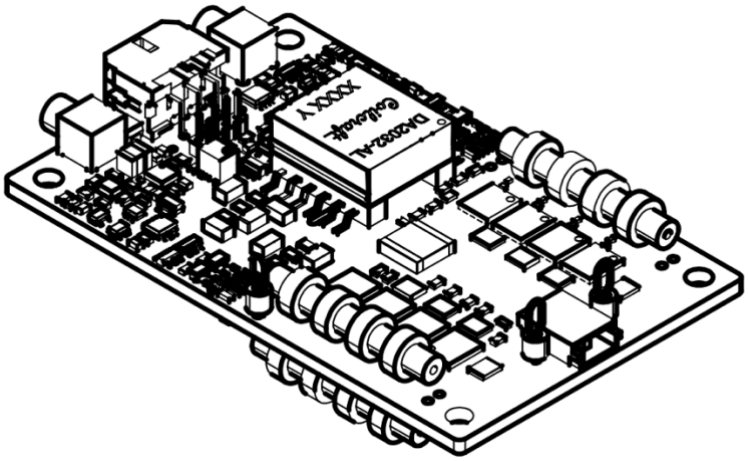
QBY-series Pockels cell drivers

User manual



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

Important note: please 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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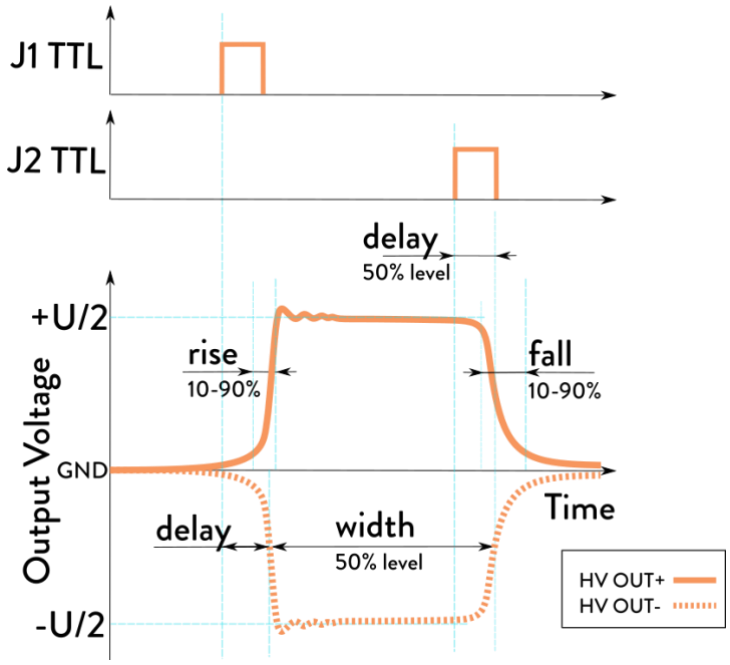
Overview / Appearance

QBY is a novel Pockels cell driver based on GaN transistors and producing high voltage pulses with high repetition rates, fast rise and fall times and adjustable pulse width and pulse amplitude.

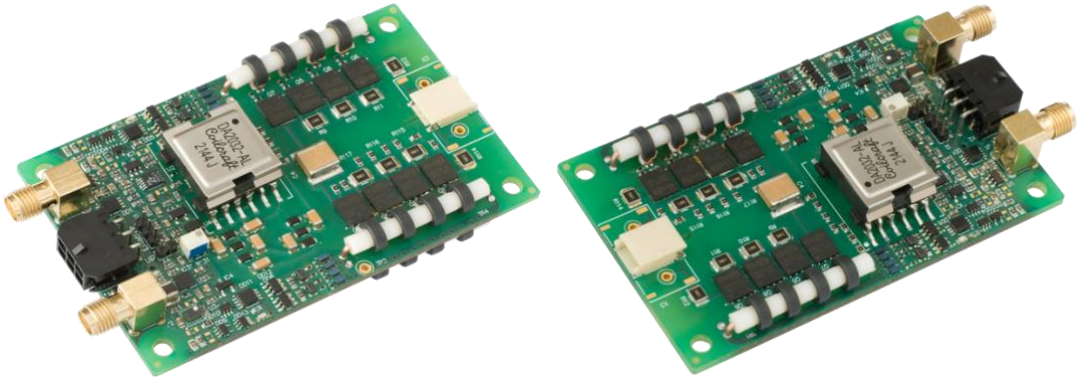
Main parameters are as below:

