CONTROL SYTEM HARDWARE UPGRADE

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Abstract

The Paul Scherrer Institute builds, runs and maintains several particle accelerators. The proton accelerator HIPA (High Intensity Proton Accelerator), the oldest facility, was mostly equipped with CAMAC components until a few years ago. In several phases, CAMAC was replaced by VME hardware and involved about 60 VME crates with 500 cards controlling a few hundred power supplies, motors, and digital as well as analog input/output channels. To control old analog and new digital power supplies with the same new VME components, an interface, so called MULTI-IO, had to be developed. In addition, several other interfaces like accommodating different connectors had to be built. Through a few examples, the upgrade of the hardware will be explained.

ARGUMENTS FOR AN UPGRADE

- Increasing susceptibility of old hardware
- Limited lifetime of the components
- Mixed systems (old, new) - more effort for support and spare parts
- Reduction of system diversity
- Obsolescence of components
- No EPICS support for old hardware

UPGRADE PLANNING

In a transition phase, both old and new systems have to be operated. The HIPA upgrade was completed in a period of five years. During the yearly shutdowns a part of the control system has been upgraded. Early planning of the work is very important: Fabrication, testing, firmware development, software development, commissioning. To connect the new electronics to the existing wiring and its connectors, different interfaces must be built.

SAME VME HW FOR OLD ANALOG AND NEW DIGITAL POWER SUPPLIES

MULTI-IO (Interface for Old Analog PS)

Features:

- 16 analog out
- 16 analog in
- 48 digital out
- 48 digital in
- 8 Opto transmitter
- 8 Opto receiver
- FPGA Spartan 3 XC3S1500
- Soft core MicroBlaze microprocessor
- IP User Core

New digital controlled power supplies and old analog power supplies are controlled with the same VME cards VICB8003 [1] carrier board equipped with PSC-IP2 [2] Industry pack and PSCILK-TM [3] Transition board. The link over POF (plastic optical fiber) goes directly to the digital controlled power supply. In case of analog power supplies a MULTI-IO device is in between. The MULTI-IO interprets the serial signal of the Optolink and provides the appropriate DAC setting, ON/OFF and so on. The analog voltage representing the magnet current is converted by an ADC. The status information of the power supply is read by a digital input. Status and current information are converted to the serial protocol for the Optolink.

The MULTI-IO (See Fig. 1) is an in-house development. It can be used for various applications. At PSI it is used mainly for magnet power supplies. It consists of a 19 inch chassis (See Fig. 2), a main board, a backplane interface board and plugins like DAC, ADC, digital in and digital out. There is a galvanic isolation for each DAC, ADC, digital in and digital out. For the different types of power supplies it is necessary that connectors and pin orders can vary. Therefore, a big number of differently configured MULTI-IOs are used. DAC and ADC ranges are 0..1 V, 0 .. 10 V, −5 V .. + 5V. Digital output can be level or pulse. Firmware: DAC ramping, serial to parallel conversion for DAC and ADC, digital output pulse length, Optolink protocol encoding and decoding and other functions are directly implemented as FPGA logic. Data aquisition and command interpretation is done by software using the soft core MicroBlaze microprocessor.

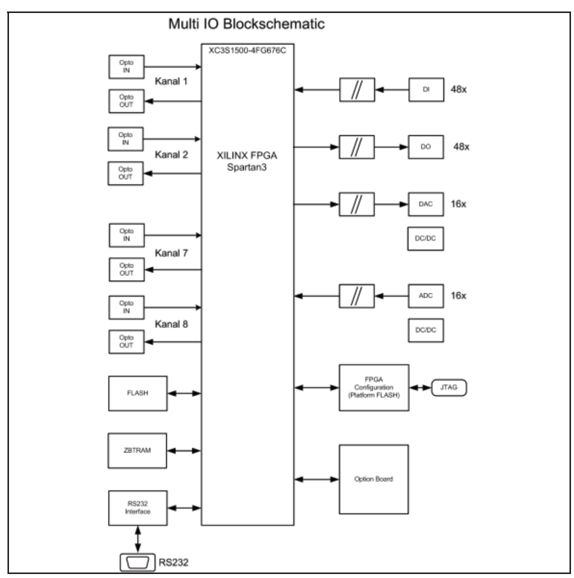

Figure 1: MULTI-IO block schematic.

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Figure 2: MULTI-IO chassis.

VICB8003 (VME CARRIER BOARD WITH DSP FUNCTIONALITY)

The VICB8003 [1] VME carrier board (See Fig. 3) is equipped with a DSP (Analog Device SHARC 21062). The software controls up to eight power supplies: comparison setpoint – supply current, current limits, interlock generation depending on power supply status ... All power supply information is stored in a shared memory accessible by the contol system. The commands to the power supplies are stored in the same shared memory and are interpreted by the DSP program.

Figure 3: VICB8003 and transition module.

INTERLOCK

The Interlock system is built from VICB8002 [4] / VICB8003 [1] carrier boards equipped with MRPM [5] Industry packs and TILK [6] transition modules or PSCILK-TM [3] transition modules. The Interlock logic is programmed inside the FPGA on the MRPM [5]. The MRPMs have hardware and so called software inputs. Magnet power supply intelocks are generated by the DSP program on the VICB8003 [1] to the software inputs.

MOTION CONTROL

At HIPA there are stepping motors, DC motors and AC motors. The position feedback is implemented with potentiometers. Stepping motors are controlled by MAXv-8000 [7] VME Modules together with PSI 2020 [8] transition boards. To read back the position, we use VICB8002 [4] carrier boards equipped with ADC8401 [9] IP - Analog in - 8ch/16bit and VTB8201 [10] VME transition board - Analog - 32 inputs −/+10V. For DC and AC motors, we use VICB8003 [1] carrierboards, MKTB [11] motor control transition boards and ADC8401 [9]. Control is done by the DSP program of the VICB8003 [1].

