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CONTROL SYSTEM IN 10 MeV CYCLOTRON BASED ON IoT

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Abstract

Many The Internet of Things is one of the new most advanced technologies in the world. One of the applications of this technology is using it in places where remote control is preferred or it needs to control various processes at different times throughout the day. The cyclotron accelerator is one such system in which the start-up process until radio medicine production requires continuous monitoring and inspection. In this research, we have tried to use the internet of things technology in the process of cyclotron control system specially in fine tuning section.

INTRODUCTION

Every process needs control and monitoring to properly execute and monitor performance. The purpose of the cyclotron accelerator control system is to do the same. System control will also prevent possible damage and facilitate troubleshooting.

In the past, the cyclotron control system was fully hardware designed by relays and then wired. The major drawback of this method was that, if there was a change in the control system, the hardware and wiring of the relays would also have to be changed. This increased the cost and time. Relay systems also had a slower operating speed and were much more difficult to troubleshoot due to wired communication.

With the advent of intelligent control devices and the use of a series of programmable tools and software that operate intelligently, the above issues have been resolved, as well as with the benefits of smaller system dimensions and the possibility to exchange information with other systems, causes that using the Internet of Things for ease of communication.

Our 10 MV cyclotron is comprised of several components including: magnet, RF system, vacuum system, cooling section and ion source. Each of these parts contains components that must be carefully monitored by accurate sensors during the process, and if necessary, automatically assigned the commands to these parts. As a result, it is better to have all of its subsystems intelligently controlled and monitor in order to sustain the cyclotron accelerator performance. All of these subsystems are controlled by programable components and have a communication through the IoT protocols. In this research, we have tried to use the internet of things technology in the process of cyclotron control system specially in fine tuning section.

CYCLOTRONS

As mentioned, the cyclotron accelerator is composed of various components, including ion sources, magnets, cavities, and the vacuum system. When the charged particles leave the ion source, they travel through the space between the poles and accelerate as they pass through the cavity. What drives the charged particles in this device is a variable electric field generated by the cavity. And what holds the particles in a circular path is the force of the magnetic field. Thus, the particle is accelerated through the electric field and driven by the magnetic field, both focal and in a circular path, after being injected into the middle plane and positioned in the appropriate rotation plane. Finally, the particle is extracted by a stripper in a radius of proper energy [1].

Accelerators are used in the medical field to produce diagnostic radio-medicine, radiotherapy, and rapid neutron production for the treatment of cancers. The 10 MeV cyclotron was designed to produce FDG radio-medicine for PET spectroscopy.

INTERNET OF THINGS (IoT)

IoT technology is the creation of a global network of uniquely addressable objects based on a standard communication protocol. Active involvement of "objects" in commerce, information gathering and processing processes while being able to interact with each other and with the environment, with the ability to transmit information and to respond automatically to natural or physical events by performing a process or without direct human intervention in many industries can be helpful.

Not long after the idea of the IoT was developed by Kevin Ashton, who pointed to factors such as increasing data volume in the world, the importance of controlling objects, human limitations, time, speed and accuracy. But in various industries and everyday life is expanding rapidly.

In the IoT structure, the human structural system is inspired by the way that equipment and sensors play the same role as the human five senses and wireless cellular networks, local area networks, data storage and processing security, and transactional and analytical systems, replaces the brain. As a result, the system consists of three main parts: sensors, communications and protocols, and data processing.

In each application, the sensors are characterized by what is appropriate for that control system. In the selection of sensors, the type of sensor and the its accuracy should be specified and taken into account.

For the cyclotron, these sensors include pick up probes for feedback from the RF field inside the cavity, directional coupler outputs to investigate the rate of return wave at the beginning of the tuning system, tuner capacitor location, phase and frequency of the RF signal from the LLRF section, temperature and Pressure sensors, output beam flow, etc. [2].

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In order to achieve the goals of IoT and what it is intended for, smart devices must be able to seamlessly exchange information. The collected information should then be sent to the server through the infrastructure, then the data analysed and the commands sent to the devices, applications, or individuals, as shown in Fig. 1. In cyclotron control system, these communications are considered in two ways: Wi-Fi and cable communications. Also, data processing in the central operating system and data transfer is done through PLC and Raspberry Pi interacting with each other according to expected performance.