- Input – 24VDC
- Output – bipolar pulses of high voltage
- Pulse amplitude – adjustable up to 4000V (other on request)
- Pulse width – adjustable from 10ns to 1000ns (other on request)
- Rise and fall times – 3-4ns (also depend on load capacitance and pulse amplitude)
- Maximum repetition rate – up to 1kHz @ 4kV with convective cooling and up to 10kHz @ 4kV with conductive or forced-air cooling (and much higher at smaller voltages)



At the moment the QBY-series currently includes four models: the QBY-4001 base model; the QBY-4010-C, which dissipates heat through a heat-dissipation case with thermal bridges to the customer's heatsink; the QBY-4010-P, an enhanced model with integrated heatsinks; and the QBY-4010-A, an enhanced model with forced-air cooling, which made it possible to increase the maximum repetition rate up to 10kHz @ 4kV and up to 100kHz at smaller voltages.

QBY-4001 (bare PCB)



QBY-4010-C (conductive cooling through the bottom to a customer's heatsink)



QBY-4010-A (forced-air cooling)



QBY-4010-P (passive/convective cooling)



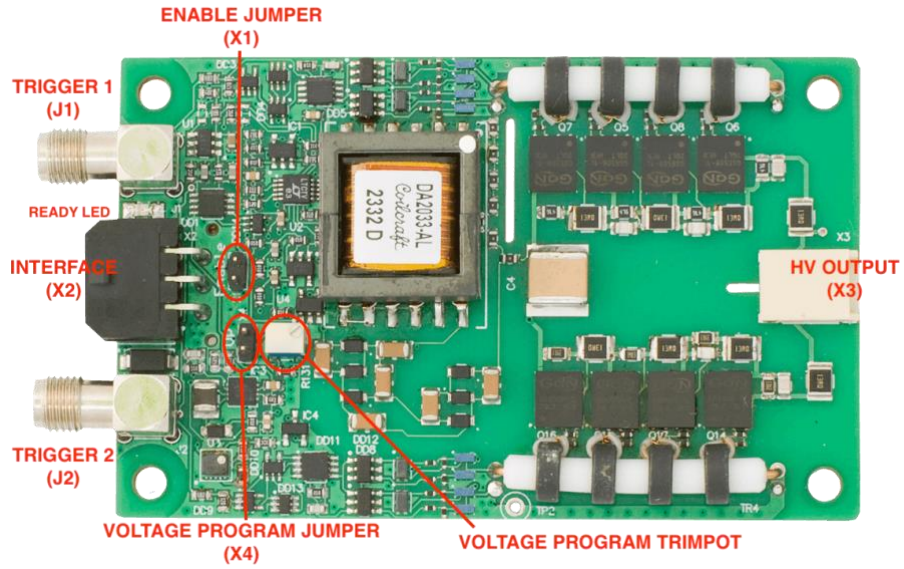
Contents of delivery

By default, the following items are supplied as standard:

- QBY driver – 1pc
- Mating INTERFACE cable (30cm length) – 1pc
- Mating HV OUTPUT cable (15cm length) – 1pc

SMA cables are considered as standard items and not included in supply.

Connections, signals, signal descriptions



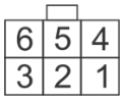
TRIGGER 1 (J1) and TRIGGER 2 (J2):
SMA (TE connectivity 5-1814400-2)

Trigger pulse inputs – 5 V TTL; input impedance 50 Ω; rising edge is active; fast transition (<2ns) is highly recommended; due to EMI immunity considerations, the recommended pulse width is 15-20ns.

TRIGGER 1 rising edge determines the beginning of HV pulse at driver's output. TRIGGER 2 rising edge determines the end of HV pulse at driver's output.

