



**FOUR-CHANNEL  
NANOSECOND PULSE GENERATOR  
NPG18P14 (positive output pulse polarity)  
AND  
NPG18N14 (negative output pulse polarity)**

**USER MANUAL**

v. 0.1

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## PACKAGE CONTENT

Please check the package for the following items:

- ✓ NPG18P14 (NPG18N14) four-channel nanosecond pulse generator (hereinafter "generator")
- ✓ Power supply cable
- ✓ High voltage output coaxial cables, 4 pcs.
- ✓ User manual (electronic or printed version)



Fig.1. General view of NPG18P14 (positive output pulse polarity) or NPG18N14 (negative output pulse polarity) nanosecond pulse generator.

# SAFETY MANUAL

## Electrical safety

- NPG18P14 (NPG18N14) pulse generator is high voltage equipment. Please be very careful and operate by qualified personnel only.
- There is a risk of electric shock, strong electromagnetic interference, damage to the generator or other electronic equipment in case of improper use.
- Do not switch on the generator without proper grounding. A three-terminal power supply outlet with ground contact should be used.
- It is strongly prohibited to switch on the generator without the output coaxial cables connected to all four HV outputs on the rear panel. The electrical arcing on the open coaxial connector may damage the generator. Please use our special high voltage coaxial connector and cable only. Standard N-, HN- or 7/3-types connectors are not suitable. High voltage connectors should be clean and dry, free from dust and dirt. The mating Teflon parts should be lubricated by silicone grease.
- When adding or removing the generator to or from the system, ensure that the main power supply ON/OFF switch is turned off and/or power supply cable is unplugged before the output HV cables are connected or disconnected.
- Please connect or disconnect any equipment, toggle between internal and external triggering modes while the generator is in high voltage OFF state by HV ON/HV OFF switch.

## Operation safety

- Please read this manual before installing and using the generator.
- Before using the product, make sure that all cables are applicable and not damaged.
- Please keep metal parts like clips, screws, and staples away from the generator to avoid a short circuit.
- The generator is designed to work in normal laboratory conditions. Please avoid dust, humidity, and temperature extremes. Do not place the generator in any place where it may become wet.
- Place the generator on a stable surface.
- If you encounter any technical problem with the generator, please contact Megaimpulse Ltd. Do not repair the generator by yourself.

## TECHNICAL SPECIFICATION

Output pulse amplitude (typical)	smooth regulated within 13.0 kV ... 18.0 kV (50 steps) on matched 75 Ohm load; up to 36kV on open cable and discharge
Number of channels	4
Type of the output connectors	special HV coaxial connectors with 75 Ohm impedance
Type of the output cables	75 Ohm impedance coaxial cables, outer diameter 9.6 mm
Pulse polarity	positive (NPG18P14), negative (NPG18N14)
Pulse rise time	< 4 ns (fast part of the output pulse)
Pulse width (FWHM)	10 ns
Pulse energy	regulated within 15 mJ ... 30 mJ (50 steps)
Peak pulse power	up to 4.5 MW
Operation modes	continuous, burst, single pulse modes; internal and external triggering
Continuous mode repetition rates (each channel)	from 1 Hz to 4 kHz (internal triggering) from single pulse to 4 kHz (external triggering)
Burst mode repetition rates; number of pulses in a burst (each channel)	up to 100 kHz; up to 400 pulses within a burst or 100 ms interval (max 4000 pulses in a second)
External triggering	BNC connectors, +2.4V ... +5V amplitude
Internal generator delay	< 1 $\mu$ s
Jitter RMS (typical)	1 ns
SYNC OUT	BNC connector, TTL level
Power supply	AC 110-230V, 50-60 Hz
Size	460 x 360 x 140 mm <sup>3</sup>
Weight (without cables)	16 kg

## OPERATION PRINCIPLES

The nanosecond pulse generator is a powerful and smart device. Despite of its compact size and a small number of control elements, it implements a lot of operation regimes and high output power according to the user demand. Please read this manual carefully to be familiar with the basic operation principles.

The generator produces high voltage unipolar nanosecond pulses. The typical output pulse waveforms on the matched impedance 75 Ohm load are presented in Fig. 2 and Fig.3. The front panel control elements are shown in Fig.4 and emphasized in the text by **bold red** color.

- There is open and short load protection as well as overheating protection. However, it is strongly prohibited to switch on the generator without output cables attached to all output HV connectors or use less than 3-meter length output cables. Otherwise, it may lead to permanent damage to the output circuits or HV connectors.

