



NANOSECOND PULSE GENERATOR

NPG-18/100k (NPG-18/100kN)

USER MANUAL

v. 2.0

© 2024 Megaimpulse Ltd.

Copyright © 2024 MEGAIMPULSE Ltd. All Rights Reserved.

MEGAIMPULSE LTD. PROVIDES THIS MANUAL "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OR CONDITIONS OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL MEGAIMPULSE LTD., ITS DIRECTORS, OFFICERS, EMPLOYEES OR AGENTS BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES (INCLUDING DAMAGES FOR LOSS OF PROFITS, LOSS OF BUSINESS, LOSS OF USE OR DATA, INTERRUPTION OF BUSINESS AND THE LIKE), EVEN IF MEGAIMPULSE LTD. HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES ARISING FROM ANY DEFECT OR ERROR IN THIS MANUAL OR PRODUCT.

SPECIFICATIONS AND INFORMATION CONTAINED IN THIS MANUAL ARE FURNISHED FOR INFORMATION ONLY, AND ARE SUBJECT TO CHANGE AT ANY TIME WITHOUT NOTICE, AND SHOULD NOT BE CONSTRUED AS A COMMITMENT BY MEGAIMPULSE LTD. MEGAIMPULSE LTD. ASSUMES NO RESPONSIBILITY OR LIABILITY FOR ANY ERRORS OR INACCURACIES THAT MAY APPEAR IN THIS MANUAL, INCLUDING THE PRODUCTS AND SOFTWARE DESCRIBED IN IT.

Products and corporate names appearing in this manual may or may not be registered trademarks or copyrights of their respective companies, and are used only for identification or explanation and to the owners' benefit, without intent to infringe.

Megaimpulse Ltd. contact information

Address: 28 Polytechnicheskaya str., St. Petersburg, 194021 Russia
www: <http://www.megaimpulse.com>
e-mail: mp@power.ioffe.rssi.ru
fax: +7-812-297-3145

CONTENTS

Package content	4
General view	4
Safety manual	5
Technical specification	6
Front view	7
Rear view	7
Description of the operation	8
Front panel in detail	9
Putting into operation	11
Triggering the generator	14
SYNC OUT pulse	19
Overheating	20
Fuse replacement	21
Warranty	22
Appendix A. List of presets frequencies and number of pulses per burst.....	23

PACKAGE CONTENT

Please check the package for the following items:

- ✓ NPG-18/100k (NPG-18/100kN) nanosecond pulse generator (hereinafter "generator")
- ✓ Power supply cable
- ✓ High voltage output coaxial cable
- ✓ User manual (electronic version available through QR-code or on the Megaimpulse website)



Fig.1. General view of NPG-18/100k (NPG-18/100kN) nanosecond pulse generator.

SAFETY MANUAL

Electrical safety

- NPG-18/100k (NPG-18/100kN) is a high voltage pulse generator. Please be careful and operate with qualified personnel only.
- There is a risk of electric shock, strong electromagnetic interference, and damage to the generator or other electronic equipment in case of improper use.
- Do not switch on the generator without proper grounding. We recommend using a grounding cable connected to the terminal on the rear panel of the generator or a three-terminal power supply outlet with a ground contact.
- It is strongly prohibited to switch on the generator without an output coaxial cable. The electrical arcing on the open coaxial connector may damage it and/or the output circuit of the generator. Please use only our special high-voltage coax cables and connectors. High-voltage connectors should be kept clean, free of dust and dirt, and any obstacles. Mating Teflon parts of connectors should be lubricated with silicone grease.
- When adding or removing a generator to or from a system, ensure that the power supply ON/OFF switch is turned off before connecting or disconnecting the output HV cable.
- Please connect or disconnect any equipment, toggle the generator from the internal to the external triggering mode or vice versa, only while the generator is in the high-voltage OFF state set by the HV ON/OFF switch.

Operation safety

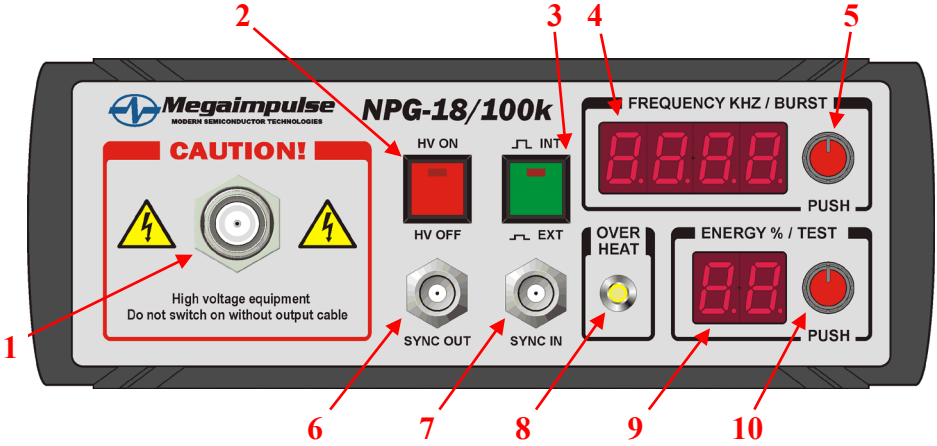
- Please read this manual before installing and using the generator.
- Before using the product, make sure that all cables are suitable and not damaged.
- To avoid a short circuit, please keep metal parts such as clips, screws, and staples away from the generator.
- The generator is designed to operate under normal laboratory conditions, avoiding dust, humidity and temperature extremes. Do not leave it in a wet place.
- Place the generator on a stable surface.
- If you encounter any technical problems with the generator, please contact Megaimpulse Ltd. Do not attempt to repair the generator yourself.

