Common problems of grounding of the ICARUS detector.

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Experience of the test the electronics on the 10M3 module at Pavia and LNGS (L`Aquila).

During February, March and April two racks with 960 channels of ICARUS DAQ electronics have been installed on the top of 10M3 module. Some experience was received and there are several technical requirements that must take account in the future to build bigger electronics system of 600T module.

A. Connection of sensitive wires to the Front-End electronics.

All wires inside of the detector must be have only tree type of the connections:

a. To Front-End electronics through DB module.
b. To high voltage through backplane of analogue crate.
c. There aren't any connections.

B. Connection monitor system of cryogenic system.

There are different circuits that have been using to monitor several parameters of argon liquid. The first and big problem is connection to analogue Ground of detector. Any connection with analogue ground must be make with attention to avoid cross talk from monitor circuits to Front-end circuits.

Obviously, best solution to avoid cross talk is using high impedance

Differential buffers and good shield of monitor system cables inside and outside detector. Really, it isn't possible at any cases, but may be some revision of common scheme of interconnection is needed.

C. Connection computing NET cables.

C1. All cables of net must be connected between rack to rack above of the rack. They must be shielded by screening cable's box.

D. Noise requirements of High Voltage system.

There are three parts of high voltage systems. The first of them is KATOD power supply. This power supply must be have low ripple of output voltage and must be connected to KATOD of detector though low pass filter. Serial resistance of the filter can't be more 1 Mohm.

The second of them is power supplies of sensitive wires. Between P.S. and backplane the high Voltage filter is placed. This board help to cut low and high frequency disturb. The power supply of wires must be linear because of a maximum applied voltage is 400 volt and we can use low cost circuits for this application. Last test show to us that to avoid 50 kHz noise we must be use a very high costly switching power supply. Simple linear power supply has cost very low.

Third part is P.S. for photo multiply tubes. Technical requirements of this P.S. must be very same NOVOLEC N… module or better.

E. Line cables connection and filtering.

There are two solutions to avoid problems earthen equipment:

1. Star-ground configuration for connection our instruments.
2. One isolation transformer can be use for 220 Volt of front-end electronics. The second coil of transformer will be connected to analogue ground. Max. Power is about 0,5 MW. This transformer help to receive a good ground that will be connect with detector and earth under the detector. See. Fig 1.

F. Digital Crate.

Digital crate is really big noise producer. After the test of ICARUS electronics we found that there are some electromagnetic interference between front-end electronics and digital crate. During of the measurement we had a noise signal about 100 kHz and altitude about 15 counts. The problem was resolved by screening of a digital crate inside of the rack. Sheet aluminium was used to screen. The thickness is 2,5 mm. This test shows to us that some technical requirements of a rack and digital crate are needed. The main producer of a noise is power supply (+/-12 V) of the SHROFF crate.

Normally, Any switching power supplies produce big noise with a frequency from 40 to 100 kHz. There are two components of noise:

1. Radiated emission (enclosure).
2. Conducted emission (AC input).

We found that AC component is very small and star connection of main cables is considered. To cut the noise of radiated component the screening box (for example, case of crate can be used like screening box) have been using inside of rack.

To choose a crate for our application is not so difficult. There are some different standards of Electromagnetic Compatibility of a power supplies. Best solution will be USA standard FCC 47 CFR Part 15

(Level B) or VDE0871 (level B). These standards require a minimum EM emission at distance just 3-meter. There is another standard and requirements are different.

For example, the SHROFF crate was tested according EN55011 (level B) standard require 40 dBuV at distance 10 meter but when a steel box shields the power supply of a crate. It means some attention in choosing of finally model of crate is needed.

Solutions:

a. To choose a crate with minimum EM emission (Level B for components and circuitry vulnerable to the influence of EMI.).
b. To choose a power supply of crate with minimum ripple of output voltage (V ripple, p-p < 15 mV).
c. To make an electrical isolation between a rack and a metal parts of the digital crate.
d. To make a screening part inside of the rack.

