The Dark Side of Instrument Responses

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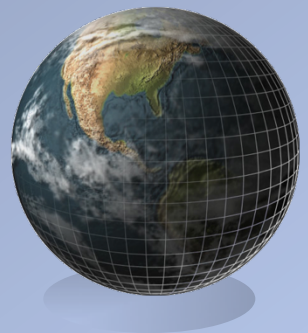
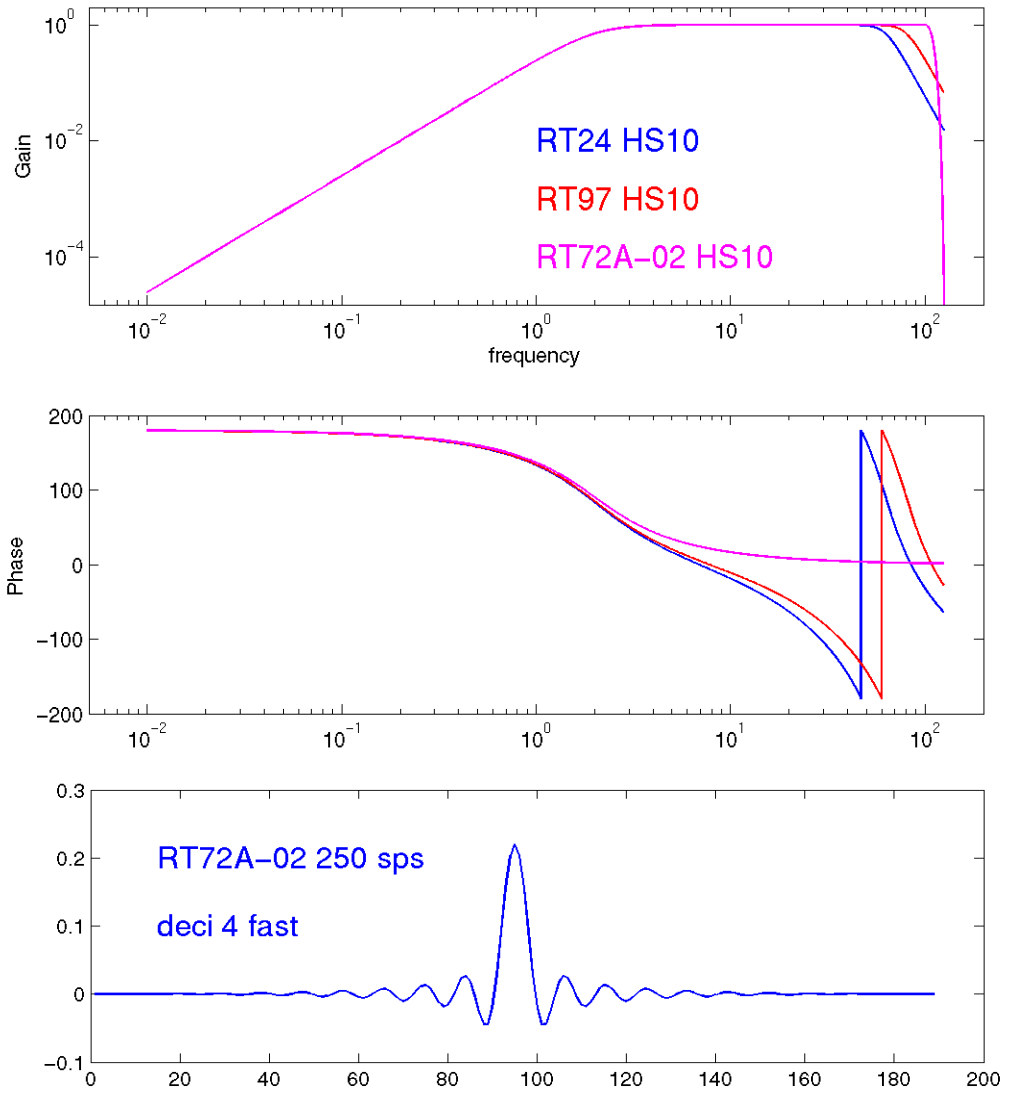
Maintaining PASSCAL Metadata

- **All site characteristics:**
  - Latitude, longitude, elevation
- **All instrument characteristics:**
  - Detailed responses - calibration, transfer functions
    - Sensor
    - External Preamp and Filter(?)
    - Datalogger
  - Orientation angles and depth of emplacement
  - Serial numbers
  - Instrument types



