The Low Level RF System of ELETTRA.

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Abstract

The Elettra RF cavities have been successfully operated at full power. The low level distribution and the feedback loops around the cavity have been completed to the operating configuration and some measurements have been performed. The results are presented here. The behaviour of the system in the presence of the electron beam has been examined and future improvements are discussed.

1. INTRODUCTION

The Elettra control loops around the RF cavities [1] have been installed in the Elettra storage ring. The data on the final working configuration is presented, together with considerations arising from the first months of operation. The frequency control loop can be considered at its definitive setting, on the amplitude loop, that worked properly, we will reduce the time constant after a more detailed study of the interaction with the fast phase control loop, whose prototype has already been successfully tested on the machine.

2. THE FREQUENCY CONTROL LOOP

The mechanical tuning of the RF cavities allows to operate the plant at the fixed frequency chosen to compensate for the beam loading effect. This is obtained with an elastic deformation of the RF cavities in the direction of their axial symmetry, as already described [1].

The phase detection is made by comparing a reference signal, with the signals coming from two loops, opposite in phase, coupled -40 dB to the RF in the accelerating cavity. The sensitivity of the phase detector is 10 mV / deg and it has been tested to have a stability of 1 deg for 50 °C of temperature variation.

The DC amplifier gain is approximately 130 and has a 30 KHz bandwidth.

The choice to make the tuning motor work at a fixed speed led us to adopt a Schmidt trigger circuit followed by a differential amplifier. The motor runs at almost 3000 turns per minute and the demultiplication by 224 brings the correction speed to 700 Hz / sec, which means about 3.5 deg / sec; the motor control leads the motor to full power in 50 msec. The correction speed has been chosen taking into account the interaction with the water cooling system of the cavity [2]. A non secondary problem was represented by vibrations transmitted by the motor itself to the cavity, by means of the motor bearing and by the drive belt; these were solved using PVC vibrations absorbers and controlling carefully the tightening of the belt.

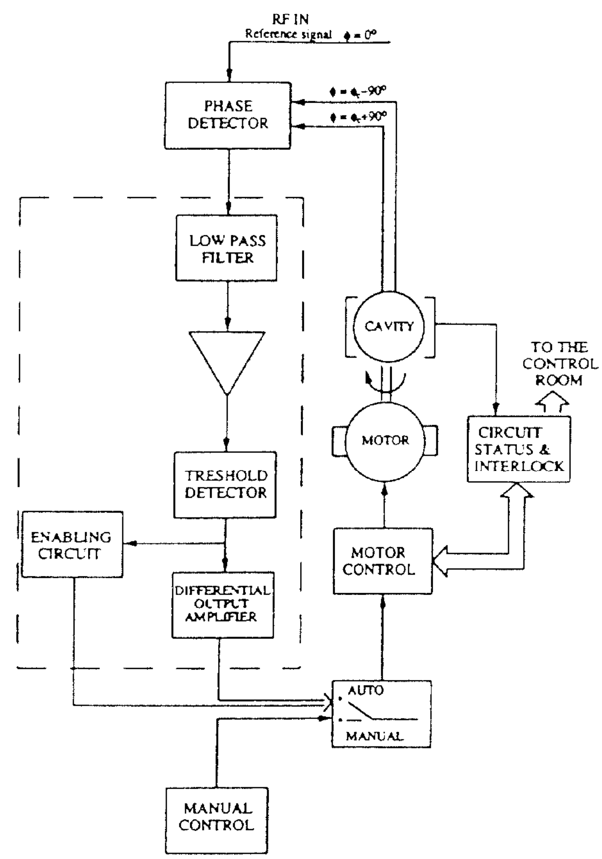

Fig. 1 Block diagram of the frequency control loop

3. THE AMPLITUDE CONTROL LOOP

The voltage amplitude at the gap of the cavity must be kept constant to less than 1% of the set value. Since we wanted to keep the amplitude loop [1] always in operation, from zero voltage to the nominal gap voltage, the choice of a rectifying diode the more linear as possible over the full scale was readed, in order to get a constant operating performance of the whole system. A fast response requirement suggested the adoption of a full wave rectifier.

