AN S-BAND MICROWAVE SYSTEM FOR A 12 MeV MICROTRON FOR MEDICAL APPLICATIONS

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Abstract

A 2MW S-Band Microwave system has been designed for a 12MeV Microtron for the medical applications. The microwave system has been developed, tested and has been interfaced with the microtron. A 2MW magnetron has been used as a microwave generator. A line type pulse modulator supplies over 41kV pulses of 5 microsecs duration to the magnetron. The power to the microtron accelerating cavity is supplied through a pressurised waveguide line consisting of four port circulator, dual directional coupler, rotating joint, flexible waveguide and a microwave vacuum window. Details of each subsystem and performance results are described.

1 INTRODUCTION

A12MeV microtron for medical applications is under commissioning at CAT. The microtron needs upto 1.6 MW peak microwave power for achieving 12 MeV , 30mA electron beam. A type II cavity operating in E010 mode has been used. Cathode is indirectly heated LaB6 pallet. High emission of electrons from the emitter is due to Schottky effect under the influence of RF electric field. The main specifications of the medical microtron are summarized in Table 1. The complete microwave system for the microtron has been developed and performance specifications are brought out in table 2.

Table 1: Specifications of medical microtron

1. Type of Machine	Isocentric Dual mode
2. Therapy Mode	Stationary Beam Therapy & Dynamic arc Therapy
3. Type of Accelerator	Microtron
4. Electron Beam energy	6MeV, 9MeV, 12MeV
Beam current	50/30 mA
Dose rate	50 RAD/min. ty 500 RAD/min.
Field size	5×5 Sq.cm to 25×25 Sq.cm
5. Photon Beam energy	6MV, 12MV
Dose rate	50 RAD/min. to 300RAD/min.
Field size	0×0 Sq.cm. to 40×40 Sq.cm.
6. Energy spread	0.35% additional
7. Cathode Material	LaB6
8. Number of Orbits	14
9. Electromagnet Diameter	740 mm
10 .Magnetic field strength	1285/1928 Guass
11. Microwave Power	2MW
12. .Pulse width	2.5 μs
13. Pulse repetition rate	1 to 250 Hz.
14. Voltage in RF cavity	0.7/1 MV
15. Frequency of Operation	2998 MHz

