HVSW-04
high voltage high repetition rate
Pockels cell driver

User manual

Warning! This equipment produces high voltages that can be very dangerous.
Please read user manual before starting operations.

Important note: measure the output with symmetrical (differential) high voltage probe only. Measurement made with inappropriate equipment is a common cause of driver's failure.

Description / Appearance

HVSW-04 is a specialized Pockels cell driver which performance is optimized for pico- and femtosecond lasers. Main applications are pulse picking and regenerative amplifier control.

Maximal output voltage is 4kV; maximal repetition rate is 4MHz at lower voltages. Target performance is as below:

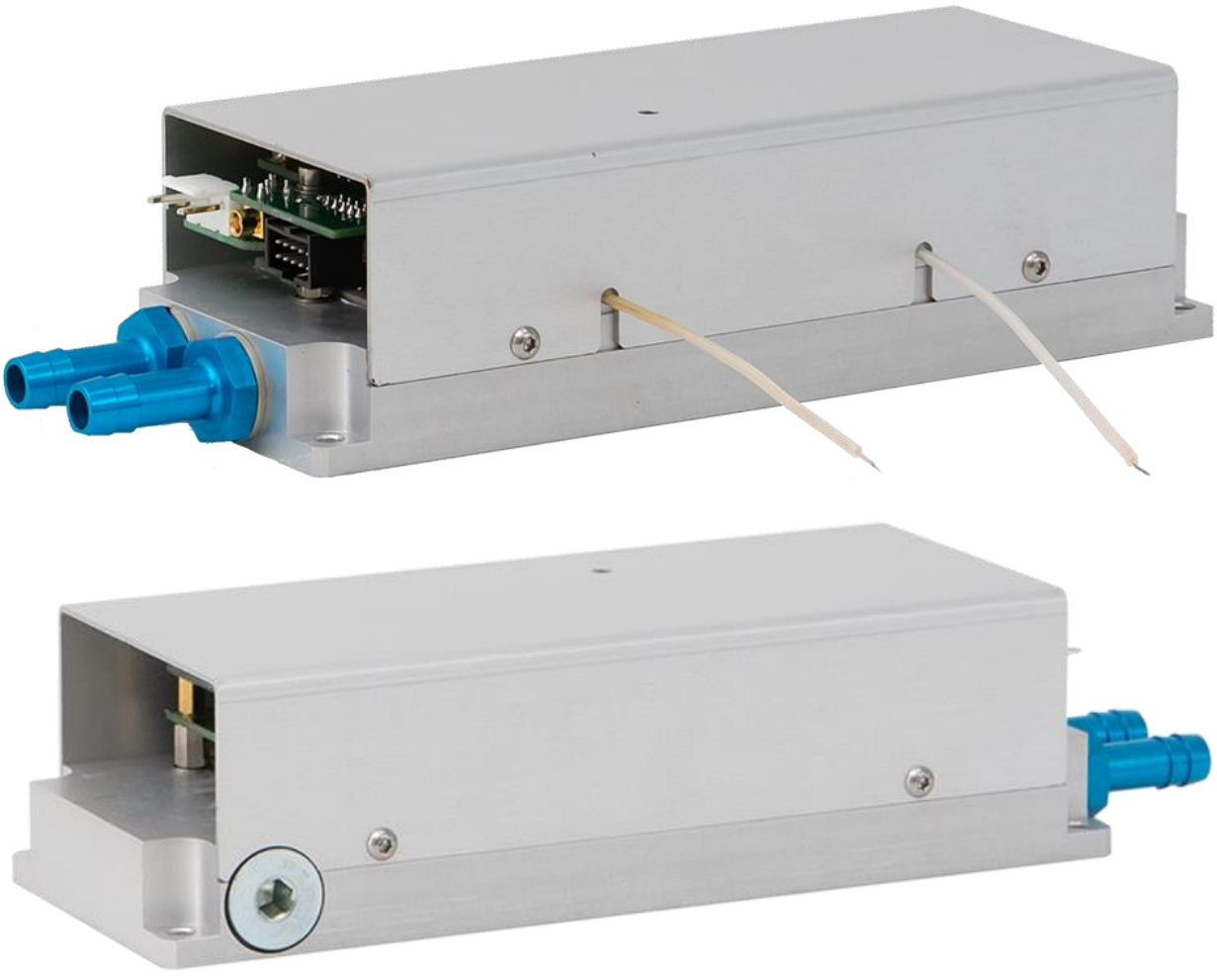
- 4.0kV, 500kHz, <300W power consumption
- 3.2kV, 1MHz, <400W power consumption
- 2.0kV, 2MHz, <300W power consumption
- 1.6kV, 3MHz, <300W power consumption
- 1.4kV, 4MHz, <350W power consumption

Transition times are from 5-7ns to 9-11ns in dependence on operating voltage, load capacitance and driver's configuration. Pulse width is adjustable from 15-20ns to 2000ns (longer on request). See also *Software description, Performance* and *How to order?* sections.

