TMS and Magstim control using Signal

A guide to setting up CED acquisition and analysis systems for TMS studies

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Cambridge Electronic Design Ltd.

Preface

Signal, along with a 1401 interface and 1902 amplifier, offers a complete solution for evoked response recording when used in conjunction with the Magstim range of transcranial magnetic stimulators.

Signal is a sweep-based data capture and analysis software package. It provides direct control of Magstim stimulator parameters during sampling, including adjustment of stimulus intensity and trigger timing. This guide is intended to help you setup a TMS system for evoked potential recording using Signal, a 1401 interface, a 1902 amplifier and a Magstim stimulator.

Requirements: Signal for Windows version 3.08 or higher, Power1401 or micro1401 laboratory interface, Magstim 200², BiStim², Rapid², Super Rapid² or Super Rapid² Plus stimulator.

Optional: CED 1902 amplifier or other software-controllable amplifier (e.g. Digitimer D360), Electrode adaptor box, USB to serial adaptor.

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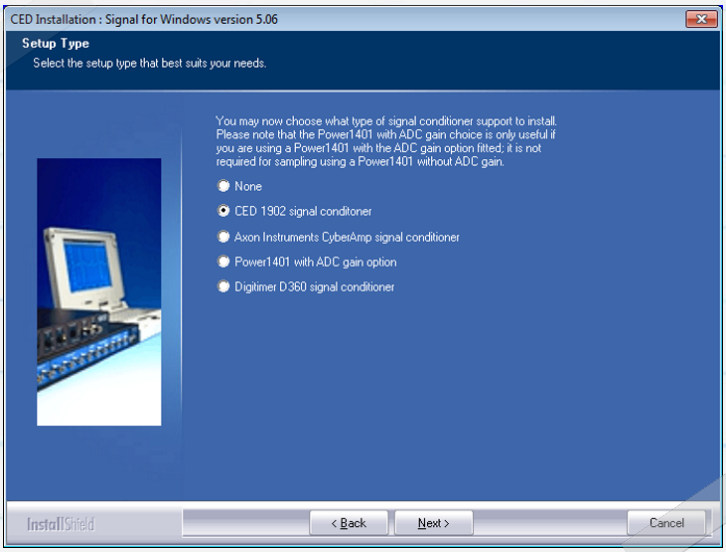
Software installation

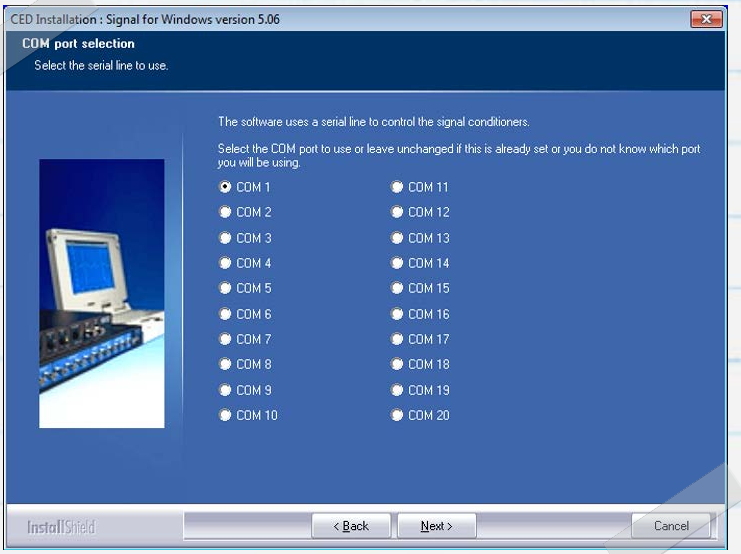
Install the Signal software from the supplied CD. There are a number of options given during the installation process and the following steps should be followed to ensure the correct features are installed. After setting the installation directory, your name and organisation and selecting Compact, Custom or Typical setup, the following page will appear.

Signal conditioner support

This option is to install software support for a signal conditioner. If you are using a CED 1902 amplifier, select CED 1902 signal conditioner and click Next. Information on setting up a 1902 amplifier for recording can be found in the 1902 amplifier setup section.



If using a Digitimer D360 amplifier select the Digitimer D360 signal conditioner option. This device connects with a USB to serial interface which is automatically selected

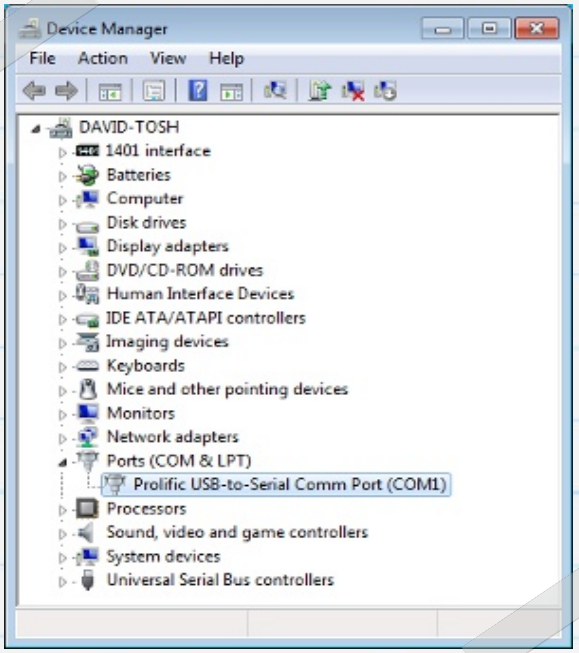


The CED 1902 amplifier is controlled via a COM port (RS232). Many desktop PC's will have at least one COM port available (usually COM1). For laptops and PCs without an available COM port, a USB to serial adaptor can be used instead. This should be plugged in to an available USB port before continuing.

If you know the COM port you want to use, select it here and click Next. If you are not yet sure which port you want to use you can check for available COM ports as described below, or select COM1 at this stage and then simply change the 1902 COM port in the Edit menu Preferences > Conditioner section in Signal later on.