Important note! TRIGGER 2 pulse must be applied at least 10ns later than TRIGGER 1 pulse. Simultaneous applying of TRIGGER 1 and TRIGGER 2 can lead to driver's failure.

INTERFACE (X2): Molex Micro-Fit (43045-0602)



PIN (color)	DESIGNATION	DESCRIPTION
1 (red)	+24VDC	+24VDC power supply is to be connected here. Power consumption 0.5A max.
2 (blue)	24VDC RETURN	
3 (black)	GND	Common ground of interface signals (Enable, Ready, Voltage Program).

<table>
<tr><td></td><td></td><td>Pin 3 is galvanically connected to Pin 2 (via inductor).</td></tr>
<tr><td>4 (green)</td><td>Voltage Program</td><td>Analog signal 0-3V determining the amplitude of high voltage pulses at driver’s output.
Calibration table is given below:<table><tr><th>U_{IN}, VDC</th><th>U_{OUT}, kV_{PEAK}</th></tr><tr><td>< 1.77</td><td>0.00</td></tr><tr><td>1.80</td><td>0.08</td></tr><tr><td>1.83</td><td>0.19</td></tr><tr><td>1.90</td><td>0.40</td></tr><tr><td>2.02</td><td>0.80</td></tr><tr><td>2.21</td><td>1.40</td></tr><tr><td>2.39</td><td>2.00</td></tr><tr><td>2.57</td><td>2.61</td></tr><tr><td>2.69</td><td>3.00</td></tr><tr><td>2.88</td><td>3.60</td></tr><tr><td>3.00</td><td>4.02</td></tr></table></td></tr>
<tr><td>5 (yellow)</td><td>Enable</td><td>Switches driver’s output on and off.
5V TTL, 10 kOhm input impedance.</td></tr>
<tr><td>6 (orange)</td><td>Ready</td><td>5V TTL output signal returning driver’s ready status (driver is enabled, there is no internal fault or overheating and driver is ready to work).</td></tr>
</table>

HV OUTPUT (X3): JST SM02B-BHSS-1-TB

PIN (color)	DESIGNATION	DESCRIPTION
1 (red)	**HV OUTPUT POSITIVE**	High voltage output of the driver. HV OUTPUT POSITIVE varies from 0V to +2kV relative to the ground. HV OUTPUT NEGATIVE varies from 0V to -2kV relative to the ground. Voltage difference between HV OUTPUT POSITIVE and HV OUTPUT NEGATIVE varies from 0V to 4kV relative to the ground.
2 (red)	**HV OUTPUT NEGATIVE**	

Mating part (JST BHSR-02VS-1) is supplied together with the driver.

Jumpers and LEDs

In stand-alone mode driver can be controlled manually without applying most of interface signals from the controlling device.

ENABLE JUMPER (X1)	**ON**	Driver is enabled.

	OFF	Driver will be enabled only when Enable signal is applied to Pin 5 of INTERFACE connector.
VOLTAGE PROGRAM JUMPER (X4)	**ON**	Output voltage is determined by the state of VOLTAGE PROGRAM TRIMPOT (R131 on PCB).
	OFF	Output voltage is determined by Voltage Program signal applied to Pin 4 of INTERFACE connector.
VOLTAGE PROGRAM TRIMPOT (R131)	**-**	Determines the driver's output voltage when VOLTAGE PROGRAM JUMPER (X4) is on. Clockwise rotation increases the output voltage.

There is an ENABLE LED onboard indication the driver is enabled and ready to deliver HV pulses to the output.

Grounding and mounting

Grounding
All the driver's circuits (HV OUTPUT central point, 24VDC negative, INTEFACE common ground and trigger pulse returns) are galvanically interconnected to each other, although some via inductors.

Driver is to be mounted with M3 screws.

