- Independent strobe option implemented as per HIRA setup requirement.

In continuation of the successful facility run, the experimental beam time (19F+64Zn) was taken by the user with ROSE based VME-DAQ.

3.1.9 COMPUTER AND COMMUNICATIONS

Abhishek Kumar, S. Bhatnagar, Deepak Kumar Munda, S.A. Khan and B.K. Sahu

The year brought in two new waves of COVID-19 which again affected the hosting of events and academic programs in the centre. They were organized in the online mode for the most of the year but hybrid mode became the preferred choice towards the end of the year. The group had put the necessary infrastructure for the online mode in the last year. Necessary upgradation and arrangements took place for implementing hybrid mode this year. Apart from these, development and the regular maintenance of packages, networking infrastructure and servers were carried out. Highlights of these activities are mentioned below.

3.1.9.1 Status of servers

(a) Central servers

This year the group faced major breakdown of the ERP (Enterprise Resource Planning) server. The hard drive of this server crashed due to which it stopped functioning. After retrieving data from the server, a new ERP server was installed and deployed with the upgraded Linux OS ubuntu 18.04 server edition and newer versions of PHP 7.2 and postgres 10 server as compared to the old ERP server. Performance of all the other servers were found to be satisfactory.

(b) Solid work licensing server installation

The group was given the responsibility of relocation, installation and maintenance of solid works licensing server in the data center. The group received the server and implemented the appropriate changes in the configuration of the server necessitated due to its relocation. At the client end also appropriate change in the network configurations for the licensing server was done. With these changes, the server is regularly providing the licensing services to the solid work clients of the center from its new location as earlier.

(C) Nagios server for monitoring

A Nagios server was installed for the network switches and central servers in order to facilitate continuous monitoring of devices for their uptime. The Nagios server is presently under testing and other devices are being added to its list for monitoring purposes. Later, it is planned that Nagios server will be able to send instant email notification whenever a device or a service fails under its purview.

3.1.9.2 Status of Network and Internet services

(a) Switch installation

One of the access switches went down which resulted in network downtime for one of the floors of the LEIBF (Low Energy Ion Beam Facility) building. A new spare switch was configured and was deployed in place of the faulty switch. Ten years old switches installed at various locations have been showing signs of abrupt failing. So the group has projected procurement of sufficient spare switches which will be kept pre-configured in order to minimize network downtime.

(b) Firewall re-installation

The SOPHOS firewall serves as the secure gateway for the internet traffic of the devices in the LAN (Local Area Network). It is also the device for NAT (Network Address Translation) and port forwarding for the website, mail and application servers. The Sophos firewall stopped functioning in the first week of March 2022 which resulted in four days of downtime for various IT services as the firewall had been the 'Single Point of Failure' for the services. The firewall was replaced with a replacement unit obtained from the OEM since the firewall was under the AMC. It was decided that two firewalls shall be installed in HA (High Availability) Mode to avoid major downtime.

3.1.9.3 Communication systems

(a) Installation of new IP based PABX System

The Siemens HICOM 330E EPABX system operating for last 21 years has been upgraded to a hybrid EPABX system from Matrix technologies in April 2021. The Switching system of the EPABX is upgraded with IP at the core allowing fully distributed IP solutions across data networks. The installed system is digital and fully non-blocking switch, offering IP-PBX, enabled with Unified Communication and Collaboration Application. At present new EPBAX system cater to nearly 290 analog extensions including connections to housing blocks, common areas, guest houses and hostels having limited network access. Nearly 20 IP based phones are installed in the existing network and 30 more are going to be installed soon. Besides this, as the IP EPABX provides full mobility in most of the lab complexes including experimental areas in the Beam halls, soft phone connections are being provided in the existing mobile through a dedicated application for resource persons. The operational efficiency of the new EPABX system is found to be 99% with no major breakdowns.

(b) Status of Video conferencing systems and CCTV surveillance

During the year of pandemic, in order to follow social distancing protocol, all the events listed in the academic calendar were organized in virtual mode using online video conferencing using Google Meet, Webex platforms. Dedicated hardware is also added for holding meetings on hybrid mode. Ph.D. classroom programs are conducted in online mode using dedicated link. Automated creation and dispatch of e-certificates for online participants for these events has been implemented by the group. All the installed Audio video systems in Auditorium ,Seminar hall etc. are being used as per the need and functional. IP based CCTV surveillance system is being extended for the experimental beam hall area of Pelletron and FEL facility. No major breakdown of the Audio Video system or CCTV systems was reported during the last academic year.

