EKSMA OPTICS

pMaster

Pulse Picker

User's manual

CONTENTS

1. GENERAL INFORMATION

1.1. SAFETY INSTRUCTIONS

1.1.1. General safety features

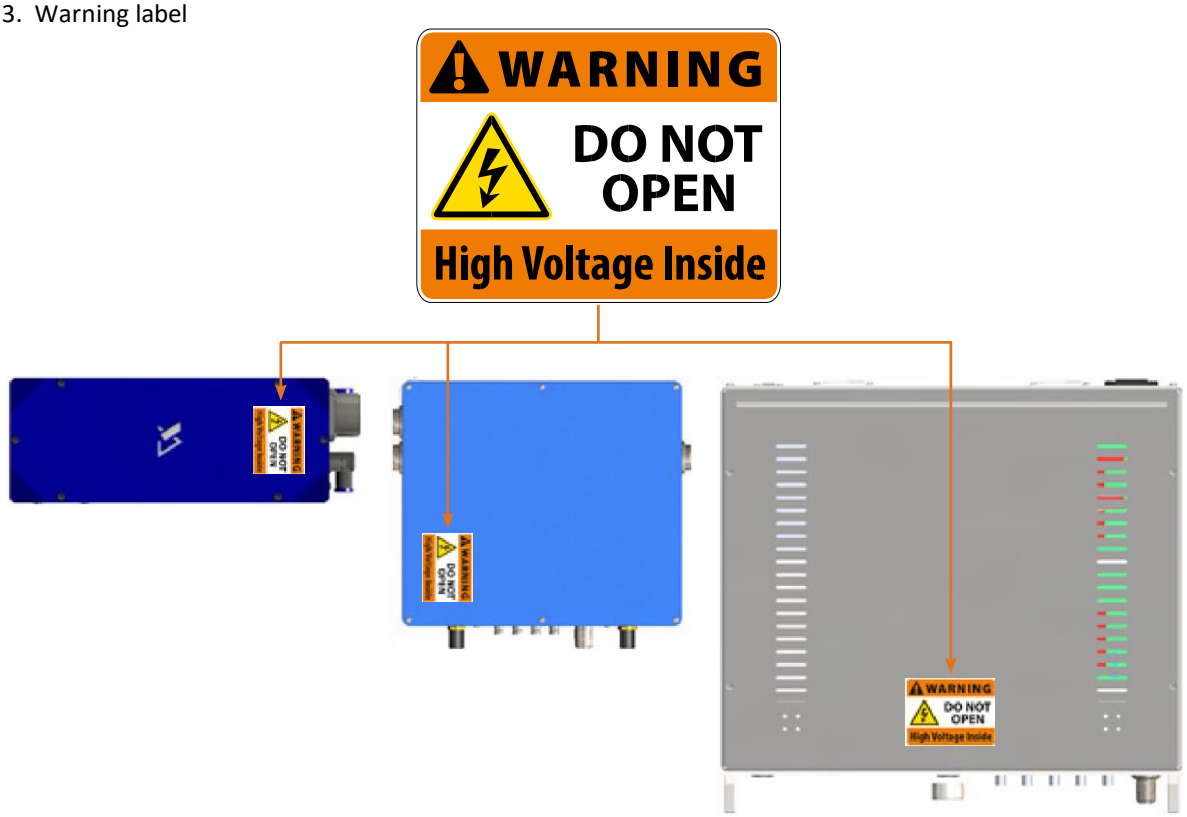
Safety labels are affixed near sensitive components of the pulse picker. Please make sure you have located those labels and follow the safety instructions.

Do not open covers of pMaster, MP1 or UP2 units. Warranty void if covers are removed without agreement from manufacturer. All service is done on manufacturer facilities.

Label 1. Identification label

Label 2. Aperture label

Label 3. Warning label



1.1.2. Laser safety

WARNING!
This equipment is used together with visible and invisible laser radiation. Eye or skin exposure to direct or scattered radiation can cause serious injuries including blindness.

The following is a partial list of precautions to follow when working with laser:

› Only authorized and trained personnel should be allowed to operate the laser related equipment.
› When operating laser equipment, all people within the laser room must wear protective eye-wear adapted to the emitted radiation wavelength.
› Never look directly into the laser beam. Even after secular or diffuse reflections a laser beam can cause serious injuries.
› Set up experiments so that the laser beam is either well above or well below eye level.
› Set up controlled access area for laser operation.
› Post clearly visible warning signs near the laser operation area.
› Block unused laser beams with absorbing, diffuse and fire-resistant targets.
› Whenever possible, work with high ambient light in order to keep eye pupils contracted.
› Make sure the laser beam is not accidentally pointed towards a reflecting surface.
› People working on the laser must avoid wearing reflective objects (wedding ring, watch, etc...)
› The reflections of the laser beam are generally in the plain of incidence of the laser and it is strongly recommended not to have the eyes in this plain.
› The interaction between a laser beam and certain classes of materials (flammable, explosives or volatile solvents) may be a source of fire. Do not use the laser in the presence of such materials.

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1.1.3. Electrical safety

WARNING!
High voltages used by this equipment are sources of serious hazards.

Some components used in the pulse picker are supplied with high voltage. These devices are protected with housings. Never remove the protection covers. Only an authorized and qualified person can manipulate these devices.
In order to ensure the safe operation and optimal performance of the product, please follow these warnings and cautions in addition to the other information contained elsewhere in this document.

› If possible, familiarize yourself with the equipment being used and the location of its high-voltage points.
› Turn off equipment while making test connections in high voltage circuits. After the power off please wait few seconds before making any connections, in order for capacitors to discharge.
› Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment. Make certain such surfaces are not damp or wet.
› Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contact with metal objects that could provide a good ground return path.
› **Make sure that instruments are properly grounded.**
› Before supplying the power to the instrument, make sure that the correct voltage of the AC power source is used.

1.2. IMPORTANT NOTES

› Do not connect oscilloscope or other device ground to any driver HV output connectors. It may damage the driver!
› Do not measure any driver electronics scheme by oscilloscope, especially when driver is running in pulsed regime. Measurement of some specific elements will get them damaged.
› Ensure that driver is turned on only with capacitance load (<6 pF) present, otherwise driver can be damaged.
› Driver output, which gives several kV with very fast edges, is a powerful source of EMI. Please take care about the right wiring and grounding to avoid problems caused by interference.

1.3. ACRONYMS AND ABBREVIATIONS

PC	–	Pockels cell	COM	–	Component Object Model
HV	–	High voltage	TTL	–	Transistor-transistor logic (5 V)
ETP	–	External trigger pulse	LCD	–	Liquid crystal display
USB	–	Universal serial bus	FAM	–	Fast amplitude modulator

2. GETTING STARTED

2.1. PRINCIPLES OF OPERATION

Pulse pickers are used to pick out single optical pulses of picosecond or femtosecond laser pulse from a sequence of pulses (pulse train) and for controlling femtosecond multi-pass and regenerative amplifiers. The UP2 pulse picker in setup with pMaster 4.2 generator is able to select pulses at up to 2 MHz rate from max 100 MHz repetition rate pulse train.

The pulse picker operation is based on the linear electro-optic effect (Pockels effect). An electro-optical crystal is placed between two crossed polarizers. Linearly polarized light passes through the first polarizer. When applying high voltage to the electro-optical crystal an induced birefringence occurs. When the birefringent phase difference reaches λ/2, polarization is rotated by 90° and linearly polarized light freely passes through the second polarizer. When no voltage is applied the polarization does not rotate and the second polarizer reflects the light (Figure 2.1.).

