

# **NANOSECOND PULSE GENERATOR**

**NPG-18/100k(N)**

## **USER MANUAL**

v. 1.0

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## PACKAGE CONTENT

Please check the package for the following items:

- ✓ NPG-18/100k(N) nanosecond pulse generator (hereinafter "generator")
- ✓ Power supply cable
- ✓ High voltage output coaxial cable
- ✓ User manual



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

# SAFETY MANUAL

## Electrical safety

- NPG-18/100k(N) 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 of generator or other electronic equipment in case of improper use.
- Do not switch on the generator without proper grounding. We recommend using grounding cable connected to the terminal on the rear panel of the generator or three terminal power supply outlet with ground contact.
- It is strongly prohibited to switch on the generator without output coaxial cable. There is a risk of electrical arcing on the open coaxial connector and damage of output circuit of the generator. Please use our special high voltage coaxial connector and cable only. Standard N-, HN- or 7/3-types connectors are not suitable.
- When adding or removing generator to or from the system, ensure that the power supply ON/OFF switch is switched off and power supply cable is unplugged before the output cable is connected or disconnected.
- Please connect or disconnect any equipment, toggle generator from internal to external triggering mode or vice versa while generator is in high voltage OFF state only by HV ON/OFF switch.

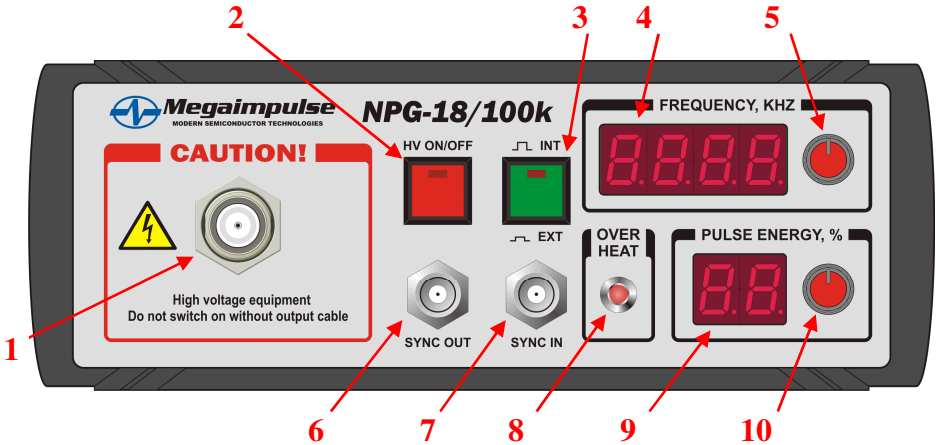
## Operation safety

- Please read this manual before installing and using of the generator.
- Before using the product, make sure that all cables are applicable and not damaged. High voltage connectors should be clean and dry, free from dust, dirt and any obstacles.
- To avoid short circuits keep metal parts like clips, screws and staples away from the generator.
- The generator is designed to work in normal laboratory conditions. 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 with Megaimpulse Ltd. Do not try to repair the generator by yourself.