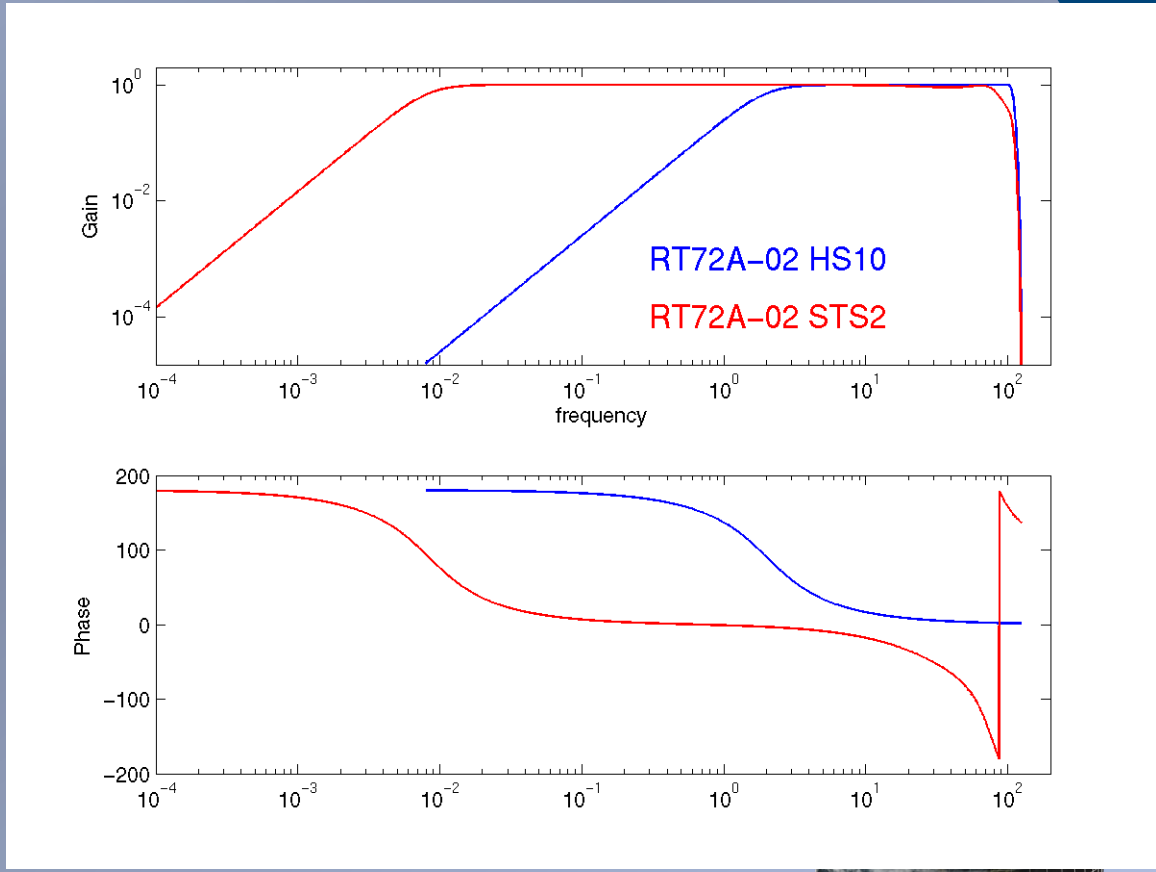
When life was simple

- Sensor
  - 2 Poles
    - -.8886E+01 0.8886E+01
    - -.8886E+01 -.8886E+01
  - 2 Zeros
    - 0.0000E+00 0.0000E+00
    - 0.0000E+00 0.0000E+00
- Anti-alias filter
  - 6 Poles
    - -.3793E+03 0.1016E+03
    - -.3793E+03 -.1016E+03
    - -.2777E+03 0.2777E+03
    - -.2777E+03 -.2777E+03
    - -.1016E+03 0.3793E+03
    - -.1016E+03 -.3793E+03
  - 0 Zeros

