PERFORMANCE OF 5MW MICROWAVE SYSTEM FOR 20MeV PREINJECTOR MICROTRON FOR INDUS-I SRS

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Abstract

At Centre for Advanced Technology, CAT, Indore a 450MeV Synchrotron Radiation Source INDUS-I is in operation. A 20 MeV Microtron has been used as a preinjector for a 450/700 MeV Synchrotron for the 450MeV Storage Ring. Present paper describes the performance review of the 5MW S-Band Microwave System developed at CAT for the microtron. The microwave system has completed over 7years(more than 30,000- hours) of continuous and successful operation. A 5MW klystron is used as the final amplifier and a line type pulse modulator has been developed to supply up to 130kV peak anode voltage to the klystron. The drive signal to the high power klystron is supplied by a stabilized microwave source followed by a driver amplifier chain. The high power microwave to the microtron cavity is supplied from the output of the klystron by means of a pressurised wave- guide line(WR 284) incorporating a four port circulator, dual directional coupler, flexible wave-guide and microwave vacuum window. The paper describes various efforts exercised to shape the pulse output of the klystron modulator as well as other efforts to improve the overall system performance to suit the accelerator demand. Final results of the microwave system and the microtron are discussed

1 INTRODUCTION

The acceleration of electrons in the microtron is achieved by energizing the accelerator cavities by means of a microwave system, which supplies microwave power in the peak power range upto 5MW depending upon the energy and current requirement of the accelerator. The microwave power is supplied in pulses of 3.6 μSec duration repeating at 1-3 Hz. The microwave system is one of the most crucial systems for the development, operation and beam quality of the electron accelerator. Microwave system consists of a high power *klystron, pulse modulator* to energize the klystron and a wave-guide line for transmitting the high output power from the tube to the accelerator cavity. The wave-guide line consists of four port circulator, dual directional coupler, wave-guide pressurizing unit, microwave window and dummy loads. Pulse modulator is line type modulator consisting of a regulated high voltage DC power supply, charging choke, charging diodes, pulse forming network, thyratron switch and a pulse transformer whose secondary is connected to the device. The high power klystron needs driver amplifiers and a microwave generator.

2 SYSTEM DESCRIPTION

The 20MeV injector microtron, for needs upto 3.4MW peak microwave power. At this power level an electric voltage of 980kV is generated across the accelerating gap of the microtron cavity. Microwave system with a capability upto 5MW peak power has been developed and commissioned with the injector microtron(Fig 1). The performance results and main specifications of the microwave system are given in the table 1. The stable microwave signal is obtained from a synthesized signal generator at a power level of 10mW. The power from generator is amplified to 100mW by means of a solid state microwave amplifier so as to compensate for the losses in the microwave cables from control room to the driver klystron. The driver klystron amplifies this signal to 400 Watts, which is fed to main klystron by means of a microwave cable incorporating a microstrip line dual directional and a coaxial isolator. The main klystron amplifies the 200 W signal to 5 MW which, is then fed to waveguide transmission line for onward transmission to microtron cavity. The waveguide line incorporates a flexible waveguide, a four port `circulator terminated with water loads at its isolated ports, a dual directional coupler and microwave vacuum window . The most crucial component of the microwave system is the 130kV-pulse modulator (See Fig 2). The pulse modulator has been designed and developed carefully for device, component as well as human safety. The pulse modulator consists of a regulated high voltage DC supply (15kV), a charging choke, charging diodes, pulse forming network, high voltage thyratron and 1:10 pulse transformer. The pulse forming network is designed for optimum pulse shape and pulse transformer is a bifilar

