ACCELERATOR PROGRAMME

Microtron Injector

A 20 MeV microtron, to be used as the injector for the 700 MeV synchrotron of Indus-I Synchrotron Radiation Source (SRS), has been designed and constructed at CAT. The assembled microtron shown on cover photograph is being commissioned and is expected to be operational soon. It has been designed to provide a 20 MeV electron beam with a current of 30 mA in pulses of 1 to 2 μs duration at a repetition rate of 1 to 2 Hz. The expected values for beam energy spread and transverse emittance are 0.2% FWHM and 3π mm mrad respectively. These characteristics are adequate to achieve a current of around 20 mA in the synchrotron at extraction energies. The various subsystems of the microtron have already been individually tested and made operational.

Development of microtrons for medical and industrial applications has also been taken up. Various subsystems of a 8 MeV microtron being developed for radiation damage studies on samples irradiated to high integrated dose have already been fabricated.

R.F. Amplifier for Indus-II

The 2 GeV SRS Indus-II requires 189.6 MHz, 70 kW RF amplifiers for its cavities. For indigenous development of these amplifiers, a modular design approach has been adopted. The amplifier consists of three stages. In the first low power stage, a 600 W amplifier driven by an inbuilt solid state source is used. This amplifier drives a 15 kW amplifier which constitutes the second stage. The 15 kW amplifier then drives the third stage of two 35 kW amplifiers whose outputs are combined to achieve the 70 kW of RF power.

The 600 W amplifier will be made by combining outputs of two 250 CX tetrode tube based amplifiers which have already been made and tested. A quadrature bridge combiner to be used to combine RF power has been designed and is under fabrication. For the input of the amplifier a Wilkinson type splitter has been made and tested at 50W and the bandwidth has been found to be an octave.

For 15 kW amplifier, a 15000 CX tetrode tube and a coaxial cavity will be used. The fabrication of this amplifier is in progress. The output of the amplifier is split using a quadrature bridge splitter and fed to the last and third stage of two 35 kW amplifiers. For 35 kW amplifiers CR 1653 tetrode tubes will be used and outputs of these amplifiers will be combined in a quadrature bridge coupler.

DEVELOPMENT OF FERRITES FOR ACCELERATORS

The Synchrotron Radiation Sources being developed at CAT requires a wide variety of magnets and other critical components (high frequency transformers, microwave devices, pulsed beam current monitors etc.) which need magnetic materials with fast response (30-50 ns) and low magnetic losses. Ferrites are the magnetic materials of choice for these applications.

Ferrites are mainly a mixture of ferric oxides with different combinations of divalent metal oxides. Their technological importance lie in their high electrical resistivity which allows operation at high frequencies without appreciable eddy current losses. Though high quality ferrites required for consumer electronics products are produced by Indian industries, special ferrites required for the development of accelerator sub systems were not indigenously available. Since ferrite parameters are strongly influenced by method of preparation, their preparation requires elaborate and sophisticated intrumentations. Development of the special ferrites has therefore been taken up at CAT in collaboration with Solid State Physics Laboratory, Delhi, M/s Winner Electricals, New Delhi and M/s Morris Electronics, Pune. These institutions are already equipped with the required facilities. In the present article we provide a brief overview of the succesful indigenous development of some of the special ferrites required for accelerator programme at CAT is presented.

Ferrites for Kicker Magnets

Synchrotron requires kicker magnets with fast magnetic response (~30-50 ns) to inject or extract the electron beam. Since the kicker magnets have to be inside the vacuum enclosure they should be compact and vacuum compatible (i.e. they should have low outgassing rate and should be bakeable to 300°C). The Ni-Zn-Co-Cu mixed ferrites meeting these specifications have been developed. Special techniques with low sintering temperature (~1000°C) and long sintering time were used for this purpose. Kicker magnets using various sizes of ferrite slabs have been fabricated. The injection kicker magnet will be excited with a half sinusoidal signal of 1000 A peak current, 12 μs width at 1 Hz. repetition rate. The measured pulse response of the injection kicker magnet is shown in fig.1.