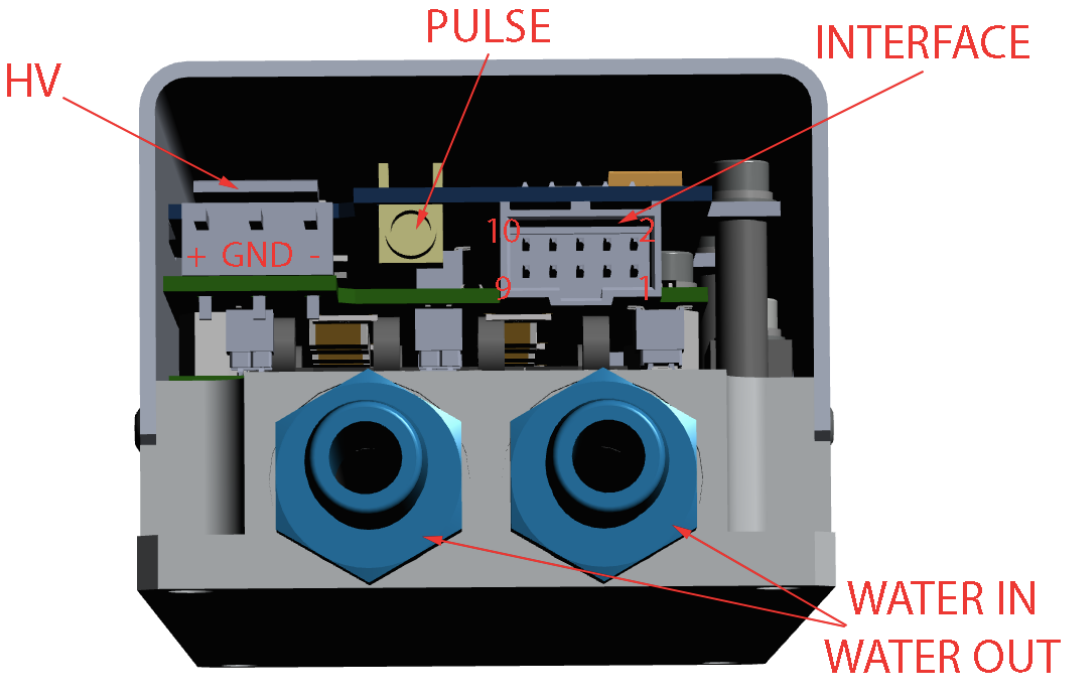
For operations the driver needs both HV and LV power. HV DC input should be bi-polar. LV power is 24VDC, <2.5A.

Module is water cooled. Different configurations of water inlets available on request.

Interfaces are analogue and RS-485. Configuration software for Windows® 7 is available.



Connectors, pins, interface signals



HV INPUT (1744048-3 TE Connectivity):

PIN (color)	DESIGNATION	DESCRIPTION
1 (red)	**HV Positive**	To produce 4kV pulses at the output of the driver, +2kV DC should be supplied to this pin.
2 (black)	**GND**	Grounding pin
3 (blue)	**HV Negative**	To produce 4kV pulses at the output of the driver, -2kV DC should be supplied to this pin.

INTERFACE (Molex 901303110):

PIN (color)	DESIGNATION	DESCRIPTION
1, 2 (red)	**+24V DC**	+24V DC power supply positive. Rated current – 2.5A max.
3, 4 (black)	**+24V DC Return**	+24V DC power supply negative
6 (black)	**Interface Return**	Return of Interface signals (Enable, Pulse, Fault). Grounding of RS-485 interface to be used in the case of high level of EMI affecting quality of RS-485 connection and the need to equalize the potentials of receiver and transmitter.
5 (orange)	**Gate limit fault**	Gate limit is a hardware protection of laser optics from too long pulses applied to the

		Pockels cell controlling the regenerative amplifier. If pulse width applied to Pulse pin exceeds Gate limit value driver forcibly cuts off the pulse and sets up the Gate limit fault (TTL high – fault, low – no fault). Despite the fault state driver continues the operations. To remove fault state driver should be disabled and enabled again.
7 (violet)	**RS-485 "+"**	RS-485 «+» to be applied here
8 (blue)	**Enable**	By default, +5V applied to this pin enables the output. Optional behavior when pin 8 should be pulled to the ground to enable the output can be set via RS-485 interface / software (see *Software description* section for the details). This pin is also used to reboot the driver in the case of overheating and other faults. To remove fault state driver should be disabled and enabled again.
9 (green)	**RS-485 "–"**	RS-485 «–» to be applied here
10 (red)	**Fault**	In the case of overheating driver sets up the fault on this pin (TTL high – fault, low – no fault) and stops the operations till fault reason is eliminated and driver is rebooted (disabled and enabled again).

