Adaptive FIRs

taking place at lasti

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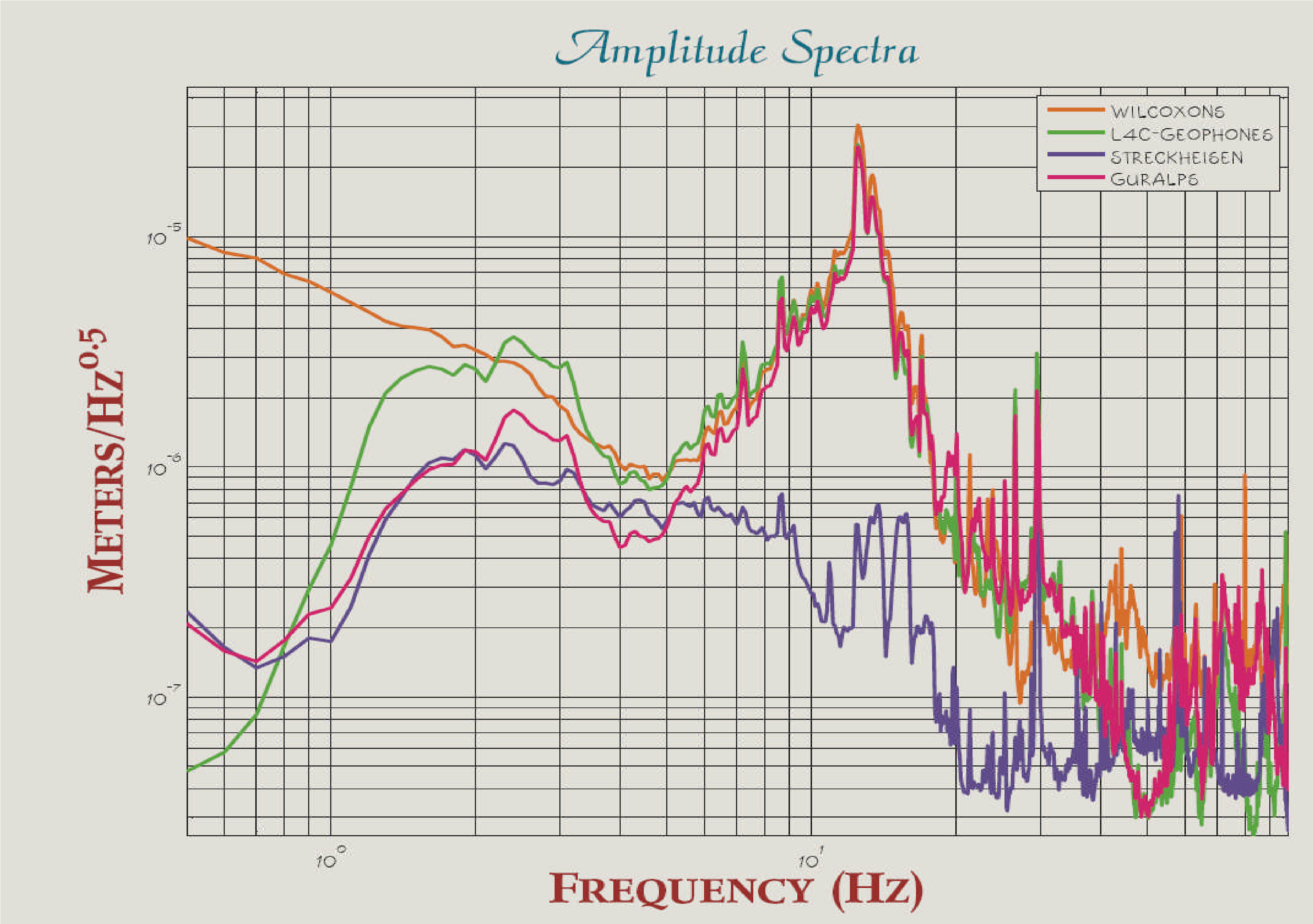
LIGO-G060161-00-Z

