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RADE-N: An Automatic Nuclear Radiation Detector Using Raspberry PI

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ABSTRACT: After Chernobyl and more recently, Fukushima nuclear accident, people are concerned about their safety and health. Radioactivity cannot be noticed by our five senses. To know how much radioactivity is there in a place we need a specific device.

This paper attempts to design an economical, easy to use, accurate system for the non-technical public to keep at home or work place and monitor the radioactivity level in the area. Primary objective is to sense the gamma radiation, display its intensity and save the data in memory so that it can be further analyzed. Here integrates Raspberry pi, Neo6mv2 GPS and Nuclear Radiation detector circuitry into a robot.

KEYWORDS: Radiation detector, Low power, Low cost, Robot, Atomic energy, Embedded electronics.

I. INTRODUCTION

Radioactive contamination is the disastrous existence of radioactive elements in the solids, liquids or gases. This radioactive contamination may be due to naturally occurring radioactive elements, a nuclear weapon discharge, a nuclear reactor containment fissure or a spilled vial of radioactive material etc. Owing to the frequent radiation hazards like Chernobyl and more recently, Fukushima nuclear accident caused by this radioactive contamination, people are very concerned about their health and safety, this trepidation lead to the development of efficient radiation detection systems.

To know how much radioactivity is there in a place we need a specific device, a Radiation detector; The nuclear radiation detectors available in market are of high cost and not user friendly, to overcome this problem in this paper introduces a device called RADE-N It has been designed as economical, easy to use, accurate for the non-technical public to keep at home or work place and monitor the radioactivity level in the area. Our objective is to sense the gamma radiation, display its intensity and save the data in memory so that it can be further analyzed. The system consists of a gas filled radiation detector (Geiger Muller tube) which will sense the radioactivity. The high DC voltages necessary to polarize GM tube (400-900 V) can be obtained from batteries and a boost converter module with few and less expensive electronic components. It also has the facility to take the picture of environment and can track the location of the source using a GPS module. The entire circuitry is embedded in a robotic vehicle.

II. LITERATURE REVIEW

For the past few decades, the monazite bearing coastal region of Kerala in South West part of India is under investigation by various agencies, to study the biological and health effects of natural chronic low dose exposure of natural background radiation, on human population residing in that area. The level of background radiation varies from >1mGy per year to 45 mGy per year [10][8] and the areas with a dose level of <1.5 mGy per year are considered as Normal Level Natural Radiation Areas (NLNRAs), whereas areas having the background dose >1.5mGy per year are High Level Natural Radiation Areas (HLNRAs). By analyzing the non uniform distribution of radiation level in this coastal belt from various references, the average radiation intensity varies from <1.0 mGy to 45 mGy per year and

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some areas it is as high as 70 mGy per year [9][7][6]. Studies on biological and health effects of the human population living in High Level Natural Radiation Areas (HLNRAs) provide an important source of information on the effects of chronic low dose rate exposures to ionizing radiation. BARC has its field laboratory at Kollam [presently Low Level Radiation Research Laboratory (LLRRL)] in order to carry out detailed genetic and epidemiological survey of the residents. A study on the Natural background radiation by Atomic energy commission, Government of India reveals that in Kerala coastal chavara region has background radiation 1305 micro Gy /quarter.[5]

The fear of health effects of the nuclear radiation lead to the development of efficient detection systems or devices. Some of the best available products for nuclear radiation detection and monitoring are analyzed as a part of the product review. (SOEKS 01M Geiger Counter Portable handheld radiation detector [25], RADEX RD1212-BT, an advanced nuclear radiation detector with Bluetooth link to smart phone[26], TI—JB4020 Geiger Dosimeter Counter[27]). All of these products are portable and hand held devices. They can detect the intensity of the radiation and inform the user by alarm, graphical or numerical displays etc. Some devices have the facility to connect other devices like mobile phone or PC through Bluetooth. But the important concerns about these products are their cost and operation.

III. SYSTEM DESIGN

The proposed device is an advanced, low cost, safe and easy to use automatic nuclear radiation detector using GM counter Sensor. Entire device will be mounted on a robotic vehicle with location tracking facility.

A. Proposed System

Proposed device uses Geiger Muller tube as the sensor; its output will be converted to the corresponding voltage level using an interfacing circuitry and then given to the microcontroller GPIO pin. Other than the sensor module the system consists of a camera module to take the picture of the environment of the radiation source, a GPS module to track the location of the source, geared motors for the robotic vehicle.