PULSE (Linx Technologies CONMCX002**):**

PIN (color)	DESIGNATION	DESCRIPTION
1 (black)	**Pulse**	**In Fixed pulse width mode (see also *Software description* section):** TTL signal applied to this pin initiates HV pulse at driver's output. Rising edge triggered. Trigger level is 3V. HV pulse width is fixed and equal to 15-20ns. **In Variable pulse width mode (see also *Software description* section):** Driver's output repeats TTL signal applied to this pin. Minimal pulse width is 100ns, maximal pulse width is 2000ns or Gate limit (what's less). Minimal inter-pulse interval is 50ns. **Input impedance is 50Ohm.** **Signal amplitude delivered to the switch should be +5V DC assuming divider of switch's input impedance and pulse generator output impedance.**

HV OUTPUT (flying leads):

Two wires, each of 70mm length

Other wire's length and termination are available on request. Shielded output wires reducing EMI, but slightly decreasing the performance are available on request.

LEDs:

POWER (green):

- LED lits steadily while device is powered.

STATE (blue):

- In standby mode LED blinks slowly when device is being controlled via RS-485 interface (i.e. when RS-485 connection is established).
- LED lits steadily when HV output is enabled.

FAULT (red):

- LED blinks slowly when Gate limit fault occurred.
- LED lits steadily when Overtemp fault occurred.
- In bootloader (update) mode this LED makes double blinks.

MOUNTING AND GROUNDING:

Driver to be mounted with 4pcs M4 screws (recommended screws are DIN 912, M4x10 or longer).

Grounding policy

By default all grounds (of HV power supply, LV power supply, Interface and Pulse connectors) are interconnected inside HVSW-04 and then to its chassis.

Other grounding policies could be discussed.

WATER COOLING:

Driver is water cooled. Recommended water temperature – 20-30C. Water temperature must be above ambient condensing point.

GATE VOLTAGE TRIMPOT:

Adjusting this trimming potentiometer makes the transitions at the HV output either "harsher" (faster risetime and faster falltime, but by the cost of a little higher overshoot) or "softer" (lower overshoot, but by the cost of a little slower risetime and falltime).

Default position is "soft". Clockwise rotation is from "soft" to "harsh".

Safety

Warning! This equipment produces high voltages that can be very dangerous. Don't be careless around the equipment.

Assemble the entire setup before powering the device.

- Avoid casual contacts of personnel with output cables and with the load
- Do not connect / disconnect output cables while driver is turned on
- Do not operate with disconnected load
- Do not turn the driver on if it was already damaged with water, chemicals, mechanical or electrical shock
- Do not self-repair the driver, there are no user-serviceable parts inside
- Driver's input-to-output insulation isn't a safety feature, but just functional one, so we highly recommend to use low voltage power supply with input-to-output insulation providing appropriate level of protection (4000VAC or 2500VAC in dependence on your application)

Operations (analogue interface)

[Pre-configuration, optional]

1. Connect +24V DC power supply to the driver, connect driver to PC (or to another controlling device)
2. Run provided Windows® software (or terminal software)
3. Configure the driver using provided Windows® software (or using RS-485 commands)
4. Disconnect the driver from PC (from another controlling device)

[Power up and operations]

1. Connect driver to the chiller or another cooling device (for low repetition rate regimes this step can be skipped)
2. Connect +24V DC power supply, HV power supply, Pockels cell and pulse generator to the driver. Do not apply +24V DC power and HV power before the entire setup is completely assembled
3. Turn on +24V DC power supply to power up the driver
4. Turn on HV DC power supply; set the desired output voltage using controls of HV DC power supply

Warning: please strictly observe the power up sequence described above (24V power is applied first, HV power is applied only after then).
Another power up sequence destroys the driver.

5. Enable the driver using HV Enable signal (pin 8 of INTERFACE connector)
6. Apply Pulse signal (pin 1 of PULSE connector) with the desired pulse width and repetition rate

[Power down]

Warning: please strictly observe the power down sequence described below (HV power is removed first, 24V power is removed only after then).
Another power down sequence destroys the driver.

1. Remove HV power from HVSW-04 (e.g. disable HVPS-300)
2. If necessary wait until residual voltage at HV input of HVSW-04 disappears completely (60s for HVPS-300)
3. Remove 24VDC from HVSW-04

Note: that's impossible to command the driver via RS-485 interface and via analogue interface at the same time. Once RS-485 connection is established, driver ignores signals applied to the analogue interface.

To switch driver from RS-485 interface to the analogue interface (or vice versa), power should be removed from the driver and then applied again.

RS-485 interface description

RS-485 connection parameters: 57600 bps, 8 data bits, 1 stop bit, no parity.

Default protocol is described in Appendix A.

Simplified protocols are available on request.

