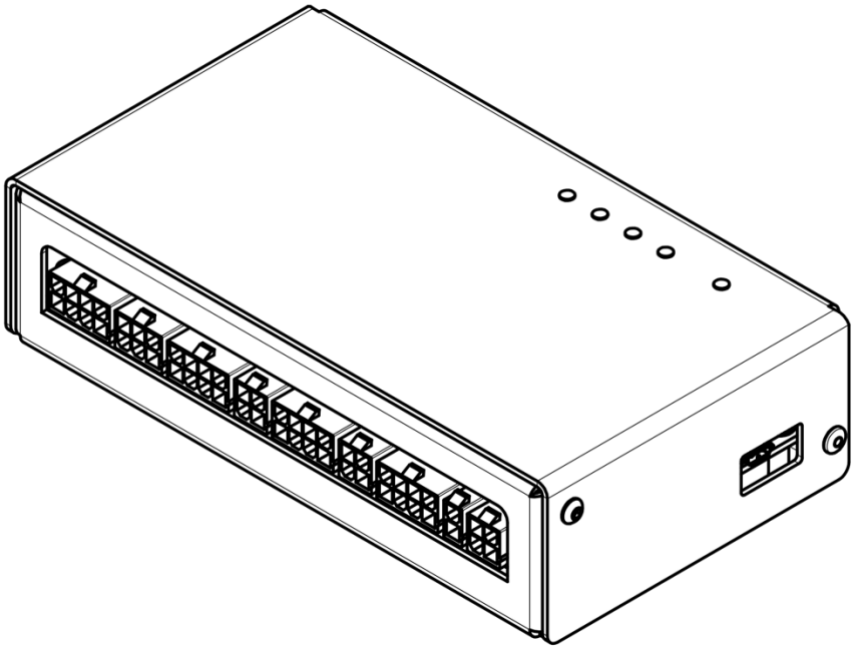
rev 1.30 / 2025 09 20

LSCB control board

User manual



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Overview

The LSCB is a control board developed to simplify the design and use of flashlamp drivers based on OEM Tech's power modules. It allows the user to set and change an output voltage value for the capacitor charger and Pockels cell driver. The LSCB also allows the user to form the output pulses for the discharge circuit(s) and Pockels cell driver with user-defined delays and to vary other parameters. The output signals can be synchronized either internally or externally.

By default, LSCB controls single or dual-channel laser or IPL system with average power from 1 kW to 4 kW level and supports the following devices:

1) One capacitor charger from PCA-series
2) One or two NBU-1012 discharge circuits
3) One Pockels cell driver from QBU- or QBD-series
4) Full set of minor features like IDC, footswitch, synchro input and outputs

Besides, several customized modifications of LSCB are available on request (see also *How to order?* section):

- "4 channel" version – for high-power multi-channel Holmium lasers (it is able to control up to four flashlamps and synchronize their flashes with the rotating mirror)
- "PWM" version – for Nd:YAG, Alexandrite and IPL systems with long and truly rectangular pulses (it works with PWM-based discharge circuits from NBD-series)
- "Pico" version – for picosecond Nd:YAG lasers used in aesthetics (in addition to the standard equipment it is able to control a seed-oscillator driver)
- "RF" version – for aesthetic machines combining flashlamp (laser, IPL) and RF technologies (in addition to the standard equipment it is able to control an RF power module from RFGM-series)
- "Diode" version – for aesthetic machines combining flashlamp (laser, IPL) and diode technologies (in addition to the standard equipment it is able to control a diode driver from PDD-series)

The basic interface to connect the LSCB to a PC or master control board is the RS-232. The RS-485 interface, as well as other variations, are available upon request. Simple PC software is supplied together with the module.

Appearance

Cooling

No external cooling is required.

Contents of delivery

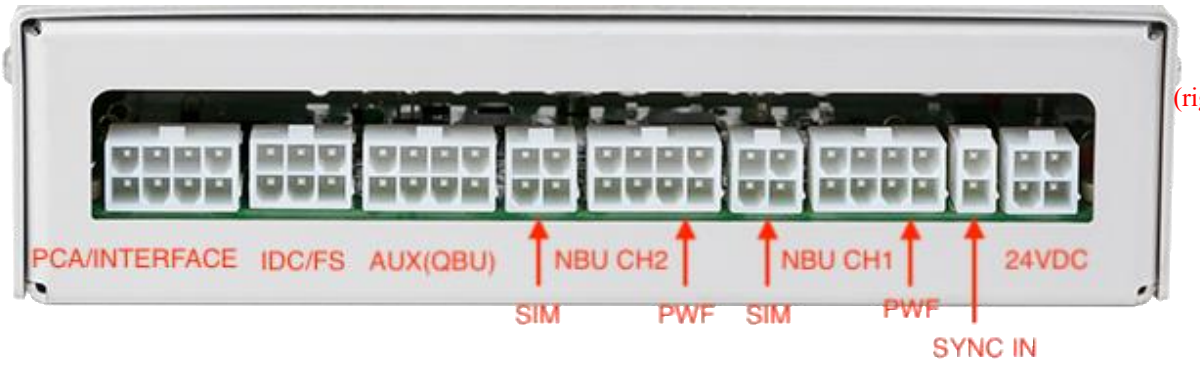
By default, the delivery package contains the following parts:

- LSCB controller board – 1pc
- PCA/INTERFACE cable (50cm length) – 1pc
- IDC/FS cable (50cm length) – 1pc
- AUX cable (50cm length) – 1pc
- NBU/SIM cable (50cm length) – 2pcs
- NBU/PWF cable (50cm length) – 2pcs
- SYNC IN cable (50cm length) – 1pc
- 24VDC cable (50cm length) – 1pc
- RS-232 cable (100cm length) – 1pc
- USB/RS-232 adapter – 1pc
- USB Flash stick with software – 1pc

Customized delivery content is available upon request.

