

## Application Note 285: How to Identify a Stimulation Threshold

This application note details various protocols for identifying a stimulation threshold. The purpose of establishing this threshold is to ensure the subject's comfort level and safely determine the point at which a stimulation signal becomes unpleasant, or even painful. This is accomplished by sending a series of very short stimulus pulses to the subject and gradually increasing the voltage. The subject then indicates his or her level of comfort or discomfort, and the stimulation is adjusted accordingly.

- Case 1** MP150 + UIM100C + STM100C + STMISOLA or STMISOC/D/E + LEAD110A x2 + EL509 + GEL104
- Case 1a** MP160 + HLT100C + STM100C + STMISOLA or STMISOC/D/E + LEAD110A x2 + EL509 + GEL104
- Case 2a** MP150 + UIM100C + STM200 + LEAD110A x2 + EL509 + GEL104 **OR** MP160 + HLT100C + STM200 + LEAD110A x2 + EL509 + GEL104
- Case 2b** 3<sup>rd</sup>-party hardware and software + STM200 + LEAD110A x2 + EL509 + GEL104
- Case 3** E-Prime software + STMISOLA or STMISOC + LEAD110A x2 + EL509 + GEL104
- Case 4** 3<sup>rd</sup>-party application + STMISOLA or [STMISOC + STM100C + IPS100C + HLT100C + INISO] + LEAD110A x2 + EL509 + GEL104
- Case 5** MP160 or MP150 + STM100C + STMISOC + LEAD110A x2 + EL509 + GEL104
- Case 6** 3<sup>rd</sup>-party equipment + STP100C + IPS100C + STM100C + STMISOC + LEAD110A x2 + EL509 + GEL104
- Case 7** 3<sup>rd</sup>-party equipment + MP150/IPS100C + STP100C + STM100C + STMISOC or STMISOLA + LEAD110A x2 + EL509 + GEL104

Electrodes should always be placed on the participant at least 10 minutes prior to starting any electrical stimulation.

### NOTES REGARDING USE OF ELECTRODES

For electrical stimulation, generally, the lower the electrode salt content, the less skin irritation will be experienced by subject. This is because fewer salt ions are driven into skin during stimulation. This strategy puts more demand on the stimulator, because skin impedances are higher with low salt electrodes. There is no one size fits all requirement. For example, it's possible to help mitigate the undesirable effects of higher salt content electrodes by stimulating the subject with bipolar pulses, instead of unipolar pulses.

[Click here for more details about using BIOPAC electrodes and gels.](#)

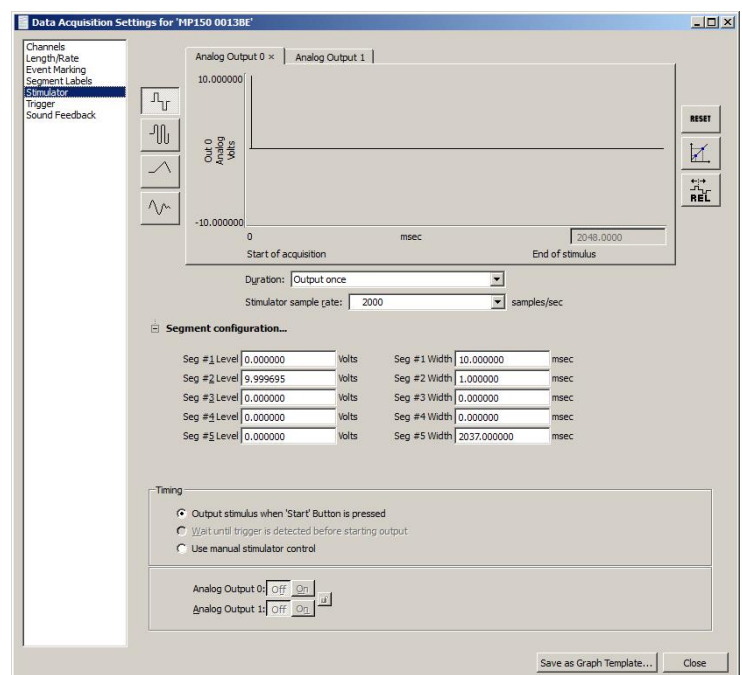
Current Feedback Monitor Cable [CBLCFMA](#) is recommended for use with any voltage stimulator to monitor and record the actual current delivered to the participant at ALL times; to isolate CBLCFMA output, use INISO + HLT100C. A large enough change in current delivered to the participant will alter the subjective perception of the stimulation. Thus, an unpleasant shock may become painful if more current starts being delivered or become ineffectual if less current is being delivered than during threshold identification. Changes in the levels of delivered current are due to changes in impedance. Changes in impedance could be due to a number of factors: gel saturating the skin over time; gel drying up over longer periods of times; hydration level of participant; sweating; decoupling of electrodes and skin due to motion artifacts; etc.

