

PSI digital power supply controller

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Credits & contact persons:

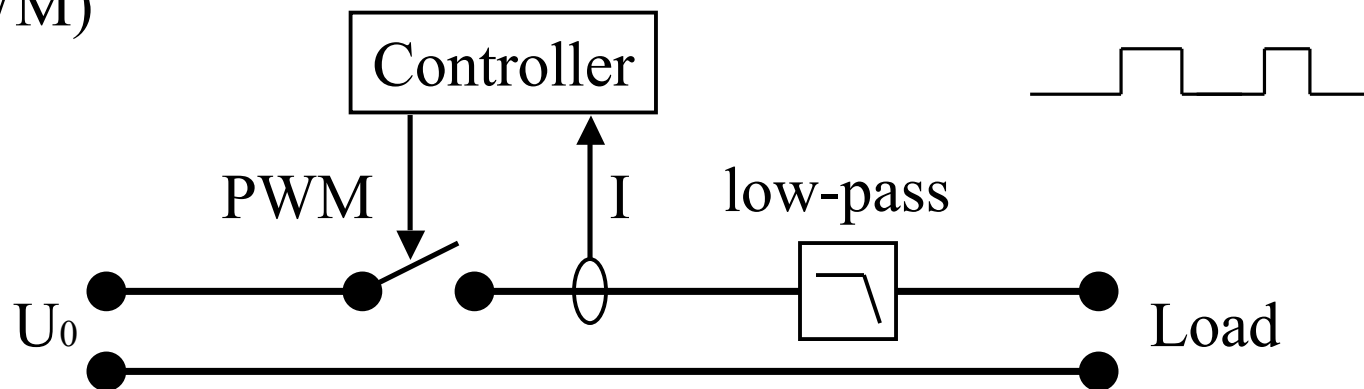
- EPICS interface, drivers: Andreas Luedeke (andreas.luedeke@psi.ch)
- Power supply controller: Felix Jenni (felix.jenni@psi.ch) & the PSI Power Supply group
- PS-link Industry Pack design: Guido Janser (guido.janser@psi.ch)
- Fast Orbit feedback: Thomas Schilcher et.al. (thomas.schilcher@psi.ch)

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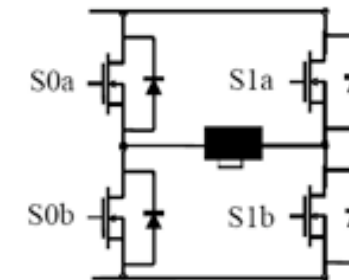
- Introduction to “digital regulated power supplies”
- Controllers and control link
- Particularities of the EPICS Interface
- Applications at PSI and elsewhere

Introduction: “Digital Regulation”

- Regulation by “pulse width modulation” (PWM)



- Digital “set-value” (switch U_0 *on* or *off*)
- No analogue outputs (for control), regulation quality determined by system bandwidth (switch & control loop performance)