Connections, signals, signal descriptions

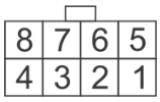
RS-232/485
(left side)



USB
(right side)

PCA/INTERFACE: Molex 3930-1080

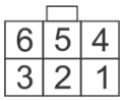
A capacitor charger from the PCA-series should be connected here.



PIN (color)	DESIGNATION	DESCRIPTION
1 (black)	**Interface Return**	See the user manual for the PCA-series capacitor charger for a detailed signal description.
2 (white)	**Fault**	
3 (blue)	**Inhibit**	
4	**N/C**	
5 (red)	**+15V DC**	**Important note: The signals on the PCA/INTERFACE connector are galvanically isolated from other circuits of the LSCB controller.**
6 (green)	**Ready Indicator**	
7 (yellow)	**Voltage Program**	
8 (violet)	**Voltage Monitor**	

IDC/FS: Molex 3930-1060

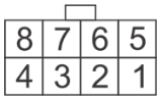
The door interlock connector and/or footswitch or fingerswitch should be connected here.



PIN (color)	DESIGNATION	DESCRIPTION
1 (green)	**IDC**	Door interlock connection. The pin should be pulled to the ground to allow module operation.
2 (blue)	**Footswitch (Fingerswitch)**	Footswitch (fingerswitch) connection. Once output is enabled, the pin should be pulled to the ground to start flashes.
3 (white)	**Synchro Output 1**	Synchro output signal coincident with Pulse signal applied to the flashlamp (NBU PWF connector).
4 (black)	**GND**	Common ground of IDC, Footswitch, Synchro Output 1 signals
5 (white)	**Synchro Output 2**	Synchro output signal coincident with Pulse signal applied to AUX(QBU) connector.
6 (black)	**GND 2**	Ground of Synchro Output 2 signal

AUX (QBU): Molex 3930-1080

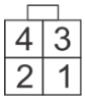
Auxiliary equipment, such as a QBU-series Pockels cell driver, should be connected here.



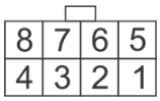
PIN (color)	DESIGNATION	DESCRIPTION
1 (white)	Pulse	See the user manual for QBU-series Pockels cell drivers for a detailed signal description. Another equipment with a compatible set of control signals can be connected here instead of the QBU. In this case, 15V DC must be applied to pin 3 to ensure the correct behavior of all signals.
2 (-)	N/C	
3 (red)	+15V DC	
4 (blue)	Enable	
5, 6 (black)	GND	
7 (yellow)	HV Monitor	
8 (green)	HV Program	

NBU/SIM CH1 and NBU/PWF CH1: Molex 3930-1040 and Molex 3930-1080

A discharge circuit from the NBU-series should be connected here.



PIN (color)	DESIGNATION	DESCRIPTION
1 (violet)	GND	See the user manual of the NBU-1012 discharge circuit for a detailed signal description.
2 (yellow)	Simmer Sensor	
3 (red)	Simmer Enable	
4 (black)	GND	



PIN (color)	DESIGNATION	DESCRIPTION
1, 6 (black)	GND	See the user manual of the NBU-1012 discharge circuit for a detailed signal description.
2, 4, 7, 8	N/C	
3 (orange)	Pulse	
5 (green)	Discharge	

NBU/SIM CH2 and NBU/PWF CH2: Molex 3930-1040 and Molex 3930-1080

The second discharge circuit from NBU-series is to be connected here (of course, it is possible to operate LSCB control board with only one NBU discharge circuit connected).

The pin layout and signal description are identical to those of the NBU/SIM CH1 and NBU/PWF CH1 connectors.

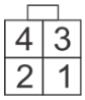
SYNC IN: Molex 3930-1020

Synchronization input for operations in regimes with external synchronization of flashes.

PIN (color)	DESIGNATION	DESCRIPTION
1 (white/blue)	Synchro Input	Incoming synchronization pulses should be applied to these pins if controller runs in external synchronization mode.
2 (black)	GND	

24V DC: Molex 3930-1040

The connector is used to power the LSCB controller.



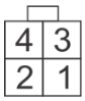
PIN (color)	DESIGNATION	DESCRIPTION
1, 2 (red)	24V DC	24V DC power should be applied here.
3, 4 (black)	GND	

USB: Micro USB type

The LSCB can be connected to a PC using this connector via standard USB to micro USB cable.

RS-232: Molex 43045-0400

The LSCB can be connected to the master control board using this connector. Connecting it to a PC is also possible, but an appropriate USB to RS-232 adapter is needed.



PIN (color)	DESIGNATION	DESCRIPTION
1 (orange)	RX	to be connected to TX of the host
2 (blue)	TX	to be connected to RX of the host
3, 4 (black)	GND	

LEDS:

There are several LEDs that indicate the state of the LSCB controller.

Power LED (blue):

- lights steadily while the LSCB is powered

Simmer LED (yellow):

- blinks if at least one simmer supply is enabled (“s 1”), but the simmer monitor returns the absence of the simmer discharge (mS returns 0)
- lights steadily if all active flashlamps are simmered successfully

Charger LED (yellow):

- blinks if the capacitor charger is enabled (“c 1”), but the capacitor bank isn’t charged yet (charger is not ready, i.e. mR returns 0)
- lights steadily if the capacitor charger is enabled (“c 1”) and the capacitor bank is charged up to the required value (charger is ready, i.e. mR returns 1)

Pulse LED (green):

- off when outputs are disabled
- in run mode, it lights steadily if the output in two channels is set to synchronous (“g 0”) and blinks if output in two channels is set to counter-phasal (“g 180”)

Error LED (red):

- lights steadily if one of connected devices reports about failure
- blinks if internal Fault of the LSCB has occurred

Operations (first run procedure)