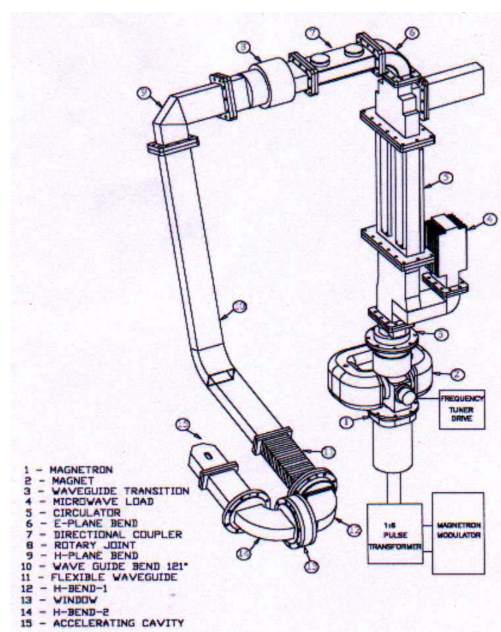

Figure 1: 2MW microwave system scheme

Figure 2: See From left Magnetron pulse modulator

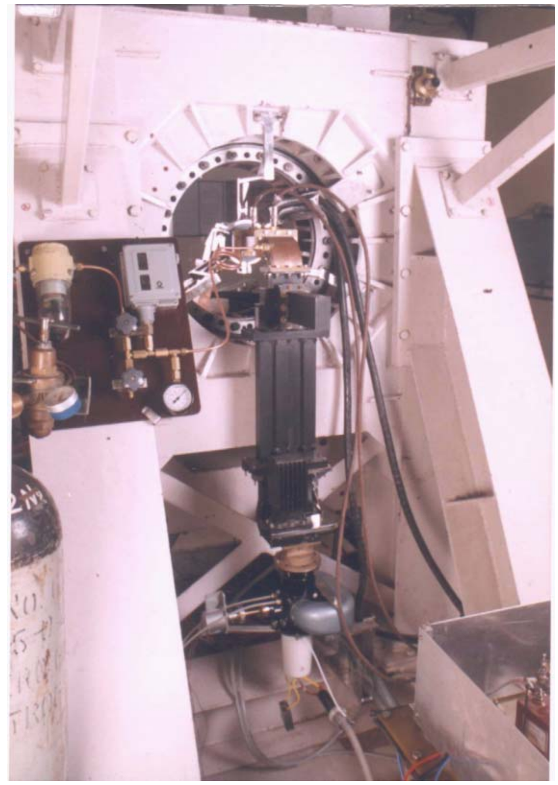

Figure 3: Assembly of magnetron and microwave waveguide line with gantry of medical microtron.

2 DESCRIPTION OF SYSTEM

The microwave system consists of 2 MW magnetron, 41kV output line type pulse modulator (with filament supply, control and interlock circuits), output waveguide circular to rectangular transition, high power circulator with isolation of 22dB and insertion loss of 0.2dB, waveguide pressurising section, dual directional coupler with forward coupling of 60dB and reflected power coupling of 45dB, waveguide rotary joint, waveguide bend sections, flexible waveguide and microwave vacuum window(see Fig. 1) . The waveguide line is

Table 2: Specifications of 2MW microwave system

Peak power output	2 MW
Frequency of Operation	2992-3002 MHz
Pulse duration	4 µsec
Pulse rise time	0.5 µsec
Pulse fall time	0.7 µsec
Pulse repetition rate	1-250Hz
Magnetron anode voltage	41kV
Magnetron anode current	100Amp.

pressurized to 30 psi with dry nitrogen. The response of a magnetron largely depends on the shape of the anode current pulse. The rate of rise of anode voltage for present magnetron is 110kV/microsecs to 120kV per microsecs. At this power level an electric voltage of 0.7/1 MV is generated across the accelerating gap of the microtron cavity. The most crucial component of the microwave system is the 41kV-pulse modulator. 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 (7kV), a charging choke, charging diodes, 12 section pulse forming network, high voltage thyratron and 1:6 step-up pulse transformer. Necessary interference suppression and damping circuits have been incorporated at various stages of the modulator. A 12 section pulse forming network has been used in which the capacitors are 0.012 microfarads each and the inductors are tunable.

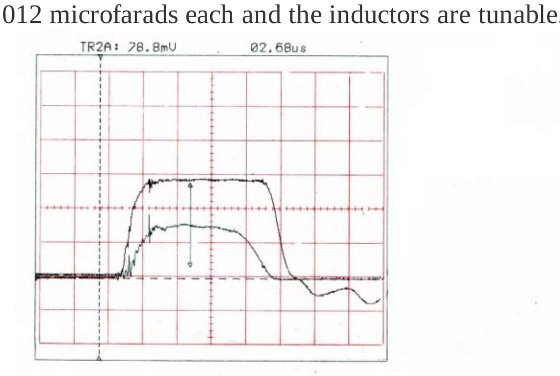

Figure 4: Upper trace is Magnetron anode votage pulse at 41kV and Lower trace is microwave pulse at 2MW power level on a microwave load horizontal scale is 1microsecs/div.

from 1.6 micro henry to 4 micro henry. Pulse transformer is bifilar wound with leakage inductance and shunt capacitances optimised for desired pulse characteristics. Ribbon wound core made from 100 micron thick CRGO material has been used. Flat top variations are kept minimum by adjusting the impedances of the individual sections of the pulse forming network. Most of the parts of 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, modulator damping circuits, waveguide sections, dual directional couplers, microwave windows and high power water loads. The modulator is constructed in a cabinet of size 1540mm heightx580mm widthx875mm depth. The magnetron frequency in controlled in two modes 1) Manual mode for initial commissioning 2) Automatic frequency control taking feed back from the reflected power from the microtron cavity.

3 RESULTS AND DISCUSSION

The microwave system has been interfaced with the microtron. Initial beam trials on the microtron have been started. System has performed satisfactorily upto the rated 2MW power level upto 250Hz repetition rate. Adjustments were done for shaping the pulse output of the magnetron. Internal probing of electron beam upto 14 orbits of microtron of t is under progress. Performance of the microwave line at various positions of rotating gantry has been checked and is found to be satisfactory.

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