

## Application Note 103 Remote Monitoring System (TEL100C)

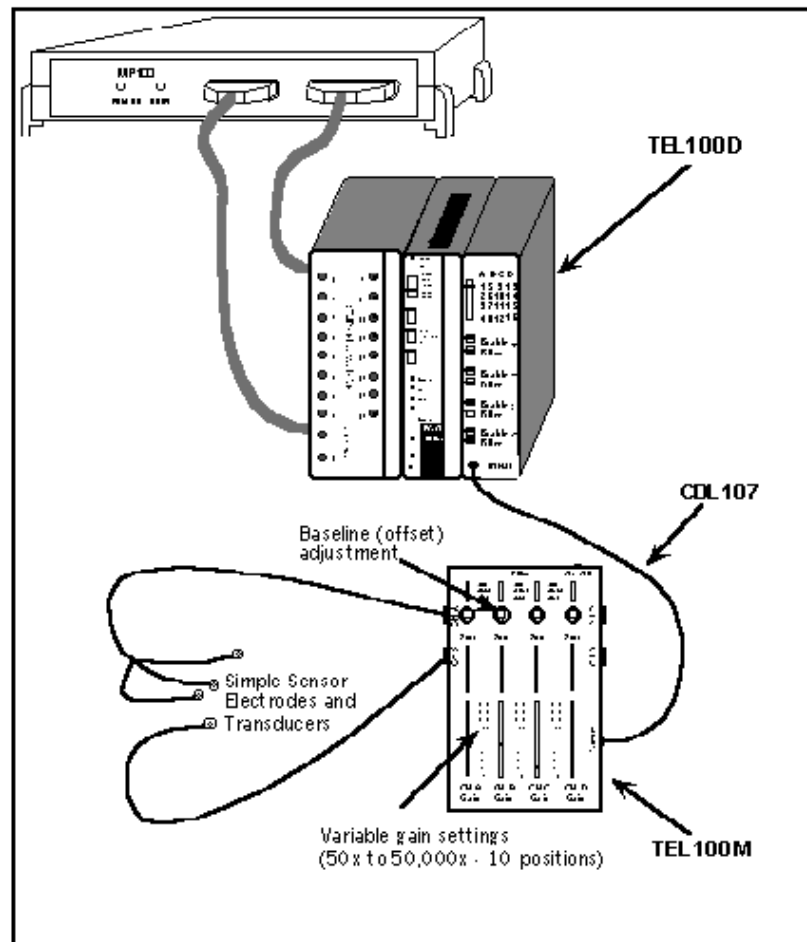
The **TEL100 System** is an earlier model of the BIOPAC Remote Monitoring System that is functionally equivalent to the TEL100C System described in this note; it uses different cables to connect the TEL100M to the TEL100D.

The TEL100C is a remote monitoring system designed for use with an MP System on either Windows or Macintosh platform. In addition, the TEL100C system can be used along with existing BIOPAC amplifiers (e.g., ECG100, RSP100) 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.

A wide range of physiological activity can be monitored with the TEL100C, including ECG, EOG, EEG, EDA, SKT, PPG, RSP and surface EMG. Specialized signal processing of physiologic variables (like RMS filtered EMG, or QRS detection) can be performed on the computer via calculation channels.

The TEL100C system (module set) has an upper frequency limit of 500 Hz for each channel.

- The TEL100C is not recommended for physiological measurements requiring higher frequency measurements (e.g. certain evoked response applications).



Each TEL100C system consists of four major components:

- TEL100M transmitter with 4 channel inputs
- TEL100D receiver
- CBL117 (or optional extension CBL118) to connect the TEL100M to the TEL100D
  - The TEL100 uses CBL107 (or optional extension CBL118)
- Up to four "Simple Sensor" electrode/transducer assemblies (must be purchased separately)

## TEL100M

Each TEL100M is a miniature four-channel remote amplifier/ transmitter, which connects directly to the TEL100D via a lightweight coaxial transmission cable. The TEL100M does the work of four 100 series amplifiers and includes filtering, offset and gain control for each of its four channels. The TEL100M requires one 9V alkaline battery for operation. A low battery indicator light will flash when the battery requires replacing. Expected battery life is approximately 12 hours of continuous operation. All BIOPAC SS series transducers and electrodes will function directly with the TEL100M. Excitation voltages are available on each channel input to provide power for "Simple Sensor" transducer assemblies such as RSP, EDA, PPG and SKT.

