tools. Mouse-over tool tips (for sample rate, channel rate, measurement results, etc.) help guide application use.
- **Analysis Features** — signal averaging, sophisticated pulmonary integration routines, filtering, FFT, histogram, automatic data reduction, template analysis, peak detection features, find rate settings, and an equation generator.
- **Automated Analysis Routines** — ECG, HRV, EDA, EMG, EEG, BP, LVP, MRI, Pulmonary, and more!
- **MRI optimization routines** — artifact removal, signal blanking, and slew rate limiter.
- **BIOPAC Developer** — Customize and automate your analysis routines with Developer tools including BIOPAC Basic Scripting, Network Data Transfer, or API.
- **Support Features** — real-time, searchable user guides (PDF) as well as extensive online support and training options. Plus, *Quick Start* template files are included to make it even easier to start your experiment.



MRI Product Line for Human and Animal Protocols

NEW!

BIOPAC has expanded its line of specialized MRI products. New MRI Smart Amplifiers and the MRI Cable/Filter systems provide isolated and RF-filtered interfacing between the subject/MRI chamber and the MRI control room to improve signal quality and optimize safety.

With BIOPAC's expanded line of MRI Smart Amplifiers and compatible transducers, you can record physiological signals such as: ECG, EEG, EGG, EMG, EOG, noninvasive blood pressure for human and animal, pulse, respiration, temperature, electrodermal activity (EDA, EDR, SCL, SCR or GSR), hand grip strength (dynamometry), finger twitch, and a variety of pressure-based signals.

For small animal cardiovascular and neuro studies, use the TSD104A-MRI Pressure Transducer or a Micro Pressure Measurement System to record pressure signals such as BP, LVP, and cranial pressure. Measure microvascular blood perfusion with the Laser Doppler Flow System.

Radiotranslucent and MRI-compatible electrodes, leads, and stimulus options provide safe data acquisition of physiological signals in the MRI environment. Caution is required whenever employing electrode leads and electrodes in an MRI environment—see “[Safety Guidelines](#)” online.

“Radiotranslucent” products have no metal at all in the applied part. These are best suited for MRI applications.

“MRI-compatible” products have no ferrous metal in the applied part. They may include nonferrous metal, but cannot be significantly mechanically influenced by a magnetic field.

Generally considered, if the transducer is MRI-compatible, the transducer signal can be recorded during MRI scanning. Transducer signals are typically high level and slow moving. These two features allow the transducer signal to be easily filtered to remove MRI artifact, if any.

Go to www.biopac.com for MRI Compatibility details and Application Notes on connections, analysis tools, and safety when recording physiological data in MRI or fMRI.

BIOPAC's MRI solutions include:

Airflow & Gas Analysis	Electrodermal Activity	Pulse Signal	Stimulation
Biopotential Signals	Gating (Trigger/Synch)	Respiration	Subject Feedback
Blood Pressure	Laser Doppler Flow	Temperature	

MRI Cable/Filter System Interface Guide



Sample isolated RF filters and cables



MECMRI-BIOP System

Biopotential Amplifiers

ECG100C-MRI EMG100C-MRI
EEG100C-MRI EGG EOG

MECMRI-DA System

General-purpose Trans. Amplifier
TSD104A-MRI TSD117-MRI
TSD121B-MRI

MECMRI-HLT System

High-level Transducer Amplifier
TSD131-MRI TSD115-MRI

MECMRI-TRANS System

Transducer Amplifiers

EDA100C-MRI RSP100C
SKT100C PPG100C-MRI

MECMRI-STMISO System

STMISOC/D/E to STM100C
CBL207 to STM200

PNEUMATIC LINES

No electrical MRI Cable/Filter required—use DA100C.

TSD110-MRI TSD114-MRI
TSD137 series TSD237 series



When recording biopotentials in the MRI, several scenarios are possible:

- MRI Gating: gate the MRI using one or two signals: ECG or blood pressure and respiration—see DTU100 and DTU200/300, page 6.
- Record between periods of MRI operation (gradient switching and RF pulsing) with latency periods long enough to acquire the signal of interest.
- Record continuously concurrent with MRI operation—see *MRI App. Notes* for details.

New MRI Smart Amplifiers remove MRI artifact from the source physiological data. Signal processors distinguish between the physiological signal and MRI artifact as manifested by gradient switching during MRI sequences, such as Shim or EPI. Since MRI Smart Amplifiers remove MRI-related artifact at the source, signals can be sampled at the same rate as during non-MRI recording.

