The RF System for the LNLS Synchrotron Light Source

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Abstract

The RF system for the 1.15 GeV storage ring was designed, built and tested at the LNLS. The system is designed to deliver 60 kW CW at 476 MHz. The transmitter comprises a 160 kW, 25.5 kV DC power supply, auxiliary control and protection circuits and uses a commercial TV klystron with external cavities. A description is given of the low power RF system, the klystron control loops and cavity tuning and gap voltage control circuits. A one-cell RF cavity was designed, machined and brazed. It has three wave guide dampers to reduce HOM instabilities and a wave guide-cavity coupler with movable short to adjust the coupling factor.

I. INTRODUCTION

The LNLS synchrotron light source, under construction in Brazil[1], will operate with beam energies in the range of 1.15 to 1.37 GeV. A single-cell cavity tuned at 476 MHz will be installed in the storage ring. The RF system was specified and designed to deliver 55 kW at the cavity input coupler (produced by a 62 kW CW Klystron), which should allow storage of up to 400 mA of beam current. The RF system main parameters are:

Maximum power: 62 kW CW
Frequency: 476.000± 0.1 MHz
Cavity shunt impedance: 3.5 MΩ ($P=V^2/2R_s$)
Unloaded Q: 30.000
Peak cavity voltage: 500 kV
Coupling: continuously variable up to 1.5.

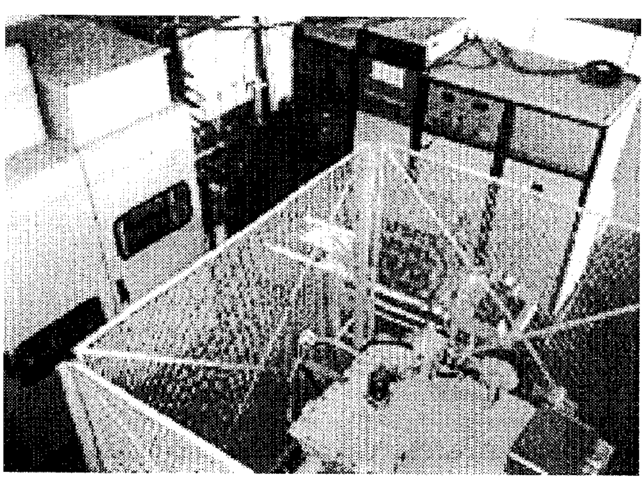

Figure 1: Transmitter test area.

II. RF POWER SYSTEM

A. Transmitter.

Fig.2 shows the transmitter test area. The power amplifier is a Philips Klystron model YK 1265 with 4 external cavities tested at 62 kW with a 36 db gain and 43% efficiency.

The power source was designed according to the requirements of the Klystron. It supplies 25.5 kV @ 6A. It has a 12 pulse rectifier with an LC filter which provides an attenuation of 46 db for voltage ripple and 27 db for maximum line voltage unbalance. Voltage regulation is obtained by means of a 3 phase booster connected in the primary windings of the HV transformer. The primary of the booster has a motor-driven variable transformer run by a feed back voltage loop which gives a 1% stability for slow line voltage variations. This corresponds to 5° phase stability between the master generator and the klystron output. A fast phase shifter, acting on the drive circuit reduces the relative phase to less than 1°. The general picture of the power supply is shown in fig. 2

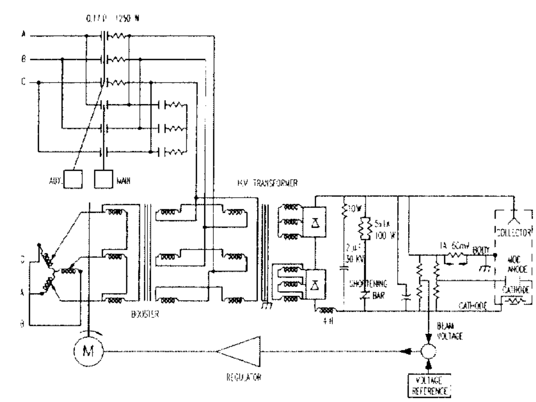

Figure 2: Schematics of the Power Supply.