3.1.9.4 Developmental projects

(a) Development of IUAC forms server

In the pandemic times when every event was being organized in online mode, necessity of a server which can host online forms was felt. Since, there are wide variety of events that are organized in an academic calendar year, the forms should be customizable and should be able to be created by individuals without seeking help from an IT professional. Keeping this in mind, a user interface was created which can create forms and host forms. The data entered in the forms are accessible to the administrator of the form and can be exported as a CSV file from the portal itself. The form could also be deactivated or deleted by its administrator. Different roles like superuser, form creator etc. can be created using the portal depending on the requirements.

(b) Recruitment portals for Academic and Non-Academic posts

The group developed a recruitment portal which can serve the needs of the Personnel section. The recruitment portal was created with the integration of payment gateway through API (Application Programming Interface) provided by the gateway services. This facilitated the form submission along with fee deposition by the candidate on the portal.

(c) KVM installation

Kernel Virtual Machine (KVM) is an open-source virtualization tool for running multiple OS on a single Linux machine. It helps in easier management of compute and storage resources of the server acting like a cloud environment. The KVM server is serving as a test bench for the installation of various application servers under testing environment.

(d) 3PF supercomputing facility related

National Supercomputing Mission (NSM) has approved installation of 3 PF Supercomputing system at IUAC with support of technical team from CDAC. The design specification of the upcoming computing facility is shown in figure 3.21. Appropriate data centre with storage facility is being worked out in consultation with CDAC. Approximately 1800 Sq. ft. place is identified in the existing building of IUAC for the setting up the server room along with another 2000 Sq. ft. for supporting infrastructure. Both Data Centre along with required supporting system located on the ground floor to withstand load of the servers which is estimated up to 2 Ton per sq. m. will be set up soon. The computing facility is being designed and manufactured by CDAC under make in India supercomputing facility in phase 3 plan of NSM and will be installed in the new data centre. A Memorandum of

Understanding is signed with the CDAC for setting up the facility at IUAC. The Computing facility will serve as virtual inter university computing centre and provide high performance computing access to all the researchers in the university system. In the meantime IUAC is also started interacting with various computing user community for creating potential user base from interdisciplinary branches within the university community.

Sr.No.	Description	Unit	Details
1	Compute Power	Peta Flop	3
2	Storage	Peta Byte	4

Sr.No.	Description	Unit	Number of Racks	Power Per Rack Kw	Total Power - KW
1	Compute Racks	Nos.	11	40	440
2	Storage Racks	Nos.	4	12	48
3	Master and Service Node rack	Nos.	2	10	20
4	**Total IT Power Required**	**KW**	**508**		
5	**Spare Rack**	**Nos.**	**2**		
6	**Total Number of Racks**	**Nos.**	**19**		

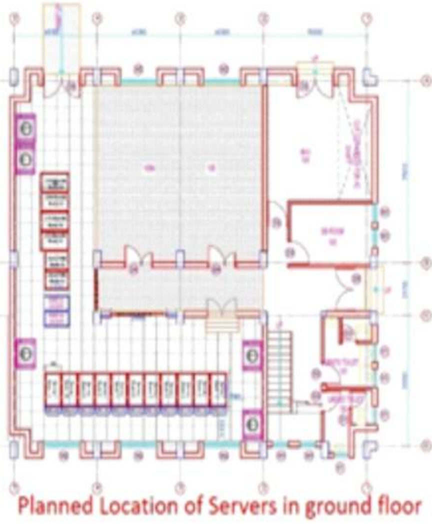

Figure. 3.21. IUAC Computing facility specification and location

3.1.10 ELECTRONICS FOR CRYOGENICS, IFR & MRI

Joby Antony and Rajesh Nirdoshi

3.1.10.1 CRYOGENICS CONTROL SYSTEM & ASSOCIATED ELECTRONICS

The IUAC Cryogenics control system and associated electronics have been functional throughout this year. At present, the Cryogenics control room has four control terminals for control and data acquisition as shown in figure 3.22.

