Detector control system for the EMC

Tobias Triffterer

Experimentelle Hadronenphysik
Ruhr-Universität Bochum

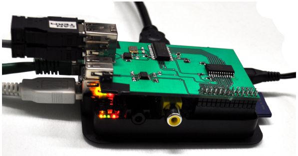
XLV. $\overline{\text{P}}$ANDA Collaboration Meeting
25th June 2013

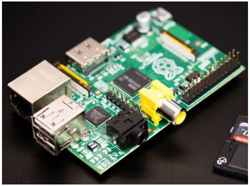
$\overline{\text{P}}$ANDA slow control standards

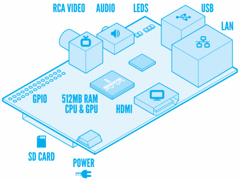
- CAN bus should be used for all slow control devices
- Chosen as bus system for $\overline{\text{P}}$ANDA DCS
- Two-wire data bus (differential signaling), data rate up to 1 Mbps
- Most devices of the EMC DCS use CAN bus
- Drivers read out CAN devices and feed the data to EPICS
- EPICS distributes the data to operator interfaces, alarm systems, archive engines, etc.

RaspberryPi CAN Readout

- Developed by Florian Feldbauer in Bochum and Mainz
- Based on RaspberryPi credit-card sized computer and custom adapter PCB for CAN bus
- One device in laboratory use in Bochum for several months
- More RasPi CAN interfaces currently rolled out
- EPICS drivers for iseg HV successfully tested
- Drivers for other components will be tested in the next weeks





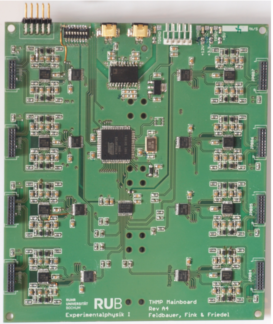


Temperature and Humidity Monitoring

- **T**emperature and **H**umidity **M**onitoring Board for $\overline{\textbf{P}}$ANDA
- Developed by Florian Feldbauer, Patrick Friedel, and Mario Fink at RUB during their Master/Diploma studies
- Lightweight solution to monitor environmental conditions:
  - Temperature (high precision)
  - Humidity
  - Air pressure
  - Flux in cooling tube
- Mountable close to/in the detector
- Generation 1 in use at Proto192 (FEMC) for > 3 years
- Gained lots of experience in these years
- Redesigned for final use in $\overline{\text{P}}$ANDA EMC $\Rightarrow$ Generation 2
- Distribution to other groups when new RasPI CAN PCBs available

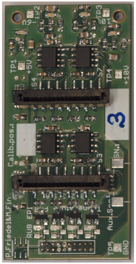
The mainboard

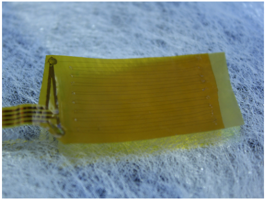
- Powered by AT90CAN128 μC (16 MHz)
- Connected via CAN bus
- Modular design:
    - Connectors for 8 piggyback boards (PBB)
    - Various types of PBBs for different tasks
- 8 channels per PBB $\Rightarrow$ 64 channels per THM$\overline{\text{P}}$
- 14 bit ADC (Maxim MAX1148)
- Channels multiplexed to ADC
- Low power consumption (< 3 W)



Temperature Piggyback Board

- Temperature measured by change of resistance of platinum
- Four-wire measurement
- Piggyback board drives a current of 1 mA
- Voltage drop over resistor (Pt100) is measured through separate wires
- Very precise measurement
- Independent of cable length
- Range $-50\,^{\circ}\mathrm{C}$ to $+50\,^{\circ}\mathrm{C}$
- Resolution < 0.05 K



