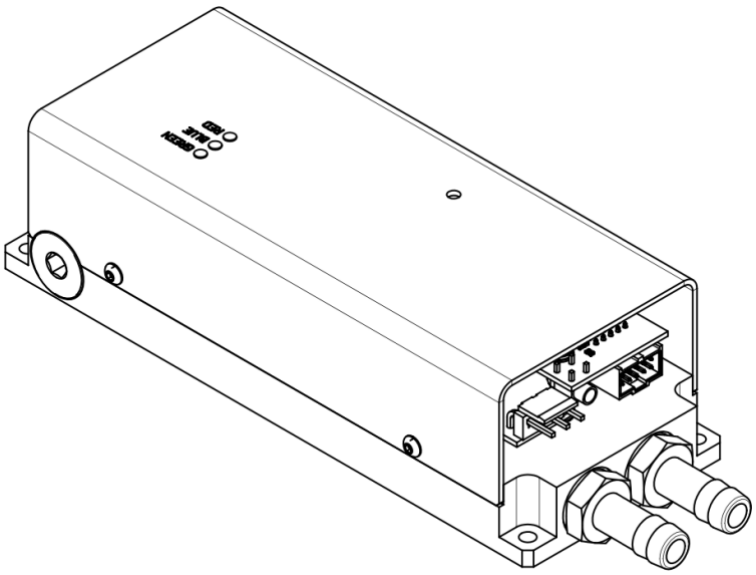
HVSW-04
high voltage high repetition rate
Pockels cell driver

User manual



Warning! This equipment may be dangerous.
Please read the entire user manual carefully before using the product.

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.





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Overview / 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.

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

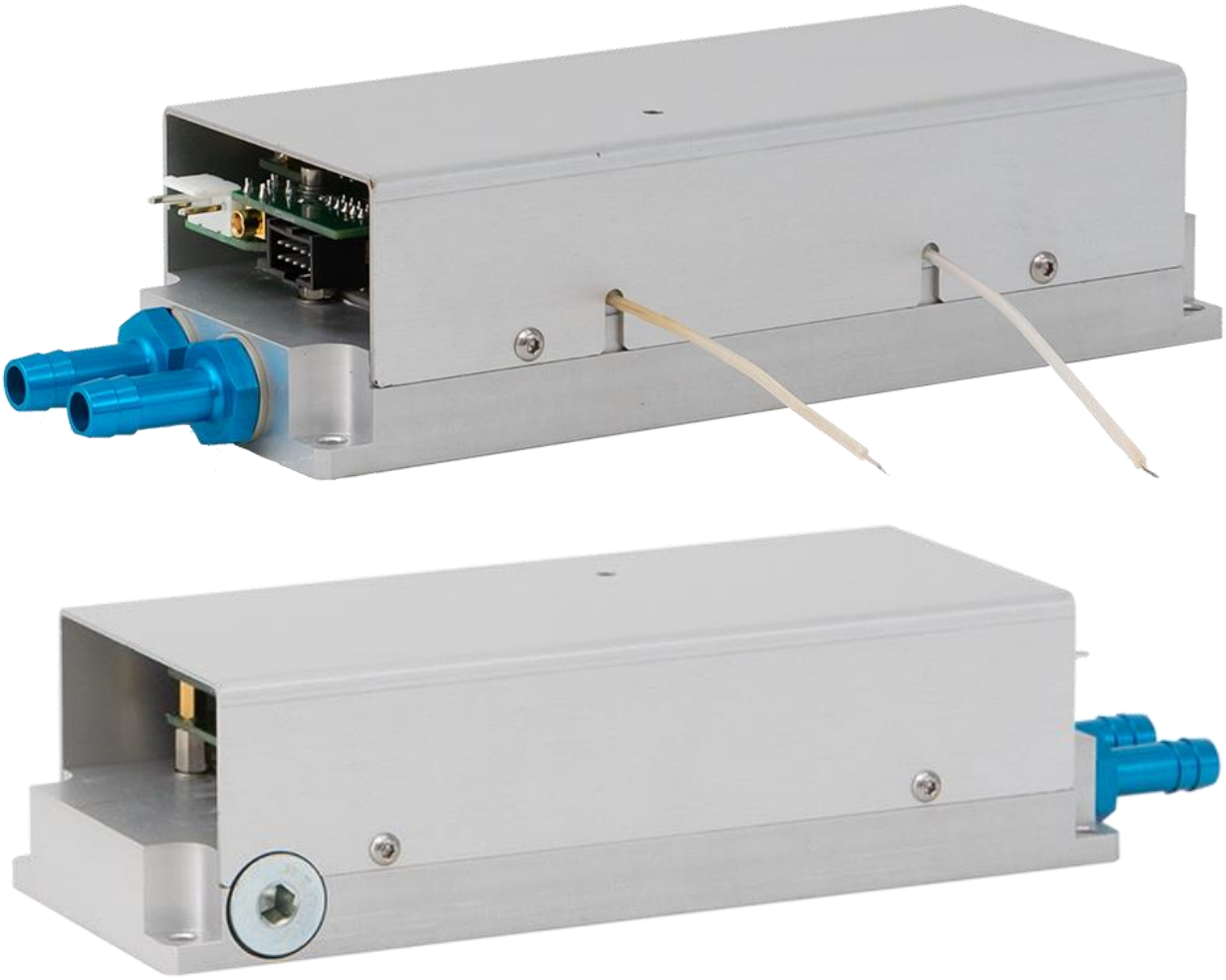
- 4.0kV, 500kHz, <300W power consumption
- 3.2kV, 1MHz, <400W power consumption
- 2.0kV, 2MHz, <300W power consumption
- 1.6kV, 3MHz, <300W power consumption
- 1.4kV, 4MHz, <350W power consumption