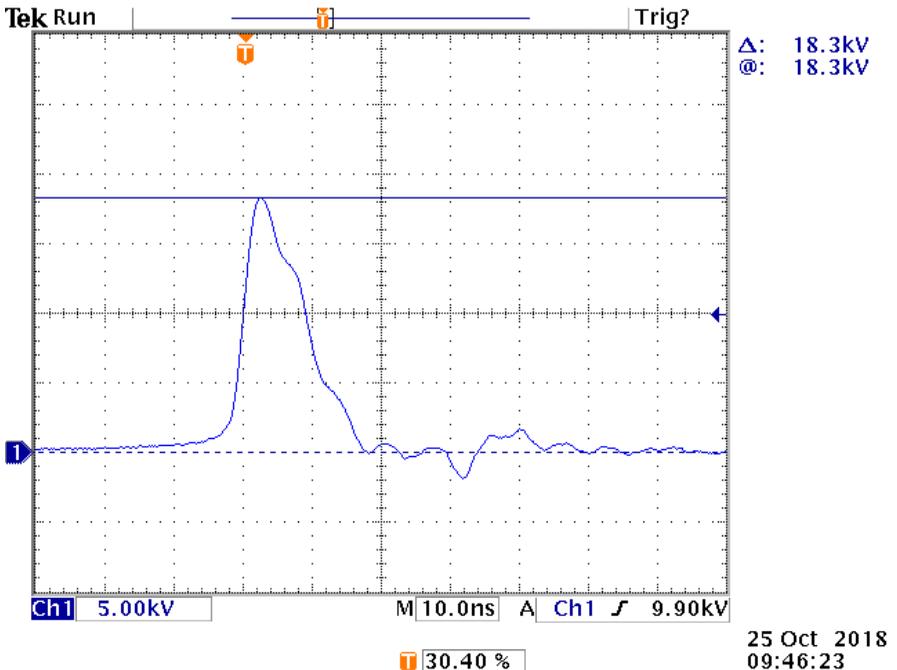


Fig.2. The oscillogram of typical output pulse waveform of NPG18P14 positive pulse polarity generator at 99% (maximum) energy level. Zero voltage level is shown by dashed line and marker . The scales are 10ns/div and 5kV/div, the measured pulse amplitude is 18.3kV.

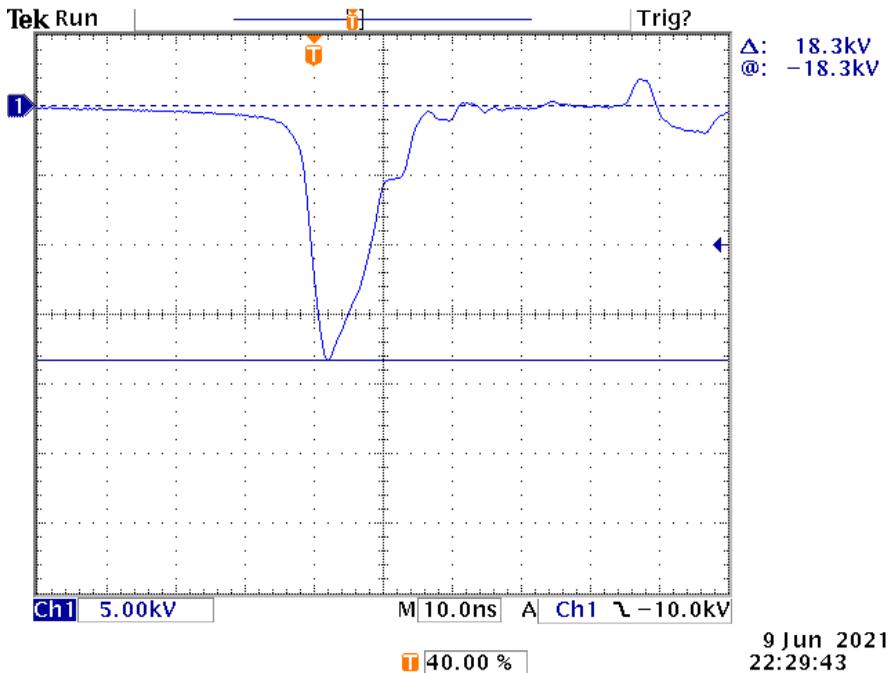


Fig.3. The oscillogram of typical output pulse waveform of NPG18N14 negative pulse polarity generator at 99% (maximum) energy level. Zero voltage level is shown by dashed line and marker **1**. The scales are 10ns/div and 5kV/div, the measured pulse amplitude is -18.3kV.

