# *Antelope* sensor calibration

June, 2008
Antelope User Group Meeting
Skamania Lodge, WA

BRTT
BOULDER REAL TIME TECHNOLOGIES, INC.

# Objectives

- Initial version written to support USArray/TA
- Q330 dataloggers, STS2, CMG3T and Trillium broadband sensors
- Design software so it could be expanded to work with other dataloggers and sensors

# Q330 sensor calibration capabilities

- High resolution DAC with precise timing
- A variety of waveforms including step function, sine, random telegraph, white noise, red noise (white noise produces best results over entire frequency band)
- Ability to monitor DAC output simultaneously with sensor output
- Special data “markers” inserted into output data stream that clearly identify calibrations regardless of the command source

# Sensor calibration strategy using Antelope and Q330 dataloggers

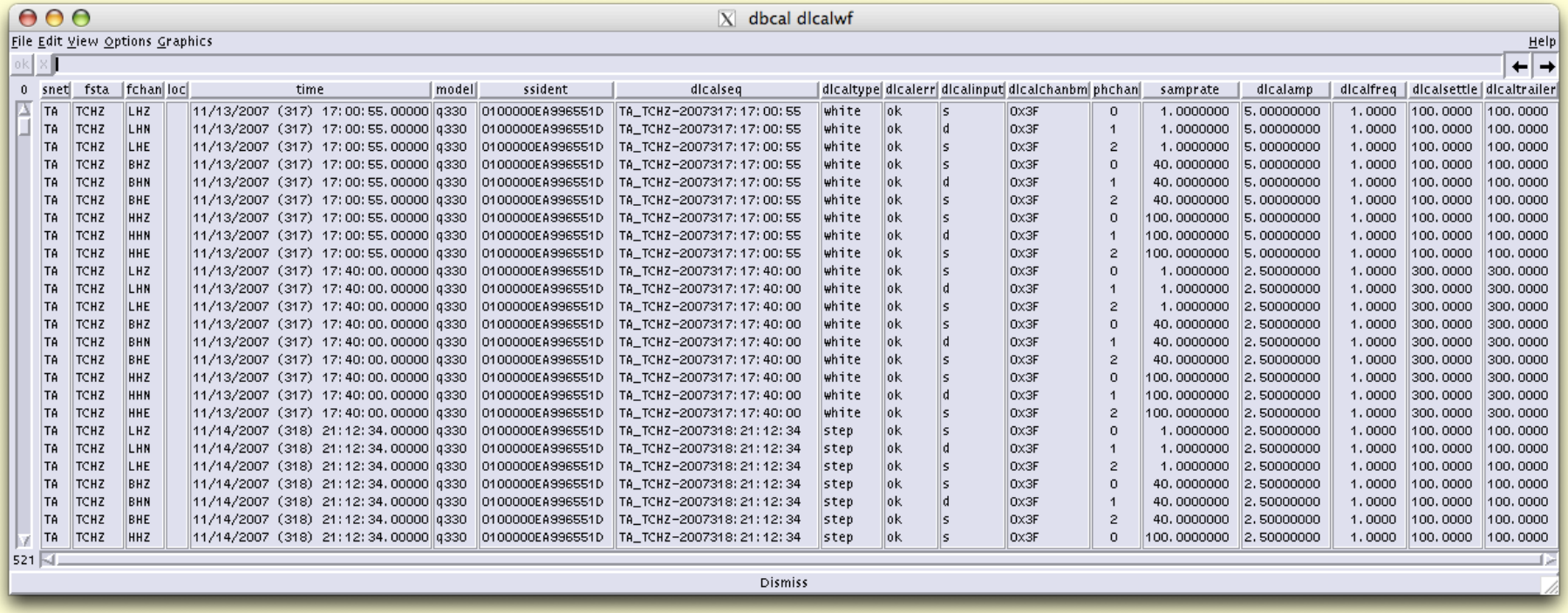
- Q330 calibration command can be done either using the Antelope **`dlcmd`** mechanism, or any other extra-Antelope mechanism, such as **`willard`**
- As the calibration sequence runs on the Q330, special data markers are generated and inserted into the waveform data stream.
- **`q3302orb`** looks for these calibration data markers and generates special database ORB packets, using the new **`dlcalwf`** relation, for each data channel that contains calibration waveforms (either sensor or monitor)
- The calibration waveforms and the **`dlcalwf`** relation ORB packets flow through the Antelope real-time system and eventually are stored in one or more archive databases.
- Post analysis is accomplished with the new **`dbcalibrate`** program which reads all of its input and writes all of its output from/to archive databases
- Calibration results can be displayed and hard copy Postscript can be generated by the new **`displayscal`** script
- Note the decoupling of command, capture and analysis functions


