DESIGN OF KIRAMS-13 CYCLOTRON CONTROL SYSTEM*

Yu-Seok Kim *, Dong Hyun An, Hong Suk Chang, Bong Hwan Hong , Min Goo Hur, In Su Jung, Joon Sun Kang, Sang Wook Kim, Tae Keun Yang, Jong Seo Chai
Korea Institute of Radiological And Medical Sciences , Seoul, Korea

Abstract

Korea Institute of Radiological & Medical Sciences (KIRAMS) has developed PET-dedicated cyclotrons as well as a large ranged of targets and automated chemistry modules. And now, this cyclotron was selected from five regional cyclotron centers in Korea.

For the user of regional cyclotron centers, control system of the cyclotron and FDG synthesize system needed to be design with high reliability and flexibility.

The KIRAMS-13 cyclotron has been commissioned over last two years and improved that the hardware and software structure of control. Control system can display the dynamic status GUI for operator and hardware interfaces used serial adds-on cards for PC, PLCs and/or micro-controllers. Auto tuning requiring no operators during routine production and embedded control system will be help for the operation in local regional cyclotron centers.

INTRODUCTION

KIRAMS-13 cyclotron was developed at Cyclotron Application Laboratory in Korea Institute of Radiological & Medical Sciences (KIRAMS). This cyclotron dedicated to Positron Emission Tomography (PET) radioisotope purpose. This cyclotron with maximum beam energy of 13MeV can produce radioisotopes especially F-18[1].

Control of cyclotron and FDG synthesize system need a compact and sophisticated control system to coordinate these devices, to deal with sequence control, parameter tuning, status display and human interface [2]. Controller can be provides a simple solution to the logic control, process automation and status monitoring.

Distributed control method was chosen due to that is more suitable for reliable, stable and flexible task. 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, FDG synthesize, 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. The KIRAMS-13 cyclotron has been commissioned over last two years and improved in the hardware and software structure of control system.

CONTROL SYSTEM DESIGN

Control system is suitable for the task, especially, it can provide a fully integrated 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 and easy maintenance.

Programmable logic controllers (PLC) are more or less standard devices for the control of small and middle-sized cyclotrons [3]. But today, most of all instruments and power supply have controller and serial communication ports.

Control system of KIRAMS-13 cyclotron informs operator all input and output signal of cyclotron and current status. Cyclotron has several independent control devices. For example, cyclotron can classify the magnet power supply, 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.

Cyclotron system needs the continuous monitoring in order to produce RI for 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.

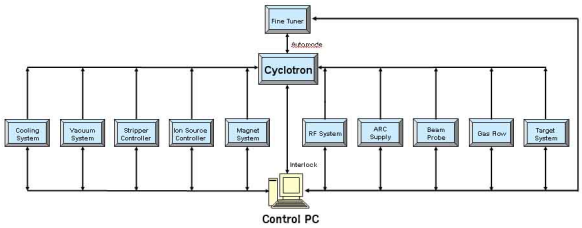

Fig.1 Control Layout of KIRAMS-13

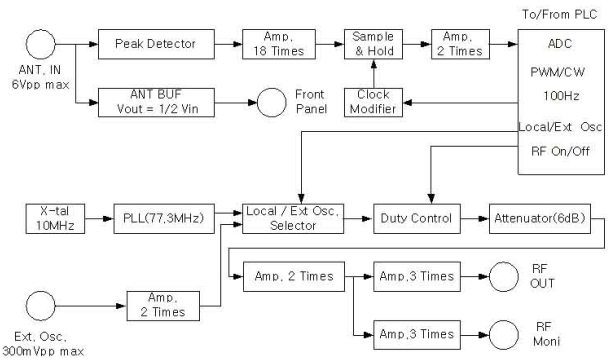

Fig.2 Example of local controller

Distributed Control System

The integrated automation of the plant instrumentation and control system started with the introduction of the direct digital control (DDC). The use of the distributed control system (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 of flexibility, openness and maintainability. According to this merits, we used the distributed control systems in KIRAMS-13 such as Fig.3.