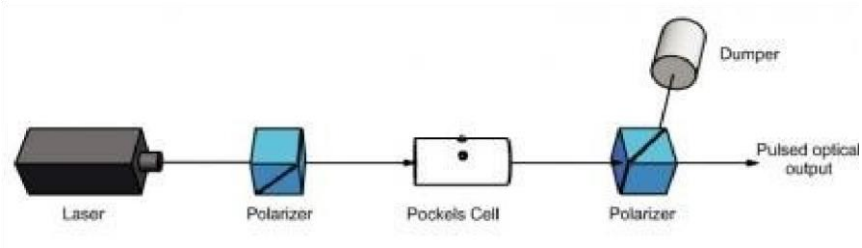

Figure 2.1. Principal operation scheme

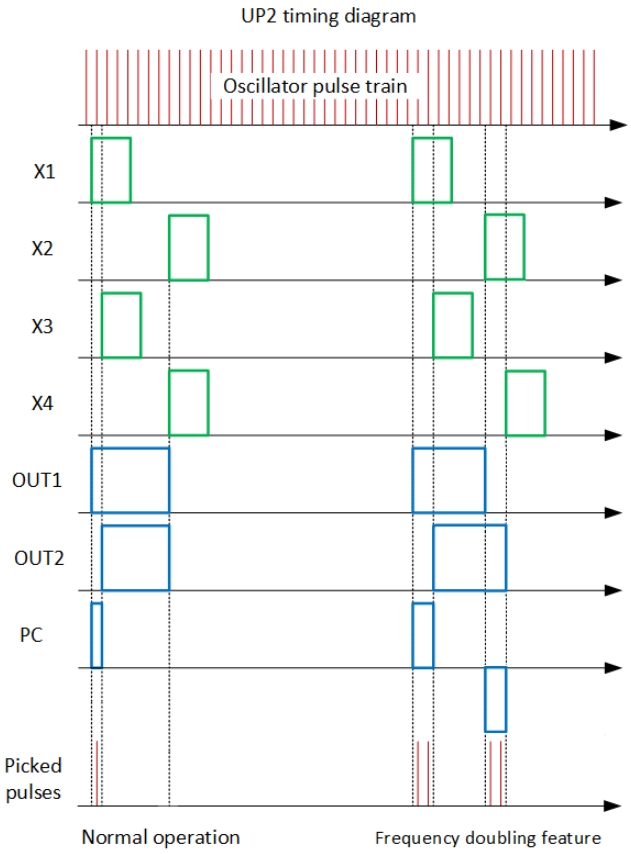

Figure 2.2. UP2 pulse picker timing diagram

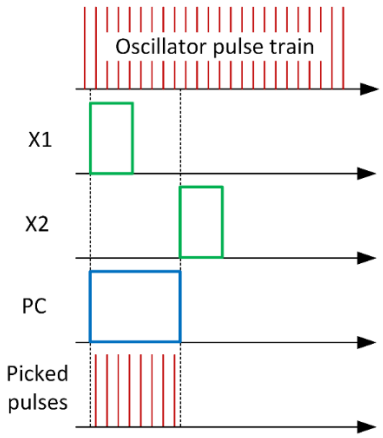

Figure 2.3. MP1 pulse picker timing diagram

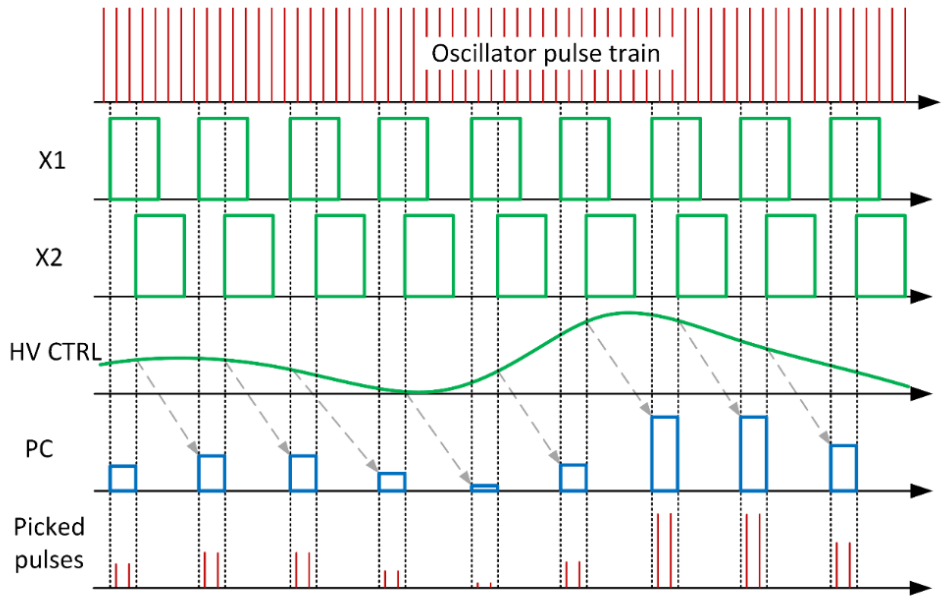

Figure 2.4. MP1 FAM pulse picker timing diagram

Oscillator's pulse train, converted to electrical signal, must be connected to CLK IN or SYNC IN inputs. X1, X2, X3, X4 are control signals supplied from pMaster to Pulse picker. PC – HV pulses supplied to the Pockels cell.

In the case of UP2 pulse picker (Figure 2.2) the OUT1 and OUT2 are Pockels cell driver outputs. The resulting HV pulse on the PC appears as a difference of these two outputs. Normal operation occurs when UP2 pulse picker operates at low repetition rate (<250 kHz). In this case, the delay between the rising edges of OUT1 and OUT2 controls the pulse duration of the PC. Falling edges of OUT1 and OUT2 occur at the same time which results in no pulse on the PC. Frequency doubling feature is automatically enabled when UP2 pulse picker operates at higher repetition rate (>250 kHz). In this case, the delay between the rising and falling edges of OUT1 and OUT2 controls the pulse duration of the PC. Enabling/disabling frequency doubling feature may cause a slight change in PC pulse delay and duration. A warning is displayed to indicate this.

When MP1 pulse picker is used (Figure 2.3), delay between the rising edges of X1 and X2 controls the pulse duration of the PC.

When MP1-FAM pulse picker is used (Figure 2.4), amplitude of PC is modulated using high voltage control (HV CTRL) input. HV CTRL input amplitude is readout at rising edge of X2 pulse and is used to set amplitude for next PC pulse which is started with rising edge of X1.

2.2. HARDWARE

2.2.1 pMaster description

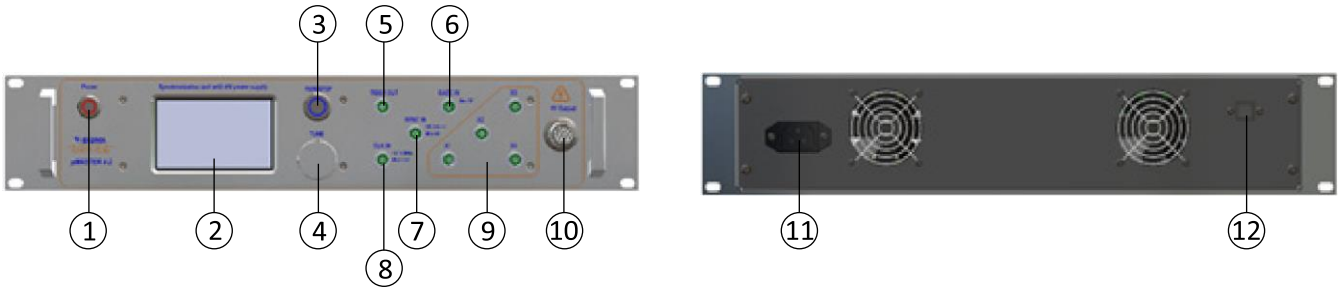

Figure 2.5. pMaster device

1. **POWER button.**
2. **LCD touch screen**: Used to display and change parameters.
3. **TUNE knob**: Used to adjust selected value from the touch screen.
4. **RUN/STOP button with LED**: Used to start or stop the propagation of pulses. LED indicates the status of pulse picker.
5. **TRIG1OUT**: General trigger output with configurable source. (4.5 V @ 50 Ω)
6. **GATE**: Configuration switch and burst control input. (LVTTL, tolerates 5 V. 0.2 mA pull down)
7. **SYNC IN**: Trigger input for DC to 20 MHz frequencies. (LVTTL, tolerates 5 V. 0.2 mA pull down)
8. **CLK IN**: Clock input for 10 MHz to 100 MHz frequencies.
   (0.5 V to 3.3 V @ 50 Ω pk-pk, sine or pulses)
9. **X1, X2, X3, X4**: Output channels to control the pulse picker.
10. **HV output**: HV output connection for the pulse picker.
11. AC power input connector.
12. USB connector.