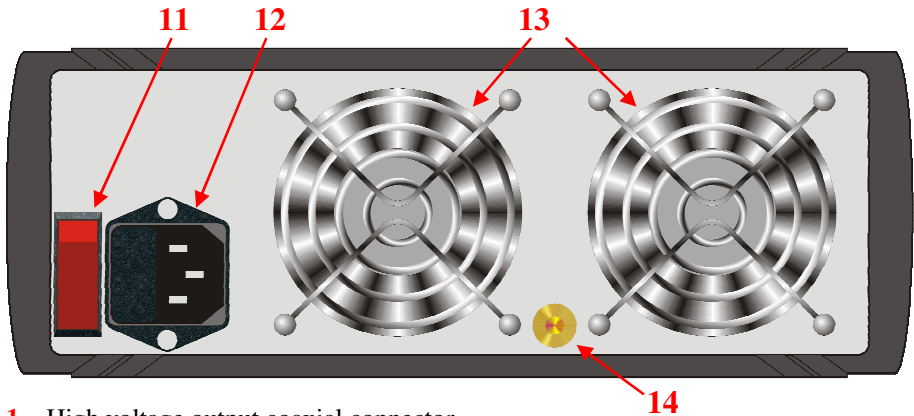
## TECHNICAL SPECIFICATION OF NPG-18/100k(N) NANOSECOND PULSE GENERATOR

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 reactor
Output impedance	75 Ohm
Output connector	special HV coaxial type connector
Output cable	coaxial cable with 75 Ohm impedance, outer diameter 9.6 mm
Pulse polarity	positive (NPG-18/100k) negative (NPG-18/100kN)
Pulse rise time	< 4 ns (fast part of output pulse)
Pulse width (FWHM)	9 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	from 1 Hz to 4 kHz (internal triggering) from single pulse to 4 kHz (external triggering)
Burst mode repetition rates; number of pulses in burst	up to 100 kHz; up to 4000 pulses in burst / each one second interval
External triggering	BNC connector, +2.4 .. +5V amplitude
Internal generator delay	~ 1.2 $\mu$ s
Jitter RMS (typical)	1 ns
Output pulse monitoring	BNC connector, TTL level
Power supply	AC 220-230V / 50 Hz
Size	248 x 90 x 250 mm <sup>3</sup>
Weight (with cables)	6 kg

## 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 in burst 4-digit display
- 5 – Frequency and number of pulses in 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

## OPERATION DESCRIPTION

NPG-18/100k generator is powerful and smart device. In spite of compact size and small number of control elements it has a lot of operation regimes and provides high output power according to the user demands. Please read this manual carefully to be familiar with the basic operation principles.

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

The generator can operate in single pulse, continuous and burst operation modes as well as internal or external triggering. The generator's control system provides quartz stabilized triggering pulses in continuous and burst operation modes and prevents improper triggering in case of external triggering mode. The complete list of the internal triggering modes, please see in Appendix A.

- ➔ In all operation modes the minimum pulse-to-pulse interval is limited to 10  $\mu$ s, which corresponds to 100 kHz repetition rate; the maximum number of pulses within one-second interval is limited to 4000. Therefore, the maximum operation frequency in continuous mode is 4 kHz. Higher repetition rates are available in burst mode only.

The following operation parameters should be set by front panel controls:

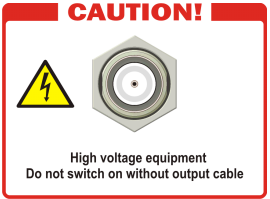



- FREQUENCY from 1 Hz to 100 kHz, default value is 100 Hz;
- NUMBER OF PULSES in the burst (within one-second interval) from 1 to 4000, default value is 1000;
- Output PULSE ENERGY from 50% to 99%, default value is 50%.

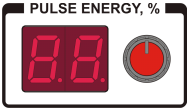



If the current repetition rate in Hz is lower than or equal to set number of pulses (within one-second interval) then the generator operates in continuous mode, otherwise it switches into burst mode automatically. The period of bursts is fixed and is equal to one second. So, FREQUENCY parameter sets the time interval between pulses, while NUMBER OF PULSES sets the burst length or number of pulses followed by a pause within one-second interval.

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



FRONT PANEL IN DETAIL

	<p>Special type coaxial connector suitable for HV nanosecond pulses feeding. Please attach output HV cable firmly before turn-on of the generator. It is very important to keep HV connector clean and dry to prevent unwanted arcing inside it. If necessary, please clean the connectors by cotton with alcohol and then apply a drop of pure silicon oil before mating the connectors. Oil fills air gaps and eliminates possible arcing.</p>
	<p>Non-latching push button, which toggles HV system ON and OFF. When HV system is activated and ready for triggering by internal or external triggering pulse red LED on the button lights on. HV is in OFF state at the generator power on and automatically switches to OFF state in case of overheating or activation of triggering test mode.</p>
	<p>Latching push button, which toggles internal or external triggering modes. Internal triggering mode is activated in depressed state; red LED on the button lights on and indicates immediate triggering when HV ON/OFF button is activated. LED lights off if the button is pressed and no external triggering pulses are applied. LED blinks with one-second interval in case of successful external triggering.</p>
	<p>4 digit LED display and control knob with push button, which set FREQUENCY and NUMBER OF PULSES parameters. The FREQUENCY is indicated in kHz with decimal dot. For example, 1 Hz is indicated as <b>0.000</b>; 100 kHz is indicated as <b>100.0</b>. Please press on the control knob up to click and hold during one second to switch into NUMBER OF PULSES mode. LED display should blink and indicate NUMBER OF PULSES without digital dot. For example, 1 pulse is indicated as <b>0001</b>; 4000 pulses are indicated as <b>4000</b>. Please press on the control knob and hold during one second again to switch back into FREQUENCY mode. The complete lists of internally preset frequencies and number of pulses are shown in Appendix A.</p>

