Identifying the Level of Ionizing Radiation Using a Device Implemented on the Arduino Development Board

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Abstract. This article discusses how to build an inexpensive radiation identification device. The device can be used in the X-ray environment and can be a real-time indicator of large variations in ionizing radiation. The device is made of two compatible data acquisition boards, the main sensor involved is SBM-20-Geiger Muller. Current devices, such as photographic dosimeters or Geiger-Muller sensors, are not digital and do not alert quickly if there is significant radiation exposure. The device developed and presented in this article makes it possible to quickly identify and prevent ionising radiation. The device was calibrated using a Gamarad DL7 device, with a radiation source: Americium 241, by identifying the radiation level, the presented study was performed.

Keywords: Arduino · SBM-20 · Radiation · Protection · Geiger-Muller

1 Introduction

Since humans have lived on Earth, they have been subject to environmental factors, including ionizing radiation. Even though before technology radiation was natural, after human evolution, artificial radiation began to appear, because of their activities. In the 20th century, nuclear energy was discovered as one of the greatest realizations. Although artificial radiation has provided many benefits to humans, its harm endangers human life. As a result of the Chernobyl nuclear accident in Ukraine in April 1986, there has been an increase in human radiation activity. Researchers, as well as experts in the field, have been looking for ways to reduce or eliminate radiation [1].

Placing the body close to a radioactive source is exposure. To evaluate the hazard of such exposure, it is necessary to calculate the absorbed dose. This is defined as the energy required for a certain mass of tissue. In general, the dosage is not consistent throughout the body. A radioactive substance may be selectively absorbed by various organs or fabrics [2].

Radiological dosimetry refers to methods for the quantitative determination of the energy stored in a given environment by direct or indirect ionising radiation. Certain quantities and units have been defined to describe beam radiation, as well as the most commonly used dosimetric quantities and their units defined below. A simplified discussion of cavity theory, the theory that deals with calculating the response of a dosimeter in an environment [3].

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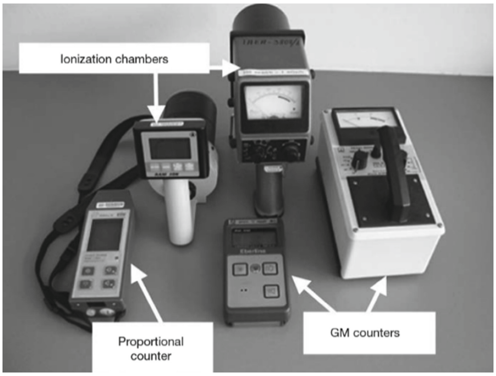


Fig. 1. Counter radiations [3]

The area meters commonly used for measuring radiation levels are of the following types: ionization chambers, proportional meter and GM meters, in Fig. 1.

2 Device Design and Realization

Arduino is known as a physical platform or embedded computing, which means that it is an interactive system, which through the use of hardware and software can interact with its environment. For example, simple use of the Arduino would be to turn on a light for a certain period, 30 s, after a button has been pressed. Arduino would wait patiently for the button to be pressed. When the button is pressed, the lamp will turn on and counting will begin. Once it has counted 30 s, it would deactivate it and then continue to wait to press another button. You can use this setting to control a lamp in a closet under stairs, for example [4].

Fig. 2. Arduino Uno [5]

The radiation detector compatible with Arduino Uno, in Fig. 2 has the following components: 1. Terminal Block DG301, has screws for fixing the battery wires, for connecting the wires the polarity of the wires must be checked, 2. Slide switch, 3. Toner Trimmer, marker 103, 4. Base for installing CD4011 IC (14-pin) with CD4011BE processor; 5. LED (Tube Event Indicator); 6. Buzzer; 7. Radial inductor; 8. SBM-20 sensor; 9. Pins for connection between Arduino Uno board and Radiation Detector compatible with Arduino Uno; 10. Electrolytic capacitor (10 μF) (Fig. 3).

Fig. 3. Radiation detector compatible with Arduino Uno

To make a dosimeter implemented on an Arduino Uno R3 board, we needed: development board - radiation detector compatible with Arduino Uno, Arduino One board, SBM-20 sensor for radiation detection, connecting wires between the two components, the communication cable between the device and the laptop, the Arduino program, and the program will record and show all the measurements made by the device.

In the first part, to achieve the digitized dosimeter, the components of the radiation detector compatible with Arduino Uno (resistors, capacitors, diodes and others) were assembled. After identifying the components of the radiation detector compatible with Arduino Uno, they were glued using a soldering iron (soldering gun) and tin (Fig. 4).

