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Report on the development of the DisOpto board for the HET taggers of KLOE2

L. Iafolla[1], A. Balla[1], P. Ciambrone[1], M. Gatta[1]
M. Mascolo[2,3], R. Messi[2,3]

[1] *INFN-Laboratori Nazionali di Frascati, via E. Fermi 40, 00044 Frascati, Italy*
[2] *Università Tor Vergata, Italy*
[3] *INFN Roma-2*

Abstract

For the KLOE upgrade (KLOE-2) we built a new couple of subdetectors: the HETs, two position detectors for electrons and positrons dedicated to the study of the $\gamma\gamma$ physics. The developed Data AcQuisition (DAQ) system of these two detectors is fully compatible with the data acquisition and trigger systems of KLOE. The DAQ of the HETs transfers the data to the KLOE acquisition through a VME bus while the trigger systems are connected through lemo cables. The electrical ground of the two systems must not to be connected in order to reduce the noise effects. This led us to develop a decoupling board called DisOpto.

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Introduction

The main issues on the development of the dis_opto board were:

- the constraint to not connect the electrical ground of the transmitter and of the receiver;
- the different electric standard of the DAQ of the HET (LVTTL) and that of the trigger boards of KLOE (NIM).

Many solutions were examined and finally we chose one which let us to use the same board on both sides. This solution is mainly based on 3 circuits: one to broadcast the signals both from KLOE that from the HET; one is to receive the signal without coupling of the ground; one is to convert the signals from the LVTTL to the NIM standard. In the next chapters a description of the board will follow a more detailed examination of the requirements for the board.

Requirements

The DAQ systems of HET detectors are interfaced to the trigger system of KLOE-2 through 5 signals: T1, T2, SyncR, SyncF and Busy. These signals are provided and received by two boards of the KLOE trigger chain: the trigger distributor board for the T1 and the FIO board for all other signals.

All these signals must agree with the NIM standard (0 mV for 0 logic level, -800mV for 1 logic level if the output is terminated on 50 ohm impedance) on the KLOE side, while they must agree with the LVTTL standard on the HET DAQs side (0 V for 0 logic level, 3.3 V for 1 logic). The timing requirements are not very high: the positive and negative edges of the signals can be as slow as 2 ns and the width of each pulse is longer than 150 ns; the time between two pulses is bigger than 2 us. These can be matched with standard LVTTL devices.

The electronic ground of the HET detectors and of their DAQ systems is connected to the DAFNE ground: this is because the detector is installed on the accelerator. It was decided to take the electronic ground of KLOE not connected to that of DAFNE, in order to reduce the noise. This makes that the signals from and to the trigger boards of KLOE can't be simply connected to the DAQ boards of the HETs.

Another problem is due to the distance of the HET DAQ to the KLOE trigger system (about 11 m); the cable path is longer (24 m - about 120 ns of delay).

The implemented solution is based on the Toshiba photo-coupler TLP117: in this Integrated Circuit (IC) the input drives a LED whose emitted light is detected by a photodetector. So the ground of the input signal and that of the output are not connected (Fig. 4 and Fig. 5). Due to the dynamic behavior of the input impedance of the TLP117 is not easy to match the impedances so reflections can arise on the cable.

We developed a general purpose VME board (Dis_Opto board, Fig. 1) that can be used in both sides of KLOE and HET. There are 6 transmission and 6 receiver circuits replicated in each board.