### Case 1

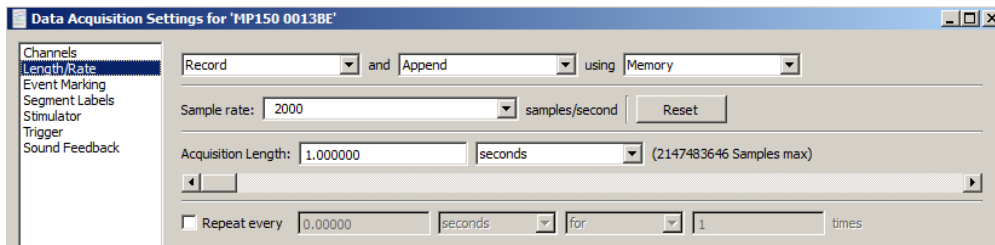
**Hardware:** MP150 + UIM100C + STM100C + STMISOLA (current and voltage mode) or STMISOC/D/E (voltage mode only) + LEAD110A x2 + EL509 + GEL104

**Note** For MRI use, add MECMRI-STMISO to this setup and use LEAD108B x2 instead of LEAD110A. Only carbon fiber leads can be used in the MRI.

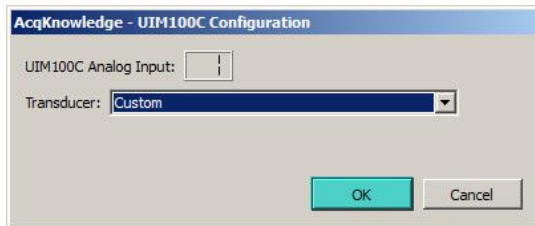
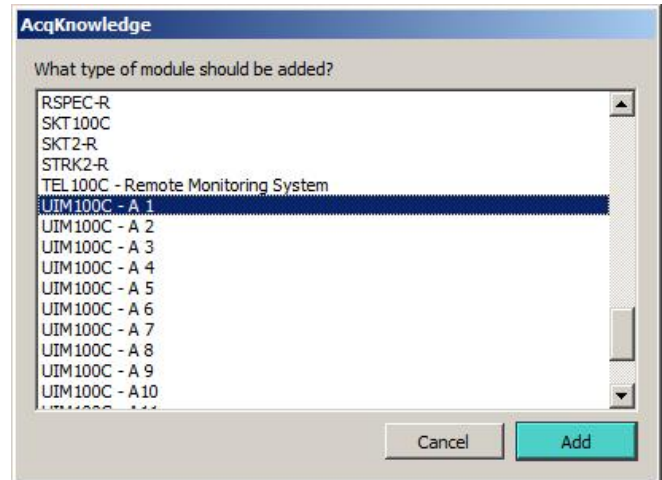
1. Open the *AcqKnowledge* Stimulator window (MP > Set Up Data Acquisition > Stimulator).
  - a. Set the Stimulator to deliver a single 1 msec pulse with an amplitude of 10 volts as shown here.
  - b. Set **Duration** to **Output once**. Under this setting, a new acquisition must be started in order to deliver each stimulation pulse:



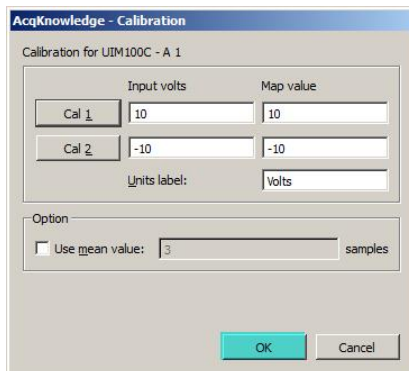
- Set the **Acquisition Length** to 1 second.