	<p>2 digit LED display and control knob with push button, which set PULSE ENERGY parameter. The energy can be adjusted from 50% to 99% with 1% step. Please press on the control knob up to click and hold during one second to switch into TRIGGERING TEST mode. HV ON/OFF push button is blocked in this mode; LED display shows <b>00</b>, which corresponds to zero output power; triggering sequence from internal or external source goes to SYNC OUT connector. This mode allows to test the triggering and see the exact triggering sequence without applying HV pulses to the load. Please press on the control knob and hold during one second again to switch back into PULSE ENERGY mode. 2 digit LED display lights on constantly in idle or continuous operation modes. It blinks in burst mode, the duration of LED ON and OFF states are proportional to duty cycle.</p>
	<p>If the internal temperature exceeds safe level then OVERHEAT LED lights on and generator stops the operation. It may occur in case of high ambient temperature / insufficient cooling or after long time operation at maximum amplitude and high repetition rate. HV ON/OFF button is blocked while the generator is overheated. Please stay the generator in idle mode and allow cooling by the fans during several minutes. Generator will return to normal operation automatically when the temperature decreases; press HV ON again to continue the operation.</p>
 <p>SYNC IN</p>	<p>BNC input connector for external triggering pulses. The amplitude should be +2.4V ... +5V, nominal pulse width is 1 <math>\mu</math>s. External synchronization mode is activated by pressing INT/EXT green push button.</p>
 <p>SYNC OUT</p>	<p>BNC output connector for SYNC OUT pulses. The front edge of SYNC OUT pulse precedes HV output pulse by <math>\sim 1.2\mu</math>s. SYNC OUT pulse duration is 400 ns, amplitude is 3V@50<math>\Omega</math>.</p>

## PUTTING THE GENERATOR INTO OPERATION

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

### Step 1.

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

- NPG-18/100k(N) generator
- power supply cable
- output 75 Ohm coaxial cable

### Step 2.

Set up the generator. Ground it obligatory by connecting ground cable to terminal at the rear panel (14) or use three terminal power supply outlet with grounding contact.

### Step 3.

Check the output coaxial female connector on the front panel of the generator and co-pair male connector on the cable. Both connectors should be clean and dry, free from dust, dirt and any obstacles. Clean the connectors by alcohol and/or cotton bud if necessary. After cleaning, please apply a drop of pure silicon oil before mating the connectors. Oil fills air gap between insulators of the co-pair connectors and eliminates possible arcing.

Attach the cable connector to the generator front panel connector (1). The tight and firm contact of the connectors is very important for normal operation of the generator. Even small air gap between the connectors may result in arcing, destroying of the generator and the cable.

To obtain good and tight contact the following procedure is recommended:

1. Align both connectors.
2. Hold the generator by one hand to prevent moving and press the cable connector by other 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. Finally screw the cable connector nut firmly by both hands.

It is highly recommended to check whether the tight contact obtained or not after the first testing of the generator. Unscrew the cable connector; it should be no any ozone or burnt smell from the connectors or any burnt traces.

During normal operation, please do not disconnect and connect again the high voltage connectors many times to prevent the contacts wearing and contamination. Silicon oil has been already applied to both connectors at the factory. It remains inside the mating connectors during very long time and prevent arcing.

