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Control of Collimator for Conformal Radiation Therapy based on FPGA Implementation

Khan Zarrarahmed Zaferullah[1]

[1] Mumbai University

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Abstract

In this paper of Collimator control system we discuss the beam shaping device namely secondary collimator which creates field intensity. Due to different arrangement of jaws different field size can be created. The hardware design for control of collimator for treatment of cancerous tissue leads towards the conformal treatment and thereby sparing good tissue which leads toward the increase in quality of treatment. Cadence FPGA System planner is used to generate the schematic for the hardware of collimator. VHDL code is written in XILINX ISE 13.9 and it is implemented on SPARTAN 6LX9TQG 144. VHDL code is tested on design PCB.

Index terms— stepper motor, collimator, field programmable gate array (FPGA), linear accelerator (LINAC), dynamic, radiotherapy, multi-leaf collimator (MLC).

1 Introduction

ancer is one of the leading diseases in the world. Cancer is a term used for diseases in which abnormal cells divide without control and are able to invade other tissue. Cancer cells can spread to other parts of the body through the blood and lymph systems. Cancer cells can spread to other parts of the body through the blood and lymph systems. There are more than 100 types of cancer, including breast cancer, skin cancer, lung cancer, colon cancer, prostate cancer. Cancer symptoms vary widely based on types of cancer. Cancer treated using Chemotherapy (drugs), Radiation therapy (radiotherapy and brachytherapy), Surgery. The choice of treatment depends on a number of factors including the size of the tumor and position of the tumor [1].

Radiation therapy involves the use of machine known as linear accelerator which focuses the high radiation beams on the area which require treatment. The major components of the high energy LINAC are: the operator console, modulator cabinet, drive stand and gantry. The operator console is used to input all operator commands and consists of a high resolution color monitor and a dedicated keyboard. The monitor displays the treatment parameters that have been entered via the dedicated keyboard. Some of the important parameters shown are the selected photon energy, dose, dose rate, time, gantry angle, field size, and other patient information. The modulator cabinet contains the high voltage power supply (HVPS), the pulse forming network (PFN), a voltage regulator, and thyratron tubes. The drive stand contains the radiofrequency (RF) driver, klystron, and the PFN pulse transformer. The gantry contains the Linear accelerator structure, electron gun, energy switch, vacuum system, automatic frequency control (AFC) system, bending magnet electron transport system, primary collimator, secondary collimator, beam shaping system and Multi-Leaf Collimator (MLC) [2].

2 II.

3 Collimator

Collimators are mainly used to align the beam to a specific area. It has its application in the treatment of cancer therapy. The accelerated beams from the LINAC hits a target and produces X-rays. These rays are undefined and scatter in all direction. To get this ray's fall in the region of operation, they are confined by collimating the beam [3,4]. There are three types of collimator used in medical linear accelerator i.e. primary collimator, secondary collimator and Multi-Leaf Collimator (MLC). The primary collimator is used to align the beam in fixed conical beam. The secondary collimator is positioned after either a scattering foil (for electron therapy) or a flattening filter (for photon therapy). MLC is used after the secondary collimator to further confining of the beam for precise treatment of heart and kidney.

This paper deals with the control of secondary collimator for conformal radiation therapy. Secondary collimator consists of four jaws i.e. X1 and X2 to collimate the beam in X-direction and Y1 and Y2 which collimates the beam in Y-direction, this operation controlled to get conformal radiation treatment. The secondary collimator consists of two movement they are Symmetric and Asymmetric movement. In symmetric movement both the jaws of X and Y direction are moved simultaneously by equal distance giving symmetric field along the beam axis. In asymmetric movement each jaws i.e. X1 and X2 or Y1 and Y2 can be moved in a plane independently to generate asymmetric field along the beam axis. After accurately positioning the jaws to get confined field beam is fired.

Secondary collimator can also be used in dynamic mode. In dynamic mode the jaws is moved in beam ON state to generate a spatial dose distribution. In earlier physical wedges are used for this purpose for the variation in the intensity. The dynamic mode has many advantages over conventional physical wedge since physical wedges are graduated piece of brass that has a thick and thin end. The thick end causes the less attenuation than thin end; this causes a shift in the isodose curve within the treated volume.

4 III.

5 Hardware Description

6 b) Stepper motor and its Driver

Here Stepper motor is a brushless open loop electromechanical device which can rotate in the small resolution of angle. It is highly effective in motion control application for high precision and high performance of torque control. Instead, it is low cost, simple and offers better torque performance over wider speed ranges.

