licel
lidar computing and electronics

Trigger Timing Controller

rev 1.01

February 15, 2023

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1 Overview

The Trigger Timing controller is designed to meet typical lidar measurement requirements. It will be useful in the following scenarios:

- get a quartz time based delay between laser lamp and Q-switch,
- synchronize the laser with an external trigger source like a chopper wheel,
- generate a pretrigger for the data acquisition
- generate a gate pulse for gated PMTs

The trigger generator input and all outputs are galvanically isolated to ensure that no additional ground connection is created between the rack and the laser.

2 Getting started

2.1 Mechanical Installation

The Licel Timing Controller is mounted in a standard 3 height unit, 10 widt unith cassette. It can be mounted in a compatible 19" rack system crate.

2.2 Power supply

Connect the power supply connection to a +5V, 0.4A min DC supply.

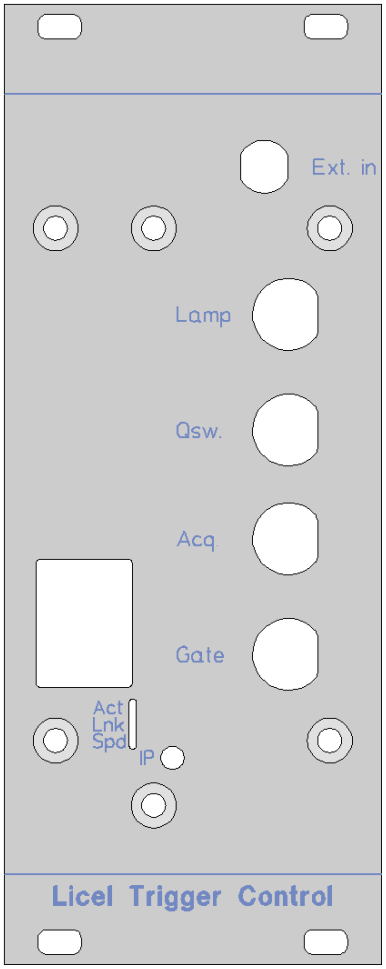
2.3 Ethernet connection

Connect the Ethernet port of the Gating Controller directly to your PC using the red crosslink cable which is supplied with the unit. Follow the steps 6.1, 6.3, 6.4 and 6.5 in the Ethernet Manual to set the IP adress of the controller according to your local network adress range. Once this is done, you can connect the controller to your local Ethernet network hub or switch using a straight Ethernet cable (not supplied).

2.4 Front Panel Connections

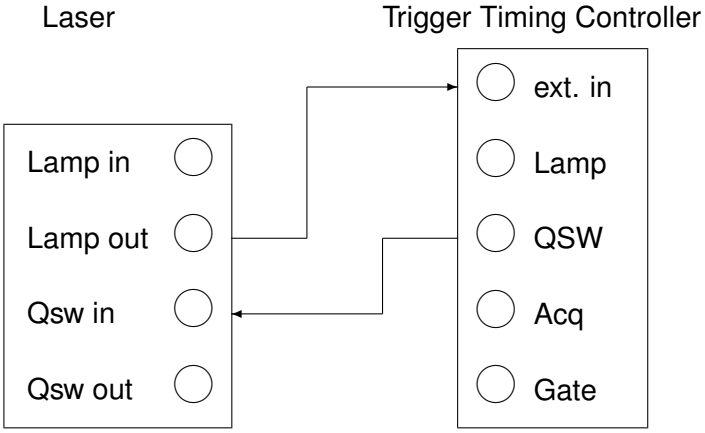
Power up the Gating controller, start the software using the "Control Timing" program. To get familiar with the controller it's a good idea to take a look at the pulses by using an oscilloscope. The output signals deliver max. 64mA. This corresponds to 3.2V@50Ohm. The following connectors can be found on the front panel:

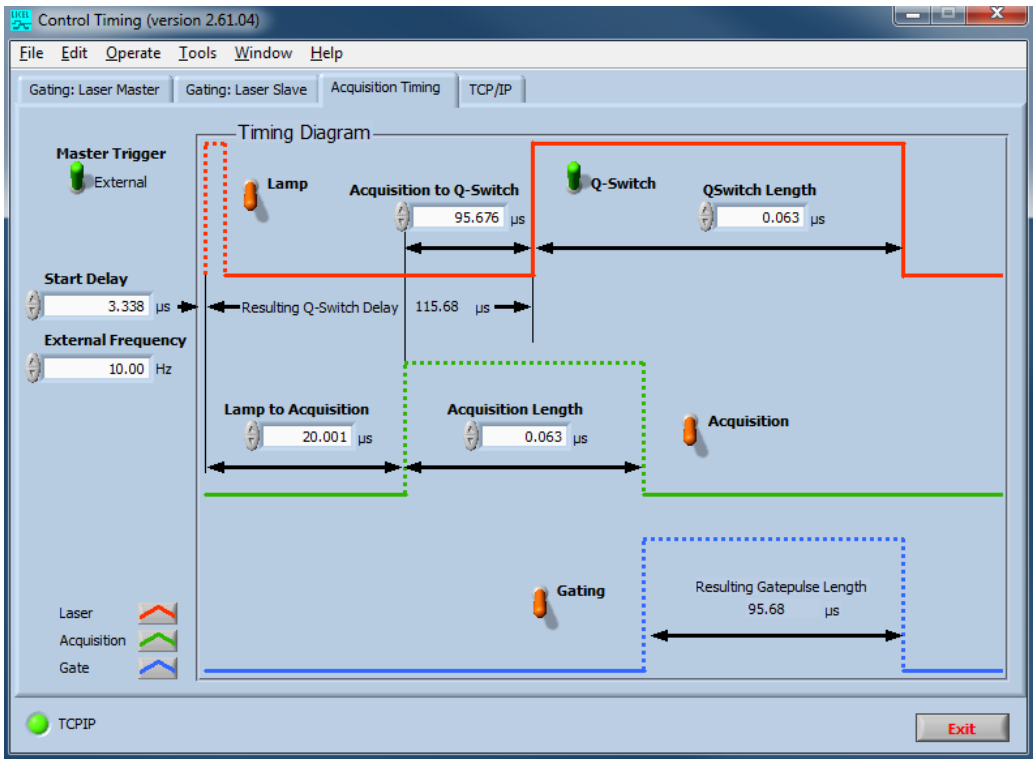
Ext. in	TTL-input, rising slope, start the pulse sequence by an external trigger pulse
Lamp	Output of a positive pulse. Active when "Master Trigger" switch is set to "transient" in the software. Fixed duration 6.4µs.
Q-sw	Output of a positive pulse. The total delay of the Q-sw pulse with respect to the Ext. in pulse or the lamp pulse is the sum of Q-Switch - Pretrig Delay + Pretrigger delay.
Acq	Output of a positive pulse. The pulse starts after the Lamp to Pretrigger delay and has the Pretrigger length.
Gate	Output of a positive pulse. The gating pulse starts with the falling edge of the Pretrigger pulse and ends at the falling edge of the Q-sw pulse.



3 Quartz Based Q-Switch Timing

This will be achieved by connecting the laser lamp output to the external trigger and the QSW signal from the trigger generator to the Q-switch input of the laser.



