lidar computing and electronics

TR40-16bit-3U -OVFL

Lidar transient recorder

Manual

October 8, 2025

Licel GmbH, Gustav-Meyer-Allee 25, 13355 Berlin, Germany

Contents

1 Product description

The Licel transient recorder is a data acquisition system for fast repetitive photomultiplier current signals, which are transformed at the internal 50 Ohm termination to a voltage between 0... -500 mV. The signal is recorded simultaneously by a 16bit, 40MHz analog to digital converter and a discriminator which detects voltage pulses above a selected threshold in the range 0... -100 mV. By using this combination of analog and photon counting detection the Licel transient recorder is especially suited to record high dynamic range signals in LIDAR applications.

Each TR40-16bit-3U contains 2 preamplifiers optimized for high linearity for analog detection and for maximum speed and gain for photon counting, a 16-Bit A/D converter with fast memory for 32k of single shot data,a discriminator with variable threshold, counter and multichannel scaler as well as a hardware adder to perform summation of up to 65534 shots on board.

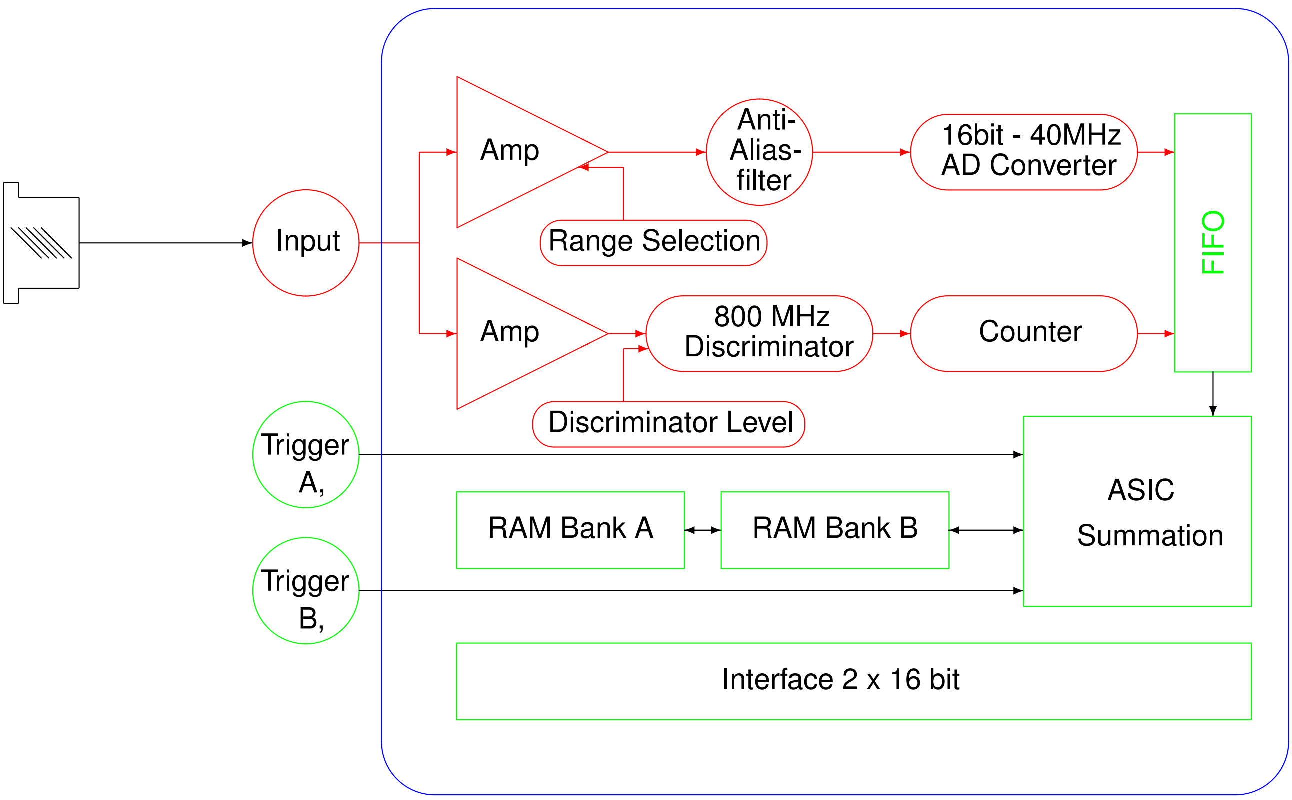
Data transfer and selection of input ranges and discriminator threshold is realized by a parallel data bus connected to a Ethernet controller. Up to 16 transient recorders can be controlled and readout using the same bus.

2 Principle of operation

An acquisition system using the TR40-16bit-3U can be configured for up to 16 simultaneous detection channels. A detection system consists of a rack with a power supply and an Ethernet IO module connected to the transient recorder channel with a flat ribbon cable. Each channel can be configured and controlled separately by the host computer.

The basic setup used to amplify and record signals in the Licel transient recorder is shown in the schematic below: For analog detection the signal is amplified, according to the input range selected, and signals below a frequency of 20MHz are passing the anti-alias filter to be digitized by a 16Bit 40MHz analog to digital converter. Each signal is written to a fast memory which is readout after each shot and added to the summed signal in a RAM. Depending on the trigger input on Trigger A or Trigger B, the signal is added to RAM A or B, which allows acquisitions of two repetitive channels if these signals can be measured sequentially.

At the same time the signal part in the high frequency domain above 10 MHz is amplified and a 800 MHz fast discriminator detects single photon events above the selected threshold voltage. Two different settings (threshold low and threshold high mode) of the preamplifier can be controlled by software together with 64 different discriminator levels. Again the signal is written to a fast memory and added to the summation RAM after each acquisition cycle.



Schematic setup

3 Preparation for use

3.1 Software driver installation

The software package supplied with your Licel transient recorder contains LabVIEW modules and alternatively C-sources to be integrated in your own acquisition programs and a few ready to use LabVIEW acquisition modules to perform multichannel measurements.