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 bipolar. LV power is 24VDC, <3A.

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

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



Contents of delivery

By default, the package contains:

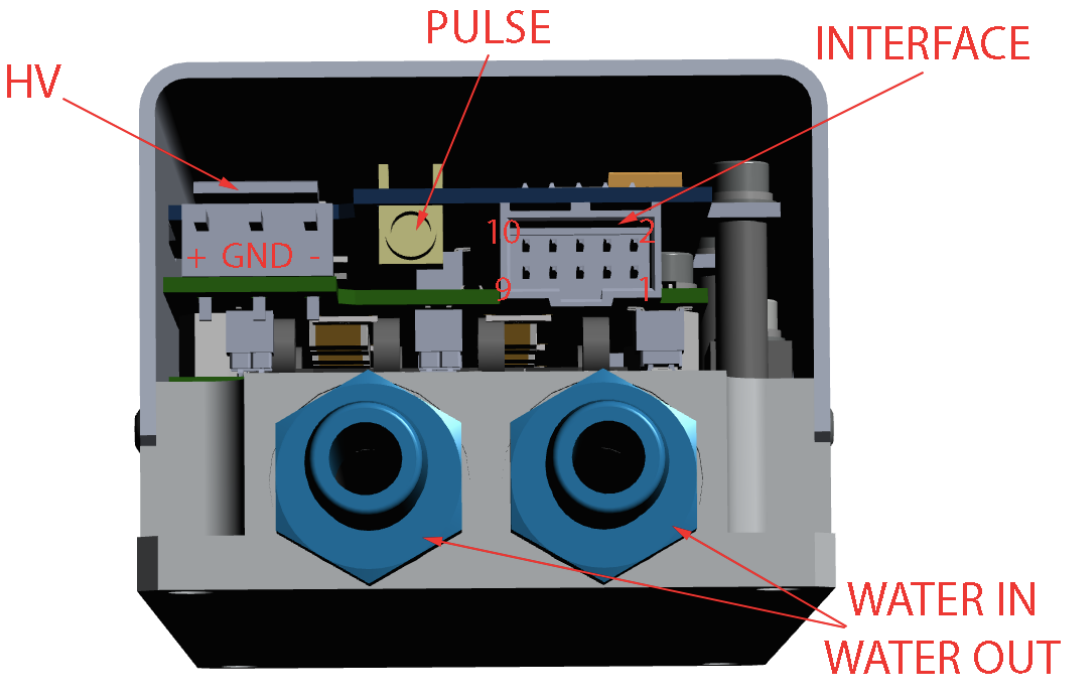
- HVSW-04 Pockels cell driver – 1pc
- Mating INTERFACE cable (0.5m length) – 1pc
- Mating PULSE cable (0.5m length, BNC connector at the other end) – 1pc
- Mating PULSE cable (0.5m length, MCX connector at the other end) – 1pc
- Mating HV INPUT cable – not supplied, comes with HVPS-BT-300 or HVPS-300 (see below)
- USB/RS-485 adapter – 1pc
- USB Flash stick with software – 1pc

Customizations are possible on request.

Please note, HVSW-04 is not a stand-alone device and for proper operations requires a bipolar HV DC power supply. We recommend using HVPS-BT-300 (bench-top) or HVPS-300 (embedded) power supplies by us.

	
HVPS-BT-300 power supply	*HVPS-300 power supply*

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 – 3A 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 is 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 «+» is 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 «–» is 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).