2.2.2. UP2 description

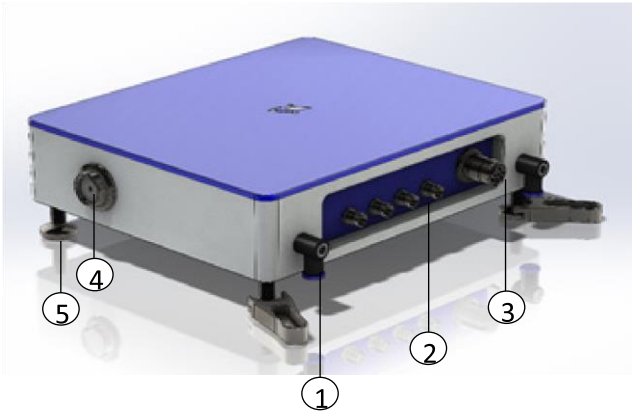

Figure 2.6. UP2 pulse picker device

1. **Water hose connection**: Device has to be actively cooled by external water-cooling unit. Water-cooling unit recommendations can be found in table 2.1.
2. **X1, X2, X3, X4**: Input channels from the pMaster.
3. **HV input**: HV input connection from the pMaster.
4. **Laser beam input/output**: External laser beam has to be aligned to pass from input to output of the pulse picker.
5. **Mounting posts**: Used to adjust the height of the device.

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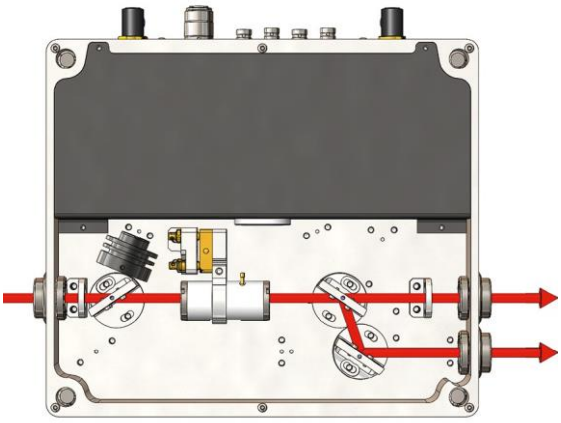


Figure 2.7. Single pass operation scheme inside UP2 device

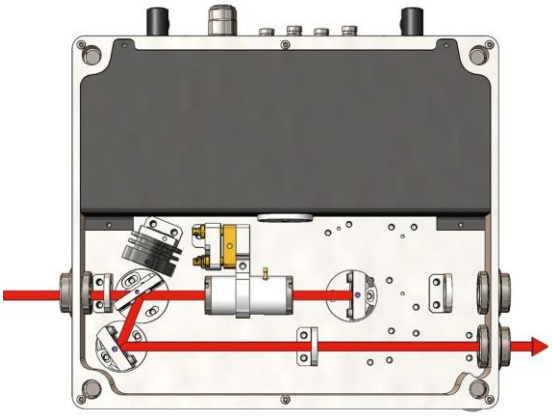


Figure 2.8. Double pass operation scheme inside UP2 device

2.2.3. MP1 description

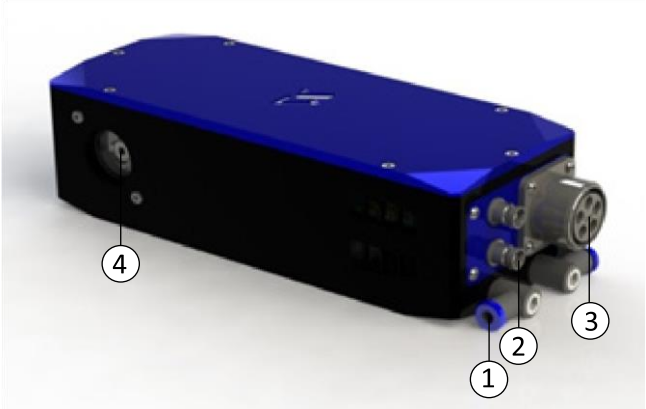


Figure 2.9. MP1 pulse picker device

1. **Water hose connection**: Device has to be actively cooled by external water-cooling unit. Water-cooling unit recommendations can be found in table 2.1.
2. **X1, X2**: Input channels from the pMaster.
3. **HV input**: HV input connection from the pMaster.
4. **Laser beam input/output**: External laser beam has to be aligned to pass from input to output of the pulse picker.

HV CTRL (FAM version only): Input used for modulation of HV pulse amplitude by external signal source. (0.1V to 4.9 V @ 50 Ω).

2.2.4. Connecting the pulse picker device

Before starting make sure that **ALL DEVICES ARE TURNED OFF AND UNPLUGGED** from external power sources. Connect pMaster 4.2 to UP2 or MP1 according to connection diagram below.

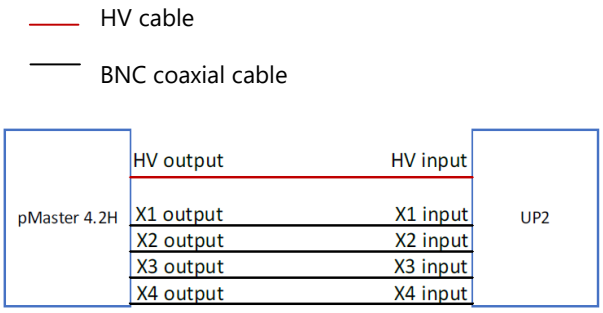


Figure 2.10. pMaster 4.2 to UP2 connection diagram

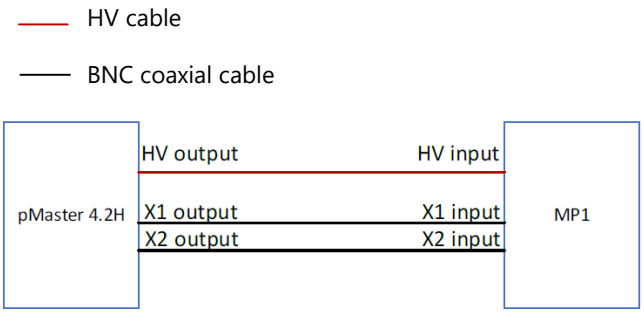


Figure 2.11. pMaster 4.2 to MP1 connection diagram

Connect external water-cooling unit. Water connections are push in fitting type. The direction of water flow is not important for cooling the pulse picker device. Recommendations for cooling unit are shown in the table below. **Pulse picker unit has an integrated over-temperature protection. LCD screen will inform if high voltage drivers heat-sink needs to be cooled. If heat-sink temperature reaches 35 deg, device will stop propagating pulses**.