#### Step 4.

Connect the other side of coaxial cable to the load. The teflon cone insulator is installed on the cable end to prevent the barrier discharge between central wire and the cable braid across the polyethylene insulator (See Fig.2). You may use additional wires for connection to the load. Solder the high voltage load wire to the central cable wire and screw/solder ground load wire to the ground clamp. Please use as short additional wires as possible.

- ➔ More than 10 cm additional wires between the load and coaxial cable result in excessive stray inductance and significant reducing of the pulse amplitude on the load.



Fig.2. Teflon cone insulator on the cable end.

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

### **Step 5.**

Connect power supply cable to wall power outlet.

Switch on the generator by power switch on the rear panel. The internal fans should start to rotate.

### **Step 6.**

Depress INT/EXT push button. Red LED on the button should light indicating internal triggering mode.

Set the required frequency, number of pulses and energy by the knobs. It is clever to start the experiments with low operation parameters, which helps to prevent possible damage of the equipment in case of any fault.

Press HV ON/OFF push button. Red LED on the button should light and output HV pulses should be generated. Increase the amplitude and frequency by corresponding knobs as necessary.

### **Step 7.**

Always stop the operation of the generator by HV ON/OFF switch, after that you can switch off the generator by power switch. After long time of operation at high pulse amplitude and frequency please allow fans to rotate several minutes in idle mode for cooling.

## **TRIGGERING OF THE GENERATOR**

The generator can operate in internal and external triggering operation modes.

### **Internal triggering**

Internal triggering mode is set if INT/EXT latching push button is in depressed state. Red LED on the button continuously lights on indicating the internal triggering mode. No any external triggering pulse generator is required in this regime for continuous and burst operation modes. Output pulses repetition rate can be adjusted by FREQUENCY regulation knob within 1 Hz ... 100 kHz. Number of pulses in the burst can be set by the same knob after one second pressing within 1 to 4000 pulses. The complete lists of internally preset frequencies and number of pulses are shown in Appendix A.

## External triggering

External triggering mode is set by pressing INT/EXT latching push button. Red LED on the button lights off indicating the external triggering mode. External triggering pulses should be applied to BNC SYNC IN connector by coaxial cable with 50 Ohm impedance. Recommended pulse amplitude is +2.4 ... +5V, which allows triggering the generator by TTL, 5V CMOS or 3.3V LVTTTL/LVCMOS level pulse. The delay between triggering pulse front and output pulse (internal generator delay) is about 1.2  $\mu$ s, typical jitter (RMS) is about 1 ns. Red LED on the button should blink in one-second interval indicating the successful triggering of the generator.

- ➔ The maximum allowable pulse repetition rate and number of the pulses within a burst are limited by internally set FREQUENCY and NUMBER OF PULSES parameters. Please set these parameters to the maximum allowable values by FREQUENCY knob.

Short external triggering pulse, for example 1 $\mu$ s duration, generates one output pulse, of course, if it is permitted by internally set parameters. However, long enough triggering pulse generates burst of pulses with repetition rate set by FREQUENCY parameter. SYNC IN pulse works as enable signal in this case.

The generator can operate also in single pulse mode.

Several samples of the different triggering modes are shown below.

## Triggering test mode

Press on the PULSE ENERGY knob up to click and hold during one second to switch into TRIGGERING TEST mode. HV ON/OFF push button is blocked in this mode; LED display shows **00**, which corresponds to zero output power; triggering sequence from internal or external source goes to SYNC OUT connector. This mode allows to test the triggering and see the exact triggering sequence without HV output pulses generation. Please press the PULSE ENERGY knob and hold during one second again to switch back from this mode.