The generator has four channels that produce HV output pulses and can be turned on and turned off independently by buttons **17**. LED indicators **18** show the channels which are currently active. The output pulse width, rise time, and polarity are fixed. The adjustable parameters are pulse energy (amplitude), frequency, and the number of pulses in a burst, which can be set by the front panel knobs **10** and **6**. The min/max ranges and default values of these parameters are the following:

- FREQUENCY from 1 Hz to 101 kHz, the default value is 10 kHz;
- For the internal triggering mode, NUMBER OF PULSES in a burst from 1 to 400 (in each channel), the default value is 100, the period of the bursts is fixed to 100 ms (10 Hz);
- For the external triggering mode, maximum NUMBER OF PULSES within a one-second interval from 10 to 4000 (in each channel), the default value is 1000;
- Output PULSE ENERGY from 50% to 99%, the default value is 75%.

These parameters are common and define the operation regime for all the channels. The currently set values are indicated by displays **3** and **7**. 4-digit display **3** is used to indicate the frequency or the number of pulses. Please push knob **6** up to a click to toggle between them. Indicators **4** and **5** show which parameter is displayed at the moment.

HV ON/HV OFF button **1** activates/deactivates the HV system and allows the generation of HV pulses in the active channels. Red LED on the button lights on if the HV system is active. The generator can operate in a single pulse, continuous, and burst operation modes and has both internal and external triggering. Button **14** toggles the internal and external triggering modes. The currently chosen mode is shown by indicators **13** or **15**.

- The default values after powering the generator are 10 kHz and 100 pulses (for the internal triggering mode). Therefore, if HV is activated by pressing button **1** and the internal triggering mode with the default parameters is chosen, then the following pulse sequence should be generated: 10 bursts per second in each channel (100 ms bursts period), 100 pulses per burst, 100  $\mu$ s interval between the pulses in a burst (10 kHz), the burst length equal to 10 ms (100 pulses with 100  $\mu$ s interval), and the channels are shifted in time by 25 ms one relative to another.

In the case of internal triggering, the control system provides the quartz stabilized triggering pulses. The HV output pulses with set parameters are generated in all active channels just after activating the HV system by HV ON/HV OFF button **1**. The complete list of the preset frequencies and the preset number of pulses in a burst are shown in Appendix A. If the currently set frequency in Hz is lower than or equal to the set number of pulses in a second (displayed number of pulses value multiplied by 10), then the generator operates in continuous mode. Otherwise, it switches into burst mode automatically. In other words, the FREQUENCY parameter sets the interval between the pulses, while the NUMBER OF PULSES sets the burst length or the number of pulses within 100 ms period.

In the external triggering mode, the FREQUENCY and NUMBER OF PULSES parameters work as the limits for the external triggering pulses. In this way, the control system prevents overloading and damage to the generator or load in case of improper external triggering. The FREQUENCY parameter sets the maximum allowable external pulse frequency (minimum interval between the pulses), and NUMBER OF PULSES sets the maximum number of pulses within each one-second interval.

- The maximum number of pulses within 100 ms interval is limited to 400, which corresponds to 4000 pulses in a second in each channel. Therefore, the maximum operation frequency in continuous mode is 4 kHz. Higher repetition rates are available in burst mode only.

The external triggering pulses for each channel should be applied to BNC connectors **16**. It is possible to turn on and turn off each channel independently by buttons **17**. The indicators **18** of the active and properly triggered channels blink with 2 Hz frequency and confirm the triggering.

Two external triggering modes are available: external triggering and external burst enable. If the external triggering pulse is short, 1  $\mu$ s for example, then each external triggering pulse results in a single HV output pulse in the corresponding channel, of course, if the triggering is not blocked by the control system due to too high frequency or too many pulses in a second. If the triggering pulse is long, then HV output pulses run continuously with the set frequency until the triggering pulse level is high. Please see the External triggering section of the User Manual for more details.

The SYNC OUT pulses go to the front panel BNC output **12** simultaneously with each pulse generated in each channel. The SYNC OUT pulses can be used for the synchronization of the external equipment with the generator as well as testing the pulse sequence.

