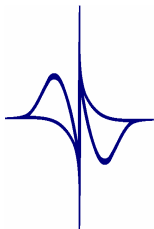


# Pulse Picker

## MODEL OG8-25

### MANUAL

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Please take time to read and understand this Manual and familiarize yourself with the information that we have compiled for you before you use the product. This Manual should stay with the product to provide you and all future users and owners of the product with important operating, safety and other information.



**Do not open the Pockels cell and control unit devices. There are no user serviceable parts, equipment or assemblies associated with this product. All service and maintenance will be performed only at the factory.**

# GENERAL SAFETY INSTRUCTIONS

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.

**WARNING:** Make sure this instrument is properly grounded through the protective conductor of the AC power cable. Any interruption of the protective grounding conductor from the protective earth terminal can result in personal injury.

**CAUTION:** Before supplying the power to the instrument, make sure that the correct voltage of the AC or DC power source is used (*see paragraph 5 Performance characteristics*). Failure to use the correct voltage could cause damage to the instrument.

**WARNING:** *Do not open the Pockels cell and control unit devices. No operator serviceable parts inside. Refer all servicing to qualified AVESTA Project Ltd. personnel. To prevent electrical shock, do not remove covers (because hi-voltage - ~ 8-12kV). Any tampering with the product will void the warranty.*

**WARNING:** For continued protection against fire hazard, replace the line fuses with only the same types and ratings. The use of other fuses or material is prohibited.

**WARNING:** If this instrument is used in a manner not specified in this document, the protection provided by the instrument may be impaired. This product must be used only in normal conditions.

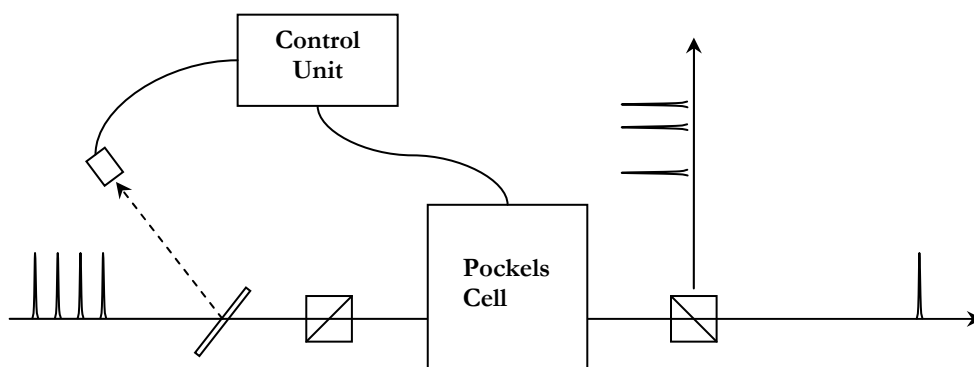
# TABLE OF CONTENTS

1.	<a href="#"><u>PRINCIPLES OF OPERATION</u></a>	4
2.	<a href="#"><u>ACCESSORIES</u></a>	5
3.	<a href="#"><u>CONTROLLING THE POCKELS CELL</u></a>	6
4.	<a href="#"><u>CONTROL UNIT - GENERAL DESCRIPTION</u></a>	7
5.	<a href="#"><u>PERFORMANCE CHARACTERISTICS</u></a>	9
6.	<a href="#"><u>DEVICE CONTROL</u></a>	11
6.1	<a href="#"><u>EXECUTABLE STRINGS IN MENU</u></a>	11
6.2	<a href="#"><u>LED DESCRIPTION</u></a>	12
6.3	<a href="#"><u>MENU DESCRIPTION</u></a>	12
7.	<a href="#"><u>ALIGNMENT</u></a>	19
7.1	<a href="#"><u>PULSE PICKER ALIGNMENT</u></a>	19
7.1.1	<a href="#"><u>OPTICAL PART OF PULSE PICKER ALIGNMENT</u></a> <a href="#"><u>(<math>\lambda/2</math> setup)</u></a>	20
7.1.2	<a href="#"><u>OPTICAL PART OF PULSE PICKER ALIGNMENT</u></a> <a href="#"><u>(<math>\lambda/4</math> setup)</u></a>	22
7.2	<a href="#"><u>ELECTRICAL PART OF PULSE PICKER ALIGNMENT</u></a>	24

# 1. Principles of operation

A Pulse Picker (PP) is used to pick out single optical pulses of picosecond or femtosecond duration from a sequence of pulses and for controlling femtosecond multipass and regenerative amplifiers.

The pulse picker operation is based on the linear electrooptic effect (Pockels effect). An electro-optical crystal (DKDP) is placed between two polarizers oriented at a  $90^\circ$  angle to one another (*see fig. 1*). Linearly polarized light passes through the first polarizer (Glan Prism). By applying a high voltage ( $\sim 10$  kV) to the electro-optical crystal an induced birefringence occurs. When the birefringent phase difference reaches  $\lambda/2$ , polarization is rotated by  $90^\circ$  and linearly polarized light freely passes through the second polarizer (Glan Prism). When no voltage is applied the polarization does not rotate and the second polarizer reflects the light.



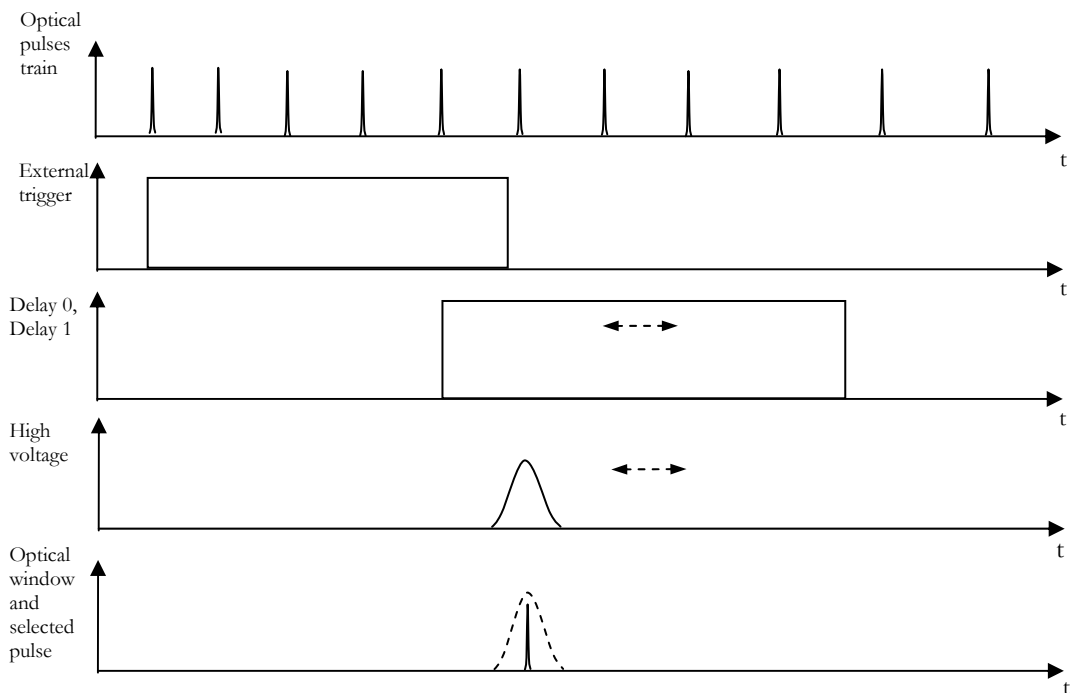
*Figure 1. Pulse Picker Operation Scheme*