BRTT

June 2008


BRTT

June 2008

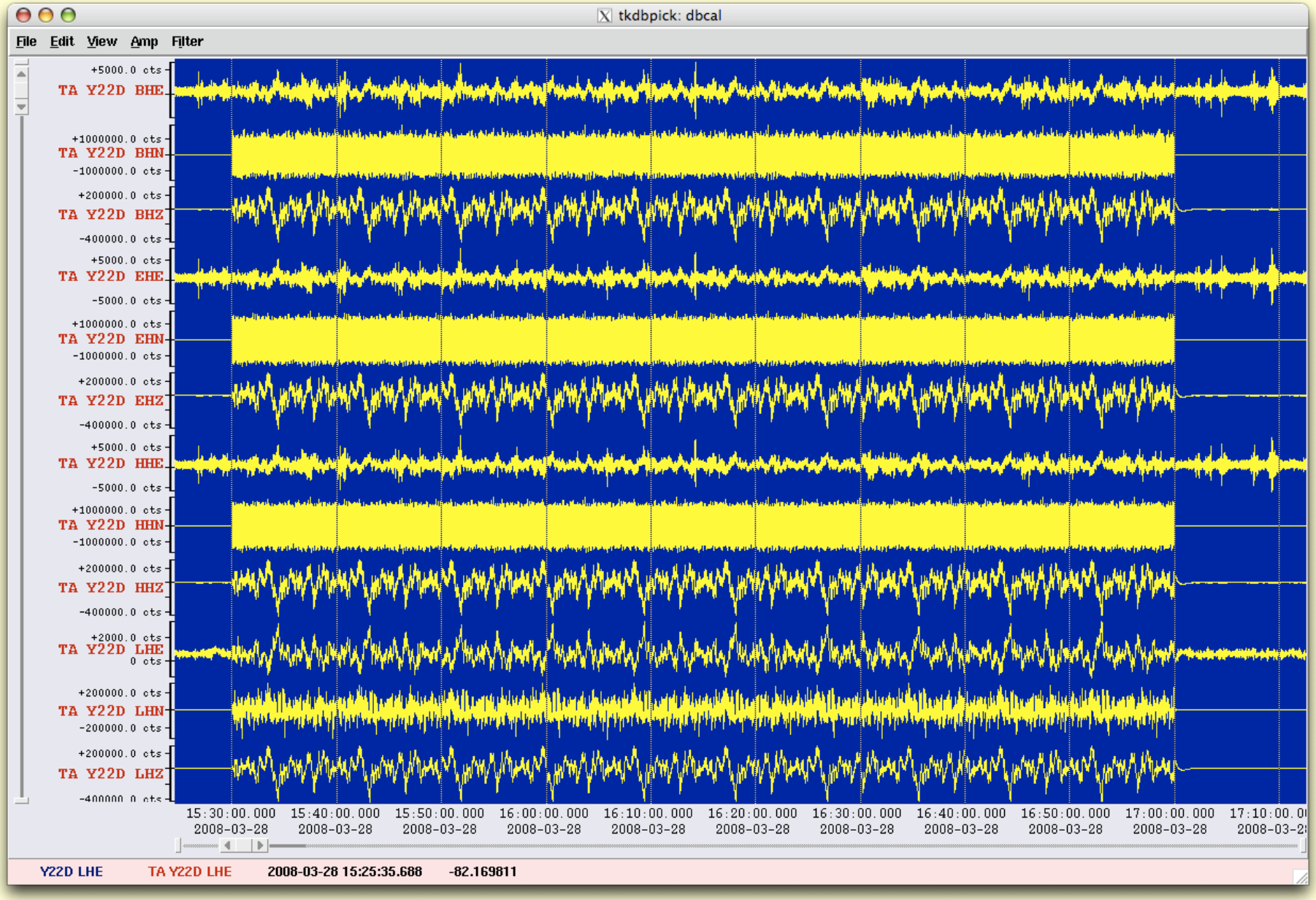



| 0 | snet | fsta | fchan | loc | time | model | ssident | dlcalseq | dlcaltype | dlcalerr | dlcalinput | dlcalchanbm | phchan | samprate | dlcalamp | dlcalfreq | dlcalsettle | dlcaltrailer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TA | TCHZ | LHZ | | 11/13/2007 (317) 17:00:55.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:00:55 | white | ok | s | 0x3F | 0 | 1.0000000 | 5.00000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | LHN | | 11/13/2007 (317) 17:00:55.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:00:55 | white | ok | d | 0x3F | 1 | 1.0000000 | 5.00000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | LHE | | 11/13/2007 (317) 17:00:55.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:00:55 | white | ok | s | 0x3F | 2 | 1.0000000 | 5.00000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | BHZ | | 11/13/2007 (317) 17:00:55.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:00:55 | white | ok | s | 0x3F | 0 | 40.0000000 | 5.00000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | BHN | | 11/13/2007 (317) 17:00:55.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:00:55 | white | ok | d | 0x3F | 1 | 40.0000000 | 5.00000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | BHE | | 11/13/2007 (317) 17:00:55.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:00:55 | white | ok | s | 0x3F | 2 | 40.0000000 | 5.00000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | HHZ | | 11/13/2007 (317) 17:00:55.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:00:55 | white | ok | s | 0x3F | 0 | 100.0000000 | 5.00000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | HHN | | 11/13/2007 (317) 17:00:55.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:00:55 | white | ok | d | 0x3F | 1 | 100.0000000 | 5.00000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | HHE | | 11/13/2007 (317) 17:00:55.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:00:55 | white | ok | s | 0x3F | 2 | 100.0000000 | 5.00000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | LHZ | | 11/13/2007 (317) 17:40:00.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:40:00 | white | ok | s | 0x3F | 0 | 1.0000000 | 2.50000000 | 1.0000 | 300.0000 | 300.0000 |
| | TA | TCHZ | LHN | | 11/13/2007 (317) 17:40:00.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:40:00 | white | ok | d | 0x3F | 1 | 1.0000000 | 2.50000000 | 1.0000 | 300.0000 | 300.0000 |
| | TA | TCHZ | LHE | | 11/13/2007 (317) 17:40:00.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:40:00 | white | ok | s | 0x3F | 2 | 1.0000000 | 2.50000000 | 1.0000 | 300.0000 | 300.0000 |
| | TA | TCHZ | BHZ | | 11/13/2007 (317) 17:40:00.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:40:00 | white | ok | s | 0x3F | 0 | 40.0000000 | 2.50000000 | 1.0000 | 300.0000 | 300.0000 |
| | TA | TCHZ | BHN | | 11/13/2007 (317) 17:40:00.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:40:00 | white | ok | d | 0x3F | 1 | 40.0000000 | 2.50000000 | 1.0000 | 300.0000 | 300.0000 |
| | TA | TCHZ | BHE | | 11/13/2007 (317) 17:40:00.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:40:00 | white | ok | s | 0x3F | 2 | 40.0000000 | 2.50000000 | 1.0000 | 300.0000 | 300.0000 |
| | TA | TCHZ | HHZ | | 11/13/2007 (317) 17:40:00.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:40:00 | white | ok | s | 0x3F | 0 | 100.0000000 | 2.50000000 | 1.0000 | 300.0000 | 300.0000 |
| | TA | TCHZ | HHN | | 11/13/2007 (317) 17:40:00.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:40:00 | white | ok | d | 0x3F | 1 | 100.0000000 | 2.50000000 | 1.0000 | 300.0000 | 300.0000 |
| | TA | TCHZ | HHE | | 11/13/2007 (317) 17:40:00.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007317:17:40:00 | white | ok | s | 0x3F | 2 | 100.0000000 | 2.50000000 | 1.0000 | 300.0000 | 300.0000 |
| | TA | TCHZ | LHZ | | 11/14/2007 (318) 21:12:34.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007318:21:12:34 | step | ok | s | 0x3F | 0 | 1.0000000 | 2.50000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | LHN | | 11/14/2007 (318) 21:12:34.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007318:21:12:34 | step | ok | d | 0x3F | 1 | 1.0000000 | 2.50000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | LHE | | 11/14/2007 (318) 21:12:34.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007318:21:12:34 | step | ok | s | 0x3F | 2 | 1.0000000 | 2.50000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | BHZ | | 11/14/2007 (318) 21:12:34.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007318:21:12:34 | step | ok | s | 0x3F | 0 | 40.0000000 | 2.50000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | BHN | | 11/14/2007 (318) 21:12:34.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007318:21:12:34 | step | ok | d | 0x3F | 1 | 40.0000000 | 2.50000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | BHE | | 11/14/2007 (318) 21:12:34.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007318:21:12:34 | step | ok | s | 0x3F | 2 | 40.0000000 | 2.50000000 | 1.0000 | 100.0000 | 100.0000 |
| | TA | TCHZ | HHZ | | 11/14/2007 (318) 21:12:34.00000 | q330 | 0100000EA996551D | TA_TCHZ-2007318:21:12:34 | step | ok | s | 0x3F | 0 | 100.0000000 | 2.50000000 | 1.0000 | 100.0000 | 100.0000 |