1. **If LSCB is controlled from PC via USB:**
   - Connect the LSCB to your PC using the USB to micro USB cable
   - Drivers will be installed automatically on Windows 8 and higher
   - Run Windows software supplied together with the LSCB

   If LSCB is controlled from another device via RS-232/RS-485 interface:
   - Apply 24V DC power to the LSCB
   - Connect the LSCB to the controlling device via RS-232/RS-485 interface
   - Be prepared to send text commands to the LSCB
2. Ensure that the IDC and Footswitch circuits are connected properly and do not block operations
3. Before starting the operations, please check if the states of the following parameters (commands) match your application and re-set their values if necessary:

Parameter (If LSCB is controlled from PC via USB, see Appendix 1 for the details)	**Command (If LSCB is controlled from another device via RS-232/RS-485 interface, see Appendix 2 for the details)**
Active and non-active channels (**Active**)	a
Single pulse mode or pulse train mode (**Pulse mode**)	b
Whether channels are synphase or in counter-phase (**Phase**)	g
Whether the synchronization is internal or external (**Synchronization**)	x
External synchronization trigger edge (**Triggering edge**)	t
V_{MAX} of the capacitor charger (**Maximum voltage Vmax**)	vm
Impedance of your flashlamp (**Lamp impedance K0**)	!k0
Output power limitation (**Power limit**)	h

4. Set main parameters:

Operating voltage (**Voltage**)	v
Pulse repetition rate (**Frequency**)	f
Pulse width (**Pulse length**)	p

5. Enable capacitor charger:

Charge	c

6. Trigger simmer discharge through flashlamp (flashlamps):

Simmer	s (s1, s2)

7. Enable flashes:

Start	r (r1, r2)

Specifications

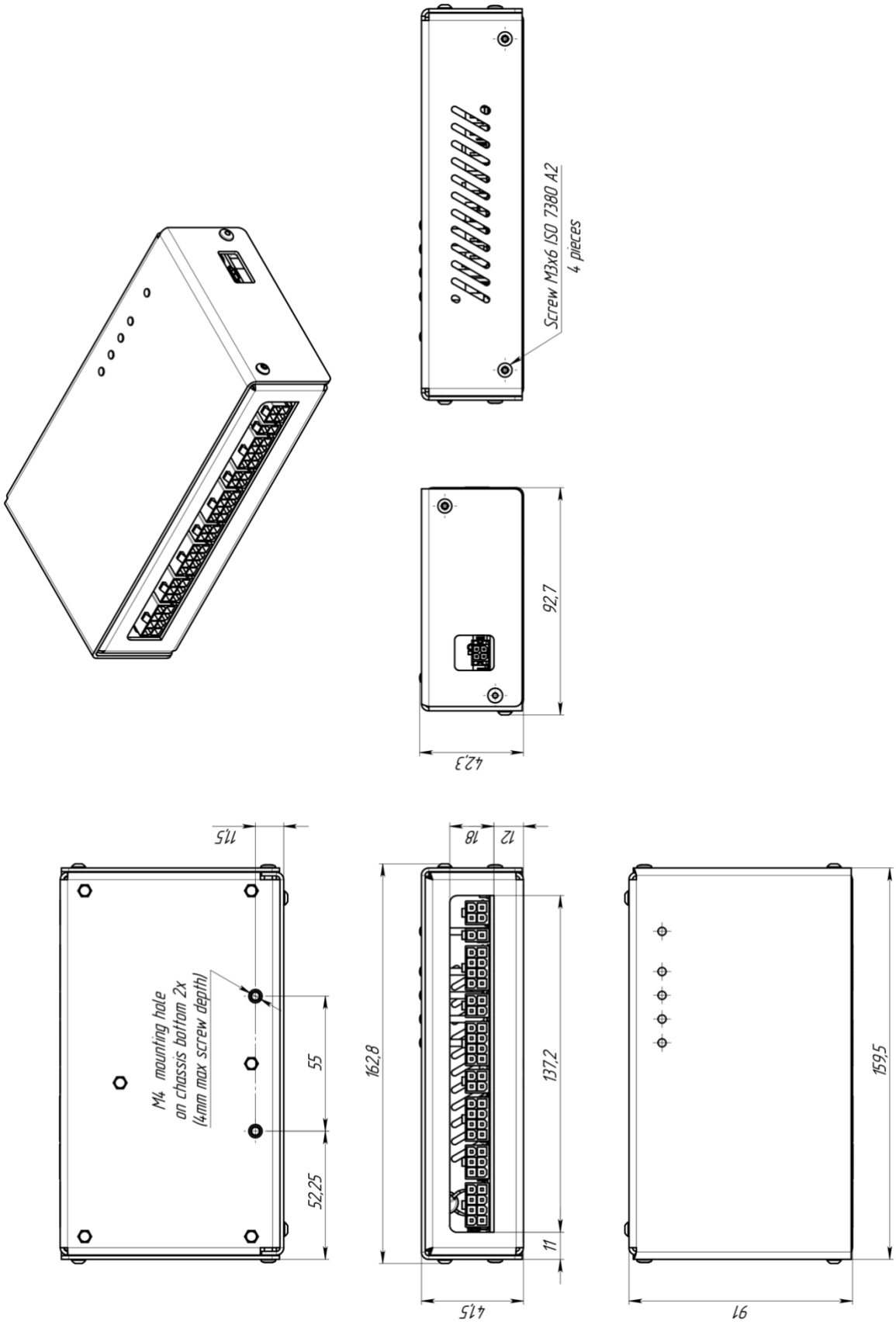
ELECTRICAL

Power:	
Input voltage	24V DC
Current consumption	1A max
Interfaces:	
Machine interfaces	USB RS-232 (by default), RS-485 (on request)
Synchronizations	1x synchro input (more in some versions, see *How to order?* section for the details) 2x synchro outputs
Controlled power equipment	Modification dependent (see *How to order?* section for the details)
Other	IDC, footswitch or fingerswitch, status LEDs
Cooling:	No external cooling is required
Environment:	
Operation temperature	+10… +40°C
Storage temperature	-20 … +60°C
Humidity	0…90%, non-condensing

MECHANICAL

Dimensions	See dimensional drawing below
Weight	Approx. 0.5 kg

Dimensional drawing



How to order?

