20 MeV Microtron Control System

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INTRODUCTION

The Centre for Advanced Technology (CAT) was set up in 1984 at Indore by the Department of Atomic Energy. The major thrusts at the CAT are in the areas of accelerators, lasers and related research and technology. The main aim of the accelerator program is to develop particle accelerators for research and development and for medical and industrial applications. As part of this program the 450 MeV Indus-1 and the 2 GeV Indus-2 electron storage rings were completed as Synchrotron Radiation Sources (SRS). The corresponding critical wavelengths of the emitted radiation spectrum are 61 A and 1-4 A respectively. Both the machines are supplied with electrons by a common Booster synchrotron (20 - 700 MeV). A 20 MeV Microtron was chosen due to its simplicity as the injector for the booster. The main design parameters of this microtron are a pulse current of 30 mA and a pulse duration of 1-2 μs with repetition rate of 1-2 Hz. This injector microtron was commissioned in 1993. This paper describes the control system for it.

REQUIREMENT

The microtron being used at CAT is a dual-purpose machine. It is used as an injector to the booster and also it is a part of a free electron laser system. Its control system is basically governed by the following requirements:

- The operation of the microtron should be controlled both centrally and from a local control room.
- The subsystems of the microtron which are to be monitored and controlled are the magnet power supply, the RF modulator and driver, the cathode power supply, vacuum, beam diagnostics, cooling system, vertical probe movement for scanning of different orbits, beam extraction, field measurement, quadrupole focusing and defocusing power supplies, analyzing magnet power supply, timing and trigger system, alarm, safety and interlocks.
- The system must work in noisy environment, noise generated by the RF modulator and other sources.
- The operation should be fail safe. It should monitor all safety aspects of machine, operator and working personnel, as the activity level is high.
- It should be reliable.
- It should be user friendly.

ARCHITECTURE

The entire control system of Indus-1 is designed around the VME-based Supervisory Control And Data Acquisition System (SCADAS) and PC/AT computers functioning as operator consoles. It is designed as two layer system. The upper layer consists of a number of PC/ATs on an ethernet. The control system architecture is modular and distributed because it is divided into a number of subsystems, each of which is partly autonomous. The microtron control system is a part of this with the ability to be controlled from two locations.. The overall system is shown in figure 1. Each console is backed by an individual SCADAS based on the VME architecture. All the interfaces have been developed in-house to avoid any future maintenance problems. The industry standard VME architecture was selected as its specification satisfies the requirement of the accelerator control environment. It is a 32-bit bus with the capability of handling a multi-CPU environment, bus arbitration, interrupts and many others useful features. The SCADAS consists of following modules:

- *CPU module: This has a 16 bit 68000 processor, 32 kB RAM, 32 kB EPROM, serial communication port and parallel port.*
- *32 bit optically-isolated input module: This is used for scanning the status of different units.*
- *32 bit relay output module, used for controlling various units.*
- *32 channel, 12 bit ADC card with memory.*
- *8 channel 16 bit DAC with hardware trimming facility and voltage to current converter.*
- *8 channel signal conditioning card (current to voltage converter).*
- *8 channel stepper-motor controller card.*
- *serial interface card to connect the field measuring unit with any other system.*