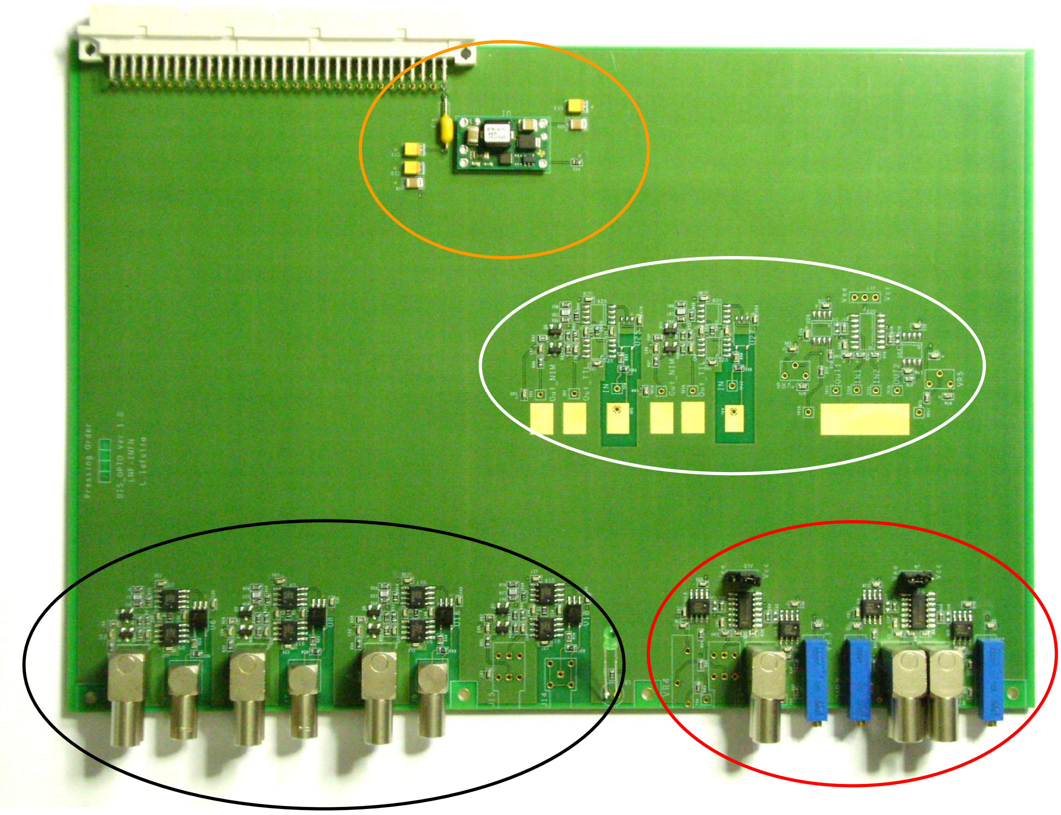

Fig. 1. The Dis_Opto board is a 4 layers board: the two internal layers are used for ground and power while the external layers are used for the routing. The circuit in the orange ellipse on the top is for the power and is based on the PTN04050A module that supplies -5V voltage while the +5V is from the VME; the circuits in the black ellipse on the left bottom are 4 receivers (just 3 completely assembled), the single lemo connectors are for the inputs and have a separated ground, the double lemo connectors are for the outputs (1 with standard NIM, 1 with standard LVTTL); the circuits in the red ellipse on the right bottom are 4 transmitters (just 3 completely assembled); the circuits in the white ellipse at the center are some spare transmitters and receivers.

Transmitter stage

Each input of the transmission circuit is first discriminated by the NE521 IC; the thresholds of these discriminators can be set (from -5V up to 5V) so they can accept signals from the KLOE trigger boards and from the HET DAQ (Fig. 2 and Fig. 3). The signals are then broadcast by a buffer from a first board through the 24 m cables to a receiver stage of a second board.

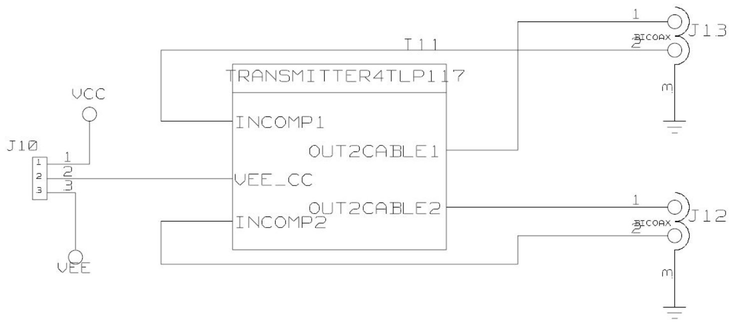

Fig. 2. General scheme of the transmission circuit. The thresholds polarity can be set with the jumper on the left for a couple of channel.