## 2. Accessories

Part	Quantity	Note
Pockels Cell	1	DKDP crystal with shutter drivers
Control Unit	1	DC power supply for shutter drivers with front display and control electronics
Connection cable	1	Cable for connecting the Pockels cell to the Control Unit
AC power cord	1	For connecting the Control Unit to 110..127/220..240V AC power source
Glass fiber	1	For use with the Control Unit
Glan Prism (ARC 800, 1064, 1560 nm)	2	For polarization of light
Retarder ( $\lambda/2$ ) (ARC 800 nm) (optional)	1	For rotation of plane-of-polarization
Mounting Post-Holder MPH (with holder-adapter for retarder, optional)	1	For mounting the Glan Prism and retarder
Mounting Post-Holder MPH	1	For mounting the Glan Prism
Mirror (R>99.8%, 1510-1610 nm)	1	For reflection light
Mirror Mount MMM-B	1	For mounting the mirror
Manual	1	This Document

### 3. Controlling the Pockels cell

High voltage pulses (duration  $\sim 8$  ns at level 0.1 of maximum) are generated by a high voltage power unit driven by the control unit. The control unit should have the following signals to generate the high-voltage pulse (*see fig. 2*): «External trigger» – system triggering signal and high-frequency optical signal - «Optical» - to lock the Pockels cell opening moment with the optical pulses. The cell opening moment is determined by the signals «Delay 0» and «Delay 1» corresponding to channels «A» and «B».



*Figure 2. Pulse picking timing.*

## 4. Control unit – general description

Control unit provides four pulses with precise delay and one dedicated pulse for pump laser triggering that can be synchronised with various signals. Each delay channel consists of 12-bit digital delay with 50MHz clock frequency and approximately 40ns range continuous delay. 50MHz delay oscillator is phase-triggered, so that is no one period jitter occurs. Besides delay channels, the apparatus contains two 12-bit frequency dividers with prescalers and starter control.

The triggering signals for delay start can be chosen from two external inputs (TTL and wide range adjustable) and frequency dividers. This triggering signal can be synchronized with optical signal (built-in Si or InGaAs sensor with fiber-optic input), or one of two external sources of RF, internal 100MHz crystal or stay unsynchronised. **After synchronisation a “Pump start” pulse with fixed 5µs duration is formed.** The front of this pulse can be precisely delayed up to 40ns to match pump optical pulse with femtosecond train. Then, after an additional digital delay, all four delay channels start. To simplify the apparatus usage with acousto-optic Q-switched lasers with large and, probably, unstable delay between trigger and optical pulses delay auto-compensation can be used. Delays are functioning in five modes: free running, skipped, enabled, single shot asynchronous and single shot synchronous. In the free running mode every triggering pulse cause delay output pulses at every channels, except frequency overrun protection takes place. If the time between two triggering pulses is less then admissible, the second pulse is ignored. In skipped mode some channels acts every time, and some – only after skipping signal edge takes place at the nearest subsequent triggering pulse. Enabled mode is like skipped one, but output pulses are present if skipping signal has high level. In the single shot asynchronous mode delay output pulses appears at the nearest subsequent to single shot command triggering pulse. The command can be given from on-screen menu, from external button (optional) or trough RS-232C interface. Single shot synchronous mode in contrast to asynchronous one gives output pulses only after first skipping signal following to single shot command. Any delay channel can be separately turned into both skipped (behaviour according to mode) and unskipped mode (output pulse at every triggering pulse). Control unit have a possibility to produce output pulse bursts with controlled length at every skipping signal edge or single pulse command. This option is available only in skipped and single pulse modes.



The output of first three delay channels can be used to start high-voltage switches (cell drivers). All delay outputs and some other signals are available on six TTL outputs: three with 50 $\Omega$  load capability on the front panel and three on "Expansion" socket. Signal can be selected independently for any of six TTL outputs. The apparatus provides up to three (depends on request) adjustable voltages for cell driver's supplies.

All device parameters are controlled with one tuning knob. Parameter selection and adjustment is accomplished with a set of menus on internal LCD display. Also, all tunings can be made from personal computer through RS-232C interface. Device configuration can be stored in one of four non-volatile memory blocks. Configuration is automatically loaded from memory block 0 during start-up and automatically saved in this block on shutdown, so it is default configuration. Other memory blocks can be accessed manually through on-screen menu.

Proper accuracy and range of delay values and output supply voltages are provided digitally by appropriate coefficients and limits. Recalibration can be done in any time with corresponding PC software utility and proper measuring instruments. Calibration is stored in non-volatile memory.

Main portion of the apparatus is realised in programmable logic device (FPGA) that is configured from microcontroller program memory at start-up. Microcontroller software can be updated at any time through RS-232 interface. So, apparatus functions can be adopted flexibly to a wide set of tasks.

## 5. Performance characteristics

<b>RF external BNC input</b>	
Frequency range	30...250MHz
Level	30...600mV RMS @50Ohm (60mV min over 150MHz)
<b>RF external DB input</b>	
Frequency range	0...130MHz
Level	TTL @18kOhm/10pF
<b>Optical input (fiber-coupled)</b>	
Wavelength range	500...1650nm with Ge detector (50um glass fiber)
Frequency range	10...150MHz
<b>Trigger external BNC input</b>	
Level	0.2...30V, positive and negative, adjustable
Input coupling	DC and AC
Input impedance	25kOhm/2.2kOhm/50Ohm
Minimal pulse duration	20ns
Slew rate, not less then	1V/us (1:1 mode) 10V/us (1:10 mode)
<b>Trigger external DB input</b>	
Level	TTL
Input impedance	18kOhm / 10pF
Minimal pulse duration	10ns
Maximal edge duration	100ns
<b>Delay channels</b>	
Number of delay channels	4
Delay range	40ns...80us (from "Delay start" to delay output pulses)
Delay step	<20ps
Delay instability	2*10e-4*Delay+0.3ns (After 10 minutes of operation)
Jitter	less then 60ps+10ps/(every 1us delay) RMS
Output pulse duration	1.3us
Frequency overrun protection	50Hz-50kHz (depends on HV keys type)
Delay start from:	External trigger (both BNC and DB), frequency dividers
Delay RF synchronization:	External RF (both BNC and DB), optical input, internal 100MHz crystal and without synchronization.
<b>Pump start</b>	
Pulse width	5us
Fine delay	0..40ns
Delay from "Pump start" to delay channels start	20ns..40us in 10ns steps or 2..4095 periods of RF signal (depends on operating mode)
Delay between pump optical pulse and "Pump start"	-1.28us..+1.27us in 10ns steps or -128..+127 periods of RF signal (depends on mode)
Pump laser delay compensation modes	no compensation, manual compensation, auto-compensation (with additional photosensor)
<b>Frequency dividers</b>	
Divisor value	2...4096
Prescaler divisor value	16/256/4096
Input frequency range	0...180MHz (without prescaler)/ 0...250MHz (with prescaler)
Signal to divide:	External RF and trigger (both BNC and DB), optical input, internal 100MHz crystal

**Output pulses at "Out 1" – "Out 3" (front panel, BNC):**

Amplitude	4.3...5V @ 50Ohm
Edge duration	<3ns
Frequency range	0..130MHz
Available signals:	All delay outputs, pump start, frequency divider outputs, delay start, phase-triggered 50MHz oscillator, all external RF and trigger signals, optical inputs (digital)
Signal selection	Any signal from set, independent at any output.