Modification / description	Part number	Controlled equipment
Standard – suitable for the vast majority of applications including IPL, long pulsed lasers and Q-switched laser systems (Nd:YAG, Ruby, Alexandrite, Holmium, Erbium etc)	LSCB	1pc PCA-series capacitor charger (*) 1-2pcs NBU-1012 discharge circuits 1pc Pockels cell driver from QBU-series or QBD-series
4-channel – for high-power multi-channel Holmium lasers (it is able to control up to four flashlamps and synchronize their flashes with the rotating mirror)	LSCB-4	1pc PCA-series capacitor charger (*) 1-4pcs NBU-1012 discharge circuits
PWM – for Nd:YAG, Alexandrite and IPL systems with long and truly rectangular pulses (it works with PWM-based discharge circuits from NBD-series)	LSCB-PWM	1pc PCA-series capacitor charger (*) 1-3pcs discharge circuits from NBD-series (with PWM) or NBU-series (free discharge)
Pico – for picosecond Nd:YAG lasers used in aesthetics (in addition to the standard equipment it is able to control a seed-oscillator driver)	LSCB-Pico	1pc PCA-series capacitor charger (*) 1-2pcs NBU-1012 discharge circuits 1pc SDC-series seed-oscillator driver
RF – for aesthetic machines combining flashlamp (laser, IPL) and RF technologies (in addition to the standard equipment it is able to control a RF power module from RFGM-series)	LSCB-RF	1pc PCA-series capacitor charger (*) 1-2pcs NBU-1012 discharge circuits 1pc RFGM-series RF power supply
Diode – for aesthetic machines combining flashlamp (laser, IPL) and diode technologies (in addition to the standard equipment it is able to control a diode driver from PDD-series)	LSCB-PDD	1pc PCA-series capacitor charger (*) 1-2pcs NBU-1012 discharge circuits 1pc PDD-series pulsed diode driver

(*) multiple capacitor chargers can be connected in parallel in master-slave configuration and controlled from a single LSCB

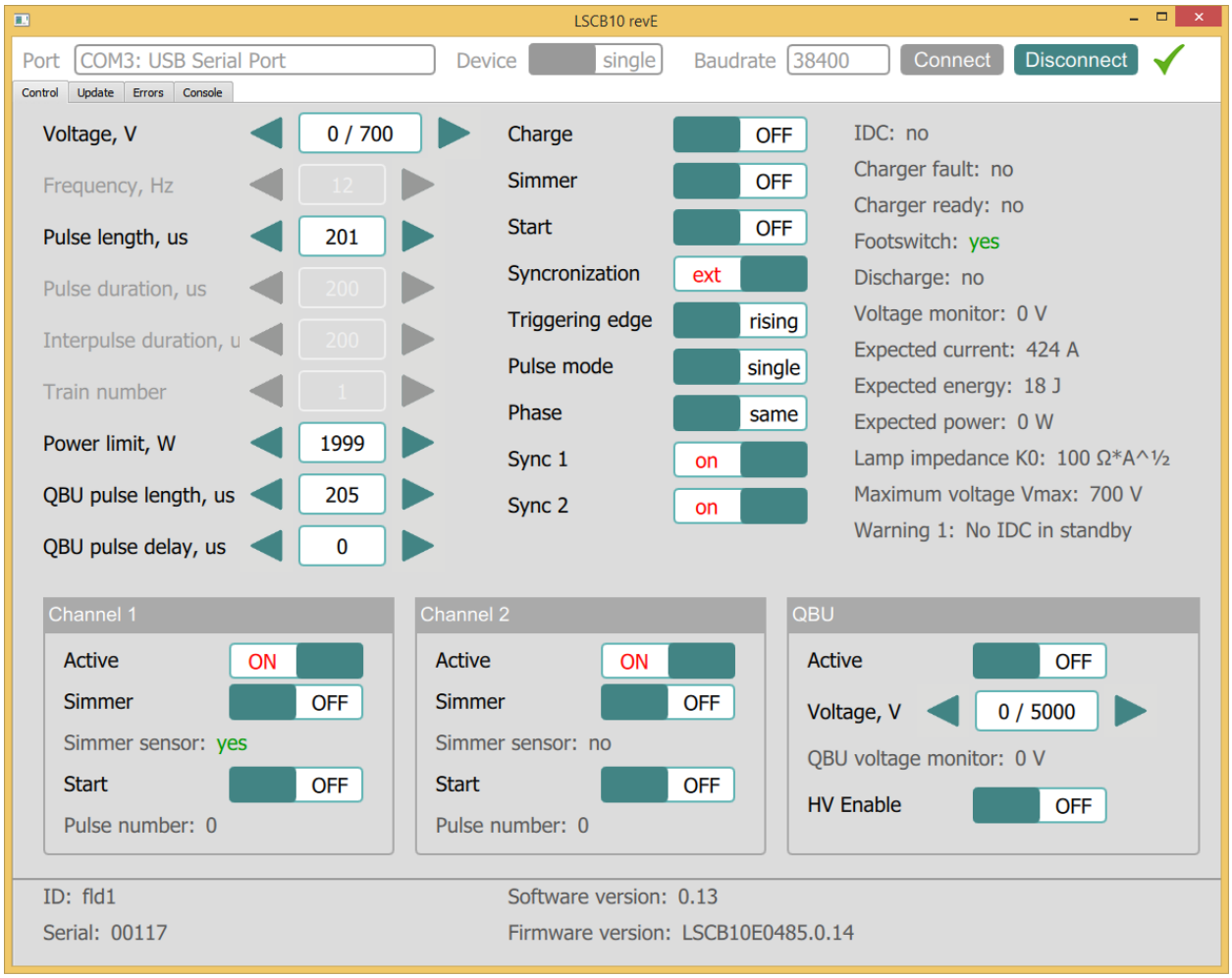
The LSCB has an additional hardware protection from too long flashes caused by MCU failure. In other words, the maximum allowed pulse width may depend on hardware configuration. Please let us know the desired protection level at the moment of order by adding the corresponding suffix to the LSCB's part number:

- -1ms – hardware protection limits the maximum pulse width at 1ms level (this version is supplied by default)
- -10ms – hardware protection limits the maximum pulse width at 10ms level
- -100ms – hardware protection limits the maximum pulse width at 100ms level
- -XXms – other level (XX milliseconds)

Examples:

- LSCB – standard LSCB, 1ms maximum pulse width
- LSCB-1ms – standard LSCB, 1ms maximum pulse width
- LSCB-PWM-20ms – PWM version of LSCB, 20ms maximum pulse width

Appendix 1. Software description



Voltage – sets the desired output voltage (V)

Frequency – sets the desired repetition rate of flashes (Hz)

Pulse length – in **Single pulse mode** – sets the desired pulse width (us)

Pulse duration – in **Pulse train mode** – sets the duration of individual pulselets (us)

Interpulse duration – in **Pulse train mode** – sets the interval between the individual pulselets (us)

Train number – in **Pulse train mode** – sets the number of pulselets in each train

Power limit – sets the average power limit (W)

QBU pulse length – sets the pulse width which is sent in the form of TTL "1" to the Pulse pin of the AUX(QBU) connector

QBU pulse delay – defines the delay between pulses applied to the NBU and the QBU; it can be positive or negative

Charge – turns the capacitor charging module on and off

Simmer – turns the simmer supplies of all **active** NBU-1012 on and off

Start – enables and disables flashes in all **active** channels

Synchronization – selects the synchronization mode – **Internal synchronization** / **External synchronization**

In **Internal synchronization mode** flashes are defined by the LSCB

In **External synchronization mode** flashes are defined by an external signal applied to the SYNC IN connector of the LSCB

Triggering edge – in **External synchronization mode** defines the triggering edge of the synchronization signal – either the rising edge or the falling edge

Pulse mode – switches the LSCB between **Single pulse mode** and **Pulse train mode**

Phase – switches the LSCB between synphase and counterphase operations of Channel 1 and Channel 2 (if both are active)

Sync 1 and **Sync 2** – define if the first and the second synchro outputs are active or not

Channel 1 Active and **Channel 2 Active** – make the corresponding channel active or inactive

Channel 1 Simmer and **Channel 2 Simmer** – start/stop the simmer supply in Channel 1 and Channel 2, respectively

Channel 1 Start and **Channel 2 Start** – start/stop flashes in Channel 1 and Channel 2, correspondingly

QBU Active – makes the QBU channel (i.e. AUX(QBU) connector) active or inactive

QBU HV Enable – enables/disables the high-voltage output of QBU

QBU Voltage – defines the output voltage of the QBU

IDC – status of the Door Interlock (IDC signal of IDC/FS connector) – flashes are prohibited if the IDC loop is open

Charger fault – internal fault status of the capacitor charging power supply (Fault signal of the PCA)

Charger ready – Ready signal of the PCA

Footswitch – footswitch status (FS signal of IDC/FS connector)

Discharge – status of the discharge resistors (Discharge signal of the NBU-1012)

Voltage monitor – the actual voltage on the capacitor bank (Voltage monitor of the PCA)

Expected current – the calculated current through the flashlamp (calculations are based on Voltage and Flashlamp impedance K0 values)

Expected energy – the calculated flash energy (calculations are based on Voltage, Flashlamp impedance K0 and Pulse length values)

Expected power – the calculated power through the flashlamp (calculations are based on Voltage, Flashlamp impedance K0, Pulse length and Frequency values)

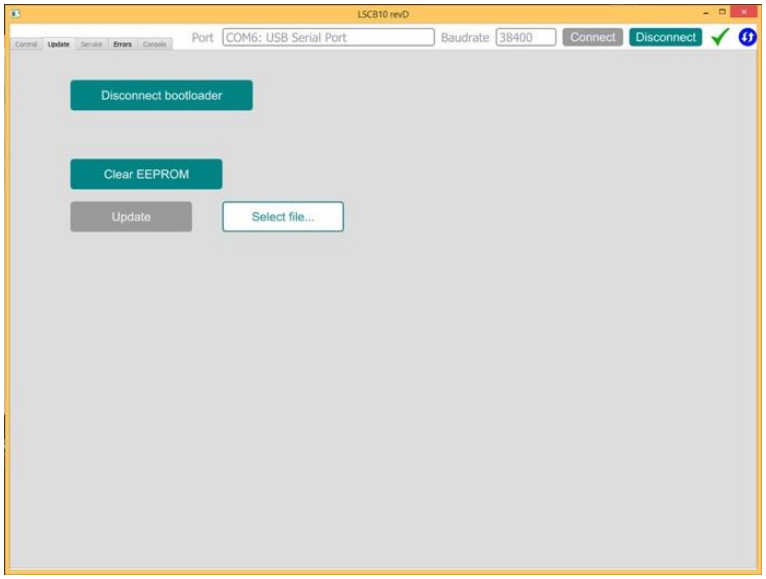
Lamp impedance K0 – should be set in accordance with the flashlamp datasheet