The detectors available for sensing radiation are gas filled tubes and scintillation detector. Scintillation detectors use a crystal that fluoresces when a particle travels through it. This crystal is placed on top of a sensitive photomultiplier, which will detect the presence of any light pulse in the crystal. Scintillation tubes are expensive and require a complex power supply and amplifier; this makes them unsuitable for our requirement. The gas filled tubes on the other hand, are simple to construct and inexpensive.

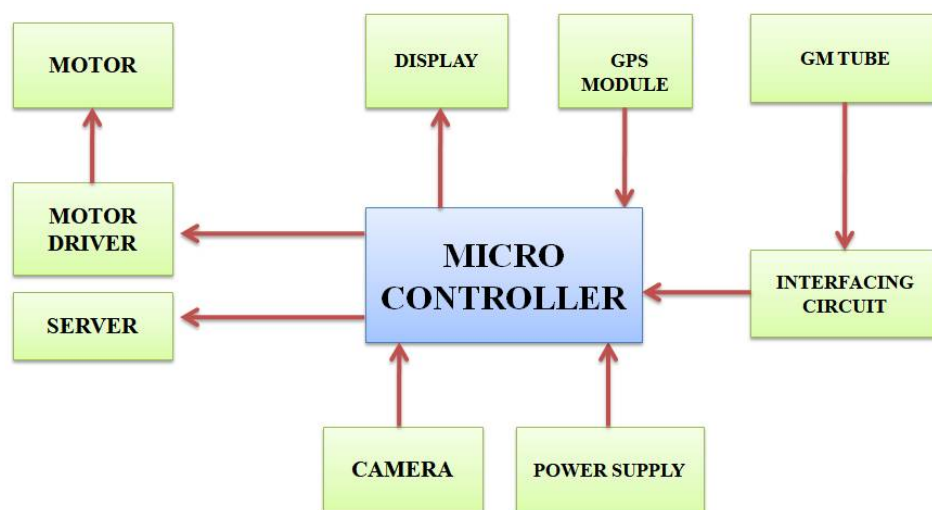


Fig 1: Here uses GM tube as the radiation sensor.

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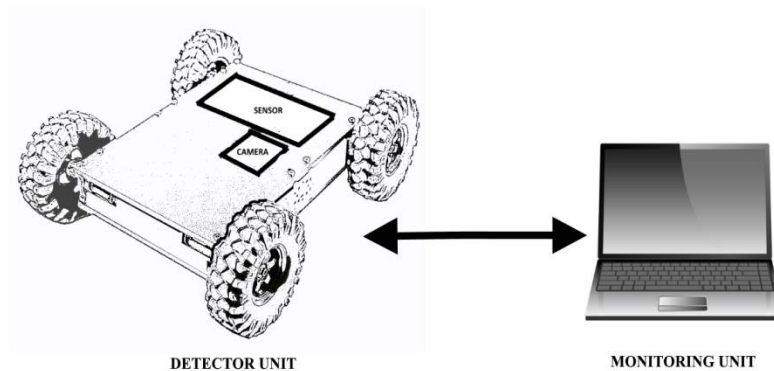


Fig 2: Moving detector module and monitoring base unit

The proposed device consists of a moving detector module and monitoring base unit

B. Mechanical Description

The robotic vehicle has dimension (37x35) cm consists of 4 geared motors (12V , 300 rpm) , each pair connected parallel, 4 wheels(100mm dia,45mm width) .The camera module, GPS antenna and Sensor modules are kept over the vehicle

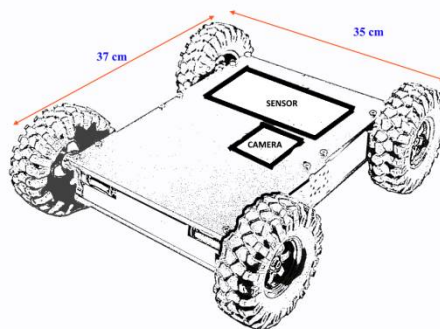


Fig 3: Design of the Robotic vehicle

IV. IMPLEMENTATION

The sensor module consists of

- i. Op-Amp stage
- ii. Buzzer indicator
- iii. 400V Boost converter

The Op Amp stage uses LM339 quad comparator IC as the core component, It consists of 4 internal comparator modules, which will convert the GM Tube output analog voltage to digital pulses and feed to the micro controller and to the Buzzer stage for indication. The buzzer stage consists of 555 timers IC configured as monostablemultivibrator and a buzzer is connected at the output.

