quadEM: New Beam Position Monitor & Electrometer Hardware and Software

Mark Rivers

GeoSoilEnviroCARS, Advanced Photon Source

University of Chicago

Outline

- Hardware
  - TetrAMM from CaenEls
  - NSLS_EM from Peter Siddons at BNL
  - SYDOR SI-EP-B4 4, same as NSLS_EM with bias supply
  - AH401B, AH501D from CaenEls previously presented
    - Older technology, device is 1 Mb/s serial, internal 10/100 MB Ethernet Lantronix terminal server
  - APS electrometer (Steve Ross) no longer in use
- EPICS software
  - Support for TetrAMM
  - Using new NDPluginTimeSeries
  - Using new NDPluginFFT
- Demonstration with TetrAMM
- Enrico Braidotti and Erik Soiman from CaenEls are here today

Hardware: Common Features

- 4-channel electrometers for measuring currents in the pA to mA range.
- Main application reading x-ray beam positions using 4 photodiodes or split ion chambers.
- Compact electrometer box, can be placed close to the position monitor hardware
  - Keep signal leads short!
- Outputs digital data at high-speed (~1-10 kHz) over Ethernet
- Digital interface allows reliable data transmission over long distances, for example from a BPM in an experiment station to a VME crate in the FOE, where feedback to a monochromator crystal can be implemented.
  - No analog signal runs over long distances!
- For example, TetrAMM (~$9,000) replaces with much higher speed:
  - 4 SRS570 current amplifiers (~$10,000)
  - 4 ADCs, or 4 V/F converters and 4 scaler channels (~$2,000)
  - Programmable high-voltage power supply (~$2,000)

TetrAMM

- Based on transconductance amplifier
  - Another model based on current integration is in development
- 2 ranges: +-125uA, +-125nA
- IEEE 64-bit float data (amps)
- Programmable bias power supply (up to 4kV)
- Programmable number of channels (1,2,4)
- Ethernet TCP interface
- 100 kHz fixed sampling rate
- On-board averaging
- Minimum # samples to average=5 (20 kHz) in continuous mode
  - Data rates can burden slow VME crates – need to average
- Very flexible gating and triggering modes
- Can be used for beam position, monitoring, or data acquisition with ion chambers or photodiode detectors

TetrAMM


HV OUT
HV ON
OVC
TetrAMM
CAENels
Gear for Science
CH4
CH3
CH2
CH1
RANGE
µA nA
STATUS
+12 VDC
DC OK
TRIGGERS
CFG
IN 1
IN 2
OUT
ITLK+
ITLK-
I / O
RST
ETH
SFP
TetrAMM
4-channel Fast Interface Bipolar Picoammeter

quadEM Driver

- drvQuadEM
  - C++ base class, inherits from asynNDArrayDriver
  - Exports data as NDArrays so all areaDetector plugins can be used
  - Can stream data to disk, do time-series, FFTs, etc.
- drvNSLS_EM
  - Derived class for NSLS/Sydor electrometer
- drvAHxxx
  - Derived class for AH401 and AH501 series
- drvTetrAMM
  - Derived class for TetrAMM

Common Controls

- Acquire – Start and stop acquisition
- AcquireMode (Continuous, Multiple, Single)
- Range (sensitivity)
- Geometry (Diamond, Square)
- Reset (allows power-cycling device without rebooting IOC)
- ValuesPerRead (on-board TetrAMM, driver software on others)
  - Reduces CPU time when bandwidth is not needed
  - Reduces number of asynOctet read operations
  - Limits maximum rate of time series and fast feedback
- AveragingTime (averaging done in NDPluginStats)
- Current offset and scale (software)
- Position offset and scale (software)
- Time-series (via NDPluginTimeSeries)
- FFT (via NDPluginFFT)
- All commonPlugins from areaDetector

