BEAM POSITION MEASUREMENT IN TRANSPORT LINE-1 OF INDUS ACCELERATOR

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Abstract

In Indus Accelerator Complex at RRCAT Indore, 20 MeV electron beam is transported from injector Microtron to Booster Synchrotron through Transport Line-1 (TL-1). This beam has nominal pulse width of 500 ns with repetition rate of 1 Hz. A split electrode type beam position Indicator (BPI) is planned to be used to detect position of beam in TL-1, for which a four-channel processing electronics has been designed and developed. The circuit consists of microcontroller based four-channel peak detector circuit followed by multiplexer and ADC. The microcontroller is triggered from the timing system of microtron, which enables microcontroller to control and synchronize various parts of electronics. Microcontroller also sends the digitized data to a PC on serial link. During development, a problem of overcharging of capacitor was faced, which was resulting in false peak detection. Circuit was simulated and necessary modifications were incorporated in the circuit to solve this problem. A test setup with provision to simulate the beam signal using an antenna was used for testing the circuit in lab and a suitable graphical user Interface (GUI) program was developed in LabVIEW. This GUI can also be used to calibrate the BPI. The prototype BPI was tested under simulated beam condition, which gave positional accuracy of ± 200 microns.

INTRODUCTION

In RRCAT two Synchrotron Radiation Sources (SRS) Indus -1 and Indus-2 have been built. The injector system for these sources consists of a microtron which generates electron beam pulses of duration 500ns; having energy of 20 MeV and repeating at 1 Hz. This beam is transported to Booster synchrotron through TL-1, Booster synchrotron increases the energy of electron beam form 20 MeV to 450 Mev (for storing in Indus-1) or 550 MeV (for Indus-2). It was envisaged to develop an online beam position measurement system in TL-1. The position of beam is calculated by taking four signals induced on a four electrode pick up device. A split electrode type pick up device will be used in TL-1. The induced signal of this BPI will be in the range of 30 to 300 mV.

Fig. 1 shows the block diagram of system. Signal induced on the electrodes of BPI is amplified by a four channel preamplifier. The peak of these amplified signals are detected by a four channel peak detector which is then multiplexed and sent to ADC, which converts analog peak amplitude information into digital and a microcontroller sends this digitized data to PC by a serial RS232 link.

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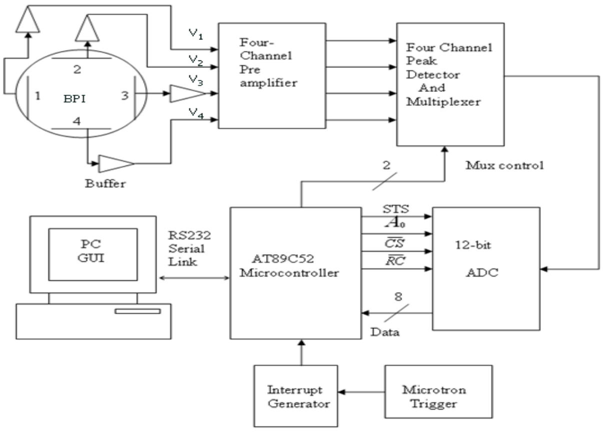

Figure 1: Block diagram of the system

A GUI has been developed in LabVIEW platform to test the circuit, determine beam position and facilitate the calibration of BPI. This program provides the user with a data log support, as well as it can also do averaging. The beam position is determined by these equations where Sx and Sy are calibration factors.

$$X_{Pos} = S_X \left(\frac{V_1 - V_3}{V_1 + V_3} \right)$$

$$Y_{Pos} = S_Y \left(\frac{V_2 - V_4}{V_2 + V_4} \right)$$

Initially a two-diode peak detector circuit was tested in lab and it was found that the circuit detects a peak which is higher than the measured peak. Circuit simulation software was used to investigate the reason behind such behavior. Simulation study shows that when the circuit is used for fast peak detection (few hundreds of nano seconds pulse width), the capacitor used for peak detection is getting overcharged because of inherent limitations of op amp. This problem was solved by controlling the charging of capacitor by placing a suitable resistance of small value in series with the charging capacitor. Further, to reduce the error due to leakage current through diode D_1, a three-diode configuration was adopted as shown in fig. 2. The circuit detects the peak properly as shown in fig. 3.

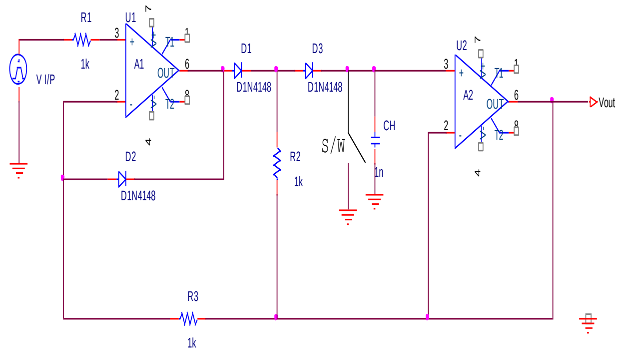

Figure 2: Three diode peak detector circuit

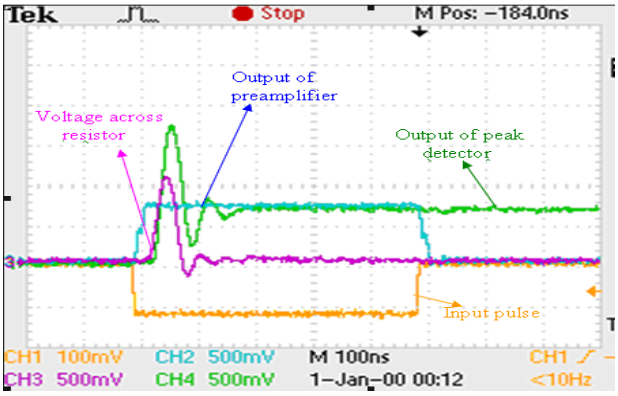

Figure 3: Response of peak detector circuit

TEST SETUP AND RESULTS

A test setup was installed to simulate the beam in laboratory and test the processing electronics with a prototype BPI. Fig. 4 shows the test setup and processing electronics.

Figure 4: Test setup

The setup consists of an antenna, which is moved by two stepper motor drivers, and excited by a pulse signal. The antenna is then moved in fixed steps and for each antenna position the signal induced on BPI electrodes are processed and peak information is calculated. By analyzing these data a polynomial is deduced and calibration coefficients are calculated. Fig. 5 shows the results of these tests with a prototype BPI for vertical position. Results of horizontal movements are similar. The maximum error in position determination was found to be ± 200 µ. The results are expected to improve with the final version of split electrode type BPI.

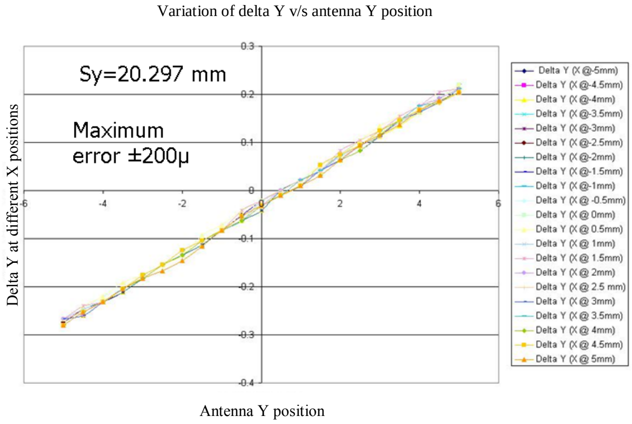

Figure 5: Results of test setup

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