

Application Note 126

TEL100C-RF/RFA System (RFA uses 230 V adapter and Euro connectors)

This application note is an addendum to [Application Note #103](#) on operating the TEL100C System.

The TEL100C-RF is a remote monitoring system that employs a completely wireless scheme and places the recording amplifiers at some distance away from the computer (75 meters nominal to 150 meters line of sight). The TEL100C-RF replaces the CBL117 or CBL118 (used in the regular TEL100C system) with a wireless transmitter/receiver pair. The TEL100C-RF system also uses a different amplifier/remodulator (TEL100D-RF) as compared to the regular (wired) TEL100C system.

A wide range of physiological activity can be monitored with the TEL100C-RF, including ECG, EOG, EEG, GSR, 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-RF system (module set) has an upper frequency limit of 500 Hz for each channel.

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

The complete TEL100C-RF system consists of five elements:

- Amplifier/Modulator **TEL100M-C**
- Amplifier/Demodulator **TEL100D-RF**
- RF Transmitter **TEL100T**
- RF Receiver **TEL100R**
- Isolation Cable **CBLTELISO**

Note If you have the older model TEL100C-RF with a gold-faced TEL100R, contact BIOPAC.

TEL100M-C

Four-channel remote amplifier/modulator that connects to the TEL100T. The TEL100M-C requires one 9 V alkaline battery for operation. The TEL100M-C includes filtering, offset, and gain control for each of its four channels. 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-C. The input connector for each channel is a 9-pin D type connector. Excitation voltages are available on each channel input to provide power for passive transducers.

TEL100D-RF

Four-channel demodulator that is shape and plug compatible with all other MP System modules. The TEL100D-RF includes filtering and channel select controls. Up to four TEL100D-RF units can be connected to a single MP System, allowing for up to 16 channels of transmitted data originating from up to four distinct locations. The TEL100D-RF can only be used with the TEL100T, TEL100R, and CBLTELISO when connecting to a TEL100M-C.

TEL100T

Compact R/F transmitter which connects directly to the TEL100M-C via a short cable. The TEL100T requires one 9 V alkaline battery for operation. A low-battery indicator light will flash when the battery requires replacing. Expected battery life is approximately 8 to 10 hours of continuous operation. Eight operational frequencies are available; the transmission channel ID for the TEL100T is located on the back of the unit and is accessed via a small screwdriver.

TEL100R

R/F receiver designed to function with TEL100T. The receiver front-end design minimizes dropouts. The TEL100R connects directly to the TEL100D-RF. The TEL100R comes supplied with a 15 V power adapter. Eight operational frequencies are available; the reception channel ID for the TEL100R is located on the bottom of the unit.

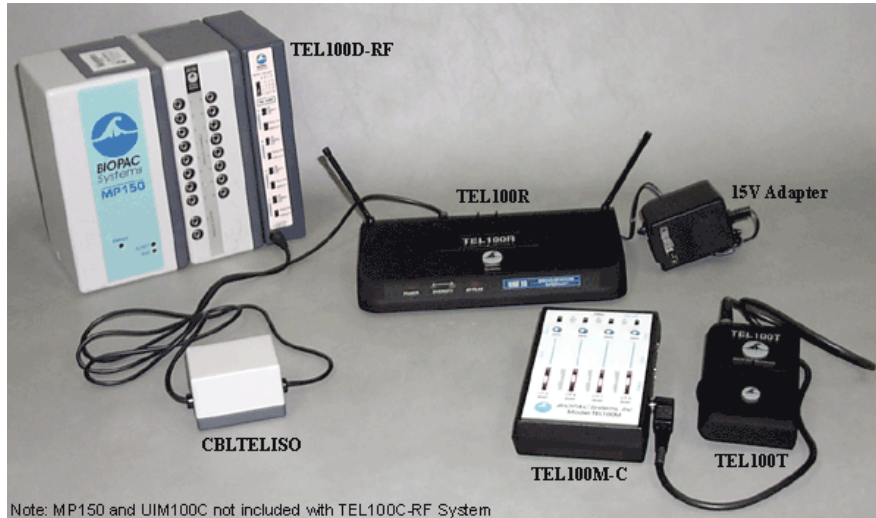
Note The channel frequency IDs for the TEL100T and the TEL100R should be identical.

The TEL100R incorporates a single user adjustment when using the TEL100C-RF system. This adjustment is marked "AUX VOLUME" and will control the signal level as seen by the TEL100D-RF. Proper adjustment of this control is relatively critical for TEL100C-RF system operation, but usually it is acceptable to turn the AUX VOLUME knobs to the furthest clockwise position (MAX). The "SQUELCH" adjustment on the back of the TEL100R should always be left in the furthest counterclockwise position.

CBLTELISO

This 2-meter isolation cable connects the TEL100D-RF and the TEL100R receiver (RCA-M to 1/4-M mono).

Setting up the TEL100C-RF with an MP System



*If you have the older model TEL100C-RF with a gold-faced TEL100R, contact BIOPAC.