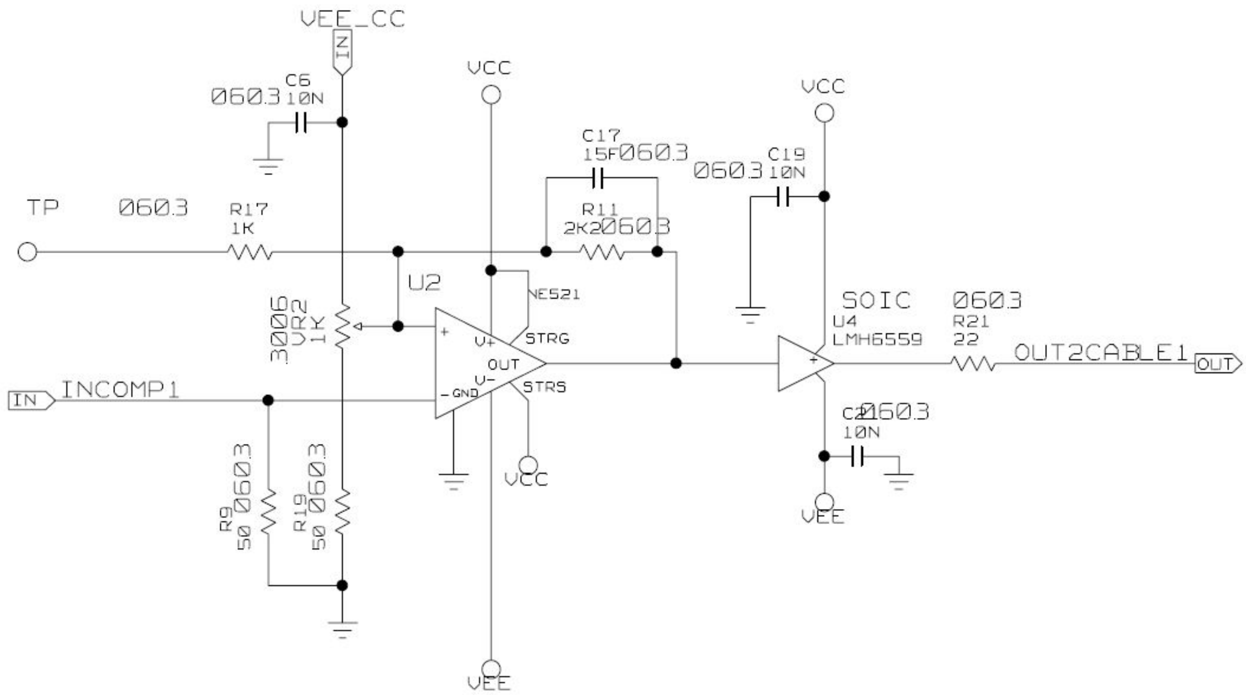

Fig. 3. The input stage of the transmitter circuit (Transimitter4TLP117) is based on the NE521 comparator. The threshold can be modified using the trimmer VR2 and read through the test point "TP". The output is driven by the LMH6559 buffer through a resistor (R21) which reduces the reflections on the 24 m cable.