Introduction: Digital PS Controller

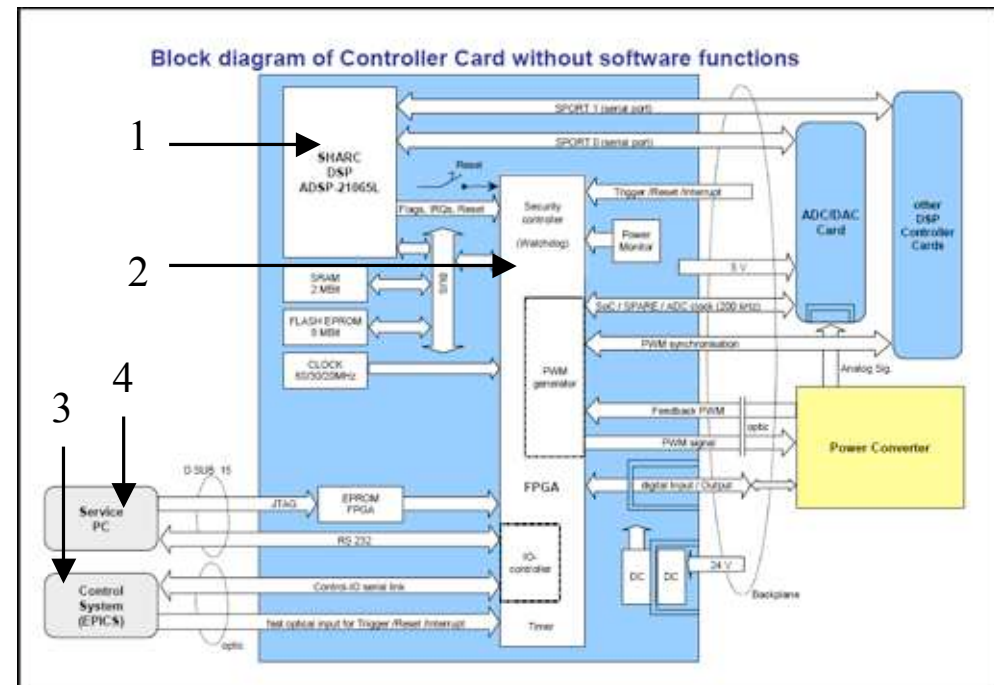
- The PSI type “digital” controller
 - To be built into power supply
 - FPGA to generate PWM signal
 - DSP to run 50 kHz regulation loop
 - Fast optical fibre + RS232 service IF
- ADC card for digitizing output-current
 - Two ADC 16 bit , 50 kHz
 - High-precision voltage reference



PS controller structure

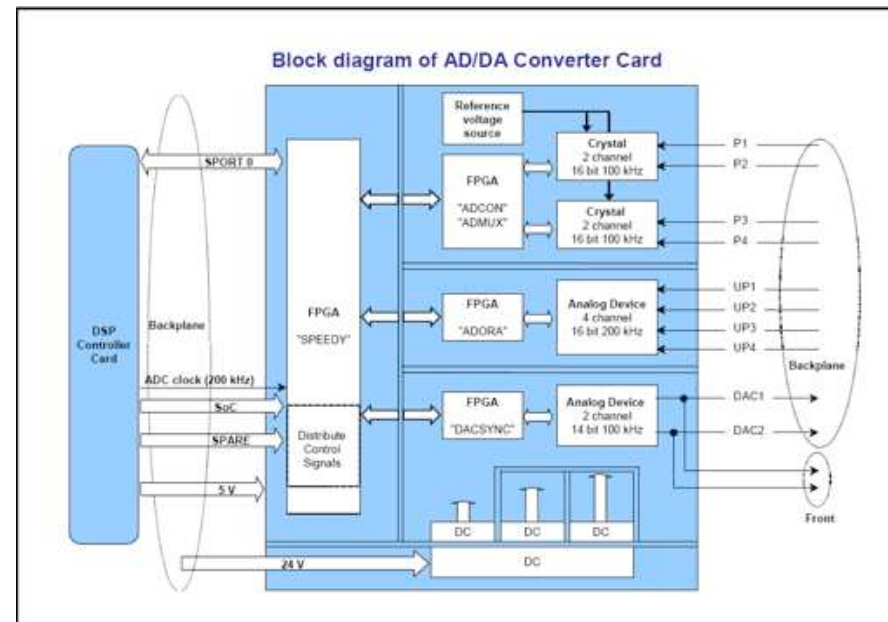
- 1) DSP for the feedback control loop
- 2) FPGA to generate the PWM switching pulses
- 3) Control system interface (optical link): POF, 5 MHz
- 4) Service PC interface: full control of the power supply/controller card with a service program, used in commissioning and debugging