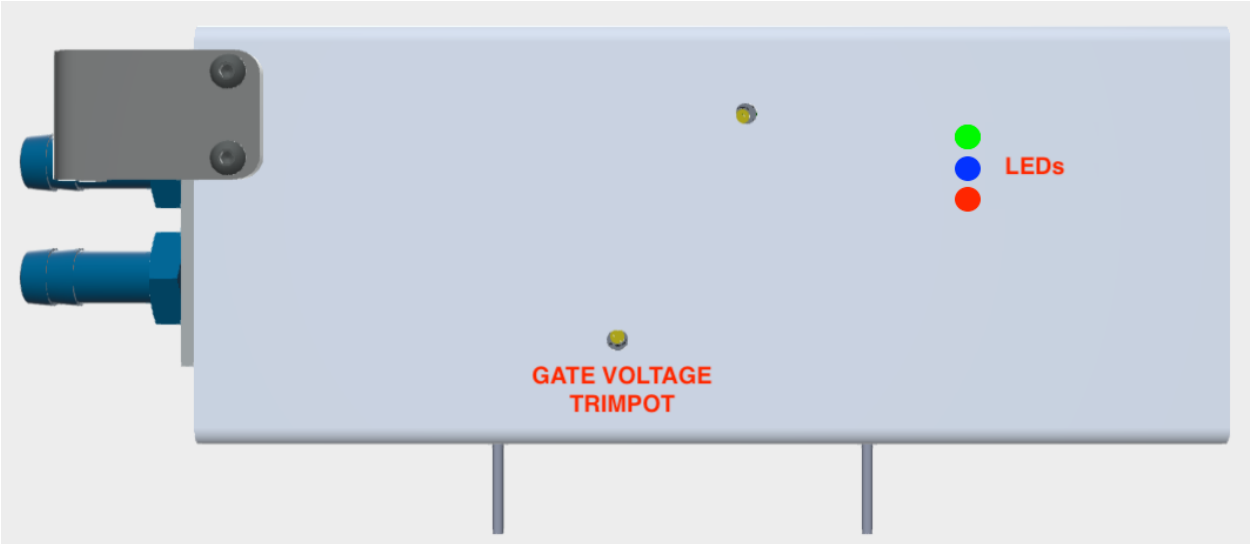
PULSE (Linx Technologies CONMCX002**):**

PIN (color)	DESIGNATION	DESCRIPTION
1 (black)	**Pulse**	**In a 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 a Variable pulse width mode (see also *Software description* section):** Driver's output repeats TTL signal applied to this pin. Minimum pulse width is 100ns, maximum pulse width is 2000ns or Gate limit (what's less). Minimum interpulse interval is usually ~60ns. **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 100mm 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 lights 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 lights steadily when HV output is enabled.

FAULT (red):

- LED blinks slowly when Gate limit fault occurred.
- LED lights steadily when Overtemp fault occurred.
- In bootloader (update) mode this LED blinks twice regularly.

GATE VOLTAGE TRIMPOT:

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

The default position is "soft".
A clockwise rotation changes smoothly the regime from "soft" to "harsh".

MOUNTING AND GROUNDING:

Driver should be mounted with 4pcs of 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.

Cooling

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

Safety

Warning! This equipment produces high voltages that can be very dangerous.
Be careful in a high-voltage appliances area

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 the residual voltage at the 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.