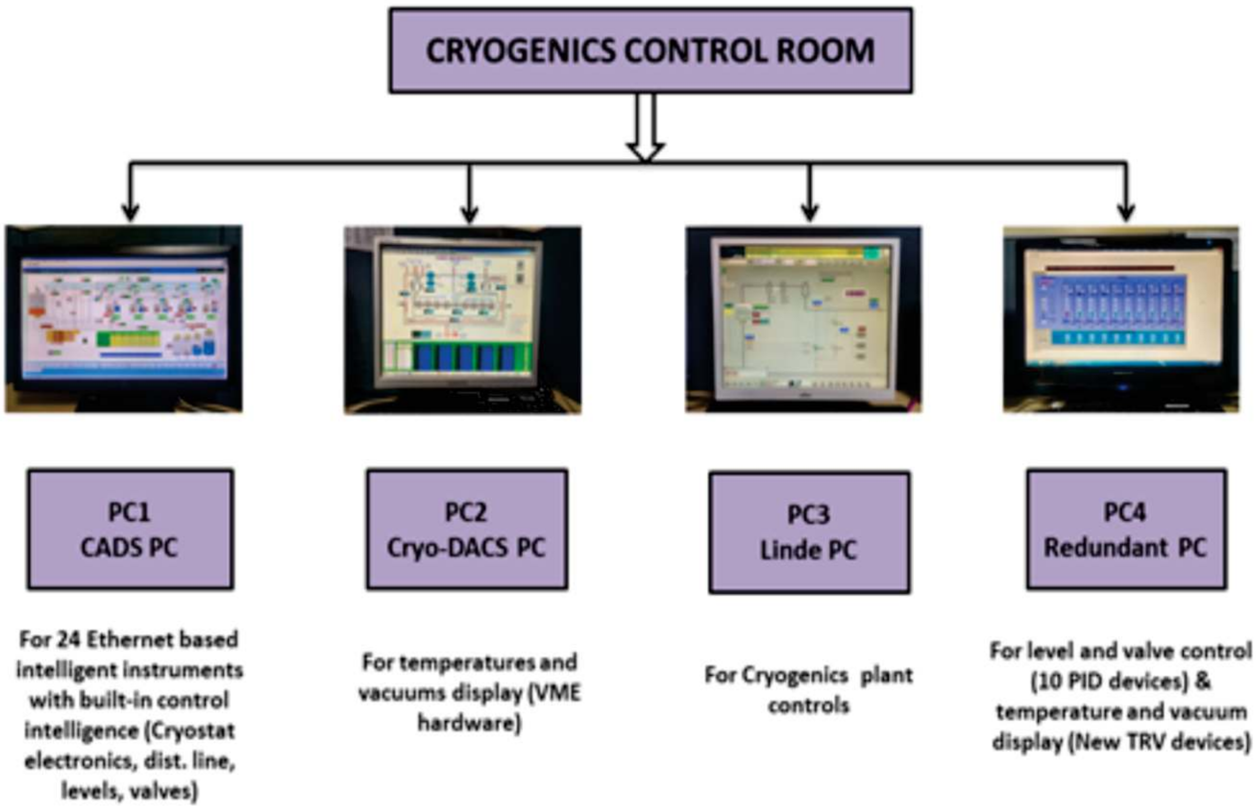

Fig. 3.22: The Cryogenic Control Room Terminals.

a) CADS PC

The CADS system has been operational throughout this year. As part of the recalibration activity, all the electronics & control instruments have been calibrated offline. To be updated with the development tools from time to time (revised MBED IoT ecosystem and cloud compiler), the firmware of each device has again been updated this year.

b) Cryo-DACS PC

Cryo-DACS is the oldest VME system of IUAC built in the year 2002. Considering the obsolete operating system (WIN2000) of the Cryo-DACS PC and 20-year-old VME hardware & drivers, we are in the process of upgrading the entire system with indigenous hardware (TRV hardware devices) and software. The production of temperature and vacuum devices has been completed and two such devices were also tested online for a long time during the last Linac run. Unlike the VME hardware, now these TRV devices can be installed far off from the radiation area (314 area near old LHe plant) for easy access during experiments.

c) LINDE Control PC

This PC is a critical standalone system used for Cryogenic plant controls originally supplied by M/S Linde, Switzerland with Siemens software. Last year, the main control server (RMCS) failed due to motherboard failure. With a lot of effort, this system was repaired in-house and therefore, we could use it in the last Linac run.

d) Redundant PC

This PID redundant system with a switch-over unit between indigenous IUAC soft-PID (10 channels) and commercial Fuji hard-PID meters (9 channels), is used in conjunction with 10 IUAC-make LHe & LN2 level meters from the back-end. This year, this PC was also used in parallel to test the temperature and vacuum signals of two Linac Cryostats connected to 2 new TRV devices during the Linac run.

e) Historical Trends Utility

An additional GUI software utility has been tested successfully for the off-line and online analysis of complete analog & digital parameters of every experimental run of long duration (i.e. up to several months or years). It has a large number of historical trends to simultaneously view & analyze different parameters online & offline by operators. The parameters are levels, vacuum, valve positions, DIO, pressures, etc. of Linac as shown in figure 3.23.

