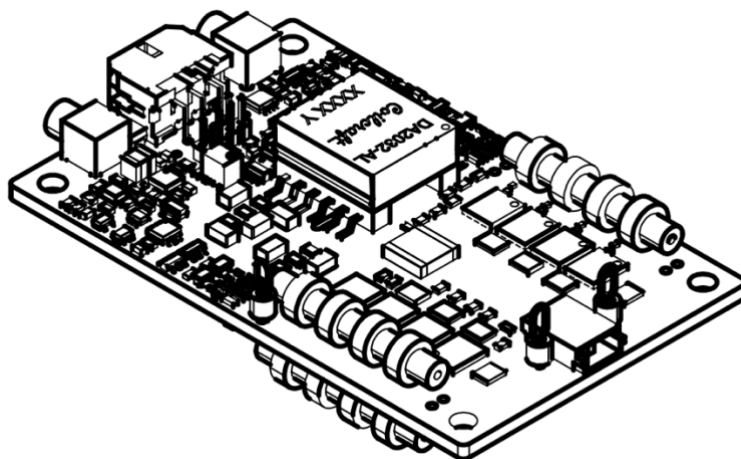# QBY-series Pockels cell drivers

User manual (preliminary)

> **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.

Overview

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)
- Maximal repetition rate – up to 1kHz @ 4kV with convective cooling and up to 10kHz @ 4kV with forced air cooling (and higher at smaller voltages)
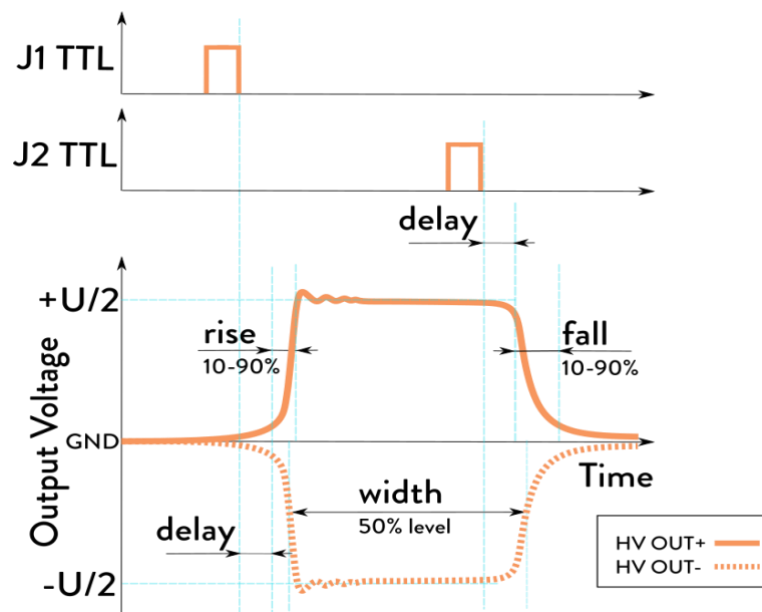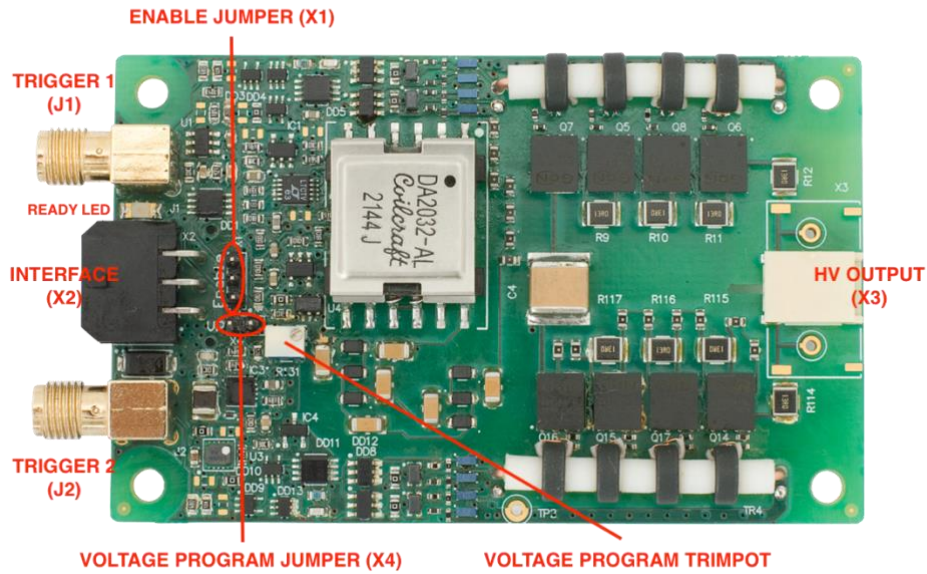