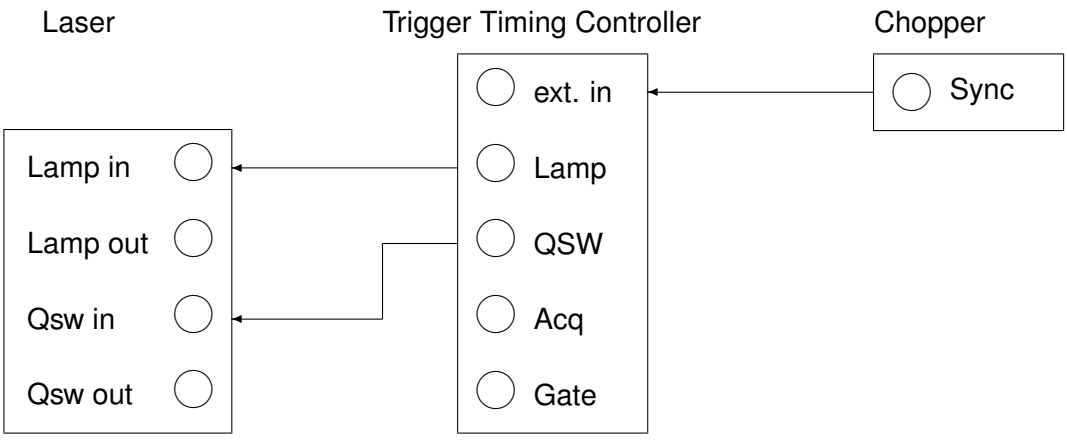


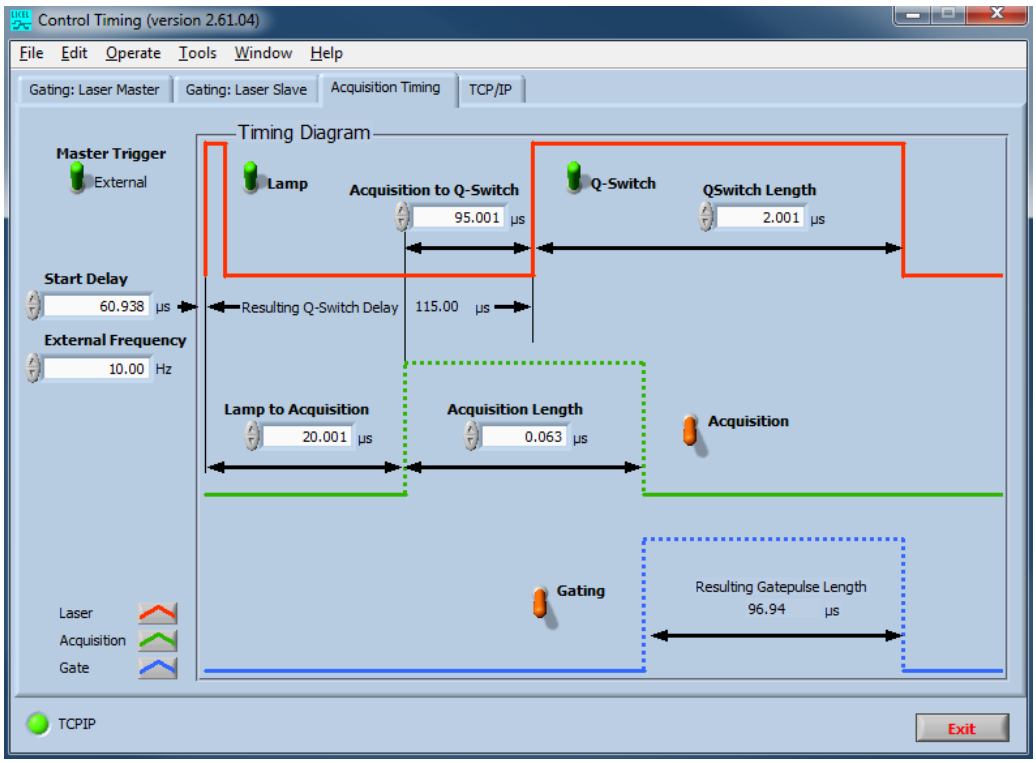
The shown configuration will accept an external trigger. The top left switch needs to be switched to the shown position: `Master Trigger: External`. Please enter the estimated frequency of your trigger source in Hz into the field `External Frequency`. This value will help newer controllers to avoid unexpected irregularities when changing the timings. The switch for the `Q-Switch` output needs to activated. To setup a delay of 120.0 µs One needs to setup three times:

1.	Start Delay	3.338 µs
2.	Lamp to Acquisition	20.001 µs
3.	Aquisition to Q-Switch	96.676 µs
	Overall	120.015 µs

4 External Laser synchronization with a chopper

This will be achieved by connecting chopper sync out to the external trigger. The Lamp and the QSW signal from the trigger generator to the lamp and Q-switch input of the laser.