Stepper motor are used in wide range of precise motion and measurement applications such as nuclear power plant, aeronautics, robotic, automotive, medical, manufacturing industry etc. An ideal example is the pick and place machines used in Surface Mount Technology (SMT) line **??**7]. Stepper motor uses different types of drives for commercial and industrial use. There are three different types of drives which can be design to control the stepper motor. The types of drives are unipolare drive, L/R drive and bipolar drive. Now-a-days due to advancement in the technology the stepper motor industries provide the drive with motor itself for position and speed control. For controlling the jaws the stepper motor and the driver is selected by PARKER AUTOMATION **??**8]. The signals given to the driver by FPGA are step, direction, remote and gear. Fault signal is received by FPGA from driver.

7 c) Double Feedback System

There is double feedback used in the control of collimator. The double feedback system involves feedback from both encoder and to compare the value to get precise position. These two encoders are optical encoder which is attached to the motor using the chain mechanism and linear encoder which is attached to the jaw perpendicularly. Optical encoder output is given to FPGA via SSI while output from linear encoder is given to FPGA via ADC. These two outputs are than compare inside the FPGA using comparing window to give the feedback about the current location of jaws. The signals given for the optical encoder are clk, data and fault. The signals given from FPGA to ADC are chip select (CS), Sclk and the digital data is read from ADC by FPGA.

IV.

8 Results and Discussion

The top view and the bottom view of designed PCB for controlling collimator pair of jaws is shown in Fig. 2 and Fig. **??**. The schematic for the design PCB is made in the Cadence FPGA System planner. The hardware is tested using chipscope in XILINX ISE 13.9.

Fig. **??** shows the simulation result of the VHDL code of stepper motor signal i.e. clk out, direction, optical encoder, linear encoder and UART design for communication. The VHDL code was written and simulated in XILINX ISE 13.9. The simulation results shows as the rx command send from the Treatment Delivery Controller (TDC) the operation starts. Since time required sending each bit is 8.6µs hence the total time to send 8 bit data total time required is 68.8µs.

9 Conclusion

This study investigated the feasibility of using the collimator to vary according to given field size. Calculation and simulation were conducted that successfully generate the movement of stepper motor and feedback from optical encoder is checked. This algorithm implemented on FPGA allows a substantial decrease of the equivalent processing time develop by classical other controller. For making design faster Dual port RAM can also be implemented.

Due to the system architecture, one FPGA can drive other stepper motors of the jaws simultaneously without increasing the processing time. And hence we can control more than one motor for controlling of collimator other jaws. Also the feedback system design using optical and linear encoders provides successful results for the movement of jaws and stepper motors VI.

10 SPARTAN

Figure 1: C

[1] [2] [3]

