Construction of digital survey meter model smd-03 using atmega 8 microcontroller

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Abstract. Digital Survey Meter model SMD-03 has been made. The Digital Survey Meter model SMD-03 was built using the GM LND-714 as the detector, CD4011 as pulse shaping circuit, ATMega 8 as a counter circuit and 8x2 LCD as a display. The purpose of the construction of this digital Survey Meter SMD-03 is to develop nuclear instrumentation, especially digital survey meter, especially in improving the stability counting system. The works principle of GM detector to convert the radiation beam into electric pulses. The electrical pulses are inserted into the inverting circuit and pulse shaping circuit to invert the pulses and formed into digitals pulse. The digitals pulses then are inserted into ATMega 8 to be counted and converted into mR/h and then displayed on the 8x2 LCD, measurement range: 0 – 30 mR/h. This instrument is equipped with a buzzer as a sound indicator, this activity includes the manufacture of hardware and software and testing. From the DC high voltage stability test the value of high voltage instability is 0.1%, and from the test results shows the counting linearity value $R^2 = 1$, and counting stability test/chi-square test ($X^2$) = 9.58. The data test results show that the digital survey meter model SMD-03 has been made can function properly.

1. Introduction
Nuclear radiation within certain doses limits can be harmful to humans, but also useful to humans depending on how these are handled. To find out and utilize nuclear radiation substances, nuclear radiation detection equipment is needed [1]. At present a few advanced countries and developing countries have continued to strive to utilize radioactive energy in various fields. In the utilization of nuclear radiation, in order to keep an accepted dose by radiation worker does not exceed the limit value, it is necessary to conduct routine monitoring of the individual dose of the radiation workers. With regular dose monitoring programs that are carried out periodically the doses be accepted by radiation workers will remain controlled and if there is an overdose, protection measures can be taken as soon as possible [2]. Then protection of humans, workers and related officers with radioactive substances needs to be done, namely by monitoring the radiation exposure received by radiation workers not to exceed the permissible threshold. To realize based on government regulations of Head of BAPETEN Regulation No.04 of 2013 [3], about radiation protection and radiation safety on the utilization of nuclear energy for workers and the environment, a suitable radiation protection digital beta-gamma survey meter is needed [4], so radiation exposure can be measured and radiation hazards can be minimized. In the activity of construction the survey meter, modifications were made on the electronic circuit, the counter circuit by using an ATMega 8 microcontroller and an 8x2 LCD digital display as a digital viewer. From the test results shows the counting linearity value $R^2 = 1$ [5], and counting stability test/chi-square test ($X^2$) = 9.58. From the data test results show that the digital survey meter model SMD-03 has been made can function properly.
2. Theory
The digital meter survey model SMD-03 consists of a DC high voltage power supply, GM LND-714 type detector [6], inverting, pulse shaping [7], ATMega 8 microcontroller [8], 8x2 LCD digital viewer, and buzzer. The block digital survey meter diagram of the SMD-03 model is presented in Figure 1.

![Figure 1. Diagram Digital Survey Meter SMD-03](image)

The working principle of GM detectors is to convert radiation beams into electric pulses. These pulses entered into pulse shaping and then to be changed into the digital pulse, at ATMega 8 the pulses are then chopped and converted into units of mR/h and displayed on LCD 8x2 [9], this tool is equipped with a buzzer as a sound indicator. The electronic circuit of the digital survey meter SMD-03 is presented in Figure 2.

![Figure 2. Circuit Digital Survey Meter SMD-03](image)

3. Methodology
Construction of digital survey meter model SMD-03 starts by designing electronic circuits and PCB layouts using the ALTIUM-6 program[10]. Then PCB it continuous by manufacturing process, supplying electronic components, making digital survey meter counting software, downloading counting software to AT Mega 8 Microcontroller, assembling components on the PCB, testing each sub-section starting from the pulse shaping section, DC high-voltage circuit and counter circuit, testing all parts by performing counting stability tests, evaluating test results data.

The prototype results of Digital Survey Meter SMD-03 made are presented in Figure 3.
Figure 3. Prototype results of Survey Meter Digital SMD-03

3.1. Specifications:
Name instrument: Digital Survey Meter model SMD-03
Function: For dose rate beta and gamma measurements.
Detector: GM LND-714, operating voltage 500 V.
Measurement range: 0 – 30 mR/h
Power supply: Bateray 9 V
Dimension: (3.5x7x14.5) cm
Weight: 0.30 kg

4. Results and Discussion

Table 1. Pulse Shaping Circuit Testing Data

| No | Observed               | Measurable |
|----|------------------------|------------|
| 1  | Input pulse            | 3V         |
| 2  | Input Frequency pulse  | 1 kHz      |
| 3  | High pulse out         | 5V         |
| 4  | Width pulse out        | 2.5mS      |
| 5  | Form pulse out         |            |
The results of the DC high voltage stability test are then presented in graphical in Figure 4.

![Figure 4](image1.png)

**Figure 4.** Stability DC high voltage power supply
From the data measurement, the linearity counting system of the count vs input frequency is presented in the graph in Figure 5.