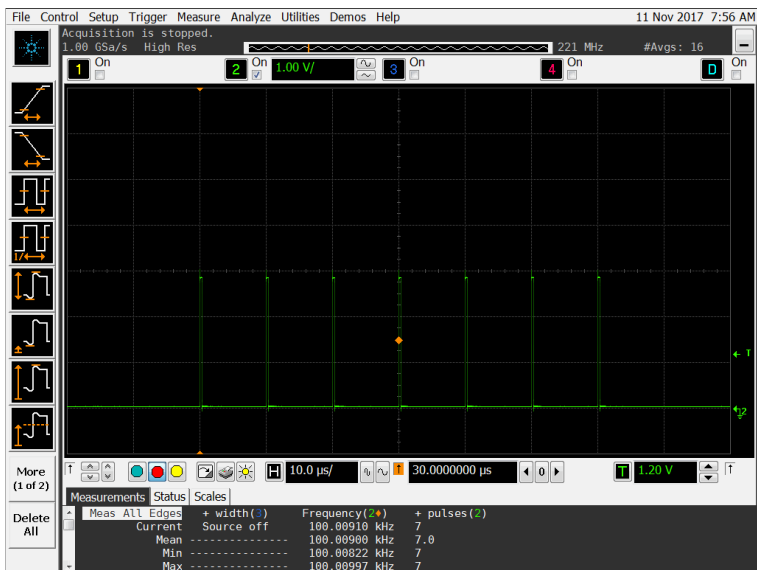


Fig.3. Internal triggering burst mode. 100 kHz rep. rate is set by FREQUENCY parameter, burst length is set equal to 7 pulses by NUMBER OF PULSES parameter. CH2 (green line) shows output SYNC OUT pulses.

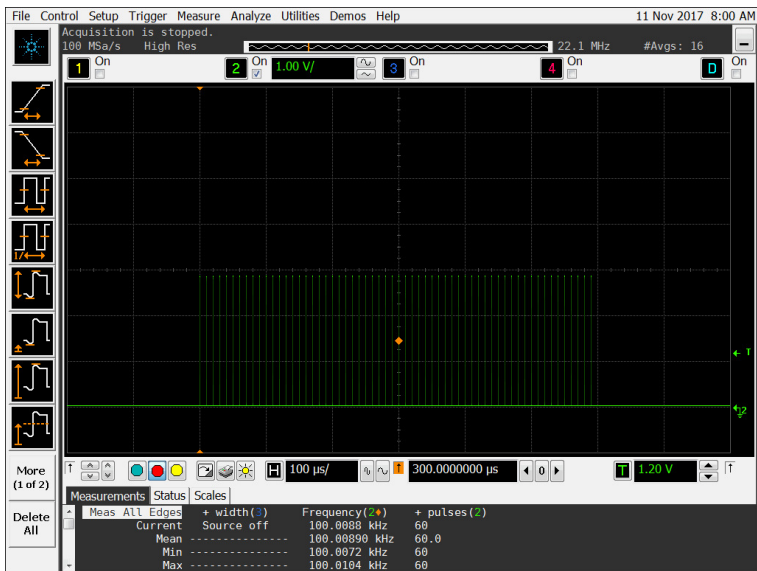


Fig.4. Internal triggering burst mode. Repetition rate is set equal to 100 kHz, burst length is set equal to 60 pulses by NUMBER OF PULSES parameter. CH2 (green line) shows output SYNC OUT pulses.

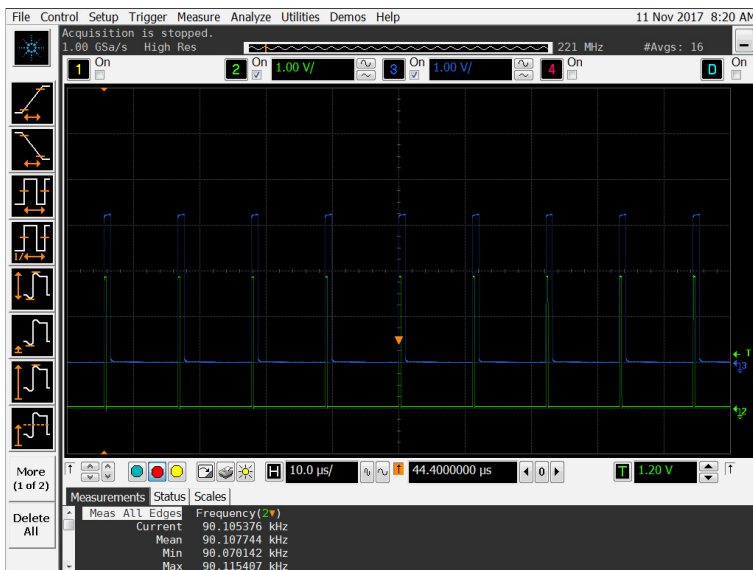


Fig.5. External triggering mode. Repetition rate is defined by external triggering pulses frequency. CH2 (green line) shows output SYNC OUT pulses, CH3 (blue line) shows input SYNC IN pulses.

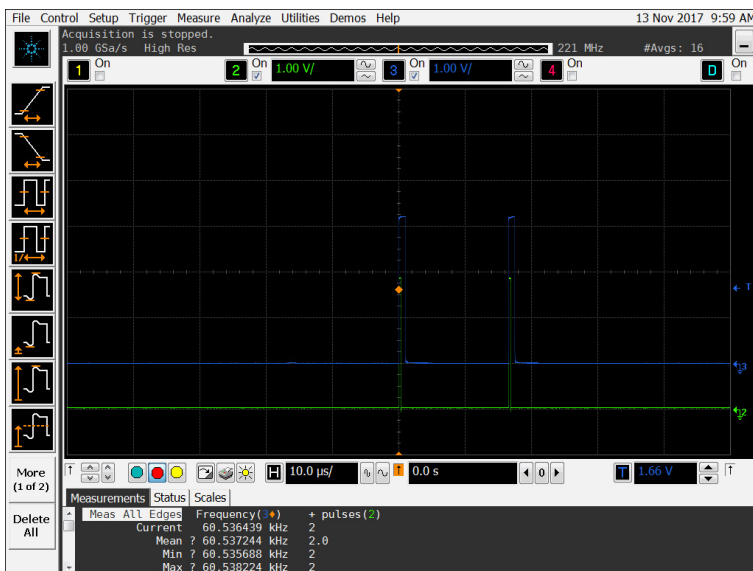


Fig.6. External triggering burst mode. External triggering pulses set repetition rate (60 kHz) and number of pulses in burst (2 pulses). CH2 (green line) shows output SYNC OUT pulses, CH3 (blue line) shows input SYNC IN pulses.



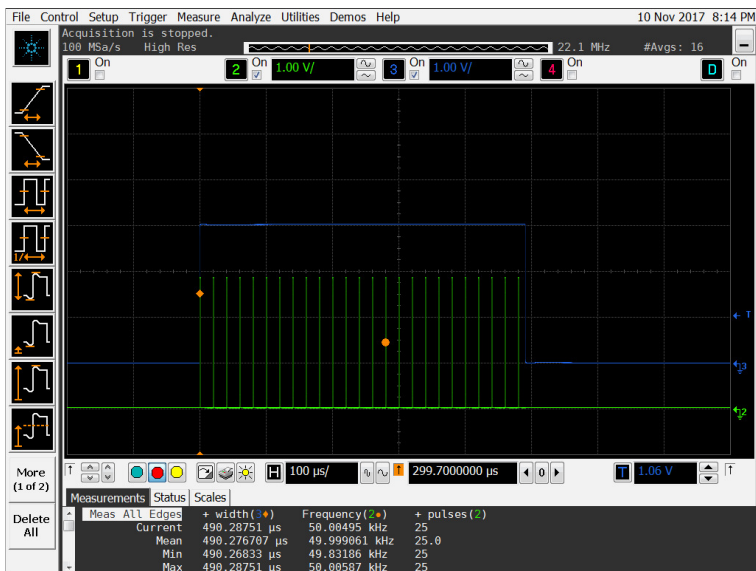


Fig.7. External triggering burst enable mode. FREQUENCY parameter sets the repetition rate (50 kHz) of output pulses (CH2, green line), burst length is determined by SYNC IN pulse duration (CH3, blue line).