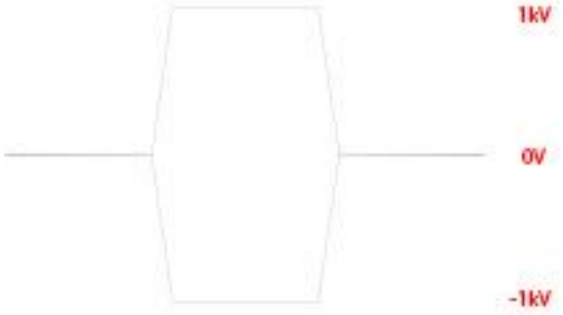
Technical notes

- **Performance of the module greatly depends on load capacitance.** Full performance is achievable at load capacitance typical to Pockels cells used in laser industry (5-7pF).

Important note: Higher load capacitance increases power consumption approx. 35% for every 6pF added. Maximal achievable repetition rate is decreased accordingly.

HV probes attached to the output to measure output parameters also decrease the performance of the driver accordingly to their capacitance – from 20-40% for low capacitance probes (4-6pF) and up to a few times for high capacitance probes (10-20pF)

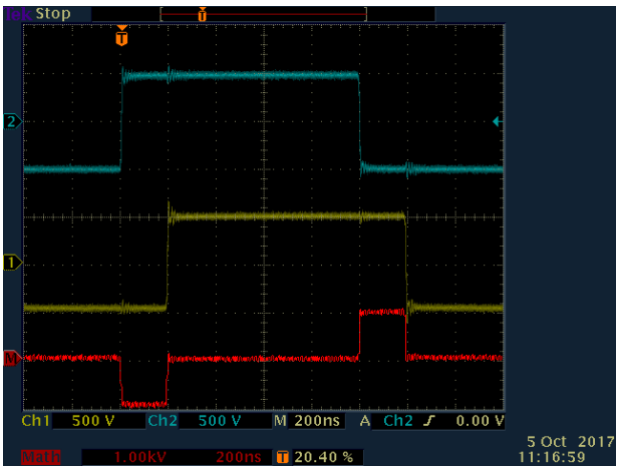
- **Module's output is bipolar.** This means that e.g. 2kV pulse is physically formed by applying +1kV to one output wire and -1kV to the other (see figure)



Nevertheless, all descriptions of HV output are given in terms of voltage differences. Please keep this in mind!

- **Module's input is bipolar.** This means that to produce e.g. 2kV pulse driver must be fed with +1kV by one input wire and -1kV by the other. A special power supply unit is needed.

- **Sequential pulses have opposite polarity.** Since driver is built on full bridge schema, every output wire switches its potential between +V and –V values (blue and yellow curves below). As a result, the voltage difference between two wires can be either positive or negative (red curve on the picture below).