Check for available COM ports

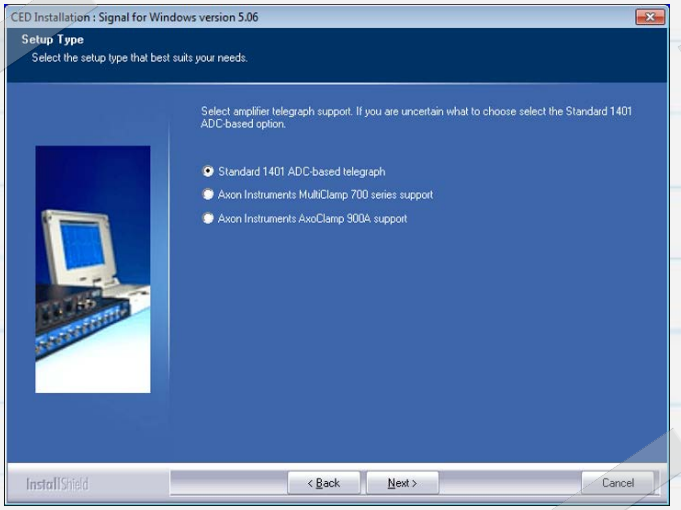
All available COM ports are listed in the Windows Device Manager. The quickest way to open the Device Manager on any version of Windows is to use the Windows key + R keyboard shortcut to open the Run command, enter **devmgmt.msc** in the dialog and Click OK.

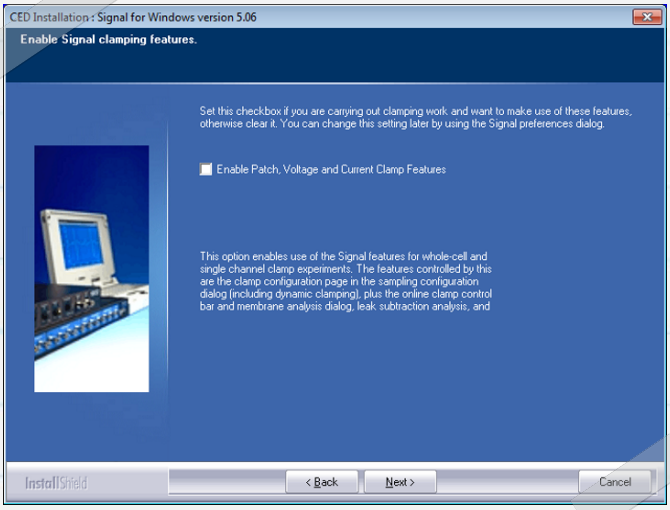


You can also open the Run command from the Start menu in Windows XP. In Windows 7 you can access the Device Manager from the Control Panel in the Start menu or open the Run command from the All Programs > Accessories folder in the Start menu.

In the list of hardware devices should be an entry for Ports (COM & LPT). Click on this to show the available ports. You can edit the COM number assigned to a port for most devices by double-clicking on the entry. Click on the Port Settings tab and then the Advanced... button. You can set the COM port number from a drop-down list.

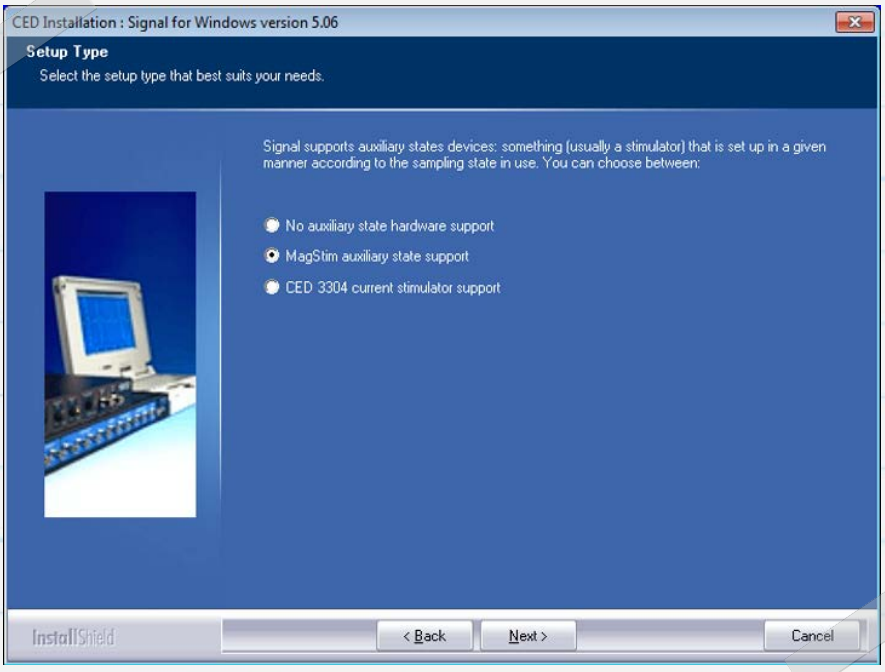
The following two installation options are for the inclusion of telegraph support and patch and voltage clamp features within Signal. These are specialised features for electrophysiology research so click Next to accept the default settings if you do not need these options.





Magstim support

Select the Magstim auxiliary state support option if the model of your stimulator is a 200², BiStim², Rapid², Super Rapid² or Super Rapid² Plus, otherwise select No auxiliary state hardware support. You can use Signal to generate output pulses and trigger older Magstim models, but only those models in the xxx² range can be fully configured and controlled using the auxiliary states system. Magnetic stimulators from other manufacturers are also available, but these are usually only able to accept trigger inputs.



Continue the installation accepting the default options by clicking Next until the installation completes.

The 1401 interface

Confidence check

The device drivers for the Micro1401 and Power1401 interfaces are installed automatically along with Signal. Once the Signal installation has completed, connect the 1401 power brick to the DC Power port on the rear of the unit and plug in to a mains outlet. Connect the 1401 to your PC using the supplied USB cable and switch it on. Windows will detect the 1401 and automatically display a message stating that it is looking for the driver. Once it has found the CED1401 driver and installed it the message will disappear.