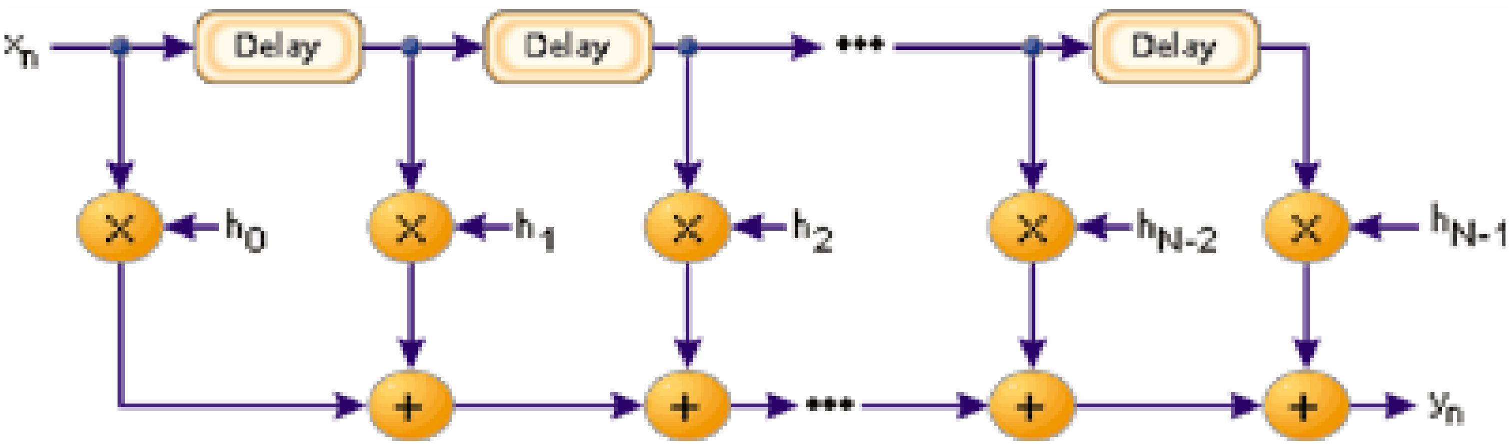
The Problem



Amplitude Spectra
WILCOXONS
L4C-GEOPHONES
STRECKHEISEN
GURALPS
10^-5
10^-6
10^-7
10^0
10^1
METERS/HZ^0.5
FREQUENCY (HZ)

FIR Implementation

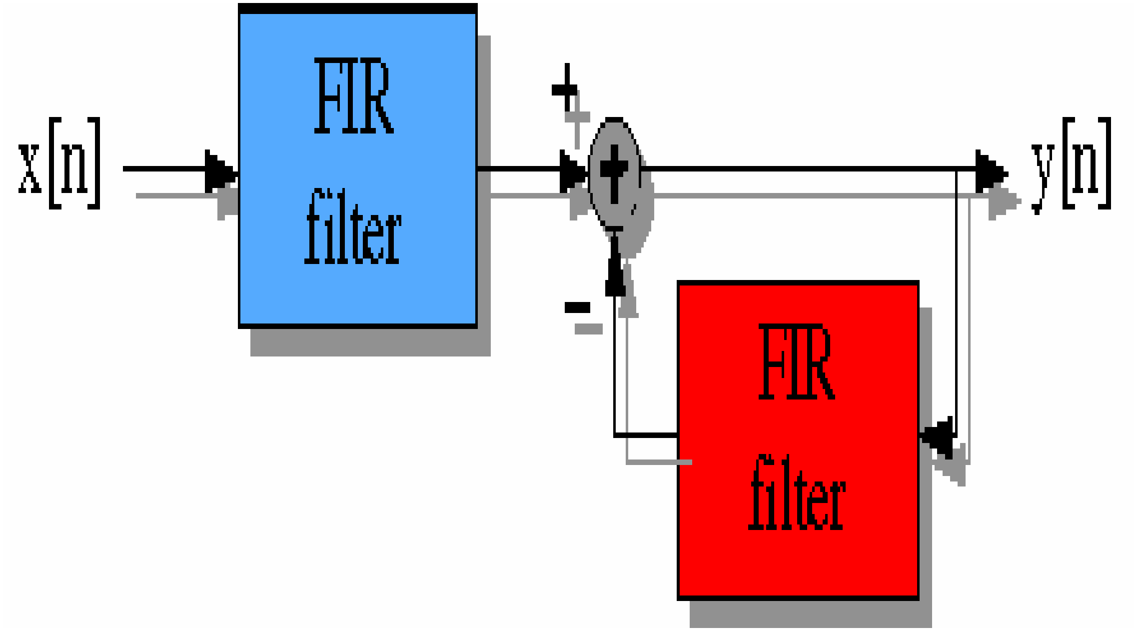
The basic block diagram for an FIR filter of length *N*. The delays result in operating on prior input samples. The *hk* values are the coefficients used for multiplication, so that the output at time *n* is the summation of all the delayed samples multiplied by the appropriate coefficients.