Special TEST mode can be activated by pressing knob **10**. The HV output pulses are blocked for all channels in this mode, HV ON/HV OFF button **1** is deactivated, and display **7** indicates 00 value, which means zero output power. Therefore, it is possible to check the triggering of the generator and output pulses sequence on the SYNC OUT connector **12** without applying HV pulses to the load. Press knob **10** again for returning to the normal operation regime.

## FRONT PANEL

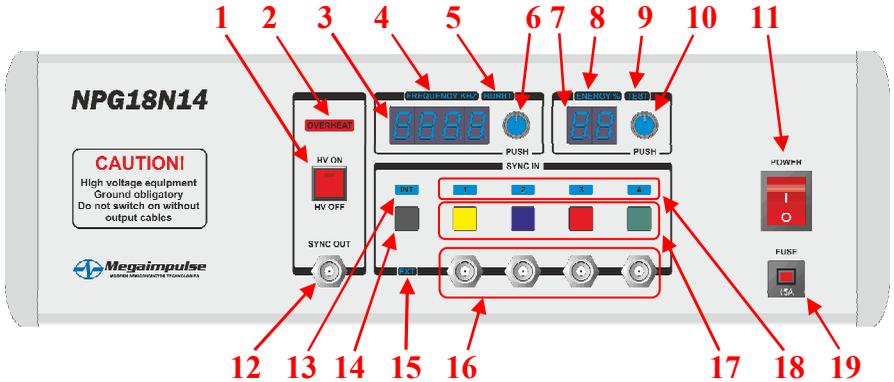


Fig.4. Front panel control elements:

- 1 – High voltage ON/OFF push button with ON state LED indicator
- 2 – Overheat LED indicator
- 3 – Frequency and number of pulses in burst 4-digit display
- 4 – Frequency mode LED indicator
- 5 – Number of pulses in a burst mode LED indicator
- 6 – Frequency and number of pulses in burst regulation knob with push button
- 7 – Output pulse energy 2-digit display
- 8 – Energy mode LED indicator
- 9 – Test mode LED indicator
- 10 – Output pulse energy regulation knob with push button
- 11 – Main power supply ON/OFF toggle switch
- 12 – BNC type SYNC OUT connector
- 13 – Internal synchronization mode LED indicator
- 14 – Internal/external triggering push button
- 15 – External synchronization mode LED indicator
- 16 – BNC type SYNC IN connectors (four channels)
- 17 – Channels ON/OFF push buttons (yellow, blue, red, green)
- 18 – LED indicators of the active channels
- 19 – Electronic fuse

Four HV output connectors, main power supply connector, and the fans inlets/outlets are located on the rear panel.

## FRONT PANEL IN DETAIL

 <p>HV ON HV OFF</p>	<p>Non-latching push button, which toggles HV system ON and OFF. Red LED on the button lights on when the HV system is activated and ready for triggering by internal or external triggering pulses. HV system is set to OFF state when the generator is powered on and automatically toggles to OFF state in case of overheating or TEST mode activation.</p>
 <p>OVERHEAT</p>	<p>If the ambient temperature is high or the cooling is insufficient, then the internal temperature may exceed the safe level. OVERHEAT LED lights on, and the generator stops the operation. Please allow fans to cool it for several minutes. When the temperature decreases OVERHEAT LED lights off, and the generator returns to normal operation automatically. Press HV ON again to continue the operation.</p>
 <p>FREQUENCY KHZ BURST PUSH</p>	<p>Four-digit LED display and control knob with push-button, which sets FREQUENCY and NUMBER OF PULSES parameters. Push the knob up to a click to toggle between them. The light on LED indicator above the display shows the current mode. The FREQUENCY is indicated in kHz with a decimal dot. For example, 1 Hz is indicated as <b>0.00</b>; 100 kHz is indicated as <b>100.0</b>. The complete lists of the preset frequencies and number of pulses are shown in Appendix A.</p>
 <p>ENERGY % TEST PUSH</p>	<p>Two-digit LED display and control knob with push-button, which sets pulse ENERGY parameter. The energy can be adjusted from 50% to 99% with 1% step. Push the knob up to a click to switch into TEST mode. The light on LED indicator above the display shows the current mode. HV ON/HV OFF push button is blocked in the TEST mode. LED display shows <b>00</b>, which means zero output power. Triggering sequence from the internal or external sources goes to SYNC OUT connector, which allows testing the triggering and checking the triggering sequence without applying HV pulses to the load. Push the knob again to toggle back into pulse ENERGY mode.</p>