521

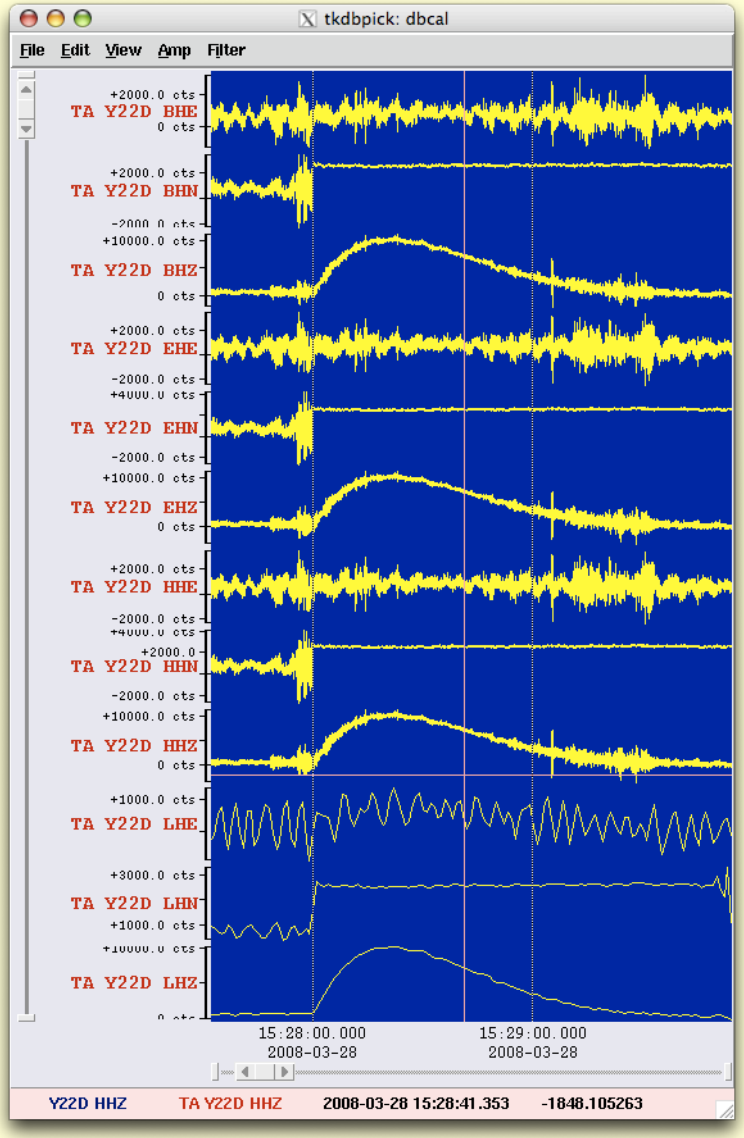
- **`q3302orb`** automatically generates special database ORB packets, using the new **`dlcalwf`** relation, for each data channel that contains calibration waveforms (either sensor or monitor)
- The calibration waveforms and the **`dlcalwf`** relation ORB packets flow through the Antelope real-time system and eventually are stored in one or more archive databases.
- The **`dlcalwf`** rows act as markers in the archive database to identify calibration waveforms and their associated parameters

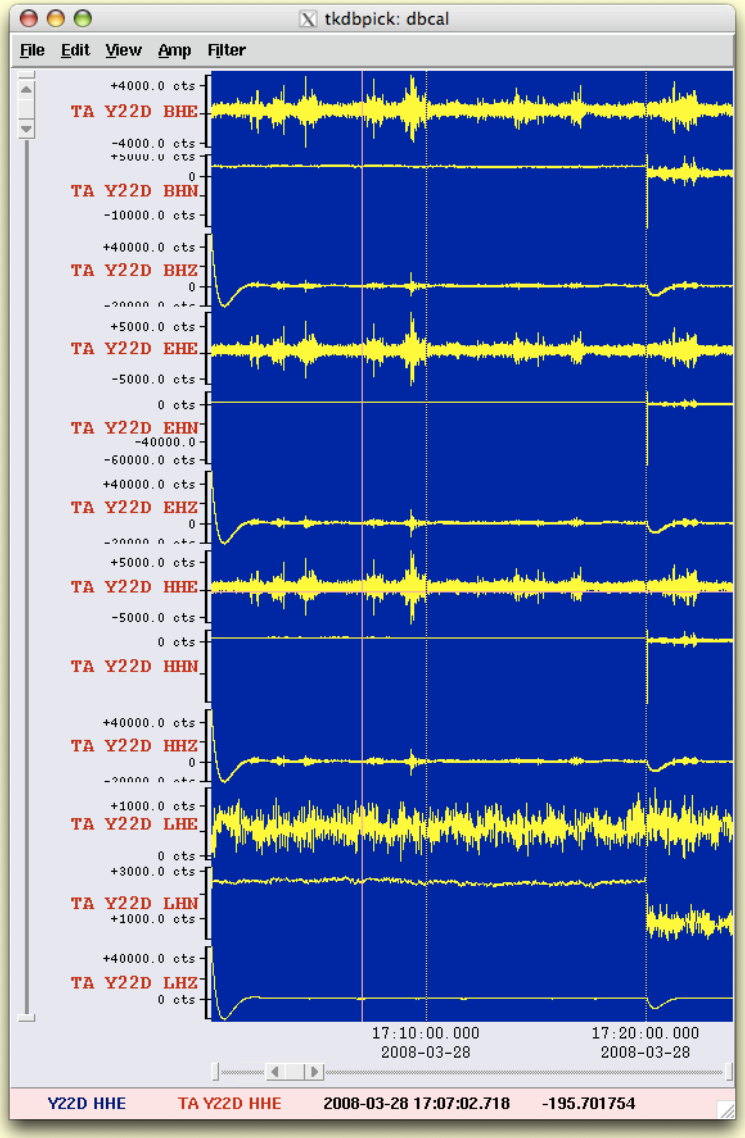
BRTT




BRTT

June 2008




BRTT

June 2008

# Sensor calibration analysis using **dbcalibrate**

- **dbcalibrate** operates strictly by computing smoothed spectral ratios in amplitude and phase, including statistics, between pairs of waveforms that can span different time periods, stations and channels
- An estimate of sensor response (as seen through the calibration circuitry and mechanics) can be obtained by ratioing a recorded sensor calibration output and a direct loopback signal from the datalogger calibration signal DAC back through the datalogger ADC (Q330 monitor channel)
- Spectral comparisons of like calibration output signals across different time period and/or different stations and/or different channels can also be computed to produce spectra of changes (should be flat and zero phase if there are no changes)
- Noise to calibration signal spectral power ratios can also be generated to determine valid comparison spectra frequency ranges
- Note that **dbcalibrate** can only compare two recorded waveforms and not a recorded waveform with an internally generated theoretical waveform

# Sensor calibration analysis using **`dbcalibrate`**

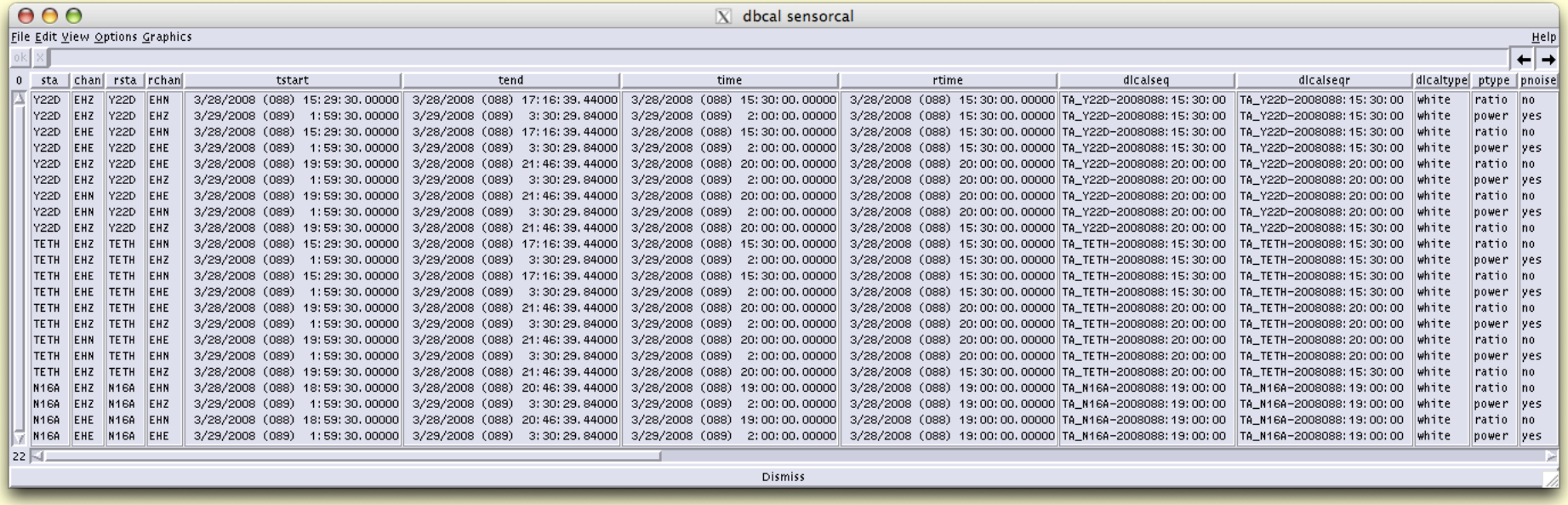
- **`dbcalibrate`** produces its output spectra only as frequency, amplitude, phase, amplitude error, phase error tables - no pole and zero fitting or “post spectra” smoothing are performed
- Spectral ratios are computed by dividing the cross correlation spectrum between the numerator (subject) and denominator (reference) waveforms by the autocorrelation spectrum of the denominator waveform
- Spectral smoothing and statistics determination are computed through accumulations of the frequency domain cross correlation matrix elements from a set of tapered moving time windows through the waveform data
- In order to reduce the size of the resulting response functions (1000 sec to 100 hz response would produce a spectrum with 200,000 points) and to provide many short time windows for the higher frequencies vs. fewer longer time windows for the lower frequencies, we do the analysis in multiple frequency bands
- Try **`man dbcalibrate`** for more detailed information