Many variables can influence biopotential recording in an MRI (lead placement and length, electrode location, MRI protocol, etc.). For best performance, use the shortest lead possible. Attention to detail is required to record continuous biopotentials during MRI scanning.

IMPORTANT! Caution is required whenever employing electrode leads and electrodes in an MRI environment—see “Safety Guidelines” online.



Radiotranslucent Leads & Electrodes

- Leads: LEAD108 (1.8 m) LEAD108A (3.6 m) LEAD108B (15 cm) LEAD108C (30 cm)
 Electrodes: Disposable EL508 (gelled) or EL509 (dry)
 Reusable EL254RT (4 mm) or EL258RT (8 mm)

ECG Electrocardiogram

- MECMRI-BIOP + ECG100C-MRI amp + lead/electrodes
- Record small animal ECG with the cable/filter system and radiotranslucent electrodes
 - For an audible reference of the subject's heart rate while in the imager, add an ECG alarm (OUT102)
- Alternatives when looking at real-time BPM, HRV, etc.
- MECMRI-DA + DA100C + AFT30-XL tubing (included) through wave guide + TSD110-MRI

EEG Electroencephalogram

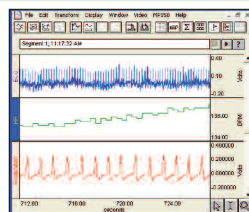
- MECMRI-BIOP + EEG100C-MRI amp + lead/electrodes

EGG Electrogastragram or EOG Electrooculogram

- Contact BIOPAC for setup options.

EMG Electromyogram

- MECMRI-BIOP + EMG100C-MRI amp + lead/electrodes
- Recommended alternatives—see Subject Feedback, page 9.
- Clench Force: MECMRI-DA + DA100C amp + TSD121B-MRI
 - Hand Response: DA100C amp + TSD114-MRI
 - Facial Twitch /Finger Tap Response: DA100C amp + TSD110-MRI
 - Finger Twitch: MECMRI-HLT + HLT100C interface + TSD131-MRI



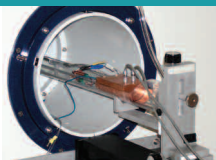
Mouse ECG, HR, Respiration



Airflow & Gas Analysis
Biopotentials — page 4
Blood Pressure

Gating Systems
Respiration

Microvascular Flow
Stimulation — page 10



Airflow & Gas Analysis

Setup: TSD137 or TSD237 series + DA100C amp (flow heads from .05 L/sec to 2.6 L/sec)

Transducers consist of a low flow, pneumotach airflow head coupled to a highly sensitive, differential pressure transducer (TSD160A) and connect directly to an airflow cannula and non-rebreathing valve.

TSD137 (heated) or TSD237 (unheated; low thermal inertia)

Important: Contains ferrous material—must be clamped down in the safe MRI operating area.

Gas Analysis

Setup: CO2100C amp + 02100C amp + AFT31-MRI gas sampling tubing

Blood Pressure

Arterial Blood Pressure

General arterial pressure

Setup: MECMRI-DA + DA100C amp + TSD104A-MRI transducer

Micro Pressure

Setup: MPMS100A control unit + TSD173A/B transducer



The Micro Pressure Measurement System consists of a Control Unit and a Micro Pressure Transducer, purchased separately.



Ultra-miniature fiber optic pressure sensor — no bigger than a grain of salt on a hair!

Control Unit: MPMS100A-1 one channel, MPMS100A-2 two channels

MRI-compatible Transducers: TSD173A 5 cm fiber/8 m cable or TSD173B 15 cm/8 m

This compact unit is used for a variety of pressure measurements including arterial venous BP, cranial pressure, LVP and RVP. Analog output makes connection with a BIOPAC MP unit easy. Calibration data is stored in the connector.

Small Animal Noninvasive Blood Pressure

Setup: NIBP200A system + RXCUFSEN9.5/11/13-MRI transducer

The NIBP200A incorporates a built-in pump that automatically inflates the blood pressure cuff to occlude the vessel. Once the pump reaches the inflation point it slowly deflates the cuff, providing a linear drop in pressure. A single pushbutton controls both the inflation and deflation cycles, making the system very operator friendly. MRI-compatible fiber optic cuff/sensor transducers have an 8 m cable and fit 9.5, 11, or 13 mm tail diameters (approx. animal size 100 g -350 g).