Note: The SHROFF crate has three voltages:

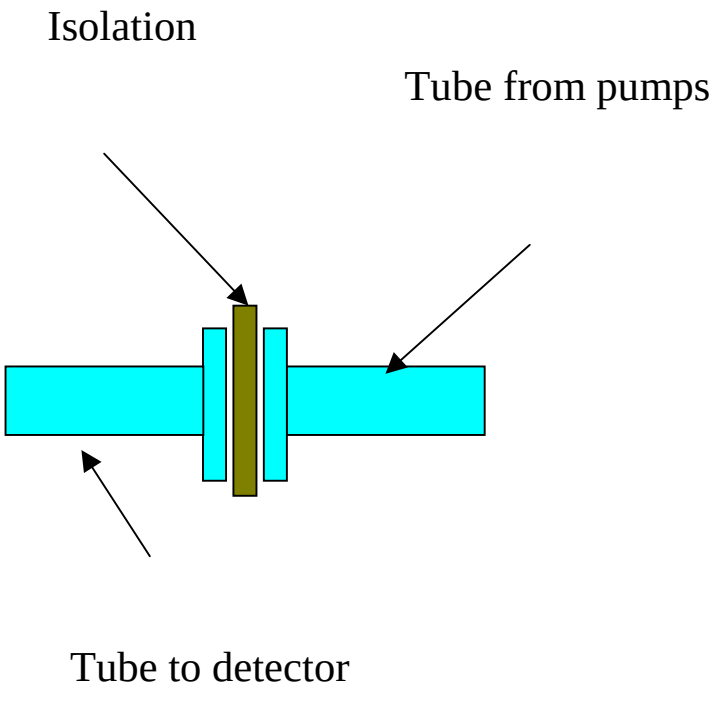
+5Volt (switching rate 200 kHz), V ripple (+5V) - 40 mV.

+/-12 Volt (switching rate 100 kHz), V ripple (+/-12V) - 200 mV.

According shielded effectiveness of sheet aluminium really electromagnetic emission of a digital crate must be at least 40 dB less then SHROFF crate.

G. Connection Vacuum equipment.

All metallic tube of different pumps must be isolated electrically from Analogue ground.



H. Front End electronics Ground Connection.

There are tree type of Ground (Groung-in, Clean Ground and Analogue Ground) and each of them can be use just definite equipment (fig.1). Each rack of Front End electronics has connection with analogue ground just in one point (fig 2.). Another connection with Analogue Ground not acceptable. All cables that are arrived from control room, calibration crate, trigger system and a.t. must be shielded by screening

box. General view a kind of used signal is defined by electrical compatibility of system and noise levels. To communicate between Front-End electronics and control rooms have been using the low-level noise interface signals (NIM, LVDS, and I2C). TTL and other kind of signal in not acceptable.

Victim is WIRE.

Electromagnetic Influence from:

Systems of the detector:

- Vacuum pumps.
- Monitor system of Cryogenics.
- Computers.
- High Voltage Supplies.

Outside influence:

- Conductive influence - refrigerator, .. and other …
- Radiated influence - Radio, TV and other…

Solutions

- EMC Filter of AC power (220 Volt) for each rack.
- Digital crate with shield box.
- All High Voltage supplies must be low noise power supplies and output filter for them is needed.
- Electrical isolation between all pumps and detector.
- The "Star" connection of AC power cables.
- All interconnection cables must be put inside screen box.
- Isolation transformer for front end electronics.
- Low impedance ground of the Detector. Driven rod.
- Cryogenic monitor system (high impedance and differential input). Shielding of cables.

Note 1:

THE DRIVEN ROD.

The resistance to the earth for driven rod depends on its diameter D and on its length L. Using methods is

$$R = (\rho/2\pi L)*\log(4L/D)$$

ρ is about 10000 **Ω** -cm. It can be from 500 to 10000 **Ω**-cm

R can be from 1 to 5 **Ω.** More then 5 Ω can't be - safety requirements.

L - from 5 to 20 meters.
D - from 1 to 3 inch.