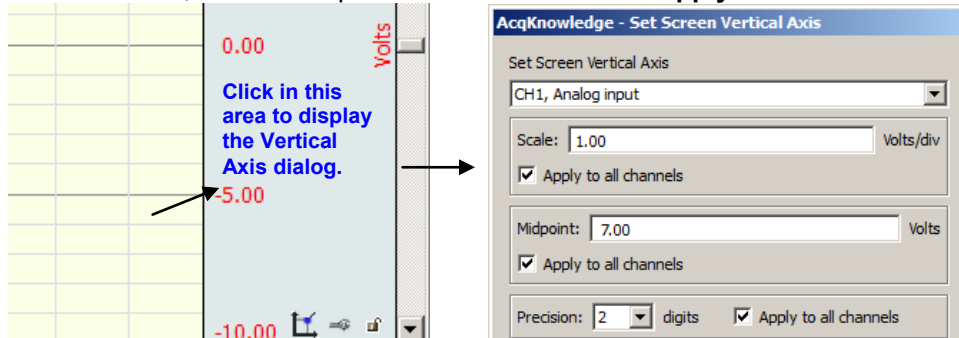
1. Snap the TEL100D-RF into the right side of the UIM100C.
 2. Connect the TEL100R to the TEL100D-RF using the CBLTELISO Isolation Cable.
 3. Plug the wall adapter into a power outlet and connect the power cable to the rear of the TEL100R.
 4. Turn the AUX VOLUME knob on the back of the TEL100R to (MAX), the furthest clockwise position.
 5. Set the SQUELCH adjustment to its furthest counterclockwise position.
 6. Plug the TEL100T extension cable, with the RCA plug, directly into the TEL100M output jack.
 7. Make sure both the TEL100M and the TEL100T have fresh 9 V alkaline batteries installed.
 8. Turn the TEL100M on by sliding the power switch from right to left. (With a good battery, the green LED indicator should blink once and then turn off.)
 9. Turn the TEL100T on by sliding the top switch (OFF/STANDBY/ON) from left (OFF) to right (ON). The red LED indicator should blink once and then turn off.
 10. Turn the INPUT LEVEL control on the top of the TEL100T to the maximum (clockwise) position.
 11. Fully extend the TEL100R antennas and place them at a 90 degree angle with respect to each other.
 12. If using multiple TEL100C-RF systems in the same location, each TEL100C-RF system will need to run at a different transmission/reception frequency channel.
- Once the TEL100T is powered on and transmitting to the TEL100R, the "A" and/or "B" lights on the front panel of the TEL100R will light up. The TEL100R is a "dual diversity" receiver. Both channels of the TEL100R are involved in the data reception process.
 - Refer to [Application Note #103](#) for more information on setting up the TEL100 system.

Wireless Adjustments

Prior to using the TEL100C-RF system, the wireless link established by the TEL100T and TEL100R may require some user adjustment.

1. On the face of the TEL100C:
 - a. Slide the Bank Select switch to the top row for channels 1, 5, 9, and 13.
 - b. Set each channel switch to On.
 - c. Set each channel's LP filter to 35HzLPN.
2. On the TEL100M-C:
 - a. Set the four filter switches to DC.
 - b. Set the four gain switches to 1K.
3. In *AcqKnowledge*, select **MP menu > Set Up Data Acquisition > Channels** and set up the software to acquire for channels A1, A5, A9, and A13 (which correspond to the selected TEL100 channels).
4. With the software acquiring data, use a screwdriver to turn all the zero adjustment potentiometers on the TEL100M-C counterclockwise until the on-screen signal stops climbing and levels off between +8 V and +9 V.

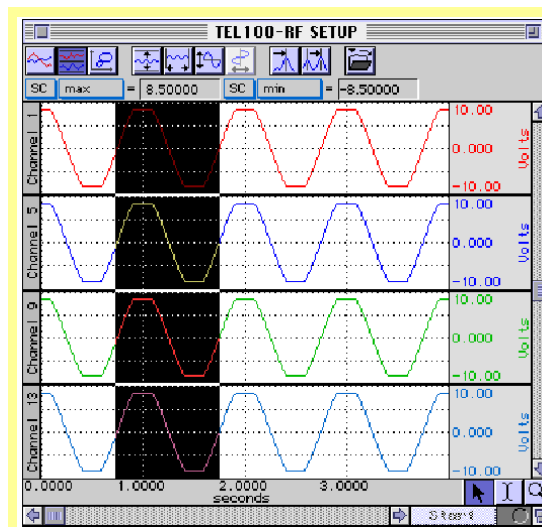
- Click the vertical axis of the graph in *AcqKnowledge* to display the Set Screen Vertical Axis dialog. Set the scaling to 1.0 Volts/div; set the mid-point to 7 Volts. Check the **Apply to all channels** box for each setting.



- On the back of the TEL100R, adjust the VOLUME knob so that the signal on all four channels resides at approximately +8.0 V.
- Click again in the vertical axis of the graph and reset the scale to 10 Volts/div and the midpoint to 0.0 Volts and apply to all channels.
- Turn all the zero adjustment potentiometers on the TEL100M-C clockwise until the signal stops descending and levels off at approximately -8.0 V.
- Repeat the above procedure if the maximum positive and maximum negative values of the signal are not approximately equidistant from the baseline with a variance of ± 1 V.

