PUMPING AND PRESSURE MEASURING SYSTEM FOR THE LINAC OF THE ELETTRA SYNCHROTRON LIGHT SOURCE

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ABSTRACT

Based on two years of excellent experience with the storage ring (SR) vacuum system, it was decided to install a similar pumping and measuring system on the Linac. The system allows to check vacuum conditions during Linac operation from the control room. As in the SR, the current absorbed by sputter-ion pumps (SIPs) is used to determine the pressure. The protection against vacuum failure is performed by means of two interlock levels using pressure measurements. At the lower level the radio frequency system is switched off to protect the wave guides and the resonant cavities, while the higher level closes the section valves of the vacuum system. Varian StarCell SIPs of 60 l/s and 230 l/s are used which were calibrated (i.e. the coefficients K and n were found to perform conversion current to pressure - $I = K.P^n$) in the pressure range from 10^{-10} to 10^{-6} mbar, by comparing pressure values given by cold cathode Penning gauges. Due to the strong EMI and RFI noise, which is present in the whole Linac area, different technologies were used to interface the SIP power supplies with the control room and the interlock system.

1 LINAC VACUUM SYSTEM

From the vacuum point of view, the Linac is divided into three parts: i) the injection part, comprising the "gun", ii) the 100 MeV accelerator, iii) seven equal sections of acceleration. All of these sections are separated by gate valves and are pumped by SIPs shown in fig. 1. The pressure without beam rises from $1x10^{-9}$ to $4x10^{-9}$ mbar and there is no significant pressure increase during operation.

At the present time the whole Linac vacuum system is only partially monitorable from the local control room and there is no interlock for vacuum safety. However, the system has an automatic shut-down for the RF when some discharges occur in the resonant cavity or in the wave guide. These discharges are registered measuring the current absorbed by SIPs.

The upgrade is oriented to have the complete control of the vacuum from the main control room and to add a new "vacuum interlock" to the already existing "RF interlock". This interlock should protect the vacuum system against possible leaks from other parts of the Linac or from other facilities, e.g. FEL, which will be installed at the end of the 100 MeV section.

As can be deduced from fig. 1, it is convenient to apply a similar pumping and measuring system as is already used in the SR [1], only in the seven acceleration sections. In fact, here are five SIPs in between two valves for each section. Moreover, it could be checked that the sum of the current absorbed by these five pumps at the maximum admissible pressure, is lower than the maximum current supplied by the power supply (PS). In the 100 MeV section such modification is impossible because pumps are separated by valves, and if a valve is closed the PS must be able to supply two pumps which are working in two very different ranges of pressure (at limit one pump can be switched off due to a leak, the second can work normally). In the injection part such modification is not convenient. In fact, only two Triode pumps (-7 kV) or two diode pumps of 2 l/s (+5 kV) can be supply together.

At the beginning of the operation all of the Linac pumps' PSs were a Varian linear type, (30 in total). Recently some of them were substituted by the new MULTIVAC PS. The best solution, in agreement with economical consideration, is to maintain the linear type of PS, one for each pump, only for the injection and 100 MeV part.

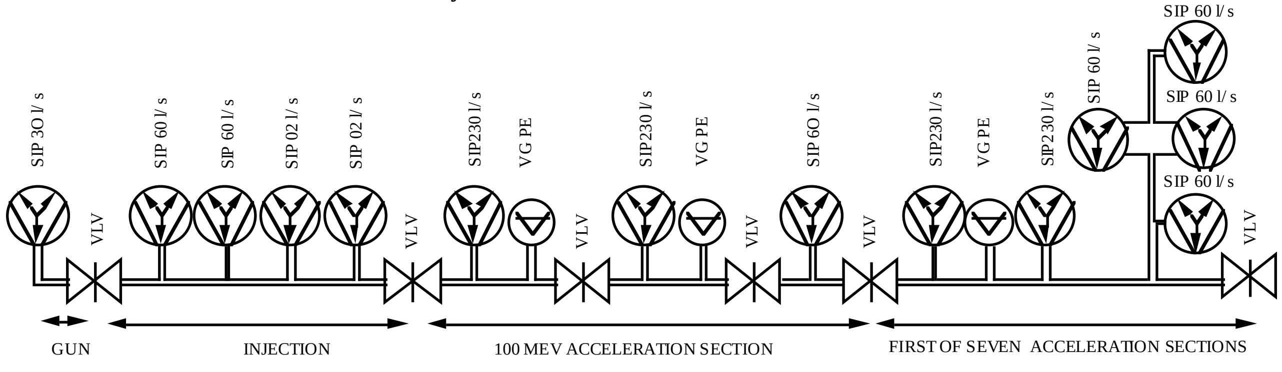

Fig. 1 - Schematic diagram of the Linac vacuum system, (only the first of seven acceleration sections is shown)

Seven MULTIVAC PS, one for each section, are sufficient to supply 35 SIPs installed in the acceleration sections. Some tests confirmed that the linear unstabilized PS is not suitable to measure the current absorbed by SIPs due to strong electrical noise present in the Linac hall.