B. Low Power RF.

A schematic diagram of the low power RF driver and of the different control loops is shown in fig.3. The power input is generated from a high stability, low noise master oscillator with a frequency of 476.000±0.015 MHz, a linac sub-harmonic. From the master generator, using a series of

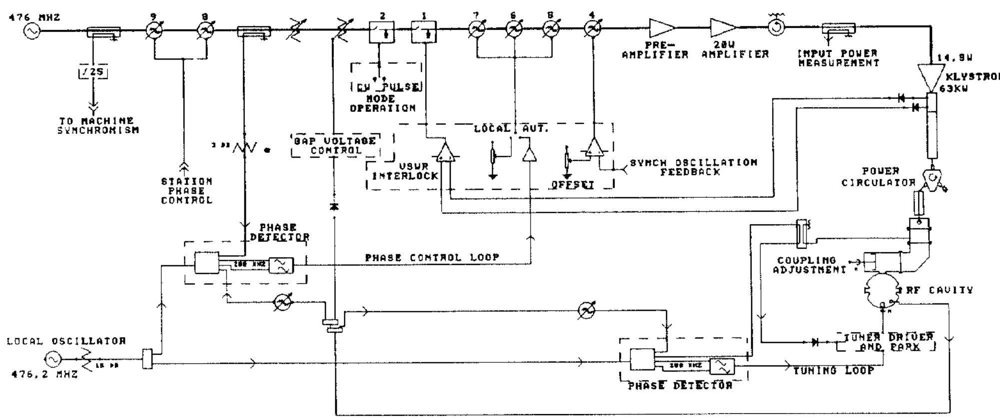

Figure 3: Low power RF system.

frequency dividers, a 19.04 MHz signal for the general machine synchronism is produced. A chain of electronically controlled phase shifters, attenuators and amplifiers is used between the master oscillator and the Klystron input to control the phase and amplitude of the RF delivered into the cavity. There are 2 separate heterodyne phase loops. The first one keeps the difference between klystron and master phases within 1°. The loop amplification has a unit gain band width at 1 kHz, it corrects the 720 Hz power supply ripple and is well below the synchrotron frequency at 32 kHz. A second loop is used to compensate the cavity temperature drift and beam loading. It compares the cavity voltage phase with the klystron current phase and acts, via a step motor, on the cavity plunger. Separately there is an amplitude loop. The cavity voltage is monitored and compared with the gap voltage reference. The result acts on an electronically controlled variable attenuator which corrects the klystron driver.

III. RF CAVITY

In a previous paper[2], a prototype design for the LNLS RF cavity was reported. It is a reentrant type cavity with 3

