CONTROL SYSTEM DESIGN OF KIRAMS-13 CYCLOTRON

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Abstract

Cyclotron has several independent control devices. For example, cyclotron consists of the magnet power supply as like main power supply of high output, vacuum system, RF system, RF fine tuner, ion source, beam diagnostic device and cooling system. In addition, each device due to being one or several devices includes controller for control them. KIRAMS-13 cyclotron developed the first in Korea at Cyclotron Application Laboratory in KIRAMS. Controllers of KIRAMS-13 automatically communicate with each other in order to maintain the cyclotron to be the best condition. And control system of KIRAMS-13 was designed the distributed control system method in order to fast communication and protective systems. Cyclotron needs the continuous monitoring because of produce RI for several hours. Therefore control system informs operator an analysis about all input and output signal of cyclotron and current situation. And in case of providing cyclotron's trouble, this is organized easily user-friendly control program. Each device basically uses RS-422 in order to use asynchronous communication that hardly error during communication with the main computer. In this work, we will present to improve control system based on LabVIEW program through analyzing the device control of existing cyclotron.

INTRODUCTION

KIRAMS-13 cyclotron developed the first in Korea at Cyclotron Application Laboratory in Korea Institute of Radiological & Medical Sciences (KIRAMS), Korea Atomic Energy Research Institute (KAERI) in Seoul. This cyclotron can be used for a Positron Emission Tomography (PET) purpose. This cyclotron with maximum beam energy of 13MeV can produce radio isotopes especially F-18. It is a fixed field, fixed frequency cyclotron. The main magnet assembly consists of the steel yokes and of two coils located symmetrically above and below the median plane. The RF system provides an oscillating electric field that pulls the ions through acceleration gaps where they gain energy with each turn, until they reach the 13MeV at the extraction radius. RF dees, located in opposite valleys, are brought to 45kV at a frequency 77.3MHz. The negative ions are produced by a PIG ion source. Cyclotron controller asks inputs of every sensor and output of every instrument for notifying current condition to operator. It has independent controllers, for example DC power supply, vacuum system, beam profile system, beam extraction system, RF system, ion source, cooling unit and so on. Basically, each control system uses RS-422 for communication to main control computer.

CONTROL SYSTEM DESIGN OBJECTIVES

- Fully integrated control system
- Easy data access and analysis
- Remote control/diagnostics based on Network
- High level security
- Well defined auto/manual control mode
- Practicable to local control in emergency
- Stable beam current
- Control various devices in real time
- Convenient operation
- Easy maintenance

CONTROL SYSTEM OF KIRAMS-13

Control system of KIRAMS-13 cyclotron informs operator all input and output signal of cyclotron and current situation. Cyclotron has several independent control devices. For example, cyclotron can classify the magnet power supply as like main power supply of high output, vacuum system, RF system, RF fine tuner, ion source, beam diagnostic device and cooling system. In addition, each device due to being one or several devices includes controller for control them. Each device basically uses RS-422 in order to use asynchronous communication that hardly error during communication with the main computer. If we use the DC servomotor and driver, we use the controller for control the each motor. Cyclotron system needs the continuous monitoring in order to produce RI for several hours. And preparing for cyclotron's trouble, this is organized easily user-friendly control program. Consequently this paper set a goal that we develop correct control system through analyzing the device control of existing cyclotron. And we designed control system used LabVIEW program.

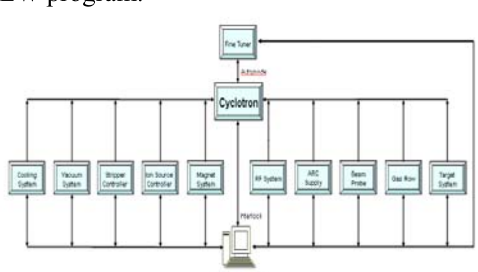

Fig.1 Control Layout of KIRAMS-13

Distributed Control System

The integrated automation of the plant instrumentation and control system started in the 1960's in Korea with the introduction of the direct digital control (DDC). The use of the distributed control system (DCS) followed in the 1970's. The DCS was developed primarily to overcome the degraded reliability, which is typical of the centralized control system such as the DDC. The distributed control systems architecture, if properly designed, offers additional benefits: (1) *composability*: large systems can be built in an incremental manner by integrating a set of well-specified and tested subsystems; (2) *openness*: existing systems are open to incremental modification and extensible without some predefined upper limit; and (3) *maintainability*: it is possible to implement well-defined error-containment regions and to achieve fault tolerance by replicating nodes. According to this merits, we used the distributed control systems in KIRAMS-13 such as Fig.2.