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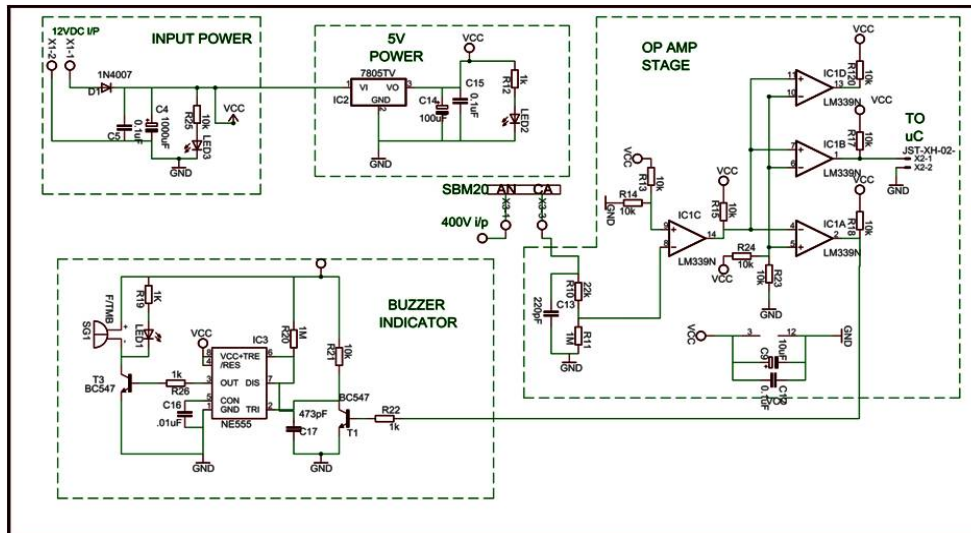


Fig 4: Schematic of sensor module

The SBM20 Gm tube operates at 400 V dc, this voltage will be generated by using 400V boost converter stage in the detector module. This circuit uses SG3525 PWM controller IC, a 10mH inductor and IRFZ530 MOSFET (it has fast switching properties) as the key components.