Table 2.1. Recommendations for water-cooling unit

Heatsink temperature		< 35°C (95 °F)
Maximum coolant pump pressure		2 bar
Water flow capacity		>2 l/min
Tubing	Outside diameter	6 mm
	Inside diameter	4 mm

Connect IEC 230V AC cable to pMaster back side connection. Turn on pMaster device via "POWER" button.

2.3. POCKELS CELL ALIGNMENT

For MP1 pulse picker input polarization plane is preferred to be vertical or horizontal in relation with the Pockels cell holder (Figure 2.12). However, UP2 pulse picker input beam must be p-polarized (Figure 2.13). Polarization planes are displayed in red.

Figure 2.12. MP1 input polarization planes

Figure 2.13. UP2 input polarization planes

Pockels cell alignment is only required at the case of MP1. It is strongly recommended that the initial alignment of Pockels cell is done with a low power (0.5 to 2 mW) He-Ne laser to assist in visualizing beam position. If alignment is performed with an IR laser, the power of this laser must not exceed 5 mW. The objective is to center the laser beam in the device apertures and then generate an optical pattern which accurately locates the optical axis of the crystal with respect to the laser beam. This will probably require several adjustments of pitch, azimuth and translation to optimize the alignment but it will provide positive, visual confirmation of the alignment.

1. Position the He-Ne laser beam to go through the center of the apertures without touching the aperture edges.
2. Place a light-colored card in the path of the beam at a distance of about 8 to 12 inches from the exit aperture of the EOM. Mark the beam location on the card with a circle or dot and leave the card in place.
3. Place the input polarizer in the beam with its polarizing axis aligned horizontally. Place the output polarizer (analyzer) at the output side of the device and ensure that its polarizing axis is rotated 90° from that of the input polarizer.
4. Place the diffuser over the device's entrance aperture. A pattern (or some part of it) will be projected on the card. It is called an isogyre pattern as illustrated below. When the diffuser is in place, laser beam may become so diffused that the central spot may not be visible on the card. Do not move the card. It is usually safe to assume that the spot is really there, in its original position.

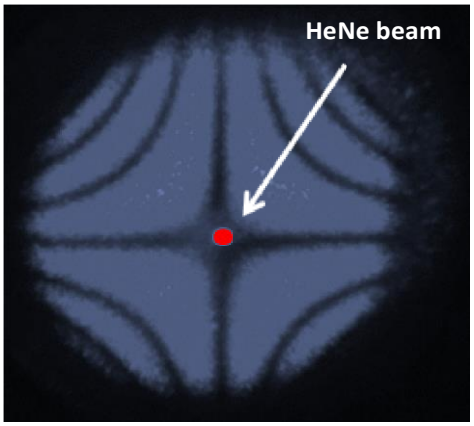


Figure 2.14. KTP crystals isogyre pattern

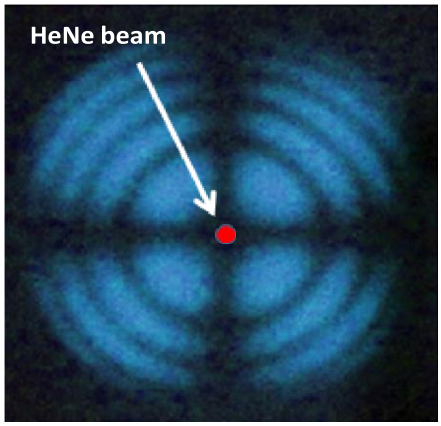


Figure 2.15. BBO and DKDP crystals isogyre pattern

An isogyre is a representation of direction through the crystal, not position on a surface. If the beam direction is not parallel (within a few degrees) to the optic axis, the beam will form incomplete distorted isogyre patterns. If the beam is parallel to the optic axis, the pattern will result when there is no voltage present.

If the optical axis of the crystal is not parallel to the path of the laser beam, the isogyre pattern will be off-center and the device must be moved in pitch and azimuth. If the isogyre is centered over the circle or dot in the card, it indicates that the device is well aligned i.e., the crystal optic axis is parallel to the laser beam.

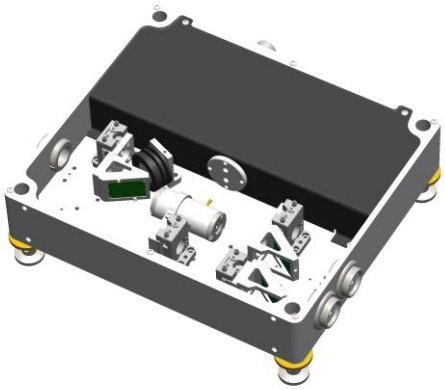
This alignment procedure works with all devices utilizing uniaxial crystals such as KDP, DKDP, lithium niobate, etc. It is also useful with crystals such as KTP, BBO and RTP.

The beam must propagate through both apertures without touching edges of apertures and with adequate clearance. If it does not, employ horizontal and vertical translation until clearance is confirmed. If the figure is not in the form of a cross, then the polarizers are not rotationally aligned to the faceplate mark or at 90˚ to each other. After the cross of the isogyre is centered, polarizers can be slightly rotated to maximize the darkness of the center of the cross. Once this is done, the device is not only aligned with the laser beam, it is also nulled in respect to the crossed polarizers for best contrast ratio and is ready for operation. When the modulator is in actual use, very fine adjustments of the pitch and azimuth controls can further optimize performance.

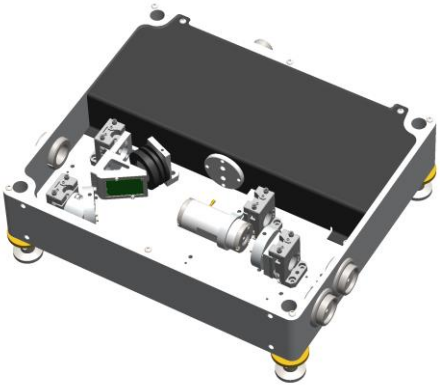
2.4. PULSE PICKER TFP ASSEMBLY

Configurations of pulse picker:

Single pass

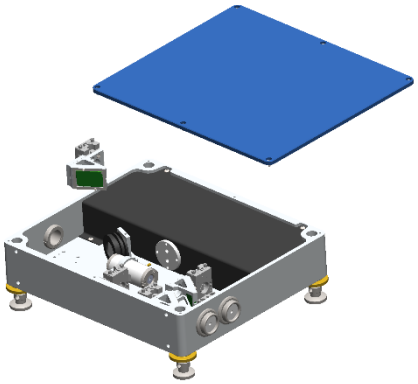


Double pass



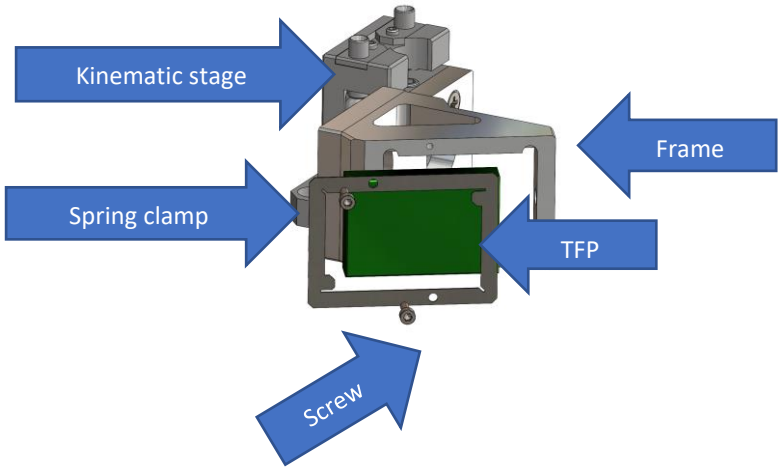
Step 1. Removing TFP holder

- Take off blue cover
- Unscrew TFP holders' screws



Step 2. Remove screws and clamps

- Remove screws and clamp
- Replace TFP
- Put spring clamp on the holder



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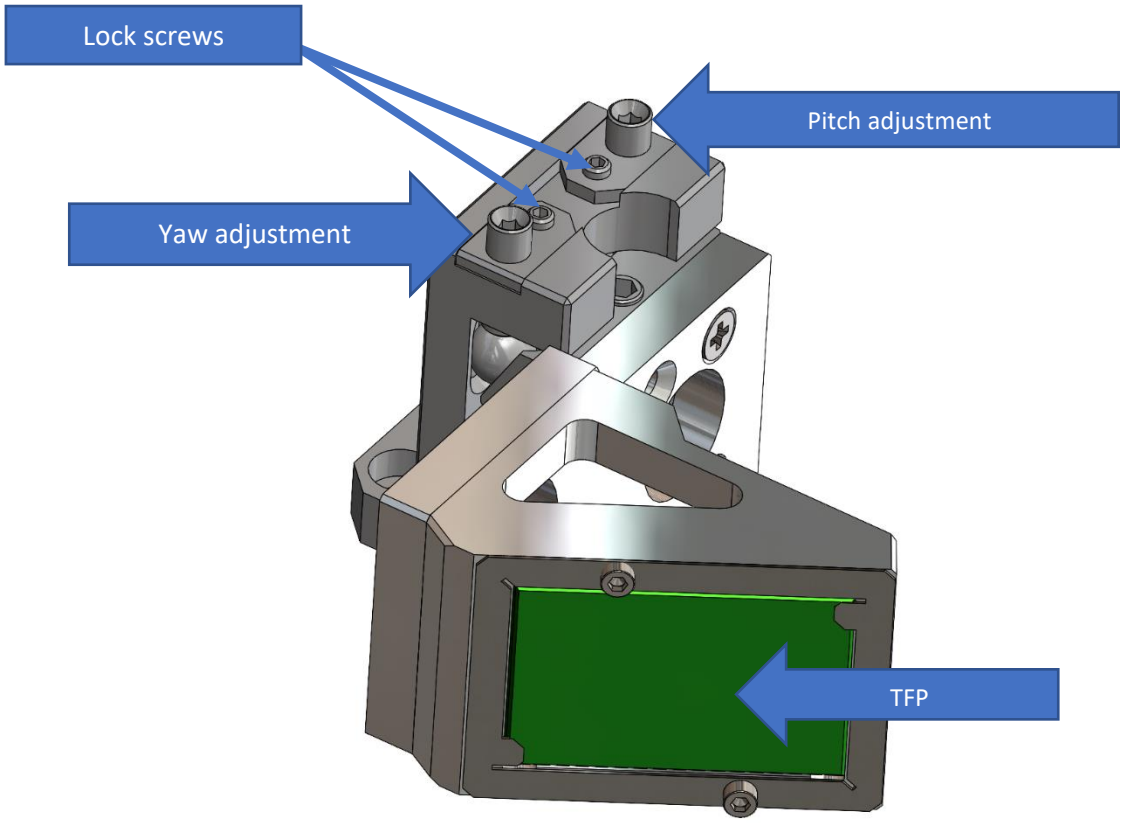
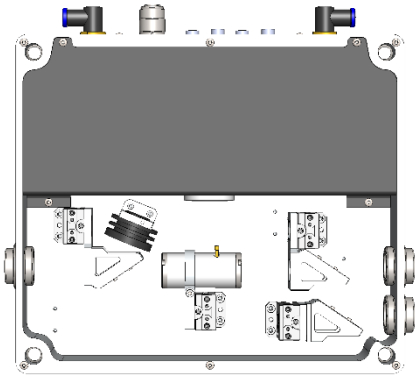


TFP holder

Adjustment of pulse picker

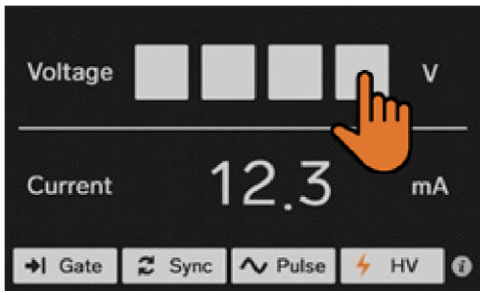
- Adjust optical components according by output signals
- Kinematic stages of Pockels cell, mirrors are the same like TFP holder. Adjustment screws are reached from the top of device
- Lock screws when the best performance is reached
- Close the box

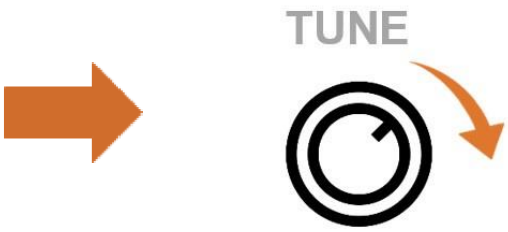


2.5. USER INTERFACE

2.5.1. Interfacing the device

Interfacing the device is done via LCD touch screen and encoder knob. In order to change the numeric value in the interface:





ADJUST SELECTED VALUE

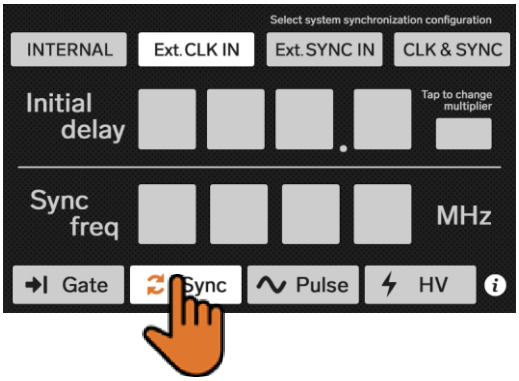
Repetition rate and voltage values are set after value deselection. Deselection is done by taping the screen or not changing the value for 6 seconds. Only exception is the initial delay and pulse width. They are set once changed.

SINGLE TAP TO CHANGE MULTIPLIER

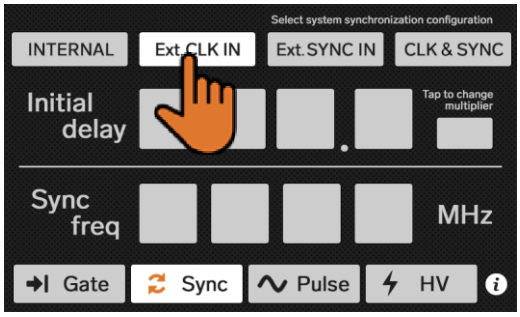
In order to change the multiplier single tap is required:

2.5.2. Synchronization

Interfacing the device is done via LCD touch screen and encoder knob. In order to change the numeric value in the interface:



TAP ON SYNC TAB TO CHECK THE CURRENT SYNCHRONIZATION METHOD

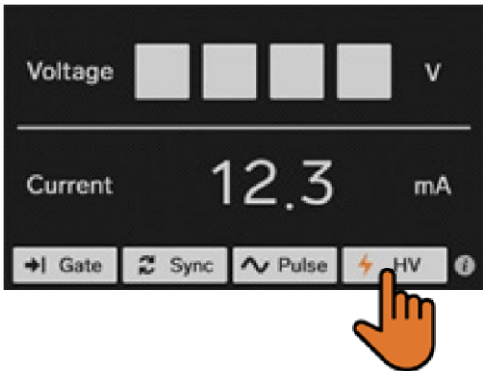


TAP TO SELECT ONE OF FOUR SYNCHRONIZATION METHODS

External synchronization methods require to connect external signal source to CLK IN or SYNC IN inputs of pMaster device (see 2.2.1). External signal frequency must be entered in Sync freq field. Internal delay can be adjusted if HV pulse is out of phase with the synchronization source. When CLK & SYNC is selected system is triggered via SYNC IN and re-clocked to external clock (supplied to CLK IN). This mode is used when output pulses with stable phase relations with respect to the external clock is required.
Note: once synchronization source is taped repetition rate and pulse width in pulse tab values will reset.