Self-test

The first and easiest check to perform is to run the 1401 standalone self-test, which runs automatically when the 1401 is switched on. Remove the USB connection from the 1401 and all other connections from the front and rear panels. Once all connections have been removed, power up the 1401. The self–test will then run with the main switch LED lighting up red and the LED's on the front panel flashing in sequence. Once the self-test completes the LED should turn blue (Micro1401) or green (Power1401) if all is well. If the 1401 passes this test, but shows a fault during use while connected to the PC or other devices, it is likely that the fault lies in the host computer hardware or software.

Try1401

If the LED on the 1401 continues to flash red, then the standalone self-test has detected a problem. A 1401 diagnostic program, Try1401 is installed along with Signal and can be used to provide details of the problem. Re-connect the 1401 to the host PC with the USB cable and open the Try1401 program, which can be found in the Signal folder and accessed from the Start menu.

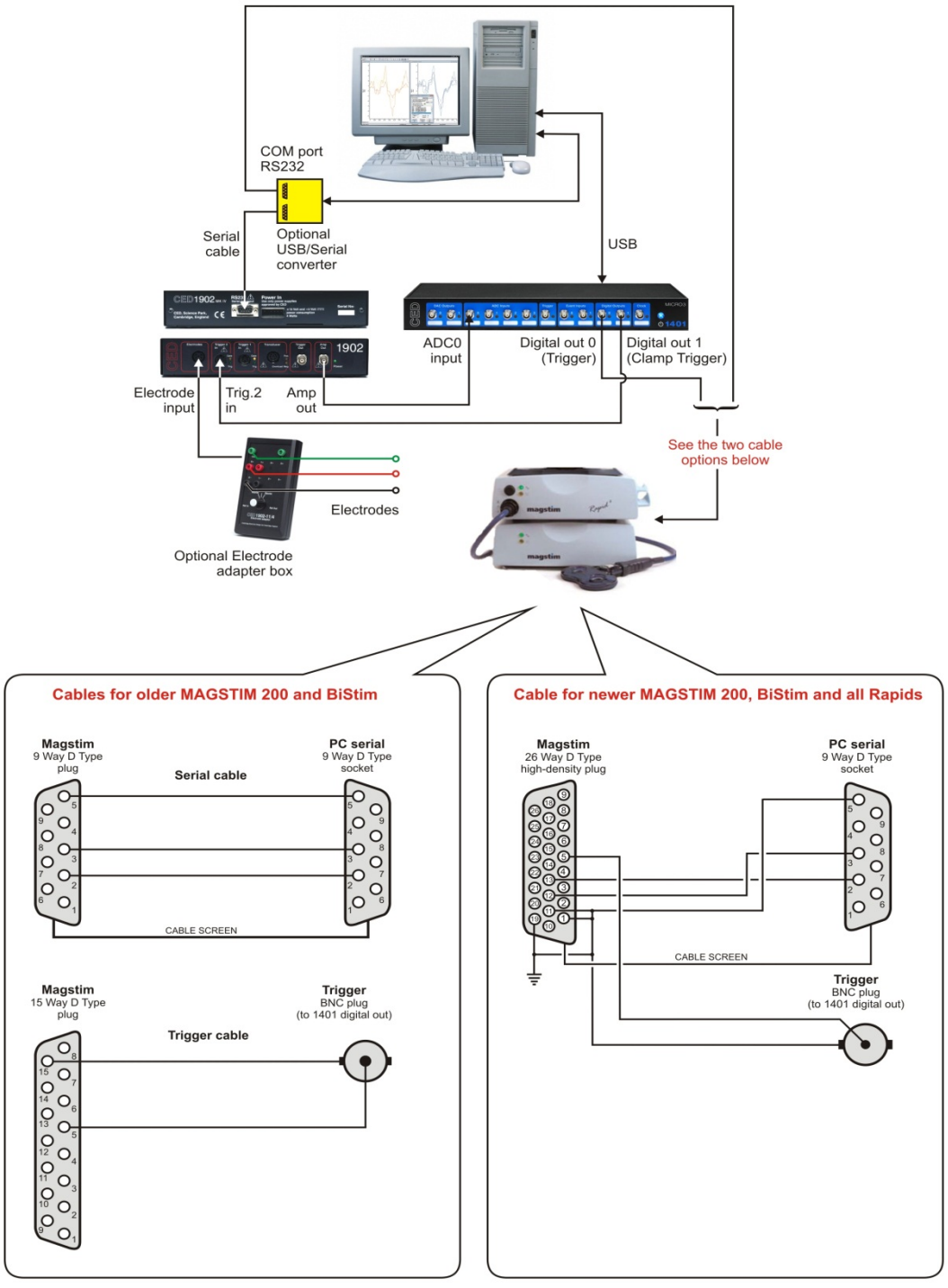
From the File menu in the Try1401 program select 1401 info... which will return information about the 1401 hardware and installed firmware. If Try1401 returns an error at this stage refer to the Troubleshooting guide in your 1401 manual or contact CED for assistance.

If the 1401 info... returns a list of information, then communication is fine and you can proceed with the Try1401 tests. Check the Self test option in the main toolbar and click Run once. This performs a series of tests on the 1401 and reports the results. If no errors are detected at this stage it is worth selecting the Run cont option to try and pick up any intermittent faults. You should then inform CED of any errors: The Send email option from the File menu will create a new email, with the Try1401 report as an attachment that can be sent to hardhelp@ced.co.uk

If the main LED on the 1401 remains red, but does not flash, you should contact CED directly for help either by phone or email at hardhelp@ced.co.uk.

