Design of the controller module of mobile carrier radioactive source

D F Atmoko, J Triyanto, M Amin H D, F Harahap, T Jayadiharja

- Center for Nuclear Facility Engineering (PRFN) – National Nuclear Energy Agency of Indonesia BATAN, Kawasan PUSPIPTEK Gd. 71, Tangerang Selatan, Banten, 15314, Indonesia
- Pertamina University, Jakarta

E-mail: dian_fa@batan.go.id

Abstract. A control module for mobile carrier radioactive source has been designed. Mobile carrier radioactive source is a tool used to carry out testing for radiation characteristics both statically and dynamically and to conduct calibration on the Radiation Portal Monitor according to the requirements of SNI IEC 62244-2016. The control module is designed to meet the requirements, it can set a carrier speed of at least 8 km/h, it can adjust the height of the radioactive source between 1 m and 2.5 m, it has automatic forward and backward direction mode. Furthermore, the mobile carrier can be controlled remotely for personnel tester safety. The control module can stop the mobile carrier suddenly when an emergency occurs. The mobile carrier uses a portable power supply so that it can move freely and easily shifted. To meet these requirements, the driving power of the carrier a motor of 24-volt dc with 250 watts. The radioactive source uses a driving power of 12-volt dc motor with a minimum lift power of 5 kg. The control module designed uses a microcontroller with an android application-based interface that is connected by wireless. In the android application there are virtual numbers and input buttons to give commands to the control module. The application can also receive carrier speed information and the height of the radioactive source. To break the power of driving motor of carrier and the driving power of the lifter of the radioactive source, the mobile carrier uses two-level relays, namely low current conductivity relays and relays with high current conductivity. Next in order to move forward and backward automatically, at each end of the carrier is equipped with a limit switch. The button and top position barriers on the radioactive source lifter use a limit switch.

1. Introduction
Radiation portal monitoring device (RPM) is fixed installed radiation monitors with typically consist of an array of detectors in one or two vertical pillars with associated electronics. Since 2014 PRFN BATAN has started to develop a radiation monitoring portal (RPM) device. Until 2019, three types of PMR have been produced, namely PMR 15 using type PVT gamma detector [3][4], currently installed in the Kawasan Nuklir (KN) Pasar Jumat. PMR 16 uses a NaI(TL) type gamma detector and a neutron detector, this type of PMR is generally used for nuclear installation areas. The third type is RPM PPTI with a cylindrical NaI(TL) gamma detector, RPM PPTI is designed for use in the area of the sea and airports. PMR 16 and RPM PPTI are currently under testing for product certification based on SNI IEC 62244:2016. One of the tests included testing the characteristics of radiation. In testing the
radiation characteristics required a device with the ability to move vertically and horizontally represents the vehicle that passes through the monitor portal. We call this device a mobile carrier of the radioactive source. This paper will be presented how to design a mobile carrier of the radioactive source.

![Figure 1. Indonesian RPM,PMR-15](image1)

![Figure 2. Indonesian RPM PMR-16 and RPM PPTI](image2)

2. Methodology
The design method uses the V-shaped method, shown in Figure 3.

![Figure 3. V-Shaped method design](image3)

Design specifications are the initial stages in the preparation of requirements. In the parameters design specifications, each module / sensor has been determined in accordance with the needs or standards referred to in this case SNI IEC 62244-2016. The next step determines the function of each module or sensor needed. Specifications and functions are then used as parameters in the requirements for preparing hardware (HW) and software (SW) designs. HW design and software are implemented in the manufacture and installation of modules for testing. The next step is to validate the components according to the function. System validation as a whole is based on reference to specifications at the initial stage according to the requirements document.
3. Result

The design requirement or specifications of the mobile carrier of radioactive source based on SNI IEC 62244:2016 Standard [1]. The Mobile carrier of a radioactive source is a device that can be moved on vertical and horizontal axes. The vertical axis functions as the position of the height of the source of the radioactive source to the detector and the horizontal axis functions as the position of the distance of the detector to the radioactive source. Visually shown in figure 4. In the clausal 6.3.2 about the method of testing gamma radiation detection, the radioactive source testing must be moving through the top, middle, bottom and center of the lower and upper detection areas.

The speed of horizontal moving must not exceed 8 km/h. The Centre of processing module using a microcontroller with analog output, digital input-output and serial communication to connect with Bluetooth. Input control is given by mobile phones with the android application and connected to the controller module by wireless communication. DC motor driver will be controlled the speed of the horizontal motor with variation input speed from microcontroller analog output. To change the direction of movement the motor, digital out from controller will be driving a low current relay module. DC motor for horizontal moving and vertical moving that require a high current dc power to connect the dc power source with these motors using a high current relay module controlled by a low current relay module. To measure the speed of the horizontal motor using a proximity sensor to read pulses of wheel rotation and the controller will be converted to speed parameter. Height of radiation source measuring by the ultrasonic sensor.

