Design and development of an ethernet interfaced remote control system for pulse shape discriminator

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Introduction

In neutron spectroscopic measurements, most common electronics is the pulse shape discriminator (PSD). Neutron and gamma induced events can be discriminated according to their pulse shapes using PSD module. Commercial make PSD modules like Fast comtec 2160A [1] and also some custom made PSD modules [2] are manually controlled. To obtain a high duty cycle in an ongoing experiment with beam, remote control operation of electronic module is required. Although, mesytec make PSD module named MPD-4 [3] is remotely controllable but this requires minicom software along with a USB connection.

An Arduino based ethernet interfaced remote control system for a PSD is designed, developed and tested which is presented in this paper.

Design

For optimisation of n - γ discrimination, four major controls viz., lower level threshold (LLTH), CFD-walk, Zero cross (Z/C) and PSD-Delay need to be varied during experiment. To control these four parameters, a firmware was developed using pulse width modulation technique [4].

The Arduino Mega 2560 board with its compatible ethernet shield were designed as a web based server and assigned with a unique internet protocol (IP) address to access the module. A custom webpage was developed using Hyper Text Markup Language (HTML) in the control server as user interface. The Arduino was coded to find the four parameter values (viz. LLTH, CFD-walk, Z/C, PSD-Delay) submitted by user as characters in HTML interface. These characters were converted to floating numbers and were stored in a non-volatile memory to remember the previous inputs after reloading the page. The Arduino board calculates the ADC values for desired settings and creates pulse width modulated (PWM) outputs accordingly. The flow of data and the control sequence is described in figure 1.

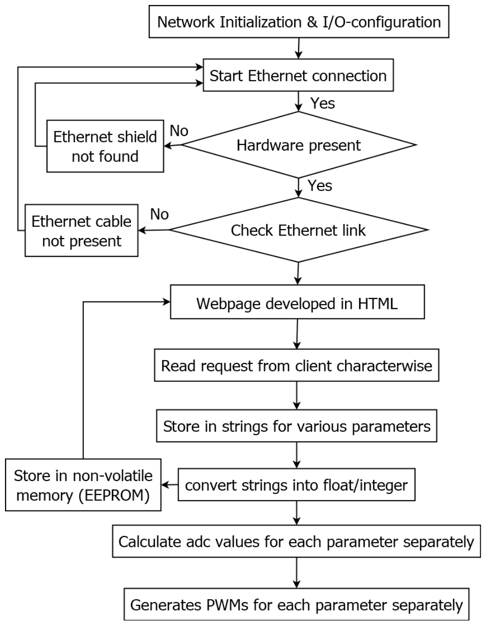

FIG. 1: Data flow of the program burnt in Arduino.

The PWM outputs are converted to DC voltages by RC-low pass filters. These DC voltages are fed to respective point on mother board of the developed PSD after passing through a voltage buffer to avoid loading effects. Electronic circuit of the control system is shown in figure 2.

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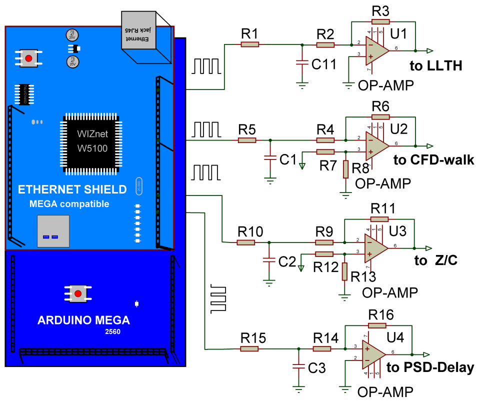

FIG. 2: Circuit diagram of PSD control system.

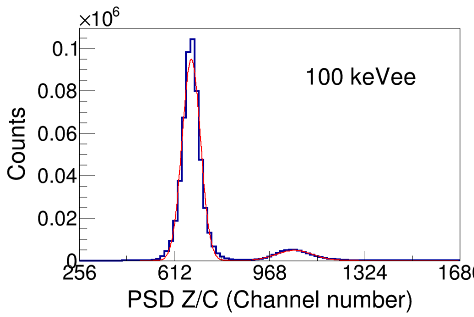

FIG. 3: PSD Z/C spectrum at 100 keVee fitted with double gaussian distribution curves (red colour).

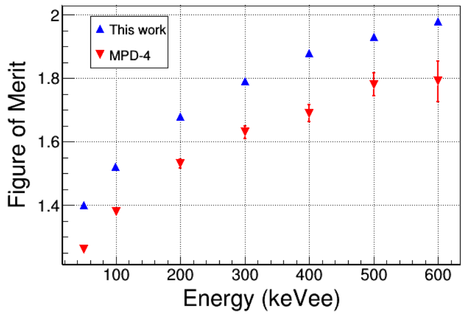

FIG. 4: Variation of FOM of the developed module and MPD-4 with energy.

Development

The ethernet interfaced dual PSD module is developed using surface mount components in a double width Nuclear Instrumentation Module (NIM). The module consists of a mother board and a controller board. The controller board consists of Arduino boards, RC-low pass filters and buffers. The input, output and monitoring lemo connectors are provided at the front panel while a RJ-45 connector and a reset button for ethernet connection are provided at the rear panel of the module.

Result

The developed module has been tested with a 5" diameter × 5" thick liquid scintillator based neutron detector [5] with a ^{252}Cf neutron source and the result was compared using MPD-4 in place of the developed module in the same setup.

The neutron detector signal was calibrated using the Compton edges of γ-rays spectra from the radioactive sources ^{22}Na and ^{137}Cs.

The Z/C over separation spectra with this module at 100 keVee is plotted in figure 3.

The Z/C over separation spectra can be quantified in terms of figure of merit (FOM). At a given energy threshold the FOM is defined as the ratio of centroid separation to the sum of the full width at half maximum (FWHM) of the neutron and gamma peaks [6]. The neutron and γ peaks are fitted with two Gaussian distribution curves. Their Means and FWHMs with errors are used to calculate FOM. A plot of FOM as a function of pulse height using both the developed module and the MPD-4 is shown in figure 4 which indicates a better response of the developed module as compared to commercially available MPD-4.

References

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