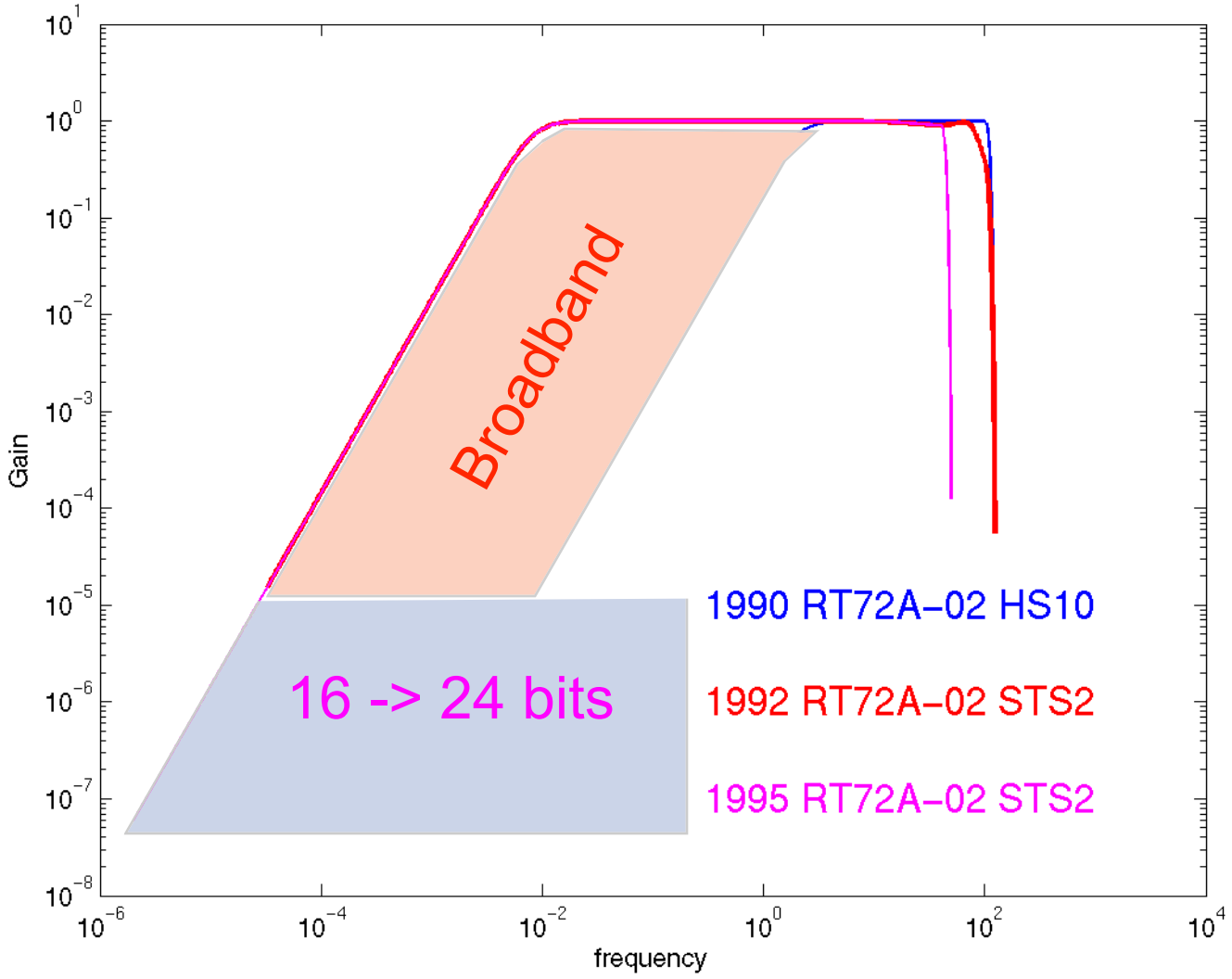


New Frontiers in Bandwidth

- Datalogger
  - RT72A-02
  - 16 bit (96 db)
- Sensors
  - Short period
  - Broadband

