New SWIC Scanner/Controller System

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Abstract

Since the early 1970s Segmented Wire Ion Chambers (SWICs) have been used in the Fermilab Switchyard beam transport lines to measure beam positions, emittances and intensities by generating horizontal and vertical beam profiles. Each plane utilizes 48 wires positioned in an electric field to collect beam ionization current. By integrating the current in each wire, two-dimensional beam profiles can be generated. The Switchyard SWICs as originally engineered are geographically multiplexed. There are 26 physical devices and only 7 scanners/controllers; therefore all profile data cannot be collected in one beam cycle. In the Main Ring era short cycle times (~10 seconds) lessened the impact of this limitation. Tevatron era operation of Switchyard uses both SWICs and BPMs. SWICs will show profile information and have a much lower beam intensity threshold as compared to BPMs. This is an advantage during tune-up at low intensity especially when dealing with cryogenic transport lines. Long Tevatron cycle times (~60 seconds) coupled with the need to sequence various SWICs and their gains on a given controller, have been seen to increase the required startup/tuning time, necessitating the upgrade presented here.

Hardware Implementation.

The new SWIC controller/scanner system (figure 1) has been designed to ease the limitations noted in the current one. Each SWIC has an associated rack-mounted controller chassis which contains an integrator channel per wire, timing and control circuitry, a dedicated 80186 CPU and an ARCNET communication coprocessor. The controller is capable of taking and storing successive beam snapshots under various timing and gain settings. Triggers for data collection are derived from the Tevatron real-time clock or from direct processor commands. The SWIC position, in or out of beam, and the associated high voltage supply are interlocked and controlled by the chassis as well. All of the SWIC controllers reside on an ARCNET LAN and deliver data to a front end processor (68060 residing in the VME chassis). This front end processor does data organization and statistical processing before the final data is presented to the control consoles for operator analysis. New cabling combined with a new scanner/processor system will allow simultaneous data collection from all SWICs. Existing "Automated Tuning" programs will be able to use either BPM or SWIC position information.

Software Implementation.

Software support for the SWIC system will include programming SWIC scanners to do certain measurements, store the results of the measurements and calculations performed on them in various buffers, and provide convenient user access to these buffers. A major problem in this system is that of somehow tying together multiple various pieces of data belonging to simultaneous measurements.

The most convenient way to do this, in our opinion, is to use the Finite State Machine (FSM) paradigm. If we apply this paradigm then we can view the VME system as running 26 FSMs (one per actual SWIC processor). These FSMs are comprised of states, each corresponding to one measurement. Every state is set up independently, defining the type of measurement (fast spill, slow spill, early in spill, late in spill, beam-off background, etc.) it represents, integration time, integration time prescale, gain, calculations to be performed on the collected data, where this data should be written (associated buffers), etc. Each FSM is also settable, allowing the user to define which states are to be executed and in which order.