Hardware configuration

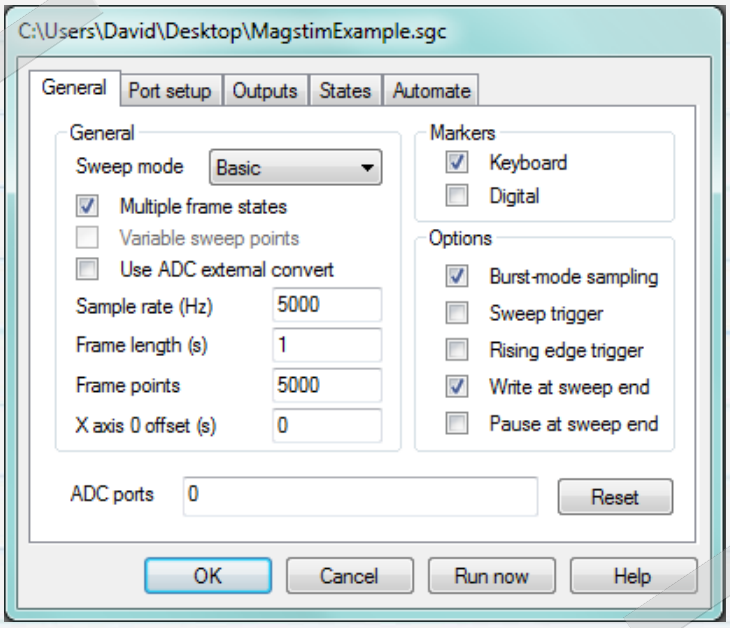
The connection diagram below shows a common hardware configuration for TMS recording. This includes a single 1902 amplifier connected to the PC via a serial line with a dual USB to serial adaptor along with a Micro1401-3 and Magstim Rapid². The Magstim connects to the PC using the second serial-line input on the USB to serial adaptor.



In the diagram above the CED 1902 is fitted with an input clamp option, which can be used to suppress the artefact that occurs after stimulation. This is generally only required with very fast responses (i.e. 2-10ms after stimulation), or if recordings are taken close to the site of stimulation. The input clamp is triggered with an input to the Trigger 2 port on the 1902 as shown. See 1902 amplifier setup for further details.

Signal sampling configuration

All settings for sampling data, 1902 amplifier control and Magstim control are set-up within a sampling configuration in Signal. The downloadable configuration file, MagstimExample.SGC, contains example settings that you can use to generate output pulses to trigger a Magstim and record the response data. Open Signal and load the MagstimExample.SGC file from the Load sampling configuration option in the File menu.



1902 amplifier setup

The following section describes how to setup a CED1902 amplifier for evoked potential recording. If you are using a third-party amplifier that is not software controlled you can skip directly to Magstim setup.

With mains power off, connect the power brick and included RS232 serial cable to the rear of the 1902. Connect the power brick to a power outlet and the RS232 cable to an available COM port on the host PC or to the USB-serial adaptor that you connected to an available USB port on the host

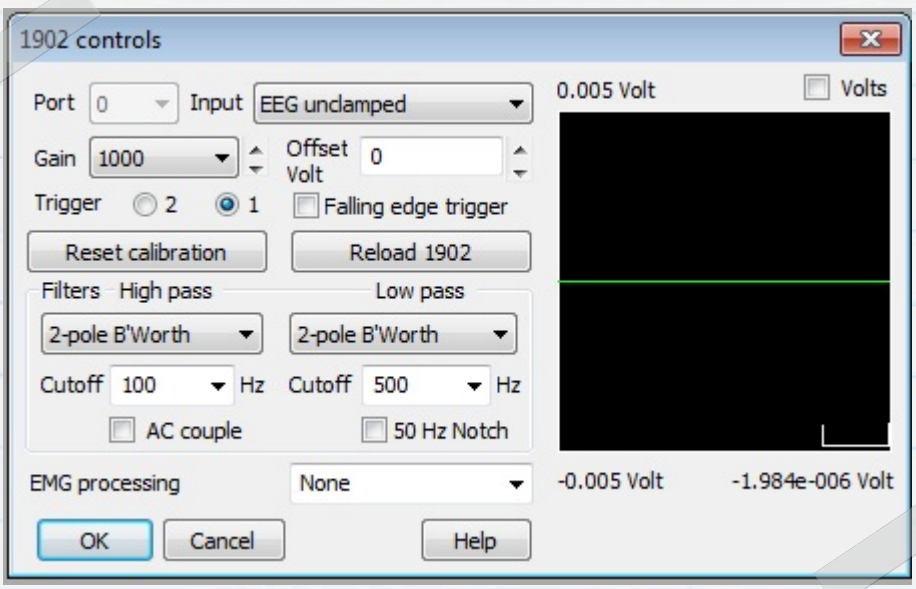
computer during installation of the Signal software. Switch on the mains outlet to power up the 1902. Once the green Power LED is lit, the 1902 is ready for use.

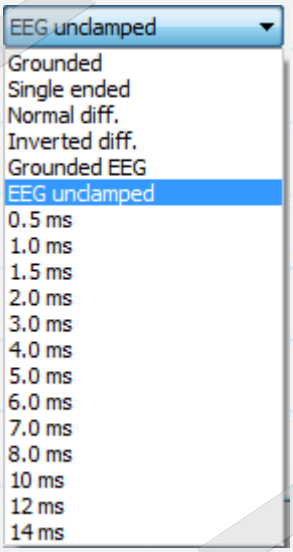
If 1902 conditioner support was selected during the installation, Signal provides complete control over the 1902 amplifier settings via a control panel which can be used to adjust amplifier gain and offset, modify filter settings and enable triggering and clamp duration if the 1902 has been fitted with the input clamp option. By default, the control software expects each 1902 channel to be connected to the corresponding ADC port number on the 1401 interface using a BNC cable, which you should connect now. This example uses a single 1902, channel 0, which is connected to ADC 0.

Remember that, although the hardware port connections start with channel 0, channel numbers in Signal data files always begin at 1

The 1902 control panel is available from the Port setup tab of the Signal sampling configuration. If you select an ADC port in the list, and there is a corresponding 1902 attached, the CED 1902 button is enabled. Click on this to open the 1902 controls. To the right of the main control panel is an oscilloscope window which shows incoming data for the currently selected 1902. The control panel can also be accessed during sampling by selecting Signal conditioner... from the Sample menu.