Specifications

ELECTRICAL SPECIFICATION

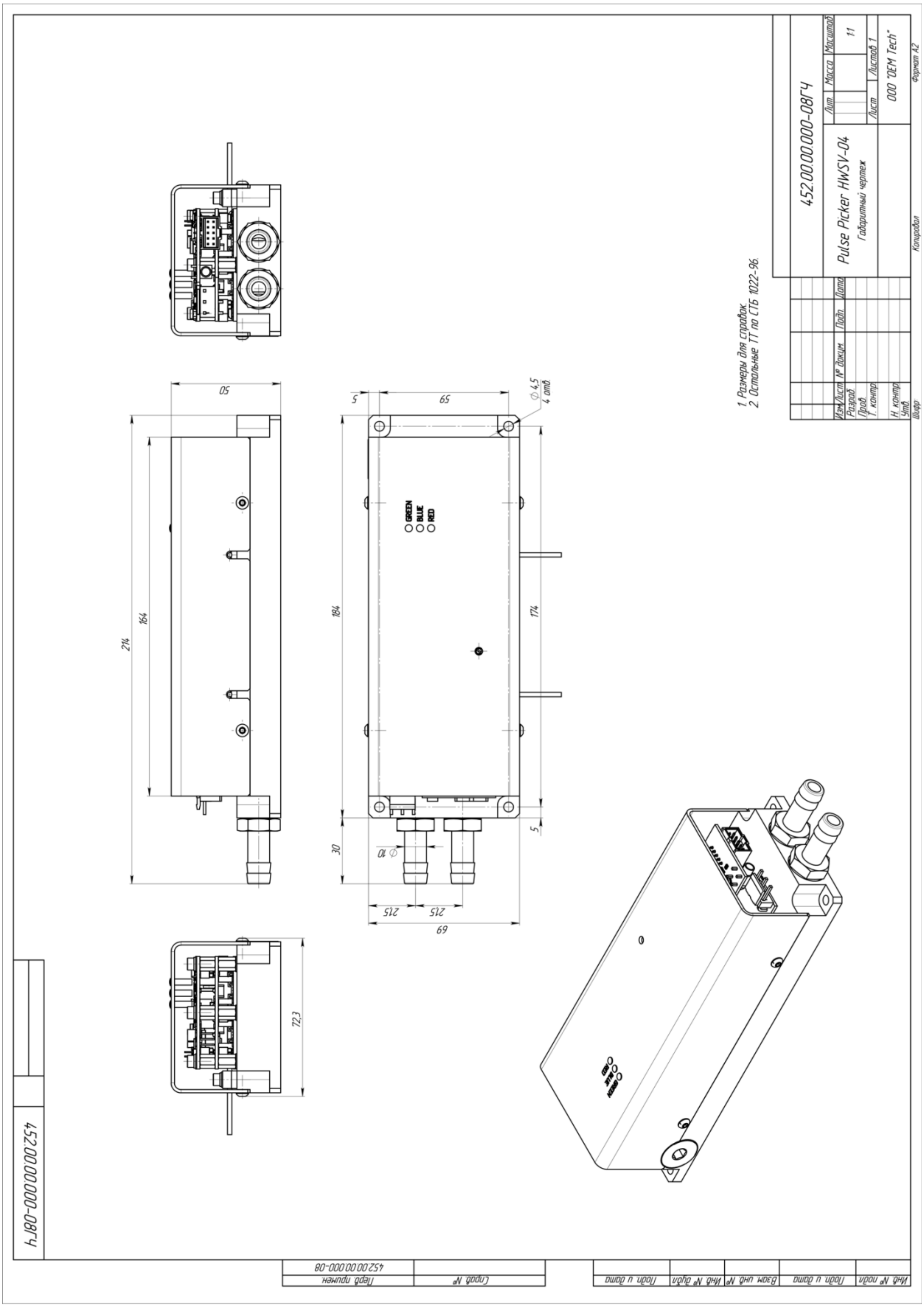
LV input	+24V DC; 2.5A max
HV input	+HV/2 by one wire; -HV/2 by another wire
Output	Pulses of high voltage and high repetition rate delivered to the capacitive load (e.g. to the Pockels cell)
Output type	Bipolar (see also *Technical notes* section)
Pulse basement [1]	0V, fixed
Pulse amplitude [1, 2]	0-4kV (the same as voltage applied to HV Input)
Maximal repetition rate [2]	Up to 4MHz (see also *Performance* section)
Minimal repetition rate	Single shot (there is an internal restriking circuit which makes the operations at such a low repetition rate possible)
Pulse width	In **Fixed pulse width mode** – fixed, 15-20ns (modification dependent) In **Variable pulse width mode** – adjustable either in 15-2000ns or in 100-2000ns range (other on request) See also *Performance*, *Software description* and *How to order?* sections
Interpulse interval	>50ns
Risetime/falltime [3]	From 5-7ns at small output voltages (1kV) to 9-11ns at the maximal voltage (4kV)
Delay time	<50ns
Jitter	<0.5ns (±250ps)
Load capacitance	5-7pF typically
Protections	- From too long pulses (Gate limit), adjusted by the customer in 200ns to 2000ns range [4] - From overheating
Environment	
Operation temperature	+10...+40 °C
Storage temperature	-20...+60 °C
Humidity	90%, non-condensing

[1] In terms of bipolar output (see also *Technical notes* section)
[2] Maximal pulse repetition rate depends on pulse amplitude, pulse amplitude and pulse repetition rate cannot achieve their maximums at the same time
[3] 10-90% level, also depends on load and cable capacitance, Harsh/Soft mode of triggering etc
[4] These and other parameters might be changed upon request

MECHANICAL SPECIFICATION

Size (LxWxH)	176x69x50mm (without inputs and outputs)
Weight	<0,5kg

Dimensions



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Pulse Picker HWSY-04
Габаритный чертеж
ООО "OEM Tech"
Лит
Масса
Масштаб
1:1
Лист
Листов 1
Изм
Лист
№ докум.
Подп.
Дата
Разраб.
Пров.
Т. контр.
Н. контр.
Утв.
Копировал
Формат А2
1. Размеры для справок.
2. Остальные ТТ по СТБ 1022-96.
GREEN
BLUE
RED
Ø 4,5
4 отв.
Ø 10
50
65
5
214
164
184
174
30
21,5
69
72,3
Перв. примен.
452.00.00.000-08
Справ. №
Подп. и дата
Инв. № дубл.
Взам. инв. №
Инв. № подл.

How to measure the output?