# Example run of **dbcalibrate**

```
2615 ruper% dbcalibrate -v -outrecno \
                    -dlcalwf_sifter 'fchan =~ /EH./ && (fchan == "EHZ" || dlcalinput == "d")' \
                    -out dbcal dbcal TA_Y22D-2008088:15:30:00


dbcalibrate: Processing calibration sequence TA_Y22D-2008088:15:30:00
dbcalibrate: for q330 sn 0100000A27B8E96F at  3/28/2008  15:30:00.000:
dbcalibrate:               type  =  white
dbcalibrate:           duration  =  5400.0000 Seconds
dbcalibrate:        disposition  =  ok
dbcalibrate:     channel bitmap  =  0x7
dbcalibrate:          amplitude  =  2.5000 Volts
dbcalibrate:          frequency  =  1.0000
dbcalibrate:        settle time  =  120.0000 Seconds
dbcalibrate:       trailer time  =  1200.0000 Seconds
dbcalibrate:      found 1 sensors attached to datalogger:
dbcalibrate:           A -> sts2_g3:30716
dbcalibrate:               type=V, drive=c, active=yes, calgen=0.0300238cm/V, cal2rsp=1, sngen=1500V/cm/s, calper=1.000
dbcalibrate:      found 2 channels in this sequence:
dbcalibrate:           TA_Y22D_EHN -> Y22D:EHN, sensor=sts2_g3:30716, nomresp=yes, input=d, phchan=1, samprate=200.0
dbcalibrate:           TA_Y22D_EHZ -> Y22D:EHZ, sensor=sts2_g3:30716, nomresp=yes, input=s, phchan=0, samprate=200.0
dbcalibrate:      found 1 samplerate groups in this sequence:
dbcalibrate:           for samplerate 200.0, found 1 channels to process:
dbcalibrate:               reference trace at TA_Y22D_EHN -> Y22D:EHN, data samples ok
dbcalibrate:               TA_Y22D_EHZ -> Y22D:EHZ, timing ok, time window ok, data samples ok
dbcalibrate: specdiv: Total process window of 6430.000 seconds starting at 2008088:15:29:30.000:
dbcalibrate: specdiv: Processing 4 frequency bands to produce 1150 frequency points:
dbcalibrate: specdiv: For band 0, Processing 1 windows of 10485.760 seconds with fmax=100.000 and df=0.000095
```

- **`dbcalibrate`** disposes its output into a new database relation **`sensorcal`** and a set of ASCII response files
- Response files include the spectral ratio itself, a nominal response and amplitude and phase differences (errors?) between the ratio and the nominal response
- Also computed as an absolute gain term that is used to infer the effective sensor generator constant, although it is unclear how this relates to the true sensor generator constant