Fig. 4. The process of gluing the elements

After the Arduino compatible detector was made, the connection pins with the Arduino Uno board were identified.

Each wire was connected between the boards, following Table 1.

Table 1. Correspondence of the pins of the plates

Arduino Uno	Compatible Board- with SBM-20
5 V	5 V
2	INT
GND	GND

3 Measurements on the Source of Americium 241. Device Calibration

Americium-241 (Am^{241}) is an isotope of americium. Like all American isotopes, it is radioactive. Americium-241 is the most common isotope of americium.

It is the most widespread American isotope in nuclear waste. Americium-241 has a half-life of 432.2 years. It is commonly found in ionization smoke detectors. It is a potential fuel for long-lived radioisotope thermoelectric generators (RTG). Americium-241 is fusible, and the critical mass of an empty sphere is 57.6–75.6 kg and a sphere with a diameter of 19–21 cm.

Americium-241 has a specific activity of 3.43 Ci/g (Curie per gram or 126.9 gigabequerels (GBq) per gram). It is usually found in the form of Americium-241 (Am^{241}). This isotope also has a meta-state, with output energy of 2.2 meV and a half-life of 1.23 µs. Its presence in plutonium is determined by the initial concentration of plutonium-241 and the age of the sample. Due to the low penetration of alpha radiation, americium-241 poses a health risk only when ingested or inhaled.

Older plutonium-241-containing samples contain an accumulation of Am-241. Chemical removal of americium 241 from the redesigned plutonium (e.g., during the process of processing plutonium quarries) may be necessary in some cases [6].

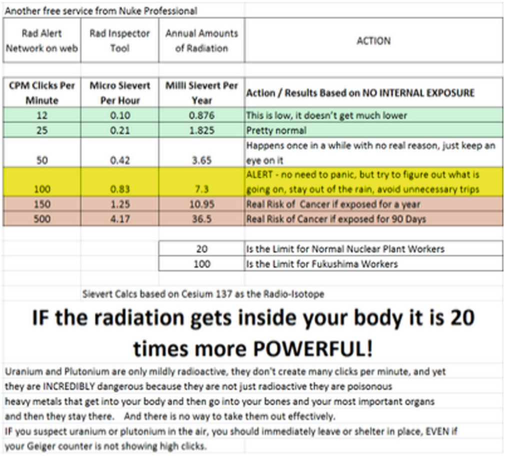
The calibration, as well as the measurement of the radiation level with the SBM-20 sensor, was possible with the Gamarad DL 7 device, shown in Fig. 5, which has a radiation source with Am-241 (Americium^{241}, with 12 µCi (microCurie)).

The dosimeter was subjected to the Am^{241} source, to measure the radiation level given by the Gamarad DL7 device.

It is known that 1 Sv = 100 REM, and for the cosmic background, there are 2 * 10–5 REM, so we find that the cosmic background has 0.2 µSv/h, dose rate.

In the case of the Am^{241} source, with a test at 0.25 mREM, we have 1 Sv = 100 REM, and the source has 0.25 * 10–3 REM, so the source indicates a dose rate of 2.5 µSv/h.

Fig. 5. Gamarad DL7



Another free service from Nuke Professional

Rad Alert Network on web	Rad Inspector Tool	Annual Amounts of Radiation	ACTION
CPM Clicks Per Minute	Micro Sievert Per Hour	Milli Sievert Per Year	Action / Results Based on NO INTERNAL EXPOSURE
12	0.10	0.876	This is low, it doesn't get much lower
25	0.21	1.825	Pretty normal
50	0.42	3.65	Happens once in a while with no real reason, just keep an eye on it
100	0.83	7.3	ALERT - no need to panic, but try to figure out what is going on, stay out of the rain, avoid unnecessary trips
150	1.25	10.95	Real Risk of Cancer if exposed for a year
500	4.17	36.5	Real Risk of Cancer if exposed for 90 Days
		20	Is the Limit for Normal Nuclear Plant Workers
		100	Is the Limit for Fukushima Workers

Sievert Calcs based on Cesium 137 as the Radio-Isotope

IF the radiation gets inside your body it is 20 times more POWERFUL!

Uranium and Plutonium are only mildly radioactive, they don't create many clicks per minute, and yet they are INCREDIBLY dangerous because they are not just radioactive they are poisonous heavy metals that get into your body and then go into your bones and your most important organs and then they stay there. And there is no way to take them out effectively.
IF you suspect uranium or plutonium in the air, you should immediately leave or shelter in place, EVEN if your Geiger counter is not showing high clicks.