Or $$Y = \vec{X} \bullet \vec{H}$$

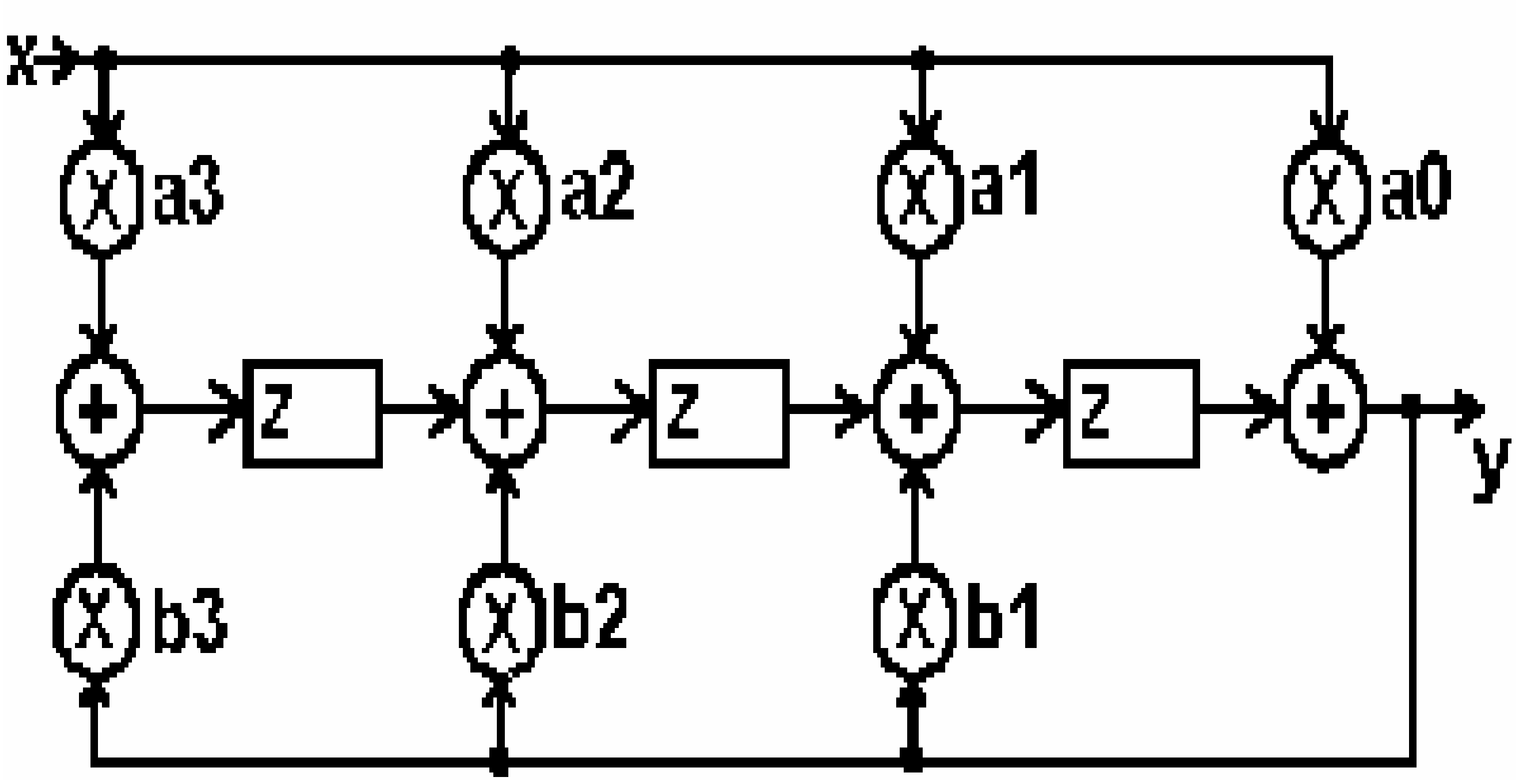
H = Filter Coefficients
X = Input Values
Y = Output Value

