Control System for 6 MeV Linear Accelerator at LINAC Project PINSTECH

ICALEPCS 2021

Najm us Saqib

Control Systems Engineer

Accelerator Controls and Electronics (ACE) Group

LINAC Project Introduction

OBJECTIVE

6-20 MeV Indigenous RF LINACs

Medical and Industrial Applications

MOTIVATION

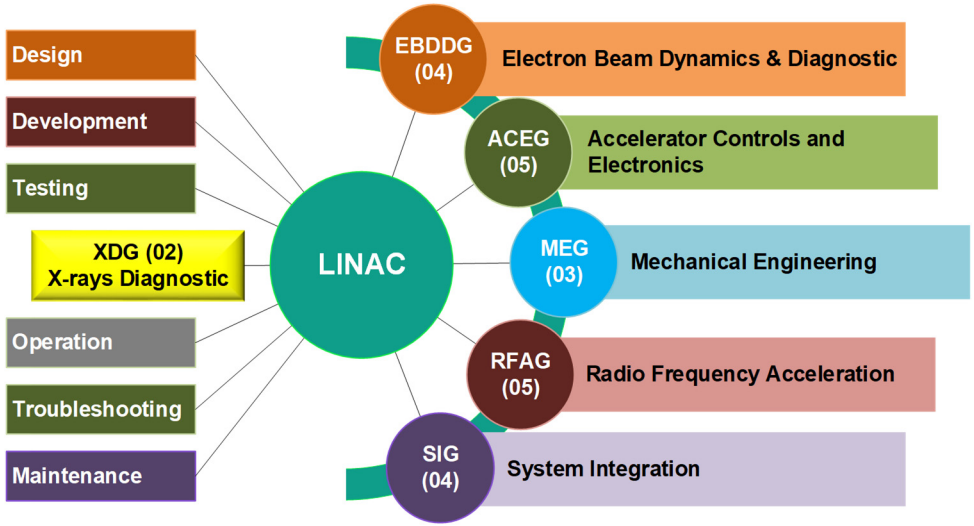
Expensive LINACs

Development Budget Phase I (2012 - June 2020)

PKR 790 Million

Development Budget Phase II (July 2020– Present)

PKR 840 Million



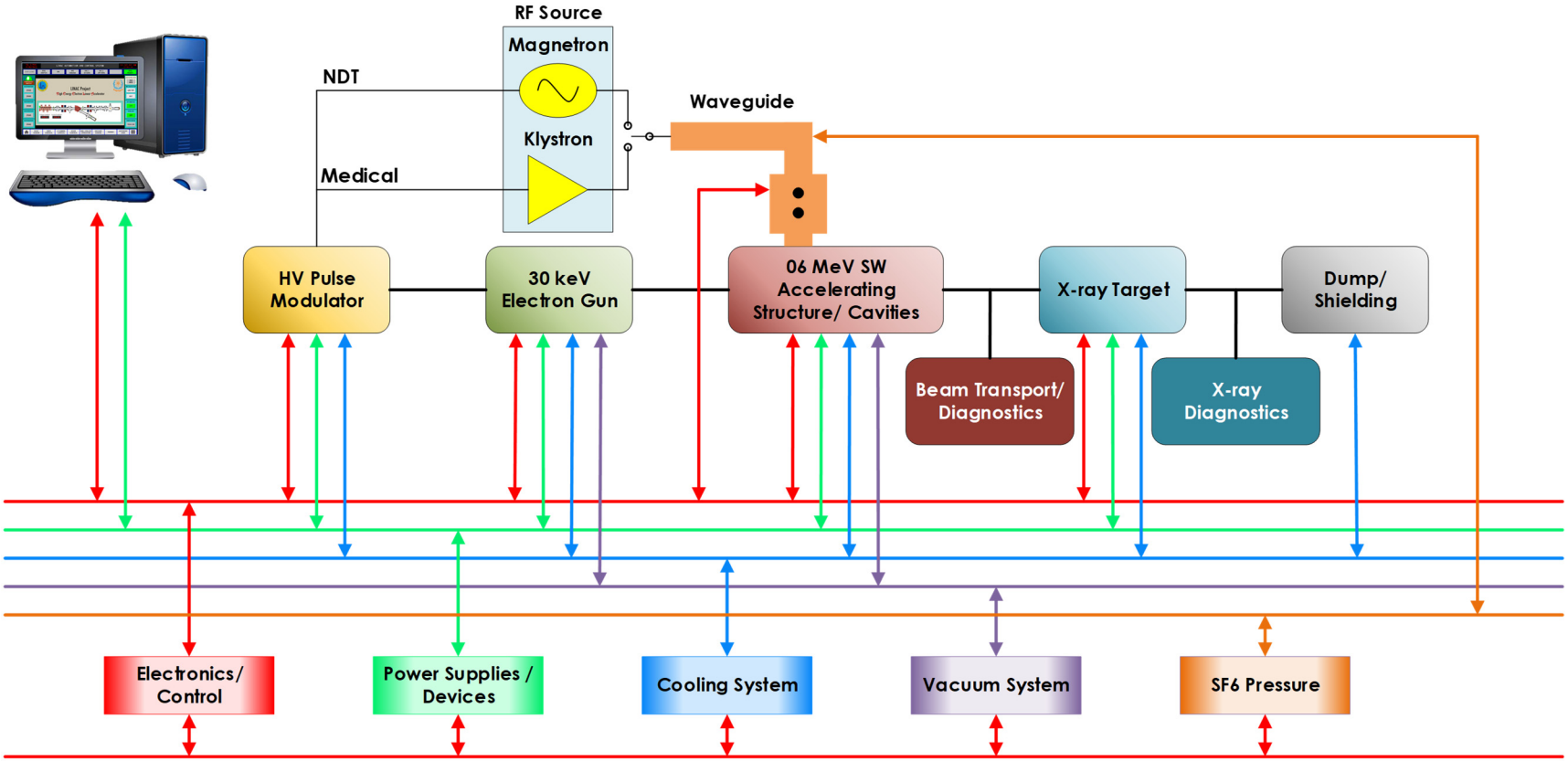
Medical & Industrial LINAC Prototypes

Application	Energy	Status
Medical (Radiotherapy)	6 MeV	In process
Industrial (NDT)	6 MeV	Final Stage

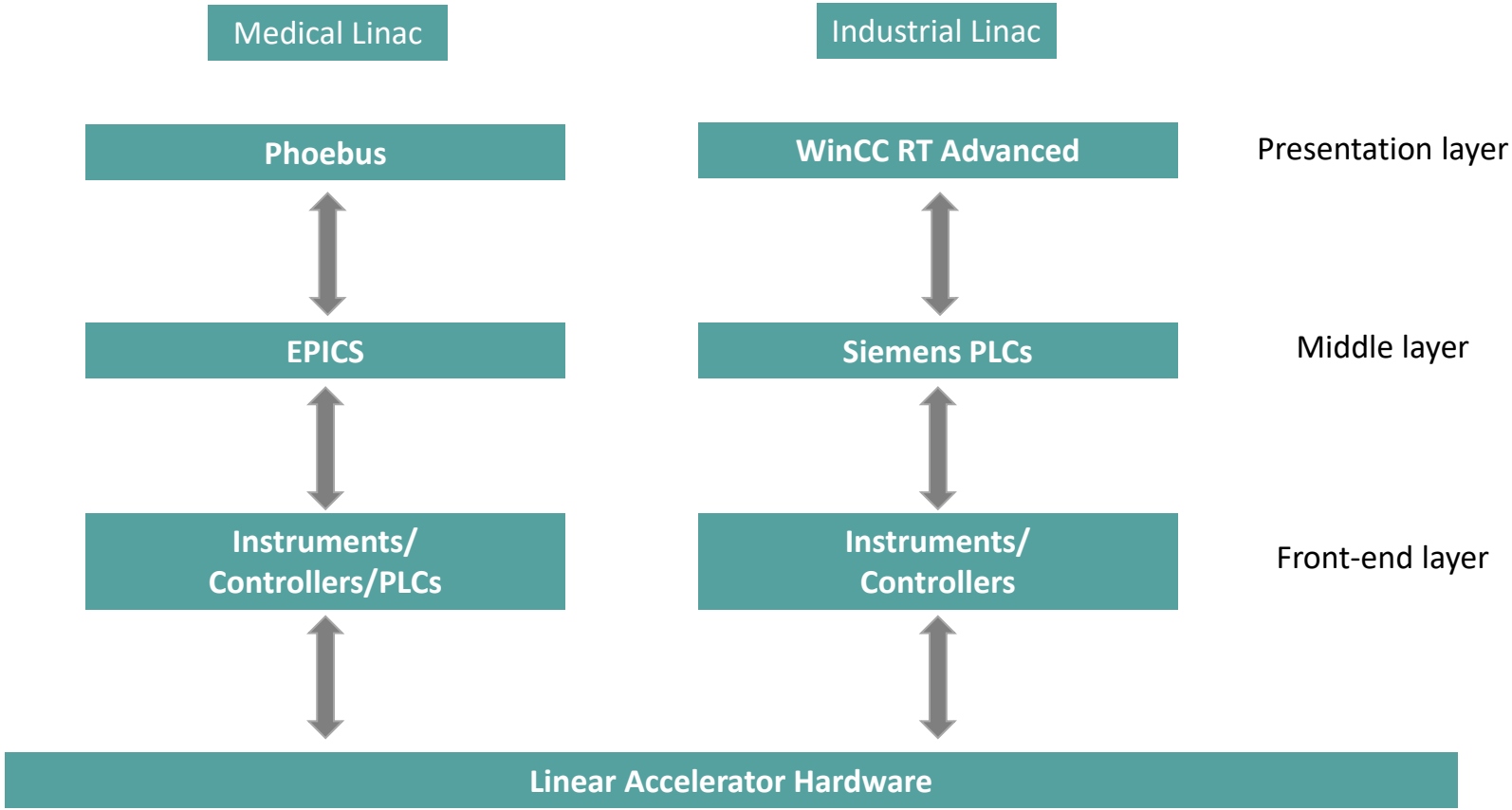
Medical

Industrial

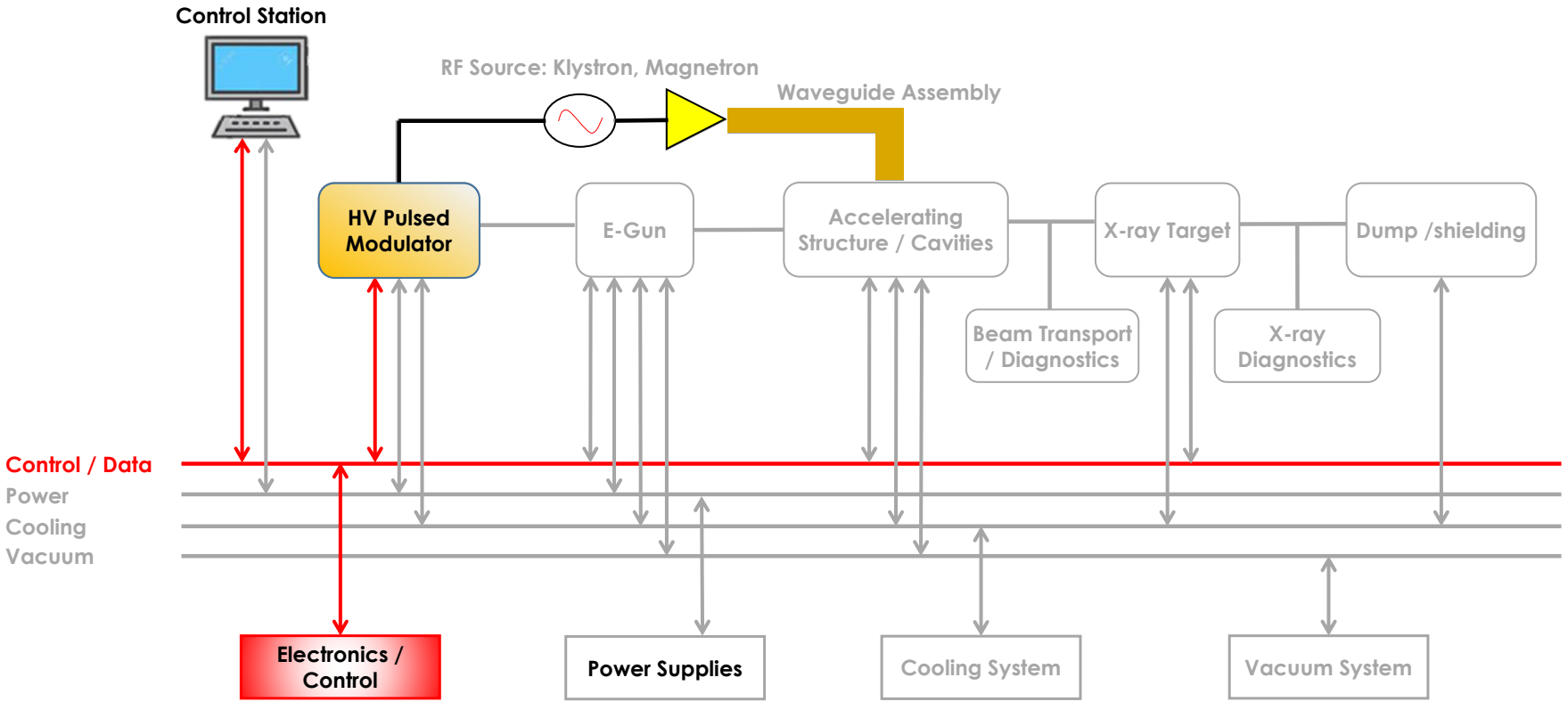
Linac Prototypes Block Diagram



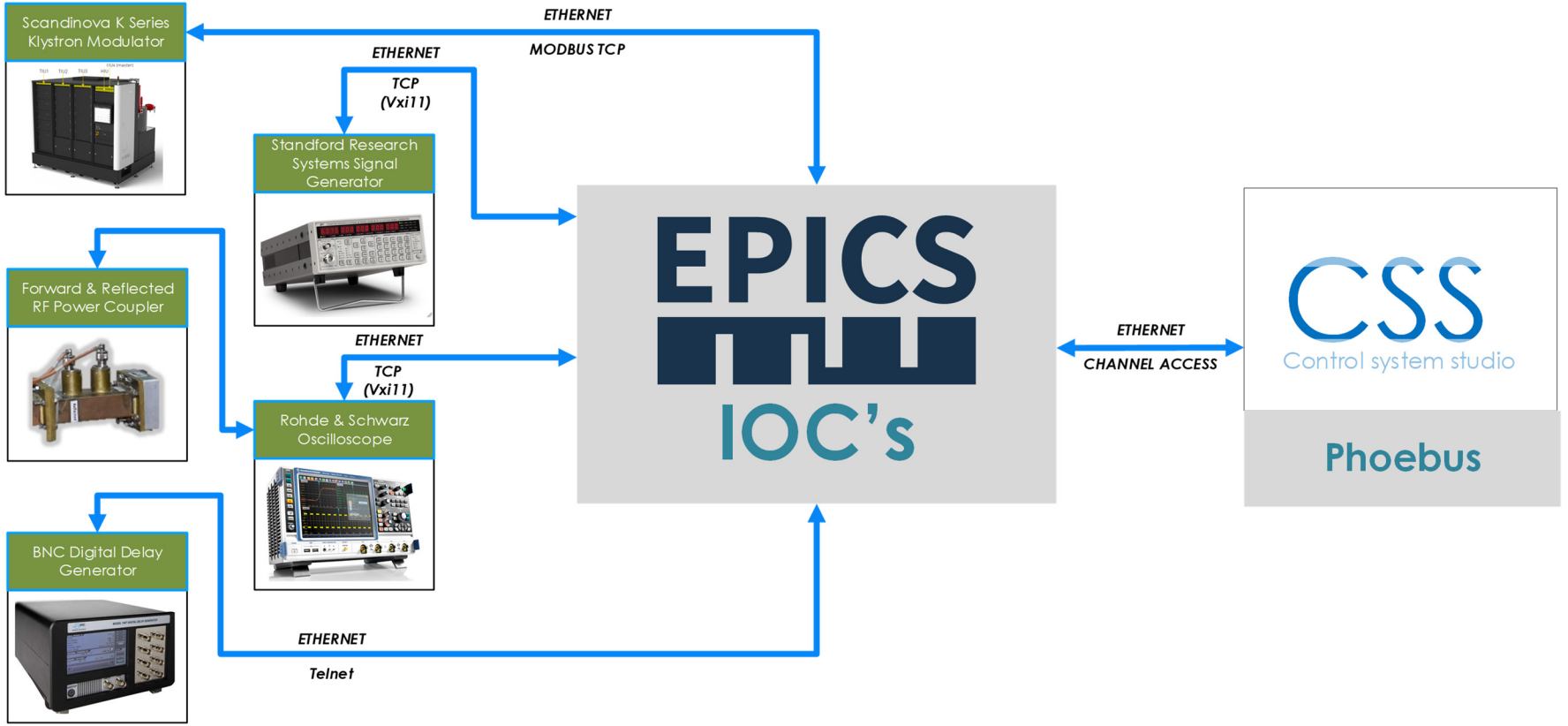
Control System Architecture



RF System


Control Station
RF Source: Klystron, Magnetron
Waveguide Assembly
HV Pulsed Modulator
E-Gun
Accelerating Structure / Cavities
X-ray Target
Dump /shielding
Beam Transport / Diagnostics
X-ray Diagnostics
Control / Data
Power
Cooling
Vacuum
Electronics / Control
Power Supplies
Cooling System
Vacuum System

Medical Linac RF System



Industrial Linac RF System

Indigenously developed 48 kV/ 110 A Pulse Modulator

Digital I/O, analog I/O, RS485, RS232

Digital and analog signals

Magnetron Electromagnet Power Supply

RS-422

Message

SIEMENS

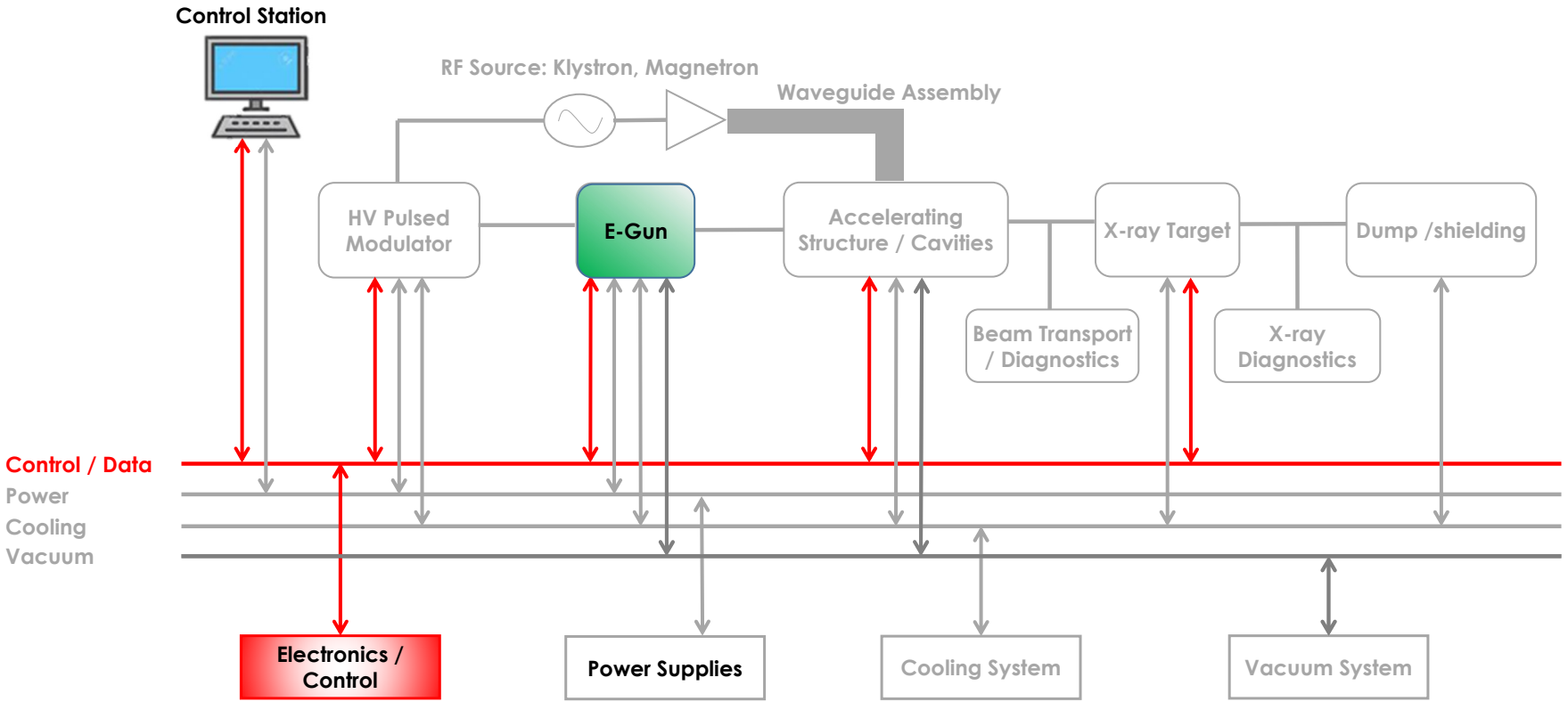
S7-1200

ETHERNET

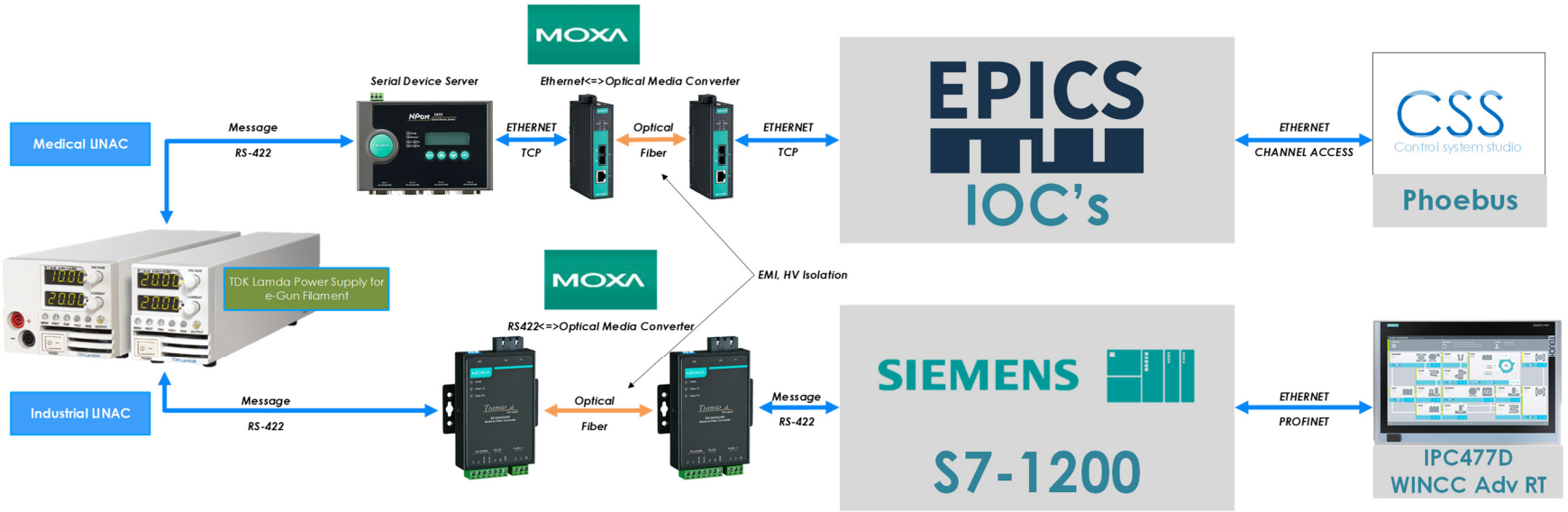
PROFINET

IPC477D
WINCC Adv RT

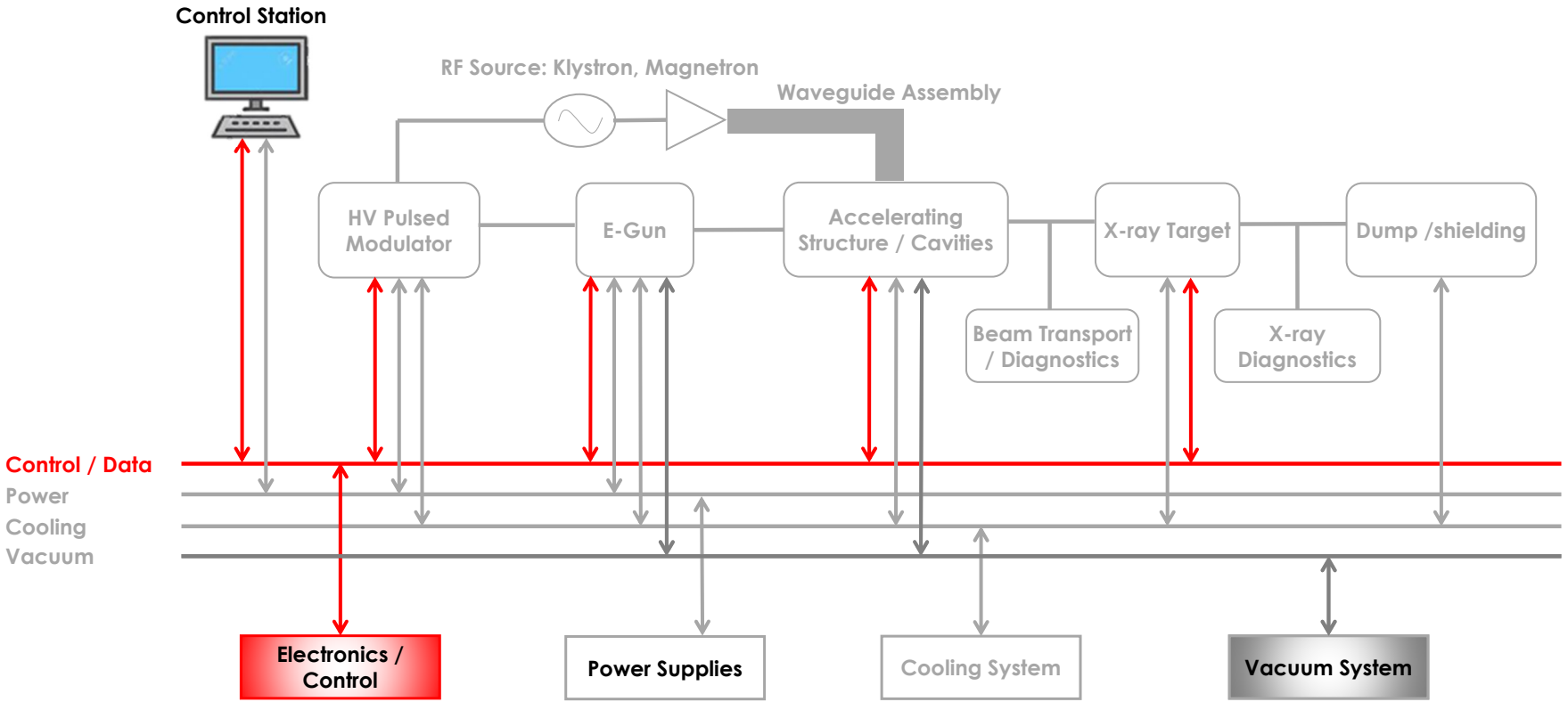
Electron Gun Filament System



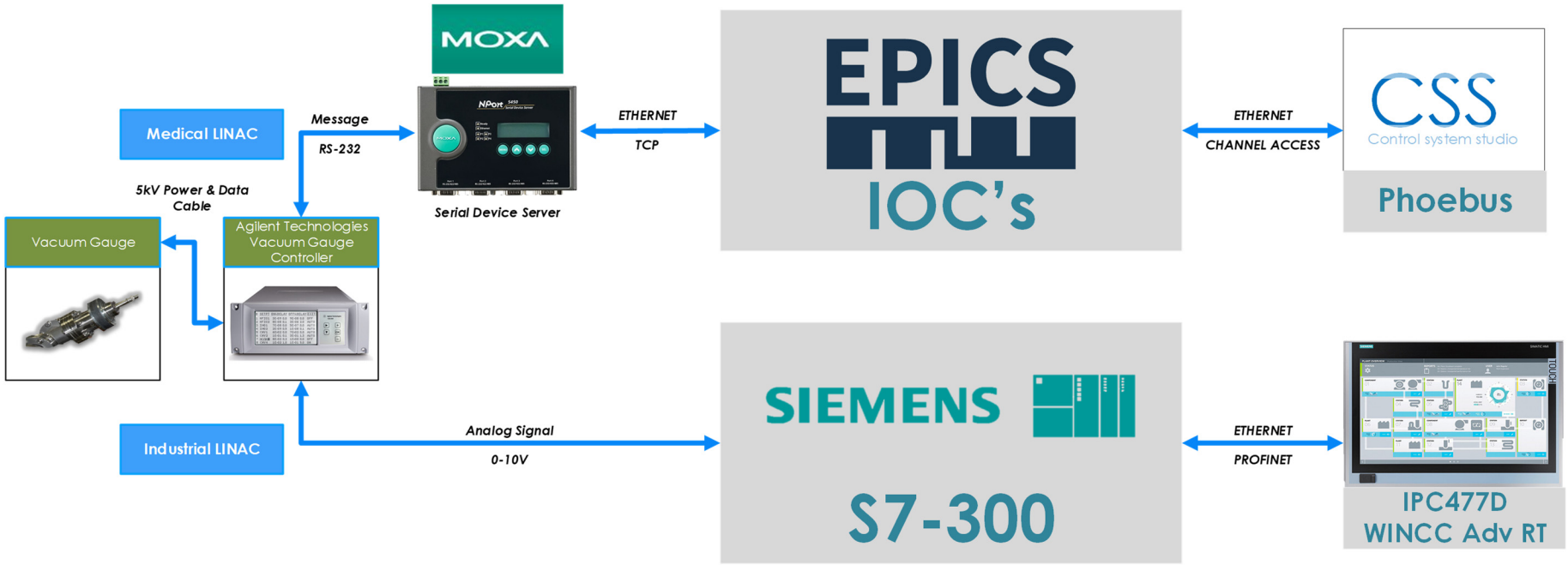
Electron Gun Filament System



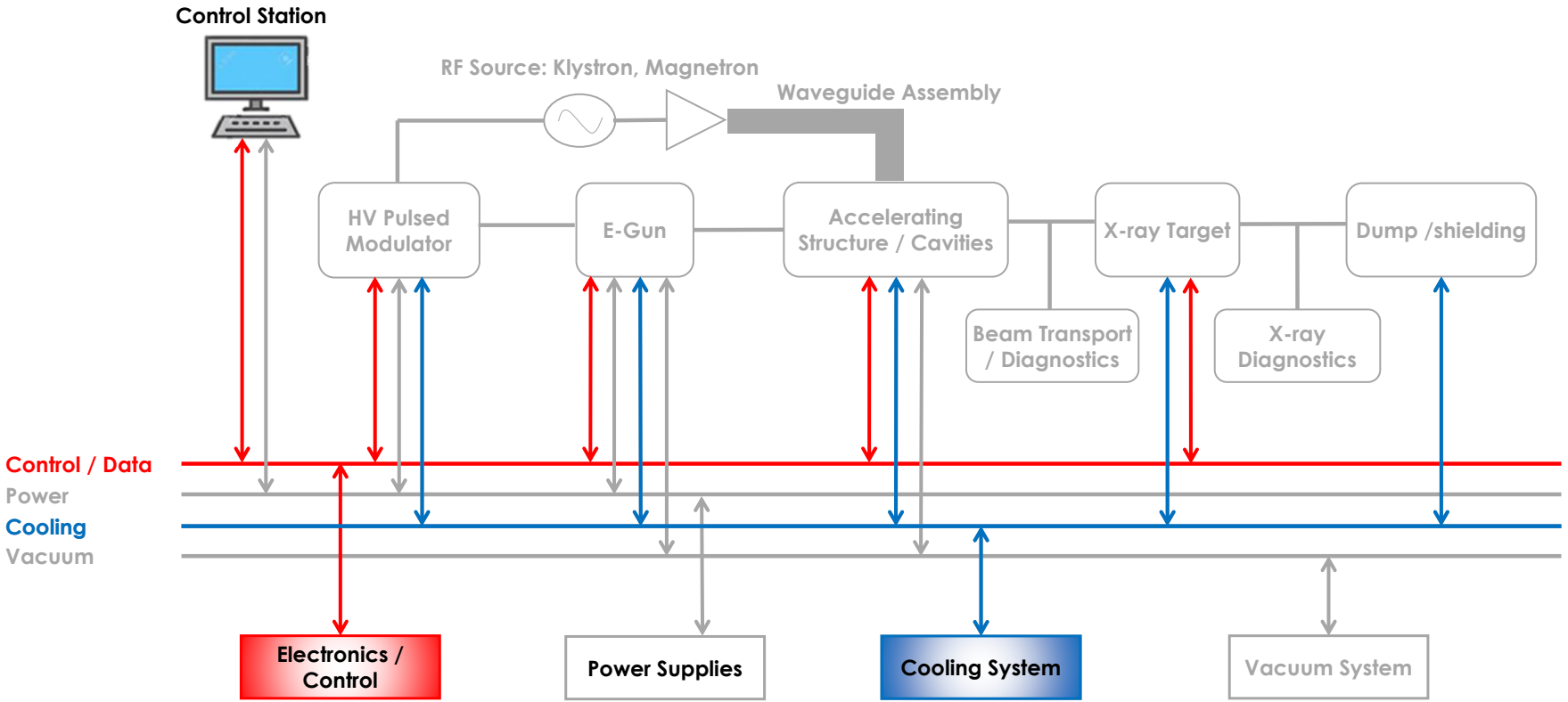
Vacuum System



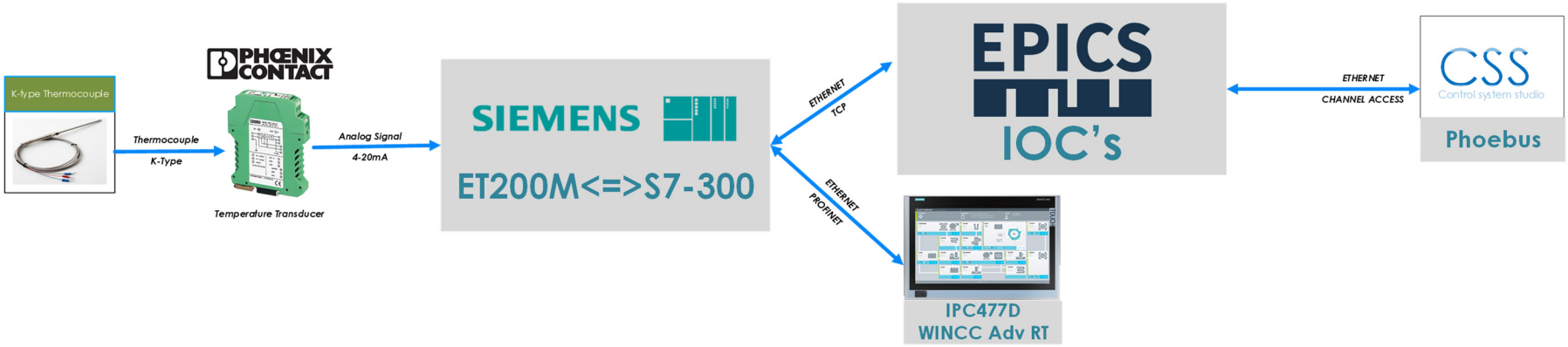
Vacuum System



Cooling System

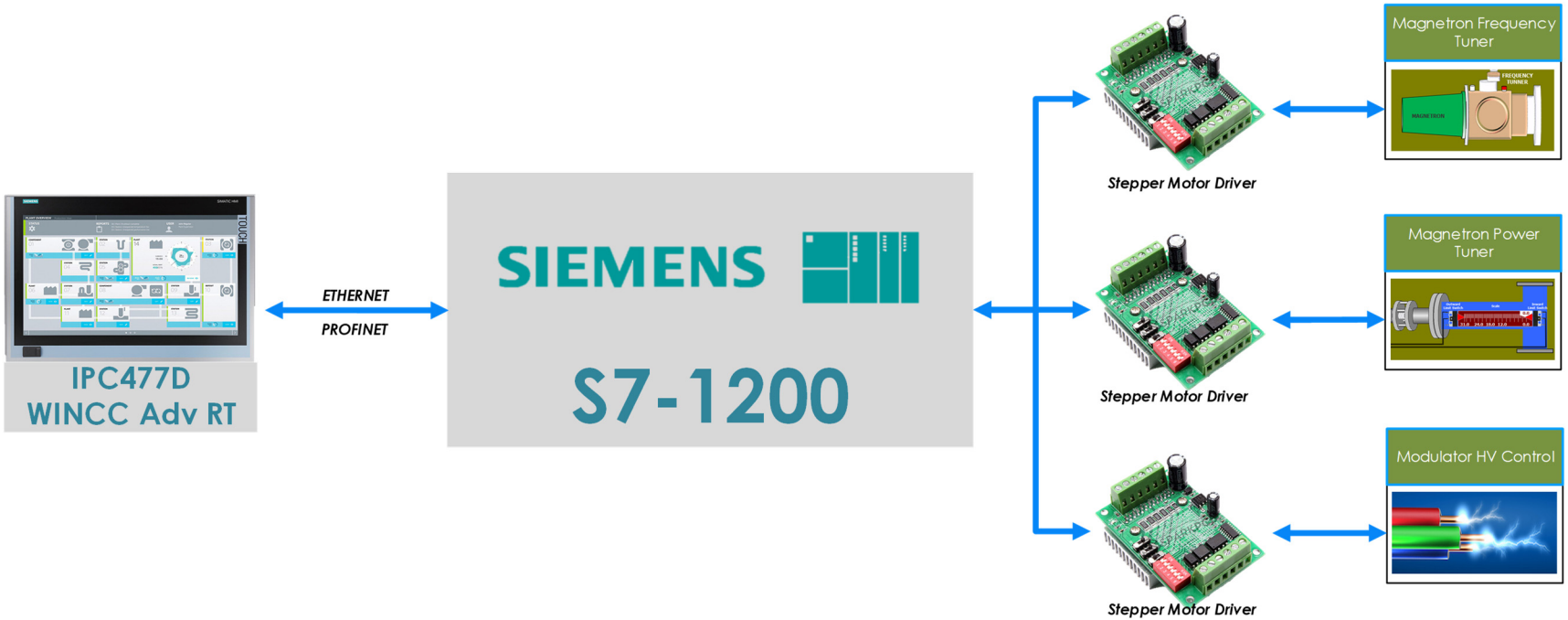


Cooling System

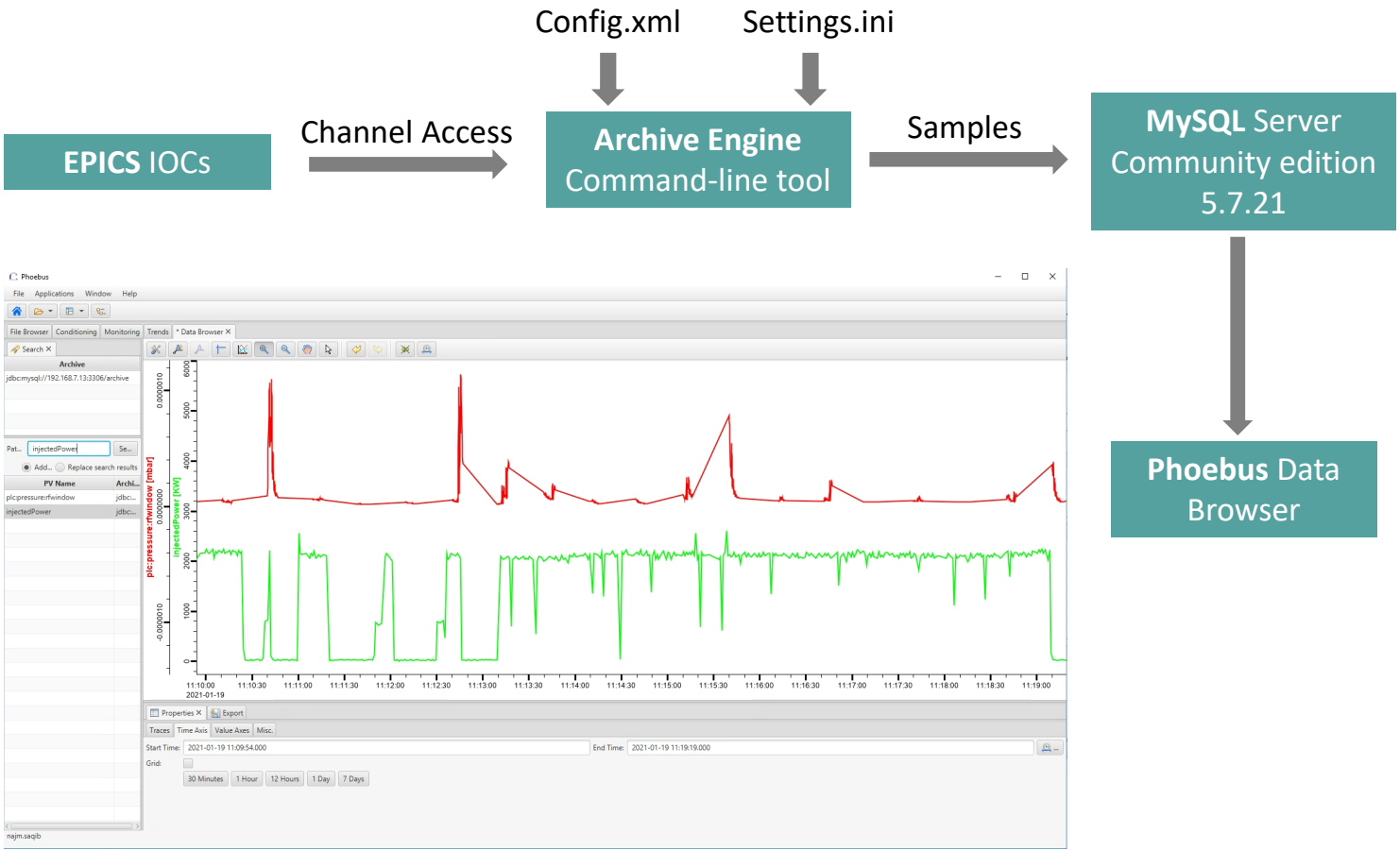


Indigenously designed chiller

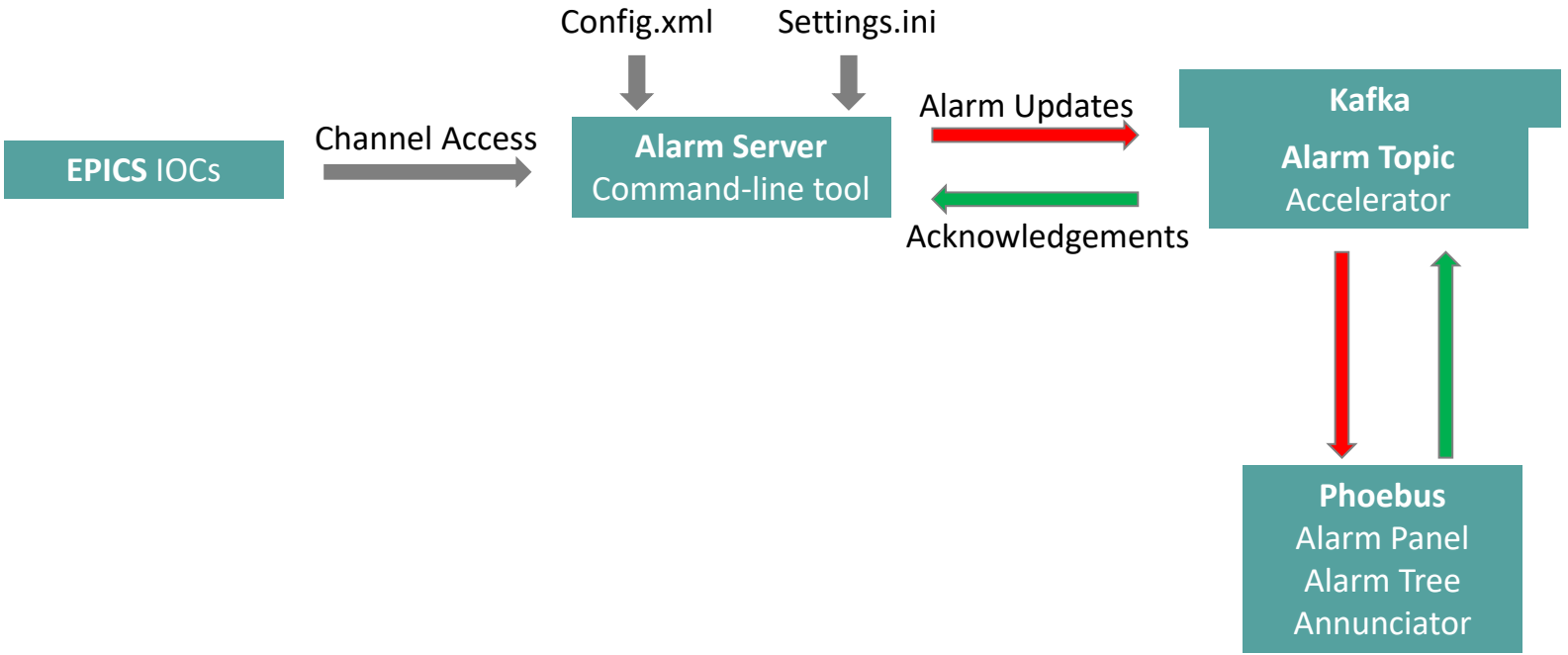
Motion Control System



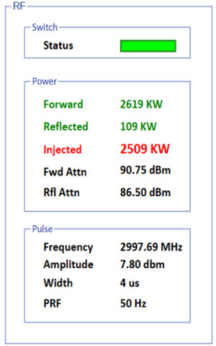
Data Archiver System

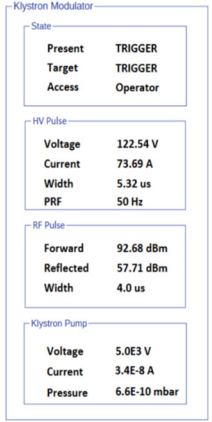


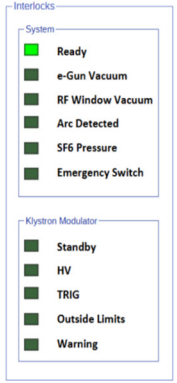
Alarm System

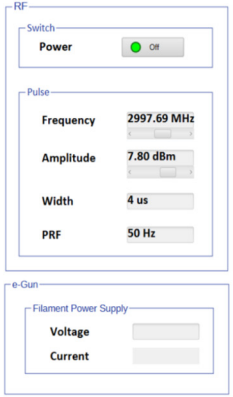


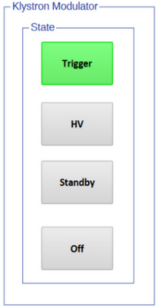
Medical Linac Phoebus OPIs

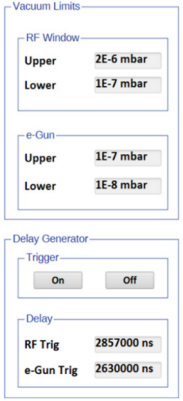


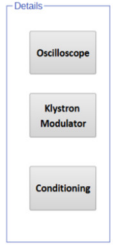


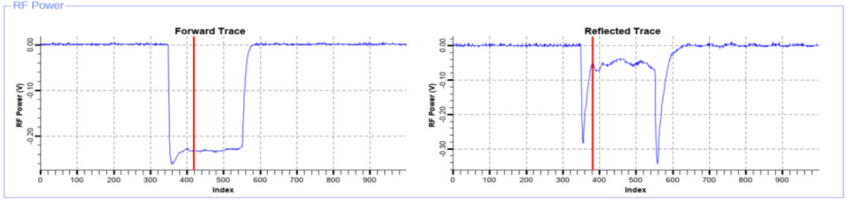












Temperatures

Temperature Sensor # 1	18.00 C
Temperature Sensor # 2	18.20 C
Temperature Sensor # 3	19.00 C
Temperature Sensor # 4	18.90 C

Oil

Temperature	17.86 C
Level	-34.25 mm

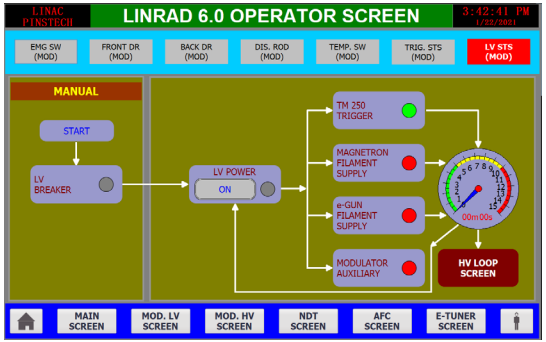
Delay

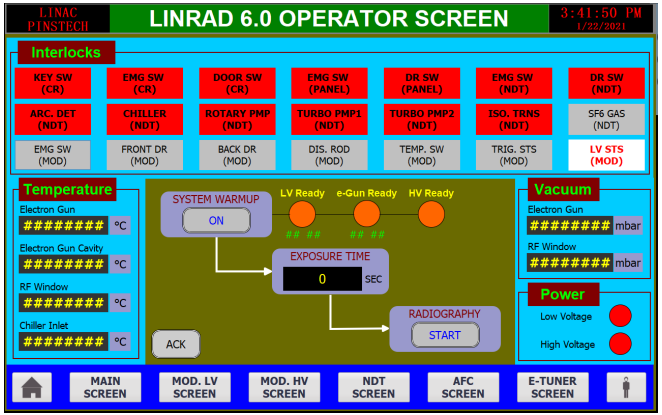
Remaning Time	0 sec

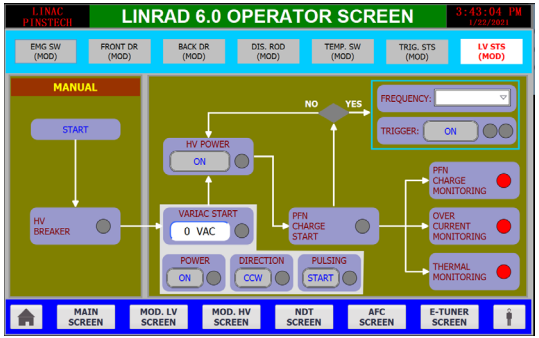
Flow Rates

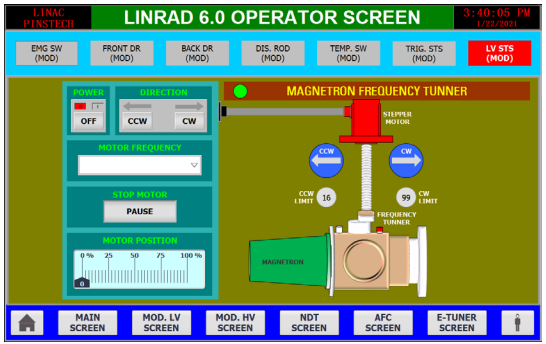
Flow Sensor # 1	0.00 l/m
Flow Sensor # 2	0.00 l/m
Flow Sensor # 3	0.00 l/m
Flow Sensor # 4	0.00 l/m
Flow Sensor # 5	0.00 l/m
Flow Sensor # 6	0.00 l/m
Flow Sensor # 7	0.00 l/m

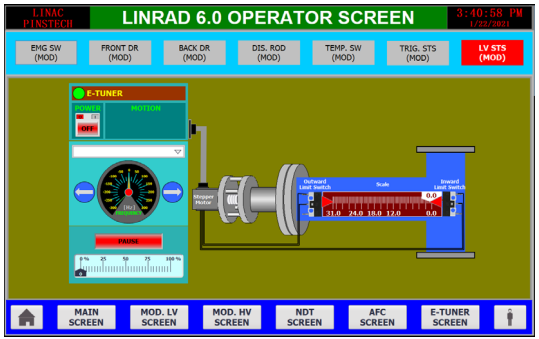
Industrial Linac WinCC RT Advanced HMIs











TUPV020

Automatic RF and Electron Gun Filament Conditioning Systems for 6 MeV LINAC

Authors: A. Majid, D. A. Nawaz,, N. U. Saqib, F. Sher
(LINAC Project, PINSTECH, Islamabad)

ICALEPCS 2021

Introduction

RF conditioning of vacuum windows and RF cavities is a necessary task for eliminating poor vacuum caused by outgassing and contamination. Also, startup and shutdown process of linear accelerator requires gradual increase and decrease of electron gun filament voltage to avoid damage to the filament. This poster presents an EPICS based multi-loop automatic RF conditioning system and Electron Gun filament conditioning system for Klystron based 6 MeV Linear Accelerator.

RF Conditioning System

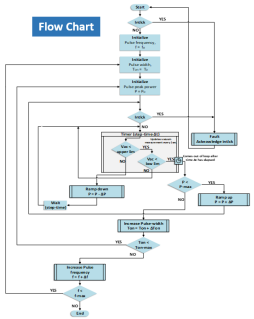
- ✓ Gradual Increase of injected RF power to avoid breakdowns
- ✓ Direction and magnitude of power gradient is adjusted on the basis of vacuum dynamics of LINAC cavity
- ✓ Design & development of automatic RF conditioning system using EPICS
- ✓ Incorporation of alarms and interlocks
- ✓ Hardware Setup
  - ✓ Siemens PLC (digital and analog I/Os)
  - ✓ Field Devices (vacuum gauge controller, signal generator, oscilloscope, delay generator and klystron)
  - ✓ Sensors & Relays (temperature switches, arc detector, flow meter, and RF-switch)
- ✓ Software Design
  - ✓ Configuration of main control software in EPICS
  - ✓ Development of soft-IOCs for interfacing PLC, hardware electronics and field instruments
  - ✓ Implementation of control logic and conditioning algorithm using EPICS sequencer program
  - ✓ Data archiving and alarms
  - ✓ Development of front-end application using Phoebus

Electron Gun Filament Conditioning System

- ✓ Low voltage conditioning of electron gun filament is necessary for safe operation
- ✓ Applied voltage is ramped up in steps while constantly monitoring vacuum level of accelerator cavity
- ✓ Development of software and hardware setup for automatic ramp-up/down of electron gun filament voltage
- ✓ Interfacing of e-gun power supply with EPICS IOC using TCP/IP communication protocol
- ✓ Interfacing of vacuum gauge controller with EPICS to monitor pressure level
- ✓ Development of ramp-up/down algorithm using EPICS sequencer module
- ✓ Integration of safety Interlocks
- ✓ Development of front-end application using Phoebus

Conditioning Strategy

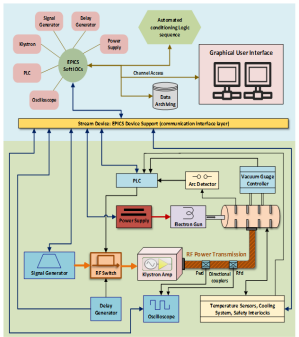
Flow Chart



States (According to Vacuum)

Design & Development of control logic in State Notation Language (SNL) using EPICS-sequencer module	
Start	All variables, step sizes and limits are set by user and conditioning process is initialized
Vacuum Monitor	Decides and selects next state (hold, increase or decrease) on the basis of vacuum level reading
Increment	Increase RF power in nested loops (RF pulse amplitude, pulse-width and frequency)
Decrement	Decrease RF power by reducing pulse amplitude
Fault	Pauses conditioning process until the fault is resolved and acknowledged

Control System Layout

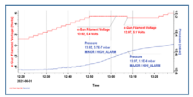


Results

RF Conditioning System

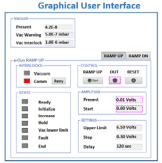
Graphical User Interface

Data Browser History

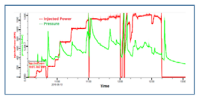


Electron Gun Filament Conditioning System

Graphical User Interface



Data Browser History



THPV046

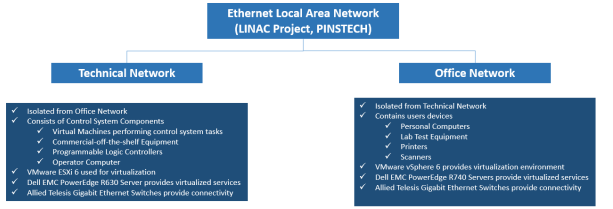
Virtualized Control System Infrastructure at LINAC Project PINSTECH

Authors: N. U. Saqib, F. Sher
(LINAC Project, PINSTECH, Islamabad)

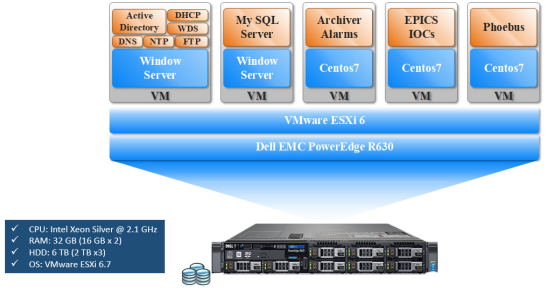
ICALEPCS 2021

Introduction

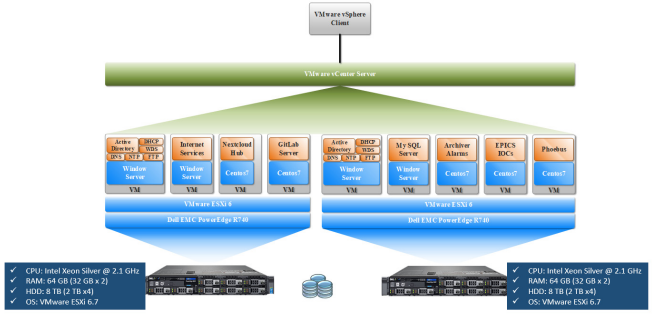
IT infrastructure is backbone of modern big science accelerator control systems. Accelerator Controls and Electronics (ACE) Group is responsible for controls, electronics and IT infrastructure for Medical and Industrial NDT (Non-Destructive Testing) linear accelerator prototypes at LINAC Project, PINSTECH. All of the control system components such as EPICS IOCs, Operator Interfaces, Databases and various servers are virtualized using VMware vSphere and VMware Horizon technologies. This paper describes the current IT design and development structure that is supporting the control systems of the linear accelerators efficiently and effectively.



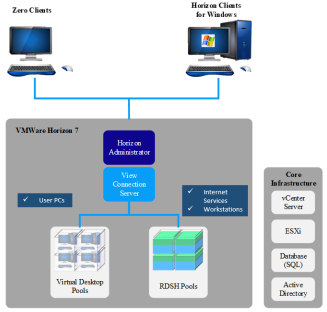
Technical Network Virtualization



Office Network Virtualization



Virtual Desktop Infrastructure



TUPV019

Control System for 30 keV Electron Gun Test Facility

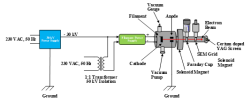
Authors: D. A. Nawaz, M. Ajmal, A. Majid, N. U. Saqib, F. Sher
(LINAC Project, PINSTECH, Islamabad)

ICALEPCS 2021

Introduction

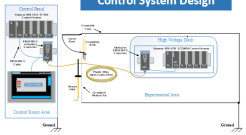
An electron gun test facility for indigenously developed 30 keV electron guns is developed to control and monitor various beam parameters by performing electron beam tests and diagnostics. After successful testing, electron gun is then integrated into 6 MeV standing wave linear accelerator. This poster presents the control system design and development for the facility.

Experiment Test Bench



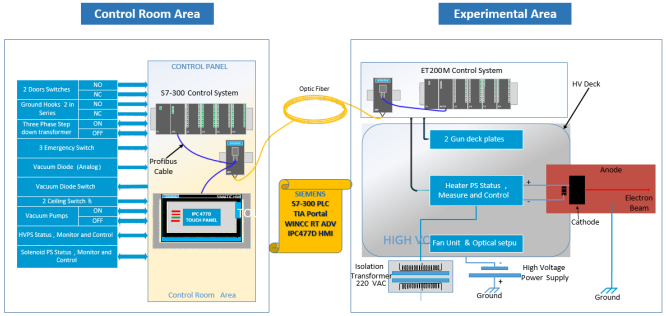
- CF-63 based test bench
- Diode type electron gun based on thermionic emission
- System evacuated down to 1e-8 mbar with turbo pump
- IMG-300 ionization gauge
- Faraday cup for target current
- Ce doped YAG screen to measure beam profile
- Low Voltage DC supply for electron gun filament
- High Voltage DC Supply for extraction

Control System Design



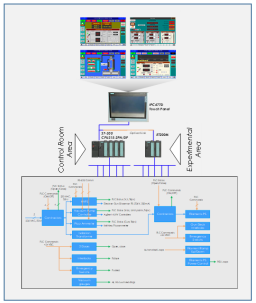
- Isolation of High Voltage (HV) and Low Voltage (LV) Area
- Modular and Centralized configuration
- SIEMENS Hardware
  - SIMATIC S7-300 CPU
  - ET200M Slave
  - I/O Modules
  - IPC 477D Touch Panel
- SIEMENS Software
  - TIA Portal
  - WinCC RT Advanced

Control System Layout



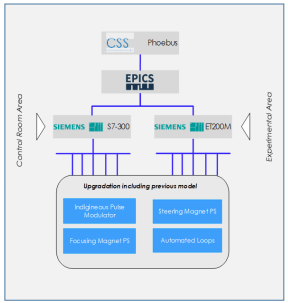
Control System Upgrade

Present Layout



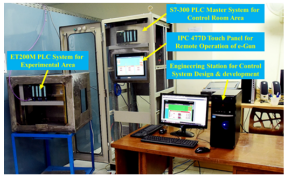
Upgrade

Planned Layout

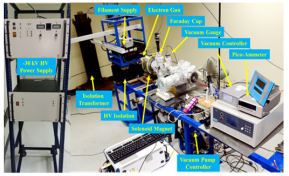


Experimental Facility

Control Room Area (Low Voltage)



Experimental Area (High Voltage)



Faraday Cage

Thank You