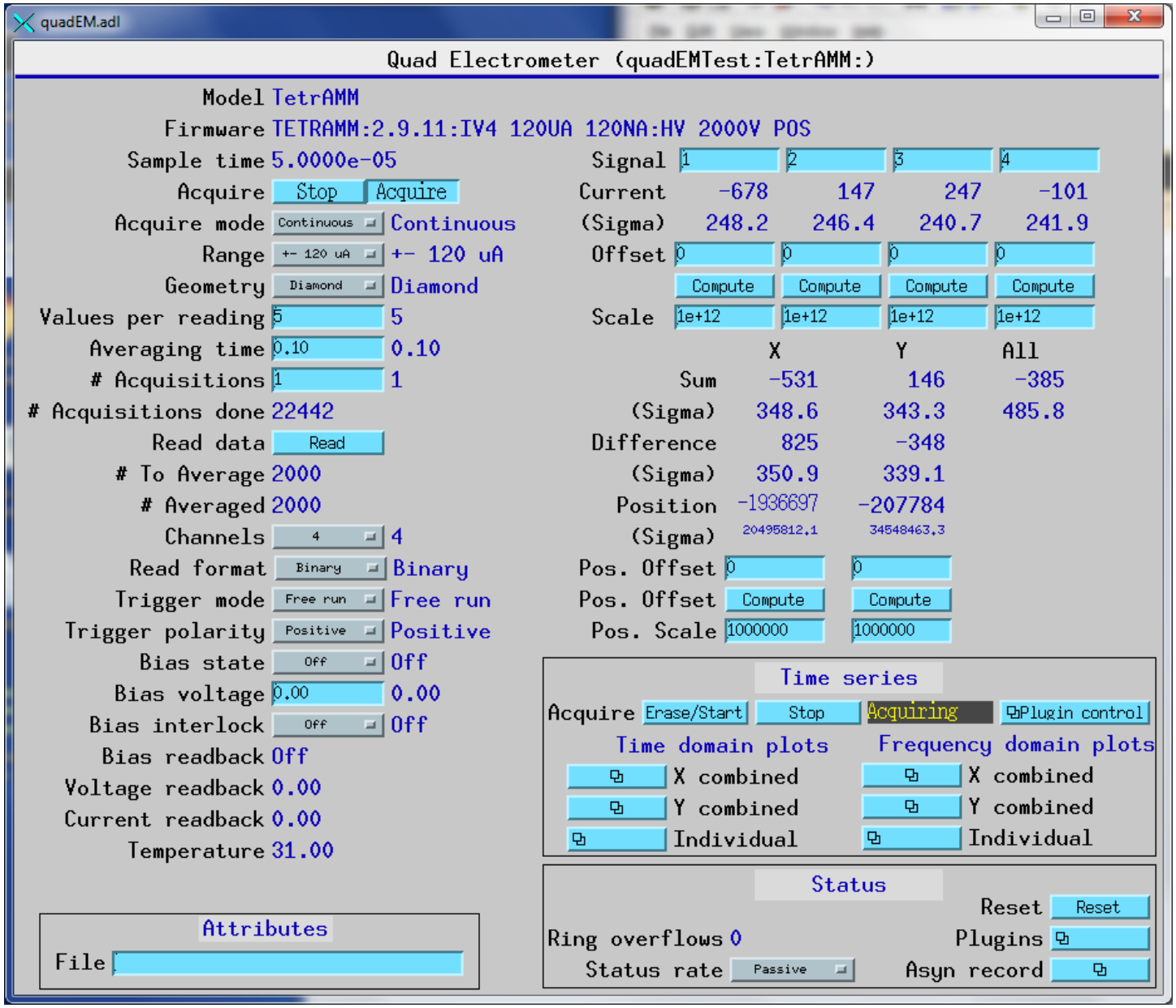
Hardware Specific Controls

- Integration Time (NSLS_EM, AH401, charge integration models)
- PingPong (NSLS_EM, AH40)
- Read Format, Binary/ASCII (AH401, AH501, TetrAMM)
- Number of Channels (AH501, TetrAMM)
- Resolution (16 or 24 bits) (AH501)
- External Trigger/Gate (AH401, AH501, TetrAMM)
- Trigger Polarity (TetrAMM)
- Bias Supply Enable and Voltage (AH501C, AH501D, TetrAMM)
- Bias Interlock (TetrAMM)
- Voltage Readback (TetrAMM)
- Current Readback (TetrAMM)