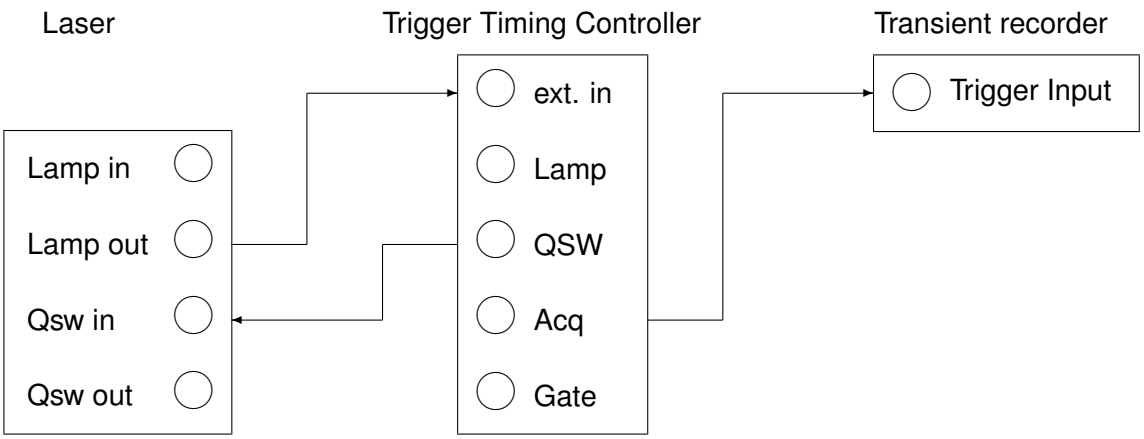


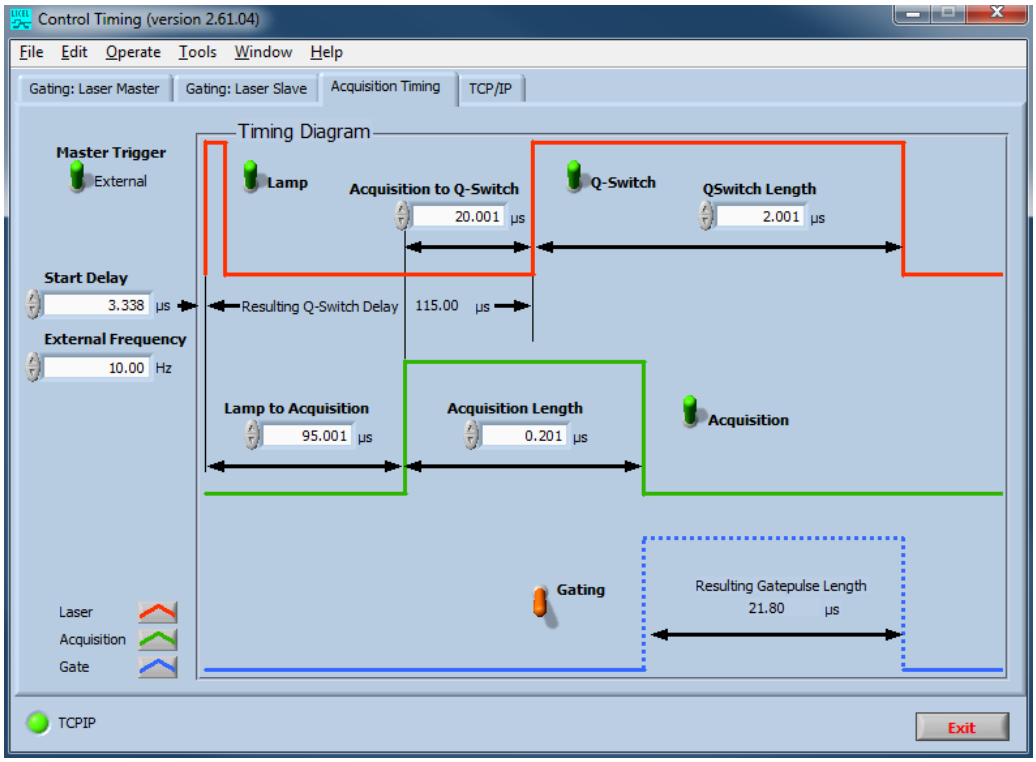
The shown configuration will accept an external trigger from the chopper. The top left switch needs to be switched to the shown position: `Master Trigger: External`. Please enter the estimated frequency of your trigger source in Hz into the field `External Frequency`. This value will help newer controllers to avoid unexpected irregularities when changing the timings. The switches for the `Lamp` and `Q-Switch` output need to activated (green state). The start of the lamp pulse can be adjusted with the Start Delay. The Q-switch pulse needs to adjusted with respect to the laser lamp. To setup a delay of 60.9 µs between the shopper and the laser and to have the Q-Switch 115.0 µs after the laser lamp one needs to setup three times:

1.	Start Delay	60.938 µs
2.	Lamp to Acquisition	20.001 µs
3.	Aquisition to Q-Switch	95.001 µs
	Lamp to QSW	115.002 µs
	Chopper to QSW	175.938 µs

5 Pretrigger for the data acquisition

This will be achieved by using the lamp out as the master trigger pulse. The QSW signal from the trigger generator should be connected to the Q-switch input of the laser. The Acq signal should be connected to the trigger input of the rack.





The shown configuration will accept an external trigger from the laser. The top left switch needs to be switched to the shown position: `Master Trigger: External`. Please enter the estimated frequency of your trigger source in Hz into the field `External Frequency`. This value will help newer controllers to avoid unexpected irregularities when changing the timings. The switches for the `Lamp`, `Q-Switch` output and the `Acquisition` need to activated (green state). To setup a delay of 115.0 µs between the laser lamp and the Q-Switch and a 20 µs pretrigger for the data acquisition one needs to setup three times:

1.	Start Delay	3.338 µs
2.	Lamp to Acquisition	95.001 µs
3.	Aquisition to Q-Switch	20.001 µs
	Overall	118.338 µs
	Pretrigger	20.001 µs

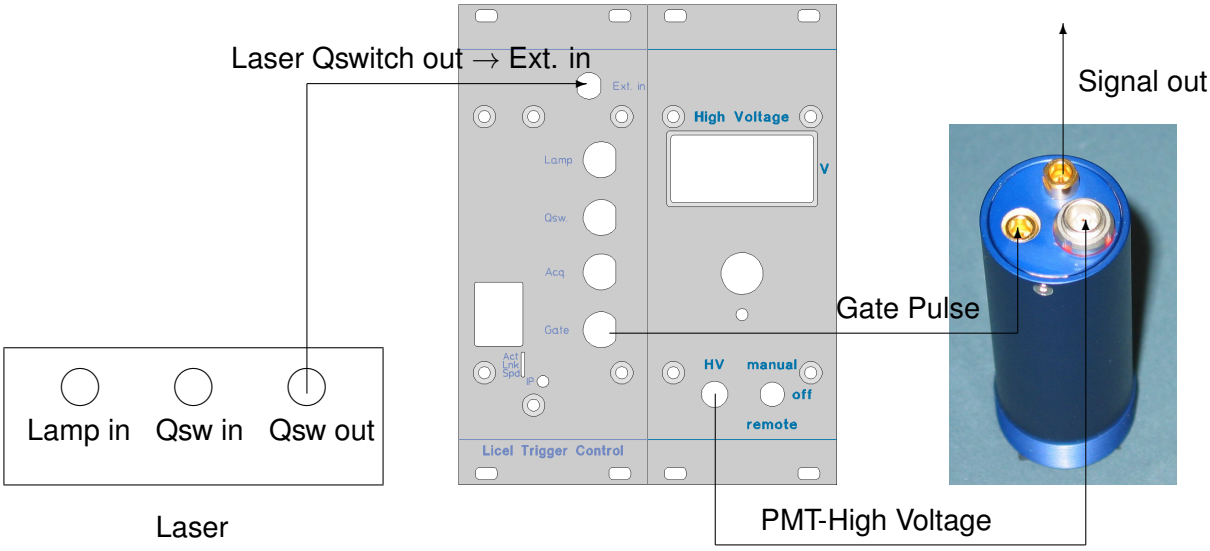
6 Gating

6.1 Selecting the master trigger

There are 2 operational modes for using the Gating controller. The starting pulse of the pulse sequence can be generated by the laser (Laser Master) or by the Gating Controller (Laser Slave Mode).