2 ELECTRONIC CIRCUITS

2.1 The Block Diagram

In the block diagram there are no important differences in respect to the circuit used in the SR and TLas described in [1]. Obviously, only the number of SIPs powered by the same PS is varied, but this is not a significant modification.

2.2 The Current Measurements Board (CMB)

The working principle of this card [2], is the same as it was described in ref. 1, but the most important modification is made in the optoisolation system from the H.V. and the subsequent transmission of the data relative to the current absorbed by SIPs. The schematic block of the CMB is shown in fig. 2.

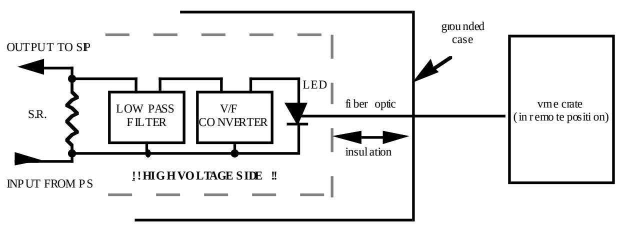

Fig. 2 - Schematic diagram of the CMB

An optic fibre is used, instead of the traditional H.V. optocoupler, to electrically separate H.V. components from the signal components. At the output of the voltage to frequency converter (related to the H.V. side), a special LED is installed. This LED allows to connect the optic fibre to its case. In this way all parts connected to H.V. can be brought into a shielded chassis, and all components related to the signal ground can be installed outside. It consequently improves human safety and transmitted noise. The insulation of the H.V. increases with the length of the optic fibre (up to the point in which it is connected to the chassis).

2.3 The MULTIVAC Interface Board and the THEMIS Board.

No significant changes are necessary to be performed on the µ8000 PS interface board to connect the MULTIVAC PS. Only a simple modification on the output interface connector is inevitable for the MULTIVAC PS, to obtain a signal corresponding to the H.V. output of the PS. This value is used to calculate the pressure in vacuum chamber. It is important to remember that the modes of operation Start and Protect, have a different meaning for the "old" µ8000 PS and for the MULTIVAC one.

It was observed that the timers of the interface board are often reset by spikes due to high level of electrical noise present in the Linac. This effect causes the resetting of the calculation of the current absorbed by SIPs. It was found useful to change the optocouplers HCPL 2630, which separate the hardware ground from the VME ground on the interface board, with the HCPL 2631. This last one has a shielding connected to the ground in between the LED and output transistor.

2.4 The Linear Interface Board (LIB)

This interface board permits to control the linear PS from the control room even thought it does not have all of the interface facility of the MULTIVAC PS. There is in fig. 3 the schematic block diagram of the board.

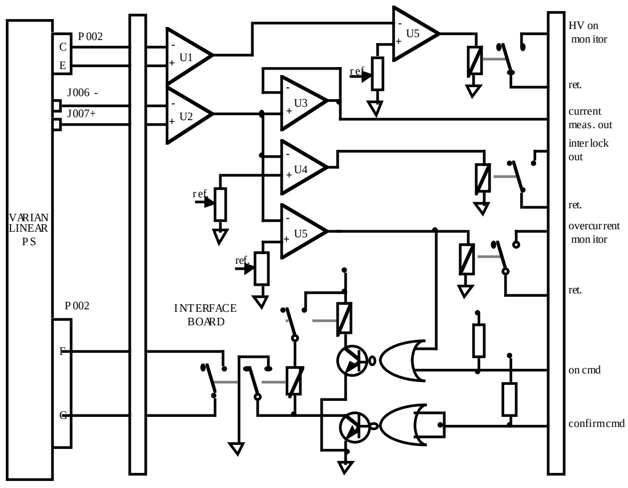

Fig. 3 - Simplified schematic diagram of the LIB

The LIB input signals from the PS are: i) a signal from 0 to 100 mV corresponding to the current absorbed by the pump, ii) a signal from 0 to 10 V corresponding to the output voltage of the PS and iii) a safety contact to inhibit the power-on command of the PS. Two adjustable interlock levels are obtained from the first input by means of comparators: the lower one is used to switch off RF, and the higher one is used for vacuum interlock. It switches off the PS and gives an output signal for a possible closure of the section valves. By means of the third comparator the PS is automatically switched off when the absorbed current is dangerous for the PS itself. The last comparator is used to obtain a signal indicating that the PS is off or on. Thanks to these circuits, from the control point of view, the linear PS becomes identical to the MULTIVAC PS.

