Design and construction of portable survey meter

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Abstract. This work was aimed to design and construction of portable survey meter for radiation dose measuring. The designed system consists of 4 main parts consisting of low voltage power supply, radiation detection, radiation measurement and data display part on android phone. The test results show that the ripple voltage of low voltage power supply is less than 1%, the maximum integral counts are found to be 10^4 counts per second and the maximum distance of wireless commination between the server and the client is about 10 meter. It was found that the developed system had small size and light weight for portable instrument.

1. Introduction

The Geiger–Müller tube (G-M tube) was introduced in 1928 and is still a popular radiation detector in applications where energy sensitivity is not required [1]. The Geiger counters developed from the G-M tube are an instrument used for measuring ionizing radiation used widely in applications such as radiological protection, experimental physics and the nuclear industry. However, it is expensive tools why it did not widely to use. To construct a low costs survey meter that is a main goal of the author. In addition, it is designed to small, convenient, easy to use and wirelessly interfacing.

This proposes overview of design and construction of the survey meter that operates together the developed Transmission Control Protocol applications (TCP app) on Android phone for data display which can download from a Google play store to measure external or ambient ionizing radiation fields. The ESP8266 controller board which is an available commercially was used as a processing subpart to count signals with an interrupt function of board. Additionally, this board can interface and send data to application on an android phone based on wireless communication why was picked to this project.

2. Design of radiation measuring system

The portable survey meter was designed and constructed to detect the radiation dose such as alpha and beta particles and gamma ray where energy sensitivity is not required. The main system consists of radiation detection and radiation measurement as shown in figure 1. The 5 volts power supply was applied to nourish the integrated circuit system to work and its ripple voltage was rectified with decoupling capacitors.

2.1. Radiation detection

The LND712 G-M tube that was filled with mixed gas such as Neon and Halogen at low pressure was used to detect the radiation in this work. Its shape is cylindrical end-window tube with 1.5-cm diameter of thin Mica which is called as window plate and 4-cm length with enclose by the grade 446 stainless steel. The high voltage power supply (HV) at 500 volts through R_A and R_B was applied to its anode for the maximum count rate and lifetime of the tube. The capacitor C was connected by alternating current (AC) coupling type to AC signals pass through as shown in figure 2. The tube briefly conducts electrical charge when particles or photon of incident radiation makes the gas conductive by ionization.

The output signal detected at the anode of the tube on the diagram of the figure 2 by an oscilloscope is the negative trigger pulse. The signal is sharp peak about 550 volts as shown in the figure 3. This signal will send to a next part to adjust its shape for a data counting.

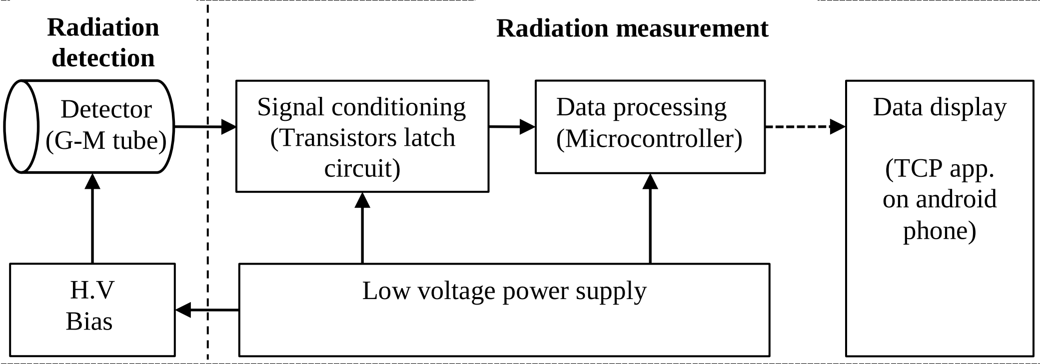


Figure 1. The diagram of the portable survey meter system.