Pulsed Beam Current Monitor

Measurement of pulsed currents requires ferrites with high pulse permeability. For this purpose high frequency, high permeability (>2500) Mn-Zn-Ni ferrites were developed. In order to measure the injected current (~30 mA, 2μs pulse width, 1Hz repetition rate) in the microtron - booster synchrotron transfer line, a current monitor with large circular aperture (90 mm) was made using the ferrite toroids (120mm x 100mm x 15 mm) developed indigenously. Fig.2 shows the monitor developed along with the measured current response. The measured sensitivity and rise time were ~0.02 V/mA and ~ 60 ns respectively.

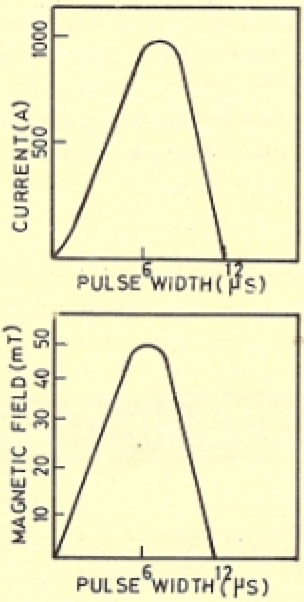

Fig. 1. Excitation current wave form and magnetic field response of the injection kicker magnet.

Ferrite Magnets for Sputter Ion Pumps

A large number of sputter ion pumps are required in the SRSs to achieve ultrahigh vacuum conditions. These need to be baked at 300°C along with the vacuum system. The permanent ferrite magnet used in the pump should therefore be capable of withstanding repeated thermal cycles. The oriented strontium ferrites required for this purpose have been developed. The strontium ferrite is composed of SrO and Fe_2O_3. Their homogeneously mixed powders were processed by ceramic techniques and the slurry was pressed as slabs in a magnetic field (~10kO_e) oriented parallel to the thickness of the slab. Ferrite slabs of size 156mm x 102mm x 12.7mm were fabricated.

The sputter ion pump magnetic circuit made from these magnet slabs have been tested for repeated temperature cycling and found satisfactory.

Ferrites under development

Development of some other important ferrites has also been taken up. Mn-Zn-Ti-Sn mixed ferrites have been developed for use in high frequency (~500 kHz) switched mode power supplies and found to exhibit good switching characteristics under full load conditions. Large (120mm x 100mm x 25mm) U-U cores of this ferrite are under development.

Yittrium Iron Granet (YIG) ferrites are under development in collaboration with Solid State Physics Laboratory, Delhi. These will be used for making three port Y - Junction waveguide circulators (2 MW peak power) and four port differential phase shift ferrite circulators with 5 MW peak power.

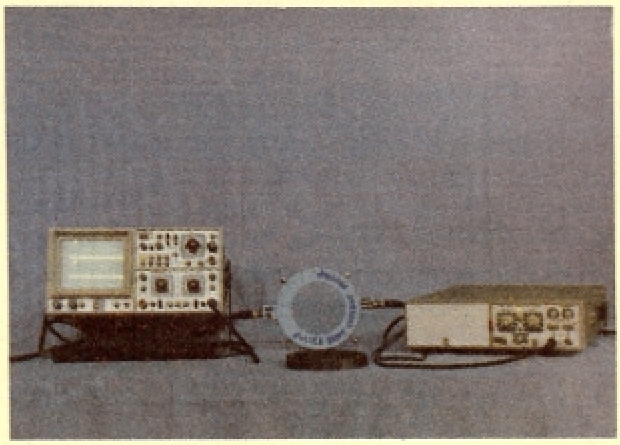

Fig. 2. Pulsed beam current monitor developed at CAT.

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