

Simulated Data Sets

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Goal:

Generate "noise" with spectral character of LIGO I

Use:

Monte Carlo testing of, e.g., data analysis pipelines,
artifact removal

Requirements:

Deliver in Frames

Instrument artifacts

Signals

(non) Gaussian background

Power Lines,
Violin modes, transients, ...

} Better than
"Real-time"
Performance

Expression of interest:

Ed Daw, Bernard Whiting, Susan Scott

Relationship to E2E:

● "Macro" vs. "Micro" model - eventually integrated
into E2E

General Design:

Quasi-Stationary Background

Seismic noise: ground measurements + HYTEC xfer function

Thermal, shot, rad pressure: linear filters + white noise

Power lines
Transients
Signals

} Add-ons

Implementation:

Prototype: Matlab

Final: E2E (DMT?)

Schedule:

First Matlab Prototype 1 November 1999

Fundamental noise (includes violin modes)

Seismic noise

No frames

Second Matlab Prototype 15 December 1999

Writes frames

Simple transients

Non-Gaussian noise (mixture Gaussian)



Simulating

Thermal Noise from Structurally-damped Systems

Examples:

Violin suspension modes, test masses

Idea:

Linear filter + White noise

$$\begin{aligned} \downarrow S_x(f) &= S_0 \\ y &= Hx \\ \uparrow S_y(f) &\propto |H(f)|^2 S_x(f) \end{aligned}$$

Problem:

$$\left. \begin{aligned} f_0 &\approx 400 \text{ Hz} \\ Q &\approx 10^6 \\ f_s &= 16384 \text{ Hz} \end{aligned} \right\} \begin{aligned} \Delta f_{\text{FWHM}} &\approx \frac{f_0}{Q} \approx 4 \cdot 10^{-4} \text{ Hz} \\ N_{\text{FIR}} &\gg \frac{f_s}{\Delta f} \approx 4.1 \cdot 10^7 ! \end{aligned}$$

Problem:

1) $H(t < 0) = 0$

Causality

2) $H(s)$ has poles in left-half-plane

Stability

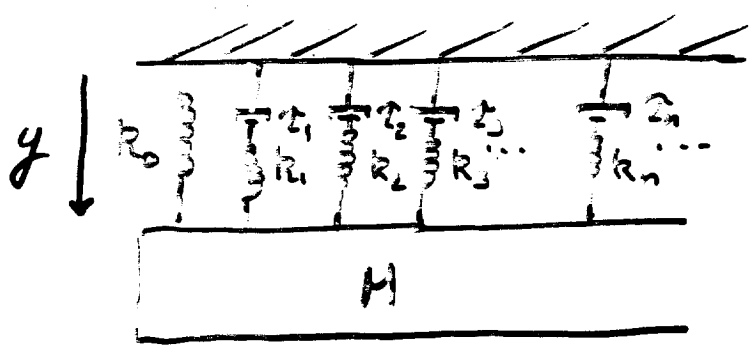
3) $|H(f)|^2 \propto \frac{\phi}{f} \frac{1}{(f^2 - f_0^2)^2 + (f_0^2 \Phi)^2}$

Spectrum

Note: ϕ constant in-band, but can't be constant everywhere

Note :

- ① Causality ($H(t < 0) = 0$) $\rightarrow H(2\pi if) = \tilde{H}(f)$
- ② Adopt physical system model to get "physical" $\phi(f)$



$$\Phi \approx \sum_n \frac{k_n}{k_0} \frac{2\pi f \tau_n}{1 + (2\pi f \tau_n)^2}$$

choose $\frac{k_n}{k_0} = \epsilon$
 τ_k / τ_{k+1} constant

③ "Factor" $|H(s)|^2 = |\tilde{H}(-is/2\pi)|^2 = S_y(-is/2\pi)$

$N+2$ poles, N zeros
 poles, zeros in left half-plane for stability, invertibility