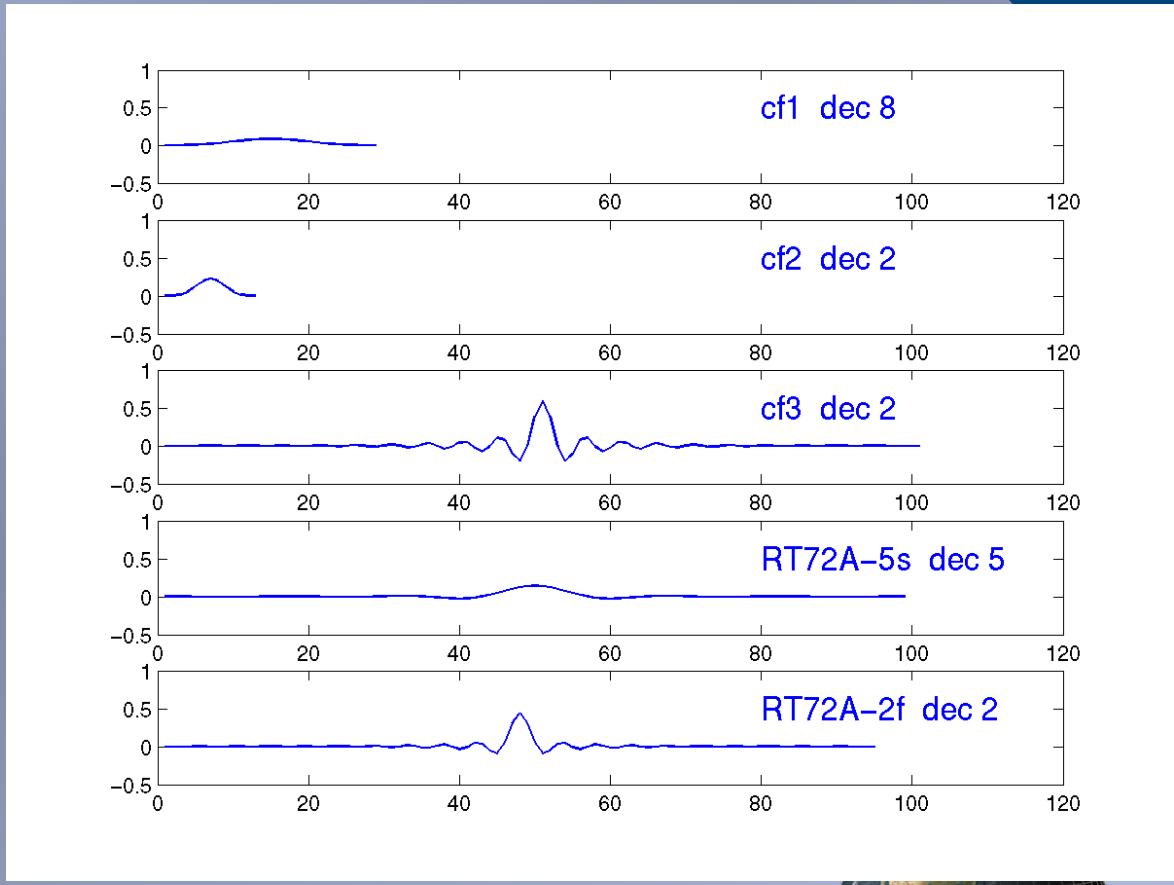


New Frontiers in Dynamic Range



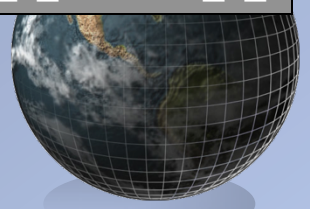
Basic RT72A-08

- 128k sps a/d rate
- 526315 cnts/V
- Crystal Filters
  - 1 cf1
  - 3 cf2
  - 1 cf3
- Reftek filters
  - Decimation
    - 5, 4, 2
  - Fast / Slow
- Zero Phase Linear Filters



RT72A-08 - One Sample Rate

	Crystal	Reftek
• 1000sps	a/d cf1 cf2 cf2 cf2 cf3	
• 500sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_2_f
• 250sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_4_f
• 200sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_f
• 125sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_4_s RT72A_2_f
• 100sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_2_f
• 50sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_4_f
• 40sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_5_f
• 25sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_4_s RT72A_2_f
• 20sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_5_s RT72A_2_f
• 10sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_5_s RT72A_4_f
• 8sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_5_s RT72A_5_f
• 5sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_5_s RT72A_4_s RT72A_2_f
• 4sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_5_s RT72A_5_s RT72A_2_f
• 2sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_5_s RT72A_5_s RT72A_4_f
• 1sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_5_s RT72A_5_s RT72A_4_s RT72A_2_f

