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STUDY ON THE DESIGN AND PRODUCTION OF A PROTOTYPE LIQUID LEVEL DETECTION EQUIPMENT UTILIZING GEIGER-MULLER DETECTOR

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Introduction

The article discusses a research presentation on the design and manufacture of handheld radiation measurement devices using Geiger-Muller tubes counting gamma radiation, applied in educational settings. The research and development aim to support educational training, aiding students in comprehending the interactions of radiation with matter, contributing to the dissemination of knowledge about atomic energy applications, and enhancing the quality of presentations at the Nuclear Research Institute Training Center. Initial results have led to the creation of a portable radiation measurement device utilizing Geiger-Muller tubes and a 10µCi Cs-137 gamma source, displaying the count on a 16×2 LCD screen, and powered by a 9VDC supply for ease of use and safety. This serves as a foundation for further research in developing radiation measurement devices using X-rays, with the goal of enhancing the visual and vivid aspects of lectures on atomic energy applications. The objective is to use gamma transmission methods without relying on complex and expensive equipment, ensuring radiation safety at the Training Center.

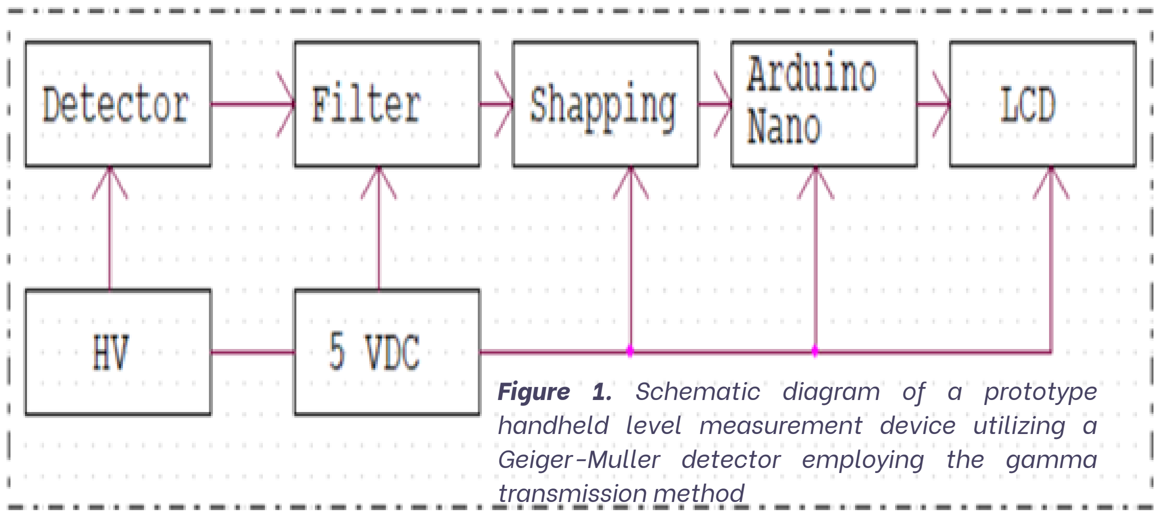

Figure 1. Schematic diagram of a prototype handheld level measurement device utilizing a Geiger-Muller detector employing the gamma transmission method

Objective

- A handheld radiation measurement device using Geiger-Muller tubes was developed for teaching and learning about atomic energy.
- A compact, user-friendly device was designed to assist students in grasping the interaction mechanisms of radiation.

Methodology

- An Arduino Nano CH340 was used to process signals and display data on a 16x2 LCD screen.
- The gamma transmission method was applied to measure the level of liquid:

$$I = I_0 e^{-\mu.\rho.x}$$

In which:
I: Intensity of the gamma ray beam passing through the material layer (count rate)
I_0: Intensity of the gamma ray beam emitted from the source (count rate)
µ: Attenuation coefficient of the material (cm^2/g)
ρ: Mass density of the attenuating material (g/cm^3)
x: Thickness of the material (cm)

Results

A portable radiation measurement device was developed, incorporating a GM7124 counting tube and comprising: (1) an electronic system designed to capture signals from the GM tube, which included filtering circuits, shaping circuits, high voltage blocks, and power supply blocks; (2) programming on the Arduino platform to tally TTL signals from the newly assembled electronic system and present the data on an LCD screen; (3) the creation and assembly of a Cs-137 power source and GM7124 counting tube mount, aimed at educating students about the interaction of gamma radiation with materials. This effort underscored the importance of creating a highly portable, compact, and user-friendly measurement instrument.