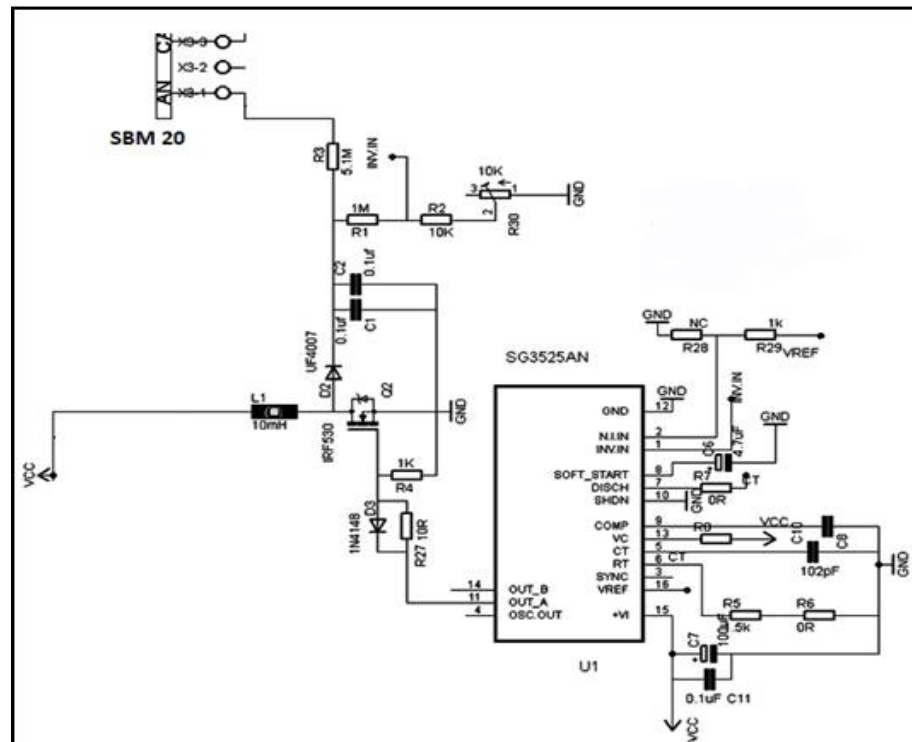


Fig 5: Schematic of 400 V boost converter

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The PWM frequency for the generation of 400V dc is 7.5 KHz [22], the actual working frequency will be double the PWM frequency, 15 KHz. Initially the inverting input will be zero (feedback), no inverting input will be 5.1 volt (Reference voltage). The PWM output switches the MOSFET; this switching induces a back EMF in the inductor coil. This induced back EMF charges the capacitors C1 and C2, and thus the output voltage increases, a portion of this output voltage will be feed back to the inverting input of SG3525. This feedback voltage varies from 0 to 5.6 volt. By comparing this Feedback and reference voltage the width of the PWM pulse would be controlled. As the width of the PWM pulse reduces the switching time reduces and so as the magnitude of the induced back EMF. Thus a constant output voltage can be obtained. R5 and CT determines the oscillating frequency 7 KHz, Output current will be 10mA.

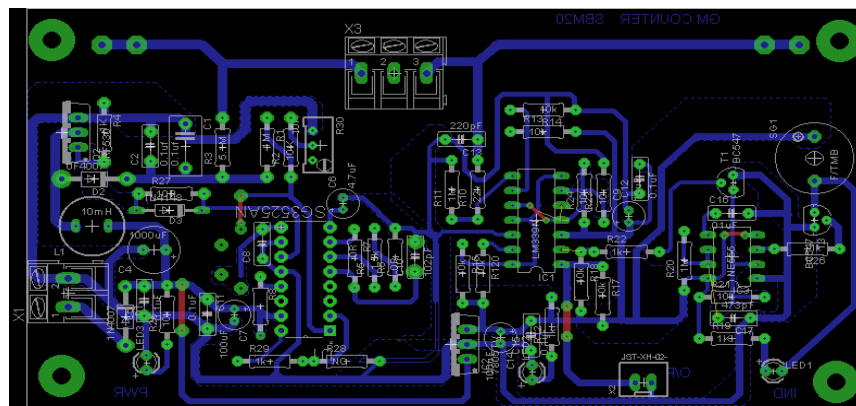


Fig 6: Layout of the PCB(sensor module)

The PCB is printed according to the layout discussed above; The material used is Glass epoxy

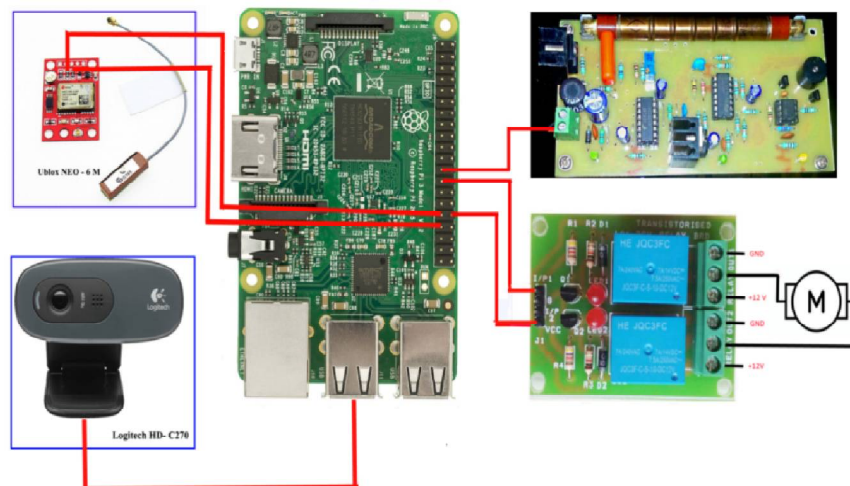


Fig 7: Interfacing of the modules

Functionality of each module (Sensor module, GPS, Camera) were tested during fabrication, development and integration. Each module was interfaced with the Raspberry Pi, firmware was developed using Python and Open CV.

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V. FUNCTIONAL ASSESSMENT

RADE-N upon sensing Radiation, activates its alarm, sends message to a base station. This message can alert authorities. The base station can receive data's of radiation intensity and GPS location through email. The user can monitor and control the measurement process remotely by using a server connected to the device.

When a radiation source is detected, the controller will check for the strings A and N in the NMEA data format, to detect the longitude and latitude of the source. The GPS uses IPX protocol for the data transmission.

