DØ High Voltage System Tutorial

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Outline

- Hardware
- EPICS Support
  - HV Record
  - HV Alarms
- Operator GUI Programs
  - HV Utility Display
  - Global HV Display
  - HV Channel Display
- Diagnostic Guidelines

Ref:
- \D0server4\projects\Online_Computing\Tutorials\HvTutorial.ppt
Hardware - HV Crate

MVME2301 IOC Processor

4877 Module
Hardware - HV Module

Replaceable Generator Pod

January 22, 2003
Hardware - HV Channel

Voltage Test Point

Voltage Trimpot
Hardware

- **VME crate**
  - 6U size
  - Custom backplane
  - Additional voltage supplies
    - +5V Digital, +- 12V Analog, +-12 V Bulk(Unfiltered)

- **Fermilab/BiRa 4877 module**
  - Cockroft-Walton generator
  - Six modules per VME crate
  - 8 channels per module
  - 10 voltage generator pod types
  - Backplane trip links
  - Backplane module address encoding (geographical)
Hardware

• Reference
  ◆ Bi Ra - “Model VME 4877PS High Voltage Power Supply System Manual”
HV Record

- HV Record - hv
  - High-level device interface
  - Sequential state machine model (limited implementation of Harel state diagram)
  - Ramp algorithm
    - Parabolic end sections
    - Linear center section
  - Convergence algorithm
    - Repeat ramp until within tolerance limit
    - Enter PAUSE state if repeat limit exceeded
HV Record

• **Purpose**
  ◆ Control and monitor an individual HV channel
  ◆ Add high-level operations to a basic voltage generator

• **Implemented as a sequential state machine with states, transitions, actions, and events**

• **Ramping to a target voltage is a software function**
## HV Record - Pod Types

<table>
<thead>
<tr>
<th>Pod Name</th>
<th>Max Voltage</th>
<th>Max Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>P5.5KV1</td>
<td>+5.5kV</td>
<td>2.3 mA</td>
</tr>
<tr>
<td>M5.5KV1</td>
<td>-5.5 kV</td>
<td>2.3 mA</td>
</tr>
<tr>
<td>P5.5KV2</td>
<td>+5.5 kV</td>
<td>1.0 mA</td>
</tr>
<tr>
<td>M5.5KV2</td>
<td>-5.5 kV</td>
<td>1.0 mA</td>
</tr>
<tr>
<td>P5.5KV3</td>
<td>+5.5 kV</td>
<td>0.1 MA</td>
</tr>
<tr>
<td>M5.5KV3</td>
<td>-5.5 kV</td>
<td>0.1 mA</td>
</tr>
<tr>
<td>P3.5KV</td>
<td>+3.5 kV</td>
<td>3.5 mA</td>
</tr>
<tr>
<td>M3.5KV</td>
<td>-3.5kV</td>
<td>3.5 mA</td>
</tr>
<tr>
<td>P2.0KV</td>
<td>+2.0 kV</td>
<td>3.2 mA</td>
</tr>
<tr>
<td>M10V1</td>
<td>-10 V</td>
<td>0.2 mA</td>
</tr>
</tbody>
</table>
HV Record - Ramp Algorithm

- Compute average voltage
- Compute voltage step size and number of steps to reach target voltage
- Execute ramp steps
- Compute average voltage
- Compare $|V_{\text{average}} - V_{\text{target}}|$ with $V_{\text{tolerance}}$
  - less or equal - Enter HOLDING state
  - greater - Repeat ramp sequence
HV Record - Ramp Algorithm

- If the number of ramp cycles exceeds the limit, enter the PAUSE state and set an alarm condition
HV Record – Time Plots

- Decay profile
  - Capacitive load
HV Record – Time Plots

• Ramp regions
  ◆ Parabolic ends
  ◆ Linear center
HV Record - Trips

• Channel
  ◆ Overvoltage
    ■ Trimpot setting
  ◆ Overcurrent
    ■ Register setting
  ◆ External
    ■ Backplane connection

• Module
  ◆ Watchdog
    ■ Access timeout (unused)
  ◆ Interlock
    ■ Front panel connector (unused)
  ◆ External
    ■ Backplane connection
HV Record - Parameters

- **ACCL**
  - Parabolic acceleration rate (Volts/Sec**2**)
    - \(\text{RATE/ACCL} = \text{Duration of parabolic region (Sec)}\)

