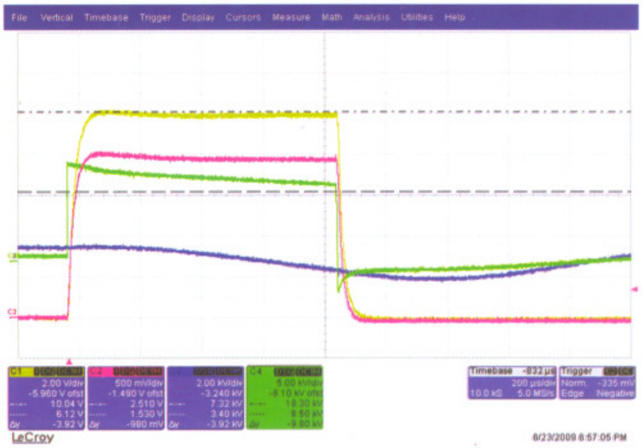

Fig. A.7.3: Testing of modulator at resistive load. Waveforms from top indicate output voltage 104kV@20kV/div, output current@5A/div, primary voltage referred to ground, and bouncer voltage respectively.

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A.8: Development of 1.3 MW, 352.2 MHz Pulsed Test Stand at RRCAT

At RRCAT, several research and development activities are being persued towards realisation of high power pulsed RF technologies for contributions towards the international collaboration projects (like DAE CERN Collaboration in NAT Projects) as well as the domestic projects like H^- ion injector LINAC for future SNS at RRCAT. In order to qualify the subsystems, electronics and components, RRCAT has built a pulsed 1.3 MW, 352.2 MHz test stand. It is built around the LEP klystron obtained from CERN under India CERN Collaboration. The overall test stand consists of a signal generator, a 300 W solid state pulsed driver amplifier, the 1.3 MW LEP klystron, 110kV solid state bouncer pulse modulator and output WR 2300 waveguide system. The waveguide system consists of harmonic filter, dual directional coupler, three port circulator, flexible waveguides, magic tee power divider chain and RF loads.

The other auxiliary power supplies for the klystron like the filament power supply, solenoid power supply and the ion pump power supply are also incorporated. The major specifications of test stand are listed in Table 1. Fig.A.8.1 shows the photo of the test stand constructed at RRCAT. Fig.A.8.2 shows the modulator and control system, Fig.A.8.3 shows the wave guide components developed at RRCAT. Fig.A.8.4 shows the test results.

Table A.8.1. Specifications of the 1.3 MW Test Stand at RRCAT

Parameter	Value	Unit
Peak Output power max.	1.3	MW
Operating Frequency	352.21	MHz.
-1dB Bandwidth	±0.8	MHz.
High Voltage pulse width measured at 70% to 70 % of peak.	800	μsec
Waveguide System	WR 2300	
Energy dissipation limited in klystron during klystron arc	<10	J

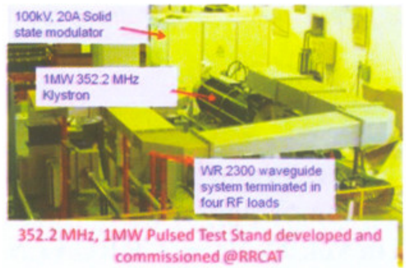

Fig. A.8.1: 352.2MHz, 1MW pulsed test stand commissioned and tested at RRCAT.

Fig.A.8.2: Modulator and controls for test stand

Fig.A.8.3: Some of the WR 2300 waveguide components viz., straight FH and HH sections, coaxial to waveguide transitions, F/H taper transitions, developed at RRCAT.(courtesy Mr. A.K. Jain, Mr. S.D. Sharma, Mr. V. K. Bhatnagar, ACEPD).