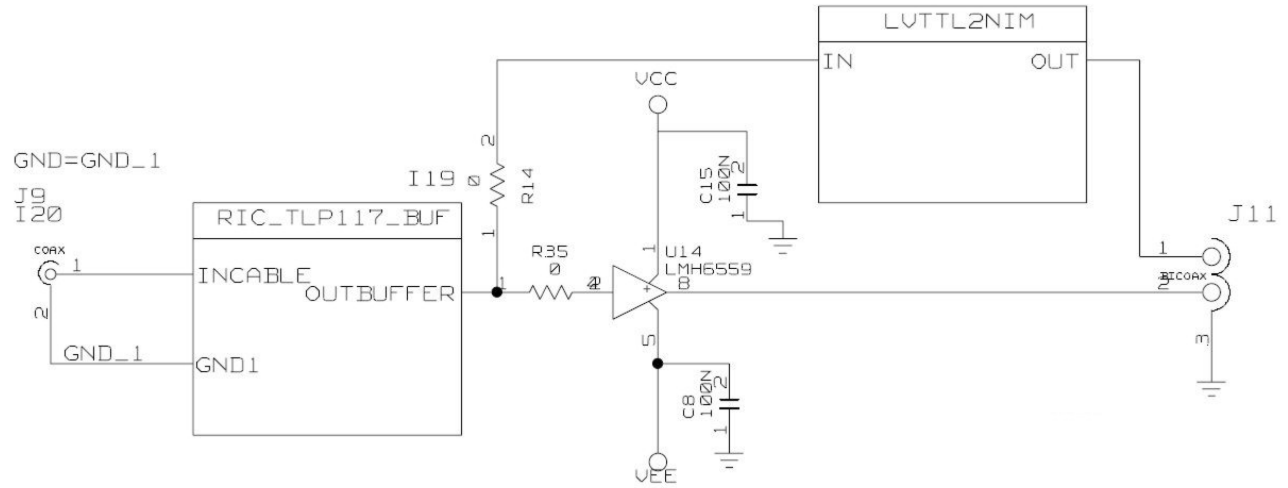

Fig. 4. General scheme of the receiver circuit. The input signal has its own electrical ground (GND_1) and it is separated from that of the other parts of the circuit. The output of the decoupling stage (RIC_TLP117) is fed to a level translator circuit (LVTTL2NIM) for the NIM output (J11-1) and to a LMH6559 buffer for the LVTTL output (J11-2).