TECHNICAL SPECIFICATION OF NPG-18/100k (NPG-18/100kN) NANOSECOND PULSE GENERATOR

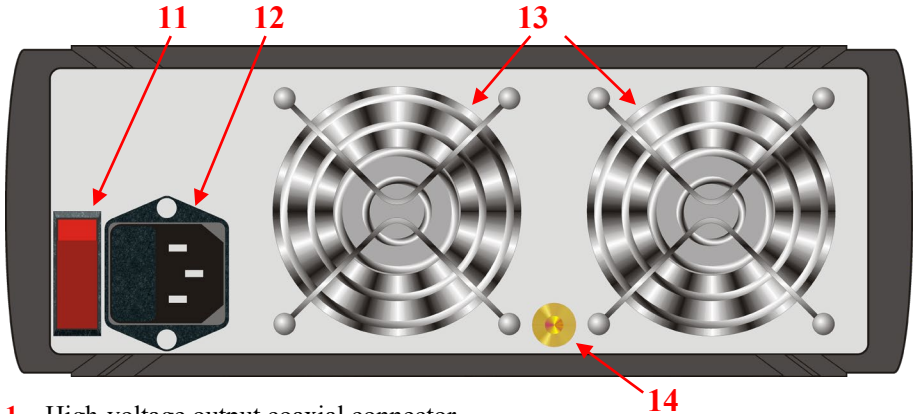
Output pulse amplitude (typical)	smoothly adjustable from 6 kV to 18 kV ¹⁾ on a matched 75 Ω load; up to 36 kV on an open cable and discharge reactor
Output impedance	75 Ω
Output connector	special type HV coaxial connector
Output cable	3m in length coaxial cable with an impedance of 75 Ω, 9.6 mm outer diameter
Pulse polarity	positive (NPG-18/100k) negative (NPG-18/100kN)
Pulse rise time	< 4 ns (fast part of the output pulse)
Pulse width (FWHM)	9 ns
Pulse energy	smoothly adjustable from 3 mJ to 30 mJ ¹⁾
Peak pulse power	up to 4.5 MW
Operation modes	continuous, burst, single pulse modes; internal and external triggering
Continuous mode repetition rates	from 1 Hz to 4 kHz (internal triggering) from single pulse to 4 kHz (external triggering)
Burst mode repetition rates; number of pulses per burst	up to 100 kHz; up to 4000 pulses per burst or within any one-second interval
External input triggering pulse / connector type	+2.4 V ... +5 V @ 50 Ω; BNC type SYNC IN connector
Internal delay	~ 1.2 μs
Jitter RMS (typical)	1 ns
Output triggering pulse	TTL level; BNC type SYNC OUT connector
Power supply	AC 110-230V, 50-60 Hz
Size	248 x 90 x 250 mm ³
Weight (with cables)	6 kg

¹⁾ extended amplitude and pulse energy adjustment range starting from 2024 production year; 13 kV .. 18 kV and 15 mJ .. 30 mJ for the older models

FRONT VIEW



REAR VIEW



- 1 – High-voltage output coaxial connector
- 2 – High-voltage ON/OFF push button with ON state LED indicator
- 3 – Internal/external triggering push button with LED indicator
- 4 – Frequency and number of pulses per burst 4-digit display
- 5 – Frequency and number of pulses per burst regulation knob with push button
- 6 – BNC type SYNC OUT connector
- 7 – BNC type SYNC IN connector
- 8 – Overheat LED indicator
- 9 – Output pulse energy 2-digit display
- 10 – Output pulse energy regulation knob with push button
- 11 – Power supply ON/OFF switch
- 12 – Power supply connector and fuse holder
- 13 – Fans
- 14 – Ground terminal

DESCRIPTION OF THE OPERATION

The generator is a powerful and smart device. Despite its compact size and small number of control elements, it implements many operating modes and high output power to satisfy the user requirements. Please read this manual carefully to familiarize yourself with the basic principles of operation.

- ➔ The generator has open and short-circuit protection as well as overheating protection. However, it is strongly prohibited to switch on the generator without an output cable or use a cable with a length of less than 3 meters.

The generator can operate in a single-pulse, continuous, and burst modes, internally or externally triggered. The control system of the generator forms quartz-stabilized triggering pulses for continuous and burst modes operation and prevents incorrect triggering when it operates in an external triggering mode. A complete list of preset frequencies and the number of pulses per burst are given in Appendix A.

- ➔ In all operation modes, the minimum pulse-to-pulse interval is limited to 9.9 μ s, which corresponds to 101 kHz repetition rate. The maximum number of pulses within any 1-second interval is limited to 4,000, the maximum operating frequency in continuous mode is 4 kHz. Higher repetition rates are only available in a burst mode.