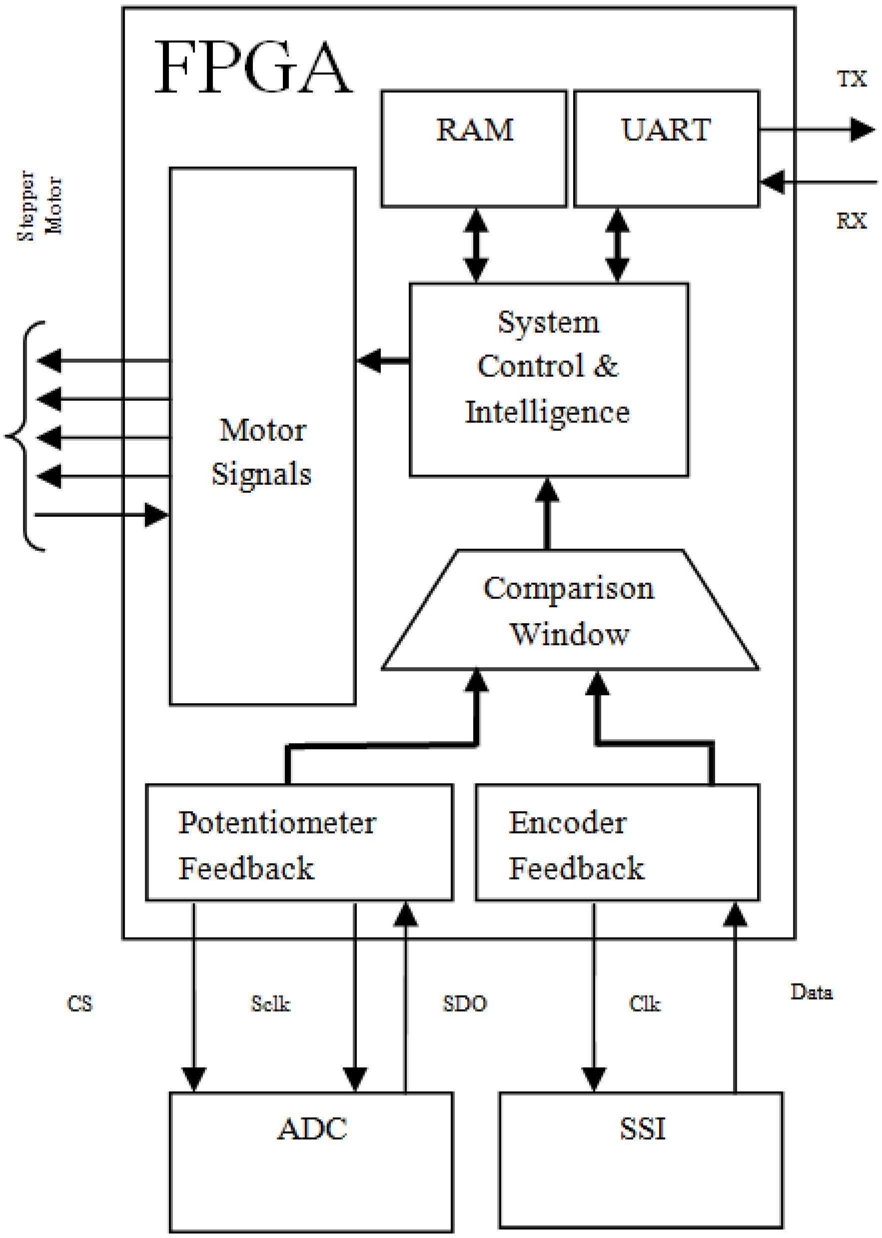

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Figure 2: Fig. 1

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Figure 3: Figure 1 :

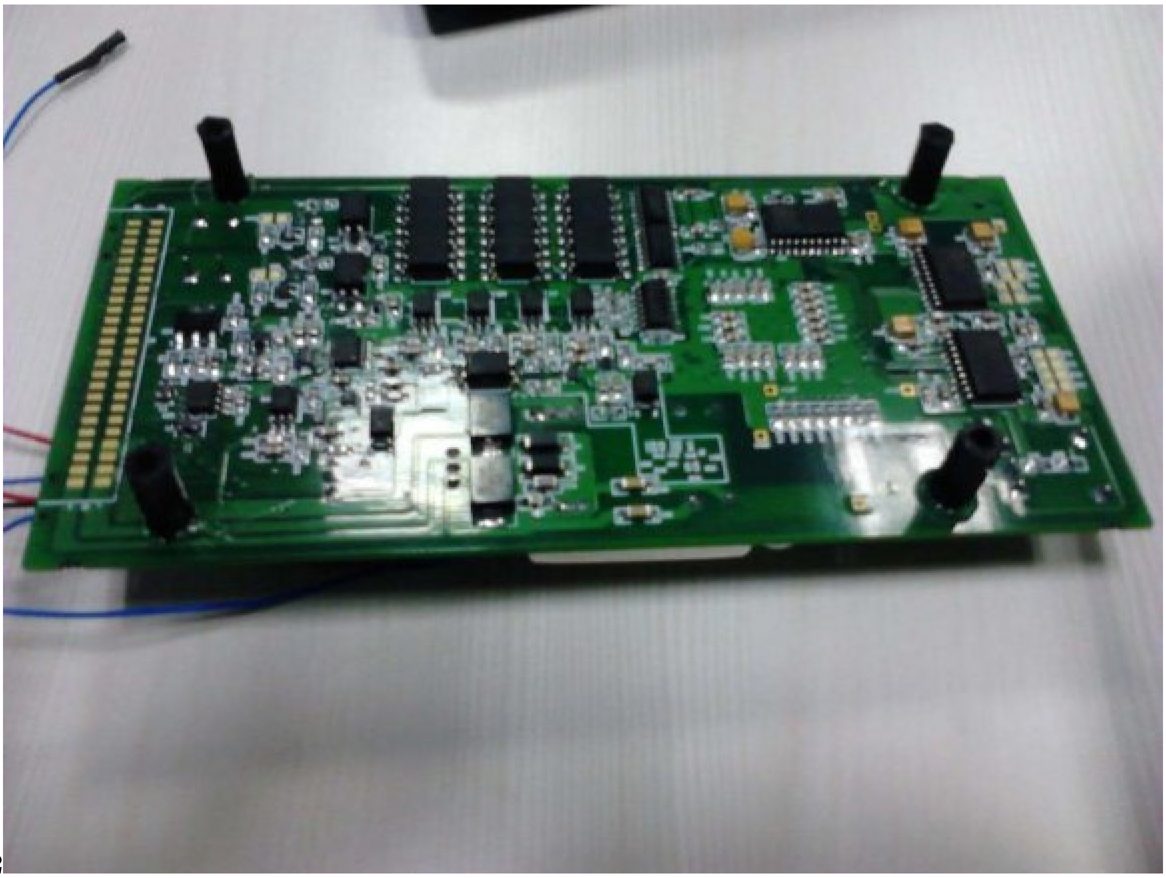
2 

Figure 4: Figure 2 :

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Figure 5: Figure 3 : 2014 Figure 4 :

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Figure 6:

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