- **CSCAL**
  - Ramping current scaling factor

- **MAXC**
  - Current trip level (\(\mu\text{Amps}\))

- **RATE**
  - Ramp rate (Volts/Sec)

- **VTOL**
  - Voltage setting tolerance

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HV Alarms

- **Invalid Alarm**
  - Hardware access error
  - OFFLINE or INVALID state

- **Minor Alarm**
  - OFF or PAUSED states
  - Current warning limit exceeded
  - Voltage warning limit exceeded

- **Major Alarm**
  - TRIPPED state
  - Current fatal limit exceeded
  - Voltage fatal limit exceeded
  - A tripped channel will pause the run
HV Alarms – SES Display

- **Voltage Limit**

- **State and Current Limit**

![Alarm Display Table]

<table>
<thead>
<tr>
<th>Group Name</th>
<th>MAJOR</th>
<th>MINOR</th>
<th>INVALID</th>
<th>DISABLED</th>
<th>GOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run Pause</td>
<td>0</td>
<td>562</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HV</td>
<td>562</td>
<td>1686</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MDT</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PDT</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>SCINT</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>L1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PROC</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>All Muon</td>
<td>566</td>
<td>1691</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Status: Connection to server started
Operator GUI Programs

- **HV Utility display**
  - Monitor crate parameters (backplane voltages and temperature)

- **Global HV display**
  - Monitor channel state for multiple crates
  - Control state change for multiple crates

- **HV Channel display**
  - Monitor channel parameters for a single crate
  - Control state change for single channel or all channels in a crate
## HV Utility Display

![HV Utility Display](image)

### Paging Tabs

<table>
<thead>
<tr>
<th>Crate</th>
<th>+5 Digital</th>
<th>+12 Analog</th>
<th>-12 Analog</th>
<th>+12 Bulk</th>
<th>-12 Bulk</th>
<th>Temp DegC</th>
</tr>
</thead>
<tbody>
<tr>
<td>M217C</td>
<td>5.04</td>
<td>12.31</td>
<td>-12.22</td>
<td>12.44</td>
<td>-12.66</td>
<td>19.32</td>
</tr>
<tr>
<td>M217D</td>
<td>5.10</td>
<td>12.23</td>
<td>-12.48</td>
<td>12.26</td>
<td>-12.45</td>
<td>20.22</td>
</tr>
<tr>
<td>M217E</td>
<td>5.09</td>
<td>12.21</td>
<td>-12.36</td>
<td>12.23</td>
<td>-12.10</td>
<td>21.33</td>
</tr>
<tr>
<td>M218C</td>
<td>5.28</td>
<td>12.14</td>
<td>-12.29</td>
<td>12.40</td>
<td>-12.34</td>
<td>22.89</td>
</tr>
<tr>
<td>M218D</td>
<td>5.17</td>
<td>12.17</td>
<td>-12.26</td>
<td>12.42</td>
<td>-12.29</td>
<td>25.60</td>
</tr>
<tr>
<td>M218E</td>
<td>5.10</td>
<td>12.28</td>
<td>-12.47</td>
<td>12.43</td>
<td>-12.26</td>
<td>21.39</td>
</tr>
</tbody>
</table>

### Central

<table>
<thead>
<tr>
<th>Crate</th>
<th>+5 Digital</th>
<th>+12 Analog</th>
<th>-12 Analog</th>
<th>+12 Bulk</th>
<th>-12 Bulk</th>
<th>Temp DegC</th>
</tr>
</thead>
<tbody>
<tr>
<td>M215C</td>
<td>5.01</td>
<td>12.36</td>
<td>-12.22</td>
<td>12.18</td>
<td>-12.27</td>
<td>20.61</td>
</tr>
<tr>
<td>M215D</td>
<td>5.04</td>
<td>12.30</td>
<td>-12.26</td>
<td>12.43</td>
<td>-12.61</td>
<td>19.65</td>
</tr>
<tr>
<td>M215E</td>
<td>5.09</td>
<td>12.22</td>
<td>-12.20</td>
<td>12.25</td>
<td>-12.33</td>
<td>21.73</td>
</tr>
<tr>
<td>M217B</td>
<td>5.02</td>
<td>12.28</td>
<td>-12.15</td>
<td>12.35</td>
<td>-12.30</td>
<td>21.93</td>
</tr>
<tr>
<td>M218B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Status:**