<p><b>SYNC OUT</b></p> 	<p>BNC output connector for SYNC OUT pulses, which are generated simultaneously with each successful triggering in each channel. The front edge of the SYNC OUT pulse precedes the HV output pulse by <math>\sim 0.7 \mu\text{s}</math>. SYNC OUT pulse duration is 400 ns, and the amplitude is <math>3\text{V}@50\Omega</math>.</p>
<p><b>INT</b></p>  <p><b>EXT</b></p> 	<p>The non-latching button (black) toggles internal and external triggering modes. The light on LED indicator shows the currently chosen mode.</p>
<p><b>1</b></p>  	<p>Channel 1 ON/OFF non-latching button (yellow), LED indicator, and Channel 1 BNC type SYNC IN connector. LED indicator continuously lights on when the channel is active and blinks with 2 Hz frequency when the channel is active and successfully triggered by the external pulses. Similar control elements are for channels 2, 3, and 4.</p>
<p><b>POWER</b></p> 	<p>Main power supply ON/OFF toggle switch.</p>
<p><b>FUSE</b></p> 	<p>Electronic fuse.</p>

## PUTTING THE GENERATOR INTO OPERATION

- ➔ Please strictly follow the described steps. It helps to prevent damage to the generator, other equipment, and personnel injury.

### Step 1.

Unpack the generator and check the presence into the package the following items:

- NPG18P14 (NPG18N14) nanosecond pulse generator,
- three-terminal power supply cable with live, neutral, and ground contacts,
- HV output coaxial cables with 75 Ohm impedance, 4 pcs.

### Step 2.

Set up the generator. Provide the proper grounding of the generator by connecting to a three-terminal power supply wall outlet with ground contact and/or by connecting grounding wire to the ground contact of the load.

### Step 3.

Check HV coaxial connectors on the rear panel of the generator and HV coaxial cables. The connectors should be clean, free from dust and dirt. Clean the connectors with alcohol and/or cotton bud if necessary. Please apply a drop of pure silicone grease before mating the connectors. Grease fills the air gap between the pair of the connectors and eliminates possible glow discharge inside.

Attach the cable connectors to the HV connectors on the rear panel. The tight and firm contact of the connectors is important for safe operation. Even a small air gap between the connector pair may results in a glow discharge, arcing, and damage to the generator and the cable.

The following procedure is recommended for obtaining good and tight contact:

1. Align both connectors.
2. Hold the generator by one hand to prevent moving and press the cable connector by another hand toward the generator connector.
3. Screw the cable connector nut by hand, usually one or two turns. Do not rotate the cable connector body.
4. Press the cable connector toward the generator connector again.
5. Again, screw the cable connector nut one or two turns.
6. Repeat steps 4 and 5 up to tight contact.

It is highly recommended after the first testing of the generator to check whether the tight contact of the connectors is obtained. Unscrew the cable connector. It should be no ozone or burnt smell from the connectors or burnt traces visible.

Do not disconnect and connect the HV connectors many times to prevent them from wearing and contamination. Silicone grease is already applied to both connectors at the factory. It remains between the mating connector pair for a very long time and prevents discharge inside.

#### **Step 4.**

Connect another side of the coaxial cables to the load. The additional wires for connection to the load may be used. Solder the high voltage contact of the load to the central coaxial cable wire and screw/solder ground contact of the load to the cable braid. Please keep the length of the wires between the coaxial cable and the load as short as possible.

- ➔ More than 10 cm additional wires between the load and coaxial cable result in excessive stray inductance and may distort the pulse waveform. In addition, long wires work like an antenna and increase the electromagnetic interference to other equipment.
- ➔ The length of the output coaxial cable is 3 meters. Using the shorter coaxial cable may result in damage to the generator.

#### **Step 5.**

Connect power supply cable to the wall power outlet.

Turn on the generator by the main power supply toggle switch on the front panel. The fans should start to rotate, and the indicators light on.

#### **Step 6.**

Test the generator operation in the internal triggering mode. Toggle the generator into internal triggering, activate all the channels, set the frequency to 10 Hz, number of pulses in a burst to 1, and pulse energy to 50%. Press the HV ON/OFF push button. Red LED on the button lights on, and output HV pulses should be generated. Increase the amplitude, frequency, and number of pulses by the corresponding knobs as necessary.