![Figure 5](image2.png)

**Figure 5.** Linearity counting system
The results of the counting test on variations of the distance for the radiation source to the detector are presented in the graph in Figure 6.
Figure 6. Radiation counting system for the distance function

4.1. Counting Stability Test
Implementation date : 17-11-2018 ; Time count : 2 Second.
Radiation source Sr-90; Exposure rate : 10 mRad/h = 0.1 mGy/h (3-1-1983).
Distance from the detector to radiation source : 2 cm

Table 2. Data counting stability test

| No. | Counting ($X_i$) | $(X_i - \bar{X})^2$ |
|-----|----------------|---------------------|
| 1   | 38             | 63.2025             |
| 2   | 32             | 3.8025              |
| 3   | 27             | 9.3025              |
| 4   | 32             | 3.8025              |
| 5   | 28             | 4.2025              |
| 6   | 26             | 16.4025             |
| 7   | 24             | 36.6025             |
| 8   | 28             | 4.2025              |
| 9   | 32             | 3.8025              |
| 10  | 33             | 8.7025              |
| 11  | 35             | 24.5025             |
| 12  | 28             | 4.2025              |
| 13  | 29             | 1.1025              |
| 14  | 25             | 25.5025             |
| 15  | 33             | 8.7025              |
| 16  | 31             | 0.9025              |
| 17  | 36             | 35.4025             |
| 18  | 25             | 25.5025             |
| 19  | 28             | 4.2025              |
| 20  | 32             | 3.8025              |

$N=2$

$\frac{\sum X_i}{\bar{X}} = \frac{601}{30.05} = 19.98$

$\sum (X_i - \bar{X})^2 = 287.85$
5. Discussion

From Table 1, the results of the pulse shaping test indicate that the pulse formation circuit has functioned as digital pulse generator with a pulse width of 5 mS and a 5V pulse height, this has fulfilled the requirements to be processed into a series of counters to be counted in units of mR/h.

From Figure 4 the value of the voltage instability can be found:

Value of voltage setting (V) = 500 V

The highest measured voltage is highest (V1) = 500.8 V

The lowest measured high voltage (V2) = 500.3 V

Instability voltage (δV) = \frac{V1-V2}{V} \times 100\%

\delta V = \frac{500.8 - 500.3}{500} \times 100\% = 0.1 \%

So the high voltage stability (SV) = 99.9%.

From Figure 5 the counting linearity graph can be seen that the value of the correlation coefficient (R²) = 1 means that the value of the linearity of counting is very good and meets the requirements for use.

From Figure 6 the graph of the radiation counting system as the distance function can be seen that the distance the radiation source Sr-90 from the detector is getting further so the radiation count value is smaller corresponding with the greater value of radiation measurement is inversely proportional to the square the distance.

From the data in Table 2 the results of the counting stability testing using Sr-90 radiation sources, source activity = 10 mRad (made in 1983), GM detector distance from source = 2 cm, counting time = 2 seconds and taking a 99% confidence level and number of measurements n = 20, obtained by the Chi-Square Test (X²) = 9.58 while the X² allowable limit must be in the ring 7.663 < X² < 36.191, so if the value of X² is inside those ranges. So that counting stability is good enough.

6. Conclusion

In terms of the linearity and stability of the counting performance of the SMD-03 digital survey meter which were made quite well, the mission of developing nuclear instrumentation by increasing counting stability has been carried out well. From the test data in the construction of the SMD-03 digital survey meter it can be concluded that the prototype of the SMD-03 digital survey meter prototype has been able to function properly for the measurement of beta and gamma radiation.

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References

[1] TRIKASJONO T, DKK, (2014), Making a Digital Radiation Monitor System Using LND-714 Detector, National Seminar SDM SDM, STTN-BATAN Yogyakarta.

[2] WISNU.A.W, 2007, Radiation Protection Nuclear Technology and Its Applications, Andi Publisher, Yogyakarta.

[3] BAPETEN, 2013, Radiation protection and radiation safety in the use of nuclear energy for workers and their environment, Perap Bapeten No. 04 of 2013, Jakarta.

[4] NURHIDAYAT S, et al, 2008, Making a digital survey meter model BEM 721D Using the AT89S52 Microcontroller, Proceedings of the Research and Management Seminar on Nuclear Devices P3TM-BATAN Yogyakarta.

[5] IAEA-TECDOC 317, "Quality Control of Nuclear Medicine Instruments", Vienna - Austria, 1984.

[6] http://www.lndinc.com, Designers and Manufacturers of Nuclear Radiation Detectors, LND-714, LND Inc. OSEANSIDE New York USA. (accessed 08-12-2018).

[7] http://www.alldatasheet.com Texas Instruments, CD4011 CMOS, Inc. (accessed 08-13-2018).

[8] http://www.alldatasheet.com, ATMega8 AVR 8 bit with 8 Kbyte Programmable Flash, ATMEL Corporation. (accessed 08-12-2018).

[9] http://www.crystalfont.com, parallel character LCD 8x2, Crystalfontz America, Inc. (accessed 08-13-2018).

[10] https://www.altium.com/ altium designer 6 the engineers and designers developing electronic products. (accessed 08-13-2018).