If Signal fails to detect the 1902, check that the COM port settings in Signal match the COM port that the 1902 is connected to. You set the COM port to use in Signal from the Edit Preferences menu Conditioner tab. To check which COM port the 1902 is connected to, see Check for available COM ports above.



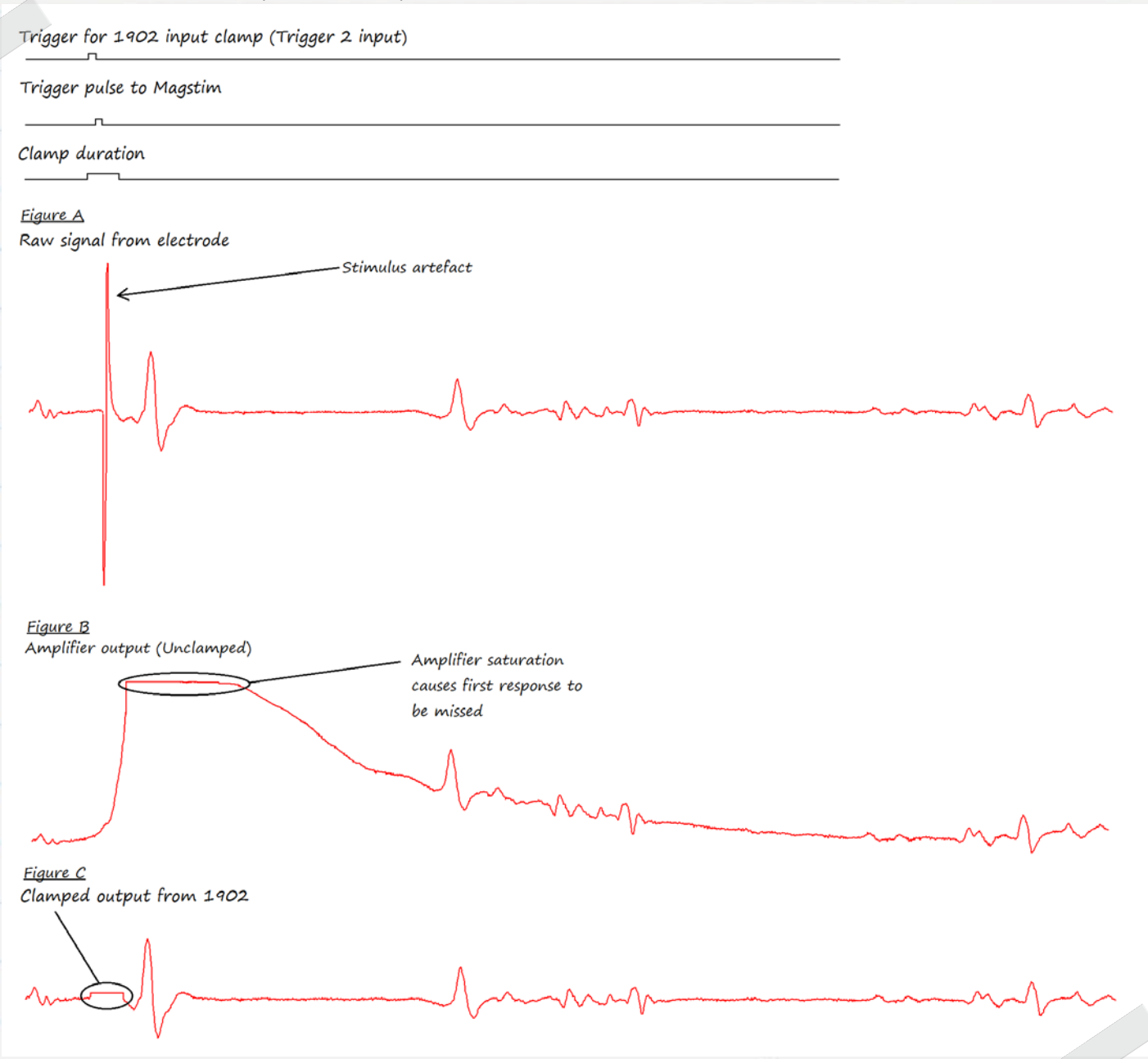


The Port list shows the current 1902 channel and the Input drop down list sets the input mode for the selected 1902. With an input clamp the list will display EEG unclamped and will also contain a list of times in milliseconds. These specify the length of time to apply the input clamp in response to a pulse input on the Trigger 2 port of the 1902. If the clamp option is not fitted you should set the input to use Isolated EEG.

The Gain and Offset controls are used to scale the incoming data. The Filter settings are used to apply input filtering as required.

The EEG unclamped, clamp duration settings and Isolated EEG options all use the isolated stage of the amplifier and are the only inputs suitable for recording responses from surface electrodes.

Triggering the input clamp



Stimulus artefacts can often saturate the input of an amplifier, causing a period of 'lost' recording while the amplifier input returns to a normal level. This can cause problems if the response is very fast or is being recorded from close to the site of stimulation. The diagram above shows a fast MEP response from the electrode (Fig. A) that is missed due to the amplifier saturation caused by the stimulus artefact (Fig. B).