Fig. 6. Conversion CPM- μSv [7]

Table 2. Measurements on the Am^{241} source

	CPM	μSv/h
Average measurements	273.7241	2.27191
The MINIMUM value recorded by the achieved dosimeter	24	0.1992
The MAXIMUM value recorded by the achieved dosimeter	9312	77.2896
Conversion factor (CPM in μSv/h)	0.0083	

For the Am^{241} source, the average value recorded is 0.25 mREM, ie 2.5 μSv/h. It is found that the average of the measurements, according to Table 2 is 2.27191 μSv/h, so the meter registers within normal limits.

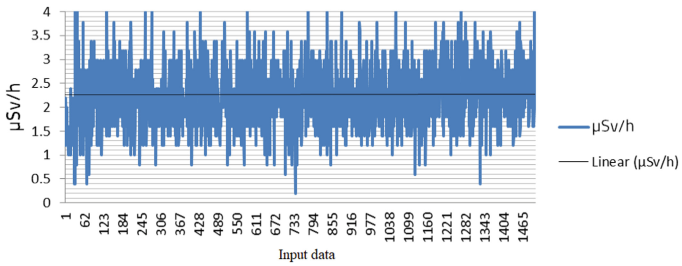


Fig. 7. Variation in radiation level (source of Americium-241)

For the interface to be friendly and to correctly and concretely identify the measured values, the device will be connected to the “Radiation Logger” program.

Keep in mind that, during the measurements, the device will be connected to the laptop, to a single port, therefore, it is impossible to run two programs, choosing only the “Radiation Logger” program to work.

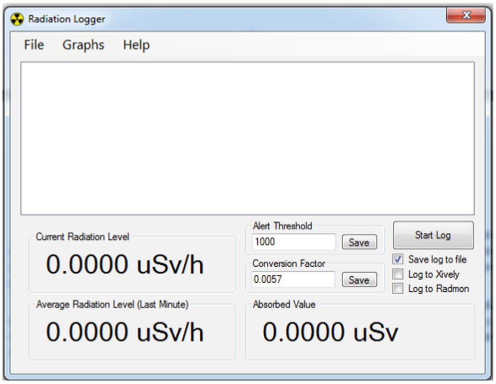


Fig. 8. "Radiation Logger" program interface

The “Radiation Logger” program shows the value area, the conversion factor of the CPM unit (counter per min or decays/minute) in µSv/h (values indicated when measuring the radiation level), the average of the values recorded in the last minute, the alert level (when the radiation dose is exceeded) and the area of the last value (Fig. 8).

On the OY axis, the measured radiation level [CPM] is observed, and the OX axis indicates the time when the measured radiation level was measured and recorded (Fig. 9).

That is why it was important to perform the conversion from the CPM unit of measurement to µSv/h, identified in Fig. 6.

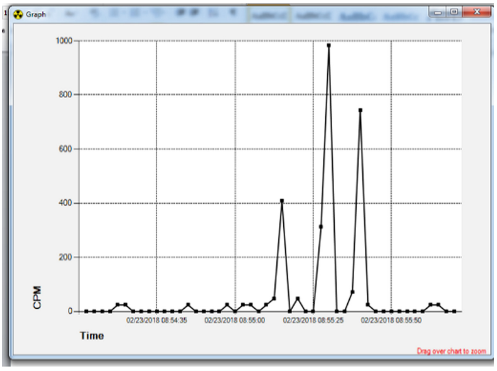


Fig. 9. Graph (example) made with "Radiation Logger"

4 Conclusions

Given that we are exposed to radiation of any kind (ionizing or non-ionizing), this must indicate the need to have a radiation monitoring device. The device used to identify and measure radiation levels is the dosimeter, in this article we have presented with can be made such a device, low-cost. The dosimeter is connected to a laptop, being digitized on friendly software (a pleasant interface) and understood by anyone. In addition to the values transmitted to the software installed on the laptop, it can emit an audible signal when the radiation is identified.

It is found that the Geiger-Muller tube registers values up to 0.2 μSv/h, this being the normal dose in the cosmic background. The average value of the Americium 241 source (2.5 μSv) is identified as approximately equal to what the device identifies, by averaging the values read by the Geiger-Muller sensor on the Arduino Uno compatible board (linear function in Fig. 7).

Conflict of Interest. The authors declare that they have no conflict of interest.

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