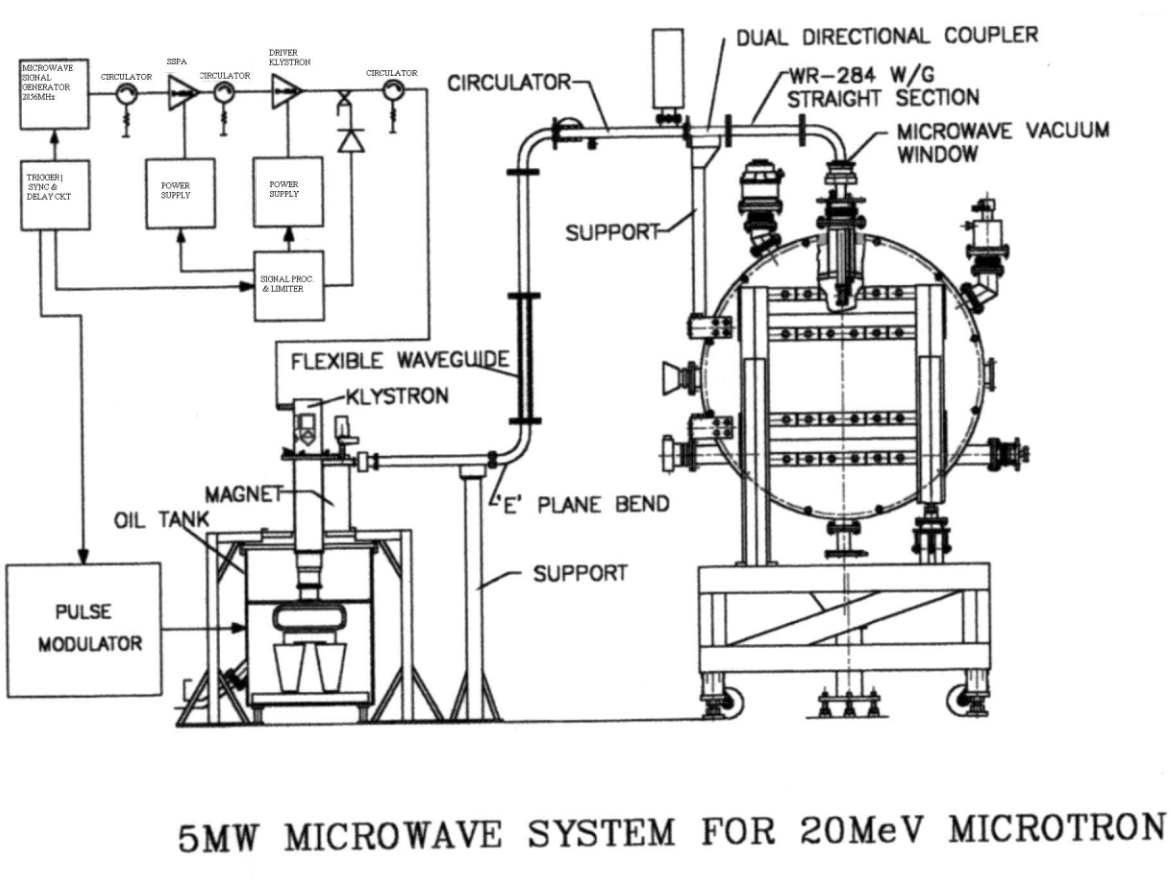

Figure 1: Schematic of 5MW microwave system for the 20MeV Microtron used as Injector for Synchrotron

wound with leakage inductance and shunt capacitances optimized for desired pulse characteristics.

Table 1
Specifications of the5MW microwave System for 20MeV Injector Microtron

Parameter		value
Peak output power	MW	5
Pulse duration	μsec	4
Pulse repetition rate	Hz	1-3
Klystron beam voltage	kV	127
Klystron beam current	A.	87
Rise time	μsec	0.5
Fall time	μsec	0.8

The modulator output pulse with the klystron impedance was improved by properly tuning the impedances of the individual sections of the pulse forming network. A hyperbolic correction in the impedances of subsequent sections of the PFN was introduced to compensate for the droop of the pulse transformer as well as to reduce the flat top variations of the modulator pulse. This way the maximum variations for present case restricted to 1% pk-pk which was found to be satisfactory for the present application. All the technologies related to the microwave system were developed at CAT. This includes the development of pulse forming networks, pulse transformers, complete interlock systems, thyratron trigger drives, high voltage capacitive dividers and pulse current transformers, klystron high voltage deck, driver amplifier, waveguide sections, dual directional couplers, microwave windows and high power water loads.