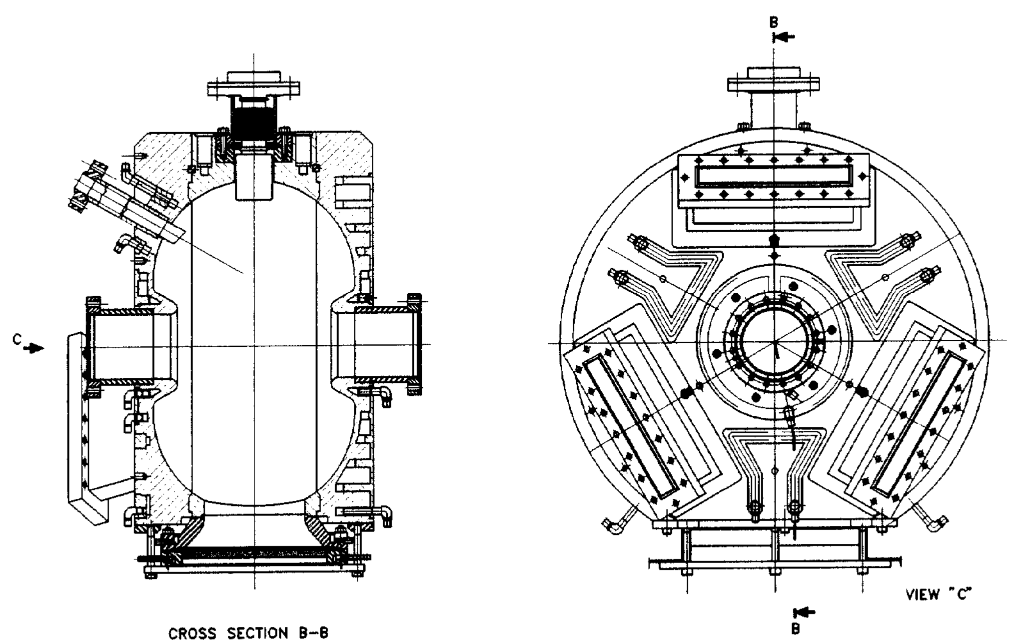

Figure 4: Design of the RF cavity.

ports located around the equatorial plane: the RF input aperture coupler, a mechanical tuner and a 45 dB RF monitor. On one of the sides it has three wave guides 120° apart, symmetrically located around the axis, for HOM damping. Tests performed with a full size prototype have shown that Q values of the longitudinal and transverse HOM are strongly reduced, while the fundamental mode is slightly altered. The design and construction of the RF cavity demanded the solution of several problems not taken into account for the prototype. The cavity cooling system was calculated to dissipate 60 kW. Special consideration was given to localized high temperature areas, as identified in the study made for the PEP B Factory[3], thus, the cavity was designed to have strong cooling of the areas near the wave guides intersection with the cavity wall. The cavity ceramic window, a 12 mm thick disk, alumina 99.5%, brazed to a conflat stainless steal flange, was located away from the high field regions. To compensate for the reduction in the input coupling, the input wave guide has a slight bump in front of the ceramic window. A movable short permits a continuous adjustment of the coupling from a maximum value of 1.5.

The cavity was built out of a ASTM B170 grade 2 (OF) ingot, produced in the local market. Chemical analyses and fragility tests made on the copper indicated < 10 ppm of O_2. The ingot was afterwards forged to reduce porosity. The cavity body was machined in three separate pieces: a central cylindrical body and two shells with cooling channels as shown in fig. 4. After machining and assembling, a preliminary tune measurement was performed. Measured resonant frequency was 50 kHz off specified value. Brazing was done in a vacuum furnace (10^{-6} mbar) with a filler at 1567°F. At the time of writing this paper, brazing of the cavity was under way. Figure 5 shows the mounted cavity before brazing.

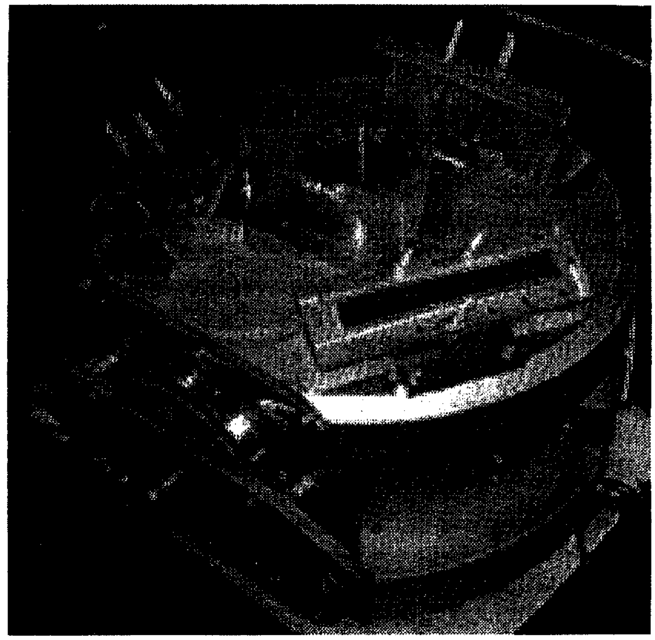

Figure 5: RF cavity mounted for brazing.

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IV. REFERENCES

[1] A.R.D.Rodrigues and C.E.T.Gonçalves da Silva, "LNLS Status Report", in these proceedings.

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[3] H.D.Schwarz et al,"Design of a High-Power test model of the PEP-II RF Cavity", PAC 93 Proc.,p1039.