| 0 | sta | chan | rsta | rchan | tstart | tend | time | rtime | dlcalseq | dlcalseqr | dlcaltype | ptype | pnoise |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Y22D | EHZ | Y22D | EHN | 3/28/2008 (088) 15:29:30.00000 | 3/28/2008 (088) 17:16:39.44000 | 3/28/2008 (088) 15:30:00.00000 | 3/28/2008 (088) 15:30:00.00000 | TA_Y22D-2008088:15:30:00 | TA_Y22D-2008088:15:30:00 | white | ratio | no |
| | Y22D | EHZ | Y22D | EHZ | 3/29/2008 (089) 1:59:30.00000 | 3/29/2008 (089) 3:30:29.84000 | 3/29/2008 (089) 2:00:00.00000 | 3/28/2008 (088) 15:30:00.00000 | TA_Y22D-2008088:15:30:00 | TA_Y22D-2008088:15:30:00 | white | power | yes |
| | Y22D | EHE | Y22D | EHN | 3/28/2008 (088) 15:29:30.00000 | 3/28/2008 (088) 17:16:39.44000 | 3/28/2008 (088) 15:30:00.00000 | 3/28/2008 (088) 15:30:00.00000 | TA_Y22D-2008088:15:30:00 | TA_Y22D-2008088:15:30:00 | white | ratio | no |
| | Y22D | EHE | Y22D | EHE | 3/29/2008 (089) 1:59:30.00000 | 3/29/2008 (089) 3:30:29.84000 | 3/29/2008 (089) 2:00:00.00000 | 3/28/2008 (088) 15:30:00.00000 | TA_Y22D-2008088:15:30:00 | TA_Y22D-2008088:15:30:00 | white | power | yes |
| | Y22D | EHZ | Y22D | EHE | 3/28/2008 (088) 19:59:30.00000 | 3/28/2008 (088) 21:46:39.44000 | 3/28/2008 (088) 20:00:00.00000 | 3/28/2008 (088) 20:00:00.00000 | TA_Y22D-2008088:20:00:00 | TA_Y22D-2008088:20:00:00 | white | ratio | no |
| | Y22D | EHZ | Y22D | EHZ | 3/29/2008 (089) 1:59:30.00000 | 3/29/2008 (089) 3:30:29.84000 | 3/29/2008 (089) 2:00:00.00000 | 3/28/2008 (088) 20:00:00.00000 | TA_Y22D-2008088:20:00:00 | TA_Y22D-2008088:20:00:00 | white | power | yes |
| | Y22D | EHN | Y22D | EHE | 3/28/2008 (088) 19:59:30.00000 | 3/28/2008 (088) 21:46:39.44000 | 3/28/2008 (088) 20:00:00.00000 | 3/28/2008 (088) 20:00:00.00000 | TA_Y22D-2008088:20:00:00 | TA_Y22D-2008088:20:00:00 | white | ratio | no |
| | Y22D | EHN | Y22D | EHN | 3/29/2008 (089) 1:59:30.00000 | 3/29/2008 (089) 3:30:29.84000 | 3/29/2008 (089) 2:00:00.00000 | 3/28/2008 (088) 20:00:00.00000 | TA_Y22D-2008088:20:00:00 | TA_Y22D-2008088:20:00:00 | white | power | yes |
| | Y22D | EHZ | Y22D | EHZ | 3/28/2008 (088) 19:59:30.00000 | 3/28/2008 (088) 21:46:39.44000 | 3/28/2008 (088) 20:00:00.00000 | 3/28/2008 (088) 15:30:00.00000 | TA_Y22D-2008088:20:00:00 | TA_Y22D-2008088:15:30:00 | white | ratio | no |
| | TETH | EHZ | TETH | EHN | 3/28/2008 (088) 15:29:30.00000 | 3/28/2008 (088) 17:16:39.44000 | 3/28/2008 (088) 15:30:00.00000 | 3/28/2008 (088) 15:30:00.00000 | TA_TETH-2008088:15:30:00 | TA_TETH-2008088:15:30:00 | white | ratio | no |
| | TETH | EHZ | TETH | EHZ | 3/29/2008 (089) 1:59:30.00000 | 3/29/2008 (089) 3:30:29.84000 | 3/29/2008 (089) 2:00:00.00000 | 3/28/2008 (088) 15:30:00.00000 | TA_TETH-2008088:15:30:00 | TA_TETH-2008088:15:30:00 | white | power | yes |
| | TETH | EHE | TETH | EHN | 3/28/2008 (088) 15:29:30.00000 | 3/28/2008 (088) 17:16:39.44000 | 3/28/2008 (088) 15:30:00.00000 | 3/28/2008 (088) 15:30:00.00000 | TA_TETH-2008088:15:30:00 | TA_TETH-2008088:15:30:00 | white | ratio | no |
| | TETH | EHE | TETH | EHE | 3/29/2008 (089) 1:59:30.00000 | 3/29/2008 (089) 3:30:29.84000 | 3/29/2008 (089) 2:00:00.00000 | 3/28/2008 (088) 15:30:00.00000 | TA_TETH-2008088:15:30:00 | TA_TETH-2008088:15:30:00 | white | power | yes |
| | TETH | EHZ | TETH | EHE | 3/28/2008 (088) 19:59:30.00000 | 3/28/2008 (088) 21:46:39.44000 | 3/28/2008 (088) 20:00:00.00000 | 3/28/2008 (088) 20:00:00.00000 | TA_TETH-2008088:20:00:00 | TA_TETH-2008088:20:00:00 | white | ratio | no |
| | TETH | EHZ | TETH | EHZ | 3/29/2008 (089) 1:59:30.00000 | 3/29/2008 (089) 3:30:29.84000 | 3/29/2008 (089) 2:00:00.00000 | 3/28/2008 (088) 20:00:00.00000 | TA_TETH-2008088:20:00:00 | TA_TETH-2008088:20:00:00 | white | power | yes |
| | TETH | EHN | TETH | EHE | 3/28/2008 (088) 19:59:30.00000 | 3/28/2008 (088) 21:46:39.44000 | 3/28/2008 (088) 20:00:00.00000 | 3/28/2008 (088) 20:00:00.00000 | TA_TETH-2008088:20:00:00 | TA_TETH-2008088:20:00:00 | white | ratio | no |
| | TETH | EHN | TETH | EHN | 3/29/2008 (089) 1:59:30.00000 | 3/29/2008 (089) 3:30:29.84000 | 3/29/2008 (089) 2:00:00.00000 | 3/28/2008 (088) 20:00:00.00000 | TA_TETH-2008088:20:00:00 | TA_TETH-2008088:20:00:00 | white | power | yes |
| | TETH | EHZ | TETH | EHZ | 3/28/2008 (088) 19:59:30.00000 | 3/28/2008 (088) 21:46:39.44000 | 3/28/2008 (088) 20:00:00.00000 | 3/28/2008 (088) 15:30:00.00000 | TA_TETH-2008088:20:00:00 | TA_TETH-2008088:15:30:00 | white | ratio | no |
| | N16A | EHZ | N16A | EHN | 3/28/2008 (088) 18:59:30.00000 | 3/28/2008 (088) 20:46:39.44000 | 3/28/2008 (088) 19:00:00.00000 | 3/28/2008 (088) 19:00:00.00000 | TA_N16A-2008088:19:00:00 | TA_N16A-2008088:19:00:00 | white | ratio | no |
| | N16A | EHZ | N16A | EHZ | 3/29/2008 (089) 1:59:30.00000 | 3/29/2008 (089) 3:30:29.84000 | 3/29/2008 (089) 2:00:00.00000 | 3/28/2008 (088) 19:00:00.00000 | TA_N16A-2008088:19:00:00 | TA_N16A-2008088:19:00:00 | white | power | yes |
| | N16A | EHE | N16A | EHN | 3/28/2008 (088) 18:59:30.00000 | 3/28/2008 (088) 20:46:39.44000 | 3/28/2008 (088) 19:00:00.00000 | 3/28/2008 (088) 19:00:00.00000 | TA_N16A-2008088:19:00:00 | TA_N16A-2008088:19:00:00 | white | ratio | no |
| | N16A | EHE | N16A | EHE | 3/29/2008 (089) 1:59:30.00000 | 3/29/2008 (089) 3:30:29.84000 | 3/29/2008 (089) 2:00:00.00000 | 3/28/2008 (088) 19:00:00.00000 | TA_N16A-2008088:19:00:00 | TA_N16A-2008088:19:00:00 | white | power | yes |

```
2628 ruper% more white_Y22D_EHZ_08088153000
##
## TA_Y22D-2008088:15:30:00 white sta=Y22D chan=EHZ time= 3/28/2008  15:30:00.000 duration=5400.000 sec
## Compared to:
## TA_Y22D-2008088:15:30:00 white sta=Y22D chan=EHN time= 3/28/2008  15:30:00.000 duration=5400.000 sec
##
## response analysis parameters:
#       {bands}[0]{fmax} = 0.02
#       {bands}[0]{fmin} = 0.000001
#       {bands}[0]{nwindows} = 1
#       {bands}[0]{overlap_percent} = 0.0
#       {bands}[0]{taper_percent} = 0.0
#       {bands}[1]{fmax} = 1.0
#       {bands}[1]{fmin} = 0.0025
 ...
#       {tlag} = 1000.0
#       {tlead} = 30.0
##
##Frequency(hz)       Amplitude      Phase(deg)   AmpUncertHigh    AmpUncertLow PhaseUncertHigh  PhaseUncertLow
##
measured 1 complete-white fap2 danny/dbcalibrate
1150
```

# White noise sensor calibration processing results

Processed by dbcalbrt:danny:redgarden at 2008134:12:49:37.095

| Channel: | Time: | Sequence: | |
|---|---|---|---|
| TA_Y22D_EHZ | 2008088:15:30:00.000 | TA_Y22D-2008088:15:30:00 | |
| DImodel: q330 | DIserial: 0100000A27B8E96F | Snmodel: sts2_g3 | Snserial: 30716 |
| Noise Channel: TA_Y22D_EHZ | Noise Time: 2008089:02:00:00.000 | Noise Sequence: TA_Y22D-2008088:15:30:00 | |
| Noise DImodel: q330 | Noise DIserial: 0100000A27B8E96F | Noise Snmodel: sts2_g3 | Noise Snserial: 30716 |
| Ref Channel: TA_Y22D_EHN | Ref Time: 2008088:15:30:00.000 | Ref Sequence: TA_Y22D-2008088:15:30:00 | |
| Ref DImodel: q330 | Ref DIserial: 0100000A27B8E96F | Ref Snmodel: sts2_g3 | Ref Snserial: 30716 |