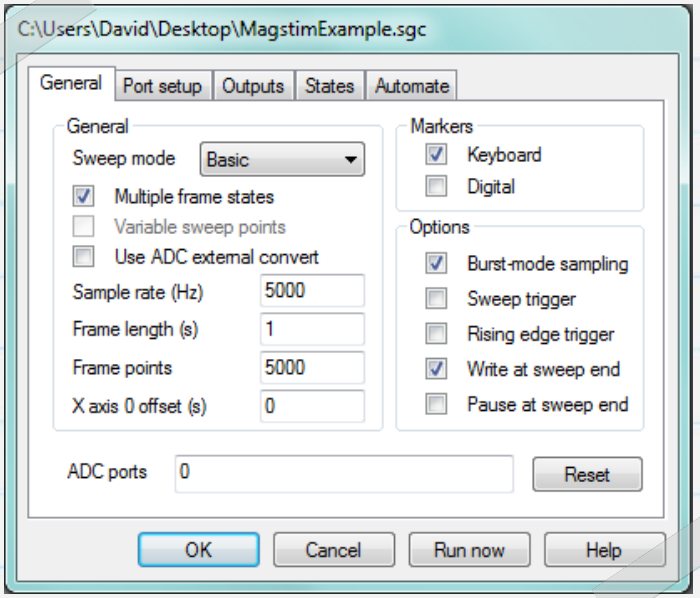
The CED 1902 amplifier can be fitted with an input clamp option that suppresses the artefact by clamping the amplifier input to ground during stimulation. This prevents saturation of the amplifier input, allowing fast responses to be recorded (Fig. C).

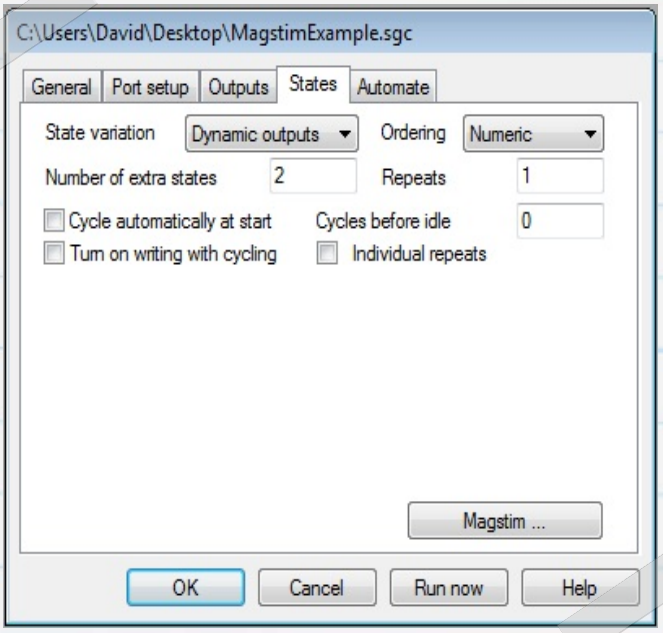
The input clamp should be triggered marginally before the Magstim to ensure that the clamp circuit is fully engaged before the stimulus is applied, as in the above diagram. One way to achieve this is to use a single pulse output of 0.5 to 1ms duration and route this to both the trigger input of the Magstim and the Trigger 2 input using a T-piece. The same pulse can then trigger the 1902 clamp with the rising edge of the pulse and the Magstim with the falling edge, ensuring the necessary delay. Alternatively you can set up a second pulse on another digital output to trigger the 1902 clamp circuit separately from the Magstim. See setting up output triggers for further details.

When using the input clamp, you should turn off the AC couple option and set the 1902 high-pass filter setting to None.

Magstim control setup

The General tab of the sampling configuration is used to set the sweep mode, number of channels to record and sample rate, as well as various options for recording marker channels, saving data and triggering sampling. To allow access to the Magstim settings, the Multiple frame states checkbox must be selected. This enables the States tab in the dialog where we can specify multiple states (stimulus protocols) and set-up the intensity and timing settings for the Magstim unit.



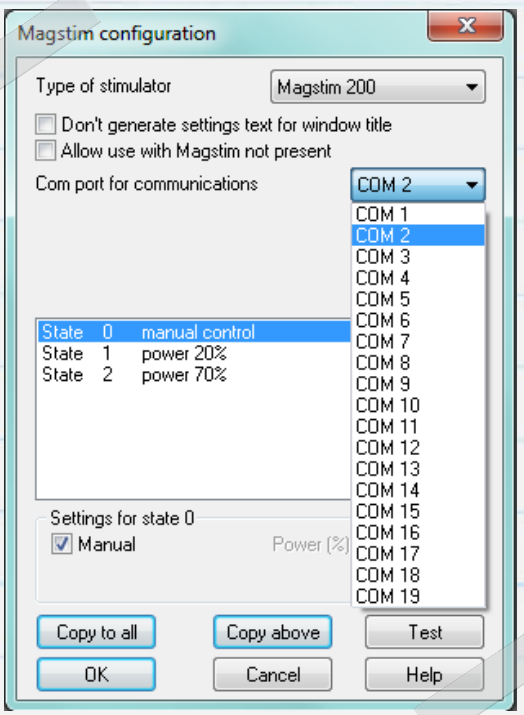


In the States tab the State variation is set to Dynamic outputs. The Number of extra states field is used to set the number of different intensity and trigger settings you want to specify for the Magstim. These extra states are in addition to the basic state 0, which gives manual control by default.

For example, consider an experiment where you would like to apply two different stimuli, one at low power intensity and one at high power intensity. Setting the Number of extra states field to 2, as in this example, will allow you to set-up two additional stimulus settings in the Magstim configuration. In this case we use one for 20% intensity and one for 70% intensity.

States can be set-up to cycle automatically during an experiment in numeric, random or semi-random order, or by following a sequence of steps defined by a protocol. For this example we have set-up numeric ordering.

Click on the Magstim... button to configure the type of Magstim to use and a COM port for communication with the unit. See Check for available COM ports for more details.



If you are using a CED 1902 amplifier you should make sure that the Magstim is set to use a different COM port.

The list of states in use is displayed and can be edited by clicking on them in the list and then changing the settings in the dialog. Depending on the type of Magstim selected, you will be able to change power intensity, number of pulses and pulse intervals.

Magstim control options by model

The table below lists all currently supported Magstim magnetic stimulators and the control options available for each model when using Signal and a 1401 interface.