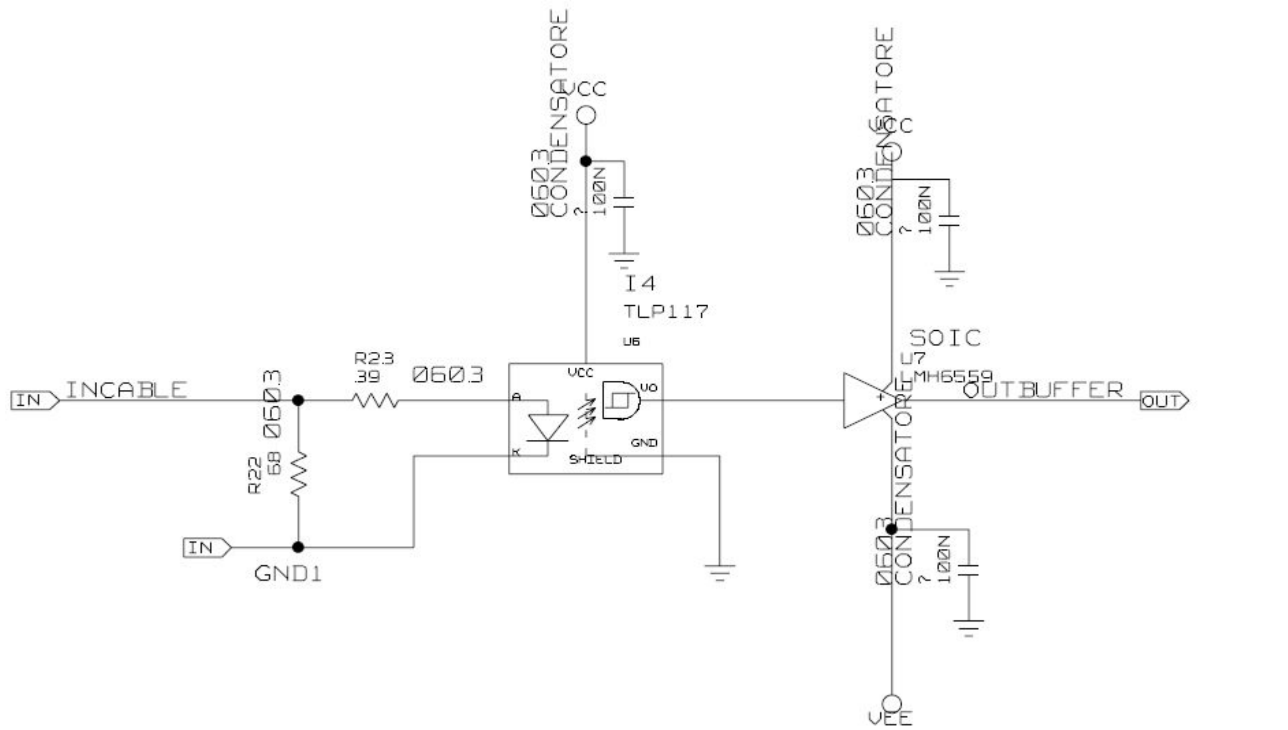

Fig. 5. The decoupling stage (RIC_TLP117) is based on the TLP117 IC. The input signal is fed to a resistor net (R22 and R23) that were chosen in order to reduce the reflections on the 24 m cable. The TLP117 drives the output through the LMH6559 buffer.

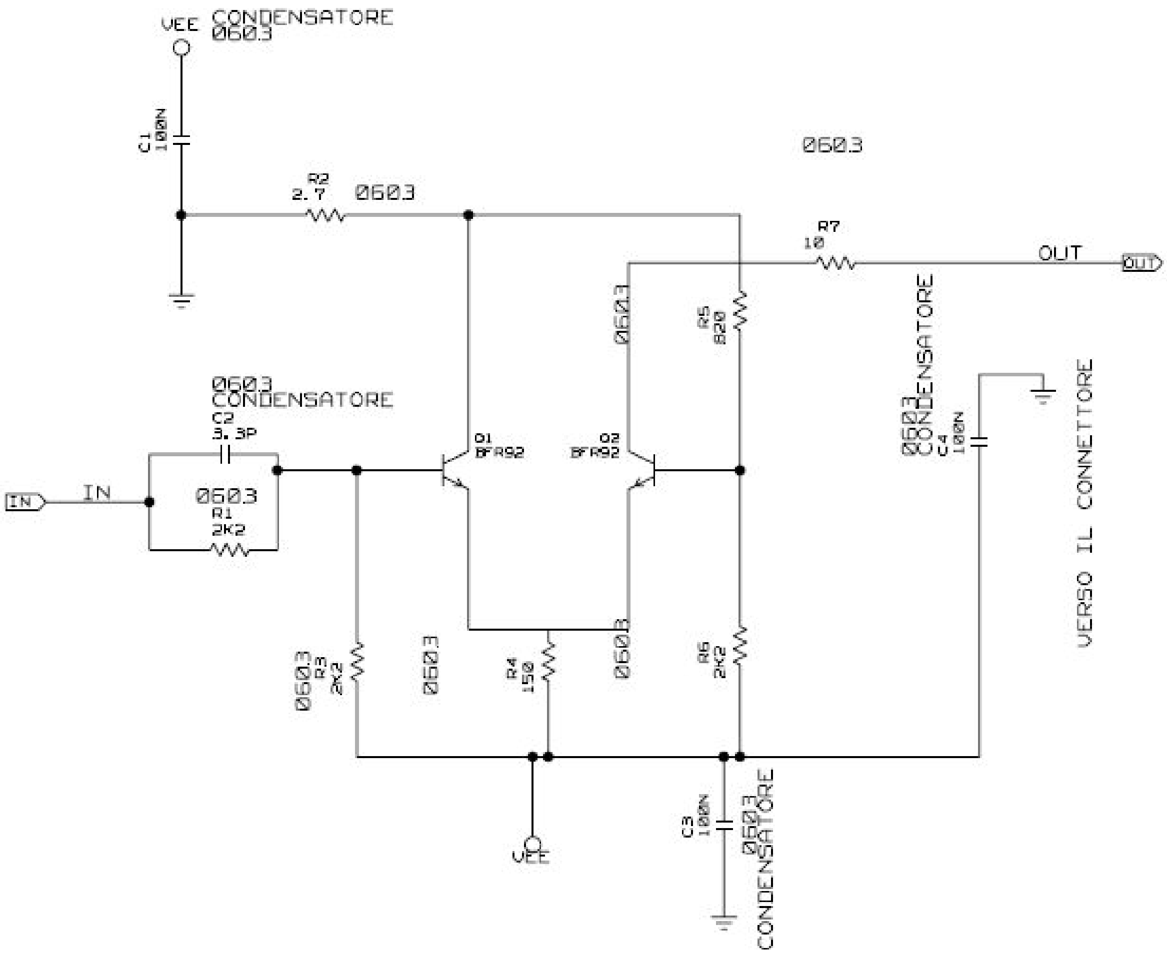

Fig. 6. The LVTTL2NIM circuit performs the translation from a standard LVTTL to a standard NIM. It is based on a discrete components net with BFR92 transistors.