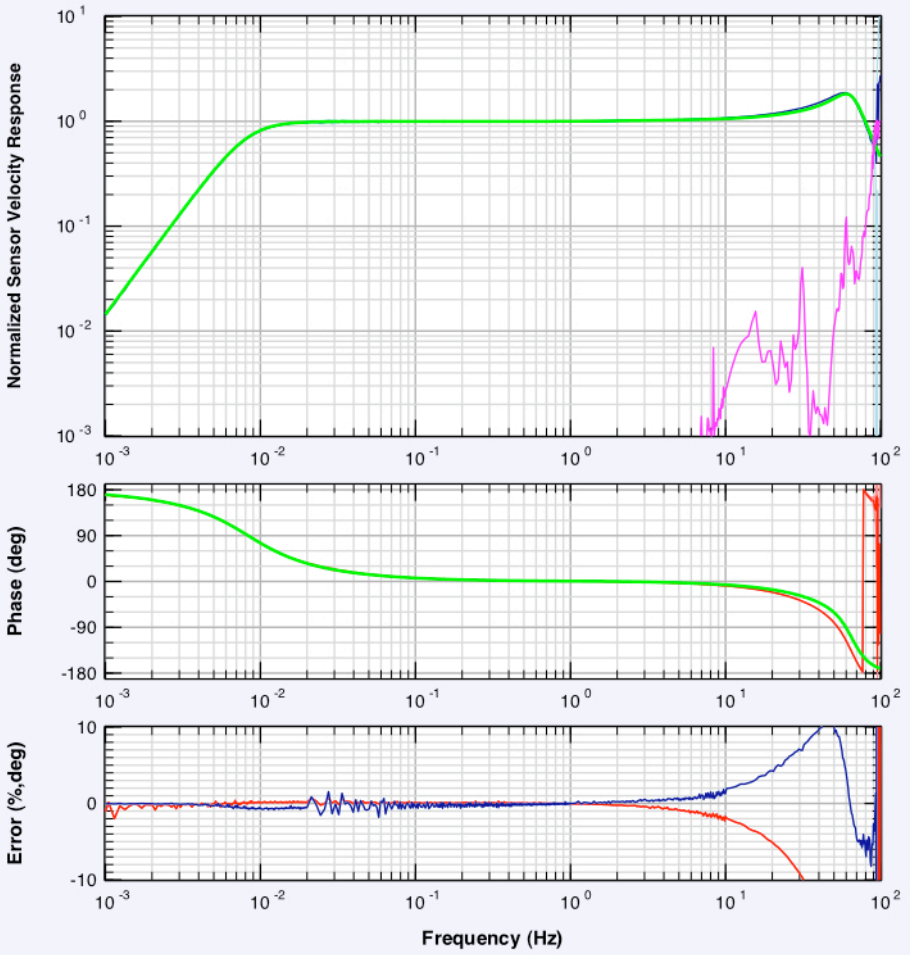
| Cal mode: | Cal Waveform: | Cal Duration: | Samplerate: | Cal Amplitude: |
|---|---|---|---|---|
| mon | white | 1:30 hours | 200 | 2.500 V |

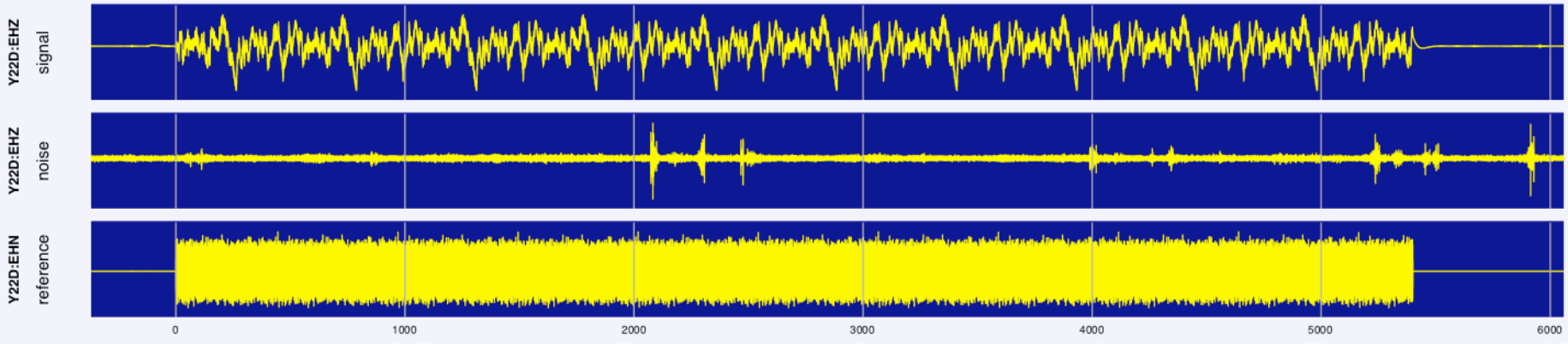
| Cal processing: | Cal Settle Time: | Cal Trailer Time: |
|---|---|---|
| ratio | 2:00 minutes | 20:00 minutes |

| Sngen: | Nominal Sngen: | Norm Freq: | Noise Relative To: |
|---|---|---|---|
| 1517.30 V/m/s | 1500.00 V/m/s | 1.000 Hz | TA_Y22D-2008088:15:30:00 |

Processing Parameters:

{bands}{0}{fmax} = 0.02
{bands}{0}{fmin} = 0.000001
{bands}{0}{nwindows} = 1
{bands}{0}{overlap_percent} = 0.0
{bands}{0}{taper_percent} = 0.0
{bands}{1}{fmax} = 1.0
{bands}{1}{fmin} = 0.0025
{bands}{1}{nwindows} = 0
{bands}{1}{overlap_percent} = 50.0
{bands}{1}{taper_percent} = 25.0
{bands}{2}{fmax} = 10.0
{bands}{2}{fmin} = 0.05
{bands}{2}{nwindows} = 0
{bands}{2}{overlap_percent} = 50.0
{bands}{2}{taper_percent} = 50.0
{bands}{3}{fmax} = 200.0
{bands}{3}{fmin} = 1.00
{bands}{3}{nwindows} = 0
{bands}{3}{overlap_percent} = 50.0
{bands}{3}{taper_percent} = 50.0
{tlag} = 1000.0
{tlead} = 30.0



# White noise sensor calibration processing results

Processed by dbcalbrt:danny:redgarden at 2008134:12:51:30.613

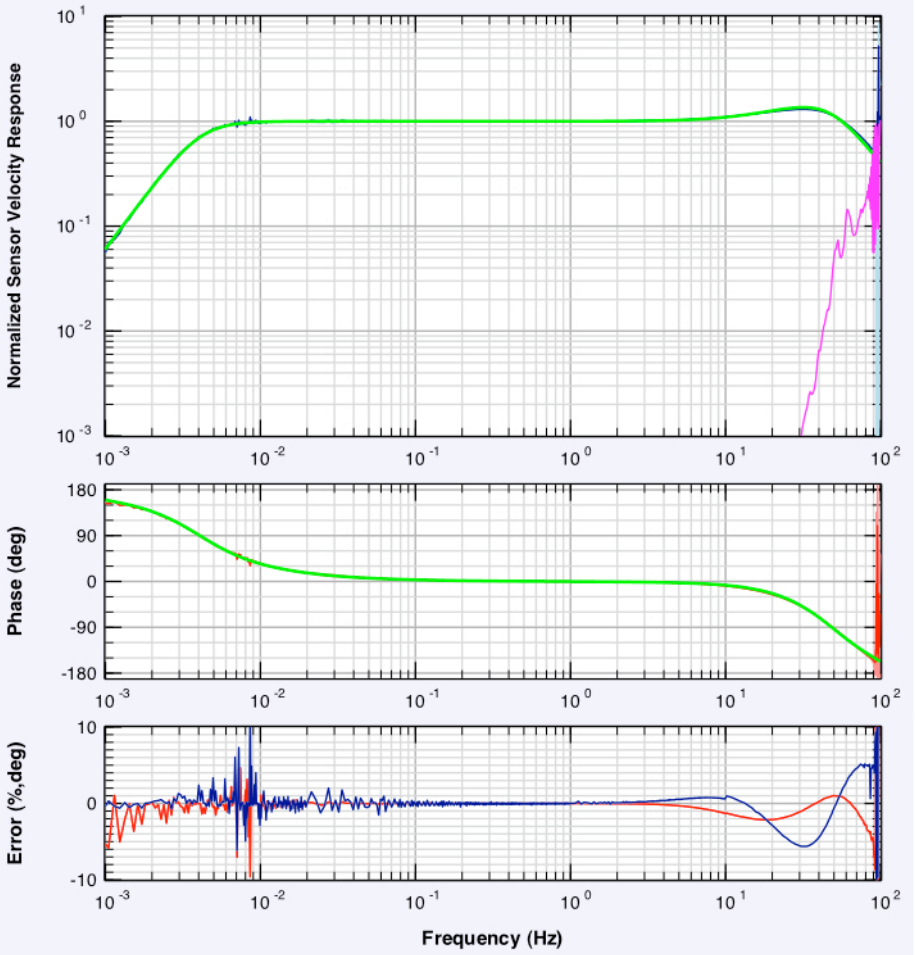
| | | | |
|---|---|---|---|
| Channel: TA_N16A_EHZ | Time: 2008088:19:00:00.000 | Sequence: TA_N16A-2008088:19:00:00 | |
| Dlmodel: q330 | Dlserial: 010000044D889446 | Snmodel: trillium_240 | Snserial: 252 |
| Noise Channel: TA_N16A_EHZ | Noise Time: 2008089:02:00:00.000 | Noise Sequence: TA_N16A-2008088:19:00:00 | |
| Noise Dlmodel: q330 | Noise Dlserial: 010000044D889446 | Noise Snmodel: trillium_240 | Noise Snserial: 252 |
| Ref Channel: TA_N16A_EHN | Ref Time: 2008088:19:00:00.000 | Ref Sequence: TA_N16A-2008088:19:00:00 | |
| Ref Dlmodel: q330 | Ref Dlserial: 010000044D889446 | Ref Snmodel: trillium_240 | Ref Snserial: 252 |