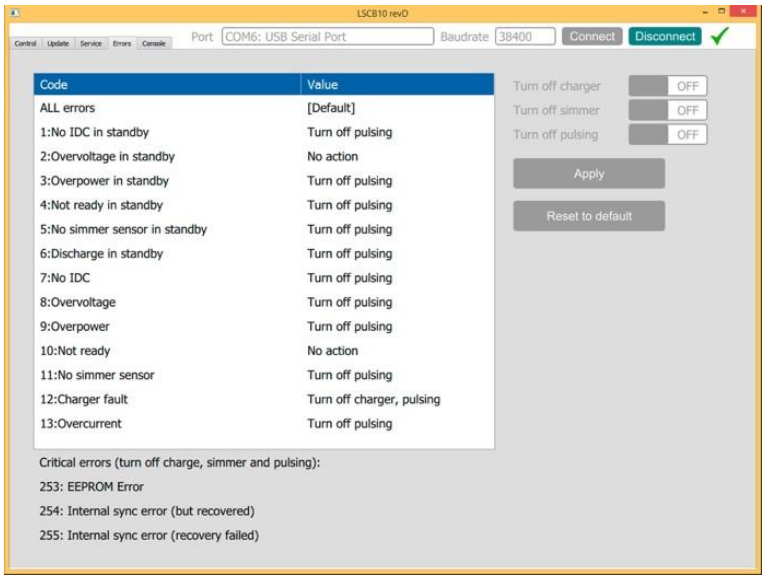
Maximum voltage Vmax – the maximum voltage of the particular capacitor charger (should be set in accordance with the PCA part number)

ERROR (or **WARNING)** – the last error that occurred

Important note. By default, the LSCB is supposed to be the only controller in the system. However, for complex systems, several LSCBs can share the same RS-485 bus and work together. Please contact the manufacturer for the details.

Other tabs of the software allow to customize the LSCB's parameters and its behavior in the case of faults (errors), as well as to update firmware.





Appendix 2. RS-232 protocol description

RS-232 connection parameters: 38400 bps, 8 data bit, 1 stop bit, no parity

Command format is: {command} {data (optionally)} {end-of-line}

- Command is 1 to 5 character long (see the list below).
- Data is an ASCII-string, the command and data must be separated by a space (space symbol).
- End-of-line symbols are \n or \r\n
- Lowercase commands set values (no return from the controller), uppercase commands return values. For example, “v 300” sets voltage to be 300, while ”V” returns 300. So, the *set* and *get* commands for a certain value use the same letter, but the *set* command is lowercase, and the *get* is uppercase.
- Monitor commands (uppercase, but with a preceding “m” letter) only return values.
- Every command (except monitors, that begin with letter *m*) has limits (lower and upper) that can be established by *_cmd* and *^cmd* commands, where *cmd* is the certain command. For example, *_p* and *^p* establish the lower and upper bounds of the available pulse length.
  Note: you may narrow the allowed range of a command with respect to the default range, but widening it may lead to abnormal functioning. **We strongly recommend to contact the manufacturer before extending the operating limits.**
  Maximum range of *_cmd* and *^cmd* commands: -214748364.8 ... 214748364.6 for commands *f*, *!k0*, *!s*, *!r* and -2147483648 ... 2147483646 for other commands. *_CMD* and *^CMD* return the lower and upper bounds of command cmd.

List of available commands:

- v – sets the desired output voltage (in volts)
  - example “v 300”
  - min 100, max 700, increment 1, default 200
- p – sets the desired pulse width (in microseconds)
  - example “p 250”
  - works in single pulse mode of operations only
  - min 50, max 1000, increment 1, default 200
- f – sets the desired pulse repetition rate (in hertz)
  - example “f 0.5”
  - “f 0” means single shot
  - min 0, max 50, increment 0.1, default 1
- V, P, F – return the corresponding set points

- b – sets “single pulse” or “train of pulses” mode of operations
  - “b 0” – single pulse, “b 1” – train of pulses
  - in train of pulses mode, parameter p is ignored, and parameter f defines the repetition rate of pulse trains
  - allowed values 0, 1, default value 0
- n – sets the number of pulses in pulse train mode
  - example “n 3”
  - min 1, max 100, increment 1, default 1
- on – sets pulse duration in pulse train mode (in us)
  - example “on 1000”
  - min 50, max 2000, increment 1, default 200
- off – sets interpulse interval in pulse train mode (in us)
  - example “off 1000”
  - min 50, max 2000, increment 1, default 200
- B, N, ON, OFF – return the corresponding set points

- x – sets the synchronization mode (internal synchronization or external synchronization)
  - "x 0" – internal, "x 1" – external
  - allowed values 0, 1, default value 0
- t – sets the triggering edge in external synchronization mode
  - "t 0" – rising, "t 1" – falling
  - allowed values 0, 1, default value 0
- X, T – return the corresponding set points
- sd – in external synchronization mode, sets an additional sync delay between the synchro input and the outputs (IGBT pulse or QBU pulse, whichever comes first) (in microseconds)
  - example "sd 300"
  - min 15, max 400, step 0.1, default 15
- SD – returns the corresponding set point
- a1, a2 – enable the first and the second synchro outputs, respectively
  - "a1 1", "a2 1" – enable, "a1 0", "a2 0" – disable
  - allowed values 0, 1, default value 1

- a – sets the mask of active channels
  - "a 0" – neither channel 1 nor channel 2 is active; "a 1" – only channel 1 is active; "a 2" – only channel 2 is active; "a 3" – both channels 1 and 2 are active
  - any use of the command forcedly sets "s", "s1", "s2", "r", "r1", "r2" to 0
  - allowed values 0, 1, 2, 3, default value 0
- A – returns the mask of active channels

