COMPUTER CONTROL AND DIAGNOSTIC EQUIPMENT FOR THE LISA PROJECT

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ABSTRACT

We present the diagnostics and controls status of the Frascati Superconducting LINAC Project LISA. The control system philosophy has been completely defined and tested on the existing ADONE accelerator. Two windows of the final LISA system have been implemented and tested in the Laboratory. The beam position monitor electronics has been tested. The position readout is stable within less than 0.1 mm (peak to peak) over a wide range.

CONTROL SYSTEM

Hardware

The LISA control system philosophy has been already presented in several papers [1,2]. Briefly, it is split into three levels (see Fig.1) where the first one (operator) is the human interface [3], the second one (supervisor) is a general communication coordinator and database storage and the third one (hardware) is the hardware interface. The hardware is made up of Macintosh IIfx computers and VME crates with Motorola MVME133 CPU's. Fast parallel buses (MacVEE [4] and VMV [5]) carry command and data transfer. The high transfer speed makes it possible to have a single central memory, lying in the second level crate and adjourned by the supervisor, presenting at every moment the status of the system to the consoles.

1700 messages per second or 400 Kbyte/sec transfer rates have been measured [6].

Software

The software environment is the CERN MacUA1 Development system [7] for the second and third level, with RTF FORTRAN [8] as language. For the first level we have chosen HYPERCARD, and we have implemented a set of XCMDs and XFCNs (External Commands and External Functions) [9] to allow interaction with the VME hardware through a MICRON [10] interface. The XCMDs and XFCNs are written using the MPW "C" language with Assembler subroutines. The versatility and ease of operation of Hypercard and of its additions (HyperWindows, Supercard, PLUS) allow easy implementation and fast updates of the human interface software.

Test on ADONE

A field test of the system has been carried out on ADONE, the e+ e- storage ring operating in Frascati.

Beam steering in the ADONE LINAC is performed by a set of 30 coils, originally controlled by a bank of manual potentiometers. This setup was a source of problems, not only because of the lack of stability, but also because the transition between two different states of the machine (typically electron or positron injection) was slow and cumbersome.

We have therefore implemented an automatic system capable of fast transitions between different states and of continuous closed loop control against slow drifts [11] .

The original three level structure has been reduced to two levels, where the supervisor and the hardware interface have been implemented in the same VME processor. This has been made possible by the limited dimensions and by the uniformity of the system.

The interface with the second level has been realized using two different mechanisms:

i) .direct memory access to update the screen data, using the VME memory which is continuously updated by the second level.

ii).message exchange with the second level CPU through two mailboxes:

a) Commands from the console to the control processor to activate an action.

b) Warning or Error messages from the control processor to the console.

The user interface is made up of a central data acquisition card, four initialization cards and four graphic routine cards.

The main acquisition card (see Fig.2) shows a number of data on the status of the system, and many buttons and controls to change settings.

Four buttons allow to access graphical routine cards:
- time diagram of the current value of a selected coil;
- histogram of the current values in the coil ;
- ramp calibration (performed on line through a series of steps);
- space diagram of the current in the coils;

A set of 3 initialization cards allows to download software to the lower levels and to set system parameters.