IIR Implementation

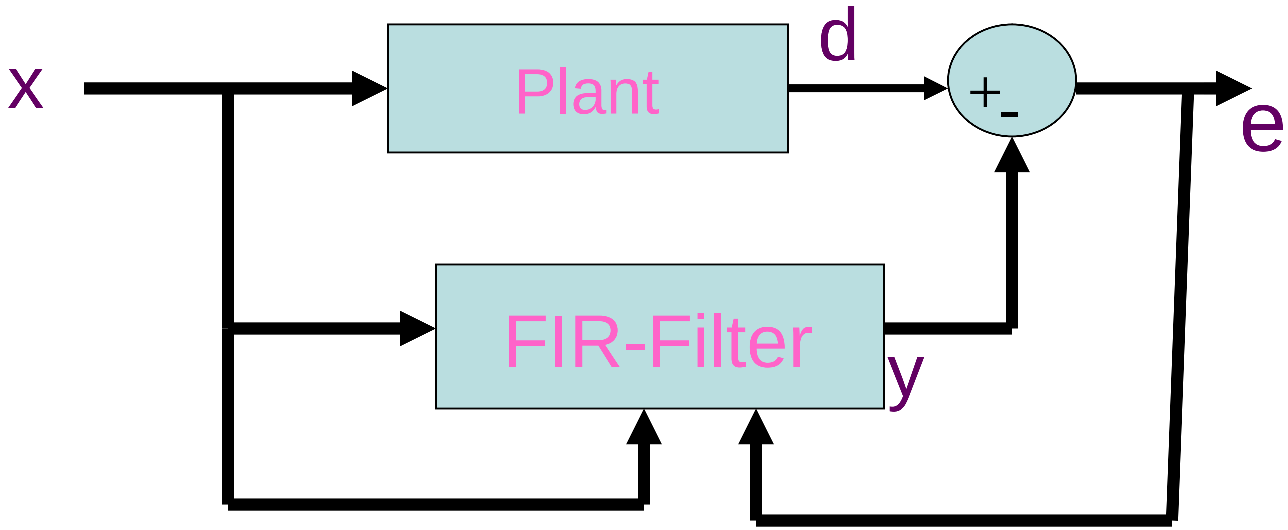


Or $$Y = \vec{A} \bullet \vec{X} + \vec{B} \bullet \vec{Y}_{-1}$$

IIR Implementation



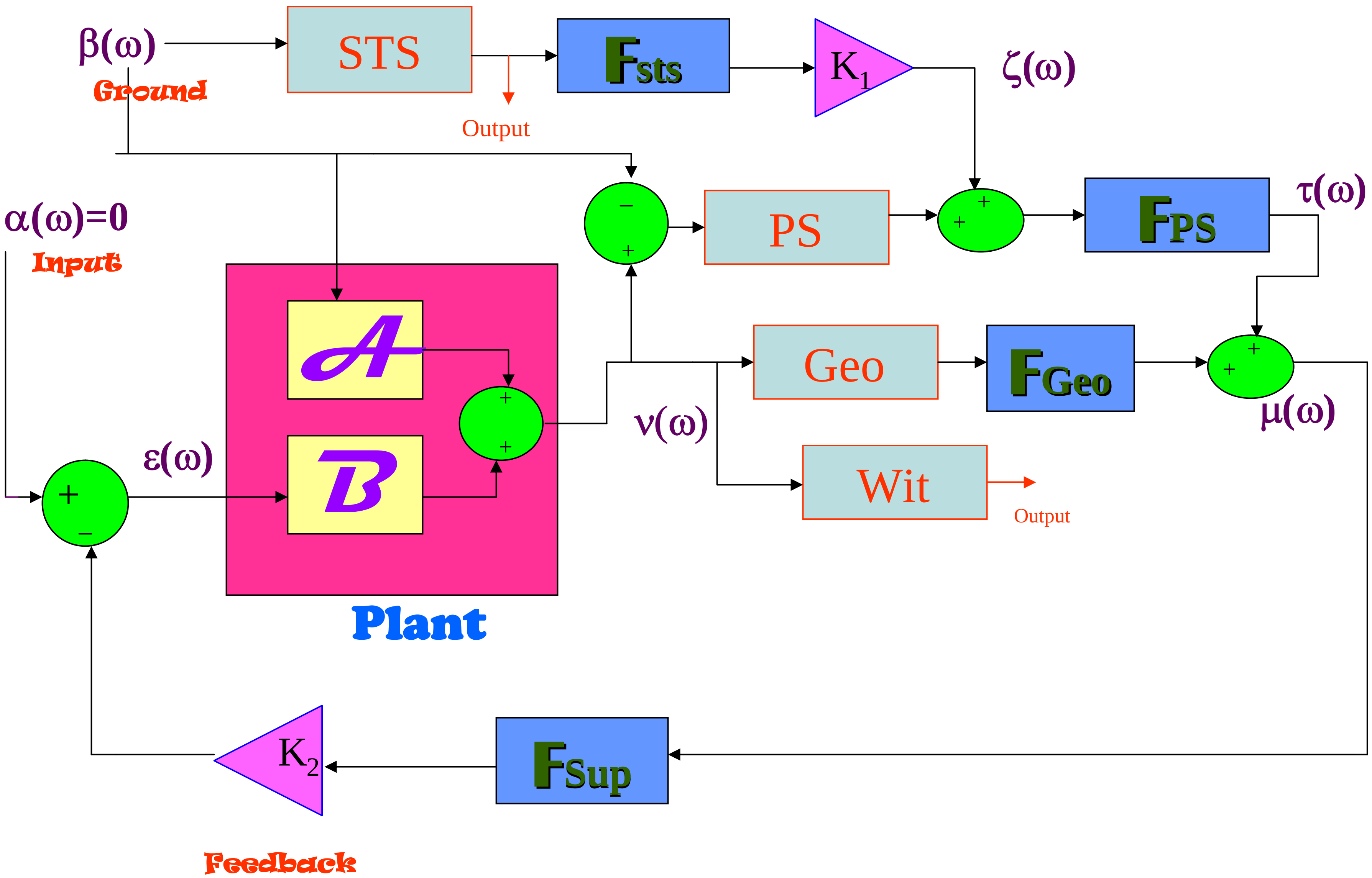
Adaptive Algorithm



Gradient = $$\frac{\partial}{\partial h_i}|e|^2 = 2e\frac{\partial}{\partial h_i}[d-y] = 2e\frac{\partial}{\partial h_i}\left[d - \sum_{i=0}^{N-1}(h_i\, x_{N-i})\right]$$