Operations (in stand-alone mode)

1. Connect 24VDC power supply, pulse generator and Pockels cell to the driver
2. Ensure that power is off, and driver is disabled (i.e. ENABLE JUMPER X1 is removed)
3. Switch on 24VDC power supply
4. Set VOLTAGE PROGRAM JUMPER (X4) on, then set VOLTAGE PROGRAM TRIMPOT accordingly to the desired output voltage (minimum, maximum, other)
5. Switch on pulse generator and apply pulses to TRIGGER 1 and TRIGGER 2. Keep minimum distance between trigger pulses (10ns).
6. Short Pins 2 and 3 of ENABLE JUMPER (X1) to enable the driver

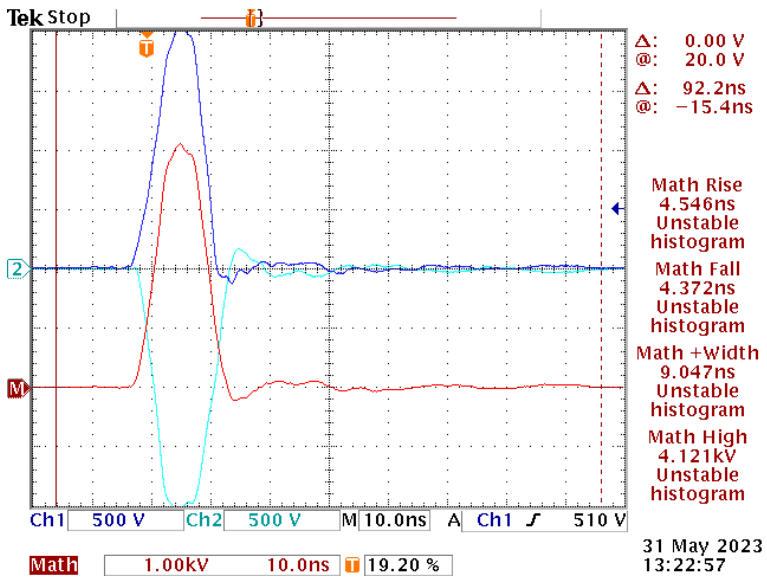
Note: Some low-quality pulse generators may produce unstable waveforms during startup. An oscillating input signal applied to J1 and/or J2 may potentially damage the QBY driver. Therefore, we recommend enabling the QBY driver only after the trigger pulses have been applied and stabilized.

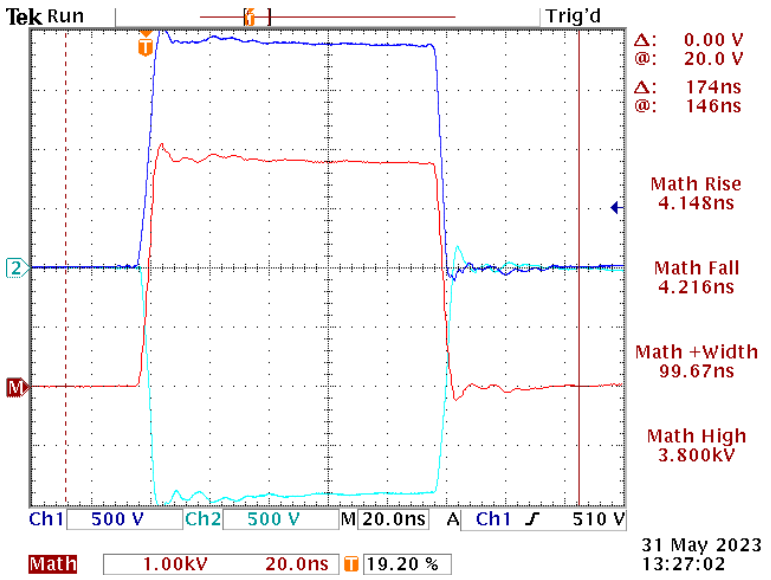
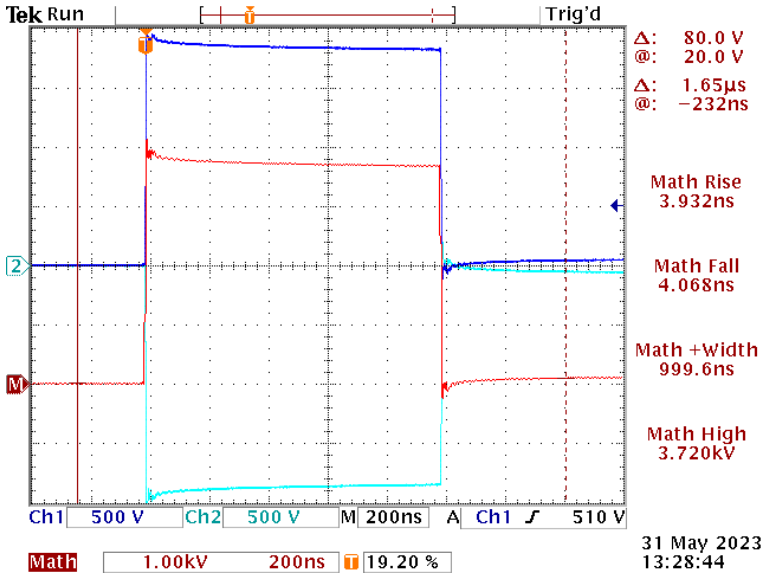
Output oscillograms