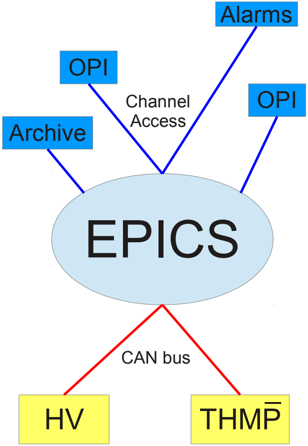


Other Piggyback Boards

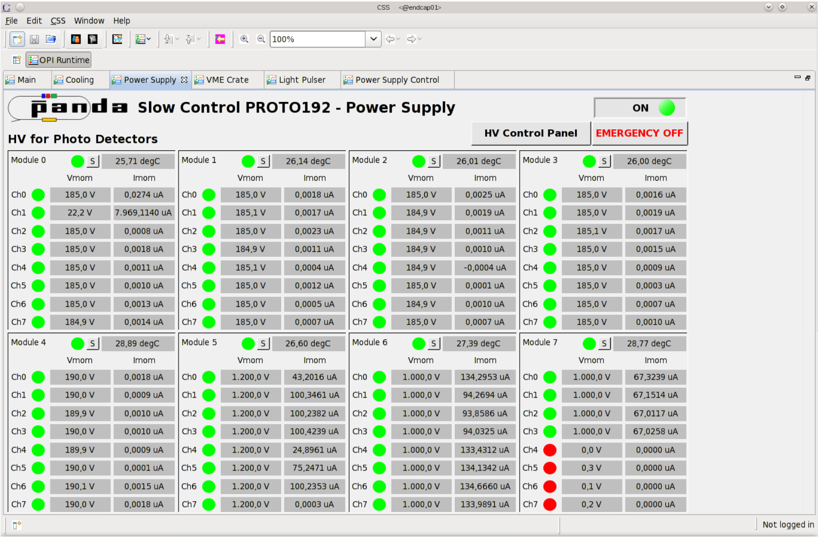
- Humidity (HIH-4000) and pressure (MPX4115A)
  - Same four-wire cables as temperature sensors
  - One wire to power the sensor
  - One wire for readout
  - Two wires common ground
  - Sensor response fed to ADC
- I/O board (planned):
  - Generic communication interface for e.g. relays, end-point switches, safety loops etc.
  - Remote-controllable using the CAN bus of the THM$\overline{\text{P}}$
- Generic interface for new PBB types:
  - New types of PBB without changes to the mainboard
  - PBBs can provide up to 4 V to the ADC
  - Two-wire interface (I^2C) for direct communication with the μC
    $\Rightarrow$ may need firmware extension

Control System Studio

- Developed by DESY, SNS, BNL and others
- Based on Eclipse Indigo RCP
- Three main applications:
  - GUI with operator interfaces
  - Archive Engine
  - Alarm Server
- Communicates with EPICS via network (Channel Access)

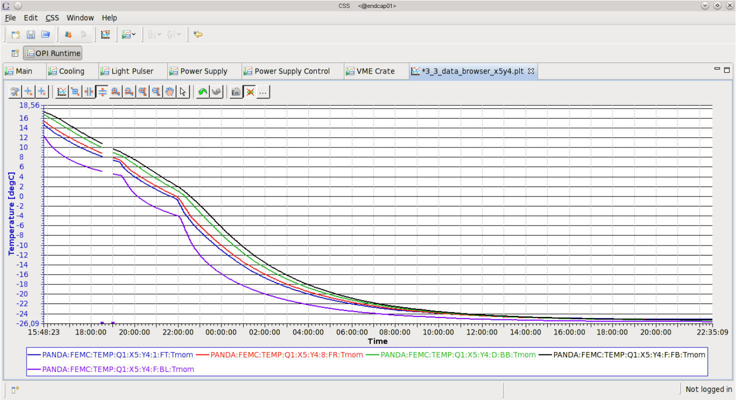


Operator Interfaces



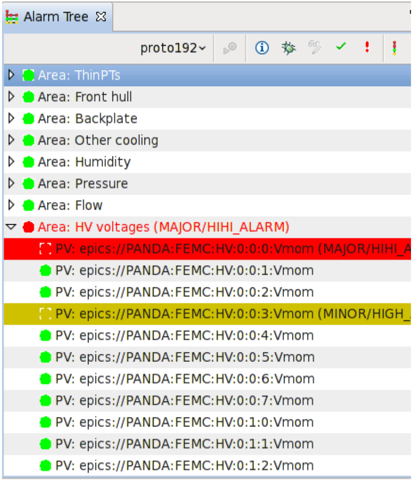
Archive Engine

- Background process
- Writes current data into database
- Data browser in CSS GUI to view data from archive



Alarm Server

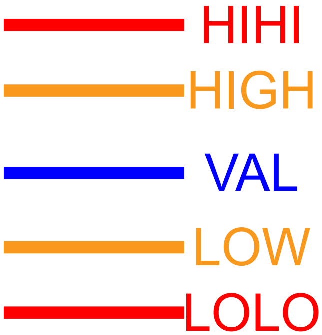
- Background process
- Monitores EPICS data for violation of alarm borders
- Notifies CSS GUIs and can take further action (e-mail etc.)
- Several GUIs in CSS to display alarm states



EPICS alarm borders

- Two upper (called "HIGH" and "HIHI") und two lower borders (called "LOW" and "LOLO") for each value in EPICS
- Each border can be
  - "No Alarm"
  - "Minor Alarm"
  - "Major Alarm"
- Alarm borders are plain double values, no relations etc. possible

$\Longrightarrow$ Write application to read data from EPICS and set alarm borders



New EPICS alarm software from Bochum

- Sets alarm borders for HV and temperature and current limits
- Three modes of operation:
  - Maintenance
  - Laboratory
  - Beamtime
- Data sources:
  - HV: Module type, detector type and current set voltage for HV
  - Temperature: Maximum and minimum chiller bath temperature within the last eight hours
- Built to be reusable by other groups