- Connect a CBL100 cable (3.5 mm mono to 3.5 mm mono) from the STM100C 50 Ohm output to the UIM100C Analog Channel 1 input.
- In *AcqKnowledge*, choose %Add New Module.+
- Select UIM100C-A1 in the add module list and click %Add.+
- Select the %Custom+Transducer option in the UIM100C Configuration screen and click OK.



- Click OK in the subsequent Scaling dialog.



The completed Analog Channel setup should appear as shown below.



- Turn the STM100C %Level+knob fully counter-clockwise to 0%. This assures a stimulation level of 0 V at the start of the recording.
- Start the recording and instruct the subject to report when he or she feels the stimulation pulse.
  - After each trial, slightly increase the stimulation intensity via the STM100C %Level knob+until the subject reports the first sign of discomfort. (For example, if Channel A1 displays 2.8 volts and the multiplication factor of the stimulation isolator was set to 10, this would indicate that 28 V is the threshold for this participant.)

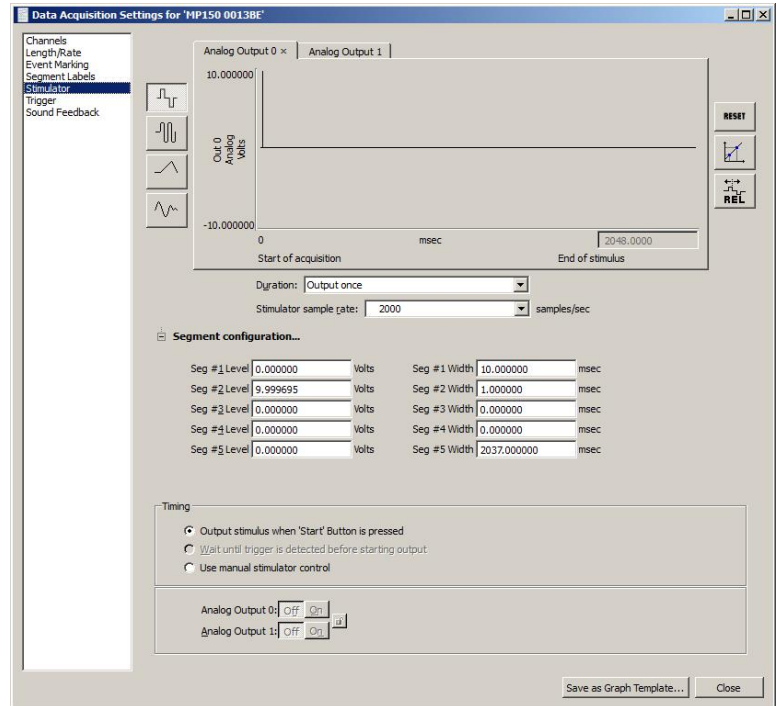


Case 1a

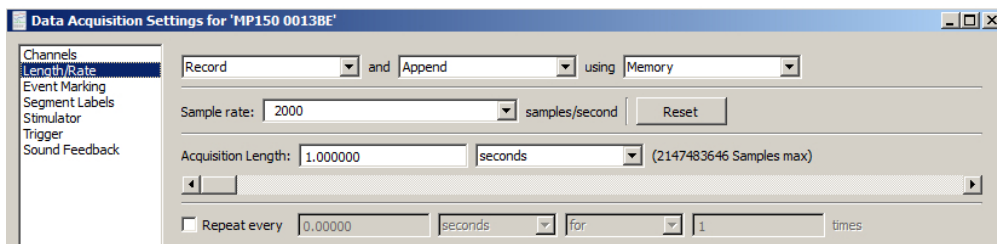
**Hardware:** MP150 + HLT100C + STM100C + STMISOLA (current and voltage mode) or STMISOC/D/E (voltage mode only) + LEAD110A x2+ EL509 + GEL104

**Note** For MRI use, add MECMRI-STMISO to this setup and use LEAD108B x2 instead of LEAD110A. only carbon fiber leads can be used in the MRI.

