1 MW, 352.2 MHz, CW and Pulsed RF Test Stand

M. K. Badapanda*, Akhilesh Tripathi, Rinki Upadhyay, Rajiv Tyagi and P. R. Hannurkar
Raja Ramanna Centre for Advanced Technology, Indore-452013

Abstract

A 1 MW, 352.2 MHz, RF test stand based on Thales make TH 2089 klystron amplifier is being developed at Raja Ramanna Centre for Advanced Technology (RRCAT), Indore for characterization and qualification of RF components, cavities and related subsystems. Provision to vary RF power from 50 kW to 1 MW with adequate flexibility for testing wide range of HV components, RF components and cavities is incorporated in this test stand. The paper presents a brief detail of various power supplies like high voltage cathode bias power supply, modulating anode power supply, filament power supply, electromagnet power supplies and ion pump power supplies along with their interconnections for biasing TH 2089 klystron amplifier. A digital control and interlock system is being developed to realize proper sequence of operation of various power supplies and to monitor the status of crucial parameters in this test set up. This RF test stand will be a unique national facility, capable of providing both CW and pulse RF power for realizing reliable RF power sources for various projects including the development of high energy proton linac under ADSS program of the Department of Atomic Energy.

INTRODUCTION

Advanced particle accelerators like high energy proton linac and rapid cyclic synchrotron consists of several complex subsystems, which needs to be tested extensively. RF system plays a vital role in these advanced accelerators and its reliability is of prime importance. To test and qualify various RF system and their components, a 1 MW, 352.2 MHz, RF test stand with CW and pulse capability is being developed at RRCAT, Indore. Major subsystems of this test facility includes Thales make TH 2089 klystron amplifier [1], its various power supplies, RF driver amplifier, waveguide transmission line, 3-port circulator and directional coupler along with their associated control interlock system.

Generally, klystron amplifier employs modulating anode power supply floated on its HV cathode terminal. Its control and monitoring of crucial signals become difficult due to the adverse influence of parasitic elements, reducing the reliability of the overall system. This paper presents a unique interconnection arrangement requiring a negative modulating anode DC power supply referenced to ground, in contrast to the standard practice of employing a positive floating modulating anode power supply. Suitable bleeder resistor is provided in this modulating anode power supply, which enables the mod anode to sink the intercepted electron current. Again as the waveguide transmission line, output window, collector and the body of klystron amplifier are at ground potential, it's filament has to be at negative high voltage to allow acceleration of electron beam into the collector. In principle, filament can be excited by AC as well as DC source, but AC filament excitation is reported to cause the RF phase as well as amplitude modulations, degrading the quality of RF output. To avoid RF modulations, a 20 V, 25 Amp current controlled DC filament power supply is employed for this test set up. The schematic of interconnection of various power supplies with TH 2089 klystron amplifier is shown in Figure 1.

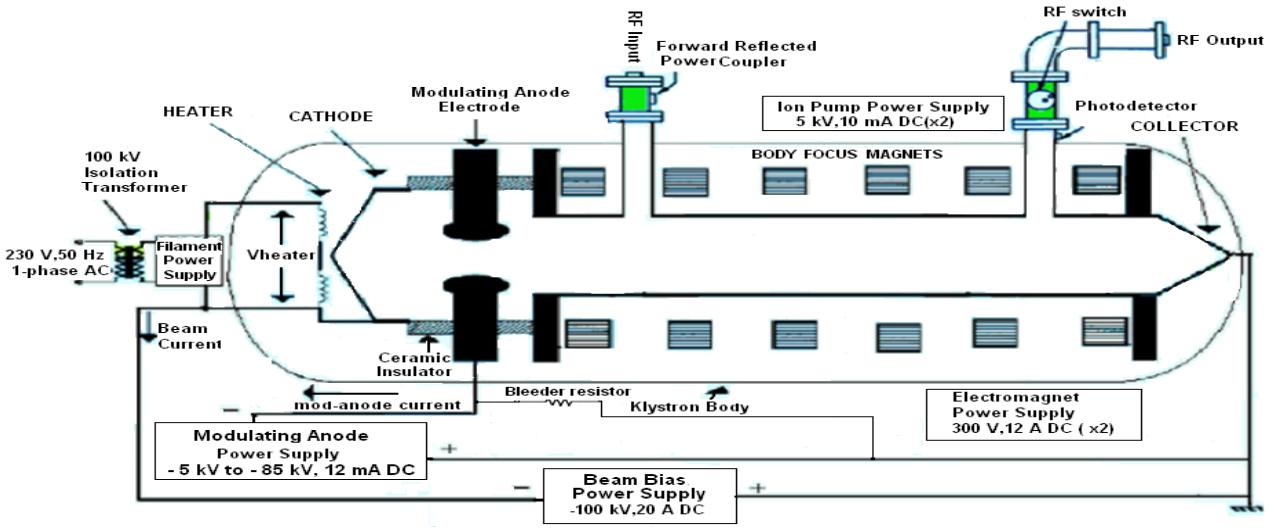

Figure 1: Interconnection of various power supplies with TH 2089 klystron amplifier