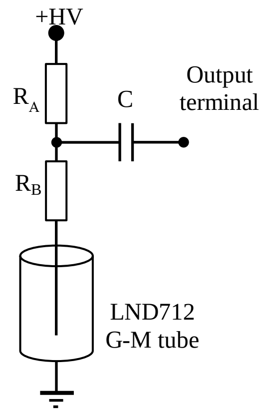


Figure 2. The workable circuit of G-M tube which R_A and R_B resistance are 1 MΩ and 10 MΩ, respective and C coupling capacitance is 47 pF.

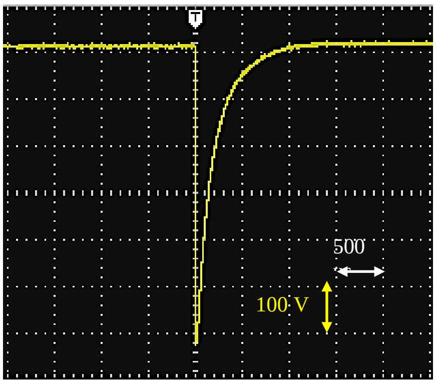


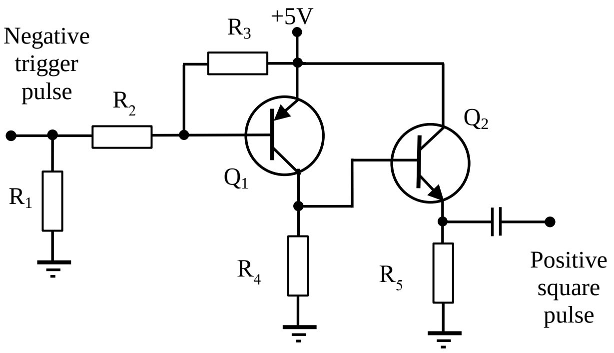
Figure 3. Typical output signal from a radiation interaction in a LND712 G-M tube with anode read out. The G-M tube capacitance is 3 pF.

2.2. Radiation measurement

The radiation measurement part consists of two parts. Firstly, a signal conditioning was designed to transform a negative trigger pulse to a positive narrow square pulse. Another, a data processing designed to count the square pulses and to convert to radiation dose and to send data into data display part.

2.2.1. Signal conditioning

The signal conditioning part was established to transform an input signal that is a negative trigger pulse by a transistor latch circuit including two types of a bipolar junction transistor (BJT) as shown in figure 4. In addition, the base of PNP and the emitter of NPN transistor are input and output port, respectively. The input signal voltage is divided by R_1 and R_2 to limit the input current for decreasing damage and increasing lifetime of the circuit. The resistor R_3 is criterion to control voltage level of operating of PNP transistor. The result shows, the output signal compare with the input signal as shown in the figure 5.



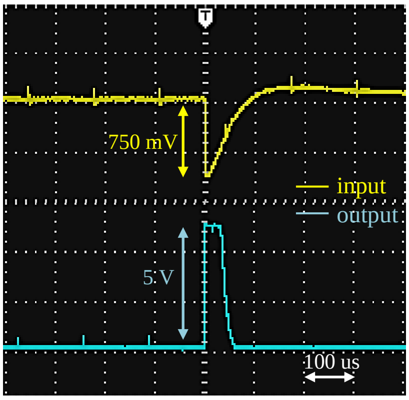
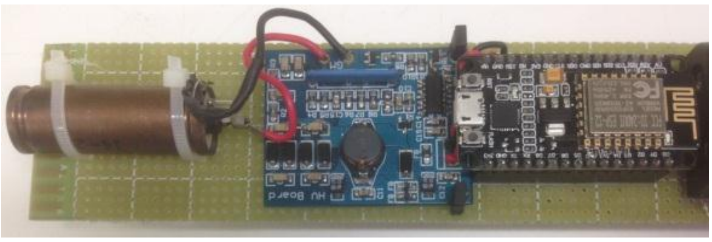


Figure 4. The Q_1 and Q_2 are PNP and NPN transistor, respectively. The R_1, R_2, R_3, R_4 and R_5, resistance values are 56kΩ, 22kΩ, 8.2kΩ, 10kΩ and 10kΩ, respectively.