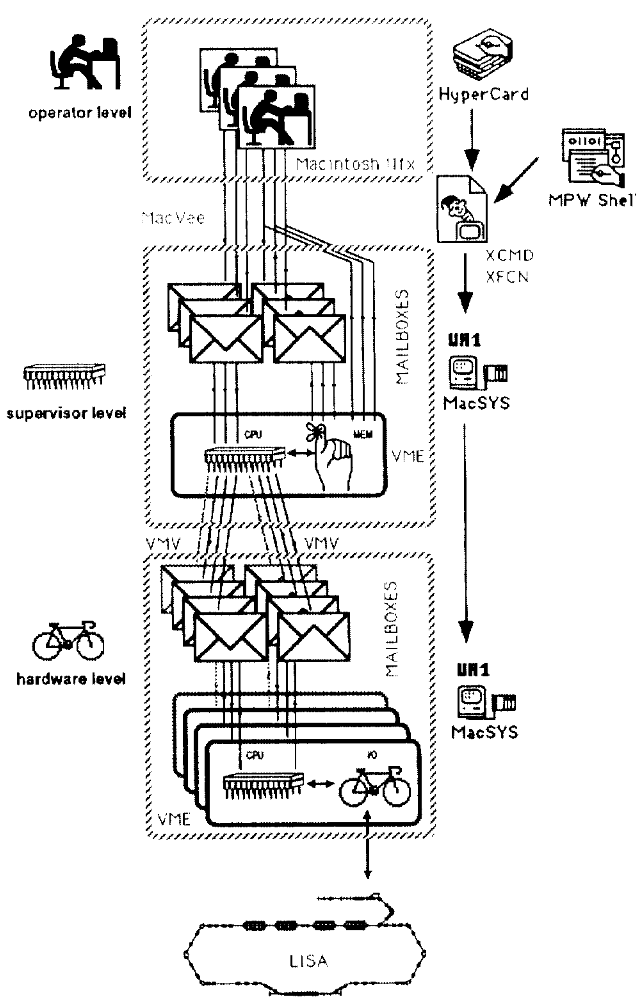

Fig. 1: LISA control schematic diagram

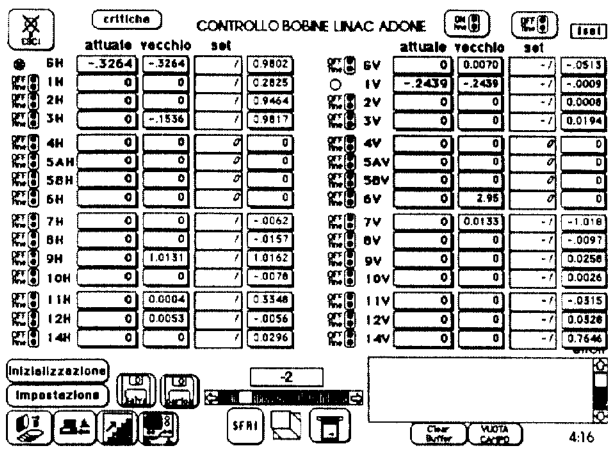

Fig. 2 : Layout of the control card for the ADONE LINAC coils control

LISA CONTROL

The ADONE application has been applied to the first eight solenoids of LISA, using the full three level system. Thus we have been able to test in full the second and third level software. The system is in operation in the laboratory using one of the real solenoid power supplies.

We have also developed the control window for the RF chopper (see Fig. 3). The central control mechanism is identical to the solenoid window, to maintain uniformity throughout the control system structure. This system has been implemented on a Macintosh Plus to be used by the RF group during tests and construction in the laboratory.

Several other windows are under development.

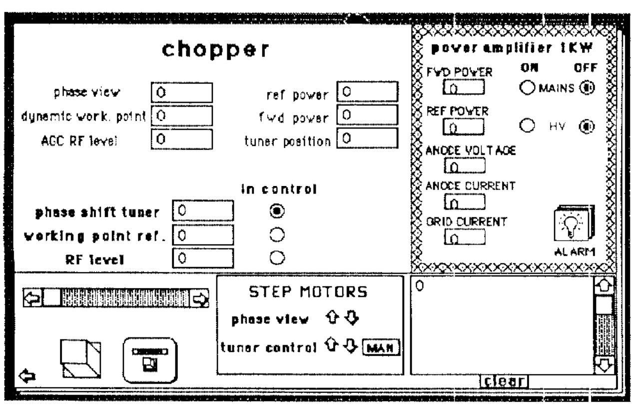

Fig. 3 : LISA RF chopper control window

APPLES vs. BANANAS

Histograms and plots are necessary for any control system. Using the Macintosh facilities, we have implemented a very powerful and flexible tool for the classic task of plotting anything (apples) as a function of everything else (bananas).