Please keep in mind the next points while measuring the output:

1. Improper measurements can destroy the driver

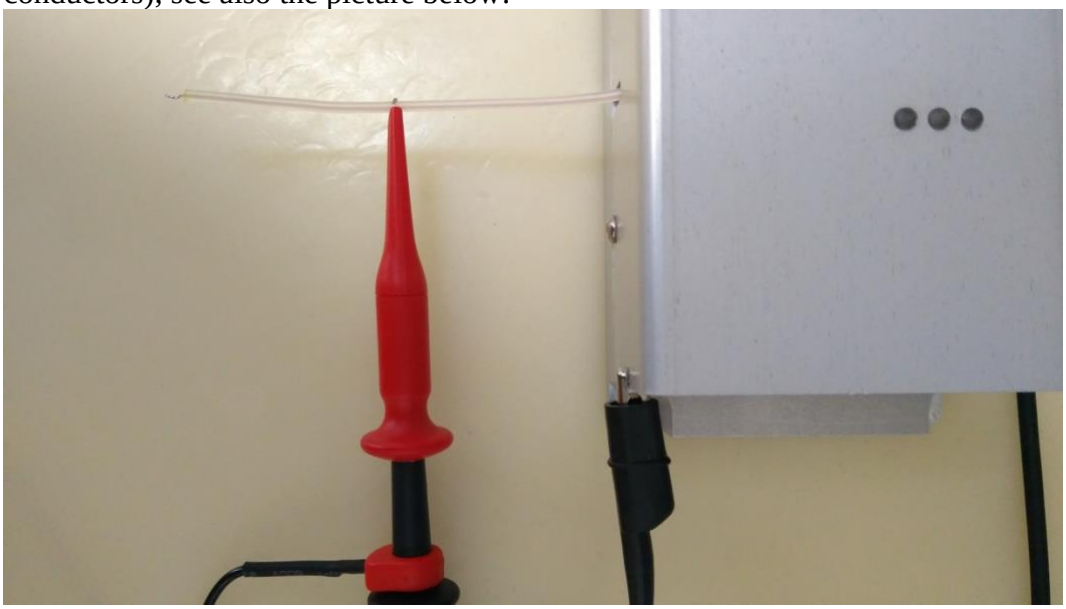
Important note: measure the output with symmetrical (differential) high voltage probe only. Measurement made with inappropriate equipment is a common cause of driver's failure.	
	

2. Measurements, even proper, decrease driver's performance.

Important note: Higher load capacitance increases power consumption approx. 35% for every 6pF added. Maximal achievable repetition rate is decreased accordingly. HV probes attached to the output to measure output parameters also decrease the performance of the driver accordingly to their capacitance – from 20-40% for low capacitance probes (4-6pF) and up to a few times for high capacitance probes (10-20pF)

3. Measurements, even proper, increase risetime and falltime comparing to the "true" risetime and falltime measured by optical means. Effect might be as high as 1-2ns in dependence on particular HV probe used.

4. We do not recommend to run driver in powerful regimes (i.e. at maximal repetition rates) with any probe attached to the output. In these cases we recommend to measure the output by measuring EMI (i.e. without actual contact of the probe with output conductors), see also the picture below:



How to order?

At the moment there are two modifications different with maximal operating voltage and maximal repetition rate:

Modification	Maximal repetition rate	Maximal voltage	Risetime / falltime
HVSW-04 or HVSW-04-4kV (standard modification, 4kV max)	1MHz (can be damaged if operated at higher repetition rate)	4kV (can be damaged if operated at higher voltage)	9-11ns (at 4kV)
HVSW-04-2kV (high repetition rate modification, 2kV max)	4MHz (can be damaged if operated at higher repetition rate)	2kV (can be damaged if operated at higher voltage)	7-9ns (at 2kV)

By default HVSW-04 is supplied with the following range of pulse widths available:

- Fixed pulse width mode – fixed, 15-20ns (depends on modification)
- Variable pulse width mode – adjustable, 100-2000ns (longer on request)

This means that 20-100ns range of pulse widths is unavailable in standard modifications and this is a reason why we also offer -WR (Wide Range) modifications, please see their description below:

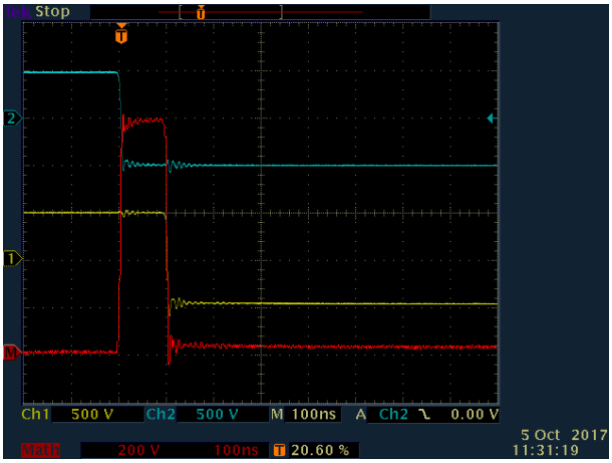
	Wide range modifications (HVSW-04-2kV-WR and HVSW-04-4kV-WR)	**Standard modifications** (HVSW-04-2kV and HVSW-04-4kV)
Advantage	Continuously adjustable pulse width in 15-2000ns range (longer on request)	Pulse amplitude at the output is exactly the same as DC input voltage
Disadvantage	Pulse amplitude at the output is slightly less than DC input voltage (10-15% difference in dependence on the load)	20-100ns range of pulse widths is unavailable
Comment	*The mentioned disadvantage of Wide range modifications isn't something vendor specific. All Pockels cell drivers allowing continuous adjustment of the pulse width from short to long have the same difference between input and output voltages. This is a physical limitation and it cannot be bypassed, although many of our competitors prefer do not mention about this effect.*	*The mentioned advantage of standard drivers by us is quite a rare feature absent in most of the 3rd party Pockels cell drivers we know. HVSW-04 of standard modifications forcibly refreshes state of the idle end of Pockels cell both in the beginning and the end of every pulse ensuring that 100% of input voltage are delivered to HVSW-04 output.*