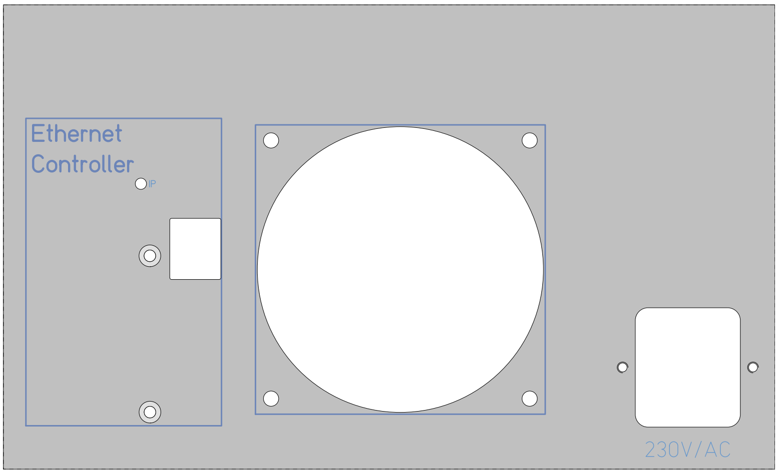
The module ”TCPIP-Track.vi” can be used to check your signal at different input ranges and discriminator thresholds. The output is displayed on screen only.

The module ”TCPIP-Live display.vi” can be used can be used to have an oscilloscope like display for a single transient recorder.

The module ”TCPIP-Acquis.vi” can be used to perform a set of consecutive measurements with a predefined number of shots where the summed signals are written to disk.

3.2 Network Setup

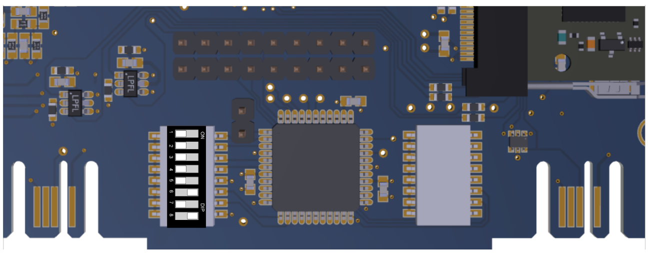
The Ethernet controller is accessible from the rear of the rack.



Please see the Licel Ethernet Manual Chapter 4 how to setup the network connection.
If the rack has additional remote control for APD and PMTs, then it is accessible through this Ethernet port. To check if your system has those boards installed, just run the `Control APD PMT.vi` (see Licel Ethernet Manual Chapter 6). It will show you the installed capabilities or warn you that the hardware support is missing.

3.3 Transient recorder hardware address

Each transient recorder is identified by its hardware address, which can be set using the DIL switch on the board, which is located in the middle bottom part of the board.



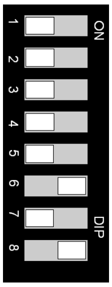
To access it you need to remove the TR from the rack see https://licel.com/manuals/TRMech.pdf

Licel Transient Recorder Mounting. Once you have removed it you need to remove the right side panel when viewing the cassette from front so that you can see PCB. Once you see the PCB the DIP switches are in the lower middle of the board.

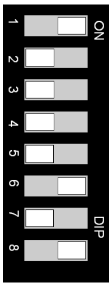
There are two dip switches, the left one is used for addresses and memory configuration. The right one is for hard coding the oversampling.n multichannel systems the transient recorders are factory set to consecutive addresses, starting at 0 for the leftmost channel in the rack.

The addresses range from 0 to 15. Each address should be unique in the system. In order to change the transient recorder address later you need to unmount the transient recorder first. (See http://licel.com/manuals/TRMech.pdf Transient recorder mounting instructions.) Once the right side panel is open on the middle bottom side of the board two black switches should be visible. The left switch encodes binary the address

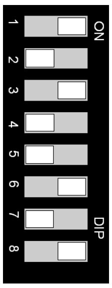
The ON position corresponds to a binary 1.



All switches are off, the resulting address is 0. This is the factory default for the left most transient recorder in a Rack- 8.



The lowest switch is on (2^0), the resulting address is 1



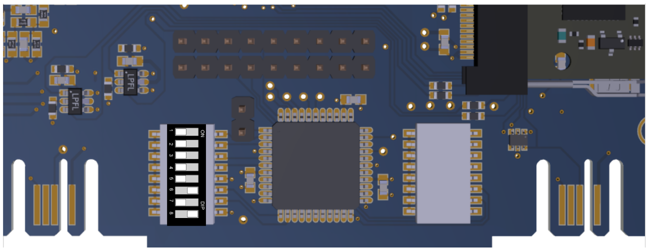
The lowest switch is on (2^0), the switch corresponding to four is also on (2^2), the resulting address is 5

Connect the rear connector of the transient housing to the Ethernet or to the I/O-card, using the interface cable supplied and turn on the power of transient recorder and computer. The hardware address of each channel can now be verified by watching the Host I/O indicator, when different channel numbers are selected in the acquisition software and any command is sent.

3.4 Memory Length

The TR units have a 32k deep memory, which can be configured by the user for shorter memory depths. The default configuration is 16k. Usually this is sufficient for lasers that run below 600Hz. For faster DPSS systems the length should be adapted so that no shot is lost.

The memory DIP switches are on the same DIP switch register as the address. Please the section above for unmounting the TR, opening it and finding the switches



The memory length defines the maximum length that a data set can have. One can easily read with the Acquis software only a dataset of 100 bins if the memory is configured for 16k. But if one reads 17k of data points on a 16k memory the last 1k data will be constant.

There are two main reasons to change memory length first: the default memory configuration requires to much time for acquisition and summation so that one looses shots, then redcuing the memory size proportionally decreases the time for acquisition and summation. This allows a lossless acquisition that comes at the expense that the far field is shorted.