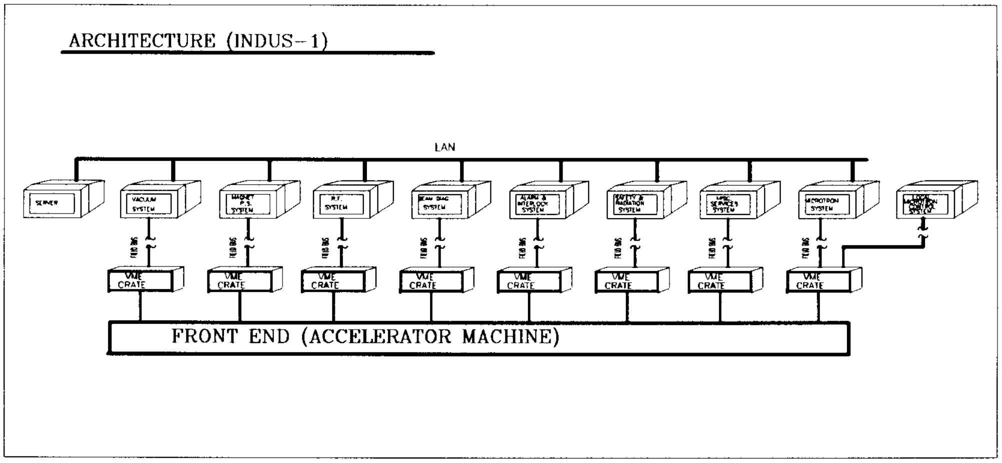

Figure 1

SCADAS is housed in a 19 inch rack located at the local control room together with an RF synthesizer, a digital CRO, a video monitor, a status monitoring and display system, the timing and trigger system, a PC/AT as a console and radiation monitor, safety and interlock systems. SCADAS is connected serially to the console through one of the communication ports. The microtron control system is shown in figure 2.

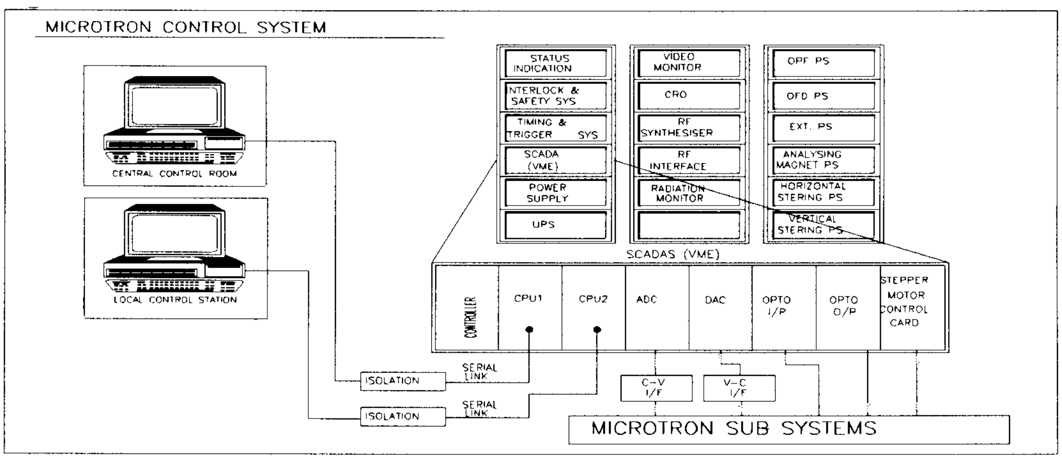

Figure 2

OPERATION

There are two modes of controlling the microtron, for commissioning and for normal operation. Some interlocks are bypassed during commissioning to obtain the results in the shortest possible time. This is allowable, as experts are handling the machine during this period, but interlocks must be in use for normal operation. In the initial phase of commissioning, we started with a probe, driven by a stepper motor, raised in the vacuum chamber to check the beam orbit by orbit, from the first to the 22nd. In a later phase, the probe was removed and the extraction channel was mounted, with a fluorescent screen at the end, viewed by a video camera. The current pulse was viewed on a digital oscilloscope. The beam was extracted after aligning the channel parallel to the beam. There are quadrupole lenses in the straight beamline to adjust the beam size according to requirements.

The vacuum required is 10^{-6} torr or better. The power supply for the heater of the lanthanum hexaboride cathode is interlocked with the vacuum, to prolong its life. RF power is provided by a frequency synthesizer, amplifier and modulator. The cavity is tuned by varying the synthesizer, manually when operating from the local control room and through GPIB from the central control room. The cavity temperature is stabilized to within 5^{o} C to avoid excessive frequency shift.

There are three important parameters to control in a microtron; RF power, magnetic field and emission current. The settings of such parameters are entered digitally by the operator at the console. These values are converted by 16-bit DACs into analogue currents in the range 4-20 mA. These are connected with shielded cables to the units to be controlled, where they are converted to voltages in interface boxes. Isolation amplifiers have been used for the important parameters to avoid corruption of the signals by noise, mostly coming from the nearly 130 kV RF modulator pulse. Parameters are monitored by converting the signals to currents in the 4-20 mA range in interface boxes. After transmission to the central control room, the currents are converted into voltages by a signal conditioning cards at the SCADAS and then converted by a 12-bit ADC. On/off commands are carried out by relays and the system and interlock status is sensed via opto-isolators.