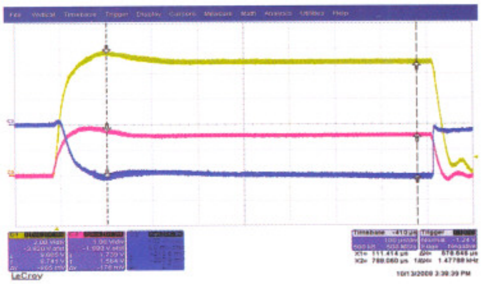

Fig.A.8.4: Traces from top show the klystron anode voltage @20kV/div, klystron anode current @10A/div and 1.3MW, 352.2 MHz, pulsed power output from the CERN LEP Klystron.

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Erratum in Accelerator Report A.10: Induction Heating Power Supply for MOVPE System, published in Vol. 22, Issue 2, RRCAT Newsletter (2009).

We deeply regret that the Fig.A.10.1 of the above-mentioned report published in the previous issue of RRCAT Newsletter was wrong. Also, the aspect ratio of Fig. A.10.2 had changed by mistake. We are therefore publishing this report again in this issue of the Newsletter in correct form.

(Editors, RRCAT Newsletter)

A.9: Induction Heating Power Supply for MOVPE System

A 25 kW/ 25 kHz induction heating power supply for MOVPE system in Semiconductor Laser Section, Solid State Laser Division, RRCAT has been developed based on a novel high-frequency LCL-T resonant inverter. It is required to heat graphite susceptor to 1200° C.

Conventionally, voltage-source series resonant inverter (SRI) and current-source parallel resonant inverter (PRI) schemes are used for induction heating. While design of matching transformer is difficult in SRI (since the current in induction heating coil flows also through the transformer secondary) and bulky inductor is required to realize input current source in PRI, the proposed scheme using LCL-T resonant converter offers many advantages: The converter offers high current gain, which in turn reduces the current rating of the secondary winding of matching transformer and the feeder to the coil. The coil current is constant irrespective of changes in effective load resistance due to temperature or work-piece change. Transformer design is further simplified since its turns ratio is no longer dependent on the Q of the resonant network.

Schematic diagram of the developed induction heating power supply is shown in Fig. A.10.1 A two-stage conversion strategy is adopted. The first stage is a dc-dc buck converter with lossless turn-on and turn-off snubbers, which receives unregulated dc input voltage from a three-phase diode bridge rectifier (not shown in Fig. A.10.1), and the second stage is the free-running LCL-T resonant inverter. Work coil acts as one of the resonant inductor in the LCL-T resonant network and the second resonant inductor is integrated as the leakage inductance of the matching transformer. Water-cooled resonant capacitor is placed near the work coil to minimize the loop of high reactive current (700 A rms) circulating in the work coil. This way, only active current flows in the transformer secondary winding and the feeder to the coil (typically, 70 A rms), greatly simplifying their design. A phase-locked-loop is implemented to track the resonant frequency change with time and temperature. The power supply is housed in standard 24 U rack. Fig. A.10.2 shows the photographs of the power supply being tested in the lab to heat graphite block in air to 1200°C.

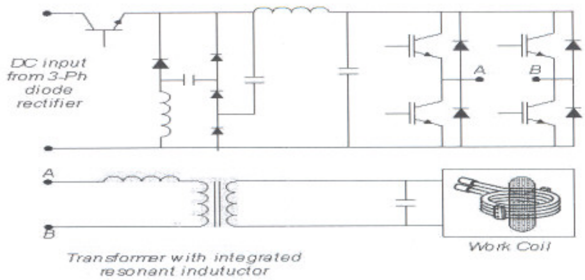

Fig. A.10.1: Schematic of induction heating power supply.

(a)

(b)

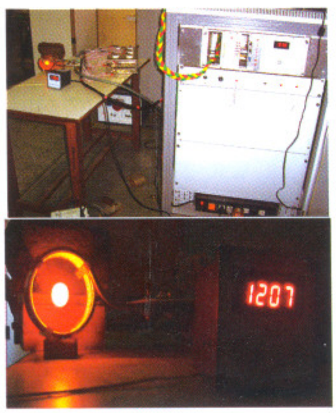

Fig. A.10.2: Photographs showing (a)The induction heating power supply and (b) A graphite block heated to 1200°C.

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