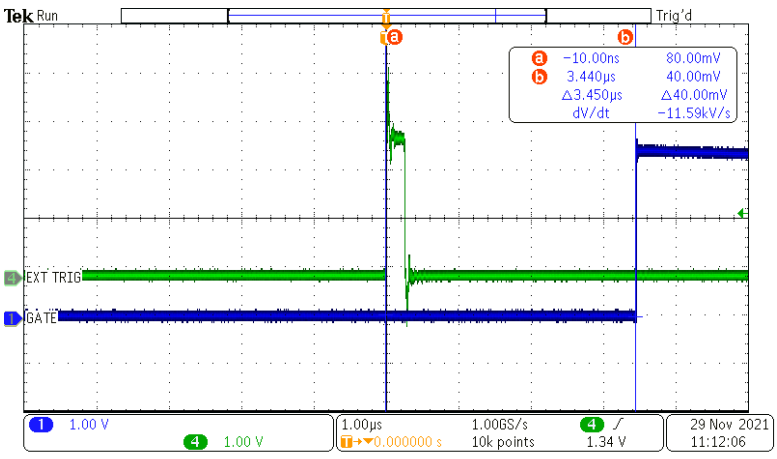
6.1.1 Laser Master mode

In The Laser Master mode,the laser is producing its own lamp trigger and Q-switch trigger pulses and the gating pulse is derived from the Q–Switch out pulse of the laser.

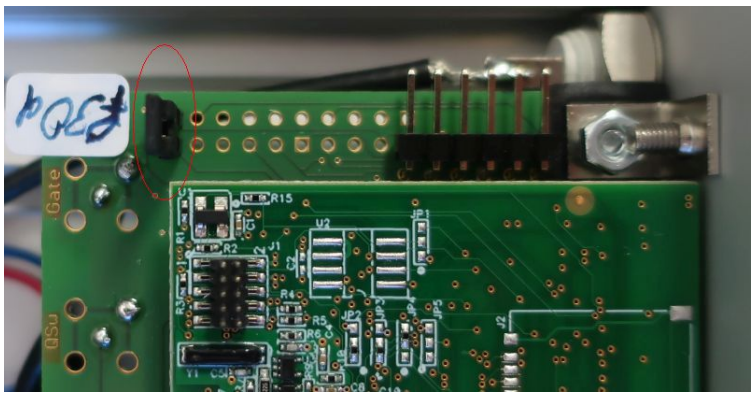


Reducing the Delay between the external trigger Pulse and the rising edge of the Gate pulse.

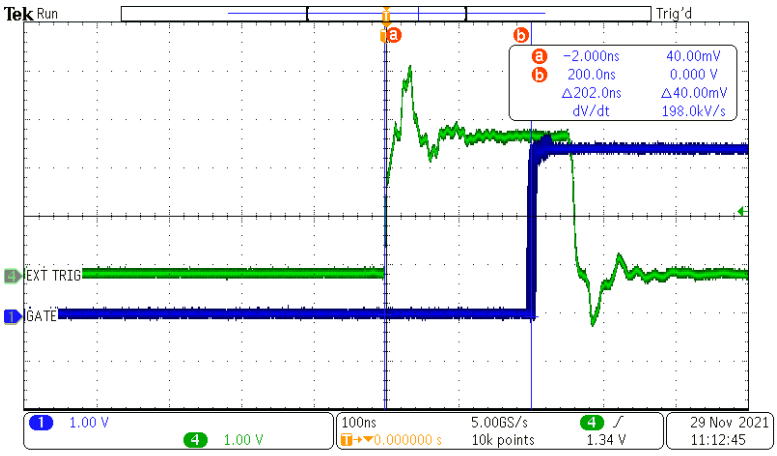
The start delay for the lamp pulse has a minimum delay of 3.38 µs between the external trigger and the rising edge of the lamp out signal. Since this signal always before the gate pulse under standard operation conditions the gate pulse rises only 3.4 µs after the external trigger pulse.



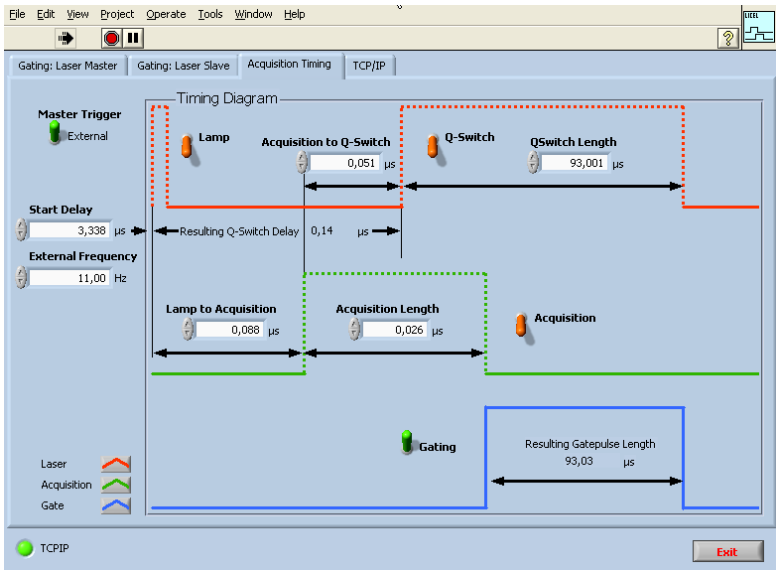
If this delay is not desired and the start delay should be as short as possible a jumper/solder bridge needs to be placed on left most two pins on the trigger generator board.



