



Front-end electronic system for large area photomultipliers readout

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Abstract

We developed a front-end electronic system for large area photomultipliers (PMT). Connection to the PMT can be made by a single cable, useful to minimize cabling in an underwater detector. The cabling is done in the rear part of the crate to permit easy access to the electronic boards. A front-end board houses 8 channels each one is composed by a preamplifier and a leading edge discriminator. Up to 8 front-end boards can be housed in a crate, giving a modularity of 64 channels. A controller board is needed to setup and monitor the front-end parameters. This board implements also scalars and time to digital converters (TDC) with time over threshold (TOT) capability. The communication with the outside world is made using a standard gigabit Ethernet (GbE) line.

SUMMARY

In the framework of R&D for the DarkSide-20K experiment, we developed a compact modular electronic system to handle a large number of large area (20 inches) photomultipliers (PMT). The PMT can be connected to the system using a single cable carrying both high voltage (HV) and signal: this is useful to minimize the cabling in an underwater detector.

- Inside a standard 6U crate up to 64 channels can be handled:
- the HV is coupled to the cables in a dedicated module in the back side of the crate;
 - the PMT signal is then extracted and feeds a 8 channels preamplifier-discriminator board;
 - the amplified signal can be sent to external Analog to Digital converters;
 - a digital controller board (one each crate) will receive the discriminated signals and handle all the slow control functions (setting and monitoring of various parameters like the discriminator thresholds, channel masking, low voltage and current measures, ...);
 - the digital board implements scalars and time to digital converters (TDC) to monitor and measure both the arrival time and time over threshold (TOT) for all the 64 channels;
 - the digital board can be time synchronized using a GPS reference clock or implementing a more sophisticated White Rabbit scheme;
 - the system is then connected to the outside world through the digital board using gigabit Ethernet standard with copper or optical fiber cables.

The system has been completely designed and prototypes have been manufactured, it is currently under test in the lab.

Front-End Crate



Analog Board Test Bench connected to large 20" PMT

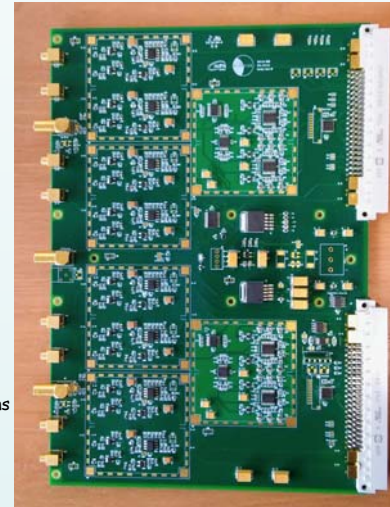


ANALOG BOARD

The Analog Board specifications:

- 8 channels, $V_{out\ max} = 2\ V_{pp}$
- Dual power supply: +5 V and -5 V
- Can be plugged in a standard VME crate
- Input on backplane connectors
- Output on front panel MCX
- Gain: 10 V/V
- Z_{in} : 50 Ω
- Bandwidth (-3dB): 120-150 MHz
- Output noise: < 0.2 mV_{RMS}
- Crosstalk: $\approx 1\%$
- Sum of 4 channels on front panel LEMO
- Common calibration input for 8 channels
- Discriminator for negative signals
- Independent threshold setting from 0 to -100 mV
- LVDS discriminator outputs on backplane
- Discriminator minimum pulse width: 5 ns
- Discriminator double pulse separation: 4 ns
- Temperature sensor

Configuration via digital board or local I²C interface



DIGITAL CONTROL BOARD

Digital Control Board features:

- Form factor: 6U x 160 mm
- Can be plugged in a standard VME crate
- Receives 64 discriminator signals (LVDS) from 8 Analog boards via backplane
- I²C and 1-wire interfaces on backplane
- Main component: Intel Altera Arria V FPGA
- Embedded FPGA programmer USB Blaster
- User interface: bicolor LEDs, switches, OLED display, rotary switch
- Fast communication interface: SFP for optical or copper Gigabit Ethernet
- Dual UART on USB
- Memory resources: 256 MB DDR3, MicroSD
- Coax I/O: 6 In, 4 Out, NIM-LVTTL
- 2 fast ADC: 14 bit up to 250MHz
- 2 fast DAC: 14 bit up to 250MHz
- Tunable oscillators for White Rabbit
- Dual power supply: +5 V, -5V
- Debug preamplifier for SiPM



Digital Control Board functions:

- Analog boards configuration
- TDC and Scalars for discriminators
- User commands from front panel or GBE
- Timing synchronization with GPS or White Rabbit
- System debug:
 - Signal sampling
 - Waveform generator
 - Dual gain SiPM amplifier

Large 20" PMT in the dark box
connected with single 50 m submarine cable