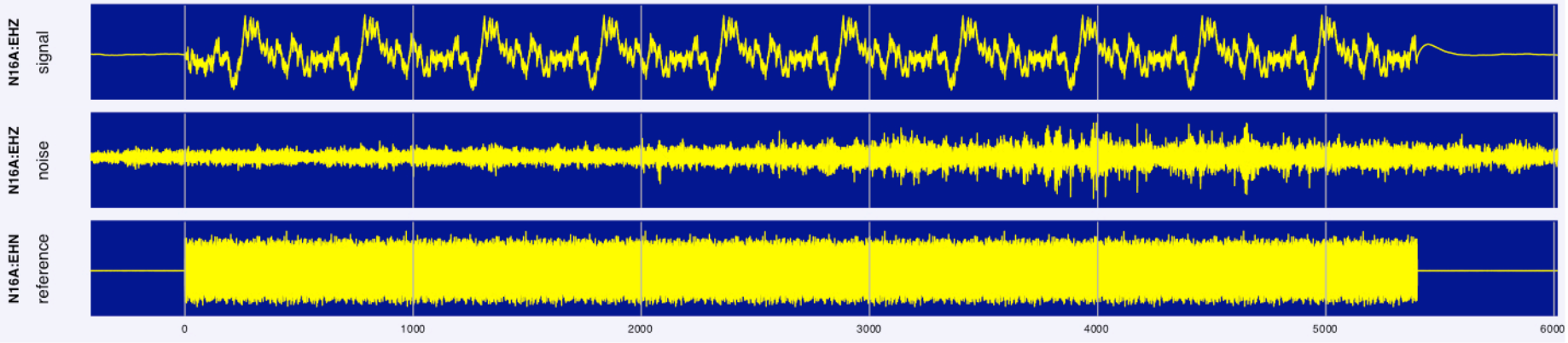
| | | | | |
|---|---|---|---|---|
| Cal mode: mon | Cal Waveform: white | Cal Duration: 1:30 hours | Samplerate: 200 | Cal Amplitude: 0.312 V |
| Cal processing: ratio | Cal Settle Time: 20:00 minutes | Cal Trailer Time: 20:00 minutes | | |

| | | | |
|---|---|---|---|
| Sngen: 1500.70 V/m/s | Nominal Sngen: 1500.00 V/m/s | Norm Freq: 1.000 Hz | Noise Relative To: TA_N16A-2008088:19:00:00 |

Processing Parameters:

{bands}{0}{fmax} = 0.02
{bands}{0}{fmin} = 0.000001
{bands}{0}{nwindows} = 1
{bands}{0}{overlap_percent} = 0.0
{bands}{0}{taper_percent} = 0.0
{bands}{1}{fmax} = 1.0
{bands}{1}{fmin} = 0.0025
{bands}{1}{nwindows} = 0
{bands}{1}{overlap_percent} = 50.0
{bands}{1}{taper_percent} = 25.0
{bands}{2}{fmax} = 10.0
{bands}{2}{fmin} = 0.05
{bands}{2}{nwindows} = 0
{bands}{2}{overlap_percent} = 50.0
{bands}{2}{taper_percent} = 50.0
{bands}{3}{fmax} = 200.0
{bands}{3}{fmin} = 1.00
{bands}{3}{nwindows} = 0
{bands}{3}{overlap_percent} = 50.0
{bands}{3}{taper_percent} = 50.0
{tlag} = 1000.0
{tlead} = 30.0



# White noise sensor calibration processing results

Processed by dbcalbrt:danny:redgarden at 2008134:12:50:59.008

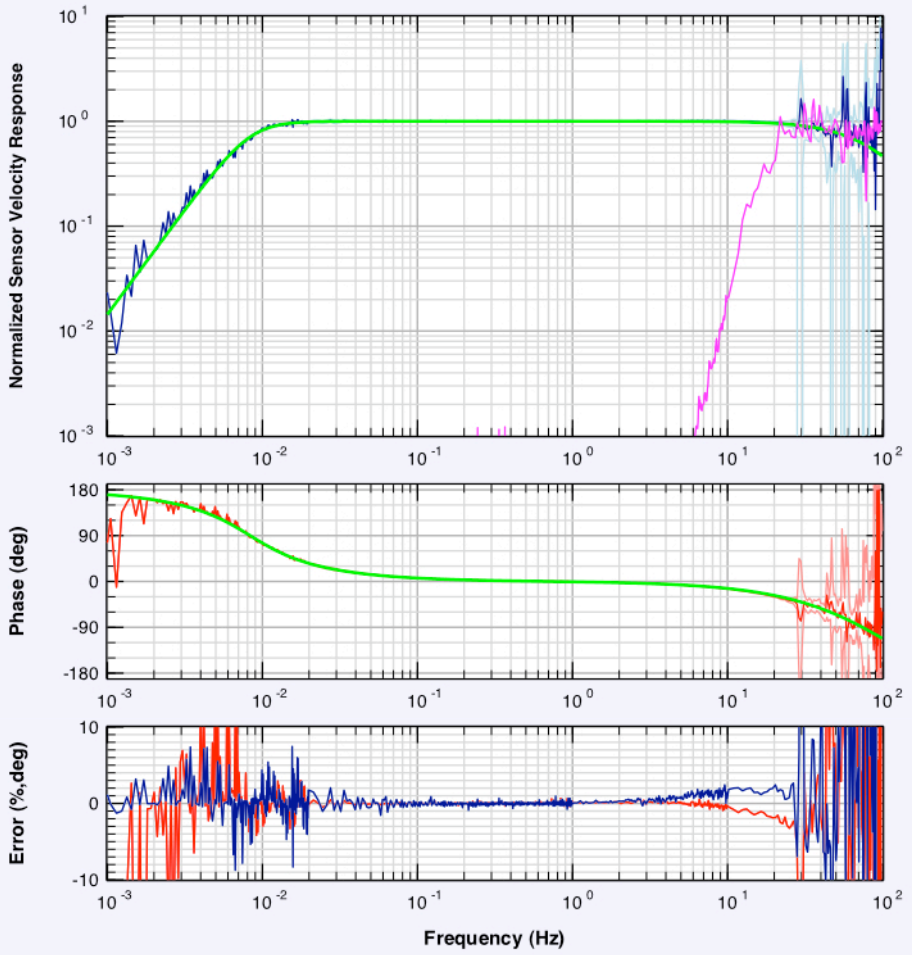
| Channel: | Time: | Sequence: | |
|---|---|---|---|
| TA_TETH_EHZ | 2008088:20:00:00.000 | TA_TETH-2008088:20:00:00 | |
| Dlmodel: | Dlserial: | Snmodel: | Snserial: |
| q330 | 0100000EBDCFB1B8 | cmg3t | 0001 |
| Noise Channel: | Noise Time: | Noise Sequence: | |
| TA_TETH_EHZ | 2008089:02:00:00.000 | TA_TETH-2008088:20:00:00 | |
| Noise Dlmodel: | Noise Dlserial: | Noise Snmodel: | Noise Snserial: |
| q330 | 0100000EBDCFB1B8 | cmg3t | 0001 |
| Ref Channel: | Ref Time: | Ref Sequence: | |
| TA_TETH_EHE | 2008088:20:00:00.000 | TA_TETH-2008088:20:00:00 | |
| Ref Dlmodel: | Ref Dlserial: | Ref Snmodel: | Ref Snserial: |
| q330 | 0100000EBDCFB1B8 | cmg3t | 0001 |