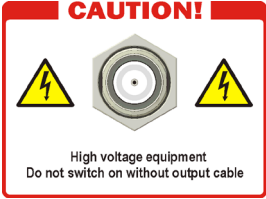


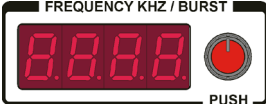
The following operation parameters can be set using the front panel controls:

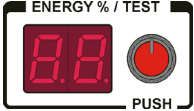



- FREQUENCY from 1 Hz to 101 kHz; the default value is 100 Hz;
- NUMBER OF PULSES per burst (within a one-second period) from 1 to 4000; the default value is 1000;
- Output PULSE ENERGY from 10% to 99%; the default value is 50%.

If the currently set repetition rate is less than or equal to the number of pulses per burst (within a one-second period), then the generator operates in continuous mode. Otherwise, it automatically switches to burst mode. In case of internal triggering, the burst period is always fixed at one second. Therefore, the FREQUENCY parameter determines the time interval between pulses, and the NUMBER OF PULSES determines the length of the burst or the number of pulses followed by a pause until the end of a one-second period.

- ➔ The FREQUENCY and NUMBER OF PULSES parameters set the limits for external triggering pulses. Therefore, the FREQUENCY determines the maximum allowable frequency of external pulses (minimum interval between pulses), and the NUMBER OF PULES determines the maximum burst length or the maximum number of pulses within one second. By the way, the generator's control system prevents overload and damage to the generator in case of improper external triggering.

FRONT PANEL IN DETAIL

 <p>CAUTION!</p> <p>High voltage equipment Do not switch on without output cable</p>	<p>Special type coaxial connector suitable for HV nanosecond pulse feeding. Please firmly attach the output HV cable before switching on the generator. It is important to keep the HV connector clean to prevent unwanted arcing and glow discharge inside. If necessary, clean it with cotton and alcohol, then apply a drop of pure silicone oil before mating the connectors. The oil fills the air gap between the mating pair and eliminates possible discharges inside.</p>
 <p>HV ON HV OFF</p>	<p>Non-latching push button that toggles the HV system ON and OFF. The red LED on the button lights up when the HV system is activated and ready to be triggered by internal or external triggering pulses. The HV system sets to the OFF state when the generator is powered on, and automatically switches to the OFF state in case of overheating or operating in the TRIGGERING TEST mode.</p>
 <p>INT EXT</p>	<p>Latching push button that toggles between internal and external triggering modes. Internal triggering is activated when the button is depressed. The red LED lights up and indicates that output pulses are ready to be generated immediately after the HV system is activated by the HV ON/OFF button. If the button is pressed and no external triggering pulses are applied, then the LED does not light, and it blinks at 1 Hz if successful external triggering occurs.</p>
 <p>FREQUENCY KHZ / BURST PUSH</p>	<p>Four-digit LED display and a control knob with a push button to set FREQUENCY and NUMBER OF PULSES. The FREQUENCY is displayed in kHz with a decimal point. For example, 1 Hz is shown as 0.001, and 100 kHz as 100.0. Press the control knob to click and hold for one second to switch to the NUMBER OF PULSES mode. The LED display will blink and indicate NUMBER OF PULSES without digital point. For example, 1 pulse is shown as 0001, and 4000 pulses as 4000. Press the control knob and hold for one second again to switch back to FREQUENCY mode. All preset frequencies and number of pulses are listed in Appendix A.</p>

	<p>Two-digit LED display and a control knob with a push button to set PULSE ENERGY. The energy level can be adjusted from 10% to 99% in 1% increments. The LED lights continuously in idle or continuous mode, or blinks in burst mode with light on and off corresponding to the duty cycle. Press the control knob to click and hold for one second to switch to TRIGGERING TEST mode. In this mode, the HV ON/OFF button is blocked, and the LED displays 00 to indicate zero output power. A formed triggering sequence from an internal or external source is sent to the SYNC OUT connector. This mode allows us to test triggering and shows the triggering sequence without applying HV pulses to the load. To return to PULSE ENERGY mode, press the control knob and hold it for one second again.</p>
	<p>If the internal temperature exceeds the safe level, then the OVERHEAT LED lights up and the generator stops operation. This may happen in cases of high ambient temperature, insufficient cooling, or after a long period of operation with high amplitude and repetition rate. The HV ON/OFF button is blocked while the generator remains overheated. Please allow cooling down by leaving it idle for a few minutes with fans running. After the temperature reduces, the OVERHEAT LED lights off and the generator automatically returns to normal operation. Press the HV ON button again to resume operation.</p>
 <p>SYNC IN</p>	<p>BNC input connector for external triggering pulses. The amplitude should be within +2.4V ... +5V, and the nominal pulse width is 1 μs. External synchronization mode is activated by pressing the green push button INT/EXT.</p>
 <p>SYNC OUT</p>	<p>BNC output connector for SYNC OUT pulses. The delay between the leading edge of the SYNC OUT pulse and the HV output pulse is $\sim 1.2\mu$s. The duration of the SYNC OUT pulse is 400ns, and its amplitude is 3V at 50 Ω.</p>

PUTTING INTO OPERATION

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

Step 1.