**Shutter drivers power supply**

Voltage range	up to 270 V
Maximal output current	160mA
Overload protection	Yes

**Power consumption** < 150 W

**Power circuit voltage** 85-230V AC / 110-320V DC

**Dimensions** 482x250x88 (19" 2U case)



*Figure 3.1. Photo of front and rear panel of control unit*

## 6. DEVICE CONTROL

Almost all device settings are controlled with one knob. One can select parameter of interest with the help of hierarchical menus, which appears at LCD display. To choose desired item one must set cursor (black triangle at the left of the screen) at it and push the knob. Menu can be larger than the screen size, scroll bar at the right of the screen shows the proportion between visible and full size of menu and visible part position. Menu header is always at the top of the screen. When cursor is at the last menu item it can jump to the first item, and similarly at the first item, i.e. every menu have ring structure. There are two kinds of strings in menu: executable and non-executable. Cursor stops only at executable strings.

### 6.1. EXECUTABLE STRINGS IN MENU

Each executable string can be of following five types.

**Menu.** Choosing of menu will cause the appearance of new menu. The string that was selected is now menu header.

**Command.** Choosing of command will cause some action, may be without any visible results (for example saving settings in non-volatile memory). The particular kind of command is "UpDir", which is the first item in all menus, except the main one. This command returns the previous menu to the screen.

**Two position switch.** After choosing of this item, it will be marked with a tick that indicates alternative state of a switch (string can also be changed). To return to initial state choose this item once more.

**Multiple-position switch.** After choosing of this item cursor goes one position right, what means switch modification mode. Now, knob rotation causes changing of the string without cursor movement, i.e. changing of switch position. New selection actually comes into effect only after leaving modification mode. To leave this mode push the knob.

**Parameter.** This type is just like previous one. To change parameter value one must choose it, then modify it and push the knob once more to leave modification mode. In fact, all parameters in microcontroller systems are discontinuous, so parameter is changed by steps. To change it by the least steps rotate the knob slowly and carefully. When the knob speed increases, each knob (encoder) step causes multiple parameter steps to make large changes more convenient. Maximal speed is reached at approximately 2 revolves per second, faster knob rotation can even cause some decrease of parameter speed due to software filtering.

## 6.2. LED DESCRIPTION

Four LED at the left of front panel are used for fast system diagnostics. More detailed description of their meaning is given below.

**“Synchronization”** – This LED is green when synchronization is OK. Orange means that synchronisation signal is present, but unstable, red – synchronization signal takes place from time to time. No illumination means no signal. This LED represents only the state of signal, which is chosen for delay start time reference. Other RF signals are not taken into account, but can be used (for example for frequency dividing).

**“Triggering”** – Orange means that new triggering signal came before time-out period passed, i.e. triggering frequency is too high or triggering pulse edges are improper. Green means OK, no illumination means no signal.

**“Pulses”** – Indicates with green illumination the presence of delayed pulses, availability of both synchronization and triggering signals is necessary. Orange means that some delay channels gives no pulses, this can occur in following cases. 1<sup>st</sup> -during fine sweep re-calibration reference voltage is over the limit, so delay channel produce no pulses. 2<sup>nd</sup> -in single shot and thinned modes selected channels produces pulses not after every triggering, but under special conditions. Red means no output pulses.

**“Power”** – Green means, that at least one HV power supply is on. Yellow means, that at least one HV power supply is intended to be on, but all supplies functioning is forbidden. Red means no supplies is on, but functioning is forbidden. No illumination - no supplies is on, functioning is permitted.

## 6.3. MENU DESCRIPTION

To switch the device on turn on main power switch on the rear panel and after a few seconds push button “Power” on the right-bottom of front panel. After that main menu entitled “Welcome” is shown. It contains items, listed below.

**“Delay channels”** – Menu – Contains four submenus entitled “Channel X” for each of five delay channels and submenu “Pump start”. These menus takes possibility to adjust delay values, HV power supply voltages and switch on and off these supplies independently for each channel . (See below)

**“Monitor outputs”** – Menu – Contains three switches for BNC outputs at the front panel (marked “Out1”-“Out3”) and three for “Expansion” socket outputs. (See below)

**“Saving/Loading”** – Menu – Takes possibility to save and restore current settings into non-volatile memory. Note that memory block 0 is used for automatic saving during device shutdown and is automatically restored at system start.

**“Synchronization”** – Menu – Contains all RF synchronization and triggering adjustment. (See below)

**“Service”** – Menu – Takes possibility to set RS-232 port baud rate, display backlight brightness and adjust starter settings.

**“Shutdown”** – Command – switches the device off. Before switching off all current settings are stored in non-volatile memory block 0. To avoid this storing one can use “On/Off” button. To switch off the device press the button and left it pressed for at least 4 seconds. In 2 seconds after button will be released device will be off.

**“Channel X”** – Menus – Contains rough and fine delay settings (for all five channels) and HV power supplies settings (only for channels 0-2). Note, that device can include not all three HV supplies. Each delay channel consists of two parts: digital delay with 20ns step and 80us (12 bit) range, and analogue one with approximately 40ns range and approximately 15ps step. Total delay is the sum of minimal delay (approx. 40ns with <1ns mismatch between channels – not indicated), digital delay and analogue delay. Range for analogue delay can vary from channel to channel due to digital method of calibration. “HV key off/on” switch at the bottom of menu really switch supply on only if global permission is present. This global permission is controlled with “On/Off” button: short pressure (from 0.3s to 4s) toggles it on and off. Current state of global permission is indicated at “Power” LED, the presence of red colour means that supplies working is forbidden. Otherwise, the presence of HV key start pulses (DB-9F sockets marked “OutA” - “OutC” at the rear panel) depends only on “HV key off/on” switch state. This switch has no action on signals at monitor outputs (“Out1” – “Out3” at front panel). “With skipping”/“Without skipping” switch allows one to override “Operating mode” settings for this channel and force it to “Normal” mode.