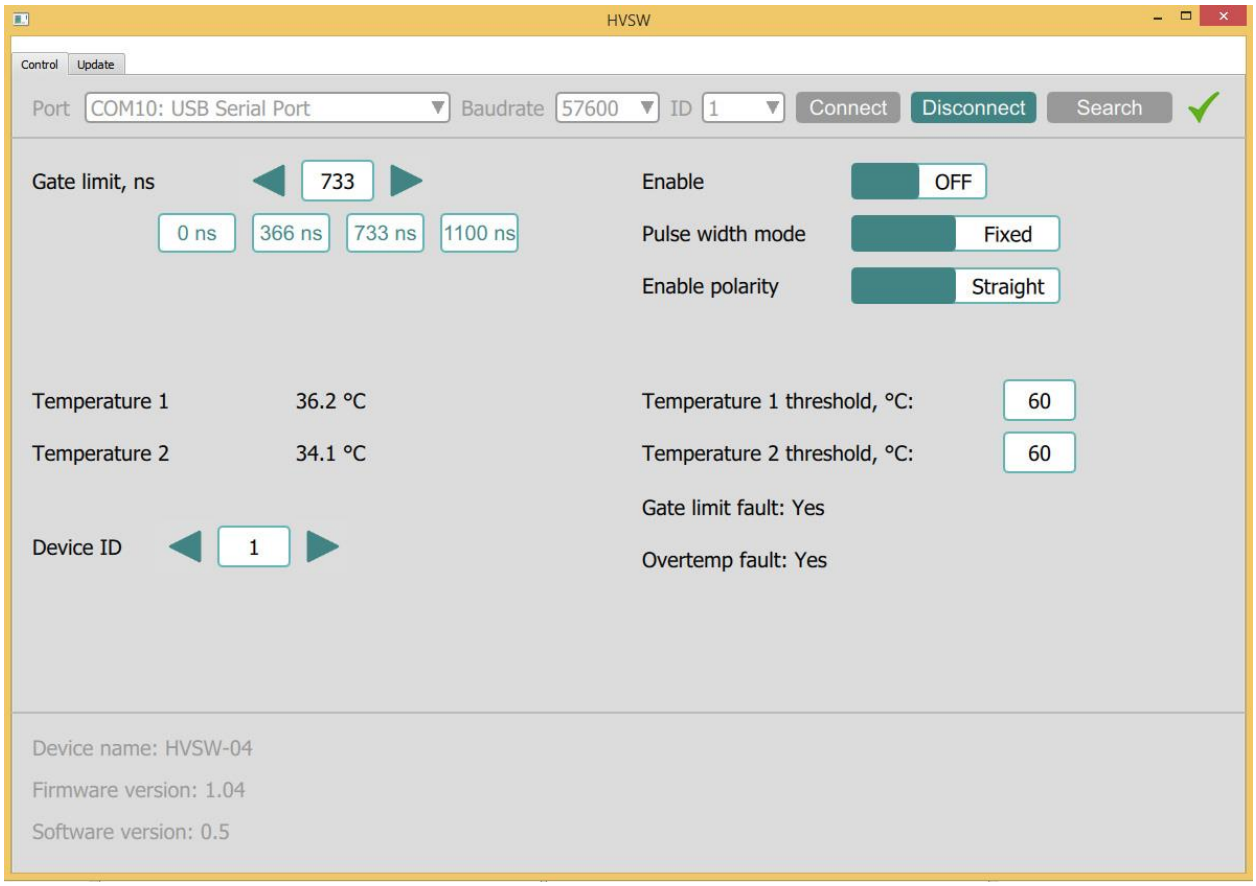
RS-485 interface description

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.

Software description



Gate limit – defines the maximum 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 – maximum allowed temperature, Overtemp fault occurs if the temperature is exceeded, **default value 65 °C**

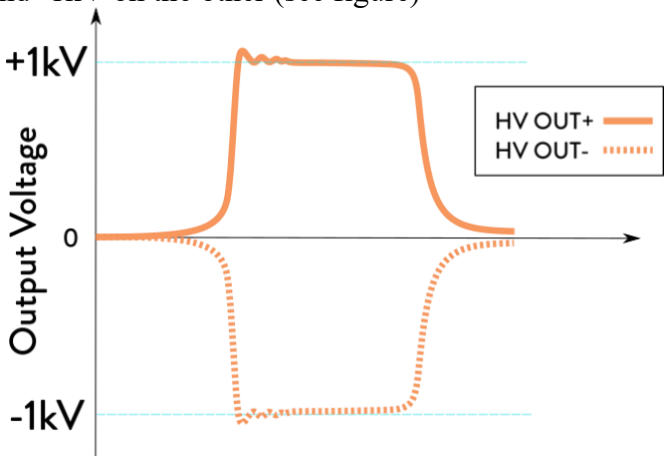
Technical notes

- **The performance of the module greatly depends on the 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. Maximum 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 producing +1kV on one output wire and -1kV on the other (see figure)

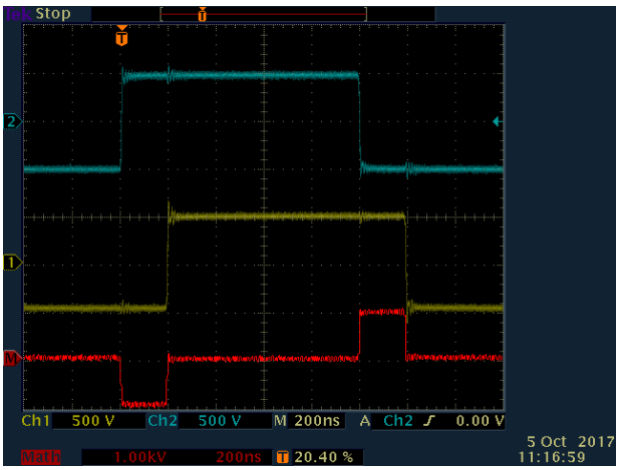


  Nevertheless, all descriptions of HV output are given in terms of voltage differences. Please keep this in mind!

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

- **Sequential output pulses have alternating polarity by default.**
  Since the driver is built on full bridge schema, each of two output wires varies its potential between +V and –V values. As a result, the voltage difference between two wires can be both positive and negative.

  By default we supply HVSW-04 drivers in modification, where sequential output pulses have alternating polarity (see the picture below for the details).



Blue curve – Output wire #1 potential relatively to the ground
Yellow curve – Output wire #2 potential relatively to the ground
Red curve – Voltage difference (wire #2 minus wire #1)

Version with fixed polarity of sequential pulses is available as an option. See also *How to order?* section for the details.

- **Pulse width adjustment range.**
  The standard version of the driver can operate in two regimes:
  - Fixed pulse width mode where the output pulse width is ~15ns, and
  - Variable pulse width mode where the output pulse width is adjustable in the range 100-2000ns.
  In other words, the standard version of the driver cannot produce pulses in the 15-100ns range.

  For customer who needs continuous adjustment of the pulse width we offer WR (wide range) modification of the driver with continuous 15-2000ns adjustment of the pulse width. Advantages and disadvantages of this version are described in the table below:

	Wide range version	**Standard version**
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*	*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*

	bypassed, although many of our competitors prefer do not mention about this effect.	*that 100% of input voltage are delivered to HVSW-04 output.*

- **Arbitrary (random) signal applied to Pulse pin may damage the driver.**
  Please ensure that Pulse signal follows the next rules:
  - Minimum allowed pulse width is 15ns
  - Maximum allowed pulse width is 2000ns
  - Minimum allowed distance between pulses is 100ns
  - Maximum allowed distance between pulses – no limitation
  - Maximum allowed repetition rate is 4MHz

  Not every point above has the corresponding hardware protection. Please ensure the applied signals are within the allowed ranges.