Unpack the package and check the presence of the following items:

- NPG-18/100k(NPG-18/100kN) generator;
- power supply cable;
- output 75 Ω coaxial cable.

Step 2.

Set up the generator. Ground it obligatory by connecting ground bus to the terminal on the rear panel (14) and/or use a three terminal power supply outlet with a grounding contact.

Step 3.

Check the output coaxial female connector on the front panel and the pair male connector on the cable. Both connectors should be clean, free from dust, dirt and any obstacles. If necessary, clean the connectors with alcohol and cotton bud. After cleaning, apply a drop of pure silicone oil to the Teflon parts of the mating connectors. This oil fills the air gap between the mated connectors and eliminates possible glow discharge inside.

Attach the cable connector to the front panel connector of the generator (1). A tight and firm connection is essential for safe operation. Even a small air gap between connectors can cause glow discharge, arcing and damage to the generator or cable. To obtain a good and tight connection, the following procedure is recommended:

1. Align both connectors.
2. Hold the generator with one hand and press the cable connector with the other hand towards the generator's connector.
3. Screw the cable connector nut by hand, usually one turn. Do not rotate the cable connector body.
4. Press the cable connector towards the generator's connector again.
5. Screw the cable connector nut one or two more turns.
6. Repeat steps 4 and 5 until the connection is tight.

It is highly recommended to check whether a tight connection was obtained after the first testing of the generator. Unscrew the cable connector; there should be no any ozone or burnt smell coming from the connectors, or any burnt traces.

During normal operation, do not disconnect and reconnect again the high voltage connectors many times to prevent contacts wear and contamination. Silicone oil has already been applied to both connectors at the factory. It stays inside the mating connectors for a long time and prevents unwanted discharge.

Step 4.

Connect the other side of the coaxial cable to the load. A Teflon cone insulator (see Fig. 2) is installed on the cable end to prevent barrier discharge between the central wire and the braid across the solid polyethylene cable insulator. The additional wires can be used for connection to the load. Solder the center wire of the cable to the high-voltage contact of the load, and screw the ground contact of the load to the ground cable clamp. 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 the coaxial cable causes excessive stray inductance and significant distortion of the pulse waveform at the load.



Fig.2. The Teflon cone protection on the load side of the HV coaxial cable.

- ➔ The length of the output coaxial cable is 3 meters. Using a significantly shorter coaxial cable may result in damage to the generator.

The Teflon cone can be easily changed or replaced by a hermetic feed-through (optional accessory, Fig.3). Please unscrew the nut on the connector and slide out the cable.

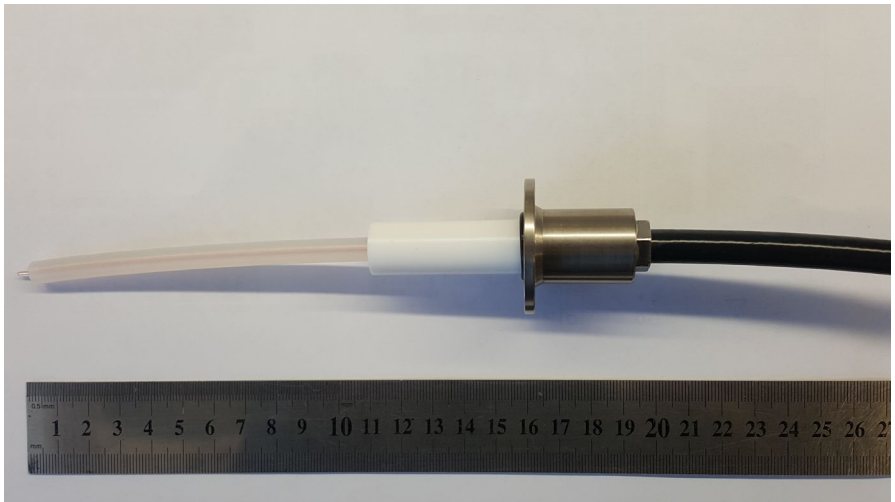


Fig.3. Optional hermetic feed-through on the load side.

Step 5.

Connect the power supply cable to the power outlet.

Turn on the generator using the toggle power switch on the rear panel. The internal fans should start rotating.

Step 6.

Check the internal triggering mode. The red LED on the INT/EXT button should light up. Otherwise, depress the button.

Set the required frequency, number of pulses and pulse energy using the knobs. It is wise to start experiments with low operating parameters, which can help to prevent possible damage to the equipment in case of any fault.

Press the HV ON/OFF button. The red LED on the button should light up and HV output pulses should be generated. Increase the amplitude and frequency using the corresponding knobs if necessary.

Step 7.

Always stop the operation of the generator by using the HV ON/OFF button before turning it off with the power switch. After a long period of operation at high pulse amplitude and frequency, leave the generator in idle mode for several minutes to allow the fans to cool it down.