Fig. 3.23: Additional Historical Trends Utility used in Linac run.

3.1.10.2 PRODUCTION OF SIX ALL-IN-ONE TRV (TEMPERATURE/RESISTANCE/VOLTAGE) DEVICES TO REPLACE VME HARDWARE

Six Cryogenic TRV instruments have been fabricated this year to replace the 20-year old VME crate system with a distributed crate-less indigenous Linac-temperature & vacuum monitoring system. This is the last part of the cryogenic-control room upgrade to replace many commercial hardware with indigenous ones. Among these devices, five of them are 8-channel low-temperature devices with multi-sensors support for 40 ch. Linac thermometry of all Cryostats (Buncher, Linac1, Linac2, Linac3, Rebuncher), and one of them is dedicated as an 8 channel vacuum monitoring device for interfacing vacuums of 5 Linac-cryostats. Each of the 8 channels is independently programmable as temperature or resistance or voltage meter. It also offers various features like an RS-232 interface, menu-driven Keypad, Flash storage, sensor calibration-curve lookup tables, custom-sensor support, a VFD display, and distributed connectivity directly to the Cryogenics control room. Each device has independent programmable current source (one for each sensor per channel) that can be configured for a variety of sensor calibration curves. The low-temperature measurement supports a wide range of Cryogenic sensors like Silicon diodes (DT470 & DT670), Pt100, Carbon ceramic sensors, custom sensors, etc. A 12-bit A/D converter reads sensor inputs. The production has been completed and we will now be building the software next year i.e a 48 channel GUI, PC-based data logger, and real-time trends software for acquisition of remote data monitoring and logging of temperature & vacuum signals at the Cryogenic control room. Unlike the VME hardware which was installed in Ph.II beam hall, now these new TRV devices are installed far off from radiation area (Room 314 old LHe plant) for easy access during experiments as shown in figure 3.24. Besides their low cost, these devices are designed to replace the standard M/s Lakeshore 318 model as an import substitution in the future.

Fig. 3.24 TRV monitors installed in non-radiation area 314 (Old He plant)

3.1.10.3 MRI-MAGNET REAL-TIME MONITOR-VER 1.0: FINAL FAST FPGA DATA ACQUISITION SYSTEM SOFTWARE

The software development of the fast MRI data Acquisition system (IMRI ver 1.0) has been completed this year with the required multi-page menu-driven graphical user interfaces as per the requirement specifications supplied by the MRI team. Thus the offline version of the fast FPGA data acquisition system for the 1.5T IMRI project is made ready. The work involved huge software development in the integration of instrumentation panels & instruments to FPGA software (with instrument-inter connections) using LabVIEW® under Windows OS.

Potential-free contacts for digital status alarm monitoring of various faults are also included for MRI health status monitoring. The offline tests and analysis were performed successfully.

a) MRI Instrumentation panel

The cabling job of different electrical & electronic components of the MRI instrumentation rack has been completed this year. This instrumentation rack will work as a gateway between various Cryogenic sensors & fast HV signals from 1.5T MRI magnet and an FPGA-based data acquisition system connected with an NI Compact-RIO crate. The front side of the rack consists of various measuring instruments like temperature meter, level meter, vacuum gauge controller, pressure controller, etc. whereas relays, MCBs, DC power supplies, terminal blocks, etc. are mounted on the backside of the rack as shown in figure 3.25.

Fig. 3.25 Front and back panel of the MRI instrumentation rack

b) LabVIEW FPGA-based fast Data Acquisition System GUI design

The final version of the FPGA-based fast data acquisition system GUI has been developed this year. This user interface consists of various pages for cool down, training, magnet monitoring, alarms, configuration, MRI health status & nomenclature. It displays real-time values of various analog and digital parameters like temperature, level, vacuum, pressure, potential free digital contacts, and fast voltage taps from 8 superconducting coils. It also has a provision for slow as well as fast data logging as and when required. The fast data logger can log all the data every millisecond using 16 channel digitizers for simultaneous logging in EXCEL format. The alarm messages get displayed on the alarm page whenever the value of a particular parameter gets out of the range of lower level and upper level. A few pages of this newly developed system are shown in figure 3.26.