Polarity of the output

Please note, driver's output is bipolar. HV OUTPUT positive has positive voltage potential relative to the ground (from 0V to +2kV), HV OUTPUT negative has negative voltage potential relative to the ground (from 0V to -2kV), their difference varies from 0V to 4kV.

Examples of waveforms:

4kV, 10ns pulse	

4kV, 100ns pulse	
4kV, 1000ns pulse	

Performance

Table below contains maximum repetition rate in dependence on output voltage and cooling conditions. Other setup parameters – total load capacitance 5pF, ambient temperature 25°C:

	4.0kV	3.0kV	2.0kV	1.5kV	1.0kV	<0.7kV
QBY-4001	1kHz	5kHz	15kHz	25kHz	40kHz	50kHz
QBY-4010-C	10kHz	15kHz	30kHz	40kHz	80kHz	100kHz
QBY-4010-A	10kHz	15kHz	30kHz	40kHz	80kHz	100kHz
QBY-4010-P	10kHz	15kHz	30kHz	40kHz	80kHz	100kHz

Higher load capacitance and higher ambient temperature result in derated performance.

Specifications

ELECTRICAL SPECIFICATION

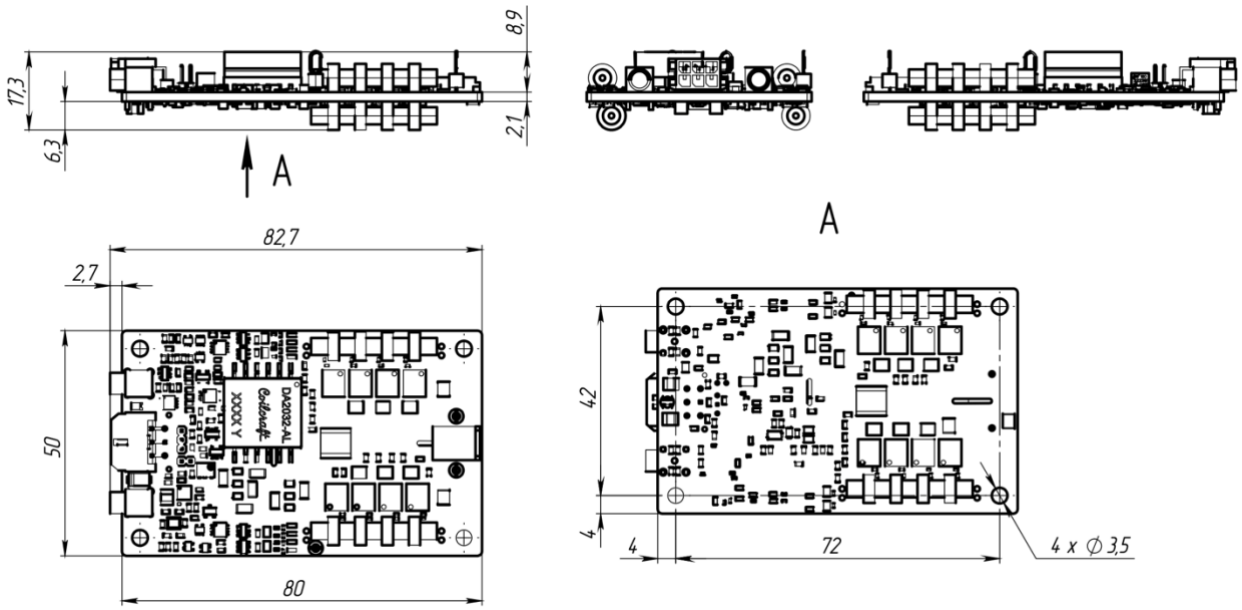
Input	
Power	24VDC, 0.5A max
HV Output	
Output type/polarity	Bipolar
Amplitude	0-4kV adjustable (other on request)
Pulse width	10-1000ns adjustable (other on request)
Repetition rate	Load and cooling dependent • >1kHz @ 4kV, 5pF for QBY-4001 • >10kHz @ 4kV, 5pF for QBY-4010-C • >10kHz @ 4kV, 5pF for QBY-4010-A • >10kHz @ 4kV, 5pF for QBY-4010-P See also *Performance* section above
Rise/fall time	3-4ns
Delay time	<10ns
Jitter	<0.2ns
Load requirements	
Load type	Capacitive
Load capacitance	<5pF recommended, 10pF max
Protections	From overheating (~80°C)
Cooling	QBY-4001: convective cooling or forced-air cooling with external fan QBY-4010-C: conductive cooling through the bottom to a customer's heatsink QBY-4010-A: forced-air cooling with integrated fans QBY-4010-P: passive (convective) cooling with integrated heatsinks
Environmental	
Operating temperature	-30…+60°C