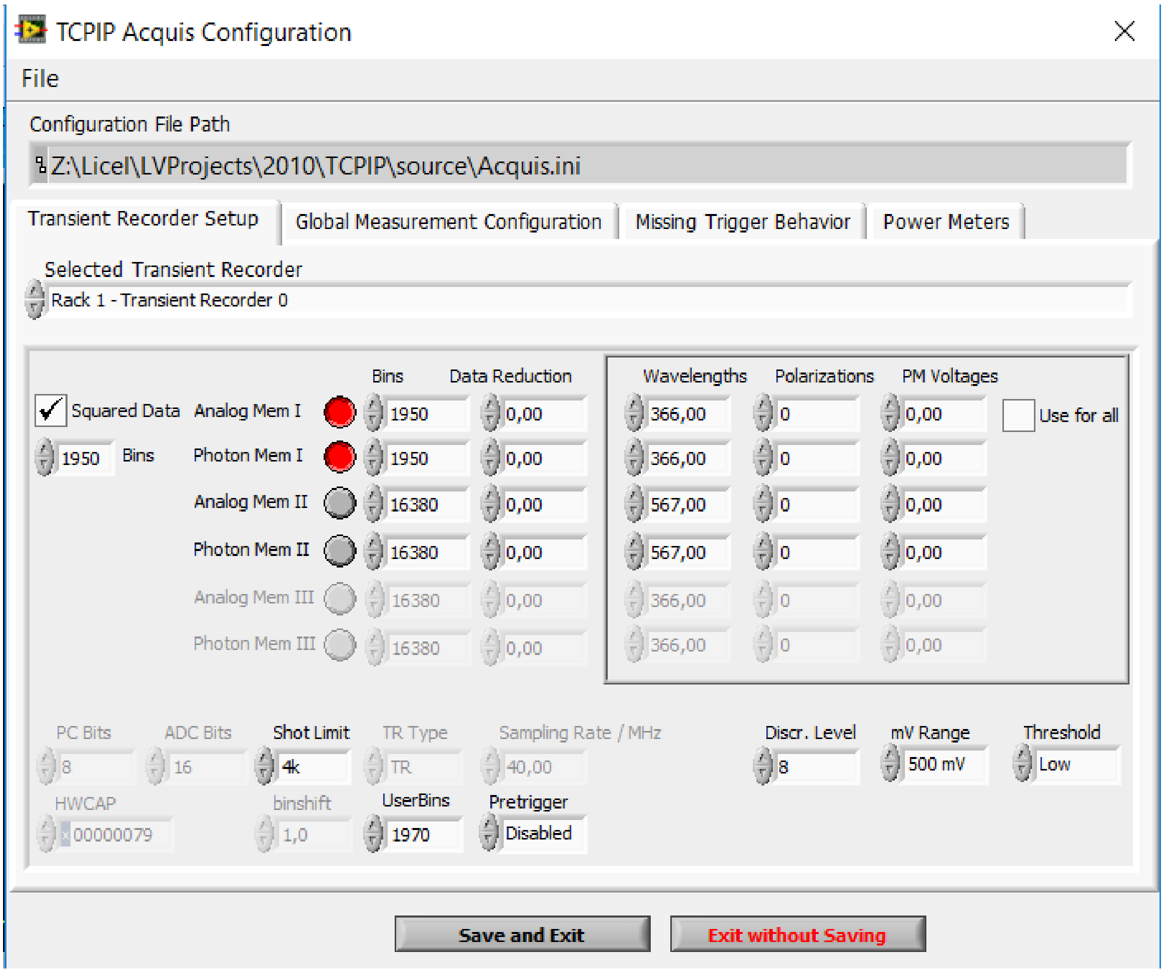
Second not enough far field then increasing the memory gives more farfield that can be read. However usually the frequency divider is the more flexible solution in this case.

Memory Depth	Address 1, 2, 3, 4	5	6	7	8
512	xxxx	OFF	OFF	OFF	OFF
1k	xxxx	OFF	ON	OFF	OFF
2k	xxxx	OFF	OFF	ON	OFF
4k	xxxx	OFF	ON	ON	OFF
8k	xxxx	OFF	OFF	OFF	ON
16k	xxxx	OFF	ON	OFF	ON
32k	xxxx	OFF	OFF	ON	ON
user length	xxxx	ON	XX	XX	XX

The address selection above shows the default a 16k memory configuration

For fast DPSS lasers (>1kHz) it is recommended to use the user definable length as outlined below. **Setting the switch 5 to the ON position will limit the memory length to 256**. This is the default power up condition. By software this can be set any value between 10 and 32768. The TCPIP Command is `SETMAXBINS <number of bins> <CRLF>`. (see *Licel Ethernet Controller - Installation and Reference Manual section 9.1 TCP/IP Command List and Syntax* *`SETMAXBINS`* and programming manual section Licel_TCPIP_SetMaxBins) The software changes will only work when switch 5 is ON.

Below is an example to configure the system in the Acquis software for a 10 kHz system



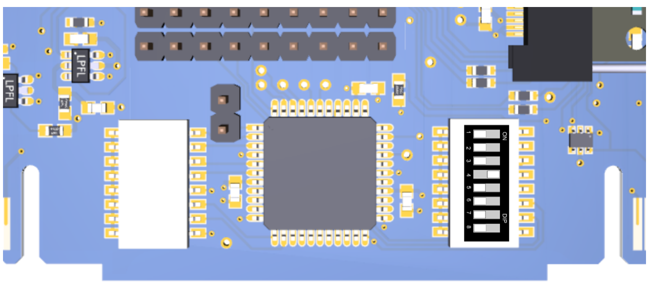
Please notice the `userBins` Value on the bottom of the dialog this defines the maximum trace length of the system. It should be larger than the `Bins` number.

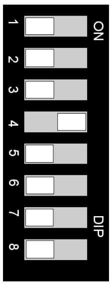
You should use this when the predefined Values for the memory configuration limit your ability to record every laser shot. The maximum repetition rate that the system can reach is defined by the memory length. If your laser repetition rate is low (10-20 Hz) the usual setting will work. But for higher repetition rates this might help to operate the system at the highest possible repetition rate.

3.5 Oversampling

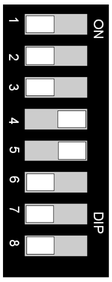
The TR40-16bit-3U supports on board oversampling. Typically this is set via software. Only for old Ethernet Controllers that do not support this feature it required to set it via DIP switch. Please consider upgrading the Software of the Ethernet controller in this case.

For the software change see the `FREQDIV` command at *Licel Ethernet Controller - Installation and Reference Manual section 9.1 TCP/IP Command List and Syntax*. How this is configured is shown also there in section 5.3.2 item 12 `Sampling Rate`

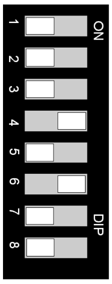




The system is shipped with the default configuration. The DIP Switches 5, 6 and 7 define the oversampling if all switches are off the system runs at base frequency.



The switch is 5 on, the resulting sampling rate is 20MHz



The switch is 6 on, the resulting sampling rate is 10MHz

For 5 MHz switch 5 and 6 would be on, for 2.5 MHz switch 7 would be on

Here switch 5 is bit 0, 6 bit 1 and 7 bit 2 of the frequency divider exponent. You divide the basic sampling frequency by $2^{\texttt{FreqExponent}}$. If the `FreqExponent` is 0 you have a 40MHz sampling frequency, if its is one - 20MHz, for 2 it will be 10MHz and so on.

This is the parameter that the TCPIP `FREQDIV` command accepts.