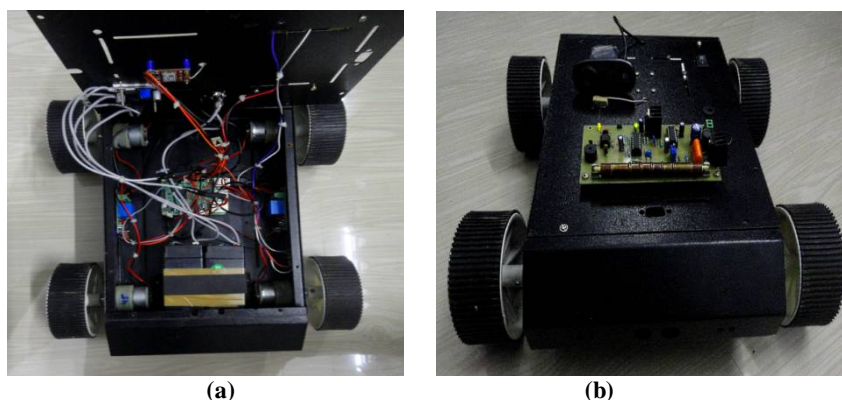


Fig 8: Final prototype (a) Wired controller part (b) Integrated prototype

VI. PERFORMANCE AND EVALUATION

The functionality of the proposed device / prototype was tested by measuring the natural background radiation in various geographical areas in Kerala, Sankhumugham, Chavara, and Alappuzha. Three soil samples were collected along the coastal regions of each; All collected soil samples were stored in sealed polyethylene bags and labeled. Tested each samples using the prototype and measured the intensity of the radiation in each sample and compared it with the reference values.

A. Experimental results

Table 1: Experimental data

Geographical region	Samples	Measured intensity of radiation(m R/hr)	Average intensity of radiation (m R/hr)
1. Shankumugham Thiruvananthapuram	S1	0.125	0.1097
	S2	0.108	
	S3	0.0961	
2. Chavara, Kollam	S1	0.191	0.158
	S2	0.150	
	S3	0.133	
3. Purakkad, Alappuzha	S1	0.05	0.0526
	S2	0.083	
	S3	0.025	

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b. Result comparison

Table 2: Comparison of experimental data with reference data

Geographical Region : Kerala Coast			
No	Experimental Result (mGy/Year)	Reference Values (mGy/Year)	Reference
1	8.31	2.17	[8]
2	11.97	< 1 – 70	[10] [7] [6]
3	3.985	2.3	[9]

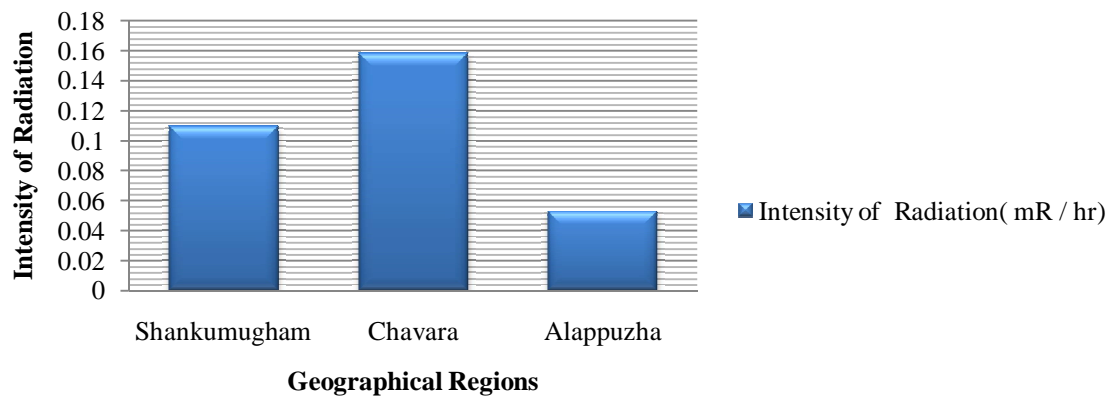


Fig 9: Level of measured Natural Background Radiation in various regions

VII. CONCLUSION AND FUTURE WORK

The product works effectively according to the features specified earlier RADE-N upon sensing Radiation; activate its alarm, sends message to a base station. This message can alert authorities. The base station can receive data's of radiation intensity and GPS location. Radiation detector uses GM tube for measuring nuclear leakage, GPS receiver receives the location data and this information can be uploaded on to a server. The Robot is battery operated and therefore they require no external connections. Once fully charged, device continuously works for about 6 hrs; they can be installed by a layman just on a watch tower. The product is aiming to have cost efficient system, compact design, easily expandable, simple to install with replaceable components. The overall cost is around Rs.9000/- , this will be one fourth of the competitive product available in market. In future up gradations size and cost can be further reduced by using SMT microelectronic components and multilayer PCBs.