At the moment QBY-series includes two models – QBY-4001 base model and QBY-4010 enhanced model equipped with cooling fans, which made it possible to increase the maximal repetition rate up to 10kHz @ 4kV and up to 100kHz at smaller voltages.

Appearance
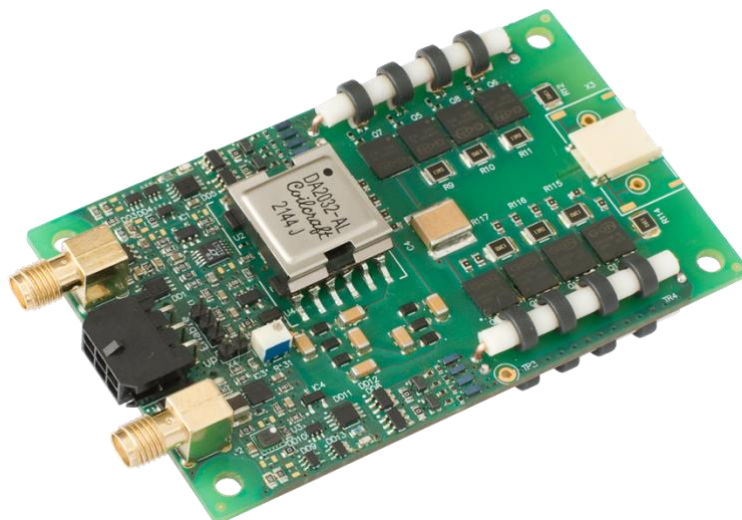
Connections, signals, signal descriptions

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

Trigger pulse inputs – 5 V TTL; input impedance 50 Ω; trailing edge is active; fast transition (<2ns) is highly recommended.

TRIGGER 1 trailing edge determines the beginning of HV pulse at driver's output. TRIGGER 2 trailing 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 (black)	24VDC RETURN	
3 (black)	GND	Common ground of interface signals (Enable, Ready, Voltage Program).

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

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.
2 (red)	**HV OUTPUT NEGATIVE**	Voltage difference between HV OUTPUT POSITIVE and HV OUTPUT NEGATIVE varies from 0V to 4kV relative to the ground.

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 (Pins 1 & 2)	Driver will be enabled only when Enable signal is applied to Pin 5 of INTERFACE connector.

	ON (Pins 2 & 3)	Driver is enabled.
	OFF	Driver is permanently disabled.
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 four 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.   Turn on 24VDC power supply

4.   Set VOLTAGE PROGRAM JUMPER (X4) on, then set VOLTAGE PROGRAM TRIMPOT accordingly to the desired output voltage (minimal, maximal, other)