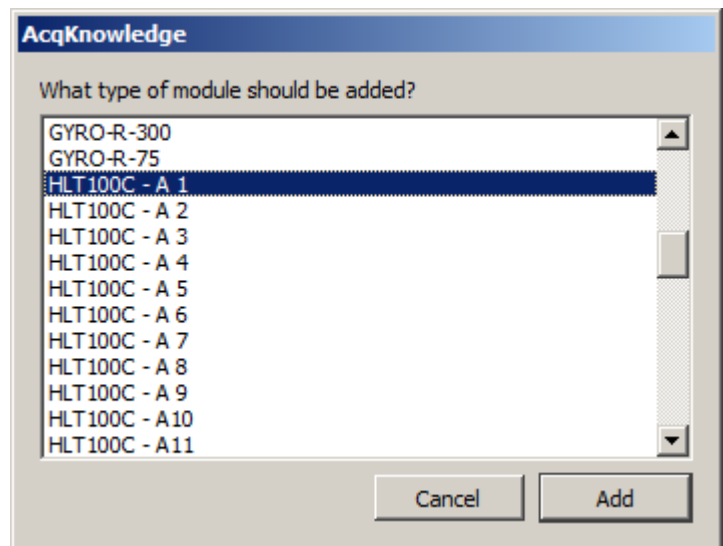
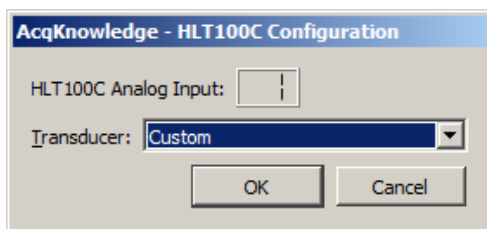
10. Open the *AcqKnowledge* Stimulator window (MP > Set Up Data Acquisition > Stimulator).
  - a. Set the Stimulator to deliver a single 1 msec pulse with an amplitude of 10 volts as shown here.
  - b. Set **Duration** to **Output once**. Under this setting, a new acquisition must be started in order to deliver each stimulation pulse:



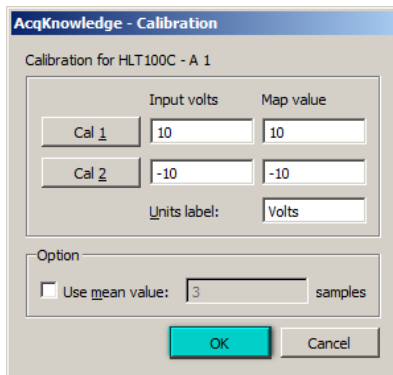
11. Set the **Acquisition Length** to 1 second.



12. Connect a CBL100 cable (3.5 mm mono to 3.5 mm mono) from the STM100C 50 Ohm output to a CBL122 (3.5 mm mono to RJ11) adapter.
13. Connect the RJ11 end of the CBL122 adapter to the HLT100C Analog Channel 1 input.
14. In *AcqKnowledge*, choose **Add New Module**.
15. Select HLT100C-A1 in the add module list and click **Add**.
16. Select the **Custom Transducer** option in the HLT100C Configuration screen and click OK.



17. Click OK in the subsequent Scaling dialog.



The completed Analog Channel setup should appear as shown below.



18. Turn the STM100C %level+knob fully counter-clockwise to 0%. This assures a stimulation level of 0 V at the start of the recording.
19. Start the recording and instruct the subject to report when he or she feels the stimulation pulse.
  - a. After each trial, slightly increase the stimulation intensity via the STM100C %level knob+until the subject reports the first sign of discomfort. (For example, if Channel A1 displays 2.8 volts and the multiplication factor of the stimulation isolator was set to 10, this would indicate that 28 V is the threshold for this participant.)



