20 Channel 14MeV Neutron Detector Electronics Readout System

Shengquan Liu, Lian Chen, Futian Liang, Feng Li, Ge Jin

***Abstract*–In order to measure the neutron flux of 14 MeV, we designed a real-time data acquisition system which can supply power for 20 neutron detectors (crystal ST-401 and PMT) and collect neutron signals and count. The system can eliminate the interference of X and γ signals by using anti saturation front end circuit and pile up rejection, etc. The instrument operation panel, built by virtual instrument technology, can monitor the status of instrument in real time and analyze the measurement results. The results show that the typical value of the neutron rate is 10 Mc/s, the stability of the high voltage is less than ±2.5 V, and the timing error is less than 1ns, the system achieves the design goal of the 10 Mc/s average count rate, anti-saturation, and stable high voltage output of 20 channel.**

I. INTRODUCTION

To measure neutron flux accurately, dozens of neutron detectors are often arranged at different locations of the experimental device. These detectors require steady high voltage power supplies during working, and output the high count rate signal mixed with a large number of X-ray and γ-ray signals. We designed a 20-channel neutron detector readout electronics system to read multi-channel neutron detector signals, and to provide stable high voltage power supplies that the swing is less than 0.5%. Four functions, discrimination and selection of neutron signals, anti-saturation of X-ray and γ-ray signals, high voltage driving of multi-channel detector and consistency correction of multi-channel, are designed to meet the special requirements of 1 Mc/s counting rate, 0.1% stability of high voltage and standard case packaged.

II. ARCHITECTURE

The system, packaged in the 19 inch 3U standard case with low voltage power supplies hardware (as shown in Fig. 1), consists of signal readout board and high voltage power supply board. The signal readout board contain two parts: the front-end circuit containing protection diode to realize the function of anti-saturation; the digital system based on FPGA to accomplish the function of pile up rejection of signal, counting, measuring time control, high voltage control and monitoring, etc. The high voltage power supply board adopts the design of modular power supplies, high precision DACs and the high voltage feedback circuit, and has the features of security and stability, high integration, etc.

Fig. 1. Photo of the readout system which has 20 neutron detectors (crystal ST-401 and PMT), the electronics system and the software.

The structure of data acquisition system is shown in Fig. 3. The front end circuit is composed of signal conditioning modules and discriminators. Neutron signals can be shaped and screened by setting the screening threshold parameter by user. The counting module receives the signals which are screened, then adds counters and saves the results to RAM. The parameters, like measurement time, the depth of storage, trigger mode, can be set by timing controller and monitoring module according to the user needs, the start and stop of the measurement can be controlled by external trigger signals or the host computer. The module is also responsible for controlling the high voltage output and monitoring the high voltage feedback by setting the high-voltage DAC module and the high-voltage ADC module.

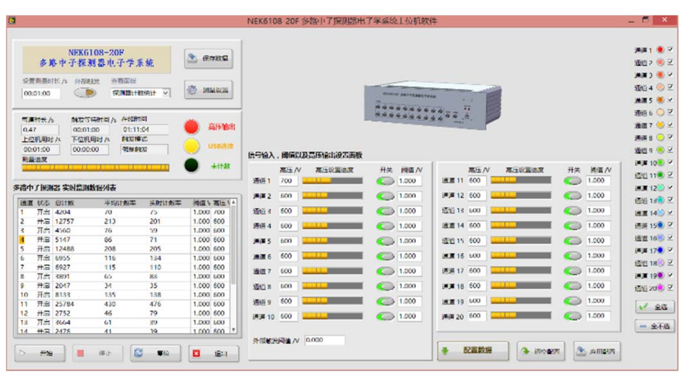

Fig.2 Interface of the host computer software.