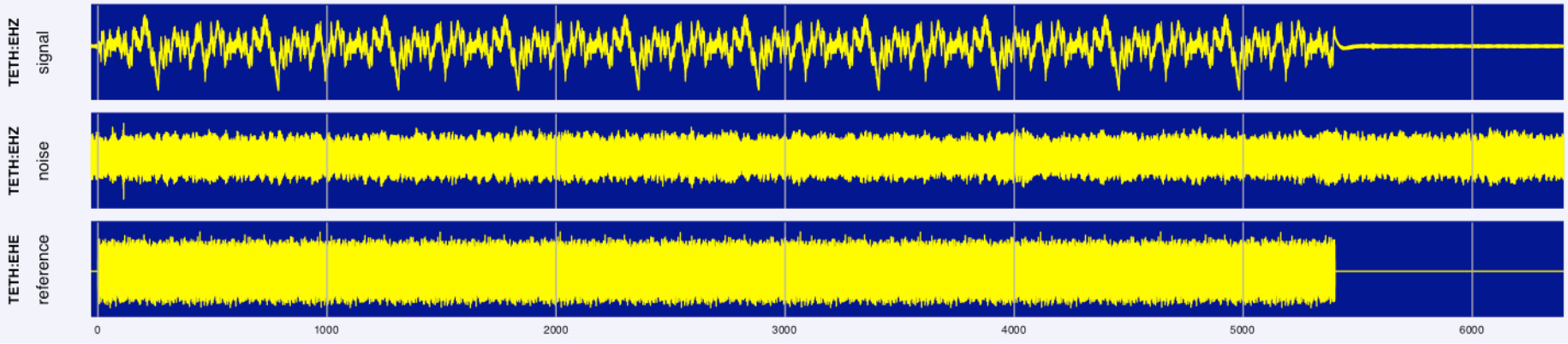
| Cal mode: | Cal Waveform: | Cal Duration: | Samplerate: | Cal Amplitude: |
|---|---|---|---|---|
| mon | white | 1:30 hours | 200 | 2.500 V |
| Cal processing: | Cal Settle Time: | Cal Trailer Time: | | |
| ratio | 10:00 minutes | 20:00 minutes | | |

| Sngen: | Nominal Sngen: | Norm Freq: | Noise Relative To: |
|---|---|---|---|
| 1501.90 V/m/s | 1500.00 V/m/s | 1.000 Hz | TA_TETH-2008088:20:00:00 |

Processing Parameters:

{bands}[0]{fmax} = 0.02
{bands}[0]{fmin} = 0.000001
{bands}[0]{nwindows} = 1
{bands}[0]{overlap_percent} = 0.0
{bands}[0]{taper_percent} = 0.0
{bands}[1]{fmax} = 1.0
{bands}[1]{fmin} = 0.0025
{bands}[1]{nwindows} = 0
{bands}[1]{overlap_percent} = 50.0
{bands}[1]{taper_percent} = 25.0
{bands}[2]{fmax} = 10.0
{bands}[2]{fmin} = 0.05
{bands}[2]{nwindows} = 0
{bands}[2]{overlap_percent} = 50.0
{bands}[2]{taper_percent} = 50.0
{bands}[3]{fmax} = 200.0
{bands}[3]{fmin} = 1.00
{bands}[3]{nwindows} = 0
{bands}[3]{overlap_percent} = 50.0
{bands}[3]{taper_percent} = 50.0
{tlag} = 1000.0
{tlead} = 30.0



# White noise sensor calibration processing results

Processed by dbcalbrt:danny:redgarden at 2008134:12:50:26.979

| | | | |
|---|---|---|---|
| Channel: TA_Y22D_EHZ | Time: 2008088:20:00:00.000 | Sequence: TA_Y22D-2008088:20:00:00 | |
| Dlmodel: q330 | Dlserial: 0100000A27B8E96F | Snmodel: sts2_g3 | Snserial: 30716 |
| Noise Channel: TA_Y22D_EHZ | Noise Time: 2008089:02:00:00.000 | Noise Sequence: TA_Y22D-2008088:15:30:00 | |
| Noise Dlmodel: q330 | Noise Dlserial: 0100000A27B8E96F | Noise Snmodel: sts2_g3 | Noise Snserial: 30716 |
| Ref Channel: TA_Y22D_EHZ | Ref Time: 2008088:15:30:00.000 | Ref Sequence: TA_Y22D-2008088:15:30:00 | |
| Ref Dlmodel: q330 | Ref Dlserial: 0100000A27B8E96F | Ref Snmodel: sts2_g3 | Ref Snserial: 30716 |

| | | | | |
|---|---|---|---|---|
| Cal mode: cmp | Cal Waveform: white | Cal Duration: 1:30 hours | Samplerate: 200 | Cal Amplitude: 2.500 V |
| Cal processing: ratio | Cal Settle Time: 10:00 minutes | Cal Trailer Time: 20:00 minutes | | |

| | | |
|---|---|---|
| Amp Ratio: 0.997160 | Norm Freq: 1.000 Hz | Noise Relative To: TA_Y22D-2008088:15:30:00 |

Processing Parameters:

{bands}{0}{fmax} = 0.02
{bands}{0}{fmin} = 0.000001
{bands}{0}{nwindows} = 1
{bands}{0}{overlap_percent} = 0.0
{bands}{0}{taper_percent} = 0.0
{bands}{1}{fmax} = 1.0
{bands}{1}{fmin} = 0.0025
{bands}{1}{nwindows} = 0
{bands}{1}{overlap_percent} = 50.0
{bands}{1}{taper_percent} = 25.0
{bands}{2}{fmax} = 10.0
{bands}{2}{fmin} = 0.05
{bands}{2}{nwindows} = 0
{bands}{2}{overlap_percent} = 50.0
{bands}{2}{taper_percent} = 50.0
{bands}{3}{fmax} = 200.0
{bands}{3}{fmin} = 1.00
{bands}{3}{nwindows} = 0
{bands}{3}{overlap_percent} = 50.0
{bands}{3}{taper_percent} = 50.0
{tlag} = 1000.0
{tlead} = 30.0