#### **Step 7.**

Always stop the operation of the generator by HV ON/OFF switch. After that, you can turn off the generator with the main power switch. Please allow cooling of the generator by fans for several minutes after a long time of operation at high pulse amplitude and frequency.

## EXTERNAL TRIGGERING

The external triggering mode is the most flexible. Some operation regimes can be realized in this mode only, for example, single pulse mode and independent triggering of the channels with different repetition rates, delays, and number of pulses in the bursts. There are two possible external triggering modes: external triggering and external burst enable.

### External triggering mode

Please toggle the generator to EXT mode by button **14**. LED indicator **15** should light on. Apply triggering pulses to the corresponding SYNC IN connector **16**. Four triggering pulse sequences should be applied to four SYNC IN connectors for the simultaneous four-channel operation. Each channel can be independently activated/deactivated by buttons **17**. LED indicators **18** light on, if the channel is active, and blink with 2 Hz frequency if the channel is active and successfully triggered by the external pulses.

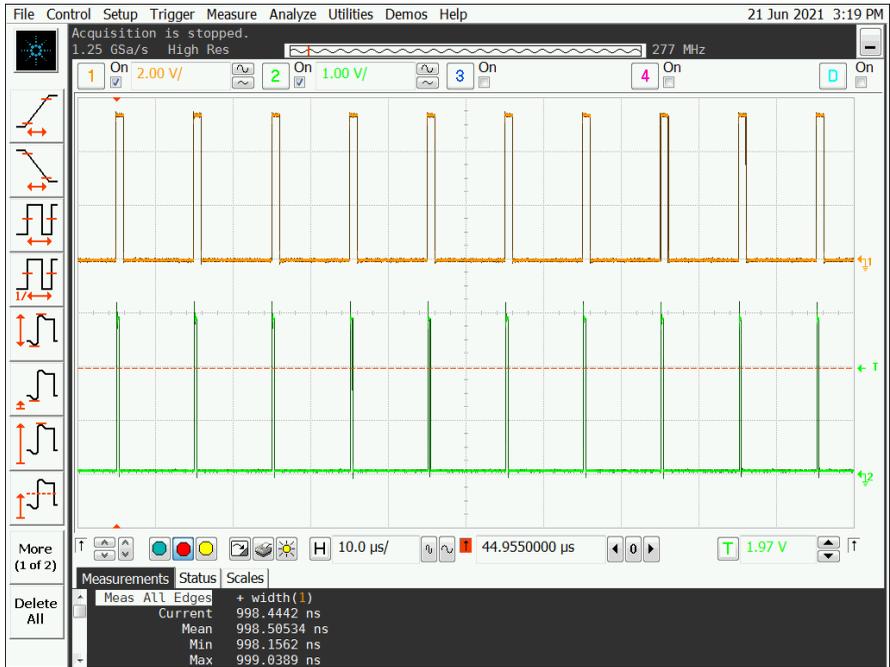


Fig.5. External triggering mode. Channel 1 (orange line) is the external triggering pulses applied to SYNC IN connector, Channel 2 (green line) is the SYNC OUT pulses. Each triggering pulse results in a single output HV pulse.

The impedance of SYNC IN inputs is 50 Ohm. Please use 50 Ohm impedance coaxial cables with BNC connectors for the triggering pulses feeding. The recommended triggering pulse amplitude is +5 V, and pulse width is 1  $\mu$ s. The triggering occurs by the rising edge of the triggering pulse, and the internal generator delay up to the output HV pulse is about 700 ns. The typical output pulses jitter (RMS) is 1 ns.

The triggering pulse should be short (1  $\mu$ s for instance) for the operation in this mode. In this case, each triggering pulse results in a single HV output pulse, of course, if the triggering is not blocked by the control system due to too high frequency or too many pulses in a second (see Fig.5).

- The maximum allowable pulse frequency and the number of pulses within a burst are limited by set FREQUENCY and NUMBER OF PULSES parameters. Please set the required values by knob 6. After the successful triggering, the control system blocks the next triggering up to the end of the period set by the FREQUENCY parameter. The control system counts the triggering events and blocks the next triggering up to the end of 100 ms interval if the number of pulses exceeds the set NUMBER OF PULSES (per second) parameter divided by 10.