![Figure 4. Vertical and horizontal moving of mobile carrier design.](image)

A speed of horizontal moving and height of source can be set by input setpoint. To change the auto direction of horizontal motor used forward and reverse limit switch. Vertical movement is protected by upper and lower limit switches. they are also used to change the position of vertical movements in an upward or downward direction. Block diagram of hardware controller of mobile carrier showed in figure 5, the device of mobile carrier radioactive source designed to be moved therefore as a power source using 2 x 12-volt dc batteries arranged in series, so as to obtain a 24-volt dc voltage as a power source for horizontal motors. The ability of the minimum battery current can travel a distance of 3 x 50 x 6 meters or equal to 900 meters. Horizontal motors have the power to pull or push a total load of a device weighing ±60 Kg. To facilitate assembly between modules using the connector as a connector.
The microcontroller is programmed to carry out the speed and direction control commands of the horizontal motor, the direction of the vertical motor which determines the position of the radiation source at the vertical position to the rpm detector. The program flow that is embedded in the microcontroller is shown in Figures 6, 7 and 8. The microcontroller command input is obtained from the remote command via the mobile carrier application on the mobile phone / smartphone. Android-based application layout design shown in Figure 7.

![Figure 5. Hardware controller of mobile carrier design](image)

![Figure 6. Software flow chart of horizontal moving of controller mobile carrier design](image)
Figure 7. Software flow chart of vertical moving of controller mobile carrier design

Figure 8. Software flow chart of horizontal motor speed control. Side by side to save space. Justify the caption.

Mobile Carrier Source

Source Level:

500 cm ON

Horizontal Motor Speed:

500 m/h Set

Horizontal Motor Direction:

Forward Reverse

Stop All Motors

Stop

Pairing Bluetooth Device

Figure 9. Design layout of the mobile phone user interface of mobile carrier placed side-by-side to save space. Justify
the caption.

4. Conclusion
From the description can be concluded as follows: mobile carrier radioactive source is needed as a tool to test the radiation characteristics of the radiation portal monitor device with horizontal and vertical motion capability, with this device, the person conducting the test can avoid exposure to the radiation source because the device can be operated remotely. In carrying out the design of a mobile carrier radioactive source, it is necessary to refer to the IEC SNI 62244:2016 standard, i.e. the horizontal motor movement speed does not exceed 8 km / hour in meeting these speeds in the design of dc motors can be controlled speed. Other requirements the position of the radioactive source can be adjusted to a height of 4 meters, in the design the requirements are met with a source-level motor that can be adjusted according to the setpoint value. in this design as a central control using a programmed microcontroller that can communicate with mobile phone devices wirelessly. Mobile carrier radioactive source devices are designed to be installed in different conditions and locations, so the connecting cables are equipped with connectors and power resources using batteries.

Acknowledgments
The author would like to thank PRFN-BATAN for all laboratory facilities and workshops, the RPM PPTI Innovation Team and the funding of innovation incentives from the Ministry of Research, Technology and Higher Education (Kemenristekdikti).

References
[1] SNI IEC 62244:2016 “Instrumentasi proteksi radiasi - Monitor radiasi yang terpasang untuk deteksi bahan nuklir khusus dan radioaktif di perbatasan wilayah (IEC 62244:2006, IDT) “, BSN 2016.
[2] Paolo Gai , Giuseppe Lipari, Marco Di Natale, Nicola Serreli , Luigi Palopoli , Alberto Ferrari , “ Adding Timing Analysis to Functional Design to Predict Implementation Errors “, SAE International , 2007, DOI: 10.4271/2007-01-1272.
[3] Triyanto Joko, Atmoko Dian Fitri, Rifai Ahmad , “Perekayasaan Perangkat Lunak Portal Monitor Radiasi Dengan LabVIEW™”, Majalah Prima, Volume 11, Nomor 2, November 2014, 35-43.
[4] Atmoko Dian Fitri, Nashrullah Erwin, Gunawan Usep S, Syawaludin Beni , “Rancang Bangun Modul Pencacah 16 Bit 3 Input Dengan Komunikasi Tcp/Ip Untuk Portal Monitor Radiasi PMR15”, Majalah Prima, Volume 12, Nomor 2, November 2015, 29-37.
[5] Radiation Safety Section , “Detection of Radioactive Materials at Borders”, IAEA-TECDOC-1312 , IAEA, September 2002.
[6] Nugroho Suryanto, Hadi Waluyo Sigit, Hakim Luqman, “Comparative Analysis of Software Development Methods between Parallel, V-Shaped and Iterative”, International Journal of Computer Applications, Volume 169, Nomor 11, July 2017, 7-11.
[7] Balaji. S, Murugaiyan M.Sundararajan Dr, “Waterfalls V-model Vs Agile: A comparative Study on SLDC”, International Journal of Information Technology and Business Management 29th., Volume 2, Nomor 1, June 2012, 26-30.