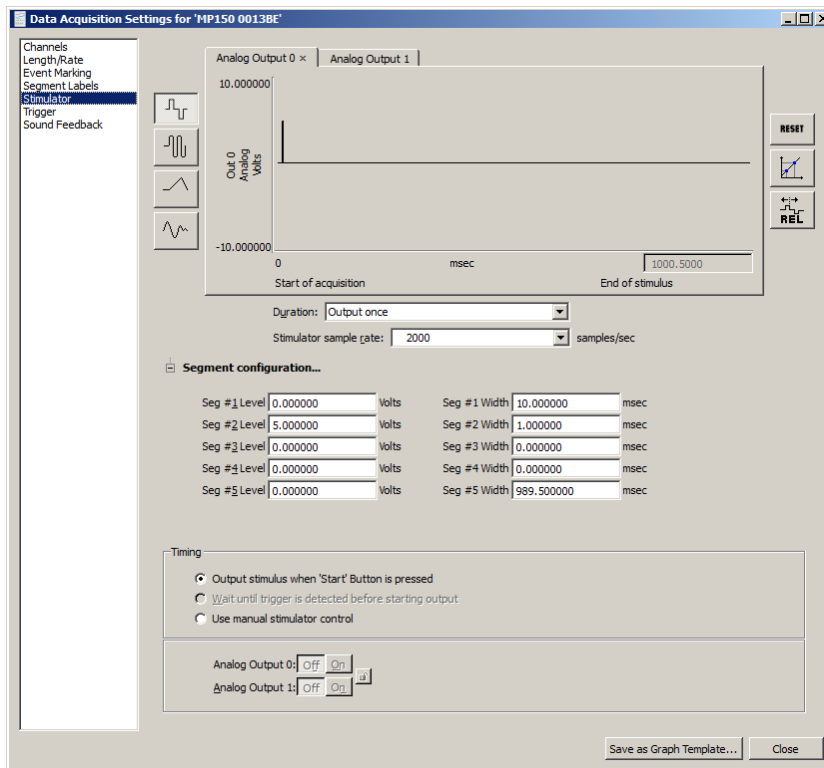
## Case 2a

## Hardware:

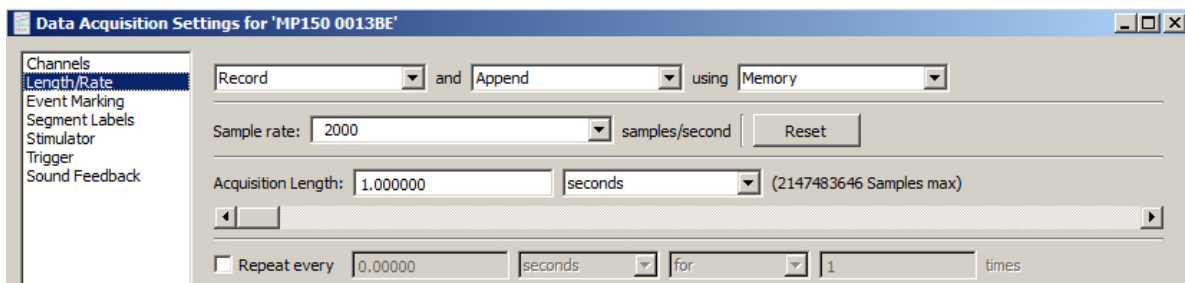
- MP150 + UIM100C + STM200 + 2xLEAD110A + EL509 + GEL104
- MP160 + HLT100C + STM200 + 2xLEAD10A + EL509 + GEL104

Since the voltage is adjusted via The STM200 %level+knob, AcqKnowledge simply needs to deliver pulses to initiate stimulation for the duration of each pulse.

1. Set up the AcqKnowledge Stimulator to deliver a single 1 msec pulse with amplitude of 5 volts as shown in the example below.



2. Set **Duration** to %Output once+so a separate acquisition is required for each Stimulator pulse.
3. Set the **Acquisition Length** to 1 second.



4. Click %Start+in AcqKnowledge. Instruct the subject to report when he or she feels the stimulation pulse. For each subsequent trial, slightly increase the stimulation intensity via the STM200C %level+knob until the subject reports the first sign of discomfort.



(For example, if Channel A1 displays 2.8 volts and the multiplication factor of the stimulation isolator was set to 10, this would indicate that 28 V is the threshold for this participant.)

### Case 2b

**Hardware:** 3<sup>rd</sup>-party hardware and software + STM200 + LEAD110A x2 + EL509 + GEL104

Examples of 3<sup>rd</sup>-party equipment capable of generating a TTL pulse include E-Prime on a PC with a parallel port or STIMTRACKER, SuperLab on a PC with a parallel port or STIMTRACKER, Vizard on a PC with a parallel port or Labjack, as well as many other combinations of stimulus presentation software and hardware.

Since the voltage is set via a knob on the STM200 itself, the STM200 simply needs to be sent a 5 V pulse (TTL high pulse) to initiate stimulation for the duration of each pulse. Such a pulse can originate from a D/A (digital to analog card) or a parallel port.

The delivery (duration and time) of stimulation is controlled in the stimulus presentation software, while the stimulation intensity for each trial is increased via the %Level+knob on the STM200 front panel. Repeat the trials until the participant reports the first sign of discomfort.