Then this start delay is reduced to 0.

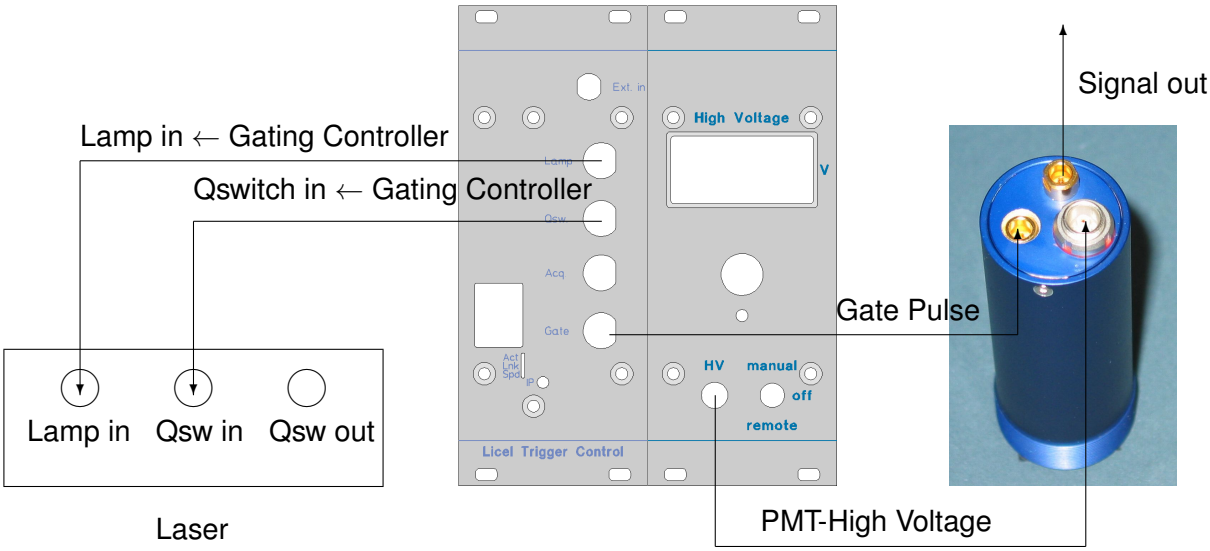


The screenshot above has been taken with the following settings in the software and demonstrates the shortest possible delay between the external trigger pulse and the rising edge of the gate pulse. Longer delays are easily possible by increasing the `Lamp to Acquisition` delay.



6.1.2 Laser Slave mode

In the Laser Slave mode, the gating controller is producing the lamp trigger and Q-switch trigger pulses as well as the gating pulse.



6.2 Adjusting the Gate Pulse

Since the Gate Pulse is derived from the falling slope of the Pretrigger (Transient Recorder Pulse) and the falling slope of the Q-Switch pulse, changes to the delays and pulse lengths of these pulses change also delay and length of the Gating pulse:

6.3 Parameter changed Effect on Gate Pulse

(Qswitch-Pretrig) Delay	Move rising and falling edge together
Pretrigger length	Move rising edge, leave falling edge unchanged
Pretrigger delay	Leave rising edge unchanged, move falling edge
Q-switch length	Leave rising edge unchanged, move falling edge

The position of the gate pulse can be computed by using:

$$(Qswitch - Pretrig)Delay + Pretriggerlength = risingedge \quad (1)$$

$$(Qswitch - Pretrig)Delay + Pretriggerdelay + Q - switchlength = fallingedge \quad (2)$$

The resulting Gate pulse length is displayed on the control panel. By using a Pretrigger length which exceeds the Pretrigger length + Q-switch length, negati- ve values for the Gate pulse width can be achieved. In this condition the gate pulse will be inverted. The LabVIEW `ControlTiming.vi` prevents this scenario.

6.4 Computing the delays from Laser requirements

This is an example scenario where the trigger generator defines the laser lamp and Q-switch. It outputs a gate pulse and the transient recorder is triggered so that the near field is blocked.