3.6 Squared Memory

The transient recorder stores in addition to the summed up values of the analog and the photon counting data also the sum of the squared analog and photon counting data. The memory layout of the squared data is documented in the Programming Manual. Starting form the summed up data and the summed up squared data one can compute the standard deviation of the averaged data for each individual bin. The computation is documented both in the Programming manual and in the Ethernet Manual. The knowledge of the standard deviation is important to judge correctly the information content of the data and provides insight on variability of the atmosphere.

Note: To get this working correctly the Ethernet controller software should be newer than 2019-12-17. The software version of the Ethernet controller can be retrieved with the `*IDN?` command or with the `Search controller.vi`

3.7 Trigger

Connect your trigger source to the Trigger A or Trigger B input. Make sure, that your trigger source is able to drive the required 1kΩ input load. Depending on your input the signal acquired will be summed and stored to memory A or B. This can be used to acquire two alternating signals.

Any trigger pulse which occurs during the acquisition and summation will be ignored as well as trigger pulses after more than 65534 acquisitions on either trigger A or B.

A valid trigger pulse is indicated by the "Run" LED.
Typical trigger sources are:

- The laser Q-switch out pulse,
- the a photodiode picking up a fraction of the outgoing beam,
- a function generator
- a timing pulse generator.

Laser Q-switch out The signal coincides with the actual laser shot. For the seldom case that the laser has difficulties to drive the required 1kΩ input impedance and produce a pulse that exceeds 2.5V for more than 150ns, the pulse needs amplification. A driving circuit scheme can be found at http://licel.com/manuals/PulseShaperTrigger.pdf.

Photodiode Licel supplies a solution for this as described under Option: Laser-Trigger which will drive the transient recorder. A custom made solution should deliver 2.5V @ 1kΩ for more than 150ns.

Function generator This is very convenient source for lab testing, connect the sync out of the function generator to the transient recorder input as described below.

Timing generator One should use this option if a pretrigger is required or a chopper wheel is used. Licel supplies a small module that fulfills the typical LIDAR system requirements.

3.7.1 Option: Rack - Trigger

In multichannel systems 2 trigger driver are integrated into the power supply of the 8-channel rack.

You can select between two setups to trigger all transient recorders in a rack 8 simultaneously or individual triggering of each transient recorder.

a) Common trigger using the rack Trigger: The trigger splitter is integrated into the power supply in the 8-channel rack. Connect your electrical trigger source to the "Trigger A" input. This trigger source will trigger all transient recorders in the rack 8 together and acquire signals into memory A. An additional connection to the BNC trigger inputs of each transient recorder is NOT required. The trigger input B does the same only the results will be in memory B.

b) Individual trigger for each transient recorder: Connect your trigger source to the Trigger A or Trigger B input of each transient recorder. Make sure, that your trigger source is able to drive the required 1kΩ input load. Depending on your input the signal acquired will be summed and stored to memory A or B. This can be used to acquire two alternating signals or to store two consecutive sets of up to 65534 acquisitions.

c) Common trigger using the rack trigger while blocking individually trigger pulses for each transient recorder: The typical use case is when the rack trigger A and B are driven but a certain channel should be active only when trigger A or B arrives.

If you have only one trigger, you can safely omit the following section.

This scenario happens when you have two laser sources in your system. Just imagine a system where you have a laser for the far field telescope and a laser for the near field telescope or a dial system.

If you have now transient recorders which are connected to the far field and to the near field in the same rack and connect both laser triggers to trigger A and B of the rack, a problem will arise: the transient recorders will react on both triggers, while your signal input has a signal input only on one of the laser shots.

While you will read out the right memory the shot number will show the sum of both trigger pulses and this shot number sum is used to stop the TR. In order to avoid this you would like to want to block the the trigger for the other telescope, and this can be done for each transient recorder individually. Then the transient recorders for the far field telescope will react only on triggers for the far field telescope and the near field transient recorder will react on the near field laser.

For the programming see the `BLOCK` command at *Licel Ethernet Controller - Installation and Reference Manual section 9.1 TCP/IP Command List and Syntax* and programming manual section BlockRackTrigger.

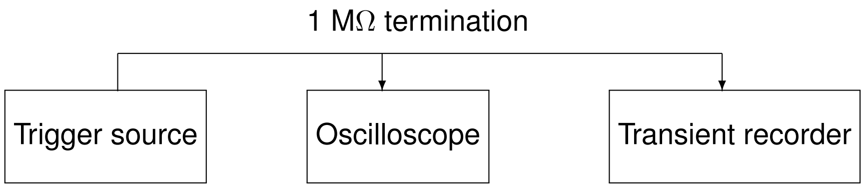
If you use our LabVIEW software this is be done by activating the `Block Trigger` option in the transient recorder setup dialog (see *Licel Ethernet Controller - Installation and Reference Manual section 5.3.2 The Configuration Dialog*).

3.7.2 Option: Laser-Trigger

In high repetition rate systems using a passive Q-switched laser, the laser pulse as detected by a photodiode can be used to trigger the acquisition. Connect the multimode SMA Fiber with a core between 200 and 1000 µm to the input ”optical input”, Direct a small fraction of the laser light (use any back-reflection) onto the other end of the fiber, while observing the ”Monitor” output on an oscilloscope. Increase the threshold with the potentiometer. At very low discriminator settings the noise signal will trigger the acquisition, at a very high discriminator setting the trigger will stop. Find both extreme values and adjust the threshold to a medium level.
The transient recorders should then be triggered via the 50 pin bus cable inside the rack.

3.7.3 Debugging trigger problems

Please connect a BNC T to the oscilloscope and select a high impedance input at the oscilloscope. Connect then one BNC cable from the trigger source to one side of the BNC T and another cable from the BNC-T to the transient recorder.



Record then the shape of the trigger pulse at the oscilloscope, it should be longer than 150 ns and more than 2.5V. The rise time should be less than 20 nsec. If it does not match you might need to amplify the signal or prolong the pulse.

3.7.4 Separate Shot counter

The unit has a separate shot counter for each memory. See the programming manual section GetShotsAB and the Ethernet Manual *Licel Ethernet Controller - Installation and Reference Manual section 9.1 TCP/IP Command List and Syntax `SHOTAB?`* how to access these counters.

3.8 Pretrigger

The Pretrigger mode the data from the ADC and the photon counts are buffered. The buffer is 1/16th of the trace length. If oversampling is activated it shortens the buffer by the oversampling factor.