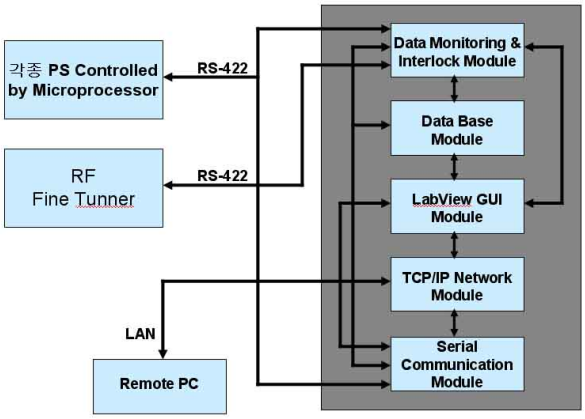

Fig.3 Distributed Control System of KIRAMS-13

Interlock System of KIRAMS-13

Interlock system is for the safe. 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.

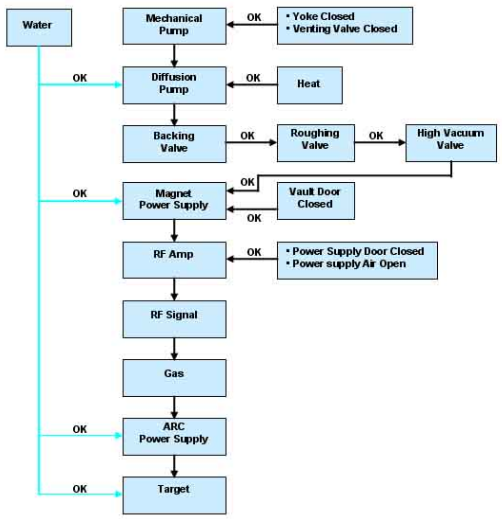

Fig.4 Interlock System Layout

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.5.

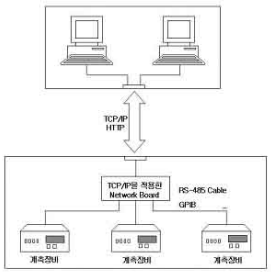

Fig.5 Organization of Network

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.

Fig. 6 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 Auto-start, Auto-stop, Log-Book, time reservation, keeping and load ability and HELP. These improvements makes beginner of cyclotron approach with ease.

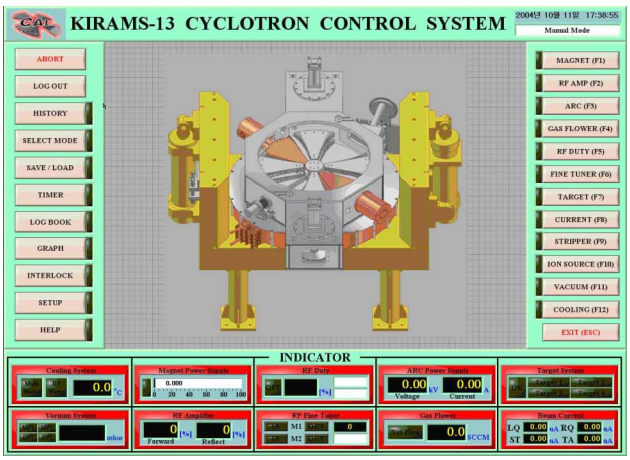

Fig.6 KIRAMS-13 control panel

CONCLUSION

Local controllers provide stand-alone operation for each unit even with switched off operation interface. The implemented architecture keeps data exchange between the master to local as low as possible. The highest rate is required between main to RF controller.

The high level control program for the master computer was developed using the LABVIEW. Each control task can be designated to master controller and new tasks can be added or extended easily. Highly informative graphical user interfaces can be display the status of the control device and their elements. The sequential starting and stop process of controller have been completely automated and it takes less than three minutes. This controller has Auto-tuned mode and it can be adjust the RF optimal parameter without operator

Operation of the cyclotron has become simpler and easier as well. The selected methods and solution will be help for the regional cyclotron centers.

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