[Reconnect]
HV Utility Display

• **Purpose**
  ◆ Monitor HV crate parameters
    ■ Backplane voltages
    ■ Temperature

• **Properties**
  ◆ Organized by detector page
  ◆ Read-only access
  ◆ Background color indicates alarm state

• **Implementation**
  ◆ Python script
  ◆ Program name - HvuGui.py
  ◆ Configuration scripts - xxx.hvu
Global HV Display

- **Channel State**
- **Channel Alarm**
- **Module**
- **Left-Click for Crate Display**
- **State Change Buttons**

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Global HV Display

• Purpose
  ◆ Monitor state of channels in multiple crates
  ◆ Execute multiple-crate actions
  ◆ Initiate crate display

• Properties
  ◆ Organized by crate
  ◆ Multi-crate action buttons

• Implementation
  ◆ Python script
  ◆ Program name - HvgGui.py
  ◆ Configuration script - xxx.hvg
Global HV Display

- **Crate button**
  - Start individual crate display

- **Action buttons**
  - OFF - set channels to OFF state
  - ON - set channels to ON state
  - RESET - reset tripped channels
  - FULL - set to a full (operational) voltage
  - STANDBY – set to standby voltage

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Global HV Display

- Buttons for other target voltages may be added in the configuration file

- Channel state colors
  - Purple - OFFLINE, DISABLED
  - Blue - OFF
  - Orange – ON, PAUSED
  - Yellow - AVERAGE, RAMP
  - Green – HOLDING
  - Turquoise – LOCKED
  - Red - TRIPPED
HV Channel Display

- **Size Control**
- **Page Cycle Control**
- **Right-Click For Limits**

*Image showing a HV Channel Display with control options and limit values.*

- **Limits**:
  - HIHI: $-1161.0$
  - HIGH: $-1670.0$
  - LOW: $-1690.0$
  - LOLO: $-1695.0$

*Image of a HV Channel Display interface with a table showing channel details and limit values.*
HV – Channel Display

Scale Selection

Channel Stripchart

Left-Click To Plot Channel

Navigation Buttons

Status Gill initialization complete

Reconnect  Offline  Online  Off  On  Ramp  Pause  Resume  Lock  Unlock  Reset
HV Channel Display

Select Voltage Scale
HV Channel Display

Select Current Scale
HV Channel Display

- **Purpose**
  - Monitor individual channels
    - State
    - Voltage and current readback
    - Target voltage
    - Voltage and current trip levels
  - Execute all-channel and individual channel actions
  - Set all-channel and individual channel target voltages
  - Usually displays a single crate
HV Channel Display

- **Properties**
  - Organized by channel
  - Multi-channel action buttons
  - Channel action menu button

- **Implementation**
  - Python script
  - Program name - HvcGui.py
  - Configuration script - xxx.hvc

- **Action buttons**
  - Similar to global display +
    - OFFLINE/ONLINE
    - PAUSE/RESUME
    - LOCK/UNLOCK

- **Channel state colors**
  - Same as Detector display
Diagnostic Guidelines

• Channel is in offline state
  ◆ Missing HV module
  ◆ Incorrect module type in database
  ◆ Faulty module

• Module trips after transition from off to on state
  ◆ After a period with the power off, the channel may not be stable. Leave the power on for ~1/4 hour, after which the channel may recover.
  ◆ Faulty module
Diagnostic Guidelines

• Module trips during ramp but has not exceeded either the voltage or current trip limit
  ◆ After a period in the off state, the channel may not be stable. Leave the channel in the on state at zero output for ~1/4 hour, after which the channel may recover
  ◆ Faulty module
Diagnostic Guidelines

- Ramp away from zero volts does not converge to target voltage
  - Record tuning parameters set incorrectly
  - Faulty module
- Current trip during ramp caused by capacitance charging
  - Reduce ramp rate
  - Increase current scaling factor parameter
  - Lengthen parabolic ramp region
Diagnostic Guidelines

- Ramp toward zero volts does not converge to the target voltage very slowly
  - Reduce load capacitance or increase shunt resistance
    - The Cockroft-Walton generator is a charge pump and can only drive the voltage away from zero (positive or negative). Ramping toward zero requires a shunt resistance to discharge the load capacitance and the voltage divider resistance in the pod is ~10-50 Megohms.