For a 16k trace this results in a 1k pretrigger. The buffered data covers then 25ns * 1024. If oversampling by factor of 4 (10MHz) is activated the pretrigger is 100ns * 256 with the identical time as before. For TR with 40 MHz, the range bin 0 will then contain the data from 25ns * 1024 before the trigger and bin 1024 will correspond to the range bin 0 without pretrigger.

without pretrigger - 40MHz

0ns	+25	+50	+75	+100	+125	+150	+175	+200	+225	+250	+275	+409.5μs
bin 0	1	2	3	4	5	6	7	8	9	10	11	16380

with pretrigger - 40MHz

-25.575 μs	-100	-75	-50	-25	0ns	+25	+50	+75	+100	+125	+383.9μs
bin 0	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	16380

with pretrigger - 10MHz

-25.575 μs	-400	-300	-200	-100	0ns	+100	+200	+300	+400	+500	+1612.5μs
bin 0	252	253	254	255	256	257	258	260	261	262	16380

3.9 Signal

Connect your photomultiplier anode output to the signal input of the selected transient recorder. The connecting cable from the signal source to the signal input should be as short as possible. The built in preamplifier are designed for direct input of a photomultiplier signal with a 50Ω termination. The signal input is diode clamped for overvoltage detection but signal levels above -5 V can lead to damage of the protection diodes and should be avoided.

3.10 Parameter settings

To select the analog input range for your measurement first observe the signal in single shot acquisitions. The peak signal amplitude should never exceed the selected input range, since this would result in an underestimation of the averaged signal. The built in overrange detection can be used to control the peak signal during an acquisition. If any single signal exceeds the input range selected, the affected memory bin will be marked as clipped. By evaluation of this information after the measurement, the affected memory bins can be identified. The discriminator setting should be selected based on the pulse height distribution. Too low discriminator levels (below 3) make the system vulnerable to RF noise.

The Threshold Range can be set to high if large photons will cause an after pulsing that would otherwise overflow the internal preamplifier.

4 Operation

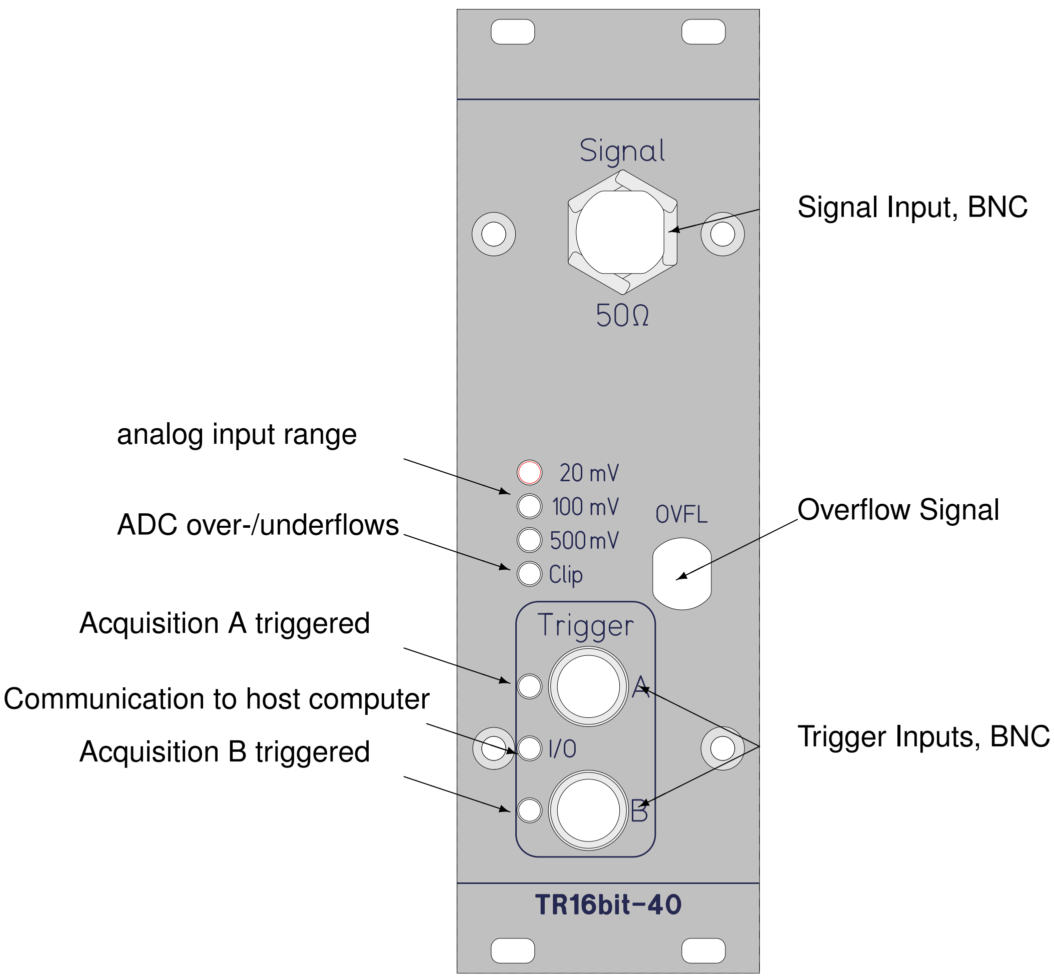
4.1 Signal acquisition

Using the LabVIEW module ”aquis.vi” you can perform automatic data acquisitions using multiple signal sources and transient recorders. Each acquisition cycle is performed by the following steps:

1. The discriminator is set to the selected discriminator threshold , the preamplifier is set to the desired input range.
2. The internal summation memory and acquisition cycle counter is cleared. This step is indicated by the ”Run” LED of each transient recorder.
3. The trigger is armed. Start of your measurement.
4. Deactivation of the trigger input, end of acquisition. This step can be done by the user or is performed automatically after 4094 or 65534 acquisitions.
5. Readout of the summed data for analog and photon counting signals from memory 1 and/or 2. Readout of the counted number of shots.

During the measurement valid trigger pulses are displayed by the LED ”Run” of each module. A signal above the selected analog input range, leading to clipping of the signal is indicated by the LED ”Clip”. Each communication between transient recorder and host computer is indicated by the LED ” I/O”.

Input and Controls



4.2 Bin shift

The analog and the photon counting data has a fixed shift between them. This is a result of two factors:

- Analog Bandwidth, the preamplifier contains an antialias filter which has a bandpass of half the sampling frequency this delays the analog signal with respect to the photon counting by 2 bins
- ADC pipelining, modern ADCs sample the voltage in a multiple step process so that the sample result will be available several clock cycles later after the actual sampling took place.