The DC amplifier can be synchronized by an external signal to inhibit the operation of the loop during short RF interruptions (5 msec). This was done to allow for a fast beam killing induced either by the interlock system to protect the ID vacuum chamber or by the control system to allow injection efficiency studies.

The possibility of switching the amplitude loop on and off either in local operation or from the remote control was foreseen and a PCB was made and successfully tested on bench.

The stability measurements have been performed using a Dynamic Signal Analyzer HP 3562A which allows to get the Bode plot of the open loop frequency response, by means of a simple algebric tool, letting the control system work in the closed loop configuration. For this purpose a summing device has been developed and inserted in the closed loop, which assures unit gain and minimum phase rotation, that is minimum perturbation to the normal operating conditions.

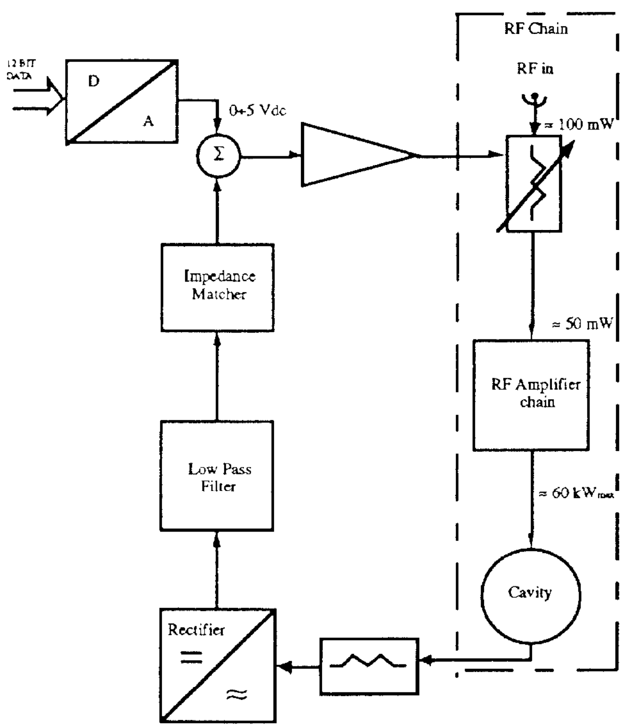

Fig.2 Block diagram of the amplitude loop

The first measurements on the amplitude loop showed a DC gain equal to 40 dB with a phase margin of 50 deg at 10 kHz, but the first tests with the beam [2] induced us to slow down the response speed and the open loop response is shownn in fig. 3

The loop is working properly over full power scale, from 0 to 60 kW of RF power from the amplifier. The former configuration led to what it was thought to be a perturbative interaction with the syncrotron oscillation period and we expect to study extensively the phenomenon in the future for a proper setting of the loop parameters.

It is worthwhile mention also that at the time of the first tests the phase loop was not yet available.

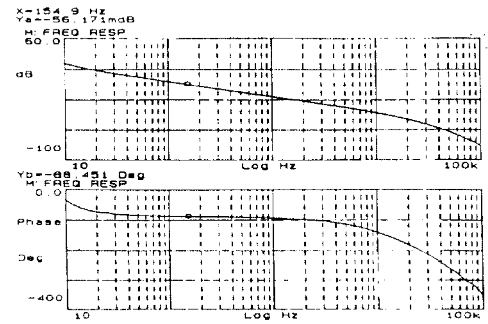

Fig. 3 Amplitude loop open circuit response

4. THE FAST PHASE CONTROL LOOP

The fast phase loop [1] is able to keep the RF phase in the cavity stable in a ± 0.5 deg range against 20 deg of phase modulation.