Performance, output oscillograms

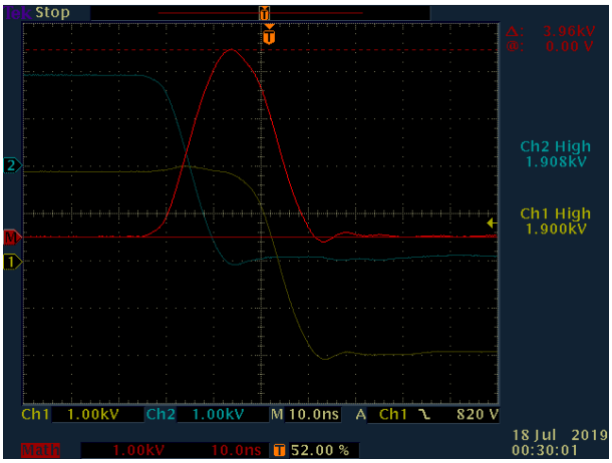
Driver's performance (i.e. the maximal possible repetition rate) depends on load capacitance, pulse amplitude and the performance of cooling system and limited with internal temperature and with the total power consumption (we do not recommend to exceed 300-400 W of power consumption).

Performance in some typical regimes is given below:

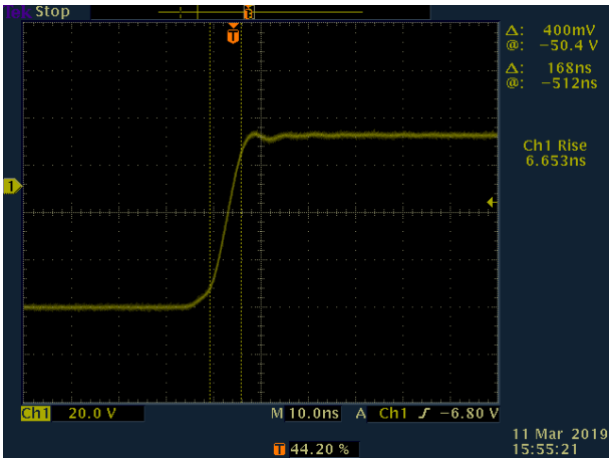
- Standard modification, ~6pF load capacitance, 4.0kV output voltage, 500kHz repetition rate, coolant temperature ~25 °C, HV power consumption ~270W, transistor temperature ~48 °C
- Standard modification, ~6pF load capacitance, 3.2kV output voltage, 1MHz repetition rate, coolant temperature ~25 °C, HV power consumption ~360W, transistor temperature ~57 °C
- High repetition rate modification, ~6pF load capacitance, 2.0kV output voltage, 2MHz repetition rate, coolant temperature ~25 °C,
  HV power consumption ~280W
- High repetition rate modification, ~6pF load capacitance, 1.8kV output voltage, 3MHz repetition rate, coolant temperature ~25 °C,
  HV power consumption ~350W
- High repetition rate modification, ~6pF load capacitance, 1.4kV output voltage, 4MHz repetition rate, coolant temperature ~25 °C,
  HV power consumption ~320W