You can verify the bin shift for your TR by measuring under dark conditions the dark counts from a PMT with applied HV. When you take single shot measurements with `Track.vi` and switch between the analog and photon counting data set you will see that the needles in photon counting also correspond to needles in the analog but they are at slightly different positions. This shift is fixed and does not change with time for a given TR. A typical value for 16 bit system is 1 bin.

4.3 Analog background

The analog background is elevated intentionally, there are several reasons

a) We use a unipolar input range of the ADC instead of a bipolar, where the signal could go from -500mV to +500mV. The reason to use the unipolar is to give you the best possible ADC resolution, as positive signals will not come out from a PMT, it is negative going usually. There are PMT's out that make this different but they are seldom and use typically a preamp inside the housing which will not fit to the TR without a modification of the preamp.

b) The signal however can not start from 0 directly because every single photon while going negative typically also shows a slight overshot into the positive direction. You can observe this using the Track.vi. Connect a dark PMT with HV to the transient recorder and look for the photon counting data, once you see a single count switch the display to the analog mode. You will see a spike and the little undershoot below the baseline. The signal is displayed inverted so negative going photons will be go in the positive direction.

c) As those overshoots are part of the signal they need to take part in the average computation. A too low offset will clip them and then your average is compromised. To make sure that this will not happen we do two things:

- we elevate the analog background level
- we provide the clipping information both on the front panel and in the data that is retrieved from the transient recorder.

d) The clipping lamp goes bright when the ADC sees a 0 or a full scale 0xFFFF = 65335 value. At both conditions we are not sure that the average is not compromised by clipping. As soon as the lamp goes on we will also mark internally the bin as clipped. (See http://www.licel.com/manuals/programmingManual.pdf section Memory organization.)

This clipping information is used in the Track.vi and Live display.vi when you switch the Set Overflow Values to 0 and it will when overflows occur mark "innocent" looking averages with down to zero going needles. It is not used in the Acquis.vi as it would reduce signal quality and make a lot of algorithms grinding to a halt.

5 Maintenance

5.1 Safety

Before opening the rack the power supply should be turned off and the power cable removed for your personal safety. When opening the power supply cassette be aware of capacitors that can be still charged and lead to high currents although the unit is not connected to AC power.

Each transient recorder can be removed after opening the 4 screws at the front panel.

To remove the power supply unit, 2 additional screws below the side cover of the 19” rack have to be removed.

5.2 Cooling

The power supply of the transient recorders is using linear voltage controllers and therefore should be air cooled during operation. The air inlet is located at the lower front side of the housing the outlet is at the top rear side. Make sure that the ventilation system is not obstructed. Two LED’s are indicating the supply voltage of +5V and -5V. If any of these LED’s is off, check the power supply fuses. They are located at the rear side of the housing. Additional fuses are located on the power supply boards inside the cassette. AC fuses are located in the power cable terminal at the rear side of the housing.

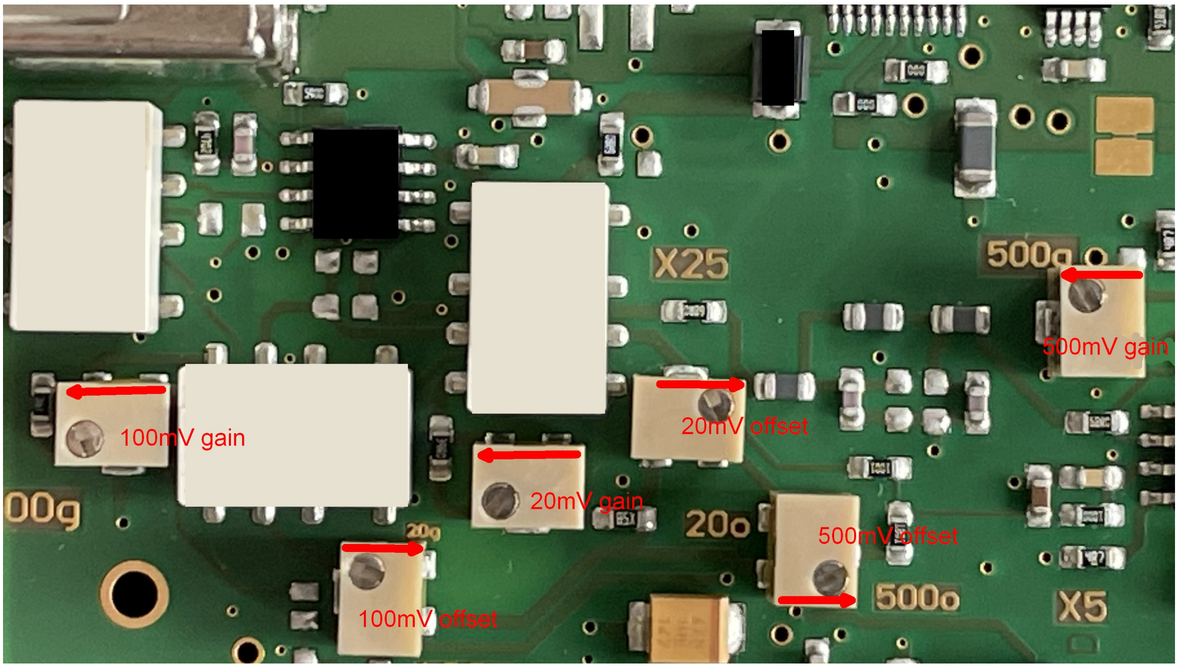
5.3 Calibration

If the clip lamp at the transient recorder flashes during acquisitions you might need to check for the over/-underflow. This is done with the Track or Live Display.vi where the ”Set Overflow to 0” switch is activated. If you see then needles that go down to 0 for small signals, then the offset for the input might be to low and changing the calibration would help to solve this. If you are in doubt send a screen shot of the Track.vi with the signal to Licel to discuss if a recalibration is required.

