

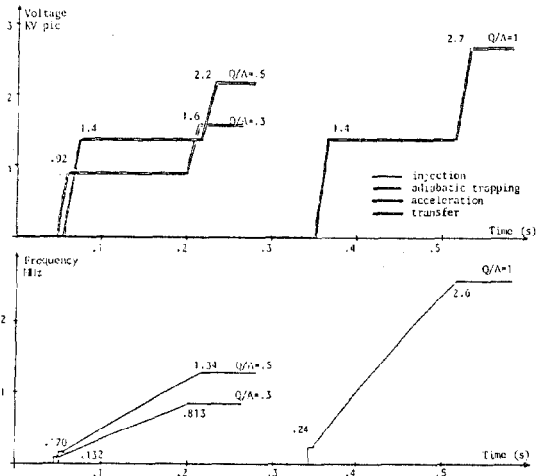
RF SYSTEM FOR "MIMAS"

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1. Introduction

Heavy ions injector project for SATURNE II, MIMAS, is planned to accumulate and accelerate several pulses from the cryogenic ion source CRYEBIS, and to inject the beam at 5 MeV/nucleon in the main ring. The RF MIMAS parameters have been chosen, after 1st harmonic acceleration, and fast extraction by kicker magnets to introduce the beam inside one of the three stable synchrotron spaces of Saturne.

That fixed the requirements on the MIMAS radio frequency system. The main RF characteristics are given on the following diagrams.



2. General description of the RF system

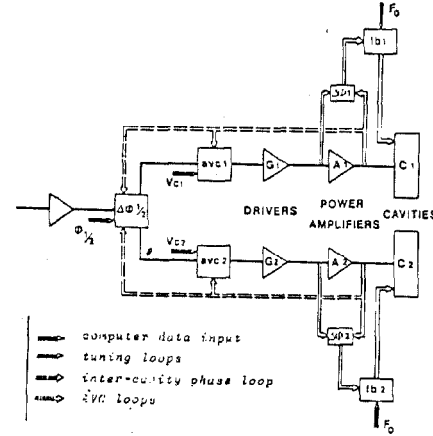
The recent experience on the SATURNE II building, and some maintenance considerations brought us to choose for MIMAS a similar RF chain, in the design and in the components.

The very large frequency range (factor 20) and the low start frequency (132 kHz) require the use of cavities loaded with very high permeability ferrite. Consequently, the RF losses in the ferrites are too high.

In accordance with the available intervals along the ring, two cavities are needful to work under the ferrite dissipation and induction limits.

The voltage law is given by the "RF High level chain". It is composed by two identical ways, one for one cavity, with the cavity itself, the amplifiers, tuning system and voltage regulation. These two ways are phase locked. (Fig. 2)

The frequency law is defined by a voltage to frequency converter, driven by the MIMAS dipoles magnetic field. It is programmed in accordance with the accelerated ion and corrected in real time by analog position regulation.



3. Ferrites choice

The cavities and amplifiers characteristics depend, for the main part, on the ferrites quality. So a great measurement number was made, on several samples from different origins (TOSHIBA M410, M4A5, TDK C1, C2, C3, C4, Phillips 4F2, 8C12, 8C14).

These measurements, and others commercial considerations, brought us to prefer the TDK C3 ferrite, though its data are very far from the required.

TDK C3	Main datas	real	wished
outer diameter		53 cm	50 cm
inner diameter		35 cm	30 cm
thickness		3	2.5 cm
remanent μ		1800	> 2000
initial μ at 130 kHz		2100	> 2500
dielectric constant		20	> 5
quality factor at 1 Gauss and 130 kHz		12	
at 300 Gauss and 130 kHz		5	> 5
at 15 Gauss and 2.6 MHz		40	> 100
polarization field for /400		24	< 30 oersted
dissipation capability		> 1 W/cm ³	0.1 W/cm ³

We took in and tested 100 toroids in small size (1.2 - 7.5 - 4.5 cm).

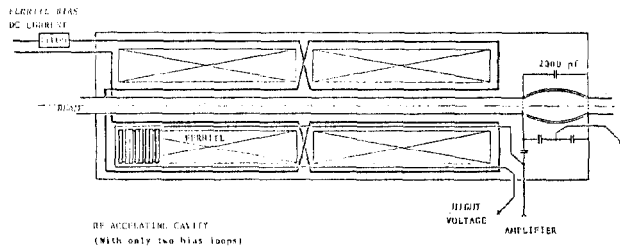
4. RF cavities

Each cavity is composed by one $\lambda/4$ resonator, by one acceleration alumina gap; and is charged by two separate equal ferrite blocks. The longitudinal and radial filling rate has been increased as well as possible, only limited by the voltage holding.