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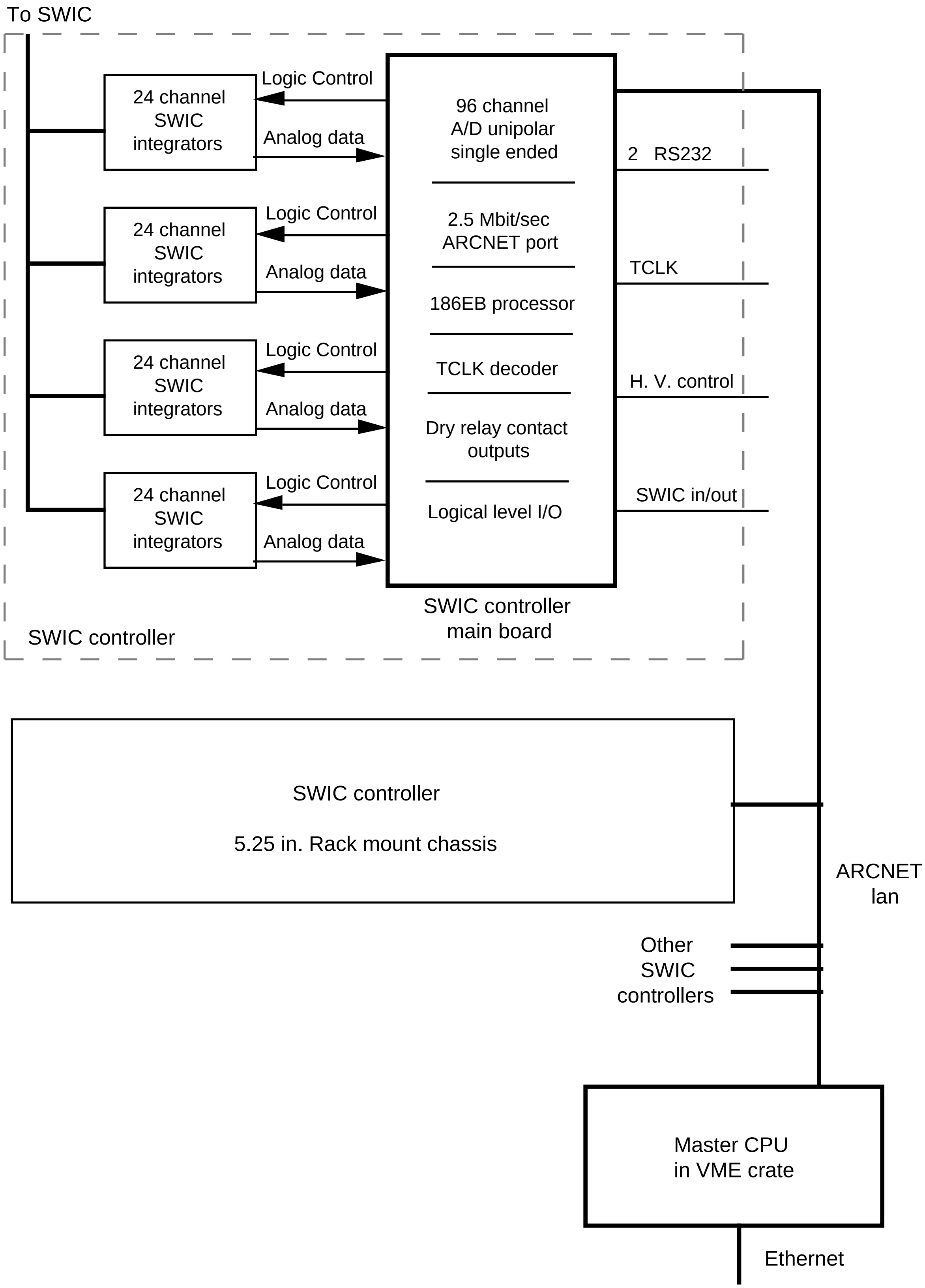

Fig 1. SWIC control and data retrival system.

Each FSM can be started or stopped manually, thus starting and stopping data collection at one particular SWIC. Part of the FSM start-up procedure is extracting the measurement table and sending it to the local SWIC processor, thus providing that processor with the guidelines for setting up actual measurements. After the FSM is started, it repeatedly runs the same measurement procedure until it is stopped. When the FSM is running, neither the FSM itself nor the states can be altered. State transition occurs on receiving data from an 80186, collected for this particular state. Additional support for the FSM includes FSM status (running/idle), current state indicator and state history over the last several transitions.

We are planning on two types of buffers, "simple" or linear and circular, allowing storage of multiple cycles of data. Software will allow connecting any buffer to any state. Each state can write its data into up to 4 buffers and each buffer can be connected to any number of states. Each buffer, whether circular or simple, will consist of the same major parts (per measurement):

- header, an ASCII string comprised of the following pieces: state, SWIC number, measurement description, time stamp, etc.;
- raw data;
- calculated data.

Interrelations between FSM, states and buffers are shown in figure 2.