5.   Short Pins 2 and 3 of ENABLE JUMPER (X1) to enable the driver

6.   Turn on pulse generator and apply pulses to TRIGGER 1 and TRIGGER 2. Keep minimal distance between trigger pulses (10ns).
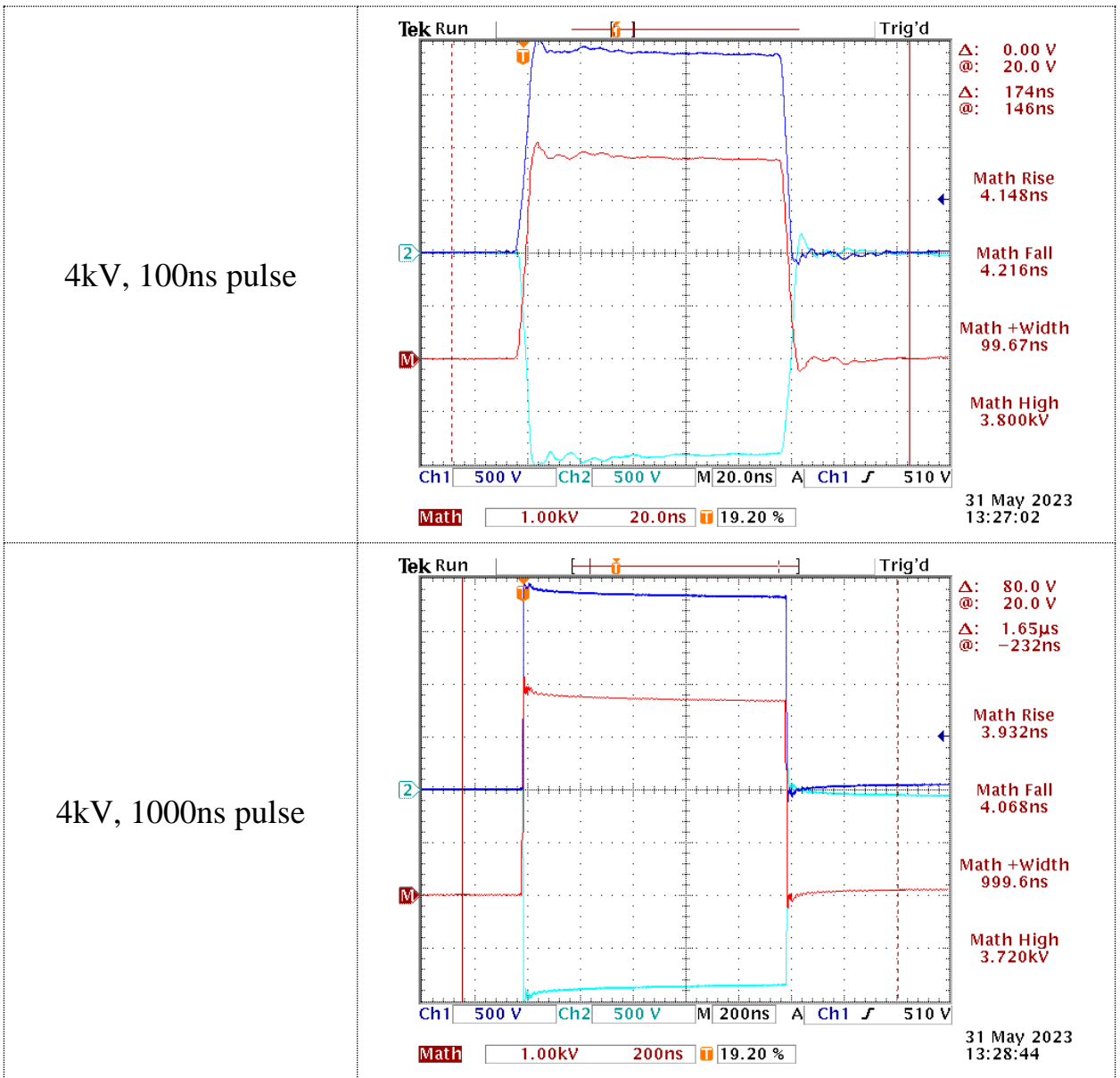
Typical output

