THE ELETTRA INJECTOR LINAC UPGRADING PROGRAM

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ABSTRACT

ELETTRA has a SLED equipped Linear injector bought as turn-key machine from a private company. Two years has passed since the Linac operation has been taken under Sincrotrone Trieste responsibility. In order to improve the low reliability of some machine subsystems, which affects the Linac operational efficiency, important modifications are now under development. The main changes will include a re-design of the control system, the timing distribution, the beam diagnostics, the vacuum layout and the RF detection and interlock system.

1 INTRODUCTION. THE LAST YEARS' OPERATION

The Linear injector of ELETTRA is made up of two parts: a 100 MeV accelerator, called preinjector, which is built using a traditional technology [1] and the real injector composed of seven, SLED equipped, accelerating sections. Eight Thomson TH2132 klystron plants are in operation to feed the whole machine [2].

Since June 1994 the operation responsibility of the ELETTRA injector has been transferred to Sincrotrone Trieste. In the very first months the main goal was to set a good reliability in the injection operation to assure continuity to the ELETTRA commissioning. At that time the main fault source was identified in electric field breakdown inside the accelerating sections and the SLED cavities. Two are the important points: a) from the end of '93 and during the first months of '94 (Jan.-April), in spite of the expectations, no appreciable results have been obtained in increasing the Linac energy; b) the maximum electric field gradient reached on the accelerating sections, up to 28 MV/m with respect to the 33 MV/m expected, seemed to be the best achievable. Furthermore, probably due to the status and the poor cleanness of the copper surfaces, the accelerating sections couldn't reliably withstand the required high electric field gradient. As a first action we improved the poor vacuum pumping speed of the system adding one 230 l/s ion pump to each accelerating section, moreover we decided to set the operation energy at 1.1 GeV with a mean gradient of 24 MV/m on the structures. This strategy took us from 25 faults/hour to the present 2 to 3 faults/hour for what concerns electric field breakdown in the RF structures.

For almost two years, up to now, we have been updating statistics of the Linac fault sources which have settled in the following histogram pattern:

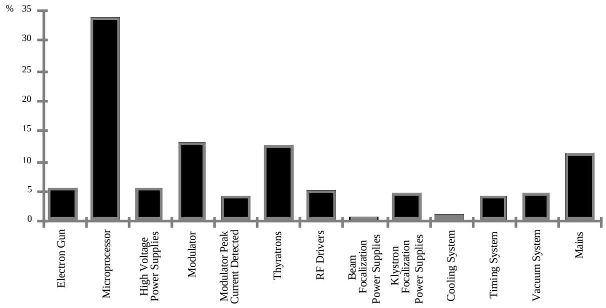

Figure: 1 Linac subsystems downtime statistics (RUN 12 - RUN 30) in percentage of the total Linac downtime.

In the meanwhile special care has been devoted to set up a monitoring procedure of the most critical parameters of the machine, which could report periodically on the health status of the plants.

The overall contribution of the Linac to the ELETTRA beam downtime is now around 14% average on the last 9 RUNs (22-30), while in the previous 9 RUNs (12-21) the percentage was over 23% average.

Looking at the histogram above, the main fault sources at this time were identified also to come from the control system of the Linac which is responsible for the whole interlock action on the injector.

In order to increase the reliability, it was decided to modify the following subsystems: the timing system, the vacuum system, which in the present setup has a too poor interface to the control and interlock system, the RF detection and interlock and the beam diagnostics which is reduced at present to only beam current monitors and fluorescent screens at the Linac output, while BPM and wall current monitors are not active, resulting in time loss and difficulties during operation. Last, but certainly the biggest change in the whole machine, comes the substitution of the current control system, which has proved to be origin of most of the misfunctioning of the Linac and moreover doesn't allow an integration in the ELETTRA control system.

2 THE CONTROL AND INTERLOCK SYSTEM

The present Linac Control System operates with a centralized architecture: the acquired signals, both analogue and digital, are taken from the field by local non-intelligent interfaces; some of the analogue signals are optically decoupled from the local ground before being forwarded to the main control unit, while the rest of the analogue and all the digital signals go to the central control rack straight; here they are passed to one of the four slave microprocessor units by interface boards. The same considerations are valid, but in the opposite way, for the output signals.

The slave microprocessor units communicate with the master microprocessor unit through a 1553 connection bus. At this level the ingoing data are processed to update the status panel of the machine and to generate the events for the interlock action.

The lack of care given to the signal distribution as regards the grounding and noise problems, the insufficient hardware architecture and the stiffness of the software interface has made this system absolutely unreliable and a source of major damage on the machine.

The new control system [3] will be built with a spread architecture: all the devices will be grouped in 9 blocks, which we will call plants, each plant will have an intelligent local processing unit where the low level software manages the local processes and talks with the high level software running on the workstations of the control desk. The connection between LPCs and workstation is fulfilled by an optical ethernet link.

The main goal is to set up a modular system keeping the signals as close as possible to the related plant in order to prevent noise propagation and, at the same time, to allow a completely flexible use of the accelerator; the big challenge is the review of the whole signal interface system from the hardware point of view to gain in isolation and signal to noise ratio, particularly for the pulsed signal detection.