A Hypercard field gets data from anywhere in the control system stacks, and creates a file containing the data in standard format. An existing and powerful program for histograms (CricketGraph) is then launched directly from Hypercard with the associated data file. This way, with a minimum of effort, we have a very good graphic package tied to our system. This is a good example of the advantages of using standard, cheap and well diffused personal computers for this kind of task. The amount of software available on the market for very limited prices is enormous.

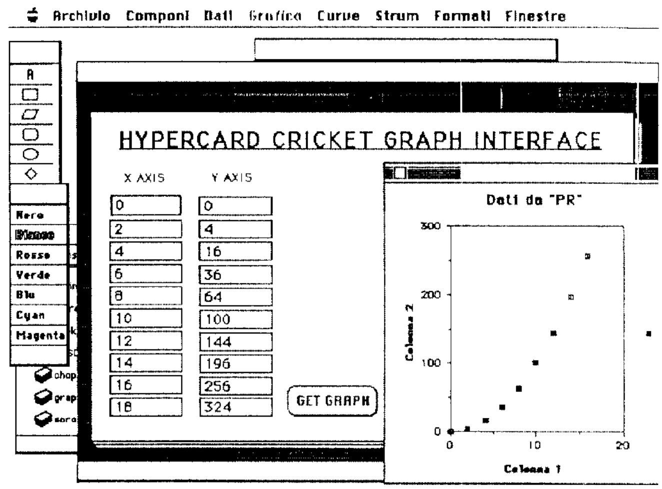

Fig. 4 : LISA histogram package

DIAGNOSTICS

The beam current is monitored by toroidal current transformers type Pearson 110A. An auxiliary winding provides a calibration signal between successive beam bursts. Such monitors are placed in the injector, at the beginning of the 1 MeV transport line and at the beginning and the end of the SC Linac.

At the exit of the 1 MeV capture section the beam is fully characterized by means of a spectrometer line for the measurement of the energy and energy spread, and a transverse cavity for the measurement of the bunch length [12].The transverse emittance is determined by measuring with a computer controlled CCD camera the beam transverse dimensions in a fluorescent screen at several orientations of the phase-space ellipse according to the change of strength of an upstream quadrupole. A Faraday cup is provided for precision current measurement.

A retractable beam dump at the beginning of the SC Linac accommodates another Faraday cup.

Beam position monitors (BPM's) are used to measure the beam trajectory in the Linac and transport channel. With four BPM's in the 1 MeV spectrometer section it is possible, in principle, to determine the beam launch parameters (horizontal and vertical position and angle, energy error).

The BPM's are designed to fit inside the quadrupoles of the transport channel and in the quadrupoles between the RF cryo-modules. The absolute accuracy of the beam position monitors is required to be ~ 0.1 mm, compatible with the accuracy of placement of the quadrupoles.

One BPM per quadrupole is provided. The BPM's consist of four 50 Ω strip-line electrodes [13] short circuited at one end inside the vacuum chamber.

The strips are two in the horizontal and two in the vertical plane. The length of each strip is 0.15 m, so that the response has a broad resonating maximum at 500 MHz, the Linac RF frequency. The voltage response of the strip-line monitor is a doublet of pulses of opposing polarity reproducing the time distribution of the beam current and separated by 1 nsec.

The narrow pulses are smoothed by the filtering action of ~ 30 m of RG223 cable connecting to the detector head and are fed to a band-pass filter resonating at the bunch frequency of 50 MHz. The resonant filter is built by a combination of a quarter-wave short circuit coaxial transmission line and a low-pass filter .

The position detection is based on the phase modulation-demodulation technique, whereby the amplitude ratio of two opposing strips, bearing the position information, is converted by means of a quadrature hybrid junction into a phase difference between two equal-amplitude sinusoidal signals [14]. The sinusoidal signals are then linearly amplified and clipped by fast comparators (AM 685). The phase difference is measured by an exclusive-OR circuit, whose average DC output is proportional to the beam displacement. A gate signal is provided by the beam timing system to inhibit the detector in the absence of beam, thus avoiding noise-induced false trigger to the detector electronics.

The main advantage of such type of detector is that it is self-normalizing, allowing a wide dynamic range: in principle the position information is independent of the current intensity.