*mkp@rrcat.gov.in

POWER SUPPLIES OF TH 2089

1 MW, 352.2 MHz klystron amplifier requires various power supplies, which are listed as under.

(a) Beam Bias Power Supply: Solid state modular -100 kV, 20 Amp DC bias power supply with 24 pulsed input system to reduce the input line harmonics and improve the input power factor is adopted for this test set up. There are number of switched power modules connected in series and suitably staggered to minimize the output ripple, thereby avoiding crowbar for protecting klystron amplifier. This power supply demands stringent performances [2] and is the most crucial power supply in this test set up. It has got both DC and pulse capability which enables CW as well as pulsed operation of klystron amplifier.

(b) Modulating Anode Power Supply: An inverter bridge based voltage controlled -85 kV, 12 mA DC modulating anode power supply, referenced to ground, is employed in this test set up. Suitable high voltage bleeder resistor is provided to sink the intercepted electron current. Initially, -85 kV DC mod anode voltage is applied and after application of full beam bias voltage, mod anode voltage is adjusted to obtain proper beam current. A typical beam current versus modulating anode is shown in Figure 2. Again, the modulating anode voltage should be varied beyond -5 kV in order to provide the essential electrostatic focusing of electrons from the mod anode to the drift tube near the first cavity of the klystron amplifier.

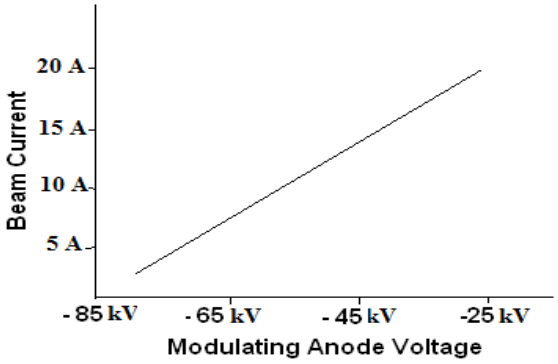

Figure 2:Variation of Beam current with modulating anode voltage

(c) *Filament Power Supply*: An IGBT buck converter based current regulated 20 V, 25 A DC filament power supply is designed and fabricated as the filament power supply. This power supply is floating at klystron cathode voltage of -100 kV DC. The filament current should be set as per the recommendation of the manufacturer to increase the life of klystron amplifier. If it is too low, field emission problem comes in to picture. On the other hand, with higher filament current, there will be increase in barium evaporation from cathode, which contaminates the gun structure reducing its life. As this is the only floating power supply in this test set up, suitable fibre optics based optical communication have been incorporated. The current stability of the filament power supply is observed to be better than 0.5 %.

(d)Ion Pump Power Supplies: Two numbers of high frequency inverter bridge based voltage regulated 5 kV, 10 mA DC ion pump power supplies are utilised for creation of vacuum level less than 10^{-9} mbar inside the klystron tube.

(e) Electromagnet Power Supplies: Two numbers of high frequency inverter bridge based current regulated 300 V, 12 A DC electromagnet power supplies are employed for proper focusing of the electron beam in the klystron amplifier.

For proper operation of klystron amplifier, these power supplies need to be operated in a particular sequence. First of all, ion pump power supplies are turned ON to ensure proper vacuum in the tube and when the ion pump current falls below 10 µA, filament power supply is turned ON in slow start mode. Then the electromagnet power supplies are turned ON. Subsequently modulating anode power supply and finally high voltage beam power supply is made ON. It should be noted that the modulating anode power supply is turned ON before high voltage beam power supply to ensure that the control action is present before the application of beam voltage. Reverse sequence is followed while tripping off the system. A digital control and interlock system is being developed to realize proper sequence of operation of various power supplies and to monitor the status of crucial parameters from a remote location.

COOLING

TH 2089 klystron's cavities and body are cooled by circulating water. The RF output window is coaxial type which is cooled by forced air. The collector is fitted with an integral water jacket and is cooled by hypervapotron method, which is more efficient in removing heat than standard laminar water flow.

CONCLUSION

A 1 MW, 352.2 MHz, RF test set up with CW and pulsed capability is being developed at RRCAT, Indore for the evaluation and qualification of advanced accelerator subsystems. Unique interconnection arrangement with a non floating negative modulating anode DC power supply is incorporated in this test set up. It has got wide flexibility, which will be very much useful for the performance evaluation of the various RF subsystems and their associated components. It will also act as a basic building block for 1 GeV proton linac of Accelerator Driven Subcritical System for generation of nuclear power.

REFERENCES

1. "TH 2089 Manufacturers data sheet," Thomson Tubes Electroniques, France.
2. M.K.Badapanda and P.R.Hannurkar, "Klystron bias power supplies for Indus-2 Synchrotron Radiation Source," *IETE Journal of Research* , 2008,vol 54, no 6, pp 403-412.