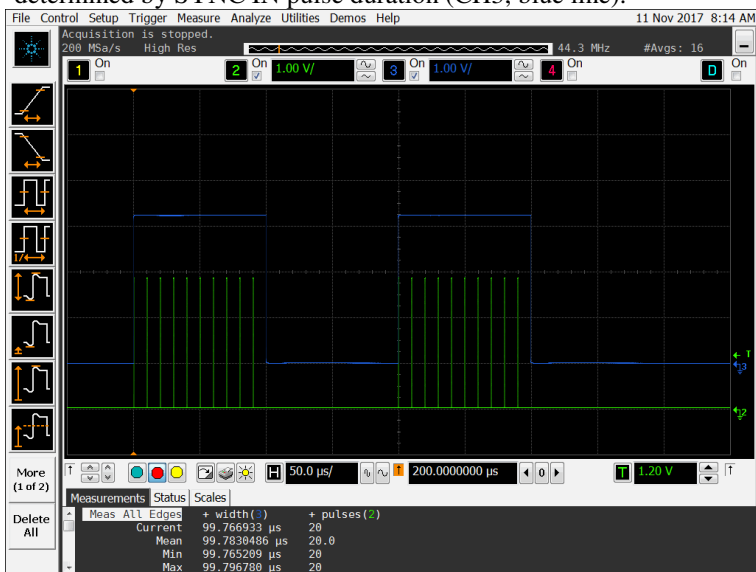


Fig.8. External triggering burst enable mode. Two SYNC IN pulses (CH3, blue line) define two bursts of output pulses (CH2, green line). FREQUENCY parameter sets the repetition rate within the bursts (100 kHz).

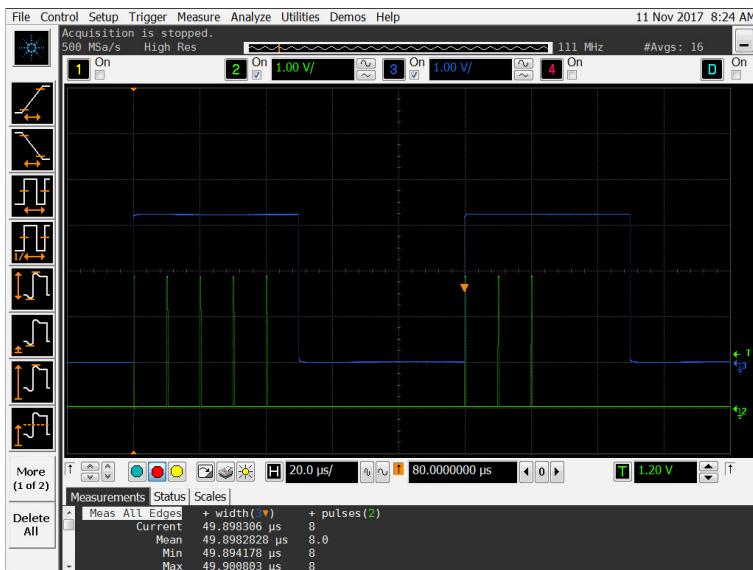


Fig.9. External triggering burst enable mode. Number of pulses is limited to 8 by internal NUMBER OF PULSES parameter. CH2 (green line) shows output SYNC OUT pulses, CH3 (blue line) shows input SYNC IN pulses.

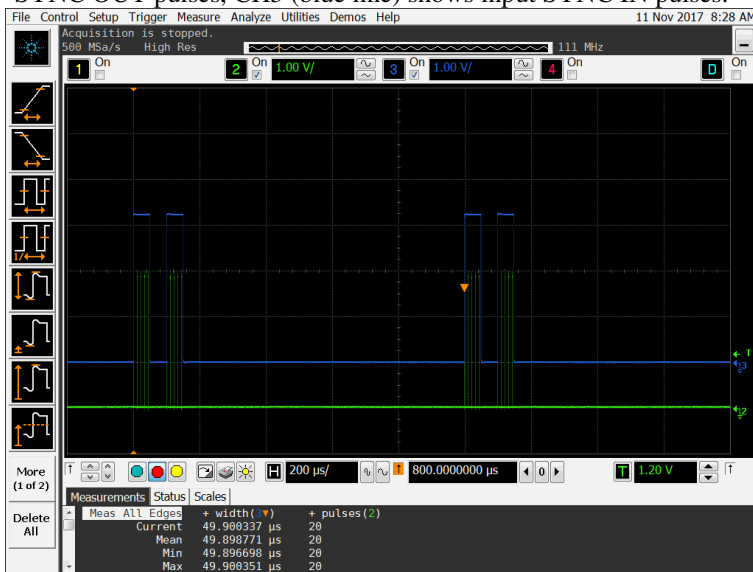


Fig.10. External triggering burst enable mode. The pair SYNC IN pulses (CH3, blue line) set the pair bursts of output pulses (CH2, green line).