Specifications

ELECTRICAL SPECIFICATION

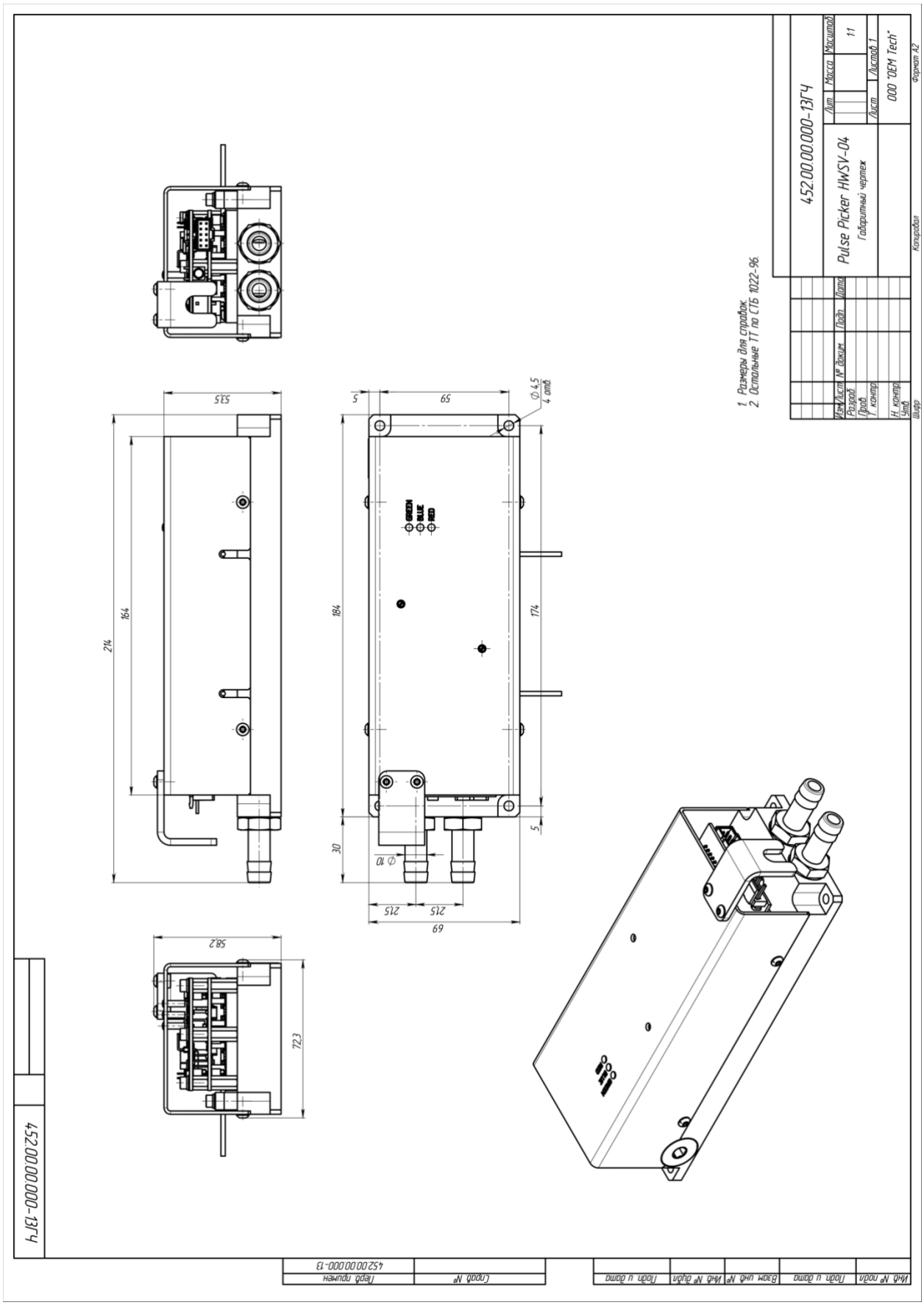
LV input	+24V DC; 3A max
HV input	+HV/2 to one wire; -HV/2 to the other
Output	Pulses of high voltage and high repetition rate delivered to the capacitive load (e.g. to the Pockels cell)
Output type	Bipolar (see also *Technical notes* section)
Pulse basement [1]	0V, fixed
Pulse amplitude [1, 2]	0-4kV (the same as voltage applied to HV Input)
Maximum repetition rate [2]	Up to 4MHz (see also *Performance* section)
Minimum 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
Minimum interpulse interval	<100ns in standard versions (~60ns typically) <200ns in FX version (see also *How to order?* section)
Rise time / fall time [3]	From 5-7ns at small output voltages (1kV) to 9-11ns at the maximum 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 - 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] Maximum 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

MECHANICAL SPECIFICATION

Size (LxWxH)	176x69x50mm (without inputs and outputs)
Weight	<1.5kg

Dimensions



452.00.00.000-13ГЧ
Pulse Picker HWSV-04
Габаритный чертеж
ООО "OEM Tech"
1. Размеры для справок.
2. Остальные ТТ по СТБ 1022-96.
GREEN
BLUE
RED

How to order?