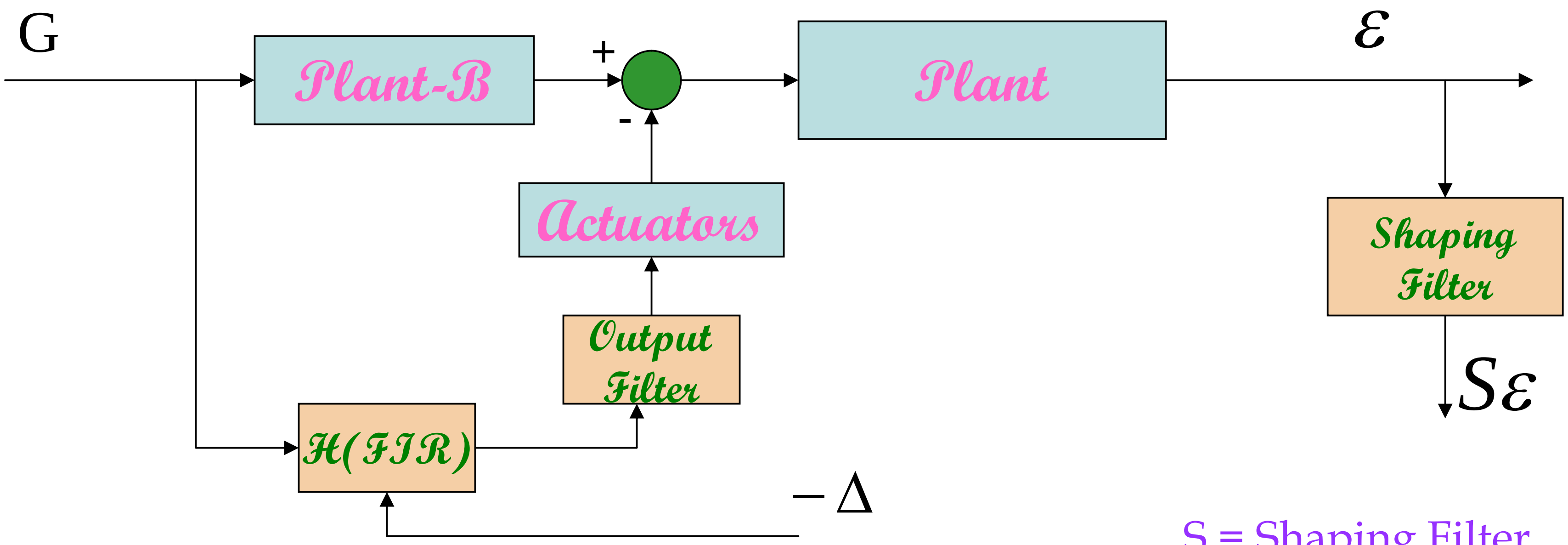
$$= 2e[-x_{N-i}]$$

FIR filter, of length N, has coefficients *h*



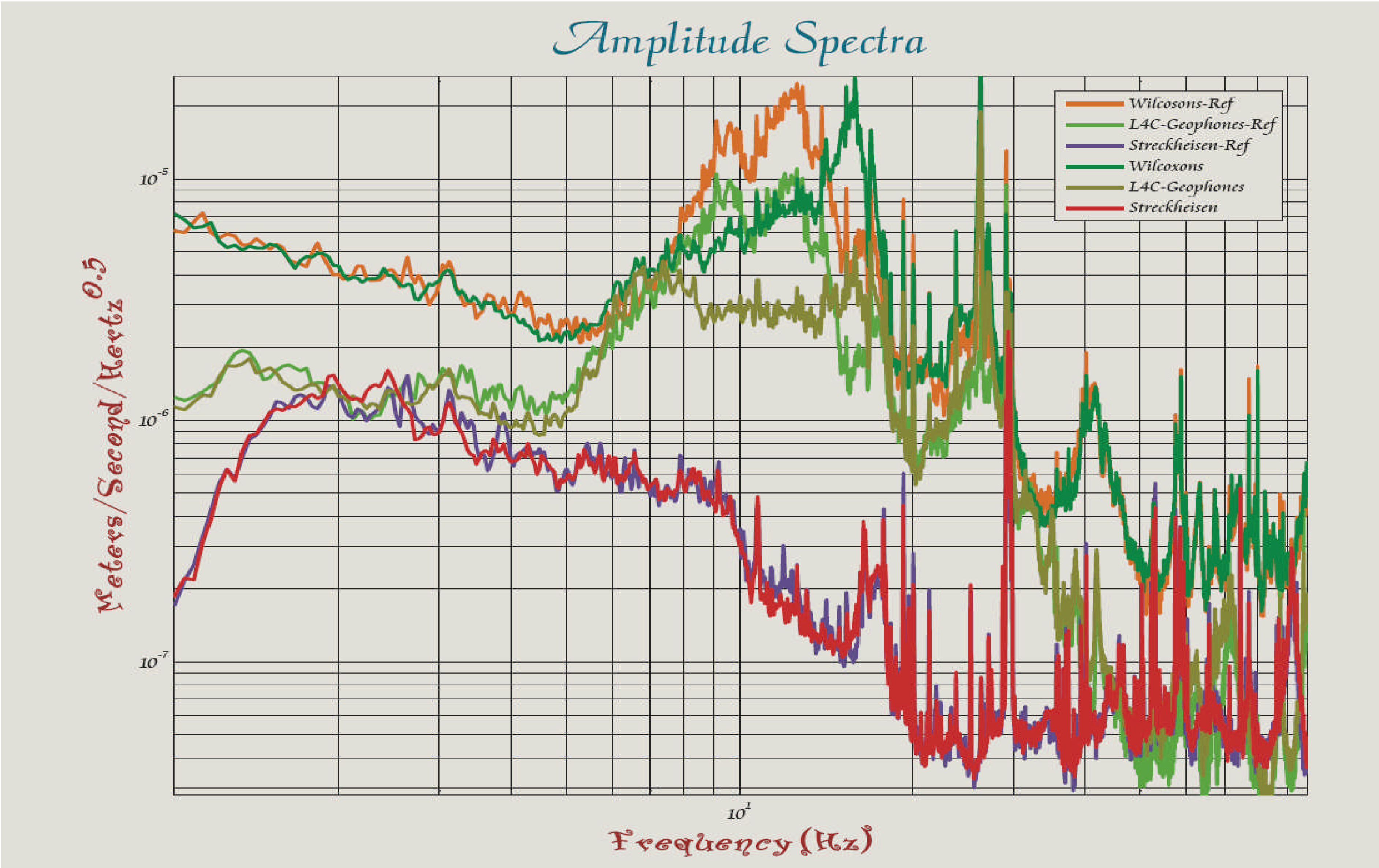