> **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
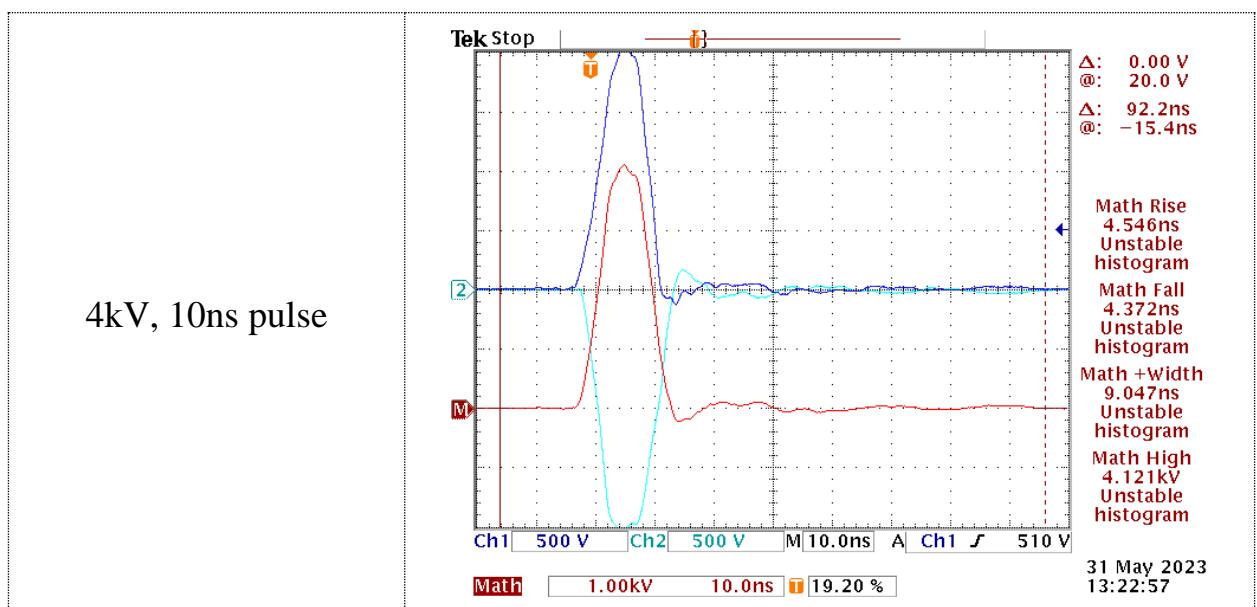
Typical performance

Table below contains maximal 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, conductive cooling	1kHz	5kHz	15kHz	25kHz	40kHz	50kHz
QBY-4010, forced air cooling	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 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: forced air cooling with integrated fans
Environmental	
Operating temperature	-30…+60°C

MECHANICAL SPECIFICATION
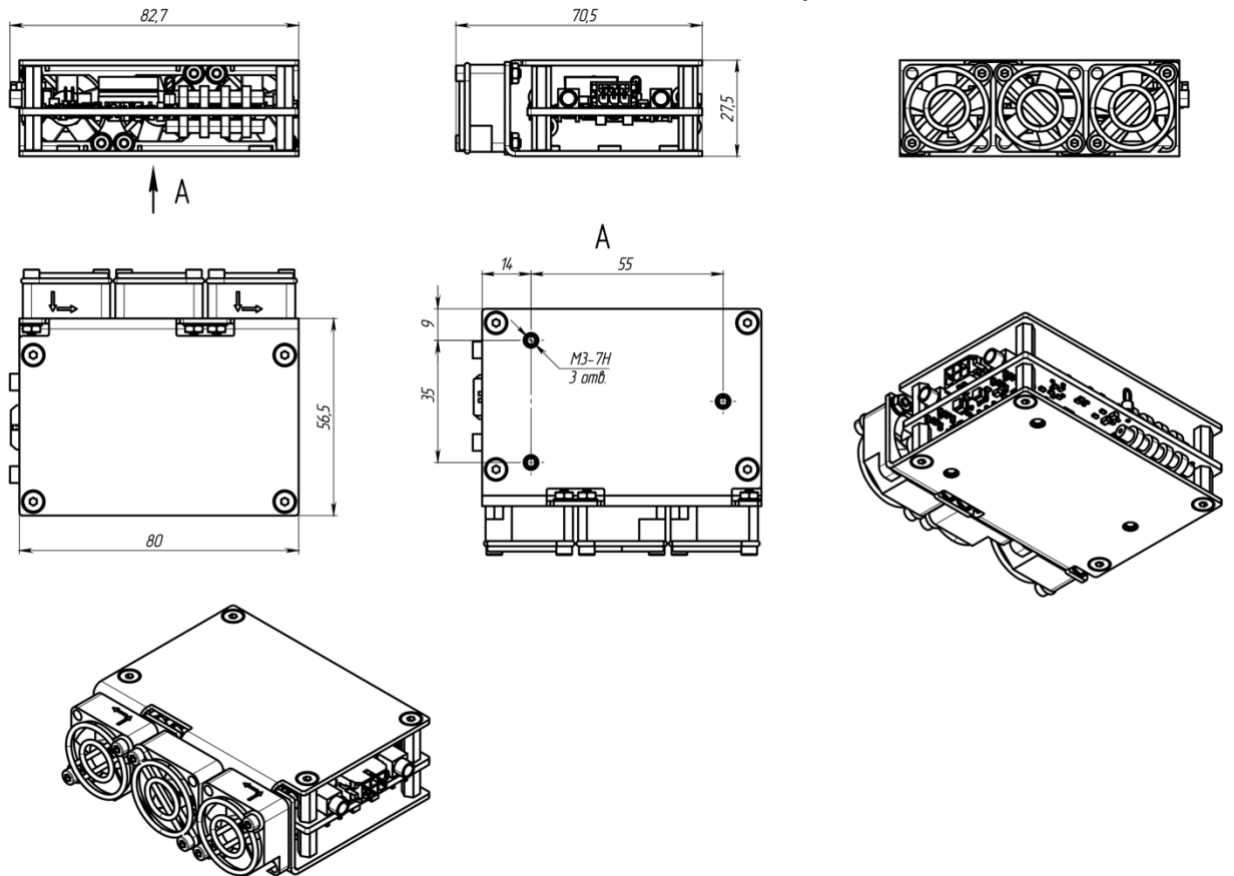
Size (LxWxH)	80x50x20 mm^3 (see also the dimensional drawings below)
Weight	Approx. 0.05 kg