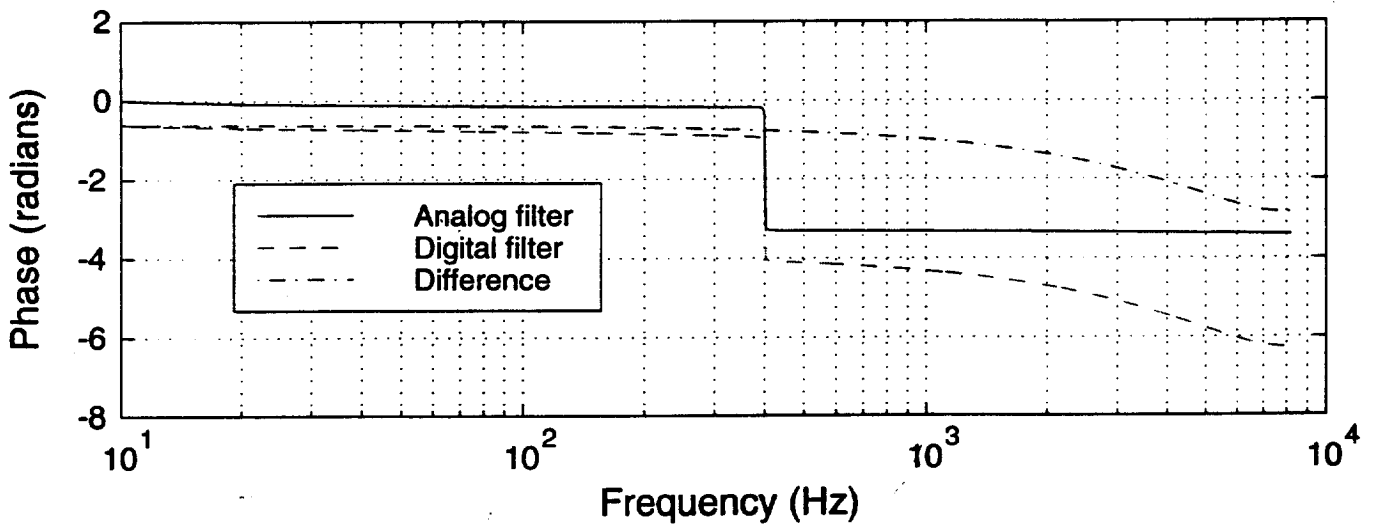
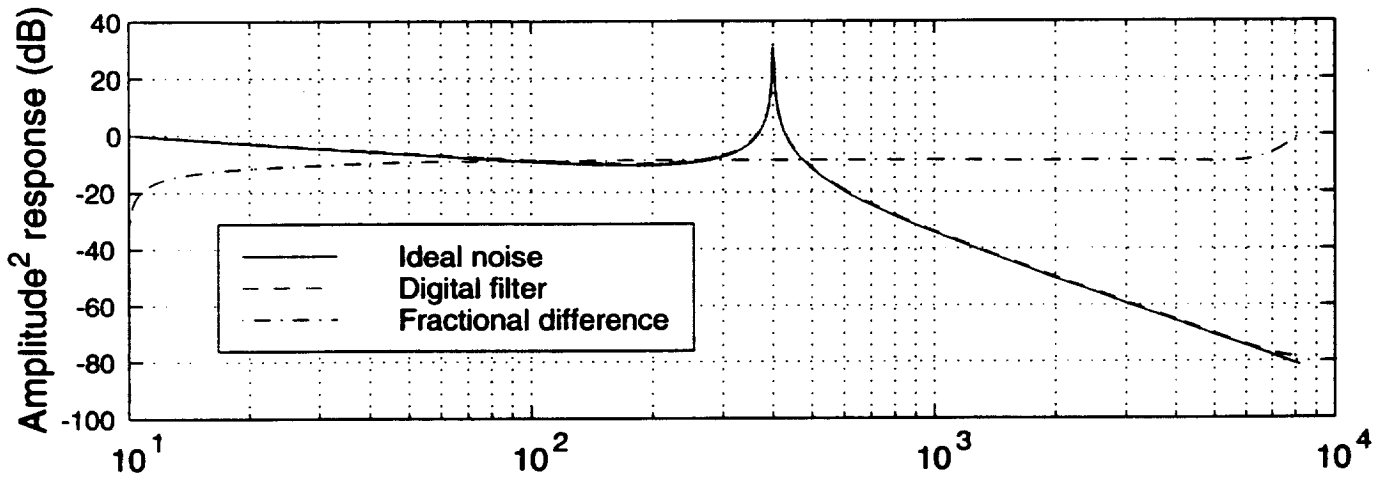
$N = 2 \cdot \# \text{ decades}$
 gives ϕ constant to better than $\epsilon/10$