## TEL100D

The TEL100D is a four channel receiver module which is compatible with all other MP System modules. The TEL100D includes filtering and channel select controls. Up to four TEL100D units can be connected to a single MP System, allowing for up to 16 channels of transmitted data originating from up to four (4) separate TEL100M units. For every TEL100M, a TEL100D must be available to receive its data signals.

## CABLE

### TEL100M to TEL100D

A 10 meter (33 feet) thin, lightweight, coaxial transmission cable for connection between the TEL100M and TEL100D is included with the TEL100C system.

- **CBL117** is equipped with dual RCA plugs for operation with the TEL100C system.
- **CBL107** is equipped with dual 3.5mm phono plugs for operation with the TEL100 system.

### Optional Extension

To extend the operational range of the TEL100C system, a 60 meter (33 feet) thin, lightweight, coaxial transmission cable for connection between the TEL100M and TEL100D is available. This optional extension cable is purchased separately.

- **CBL118** is equipped with dual RCA plugs for operation with the TEL100C system.
- **CBL108** is equipped with dual 3.5mm phono plugs for operation with the TEL100 system.

## Simple Sensor (SS) Electrodes and Transducers

The Simple Sensor electrodes and transducers are explicitly designed to connect to the TEL100M transmitter. The SS assemblies include specific circuitry to adapt various physiological variables to the TEL100M. Any SS electrode or transducer can be plugged into any TEL100M input. Simple Sensors take the place of BIOPAC's traditional electrodes and transducers in that they are only compatible with the TEL100M amplifier.

The TEL100C module set is a modulation/demodulation system. The modulation process occurs in the TEL100M, the demodulation process occurs in the TEL100D. The TEL100M 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 CBL107, CBL117, CBL108 or CBL118 to the TEL100D (see attached diagram). The TDM process intrinsically samples the four input channels at a rate of 2000 Hz / per channel. This sampling process is independent of the MP System as it occurs in the TEL100M module. Prior to the TDM process, the four input channels are low-pass filtered to 500 Hz. The TDM process always samples at 2000 Hz for each channel and each channel's maximum bandwidth is 500 Hz so accordingly, the sampling process does not affect the user or the rate at which the MP System samples data. The transmitted signal from the TEL100M is analog in character.

The TEL100D demodulates the transmission from the TEL100M. The TEL100D also incorporates user-selectable 35 Hz low-pass filters for removing noise or 50/60 Hz hum (interference) from the four input channels. Filters can be assigned on or off independently for each channel. The TEL100D produces a  $\pm 10$  volt range analog output for each channel. These analog outputs are then sampled by the MP System. The analog outputs are also available via the front panel of the UIM100, if the user wishes to direct the outputs to an alternate recording system in conjunction with the MP System.

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 2000 Hz sampling rate of the TEL100C module set is independent of the MP System sampling rate. If a TEL100C channel is low-pass filtered at 35 Hz, it would be appropriate for the MP System to sample that channel at 100 Hz.

The TEL100C module set can be used independently from the MP System. The recommended configuration requires the IPS100C in addition to the TEL100C. The TEL100C system output channels are then accessed on the front panel of the IPS100C. Up to four TEL100C systems can be used with a single IPS100C.

No special software is required to use the TEL100C module set. The TEL100C operates on the same *AcqKnowledge* software platform as the MP System. The TEL100 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). The following physiological variables terminate as shown:

- EDA        SS3
- PPG        SS4
- RSP        SS5
- SKT        SS6 (for fast response) or SS7 (for skin temperature)

For studies which 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 set to DC (or 0.05 Hz to remove baseline drift), and the filter switch on the TEL100D in the ON (35HzLPN) position.