The **“Pump start”** menu contains following items:

**“Compensation mode”** – Switch, that chooses one of three possible modes of operation: “Compensation off” – delay start and pump start occurs simultaneously, except fine delay of pump start; “Manual adjust” – delay between pump start and delay start is set manually with “Additional delay” parameter; “Auto adjust” – requires additional photosensor to determine internal delay of pump laser. The last mode is useful only for pump lasers with large and time dependent delay from

triggering to optical pulse, like some with acousto-optical Q-switch. This delay is measured and delay start is automatically adjusted to keep time between delay start and pump optical pulse. This time can be both positive and negative, but delay start cannot precede to pump start. This auto-adjust scheme is a digital one, so in fact it cannot compensate drifts less than one period of delay line clock (10ns or RF period)!

**“Additional delay”** – Takes effect in “Manual adjust” mode only. The number is true microseconds when “Delay clock” is 100MHz crystal, indicates a quantity of RF periods otherwise (1 discrete=1 period, decimal point must be ignored).

**“Delay shift”** – Takes effect in “Auto adjust” mode only. Units – like “Additional delay”. Delay from pump start to delay start is bounded below to 2 clocks of delay line without any warning!

**“Delay clock”** – Selects clock source for delay line. Two sources are possible: 100MHz crystal and current RF clock (the same as system RF synchronisation signal, see menu “Synchronization” below).

**“Fine delay”** – Lets to introduce delay up to approx. 40ns in ~10ps steps to optimise amplifier performance. Is active in all three modes of operation. Have no effect on delay start position, i.e. only a front of pump start pulse changes its position.

**“Interlock off/on”** – Switches interlock on and off. This interlock prohibits only pump start generation, when current RF synchronisation signal is bad for approximately 100ns. Interlock has no effect on other pulses.

**“Interlock time”** – Time before interlock recovery. If current RF synchronisation signal have no failures for this time, pump start pulse is restored.

**“Out X Selection”** – Switches – Controls “Out1”-“Out3” and “BackOut1”-“BackOut3” outputs. Signal at any of these three outputs can be independently chosen from the same set. This signal set includes:

Four delay channels output pulses.

Pump start pulse.

Delay start: rising edge at delay start (tied to RF synchronization), falling edge at delay time-out end (this moment is not quite stable).

Two built-in frequency dividers output signals. (See below)

External triggering signals, both from BNC socket (marked “External trigger” – rear panel) and from pin 12 DB-15F socket (marked “Expansion” – rear panel).

External RF synchronization signals, both from BNC socket (marked “External RF” – rear panel) and from pin 4 DB-15F socket (marked

"Expansion" – rear panel). Note, that monitor outputs have less bandwidth, then "External RF" input.

Signal from optical input: Note, that this is *digital* signal with standard high and low levels (as mentioned above RF signals). To see optical analogue signal use optical monitor output (rear panel).

Phase-triggered 50 MHz oscillator ("PT oscillator"). This signal starts at delay start and goes on up to delay time-out end. Initial phase of it is tied to RF synchronization signal.

Pump delay auto-compensation photosensor (not available on BackOut3, the output in auto-compensation mode is used for powering photosensor).

Note: Front BNC outputs have 50 Ohm load capability, but back outputs are intended for series line matching (50 Ohm output impedance).

The "**Synchronization**" menu contains following items:

"**Triggering**" – Switch, that lets to chose one from four triggering sources: two external and two outputs of built-in frequency dividers.

"**Adjustments**" – Menu – External triggering and synchronization inputs adjustments (see below).

"**Rising edge/Falling edge**" – Switch for proper triggering edge selection.

"**RF synchronization**" – Switch – If option "None" is chosen delays start immediately after proper triggering edge came. In other cases triggering is double-synchronised to RF signal, chosen with this switch, to provide proper phase of all delay outputs. The set of RF signals includes two external, optical and internal 100MHz crystal oscillator.

"**Frequency divider 0 and 1**" – Menus – Built-in frequency dividers adjustment (see below).

"**Skipping**" – Menu – Skipping modes and signals control (see below).

The "**Adjustments**" menu contains following items:

"**Trigger threshold**" - External BNC threshold adjustment, varies from -3 to +3 Volts.

"**Input coupling**" – Switches external triggering input between AC and DC coupling.

"**Attenuation**" – Switch –In 1:10 position trigger threshold value must be multiplied by 10.

"**Input impedance**" – Switches on 50 Ohm matching load. In "2/20 kOhm" position input impedance depends on attenuation (approximately 2 kOhm at 1:1 and 20 kOhm at 1:10 attenuation).



**“RF threshold”** – Sets (in arbitrary units) the threshold for external RF input. Can be adjusted to decrease jitter and interference sensitivity.

**“Optical threshold”** – The same adjustment for optical synchronization input.

The **“Frequency divider 0/1”** menus contain following items:

**“Signal to divide”** switch for choosing of divider input signal. External signals: RF synchronization and trigger, optical and internal 100MHz are available.

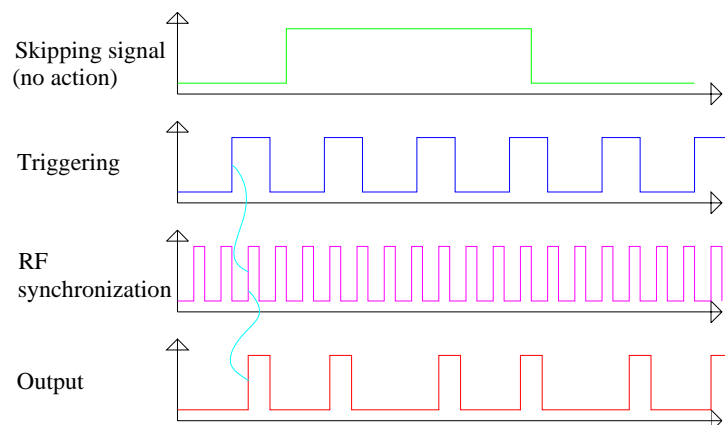
**“Divider 0 and 1 prescaler”** – Before main divider, input frequency can be pre-divided to 16, 256 or 4096. Note, that pre-divider value acts on divider output pulses – pulse width is equal to one period of pre-divided frequency. If prescaler value is 1 no pre-divider is used, in this mode frequency range is narrower.

**“Divider 0 and 1”** - divider value itself.

The **“Skipping”** menu contains following items:

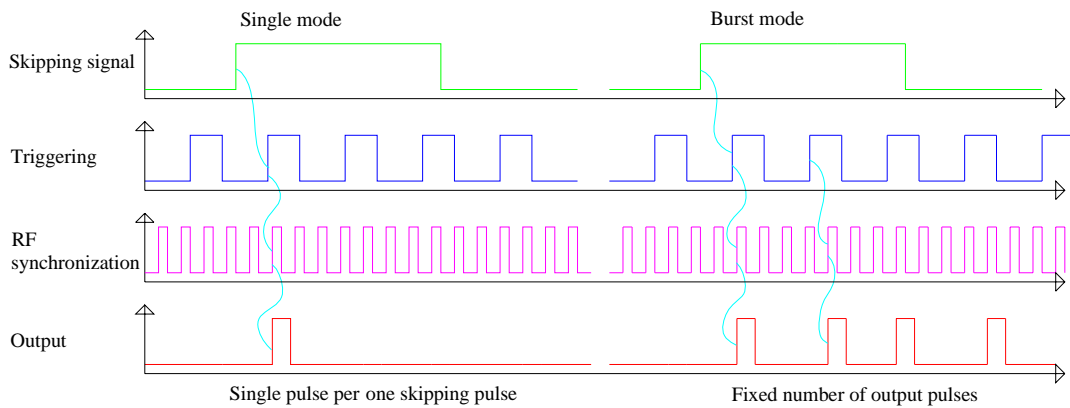
**“Operating mode”** – Switch – There are five modes of operation:

**“Normal”** - all triggering pulses (except frequency overrun case) causes output pulses at all delay channels. Every triggering pulse is tied to RF synchronization and then causes delay start (see fig. 2.13).