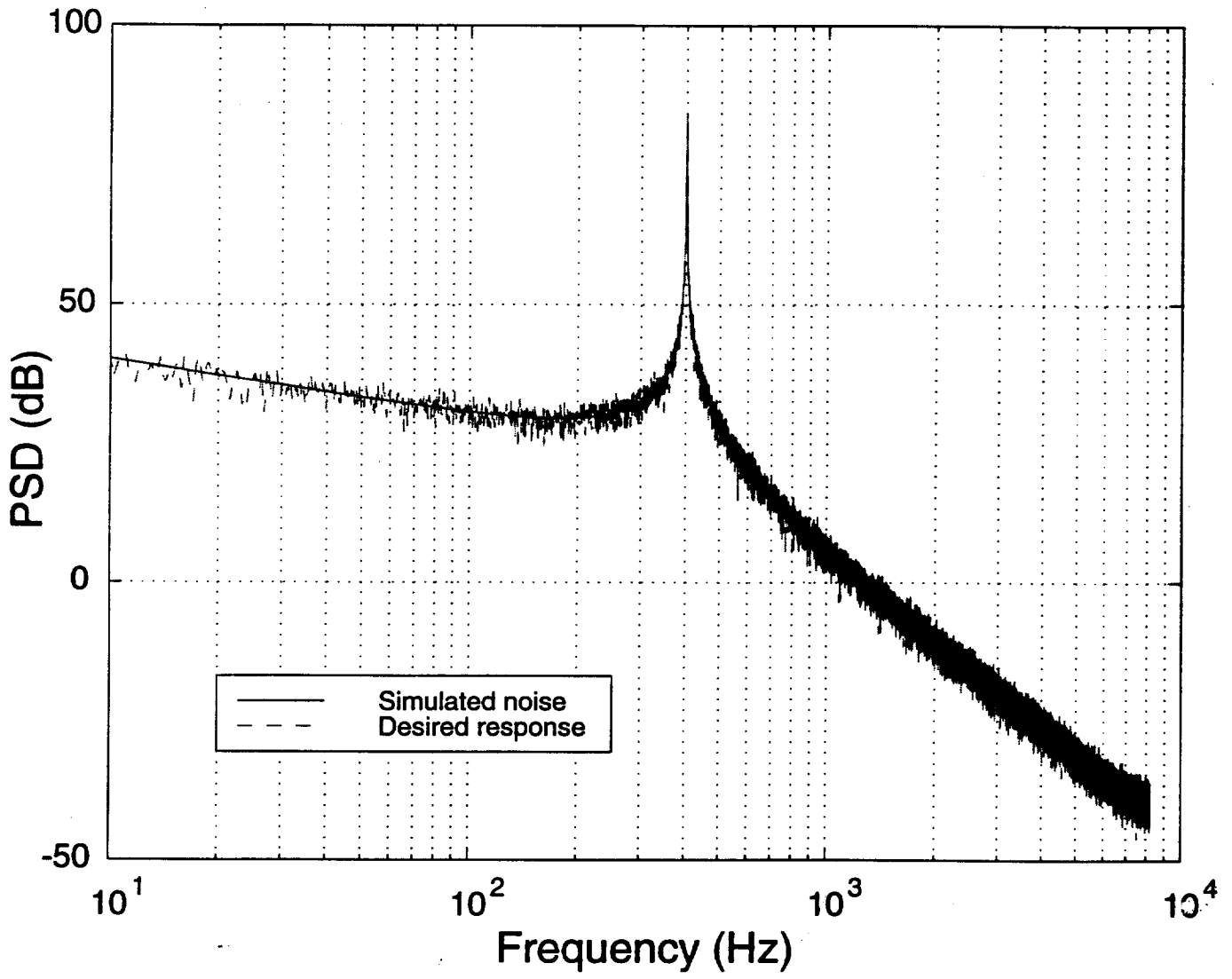
④ Continuum to discrete time (analog to digital) transformation

State Space :

state $\rightarrow \dot{x} = A \cdot x + B u$ (input) $\rightarrow x[k] = e^{A/f_s} \cdot x[k-1] + B u[k]$

$y = C \cdot x + \text{O}$ (No direct input!) $\rightarrow y[k] = C \cdot x[k]$





Note 1, Linda Turner, 08/17/99 09:12:34 PM
LIGO-G990079-40-M