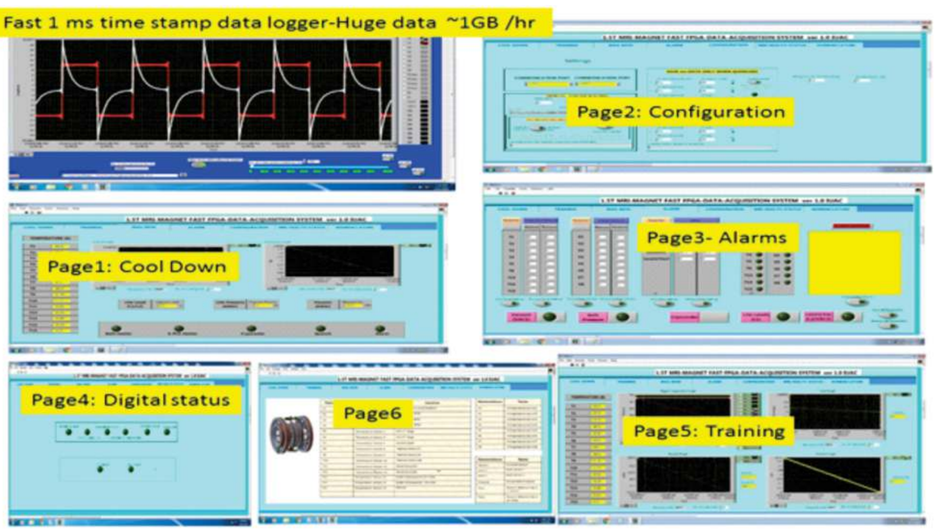

Fig. 3.26 LabVIEW FPGA-based data acquisition system GUI Pages

3.1.10.4 DEVELOPMENT OF VACUUM DATA LOOK-UP GENERATOR FOR ELECTRON BEAM WELDING MACHINE

The Electron Beam Welding (EBW) gun vacuum system malfunctioned due to repeated failure of imported vacuum controller devices. Because of this critical issue, the EBW control system was tripping frequently, not allowing it to start/operate properly. Considering the urgency to resolve this issue, we built our rapid solution by designing and building a new data-lookup generator device (figure 3.27) in-house. This device worked as a data exchanger between a local Pfeiffer vacuum controller (installed as a replacement to the faulty/malfunctioning gauge controller) & PLC and it was designed to match the transfer function of pre-programmed Schneider-PLC vacuum data with the actual vacuum in the EBW system. The 2K interpolation lookup table is embedded within the device memory. The system is now working successfully.

Fig. 3.27 Data look-up generator device

3.1.10.5 EBW CONTROL SYSTEM ACTIVITIES

There were the following issues related to the Electron Beam Welding (EBW) machine this year:

- Gun vacuum gauge went bad – Repaired
- UPS went bad – Replaced with a new one.

3.1.10.6 OTHER ACTIVITIES

- All 10 home-built LN2-server instruments & associated LN2-sensors were in-situ recalibrated individually using an LN2-filled transparent glass-dewar setup. Each meter required modification for SPAN and OFFSET errors due to large variations in sensor sizes between sensors and their varied parasitic capacitances. Linearity checks were also performed in the 4-20mA current outputs as this is critical for PID operations. After this recalibration process, the Linac operations were smoother.

- Our group organized a 2-days online workshop on Artificial Intelligence, Machine Learning & Computational intelligence (AIMLCI) during 27-28 July 2021.

- Mentored a B.Sc. student in the 2021 IUAC-Summer Internship Program for a project titled "Data science prediction experiment to learn patterns in data using ML & AI".

- Involved in the Cryogenic control room operation activities and performed shift duties regularly during Linac runs#27 & 28. (Run#27: 18 Mar 2021 to 25 Apr 2021 & Run#28: 21 Sep 2021 to 7 Jan 2022). All the electronic problems encountered during the run were addressed and resolved then and there.