HVSW-04-XXX-[WR]-[FX], where:

- XXX means voltage modification, might be either 4kV (most standard version) or 2kV (high repetition rate version)
- WR means wide (15-2000ns) pulse width adjustment range (option, please see pages 11-13 for the details)
- FX means version of the device with fixed polarity of the output pulses (option, please see pages 11-13 for the details)

Difference between 2kV and 4kV modifications:

Modification	Maximum repetition rate	Maximum voltage	Rise time / fall time
HVSW-04-4kV-[WR]-[FX] (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-[WR]-[FX] (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)

Examples:

Modification	Description
HVSW-04-4kV	Base version (4kV): - Maximum output voltage – 4kV - Maximum repetition rate – 1MHz - Rise time / fall time – 9-11ns - Short pulse (15ns fixed) and long pulse (100-2000ns adjustable) regimes - Polarity of sequential pulses – alternating
HVSW-04-4kV-FX	Version with fixed polarity of the output pulses: - Maximum output voltage – 4kV - Maximum repetition rate – 1MHz - Rise time / fall time – 9-11ns - Short pulse (15ns fixed) and long pulse (100-2000ns adjustable) regimes - Polarity of sequential pulses – the same
HVSW-04-2kV-WR	High repetition rate version with wide pulse width adjustment range: - Maximum output voltage – 2kV - Maximum repetition rate – 4MHz - Rise time / fall time – 7-9ns - Long pulse regime only (15-2000ns adjustable) - Polarity of sequential pulses – alternating

Output voltage measurements

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. Maximum 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 rise time and fall time comparing to the "true" rise and fall times 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 maximum 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:

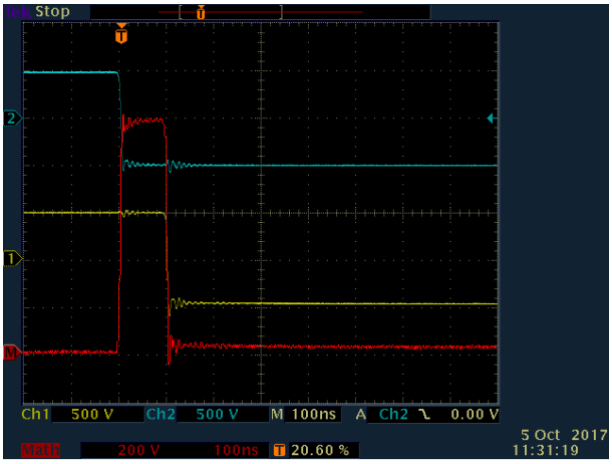


Performance, output oscillograms

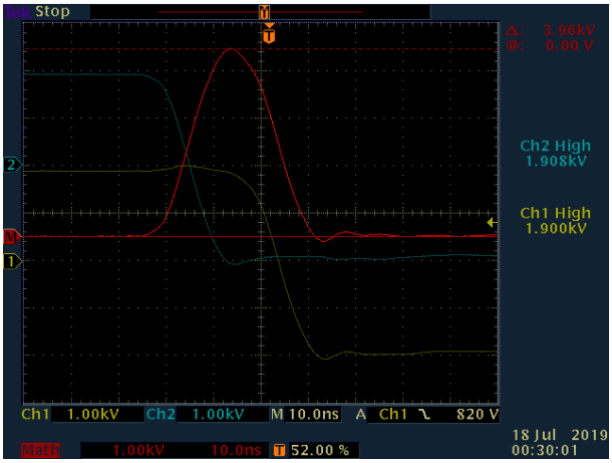
Driver's performance (i.e. the maximum possible repetition rate) depends on load capacitance, pulse amplitude and the performance of cooling system and limited with internal temperature and with the total power consumption (we do not recommend to exceed 300-400 W of power consumption).

Performance in some typical regimes is given below:

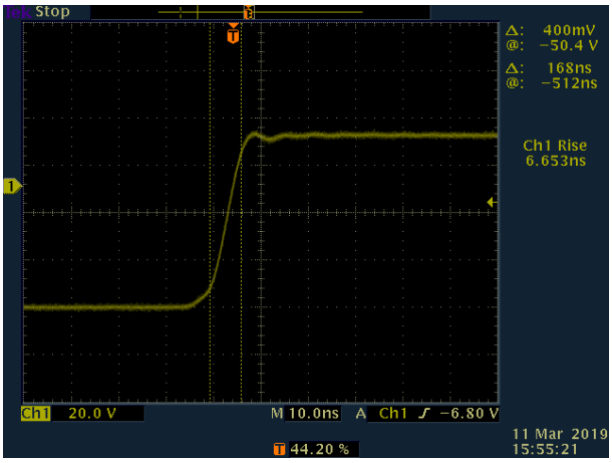
- 4kV modification, ~6pF load capacitance, 4.0kV output voltage, 500kHz repetition rate, coolant temperature ~25 °C, HV power consumption ~270W, transistor temperature ~48 °C
- 4kV modification, ~6pF load capacitance, 3.2kV output voltage, 1MHz repetition rate, coolant temperature ~25 °C, HV power consumption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