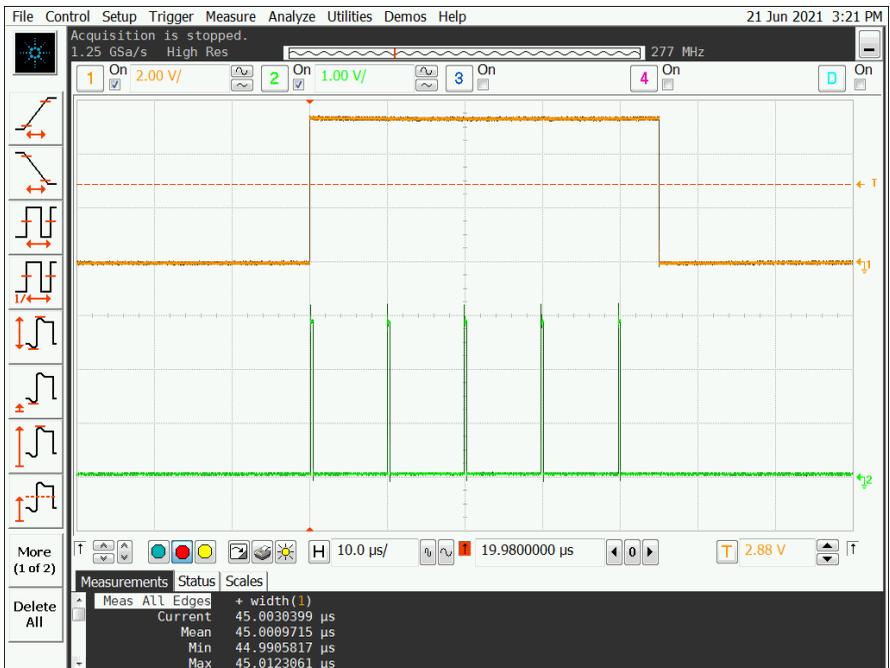


Fig.6. External burst enable mode. The burst of five output pulses (Channel 2, green line) with 10  $\mu$ s period set by 100 kHz FREQUENCY parameter is formed by a single 45  $\mu$ s triggering pulse (Channel 1, orange line).

## External burst enable mode

The generator automatically switches to this mode if the external triggering pulse is long. The external triggering pulse fed to SYNC IN connector works as enable signal, and HV output pulses run continuously with the set FREQUENCY while the triggering pulse level is high. The other operation parameters are similar to the external triggering mode. As an example, the burst of five output pulses (Channel 2, green line) with  $10\ \mu\text{s}$  pulse-to-pulse delay (100 kHz frequency) formed by a single  $45\ \mu\text{s}$  duration triggering pulse (Channel 1, orange line) is shown in Fig.6.

The operation with the bursts of 40 pulses with  $10\ \mu\text{s}$  pulse-to-pulse delay and 100 Hz burst repetition rate is shown in Fig.7. One can see the  $395\ \mu\text{s}$  duration triggering pulses with 100 Hz repetition rate (Channel 1, orange line), which result in forming the bursts of 40 pulses each (Channel 2, green line). The general view of the triggering pulses sequence and output pulses bursts is shown in the upper part of the oscillogram. The zoom view of a triggering pulse and burst of 40 output pulses is shown in the bottom part.