MECHANICAL SPECIFICATION

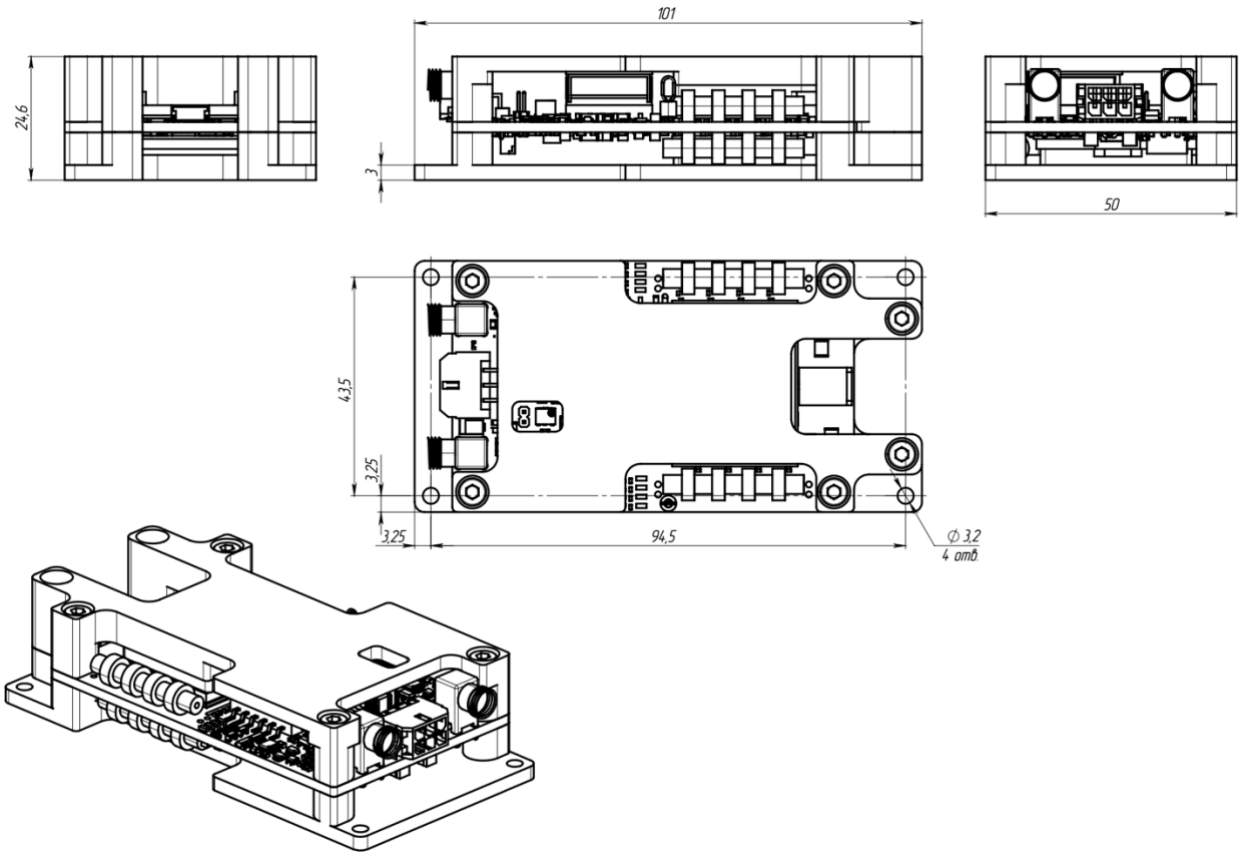
Size (LxWxH)	See the dimensional drawings below
Weight	50-250g in dependence on version