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REFERENCES

- [1] Alfredo de Blas, Juan Toral, Carlos Tapia, "Equipment for the Continuous Measurement and Identification of Gamma Radioactivity on Aerosols", IEEE Transactions On Nuclear Science October 06, 2015
- [2] ManigandanMuniraj, N Bharathi, Abdul Rehman Qureshi"Geo Tagged Internet of Things (IoT) device for Radiation Monitoring", International Conference on Advances in Computing, Communications and Informatics (ICACCI) 13-16 Sept. 2017
- [3]R.Ranjith Kumar , L.Macwin,"Nuclear Radiation Detection using Wireless Sensor Network" IEEE Sponsored 2nd International Conference on Innovations in Information Embedded and Communication Systems ICIIECS'15
- [4] LudwikDobrzyn'ski, Krzysztof W. Fornalski, and Ludwig E. Feinendegen"Cancer Mortality Among People Living in Areas With Various Levels of Natural Background Radiation". Dose-Response: An International Journal July-September 2015:1-10
- [5]KSV Nambi, VS Bapat, M David, "Natural Background Radiation And Population Dose Distribution In India", Health Physics Division Bhabha Atomic Research Centre Bombay, India 1986 Government Of India Atomic Energy Commission.
- [6] Raghu Ram K. Nair, BalakrishnanRajan, SuminoriAkiba"Background Radiation And Cancer Incidence In Kerala, India—Karunagappally Cohort Study", Health Physics, January 2009, Volume 96, Number 1
- [7]Mehdi Sohrabi , "World High Background Natural Radiation Areas: Need To Protect Public From Radiation exposure" , Elsevier-Radiation Measurements ,Volume 50, March 2013, Pages 166-171
- [8]S. Monica, A.K. Vishnu Prasad,S.R. Soniya, P.J. Jojo"Ambient Gamma Levels In The In Seaside Regions Of Alapuzha District", Kerala International Journal of Pure and Applied Physics. ISSN 0973-1776 Volume 13, November 1 (2017), pp. 179-187
- [9]T.V. Ramachandran (2011) , "Background radiation, people and the environment" , Review article, Iran. J. Radiat. Res., Vol. 9 No. 2, September 2011
- [10] Birajalaxmi Das "Radiation Biology and Health Sciences Division, Bio-Medical Group Genetic studies on human population residing in High Level Natural Radiation Areas of Kerala coas"t, BARC News letter, Issue No 313 • Mar. - Apr. 2010
- [11] <https://www.convertme.com/en/convert/radiation/rrmgray.html?u=rrmgray&v=70>
- [12] <https://docs.python.org/3/>
- [13] <http://eagle.autodesk.com/eagle/documentation>
- [14] <https://inkscape.org/en/about/>
- [15] <https://www.raspberrypi.org/forums/viewtopic.php?f=38&t=76636/>
- [16]https://www.u-blox.com/sites/default/files/products/documents/NEO_6_DataSheet_%28GPS.G6-HW-09005%29.pdf
- [17]<http://static.highspeedbackbone.net/pdf/Logitech%20960000694%20C270%20HD%20Webcam%20Data%20Sheet.pdf>
- [18]<https://robokits.co.in/motors/300rpm-12v-dc-motor-withgearbox?zenid=h6u599nnmqtt3jtaabfhcoltn2>
- [19] <http://olelectronics.com/12V-Relay-Board-Two-Channel->
- [20] <https://www.batteriesplus.com/image/pdfs/product-sheet/Duracell-Ultra-SLA-General-Purpose-Product-Sheet-ID3713>
- [21] <http://www.ti.com/product/LM2596/technicaldocuments>
- [22] <https://www.onsemi.com/pub/Collateral/SG3525A-D.PDF>
- [23] <http://category.alldatasheet.com/index.jsp?>
- [24] specification: <https://www.raspberrypi.org/products/raspberry-pi-3-model-b/>
- [25] specification: <http://www.soeks-usa.com/01m/>
- [26]specification: <https://www.quarta-rad.ru/en/catalog/dozimetr-radiometr-radon/dozimetr-radex-rd1212-bt/>
- [27]specification: <http://www.sperdirect.com/radiation-emf-nuclear-rf-7-ctg.htm>
- [28] Price: <https://www.amazon.in>
- [29] Paul Barry"Head First Python", ISBN13:978-93-5023-188-3,