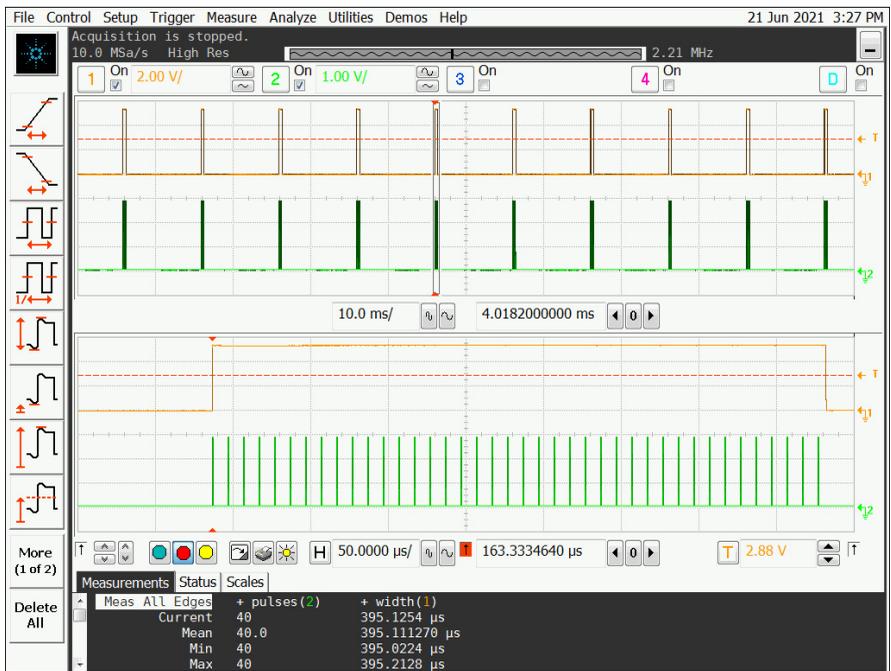


Fig.7. The bursts of 40 pulses with  $10\ \mu\text{s}$  pulse-to-pulse delay (Channel 2, green line) and 100 Hz burst repetition rate.

## **ELECTRONIC FUSE**

The generator is equipped with the electronic fuse **19**. The fuse turns off the generator in the case of a short circuit or overloading. Please turn off the generator by main power supply toggle switch **11**, push the red button on the fuse, and turn on the generator. If the fuse breaks the power again, then please consult with the manufacturer.

## **WARRANTY**

Please see your sales agreement to determine the warranty period and condition. The generator has warranty seals. Removing the warranty seals and unauthorized opening of the generator enclosure terminates the warranty.

## Appendix A.

1. List of preset frequencies. 4 kHz and above are available in burst operation mode only.

Frequency	4 digits display	Frequency	4 digits display
1 Hz	0.001	2.5 kHz	002.5
2 Hz	0.002	3 kHz	003.0
3 Hz	0.003	3.5 kHz	003.5
4 Hz	0.004	4 kHz **)	004.0
5 Hz	0.005	4.5 kHz	004.5
6 Hz	0.006	5 kHz	005.0
7 Hz	0.007	5.5 kHz	005.5
8 Hz	0.008	6 kHz	006.0
9 Hz	0.009	6.5 kHz	006.5
10 Hz	0.010	7 kHz	007.0
20 Hz	0.020	7.5 kHz	007.5
30 Hz	0.030	8 kHz	008.0
40 Hz	0.040	8.5 kHz	008.5
50 Hz	0.050	9 kHz	009.0
60 Hz	0.060	9.5 kHz	009.5
70 Hz	0.070	10 kHz *)	010.0
80 Hz	0.080	15 kHz	015.0
90 Hz	0.090	20 kHz	020.0
100 Hz	0.100	25 kHz	025.0
200 Hz	0.200	30 kHz	030.0
300 Hz	0.300	35 kHz	035.0
400 Hz	0.400	40 kHz	040.0
500 Hz	0.500	45 kHz	045.0
600 Hz	0.600	50 kHz	050.0
700 Hz	0.700	60 kHz	060.0
800 Hz	0.800	70 kHz	070.0
900 Hz	0.900	80 kHz	080.0
1 kHz	001.0	90 kHz	090.0
1.5 kHz	001.5	100 kHz	100.0
2 kHz	002.0	101 kHz ***)	101.0

\*) the default value is 10 kHz, which is set after power on the generator

\*\*\*) 4 kHz and more are available in the burst mode only

\*\*\*\*) please set 101 kHz internal frequency if you want to operate in external triggering mode with up to 100 kHz repetition rate

2. List of the preset number of pulses within a burst in the internal triggering mode. The period of the bursts is fixed to 100 ms (10 Hz).

Number of pulses	4 digits display	Number of pulses	4 digits display
1	001	50	050
2	002	60	060
3	003	70	070
4	004	80	080
5	005	90	090
6	006	100 *)	100
7	007	150	150
8	008	200	200
9	009	250	250
10	010	300	300
20	020	350	350
30	030	400	400
40	040		

\*) the default value is 100 pulses per burst, which is set after power on the generator

3. List of the preset number of pulses within a second in the external triggering mode.

Number of pulses	4 digits display	Number of pulses	4 digits display
10	0010	500	0500
20	0020	600	0600
30	0030	700	0700
40	0040	800	0800
50	0050	900	0900
60	0060	1000 *)	1000
70	0070	1500	1500
80	0080	2000	2000
90	0090	2500	2500
100	0100	3000	3000
200	0200	3500	3500
300	0300	4000	4000
400	0400		

\*) the default value is 1000 pulses per second, which is set after power on the generator