Magstim	200*	BiStim*	200²	BiStim²	Rapid²	Super Rapid²	Super Rapid² Plus
Trigger input	✓	✓	✓	✓	✓	✓	✓
Power Intensity setting	✗	✗	✓	✓	✓	✓	✓
Pulse Intervals	✗	✗	✗	✓	✓	✓	✓
Pulse frequency	✗	✗	✗	✗	✓	✓	✓
Single pulse mode	✗	✗	✗	✗	✓	✓	✓

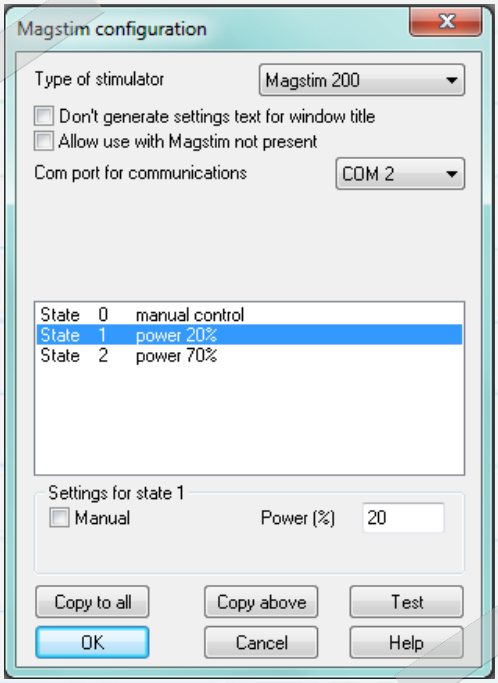
*Denotes older Magstim 200 and BiStim units without power intensity control options

Magstim 200 and BiStim units without external control

Older Magstim 200 and BiStim units can only react to pulse outputs in Signal for stimulus timing. See Setting up output triggers for further details. Power intensity settings and pulse intervals are set using the front panel controls on the Magstim unit.

Magstim 200² Settings

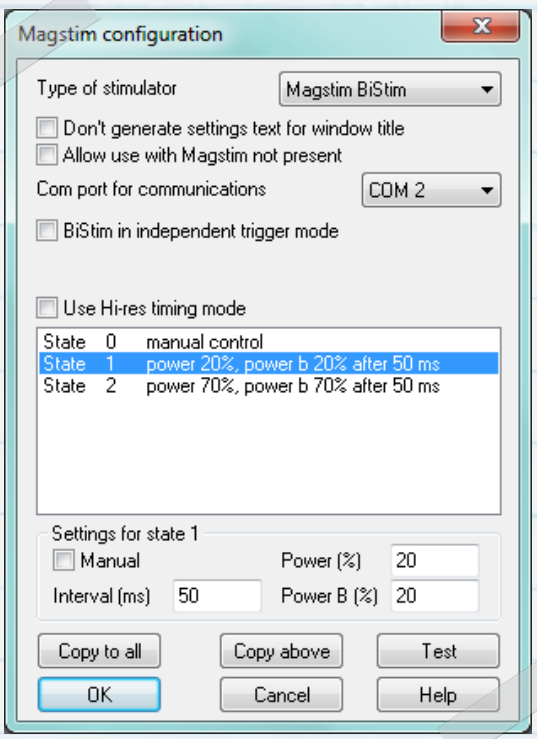
This configuration shows the available settings for a single Magstim 200² device. Power settings for each control state can be edited by double clicking the State number in the displayed list. State 0 can be set to give manual control of the Magstim device using the separate Settings for state 0 checkbox.



The Dual Magstim 200² option has the same settings as described here but requires two COM ports, one for each 200² unit.

Magstim BiStim² settings

BiStim units are comprised of two synchronised stimulators which can be used to deliver dual stimulus pulses. Normally the first pulse is delivered at the time of the external trigger and the second at a preset interval after the trigger, which can be set in the state settings of the Magstim configuration as displayed.



Setting an interval of Zero switches the BiStim into simultaneous pulse mode. In this mode both stimulators must use the same power level, which is taken as being the main Power setting in the configuration, with the power b setting ignored.

The Use Hi-res timing mode option can be used to set interval values between Zero and 999 milliseconds with a resolution of 1 millisecond.

Using a BiStim² in independent trigger (IBT) mode

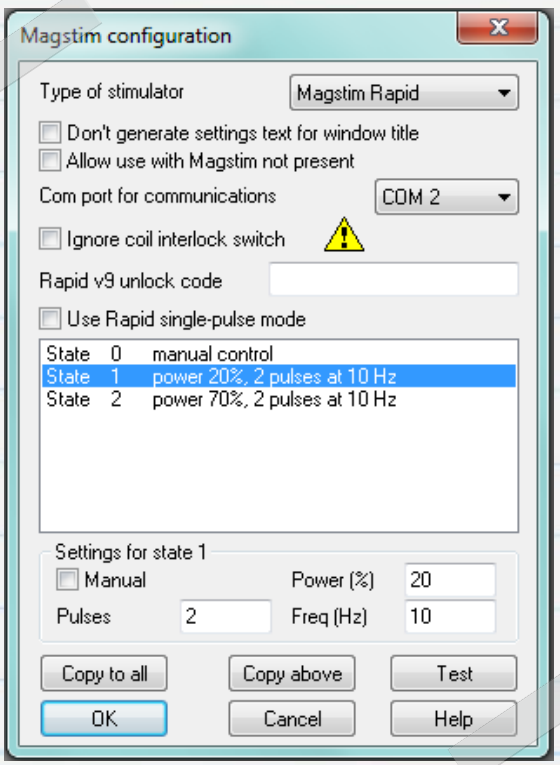
It is possible to use two digital output pulses to trigger both the first (Power) and second (Power B) stimulus. To use this method the unit must be set to use independent trigger mode (IBT mode) using the following controls on the BiStim front panel: Set the master BiStim user interface to Simultaneous Discharge, with an interpulse spacing of 0. Then hold down the UI stop button and rotate the power level knob anti-clockwise. The display on the bottom device should then show "E" to signify IBT mode.

When IBT mode has been set on the BiStim unit, The BiStim in independent trigger mode checkbox also needs to be selected in the Magstim configuration in Signal. This mode requires separate digital output connections from the 1401 to each of the synchronised units in the BiStim device.

When using independent trigger mode with different power intensity settings, DO NOT setup pulse outputs to trigger the units with an interval of less than 1ms

Magstim Rapid² settings

Magstim Rapid devices are capable of producing a train of stimulus pulses at high rates. The Rapid may have a separate control system that has to be disconnected to gain access to the serial line control port for connection to a PC. See your Rapid device documentation for details.

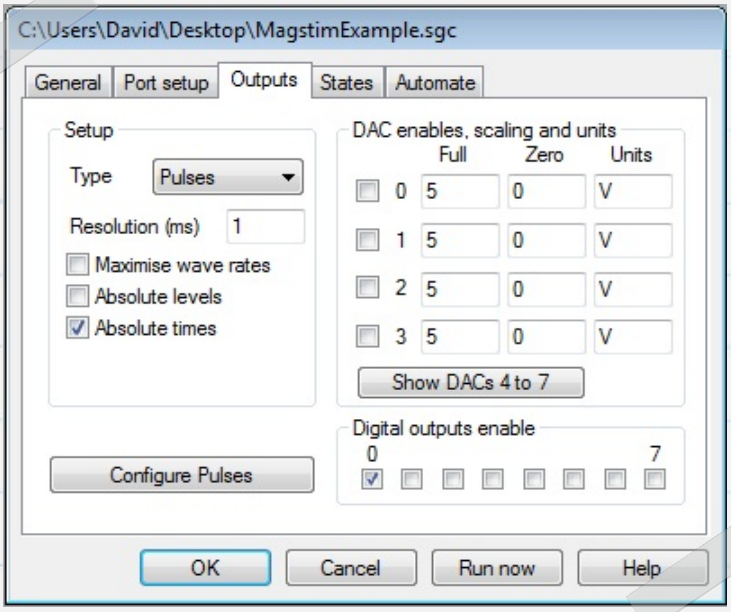


You can set the intensity, number and frequency of pulses in the settings section of the configuration. There is also a checkbox option to use single-pulse mode which allows power levels up to 110%. If this option is selected, the Rapid produces one stimulus pulse per trigger, ignoring the pulse train parameters.

The **Ignore coil interlock switch** option disables the switch on the Magstim coil handle so that the device will fire in response to triggers without the button being depressed. Magstim do not recommend bypassing the switch as this is a safety feature and should not be used unless absolutely necessary. Rapid devices with the latest version 9 firmware require an unlock code, as an additional safety precaution. The unlock code for these devices can be obtained by contacting Magstim.

Setting up output triggers

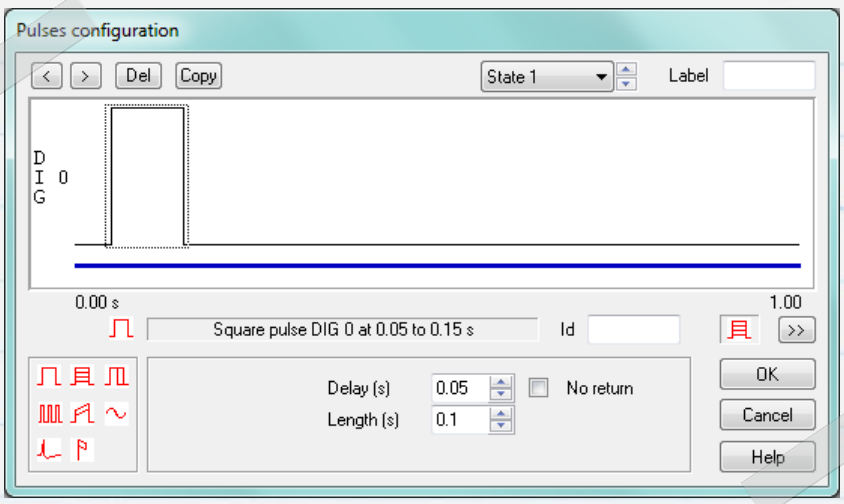
The final requirement is to set up pulse outputs for each state that can then be used to trigger the Magstim to deliver the stimulus for the given state. Pulse outputs are created in the Outputs tab of the sampling configuration. This section contains settings for enabling and disabling digital and DAC outputs. For this example of Magstim control we are only interested in using one digital output. Click on Configure pulses to open the graphical pulse editor.



If using a BiStim² in IBT mode you will need to enable two digital outputs, one to trigger each of the units of the BiStim²

Example pulse outputs to trigger a Magstim device

The graphical pulse editor shows the selected outputs as 'tracks' in the area at the top of the dialog. The thicker blue track is the control track which is used to set frame intervals when using other sweep modes. A pulse palette is available in the bottom left hand corner of the configuration from which pulses can be dragged onto any of the available output tracks.



Each of the states that we specified earlier in the Magstim configuration can have a different set of pulses configured, allowing multiple stimulus protocols to be arranged and used throughout an experiment. There is a drop-down list at the top of the dialog from which you can select the state to configure.

In our example configuration the Basic 0 state is left blank, as this is going to be our manual control state with no output triggers. State 1 and State 2 each have a trigger pulse set at 10ms. This will trigger the Magstim at 10ms into the sampled sweep and generate a pulse at 20% intensity for State 1 and 70% intensity for State 2, as we have previously specified in the Magstim configuration. Click OK to close the pulse configuration and return to the sampling configuration.

Sampling data

From the sampling configuration, click Run now to start a new data file ready for sampling. As well as a toolbar for starting and stopping sampling you will also see the Multiple states toolbar, as displayed below. During sampling this shows the current state and has controls for starting and pausing state cycling as well as options for manual selection of the current state.

Click Start in the sampling toolbar to begin sampling data. The default output and control state is set to Basic 0 when sampling starts. You can select the current output state using the toolbar buttons or the drop-down list to apply each state manually, or click Cycle to apply the states in numeric order as specified in the States tab of this example sampling configuration. State 1 and State 2 will set power intensity values of 20% and 70% respectively and will generate output pulses at the start of sampled sweeps to trigger the Magstim.