2.5.3. High voltage pulse amplitude

High voltage pulse amplitude which is supplied to the Pockels cell can be set in HV tab. Voltage edit feature is disabled in FAM version.

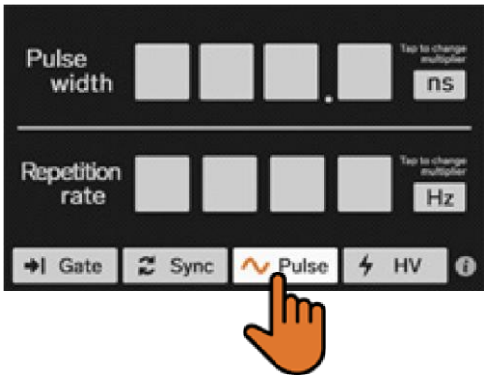


TAP ON HV TAB TO CHECK THE VOLTAGE AND CURRENT SUPPLIED TO THE POCKELS CELL

Realtime voltage is shown when digits are not selected. Once voltage digit is selected, required voltage can be entered.

2.5.4. High voltage pulse width and repetition rate

High voltage pulse width and repetition rate which is supplied to the Pockels cell can be set in Pulse tab.



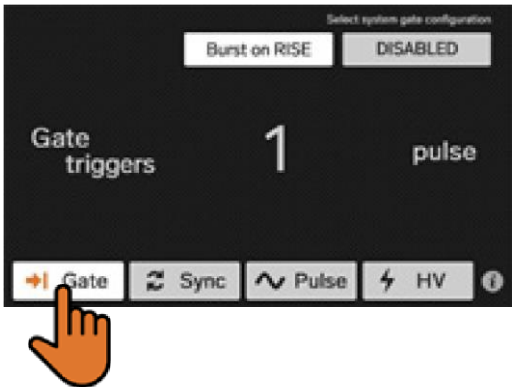
TAP ON PULSE TAB TO CHECK THE PULSE WIDTH AND REPETITION RATE

Minimal and maximal values of pulse width and repetition rate are limited by the high voltage driver. If limit is reached it is shown in info tab as a warning.

Note: repetition rate is set after deselection of the value (see 2.4.1), while pulse width is set in real time.

2.5.5. Gating

Gating options can be set in Gate tab.



TAP ON GATE TAB TO CHECK THE GATE FUNCTIONS

Gate can be disabled or enabled to trigger single burst on Gate rise. More details on Gate input parameters can be found in chapter 2.2.1.

Gate timing diagrams for different configurations is given below. Gate pulse can be asynchronous in the case when burst on RISE option is selected (PC pulse will be synchronized with oscillator pulse train).

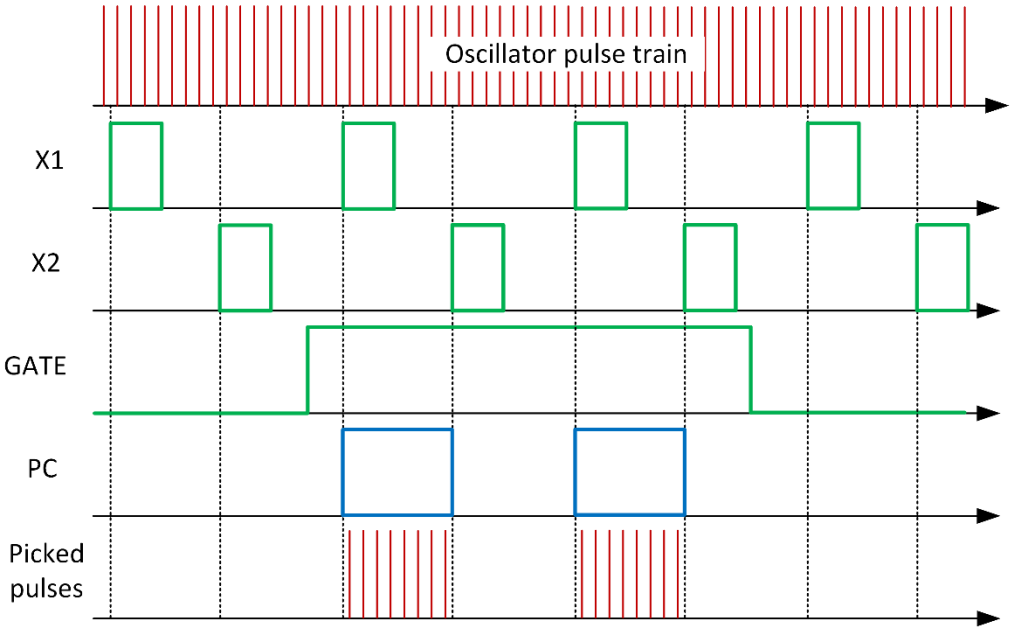


Figure 2.16. Gate enabled

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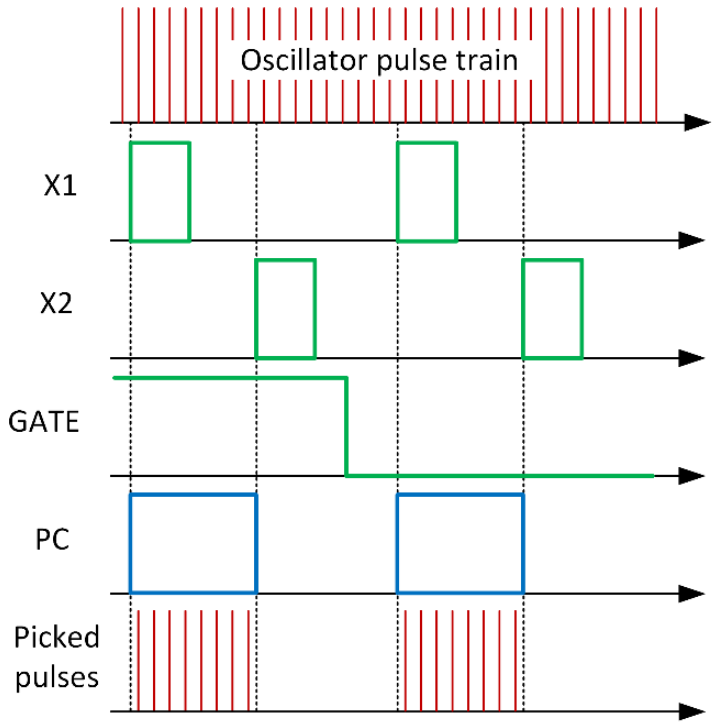