- As part of an AI development initiative, a tiny machine learning prototype portable unit was built and tried out in this Linac run to test a classification application, i.e. a digital audio-based radiation warning system. This used an AI Person-detection algorithm using a convolutional neural network using an ARM micro controller along with the Tensor Flow Lite library. The efforts are on to improve accuracy as it needs further improvements in the future before it can be deployed for any application.

- Maintenance & upkeep of electronic laboratory.

3.1.11 LOW LEVEL RF & BEAM BUNCHING GROUP (LLRF)

V.V.V.Satyanarayana, Ashish Sharma, Sarvesh Kumar, B.K.Sahu and A.Sarkar

Low Level RF & Beam Bunching Group (LLRF) is an Accelerator Support Central Group (AcSCG) that takes care of the operation, maintenance, upgradation and development of different LLRF systems like the Beam Pulsing System of Pelletron-Linac (BPS) and associated control electronics for Multi-Harmonic Buncher (MHB), Chopper, Travelling Wave Deflector (TWD), LLRF for Linac, High Current Injector (HCI) and Free Electron Laser (FEL). A brief description of the activities is given below.

3.1.11.1 Operation, Maintenance and Upgradation of Beam Pulsing System for Pelletron

During the year 2021-22, the operation of Beam Pulsing System includes several pulsed beams runs for different Pelletron and LINAC users and few stability-test runs of BPS electronics. All group members performed operational duties (On-Call mode) during these Pulse beam runs. Beam Pulsing System was extensively used with more than 99% uptime. No major facility downtime reported due to problems in BPS and failure of LLRF systems. This is basically due to the reason of maintaining enough spares and fast response as well as resolution in case of TWD related issues and drastically reduced the downtime of the BPS system. BPS facility tests helped us to confirm the stability of the electronics, specially before the LINAC run. BPS uptime reported during this year is >99%. Preventive maintenance of BPS electronics is completed along with rearrangement of BPS electronics in control room and re-routing of interconnecting cables with proper labelling on both sides of the cables.

Table-1: BPS Operation Summary

Pulsing Run	Energy (MeV)	TWD	Facility	No. Shifts
$^{16}O, 5^+$	60	2µs	HIRA	21
$^{19}F, 7^+$	100	4µs	HIRA	45
$^{16}O, 5^+$	64	4µs	HIRA	24
$^{12}C, 6^+$	85, 94	OFF	NAND	24
$^{19}F, 7^+$	120	OFF	NAND	18
$^{48}Ti, 11^+$	150	OFF	NAND	27
$^{30}Si, 10^+$	128	4µs	HIRA	6
$^{28}Si, 9^+$	120	4µs	HIRA	9
$^{28}Si, 10^+$	130, 36, 108	2µs, 4µs	HIRA	12
$^{12}C, 6^+$	81	OFF	NAND	18
$^{28}Si, 6^+$	120	OFF	Facility Test	9
$^{19}F, 6^+ 9^+$	110	OFF	LINAC Line (Stability and Tuning)	24
$^{19}F, 6^+ 9^+$	150, 130	OFF	GPSC NAND	30
$^{28}Si, 6^+ 11^+$	125	OFF	GPSC NAND	6
$^{28}Si, 6^+ 11^+$	125	OFF	INGA	24
$^{28}Si, 6^+ 7^+$	191.6	OFF	NAND	36
$^{28}Si, 6^+ 12^+$	130	4µs	HYRA	30
$^{28}Si, 6^+ 12^+$	130	OFF	NAND	21
$^{28}Si, 6^+ 11^+$	125	OFF	NAND	24
$^{19}F, 4^+$	52, 49, ..	2µs	HIRA	18
$^{28}Si, 6^+ 11^+$	125	OFF	NAND	9
$^{16}O, 6^+$	80	2µs	BPS Test Run	6
$^{19}F, 6^+ 9^+$	160,155,145,135, 125,115,105	4µs	HYRA	24
$^{19}F, 6^+$	84,86,64,65,68,98	4µs, 1µs	HIRA	18

Apart from routine preventive maintenance, few repair jobs of TWD were done and they include the in-situ replacement of faulty pre-driver transistors (2N3904) for channels #4, #6, #8 and #12 and repair of clipper bord of Bank-B of TWD electronics.