Laser rep rate	30 Hz
Laser Pulse length	more than 100 µs
Lamp to QSW Delay	230 µs
Near field blocking	3km or 20 µs
Pretrigger	10 µs
TR Signal Length	400 µs

The first requirement can be full filled in two ways if no external trigger source is used we set the
- `Master Trigger` = Internal

and generate the trigger pulse with
- `repetition rate` = 30 Hz

or if an external Trigger for instance from a LaserSync Module is used we set
- `Master Trigger` = External

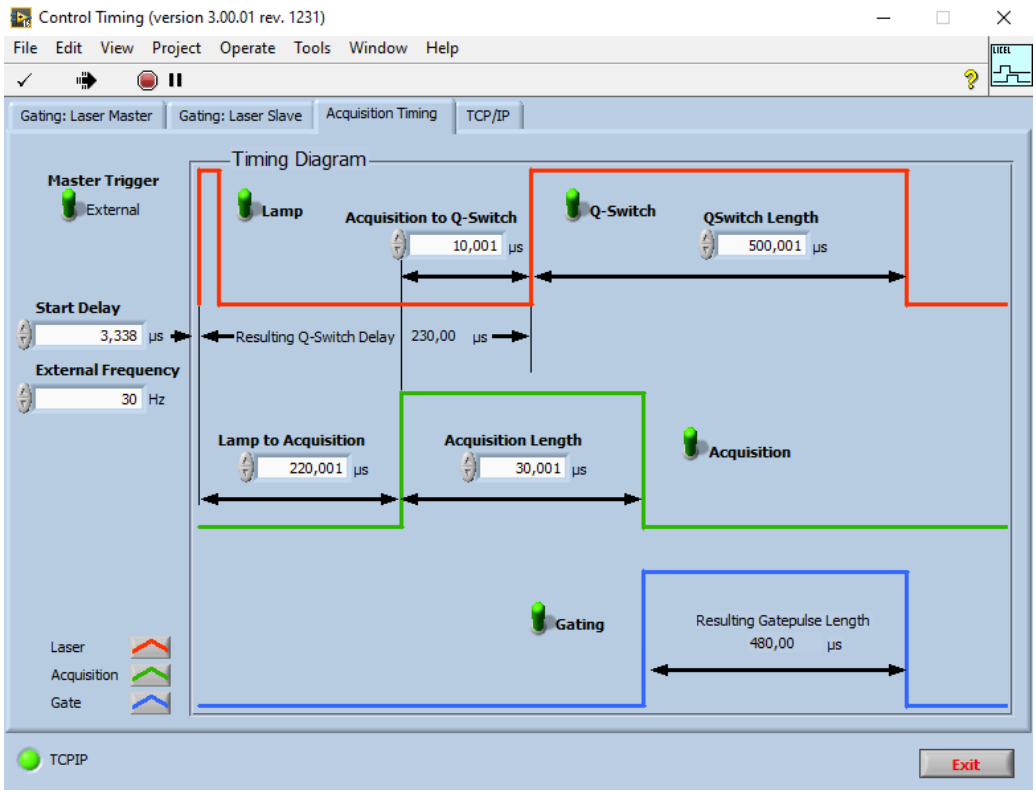
and the start delay to 3.3 µs and the
- `external frequency` = 30 Hz.

The second requirement requires a special programming of the trigger controller as the standard delay is 3.3 µ. Please contact Licel if this is required in your system.
We start with the pretrigger. This is streight forward the Pretrigger is equivalent to `Aquisition to Q-Switch` so we set
- `Aquisition to Q-Switch` = 10 µs

As the delay from the lamp to the QSW should be 230 µs the reminder should go to Lamp to Acquisition
- `Lamp to Acquisition` = 220 µs

The `Lamp` puls in this modified programming will go down when the `ACQ` goes active so this is easily full filled by the 220 µs.
The gating should go active 20 µs after the rising edge of the QSW so we make the
- `Acquisition Length` = 30 µs.

Of this 30 µs 10 µs go to the pretrigger and 20 µs to the gating suppression.



Setting the
- `QSwitch Length` = 500 µs

satisfies the TR trace length requirement.

7 Min/Max timing parameters

The following table lists the minimum and maximum timing parameters:

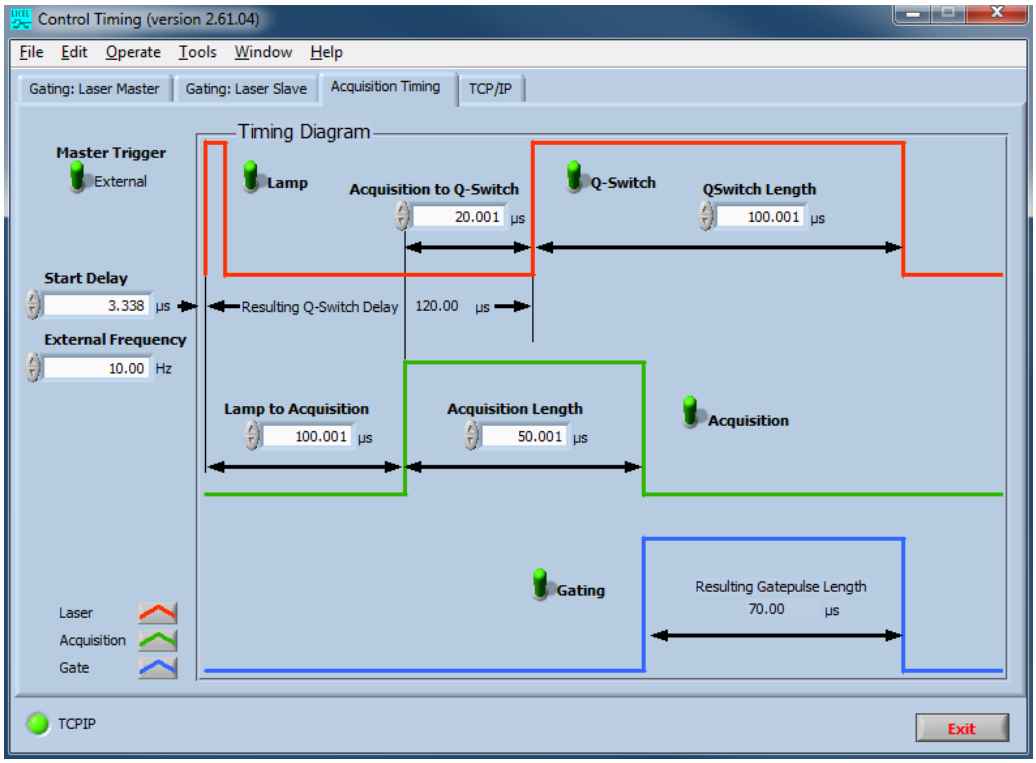
Parameter	min.	time step	max.
Repetition Rate	2.38 Hz	1/6.4 µs	78.125 kHz
Ext. Trigger to Lamp	3.38 µs	6.4 µs	419 ms
Lamp to Acquis.	87.5 ns	12.5 ns	0.819 ms
Acquis. to Qswitch	50 ns	12.5 ns	0.819 ms
Lamp pulse length	3.2 µs	fixed	3.2 µs
Acquis. Pulse Length	25 ns	12.5 ns	0.819 ms
Qsw. pulse length	25 ns	12.5 ns	0.819 ms
Extern Trigger to Gating rising edge	3.573 µs	12.5 ns	420.147 ms
Extern Trigger to Gating falling edge	3.323 µs	12.5 ns	420.966 ms[1]

[1]Gate ON must trigger after lamp trigger

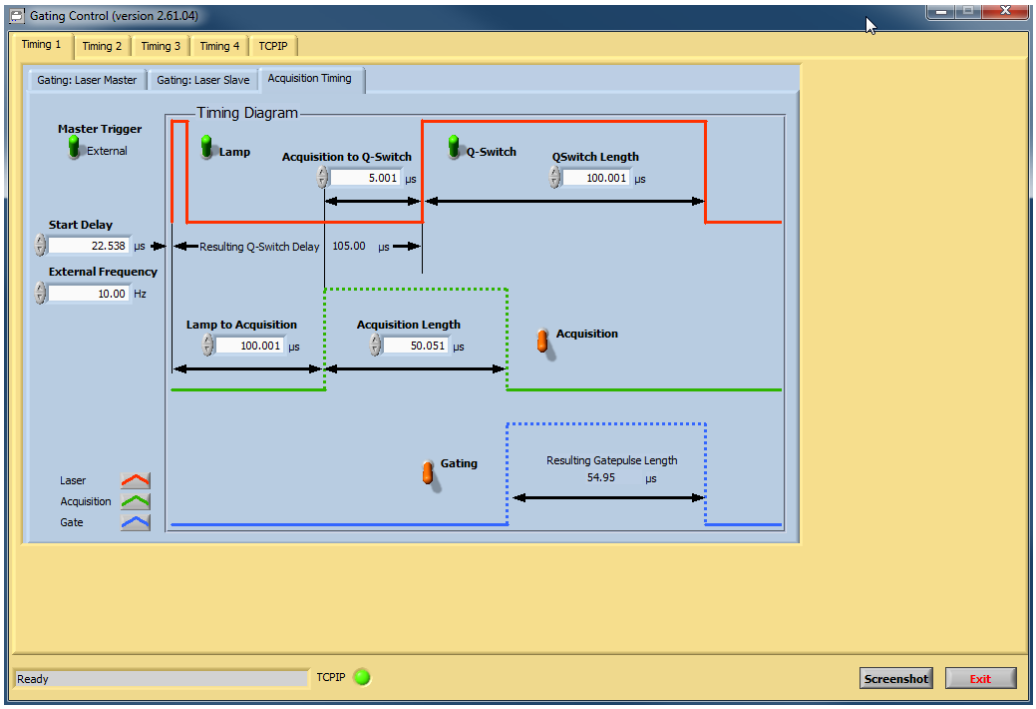
Please make sure that you do not exceed the max. duty cycle: Gate ON/Gate OFF<100. Exceeding this value will lead to a lower suppression when Gate=OFF

8 Software Interface

The LabVIEW `Control Timing.vi` / (`Control Timing.exe`) provides access to the various delays and enable switches for the trigger lines in a Licel Trigger Module equipped with a single timing sub-board.



In the case that the Licel Trigger Module is equipped with more than one timing sub-board the application `Gating Control.vi` (`Gating Control.exe`) must be used.



The usage is described in detail in the Licel Ethernet Controller Installation and Reference Manual in the sections *The Trigger Module Control Panel* and *The Gating Control Module*.

Maximum Gating Pulse Length

The parameters to achieve the maximum length for the gating pulse is shown below: