Accelerator Technology Group

The Accelerator Technology Group (ATG), one of the constituents of VECC, Kolkata is dedicated in advancing the R&D in Power Converters, Instrumentation, Superconductors, Magnet Coils, Transformers, Radiofrequency (RF) Systems, Embedded Controllers and Control Systems typically targeted to Cyclotron sub-systems but extends its scope to state-of-the-art energy storage systems, superconducting RF Linac cavity, neutrino physics experiments and radio-chemical process instrumentations as well.

The group has developed expertise on the winding of Superconducting coils and has indigenously developed the largest superconducting coil of the country for the centre's K-500 Superconducting Cyclotron (SCC) project, able to produce a magnetic field of 5.5 T, more than 100000 times the Earth's magnetic field. Along with this, the group's winding facilities has come up with novel facilities for developing high current water-cooled transformer, high voltage resin-cast transformer and high frequency ferrite core transformers and inductors. Currently the group, in the multidisciplinary collaboration environment of VECC, has explored the modern regimes of magnet designs and has indigenously developed and tested a hybrid magnet composed of a High Temperature Superconductor (HTS) coils inserted in the bore of a Low Temperature one as a part of the Superconducting Magnet Energy Storage (SMES) system project.

ATG has also been responsible for developments in the field of RF Systems for both K-500 SCC and K-130 Room Temperature Cyclotron (VEC). A solid-state wideband RF amplifier drives the final amplifier of the VEC (based on BURLE 4648 tetrode) that produces a maximum output power of 250kW. DC bias power supplies for the Filament (4V, 2000A DC), Control Grid (0 to -160V / 0.5A DC, 50ppm stability class), Screen Grid (1.2kV, 1A DC) and the Anode (0 to 20kV, 20A DC) has been indigenously developed by ATG. Tuning of the system (rated at 5.5 – 16.5 MHz) is achieved by panel movements (coarse) and motorized trimmer capacitor (fine) controls. Contrary to the single tetrode based design of VEC, the RF system of the SCC features a 3-ϕ system developed for the frequency range of 9 – 27 MHz with amplitude and phase stability of 100 ppm and $\pm 0.5^0$ respectively. Each dee along with half-wave coaxial cavity develops peak voltage of 100kV having fed with RF power (~80kW) from each of the three high power final RF amplifiers. Like main Dee-cavity, each amplifier is tuned by moveable sliding short. The amplifier (based on Eimac 4CW#150000E tetrode and operated in class-AB mode with power gain 22 dB) is given DC bias by indigenously developed power supplies, viz., Filament P/S (15.5V/215A DC), Grid P/S (-500V/0.5A DC), Anode P/S (20kV/22.5A DC) and Screen P/S (1.5kV/1A). A PC-based stepper motor controlled sliding-short movement system is used for tuning the cavities at different frequencies. The closed-loop amplitude and phase regulators are based on RF modulator and I&Q modulation technique respectively with Dee voltage pick-off signals being used as feedback. The entire supervisory control of the RF systems of both SCC and VEC is being done by independent Programmable Logic Controller (PLC)s, customized for the operation and status monitoring of the process parameters.

In addition to the abovementioned power supplies, the ATG has been regularly developing DC regulated Power Supplies, True Bipolar Power Supplies, Choppers, and Power Inverters of various power ratings, diverse topologies and precision classes to cater to general requirements of Electromagnets, RF Systems, Electrostatic Inflectors, Energy Storage Systems and Voltage Restorers.

Another facet of the group's activities centres on analog instrumentation designs for equipment protection. In addition to traditional comparator and relay based interlock systems, one of the important developments in this field was the quench protection system developed for the SMES project to safeguard the superconducting coils against possible catastrophic consequences of a quench. Fast acting crowbars (operating time ~ 2μs) were also significant contributions that were incorporated in the RF protection systems to avoid damage to the tetrode tubes in case of internal arcings.

In the prevailing age of digital designs, the group has also exploited fixed-point and floating-point DSP controllers and utilized them in design of digital feedback controllers for power converters. Besides these, the group has been developing microcontroller based embedded systems, configured in-house to incorporate functionalities such as serial communication, ADC and DAC interfacing, LCD based display designs, etc. Along with these, PC based Graphical User Interface (GUI)s were also developed for the purpose. The modular architecture, initially targeted for power converter units, has been generalized for its use in process control and automation as well.