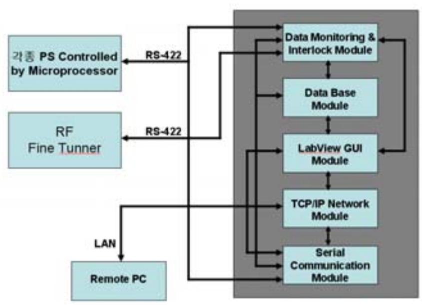

Fig.2 Distributed Control System of KIRAMS-13

Interlock System of KIRAMS-13

Operator can happen at bad circumstances that he doesn't recognize when cyclotron is operated. Therefore, the computer is added to the program for controlling by itself regarding all of situation. Other systems are wrong continuously according to the error of one system because all system is continuous with another that. And cyclotron has to caution electric shock and radioactivity because it is the equipment which happen nuclear reaction utilizing of high voltage. Such a reason interlock is very important at cyclotron and can deal with the situation promptly and exactly.Fig.3 is interlock system layout of KIRAMS-13.

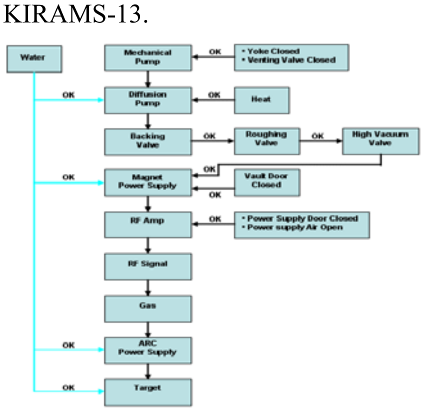

Fig.3 Interlock System Layout

Embedded System

Control program is improved strengthen embedded control through the internet. Embedded system is graft into hardware and software as the optimum system for special purposes different from other general computers. As the concept embedded processor system establish GPIB, standard interface of RS-485 and Embedded OS for supporting TCP/IP. In addition, web serer is embodied in the embedded system. Concept of the network composition construction is as follows Fig.4.

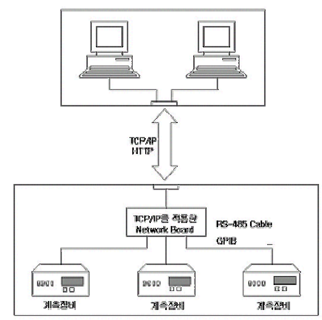

Fig.4 Organization of Network

User Interface

Cyclotron controller analyzes the current situation and input/output signal of cyclotron. And it let the operator know the current operation situation. In addition it requires input from the sensor and output from devices. When cyclotron is operated, interlock in the program is important. But above all thing it is more important that the operator recognizes the risk in advance and prevents from the emergency. Considering these problem, it is developed that the operator can acknowledge the program interface of cyclotron at a glance. Picture 5 is the interface that improved control program. And when interlock is occurred, operator can recognize the twinkling button. In addition, it is improved that it is added Autostart, Autostop, Log-Book, time reservation, keeping and load ability and HELP. These improvements makes beginner of cyclotron approach with ease.

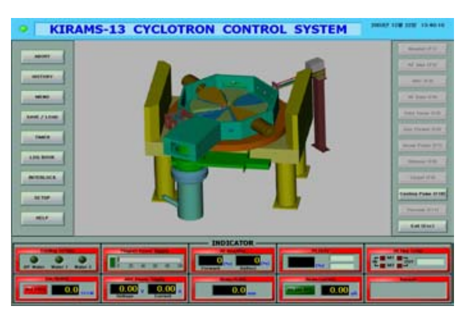

Fig.5 Interface of KIRAMS-13

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