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New DAQ Channel Types

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Summary

This is a proposal to extend the DAQ system to support:
- Fast ADC channels with sampling rates up to 262144Hz,
- Heterodyne channels, and
- Scope channels for non contiguous data.

1. Fast data acquisition channels

The maximum sampling rate is extended to 262144Hz. The data type is either short or float. This data rate is supported by an new ADCU that uses an ICS130 VME module with eight 16 bit ADCs. These channels will be available as analog test points and only be recorded in frames for special diagnostics purposes.

2. Heterodyne data acquisition channels

A heterodyne channel is described by a modulation frequency and a bandwidth. The final sampling rate is twice the bandwidth and the data values are complex floats. To heterodyne a channels it is first multiplied by $e^{\wedge}(i\ 2\ \backslash pi\ f\ (t\ -\ t0))$ and then low-pass filtered to the desired bandwidth. Multiple filters are supported.

To simplify the processing only heterodyne frequencies of the form $f = k + n/2^{\wedge}m$ are allowed with k, n and m integer quantities and with $0 <= n < 2^{\wedge}m$. The start time t0 is selected to be a multiple of $2^{\wedge}m$ (in GPS seconds). This guarantees that the phase is zero at each multiple of $2^{\wedge}m$ GPS seconds and that there is no ambiguity how the phase is set.

A heterodyne channel requires the fields fShift and fPhase to be set in the frame structure. Due to the frame convention fShift is the negative of the above modulation frequency. For frames that start at a second boundary the phase can be calculated with fPhase = - $(2\ \backslash pi\ n/2^{\wedge}m\ T)$ mod $(2\ pi)$ where $T = t0$ mod $2^{\wedge}m$ with t0 the start time of the frame in GPS seconds. Since the frame length is itself a power of 2, there are only $2^{\wedge}m$ / (frame length) different phase shifts.

3. Scope channels (future expansion)

Scope channels are using the normal data acquisition channels to embedded snippets of distinct data. One example is a fast sampling oscilloscope that produces a short data record with a high sampling rate. The idea is to be able to this type of data integrated into the DAQ so that it is available offline and so that it can be read by the tools running in the control room.

Each data snippet consists of a marker, a header and a payload. Data snippets can not be overlapping but there can be a gap between them. The marker for a short channel is four values of SHRT_MIN followed by "SCOPEMOD", whereas for a float channel it is two NaNs followed by "SCOPEMOD".

Each header contains the following five values:
- Total length of snippet including header and payload but not the marker (int).
- Length of the header in bytes (int).
- Type (int, enum): 1 - for oscilloscope data, 2 for FFT data, 3 for transfer function.
- Header version (int): 1 for now
- Time offset (double): delay of snippet in seconds

Additional header values are type specific. For oscilloscope data (type 1) we have
- Number of channels (int): 1 to 16
- Number of averages (int)
- Time base (double): sample spacing in seconds
- Vertical scale (16 x double): y units in volts/count
- Coupling (16 x int): GND (0), DC (1) or AC (2)
- Probe (16 x int): 10 for 10x
- Inverted (16 x int): yes (1) or no (0)
- Bandwidth (16 x double): channel bandwidth in Hz
...

Scope channels are designated with the unit "SCOPE" in the frame structure.

4. Infrastructure changes

DAQ configuration files:
- Allow sampling frequencies up to 262144Hz
- Add a field to specify an optional heterodyne frequency
- Add a field to specify an optional decimation filter

NDS protocol:
- Add a field to the channel record describing the testpoint number
- Add a field to the channel record describing the optional heterodyne frequency
- Add a field to the channel record describing the optional decimation filter

DTT:
- Support new heterodyne channels in time series measurement and Fourier tool.

Dataviewer:
- Display complex data channels (real or imaginary part, magnitude, phase)
- Display new scope channels