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DESIGN OF CONTROL SYSTEM FOR DUAL-HEAD RADIATION THERAPY

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Abstract

Sungkyunkwan University groups have been developed advanced radiation therapy machine named dual-head radiation therapy gantry for reducing the treatment time by up to 30%. The main difference between previous radiation therapy machine [1] is using two electron LINAC as X-ray sources at radiation therapy. In support of this system, control system based on SCADA and hardware development was implemented. The control system consists of supervisory computers and local controllers and the control network was ethernet and software was written by labVIEW. An overview of this control system is presented in paper.

INTRODUCTION

Sungkyunkwan University has developed a dual head radiation therapy system since 2012, which is a radiation therapy system that aims to reduce treatment time up to 30% than conventional radiation therapy machine [2]. To reduce treatment time, dual X-ray source, head are equipped with this system. developed dual-head gantry system is shown in Fig. 1. Those system configurations have economic benefits and advantages on account of reducing radiation treatment time but the additional installation of components result in space limit and a complexity of the system. To overcome space limit, we use 6 MeV X-band LINAC as X-ray source and it sufficiently reduce not only cavity volume but also waveguide and magnetron [3]. Controlling dual X-ray source is new challenge. in contrast to conventional TomoTherapy that use single X-ray source, dual head gantry system uses dual X-ray sources ssimultaneously or sequentially so control system requires supervisory control and sequence control that not only include data acquisition and monitoring but also two electron LINAC beam pulse synchronization.

Figure 1: Dual-head Radiation therapy system.

SYSTEM HARDWARE CONFIGURATION

Developed gantry system is consist of subsystems such as two heads, electron LINAC and gantry robot and subsystems have each local controller. Head subsystem objective is to control the radiation path from the LINAC to the patient. It measures radiation dose rate and control X-ray field size. Its appearance is shown in Fig. 2 Head's main control unit is Atmega2560 and control board has potential meters and limit switches for interlock.

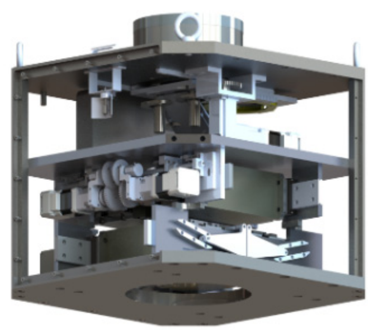

Figure 2: Gantry Head Appearance.

Five motors in head system have each driver. By using daisy-chain scheme, master motor manages other slave motors as shown in Fig. 3.

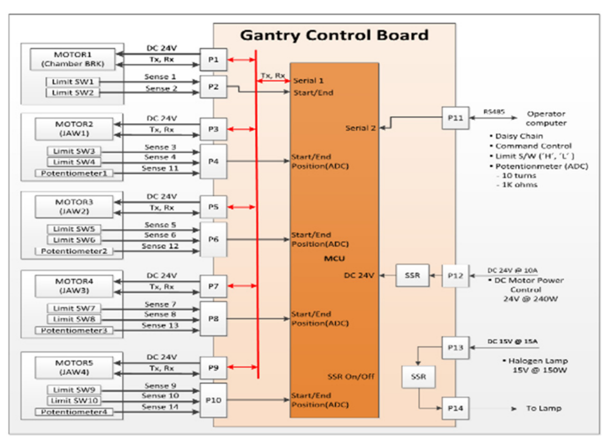

Figure 3: Gantry head system block diagram.

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Gantry robot subsystem has parallel two rotation planes. Electron LINACs and heads are equipped to each plane. It’s control system use computer as the main controller and PCI type motion board was adapted. Motions board control two motor driver and absolute encoder data is got by RS 422 communications from each motor driver. The PC controlling the gantry robot system is developed as the local server it’s block diagram is shown Fig. 4.

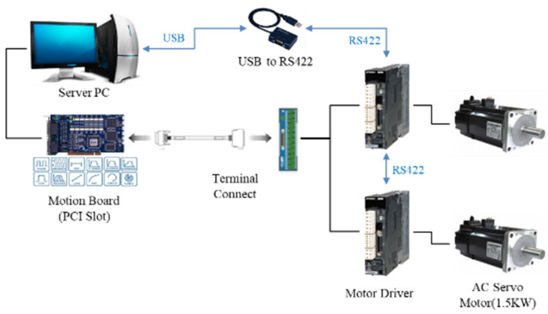

Figure 4: Gantry head system block diagram.

The main parameters of X-band 6 MeV electron LINAC were listed in Table 1.

X-band electron LINAC subsystem requires high voltage devices such as modulator and ion pump controller as shown in Fig. 6. Each device includes high voltage interlock function and in order to machine protection, status information be interlocked to other machines. In case of ion pump controller, its vacuum level digital output is transmitted to LINAC control system(CRIO-9017). This signal determines whether TTL signal from NI-9402 to RF modulator generate or not. Crio-9017 use labVIEW FPGA to microsecond level signal such as TTL signal and RF forward and reflect.