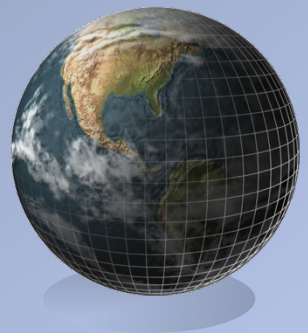


RT72A-08 - Multiple Rate

	Crystal	Reftek
• Single Rate		
– 200sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_f
– 100sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_2_f
– 40sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_5_f
• Dual rates		
– 100sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_2_f
– 40sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_s RT72A_5_f
• Dual rate		
– 200sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_f
– 40sps	a/d cf1 cf2 cf2 cf2 cf3	RT72A_5_f RT72A_5_f

Next generation: RT130

- Sample rates
  - 1000, 500, 250, 200, 125, 100, 50, 40, 25, 20, 10, 5, 1 sps
  - Removed 8, 4, 2 sps
- Single data streams
  - 1000, 500, 250, 125, 50, 25 sps
- Multiple data streams
  - 200, 100, 40, 20, 10, 5, 1 sps
- A/D rate
  - 256,000
  - 102,400
- Zero Phase linear filters



RT130 Inner Workings

Single Datastream

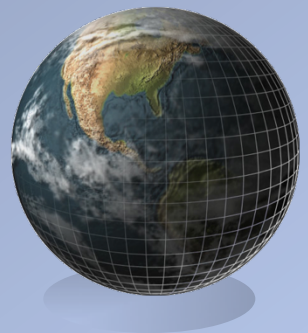
1000sps	a/d1 cf1 cf2 cf2 cf2 cf2 cf3
500sps	a/d1 cf1 cf2 cf2 cf2 cf2 cf2 cf3
250sps	a/d1 cf1 cf2 cf2 cf2 cf2 cf2 cf2 cf3
125sps	a/d1 cf1 cf2 cf2 cf2 cf2 cf2 cf2 cf2 cf3
50sps	a/d2 cf1 cf2 cf2 cf2 cf2 cf2 cf2 cf2 cf3
25sps	a/d2 cf1 cf2 cf2 cf2 cf2 cf2 cf2 cf2 cf2
cf3	

Multiple Datastreams

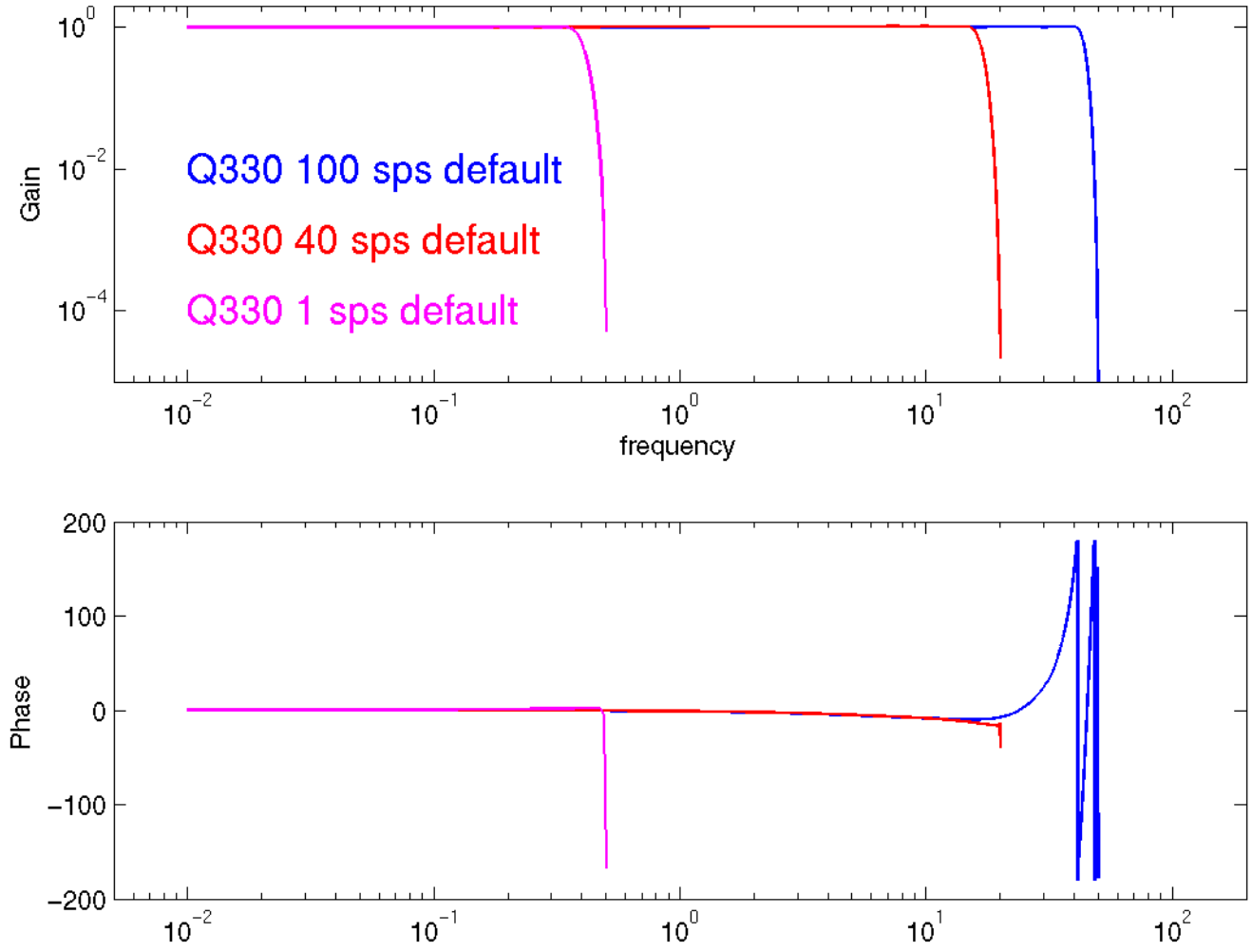
200sps	a/d2 cf1 cf2 cf2 cf2 cf2 cf2 cf3	
100sps	a/d2 cf1 cf2 cf2 cf2 cf2 cf2 cf3	RT72A_2_f
40sps	a/d2 cf1 cf2 cf2 cf2 cf2 cf2 cf3	RT72A_5_f
20sps	a/d2 cf1 cf2 cf2 cf2 cf2 cf2 cf3	RT72A_5_f RT72A_2_f
10sps	a/d2 cf1 cf2 cf2 cf2 cf2 cf2 cf3	RT72A_5_f RT72A_2_f RT72A_2_f
5sps	a/d2 cf1 cf2 cf2 cf2 cf2 cf2 cf3	RT72A_5_f RT72A_2_f RT72A_2_f RT72A_2_f
1sps	a/d2 cf1 cf2 cf2 cf2 cf2 cf2 cf3	RT72A_5_f RT72A_2_f RT72A_2_f RT72A_2_f RT72A_5_f