Figure 2.17. Gate disabled

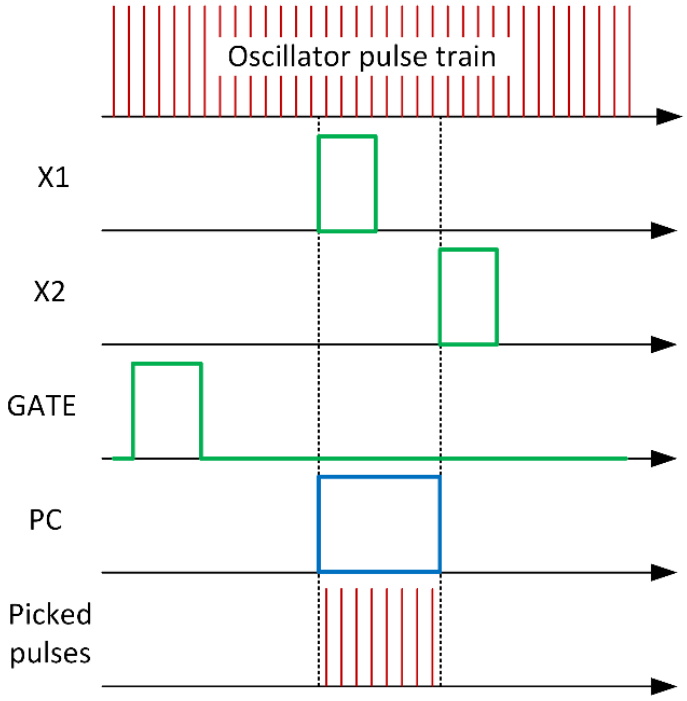
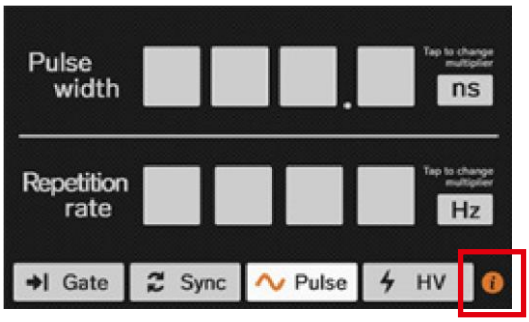


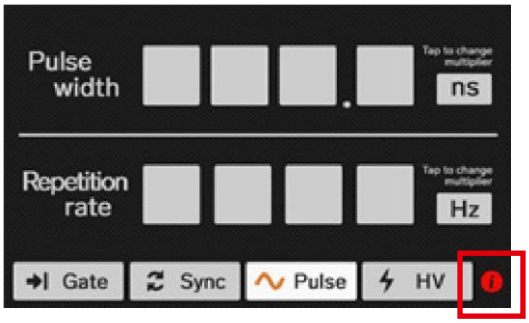
Figure 2.18. Gate burst on rise

2.5.6. Warnings and errors

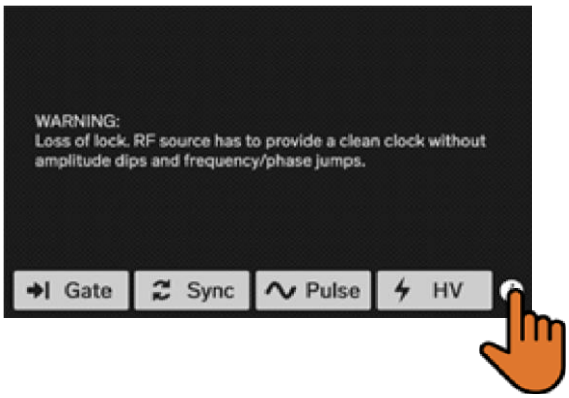
If error occurs it is displayed in info symbol in bottom right corner.



WARNING



ERROR



Error/warning details can be found in info tab.

TAP ON INFO SIMBOL TO SEE DETAILED WARNING/ERROR INFORMATION

2.5.7. Running and stopping the Pulse Picker

Push RUN/STOP button to start or stop the propagation of high voltage pulses to the Pockels cell.

RUN/STOP

TURN ON

RUN/STOP

TURN OFF

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3. SYSTEM SUMMARY

3.1. TECHNICAL SPECIFICATIONS

Table 3.1. Pulse Picker specifications

pMaster 4.2 specifications
Control modes: Internal Pulse Generator, External trigger, External RF source

INTERNAL PULSE GENERATOR	
Operation modes	Single shot, burst, normal
Delay range	1.1 nanoseconds to 140 milliseconds
Resolution	100 ps
Accuracy	25 ps + 0.000001 x delay
Time base	100 MHz, 0.2 ppm
RMS jitter	< 100 ps
Channel to channel jitter	< 30 ps

INTERNAL PULSE GENERATOR		
External trigger, SYNC IN input		
Rate		1 Hz to 20 MHz
Min pulse width		10 ns
Threshold		1.3 V
Input level		LVTTL, tolerates 5V
Impedance		0.2 mA pulldown
Slope		rising
RMS jitter	Direct SYNC IN	< 120 ps
	SYNC IN re-clocked	< 5 ns
Insertion delay		< 80 ns
External RF source, CLK IN input		
Rate		10 MHz to 100 MHz
Min pulse width		300 ps
Input level		0.5 V to 3.3 V
Impedance		50 Ω

GATE INPUT	
Min pulse width	20 ns
Input level	LVTTL, tolerates 5V
Impedance	0.2 mA pulldown

OUTPUTS	
Output level	4.5 V
Output impedance	50 Ω

COMMUNICATION, POWERING AND PHYSICAL SPECIFICATIONS	
Communication	USB
Power	230 V AC 50 Hz or 110 V AC 60 Hz
Dimensions	482 x 387 x 88 mm
Weight Neto, including standard 2 m power cable and 1.5 m HV cable	~6.6 kg