Table 1: X-band LINAC SPECFICATION

Parameter	Design value
Fc	9.309 GHz
Energy	6 MeV
Length of cavity	27.5 cm
Effective shunt impedance	104.733 MΩ/m

Subsystems are connected to the TCP/IP Ethernet network. X-ray subsystem and Gantry robot support ethernet protocol. Gantry head system support RS-485 protocol so it is connected to MoXA NPort 5650 serial device server to communicate with main server/client by Ethernet.

Master trigger for beam and other measurement instrument are controlled by BNC 505 delay generator

It has 10 ns level accuracy and it’ supported IEEE 488 protocol is converted to ethernet.

See also Fig. 5.

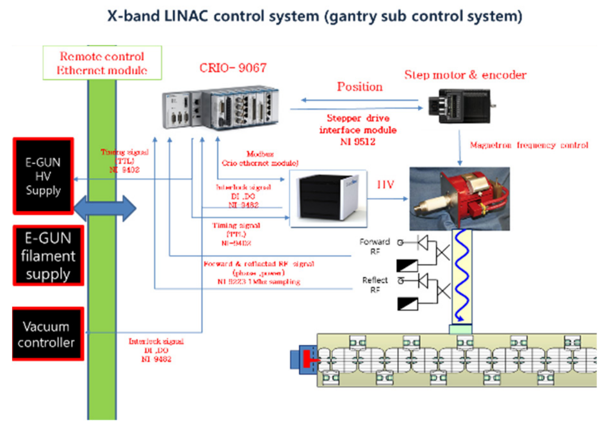

Figure 5: X-band LINAC system block diagram.

SYSTEM INTEGRATION

Dual head gantry system integration was implemented based on SCADA (Supervisory Control and Data Acquisition) Concept. In our system, Supervisory computer contain server for data acquisition and client for user operation. Integration software is developed by labVIEW. Mainly used module is Datalogging and Supervisory Control module [4]. I/O server function in this module are used for enabling communication with subsystem.it supports MODBUS, epics and OPC protocol by I/O server easily and customized developed communication protocol is also can made by Custom VI-Based I/O servers. Data in I/O server can also share data between loop on a single diagram or VI across network. Figure 6 show the deployed I/O server and library list in project explorer. After I/O Server is deployed, it is possible to access in another VIs and across network.

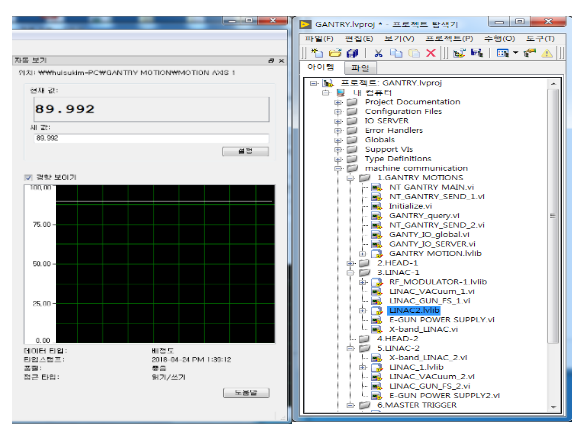

Figure 6: NI Distributed System Manager and project.

Using I/O server, main software’ communication parts from subsystems are separated from main client or server part. Main Software’ Client part consist of main view and detailed view VI as shown Fig. 7. At main view VI, system key parameters such as BEAM ON/OFF gantry rotation angle or X-ray field size can be controlled. Detailed view VI is supported for tuning and optimization devices.

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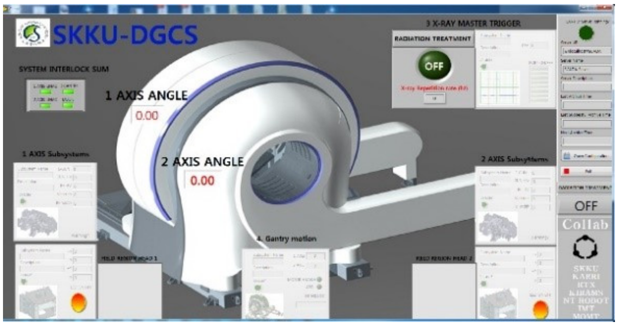

Figure 7: Client of gantry system.

CONCLUSION AND DISCUSSION

Design and development of integrated control system for dual-head gantry are carried out in this paper. Developed system is intended to integrate subsystem easily by SCADA. Next step for treatment is to integrated MV and kV image process for Preclinical study.

ACKNOWLEDGEMENTS

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