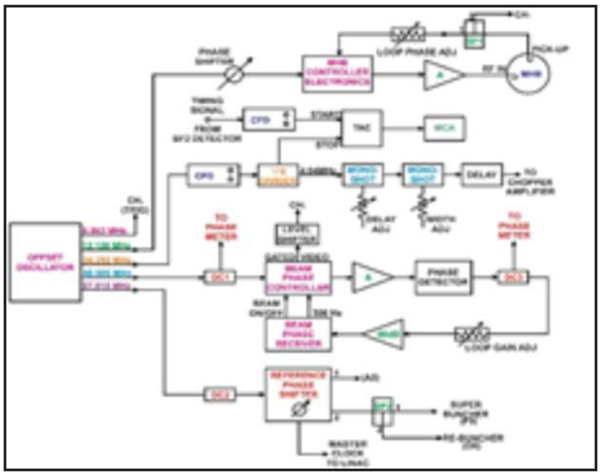

Fig. 3.28 Beam Pulsing System Electronics in Control room with Simplified Block Diagram

An important upgradation of TWD electronics is the installation and commissioning of TWD High Voltage Power supply Interlock module. This Interlock module protects the TWD deflecting plates control electronics from AC mains power glitches or failures by keeping TWD HVPS in standby mode after every AC power glitch or power failure. Provision for individually bypassing of TWD plates electronics is provided in this module and it needs to be tested.

Fig. 3.29 TWD HVPS Interlock Module

3.1.11.2 Preventive Maintenance of LLRF Systems for Linac

The operation and upkeep of all resonator controllers are done by the group members during the scheduled preventive maintenance. 27 resonator controllers and 10 spare controllers were kept ready to use. 16 Piezo controllers with 3 spare controllers are available. Few in-situ repair of LLRF electronics during Linac run was addressed with almost very negligible breakdown time. On-call assistance and support for LLRF control system of Piezo controllers during Linac run was provided. A Technical Memo on "Maintenance and In-situ repair of Resonator Controllers and Piezoelectric Tuner Controls for IUAC-LIAC" is under preparation.

3.1.11.3 LLRF Systems for High Current Injector (HCI)

Present Status

LLRF Controls were installed for all the installed cavities of HCI facility and they are in operational. Each RF cavity is connected with a set of APC and FTC controllers to control amplitude & phase and frequency respectively.