Q330

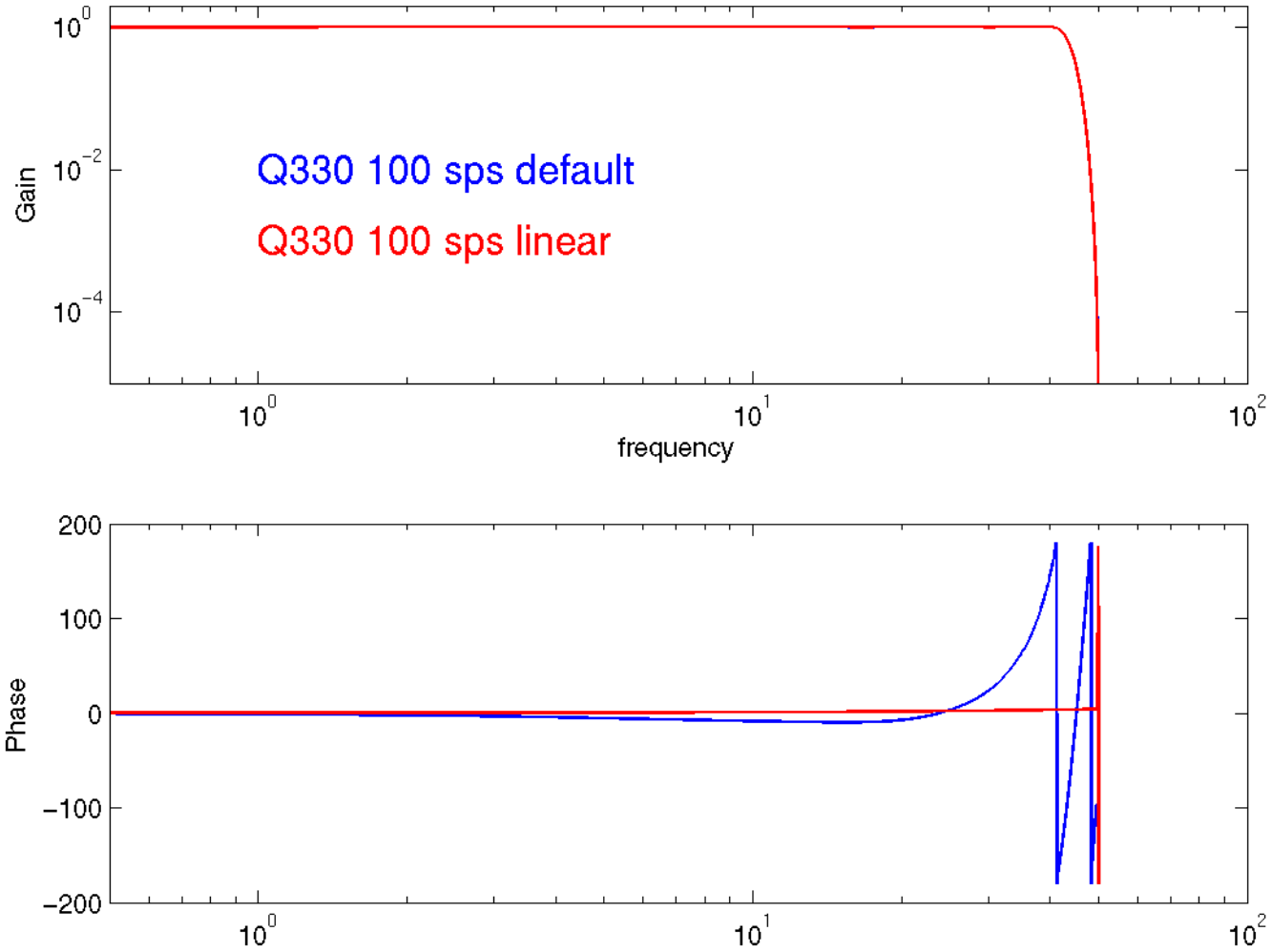
- Sample rates
  - 200, 100, 50, 40, 20, 10, 1 sps
  - 0.1 sps with baler
- Multiple data streams
  - Any combination allowed
- Filter and Decimation
  - Knowledge not allowed, considered proprietary
  - Composite filter responses provided
- Causal and Acausal filters