## OUTPUT SYNC PULSE

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

The oscillogram of SYNC OUT pulse (Channel 2, cyan line) is shown in Fig.11. The high voltage few nanoseconds rise time output pulse is a source of strong interference. Therefore, one can see the noise on the oscillograms at the moment of output pulse generation. The delay between rising front of triggering pulse and output pulse is about 1.2  $\mu$ s.

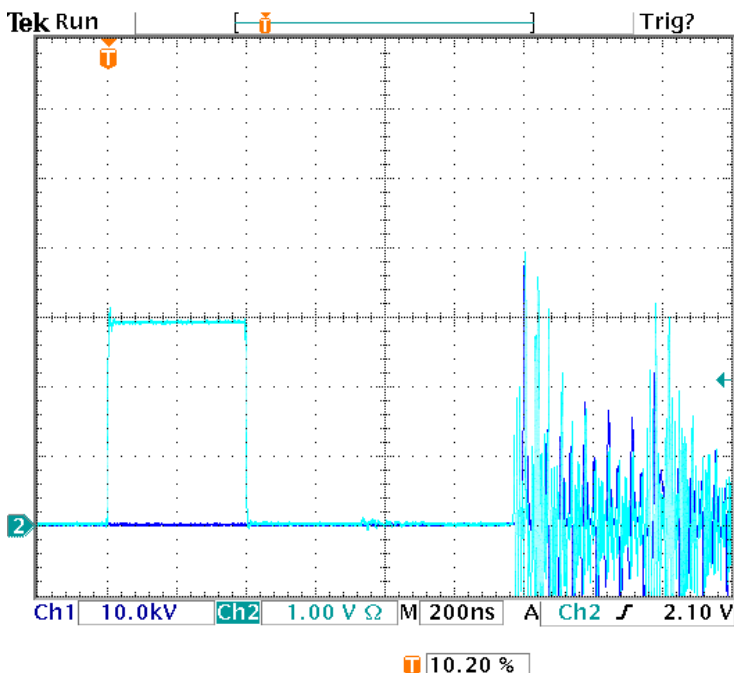


Fig.11. Oscillogram of SYNC OUT pulse (Channel 2, cyan line). The pulse amplitude is 3 V on 50 Ohm load and 5 V on high impedance load, the pulse width is 400 ns. The delay between rising front of triggering pulse and high voltage output pulse is about 1.2  $\mu$ s.

## **OVERHEAT MODE**

NPG-18/100k(N) pulse generator has overheating protection system. If the generator operates during long time at maximum amplitude and high repetition rate and/or the ambient temperature is high enough then it may be overheated. OVERHEAT LED light on in this case and generator stops the operation. HV ON/OFF push button is switched off automatically and disabled. Please stay the generator in idle mode during several minutes and allow the fans to cool the generator. OVERHEAT LED lights off when the temperature decreases and returns within the safe range. The generator is ready for the operation again.

## FUSE REPLACEMENT

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

The fuse holder is located in three terminal power supply connector. Please use flat screwdriver or other suitable tool to remove the fuse holder (see Fig.12.).



Fig.12. Removing of the fuse holder by flat screwdriver.

There are two fuses in the fuse holder including one spare fuse (see Fig.13).



Fig.13. Two fuses in fuse holder including one spare (upper in the figure).

## WARRANTY

Please see your sales agreement to determine the warranty period and condition. The generator has two warranty seals at the front and rear panels (see Fig.14.)

- ➔ Removing of the warranty seals terminates the warranty.



Fig.14. Warranty seals at the front and rear panels.

## Appendix A.

List of preset repetition rates. 4.5 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		

\*) 100 Hz is default value, which is set after power on the generator

List of preset number of pulses within a burst. 4 digit display blinks with one-second period while indicates 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 default value, which is set after power on the generator