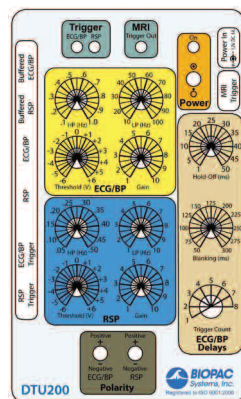
Gating Units

The gating unit is placed in the control room with the MP system and amplifiers.

Dual-Channel Gating

Setup: DTU200 Gating system

- **Cardio/Respiratory System (DTU200)** - New dual channel gating unit for small animal cardiac gating. The unit simultaneously monitors two physiological signals—ECG or blood pressure plus respiration—and provides amplification and signal conditioning. A TTL MRI trigger is output for a predetermined number of heart beats after the respiration cycle. The MRI trigger is coincident with each heartbeat and incorporates blanking to remove MRI artifact to prevent false triggering. The MRI is triggered during the animal's quiet time, which minimizes movement and maximizes image quality. A variety of output signals and conditions can be monitored during the experiment.



Digital Trigger

Setup: HLT100C interface module + DTU100 Trigger

- **Single channel gating unit (DTU100)** - provides a TTL trigger pulse from any physiological signal. The system is usually used with either ECG, blood pressure, or respiration signals. See page 7 for more information.



Microvascular/Laser Doppler Flow

Setup: LDF100C amp + TSD147AL probe (1 m) + TSD148 driver (2 m)

For acute preparations inside the MRI, use the LDF100C laser Doppler tissue perfusion monitor to measure microvascular blood flow in tissue. The LDF100C amplifier delivers a low power beam of laser light down an optical fiber to the tissue being studied; typically, the volume of tissue sampled by the light is in the order of 1mm^3 .



Respiration

Setup: DA100C amp + TSD110-MRI transducer/sensor/tubing

For high-quality respiration signals, place the anesthetized animal on the sensor pad and run the tubing through the wave guide to attach to the pressure transducer on the DA100C amp.



Temperature

Stand-alone Fiber-Optic Temperature System

Setup: FOTS100 + TSD180 fiber-optic temperature transducer. See page 10 for details.

Recommended for rectal temperature, due to size.

Temperature Amplifier

Setup: MECMRI-TRANS + SKT100C amp + TSD202A or E surface transducer

The SKT100C amplifier module measures surface, core, or air temperature with resolution up to 0.0001°C .



Airflow & Gas Analysis
Biopotentials — page 4
Electrodermal Activity — EDA (GSR)
Gating Units

Noninvasive Blood Pressure
Pulse
Respiration

Stimulation — page 10
Subject Feedback
Temperature

Airflow & Gas Analysis

Airflow & Lung Volume

Setup: MECMRI-DA + DA100C amp + TSD117-MRI + AFT11A coupler + AFT7-L tubing + AFT25 mask with valve

Use the Pneumotach Airflow Transducer (TSD117-MRI) to perform a variety of tests relating to airflow and lung volume. Place the TSD117-MRI outside the bore in the MRI Chamber Room and connect AFT7-L tubing to reach the subject. Medium flow range ± 300 L/min.

Accessories:

- Interface TSD117-MRI transducer to AFT7-L tubing: AFT11A coupler
- Extend tubing: AFT7-L (3 m) tubing + AFT11D coupler
- Facemask with non-rebreathing T-valve: AFT25



Gas Analysis

Setup: CO2100C amp + O2100C amp + AFT31-MRI tubing

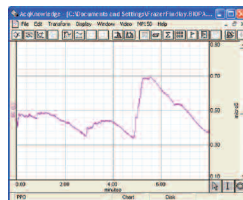
Electrodermal Activity

Setup: MECMRI-TRANS + EDA100C-MRI amplifier + lead/electrodes

Record EDA inside the MRI. Use AcqKnowledge software filters to improve the quality of the EDA signal, if required, and provide automated analysis.

Electrodes

- *Disposable Electrodes:* BIOPAC recommends EL509 dry disposable electrodes with GEL101 and LEAD108 (1.8 m) or LEAD108A (3.6 m) for excellent EDA responses.
- *Reusable Electrodes:* Disposable electrodes are recommended, but reusable TSD203 electrodes will also work for skin conductance.