The resonator ferrites are polarized with an 8 turns winding, and an - 2 A to 500 A current. This winding intercrossed between the two ferrites blocks. A water flow in intercalated copper toroids cools the cavity (fig. 3).

The low frequency is adjusted by high value and high power capacities (2000 pF at 1.5 kV and 2.6 MHz).

The impedance of this cavity decreases from 1 k Ω to 200 Ω along the frequency variation, with 1.5 kV peak.



5. Amplifiers

We choosed the water cooled tetrode TH 120 (CSF-THOMSON) used on SATURNE. One tube drives one cavity.

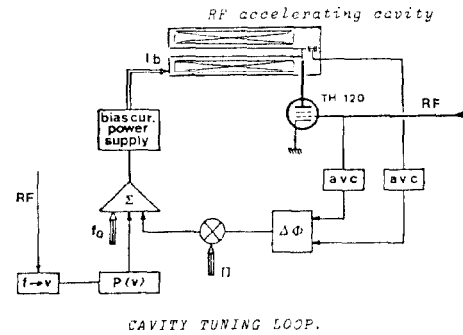
Its voltage gain will be upper 10, with a RF highest used power below 7 kW.

This tube will be driven by a 400 W/50 Ω solid state amplifier. It will stay out of the prohibited accelerator area, and be connected at the final amplifier by a 50 Ω line, adapted at the tube entrance capacity by a L.C. network.

6. Tuning and regulation

The cavity tuning is realized by regulation at 180° of the grid and plate RF phase on the last amplifier, and adjustment of the polarization current.

A gain controlled amplifier, in a closed loop, drive the required voltage on the accelerating gap.



7. Reduced size model test

We built and tested a complete RF chain with :

- . a $\lambda/4$ cavity, with 3/4 length and 1/7 radius, with an identical geometry,
- . an ENI 400 W amplifier,
- . tuning and voltage loops,
- . a master oscillator and a timing, simulating the MIMAS conditions.

We could obtain, on this model, the low frequency and the frequency range from 0.130 to 2.7 MHz with 300V pic in all the range, without consequent difficulties.

At this voltage, we had a maximum induction (at 130 kHz) = 400 Gauss and highest losses (at 2.6 MHz) = 0.24 W/cm³.

These values mean that it is possible to built the real size cavity. In its ferrites, and at the nominal voltage $\frac{dB}{dv}$ will be < 0.10 W/cm³ and B = 250 G.

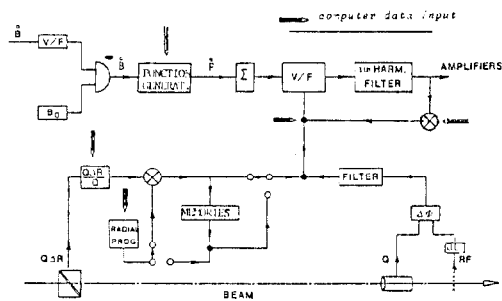
8. The frequency law

The master oscillator is constituted by a voltage to frequency DMC converter, driven by a dipole B clock, and adjusted by a function translator $\frac{dB}{dt} + \frac{dF}{dt}$. The converter square waves are transformed into sine waves by a self tuned 1st harmonic filter.

The function translator is connected to the central computer and adjusts the frequency law versus the accelerated ions. This adjustment can be made better by step to step automatic controls after reading of the beam position in the vacuum chamber.

Analog network measures the beam displacement compared with the ideal radius and the RF phase, corrects in closed loop the frequency law, and permits to control the beam position during the acceleration and extraction time.

When the intensity is too weak to be detected, local memories including the necessary correction permits to accelerate in open loop.



9. Measurements and central computer control

At all the different levels, parameters, locally driven or not by specialised processor, will be connected at the central computer by the standard CAMAC system.

The start, the adjustments and the measurements could be made by general programs from the main control room.

The RF chain will be used to have some measurements on the beam, like energy, energy spread, synchrotron data, wave number, a.s.o.

This study and these tests show the possibility to built RF system for MIMAS, able to accelerate all the ions in all the range. It is not necessary to provide for an other complementary acceleration system, like betatron accelerator.

But, during tests, and at an induction level up to the nominal value, appears ferrite high impedance losses (time depending) and instabilities due to the non-linearity of the quality factor. These phenomena are existing in all the ferrites materials and seams connected to the simultaneous being of some frequency and some polarization status.

Now, we are expecting the end of the CRYEBIS ion source tune to start building this RF chain in real size.

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