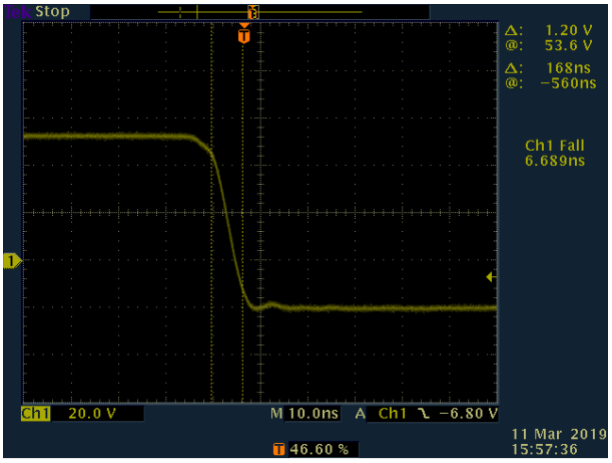
Pulse width mode - variable



Pulse width mode - fixed



Typical output – rise, EMI



Typical output – fall, EMI

Appendix A. RS-485 communicative protocol

The present section describes RS-485, binary, master-slave protocol. Only one active master (at the same time) can be connected to the bus, and one or several (up to 254) slave nodes can be connected to the same bus. HVSW-04 is a slave device and responds to the transactions initiated by the master. Each slave device has an unique address between 1 and 254 decimal and also recognizes the broadcast address 0. Available bus baudrates for device are: 4800, 9600, 19200, 38400, 57600 (default), 115200. Available baudrate for bootloader: 57600.

Data packet format from the master:

Byte	Description
0	Synchronization/flags. 1 byte in format: 1 0 1 0 S W R M *M: Master bit (1 – packet is sent by the master, 0 – by slave)* *R: Retransmit bit (1 – Retransmitted packet, 0 – Normal packet)* *W: Write bit (1 – request sends data, 0 – request asks data)* *S: Sequel bit (0 – last/only packet, 1 – indicates that a further packet(s) are to be expected*
1	Length of the data field. *1 byte (0 - no data; 1… 255 – data length)*
2	Device ID. 1 byte *(1..254, 0 indicates broadcast transmission)*
3	Parameter (or Function) 0x00 … 0x3F: common parameters 0x40 … 0xFF: device specific parameters
4	Data field (optional). *0..255 bytes, least significant byte first. Transmitting more than 255 bytes is possible by splitting up the data field in a sequence of packet transmissions by the use of the S Bit of the synchronization and flags byte.*
4+Length	CRC8 ITU-T (polynomial x^8+x^2+x+1 / 0x07) over all bytes

A slave uses the frame format described below with the same synchronization and flag byte as the master.

Byte	Description
0	Synchronization/flags: 1 0 1 0 S W R M (see flags description in master section)
1	Length of the data field. 1 byte (0 - no data; 1… 255 – data length)
2	Result, 1 byte: 0x00 ≡ no error 0x01 … 0x7F ≡ common errors 0x80 … 0xFF ≡ device specific errors Common errors: 0x01 *Parameter/Function not available* 0x02 *Parameter is read only* 0x03 *Request packet has an invalid amount of data* 0x04 *Value transmitted in the request packet is out of range* 0x05 *Current request cannot be processed at the moment*
3	Data field (optional*). 0..255 bytes, least significant byte first*
3+Length	CRC8 ITU-T (polynomial x^8+x^2+x+1 / 0x07) over all bytes

A slave responds message in less than 50ms after receiving a fully initiating a transaction from a master. Master must generate a time out at least 100ms after finishing a transaction.

Common parameters / functions

0x00: **Ping** (read only), data length: 0 byte. A slave answers by sending a packet with no data.
0x01: **Device ID** (write only), data length: 1 byte, range: 1..254, default value: 1. Function sets the new device ID, which is used immediately after this write request.
0x02: **Protocol version** (read only), data length: 1 byte, range: 1..254. A slave returns value 1.
0x03: **Device part number** (read/write), data length: 2 bytes, range: 0..65535. Function sets/returns device part number.
0x04: **Device serial number** (read/write), data length: 2 bytes, range: 0..65535. Function sets/returns device serial number.
0x05: **Hardware version** (read/write), data length: 2 bytes, range: 0..65535. Function sets/returns device hardware version.
0x06: **Software version** (read only), data length: 2 bytes, range: 0..65535. Function returns device software version.
0x07: **Device string** (read only), data length: arbitrary, ASCII string. Function returns device name or description.
0x08: **Bootloader control and status** (read or write), data length: 1 byte, data format: bit field. Function controls the bootloader using the following format:

Write request:
Bit 0: *Activate bootloader*
Bit 1: *Clear memory*
Bit 2: *Boot application*

Read request:
Bit 0: *Bootloader running (1 – yes, 0 – no)*
Bit 1: *Memory cleared (1 – yes, 0 – no)*
Bit 2: *Valid application in memory (1 – yes, 0 – no)*

0x09: **Bootloader Stream** (write only), data length: N packets of 1..255 bytes.
0x0A: **Device status** (read only), data length: 2 bytes, data format: bit field. Function returns device status in the following format:

Bit 0: *At least one warning is present*
Bit 1: *At least one error is present*
Bit 3: *Bootloader is active*
Bit 4: *Device is ready*
Bit 7: *Device is "On"*

0x0B: **Available bus speed** (read only), data length: 2 bytes, data format: bit field. Indicates availability of device specific bus speed implementations (in Bit/s)

Bit 0: 4.800
Bit 1: 9.600
Bit 2: 19.200
Bit 3: 38.400
Bit 4: 57.600
Bit 5: 115.200
Bits 6..15: reserved

0x0C: **Set bus speed** (write only), data length: 2 bytes, data format: bit field. Function sets bus speed.

Bit 0: 4.800
Bit 1: 9.600
Bit 2: 19.200
Bit 3: 38.400
Bit 4: **57.600 (Default Setting)**
Bit 5: 115.200
Bits 6..15: reserved

0x0D: **Bus mute** (read/write), data length: 1 byte, data range: 0-1 (0 = communication is on, 1 = communication is off). Switches off the serial communication of a device until it is switched on again using this parameter. After power on (supply voltage) device has its serial communication switched ON.

Device specific parameters / functions

0x41: Gate Limit (read/write), data length: 2 bytes, range: 0..1100. Sets or gets gate limit in nanoseconds.

0xA1: Gate Limit Code (read/write), data length: 2 bytes, range: 0..4095. Sets or gets DAC code for gate limit. Correspondence between gate limit code and gate limit value sets by means of gate limit calibration.

0x42: Transistors temperature threshold (read/write), data length: 2 bytes, range: 100..600. Sets or gets transistors temperature threshold in 0.1 °C (e.g. 600 corresponds to 60.0 °C)

0x43: Case temperature threshold (read/write), data length: 2 bytes, range: 100..600. Sets or gets case temperature threshold in 0.1 °C (e.g. 600 corresponds to 60.0 °C)

0x44: HV enable (read/write), data length: 1 byte, range: 0 .. 1. Enables (1) or disables (0) high voltage.

0x45: Pulse width mode (read/write), data length: 1 byte, range: 0..1. Sets or gets pulse width mode (0 – fixed, 1 – variable).

0xA4: Enable polarity (read/write), data length: 1 byte, range: 0 .. 1. Sets straight (1) or inverted (0) polarity for external enable signal.

0x60: Get sensors (read only), data length: 1 byte, range: 0..255. Returns device sensors in the following format: *bit 0*: gate limit error; *bit 1*: overtemperature error; *bit 2*: external enable; *bit 3*: device enable state

0x61: Get transistors temperature (read only), data length: 2 bytes, range: 0..1600. Returns current transistors temperature in 0.1 °C (e.g. 800 corresponds to 80.0 °C).

0x62: Get case temperature (read only), data length: 2 bytes, range: 0..1600. Returns current case temperature in 0.1 °C (e.g. 800 corresponds to 80.0 °C).

0xF2: Get all monitors (read only), data length: 5 bytes. Returns all monitors in the following format: sensors (1 byte), transistors temperature (2 bytes), case temperature (2 bytes).

0xF1: Get all parameters (read only), data length: 13 bytes. Returns all parameters in the following format: gate limit (2 bytes), transistors temperature threshold (2 bytes), case temperature threshold (2 bytes), sensors (1 byte), transistors temperature (2 bytes), case temperature (2 bytes), reserved (2 bytes)

0xF0: Calibrate gate limit – Establishes correspondence between gate limit code and gate limit value.

Data format for calibration command:

byte 0 – calibration variable (always 0)

byte 1 – calibration command *(GET POINT NUMBER: 0x00, ADD POINT: 0x01, DELETE POINT: 0x02, GET POINT: 0x03, SET POINT 0x04, TEST POINT: 0x05, CLEAR CALIBRATION: 0x06)*

byte 2 (optional): point number
bytes 3-4 (optional, least significant byte first): calibration code
bytes 5-6 (optional, least significant byte first): calibration value

GET POINT NUMBER command: returns number of calibration points (1 byte)

ADD POINT command: adds calibration point.

DELETE POINT command: removes calibration point.

SETS POINT command: sets calibration point (replaces existing one)

GET POINT: returns calibration point in format (2 bytes: code, 2 bytes: value, least significant byte first)

CLEAR CALIBRATION: removes all calibration points

TEST POINT: tests calibration point, transforms from code to temperature. Takes code as bytes 3-4 and returns 2 bytes of value