## Setup

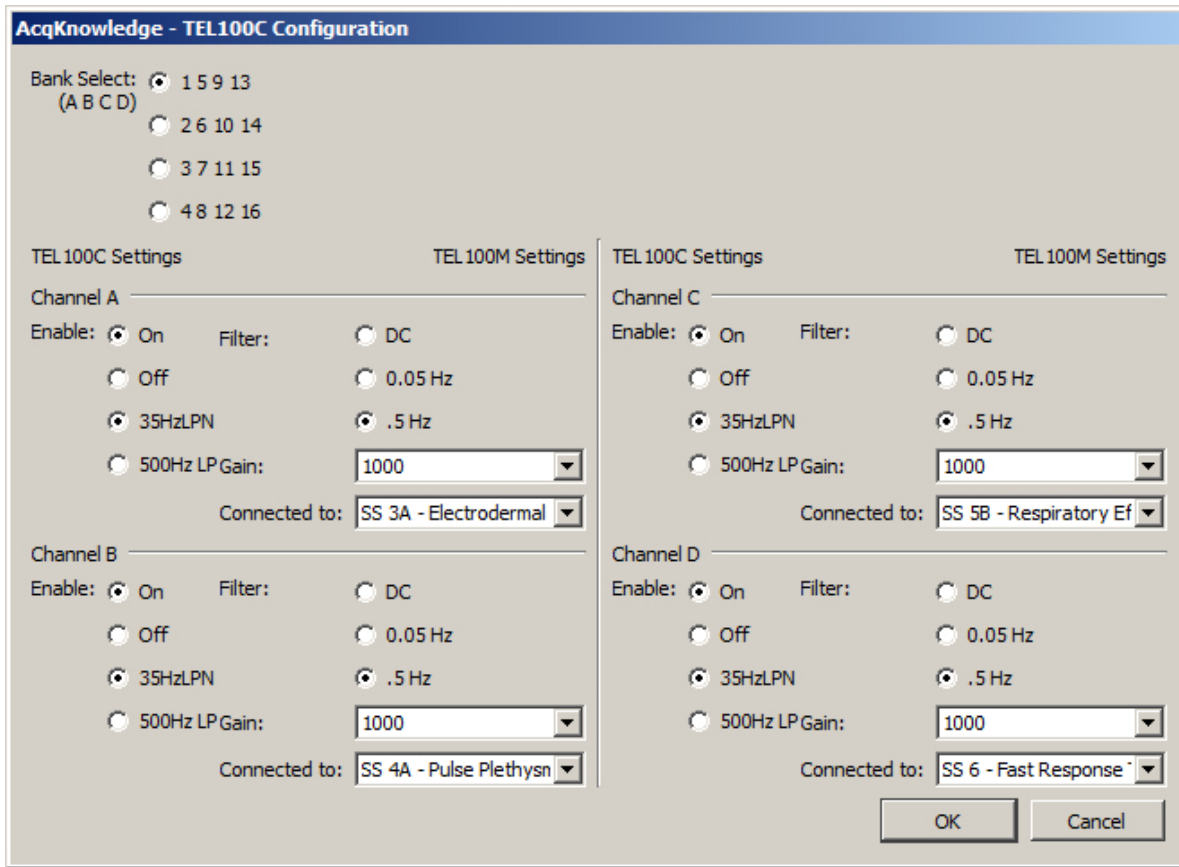
- Plug the TEL100D into the right side of the UIM100.
- Select which bank you wish the channels A, B, C and D assigned to.
  - If Bank 1 is selected on the TEL100D, then TEL100 channels A, B, C and D will be assigned to MP System channels 1, 5, 9 and 13 respectively. When using *AcqKnowledge*, select these channels when viewing data assigned to Bank 1. The following documentation assumes that Bank 1 is the selected Bank.
  - 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" switches on the front panel of the TEL100D.
- Plug the CBL107, CBL117, CBL108 or CBL118 into the TEL100M and the TEL100D.
- When recording in *AcqKnowledge*, turn on the TEL100M, by flipping the power switch from right to left.
  - The LED on the TEL100M should blink once then stay off. If the LED continues to blink, the 9V battery needs to be replaced (use 9V alkaline batteries).
- To determine correct operation, rotate the zero balance for channel A on the TEL100M.
  - Channel 1 in *AcqKnowledge* should indicate a moving baseline which changes as the zero is adjusted. Set the zero balance for channels A, B, C, and D so that the *AcqKnowledge* screen trace is centered.
- Plug the desired Simple Sensor into the TEL100M.