Receiver stage

The input stage of each receiver is made up of a net of 2 resistors and the TLP117 (Fig. 5): the resistors are chosen to reduce the reflections on the cable. The output signal of the TLP117 agrees with the LVTTL standard and it can be connected directly (or through a buffer) to the HET DAQ. Instead it has to be translated to the NIM standard before be connected to the KLOE trigger boards. So the output of the TLP117 is splitted in two output signals (Fig. 4): the first just pass through a buffer and then can be connected to the HET DAQ; the second, for KLOE trigger boards, is converted to the NIM standard by the circuit in Fig. 6.

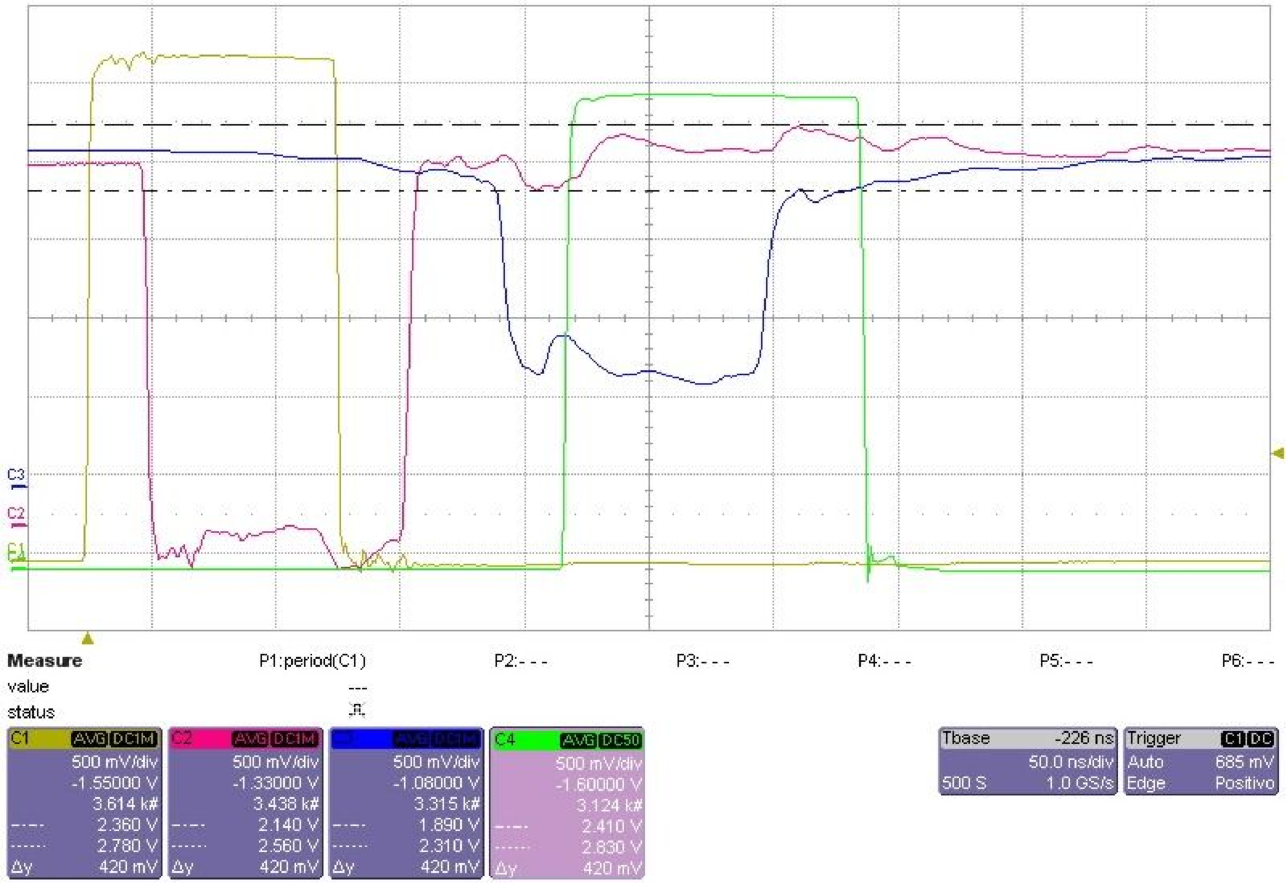

Fig. 7. This snapshot from the oscilloscope shows the main signals of the transmitter and receiver circuit. The first channel (yellow) is the signal to be broadcast; the second one (red) is the output of the transmitter stage (first side of the cable); the third one (blue) is the input of the receiver (first side of the cable); the fourth one (green) is the output of the receiver stage. The delay of the cable used to perform the test was about 140ns.

