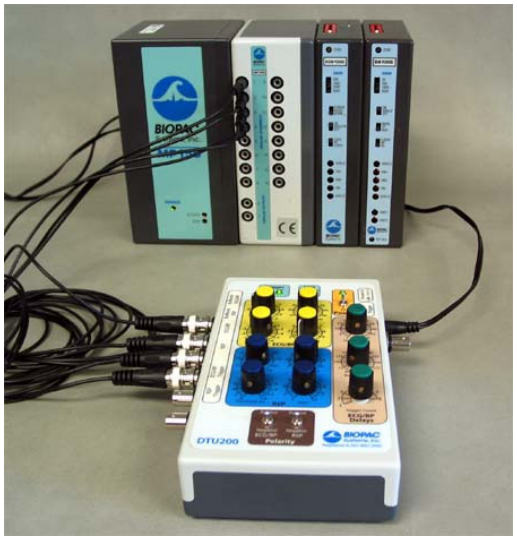
BIOPAC Systems, Inc.
Registered to ISO 9001:2015
RESEARCH
42 Aero Camino, Goleta, CA 93117
Tel (805) 685-0066 | Fax (805) 685-0067
info@biopac.com | www.biopac.com

02.14.2019

Application Note 245 DTU200/300 Dual Channel Gating Setup

The DTU200/300 Dual Channel Gating System extracts timing information from cardiac and respiratory signals to trigger MRI acquisitions. With the DTU200/300, MRI scans are triggered at the same phase of each cardiac cycle and only during cardiac cycles that occur during the quiet phase of the respiratory cycle. Consistent relative timing across scans improves the clarity of resulting magnetic resonance images. Cardiac signals are input in the form of either ECG or continuous blood pressure. The system outputs a triggering signal used to initiate an MRI scan. The unit has many configuration options that can optimize the extraction of timing information from the input signals and allows for monitoring of intermediate signals used to generate the MRI trigger.



Dials on the unit allow conditioning of the input signals. Cardiac and respiratory signals can be amplified up to 10X. Both input channels can be low pass filtered (cardiac 10-100 Hz; respiratory 1-10 Hz) and high pass filtered (cardiac 0.1-1 Hz; respiratory 0.05-0.5 Hz). Conditioned signals can be monitored in real time through analog inputs to the MP system.

Thresholds for the conditioned signals can be adjusted to create square waves that correspond precisely to the peak of the R wave (or systole) and to apnea phases of the respiratory cycle. Conversion of these signals to the output pulses that gate MRI acquisition can be delayed relative to the R wave (or blood pressure) peak. To prevent the DTU200/300 from registering MRI artifacts as cardiac cycle data, the cardiac signal can be blanked after each MRI trigger pulse. To ensure data collection only during quiescence of the respiratory signal, the number of cardiac cycles that generate MRI triggering pulses during each respiratory cycle can be configured from 1-8. Trigger signals from both cardiac and respiratory channels can also be monitored via inputs to an MP system.

Setup

Minimal setup of the DTU200/300 requires connections to the cardiac and respiratory signal inputs.

In the figure at left, a DA100C amplifier captures the respiration signal using a TSD110-MRI transducer on Channel 1, and an ECG100C amplifier captures the ECG signal on Channel 2. These signals are captured to the MP150 and the UIM100C and provide analog outputs of the signals via CBL102 cables Labeled cables are provided with the DTU200/300 system to ease setup.

For the newer model MP160 system, which uses the HLT100C or AMI100D module in lieu of the UIM100C, BIOPAC CBL122 (3.5 mm to RJ11) adapters will need to be used in series with the CBL102 cables referred to above. CBL123 BNC-to-RJ11 cables can also be used as a direct connection between the DTU200/300 and the HLT100C/AMI100D. (With the CBL123, no adapter is necessary.)

It is important to ensure that the correct amplifier channel is used to connect the analog output signal from the UIM100C to the RSP and ECG/BP inputs on the DTU200. The red slide connector on top of the amplifier determines which channel is being used by the amplifier.

- For example, if the red channel slider on top of the amplifier is set to Channel 1 for the DA100C amplifier, the CBL102 cable should connect between Channel 1 of the UIM100C (or HLT100C/AMI100D) and the DTU200 RSP input.

To monitor the conditioned respiratory and cardiac signals, additional CBL102 connectors attach the DTU200/300 to additional channels on the UIM100C. (Or CBL102 to CBL122 if using MP160 with HLT100C/AMI100D.

CBL123 can also be used to connect directly to HLT100C/AMI100D.) Any available channels (i.e., any channels not utilized by other amplifiers) can be used. If desired, the trigger signals can be monitored on two other channels (not shown) using the cables provided.

The single BNC connector on the right side of the device provides the output signals to the MRI scanner.

By monitoring the conditioned signals and triggers, the DTU200 can be adjusted to optimize the extraction of timing information.

Operating Instructions

For illustrative purposes, the following assumes ECG data are acquired for cardiac cycle timing. As in the preceding figures, RSP is on Channel 1 and ECG is on Channel 2. The conditioned RSP and ECG signals are monitored on Channels 3 and 4 respectively, and their trigger signals are monitored on Channels 5 and 6. The MRI output trigger is read (for illustration only) on channel 7.

The DTU200/300 has two sets of knobs that allow conditioning of the input signals.

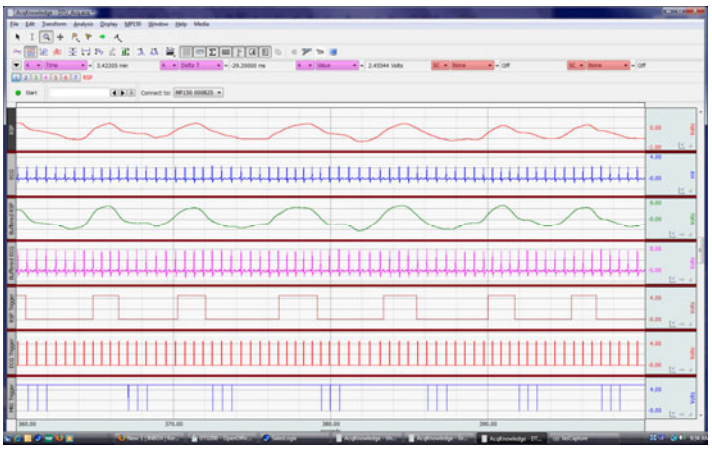
- Adjust the cutoff frequencies of high and low pass filters to narrow the bandwidth of respiration and/or cardiac signals.
- Each signal can also be amplified up to a factor of ten to sharpen the transitions utilized to generate trigger signals. Gains should be set to maximize the use of available signal range. MP systems have an operating range that covers ±10 V, so gains should be increased as much as possible without causing the signal to move outside that range.

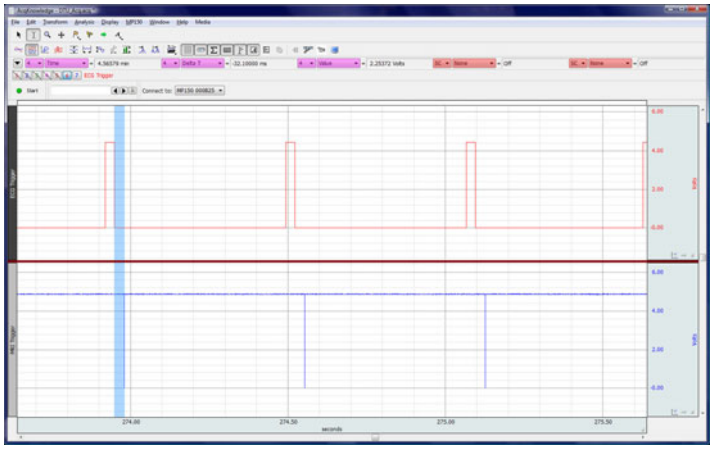
Threshold values for cardiac and respiration signals are set independently over the range of ±6 V. Thresholds can be optimized through the following procedure:

1. Set threshold to one end of range.
2. Adjust until trigger signal appears. In the adjacent figure, threshold was adjusted upward until trigger circuitry acquired the end of the QRS complex at approximately -2 V.
3. Continue adjusting threshold until signal is lost again or until the end of threshold range is reached. In the adjacent figure, threshold was 6 V, and trigger still captures QRS complex.
    - Note values from previous two steps and set threshold around the midpoint between them.

Threshold for respiration should be set in the same manner.

The figure shown below left shows all channels displayed. Note that MRI scanner is triggered by TTL OFF signals. The DTU200/300 can be set to trigger multiple scans during a single apnea phase. In the figure shown below right, this Trigger Count is set to three.





To prevent MRI artifacts from producing spurious cardiac signals, DTU200/300 can be configured to ignore cardiac input during a Blanking Interval.

MRI trigger can also be delayed by a Hold-Off setting ranging from one to 50 milliseconds. In the figure below, the Hold-Off was set slightly above 30 milliseconds. The following figure illustrates only the ECG and MRI trigger signal channels during one respiratory cycle. The Hold-Off window from the first cardiac cycle is highlighted.