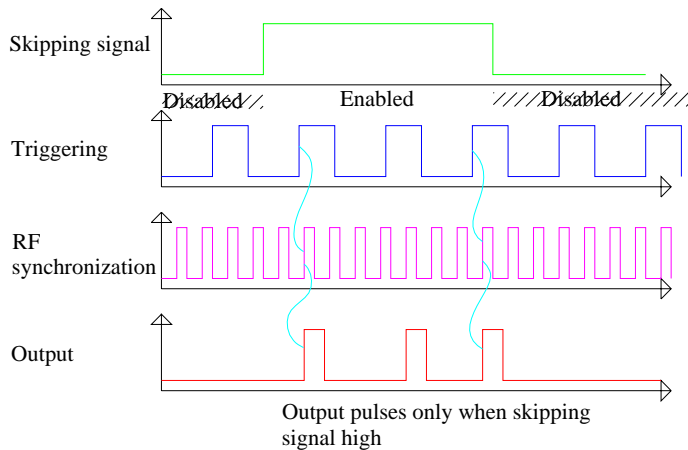
**Figure 3.2.** "Normal" operation mode of control unit description.

**“Skipped”** – some channels works every time, some only after additional skipping signal, this selection can be done in “Channel X” menu. One can chose one of four skipping signal source: two external trigger signals and two frequency dividers. Triggering pulses acts one time after skipping signal leading edge if “Single mode” is chosen or given number of times if “Burst mode” (see fig. 2.14).



**Figure 3.3.** "Skipped" operation mode of control unit description.

"Enabled" – triggering pulses acts only if skipping signal has high level, skipping signal is sampled on triggering active edge (see fig. 2.15).



**Figure 3.4.** "Enabled" operation mode of control unit description.

"Single shot async." – like "Skipped" mode, but skipping signal is generated by software. Single shot can be executed from menu ("Single shot" command) and through RS-232 interface from computer.

"Single shot sync." – the combination of "Skipped" and "Single shot async." modes: delay output is allowed only after enabling signal (see "Skipped") next nearest to single shot command from software.

**"Skipping signal"** – Switch - Skipping signal source selection. "Channels off" selections disables all channels with "With skipping" settings in all operating modes except "Normal".

**"Single shot"** – Command – Acts only in one of the two Single shot modes. Generates beep after execution.

**"Single mode/Burst mode"** – Switch – Enables generation of preset number of output pulses after every leading edge of skipping

signal. Acts only in skipped and single modes (both asynchronous and synchronous). Pulse sequence can last after skipping signal goes low.

**"Burst length"** – Parameter – Pulse quantity in one burst, can vary from 1 to 255.

The **"Starter adjust"** menu contains following items:

**"Starter amplitude"** – Adjusts the amplitude of starter motion.

**"Starter off/on"** – Enables and disables starter function. If enabled, optical RF input is monitored. If signal failure takes place in approximately 0.5sec, system begins to move starter, making one attempt to recover mode-locking in two seconds. When succeed, further attempts breaks off.

**"Manual trigger"** – Once triggers starter independently of "Starter off/on" switch position.

**"Starter speed"** – One of the four starter speed can be chosen: 1 is the slowest, 8 is the fastest.

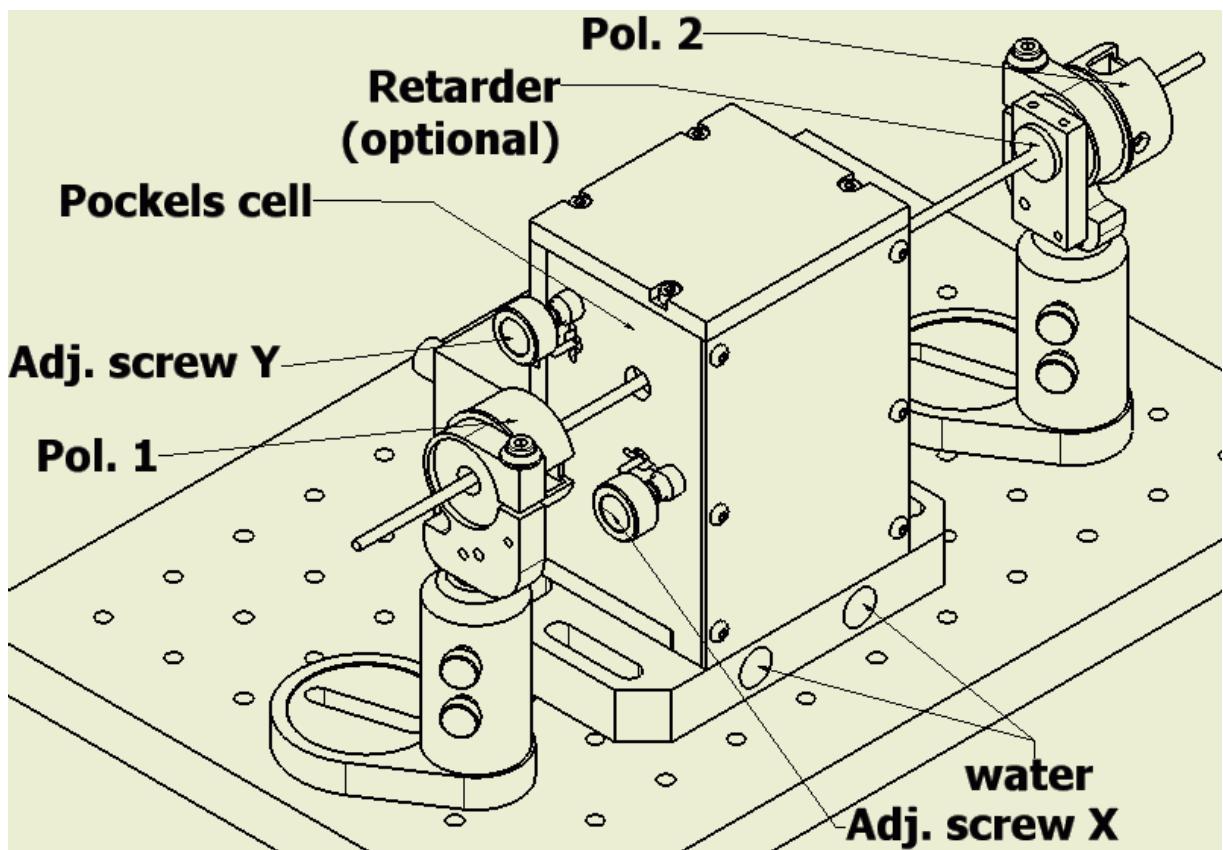
**"Attempts qty"** – Maximal starter attempts quantity. If all of them take no effect, the apparatus emits beep noise and discontinue to move starter. Starter is re-enabled under two conditions: 1. One can switch it off and on; 2. If Optical RF signal is free of failure about 1 second.