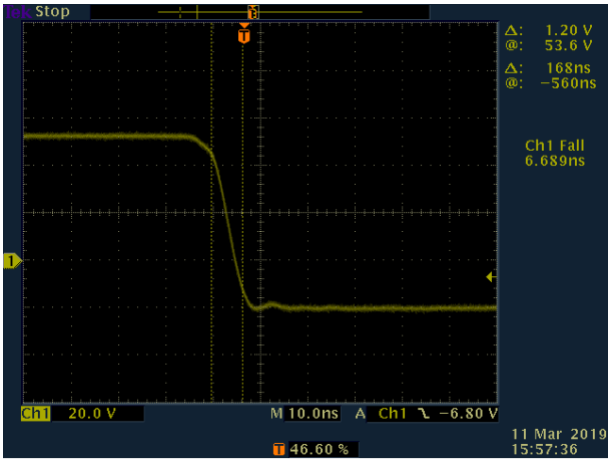
Pulse width mode - variable



Pulse width mode - fixed

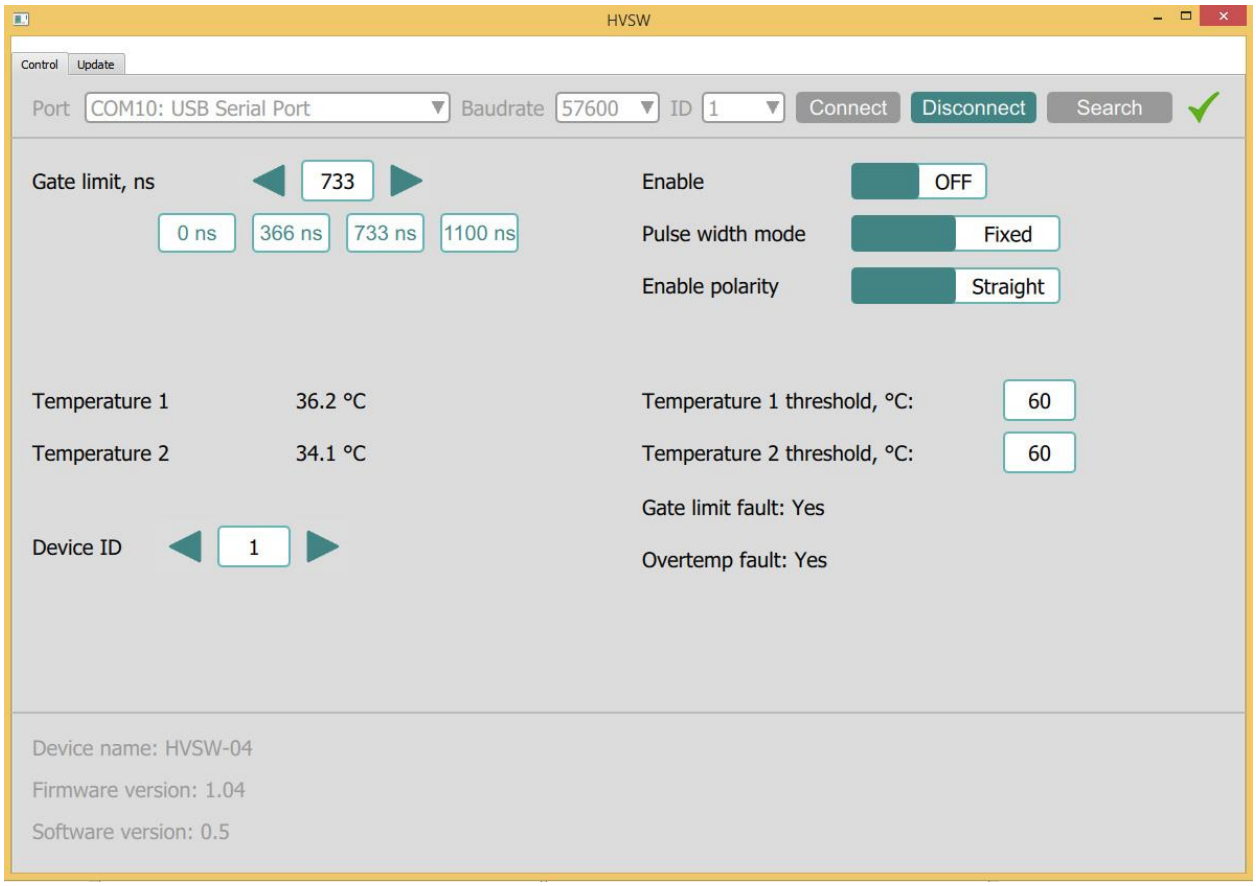


Typical output – rise, EMI



Typical output – fall, EMI

Software description



Gate limit – defines the maximal allowed pulse width (ns), 200ns to 2000ns, longer pulse causes automatic pulse interruption and Gate limit fault, **default value 2000ns**

Enable – enables/disables the pulses at the output

Enable polarity – defines the requirements to Enable signal (pin 8 of Interface connector):

- **Straight** – Enable signal should be pulled to 5V (TTL high level) to enable the output
- Inverted – Enable signal should be pulled to 0V (TTL low level) to enable the output – this might be convenient for manual control with a switch button

Pulse width mode (Fixed) – in this mode driver produces pulses of fixed pulse width (approximately 15-20ns)
Pulse width mode (**Variable**) – in this mode driver repeats incoming TTL signal (Pulse) at its output, i.e. produces pulse of variable pulse width

Device ID (**"1" by default**) – driver's ID on RS-485 bus (different ID should be assigned to different drivers if a few drivers connected to the same RS-485 bus)

Temperature 1 and Temperature 2 – internal temperatures measured in two different points of HVSW-04

Temperature 1 threshold and Temperature 2 threshold – maximal allowed temperature, Overtemp fault occurs if the temperature is exceeded, **default value 50 °C**

Appendix A. RS-485 communicative protocol

[please contact us for the actual version of the protocol]