The interlock action will be assured by an hybrid architecture composed of a local relais device for the first level intervention and a central PLC which coordinates the second level action and works as the interface to the control system. This will guarantee, we believe, a fast and reliable interlock action (< 20 ms on the first level) and will allow an easy and fast identification of the fault source.

3 THE TIMING SYSTEM

The Linac Timing System delivers five kinds of triggers to each of the eight power plants: one for the thyratrons, three for the RF pulses, one for the measurements; moreover it delivers one trigger to the 500 MHz system ad one trigger signal to the GUN pulser.

Without entering in details which can be found in [4], in the system now in operation the wide delay steps are generated moving the Storage Ring Clock delay by 864 ns at a time, while the short delay steps (12 ns) come from a 83.3 MHz clock signal distributed to the trigger delay boards. The problems we met during operation are mainly due to trigger instability, also caused by a bad 83.3 MHz signal distribution on the delay boards and to the impossibility of working offline, which results in long and tedious operations whenever a hardware fault occurs.

The new Linac Timing System [5] will be based on a local reference clock from a 50 MHz signal synchronous to the ELETTRA master oscillator; the delay boards, which have been developped at Sincrotrone Trieste, are housed in a crate VXI for optimum RF signal distribution and noise immunity; they have fully programmable trigger outputs which can be delayed from 10 ns to 1.2 ms, 10 ns/step, and each one can be independently interlocked to an external trigger. A new software will allow easy and complete control from the ELETTRA / Linac Control System.

Furthermore the in-phase synchronization with the start injection signal will allow a real bucket by bucket filling of the storage ring.

We plan to test the first boards by the end of next July and to be able to have the offline tests by the end of this year.

4 BEAM DIAGNOSTICS

The present beam diagnostics system includes three kinds of monitor devices:

- eleven toroids placed at the end of each accelerating section and two in the bunching section;
- eleven wall current monitors at the output of the toroids;
- nine beam position monitors at the output of the accelerating sections in correspondence with quadrupole triplets. These are made by four stripline detectors spaced by 45° angle inside the vacuum chamber [6].

Up to now only the toroids have been used, to have an analogue display of the beam current; the gap and wall current monitors have been tested but not really used.

The plan we are developing involves in the first stage only toroids and BPMs. The new diagnostics system [7] will acquire the beam current intensity and the beam position through 500 MHz multiplexers by means of programmable digital scopes; the data will be transferred to a dedicated VME crate which will record the whole Linac beam status every 10 seconds.

The development of dedicated detector boards will allow in a second phase to implement a slow trajectory feedback to optimize the beam transmission through the injector automatically.

As regards the wall current monitors we plan to make a check of the present design and in the near future to use them for a RF phase compensation system, to implement an automatic energy feedback.

5 THE NEW VACUUM LAYOUT

The former layout of vacuum pumping of the ELETTRA Linac consisted of one 230 l/s sputter ion pump (SIP) on each 6.4 m long accelerating section tank, two 60 l/s in the waveguide path from the klystron to the section and one 60 l/s on each of the two SLED cavities; the preinjector included 60 l/s and 2 l/s SIPs on the bunching section and one 230 l/s SIP on each of the two accelerating section tanks (3.4 m long). Each 230 l/s pump is driven by one linear power supply, (PS) while the 60 l/s are powered two by two by one PS on the injector; the signal for control and interlock system is taken from the 0 - 100 mV DC output of the PS itself. The total number of linear power supplies is 30.

In August 1994 we added one 230 l/s SIP on each 6.4 m accelerating section tank; they are fed by seven VARIAN μ8000 power supplies without any connection to the Linac control system.

The present configuration doesn't allow any control on the PS nor on the real vacuum level, since the voltage output is of poor help when the PS feeds two SIPs as for the waveguides and SLED cavities. Moreover the present action of the control system is simply to turn off the RF power whenever it sees a vacuum level higher than an adjustable safety level, e.g. no action is provided for closing valves.

The future vacuum layout for the Linac [8] will provide complete control of injector PS, which will feed five SIPs each (accelerating sections 1 to 7), and will improve control capability of the linear ones on the preinjector (100 MeV part of the Linac) through an interface board appropriately built at Sincrotrone Trieste; the vacuum level will be accurately monitored by penning gauges which we are installing on the accelerating sections and by measuring the absorbed current on each SIP.

The interlock action will be accomplished by a two level system: the first level will simply turn off the RF power on the plant, while the second level will furthermore shut the vacuum valves of the plant where the alarm happened, isolating it from the rest of the machine. A manual safety control of the vacuum valves will also be implemented. By these modifications we expect to gain a safer operation through total control of the vacuum system and the possibility of an accurate recording of vacuum behaviour in the Linac. A fast valve system will be installed at the Linac exit to protect the injector from vacuum leaks eventually occurring on the transfer line, decoupling the transfer line and storage ring from the Linac.

The program should be completed at the end of 1997 and in any case before the new control system will be finished.

CONCLUSIONS

An arduous task has been engaged in upgrading and improving the reliability of the ELETTRA injector Linac. Due to the intense scheduled operating and maintenance program required by the machine and the present available man power, we expect to complete the main activities, like the new control system, in the next two years.

Furthermore, new possible scenarios and machine configuration are now taking into the account to try to increase in the future the injector energy.

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