TRIGGERING THE GENERATOR

Internal triggering

The internal triggering mode is activated by depressing the INT/EXT latched button. The red LED on the button lights continuously indicating this mode. Both continuous and burst operations are possible in this mode without the use of an external triggering pulse generator. The repetition rate can be set by the FREQUENCY knob within 1 Hz ... 101 kHz. The number of pulses per burst can be set within 1 to 4000 pulses by the same knob after one second pressing down. All preset frequencies and number of pulses are listed in Appendix A.

External triggering

The external triggering mode is activated by pressing the INT/EXT latched button. The red LED on the button lights off indicating the activation of this mode. External triggering pulses should be applied to the BNC type SYNC IN connector. The recommended triggering pulse amplitude is from +2.4 V to +5 V at 50 Ω . The delay between the triggering pulse front and the output pulse (internal generator delay) is approximately 1.2 μ s, typical jitter (RMS) is about 1 ns. When the triggering is successful, the red LED on the button flashes at a frequency of 1 Hz.

- ➔ The maximum allowable pulse repetition rate and the number of pulses per burst are limited by the internally set FREQUENCY and NUMBER OF PULSES parameters. Please set the required values using the FREQUENCY control knob

The short external triggering pulse, for example of 10 μ s duration, generates one output pulse, of course, if it is permitted by internally set parameters. Longer triggering pulses generate bursts of pulses with a repetition rate determined by the FREQUENCY parameter. An external triggering pulse applied to the SYNC IN connector acts as an ENABLE signal. HV pulses are generated while the triggering pulse remains in the high state.

The generator can operate in a single pulse mode as well. Several samples of different triggering modes are shown below in Fig.4 – Fig.11.

Triggering test mode

Press the PULSE ENERGY knob to click and hold for one second to switch to the TRIGGERING TEST mode. In this mode, the HV ON/OFF button is blocked, and two-digit LED displays **00** to indicate zero output power. A formed triggering sequence from an internal or external source is sent to the SYNC OUT connector. This mode tests triggering and shows the exact triggering sequence without applying HV pulses to the load. To return to PULSE ENERGY mode, press the control knob and hold for one second again.

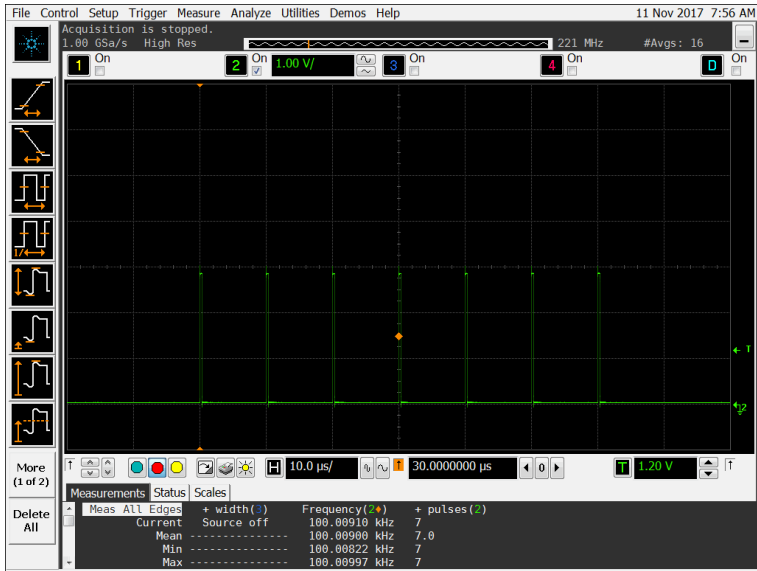


Fig.4. Internal triggering burst mode. CH2 (green line) shows the SYNC OUT pulses. The FREQUENCY is set to 100 kHz and the NUMBER OF PULSES is set to 7, which defines the burst length.

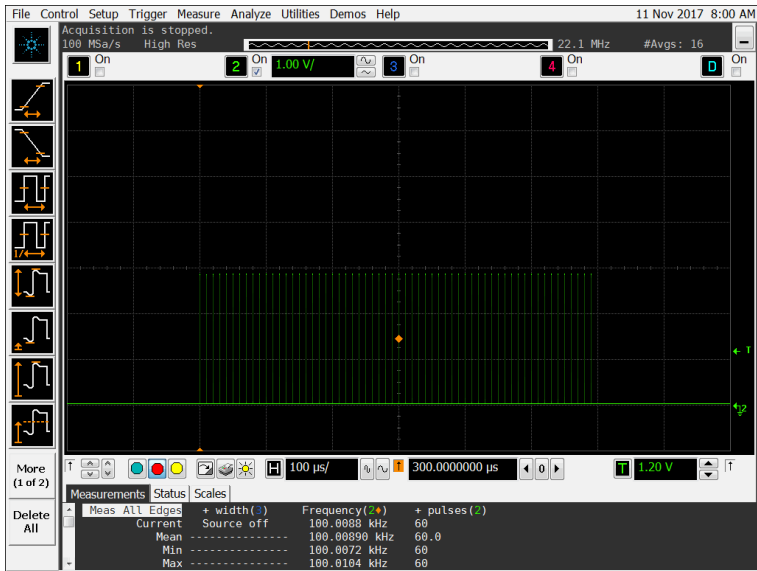


Fig.5. Internal triggering burst mode. CH2 (green line) shows the SYNC OUT pulses. The FREQUENCY is set to 100 kHz and the NUMBER OF PULSES is set to 60, which defines the burst length.