# 7. ALIGNMENT

## 7.1 PULSE PICKER ALIGNMENT

For aligning the pulse picker you will need:

- fast oscilloscope (time-division range: 200-500 MHz, sensitivity: 0.01 V/div., external trigger input);
- fast photodetector with frequency bandwidth no less than 0.1 GHz;
- IR viewer.

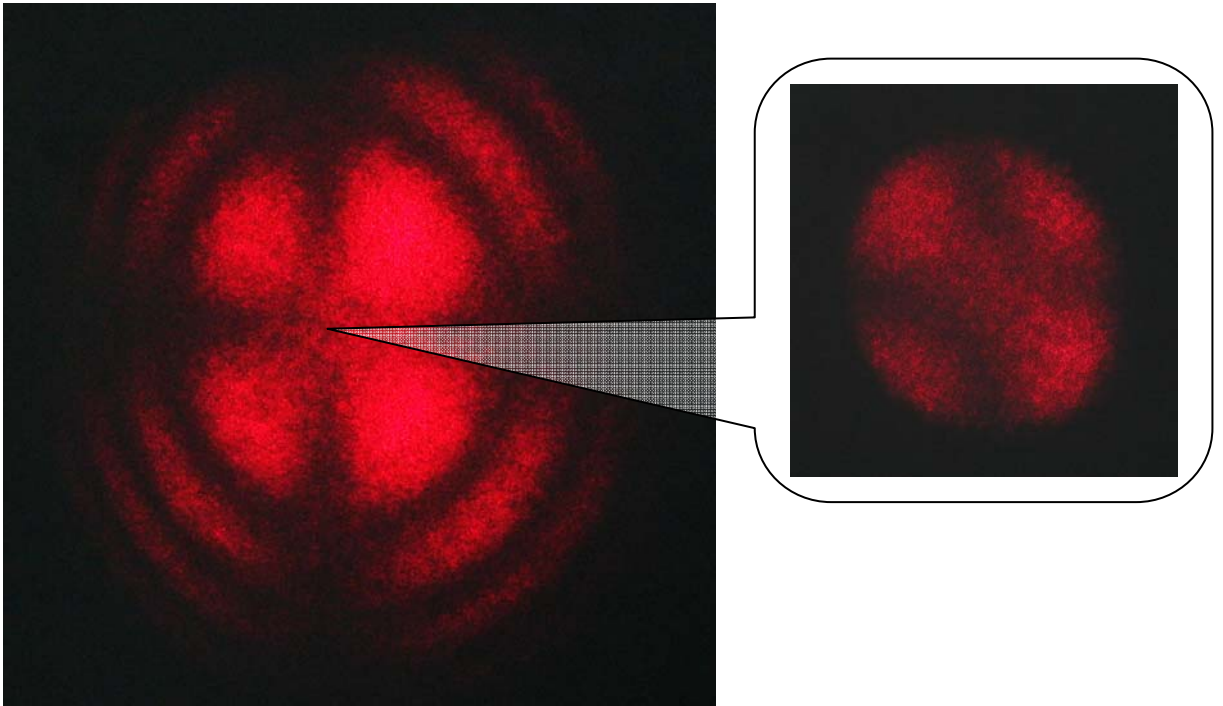


*Figure 4. Pulse picker external view ( $\lambda/2$  setup example).*

### 7.1.1 OPTICAL PART OF PULSE PICKER ALIGNMENT ( $\lambda/2$ setup)

1. Install the polarizer № 1 (*Figure 4, Pol.1*) on the optical table. The optical beam should pass through the center of the aperture. Align the polarizer around its vertical axis until the reflected beam from the front surface of the polarizer is reflected backwards (in the vertical plane). Loosen the screw and set the polarizer so as to bring the polarization axis to horizontal position.
2. Install the polarizer № 2 (*Figure 4, Pol.2*) on the table, similarly to polarizer №1 (Pol.1). The beam should also go right through the center and reflect backwards. Loosen the screw, bring the polarization axis to vertical position.
3. Install the screen behind the polarizer № 2. Use the IR viewer to find the beam position. You will see the beam spot on the screen. Mark this position. Rotate polarizer № 2, until full beam suppression is reached.
4. Install the Pulse Picker on the table. The beam should go through the centers of both apertures. By rotating the adjustment screws (Adj. Screw X and Adj. Screw Y) align the back reflection. Place the diffuser between the polarizer № 1 and the shutter (you may use a mat plate or a piece of paper for optic cleaning). You can observe a picture like "Maltese Cross" in a form of a cross on the screen as shown on Fig. 5 (use the IR viewer, you can see only central part). Move the cross to the place where the beam was by rotating the adjustment screws (Adj. Screw X and Adj. Screw Y).
5. Put away the diffuser and slightly adjust the beam suppression after the shutter. If you can see the beam spot on the screen then you

should minimize the beam intensity by rotating the adjustment screws (Adj. Screw X and Adj. Screw Y) within one turn.