TEMPERATURE MEASUREMENT

For temperature measurement we use thermocouple transmitters from Phoenix Contact. They are configurable for different temperature ranges. The output of the transmitters is DC 0 .. 10 V.

ANALOG / DIGITAL IN / OUT

Many analog and digital outputs and inputs are for old analog power supplies. They are provided by the MULTI-IO. For the other signals, we use ADC84001 [8] for analog in, DAC8402 [12] for analog out, DIO8505 [13] for digital in and out.

USED HARDWARE FOR THE HIPA CONTROLSYSTEM

Components Purchased

- Trenew 16191 VME64x Crate , 7 slot
- Trenew 16878 VME64x Crate, 21 slot
- Motorola MVME5100 VME I/O Controller
- Hytec Carrier boards, industry packs and transition boards
- Prodex MAXv-8000 VME Module, Motor Controller, 8 Channels and 8 Encoders
- Phoenix Thermoelement transmitters

Components In-house Development

- MULTI IO VME to analog power supply interface and its plugins
- Industry packs for power supply control and Interlock
- VME transition modules for different applications

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HARDWARE FOR FUTURE UPGRADES / PROJECTS (SWISSFEL)

Collaboration PSI – IOXOS Company

- IFC1210 VME Intelligent FPGA Controller (See Fig. 4)

PSI In-house Development

- TM-MMC-16CH VME Transition Module POF 16CH + 1CH Sync + 1SFP
- TM-MMC-8CH VME Transition Module POF 8CH + 1CH Sync
- IFC-TC1 VME Universal High Speed Transition Module

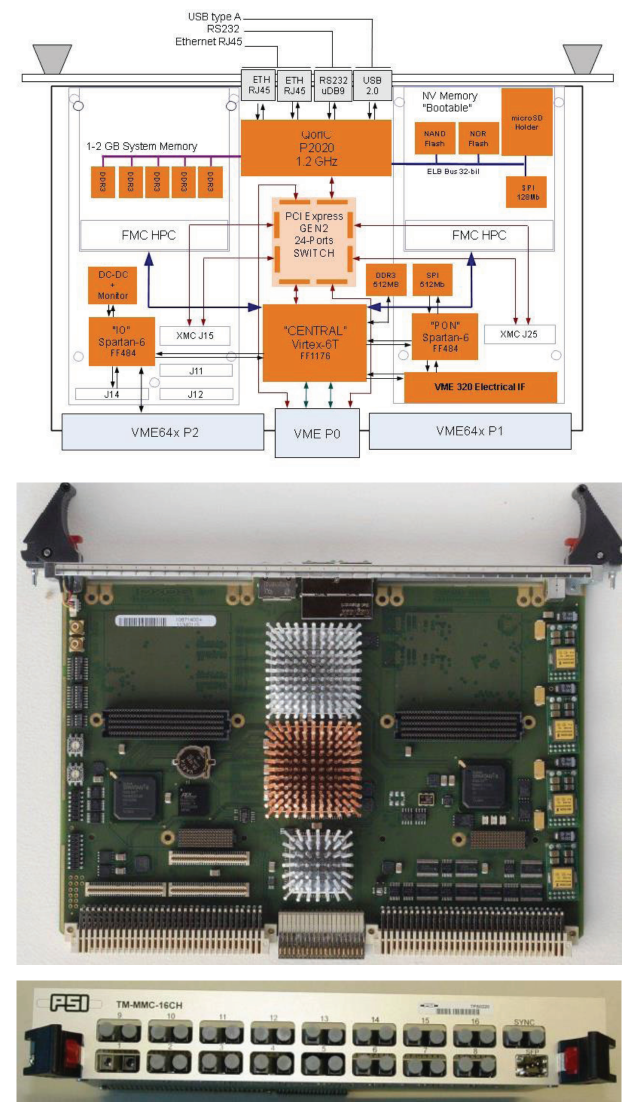

Figure 4: IFC1210 and transition bord.

CONCLUSION

Control system hardware upgrade for a big facility is a challenging task. First, a good analysis of the existing system has to be done. There are parts with high complexity and parts with less complexity. It is advantageous to start the first upgrade stage with a part of low complexity. The gained experience helps for the further steps. It is important to start early with the preparation. How many parts of which type must be purchased? What must be designed in house? Which connectors of the new electronics are compatible with the replaced electronics, which are not? How to interface to the existing cabling? The software developers must be asked to write necessary drivers. Of course, the new electronics must be tested as best as possible. If new cabling is required, the electricians have to be informed early enough. The commisioning of the new systems needs some time. If it is possible to test components without the facility in operation it should be done. Once everything is working after a shutdown, the reliability of the control system increases significantly.

REFERENCES

[1] VICB8003 Hytec VME carrier board with DSP
[2] PSC-IP2 PSI Industry pack power for supply control
[3] PSCILK-TM PSI VME transition board for power supplies and interlock
[4] VICB8002 Hytec VME carrier board
[5] MRPM PSI VME industry pack Interlock
[6] TILK VME PSI transition board Interlock
[7] MAXv-8000 Prodex VME Motion controller 8 channel
[8] PSI 2020 VME transition board for MAXv
[9] ADC8401 Hytec industry pack analog in 8 channel
[10] VTB8201 Hytec VME transition board analog in 32 inputs −/+10V
[11] MKTB PSI VME transition board for motor control
[12] DAC8402 Hytec industry pack DAC 16 channel
[13] DIO8505 Hytec industry pack digital in / out

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