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Control System Implementation for the IASA Microtron

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Abstract

A progress report on the architectural design and implementation of the Control System for the Racetrack Microtron at the Institute of Accelerating Systems and Applications (IASA) in Athens, Greece is presented. The Control System for the IASA CW Microtron is being developed on the Experimental Physics and Industrial Control System (EPICS) environment. Since top priority for this project is the construction and commissioning of the Microtron's injector, emphasis is being given to the definition and refinement of the Control Architecture and its realization for the injector. The experience gained from the Control System at the injector will guide the further development of the Control System for the entire Microtron.

1 Introduction

The IASA Microtron, a Continuous Wave (CW) Race Track Microtron (RT-M), is being built making optimal use of the available components obtained from NIST and the University of Illinois RTM projects. It is based on a recent optics study, which adopts a two-stage $\nu = 1$ Cascade scheme with a variable output energy from 5 to 240 MeV [1]. The Control System for this Microtron is totally revised as we considered the architecture and the implementation of the NIST and UIUC machines outdated. Having in mind the complexity and the large number of elements to be controlled, we decided to develop the new Control System on the EPICS (Experimental Physics and Industrial Control

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System) environment [2]. EPICS is a distributed process control system built on a software communication bus, scalable from a single test station with a low channel count to a large distributed network with thousand of channels. The physical front-end layer is built from modularized electronics (VME crates, CPU and I/O boards) while the physical back-end layer is implemented on popular workstations running Unix. Communication between them is achieved with a network layer supporting the TCP/IP protocol. A prime goal of this project is to obtain the basic functionality and performance necessary to commission and control the injector of the Athens RTM.

2 General Configuration

The injector for the Microtron consists of a 100 keV electron gun and beam transport line, which provides a chopped and bunched beam of very low transverse emittance ($< 5\pi$ mm-mrad), followed by the 6.5 MeV accelerating section. In the following we present the Control System design and loop details of some of the most important parts of the 100 keV injector line.

EPICS is installed on Sun Sparc-5 stations running Solaris 2.4. VME crates with a Fast Intelligent Controller (FIC-8234 or MVME-167, Motorola 68040 processor working at 25 MHz) and running the VxWorks real-time system are connected through Ethernet with the Sun workstations. Several VME modules are used to process the incoming or outgoing analog and binary signals.

In parallel, a CAMAC crate (Le Croy, Model 8025 with the CC-488 GPIB Crate Controller from dsp) with a large number of available modules (mostly DACs, ADCs and Motor Steppers), not yet integrated in the EPICS environment, is used separately in order to understand and to realize simple control loops.

2.1 *Electron Gun*

The electron gun provides a 100 keV electron beam of high quality (5 mA dc current, $\epsilon < 4\pi$ mm-mrad) [3]. A high voltage terminal houses the gun control electronics and is connected to the gun cathode. These electronics consist of filament power supplies and programmable bias supplies for both dc and pulsed operation of the gun. Due to the high voltage, control and monitoring of the gun parameters has to be routed via fiber-optics.

The adopted solution for the control of the electron gun is shown in Figure 1. With the help of an Ethernet repeater the Network signal is transformed to

light pulses and linked with fiber-optic cable to a mirrored repeater inside the high voltage terminal. A small VME crate is also housed in the terminal with its own controller, a DAC (VMIVME-4105) and an ADC (VMIVME-3115) card with the appropriate number of channels to control the gun. In this way, a reliable flow of control information can be achieved across a high potential.

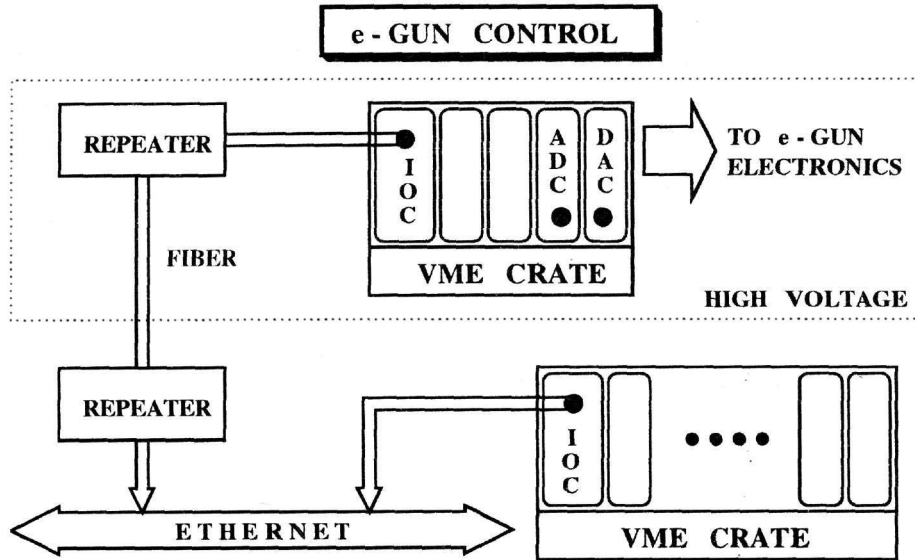


Fig.1 Design of the Control Subsystem for the 100 keV Electron Gun

2.2 Magnetic Elements of the 100 keV Beam Line

The 100 keV transport line consists mainly of the chopper/buncher system and a number of optical elements (solenoids, steerers and apertures). Its function is not only to chop and bunch, but also to limit the transverse emittance of the beam from the electron gun [1].