Figure 5. The input and output signal of a transistor latch circuit

2.2.2. Data processing.

The data processing was established to count the narrow square pulses from the signal conditioning part. An available commercially ESP8266 NodeMCU microcontroller board was used as a processing system based on an external interrupt function on D2 port of this board. This function was programed to count the square pulse and report in counts per second (CPS). The maximum integral counts were found to be 10^4 CPS.



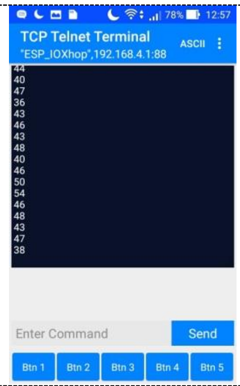


Figure 6. The picture of the completed portable survey meter design.

Figure 7. The telnet terminal application operated on android phone is used to show the data of radiation measuring.

2.3. Data display

The smartphone run on android operating system was used for data display system. A wireless connecting was used to send the string data from an ESP8266 NodeMCU microcontroller board to an application on android phone by TCP protocol. This board fixed an IP (Internet Protocol) on 192.168.4.1 and a port on 88 is server and is IP dispenser to client. An android phone is client that IP was provided by server and is data display part. The string data is sent from NodeMCU (server) to

TCP telnet terminal application on android phone (client) for display the radiation count in CPS. The telnet terminal application can be downloading from Google play store. The display page of this application is shown in the figure 6.

3. Performance and Calibration test

The performance tests show that the peak to peak of ripple voltage of low voltage power supply measured by oscilloscope is less than 1%. The wireless distance in air of wireless commination between the server and the client is about 10 meter. The CPS of device was tested and was compared with Geiger –Muller-Zahler meter. It was found at 14.52 and 6.84% different with Sr-90 and Cs-137 radiation source, respective.

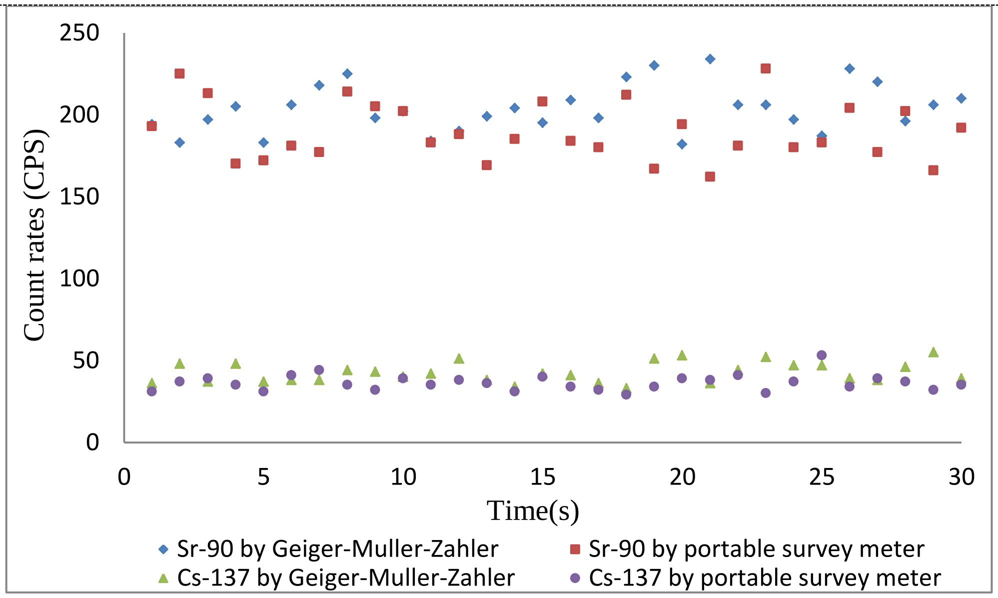


Figure 8. The count rates in CPS were measured by the Geiger-Muller-Zahler meter and the developed meter.

4. Conclusion

In this work, the authors have successfully demonstrated the portable survey meter operating in a wireless interfacing between the meter and the smartphone display client. The tests show that the ripple voltage is a very small level. The distance of measuring is safety from a radiation source at 10 meter. The calibration test shows that the different percent of measuring is able to acceptable.

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