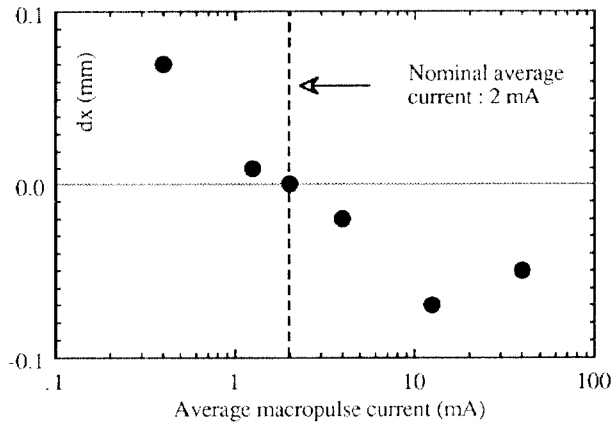

Fig. 5 : Stability of the beam position monitor readout vs. the average beam current

Experiments with a prototype showed a stability of the readout voltage corresponding to ± 60 μm over a a macropulse average current variation of ~ 20 dB below and 26 dB above the nominal value of 2 mA (see fig. 5).

CONCLUSIONS

The LISA control system has been fully tested using an implementation on an existing accelerator and building the first two final windows. The structure has proven sound and easy to implement in different applications. The full system will be ready for accelerator commissioning.

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REFERENCES

[1] M.Castellano, N.Cavallo, F.Cevenini, S.De Simone, G. Di Pirro, S.Guiducci, P.Patteri, M.Serio and L.Trasatti: "Diagnostic and Control System for the LISA project" European Particle Accelerator Conference (EPAC), Roma, June 7-11, 1988.

[2] M. Castellano, L. Catani, N. Cavallo, F. Cevenini, G. Di Pirro, S. Guiducci, C. Milardi, P. Patteri, M. Serio and L. Trasatti: "A distributed VME control system for the LISA superconducting linac" IEEE Transaction on Nuclear Science, VOL.36, NO.5, October 1989.

[3] C. Milardi: "Console Software Design for the LISA Accelerator Control System" LNF Report LNF-90/030(NT).

[4] B.G. Taylor, "The MacVEE Hardware User Manual"; Rev.4.1, CERN EP Division, 1987.

[5] C.E.S. SA, Geneva, Switzerland.

[6] L. Catani, G. Di Pirro, C. Milardi, L. Trasatti, F. Giacco, F. Serlini "The High Speed Bus System for LISA" Presented at the International Conference on "Accelerator and Large Experimental Physics Control System" Vancouver, Canada, Nov 3, (1989) *In Press to Nuclear Instruments and Methods.*

[7] S. Cittolin et al.: "MacUA1, the UA1 Macintosh-Based Development System" CERN-UA1 Technical Note 90-01 (1990).

[8] H. von der Schmitt, "RTF/68K, Real-Time FORTRAN-77 for 68K Processors"; Physikalisches Institut Universitat Heidelberg and CERN UA1, March 9, 1988.

[9] L. Trasatti: "New Languages, Hypercard and ADONE", LNF Report LNF-90/121(R), 1990.

[10] B.G. Taylor, "The MICRON User Manual", Rev.1.0, CERN EP Division, 1988.

[11] L.Catani et al.: "Automatic control and monitoring of a set of steering coils for the LNF LINAC", LNF Report LNF - 90/033(NT), 1990.

[12] B. Spataro, LNF Internal Memo LIS-30 (1988).
M. Bassetti, B. Spataro, LNF Internal Memo LIS-42 (1989).
M. Castellano, LNF Internal Memo LIS-53 (1989).
R. Boni, A. Gallo, LNF Internal Memo LIS-68 (1990).

[13] R. Shafer, IEEE Transactions on Nuclear Science, Vol NS-32, No 5, p. 1933 (1985).

[14] E. F. Higgings, J. E. Griffin, IEEE Transactions on Nuclear Science, Vol NS-22, No 3, p. 1574 (1975).