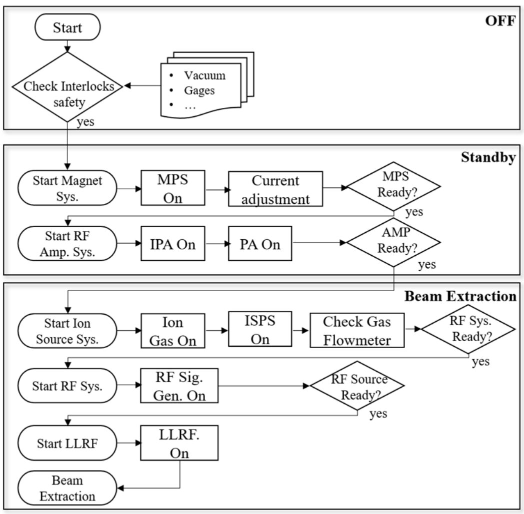

Figure 1: The different parts relation to each other and the algorithm used in programming.

CYCLOTRON CONTROL SYSTEM

As mentioned, cyclotron controlled subsystems include: cooling system control, cyclotron vacuum control, magnet system control, RF system control, etc., as shown in Fig. 2.

In order to launch the cyclotron correctly, all of these sections will start in order of priority, at specified intervals and after checking all the necessary conditions at each step. The below flowchart shows the sequence of these steps [3].

One of the major obstacles to the development of IoT equipment is the sometimes costly expense of producing it. But due to tools such as Raspberry Pi and the ever expanding ecosystem development, IoT projects should not be expensive. There are four models of the Pi Machine: Model A, Model B, Compute and Zero. In this system uses a 32-bit Raspberry Pi 3 B with 1 GHz processor and 512 MB of RAM, which is shared with the GPU. An array of general-purpose input/output (GPIO) pins are provided at Raspberry Pi. For example, the PWM module in the GPIO of Raspberry is used to control the tuner servo motor. These pins can be used for various control tasks. Python programming is also used for its programming.

In this research, we sought to streamline and smarting the cyclotron control process and to enable remote control and monitoring by IoT devices. Therefore, all control processes previously controlled through the LLRF and PLC sections were seamlessly designed in a new context as remote controls.

CONCLUSION

IoT can be used in various industries to increase efficiency, reduce costs, as well as control the system, making it easier to prevent potential damage and troubleshooting systems. In the design of the desired 10 MVA cyclotron, all control systems, in an integrated context, allow remote control and monitoring using IoT protocols. All processes are remotely done at the start of the system and all control signals are evaluated side by side. And during operating the system, the need to be near the device should be eliminated. This improves the safety of users and also controls the performance of the device more precisely.

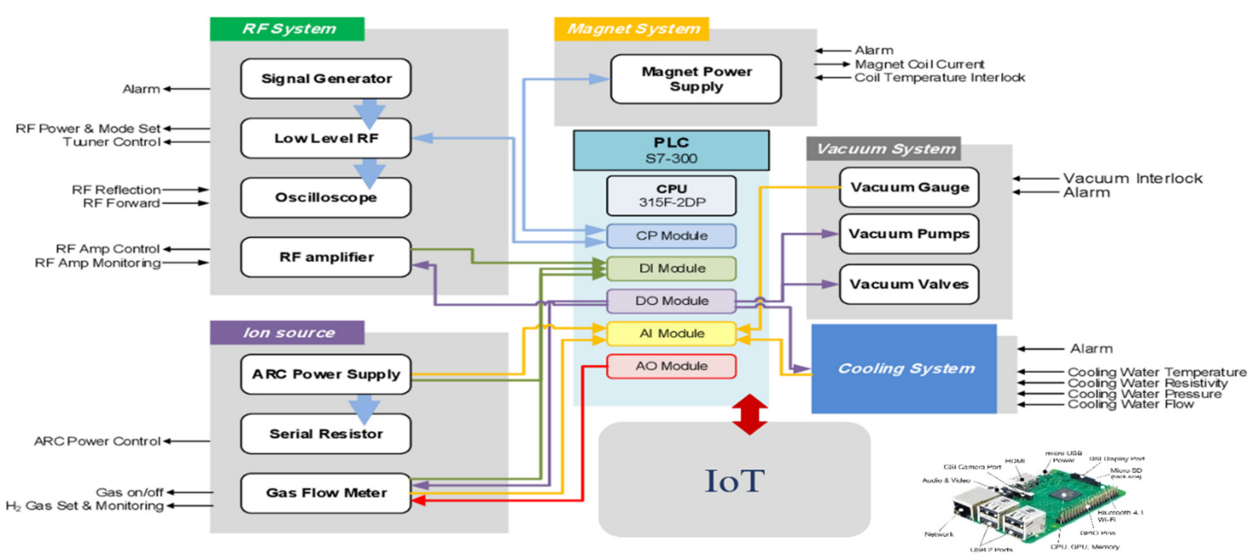

Figure 2: The 10 MeV cyclotron control system.

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