- s1 – turns the simmer supply in channel 1 on and off
  - "s1 1" – on, "s1 0" – off
  - the command is ignored if channel isn't set active with "a" command
  - allowed values 0, 1, default value 0
- s2 – turns the simmer supply in channel 2 on and off
  - "s2 1" – on, "s2 0" – off
  - the command is ignored if channel isn't set active with "a" command
  - allowed values 0, 1, default value 0
- s – turns the simmer supply in all active channels on and off
  - "s 1" – on, "s 0" – off
  - "s1" and "s2" follow "s" automatically (once the corresponding channels are set active with "a" command
  - allowed values 0, 1, default value 0
- c – turns the capacitor charging module on and off
  - "c 1" – on, "c 0" – off
  - allowed values 0, 1, default value 0
- r1 – enables / disables the output in channel 1
  - "r1 1" – enables, "r1 0" – disables
  - the command is ignored if channel isn't set active with "a" command
  - allowed values 0, 1, default value 0
- r2 – enables / disables the output in channel 2
  - "r2 1" – enables, "r2 0" – disables
  - the command is ignored if channel isn't set active with "a" command
  - allowed values 0, 1, default value 0
- r – enables / disables the output in all active channels
  - "r 1" – enables, "r 0" – disables
  - "r1" and "r2" follow "r" automatically (once the corresponding channels are set active with "a" command
  - allowed values 0, 1, default value 0
- S1, S2, S, C, R1, R2, R – return corresponding set points

- g – sets the phase shift between channel 1 and channel 2
  - "g 0" – phase shift is 0 degrees i.e. both channels are run simultaneously; "g 180" – phase

shift is 180 degrees i.e. channels are run in counter-phase
*- if the phase shift is set to 180 degrees, this means the pulses in channel 2 are delayed relatively to the pulses in channel 1 for 1/(2*f) second*
- allowed values 0, 180, default value 0

- G – returns the corresponding set point

- h – sets the maximum power limit (in watts)
  - example "h 1000"
  - "h 0" disables the protection
  - min 0, max 2000, increment 1, default 2000
- !k0 – sets the flashlamp impedance used for calculations (in $VA^{-1/2}$)
  - example "!k0 28"
  - min 5, max 50, increment 0.1, default 10
- !i – sets the maximum current limit (in amps)
  - example "!i 1000"
  - the value mustn't exceed IGBT current rating; too high value might result in IGBT blow up
  - min 1, max 3000, increment 1, default 1100
- !t – defines if the simmer sensor is mandatory to permit pulses
  - "!t 0" – mandatory, "!t 1" – isn't mandatory
  - "!t 1" might be used in systems where the load is different from flashlamp
  - allowed values 0, 1, default value 0
- !p – defines if the capacitor charger is mandatory to permit pulses
  - "!p 0" – mandatory, "!p 1" – isn't mandatory
  - "!p 1" might be used for quick discharge of the capacitor bank
  - allowed values 0, 1, default value 0
- H, !K0, !I, !T, !P – return corresponding set points

- hv – sets the desired QBU voltage (in volts)
  - example "hv 3000"
  - min 2000, max 5000, increment 1, default 2000
- l – sets the pulse width of the QBU pulse (in us)
  - synchro output #2 will have the same pulse width
  - min 0, max 1000, increment 1, default 200
- d – sets the delay of the QBU pulse relatively to IGBT pulse (in us)
  - synchro output #2 will have the same delay relatively to synchro output #1
  - min -1000, max 1000, increment 1, default 0
- qa – sets the QBU channel active or inactive
  - "qa 1" – activates, "qa 0" – deactivates
  - activation of the QBU channel allows enabling it and pulsing
  - allowed values 0, 1, default value 0
- q – enables / disables the output of the QBU
  - "q 1" – enables, "q 0" – disables
  - allowed values 0, 1, default value 0
- HV, L, D, QA, Q – return the corresponding set points

- vm – sets the maximum voltage of the capacitor charger (V_{MAX})
  - correct setting of V_{MAX} is necessary to match the output signal of the LSCB programming the voltage with the corresponding input signal of the capacitor charger unit; set vm accordingly to the p/n of the capacitor charger used
  - once vm command is sent to the LSCB, it also automatically changes the maximum voltage (^v) and recalibrates the voltage
  - example "vm 300"
  - min 100, max 1500, increment 1, default 700
- hvm – sets the maximum voltage of the QBU
  - set hvm accordingly to the p/n of the Pockels cell driver used
  - the behavior of hvm command is similar to one of hv command

- example "hvm 5000"
- min 1000, max 6000, increment 1, default 5000

- VM, HVM – return the corresponding set points

- !j1 – sets the pulse counter for channel 1
  - example "!j1 0"
  - min 0, max 2147483646, increment 1, default 0
- !j2 – sets the pulse counter for channel 2
  - example "!j2 0"
  - min 0, max 2147483646, increment 1, default 0
- !J1, !J2 – return the pulse counters for channel 1 and channel 2, respectively

Monitor and error commands:

- mV – voltage monitor (capacitor charger, volts)
- mHV – voltage monitor (QBU, volts)
- mF – returns the capacitor charger fault state
  - 0 – no fault, 1 – fault
- mR – returns the ready state (status of the capacitor charging module)
  - 0 – not ready, 1 – ready
- mI – returns the IDC state
  - 0 – open, 1 – closed
- mW – returns the footswitch state
  - 0 – footswitch is released, 1 – footswitch is stepped
- mS1 – returns the simmer sensor state in channel 1
  - 0 – off, 1 – on
- mS2 – returns the simmer sensor state in channel 2
  - 0 – off, 1 – on
- mS – command returns the mask of simmer sensors
  - 0 – both simmers are off; 1 – only the simmer in channel 1 is on; 2 – only the simmer in channel 2 is on; 3 – both simmers are on
  - generally the return value of "S", "R", "mS" commands coincides with the mask while "s1", "s2", "r1", "r2" commands aren't used, and no fault occurs
- mD – returns the state of the embedded discharging resistors
  - 0 – no discharge, 1 – discharging
- mP – returns the expected power (in watts)
- mC – returns the expected current (in amperes)
- mE – returns the expected pulse or pulse train energy (in joules)
- mJ – returns the error code:
  0 – No error (in all modes)
  1 – No IDC in standby – no IDC (on start)
  2 – Overvoltage in standby – voltage exceeds maximum voltage for charger (on start)
  3 – Overpower in standby – expected power exceeds the limit (on start)
  4 – Not ready in standby – charger hasn't got ready within certain time (on start)
  5 – No simmer sensor in standby – simmer arc hasn't been established within certain time (on start)
  6 – Discharge in standby – attempt to pulse while capacitor bank is forcibly discharged through the embedded discharge resistors of the NBU (during discharge only)
  7 – No IDC – no IDC (in run mode)
  8 – Overvoltage – voltage exceeded maximum voltage for charger (in run mode)
  9 – Overpower – expected power exceeded the limit (in run mode)
  10 – Not ready – charger is not ready during some time (in run mode)
  11 – No simmer sensor – simmer arc has been lost for some time (in run mode)
  12 – Charger fault – internal failure of the capacitor charger (in all modes)
  13 – Overcurrent – expected current exceeds the limit (in all modes)
  253 – EEPROM error – due to EEPROM error some parameters have been reset to default values; try turning the power off and on again; if the error persists, contact the manufacturer