Note For example, the maximum/minimum signal values might fall between ± 6.5 V to ± 8.0 V.

- When satisfied, adjust the zero potentiometers on the TEL100M-C so that the signal levels on all four channels is approximately 0.0 V. Re-zeroing the zero adjustment potentiometers may be necessary if changing gain settings.



Note The graph at left illustrates the proper signal levels on all channels as the ZERO potentiometers on the TEL100M-C are rotated the full extent from clockwise to counterclockwise. Adjust the VOLUME knob (back of the TEL100R) to change the mean position of all the channel signal levels simultaneously. As the graph shows, the correct mean level for each channel is 0.00.

Operational Hints

- IMPORTANT** Don't change the VOLUME level (on the back of the TEL100R) after the setup procedure.
- If the TEL100T and TEL100R are within about 2 meters of one another, the transmission signal becomes more susceptible to motion artifact (antenna movement). The transmission antenna is the cable that runs from the TEL100T to the TEL100M. Best results under all circumstances will occur with minimal antenna motion with respect to the TEL100T to TEL100R distance.
- The TEL100T and TEL100R operate best in large open spaces. If the RF system is used in a laboratory environment with separating walls and large metallic objects, the system performance will reduce rapidly. This performance reduction results from the multipath phenomena.
 - Multipath** means that the radio wave is taking multiple paths from the transmitter to the receiver simultaneously. Multiple paths are possible if the radio waves bounce off metallic objects and establish a different course of direction. If multiple pathways are present, then it's very easy for the radio wave to cancel itself out at the receiver side because of differing phase between the multiple signal paths. Accordingly, it's best to use the TEL100C-RF system in large open spaces with a minimum of large metallic objects nearby.
- Due to the potential for channel-to-channel cross-talk and increased operational noise when using the TEL100C-RF system, it is important to optimize the channel gain for each channel used for recording. Ideally, each channel should have a nominal Pk-Pk signal value of approximately 5 V. Adjust the gain for each channel, on the TEL100M-C, to obtain similar values for each channel recorded. If this procedure is not followed and there is a large magnitude difference between recorded channels, the channel-to-channel cross-talk will become increasingly visible on the reduced magnitude channel.

- E. If three or fewer channels are being used for data collection, it may be worthwhile to dedicate the remaining (unused) channel for transmission error correction. This technique, while not foolproof, is helpful to remove slower occurring baseline movement artifacts that result from certain kinds of multipath effects. To use this feature, turn the gain from the unused channel to the lowest setting (50). In *AcqKnowledge*, set up three calculation channels whereby each channel will be the mathematical subtraction of the unused channel from the collected data channel. For operation using Bank 1, the setup for these calculation channels would be (with A13 as the unused channel):

C0: A1-A13
 C1: A5-A13
 C2: A9-A13

This error correction method is based on the realization that all transmitted channels are sent via the same RF carrier wave. As this wave is subject to multipath distortion, all channels are similarly affected with respect to artifact. Unfortunately, this correction mechanism only works to alleviate multipath phenomena that results in slowly moving baseline artifact. As the artifact becomes increasingly spurious, this error correction method become less useful. This technique for transmission error correction will typically perform better when recording with the 35HzLP filters ON.

TEL100C-RF System 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 (occurs internally in the TEL100C-RF system -- transparent to user)
Encoding	TDM-DSB/LC-FM
Channel Gain Control (10 Levels):	50, 100, 200, 500, 1000, 2000, 5000, 10000, 20000, 50000
Input Signal Level	Max: ±50mV
Offset Control	Yes
AC/DC Coupling	DC, 0.05 Hz and 0.5 Hz
Transducer Excitation	± 5V @ 20ma (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 (maximum allowed by FCC)
Transmission Range	75 meters (nominal), 150 meters (line-of-sight)
Signal/Cross-talk Ratio	35 dB (nominal); measurement performed with no multipath effects
Signal/Noise Ratio (0.05-35Hz)	50 dB (nominal); measurement performed with no multipath effects
Signal/Noise Ratio (0.05-500Hz)	40 dB (nominal); measurement performed with no multipath effects
Biopotential Amplifiers (in TEL100M-C)	
CMRR (1 kOhm source imbalance)	110 dB minimum (DC-60Hz)
Differential Input Impedance	2 MOhm
Common Mode Input Impedance	DC: 11 MOhm; 60 Hz: >1000 MOhm
Pk-Pk Noise	Voltage (Shorted Inputs): 0.28µV (0.1-10 Hz) Current: 10 pA (0.1 - 10 Hz)
Component	Size & Weight
TEL100D-C	10.92 cm x 19.05 cm x 4.06 cm; 0.397 kg
TEL100M-C	8.89 cm x 14.22 cm x 3.05 cm; 0.312 kg (with battery)
TEL100T	6.35 cm x 10.67 cm x 2.24 cm; 0.170 kg (with battery)
TEL100R	11.18 cm x 21.59 cm x 4.06 cm; 0.522 kg