CUSTOM VME MODULES FOR TRIUMF/ISAC BEAM DIAGNOSTICS

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Abstract

The Beam Diagnostic system for the TRIUMF/ISAC Radioactive Beam Facility was implemented in VME. After a market survey of available commercial modules it was decided to develop four modules: an 8 channel 50-350 volt bias supply, an 8 channel variable gain current amplifier, a 96 channel current integrator and a 32 bit optically isolated digital I/O module. These modules integrate existing NIM based analog functions with onboard A/D and digital control. This has significantly reduced hardware costs and also labor costs by eliminating module interconnections and breakout panels.

1 INTRODUCTION

The control system for the TRIUMF/ISAC Radioactive Beam Facility was implemented in VME [1]. Wherever possible commercially available VME modules were used. Beam Diagnostic devices, such as wire scanners, require several functions that are not available commercially in a single package with the required density. The existing TRIUMF control system relies on NIM based current amplifiers and CAMAC based ADCs. CAMAC Digital output devices control amplifier gain. These device functions were integrated into VME modules in order to provide a more direct interface to the EPICS IOC, simplify device wiring and maintain integrity of low level analogue signals.

2 HARDWARE DEVICES

2.1 Current amplifier

The current amplifier is a single width 6U VME module that has 8 differential channels. Each channel has a 12-bit ADC that can be configured for conversion rates ranging from 1Hz to 100kHz. An acquisition memory can be triggered internally or externally to store up to 4096 sequential conversions. Multiple channels can be configured to use a single conversion clock for data synchronization. Analogue to digital conversions can also be controlled externally through a front panel connector. Each channel has eight selectable current gains ranging from ±1nA to ±1mA. A 10Hz analog filter can be selected for low frequency measurements. Analog inputs are connected via the front panel with Twinax connectors.

This module has allowed us to measure various beam properties at very low intensities. During beam tuning, currents on the Faraday cups can range from tens of picoamps up to several microamps. Figure 1 shows a mass scan after the pre-separator magnet. Measurements using an Allison-type electric sweep emmitance scanner [2] at the focal plane of the mass separator have resolved signals down to 5pA.

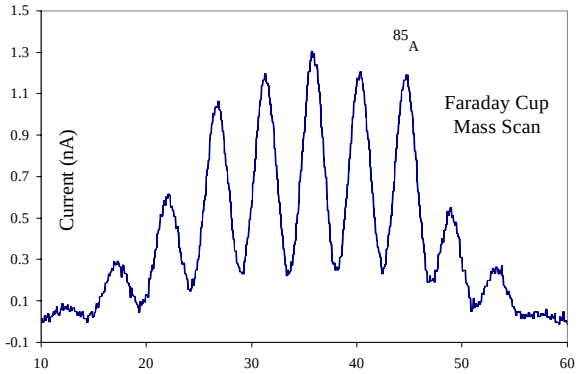

Figure 1: Mass scan

2.2 *Current integrator*

The current integrator is a double width 6U VME module with inputs for 96 channels. The inputs are divided into three groups of 32 channels and connected to the front panel via 50-pin connectors. Each group of channels is multiplexed to its own integrator and 12-bit ADC. Sixteen selectable gain ranges from ±25pA to ±2µA are common to all channels. The integration time for all 96 channels at the 25pA gain setting is 16 seconds and 200µS for the 2µA setting. A transition card was designed to connect each group of thirty-two RG174 coax signal cables to the 50-pin connector. This provided a considerable cost saving over the connector used in the NIM based integrator module.

This module was specifically designed to measure the harp beam position monitors in the DRAGON[1] installation scheduled to run in October 2000. During recent ISAC beam commissioning it was discovered that the existing NIM based current integrator does not have sufficient sensitivity to measure the signal on individual wires. This presented a good opportunity to test the prototype under actual operating conditions. Harp position measurements have resolved currents below 1pA.

[1] http://www.triumf.ca/isac/lothar/recoil/recoil.html

2.3 Bias supply

The bias supply is a double width 6U VME module that provides 8 channels of variable voltage with a range of ±50 to ±350 volts at 2mA. Each channel can be controlled and monitored from the VME interface or the front panel. The front panel interface allows local control and display for situations where VME control is not required. Outputs are connected via the front panel with high voltage SHV connectors.

This module is primarily used for providing a bias voltage to Faraday cups that are distributed along the ISAC beam line. When a faraday cup is moved out of the beam, the bias voltage is turned off to prevent any beam disturbance and to provide safety to personnel during beam line maintenance.

2.4 32 channel digital I/O

The VME input/output module is a single width 6U VME module. The 32 channels of digital input or output are connected to the module by two (25-pin) connectors on the front panel. 32 LED's display status for each channel. Each input bit is optically isolated and will accept 12-24 volts. The outputs are optically isolated in 4 groups of 8 bits. Each output can sink up to 500mA.

Initially it might seem that this type of module is readily available from a variety of manufacturers. However, we have been unable to find a commercial module that provides us with the right combination of cost and features. Since we had previous experience developing VME modules, we were able to quickly design and produce this module at a much lower cost.

3 SOFTWARE

All VME hardware is integrated into a control system based upon EPICS running on top of the vxWorks[2] real-time kernel. The software effort thus fell into the following categories.

- Diagnostic functions for probing any selected VME address.
- General-purpose vxWorks driver package for each module. Functions for hardware initialisation, status reporting and read/write operations were provided.
- Device support for EPICS.

3.1 Diagnostics

To assist in verifying hardware functionality, we took advantage of the generic EPICS VME record already available. This allows any VME address to be probed using any address modifier. EPICS tools were used to provide an operator interface.

3.2 vxWorks driver

The following functions were created to provide a standard interface to higher level applications.

- devCreate() - associates a "card number" with a VME address. This function creates a structure describing the device and adds it to a link list.
- devopen() - searches the list and returns a pointer to the device instance.
- devread/write() - read/write status/control and data.
- devReport() - displays information for all devices in the list.

3.3 EPICS support

Full device support was created for all EPICS analogue and binary input/output records. In addition, an abstraction layer of module-independent VME device/driver support was developed. This layer of abstraction allows an EPICS device to be referenced by a VME card number. The association between the card number and device driver is created during EPICS record initialisation.

4 CONCLUSION

We have successfully demonstrated that it is possible to measure picoamp currents on VME modules that are housed within the same VME crate as an EPICS IOC, a motor controller, digital I/O modules and a high voltage bias module. By combining most of the beam diagnostic functionality in a small number of in-house designed VME cards, significant cost savings were made over a combination of off-the-shelf VME and NIM based modules. Wiring and connector costs were also reduced by eliminating module interconnects and breakout panels. Standardised VME interface features simplified the task of developing reliable software drivers. New devices can be quickly and reliably integrated into the ISAC control system.

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REFERENCES

[1] Keitel R. et al, Design and Commissioning of the ISAC Control System at TRIUMF, these proceedings.
[2] P.W.Allison, D.B. Holtkamp and D.Sherman, IEEE Trans. Nucl. Sci. NS-30, 2204 (1983)

[2] Wind River Systems, Inc. Alameda, CA, USA