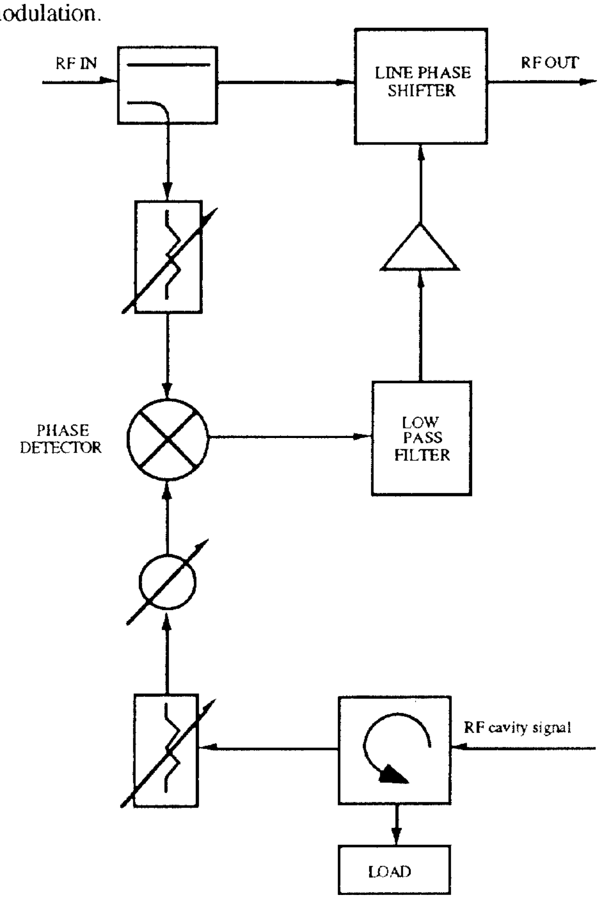

Fig. 4 Block diagram of the fast phase loop

As a phase detector we chose a mixer device which allows a rather constant sensitivity against large power variations at the RF input: 11.3 mV / deg at 6 dBm 10.6 mV / deg at 13 dBm.

The phase modulator has been slightly changed from the previous design [1] to minimize the insertion loss and the new model is sketched in figure 5.

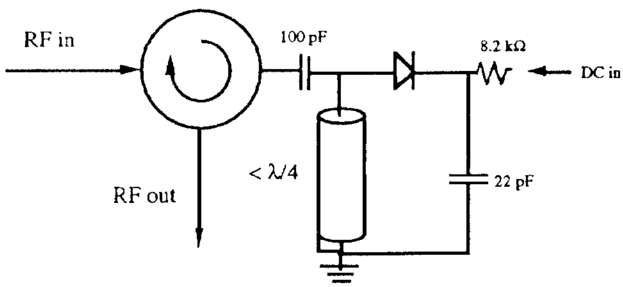

Fig. 5 Line phase modulator

The measured insertion loss is 0.04 dB in the full range of variation (± 20 deg), leading to VSWR < 1.01. The phase characteristic is linear in the useful range and equal to 1 deg / 26 mV.

Stability measurements have given satisfactory results, showing a DC gain of more than 20 dB and a phase margin of about 25 deg at more than 90 kHz.

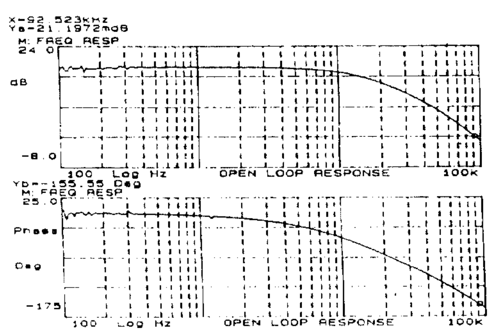

Fig. 6 Phase loop open circuit response

With this configuration some preliminary tests with the electron beam have been performed and the expected phase stability was kept during an injection of 140 mA distributed in 15 buckets [2].

The construction of the control loop circuits and mechanics is in progress, some adjustments are foreseen in the parameter configuration as soon as it will be possible to make a systematic study of the beam - phase loop interaction.

5. CONCLUSION

A satisfactory setting of all the control loops around the ELETTRA cavities has been achieved [2], allowing good operation of the synchrotron light source RF system during the whole commissioning time.

We foresee to get a better operating condition of the control system, considering the three control loops plus the water temperature control as a whole, as soon as extensive tests on the beam - cavity interaction will be possible.

6. ACKNOWLEDGMENTS

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REFERENCES

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[2] A. Fabris, G. D' Auria, A. Massarotti, C. Pasotti, C. Rossi, M. Svandrlik, "Operation of the RF System During the Commissioning of ELETTRA", this Conference.