Analog Input Records

- Input offset and scale are applied
- Position offset and scale are applied
- Uses NDPluginStats to do averaging
  - Separate plugin for each of 11 values (4 positions, 3 sums, 2 differences, 2 positions)
  - Driver accumulates NumAverage readings in buffer
  - When NumAverage readings have arrived it calls the NDPluginStats plugins to compute the mean, standard deviation, etc.

medm Control



TetrAMM Acquisition Modes

TriggerMode	AcquireMode	Description
Free Run	Continuous	Values are acquired continuously and are averaged each time the AveragingTime is reached.
Free Run	Multiple	Data is acquired for the AveragingTime. This is repeated NumAcquire times and then acquisition stops. The plugins will be called NumAcquire times, each time with NumAverage samples.
Ext. Trig.	Continuous	A fixed number of samples (NumAverage, based on AveragingTime) is acquired starting on each rising edge of the external trigger input. AveragingTime must be set to a value less than the time between trigger pulses.
Ext. Trig.	Multiple	A fixed number of samples (NumAverage, based on AveragingTime) is acquired starting on the first rising edge of the external trigger input. This repeats NumAcquire times and then acquisition stops. ValuesPerRead must be set to a value less than AveragingTime/1e5.

TetrAMM Acquisition Modes

TriggerMode	AcquireMode	Description
Ext. Bulb	Continuous	Samples are acquired while the external trigger input is asserted. On each trailing edge of the external trigger signal the plugins are called. ValuesPerRead must be set to a value less than (external trigger asserted time * 1e5). AveragingTime is ignored in this mode.
Ext. Bulb	Multiple	Samples are acquired while the external trigger input is asserted. On each trailing edge of the external trigger signal the plugins are called. This is repeated NumAcquire times and then acquisition is stopped. ValuesPerRead must be set to a value less than (external trigger asserted time * 1e5). AveragingTime is ignored in this mode.

TetrAMM Acquisition Modes

TriggerMode	AcquireMode	Description
Ext. Gate	Continuous	Samples are acquired while the external trigger input is asserted. When NumAverage samples have been acquired the plugins are called. The actual averaging time between calling the plugins will be longer than AverageTime, and is controlled by the duty cycle of the external gate signal. The trailing edge of the gate pulse is ignored in this mode. ValuesPerRead must be set to a value less than (external trigger asserted time * 1e5).
Ext. Gate	Multiple	Samples are acquired while the external trigger input is asserted. When NumAverage samples have been acquired the plugins are called. The actual averaging time between calling the plugins will be longer than AverageTime, and is controlled by the duty cycle of the external gate signal. When the plugins have been called NumAcquire times then acquisition is stopped. The trailing edge of the gate pulse is ignored in this mode. ValuesPerRead must be set to a value less than (external trigger asserted time * 1e5).

Demo

USB-CTR04/08 ($429)

- Previous TWG talk
- 8 counters (USB-CTR08) or 4 counters (USB-CTR04)
  - 48 MHz maximum count rate
  - Up to 64-bit counter depth
  - Counters can be read synchronously on-the-fly
  - 4 modes:
    - Totalize (count number of pulses)
    - Period (measure time between rising or falling edge of successive pulses)
    - Pulse width (measure time between rising and falling edge of a single pulse)
    - Timing mode (measure time between edges of two different input signals)
- 4 pulse generators
  - 48 MHz clock
  - Programmable period, width, number of pulses, polarity
- Digital inputs/outputs
  - 8 signals, individually programmable as inputs or outputs

Rigol DS1054 Digital Scope

- 50 MHz bandwidth (100MHz upgrade via keycode)
- 4 channels
- 12 M points memory
- 30,000 waveforms/s
- FFTs
- USB, Ethernet
- $399 (!!!)

Conclusions

- Fast electrometers permit:
  - High-frequency diagnostics of beam motion
  - High-frequency feedback to compensate for beam motion (or deliberate steering)
  - Data acquisition with ion chambers or photodiode detectors
- EPICS quadEM software is part of synApps
  - Home page:
    http://cars.uchicago.edu/software/epics/quadEM.html
  - Documentation:
    http://cars.uchicago.edu/software/epics/quadEMDoc.html
  - github repository
    https://github.com/epics-modules/quadEM

Thanks for your attention!