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

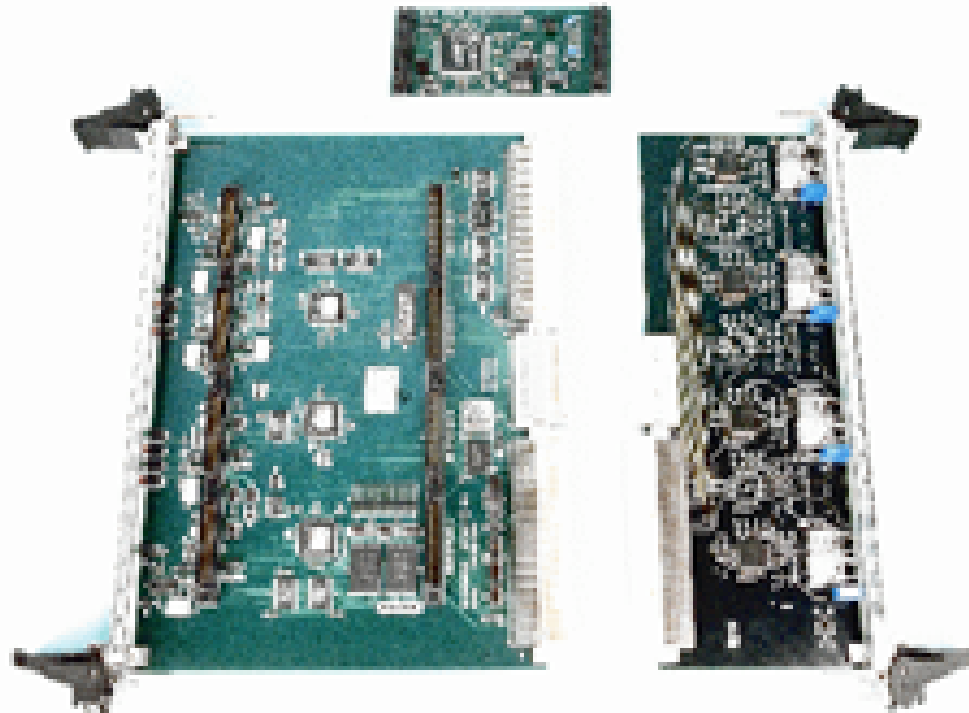
VME64x 4 slot boards

“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):

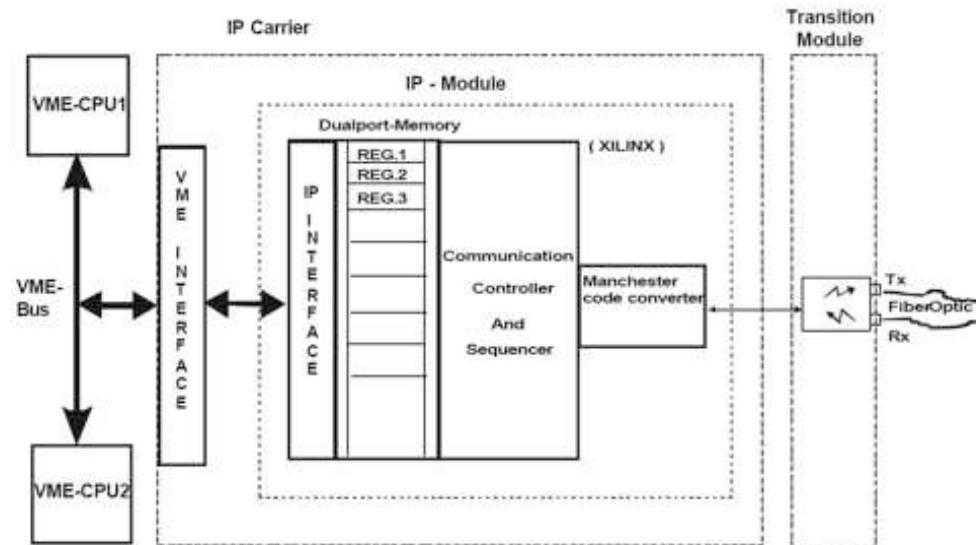
-6 register groups (3*16 bit) for communicating with the PS

- 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

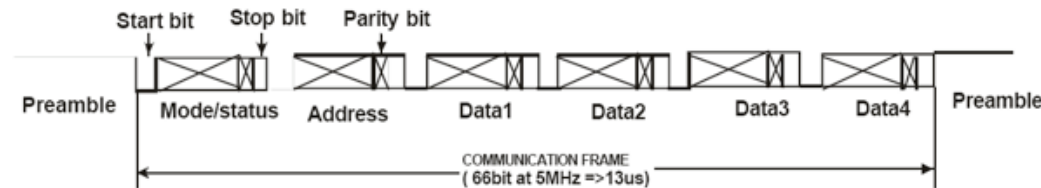


Communication registers are write-sensitive:
Writing to these registers (lowest word) triggers a communication cycle