The optics of the transport line has been extensively studied using the TRANSPORT and PARMELA codes. PARMELA calculations indicate that space charge effects are not negligible in the bunched beam at 100 keV. Therefore, an accurate setting of the magnetic fields in the solenoids is required. A *Kepeco PTR* group of modular dc power supplies is used to drive them in stabilized current mode operation. Since this family of power supplies can be externally voltage controlled, the simplified diagram shown in Figure 2 is used to set and monitor the load current.

The solenoid loop shown in Figure 2 has been realized with following VME modules: A 32-channel, 12-bit digital to analog converter (VMIVME-4132)

drives the amplifier of the power supply working in current mode. A high quality external sensing resistor is serially connected to the solenoid magnet. The voltage drop is read out by a 12-bit analog to digital converter (XVME-566). The loop is designed to be computer controlled with an underlying sophisticated application, which serves as an interface between operator and optics calculation programs.

Similar loops are also designed for the steerer pairs belonging to the 100 keV beam line. Apertures return only the information from the current intercepted on them which is used to optimize the beam transport.

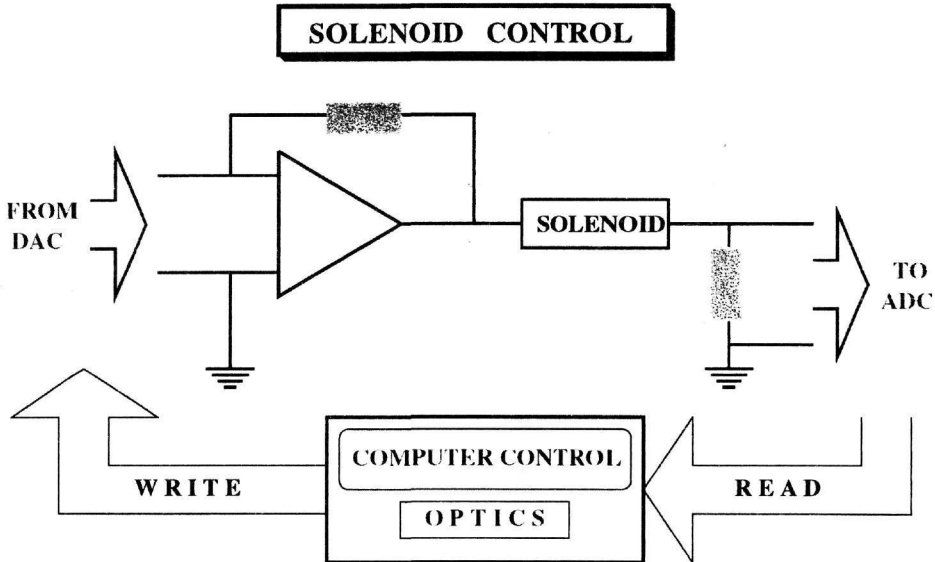


Fig.2 Simplified Control Loop for a Solenoid Magnet

2.3 Low Level RF System

The chopper/buncher system uses two square deflection cavities (operating in the TE_{102} and TE_{201} modes) and a buncher cavity (TM_{010} mode). The 100 keV electron beam is deflected by a rotating magnetic field in the first deflection cavity, forming a spiral that traces a circle on the chopping aperture, which allows only 1/6 of the input beam to pass through. The second deflection cavity is adjusted to exactly cancel the transverse kick and to bring again the chopped beam on axis. The 2380-MHz bunching cavity decelerates the head of the 60° long bunch from the chopping system and accelerates the tail. A common RF reference source is used for all these cavities, derived from a voltage-controlled crystal oscillator at 147.75 MHz, which is then frequency multiplied by 16 to 2380 MHz. The typical feedback control system, in its

original NIST-machine implementation, is shown in Figure 3 [4].

Since the control loop, based on custom electronics packaged in NIM hardware standard, has not caused any problems in the operation of the chopper/buncher system, there is no plan to modify its architectural design. A big priority is set in the integration of the stepping-motors (driven by the M540 Microstep CAMAC module from Highland) in the EPICS environment, which are used to provide the necessary phase adjustment for each device. In addition, some other critical parameters can be integrated and monitored in the final Control System Architecture.