Dimensions

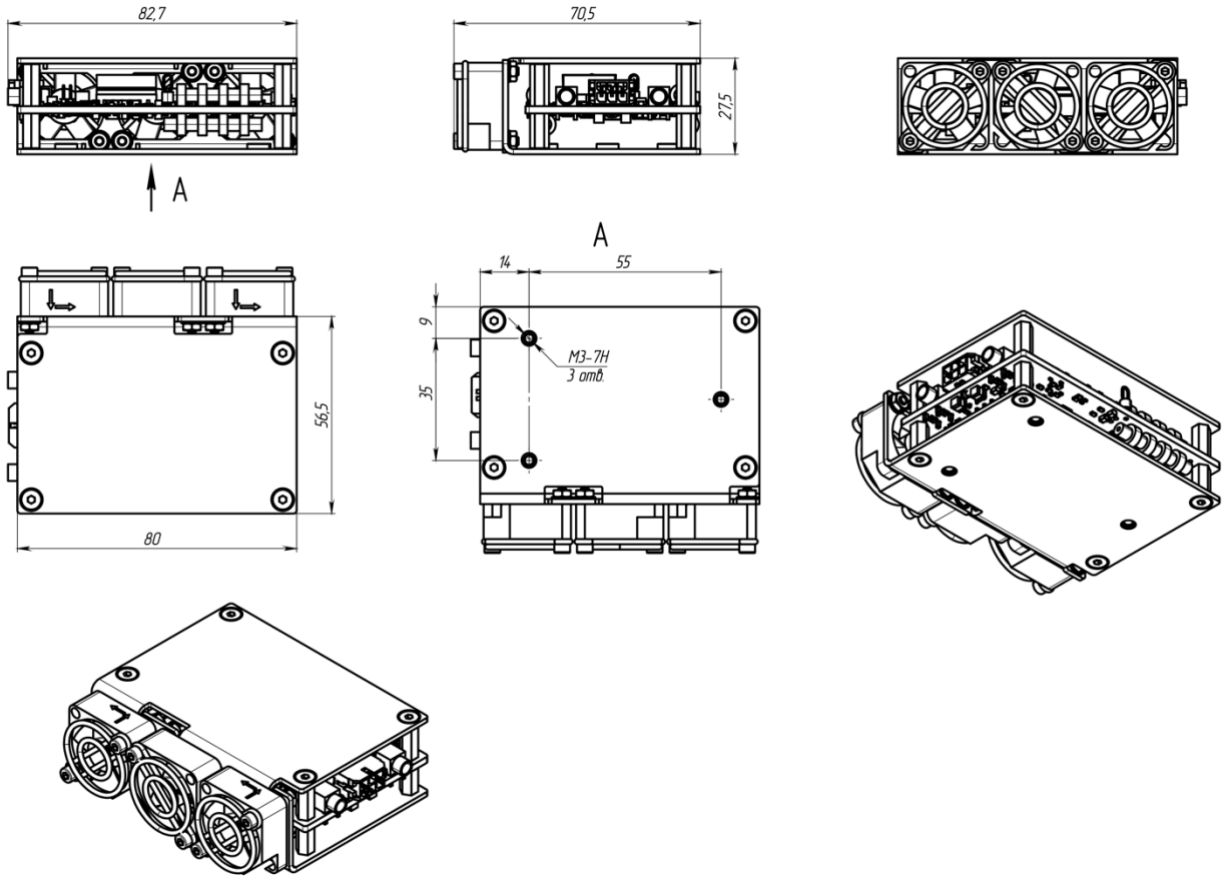
QBY-4001 (bare PCB)