Fig. 3.30 LLRF Electronics Setup in HCI Facility at IUAC

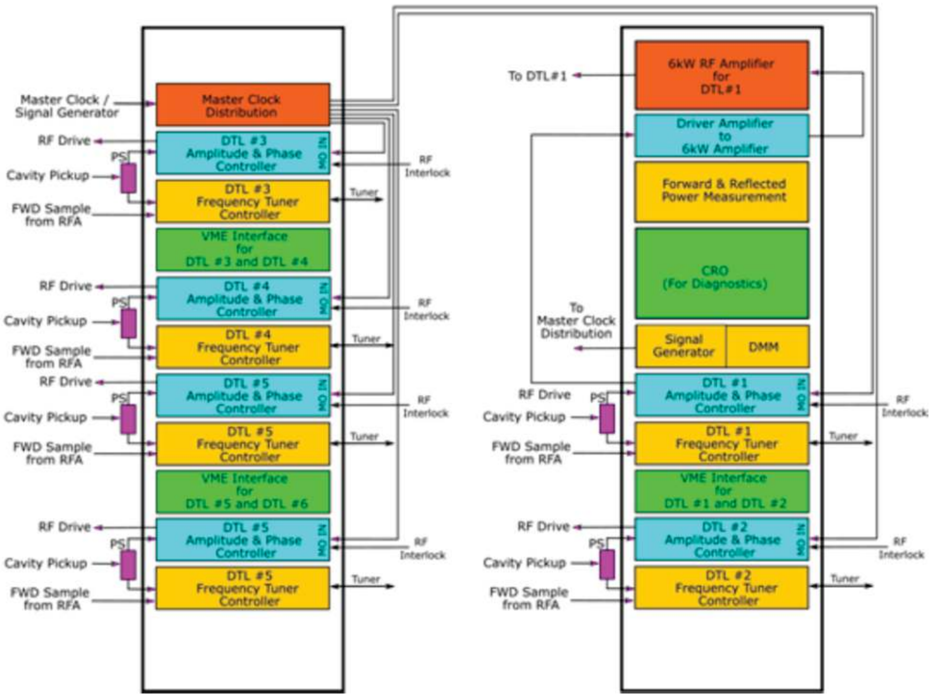

Fig. 3.31 Electrical Wiring Diagram of DTL LLRF Controls

Design and Development of LLRF-VME Interface Modules

These modules were developed for the use of remote powering/operation of RF cavities of HCI facility during conditioning as well as beam acceleration tests. These modules re-route the control and status monitor signals between LLRF controls and VME control system with or without required scaling factors to meet the requirement of the system. Each interface module is provided with two independent interface channels and will be connected between LLRF controls and VME Control system. A LLRF-VME Interface Test JIG was also designed and developed and it can be used as a Testbench to test these modules while fabrication and it can also be used as a diagnostic tool for in-situ testing as well as during preventive maintenance schedules. At present four of such modules were installed with RFQ, Spiral Buncher #1 and six DTL cavities. Two more modules are available and one of them is used with Spiral Bunchers #2 & #3, and the other one can be used as a spare module.

Fig. 3.32LLRF-VME Interface during Testing and RFQ powered remotely using the Interface

The Multi Harmonic Buncher (MHB) and its LLRF Control electronics were restored after the controller has shifted to the control room. Saw-tooth wave output was restored and FFC signal was measured with < 4ns bunch width from the control room.

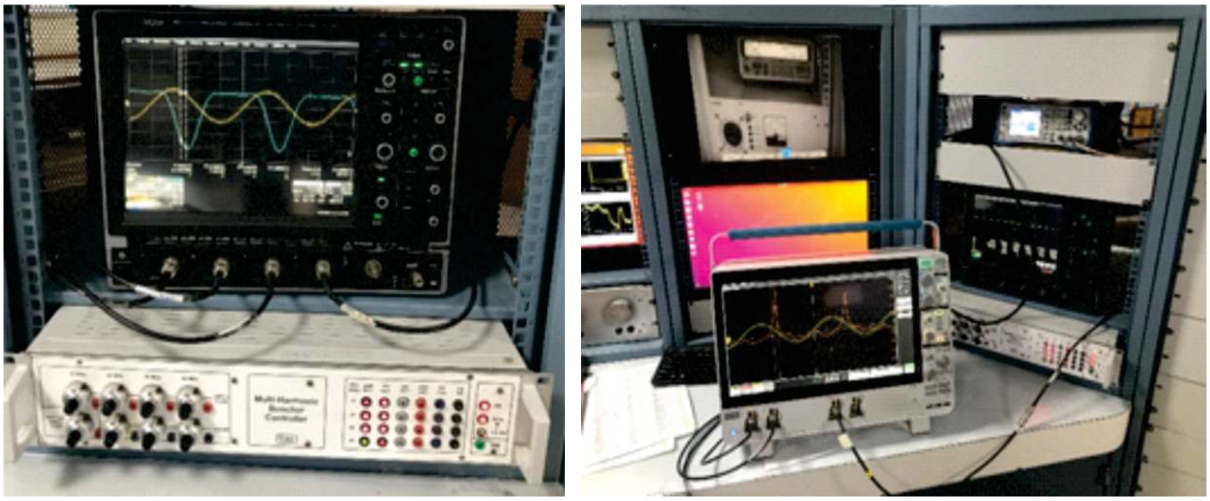

Fig. 3.33 MHB Controller installed in Control room and FFC Signal on a 4GHz Oscilloscope

3.1.11.4 LLRF Systems for Free Electron Laser (FEL)

FEL Beamline has been commissioned with 25 MW Pulsed High Power Klystron based RF source, 2.6 cell, 2860 MHz RF Gun Cavity, the photocathode, the 266 nm UV Laser, various electromagnets, BPM, LLRF, Beam Viewer and the Undulator. Recently, BPM, and LLRF electronics have been tested offline using Stretched Wire setup and Open Loop Feedforward mode respectively and are now commissioned. Beam testing and characterization is under process. An EPICS based Control Scheme is developed and operationalized.

LLRF Feed Forward and Closed Loop Test

Feedforward pulse ramping has been tried to reduce the problem of initial high level of Reflected power from the cavity. Earlier, the system could be powered upto 800kW only but using this, the system has been powered upto 1.1 MW peak power. In Amplitude Lock condition, stable peak power of 700 kW has been achieved. In the absence of circulator, fast Reflected Power INTLK (< 6 µs) to cut-off low level RF from switch in case of high reflected power has been implemented. It is in addition to existing fast interlock in the klystron modulator.