OVERVIEW OF THE PELLETRON LINAC FACILTY, MUMBAI

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Abstract

The Pelletron LINAC Facility at TIFR, Mumbai, comprising the 14 MV Pelletron and the superconducting LINAC booster caters to a variety of experiments in basic and applied Sciences. The Liquid Helium Refrigeration plant for the LINAC has been upgraded to enhance the refrigeration capacity. New instrumentation and interface for control and monitor of the cryogenic parameters, beam diagnostics and beam transport devices have been developed and installed. Digital implementation of the LLRF control has been demonstrated. All seven beam lines in new user halls have been commissioned and several new experimental setups have been added.

INTRODUCTION

The Pelletron LINAC Facility at TIFR, Mumbai, comprising the 14 MV Pelletron (commissioned in 1989) [1] and the superconducting LINAC booster (operational since 2007) [2,3] caters to a variety of experiments in Nuclear Physics, Atomic Physics, Condensed Matter Physics, Material Science, Radiochemistry, Accelerator Mass Spectroscopy, etc. The Pelletron serves both as a standalone accelerator and as an injector to the superconducting LINAC booster.

Several modifications have been made to improve the performance of accelerator. The re-circulating gas stripper has been installed in the terminal section of the Pelletron. A new heat-exchanger system is installed outside the accelerator tank in place of the earlier one housed inside, to circumvent the possibility of any water-leakage in the tank volume. The Liquid Helium Refrigeration plant for the LINAC has been upgraded to enhance the refrigeration capacity to ~450 Watts at 4.5K without LN_2 pre-cool, from the present capacity of ~300 Watts. A vacuum jacketed liquid nitrogen transport line from the Low Temperature Facility (LTF) to LINAC accelerator and user halls has been installed to provide continuous supply of liquid nitrogen.

New micro-controller based instrumentation and interface has been developed for control and monitor of the cryogenic parameters, beam diagnostics and beam transport devices. The operator Graphical User Interface (GUI) in the control room has been suitably enhanced, which communicates with the remote devices via individually addressable 16-port Ethernet to RS232 serial switch.

We have developed a digital implementation of the Low-Level RF controller based on a self-excited loop (SEL) with phase and amplitude feedback and has been tested on a single superconducting cavity.

All beam lines in new user halls have been commissioned and several new experimental setups have been added.

This paper describes some of these developments.

CRYOGENICS

The heart of the cryogenic system for the superconducting LINAC booster is a custom-built liquid helium refrigerator Linde TCF50S, installed in 1999. The refrigerator is rated for 300 Watts at 4.5 K with a dual JT (Joule-Thomson valve) at the final cooling stage, which allows simultaneous connections to the cryogenic loads (LINAC module cryostats) and to a liquid helium storage Dewar (1000 litres). The refrigeration power can be further enhanced by a maximum of 150 W with LN_2 pre-cool. The two-phase helium at 4.5 K produced at the JT stage in the refrigerator is delivered to the LINAC through a cryogenic distribution system at a supply pressure of 1.6 bara. The phase separation is achieved in the individual cryostat, typically at a pressure of 1.35 bara. The cold helium gas (4.5 K) is returned to the helium refrigerator at a pressure of 1.20 bara. The observed pressure drops in the distribution network and the mass flows have been modelled to estimate the overall thermodynamic efficiency of the system [4]. Due to the elevated delivery pressure of the cryogen to the LINAC, the effective total available cooling power reduces to ~260 Watts. For the whole system without RF power, the estimated heat load is ~140 W. Therefore, the net available cooling power for RF load is only ~120 W, which is not adequate to power up all the accelerating cavities. Hence, during the accelerator operation, the refrigerator was used with partial liquid nitrogen pre-cooling. In order to eliminate the use of liquid Nitrogen pre-cooling, the plant has been upgraded to deliver ~450 W at 4.5K. This has been done by replacing the original compressor having a flow rate of 62g/s by a new one having a capacity of 79g/s. Also, two turbines in the cold box have been replaced by more efficient versions to adapt to the higher mass flow rate. The upgraded plant has been fully tested and commissioned. The cryogenic system is now expected to be more stable during the accelerator operation.