*Figure 5. "Maltese Cross"*

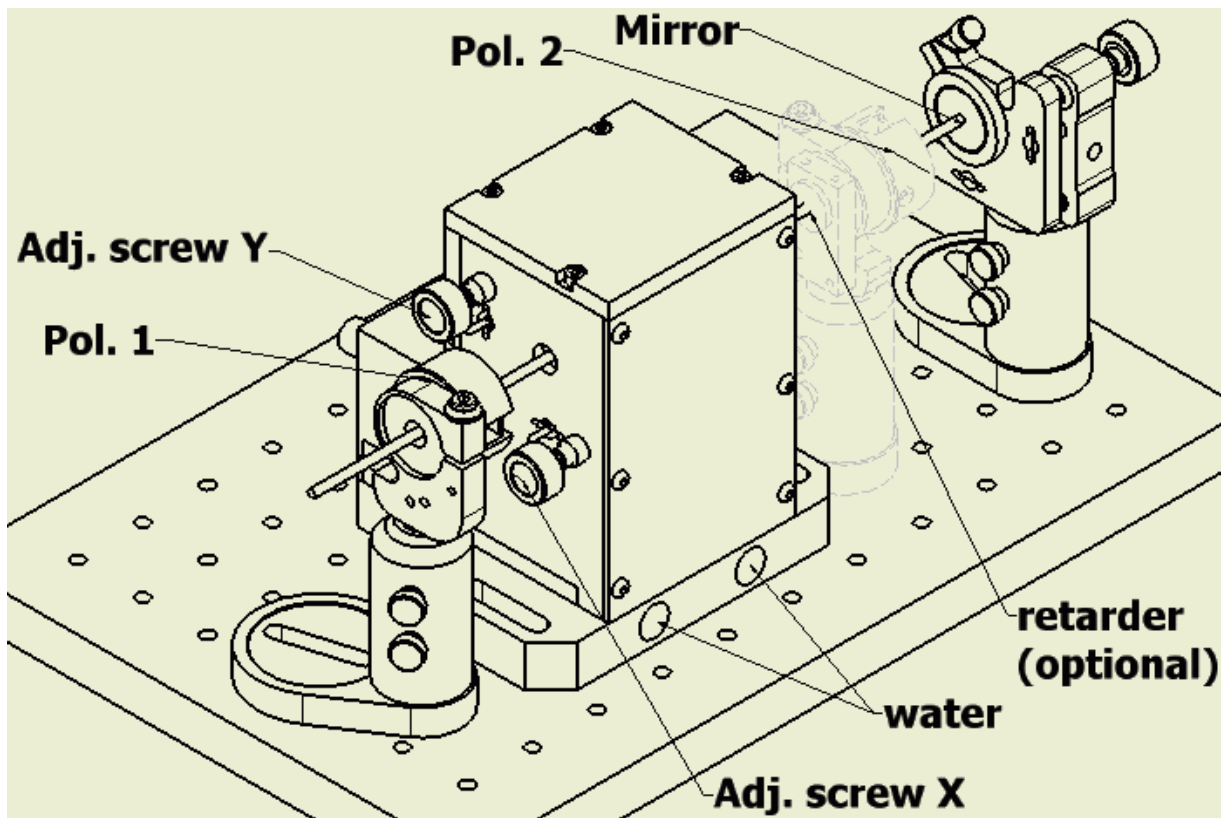
6. Turn on the control unit using "Standby" switch and "Power" button on the front panel.
7. In the menu section "Synchronization" → "RF synchronization" choose "Optical visible".
8. Plug the fast oscilloscope (time-division range: 200-500 MHz) into the "Monitor" socket on the rear panel.
9. Plug one of the fiber cable connectors (one end) into the "Optical visible" on the back panel of the control unit.
10. Direct pulse radiation into the other fiber cable connector (the other end) (from optical pulse generator  $\approx 30 - 120$  MHz).

The average power should be not more than 10 mW. You can observe the level of the streamed signal on the screen of the oscilloscope. For stable device operation the signal amplitude at the 50 Ohm oscilloscope input should be kept in the range of 150-400 mV.

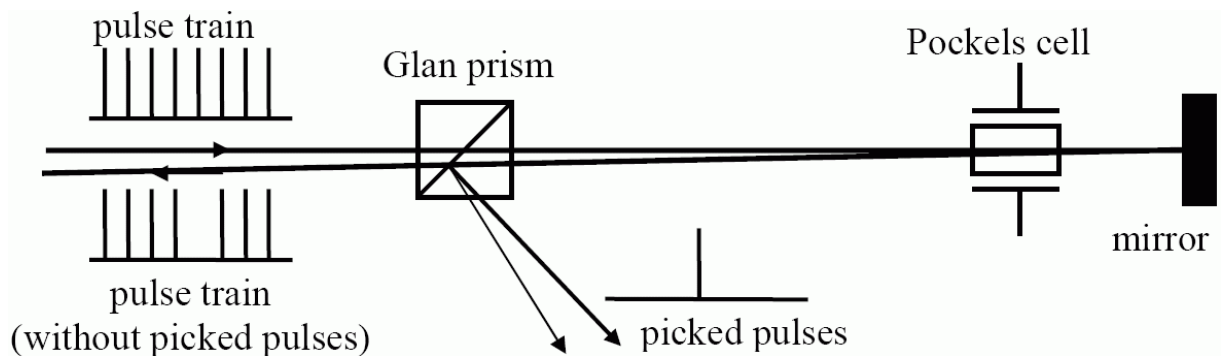
*Note: If your laser has auxiliary fiber output with average power  $\sim 2-3$  mW in femtosecond regime, you may connect the pulse picker fiber to this output using an FC connector.*

### 7.1.2 OPTICAL PART OF PULSE PICKER ALIGNMENT ( $\lambda/4$ setup)

1. Follow the instructions 1-10 of the previous paragraph.



*Figure 6. Pulse picker external view ( $\lambda/4$  setup example).*



*Figure 7. Pulse picker optical scheme ( $\lambda/4$  setup).*

2. Remove the Pol.2 from the holder and insert the mirror in the beam as shown on fig. 6. Use adjustment screws for matching the incident and reflected beams. The angle between the incident beam and the reflected beam should be in the range of 0 to 5 degrees. The exact angle value is determined by the type of your laser: if your laser has isolated output (e.g. it is isolated by the Faraday isolator), then precise matching of the incident and the reflected beams should be achieved; if the laser output is not isolated, then place the reflected beam as close to the incident as possible (i.e. near the output port of the laser).
3. Insert the retarder in the beam after the Pockels cell. Rotate slightly around the vertical axis depolarizing the radiation. Use the IR viewer to observe two beams behind the side plane of the Pol. 2 (see fig. 7). The intensity of one of them (see fig. 7) will depend on the polarization of radiation. This is the effective beam, which will contain the selected pulses train.
4. Put the screen in the effective beam and mark the spot of incidence. Remove the retarder from the beam. If you can see the beam spot on the screen then you should minimize the beam intensity by rotating the adjustment screws (Adj. Screw X and Adj. Screw Y) within one turn.

*Note: The retarder is cut for a 90-degree rotation of the polarization plane at 800 nm wavelength. Partial depolarization of radiation at other wavelengths can be achieved by rotating this retarder around the vertical axis. Thus, this optical device can be used to visualize the beam only with the pulse picker being turned off, and also to facilitate the tuning.*



## 7.2 ELECTRICAL PART OF PULSE PICKER ALIGNMENT

1. Turn on the control unit using "Standby" switch on rear panel and "Power" button on the front panel.

2. Trigger settings.

2.1. Usage of internal trigger.

a) In the menu section "Synchronization" → "Triggering" choose "Divider 0". In the menu section "Synchronization" → "Frequency Divider 0" → "Signal to divide" choose "100MHz crystal". The "Triggering" indicator on the front panel should become green.

b) Using "Divider 0 prescaler" and "Divider 0" adjust to the necessary repetition rate (for example, 1kHz = 100 MHz/256/390). The repetition rate can be changed in range of 0.5 – 25 kHz.

*Note: if you work with a repetition rate more than 10 kHz, it is important to chill the Pockels cell with water flow ~ 5 l/min. Otherwise the device will overheat.*

2.2. Usage of external trigger.

In the menu section "Synchronization" → "Triggering" choose "External trigger BNC", and plug the external pulse source to "External trigger" BNC connector on the rear panel (see page 9, "Trigger external BNC input"). The activation threshold and input types can be set up in the menu "Synchronization" → "Adjustments".