Maintenance mode

- Maximum set voltage: Hardware limit of module
- Voltage HIGH limit: No limit
- Voltage HIHI limit: No limit
- Voltage LOW limit: No limit
- Voltage LOLO limit: No limit
- Temperature HIGH limit: No limit
- Temperature HIHI limit: No limit
- Temperature LOW limit: No limit
- Temperature LOLO limit: No limit

Laboratory mode

- Maximum set voltage: 450 V for APDs, 1205 V for VPTTs
- Voltage HIGH limit: V_{max}
- Voltage HIHI limit: $V_{\text{max}} + 5$ V
- Voltage LOW limit: No limit
- Voltage LOLO limit: No limit
- Temperature HIGH limit: $T_{\text{max}} + 2\,^{\circ}\text{C}$
- Temperature HIHI limit: $T_{\text{max}} + 3.5\,^{\circ}\text{C}$
- Temperature LOW limit: $T_{\text{min}} - 2\,^{\circ}\text{C}$
- Temperature LOLO limit: $T_{\text{min}} - 3.5\,^{\circ}\text{C}$

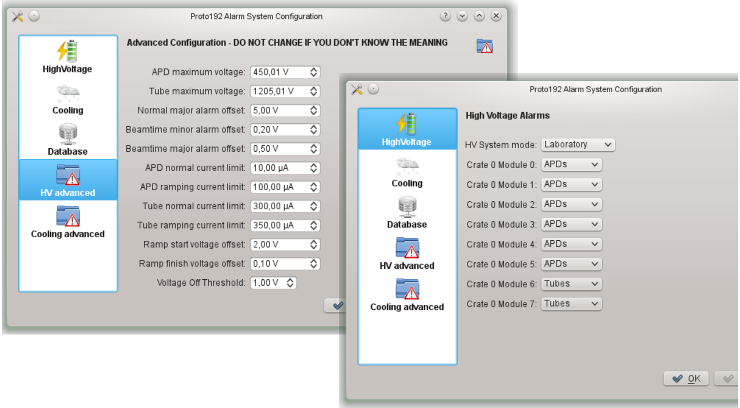
Beamtime mode

- Maximum set voltage: 450 V for APDs, 1205 V for VPTTs
- Voltage HIGH limit: $V_{\mathrm{set}} + 0.3$ V
- Voltage HIHI limit: $V_{\mathrm{set}} + 0.8$ V
- Voltage LOW limit: $V_{\mathrm{set}} - 0.3$ V
- Voltage LOLO limit: $V_{\mathrm{set}} - 0.8$ V
- Temperature HIGH limit: $T_{\mathrm{max}} + 2\,^\circ\mathrm{C}$
- Temperature HIHI limit: $T_{\mathrm{max}} + 3.5\,^\circ\mathrm{C}$
- Temperature LOW limit: $T_{\mathrm{min}} - 2\,^\circ\mathrm{C}$
- Temperature LOLO limit: $T_{\mathrm{min}} - 3.5\,^\circ\mathrm{C}$

Current limits

- APD channels drain far more current while ramping
- Implementation based on the state machine concept
- Three states:
  - Stable
  - Ramping
  - Off
- Channel off if crate off and $V_{\text{mom}} < 1$ V
- Channel goes to ramping if $|V_{\text{mom}} - V_{\text{set}}| > 2$ V or $|V_{\text{set,new}} - V_{\text{set,old}}| > 2$ V
- Channel goes to stable if $|V_{\text{mom}} - V_{\text{set}}| \leq 0.5$ V
- Current limits:
  - APDs: Stable 100 μA, ramping 200 μA
  - VPTTs: Stable 250 μA, ramping 300 μA

Configurability



- All numbers on the previous slides configurable
- Daemon reacts on config file changes and updates alarm borders

Application Structure

- Singleton class handling global EPICS resources (`EpicsAccessManager`)
- Common base class encapsulating all EPICS API calls (`EpicsPVbase`)
- Classes derived from `EpicsPVbase` for specific device types, e.g. `EpicsHvModule`
- Read and change every value, alarm border or severity
- Subscription to any value possible
- Classes for HV control can also be used in applications not dealing with alarm borders but requiring to control the HV

Current users

- THM$\overline{\text{P}}$ and EPICS/CSS DCS infrastructure already used by
  - Backward endcap group (Mainz)
  - Proto120 barrel prototype
  - Luminosity detector (Mainz)
  - Fordward endcap tests in Bonn
  - EMC tests at KVI (Groningen)
- Toolchain ready to be used by other detector groups
- Final version of the THM$\overline{\text{P}}$ available for the final endcap
- Software available in EP1 git repository (ask for access)
- If you have questions: Write me an e-mail

$\Longrightarrow$ `tobias@ep1.rub.de`

The End

Thank you for your attention!