Design and Development Aspects of 250 kW C-band High Power Klystron

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Abstract: *Klystron is vacuum electron device operating in microwave range of frequencies. It is used as power amplifier in a variety of systems including radars, particle accelerators and thermonuclear reactors. With the availability of very reliable design codes, it is now possible to optimize the design and develop a tube with minimum iterations in fabrication. In the present case standard design codes like EGUN, CST Microwave Studio, AJDISK and MAGIC have been used to estimate and optimize different design parameters of klystron for desired tube performance. The paper presents the results of simulation and cold testing* of 250 kW CW C-Band klystron with specifications as given in Table1 is under development at CEERI, Pilani,. The proposed klystron to be used as a RF source for ITER program.

Table1 Specifications of 5GHz klystron

Parameters	Specification
Operating frequency	5 GHz
Output power	250 kW
Beam voltage	60 kV
Beam current	10 A
No. of cavities	6
Efficiency	>40%
Gain	>40dB

Electron Gun:

The Pierce type electron gun has been designed with spherical cathode. Typical electron beam trajectories with and without focusing field, computed using MAGIC-2D codes is shown in Fig. 1. The BFE-Cathode spacing in being optimized to get 10 amps current without any voltage breakdown between these electrodes.

RF Section :

AJDISK is a 1-D large signal code has been used for quickly estimating the basic design of klystron. Input needed to run the program include resonant frequency, Qs, R/Q, axial distance between the gap centers, operating beam voltage, current and The output of the program includes gain, output power, gap voltages, phase diagram and velocity dispersion diagram.

RF Window:

RF window is a critical component of all microwave high power tubes and is used on the output section of the device for the transport of microwave power from vacuum to external pressurized atmosphere. The desired features of an ideal window are: minimum reflection, minimum insertion loss, high power handling capability, wide bandwidth. The electrical design parameters for the window are: thickness, diameter and dielectric constant of alumina disc, diameter and length of waveguide etc The simulation has been carried out with ANSYS software.

Collector Design:

The main function of collector is to collect the spent beam. The electron beam that acquires kinetic energy through the acceleration in the gun, delivers part of its energy to RF field in the process of interaction in the RF section. The energy still left in the beam, which depends on the efficiency of RF interaction, is allowed to be dissipated on the collector resulting in heating of latter. The collector is designed to remove the heat efficiently thus produced. Thus thermal design of the collector in high power klystron plays a crucial role in overall design of klystron. Thermal simulation has been done by using ANSYS 11.0 (multi-physics). Cooling system for collector can be efficiently designed after getting the results of thermal simulation.

***Input and Output coupler*:**

The coupler modeling is done using CST microwave studio as shown in fig.17 in which a whole assembly of output cavity, coupler, step transformer and RF window is shown. To optimize the best coupling the dimensions of slot i.e length, width and depth are varied to different values to get the corresponding return loss to be 0.33 dB at 5GHz operating frequency. The measured results of input and output sections are well in agreement with simulated results.

Conclusion

A six cavity C-band klystron for 250 kW CW output power has been designed meeting desired specifications. Various subassemblies including electron gun, RF cavities, window, step transformer and collector have been separately designed using different software such as AJDisk, MAGIC, CST microwave studio and ANSYS. The cold test measurements on RF cavities and RF window , input and output couplers show good agreement with design values.