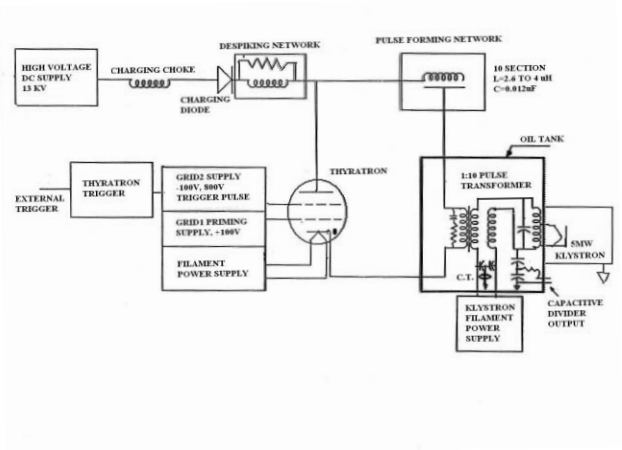

Figure 2: Klystron modulator Schematic

Figure 3: Photograph of assembly of the 5MW klystron and waveguide line with the Injector Microtron. On the back side is shown the klystron modulator.

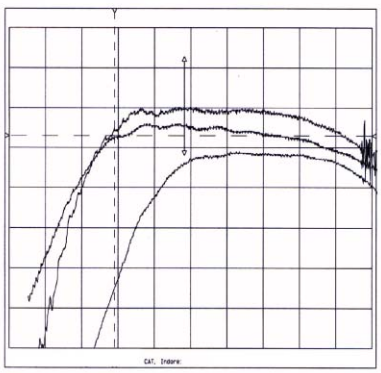

Figure : 4 See from top, traces of Klystron beam voltage at 110kV @10kV/div., klysron beam current and output microwave pulse power 2.6 MW delivered to microtron cavity

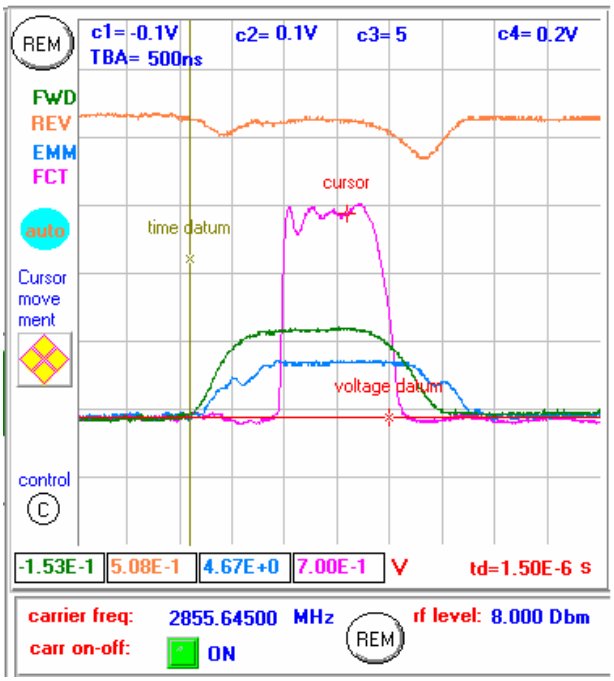

Figure 5 : See from top oscilloscope traces of reflected power from cavity, microtron output beam current 23 mA, microwave forward power detected pulse at 2.6 MW, and electron emission current from cathode 560mA. Horizontal scale is 500nS/Div.

During the operation of the microtron over the period of 30,000 hrs we had changed the 5MW klystron and driver one time. The pulse forming capacitors and the thyratrons have been replaced two times. The intervention time for maintenance due to component degradation is two to three times in a year.

3 CONCLUSION

Description of the 5MW klystron based system has been given. Pulse shaping of the modulator pulse resulted in improvement of the beam quality of the microtron. The microwave system has logged more than 30,000 hours of operating life over a span of 7 years. Presently the system is working in the 20MeV injector microtron for a 450MeV/700MeV synchrotron.

REFERENCES

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