The offset and gain of each channel can be recalibrated by using the following procedure:

1. remove the transient recorder as shown in https://licel.com/manuals/TRMech.pdf
2. remove the right side panel by unscrewing two screws at the front panel and 2 at the rear panel.
3. plug the TR again into the rack and connect again the power and the flat ribbon cable
4. Use a plastic shielded screwdriver to turn the trimmers which can now be accessed from the right hand side. Connect a trigger source and start with the offset in the 500 mV range. Without input signal the offset should be 5 mV.
5. Apply a -480 mV DC signal and set the gain until this voltage readout correct.
6. Calibrate again alternating the offset and gain until both settings are correct. The repetitive procedure is necessary since the gain setting affects also the offset level.
7. Calibrate the 100 mV and 20 mV range using the same procedure as above, at 20 mV move the offset only to 2.7 mV.
8. if the procedure is completed, turn the rack off,
9. unmount the TR,
10. mount the side panel,
11. mount the TR and
12. turn the rack again on and verify your new offset settings

An offset level above your single shot noise amplitude is necessary to prevent clipping by underflows of the A/D converter. Like overrange signals this would lead to wrong results in the summed signal of an acquisition.



The arrows show the direction to increase the offset or gain

6 Trouble shooting

Failure of a power supply: Two LED's are indicating the supply voltage of +5V and -5V. In case of failure of one supply check the fuses in the back of the power supply. Check the fuses inside the power supply cassette.

No data transfer: The LabVIEW error message "... can not write" means that no handshake signal from the transient recorder was received with the hardware address selected. Check the hardware address selected in your configuration first. Check the internal flat ribbon interface cable for correct connection. The host I/O LED of each transient recorder indicates a handshake signal between I/O card and transient recorder. Most of the transient recorder related LabVIEW programs do this check at start up, so this message should be seldom.

Analog and photon counting signal is 0 Check whether memory 1 is readout when you use Trigger input A, or memory 2 is readout when you use trigger input B. Do the "Run" LEDs for the corresponding trigger and the number of shots readout indicate valid trigger pulses? Check the slope of your trigger source (trigger on rising edge).

7 Overflow Detection

7.1 Overview

The laser beam in a a lidar can hit hard targets that enter the field of view of a lidar. Additional to conventional Radar detection, the lidar signal itself can be used to detect those conditions and to stop firing laser shots for a prolonged period of time. The transient recorder acquires the ADC data and it is continuously checked against a threshold condition. In order to prevent false positive alarms due to ice clouds or other atmospheric phenomena one defines a region of interest with respect to the trigger where this overflow condition is analyzed. Once activated the threshold condition checks run independently of the acquisition and data readout process. For operation it requires a rack trigger A signal to operate. A missing trigger is considered as not OK and the optical output signal will be inactive. A overflow event within the region of interest causes the an inactive optical signal for a user configurable time.

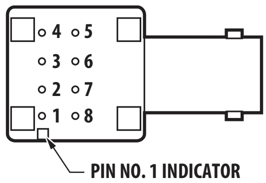
If no trigger timeout occurs and the threshold condition is not met within the region of interest the optical output will active.

7.2 Required Hardware

Licel ships this option together with an ST fiber and a AFBR-2418TZ fiber receiver.

Pin Description

Pin	Name	Function	Notes
1	NC	NC	1
2	/DO	Data Out inverted (CMOS/TTL logic)	2
3	VCC	5V/3.3V Supply Voltage	
4	NC	NC	1
5	NC	NC	1
6	RSSI	Received Signal Strength Indicator Output	
7	GND	Ground	
8	NC	NC	1



BOTTOM VIEW

Notes

1. Pins 1, 4, 5 and 8 are connected together internally. The metal port option components (suffix MZ) have an internal electrical connection between the metal port and the four grounding pins
2. The data output provides an inverted signal, thus an electrical low in case of light on and vice versa.

7.3 Parameter description

The region of interest is defined in bins after the trigger, the `StartIdx` and the `StopIdx` are in bins and stored in register `E000` and `E001`. In this region the signal is compared to a threshold level in LSB. If the signal exceeds this level an Overflow Event is registered and fiber emitter will go dark for a time specified as `Blocktime`.

The `Blocktime` increments in steps of 10000 * bin length.

For a 40 MHz TR this would be 10000 * 25ns = 250 μs. This is stored in register `E003` For pulse block of 1 second one would have there

$1000000/250 = 4000$

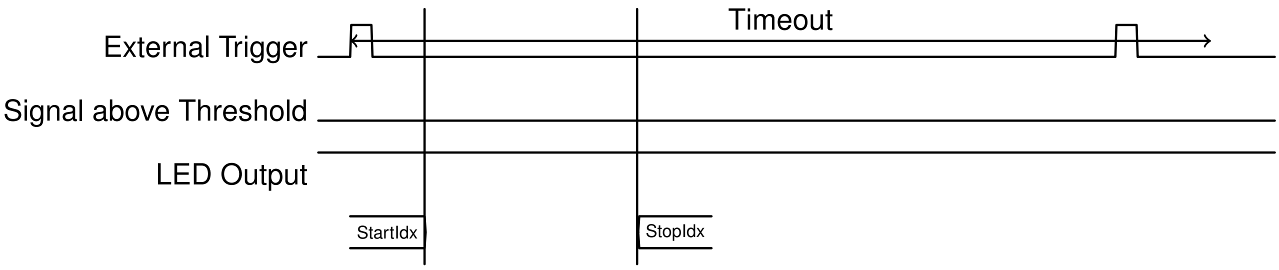
In order to assure that the detection works properly a `timeout` needs to defined. Each increment is 256 range bins. For a 40 MHz TR this would be 256 * 25ns = 6.4μs. If the time between two laser pulses the output will be dark after the `timeout` has been exceeded till the next trigger.

For a 100 Hz laser with 10 ms between pulses 16ms for a timeout would be good value.

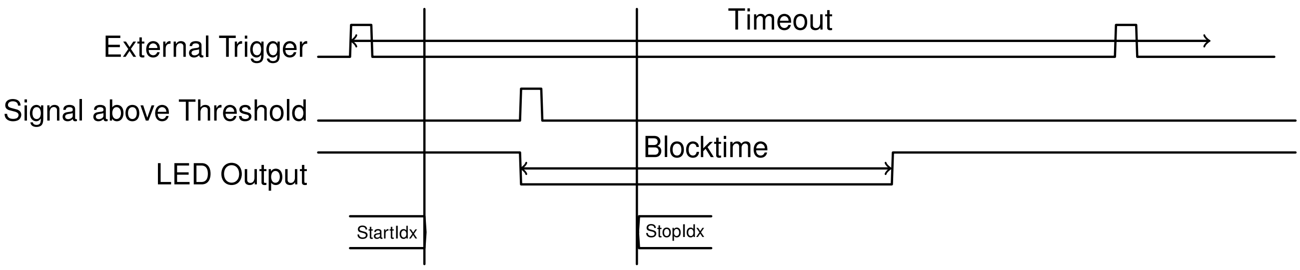
$16000\mu s/6.4\mu s = 2500$

All values are 16bit wide unsigned integer values ranging from 0 t0 65535.

