multichannel systems

Stimulus Generator 1000 Series Manual

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1 Introduction

1.1 About this Manual

This manual comprises all important information about the installation and operation of the stimulus generator STG1000 series and MC_Stimulus software. It is assumed that you have already a basic understanding of technical and software terms. No special skills are required to read this manual.

If you are using the STG for the first time, please read the **important safety advice** before **installing the hardware** and **software** (see Important Safety Advice, where you will find important information about the installation and first steps).

The **printed manual** and **Help** are basically the same, so it is up to you which one you will use. The Help offers you the advantage of scrolling through the text in a non-linear fashion, picking up all information you need, especially if you use the **Index**, the **Search** function, and the **Browse Sequences**. If you are going to read larger text passages, however, you may prefer the printed manual.

The device and the software are part of an ongoing developmental process. Please understand that the provided documentation is not always up to date. Check also the MCS Web site (www.multichannelsystems.com) from time to time for downloading up-to-date manuals and new software versions.

1.2 Terms of Use for MC_Stimulus

You are free to use MC_Stimulus for its intended purpose. You agree that you will not decompile, reverse engineer, or otherwise attempt to discover the source code of the software.

1.3 Limitation of Liability

Multi Channel Systems MCS GmbH makes no guaranty as to the accuracy of any and all tests and data generated by the use the MC_Stimulus software. It is up to the user to use good laboratory practice to establish the validity of his findings.

To the maximum extent permitted by applicable law, in no event shall Multi Channel Systems MCS GmbH or its suppliers be liable for any special, incidental, indirect, or consequential damages whatsoever (including, without limitation, injuries, damages for data loss, loss of business profits, business interruption, loss of business information, or any other pecuniary loss) arising out of the use of or inability to use MC_Stimulus or the provision of or failure to provide Support Services, even if Multi Channel Systems MCS GmbH has been advised of the possibility of such damages.

2 Important Information and Instructions

2.1 Operator's Obligations

The operator is obliged to allow only persons to work on the device, who

- are familiar with the safety at work and accident prevention regulations and have been instructed how to use the device;
- are professionally qualified or have specialist knowledge and training and have received instruction in the use of the device;
- have read and understood the chapter on safety and the warning instructions in this manual and confirmed this with their signature.

It must be monitored at regular intervals that the operating personnel are working safely.

Personnel still undergoing training may only work on the device under the supervision of an experienced person.

2.2 Guaranty and Liability

The *General conditions of sale and delivery* of Multi Channel Systems MCS GmbH always apply. The operator will receive these no later than on conclusion of the contract.

Multi Channel Systems MCS GmbH makes no guaranty as to the accuracy of any and all tests and data generated by the use of the device or the software. It is up to the user to use good laboratory practice to establish the validity of his findings.

Guaranty and liability claims in the event of injury or material damage are excluded when they are the result of one of the following.

- Improper use of the device
- Improper installation, commissioning, operation or maintenance of the device
- Operating the device when the safety and protective devices are defective and/or inoperable
- Non-observance of the instructions in the manual with regard to transport, storage, installation, commissioning, operation or maintenance of the device
- Unauthorized structural alterations to the device
- Unauthorized modifications to the system settings
- Inadequate monitoring of device components subject to wear
- Improperly executed and unauthorized repairs
- Unauthorized opening of the device or its components
- Catastrophic events due to the effect of foreign bodies or acts of God

2.3 Important Safety Advice

Warning: Make sure to read the following advice prior to install or to use the device and the software. If you do not fulfill all requirements stated below, this may lead to malfunctions or breakage of connected hardware, or even fatal injuries.

Warning: Obey always the rules of local regulations and laws. Only qualified personnel should be allowed to perform laboratory work. Work according to good laboratory practice to obtain best results and to minimize risks.

The product has been built to the state of the art and in accordance with recognized safety engineering rules. The device may only

- be used for its **intended purpose**;
- be used when in a **perfect condition**.
- Improper use could lead to serious, even fatal injuries to the user or third parties and damage to the device itself or other material damage.

Warning: The device and the software are **not** intended for medical uses and **must not** be used on humans.

Malfunctions which could impair safety should be rectified immediately.

High Voltage

Electrical cords must be properly laid and installed. The length and quality of the cords must be in accordance with local provisions.

Only qualified technicians may work on the electrical system. It is essential that the accident prevention regulations and those of the employers' liability associations are observed.

- Each time before starting up, make sure that the **mains supply** agrees with the specifications of the product.
- Check the **power cord** for damage each time the site is changed. Damaged power cords should be replaced immediately and may never be reused.
- Check the **leads** for damage. Damaged leads should be replaced immediately and may never be reused.
- Do not try to insert anything sharp or metallic into the vents or the case.
- Liquids may cause short circuits or other damage. Keep the device and the power cords always **dry**. Do **not** handle it with wet hands.

Requirements for the installation

- Make sure that the device is not exposed to direct sunlight. Do not place anything on top of the device, and do not place it on top of another heat producing device. Otherwise, the device may overheat.

3 First Use of the Stimulus Generator

3.1 Welcome to the STG and MC_Stimulus

Product line overview

Stimulus generators of the 1000 and 2000 series are general/purpose stimulators designed to serve a very wide variety of applications, both *in vitro* and *in vivo*.

Flexible and easy-to-use MC_Stimulus software enables complex stimulus waveforms (both **current** and **voltage**). Waveforms designed in the program or imported from an external ASCII file are converted by the connected STGs into pulses, which are sent to stimulating electrodes. Stimulus isolation units (**SIU**) for **each** channel are included. Thus, no external SIUs are required.

A trigger input and output for TTL signals allows to synchronize the stimulus generator with other instruments. Triggering of other devices via programmable TTL pulses (**Sync Out**) is possible, as well as triggering of the STG by external devices via the **Trigger In** input. For example, you can synchronize **stimulation** and **recording** with a digital trigger signal sent from the **Sync Out** output of the STG to the MC_Card.

Stimulus generators are available for simultaneous stimulation on up to **8 channels** (**STG1001STG1008**, **STG2004**, **STG2008**).

2000 Series

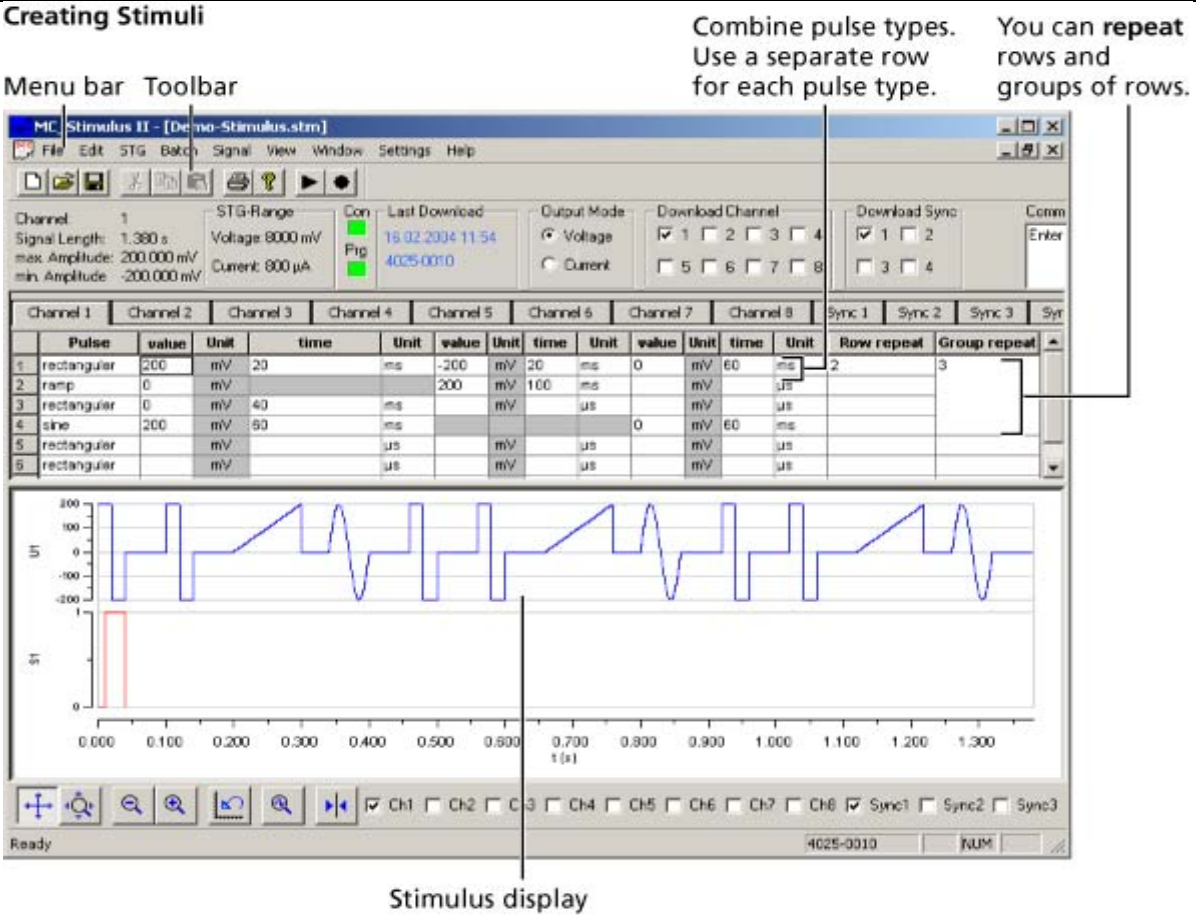
The real-time stimulus generator of the 2000 series is an advanced version and the world's first STG that is able to send continuous pulse streams to stimulating electrodes. In addition, you can trigger all (up to 8) channels **separately** by external TTL pulses. **4 trigger inputs (Trigger In)** and**4 trigger outputs (Sync Out)** are shared by 8 channels in the 8-channel version.

MC_Stimulus

Stimuli are created user-friendly by entering the desired pulses (**rectangular**, **ramp**, or **sine** waveforms) into a **worksheet**. Waveforms can be combined freely to create virtually any stimulus pattern.

Created stimuli are displayed in a **WYSIWYG stimulus display**. All channels are set up separately.

For even more convenience, **repetitive** stimulus patterns do not have to be entered separately, but can be **grouped** and **looped**. You can also **import** waveforms in **ASCII** file format and use them for stimulation. You can **print** and **save** stimuli and **comments** for later use and documentation of your experiments.



3.2 Setting Up and Connecting the STG

Provide a **power supply** and a **computer** with RS232 serial port in the immediate vicinity of the installation site. Make sure the STG is **switched off** before you connect it to the power supply.

1. Place the STG on a stable surface, where the air can circulate freely and the STG is not exposed to direct sunlight.
2. Plug the main cable into the socket on the back of the STG.
3. Connect the main cable to the power outlet.
4. Connect the RS232 connector to the serial port of the computer. The computer connection is necessary for **programming** the STG, but **not** for operating it (except in **Batch** mode).
5. Connect the required output channels with 2 mm plug cables to the stimulating electrodes. Use the +U or U outputs for voltage stimuli, and +I or I outputs for current stimuli. Connect the appropriate ground to the ground input of the stimulation setup, for example to the ground input of the MEA1060 amplifier. See also chapter "Output Signals" for more information and illustrations showing suggested setups.
6. (Optional) Connect the required Trigger In input with a BNC cable to an instrument that produces TTL signals for triggering the STG.
7. (Optional) Connect the required Sync Out output with a BNC cable to a following instrument that you want to be triggered by TTL signals from the STG, for example to one of the 16 digital inputs of the MC_Card.
8. Switch the STG on by pressing the toggle switch on the rear panel.

3.3 Installing the Software

System requirements

Software: One of the following Windows© operating systems is required: **Windows 2000** or **Windows XP** (**English** and **German** versions supported). Other language versions may lead to software errors.

Hardware: **RS232** serial port

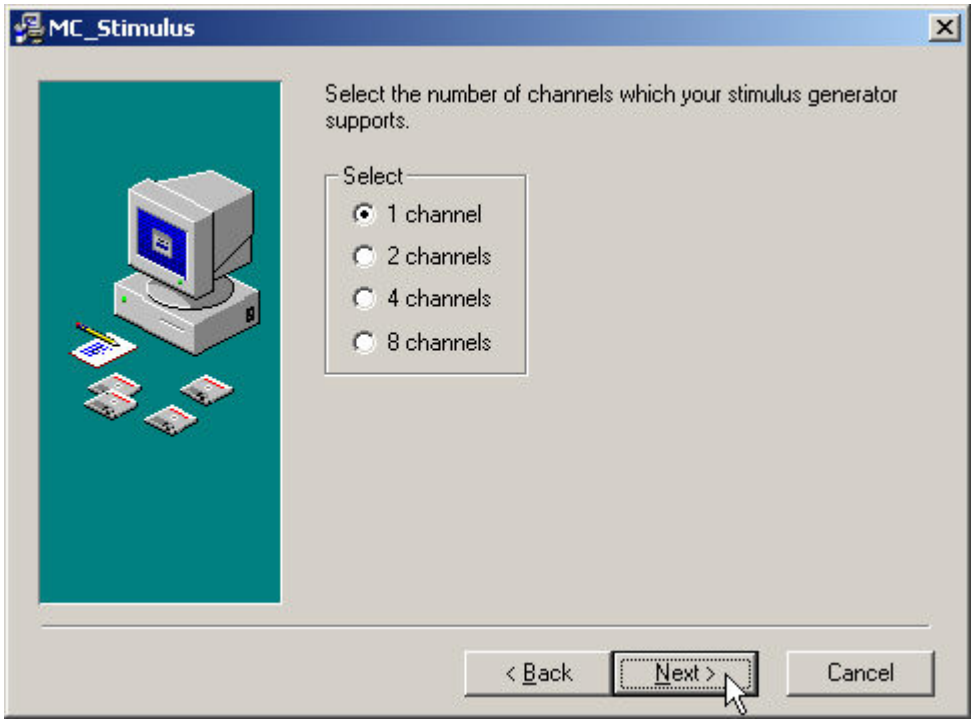
Installing the software

Please check the system requirements before you install the software. MCS cannot guarantee that the software works properly if these requirements are not fulfilled.

Important: Please make sure that you have full control over your computer as an **administrator**. Otherwise, is possible that the installed software does not work properly.

1. Double-click **Setup**.exe on the installation volume.
   The installation assistant will show up and guide you through the installation procedure.

2. Follow the instructions of the installation assistant. Please select the appropriate maximum number of analog output channels according to the connected STG. If you have different STGs in use, choose the highest number.



When you have finished the installation of the MC_Stimulus software, you can now operate the STG.

4 Operating the STG

4.1 Operation Overview

Warning: Make sure that you do not come in contact with the cables or the connectors of the STG after you have started the STG. The high voltage and power can lead to **injuries**.

Warning: Do not start the STG if you are unsure about the channel configuration or the nature of the downloaded file.

1. Set up your experiment.
2. Switch the STG on.
3. Set up your stimuli with the MC_Stimulus program.
4. Send the stimulus sequence from an MC_Stimulus file to the STG.
5. Start the STG either manually by pressing the **Start/Stop** button on the front panel, with the **software controls**, or with an **external trigger**.

Creating stimuli

Stimuli are created user-friendly by entering the desired pulses (rectangular, ramp, or sine waveforms) into an MC_Stimulus worksheet. Waveforms can be combined freely to create virtually any stimulus pattern. Created stimuli are displayed in a WYSIWYG window.

Starting stimulation

Note: You need a computer connection only when you are using the software controls for starting and stopping the stimulus generator. When you are using the STG interface or an external control (trigger), you can disconnect the stimulus generator from the computer and operate it independently. But you cannot remove the STG from the power connection. The memory is cleared when the STG has lost power.

After the download of the stimulus file on the STG, you can start the stimulation. There are several ways to start the STG.

MC_Stimulus interface: You can start the stimulation directly after the download (with the command **Download and Start (sel.)** or **Download and Start (all)**, or also later with the command **Start**. You can stop stimulation with the command **Stop**.

STG interface: You can start the stimulation by pressing the **Start/Stop** button on the **front panel** of the STG. Press the button again to stop the stimulation.

External control: You can start the stimulation on a **trigger** from an external device, for example, a switch. The trigger works the same way as when you press the **Start/Stop** button.The STG is stopped when a trigger event occurs during the time when any channel is still active.

STG status control

Two status control LEDs (light-emitting diode) are present on the front panel of the STG to give you a quick overview on its status.

POWER Lights **yellow** during startup. Lights **green** if STG is on. Lights **red** if STG is in a bad state.

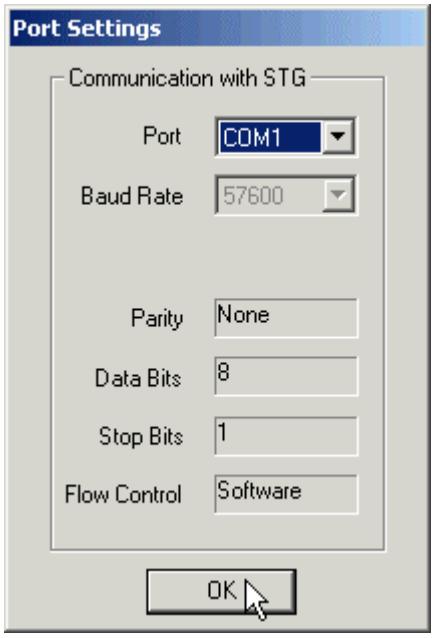
SWEEP Lights **green** if stimulus file has been downloaded to STG. STG is now ready to use. Lights **orange** when stimulation is running, that is, output channels are active.

4.2 Operating Multiple STGs

If you have more than one STG connected to the same computer, you can choose which STG you like to control from the currently active MC_Stimulus program.

- The **serial port** of the currently active STG is displayed on the status bar of the currently active instance of the MC_Stimulus program.

- Click **Port Settings** and then select the serial port to which the selected STG is connected.



- You can open multiple instances of the MC_Stimulus program and control multiple STGs at the **same** time. Please make sure that you control **each** STG only by **one** MC_Stimulus instance.
- You can also open only **one** MC_Stimulus instance and control multiple STGs one **after** the other by the same instance. Simply change the **Port Settings** and select the next STG when you have finished to program the first. The STGs can be operated without a computer connection.

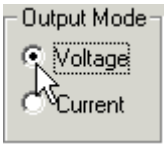
5 Programming Stimulus Protocols

5.1 MC_Stimulus Worksheet

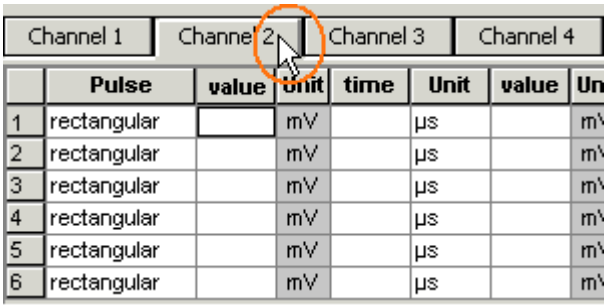
You can freely combine any pulse types. Use a separate row for each pulse type.

Hint: Several tools are provided for editing whole columns at once or autocreating entries.

1. Select the desired **output type** first. Click either **Voltage** or **Current** under **Output Mode** on the file window of MC_Stimulus.

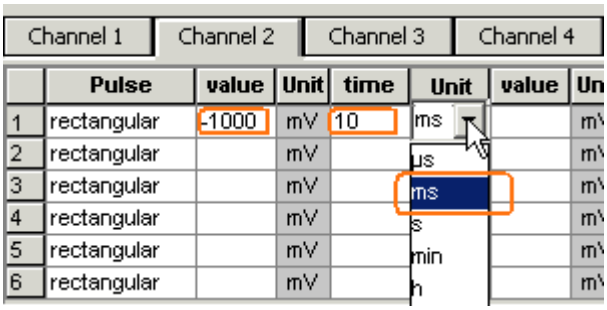


2. Click a tab to select an **output channel**.
The according channel worksheet is brought to front.

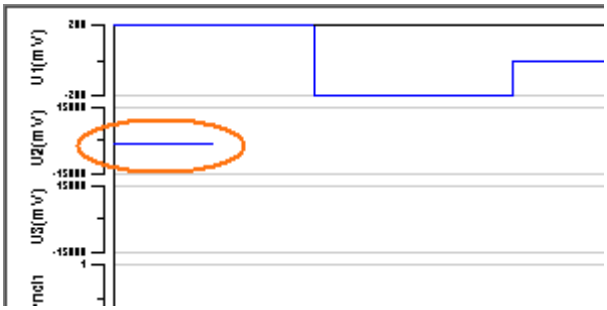


3. Now you can enter the pulses into the worksheet. Select a **Pulse** type (either **rectangular**, **ramp**, or **sine**).

4. Enter the desired voltage steps and a time length for each step.



The according pulse is displayed in the WYSIWYG display at once.



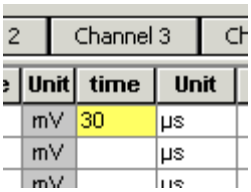
5.2 Pulse Types

Three basic pulse types are available in MC_Stimulus. You can create virtually any pulse by combining different types.

- Rectangular
- Ramp
- Sine wave

Note: The **time resolution** is **20 µs**. When you enter time steps that are not a multiple of 20 µs, the length of the step is **internally** adjusted to a valid value. The changed values do **not** show up in the worksheet, but invalid values are highlighted in yellow or red. The minimum voltage resolution is **2 mV**, the current resolution is **1 µA**. Please regard also the **minimum** and **maximum output voltage/current** of your STG version.

Note: If you work **near** the resolution **limits** of the STG, the **output pulses** may **differ** from the **programmed pulses**. In this case, you should check the output with an oscilloscope. Please see also the "Analog Output Signals" chapter.

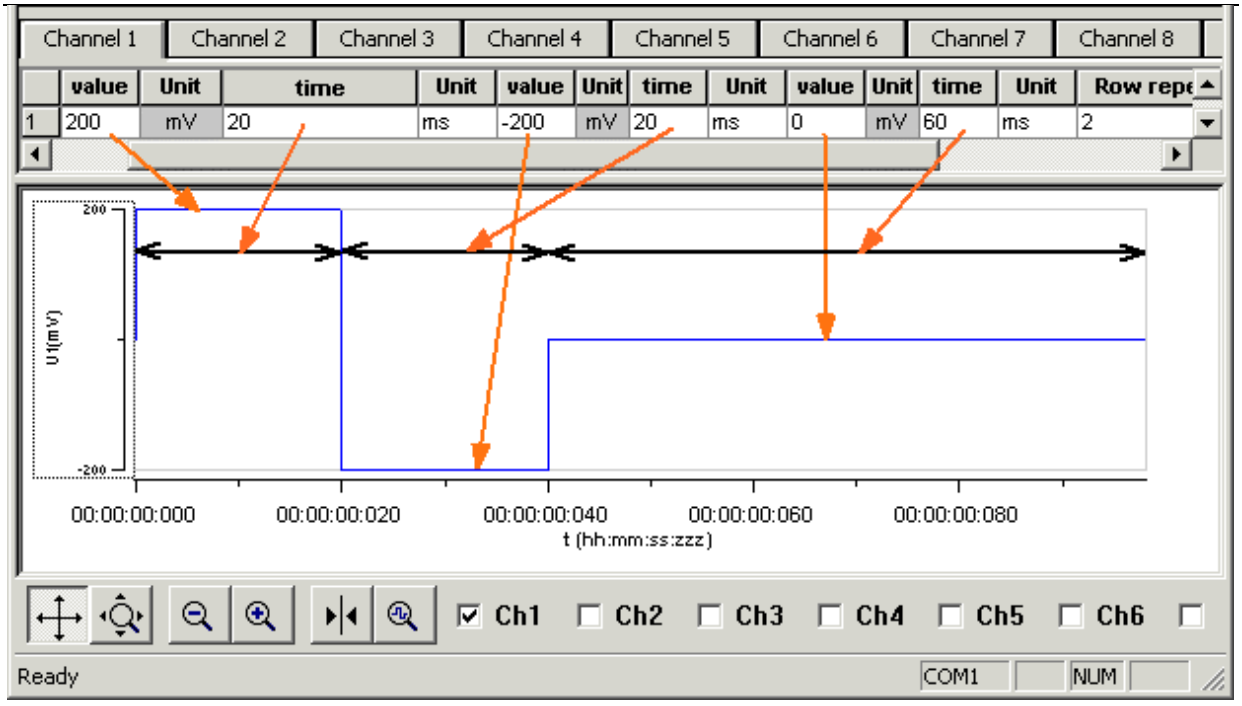


Note: The **total pulse length** of all channels has to be **identical**. If the stimuli of two channels have different lengths of time, the last used value of the shorter channel is **kept** until the longest stimulus has been finished. You will be notified with an error message at the beginning of the download.

Please note that the memory of the STG is limited. You will get an error message if the memory is full. The new generation of stimulus generators (STG2004/8) has 16 times more memory and an improved internal memory management, perfect for sophisticated or long-term stimulus protocols.

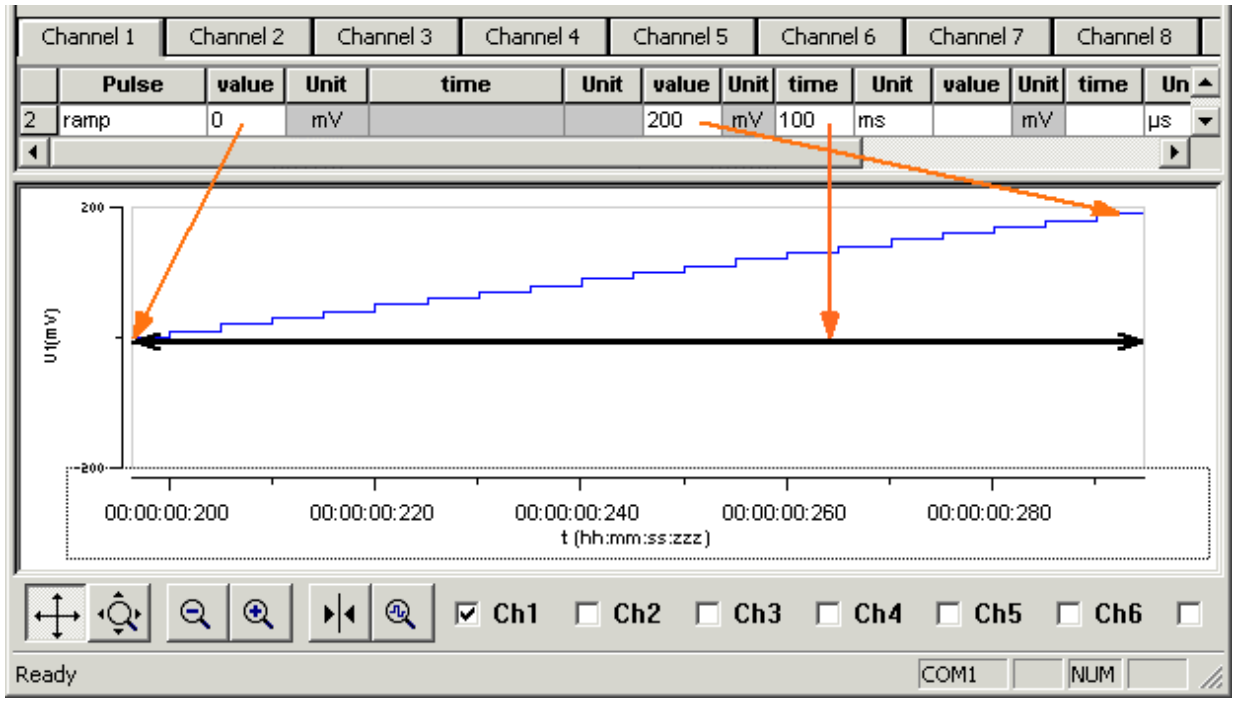
For the digital **Sync** channel, only bit patterns of 0 (LOW) and 1 (HIGH) can be programmed. A logical state of **1 (HIGH)** results in a **5 V** output signal, and a logical state of **0 (LOW)** results in a **0 V** output. Please note that the digital output is sent about **20 µs faster** than the analog output. Please see also the "Triggering Stimulation" chapter.