Design and Fabrication

- Design and Manufacture of the High Voltage Circuit

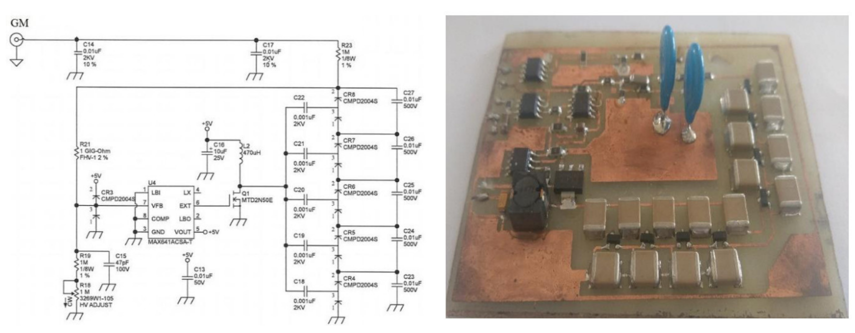

Figure 2. High Voltage Circuit; (a) Schematic diagram; (b) High-voltage circuit is designed and fabricated

- Design and Manufacture of the Pulse-Shaping Circuit

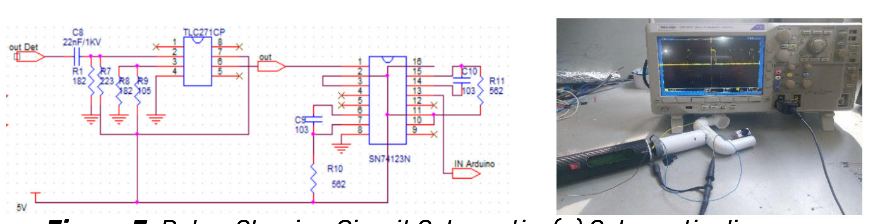

Figure 3. Pulse-Shaping Circuit Schematic; (a) Schematic diagram; (b) Output pulse signal at the pulseshaping circuit output.

Experiment

- Case 1: The measurement system was investigated using the Coca-Cola can configuration. Each measurement was conducted over a duration of 30 seconds with a Cs-137 source activity of 10µCi. The recorded data is presented in the following graph.

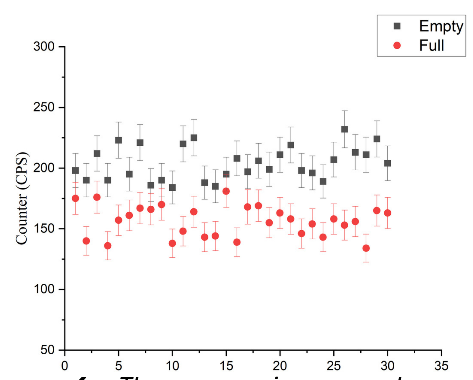

Figure 6. The comparison graph was made between the can with water and without water in the case of using a Cs-137 source with an activity of 10µCi.

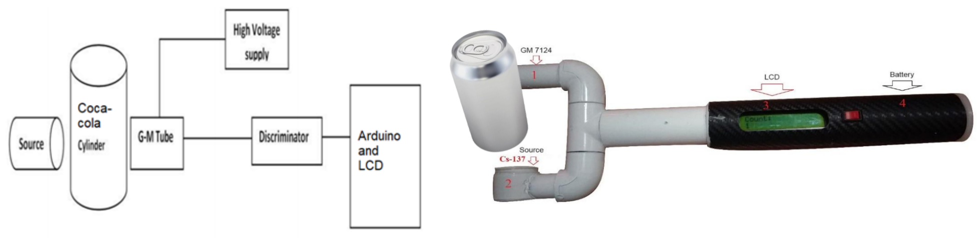

Figure 5. The experimental setup for investigating the handheld level measurement device utilizing the GM7124 counting tube was arranged.

- Case 2: Two sources of Co-60 and Cs-137, each with an activity of 10µCi, were utilized

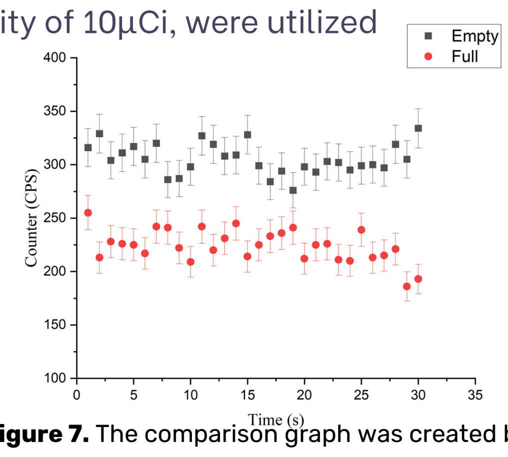

Figure 7. The comparison graph was created between the can with water and the can without water in the case of using two sources: Co-60 with an activity of 10µCi and Cs-137 with an activity of 10µCi

Figure 4. Handheld Liquid Level Measurement Device; (1) GM 7124 counting tube; (2) Cs-137 radiation source 10µCi; (3) Count display screen; (4) 9VDC battery pack

Conclusion

The GM counting tube-based level measurement device was utilized as an effective tool for student training. The visual and dynamic aspects of lectures on atomic energy applications and the gamma transmission method were enhanced without requiring complex and expensive equipment, thereby ensuring radiation safety at the Training Center. Its application extended to the teaching and introduction of the principle of transmission measurement in liquid level sensing at the Nuclear Research Institute or other educational institutions.

Related Literature

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