## Software setup in *AcqKnowledge* 4.1 and higher

*AcqKnowledge* versions 4.1 and higher have an **Add New Module** feature that eliminates the need for manual calibration or rescaling. It is recommended that Module Setup, rather Channel Setup, be used for software/hardware configuration.

To use Module Setup for the TEL100C:

1. Go to **MP menu > Set Up Data Acquisition > Channels > Add New Module**. (The "Add New Module" screen should open by default when *AcqKnowledge* is launched.)
2. Choose "**TEL100C - Remote Monitoring System**" from the Module setup list and click "**Add**."
3. In the Configuration dialog, verify that all gain and filter settings match those set on the panel of the TEL100C and TEL100M hardware. (See **TEL100C Configuration** dialog below.)
4. Select the appropriate transducer from the "**Connected to**" list. This must match the transducer and channel connected to the TEL100M.
5. Click **OK** and follow the calibration and connection prompts.



**Calibration in earlier versions of AcqKnowledge (4.0 and earlier)**

Use the rescaling feature in AcqKnowledge (MP menu > Set Up Channels > Scaling ) to calibrate the incoming signal from raw values to the desired scale.

- For **EDA (GSR)** measurements, the following gain settings correspond to microsiemens. (umho)
- For **Temperature** measurements, the following gain settings correspond to °F per Volt.

EDA	
Gain	µs/V
50	1,000
100	500
200	250
500	100
1,000	50
2,000	25
5,000	10
10,000	5
20,000	2.5
50,000	1

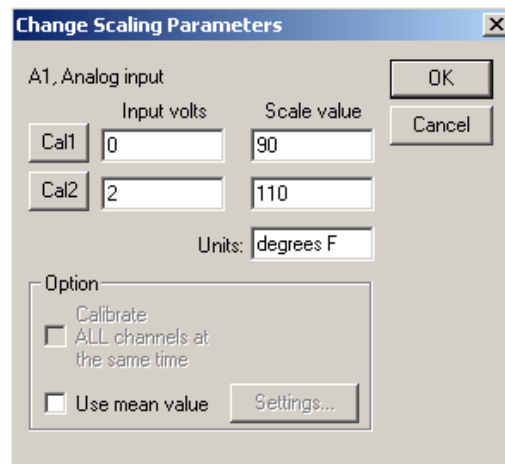
Temperature	
Gain	°F/V
50	100
100	50
200	25
500	10
1,000	5
2,000	2.5
5,000	1
10,000	0.5
20,000	0.25
50,000	0.1

## Sample calibration:

**Temperature** data collected with the TEL100C is centered around 90°F. For Temperature data acquired using a Gain setting of 500, each Volt represents an increase of 10 degrees.

- A reading of 0 Volts correspond to 90°F whereas a signal of +2 Volts corresponds to 110°F.

Select **MP menu > Set up Channels > Scaling** to enter the calibration values.



**Sample calibration dialog: Temperature at Gain 500**

## System Specifications

Number of Channels:	4	
Channel Bandwidth:	500 Hz or 35 Hz (LPN filter on) Independent bandwidth per channel	
Notch Filters:	50/60 Hz (user selectable - side panel)	
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: $\pm 50\text{mV}$	
Offset Control:	Yes	
AC/DC Coupling:	DC, 0.05 Hz and 0.5 Hz	
Transducer Excitation:	$\pm 5\text{V}$ @ 20 ma (total max current, four channels)	
Component:	Size	Weight
TEL100D:	4.3" x 7.5" x 1.6"	14 oz
TEL100M:	3.5" x 5.6" x 1.2"	11 oz (with 9v battery)
Signal/Crosstalk Ratio (0.05-500 Hz):	65 dB minimum	
Signal/Noise Ratio (0.05-35 Hz):	70 dB minimum	
(0.05-500 Hz):	65 dB minimum	
Biopotential Amplifiers:		
Differential Input Impedance:	2 MW	
Common Mode Input Impedance	11 MW (DC), >1000 MW (60 Hz)	
Pk-Pk Noise Voltage (Shorted Inputs)	0.28 $\mu\text{V}$ (0.1-10 Hz)	
Pk-Pk Noise Current	10 pA (0.1 - 10 Hz)	

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