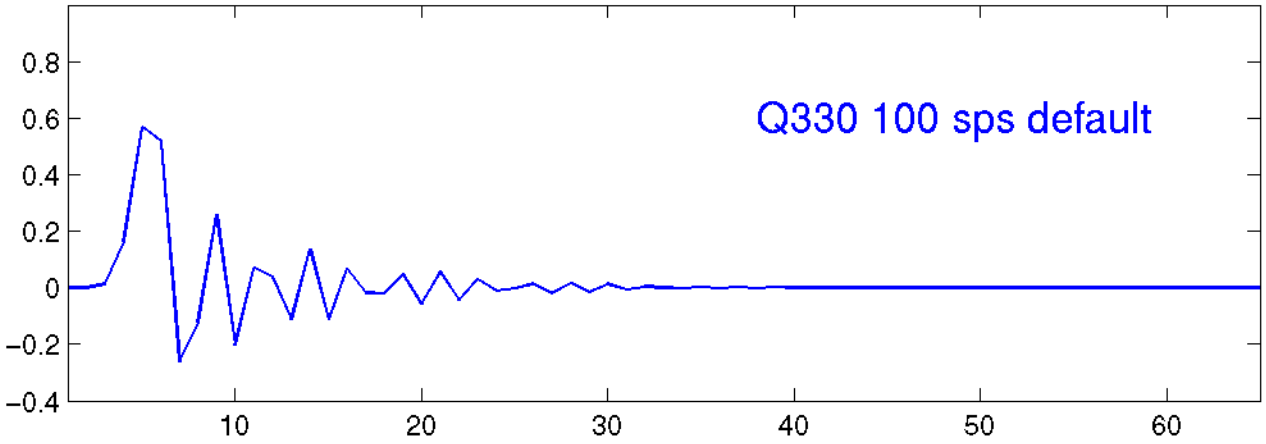
Q330 default response

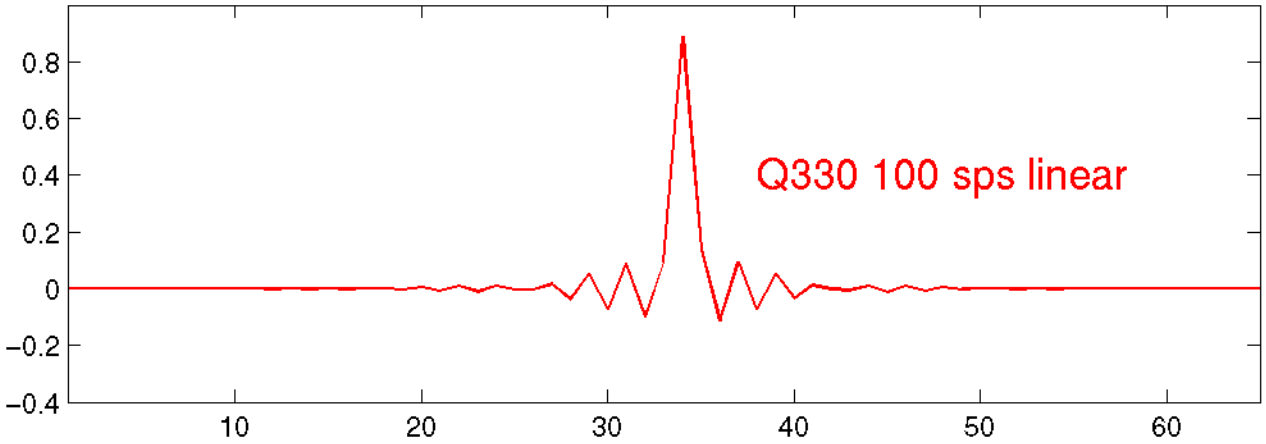


Q330 default vs linear filters



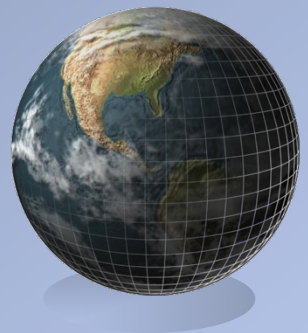
Q330 composite filters





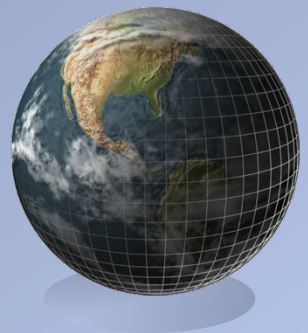
Perils of virtual networks

- Every datalogger different
- A/D's
  - Crystal
    - Reftek, KMI, Guralp, Ida, etc…..
  - Proprietary
    - Quanterra, Nanometrics
- FIR Filters
  - Zero Phase Filters
    - Reftek, Quanterra, KMI, Gurlap, Ida, Nanometrics
  - Causal
    - Quanterra, KMI



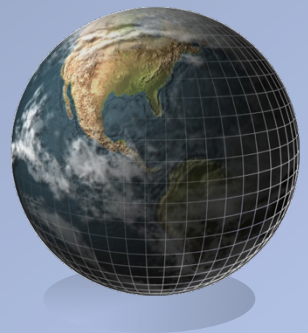
Idiosycracies

- Quanterra
  - Variable A/D constants by channel
    - Q680, Q4120, Q730
  - Home brewed filters allowed
    - Q680, Q4120, Q730
  - Q330 default
    - Causal to 100 sps
    - Acausal below
  - FIR coeffs distributed in reverse time order
- Guralp
  - Differential or Single ended inputs
- Nanometrics
  - Variable A/D gains
  - FIR Filters
    - 6 decimation rates
    - 9 decimate by 5 filters in specification
    - 6 unique decimate by 5 filters



Datalogger descriptions

- Reftek
  - RT24, RT72A-0[2678], RT97, RT130
- Gurlap
  - DM24, PEPP
- UCSD
  - Ida Mark 8
  - Lcheapo 2000
- Quanterra
  - Q4120, Q730, Q330
  - Q680 needed for USARRAY
- KMI
  - Altus, K2, Makalu
- Nanometrics
  - Trident
- Canadian
  - GD-1



Sensor Descriptions

- Streckeisen
  - STS1, STS2
- Mark Products
  - L4, L22, L28
- KMI
  - Episensor, FBA-23, Ranger
- Geospace
  - HS10
- Guralp
  - CMG3T, CMG3ESP, CMG3ESP_NSN, CMG40T
- Geotech
  - KS54000, S6000
- Terratech
  - FBA