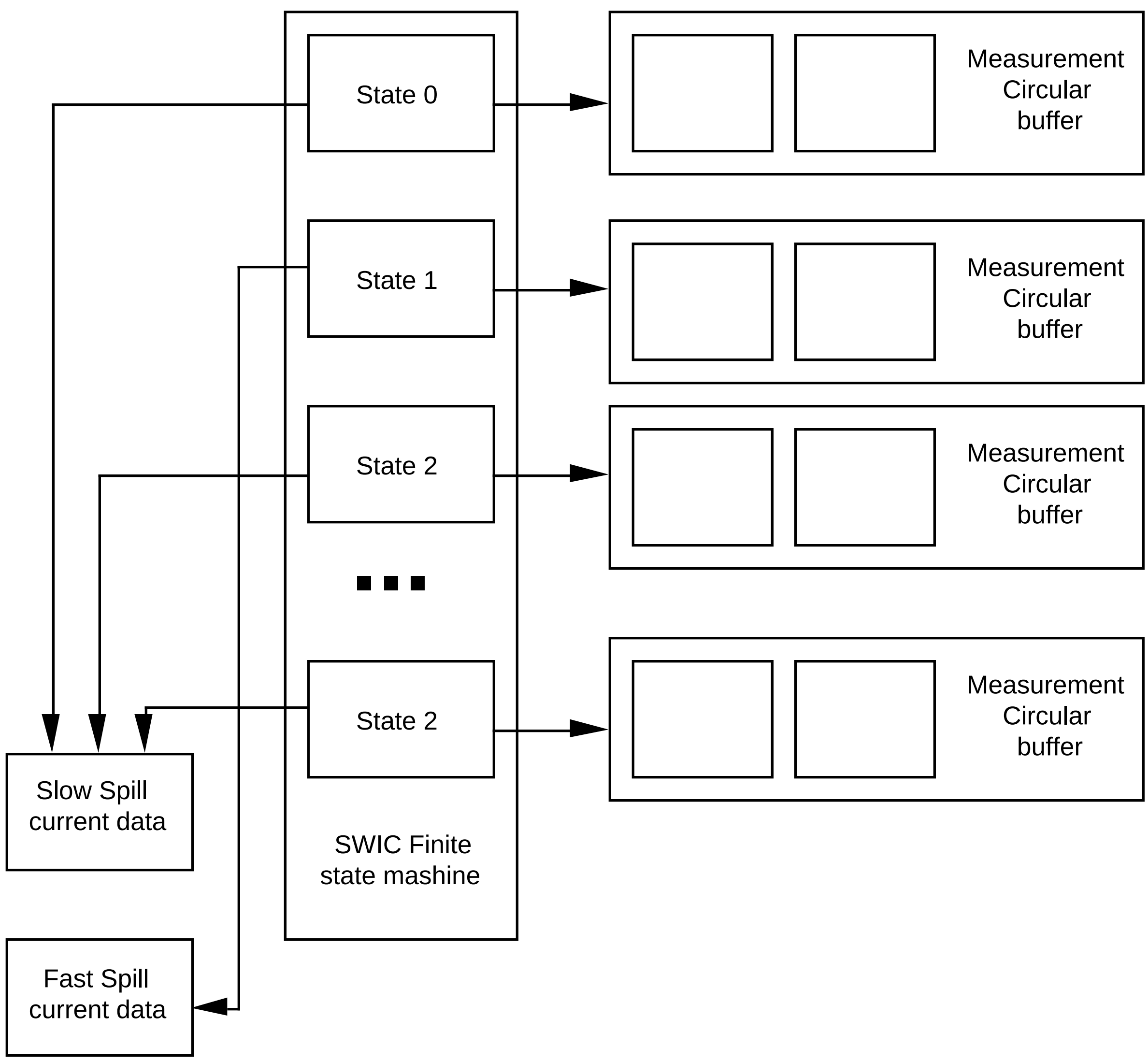

Fig 2. SWIC's Finite state machine and buffers

SWIC software is architecturally similar to that of Tevatron cryogenics [1]. Both are multiprocessor systems, consisting of a master communication CPU and multiple data collection slaves. The communications between master and slaves in both systems are based on the ARCNET link. This allows us to use without any changes that ARCNET protocol created for the cryogenic system. This protocol provides prioritized task to task communications and has proved to be reliable and easy to use. Reflective memory support created for the cryogenic control system, the virtual I/O bus (VIOB), can also be used for support of the bulk of the SWIC devices that are read and set periodically. The only extension for SWICs is data from the integrators, which is returned from the slaves to the master synchronously and bypasses the VIOB.

Summary and Conclusions.

This project has proved to be an interesting application of the reuse of software. Although the SWIC beam diagnostics discussed here differ markedly from the industrial process control of cryogenics, nonetheless distributed system operation, at a level below Fermilab ACNET, has been easily ported between them. The new software required is in the form of device drivers for the integrator boards and mathematical treatment of the profiles.

References

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2. B. Lublinsky. Shell software for Smart subsystems with front-end capabilities. Nuclear Instruments and Methods in Physics Research A 352 (1994) pp403 - 406