Rectangular pulse type



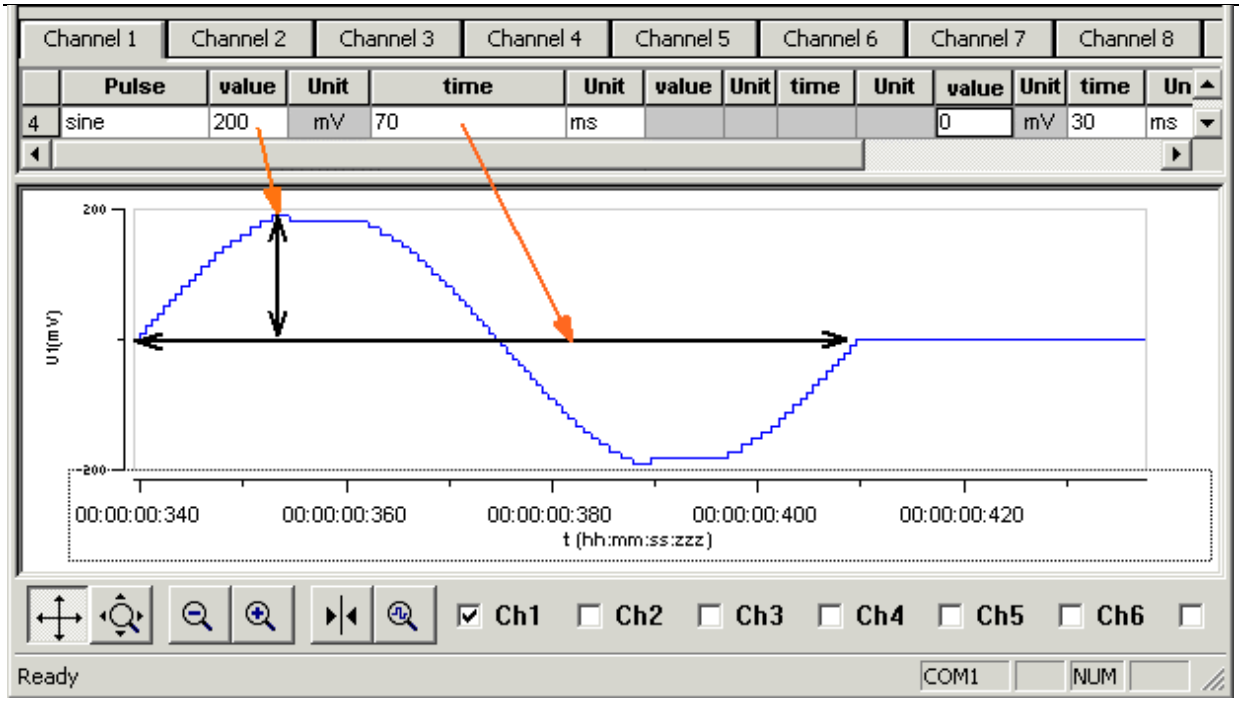
- Enter each voltage/current **level** and the **duration** of the pulse. The voltage/current jumps directly to the specified level. In one row, you can enter up to three voltage/current levels. Use the next row for programming more levels.

Ramp pulse type



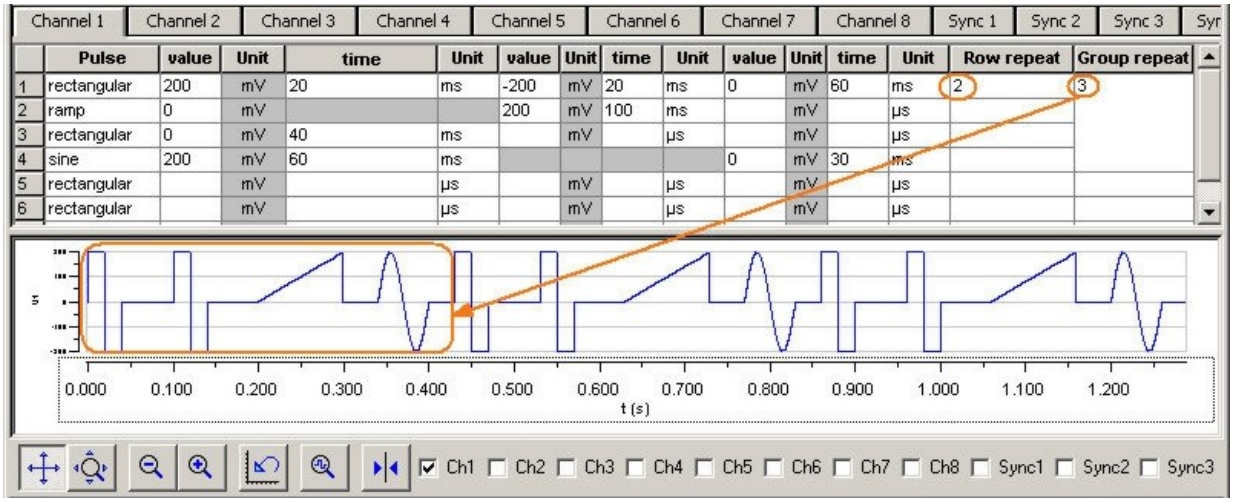
- Define the **starting point**, **end point,** and the **length** of the ramp. The ramp is then build according to these parameters in small single steps of 20 µs.

Sine wave pulse type



- Define the **amplitude** and the **period** of the sine wave. The sine wave is then computed according to these parameters with a minimum resolution of 2 mV and 20 µs. If you enter a negative amplitude, the sine wave starts with its negative alternation.

5.3 Autorepeating Pulses and Protocols



For entering complex stimuli easier and faster, you can **repeat rows** and **groups** instead of entering the pulses several times into the worksheet. You can repeat each single row. In the preceding example, the rectangular pulse in row 1 is repeated twice. You can also group several rows and repeat them altogether. In the example, pulses from rows 1 to 4 are grouped and repeated three times.

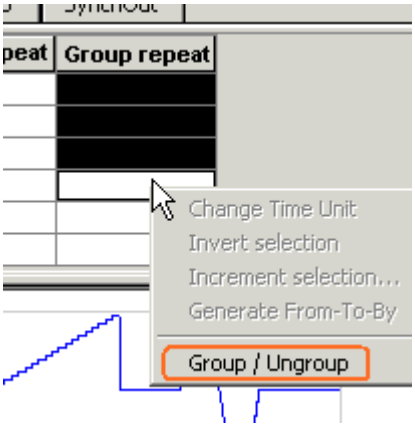
Repeating rows

- Type the number of repeats into the **Row Repeat** cell of the appropriate row.
The pulses of the complete row are than repeated the specified number of times.

Grouping and repeating groups

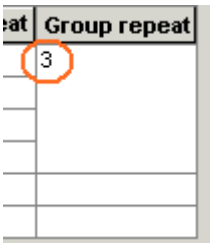
1. Select several cells by clicking and dragging cells in the **Group Repeat** column.
Selected cells are highlighted in black.

2. Point to the selected cells and right-click to open the context menu.



3. Click **Group/Ungroup**.
The corresponding rows are grouped now. This is indicated by a merging of the **Group Repeat** cells.

4. Type the number of repeats into the merged **Group Repeat** cell.



Repeating complete pulse protocols (autorepeat function), Continuous Mode

1.
2.

You can also repeat all stimuli on all channels, that is, the whole file either continuously (until stopped manually by the user) or a specified number of times.

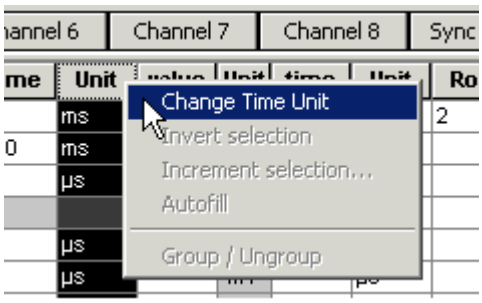
- Under **Repeat**, select continuously for repeating the stimulation until the STG is stopped by the user.
- Under **Repeat**, select n times and enter a number for repeating the stimulation n times.

5.4 Autocreating Entries and Editing Columns

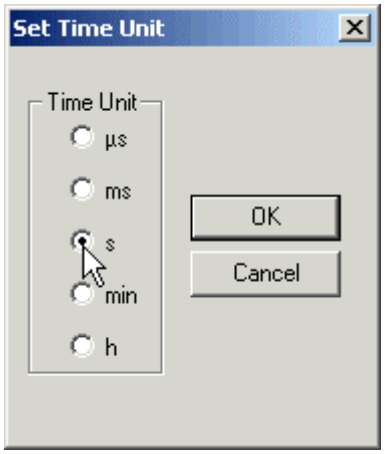
Changing time units for a complete column

1. Click any **Unit** column header to select a column.
The selected column is highlighted in black.

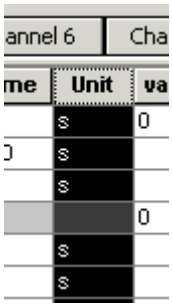
2. Right-click and click **Change Time Unit**.



3. Select the desired time unit.



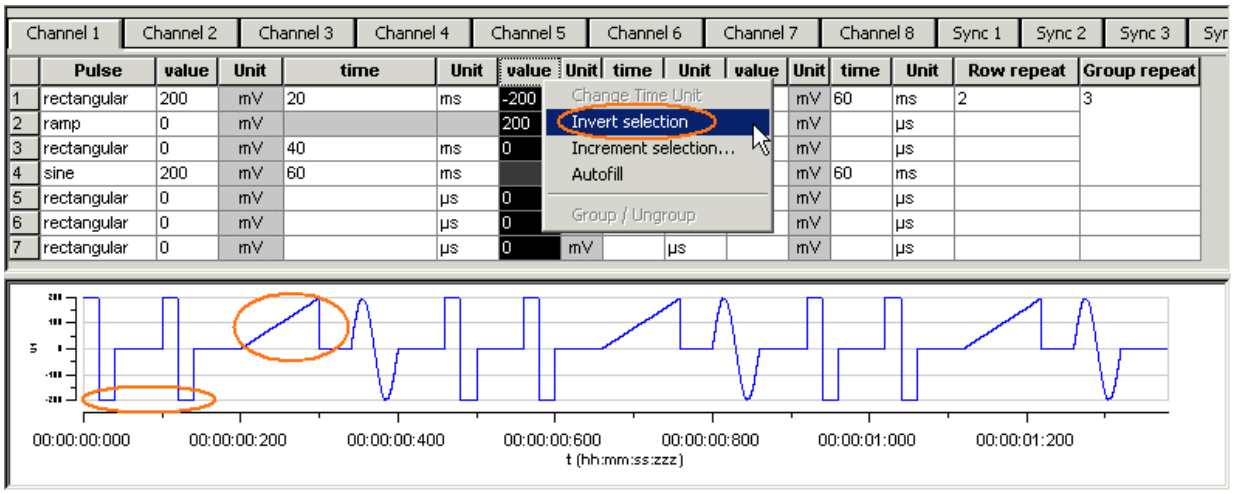
All units in the column are set to the selected time unit.



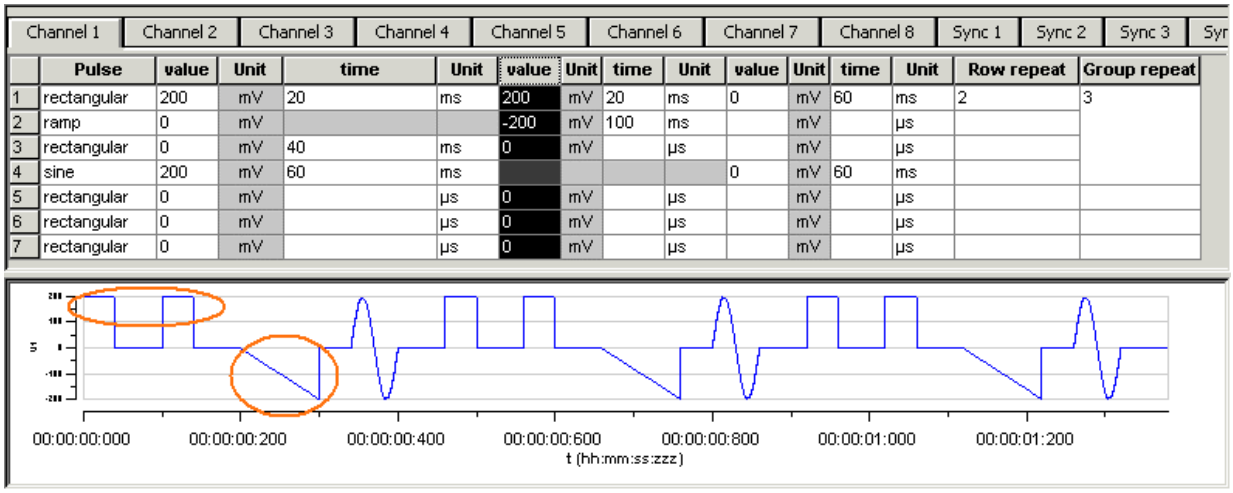
Inverting pulses in a column

1. Click any **Value** column header to select a column.
   The selected column is highlighted in black.

2. Right-click and click **Invert Selection**.



The polarity of the signals is switched from positive to negative and vice versa.



Incrementing columns

This feature is very convenient for setting up long and complex stimuli without entering each value manually. You can enter and edit multiple voltage values or time lengths.

You can keep all zero values **unchanged** with the option **Keep Zero**.

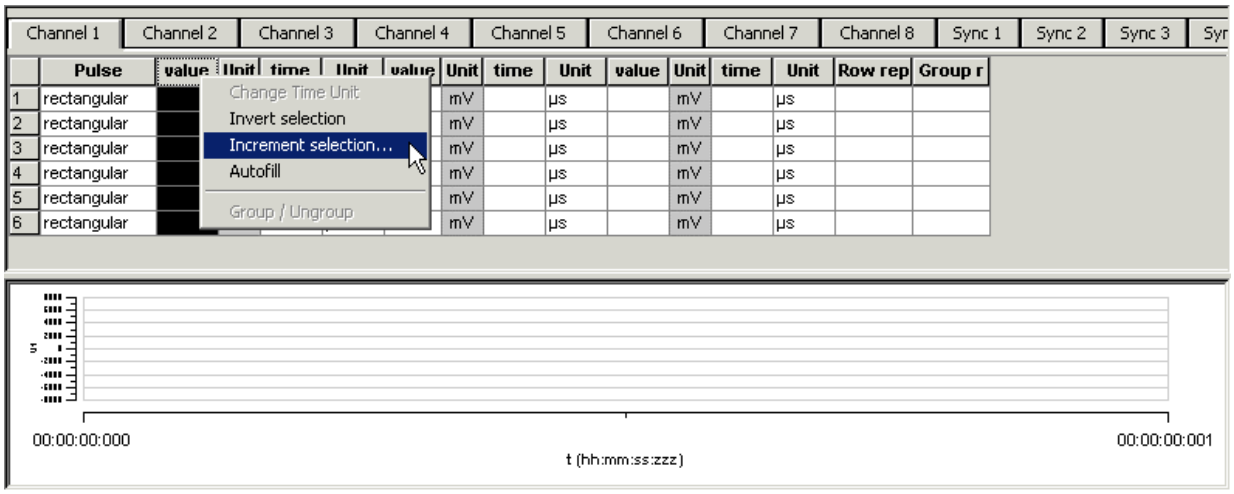
Apart from an absolute shift or increment factor, you can modify values by the **percentage** as well.

Shifting time or voltage/current values

You enter a value, which is added arithmetically to all values in the selected column. For example, if you enter "50", 50 is added to all values.

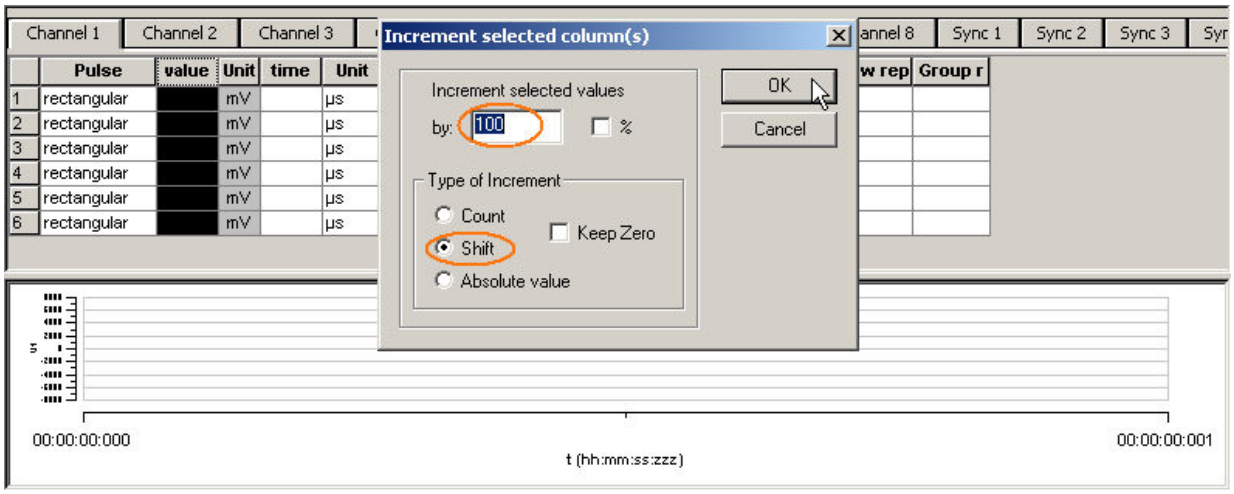
1. Click any **Value** or **Time** column header to select a column.
The selected column is highlighted in black.

2. Right-click and click **Increment Selection**.

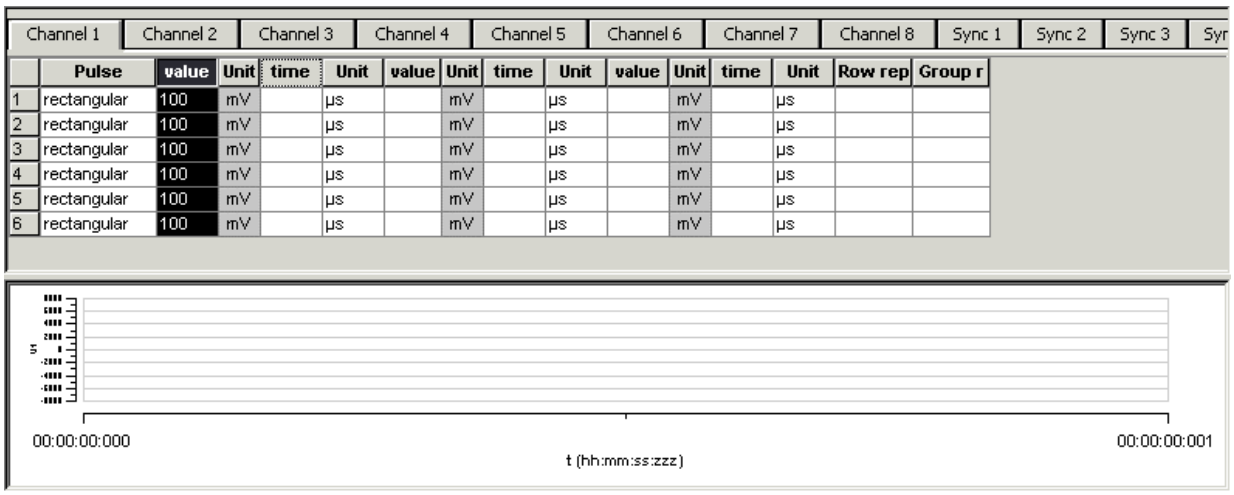


3. Under **Type of Increment**, select **Shift**.

4. Enter the desired value.



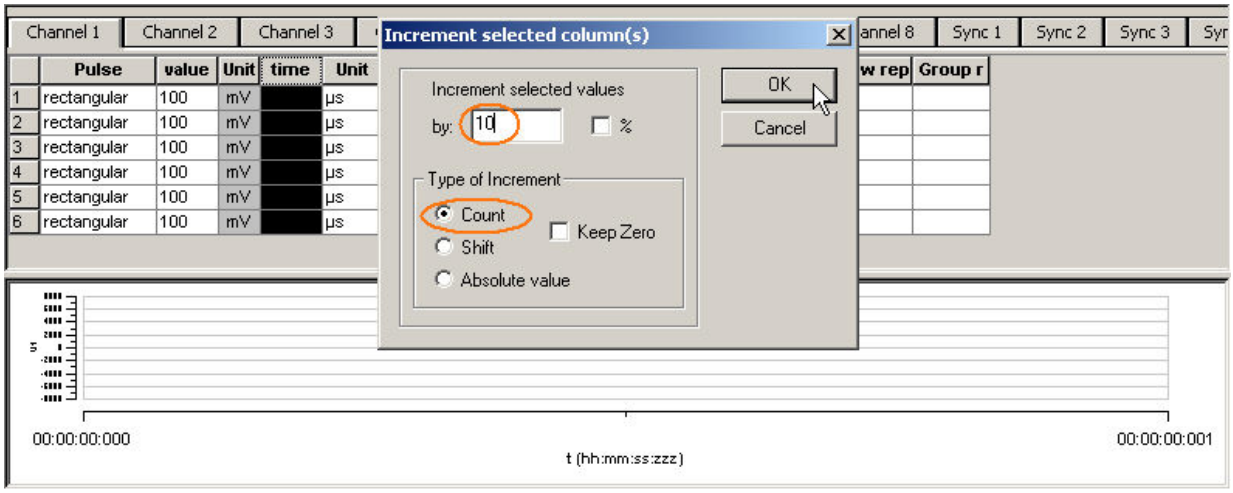
All values in the selected column are modified by the selected factor. In the example, 100 is added to all values, resulting in a total of 100 because the initial value has been 0.



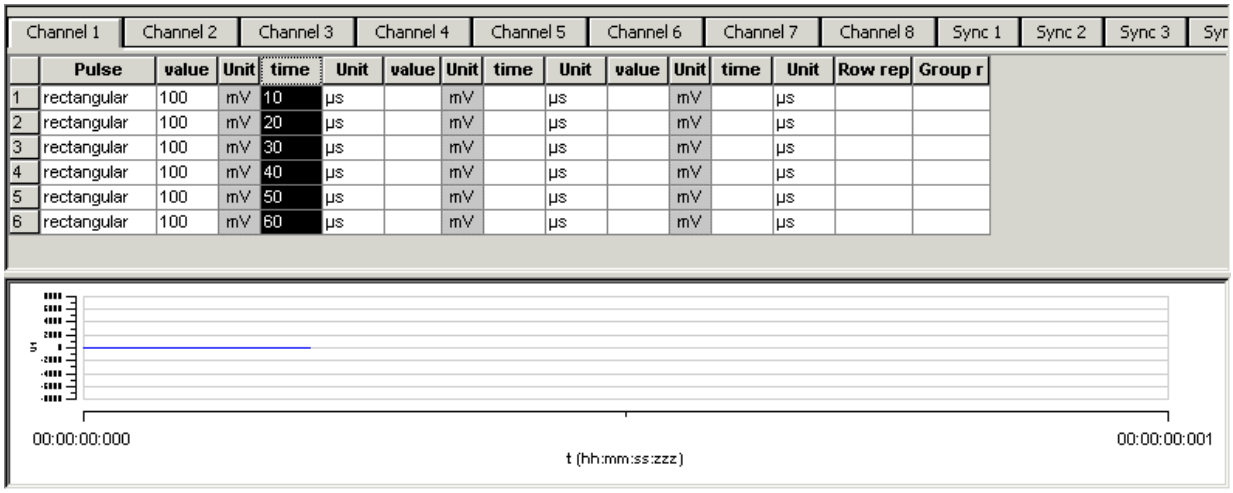
Creating time or voltage/current increments

With this option, you enter a base value for modification of all values in the selected column. The first row is modified by the base value. The second row is modified by the double value, the third row by thrice the base value, and so on. With this feature, you can easily set up time or voltage increments.

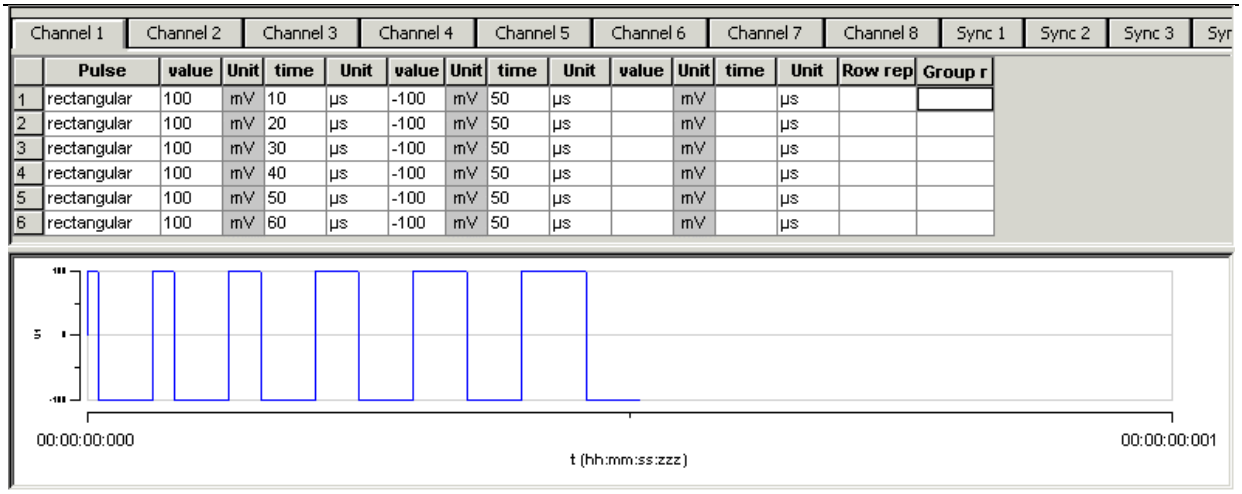
1. Under **Type of Increment**, select **Count**.
2. Enter the desired start value.



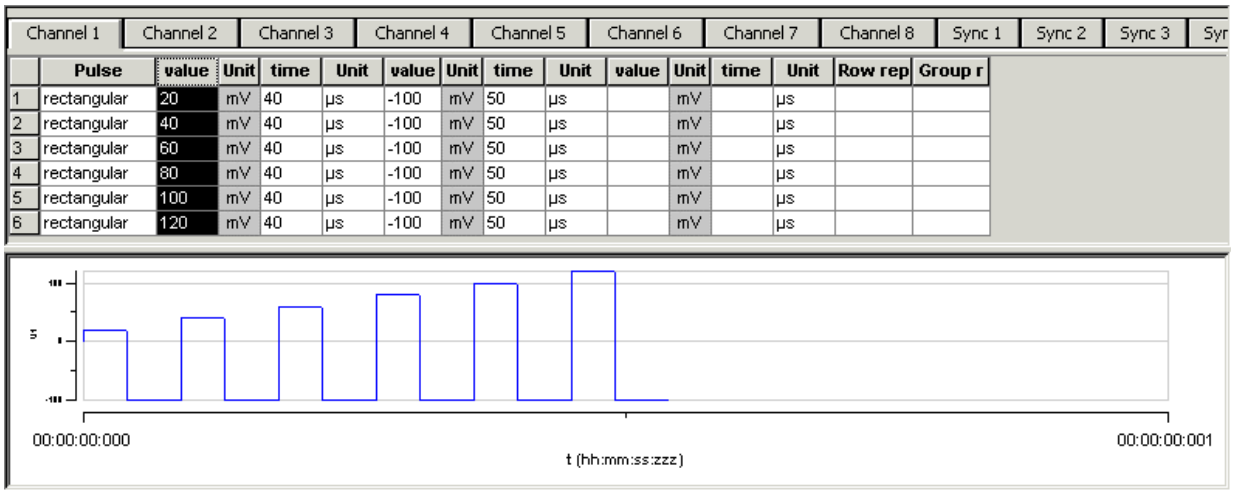
The value in the first row is incremented by the selected start value of 10. The next value is modified by the double value (20), and so on.



You can now fill further columns in the same way. Thus, you can easily set up a stimulus with incremented pulse lengths like this with only a few mouse-clicks.



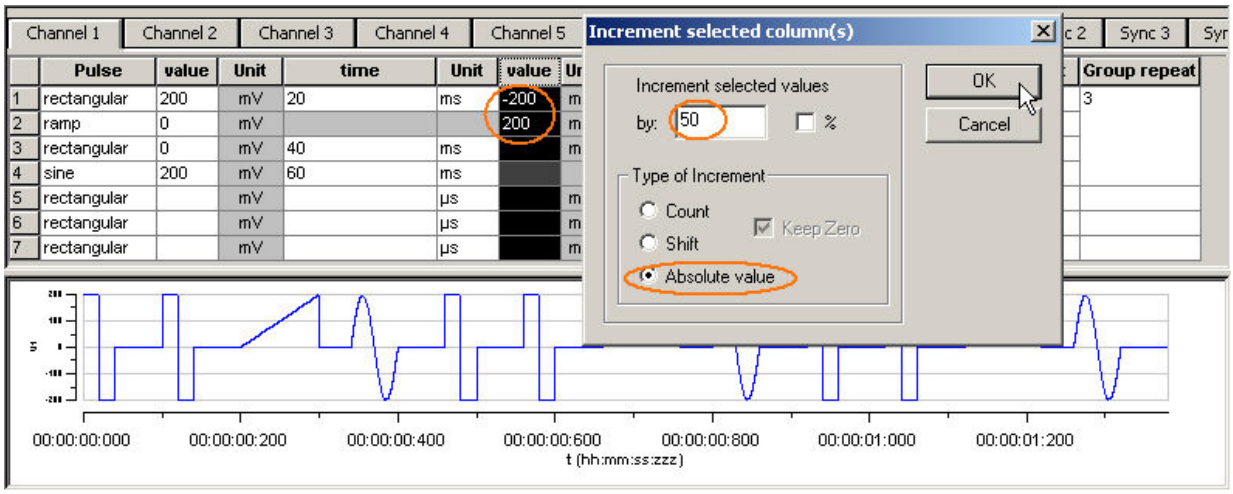
In the same way, you can set up a stimulus with voltage/current increments.



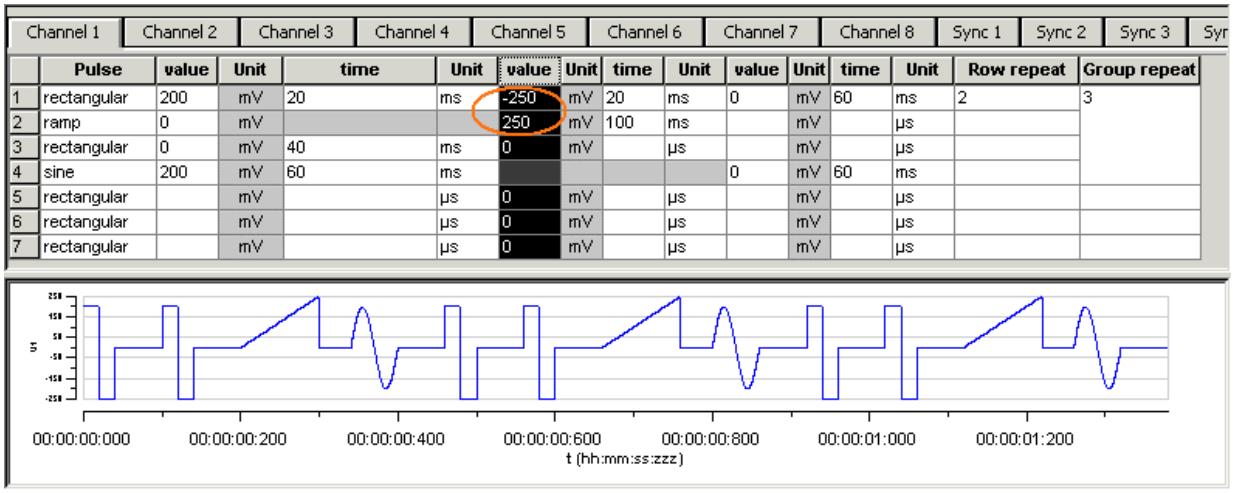
Shifting absolute time or voltage values

With this option, the signs of the selected values are ignored. Zeros are never changed, that is, the option **Keep Zero** cannot be deselected.

1. Under **Type of Increment**, select **Absolute Value**.
2. Enter the desired shift factor.



The absolute values of 200 and 200 are both 200. This absolute value of 200 is modified by the shift factor of 50, resulting in 250. The negative value is now 250, and the positive value is 250. (If you had chosen the option **Shift** instead, the computed result would have been 200 + 50 = 150.) All zero values are not changed.



Autocreating entries

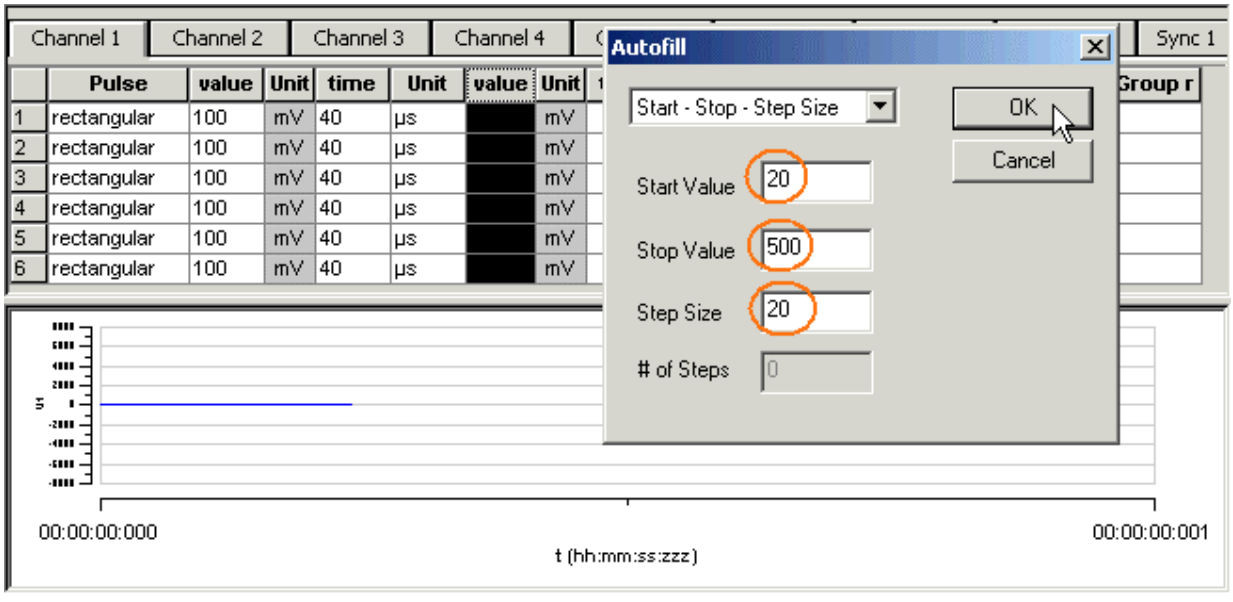
You can use the **Autofill** feature to set up advanced time or voltage/current increments. You define the **Start** and **End** value and either the **Step Size** (**Start - Stop - Step Size**) or the number of **Steps** (**Start - Stop - # of Steps**). Alternatively, you can enter the **Step Size** and the **Number of Steps** (**Start - Step Size - # of Steps**). According to these specifications, rows are inserted and the column is filled automatically.

In the following example, the **Autofill** feature has been used to create a voltage step series from 20 mV to 500 mV with an increment of 20 mV.

1. Click any **Value** or **Time** column header to select a column.
   The selected column is highlighted in black.

2. Right-click and click **Autofill**.

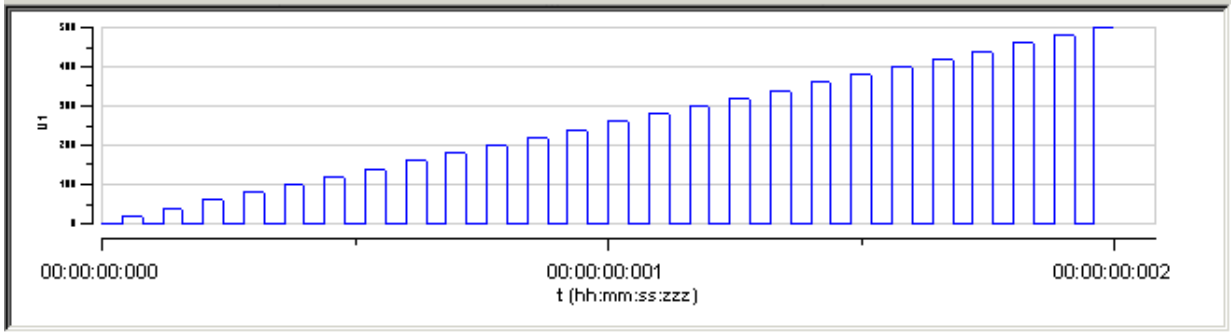
3. Select one out of three commands and fill in the white text boxes.



The column is filled according to the specifications.

Channel 1 | Channel 2 | Channel 3 | Channel 4 | Channel 5 | Channel 6 | Channel 7 | Channel 8 | Sync 1

	Pulse	value	Unit	time	Unit	value	Unit	time	Unit	value	Unit	time	Unit	Row rep	Group r
1	rectangular	0	mV	40	µs	20	mV	40	µs		mV		µs		
2	rectangular	0	mV	40	µs	40	mV	40	µs		mV		µs		
3	rectangular	0	mV	40	µs	60	mV	40	µs		mV		µs		
4	rectangular	0	mV	40	µs	80	mV	40	µs		mV		µs		
5	rectangular	0	mV	40	µs	100	mV	40	µs		mV		µs		
6	rectangular	0	mV	40	µs	120	mV	40	µs		mV		µs		
7	rectangular	0	mV	40	µs	140	mV	40	µs		mV		µs		
8	rectangular	0	mV	40	µs	160	mV	40	µs		mV		µs		
9	rectangular	0	mV	40	µs	180	mV	40	µs		mV		µs		

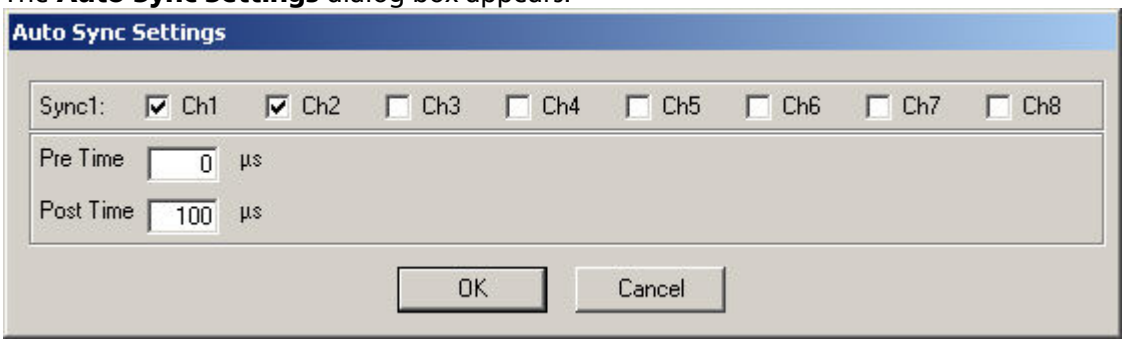


5.5 Auto Sync for Autocreating Trigger Pulses

If you want to synchronize other devices, for example a MEA1060-BC amplifier or the MC_Card with the stimulus generator, you have to set up the digital output of the Sync Out channels in synchrony to the stimulus pulses. This may sometimes be a bit tricky and time consuming, especially for complex stimulus protocols.

The **Auto Sync** feature is intended for making the work with MC_Stimulus more efficient: Digital Sync Out TTL pulses synchronous to stimulus pulses are generated automatically by this feature. Each time an analog channel generates a pulse (that is, its value is not equal to zero), the logical state of the assigned Sync Out channel is set to HIGH (=1). You can set the **time offset** of the TTL's rising edge **before** the stimulus pulse and of the TTL's falling edge **after** the pulse. If you change the stimulus protocol, corresponding **Auto Sync** pulses are updated on the fly. This feature is especially recommended for controlling the MEA1060-BC amplifier with superior stimulus artifact suppression.

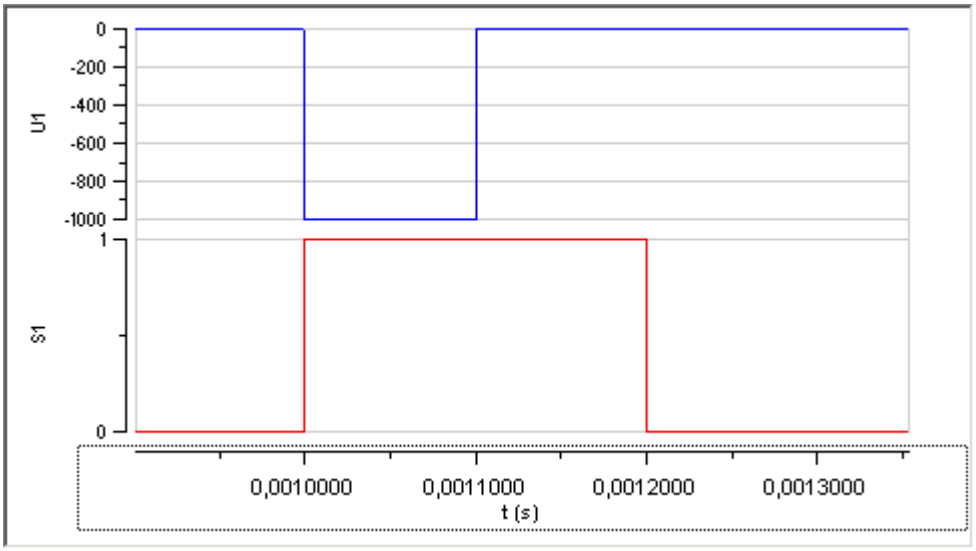
1. On the **Edit** menu, click **Auto Sync Settings**.
   The **Auto Sync Settings** dialog box appears.



2. Assign the analog stimulus channels that will be used as the basis for autocreating the protocols on the Sync Out channel. For example, if you use only stimulus channel 1, select **Ch1** under **Sync1**. If you use a MEA1060-BC amplifier, you can use up to two output channels per amplifier, that is, you may want to select **Ch1** and **Ch2** for **Sync1**, as shown in the preceding screen shot.

3. Set the time offset of the TTL's rising edge **before** the stimulus pulse (**Pre Time**) and of the TTL's falling edge **after** the pulse (**Post Time**). For operating a MEA1060-BC amplifier, a **Pre Time** of 0 µs and a **Post Time** of 100 µs are default, but especially the **Post Time** may have to be adjusted according to your stimulus amplitude and the stimulus artifact suppression performance (please see the user manual of your MEA1060-BC amplifier or the MEA_Select Help for more details).

4. On the **Settings** menu, click **Auto Sync** to enable the **Auto Sync** feature.
The Sync Out protocols will be autocreated in synchrony with the pulse protocols on the assigned channels, will show up in the **WYSIWYG window** immediately, and will be downloaded onto the STG with your next download. The **worksheets** of the Sync Out channels assigned to the **Auto Sync** feature will be **unavailable**, that is, you cannot edit them manually. The following screen shot shows an example of a monophasic 100 µs voltage pulse on channel 1 and the corresponding Auto Sync pulse (Pre Time 0 µs, Post Time 100 µs) on Sync Out 1.



5. If you later choose to edit the Sync Out worksheets of the active file manually, you can deselect the **Auto Sync** feature on the **Settings** menu.
Any information in the Sync Out worksheets that was there **before** the **Auto Sync** option was enabled will be **restored**; and all worksheets will be available for manual editing.

6 ASCII Import/Export

6.1 Loading Files

The ASCII import filter is used to load stimulus protocols from an ASCII file into the stimulus worksheet of MC_Stimulus. You can use this feature for feeding recorded signals (for example, exported from MC_Rack, see the MC_Rack User Manual) into the stimulus generator.

The current version of the import filter is version 1.10. **Only rectangular waveforms** are supported in this version.

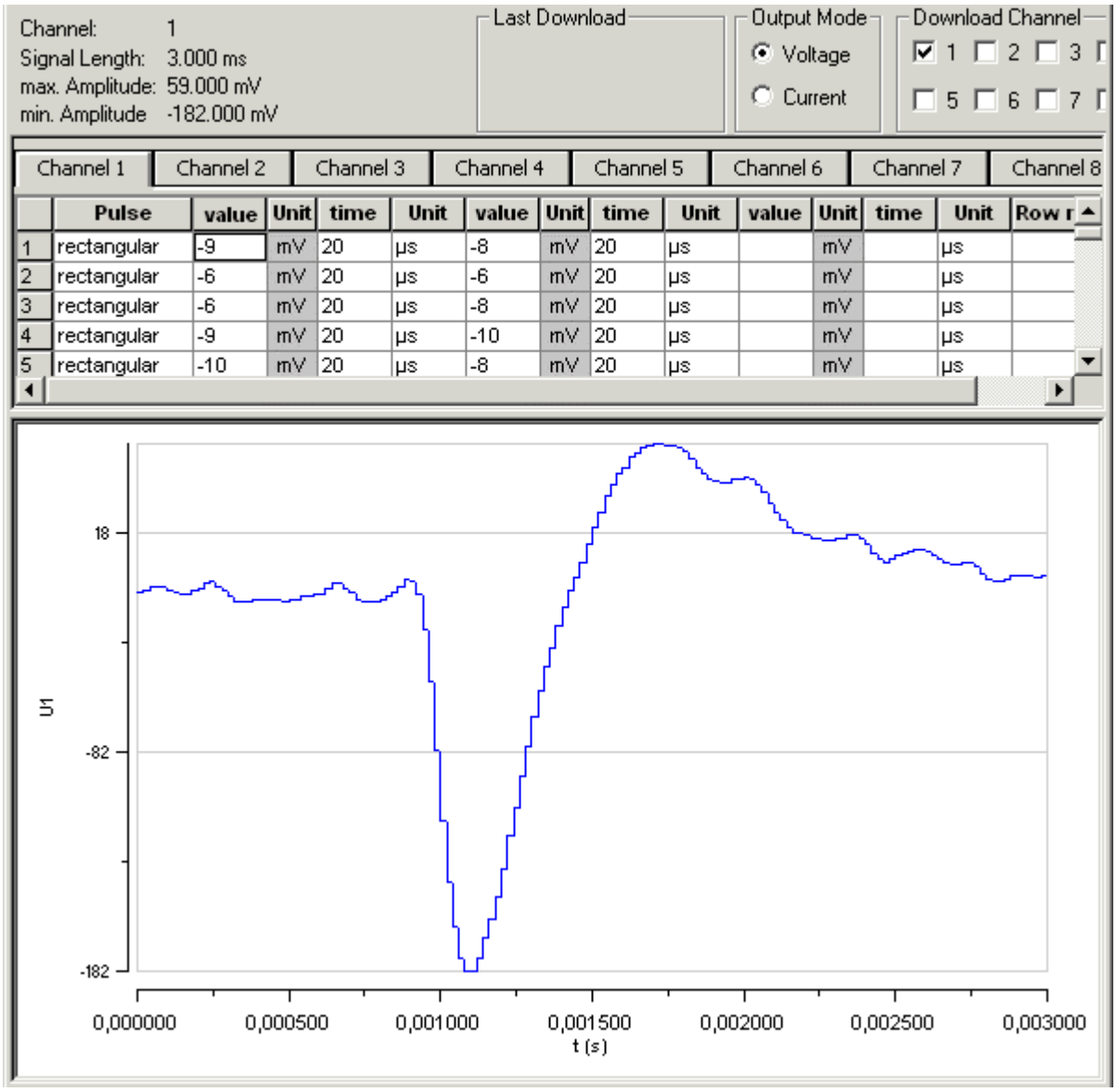


Fig. 1 ASCII import example: Stimulating with biopotential waveforms

Shown is a single spike recorded from an organotypic hippocampal culture. The spike waveform was exported as ASCII from MC_Rack and imported into the MC_Stimulus program.

Warning: All previous records in the active MC_Stimulus file (.stm) file are overwritten. Please create a new file and import the data into an empty worksheet to avoid data loss.

1. On the **File** menu, click **Import ASCII File**.
   The **Open** dialog box appears.

2. Select an appropriate ASCII file and click **Open**.
The stimuli from the ASCII file are loaded into the active MC_Stimulus worksheet. All previous records are overwritten. Channels that are not present in the ASCII file are empty. You can now edit and download the stimulus file as usual.

   If the file does not fulfill the requirements of a stimulus file, an error message will show up and tell you in which line the first error occurs. See "Supported File Format" for more information about supported ASCII files.

6.2 Exporting Files

1. On the **File** menu, click **Export ASCII File**.
The **Save As** dialog box appears.

2. Browse to the target folder and enter a file name.

3. Click **Save** to generate the ASCII file.

   All pulse protocols from the active file will be saved in ASCII file format. The MC_Stimulus ASCII format type is **format type 4**. For your convenience, the generated ASCII file includes the header that is required for reimporting the file into MC_Stimulus.

6.3 Supported File Formats

The ASCII text must exactly follow the specifications below. The parameters in angle brackets are placeholders for any valid numbers or strings.

Hint: You can set up files conveniently in any standard spreadsheet program and save them as tab-delimited ASCII.

General

- The **file name** and the file name **extension** are not important. You can use any extension you like, for example .txt, or .dat, or any other.
- **Comments** are introduced by the number sign #. The rest of the line after # is only for your information; it is completely ignored when executing the stimulus file. (You do not need comments, of course, but it is convenient for documentation.)

  Hint: Use # to comment lines out. That is, you can disable lines without removing it from the file. Thus, you can keep the lines for later uses.

- Blank lines are **ignored**.
- The **spelling** is strict. The MC_Stimulus program does not recognize a keyword if it is misspelled or if even only one character is missing, but it is **not** case-sensitive.
- The file has the following structure.

  1. File header

  2. Data

File header

The **first two** non comment lines have to be the following lines. Files for older versions of the import filter (version 1.00) can be imported with the current version as well.

```
Multi Channel Systems MC_Stimulus
ASCII import Version 1.10
```

The **next three** lines have to be the following lines (in any order).

```
channels: <number>
output mode: <mode>
format: <format number>
```

Make sure you define the total number of channels for the used STG properly (4 channels for an STG with 4 channels, 8 channels for an STG with 8 channels, and so on), according to the **software** version. You can select the maximum number of channels during the installation of MC_Stimulus. On the **Help** menu, click **About MC_Stimulus** to check your current software version.

Example:

*You have to include the following line in the ASCII file if you have installed **MC_Stimulus for STG1004**.*

channels: 4

Output mode is either voltage or current.

Example:

output mode: voltage

Three different format types are available: 1, 2, 3.

Example:

format: 3

Data

Preceding the data, the output channel number has to be specified by the following line.

```
channel: <channel number>
```

You can specify **analog** output channels from 1 to 8 (limited by the number of analog output channels of the connected STG, of course).

The digital **Sync Out** channel number directly follows the **maximum** number of output channels. For example, if you have installed MC_Stimulus for 4 channels, the Sync Out channel is channel number 5; if you have installed MC_Stimulus for 8 channels, the SyncOut channel is channel number 9.

The data follows after the channel specification line; three format types are available. All format types follow the MC_Stimulus worksheet's structure of rows and columns. See the description of the worksheet for more details. Columns are separated by blanks or tabs. The first line has to contain the column headers. The following lines contain the voltage/current and time values. Rows/lines are separated by a carriage return or line feed (CR/LF). This is the Windows standard control character inserted when you press the ENTER key.

The voltage unit is mV and the current unit is µA. Please make sure that all values are in the ranges specified for the STG you use. For the Sync Out channel, only values of 0 and 1 are allowed.

The time unit is **µs**. Time values can be in the range from 20 to 18.000.000.000 (20µs to 5 h). Time base of the STG is **20µs**, so only times that are **multiples of 20µs are valid**.

Note: Please make sure that there are no additional tabs or characters, which would lead to an error message. Show tabs and spaces in your text editor and check the file before importing it.

Format type 1

This is a basic format with two columns of **Value** and **Time** each, without **Repeat** functionality.

value time value time

Format type 2

With this format, you can repeat rows in the same way as described for the worksheet. Group repeat is not available.

value time value time repeat

Format type 3

This format type is available only in the current version of the import filter. It allows you to use a **third column** of **Value** and **Time**.

value time value time value time repeat

Example:

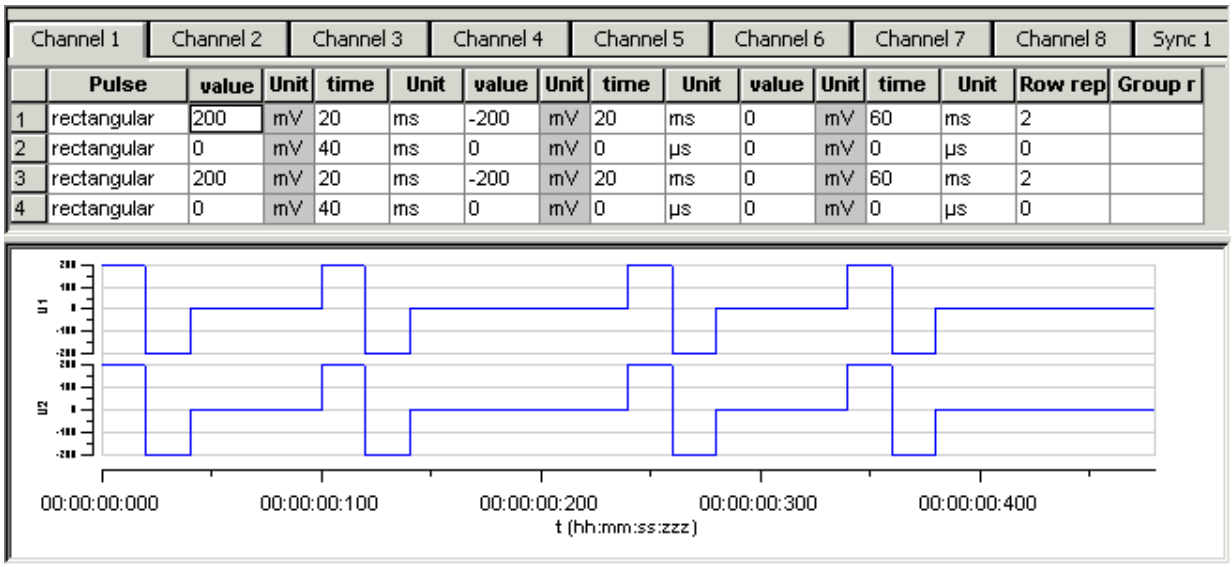
The following picture shows an ASCII stimulus file opened in a standard spreadsheet program.

	A	B	C	D	E	F	G
1	# Demo file						
2							
3	Multi Channel Systems MC_Stimulus						
4	ASCII import Version 1.10						
5							
6	channels:	8					
7	output mode:	voltage					
8	format:	3					
9							
10	channel:	1					
11	value	time	value	time	value	time	repeat
12	200	20000	-200	20000	0	60000	2
13	0	40000	0	0	0	0	0
14	200	20000	-200	20000	0	60000	2
15	0	40000	0	0	0	0	0
16							
17	channel:	2					
18	value	time	value	time	value	time	repeat
19	200	20000	-200	20000	0	60000	2
20	0	40000	0	0	0	0	0
21	200	20000	-200	20000	0	60000	2
22	0	40000	0	0	0	0	0
23							

The same file would look like this in a standard text editor program. You can see the tabs, spaces, and CR/LF.

```
1  #·Demo·file¶
2  ¶
3  Multi·Channel·Systems·MC_Stimulus¶
4  ASCII·import·Version·1.10¶
5  ¶
6  channels:»  8¶
7  output·mode:»   voltage»¶
8  format:·»   3¶
9  ¶
10 channel:»   1¶
11 value»  time»   value»  time»   value»  time»   repeat¶
12 200»20000»  -200»   20000»  0»  60000»  2¶
13 0»  40000»  0»  0»  0»  0»  0¶
14 200»20000»  -200»   20000»  0»  60000»  2¶
15 0»  40000»  0»  0»  0»  0»  0¶
16 ¶
17 channel:»   2¶
18 value»  time»   value»  time»   value»  time»   repeat¶
19 200»20000»  -200»   20000»  0»  60000»  2¶
20 0»  40000»  0»  0»  0»  0»  0¶
21 200»20000»  -200»   20000»  0»  60000»  2¶
22 0»  40000»  0»  0»  0»  0»  0
```

After loading the file into the MC_Stimulus worksheet, you can edit and download the file as usual.



	Pulse	value	Unit	time	Unit	value	Unit	time	Unit	value	Unit	time	Unit	Row rep	Group r
1	rectangular	200	mV	20	ms	-200	mV	20	ms	0	mV	60	ms	2	
2	rectangular	0	mV	40	ms	0	mV	0	µs	0	mV	0	µs	0	
3	rectangular	200	mV	20	ms	-200	mV	20	ms	0	mV	60	ms	2	
4	rectangular	0	mV	40	ms	0	mV	0	µs	0	mV	0	µs	0	

Format type 4

This format type is available only in the current version of the import filter. It is the plainest format with only **one column** for the **voltage/current values** and **one column** for the **time** lengths. This format is the standard format if you want to import data for example from Excel.

This format type is generated when exporting MC_Stimulus files as ASCII.

value time

Format type 5

This format type is available only in the current version of the import filter. It allows you to use **ramp** and **sine** waveforms as well as **rectangular** waveforms. You specify the **Pulse** type in the first column, and the waveform in the three following columns. The general rules for setting up ramp and sine waveforms fully apply (see also Pulse Types). The pulse types are defined by the following numbers: Rectangular = 0, ramp = 1, sine = 2.

You can only use the rectangular type (0) for the Sync Out channels.

Important: When setting up **rectangular** or **sine** waveforms in this format type, you need only one value column for defining the amplitude, but you have to define both value columns even so. The **first** value column is **ignored** for rectangular and sine pulse types by the MC_Stimulus program.

pulse (0, 1, 2)	value	value	time

Example:

This is an ASCII file viewed in a standard text editor program. You can see the tabs, spaces, and CR/LF.

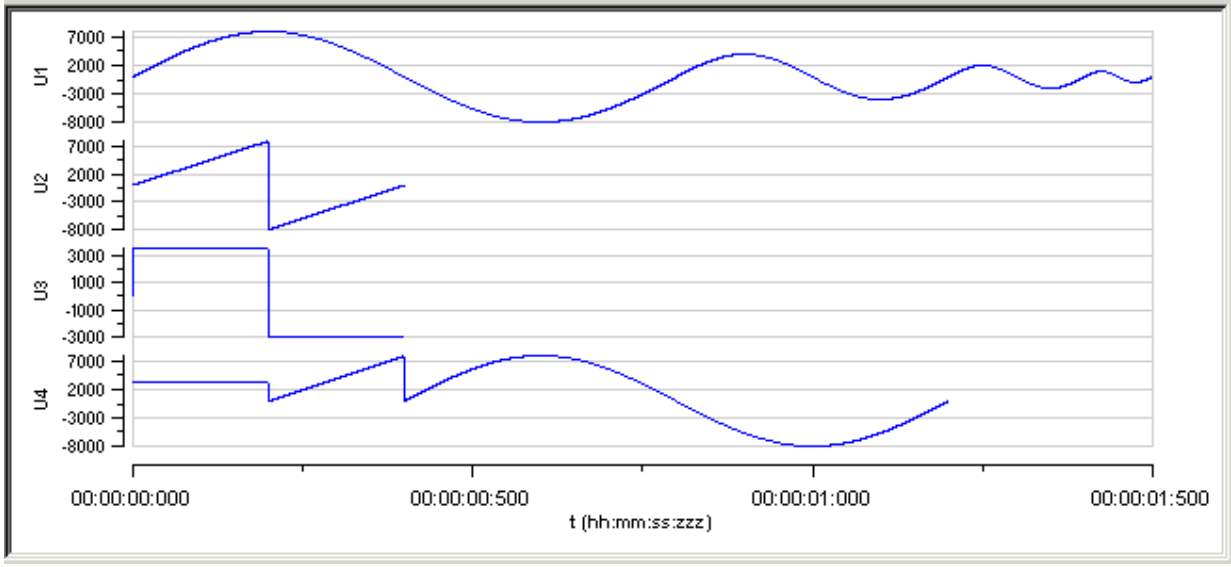
For demonstration purposes, a ramp type pulse was programmed on the first channel, a sine wave on the second channel, a rectangular waveform on the third channel, and mixed pulse types on the fourth channel.

```
 1 #·file:·example.dat¶
 2 #·Copyright·(c)·2005·Multi·Channel·Systems¶
 3 #·this·is·an·example·file·for·MC_Stimulus·ASCII·import¶
 4 ¶
 5 Multi·Channel·Systems·MC_Stimulus¶
 6 ASCII·import·Version·1.10¶
 7 ¶
 8 #·this·is·a·comment·line¶
 9 ¶
10 channels:·8¶
11 ¶
12 output·mode:·voltage¶
13 ¶
14 format:·5¶
15 ¶
16 channel:·1¶
17 ¶
18 pulse»  value»  value»  time¶
19 2»  0»  8000»  800000¶
20 2»  0»  4000»  400000¶
21 2»  0»  2000»  200000¶
22 2»  0»  1000»  100000¶
23 ¶
24 channel:·2¶
25 ¶
26 pulse»  value»  value»  time¶
27 1»  0»  8000»  200000¶
28 1»  -8000»  0»  200000¶
29 ¶
30 channel:·3¶
31 ¶
32 pulse»  value»  value»  time¶
33 0»  0»  3500»  200000¶
34 0»  0»  -3000»  200000¶
35 ¶
36 channel:·4¶
37 ¶
38 pulse»  value»  value»  time¶
39 0»  0»  3500»  200000¶
40 1»  0»  8000»  200000¶
41 2»  0»  8000»  800000¶
42 ¶
43 ¶
```

After loading the file into the MC_Stimulus worksheet, you can edit and download the file as usual.

Channel 1 | Channel 2 | Channel 3 | Channel 4 | Channel 5 | Channel 6 | Channel 7 | Channel 8 | Sync 1

	Pulse	value	Unit	time	Unit	value	Unit	time	Unit	value	Unit	time	Unit	Row rep	Group r
1	rectangular	3500	mV	200	ms		mV		µs		mV		µs		
2	ramp	0	mV			8000	mV	200	ms						
3	sine	8000	mV	800	ms										
4	rectangular		mV		µs		mV		µs		mV		µs		



7 Stimulus Display

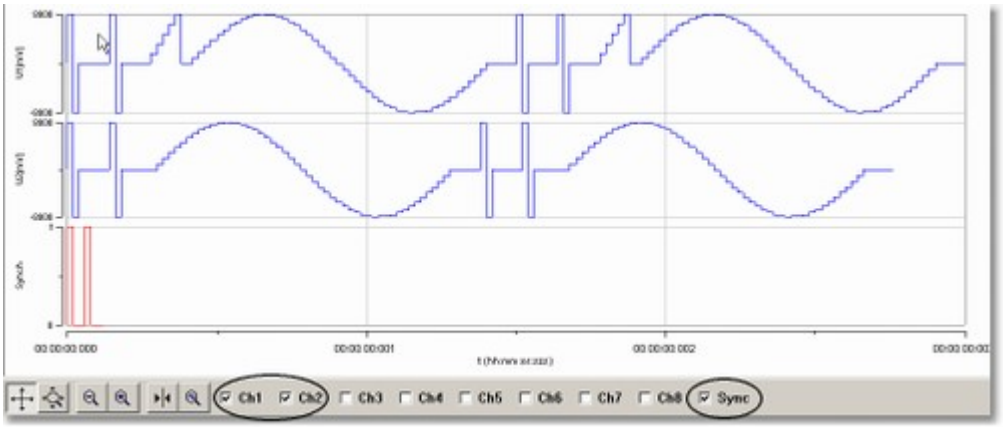
7.1 Selecting Channels

To enlarge the display size of the channels, we suggest that you show only those channels you are currently working with.

Note: This will affect only the **display**. It has **no** effect on the **download** of signals. To select or deselect channels for downloading, click the **Download Channel** check boxes in the main window of the program.

- Clear the check box of all channels that are not in use.

  All channels that are not selected are removed from the display.



7.2 Display Tools

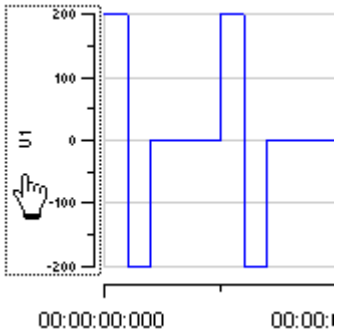
- Several tools are provided to optimize the graphical presentation of the stimuli. If you later choose to display channels, the axes of the new displays are set to the default values.
- The time axis can display only positive values.
- The y-axis of the Sync Out channels cannot be adjusted, because only values of 0 and 1 are available for these channels.

Enable scrolling	Scroll the axes by clicking and dragging with your mouse.
Enable scaling	Zoom the axes by clicking and dragging with your mouse.
Zoom out	Reduces the time scale.
Zoom in	Magnifies the time scale.
Reset	Resets the axes of all channels to the default values.
Size to fit	Adjusts the ranges to fit the largest displayed stimulus.
Show measure tool	A horizontal bar is shown that displays the current/voltage and the time value of the intersection point. Drag the bar with the mouse.

Scrolling the axes

You can scroll the stimuli forward and backward along the time axis, and up and down along the voltage/current axis.

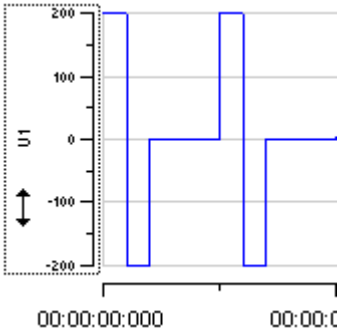
1. Click  to enable the **scrolling**.
2. Click the axis you like to scroll.
   The mouse pointer becomes a hand.



3. While holding down the mouse button, move the axis to the left and right, or up and down.
   OR
   You can use the keyboard: Press LEFT ARROW or DOWN ARROW to move the axis to the left (down), RIGHT ARROW or UP ARROW to move the axis to the right (up).
   OR
   Use the PAGE UP and PAGE DOWN keys for a faster scrolling (larger steps): PAGE DOWN to move to the left (down), PAGE UP to move to the right (up).

Zooming the display

1. Click  to enable the **scaling**.
2. Click the axis you like to scale.
   The mouse pointer becomes an arrow.



3. While holding down the mouse button, move the mouse up/right to zoom the axis in, and move the mouse down/left to zoom the axis out.
   OR
   You can use the keyboard: Press LEFT ARROW or DOWN ARROW to zoom the axis out, RIGHT ARROW or UP ARROW to zoom the axis in.
   OR
   Use the PAGE UP and PAGE DOWN keys for a faster scrolling (larger steps): PAGE DOWN to zoom out, PAGE UP to zoom in.

Size to fit

- Click  to size the display to fit.
  The ranges are automatically adjusted to fit the maximum amplitude of each stimulus. The range of the time axis will be set to fit the longest signal.

8 Downloading Stimuli

8.1 Downloading Stimulus Files

After having set up the stimulus file, you can download the file to the connected STG. You can **select** the channels that you want to download or download the **complete** file. The **Sync** channel for synchronizing other devices connected to the **Sync Out** of the STG will always be downloaded, you cannot deselect it.

You can start the stimulation **directly** after the download, or start it **manually** with the software or hardware controls, or start it **on a trigger**. See also chapter "Operating the STG" for more information.

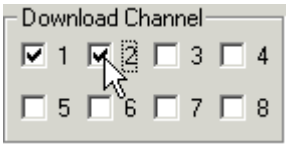
Please note that the capacity of the 1000 series is limited. You will be notified during the download by an error message when the maximum file size has been reached.

See also chapter "Batch Mode" for information how to run multiple files one after the other.

Warning: Check the file thoroughly before downloading it on the STG. The stimulus display is independent from the worksheet and from the download. Verify that you download **only** the channels that you want to use. Do **not** start the STG if you are unsure about the channel configuration or the nature of the downloaded file.

Warning: The stimulus length has to be the same on all channels. If you have programmed stimuli with different time lengths, shorter stimuli will keep the last voltage or current value until the complete stimulation has been finished on all channels. You will be notified by an error message if this occurs. This behavior can lead to unexpected results and can even lead to dangerous situations.

1. Select the channels for downloading under **Download Channel**.



2. On the **STG** menu, click either **Download (sel.)** to download only the selected channels onto the STG or **Downld. and Start (sel.**) to download only the selected channels and start the stimulation directly after the complete download. If you want to download **all** channels, you can use the commands **Download (all) or Downld.** and **Start (all)**. Be careful, because the channel selection will have **no** effect in this case.

Disable/enable warning messages

Cancel this option to disable the message boxes displaying compiler warnings during stimulus download.

The two error messages that can be disabled are: "warning: signal length shorter than the maximum" and "warning: non zero last amplitude value". They may present a nuisance if you download multiple stimulus files in batch mode.

- On the **Settings** menu, select or deselect **Enable Compiler Warnings**.

9 General Software Features

9.1 Customizing the Main Window

You can customize the size and position of open file windows and the toolbar in MC_Stimulus.

- You can **hide** the **toolbar** and the **status bar** by deselecting them on the **View** menu.
- You can **arrange** the **windows** with the commands on the **Window** menu.
- **Cascade**: Use this command to arrange multiple opened windows in an overlapped fashion. The windows are resized to the standard size.
- **Tile**: Use this command to arrange the windows so that they are not overlapping.
- **Arrange Icons**: Use this command to line up minimized windows.
- You can **resize** the windows with your mouse.
- Click an empty area on the toolbar, and then **drag** the **toolbar** to a new position.

9.2 Menu Bar

You will find most software features in the pull-down menus of the main window. Each menu displays a list of commands. Commands that are **not available** at the moment appear **shaded**.

Use the ...

- **File** menu to create new files, save files, import ASCII files, and print the stimulus worksheet.
- **Edit** menu for general editing features like copy and paste rows, remove the last entered value (**Undo**), remove and insert rows into the active worksheet. You can also **right-click** on a row and select these commands. Click **Clear Signal** to delete all values in the active worksheet. You can also specify the output ranges according to the connected STG on this menu. Please see the technical specifications of your STG.
- The **STG** menu contains all commands directly relating to the hardware, for example download commands, start and stop the STG, and trigger configurations. **Reset** deletes all data on the STG's memory.
- You can open, start, and stop a batch run of several files on the **Batch** menu.
- **Signal** menu for nice editing features like editing whole columns, and autocreate signals. You can also **right-click** on a column and select these commands.
- **View** and **Window** menu to customize the main window.
- **Settings** menu to define general settings of the software.
- **Help** menu to open the **MC_Stimulus Help** and to display the **About** dialog where you can find information about the hardware, software, and firmware versions. You will need this information when you contact the support.

9.3 Toolbar

For your convenience, you will find some of the more commonly used commands as a button on the toolbar.

New File Creates a new MC_Stimulus file (*.stm) file

Open File	Opens a previously saved MC_Stimulus file (*.stm) file
Save File	Saves the *.stm file to the chosen destination
Cut Row	Deletes selected row(s) and sends deleted row(s) to clipboard
Copy Row	Sends selected row(s) to clipboard
Paste Row	Pastes row(s) from clipboard and overwrites row(s) starting at the selected row
Print	Prints active channel of active worksheet
Information	Opens the **About** dialog, where you can find information about the hardware, software, and firmware versions
Start	Starts downloaded stimulation file (only available if STG has active computer connection)
Stop	Stops downloaded stimulation file (only available if STG has active computer connection)

9.4 Shortcut Keys

Shortcut keys offer you another way to accomplish common tasks. Using a shortcut key usually consists of pressing and holding one key while pressing a second key.

See the **list of shortcut keys** available in the software.

CTRL+A	**Download and Start (selected)**
CTRL+C	**Copy Row**
CTRL+D	**Download (selected)**
CTRL+L	**Download (all)**
CTRL+N	**Create New File**
CTRL+O	**Open File**
CTRL+P	**Print**
CTRL+R	**Start**
CTRL+S	**Save file**
CTRL+T	**Stop**
CTRL+V	**Paste Row**
CTRL+X	**Cut Row**
CTRL+Z	**Undo**

Hint: Shortcut key combinations are also listed on the toolbar menus. For example, the **File** menu shows that the shortcut key for **Save** is **CTRL+S**.

9.5 File Menu

You can save MC_Stimulus files for later use. This is very convenient if you have various similar experimental setups, or if you like to repeat an experiment later.

Open a file

You may open previously saved files for similar experimental setups.

1. On the **File menu** or on the toolbar, click **Open**  .
2. Browse your folders and choose the desired file. You may only open MC_Stimulus files (*.stm).
3. Click **Open**.
   The selected file opens.

Save a file

1. On the **File** menu or on the toolbar, click **Save**  .
   The currently active worksheet is now saved.

   You may open the file using MC_Stimulus later on to continue your experiment.

Save as

Use this command to save your file under a new name, for example, if you like to use a file as a template for a new file.

1. On the **File** menu, click **Save As**.
2. Browse your folders and enter a file name.
3. Click **Save.**
   The current worksheet is now saved under the new name.

   You may open the file using MC_Stimulus later on to continue your experiment.

Import ASCII File

Please see the chapter "Importing ASCII Files".

Printing a channel

1. On the **File** menu, click **Print Setup** to select a printer, paper format, and so on.
2. Click **Print Preview** to preview the print output.
3. Click **Print**  to print out the active channel of the active worksheet.

9.6 Settings Menu

Enable Compiler Warnings

Cancel this option to disable the message boxes displaying compiler warnings during stimulus download.

The two error messages that can be disabled are: "warning: signal length shorter than the maximum" and "warning: non zero last amplitude value". They may present a nuisance if you download multiple stimulus files in batch mode

- On the **Settings** menu, select or deselect **Enable Compiler Warnings**.

10 Synchronizing Events

10.1 Digital Output Signals (Sync Out)

The output of the digital **Sync Out** output is a **5 V TTL** signal. A logic state of **1** means 5 V, and a logic state of **0** means 0 V. Please note that the digital output is about **15 µs faster** than the analog output. This small offset is generally sufficient to make sure that the Sync Out signal precedes the stimulation, which is important for synchronizing events.

You can program the output signal of the Sync Out channel in the same way as the analog output signals, but due to the nature of a digital signal, only values of 0 and 1 are allowed. A Sync Out signal is generated each time when the STG is started.

The output signal can be used for **triggering external devices**, for example, the data acquisition with the **MC_Card** of the **ME System** and the **MEA System**. Please note that if you use it for triggering the MC_Card, you should use output signals that have a **duration** of at least **200 µs**. Otherwise, it can happen that the MC_Card ignores trigger events.

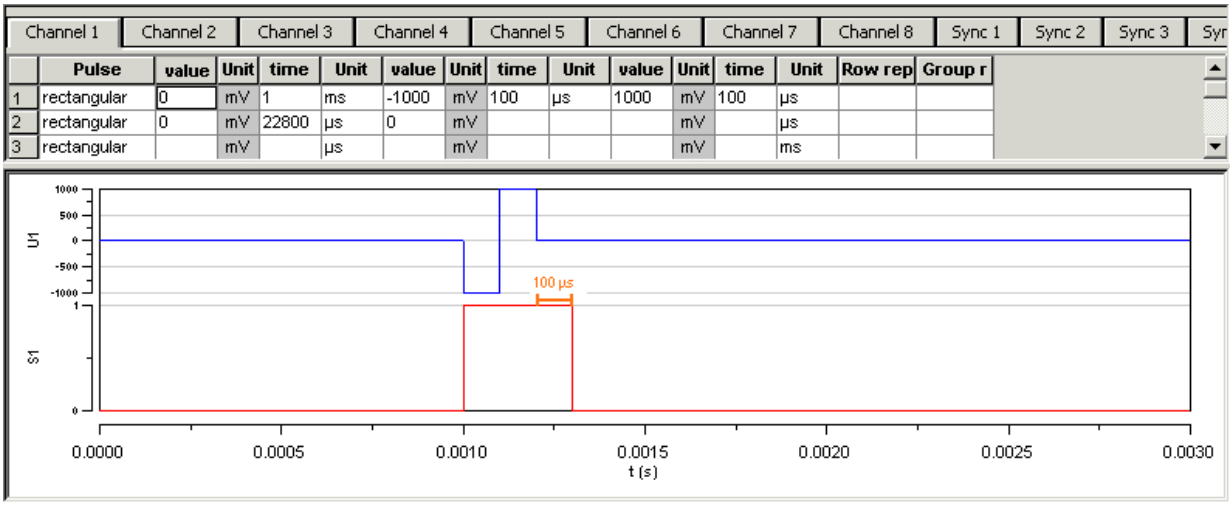
Note: **No** Sync Out signal is sent when the STG is **stopped** on a trigger event or by pressing the **Start/Stop** button, that is, if the trigger event occurs or the button is pressed when the STG has still been active.

Timing of blanking signal

If you have a MEA amplifier with **blanking circuit** in use, you can apply a blanking signal (TTL pulse) for transiently switching off the input stage of the amplifiers during the stimulus, thus avoiding the stimulus artifact.

MCS recommends a minimum blanking pulse that starts with the stimulus and **stops 100 µs after** the stimulus. The fact that the digital output of the stimulus generator from MCS is about **15 µs faster** than the analog output ensures that the blanking signal is delivered before the stimulus. It is very important that the blanking pulse is delivered shortly before the stimulus.

The following example shows a blanking signal (programmed with MC_Stimulus) of 300 µs length for a biphasic pulse of 200 µs length. See also the MEA_Select Help or the MEA Amplifier with Blanking Circuit User Manual for more information.



You can use the Auto Sync feature for autocreating the Sync Out pulses without entering values manually. Please see "Auto Sync for Autocreating Synchronous Sync Out Pulses".

10.2 Triggering Stimulation (Trigger In)

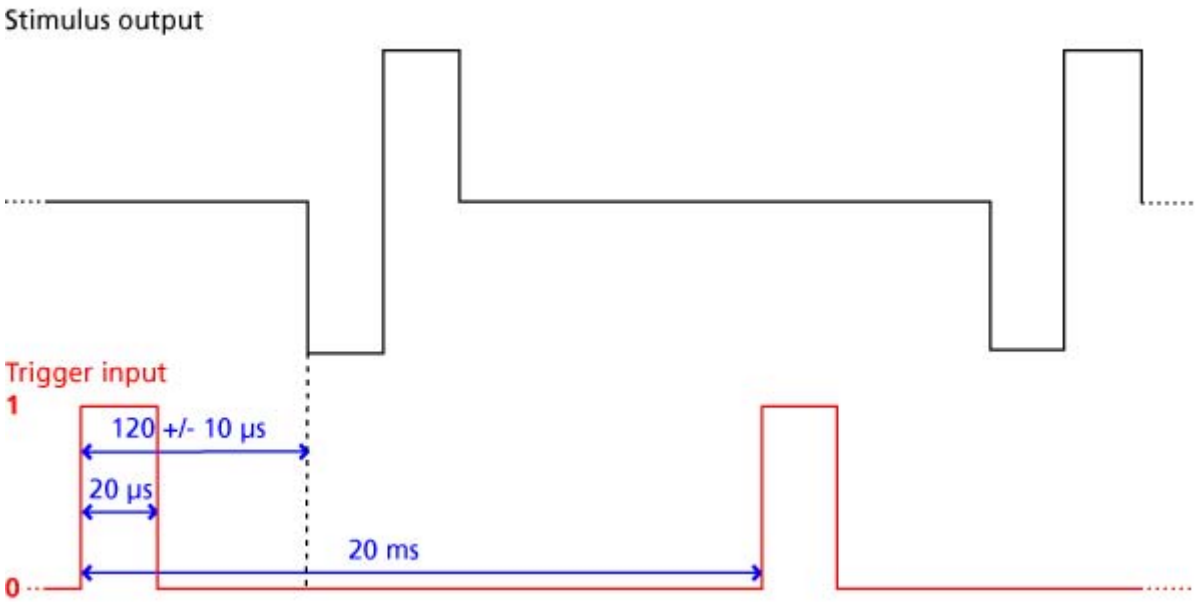
The external trigger input has to be a **TTL signal** of at least **20 µs** length. TTL pulses shorter than that may not be recognized by the stimulus generator.

A TTL pulse is defined as a digital signal for communication between two devices. A voltage between 0 V and 0.8 V is considered as a logical state of 0 (LOW), and a voltage between 2 V and 5 V means a 1 (HIGH). It is the same kind of signal as the output signal of the **Sync Out** output of the STG.

The **rising edge** of the **HIGH** trigger input starts and stops the STG. The time lag between the rising edge of the **TTL input** and the **stimulus output** is **120 +/ 10 µs**. The minimum distance between two trigger inputs is **20 ms**, resulting in a **maximum trigger frequency** of **50 Hz**. If a higher frequency is used, the stimulus generator is likely to miss trigger inputs. See the illustration below for more details on the timing. Please note that the **digital Sync Out** output is about **15 µs faster** than the **analog** outputs. See Digital Output Signal (Sync Out) for more information.

Important: Please note that the **timing** and the **amplitude** of the analog output pulses may not be accurate for very small amplitudes (**below 200 mV** or **below 100 µA**) due to the intrinsic properties of the electronic parts of the stimulus generator. Please check the output signals with an oscilloscope if you use small amplitudes in your stimulus protocol.

Timing limits

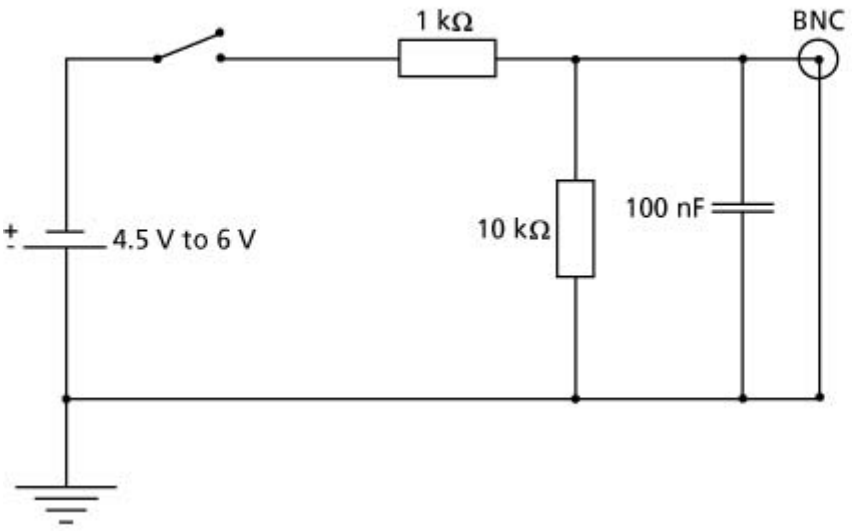


Custom switch for "remote-controlling" of the STG

You can connect any device that produces TTL outputs to the **Trigger In** connector of the STG, for example a switch. For example, you can use a trigger for remote controlling the STG if it is not within reach during an experiment. It is also possible to set up advanced experiments where stimulation depends on preceding activities of the studied object.

The following picture shows a suggested circuit diagram for a switch used for remote controlling. The resistor and capacitor work as a low-pass filter on the TTL signal and are necessary to reduce ringing of the signal.

Suggested switch for triggering the STG



10.3 Batch Mode

You can download and run several stimulus files one after the other in the **Batch** mode. The first file in the list is downloaded and started directly after the download, or started manually with the software or hardware controls, or started on a trigger. After the first file has been run, the next file in the list is downloaded, and so on, until the last file in the batch list has been run.

Triggering a sequence of stimulation protocols

The **Batch** mode is useful if you want to start a **sequence** of **different** stimulation protocols one after the other on the **same** trigger. You set up the protocols and save them as separate stimulus files. Then, you set up a batch file with a list of the desired stimulus files.

- The first trigger event starts the first file in the list.
- When a file has been **completed**, the **next** file in the list is **downloaded** automatically.
- When a trigger event occurs **after** the file has been run, the next file is started, and so on.
- When a trigger event occurs **during** the run of a file, the run is **stopped**, and the **next** file in the list is **downloaded**. The next trigger event **starts** the next file.
- Deselect the option **Start STG after Batch Download** on the **Settings** menu if you want to start the protocols **on a trigger** or **manually** with the software or hardware controls. If the option **Start STG after Batch Download** on the **Settings** menu is selected, the STG starts each file **directly** after the download without waiting for a trigger event.

Splitting up stimulation protocols to circumvent the memory limitation

If the option **Start STG after Batch Download** on the **Settings** menu is selected, the STG starts each file directly after the download, which is only useful if you need to circumvent the memory limitation of the STG. Split up your pulse protocol into several stimulus files and run them in **Batch** mode.

Setting up a batch file

You have to set up a batch file (.stb) first, which lists the full path of all files that you like to download as a batch. The batch file has to be exactly in the following format. This example is a batch list with three different pulse protocols. Replace the file paths with the correct path of the files of your choice.

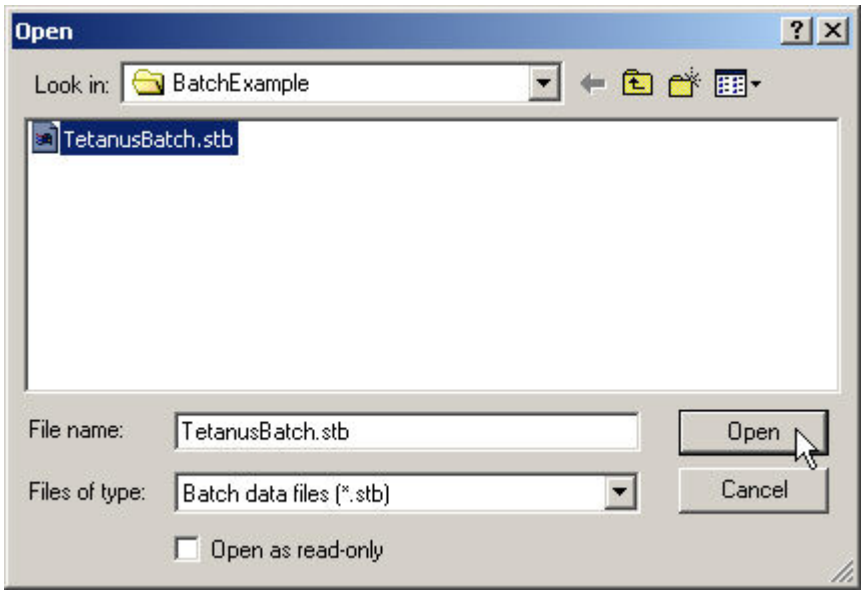
```
Multi Channel Systems MCS MC_Stimulus
Batch Control File
Version 1.00
c:\Program Files\Multi Channel Systems\MC_Stimulus\BatchExample\Baseline.stm
c:\Program Files\Multi Channel Systems\MC_Stimulus\BatchExample\Tetanus.stm
c:\Program Files\Multi Channel
Systems\MC_Stimulus\BatchExample\TestResponse.stm
```

Operating the STG in Batch mode

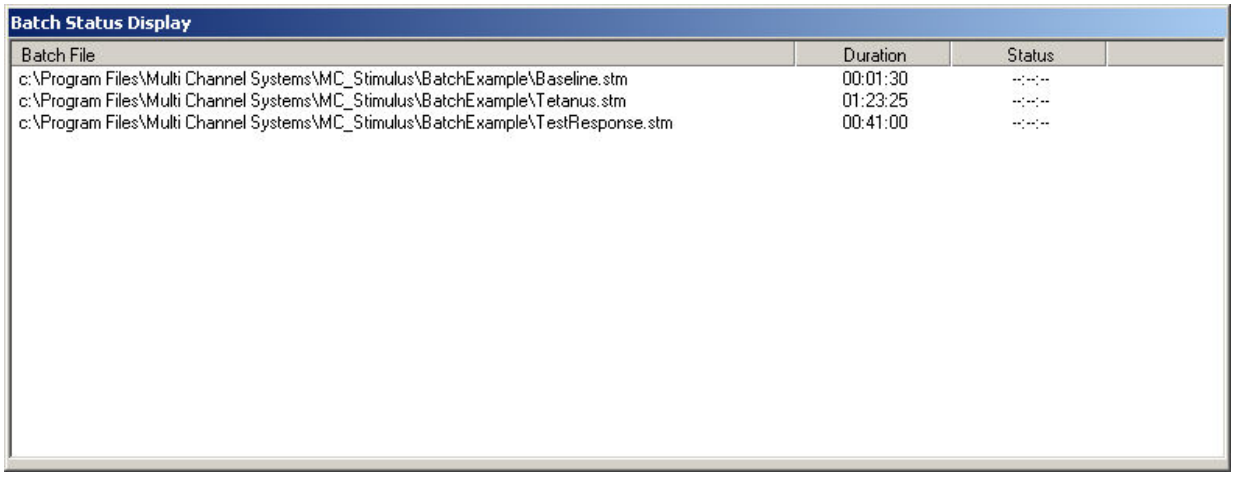
Important: You can operate the STG in **Batch** mode only with a **valid computer connection**. A file in the batch list is only downloaded **after** the preceding file has been run.

1. On the **Batch** menu, click **Open** to open a batch file.
   The **Open** dialog box appears.

2. Browse your folders and select a valid batch file, for example the sample file TetanusBatch.stb in the MC_Stimulus program folder.



3. The **Batch Status Display** opens. It lists all stimulus files in the batch and the duration of stimulation.



4. On the **Batch** menu, click **Start** to start the download of the first file in the batch list (and the STG if the option **Start STG after Batch Download** on the **Settings** menu is selected).
   The progress of the pulse protocol is displayed in the **Status** column of the **Batch Status Display**.

5. Click **Stop** on the **Batch** menu to stop the batch if necessary.

6. Close the **Batch Status Display** with the **Close** command.

Warning: The STG starts immediately after the download if the option **Start STG after Batch Download** on the **Settings** menu has been selected. Make sure to deselect this option if you do not want to start the stimulation right away.

11 Analog Output Signals

11.1 Output Modes

The stimulus generator operates in voltage and current mode and has separate voltage and current outputs for each channel. Regardless of the operation mode selected in MC_Stimulus, both current **and** voltage outputs are **active**. Please make sure that you use the appropriate output for your experiment. The main difference between the current outputs and the voltage outputs is described in the following.

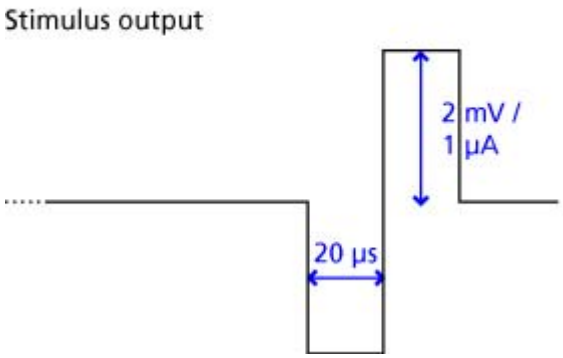
In **voltage mode**, the **voltage** level is held constant and the current output depends on the electrode resistance (the **higher** the electrode resistance, the **lower** is the output current).

In **current mode**, the stimulus generator guarantees a stable **current** output independent of the electrode resistance, where the voltage is defined by Ohm's law. The **higher** the electrode resistance, the **higher** is the output voltage. Therefore, the **kinetic properties** of the stimulus output is affected by the load resistance, that is usually the **electrode resistance**. If the resistance is too high, the output current is **limited** by the **compliance voltage**, that is, too high resistances will result in a **clipping** of the output signal.

Warning: Do not connect any device between a voltage (U) and a current output (I). This could damage the stimulus generator.

Please regard the **time** and **voltage/current resolution** of the stimulus generator. The minimum pulse has an amplitude of **2 mV** in voltage mode or **1 µA** in current mode (supported by MC_Stimulus II; the firmware/DLL supports a 13 bit resolution, which means 200 nA for an output current range of 0.8 mA), and a time length of **20 µs**. Please note that if you work near these limits, that is, if you use very small amplitudes or very short pulses, the output waveform may not match the programmed waveform.

Resolution limits



Ground

All up to 8 STG channels are optically isolated from each other. Each channel has an **independent** ground output (**GND**), which is usually connected to the ground of the experimental setup, for example the amplifier, so that all devices refer to the same ground. Please make sure that you always use the appropriate ground for the channel in use.

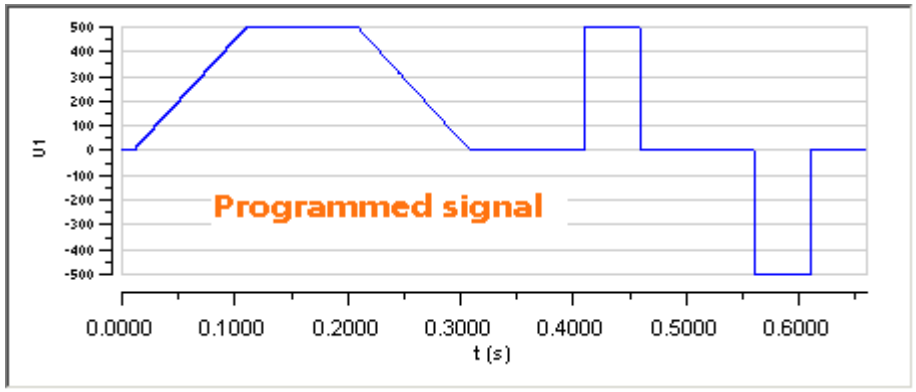
11.2 Voltage Mode

- If you operate the STG in voltage mode, you will usually use the **+U** and **GND** outputs. The output signal is identical with the programmed signal in the normal ranges of the electronics' accuracy. See illustration "Voltage mode: Standard Setup".
- It is strongly recommended to **short-circuit** the **+I** and **I** outputs with the provided cables for

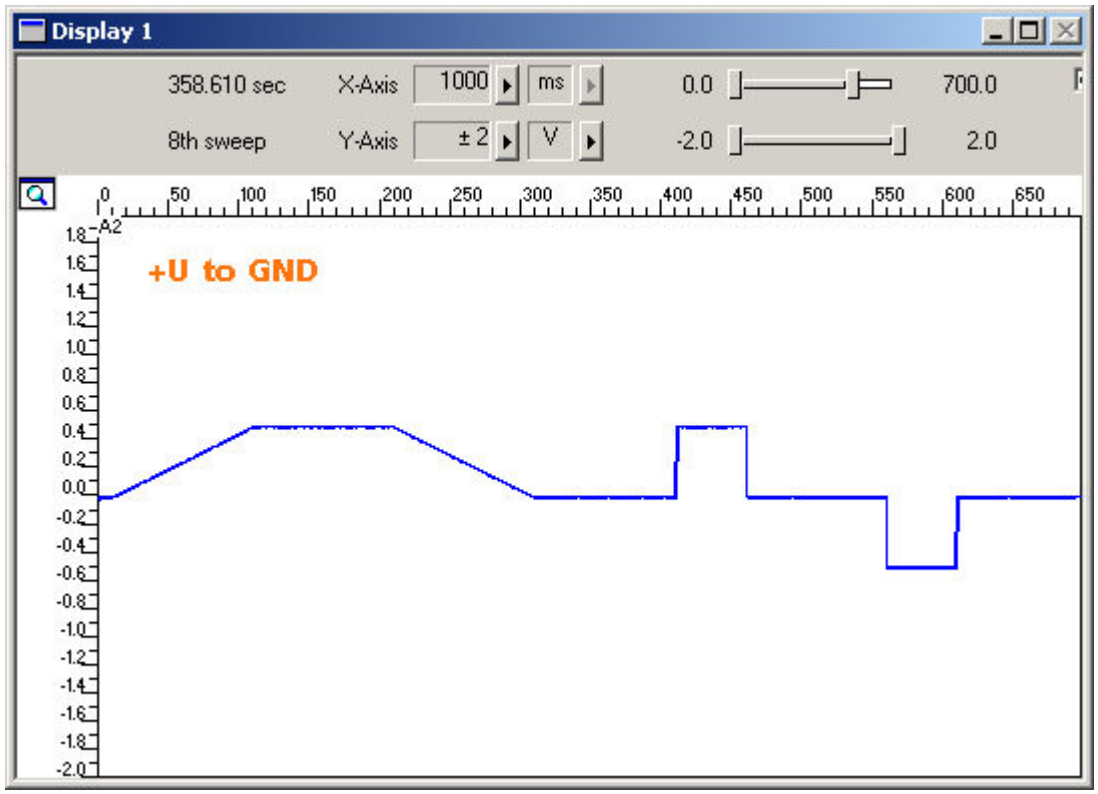
saving power and suppressing noise. Otherwise, the stimulus generator tries to hold a stable current against the indefinite resistance of the open current output.

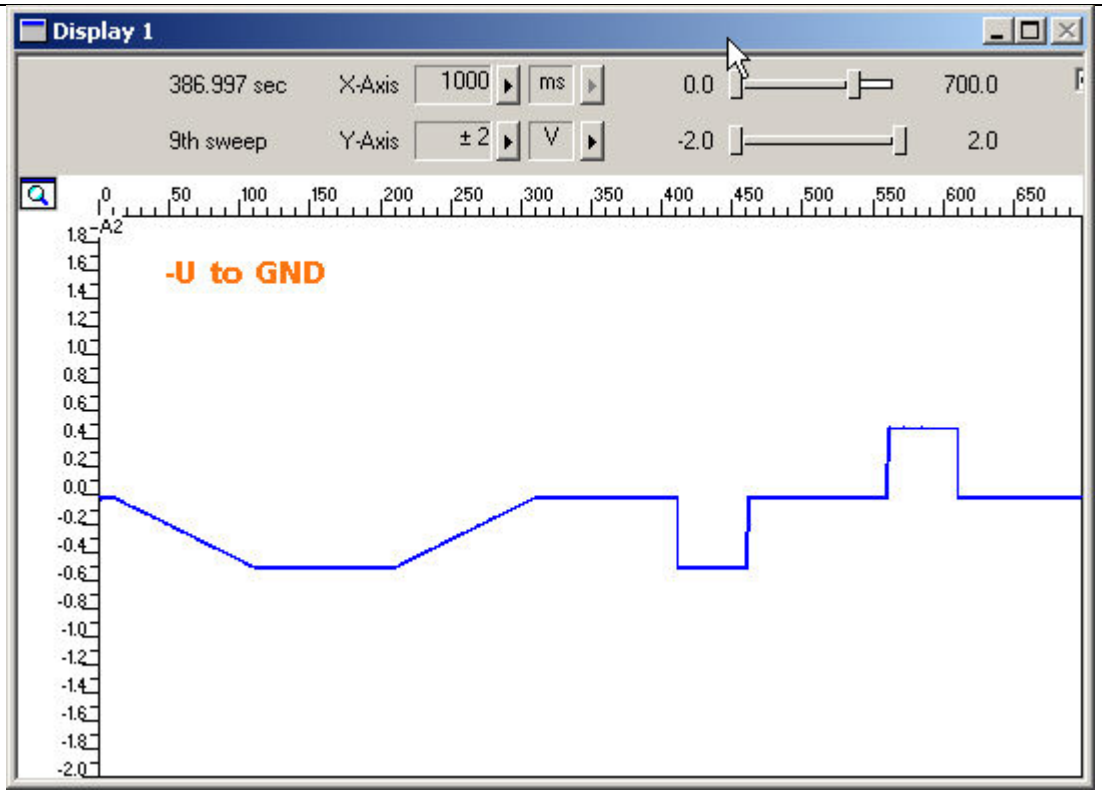
- The output signals are **inverted** (multiplied by 1) if you use the **U** outputs.
- If you use the voltage between **+U** and **U**, the output signal amplitude is **doubled**. U represents the ground (replaces GND) in this case. See illustration "Voltage mode: Doubled output signal amplitude".
- A **b**ipolar stimulation is recommended for extracellular recordings from microelectrode arrays (MEAs) if a very high output signal density in a defined area between two neighboring stimulating electrodes is needed. The current that is delivered by the first electrode flows directly back to the second electrode so that the surrounding tissue is not affected. See illustration "Voltage mode: Bipolar stimulation".
- In the **following example**, you see a signal in the MC_Stimulus display and the resulting output signals for the different connection options (viewed in an MC_Rack **Data Display**).

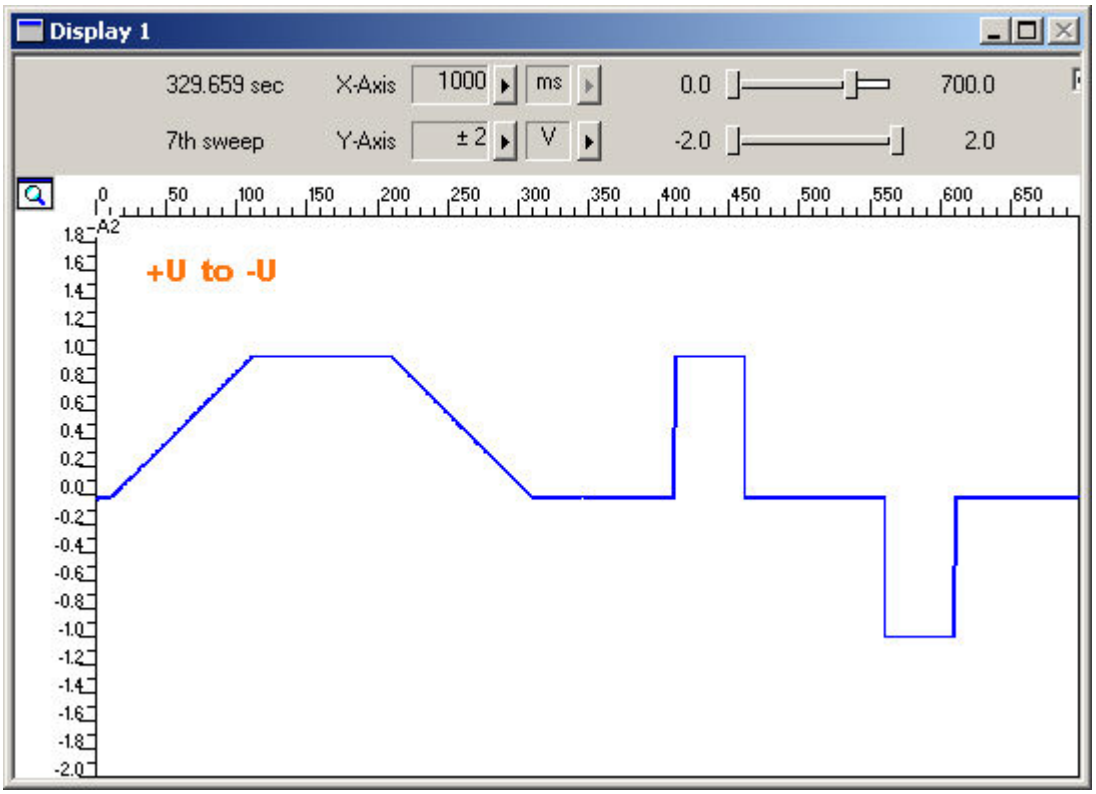
Programmed stimulus protocol viewed in MC_Stimulus:



STG output signals:







- For amplitudes greater than 200 mV, The **time lag** between the **Sync Out output** and the voltage outputs is approximately **12 µs (+/ 2 µs)**. For more information on the kinetics of smaller amplitudes, please see "Amplitude-Dependant Time Lag".

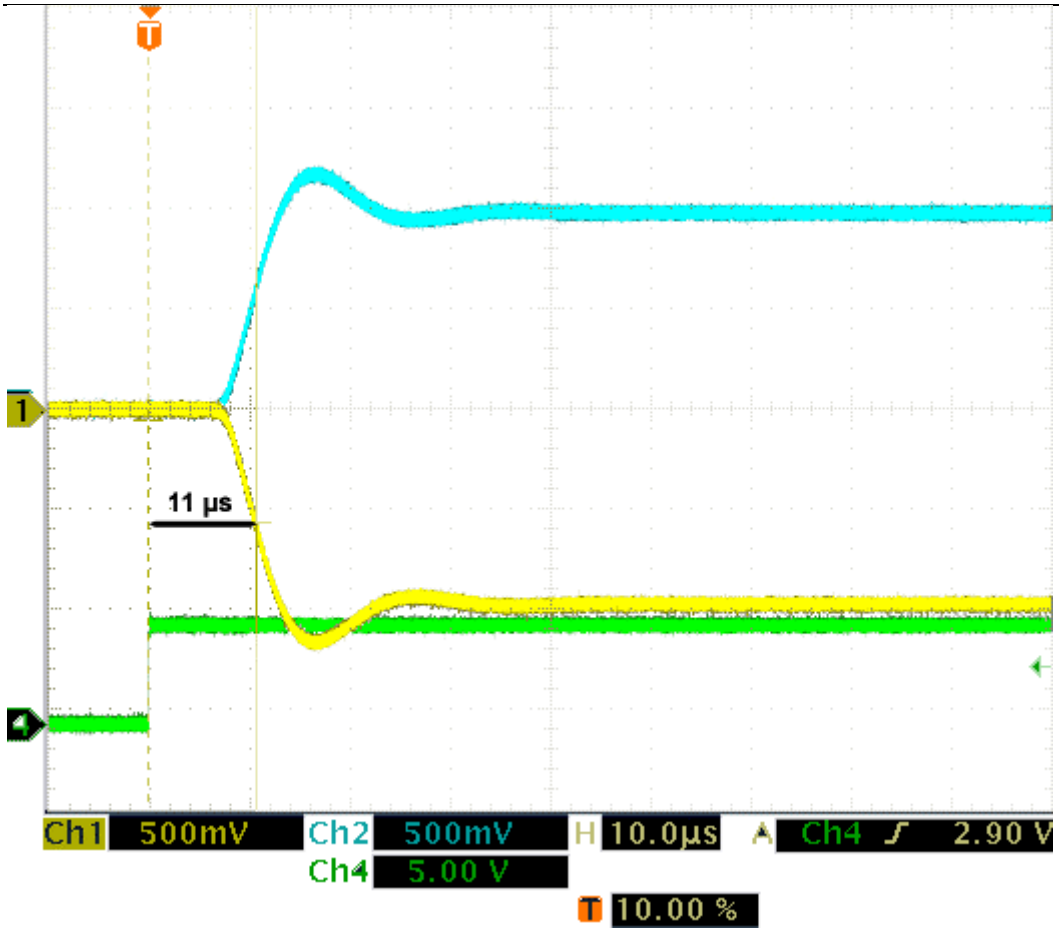


Fig. 2 Voltage output 1 V and Sync Out.

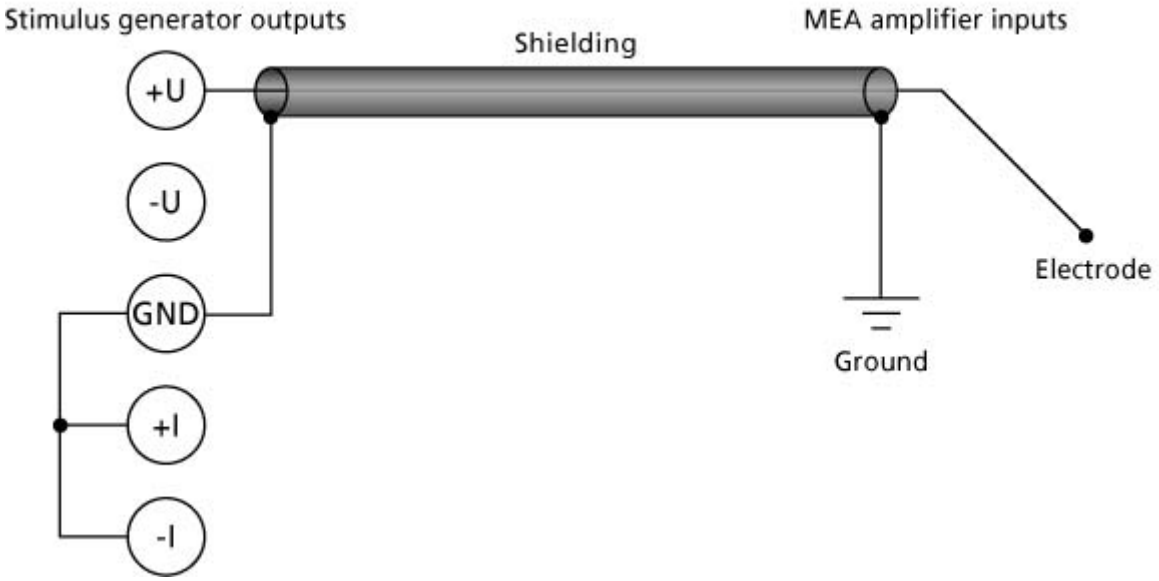
Screen shot from a standard oscilloscope triggered on the Sync Out pulse (see "Measuring output signals with an oscilloscope"). Cyan trace = voltage output (+U), yellow trace = inverted voltage output (U), green trace = TTL output from the Sync Out.

Setup suggestions for voltage mode

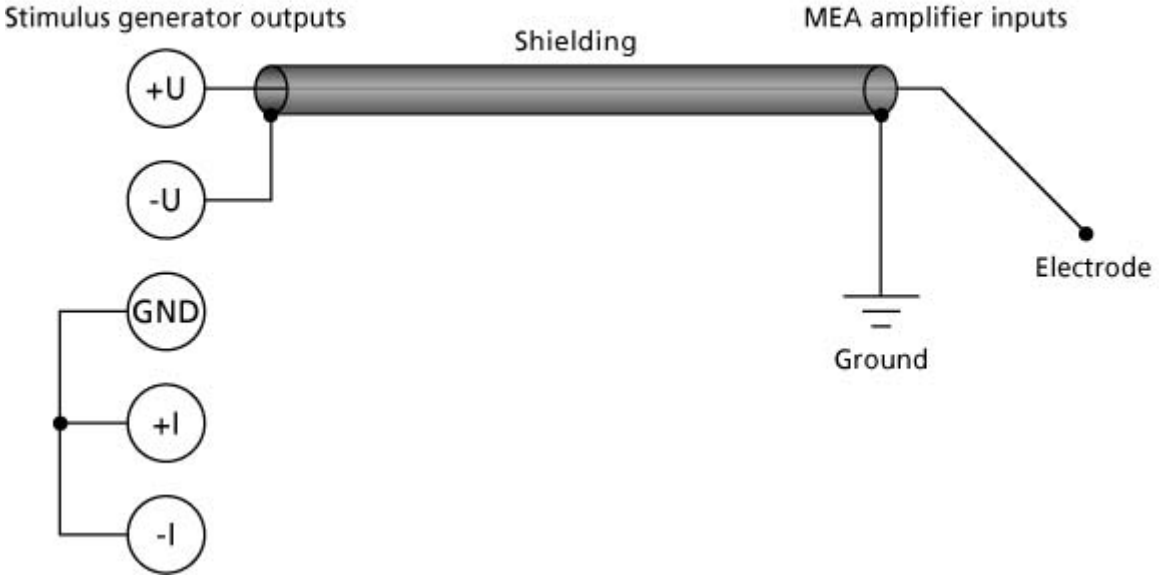
The following illustrations show circuit diagrams of suggested setups. Please note that you can use **unshielded twisted pair cables** (wires twisted round each other) instead of a shielding to prevent the amplifier from picking up noise. The experimental ground can be, for example, the amplifier's ground or a Faraday cage.

If you use the stimulus generator together with a standard MEA amplifier, you can also use the **provided 3-polar cable** for directly connecting the stimulus generator to the electrode inputs of the MEA amplifier. Please note that a shielded cable is generally not necessary if you use a MEA1060 amplifier with blanking circuit. For more details on the recommended setup for this amplifier type, please refer to the MEA1060 Amplifier with Blanking Circuit User Manual.

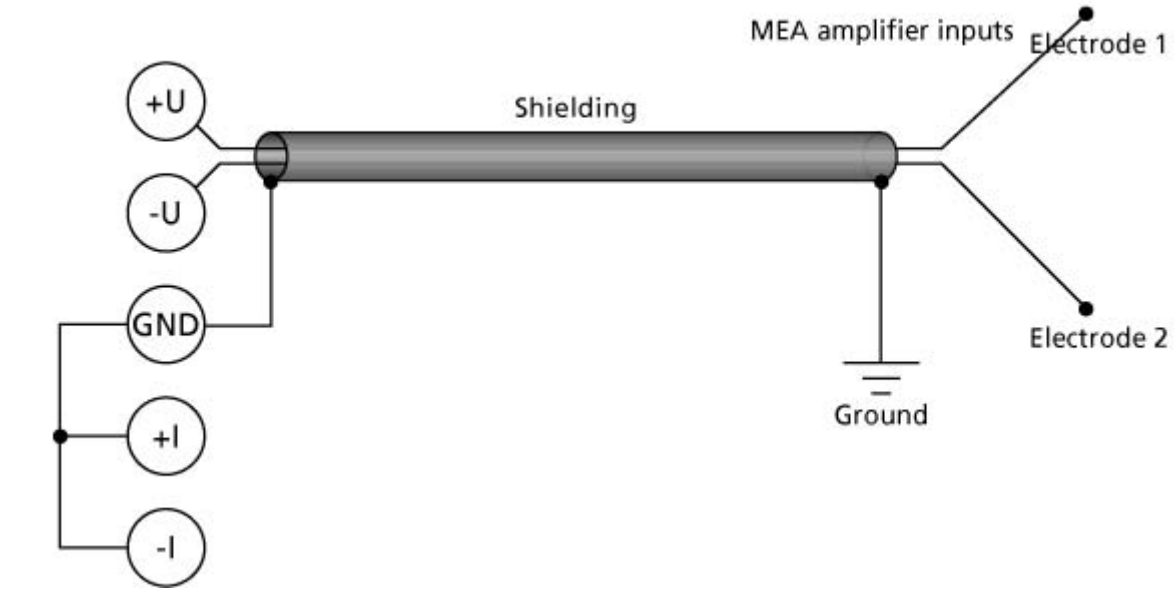
Voltage mode: Standard setup



Voltage mode: Doubled output signal amplitude



Voltage mode: Dipolar stimulation



11.3 Current Mode

- If you use current for stimulation, you will usually use the **+I** and **GND** outputs. See illustration "Standard setup".
- The output signals are **inverted** (multiplied by 1) if you use the **I** outputs.
- If the **load resistance**, that is, the **electrode impedance** is very high, the **output voltage** can get very high, too. The stimulus generator **limits** the output voltage to **75 V** between +I or I and GND. The guaranteed compliance voltage is **60 V**.
- The **current output** of the STG is **limited** by the **compliance voltage** and the **electrode impedance**. If the maximum load resistance for a given current output is exceeded, the compliance voltage (60 V between +I and GND) of the STG will not be sufficient for delivering enough current, and the output will be **clipped**. You can calculate the maximum load resistance by Ohm's law. For example, if you want to program a 100 µA pulse, the maximum load resistance will be 600 kilohms. According to Ohm's law: R = U / I = 60 V / 100 µA = 600 kΩ, that is, 60 V are sufficient for delivering a current of 100 µA at a load resistance of 600 kΩ. Therefore, if you use current driven stimulation, you should always take the impedance of the stimulating electrodes into account when planning your stimulus protocol. You should also keep in mind that most electrodes or amplifiers support only limited voltages.
- You can **increase** the compliance voltage to **120 V** by using the **+I** and **–I** outputs. The output current even at the maximum output voltage of 150 V should not be dangerous to human health because the maximum output current in current mode is only **+/ 0.8 mA**. See illustration "Doubled maximal output voltage".
- A **bipolar** stimulation is recommended for extracellular recordings from microelectrode arrays (MEAs) if a very high output signal density in a defined area between two stimulating electrodes is needed. The current that is delivered by the first electrode flows directly back to the second electrode so that the surrounding tissue is not affected. See illustration "Dipolar stimulation".
- For amplitudes greater than 100 µA, the **time lag** between the **Sync Out output** and the current outputs is approximately **15 µs (+/ 2 µs)**. For more information on the kinetics of smaller amplitudes, please see "Amplitude-Dependant Time Lag".

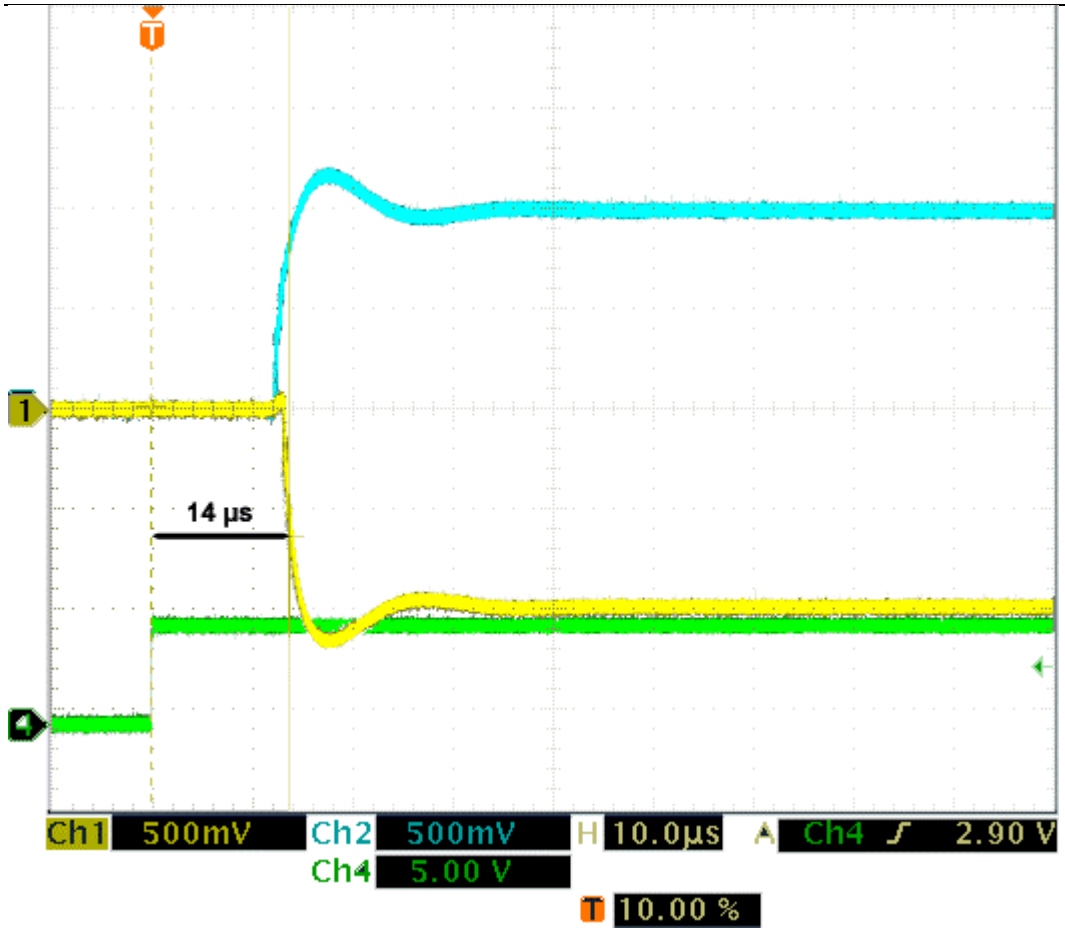


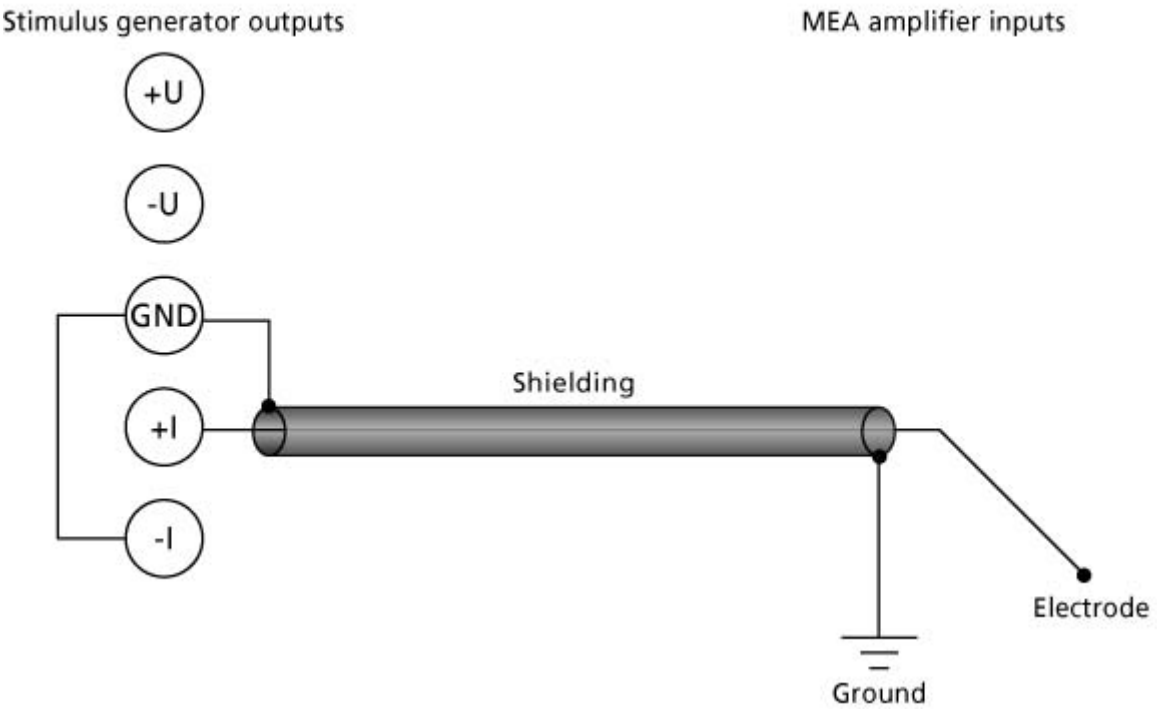
Fig. 3 Current output 100 µA and Sync Out.

Screen shot from a standard oscilloscope triggered on the Sync Out pulse (see "Measuring output signals with an oscilloscope"). Cyan trace = current output (+I), yellow trace = inverted current output (I), green trace = TTL output from the Sync Out.

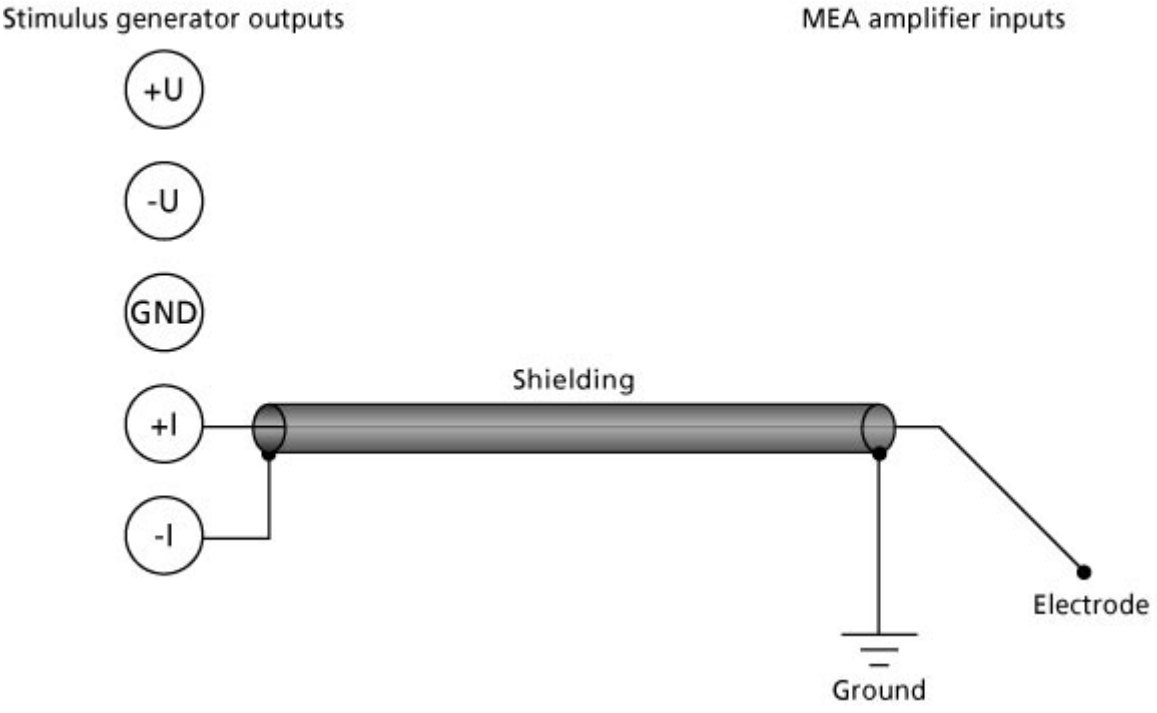
Setup suggestions for current mode

The following illustrations show circuit diagrams of suggested setups. Please note that for current stimulation, you should use shielded cables to protect your setup against electromagnetic interference. The experimental ground can be, for example, the amplifier's ground or a Faraday cage.

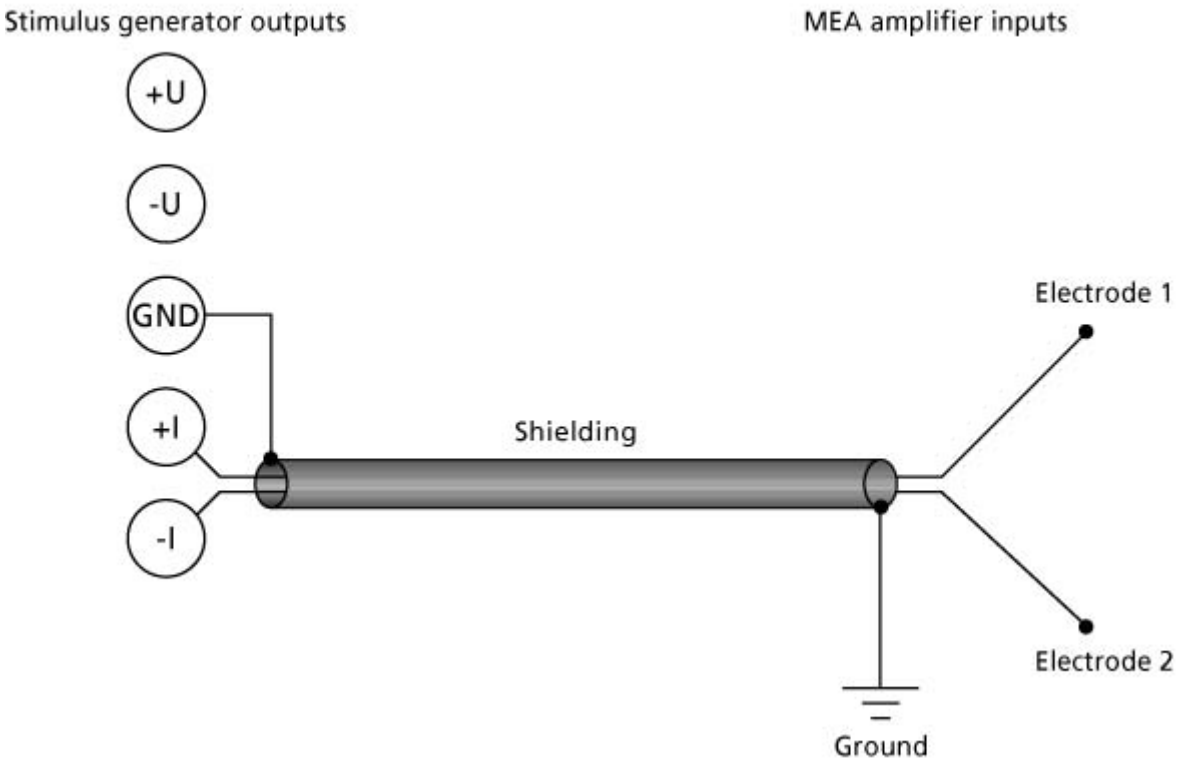
Current mode: Standard setup



Current mode: Doubled maximal output voltage



Current mode: Dipolar stimulation



11.4 Measuring Output Signals with an Oscilloscope

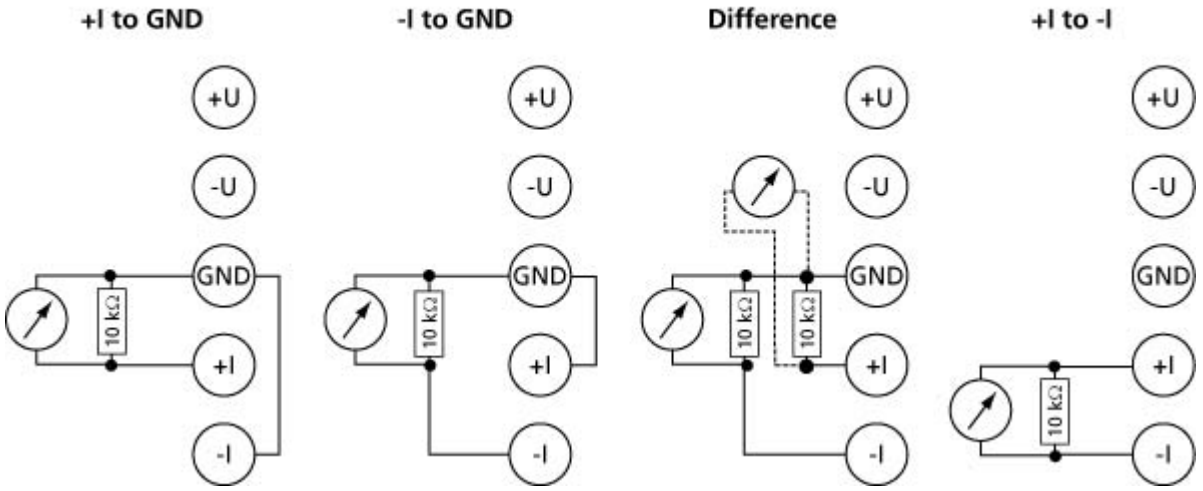
For test purposes, you can measure the output signals with an oscilloscope.

Most standard oscilloscopes have a probe with a ground cable. This probe is usually connected to the oscilloscope via a BNC socket. What you do for measuring the **voltage output** is the following: You plug in the standard STG cables into the +U output and the corresponding GND output. You then touch the open end of the cable from the +U output with the probe from the oscilloscope, and the open end of the cable from the GND output with the ground cable from the probe. This means you measure the **potential difference** between the **+U output** and **ground**.

Please note that you need a resistor in parallel to measure the **current output** properly because oscilloscopes measure voltages. If the input resistance of the oscilloscope is too low, the voltage output of the STG will be small as well, and you will not see any signals on the oscilloscope. MCS recommends a resistor of **10 kΩ** because the output signal of the current output should then be identical to the output signal of the voltage output. You can use the same test protocol (regardless of the output mode) for the current and voltage outputs, and compare the signals. As an alternative, you can also use a resistor that mimics the electrode resistance for testing your experiments.

What you do is, you plug in cables into the **+I output** and into the **GND** output of the STG. You then use alligator crimps for connecting a **10 kiloohms resistor** between the two open ends of the cables. You then touch the cable on one side of the resistor with the probe and on the other side with the ground of the probe. That is, you measure the **potential difference** over the **resistor**. You can then calculate the current output according to Ohm's law (U = R * I). For example, if you stimulate with 100 µA, the voltage over the 10 kiloohms resistor has to be U = 10000 Ω * 0.1 mA = 1000 mV = 1 V.

The following illustration shows four possible combinations of connecting the current outputs on the front panel of the stimulus generator to the oscilloscope. Again, it is important that unused current outputs are connected to ground.



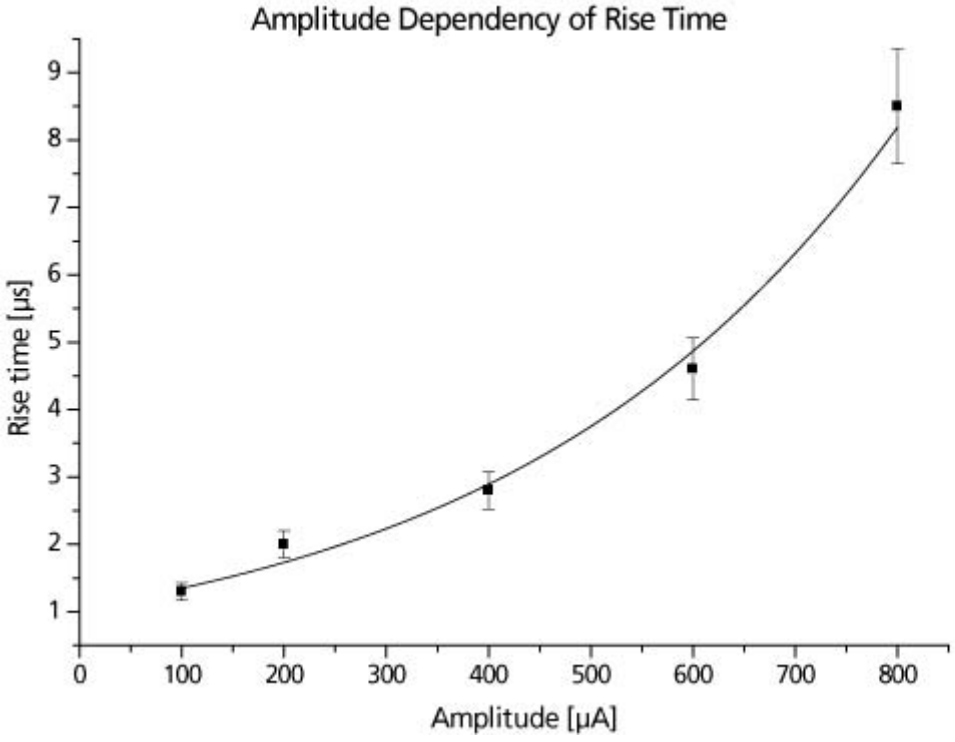
11.5 Rise Time

The **rise time** of the **voltage output** is **constant** and independant from the stimulus protocol. The **rise time** of the **current output** is no fixed hardware property.The kinetics depend on the **amplitude** of the current pulse and the **load resistance**, that is, generally the electrode impedance. The resistance affects the kinetics much stronger than the amplitude.

Generally, this does not make much difference for biological applications. If you have **very time-critical applications**, or if you use **very short pulses**, you should **check** the **output** of the STG **with an oscilloscope** before starting the experiment.

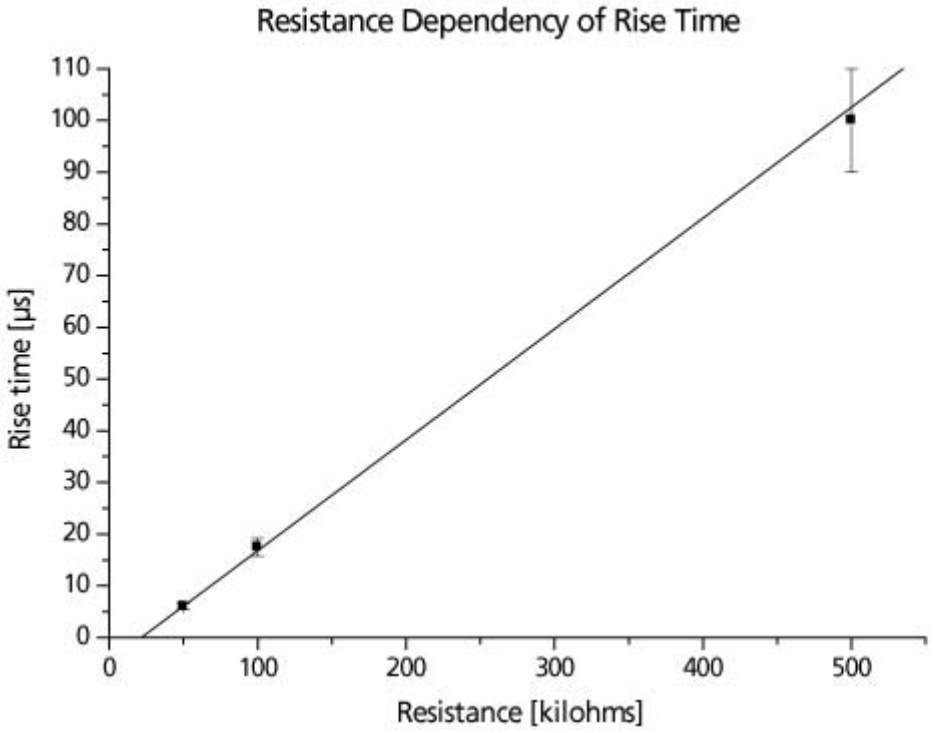
Amplitude dependency of rise time

The **higher** the **current amplitude**, the **higher** the **rise time**. The rise time (1090%) was measured with increasing current amplitudes and a constant load resistance of 10 kilohms. The **output current slope** can be estimated at **100 µA/µs**, but the relationship is not linear as shown by the following (Boltzmann fitted) curve.



Resistance dependency oft rise time

The **higher** the **load resistance**, the **higher** the **rise time**. The rise time (1090%) was measured with increasing load resistances and a constant current amplitude of 100 µA. For 100 µA pulses, the relationship is linear up to the maximum load resistance (please see "Current Mode") as shown by the following (Boltzmann fitted) curve.



Stimulus output comparison

The following figures are examples for demonstrating how the **amplitude** and **resistance** will affect the **kinetics** of a **current pulse**. These images document also that in contrast to the current mode, in **voltage mode**, the **rise time** is **constant** and not dependant on the amplitude or load resistance.

The graphs were generated by a standard oscilloscope. The devices were set up according to the recommendations under "Voltage Mode" and "Current Mode". The same pulse protocol and the same channel number of the STG outputs was used for measuring the voltage and the current output. The **yellow** traces show the voltage (**U**) output; **cyan** traces are from the current output (**+I**) with a load resistance of **10 kΩ**, and **green** traces show the TTL output from the **Sync Out** that was used for triggering the oscilloscope.

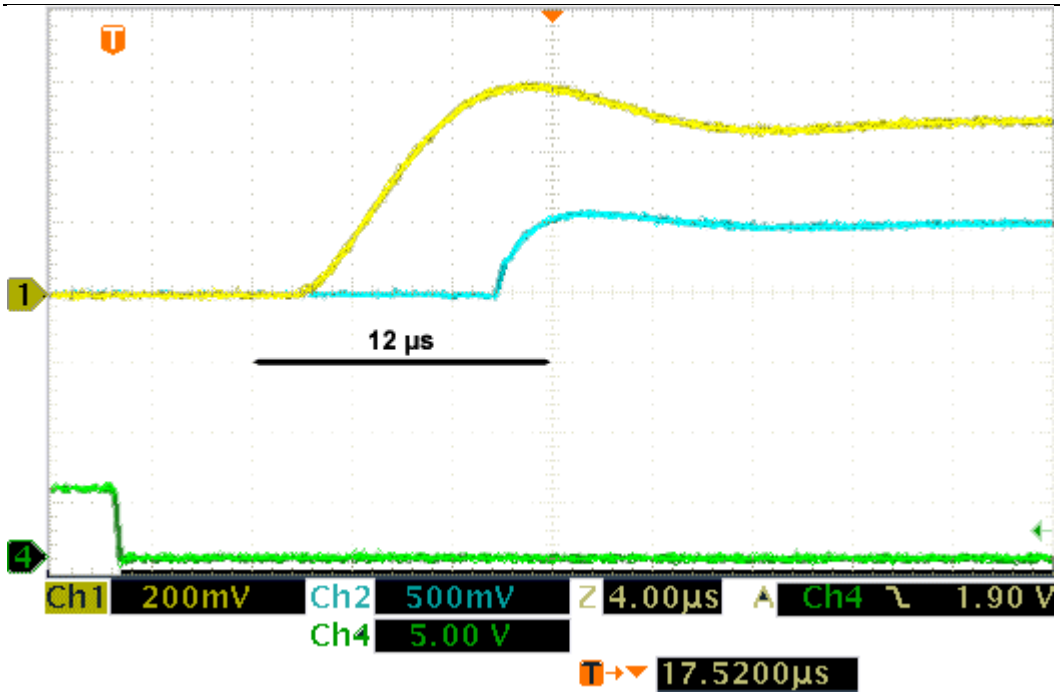


Fig. 4 Rise time with programmed 500 mV and 50 µA pulses, 10 kΩ load resistance.

The rise time is about 4 µs for the 500 mV voltage pulse (yellow), and < 1 µs for the 50 µA current pulse (cyan).

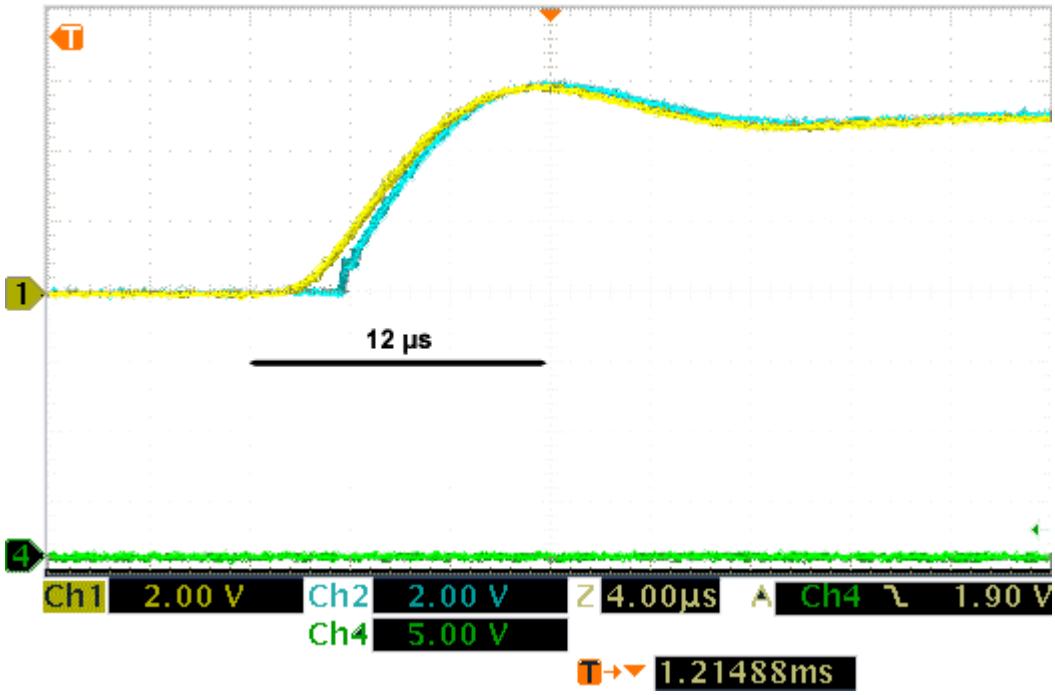


Fig. 5 Rise time with programmed 5 V and 500 µA pulses, 10 kΩ load resistance.

The kinetics and the rise time of the 5 V voltage pulse (yellow) are comparable to the 500 mV pulse. The approx. 4 µs rise time of the 500 µA current pulse (cyan) is significantly higher than the rise time of the 50 µA pulse.

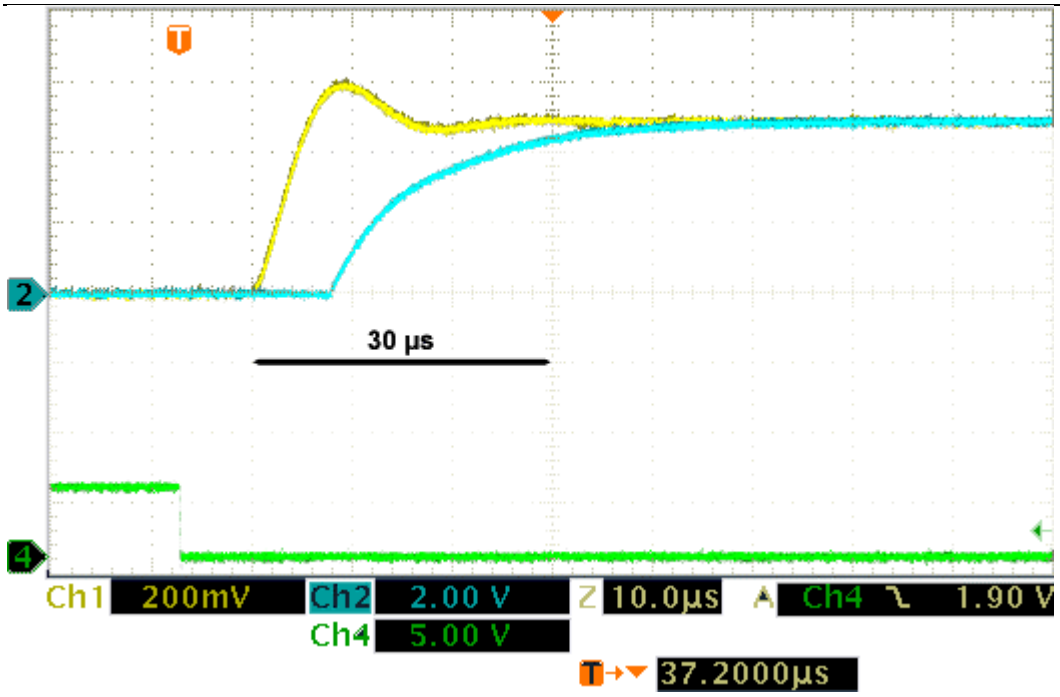


Fig. 6 Rise time with programmed 5 V and 500 µA pulses, 100 kΩ load resistance.

With a higher load resistance, the current pulse (cyan) shows a different kinetic behavior: There is no overshoot, and the rise time increases significantly (about 20 µs).

11.6 Amplitude-Dependant Time Lag

For **most standard applications**, you can assume that the STG output is identical (in normal tolerances of electronic components) to the stimulus protocol in the WYSIWYG editor of the MC_Stimulus program. However, there are some special situations where you should confirm the output with an oscilloscope. The deviation from the programmed pulse protocol is due to the intrinsic properties of the electronic components and may vary slightly between different STG units. As there is no true linear relationship between, for example, the amplitude dependant time lag and the amplitude size, the STG's behavior cannot be precisely predicted, and therefore it is not possible to show a corrected output in the MC_Stimulus display. The only possibility is to measure the output with an oscilloscope before starting the experiment.

In the following, you will find some general rules that might help you to decide whether your planned pulse protocol is subject to these limitations. It might be necessary to check and adapt your pulse protocol according to these findings.

The actual output as shown in the figures below was documented by a standard oscilloscope. The same pulse protocol and the same channel number of the STG outputs were used for measuring the voltage and the current output. The devices were set up according to the recommendations under "Voltage Mode" and "Current Mode".

For **very small pulse amplitudes** (**< 200 mV** or **< 100 µA**), which are generally not used in biological applications, the time lag between the digital Sync Out output (as a reference point) and the analog output signals increases with a decreasing amplitude, that is, the **lower** the **amplitude**, the **higher** the **time lag**. You should check the **actual pulse amplitude** and **duration** if you need short pulses with a high accuracy. It might be necessary to program longer pulses to make sure that (a) the output amplitude matches the setpoint voltage and (b) the duration is long enough for your application. This might be especially important if you apply biphasic current pulses to discharge the electrode with the inverted phase. In the following, a few general examples and recommendations are described.

Time lag of positive phase

The **time lag** of the **positive phase** (for the **+U** and **+I** outputs, negative phase for U and I) is **higher** than that of the **negative phase**. If the polarity switches directly from negative to positive, you will observe a time lag of a few microseconds at 0 V in-between the phases.

For pulses with positive phase (for the +U and +I outputs, negative phase for U and I), the **time lag** of the **falling edge** is **negligible** in contrast to the time lag of the rising edge. This means, the increased time lag directly affects the **duration** of the pulse, that is, positive pulses with low amplitudes are **shortened**.

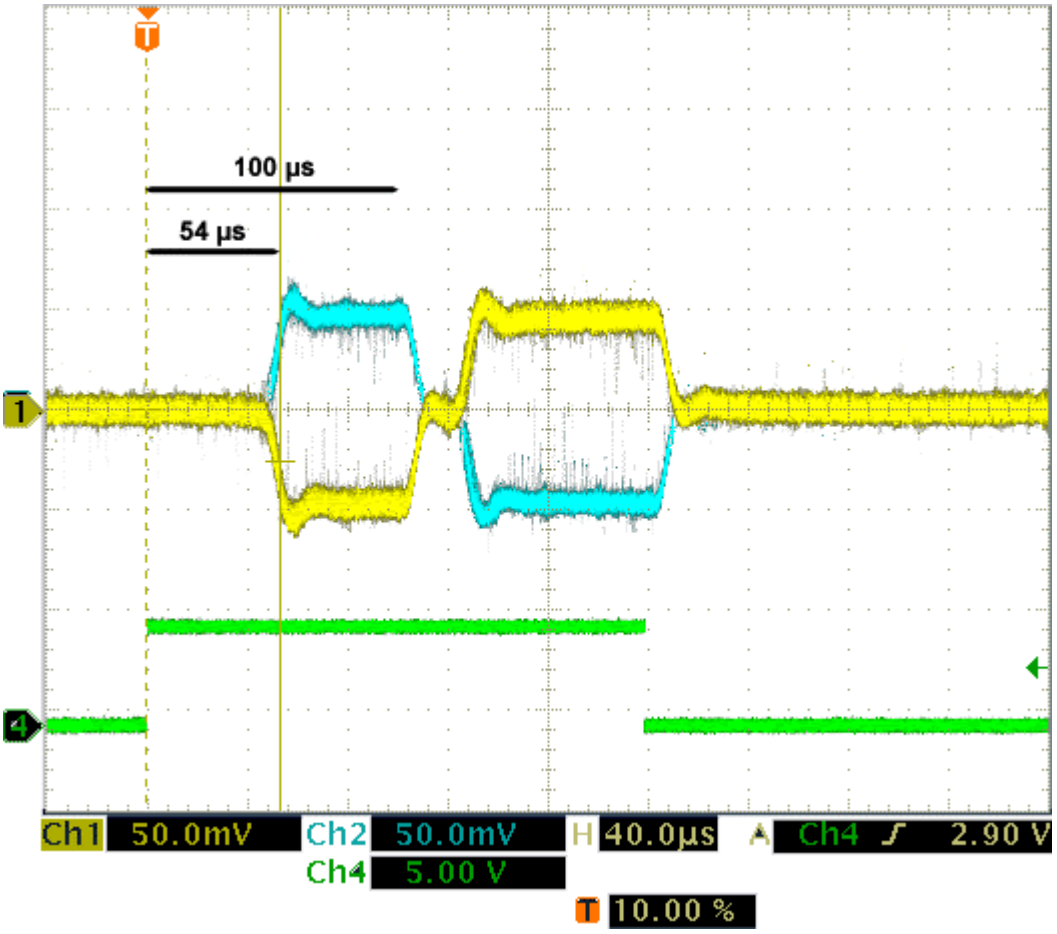


Fig. 7 STG output with programmed biphasic 50 mV pulses, positive phase first, duration 100 µs for each phase.

The positive phase of the +U output (cyan trace) and the negative phase of the U output (yellow trace) are shortened. The time lag of the positive phase with the rising edge of the Sync Out output (green trace) as a reference point is 54 µs in this example.

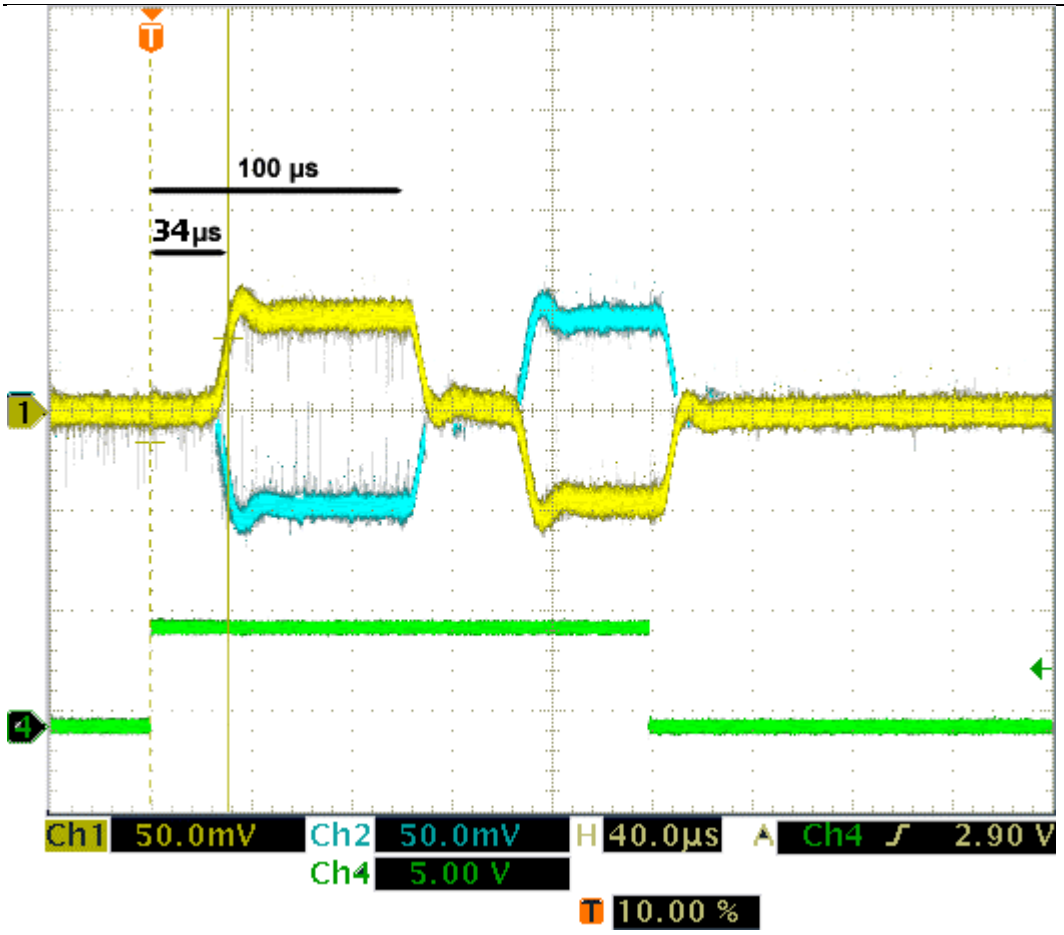


Fig. 8 STG output with programmed biphasic 50 mV pulses, negative phase first, duration 100 µs for each phase.

This figure shows the output of the same programmed pulse, but with inverted polarities. Regardless whether the positive or the negative phase comes first, always the positive phase of the +U output shows a higher time lag and is shorter than the negative phase. If the polarities are switched directly from negative to positive, there is a time lag at 0 mV between the phases.

Deviation of the amplitude

If the resulting **pulse** is much **too short**, the electronics might also not be able to reach the **setpoint voltage** or **current** in the short time, resulting in a deviation of the amplitude, too. Pulse protocols that are programmed near the resolution limit of the STG, that is, with very small amplitudes and short pulses (for example, 50 mV and 20 µs) may not generate any output at all.

If you have a **pulse train** with **very short pulses** near the resolution limit of the STG, the **amplitude of the first pulse** in the train might be **lower** than the following pulses.

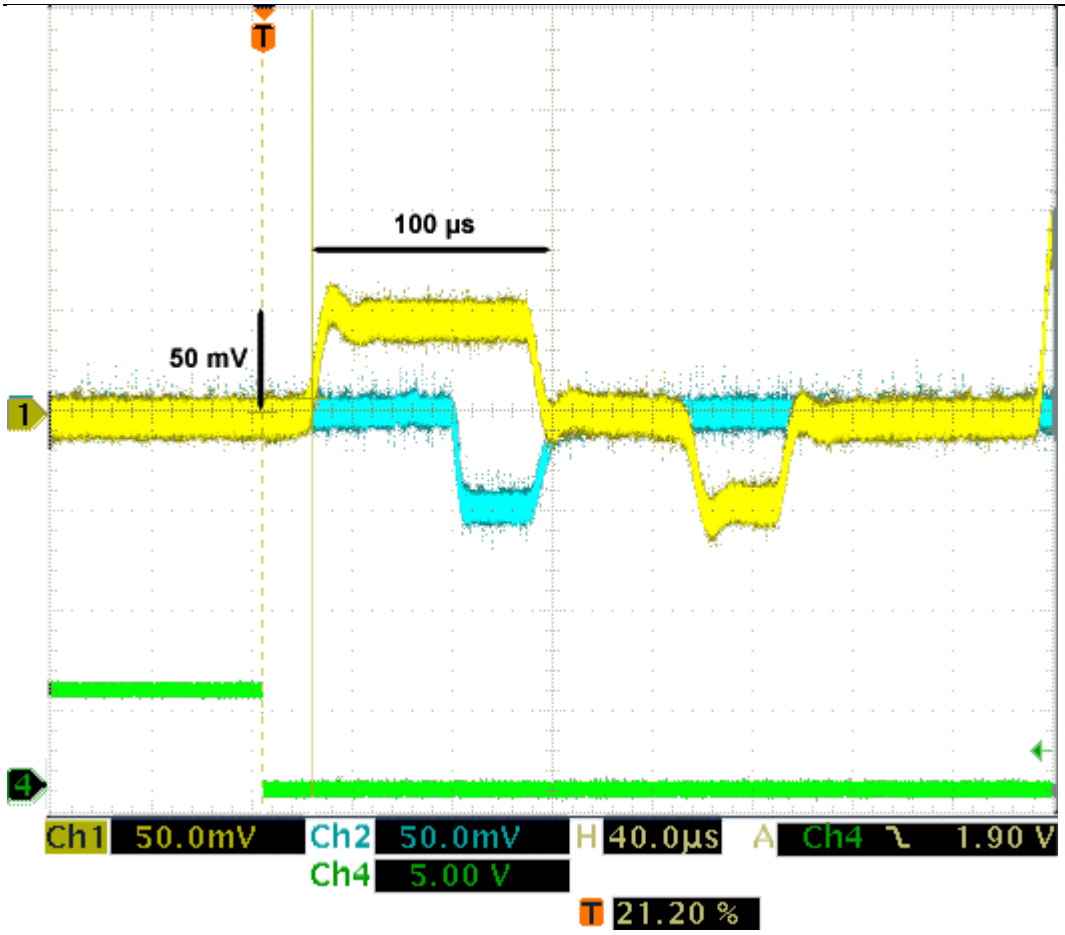


Fig. 9 STG output with programmed biphasic 50 mV and 5 µA pulses, duration 100 µs for each phase.

The negative phase of the inverted voltage output (U, yellow) and the positive phase of the current output (+I, cyan) are more delayed and significantly shorter than the other phases. The delay of the current output of the 5 µA positive phase is so high that the electronics are not able to generate any current output in the short duration of the pulse at all, that is, the actual current output is zero.