-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 ($6 \cdot 3 = 18$ 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)

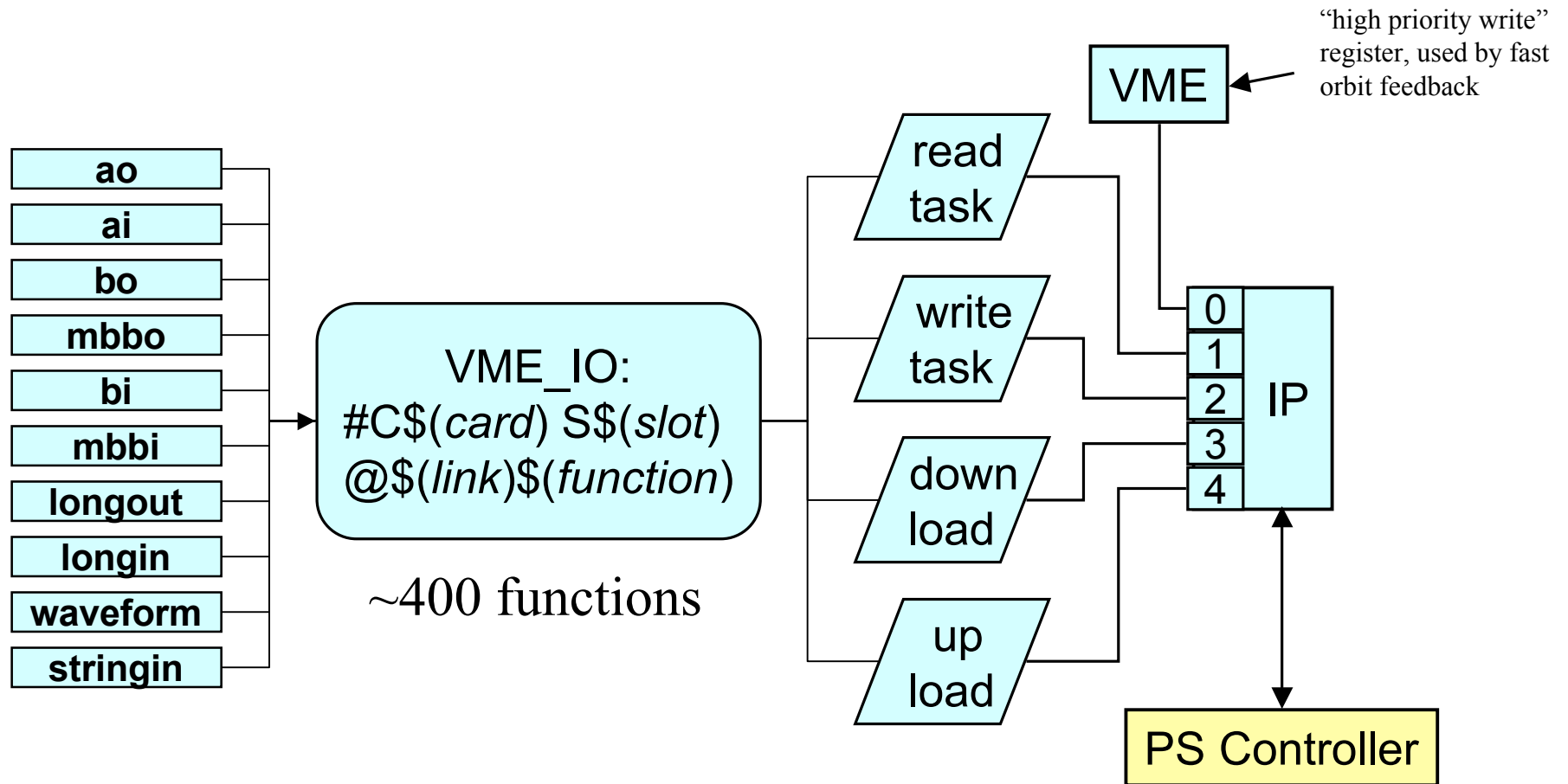
EPICS Interface: Scope

- 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 \Rightarrow cabling ok?
 - Detailed link communication diagnostics
- Allow for parallel VME bus access

EPICS Interface: Device / Driver



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

“high priority write”
register, used by 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