The liquid Nitrogen required for shield cooling in the LINAC distribution and module cryostats as well as user requirements are fully met by the LTF, TIFR. To facilitate ease of operations, a vacuum jacketed liquid nitrogen transport line from the LTF to the LINAC

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accelerator and user halls (~200m long) has been installed to provide a continuous supply of liquid nitrogen.

INSTRUMENTATION

As a part of an ongoing effort, the interface and control electronics have been upgraded for various accelerator subsystems. In particular, new micro-controller based instrumentation has been developed for cryogenic parameters, beam diagnostics and beam transport devices.

The operator GUI deployed on the Master Control Station (MCS) in the accelerator control room is designed to communicate with individual devices. All power supplies for the beam transport elements like magnetic steerers, quadrupoles and dipoles are controlled from the MCS via individually addressable 16-port Ethernet to RS232 serial switch.

Several other devices like Faraday Cups, BPMs, Cryogenic controls etc. are also connected via serial to Ethernet switches in a similar manner [5]. A local multi-channel, multiplexed cryo-control station, controls and monitors the cryogenic valves, level sensors for both LHe and LN_2, pressure and temperature of each cryostat. Two such cryo-control stations, catering to four cryostats each, have been installed. A 24 channel multiplexed, control and readout unit with a 12 bit ADC has been developed for Faraday cups as well as for BPMs. In addition, Hall probe readings for magnetic field values are also made available at the MCS via serial to Ethernet switches in a similar manner.

We have developed a digital implementation of the Low-Level RF controller based on a self-excited loop (SEL) with phase and amplitude feedback. The digital LLRF controller is expected to be inherently free of certain limitations like: DC off-sets, drifts, gain imbalance, impedance mismatch, etc besides having the flexibility and ability to execute complex algorithms. Figure 1 shows a schematic view of digital RF control architecture. The digital control card has been successfully tested on a single superconducting cavity.

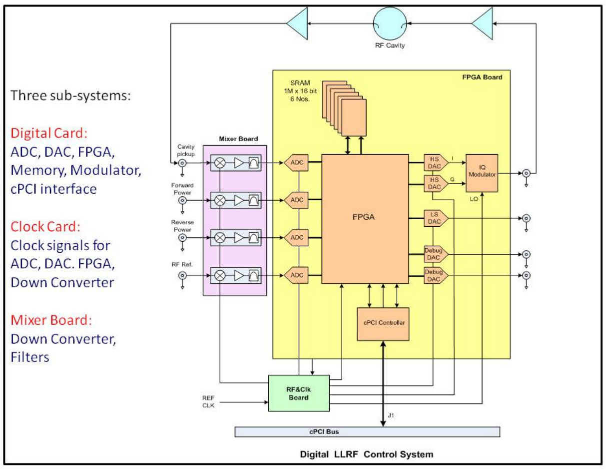

Figure 1: A Schematic of digital RF control architecture

In addition, a two channel BPM digitizer and FPGA based CAMAC ADC, DAC cards have been developed [6]. These cards have been designed in a modular fashion to enable ease of trouble shooting and maintenance. These cards are installed in the Pelletron control system.

CONTROL SYSTEM

A CAMAC based accelerator control system based on a master-slave configuration has been developed using JAVA operating on Linux OS [7]. The system consists of two layers, namely, a scanner and a GUI. The scanner acts as a TCP/IP server and directly accesses the CAMAC crates, while GUI connects to the scanner via TCP/IP. A local control station (LCS) consisting of a PC interfaced to CAMAC crates with analog and digital modules and the RF electronics controls upto eight cavities (i.e. two modules). The LCS in the accelerator hall is interconnected via Ethernet to the MCS located in the control room. The power supplies for beam line transport elements and the beam diagnostic elements (BPM and FC) are also managed by a similar two layers structure, scanner and GUI. On selection of a particular Faraday Cup, the measured beam current is displayed on an on-screen panel meter with suitable auto-scaling. Similarly, upto two BPMs can be simultaneously selected on the GUI and displayed on a multi-channel oscilloscope. The updated control system allows simultaneous setting up and monitoring of parameters for the different LINAC subsystems. The system is operator friendly, stable and very reliable.