3. Repeat steps 6-10 of paragraph 7.1.1.

4. In the menu section "Monitor outputs" → "Out 1 selection" choose "Delay 1 output".

5. Plug the fast oscilloscope (time-division range: 200-500 MHz) into the "Monitor" socket on the rear panel. The pulse train amplitude on the 50 oscilloscope input should lie between 150 and 400 mV.
6. Connect "Out 1" output on the front panel with the external synchronization input of the oscilloscope. Start the oscilloscope using the external synchronization mode.
7. Decrease jitter of the rising edge of the pulses on the screen of the oscilloscope changing the "Optical threshold" value in the menu "Synchronization" → "Adjustments". Work until the "Synchronization" indicator on the front panel turns green. At the same time "Pulses" indicator should also be green.
8. Place the retarder ( $\sim \lambda/2$ ) between the pockels cell and the polarizer № 2 (the mirror in  $\lambda/4$  setup).
9. Place the fast photodetector in the beam behind the pulse picker.
10. Using your photodetector register the optical signal. Stream it to the oscilloscope input.
11. Put away the  $\lambda/2$  retarder.
12. Connect the control unit and pockels cell shutter (BNC and TNC connectors).
13. In the menu section "Delay channels" → "Channel 1" → "Delay 1 rough" set rough delay value to "00,14  $\mu$ s" (because actuation time of the shutter is  $\sim 160$ - $180$  ns). Set fine delay value to "00,00 ns".
14. Connect the photodetector that is placed behind the pulse picker with the oscilloscope.
15. Turn on high voltage supply of the pulse picker using "Output On/Off" button. "Power" indicator should become green.
16. Increase roughly and finely the pulse picker start delay value in the menu sections "Delay channels" → "Channel 0" → "Delay 0

rough" and "Delay channels" → "Channel 0" → "Delay 0 fine". Find the optical pulse signal leaving the pulse picker.

17. Changing the fine delay value in the menu section "Delay channels" → "Channel 0" → "Delay 0 fine" to achieve maximum level of the signal on the oscilloscope.

18. The half-wave (for radiation at 800 and 1064 nm) and quarter-wave (for radiation at 1560 nm) voltage setup.

1. Step up the supply voltage of HV shutter to 260 V.

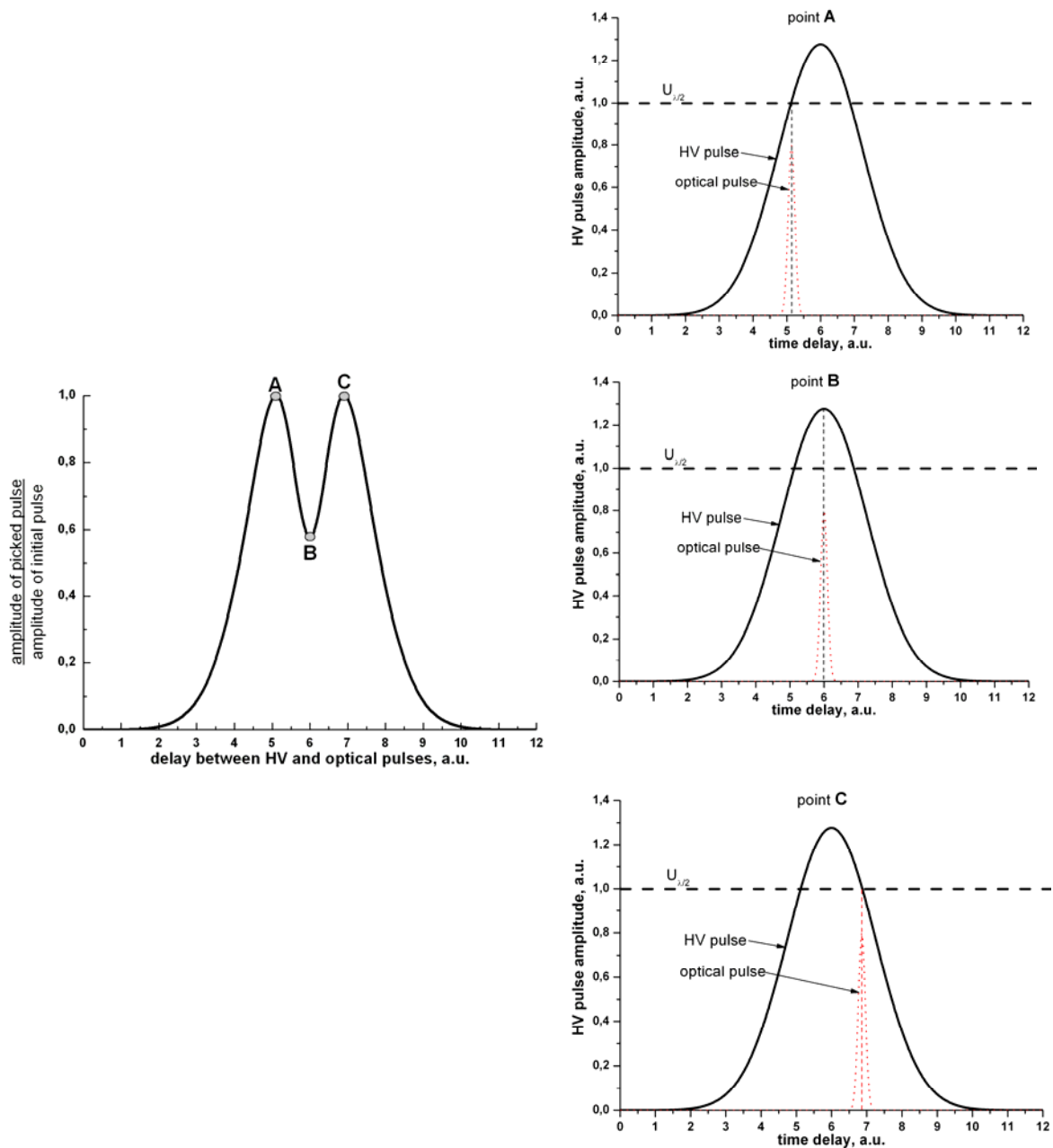


Figure 8. Half-voltage amplitude setup.

2. Change finely the pulse picker start delay value in the menu sections "Delay channels" → "Channel 0" → "Delay 0 fine".

The picked pulse amplitude change will be observed when changing the delay: amplitude increase to maximum, amplitude decrease, amplitude increase to maximum (see fig. 8, left picture). This effect is explained by the fact that a high-voltage pulse has an amplitude peak that exceeds the half-wave voltage value on the given wavelength (see fig. 8, right pictures). When the optical pulse and the peak of the HV pulse match in time, a more than 90-degree rotation of the radiation polarization plane occurs.

3. Set up the HV pulse amplitude to equal the amplitude of the half-wave voltage for the given wavelength. Accordingly, set the "Delay 0 fine" in point B (see fig. 8). By slightly decreasing the supply voltage ("Delay channels" → "Channel 0" → "Amplitude 0") of HV shutter achieve maximum amplitude of the selected pulse (~160-170 V for 1560nm and 800 nm).