When controlling the STM200 via a parallel port, it is not possible to connect the 3.5 mm stimulator input voltage line directly to the parallel port. In this case, additional items are required in order to fully assemble the connection:

#### Connection order



25-pin Parallel port to Parallel port splitter (optional so you can still use the port for other tasks):  
CBL110C-Y

Connected to a parallel port breakout box (so that you can access the individual port lines via screw terminals):

<http://www.winfordeng.com/products/brk25.php>

**Note:** If you have a 37-pin parallel output card, you will need to use a 37-pin breakout box. For example, <http://www.winfordeng.com>

And from there via CBL106 (so, for example, if you are sending a signal on pin 2, you would connect the red cable to pin 2 of the breakout box and to a ground i.e., pin 18) to BSLCBL6 to STM200 or STMISOLA 3.5 mm mono connector.

### Case 3

**Hardware:** E-Prime software + STMISOLA or STMISOC + LEAD110A x2 + EL509 + GEL104

If E-Prime is used as the software controller, STMEPM is also needed. The STMEPM includes:

- STMISOLA
- USB 4-ch D/A Unit
- Software Utility (STMISOL E-Prime) with sample E-Prime experiment Interface cables

In this scenario, E-Prime will control the stimulation by setting the level of the D/A output.

E-Prime also controls the D/A unit, which controls the STMISOLA.

The voltage must be increased incrementally in the E-Prime software until a stimulation comfort threshold is reached.



### Case 4

**Hardware:** 3<sup>rd</sup>-party application + STMISOLA or [STMISOC + STM100C + IPS100C + HLT100C + INISO] + LEAD110A x2 + EL509 + GEL104

To take full advantage of the stimulator output capability, the selected third-party hardware/software must be capable of driving analog outputs in the range -10 V to +10 V.

Examples of D/A solutions: D/A cards from National Instruments, Measurement Computing, Labjack, etc. All development work must be implemented by the end-user. Before you begin, verify which D/A cards are compatible with the stimulus presentation software being used.

**Case 5**

**Hardware:** MP160 or MP150 + STM100C + STMISOC (in current mode) + LEAD110A x2 + EL509 + GEL104

When used in current mode, the STMISOC stimulation level is set via a knob. Therefore, the paradigm is identical to Case 2a.

The human subjective sensory processing is proportional to the logarithm of the stimulus intensity. This makes the stepwise current level control of stimulus intensity on the STM100C quite acceptable for identifying a subjective threshold where a stimulus becomes unpleasant or painful (except in cases where linear control of stimulation level is absolutely necessary, such as when identifying H-reflex thresholds, etc.).

**Case 6**

**Hardware:** 3<sup>rd</sup>- party equipment + STP100C + IPS100C + STM100C + STMISOC (in current mode) + LEAD110A x2 + EL509 + GEL104

When used in current mode, the STMISOC stimulation level is set via a knob. All that is needed is a TTL pulse to trigger the stimulator. The third-party equipment would need to send a 5 V pulse to digital channel 15 over the parallel port to the STP100C. The STM100C should be set to Pulse mode with the STMISOC connected to it.

**Case 7**

**Hardware:** 3<sup>rd</sup>- party equipment + MP160 or MP150/IPS100C + STP100C + STM100C + STMISOC (in voltage mode) + LEAD110A x2 + EL509 + GEL104

In this arrangement, the pulse amplitude and duration is entirely controlled via the parallel port of the third-party computer. The third-party machine is connected to the STP100C via a parallel port cable, with STM100C set to Pulse mode. The STMISOC is connected to the STM100C. Whenever a pulse is sent on digital channel 15, stimulation will occur for the duration of the pulse.

The amplitude of the stimulation can be controlled via digital channels D0-D6. Since the STP100C can only receive data on D8-D15, connect D0-D6 to D8-D14 at the back of the UIM100C via JUMP100 cables (MP150 hardware only). This way, the third-party machine can control attenuation of the STM100C stimulator. Attenuation Control Range: 128 dB (Digital I/O 0-6, LSB-MSB).

Human subjective sensory processing is more or less proportional to the logarithm of the stimulus intensity. This makes dB level control of stimulus intensity quite appropriate for identifying a subjective threshold where a stimulus becomes unpleasant or painful (except in cases where linear control of stimulation level is absolutely necessary).

Under this protocol, the third-party software would initiate stimulation with full attenuation (max possible is 127 dB) and the attenuation level will need to be decreased until a threshold is identified.