EXPERIMENTAL FACILITIES

The complete layout of new experiment halls together with LINAC is shown in figure 2. A total of 7 beam lines are installed and commissioned in two separate user areas. A new 1.5 m diameter Scattering Chamber with remote control for precise positioning of the detector arms and target holder, has been installed in the LINAC User Hall-I. The INGA (Indian National Gamma array) setup designed for 24 HPGe Clover detectors has been installed and commissioned in the LINAC User Hall-II. Experiments for the 2010-11 INGA campaign have got started. Several new experimental facilities are planned. For example, BGO/NaI multiplicity filters, BaF_2 array for high energy gamma ray studies, 1 x 1 m^2 plastic scinitillator array for neutron spectroscopy have already been installed. A Momentum Achromat for light Radiaoactive Ion experiments (MARIE) and Charged Particle Detector Array (CPDA) comprising 50 nos Si+CsI detectors are under development.

A multi-target assembly with a maximum of six targets has been developed and installed above the analyzing magnet (6M level) to study damage in metals and alloys at high temperatures under irradiation by high current (~μA) low energy (~few MeV) proton beams. The target can be heated upto 300^{o}C on an OFHC copper block. The temperature of the target is measured by a thermocouple unit and is regulated by a PID controller. The target holder plates are insulated from base plate to provide beam current measurement. The installation of this high temperature-multi target assembly has resulted into improved beam utilization as it permits *in situ* target changeover without breaking the vacuum.

SUMMARY

The Pelletron LINAC facility is regularly operated for a variety of experiments. We also plan to upgrade the Pelletron and associated subsystems, in order to extend operations of LINAC to heavier beams. Design of low beta, high performance niobium superconducting half wave resonator (HWR) with β_0=0.05 is in progress. Instrumentation and interface for control and monitor of various accelerator subsystems is continuously being upgraded for improved performance.

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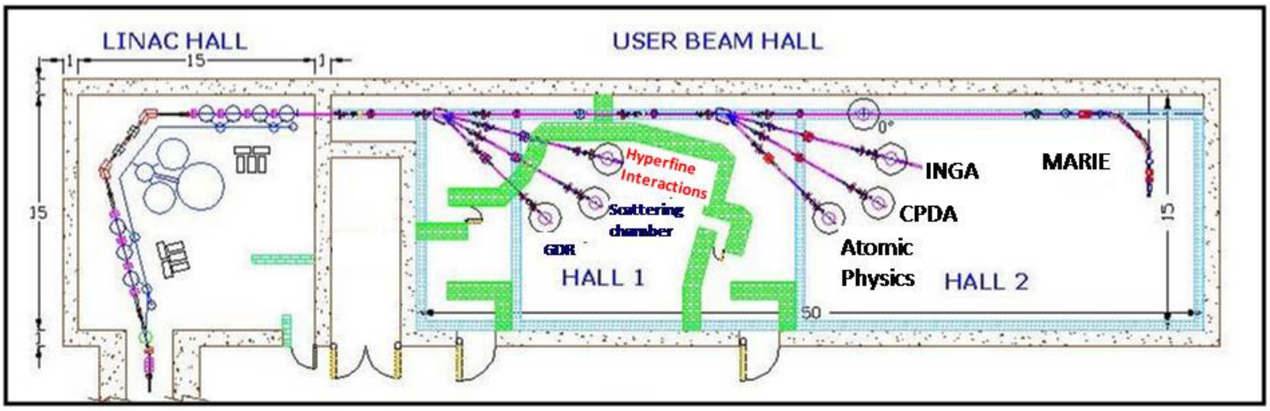

Figure 2: A Schematic layout of new user beam hall at PLF, Mumbai