Abstract

An efficient acceleration of bunched beam in the presence of consecutive particle accelerators depends on the matching of longitudinal length of bunch beam within the RF phase acceptance of subsequent accelerators. A minimally-interceptive bunch length detector system is design and developed for measurement of longitudinal dimension of the bunch beam from RFQ accelerator of the radioactive ion beam (RIB) facility at VECC. The main requirements for the detector are good time resolution and a wide range of measurements of bunch beam characteristics. The developed detector system is based on secondary electrons emission produced by the primary ion beam hitting a thin tungsten wire placed in the beam path. The aim of research work is divided in two parts. In first, to design and develop a minimally interceptive bunch length detector (BLD) system and use it for measurement of bunch width of RFQ beams. This provides help to study of beam dynamics and tuning of RIB accelerators. The design, development and optimization of various parameters of bunch width detector system along with its deflector cavity applicable in the low frequency region (few tens of MHz) have been discussed. In this thesis report the design, development and testing results of deflector cavity together with its RF system is also reported. The deflector cavity is a capacitive loaded helical type $\lambda/2$ resonators driven by RF source of 500W at 37.8MHz solid state amplifier, realized by combining two amplifier modules of 300 W each. The measured RF characteristics of the resonator, such as frequency, Q value and shunt impedance have been found to be reasonably good and close to the analytical estimation and results of simulation. The design philosophy and test results of individual components of the amplifier are discussed. The test result up to full power shows a good harmonic separation at the individual module level and this is found to improve further when modules are combined together. The results of high power performance test of the deflector cavity together with amplifier are also reported. The bunch width measurement of 98keV/u ion beam accelerated through a 3.4 m long 37.8 MHz Radio Frequency Quadruple (RFQ) Linac using indigenously developed detector is reported. The measured bunch profile of accelerated Nitrogen beam from RFQ is in close agreement with the estimated profile obtained via simulation.

A Channeltron Electron Multiplier (CEM) detector is used for detection of secondary electrons of the detector system. The electronic set up placed near the detector system measures the electron counts and sends the data to the control room. For this we require high speed low jitter

serial optical transmitters which rely on a high performance Clock Multiplier Unit (CMU). The electronic set-up used for detection and transmission of detector data is also exposed to the radiation. Therefore it is necessary that electronics device should be radiation hardened. The second part of thesis, the design and development of 2.5 GHz radiation hardened CMU has been discussed. Several mitigation techniques are also discussed which have been use incorporated during design. The design detail of all building blocks of CMU with has been reported. The CMU test chip has been developed using standard o.18μm CMOS technology. This characterization of CMU without radiation dose and post radiation dose has been reported. The 60Co Gamma chamber has been used as an irradiation source. The different parameters of CMU such as frequency, tunability, phase noise and settling time of the CMU have been presented and compared with simulation results. It is observed that there is no appreciable change in the CMU performance measures up to 400krad which validates our design goal. The performance measures are found to change (particularly leakage current) as the level of radiation dose is increased above 500krad, however, the clock frequency is observed to be almost stable up to 900krad. The test result gives the information about the dose limit and hence the life time of the device in the radiation hazard zone.

Keywords: *Beam bunch; Deflector cavity; minimally interceptive method, RF system, Radiation hardened, Clock multiplier unit, Total ionization dose.*