EDA data

Gating Units

Trigger / R-Wave Sync DTU100

Setup: HLT100C interface module + DTU100 Trigger

Trigger an MRI System with the occurrence of the R-wave present in ECG, respiratory data or blood pressure for gating purposes. This external hardware unit can accept data from any pulsatile analog output associated with an MP System and convert that analog signal into a TTL-compatible trigger to trigger an MRI.

- The timing resolution of the trigger is excellent because it is controlled solely by the real time analog reference signal and is therefore independent of the computer's operating system and associated communication delays.

Cardio/Respiratory Gating DTU300

Setup: DTU300 Gating System

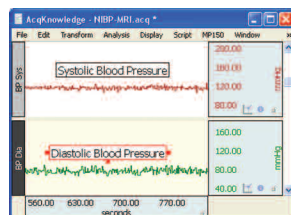
Use the DTU300 to trigger the MRI on the basis of two physiological signals (such as ECG or BP plus respiration). See page 6 for details.



Noninvasive Blood Pressure - Wireless Monitoring System

Setup: HLT100C interface module + NIBP-MRI

The new NIBP-MRI provides real-time, beat-to-beat pressure measurement values during magnetic resonance imaging. The system tracks systolic and diastolic blood pressure (using Pulse-Decomposition Analysis technology). The device analyzes the timing and amplitudes of the primary left ventricular ejection pulse as well as the arterial pulse reflections, at the middle phalanx of the middle finger, at the wrist, or on the upper arm.



NIBP-MRI data



Pulse

Pulse - Photo Plethysmograph

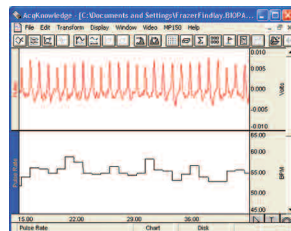
Setup: MECMRI-TRANS + PPG100C-MRI amp + TSD200-MRI transducer

The TSD200-MRI transducer is sensitive to Blood Volume Pulse (BVP) via photo-plethysmographic methods. Use it to record the blood volume pulse pressure waveform. It's primarily designed for finger or toe attachment, but can be taped to other body locations with TAPE1.

Pulse - Pressure Pad

Setup: DA100C amp + AFT30-XL tubing (included) through wave guide + TSD110-MRI transducer

The TSD110-MRI consists of a differential pressure transducer (TSD160A), sensor (RX110), and tubing (AFT30-XL). Use it to record pulse and pulse rate—it requires no electrical connections between MRI control and chamber rooms and works on a number of body locations. Affix to finger or major pulse point with TAPE1.



Pulse data



Respiration

Respiratory Effort Transducer — Recommended method

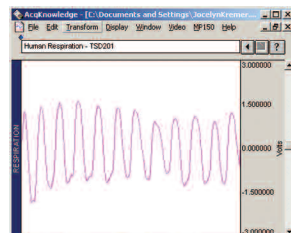
Setup: MECMRI-TRANS + RSP100C amp + TSD201 transducer

The respiratory effort transducer measures changes in thoracic or abdominal circumference that occur as the subject breathes. The transducer comes with an adjustable Velcro strap to fit a wide range of subjects.

Pressure Pad / Respiration Transducer

Setup: DA100C amp + TSD110-MRI transducer

Place the TSD110-MRI under a strap that is wrapped around the subject's chest, or tape the transducer directly to the chest to record respiration. See *Pulse* above for TSD110-MRI details.



Respiration data



Subject Feedback

BIOPAC offers a range of subject feedback devices for use inside the MRI.

Clench Force

Setup: MECMRI-DA + DA100C amp + TSD121B-MRI transducer

Use TSD121B-MRI hand dynamometer to measure clench force. The lightweight, ergonomically designed transducer provides direct readings in kilograms or pounds. The isometric design improves experiment repeatability and accuracy.



Hand Response

Setup: DA100C amp + TSD114-MRI transducer

Use TSD114-MRI Pump Bulb Transducer when the subject has to give either a monotonically variable or on/off response. The subject holds the bulb in one hand and squeezes to give a response. Use two bulbs for more complicated responses. The bulb is attached to a length of tubing that connects to a pressure transducer (TSD104A, included).