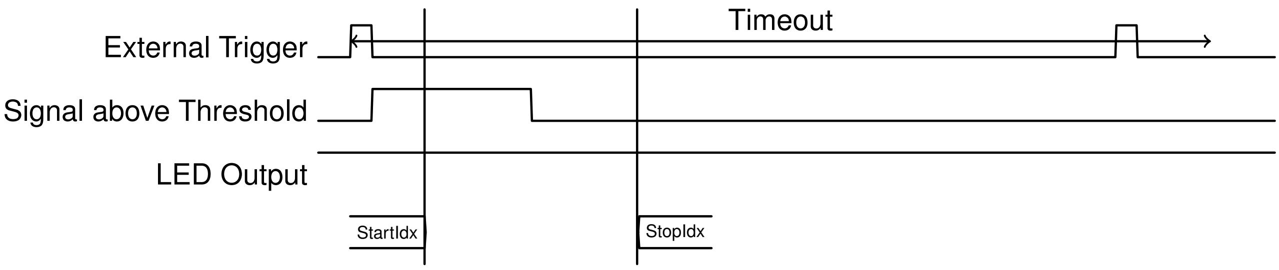
7.4 Timing Diagram normal operation no overflow



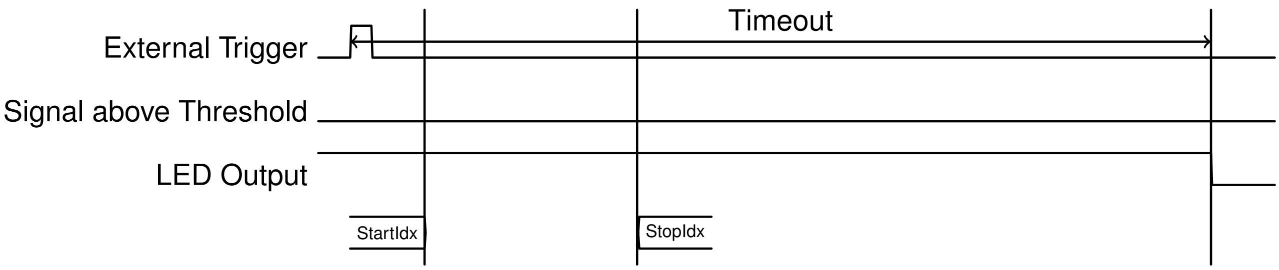
7.5 Timing Diagram normal operation with overflow



7.6 Timing Diagram normal operation with overflow before region of interest



7.7 Timing Diagram normal operation with timeout



7.8 Signal Rules

Bedingung	Output
After start of the TR until activation	LOW
If timeout is exceeded	LOW
After trigger till start time	HIGH
between start and stop time	OVFL Signal
after stop time	HIGH
If an overflow occurent between start and stop	LOW till the end of `Blocktime`

7.9 TPCIP-Commands

SIGNALTRIGGER OFF ANALOG RISING <ThresholdLevel>

Sets the threshold level in LSB. To set it to 1300 issue the command:

```
SIGNALTRIGGER OFF ANALOG RISING 1300
```

The return will be:

```
SIGNALTRIGGER 0 0 0 1300 executed
```

TR_SPI <HexRegisterValue>

Sets the TR registers:

- To set the start time set register 0 `E0000` to the number of bins as hexadecimal number. For a 2.5 μs start time this would be 100 bins and the 4 digits hexadecimal number is 0x0064 The command would then be:

  ```
  TR_SPI 0xE0000064
  ```

  the response is

  ```
  TR_SPI 0xE0000064 executed
  ```

- To set the stop time to 25 μs, this would be 1000 bins and the hexadecimal number is 0x0E38.

  ```
  TR_SPI 0xE0010E38
  ```

  the response is then

  ```
  TR_SPI 0xE0010E38 executed
  ```

- For the timeout the needs to be divided by 6.4 μs. For a 16ms timeout this would be 2500 and the hexadecimal number is 0x09C4.

  ```
  TR_SPI 0xE00209C4
  ```

  the response is then

  ```
  TR_SPI 0xE00209C4 executed
  ```

- The Blocktime needs to be divided by 250 μs. For a 1 second block time this would be 4000 the hexadecimal is 0x0FA0.

  ```
  TR_SPI 0xE00300FA0
  ```

  the response is then

  ```
  TR_SPI 0xE00300FA0 executed
  ```

Setting a register value to 0, drives the output continously low.

8 Specifications

Analog acquisition:

Signal input range:	0... -20 mV, 0... -100 mV, 0... -500 mV
A/D Resolution:	16Bit
Sampling rate:	40 MSamples/second.
Lidar spatial resolution:	3.75 m.
Bandwidth:	DC-20 MHz.
A/D differential nonlinearity:	typ. 0.5 LSB, max. 3 LSB @25^o C.
A/D integral nonlinearity:	typ. 3 LSB, max. 8.5 LSB @25^o C.
Spurious free dynamic range:	85dBc @ 3 MHz
S/N single shot:	72db @ 100 mV input range (25 μV).
Memory depth:	32768 bins.
Typical binshift:	1 bins
Summation memory:	2 channels 32 Bit, 65534 acquisitions.
Squared Memory:	2 channels 4000 bins
Protection:	Diode clamped.
Input impedance:	50 Ω
Coupling:	DC

Photon Counting Acquisition:

Max. count rate:	800 MHz.
Signal input range:	0... -25 mV/0..-100 mV (thresh low/high)
Input impedance:	50 Ω
Protection:	Diode clamped.
Discriminator:	64 levels for each input range, software controlled.
Lidar spatial resolution:	3.75 m.
Memory depth:	32768 bins.
Summation memory:	2 channels 16 Bit, 65534 acquisitions.
Input impedance:	50 Ω
Bandwidth:	0 - 800 MHz
	no dead time or overlap between bins

Trigger:	
	2 Trigger inputs to acquire signals in 2 separate summation memories.
Impedance:	1 kΩ
Threshold:	2.5 V
Slope:	positive
Trigger delay and jitter:	25 $\pm$ 12.5 ns.
Repetition Rate:	1100 Hz with 16k Memory
Power Consumption:	
+5.1V	0.8A
-5V	0.125A