QBY-4010-C (conductive cooling through the bottom to a customer's heatsink)

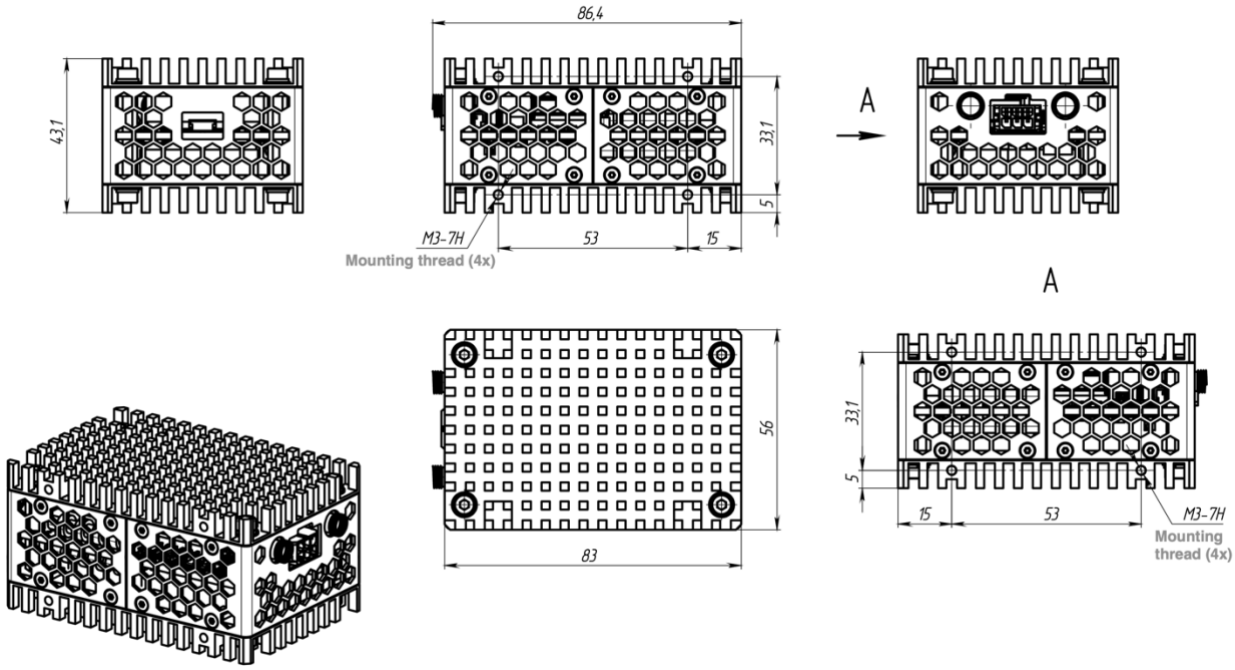


QBY-4010-A (forced-air cooling)



Caution! The mounting screw's length is essential (QBY-4010-A version)
The depth of penetration shouldn't exceed 6mm. The overall screw length should be selected accordingly. Longer screws may damage the driver.

QBY-4010-P (passive/convective cooling)



Bench-top version

Bench-top version (QBY-BT) with embedded pulse generator is available.