SAFETY AND INTERLOCK

For normal routine operation a sequential procedure has been implemented to achieve safe and accident-free operation. There are two main aspects of safety; machine safety and personnel safety. All individual units are interlocked according to requirements such as water flow, temperature, overvoltage, overcurrent, door open etc. The system interlocks such as vacuum, radiation level, air ventilation etc. affect the machine operation. All the system interlocks are monitored continuously and some of the critical ones are executed in hardware. For human safety we have installed radiation dosimeters, a search-and-scram system inside the microtron and booster hall, an alarm system, a public announcement system, a siren and door interlocks.

TIMING AND TRIGGER SYSTEM

The complete system of Indus-1 is synchronized with the 50 Hz AC line. The timing scheme is shown in figure 3. The zero crossingr pulses are derived from the cathode power supply and divided to obtain 1 or 2 Hz, which are the microtron operating frequencies. Firstly ramping of the booster dipoles is started then the septum magnet power supply is switched on. The time to switch on the modulator in the microtron is chosen such that the magnetic field at the septum has leveled out and the dipole current is at the injection level. The modulator pulse is energized during the zero crossover slot. The current through the cathode in this period is minimum, to avoid modulation of magnetic field in the vicinity of cavity when rf field is applied. The timing and trigger system is interlocked with the safety system for proper operation.

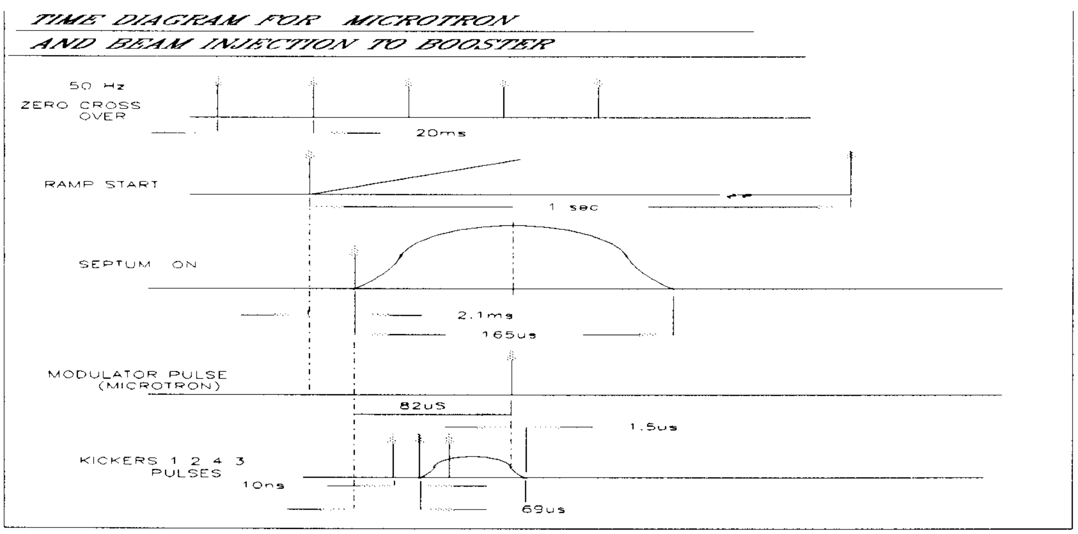

Figure 3

SOFTWARE

The main task of software is to supervise the overall system activity. The software for the operator interface has been developed using the Turbo C package under DOS. Software for SCADAS is written in assembly language using a cross assembler and then downloading. The interface was made user friendly for ease of use by the operator.

CONCLUSION

The microtron control system has been working reliably at the Centre for Advanced Technology for the last three years. There are occasional problems due to modulator noise due to the deterioration of the RF grounding. Recently we have commissioned a 12 MeV microtron system at Mangalore University for research and development. Work is going on to build a microtron for medical and industrial use. A similar control system will be used for with them.

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