DIMENSIONAL DRAWINGS

QBY-4001 (bare PCB without fans)
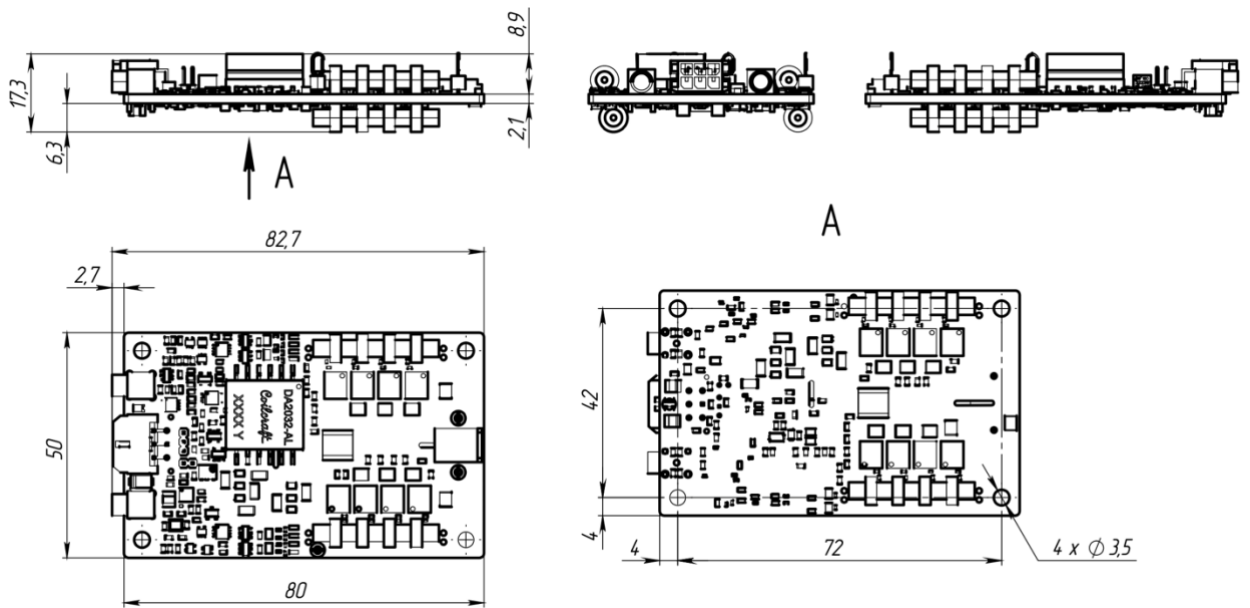
QBY-4010 (enclosed PCB with fans)

Bench-top version

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