254, 255 – Internal sync errors – try turning the power off and on again; if the error persists, contact the manufacturer; in this case further operations might be impossible

- !er1, !er2 .. !er19 – a group of commands used to define the error behavior. The command numbers coincide with the error codes listed above; some are reserved for future use. The parameter is a string, which may contain the following symbols: n – no action, c – charger, s – simmer, r – pulsing, d – set default value. The order of symbols doesn't matter. If the string contains other symbols, they will be ignored.
  - for !er1 .. !er5 parameter defines when the check for error is performed (c – on charger start, s – on simmer start, r – on pulsing start)
  - example: "!er1 n" – check for IDC is never performed
  - example: "!er5 sr" – check for simmer sensor is performed on simmer start and on pulsing start, but not performed on charger start
  - for !er6 .. !er13 parameter defines actions performed when error occurs (c – turns charger off, s – turns simmer off, r – turns pulses off)
  - example: "!er7 csr" – turn off pulses, charger and simmer when IDC is "open" in run mode
  - example: "!er12 d" – sets LSCB's behavior in the case of charger's Fault to default
- !er – sets the same mask for all errors
- !ER, !ER1 .. !ER19 – return the corresponding set points

Service commands:

- !s – sets the time during which the system waits for the simmer sensor after turning on the simmer (in seconds)
  - "!s 0" means infinite waiting time
  - min 0, max 100, increment 0.1, default 2
- !r – sets the time during which the system waits for the ready sensor after turning on the charger (in seconds)
  - "!r 0" means infinite waiting time
  - min 0, max 100, increment 0.1, default 2
- !b – sets the RS-232/485 baud rate (Molex connector)
  - allowed values 4800, 9600, 19200, 38400, 57600, 115200, default value 38400
- !b1 – sets the RS-232 baud rate (USB connector)
  - allowed values 4800, 9600, 19200, 38400, 57600, 115200, default value 38400
- !d – debug mode
  - 1 – debug mode, 0 – normal mode, default value 0
- !wd – exchange watchdog (in seconds)
  - watchdog turns off everything (i.e. pulsing, charger, simmers) when there is no communication with control board during certain amount of time
  - 0 – turns watchdog off
  - min 0, max 100, increment 1, default 0
- * – returns the firmware version
- # or !SN – returns the serial number of the device
  - format: any alphanumeric characters (except space and tab symbols) up to 20 characters long
  - to set the serial number, use !# or !sn commands
- !id – sets the ID string of the device
- !ID – returns the ID string of the device

- ^y – calibrates the charger voltage (top point)
  - set some voltage close to top point, measure PCA's output, enter real voltage on capacitors as data for this command
- _y – calibrates the charger voltage (bottom point)
  - set some voltage close to bottom point, measure PCA's output, enter real voltage on capacitors as data for this command
- -y – resets the charger voltage calibration
- ^z – calibrates the QBU voltage (top point)
  - set some voltage close to top point, measure QBU's output, enter real QBU voltage as data for this command

- _z – calibrates the QBU voltage (bottom point)
  - set some voltage close to bottom point, measure QBU's output, enter real QBU voltage as data for this command
- -z – resets the QBU voltage calibration

- **@** – "poll all" command – returns values of all parameters in certain order
  - order can be read by use of "=" command
- **=** – returns order in which "poll all" command returns values
- ***%*** – "poll limits" command – returns all limits of all parameters which have limits
  - limits are returned in order "min max step"
- There is a possibility to create user-defined poll list using @a, @b, @c, @d and @e commands
  - @a V HV F P – creates a user-defined poll list of V HV F P parameters
  - @A – returns list of V HV F P parameters (e.g. 247 2000 9.5 273)
  - =A – returns list order (V HV F P)
  - %A – returns all limits of all parameters in list in "min max step" order (e.g. 100 700 1 2000 5000 1 0 50.0 0.1 50 100000 1)

- .v – resets all values stored to EEPROM to default
- !fb – forbids EEPROM from writing
- .u – runs the bootloaders
  - a complete set of bootloader commands is available on request

Appendix 3. Parameter presets

Parameter	Minimum	Maximum	Increment	Default value
Output voltage, V	100	V_{MAX}	1	200
Pulse width, us	50	1000	1	200
Rep. rate, Hz	0 (single shot)	50	0.1	1
QBU pulse length, us	0 (disabled)	1000	1	200
QBU pulse delay, us	-1000	1000	1	0

All parameters are adjustable and can be re-set by the customer via software or RS-232 commands

Parameter	Default value	Parameter	Default value	Parameter	Default value
V_{MAX}, V	700	K0, $VA^{-1/2}$	10	Power limit, W	2000

All parameters are adjustable and can be re-set by the customer via software or RS-232 commands