Design and development of HV system for the CBM-MUCH Experiment.

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Introduction

A Gas Electron Multiplier (GEM) based micro-pattern gas detector has been envisaged for a Muon tracker for the CBM experiment at FAIR [1]. These detector systems along with its HV/LV and readout system are the responsibility of CBM-India team. In this regard, we are engaged in development of an indigenously built High voltage power supply prototype system which can feed the GEM detector reliably for the entire period of operation in CBM experiment. These power supplies are planned to be operated remotely by a common CBM-Detector Control System (DCS) and thus should meet all the requirements of the central DCS system like interface, reliability and scalability.

HV System

The HV system consists of main frame which can house 10 to 12 commercially available power-supply modules. Each module will be responsible for powering one GEM detector in CBM-MUCH Experiment. It also consists of dedicated microcontroller board for each power supply module. These microcontrollers will be controlled by a common FPGA/Raspberry-Pi based controller board, which received and send back data to a common CBM-DCS or to unified epics controller board. This HV system is cost effective as compared to the commercially available multi-channel HV power supply options. In this direction a single channel prototype has been developed to demonstrate and test feasibility of the HV system against CBM standards. For power supply module, commercially available MPS series high voltage module of rating -5kV, 2mA manufactured by Spellman shows the promising datasheet. This module has voltage stability of 200 ppm, temperature coefficient of less than 25 ppm, RoHS compliance, CE marked, safety compliance EN61010-1, and easy configuration by RS-232 make it best suited candidate for our requirement [2]

Prototyping

The prototype HV system consists of one Spellman-module, one RS-232 to RS485 converter module, one slave microcontroller (Arduino Mega) and one master controller board (Raspberry-Pi board) as shown in Fig.2

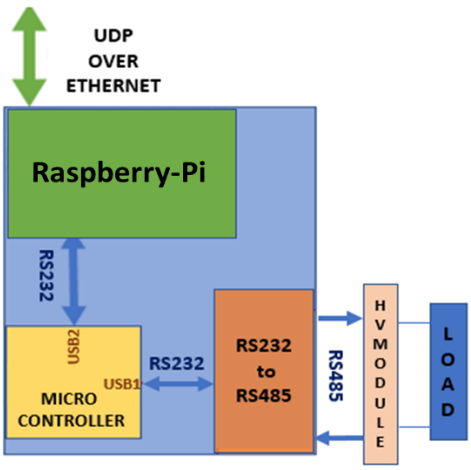

Fig. 2 Block diagram of HV prototype supply

Slave Micro-controller has two independent and dedicated UART links. Via first link, micro controller talks to the HV module through RS-232 to RS485 converter module. Other UART link receives and sends command from/to the

raspberry pi master. Rasberry-Pi board act as a master and serve as bridge between UART (Front end, microcontroller side) and Ethernet (Back End, server machine). Python scripts were written for UDP socket program, flexible buffer and UART interface, exploiting concerned I/Os of Raspberry-Pi boards. As shown in the Fig.3 the controller board sends and receives datagram via UDP socket to/from Server machine via Ethernet link.

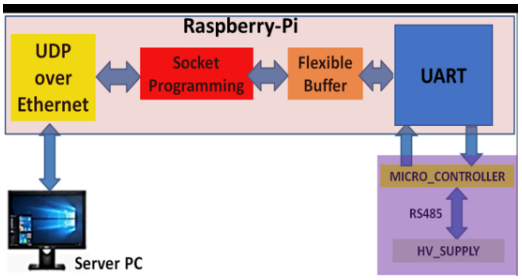

Fig. 3 Data flow in Raspberry-Pi

Python socket program collects datagram from the transport layer and after preliminary processing and segregation data loaded into flexible ring buffer. This buffer can automatically adjust its size depending upon the payload size of the datagram. Flexible ring buffer handshakes between Ethernet and UART independently, keeping data exchange between two protocols reliably and seamlessly. Python scripts for monitoring and control of prototype modules parameters were written on MUCH server.

Prototype testing

Fig. 4 shows the prototype HV system at GSI Germany.

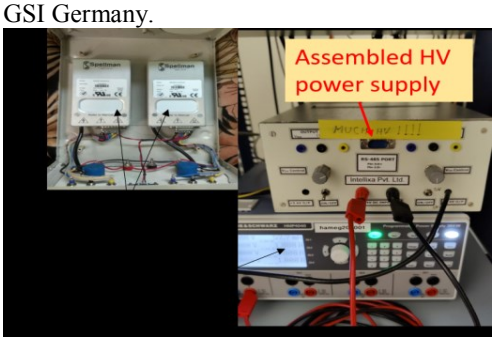

Fig . 4 HV system installed at mCBM

The HV system was tested in lab with a resistive load for it long term stability and then it was sent to GSI Germany for installation in the mCBM experiment. At GSI prototype HV system was installed in mCBM rack area and finally integrated with GEM detector module for its performance evaluation during high rate test. Custom built power supply requires 24V DC input which was taken by commercially available Hameg Power supply.

Results

The prototype HV system was tested with GEM detector in the experimental environment and parameters like voltage and current were recorded for 22 hours with the time resolution of 1 second. As shown in Fig.5 ramp up time of prototype supply is 7 minute and after that the voltage was set to 4344 V while the current monitored was 1514 uA.

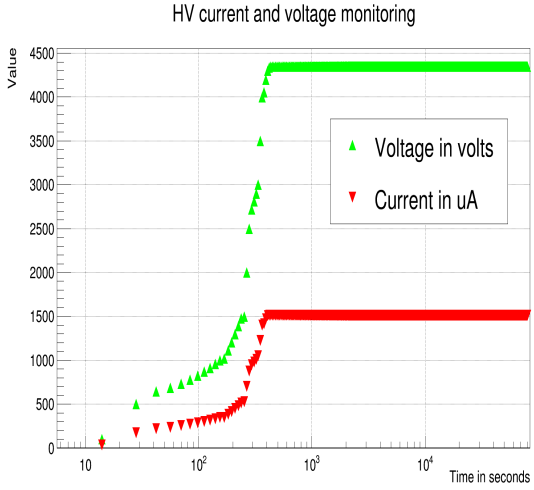

Fig. 5 Monitoring data plot.

For the entire testing period of 22 hours no glitch or any other anomaly was found. The detailed layout of the HV module and its performance will be presented and discussed.

References

[1] GEM based R&D for muon chambers of CBM experiment at FAIR

[2] https://www.spellmanhv.com/en/high-voltage-power-supplies/MPS