PSI digital power supply controller

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Contents

• Introduction to “digital regulated power supplies”
• Controllers and control link
• Particularities of the EPICS Interface
• Applications at PSI and elsewhere
Introduction: “Digital Regulation”

- Regulation by “pulse width modulation” (PWM)

- Digital “set-value” (switch U0 on or off)

- No analogue outputs (for control), regulation quality determined by system bandwidth (switch & control loop performance)
Introduction: Digital PS Controller

• The PSI type “digital” controller
  – To be built into power supply
  – FPGA to generate PWM signal
  – DSP to run 50 kHz regulation loop
  – Fast optical fibre + RS232 service IF

• ADC card for digitizing output-current
  – Two ADC 16 bit, 50 kHz
  – High-precision voltage reference
PS controller structure

1) DSP for the feedback control loop
2) FPGA to generate the PWM switching pulses
3) Control system interface (optical link): POF, 5 MHz
4) Service PC interface: full control of the power supply/controller card with a service program, used in commissioning and debugging

The controller software has to be parameterized for each load (=magnet): impedance, inductance, max. current, etc. Done when commissioning the power supply (transparent to control system.)
Controller ADC Card

2x precise 2-channel ADC with high stability voltage reference
4 channels less precise ADC
2 x DAC for utility (debugging) purposes
VME Hardware

Industry Pack Carrier
VME64x 4 slot boards
“off-the-shelf”:
• Greenspring Vipc664
• Hytec 8002

Carriers available for many different busses (PCI, …)

IP Module for 2 PS

VME64x Transition module for 8 PS (optolink drivers)
Link operation

The IP module has (for each PS):
- 6 register groups (3*16 bit) for communicating with the PS
  • High-priority write (fast feedback, etc.)
  • Write (setpoint)
  • Read (current, etc.)
  • Waveform write
  • Waveform read
  • FPGA status (error handling)
  • Concurrent access automatically prioritized (order as above)
- 2-byte status register
Link presence/absence is automatically detected
- IRQ vector register

Communication registers are write-sensitive:
Writing to these registers (lowest word) triggers a communication cycle
- Communication is handled by FPGA: serial protocol is transparent to the card.
- Response from PSC appears automatically in the registers (signaled by an interrupt)
Link protocol & performance

- Communication frame (command + data), 66 bits
  command (8 bits), address (8 bits), data (32 bits)
  “overhead”: start, stop, parity bits (6*3 = 18 bits)
- 13 us for pure transfer at 5 MHz
  transfer rate limited to 10 kHz in firmware
  one data request cycle takes about 60 us (request + reply)
EPICS Interface: Scope

- A power supply an “intelligent device”
  - Freely programmable: RAM & flash memory
  - Sending and receiving waveforms
  - Communication via 256 read/write registers (attributes)
  - Reacts to trigger inputs and digital I/O
  - Each PS has an unique ID (PSI convention)

- Fast interface
  - 5 MHz optical fibre link
  - Extra trigger input
EPICS Interface: Features

- Serializes record access to the IP registers
- Reading and writing of parameters & status
- Waveform (ramp) download & upload
- Enhanced fault diagnostics
  - Currently 135 different error messages from PS
  - Check of Controller ID ⇒ cabling ok?
  - Detailed link communication diagnostics
- Allow for parallel VME bus access
EPICS Interface: Device / Driver

VME_IO:
#C$(card) S$(slot) @$($(link)$(function))

~400 functions

“high priority write” register, used by fast orbit feedback
Applications at PSI

• About 600 magnet power supplies at SLS
  – Ring dipole PS: 440 kW, 15 ppm stability
  – Booster dipole PS: 1 MW, 10 ppm, DC+3 Hz
  – Correctors: 1 kHz BW, +18 bits, 4 kHz setpoints

• Planned to use some for the SLS RF plants

• PSI proton cyclotron facilities will replace old magnet power supplies with digital ones
Application in Fast Orbit Feedback
Applications at PSI

• In PSI Proton Cyclotron, an intelligent IP carrier board (Hytec8003) is used
  – The board communicates autonomously with the PS (up to 6 PS/carrier plus interlock channels)
  – Monitors the operating conditions and current; generates an interlock if problems detected (2 mA proton beam!)
  – Reduces IOC load, faster response, simpler interface to the control system
Applications elsewhere

• Diamond will have ~1500 digital PS
  – PSI facility license fee: manufacturer can use hard- and software for Diamond orders

• Several PS manufacturer bought PSI license
  – Just ask your favourite PS manufacturer