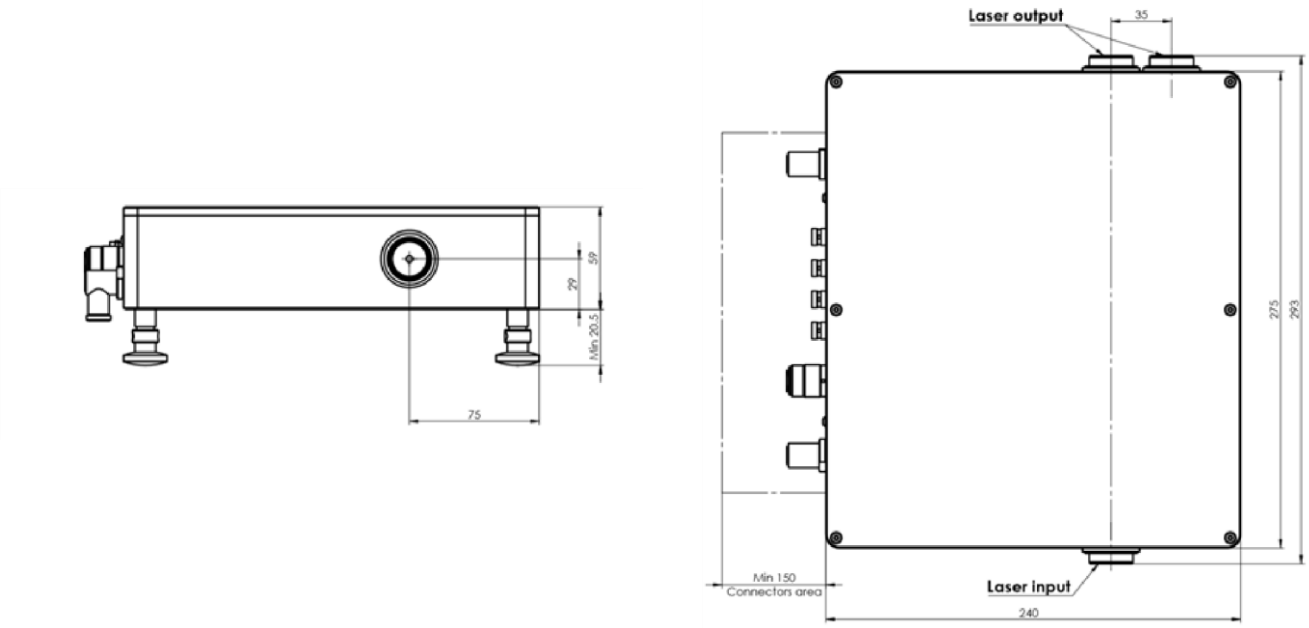

Figure 3.1. UP2 outside dimensions

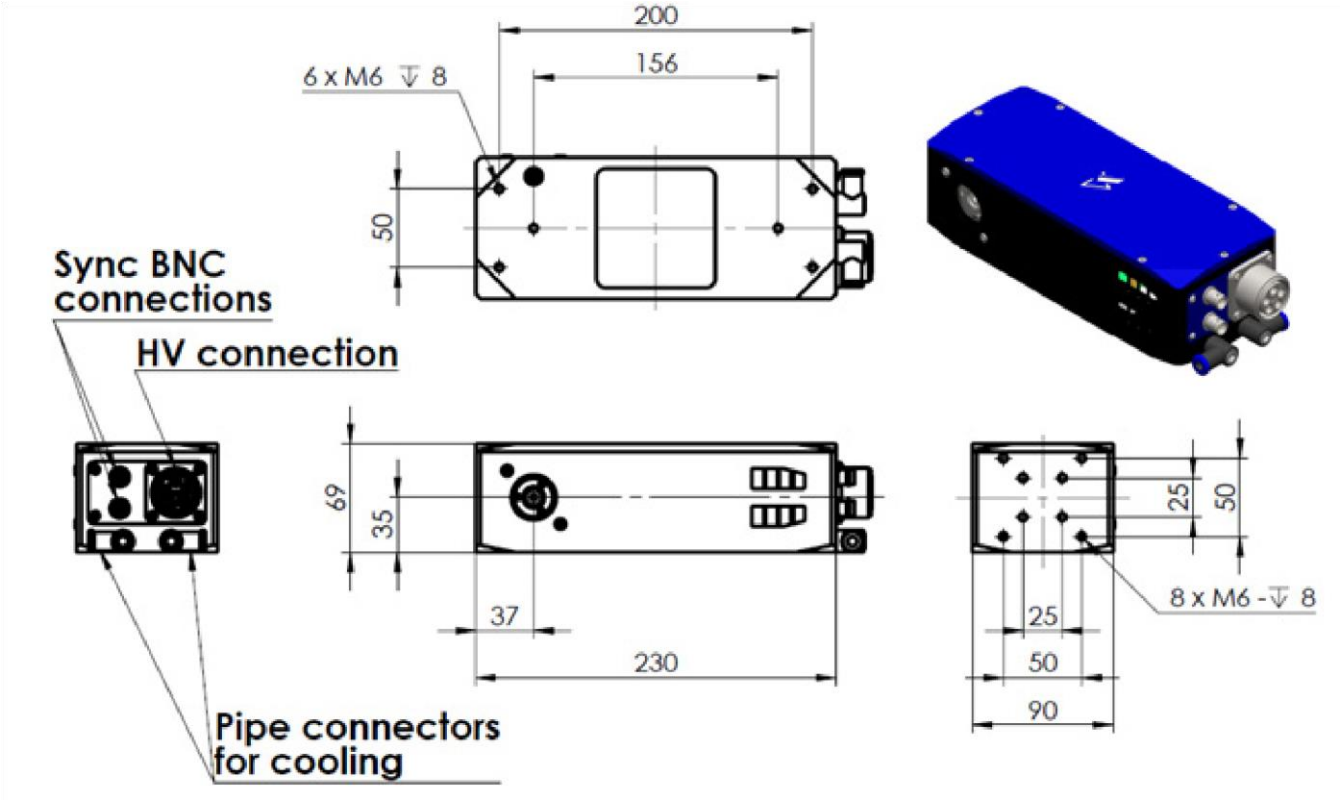

Figure 3.2. MP1 outside dimensions

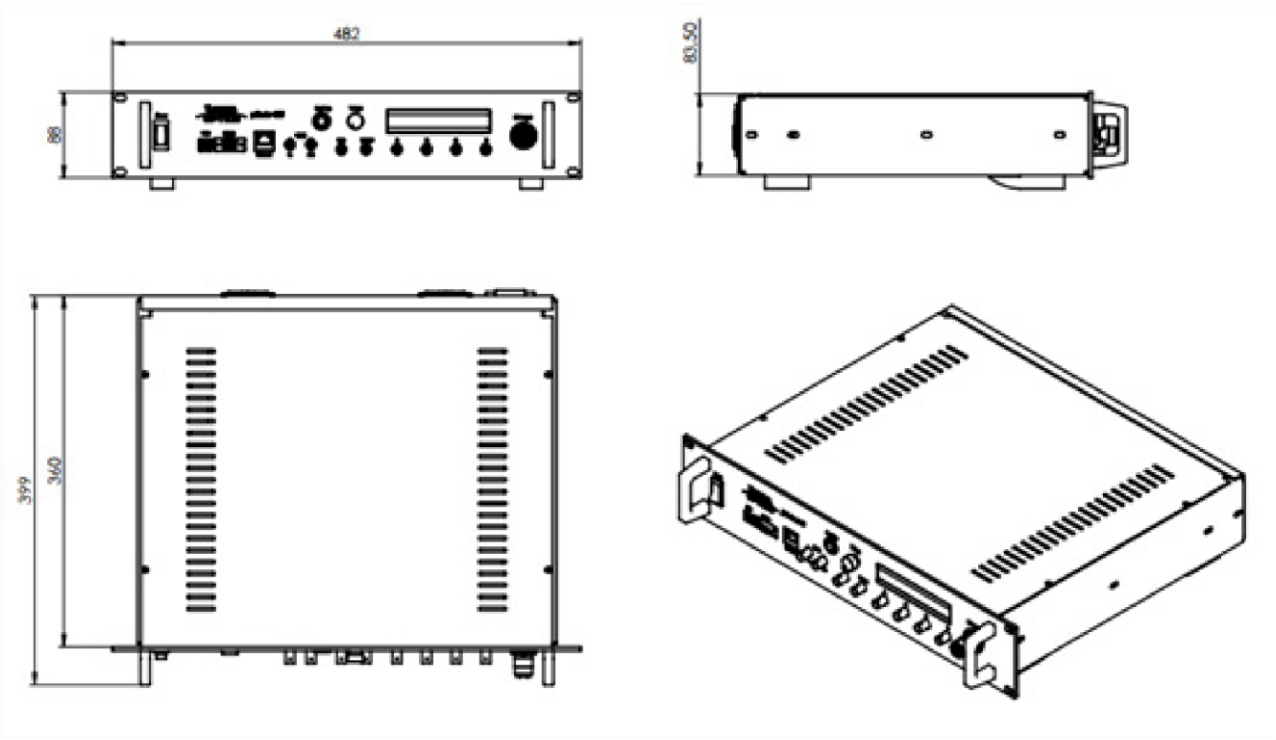

Figure 3.3. pMaster 4.2 outside dimensions

3.2. SHUTTING DOWN

In order to stop the Pulse Picker device, make sure that output pulses are not generated (RUN/STOP buttons led indicator is off). Pulse Picker device will turn off if the POWER button is pressed.

WARNING

Do not unplug any connections from pMaster or MP1 / UP2 devices while device is in operation. It may damage the device.

3.3. ENVIROMENTAL AND ENDURANCE CONDITIONS

Operating temperature: from +15°C up to +35°C (indoor use only);

Recommended transportation temperature: from -15°C up to +50°C;

Long term storage: in original packing 20°C ±10°C;

Altitude: up to 2000 m (indoor use only);

Maximum relative humidity: 80% non-condensing for temperatures up to +31°C decreasing linearly to 50% relative humidity at +35°C;

POLLUTION degree 1: no POLLUTION or only dry, non-conductive POLLUTION occurs.

3.4. WARRANTY

Models pMaster 4.2 and UP2 and MP1 are protected by one-year warranty covering labor and parts. The warranty enters into validity since the shipment date. Any evidence of improper use or unauthorized attempts at repair leads to warranty cancellation.

3.5. SERVICE CONTACT INFORMATION

In case of service required or any questions on warranty, please notify:

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