Test results

The main issue to be managed in the design of this system is the reflections on the long cable. The resistor net was designed by simulating the circuit with Pspice; other solutions are not easily applicable because of the requirements. Fig. 7 is a snapshot from the oscilloscope and shows that the output reproduces well the input although reflections are evident on the cable near the transmitter and also near the receiver. The circuit was successfully tested for input pulse width down to 30 ns (the requirement is 150 ns); instead the maximum rate of the input should be below 4 MHz (the requirement is 0.5 MHz) to avoid that the reflections overlap with the signals.

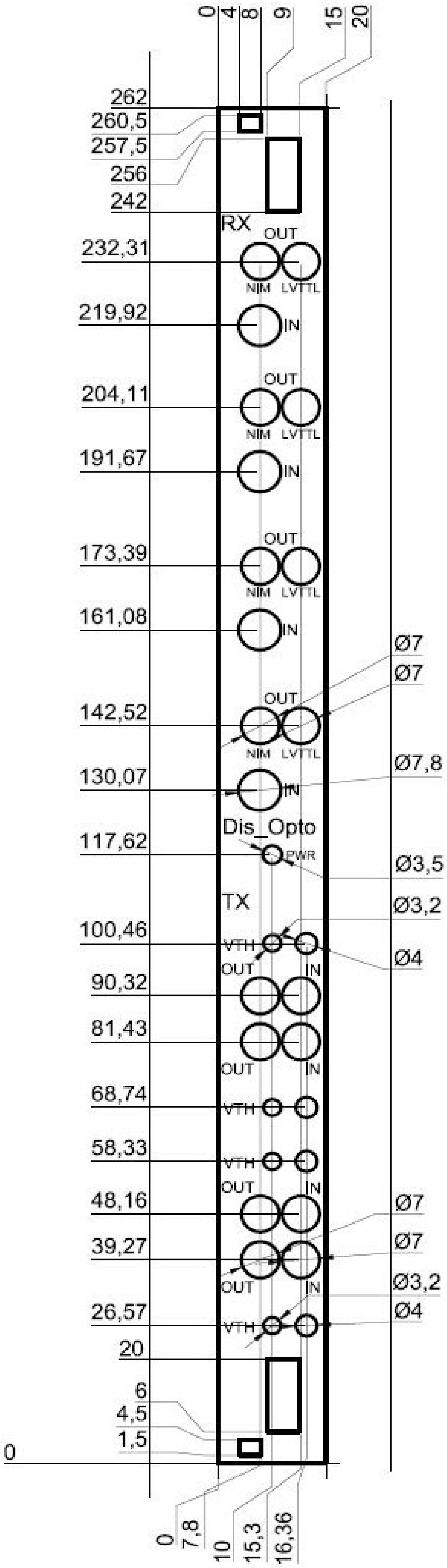

Fig. 8. Layout of the front-panel for the board dis_opto.

Conclusion

Five dis_opto boards were assembled (2 for each HET plus 1 for spare). The dis_opto boards are currently installed and used successfully at KLOE-2 with the DAQ of the HET detectors. So far no failure was detected. Also a front panel was designed and will be soon realized (Fig. 8).