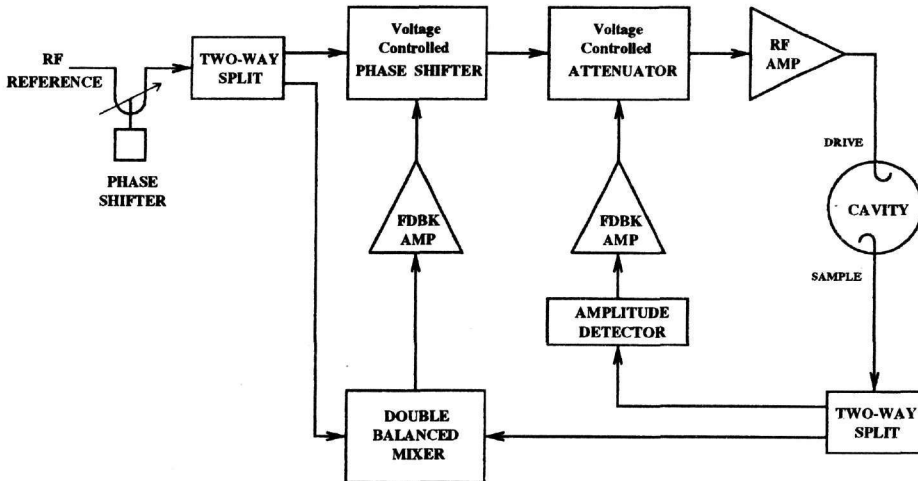


Fig.3 Typical RF Feedback-Control Diagram used to drive the Chopper/Buncher Cavities

2.4 Diagnostics

View screens and high resolution wire scanners will be used to monitor the beam profile. The wire scanners consist of two $30\mu\text{m}$ carbon filaments mounted in an "L" pattern and connected electrically. The wires are driven through the beam at 45° by a pneumatic actuator which can operate up to 8-10 cycles per second. Cycling of the actuator is controlled by a commercially available pneumatic logic system (typical cycle times: 50msec for 5cm extension or retraction of the actuator, 75msec wait). A charge sensitive preamplifier is used to amplify the current signal, while a linear potentiometer provides the wire position signal [5].

The wire-current and position signals are sent to a 32-channel, 12-bit ADC board, as shown in Figure 4. The XVME-566 module from Xycom with a 64

KB dual ported memory and a programmable multiplexer is used. Its conversion time ($< 10\mu\text{sec}$) allows the sampling of both channels simultaneously with a sampling frequency better than 50 KHz.

3 Conclusion

Important loops of the 100 keV injector line for the Athens Racetrack Microtron have been designed and partially realized. The experience gained so far and the understanding of the complexity of the various accelerator parts and their relationships will guide the further development of the project. Interlocks, Vacuum and Safety Controls have also to be integrated in the main Control System. The modularity of the EPICS environment will help in the refinement of the Control Architecture for the entire RTM facility.

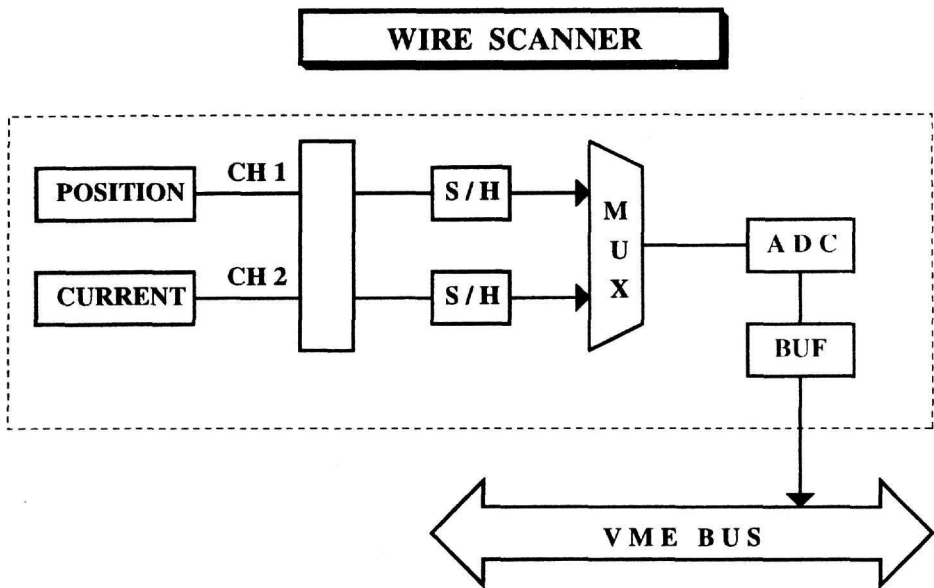


Fig.4 Wire Scanner Control Diagram

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