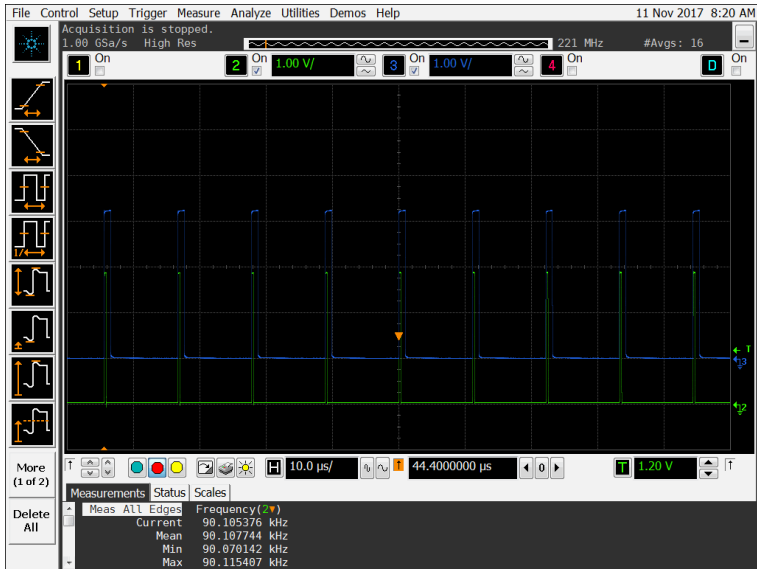


Fig.6. External triggering mode. The repetition rate is defined by the frequency of external triggering pulses. CH2 (green line) shows the output SYNC OUT pulses, CH3 (blue line) shows the input SYNC IN pulses.

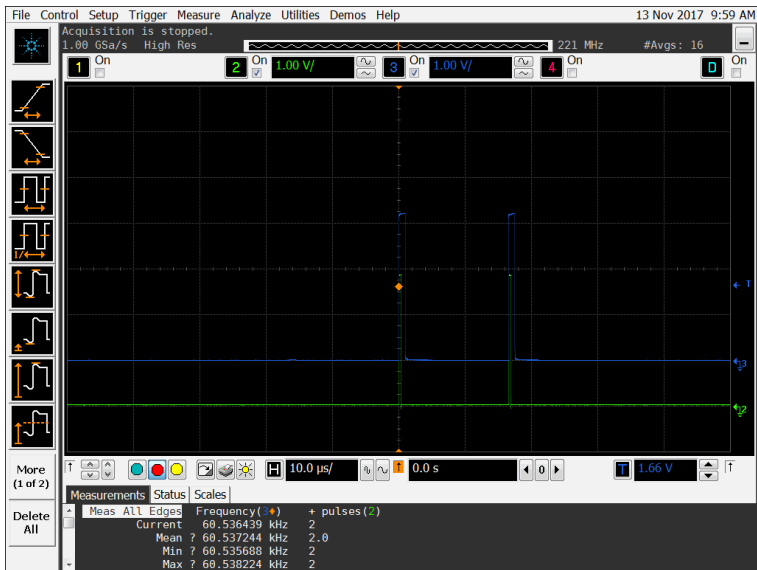


Fig.7. External triggering burst mode. The external triggering pulses set the frequency (60 kHz) and the number of pulses per burst (2 pulses). CH2 (green line) - SYNC OUT pulses, CH3 (blue line) - SYNC IN pulses.

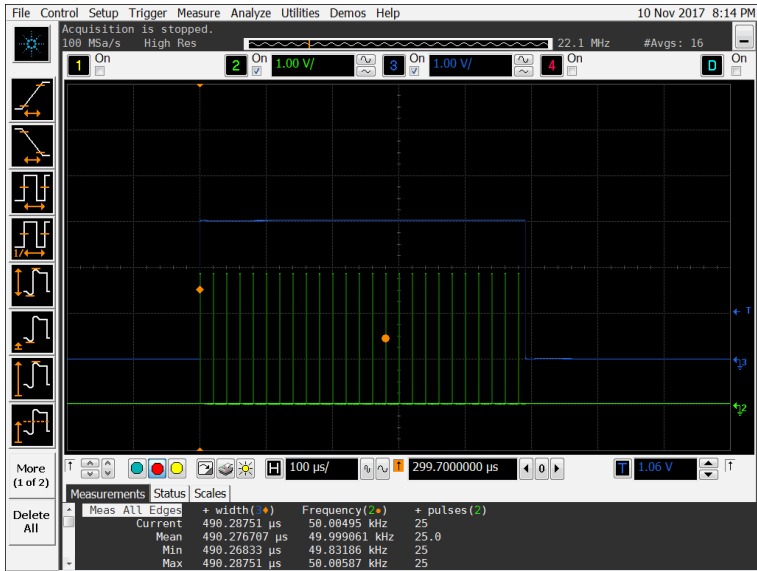


Fig.8. External triggering burst enable mode. The FREQUENCY sets the repetition rate (50 kHz), 25 pulses burst length is determined by SYNC IN pulse duration (CH3, blue line). CH2 (green line) - SYNC OUT pulses.