3 INTERLOCK

The interlock output signals measured at two 60l/s SIPs, are shown in fig. 4 and 5. The output, as explained in ref. 1, is a square wave (with a variable frequency), than the signal is reconverted in voltage to obtain the interlock signal. One of the SIPs suffers of induced noise from RF. Using the linear PS, (fig. 4) the output signal is disturbed a lot, using a switching and regulated PS, μ8000 or MULTIVAC instead, the noise signal from RF is filtered as shown in fig. 5, the small difference of the recordered pressure levels of the two graphs is due to a non perfect calibration of the cards. Obviously, all the signals are clean with the RF switched off.

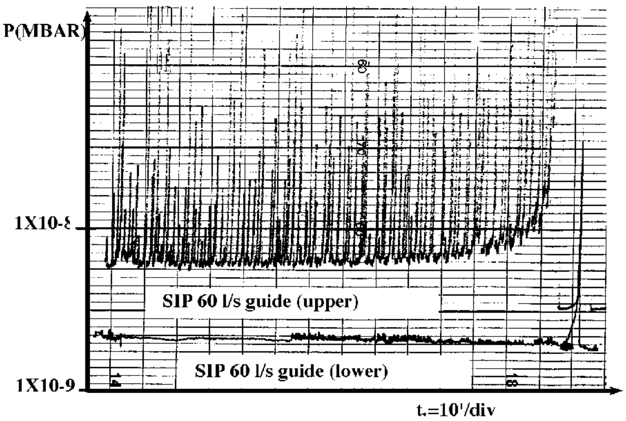

Fig. 4 - Interlock signals with linear PS

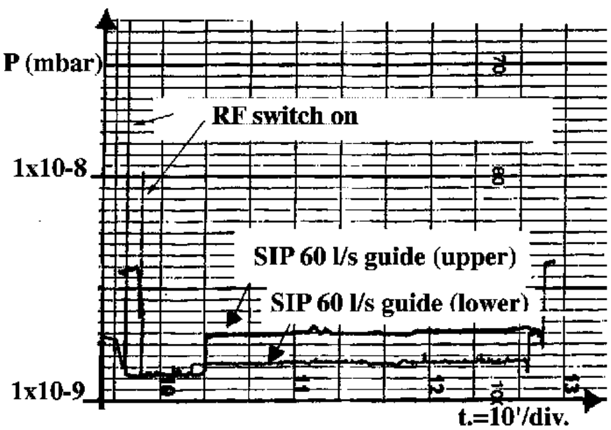

Fig. 5 - Interlock signals with regulated PS

4 CALIBRATION PROCEDURE

At the start of commissioning the Linac vacuum system was free of any vacuum gauges. The pressure might be only roughly estimated by linear type of SIPs PS. Due to a necessity to restrict discharges occurring in the Linac, pumping and measuring system was modified. Now it is possible to check the pressure by inverted magnetron gauges installed in each section. The position of these gauges is not ideal from the calibration point of view. For this reason the calibration coefficients K and n ($I = K P^n$) were determined in our laboratory.

The apparatus consists of two calibrated SIPs (60 and 230 l/s of nominal pumping speed) and one Penning gauge. The pressure increase is made by introducing dry nitrogen into the system through the needle valve. An acceptable for-vacuum pressure is maintained by turbo- and membrane pumps.

The linear dependence of the current I absorbed in the SIP, on the pressure was verified at increasing and decreasing total pressure in the system. The set of equations allowing to calculate the pressure in the Linac from the SIPs reading is as follows:

I = 1260 P {exp 1.1}   SIP 230 l/s
I = 12 740 P {exp 1.18}   SIP 60 l/s

The experimental data and a curve fitting for the SIP 230 l/s are shown in fig. 6.

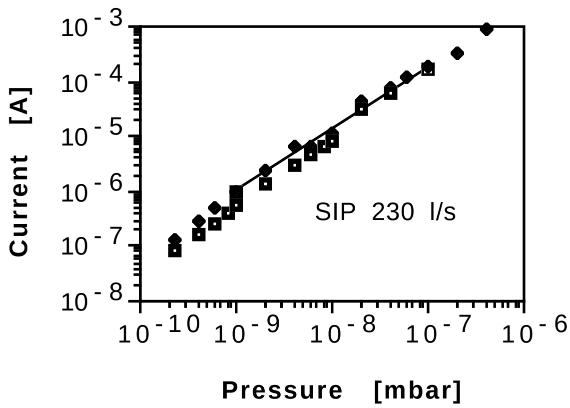

Fig. 6 - Current x pressure dependence for the SIP 230 l/s

5 REFERENCES

[1] "Total pressure measurements in the ELETTRA storage ring according to the performance of the sputter-ion pumps", F.Giacuzzo, J Miertusova, Sincrotrone Trieste, Int. report ST/M-95/2

[2] S.P. current measurement LEP 680-4221-050 D