Power Electronics & Magnet Coil Development Section (PE&MCDS)

High-Voltage Power Systems for Medical Cyclotron Applications

Power Electronics & Magnet Coil Development Section, PED, ATG, VECC has successfully designed and developed major power supply systems for the indigenous 18 MeV Medical Cyclotron (MC18) programme. A complete suite of ion-source power supplies operating up to – 30 kV has been integrated with optical-fiber-based communication systems, enabling reliable remote operation and high-voltage isolation. Successful beam extraction tests validated the robustness of the developed architecture. Filament Power Supply (FPS), Arc Power Supply (APS), e-Suppressor Power Supply (SPS) and Puller Power Supply (PPS) are being used for energizing the Ion Source and responsible for controlling the beam current output. These high power units were operated while floating at approx. -30kV and hence required power line and control line isolation greater than 50kV DC (Maximum rating of the BPS) with respect to earth. FPS, APS and EPS were designed incorporating power transformer's primary side AC Voltage Control using a pair of Thyristors connected in anti-parallel configuration [1].

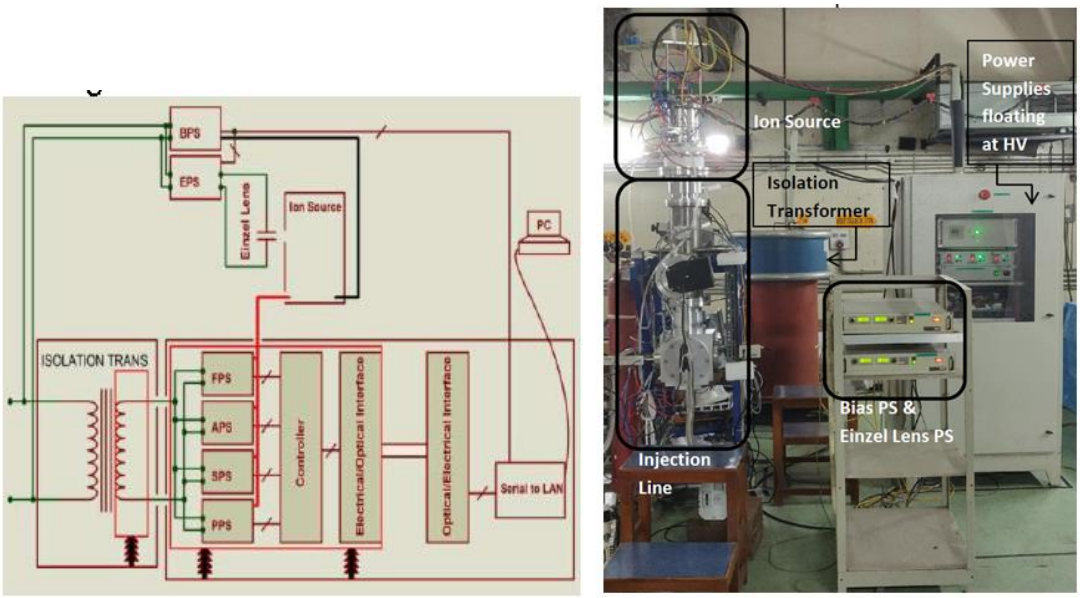


Figure 1:- MC-18 ion source powers supplies control scheme

Power supplies for Rare Isotope Beam Facilities

The section had installed and tested a sophisticated 300 kV electron-gun biasing power supply system for the ANURIB programme. VECC, in collaboration with

TRIUMF, is developing a 10 MeV injector cryomodule to serve as the front end for a high-intensity electron Linac. The bias power supply has been successfully tested at up to 300 kV DC, alongside the Grid (250 V/0.3 A) and Filament (18 V/4 A) power supplies, both floated at 300 kV DC. Power isolation for the Filament and Grid supplies is achieved using a 2.5 kVA single-phase isolation transformer with a rated isolation level of 350 kV DC [2].

The facility integrates high-voltage bias supplies, isolation transformers, optical-fiber communication and supervisory control software, demonstrating strong capabilities in high-voltage engineering and accelerator infrastructure development.

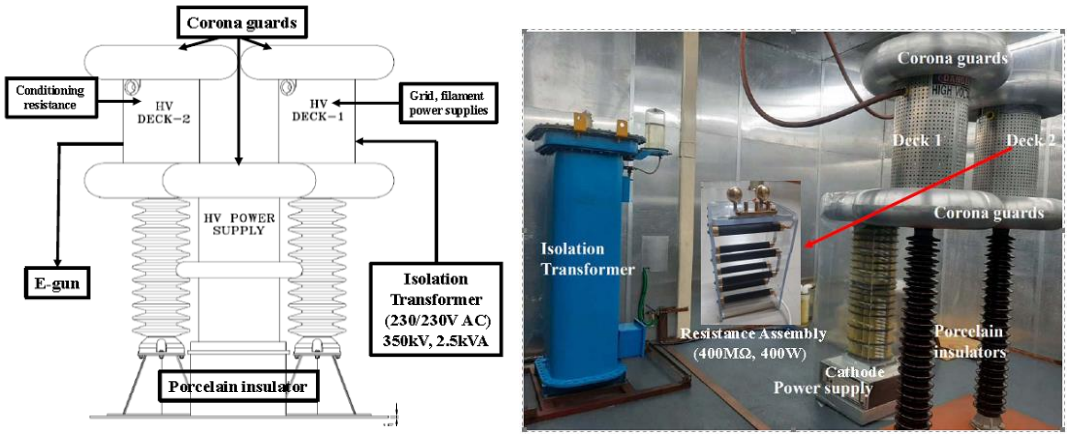


Figure 2:-Biasing scheme of 300kV power supply and Actual view

By combining expertise in power electronics, embedded systems, superconducting magnet technology, cryogenic engineering, and precision manufacturing, the PE&MCD Section continues to play a vital role in advancing accelerator science and enabling future research infrastructure.

Transformer and Magnet Coil Winding Facility

The PE&MCD Section, PED, ATG has played a significant role in facilitating the production of transformers, inductors and magnet coils for various sections of the Centre over the years. These include design, development as well as providing assistance to winding facilities for various coils for diverse applications, mostly at VECC. The facility has developed several types of coil systems during the years and is still being utilized for the purpose in DC, power line frequency and high frequency applications.

Fig 1 a: Clockwise from top left, Steering Magnet Coil for K130 RTC, 125 VA Transformer for BRIT, Set of 8 ferrite core inductors for Power Supply applications

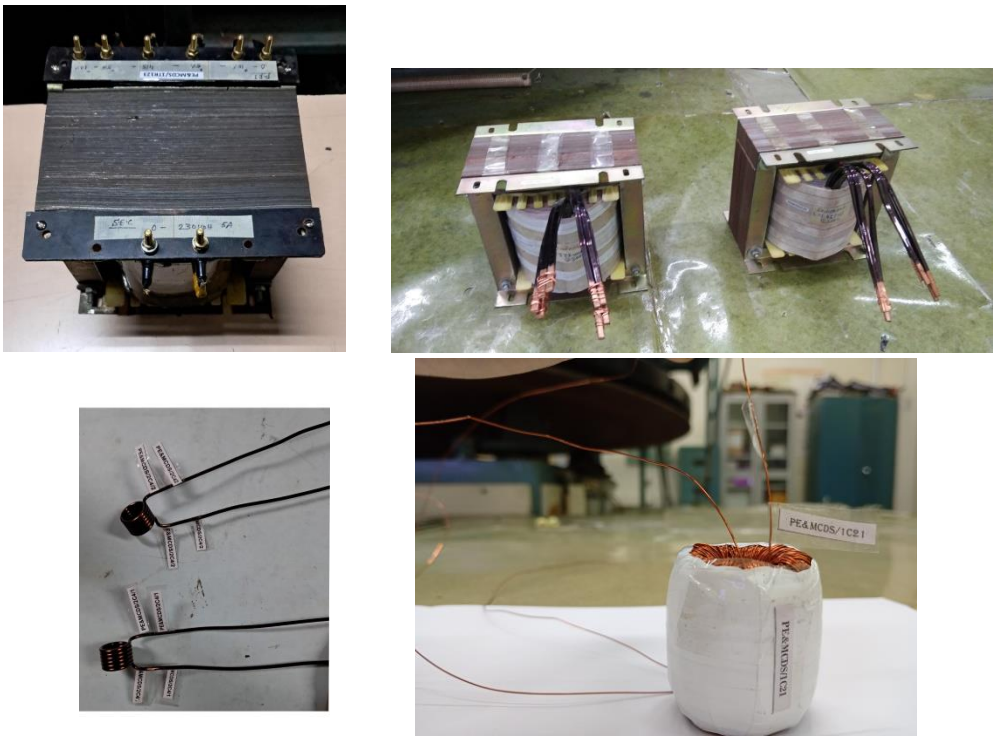
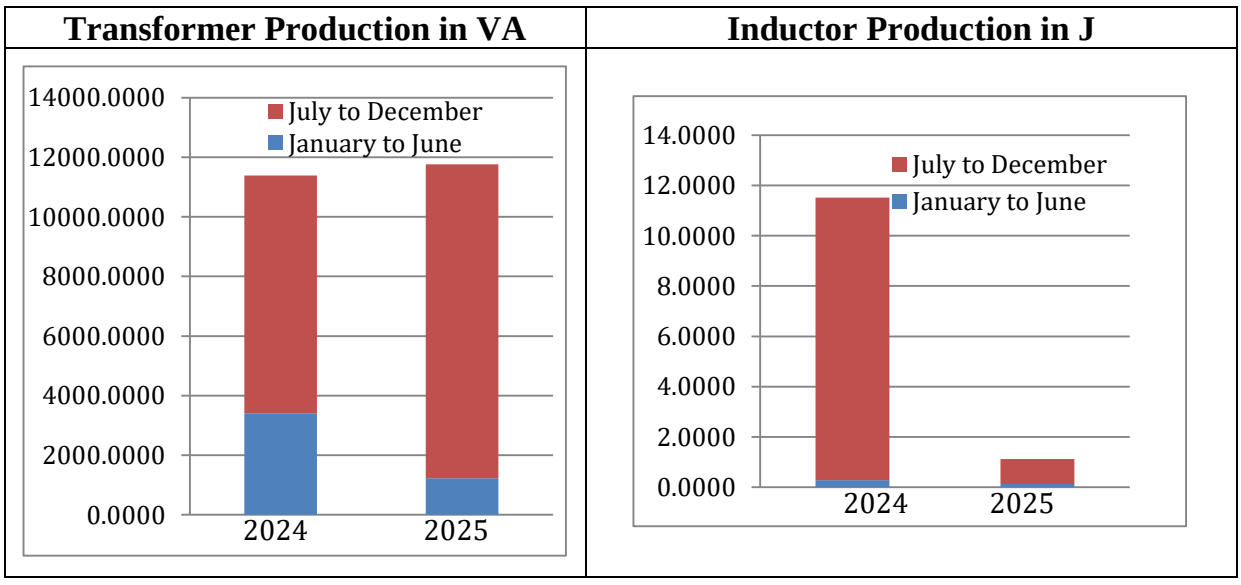


Fig 1 b: Clockwise from top left, 1.15 kVA single phase Transformer, high current inductor for Power Supply applications and low current coil for laboratory, Superconducting inductor for Penning Ion Trap

The Figure 1 shows a few of the transformers, inductors and magnet coils developed at PE&MCDS during the previous couple of years and Figure 2 shows the statistics of the facility in producing transformers and inductor coils for the year 2024-2025.



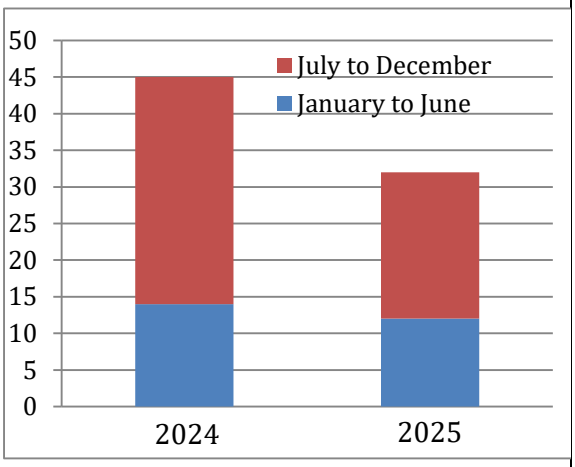
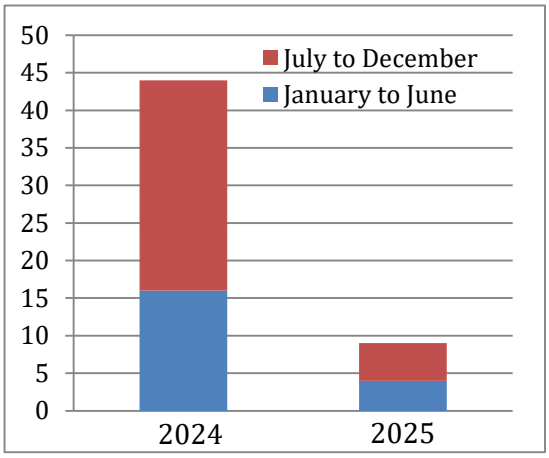
Transformer Production in Numbers	Inductor Production in Numbers
	

Figure 2: Production from January, 2024 to December, 2025

Development of digitally regulated power supplies

The division is involved in design and development of digital regulator based power supplies of various ratings incorporating digital signal processor (DSP) as the heart of power supply regulator and controller. As a regulator it performs all the control loop action and generation of required gate pulses to gate drivers of the power stage. Additionally all other supervisory functionalities i.e. remote communication, local panel control, LCD display, power supply protection etc. are also performed by the same DSP. All the required control boards along with the DSP motherboard has been designed in-house. A few of the power supplies, developed using digital regulators are tabulated with snapshots of the representative units among them following.

Sr. No.	Power Supply Name	Rating	Regulation type	Application area	Status
1	Ion Source Arc Power Supply	-500V,1.2A DC	Current regulated	RTC PIG ion source	Operating round the clock
2	Ion Source Filament Power Supply	500A, 5V DC	Current regulated	RTC PIG ion source	Operating round the clock

3	12Y Steering Magnet Power Supply	±30A, 15V DC	Current regulated	SCC beamline steering magnet	Operating round the clock
4	MCF Steering Magnet Power Supply	±50A, 60V DC	Current regulated	MCF material science beamline steering magnet	Tested with actual load
5	Compact Cyclotron Ion Source Filament Power SUpply	30A, 15V	Current regulated	1 MeV compact cyclotron test facility	Tested with dummy load
6	MCF Quadruple Magnet Power Supply	125A, 50V DC	Current regulated	MCF material science beamline quadruple magnet	Under development
7	MC-18 Ion Source Bias Power Supply	-40kV, 20mA DC	CV/CC	MC-18 ion source	Under development
8	MC-18 Steering magnet power supplies	2 x ±10A, 30V DC	Current regulated	MC-18 steering magnets	Tested with actual load

RTC Arc Power Supply

RTC Filament Power Supply Controller

Filament Power Supply Power Cabinet

SCC 12-Y Steering Magnet PS

MC-18 XY Steering Magnet PS

Collaborative developments with other sections of VECC and units of DAE

Instrumentation Development and Support

PE&MCDS also provides technical support in developing devices and instsruments for various sections in VECC and DAE.

Digitally regulated high temperature controller for Material Science applications

PE&MCDS collaborated with sections from Material Science & Medical Group and Mechanical Engineering Group to develop a microcontroller based digital regulator that was deployed for Material Science related experiments of K130 Cyclotron [3] for thermal regulated target heating applications. In this, a 32 bit microcontroller was deployed in closed loop to measure the target temperature and control the same using a compatible electrically controlled heater arrangement. The system was developed and tested upto 500 ^{0}C while maintaining the

temperature within ± 1% of the set point. The system is being recently upgraded for 600 ^{0}C applications with similar tolerance.

The unit was utilized during beam irradiation of samples of Incoloy 800 H upto 500 ^{0}C with 7 MeV proton beam from K 130 Cyclotron at VECC. The figures shows the set up an the data plotted and compared with the estimated (analytical) temperature rise.

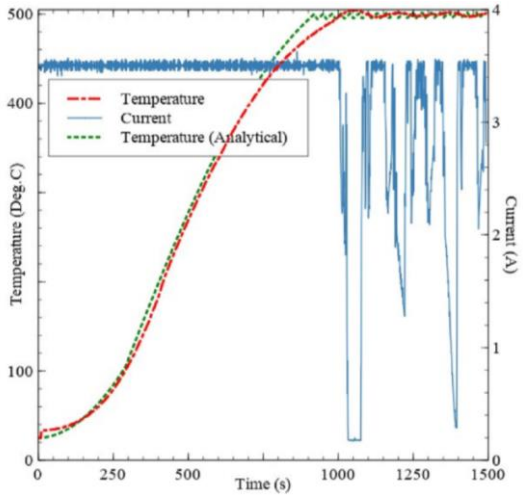


Figure: The system with the beam line (left) and the comparison of the plot of experimental temperature with analytical and the heater current

Development of Embedded System based Controller, BVSynth, for Radiopharmaceutical Synthesis for BRIT, Kolkata

PE&MCDS collaborated with BRIT, Kolkata to develop a fully automatic embedded system based programmable electronic controller, BVSynth to replace the IBA make Synthera controller that stopped working in FDG Hot Cell 2 at MCF, Chakgaria since 26.11.21. The embedded system based controller that took little more than a year to develop, gave a record production and synthesis yield of 2.53 Ci of FDG on 22.10.24, a highest since the system was deployed in 28.03.23. This yield is also the highest achieved for FDG at MCF considering both the BVSynth based system and the IBA make Synthera, running in Hot Cell 1 at the site.

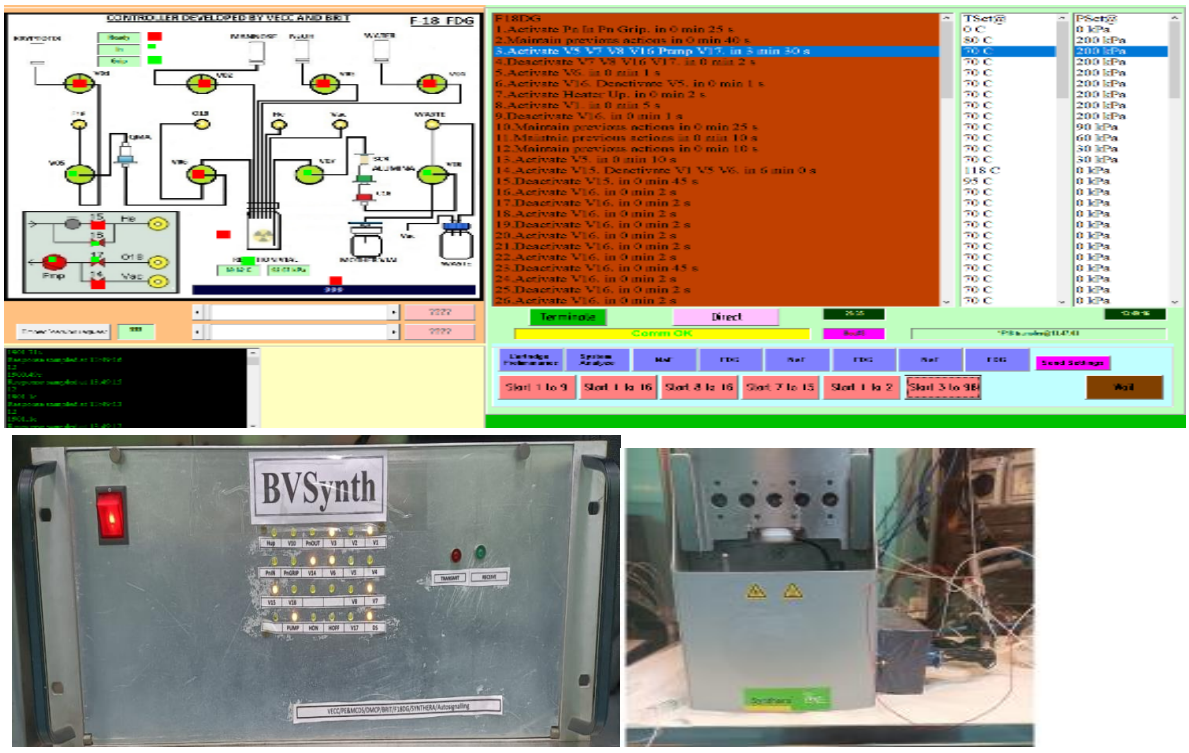


Figure (counter clockwise from top): The program sequences are on the laptop screen (GUI), BVSynth Controller unit, Retrofitted Synthera for BVSynth interfacing

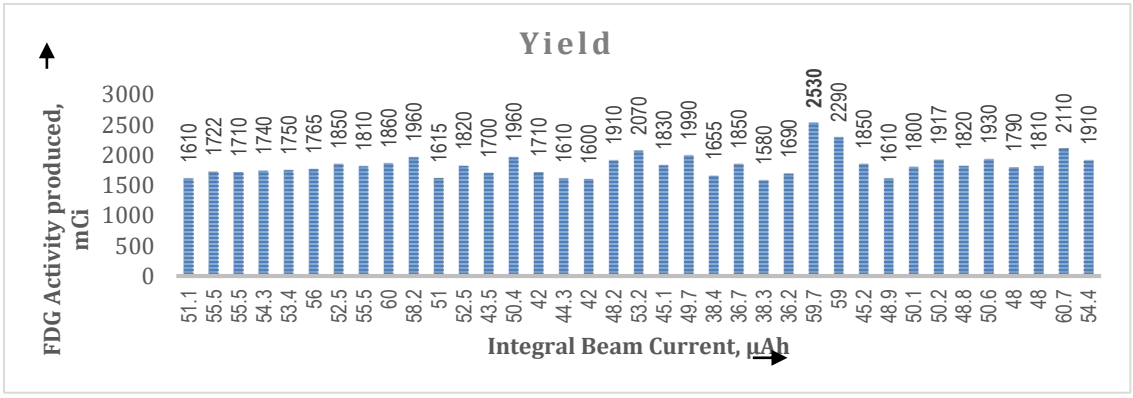


Figure: Bar graph showing FDG Activity produced against Integral Beam Current with the record yield registered till December, 2024

The figures displayed above summarize the developments and the achievements of the developed electronics

1. S. Pathak et. al., “Design and Development of DC Regulated Power Supply Bank for Prototype Ion Source of MC18 Cyclotron”, *Proceedings of InPac-2022, ID-44 conference*, India.

2. Y. Kumar et. al. “Installation, testing and study of biasing power supplies system at 300kV for electron gun of ANURIB facility at VECC”, *Proceedings of InPac-2025, ID-44 conference*, India.
3. Anjan Dutta Gupta, Sabyasachi Pathak, Anirban De et al, Design and Development of test set-up with integrated digital controller for high temperature irradiation of materials, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 1086, 2026, 171381, ISSN 0168-9002, https://doi.org/10.1016/j.nima.2026.171381