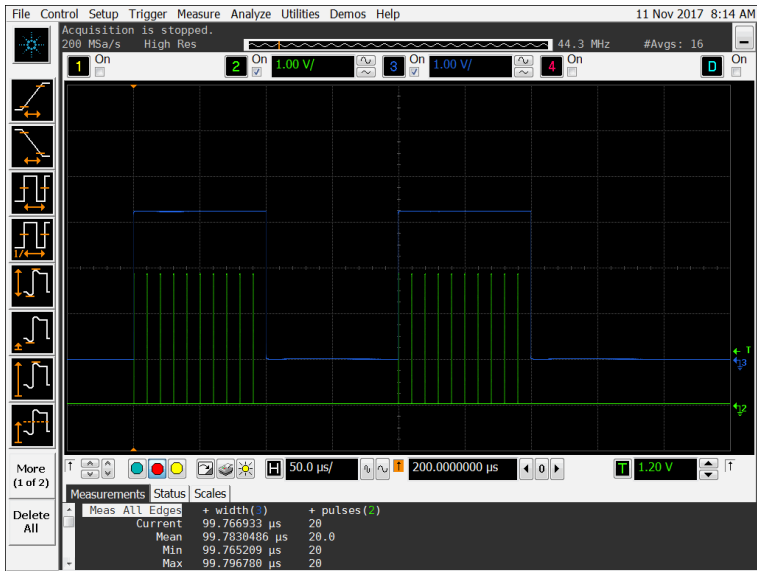


Fig.9. External triggering burst enable mode. Two SYNC IN pulses (CH3, blue line) define two bursts of 10 output pulses each (CH2, green line). The FREQUENCY parameter sets the frequency within bursts (100 kHz).

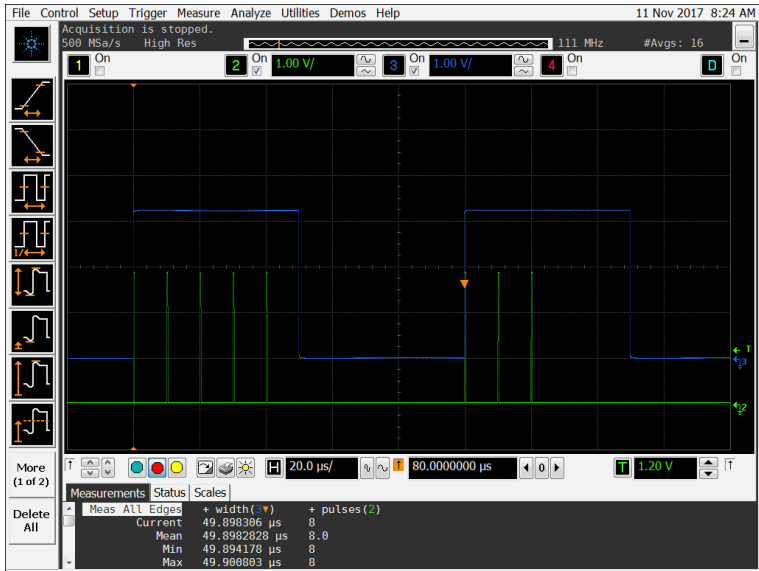


Fig.10. External triggering burst enable mode. NUMBER OF PULSES is set to 8. CH2 (green line) - SYNC OUT pulses, CH3 (blue line) - SYNC IN pulses.

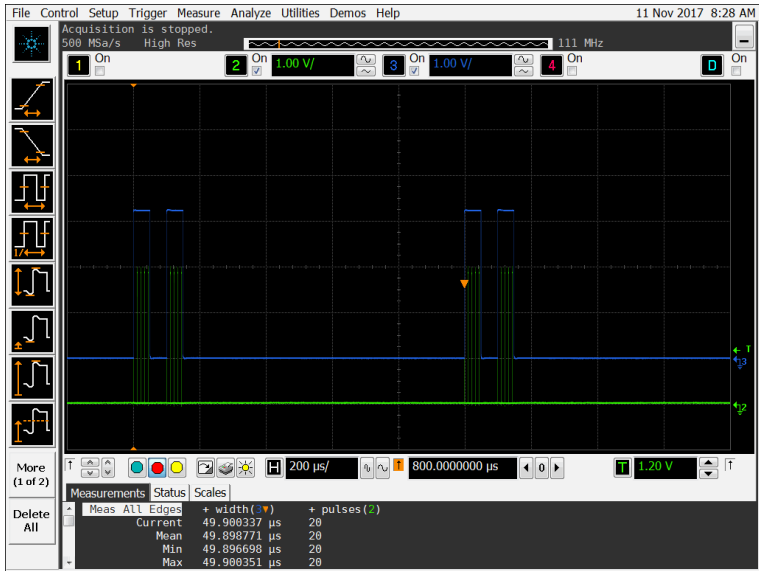


Fig.11. External triggering burst enable mode. The pair of SYNC IN pulses (CH3, blue line) sets the pair bursts of output pulses (CH2, green line).