Response Pad

Setup: DA100C amp + TSD110-MRI transducer

Mount the TSD110-MRI pressure pad/respiration transducer in the scanner so that the subject can tap it to respond (monotonically variable or on/off) to a stimulus. Use multiple transducers for complex applications. Consists of differential pressure transducer (TSD160A), sensor (RX110), and tubing (AFT30-XL). *See Pulse on page 8 for transducer details.*

The multi-purpose assembly can also be used to measure small pressing forces (like pinching fingers together) for Parkinson's evaluations, human facial expressions (including startle blink response, smiling, frowning, etc.), or spacing and pressure between teeth coming together.

Finger Twitch/Position

Setup: MECMRI-HLT + HLT100C interface module + TSD131-MRI transducer

Use TSD131-MRI to record finger twitch responses or finger position from human subjects in the MRI. Conforms to the shape of the finger and attaches via Velcro straps.



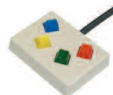
Variable Assessment

Setup: MECMRI-HLT + HLT100C interface module + TSD115-MRI transducer

The TSD115-MRI incorporates a slide control with graduated scale that allows the user to gauge his/her subjective response to a variety of different stimuli. The transducer is lightweight and fits easily into the subject's hand or lap.

Fiber Optic Response Devices

BIOPAC offers a range of fiber optic response devices that interface with the MP150 and a variety of visual presentation systems; call for details.



Temperature

Temperature Amplifier

Setup: MECMRI-TRANS + SKT100C amp + TSD202 series probe

The SKT amplifier module measures surface or air temperature with resolution up to 0.0001°C.

- TSD202A - Very small, fast response probe.
- TSD202E - Slower response; suitable for body temp.



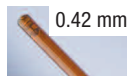
Stand-alone Fiber-Optic Temperature System

Setup: FOTS100 + TSD180 or TSD181 FO temperature probe

To interface with UIM100C, add RCA-3.5 mm cable (CBL101, not included).

System uses advanced technology with 62.5 μm core fiber and 50 Hz sampling rate. Excellent system and sensor linearity and accuracy for long-term reliability and repeatability. Not photonic intensity based. No local heating due to fiber construction.

- FO Rectal temp probe (0.42 mm dia., 8 m): TSD180
- FO Surface temp probe (3 mm dia., 8 m): TSD181



0.42 mm



3 mm



STIMULATION

For Comprehensive Safety Guidelines, see “Safe Use of Electrical Stimulators” online.



Stimulation—Constant Current/Constant Voltage

Setup: MECMRI-STMISO + STMISOC/D/E stim isolation adapter + STM100C stimulator + lead/electrodes

Use the stimulator to deliver a variety of electrical stimulation paradigms. AcqKnowledge software provides single pulse, pulse trains, and arbitrary waveform output options.



Stimulation—Unipolar Wide Pulse

Setup: MECMRI-STMISO + CBL207 + STM200 stimulator + lead/electrodes

Use the stimulator for any preparation or subject, including pain and stress studies that require lower voltages and wider pulse widths. Trigger the stimulator from the MP150 or a visual presentation system (see below). Use for high-energy nerve or muscle stimulation.



Stimulation Electrodes

Use disposable or reusable electrodes for subject stimulation.

- Disposable: EL509 dry electrodes plus GEL104 + LEAD108 electrode leads
- Reusable: EL254RT/258RT plus GEL104 + ADD200 collars
- Gel: GEL104 salt-free and chloride-free electrically conductive gel



Visual Presentation

SuperLab

Setup: STP100W Stimulus Presentation System

The STP100W can present visual stimuli or auditory stimuli, and simultaneously (1ms resolution) send trigger signals to an MP150 for data synchronization and collection purposes.

Optional: STIMTRACKER universal marker interface, provides digital trigger info from SuperLab

E-Prime, DirectRT, MediaLab, Presentation, etc.

Setup: STP100C isolated digital interface with CBL110C

Connect to the computer's parallel printer port to send digital I/O info.

High-Quality Physiological Data for MRI Studies



- **MRI Smart Amplifiers**
- **Biopotentials**
- **Airflow & Gas Analysis**
- **Blood Pressure**
- **Differential Pressure**
- **Electrodermal Activity**
- **Gating/Trigger Units**
- **Force**
- **Laser Doppler Flow**
- **Micro Pressure**
- **Noninvasive Blood Pressure**
- **Respiration**
- **Stimulation**
- **Subject Feedback**
- **Temperature**
- **Visual Presentation**



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