Decreasing time lag with increasing pulse amplitude

The following figures illustrate that the behavior of the STG's electronics improves with increasing amplitude. With amplitudes **greater than 200 mV** or **100 µA**, the time lag between the Sync Out as a reference point and the voltage/current outputs is short and stable (see data sheet).

The **yellow** traces show the inverted voltage (**U**) ouput; **cyan** traces are from the current output (**+I**) with a load resistance of **10 kΩ**, and **green** traces show the TTL output from the **Sync Out** that was used for triggering the oscilloscope.

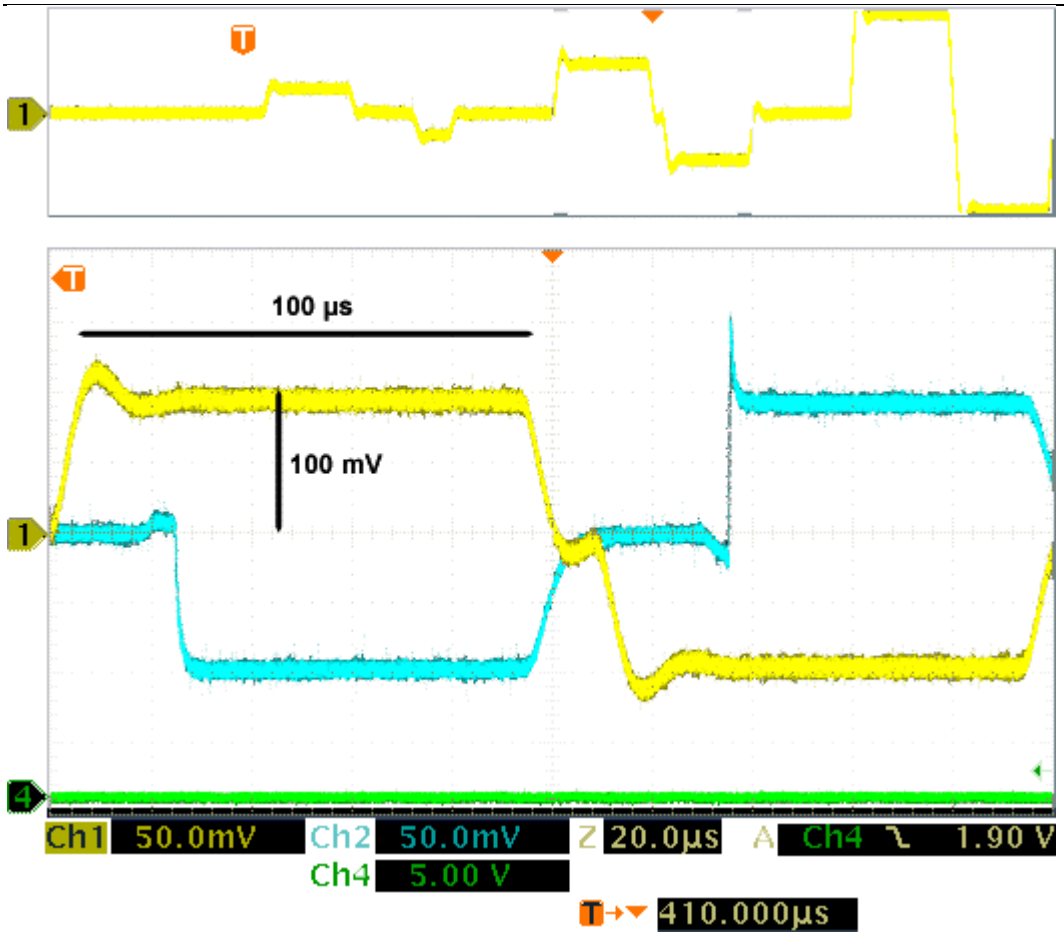


Fig. 10 STG output with programmed biphasic 100 mV and 10 µA pulses, duration 100 µs for each phase.

In comparison to the 50 mV pulses, the time lag of the negative phase of the U output (yellow) is much smaller (less than 10 µs), and the actual current output amplitudes (cyan) match the setpoint current.

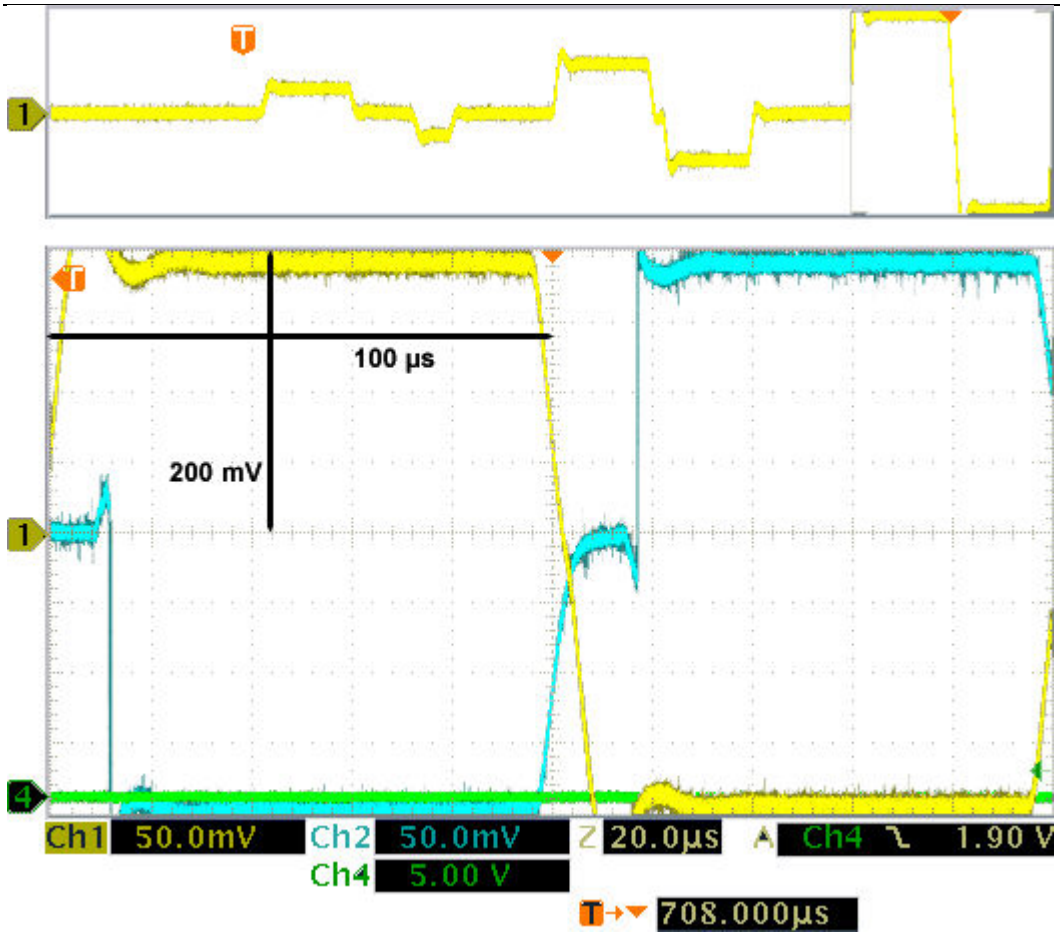


Fig. 11 STG output with programmed biphasic 200 mV and 20 µA pulses, duration 100 µs for each phase.

With a voltage amplitude of 200 mV (U, yellow), there is almost no delay between the positive and negative phase. The top part of the figure shows all three voltage steps (50 mV, 100 mV, and 200 mV). You can clearly see that the delay between the phases decreases significantly with increasing pulse amplitude.

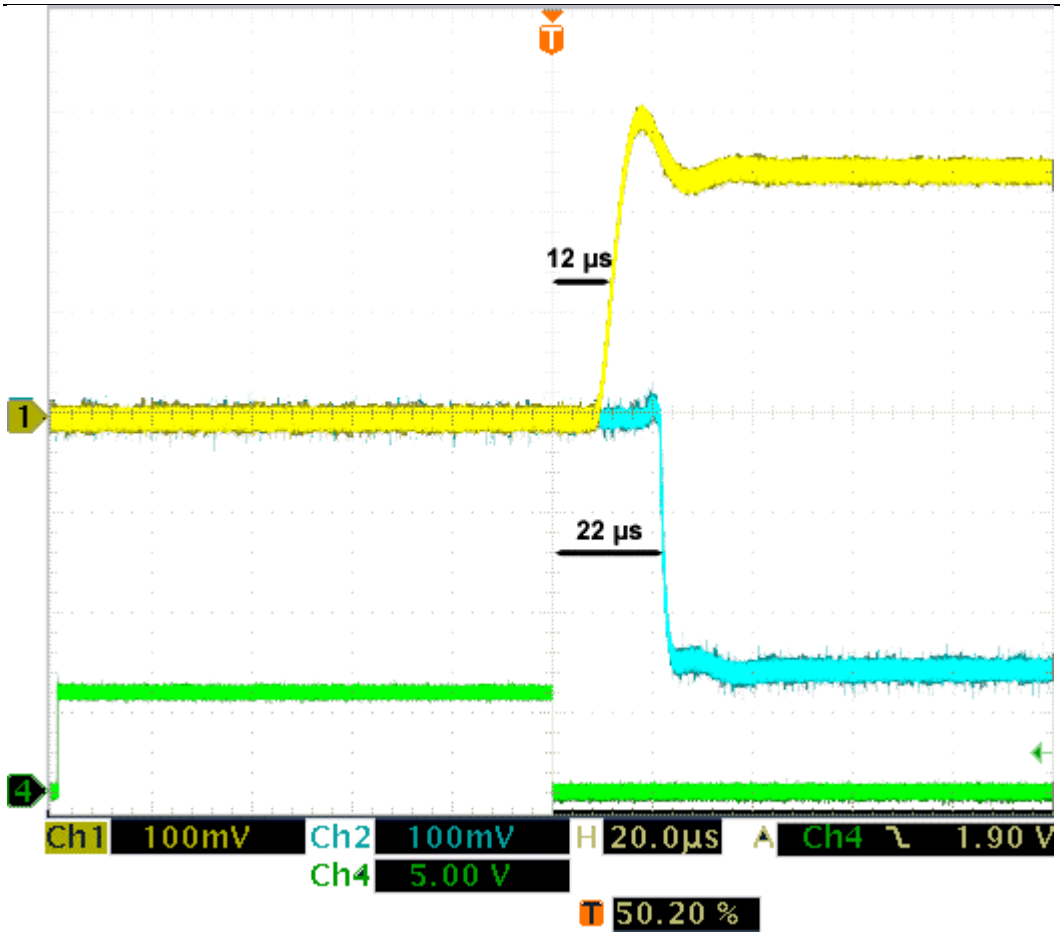


Fig. 12 STG output with programmed 200 mV and 20 µA pulses, duration 100 µs for each phase.

About 10 µs is the standard delay of the voltage output at 200 mV (U, yellow). The delay of the current output at 20 µA (cyan) is increased due to the small current amplitude. At 100 µA or higher, the time lag of the current output would be comparable to the standard delay of the voltage output.

11.7 Capacitive Behavior of Stimulating Electrodes

Regarding the generally used stimulus pulses, stimulating electrodes behave as plate capacitors. They need some time to discharge themselves after stimulation. As a result, artifacts interfere with the recording, and electrodes deteriorate over time due to electrolysis. This effect takes place especially in **current** mode because the current cannot flow back to the stimulus generator due to the high output resistance in current mode and thus is kept in the electrode.

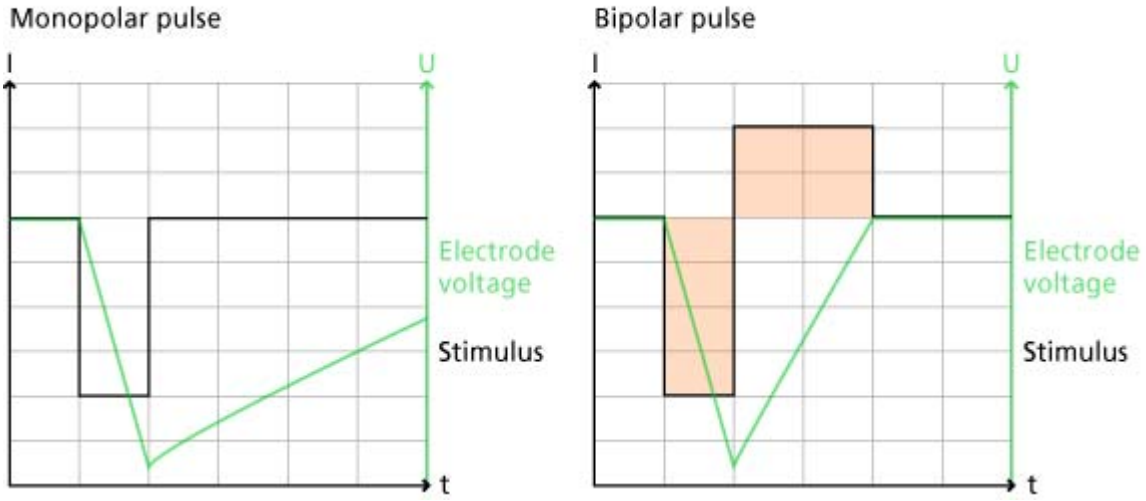
To reduce the effect described abovew in **current mode**, you should use **biphasic pulses** for stimulation. The stimulus signal should be immediately followed by an **inverse** signal of the **same** area (product of current and time), which helps to discharge the electrode. The easiest way is to use the same signal amplitude with an opposite polarity.

Multi Channel Systems recommends to use voltage driven stimulation. In **voltage mode**, it is **not** necessary to use a biphasic stimulation for discharging the electrodes, because the electrode should be discharged at a voltage of 0, that is, it would be sufficient to apply the negative phase only.

Warning: When using MEA electrodes of **TiN** material, stimulation with a higher amplitude is possible if you apply the **negative pulse first**. Also, regard the **safe charge-injection limit** as described in the MEA User Manual. Otherwise, electrodes can be damaged during stimulation.

The following illustration shows the effect of a biphasic current pulse on the discharge of the stimulating electrode. As you can see, the first monophasic pulse is followed immediately by a pulse of the opposite polarity and the same product of current and time.

Effect of a bipolar pulse on the electrode voltage



12 Troubleshooting

12.1 About Troubleshooting

Most problems occur seldom and only under specific circumstances. In most cases, it is only a minor problem that can be easily avoided or solved.

If the problem persists, please contact your local retailer. The highly qualified staff will be glad to help you. Please inform your local retailer as well, if other problems that are not mentioned in this documentation occur, even if you have solved the problem on your own. This helps other users, and it helps MCS to optimize the instrument and the documentation.

Please pay attention to the safety and service information (chapter "Important Safety advice" in the User Manual / Help). Multi Channel Systems has put all effort into making the product fully stable and reliable, but like all high-performance products, it has to be handled with care.

12.2 Technical Support

Contact your local retailer immediately if the cause of trouble remains unclear. Please understand that information on your hardware and software configuration is necessary to analyze and finally solve the problem you encounter.

If you have any questions or if any problem occurs that is not mentioned in this document, please contact your local retailer. The highly qualified staff will be glad to help you.

Please keep information on the following at hand

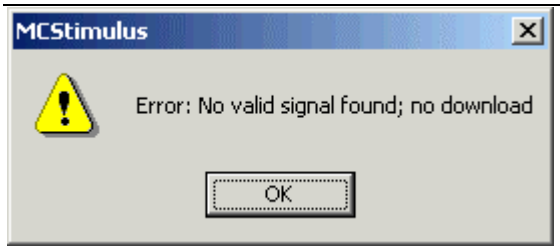
- **Description** of the **error** (the error message text or any other useful information) and of the context in which the error occurred. Try to remember all steps you had performed immediately before the error occurred. The more information on the actual situation you can provide, the easier it is to track the problem.
- The **serial number** of the device. You will find it on the device.
- The **software (SW) and hardware (HW) version** you are currently using. On the **Help** menu, click **About**. The displayed dialog box shows the version numbers.
- The **operating system** and service pack number on the connected **computer**.
- The **hardware configuration** (microprocessor, frequency, main memory, hard disk) of the connected **computer**. This information is especially important if you have modified the computer or installed new hard- or software recently.

12.3 Error Messages

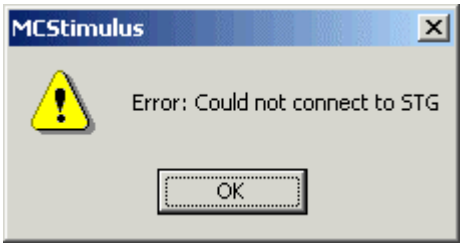
This chapter explains error messages to you that may occur during normal operation. They do not present a reason to worry and can be easily avoided.

Download

These error messages may occur during download on the STG. Please note that you can switch off some of these messages if they disturb your experiment. See chapter "Downloading Stimuli" for more details on downloading.



The worksheet is empty. No data is present that can be downloaded. Please create a stimulus or open a stimulus file before downloading.



There is no stimulus generator connected to the computer or the STG may be switched off. Please check the computer connection and the status lamp of the STG.

There is no valid connection to an STG. Download of data is not possible. Please check the computer connection and the status lamp of the STG.

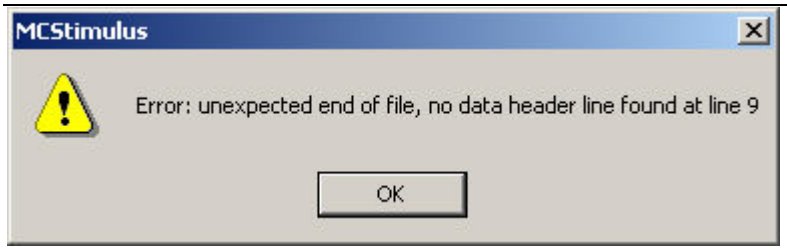
The last voltage/current values of the named channels are not zero. The last used values of these channels are **kept** until the STG is stopped.

ASCII Import

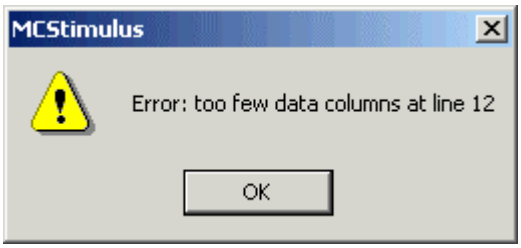
These error messages relate to a wrong file format. Please see chapter "Supported File Format" for more information.

The named line contains an unexpected character.

The channel number specification has to precede the data. The channel number either lacks or the specified number does not exist (for example, number 13).



Each data column must have a header (*value*, *time*, or *repeat*).



The number of data columns has to be consistent for all lines in a given ASCII file (for example, *value*, *time*, *value*, *time*). This error message indicates that there is a current/voltage value or a time point missing in line 12.

The ASCII file contains current/voltage values outside the STG's range. For example, if the STG's output range is +8000 mV, all values above +8000 mV are set to +8000 mV.

12.4 Strong Peak Artifacts

Strong discharges or other artifacts of the output voltage or current.

Possible causes:

One or both current outputs are open, that is, nothing is connected to them. The stimulus generator tries to hold a stable current against the indefinite resistance of the open current output. Therefore, the stimulus generator will increase the output voltage on the open current outputs to its maximum, which will result in a heavy load on the power supply. This situation may cause the power supply to become unstable, which may lead to artifacts on all channels.

- **In voltage mode: Short-circuit** the **+I** and **I** outputs with the provided cables for saving power and suppressing noise. Please see also the recommended setups in the chapter Voltage Mode.
- **In current mode: Connect** the **unused current** output to ground (GND). Please see also the recommended setups in the chapter Current Mode.

12.5 Output Signal Does not Match Programmed Signal

The amplitude or the duration of the output pulses differs from the programmed signal.

Possible causes:

The stimulus protocol works near the resolution limits of the STG, that is, the pulses are very short or the amplitudes very low (**smaller than 200 mV** or **100 µA**). Due to the intrinsic properties of the electronics, the timing and the amplitude of short or small pulses are limited. Please see also the chapters "Rise Time" and "Amplitude-Dependant Time Lag".

- Check the output signals with an oscilloscope and modify the pulse protocol so that the amplitude and timing of the pulses will match your requirements.

You operate the STG in **current mode**, and the **electrode resistance** of the **stimulating electrodes** is **too high**. According to Ohm's law, the electrode resistance directly affects the kinetics of the current output. The rise time increases with an increasing electrode resistance. If the electrode resistance is too high for the compliance voltage, the output signal will be clipped.

- Try to stimulate in **voltage mode**.
- Try to use stimulating electrodes with a **lower impedance**.
- Check the output signals with an oscilloscope and modify the pulse protocol so that the amplitude and timing of the pulses will match your requirements.

13 Appendix

13.1 Technical Specifications STG1001/2

Operating temperature	10 °C to 35 °C
Storage temperature	0 °C to 50 °C
Dimensions (W x D x H)	170 mm x 240 mm x 60 mm
Weight	1.2 kg
Fuse	1 A @ 100 to 230 V, slow blow
Supply voltage (external power supply)	100240 VAC @ 47 to 63 Hz
Number of analog output channels	1 (STG1001) or 2 (STG1002)
Output voltage	8 V to + 8V @ max. +/20 mA
Output voltage resolution	2 mV
Ouput voltage slope	4 V/µs
Rise time (1090%)	3 to 5 µs @ delta U = 1 V or @ delta I = 0.4 mA & R_L = 10 kilohms
Output current	0.8 mA to +0.8 mA @ max. 100 V compliance voltage (between +I and I)
Output current resolution	200 nA
Output current slope	100 µA/µs @ R_L = 10 kilohms
Time lag between Sync Out and voltage output	12 µs +/-2 (@ amplitude > 200 mV)
Time lag between Sync Out and current output	15 µs +/-2 (@ amplitude > 100 µA & RL = 10 kilohms)
Resolution	13 bit
Time resolution	20 µs
Output signals	Freely programmable (rectangular, ramp, sinusoidal)
Maximum frequency (rectangular waveform)	25 kHz
Timing on external trigger	
Minimum time length of trigger input (TTL)	20 µs
Time lag between trigger input and stimulus output	120 +/ 10 µs
Time lag between trigger input and Sync Out	110 +/ 10 µs
Maximum trigger input frequency	50 Hz
Interface and connectors	
Sync Out for synchronization with following devices	Digital channel via coax cable
Trigger In for synchronization with preceding devices	Digital channel via coax cable
Interface (connection to computer)	RS232 serial port
Download rate	56 Kbps
MC_Stimulus program	

Operating system	Windows© 98, ME, NT, 2000, or XP; English and German versions supported
Data import	ASCII file format

13.2 Technical Specifications STG1004/8

Operating temperature	10 °C to 35 °C
Storage temperature	0 °C to 50 °C
Dimensions (W x D x H)	275 mm x 330 mm x 115 mm
Weight	4.8 kg
Fuse	0.2 A @ 230 V, slow blow; 0.4 A @ 115 V, slow blow
Supply voltage	Available types: 100 VAC, 115 VAC, or 230 VAC @ 50 to 60 Hz
Number of analog output channels	4 (STG1004) or 8 (STG1008)
Output voltage	8 V to + 8V @ max. +/-20 mA
Output voltage resolution	2 mV
Ouput voltage slope	> 4 V/µs
Rise time (10-90 %)	3 to 5 µs @ delta U = 1 V or @ amplitude > 100 µA & R_L = 10 kilohms
Output current	0.8 mA to +0.8 mA @ max. 100 V compliance voltage (between +I and I)
Output current resolution	200 nA
Output current slope	100 µA/µs @ R_L = 10 kilohms
Time lag between Sync Out and voltage output	12 µs +/-2 @ amplitude > 200 mV
Time lag between Sync Out and current output	15 µs +/-2 @ amplitude > 100 µA & R_L = 10 kilohms)
Resolution	13 bit
Time resolution	20 µs
Output signals	Freely programmable (rectangular, ramp, sinusoidal)
Maximum frequency (rectangular waveform)	25 kHz
Timing on external trigger	
Minimum time length of trigger input (TTL)	20 µs
Time lag between trigger input and stimulus output	120 +/ 10 µs
Time lag between trigger input and Sync Out	110 +/ 10 µs
Maximum trigger input frequency	50 Hz
Interface and connectors	
Sync Out for synchronization with following devices	Digital channel via coax cable
Trigger In for synchronization with preceding devices	Digital channel via coax cable
Interface (connection to computer)	RS232 serial port
Download rate	56 Kbps

MC_Stimulus program	
Operating system	Windows© 98, ME, NT, 2000, or XP; English and German versions supported
Data import	ASCII file format

13.3 Contact Information

Local retailer

Please see the list of official MCS distributors on the MCS web site.

User forum

The **Multi Channel Systems User Forum** provides the opportunity for you to exchange your experience or thoughts with other users worldwide.

Mailing list

If you have subscribed to the General Electrophysiology Mailing List, you will be automatically informed about new software releases, upcoming events, and other news on the product line. You can subscribe to the list on the MCS web site.

www.multichannelsystems.com

13.4 Ordering Information

Product information is subject to change without notice. Please contact your local retailer for pricing and ordering information.

Stimulus/pulse generators

Product	Product Number	Description
1-Channel stimulus generator	STG1001	General purpose stimulators for a very wide variety of applications. Flexible and easy-to-use MC_Stimulus software enables complex stimulus waveforms (both current and voltage). Stimulus isolation units are integrated in the STG for each channel. With additional digital trigger in- and output.
2-Channel stimulus generator	STG1002	
4-Channel stimulus generator	STG1004	
8-Channel stimulus generator	STG1008	
4-Channel stimulus generator	STG2004	Advanced version with 4 additional digital trigger in- and outputs. About 100 x faster download via USB. 16 times more memory for long-time stimulation.
8-Channel stimulus generator	STG2008	

Spare parts

Product	Product Number	Description
Shielded 3-pole cable	C3P	For connecting the STG to MEA1060 amplifier, with ground

Red single pole cable	CR-BC	For connecting the STG to the MEA1060-Inv/Up-BC amplifier with blanking circuit
Black single pole cable	CB-BC	
Blue single pole cable	CBL-BC	
Red single pole cable	CR	For connecting the STG to the standard MEA1060-Inv/Up amplifier
Black single pole cable	CB	

MEA amplifiers

Product	Product Number	Description
MEA amplifier for inverted microscopes	MEA1060-Inv	Probe interface and 60 channel pre- and filter amplifier with custom gain and bandwidth
MEA amplifier for upright microscopes	MEA1060-Up	
MEA amplifier with blanking circuit for inverted microscopes	MEA1060-Inv-BC	Probe interface and 60 channel pre- and filter amplifier with custom gain and bandwidth. The blanking circuit prevents the amplifier from getting saturated and thus prevents stimulus artifacts.
MEA amplifier with blanking circuit for upright microscopes	MEA1060-Up-BC	

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