SYNC OUT PULSE

NPG-18/100k (NPG-18/100kN) generator has BNC output connector for the SYNC OUT pulses. The amplitude of the pulses is 3 V at 50 Ω load and 5 V at high impedance load, the pulse width is 400 ns.

The oscillogram of the SYNC OUT pulse (Channel 2, cyan line) is shown in Fig.12. A few nanoseconds rise time HV output pulse causes strong interference, which can be seen as noise on the oscillogram. The delay between the rising edge of the SYNC OUT pulse and the output high voltage pulse is about 1.2 μ s.

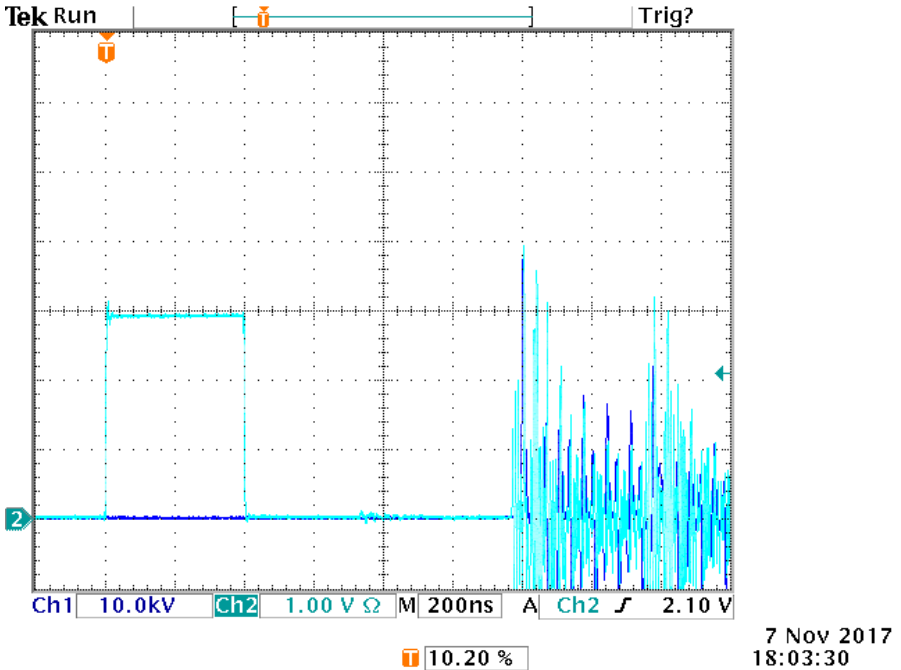


Fig.12. The oscillogram of the SYNC OUT pulse (Channel 2, cyan line). The pulse amplitude is 3 V at 50 Ω load, the pulse width is 400 ns. The delay between rising edge of the SYNC OUT pulse and the high voltage output pulse is about 1.2 μ s.

OVERHEATING

If the internal temperature exceeds the safe level, then OVERHEAT LED lights up and the generator stops operation. This may happen in cases of high ambient temperature, insufficient cooling, or after a long period of operation at high amplitude and repetition rate. The HV ON/OFF button is blocked while the generator is overheated. Please allow the generator to cool down for a few minutes by leaving it in idle mode with the fans running. After the temperature decreases, the generator automatically returns to normal operation. Press the HV ON button again to resume operation.

FUSE REPLACEMENT

- Type of the fuse is 6A/250V slow switching, cylindrical glass 5mm X 20mm

The fuse holder is located in three terminal power supply connector. Use flat screwdriver or another suitable tool to remove the fuse holder and replace the fuse (see Fig.13.).



Fig.13. Removing the fuse holder with a flat screwdriver.

There are two fuses in the fuse holder including one spare (see Fig.14).



Fig.14. Two fuses in fuse holder including one spare (upper in the figure).

WARRANTY

Please see your sales agreement to determine the warranty period and terms. The generator has warranty seals on the front and rear panels (see Fig.15.).

- Removing the warranty seals terminates the warranty.



Fig.15. The warranty seals on the front and rear panels.

Appendix A.

List of presets repetition rates. 4.5 kHz and above are available only in burst operation mode.

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

*) 100 Hz is the default value, which is set after powering up the generator.

**) Set the internal frequency to 101 kHz if you want to operate in external triggering mode with a repetition rate of up to 100 kHz.

List of presets number of pulses per burst. Four-digit display flashes at 1 Hz while it indicates the number of pulses value.

Number of pulses	4 digits display	Number of pulses	4 digits display
1	0001	100	0100
2	0002	200	0200
3	0003	300	0300
4	0004	400	0400
5	0005	500	0500
6	0006	600	0600
7	0007	700	0700
8	0008	800	0800
9	0009	900	0900
10	0010	1000 *)	1000
20	0020	1500	1500
30	0030	2000	2000
40	0040	2500	2500
50	0050	3000	3000
60	0060	3500	3500
70	0070	4000	4000
80	0080		
90	0090		

*) 1000 pulses is the default value which is set after powering on the generator.