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Shengquan Liu, Lian Chen, Futian Liang, Feng Li, Ge Jin are with State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei, Anhui 230026, P.R. of China (phone: +86-551-63606495, e-mail: lsqlsq@mail.ustc.edu.cn, goldjin@ustc.edu.cn)

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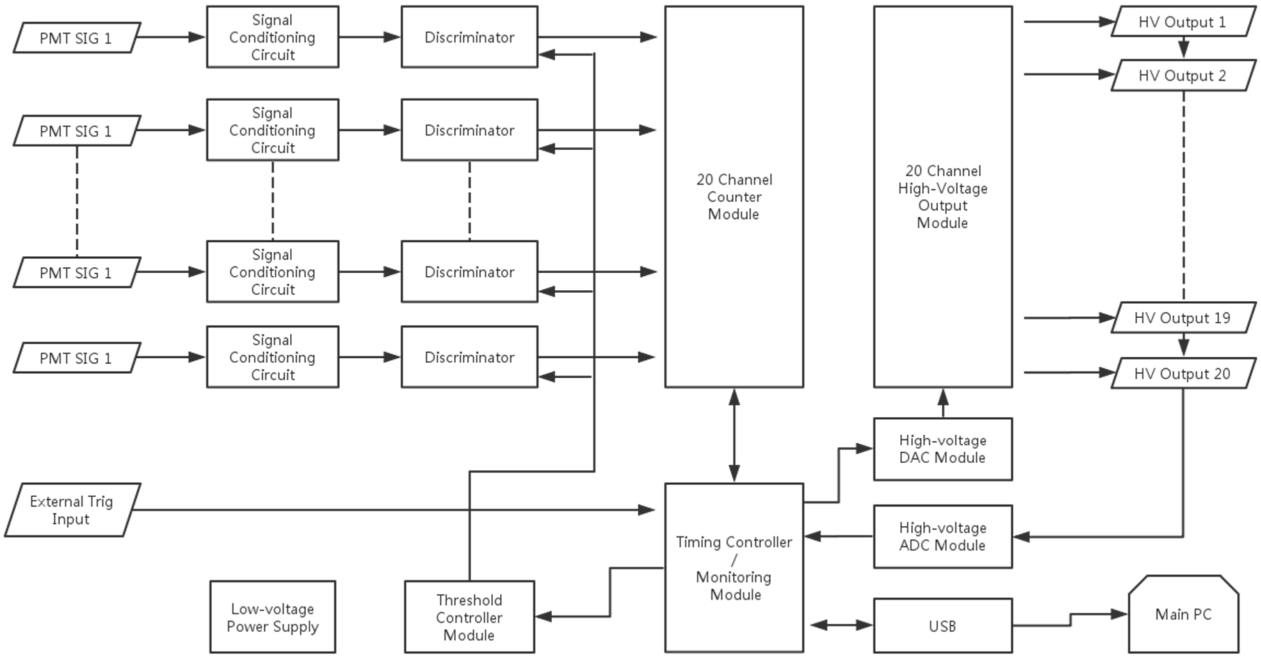

Fig.3 Schematic of the neutron flux DAQ system.

The system can receive the command from the host computer, and upload the measurement data to the host computer via USB 2.0 bus. Because of the measurement data stored in RAM, even if USB disconnected, the data will not be lost.

The software (as shown in Fig. 2), developed with virtual instrument technology, has a control panel and monitoring windows like real instruments for easy using. It can not only realize the configuration of the lower machine, get measurement data, but also has the function of monitoring the measurement state and high voltage, multi-channel consistency correction, measurement data analysis, etc. Users can monitor and control instrument, analyze measurement results, manages the experimental data and correct the detector consistency by using the software.

The result of electrical test shows that the typical value of the neutron count rate of the system is 10 Mc/s. High voltage range is 0 to 1514 V, and its stability is less than ±2.5 V. The range of threshold is 0 to 5 V and the error of threshold is 0.145%. The measured timing error is less than 1 ns.

III. CONCLUSION

In this paper, a real-time DAQ system has been built for measurements of neutron flux of 14 MeV. We designed the DAQ module based on FPGA, the high voltage control module and the software. Test results show that the system achieves the design goal of the 10 Mc/s average count rate, anti-saturation, and stable high voltage output of 20 channel.

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