Control Strategy

FIR Implementation

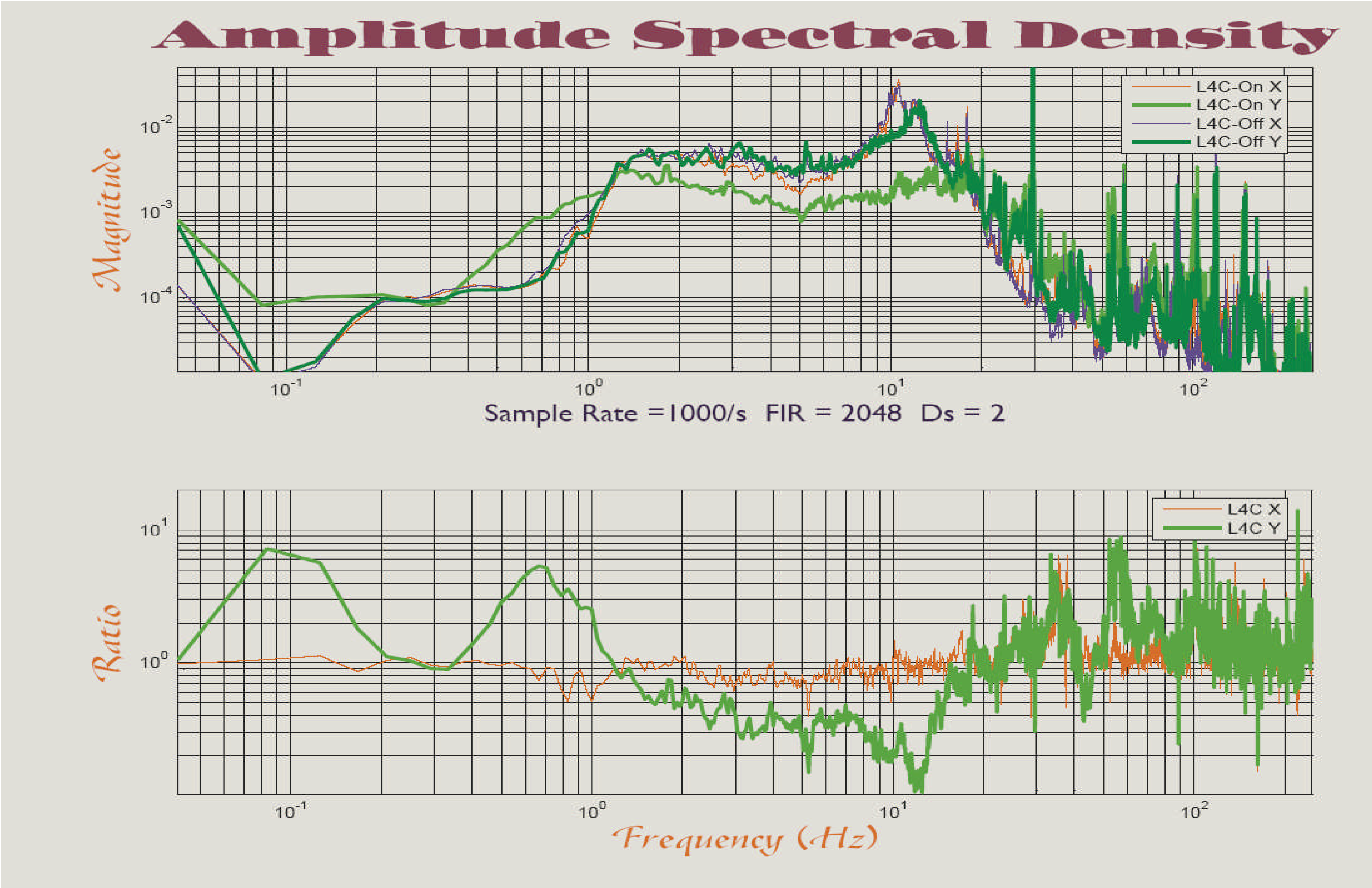


$$\Delta = \frac{\delta(S\varepsilon)^2}{\delta h_k} = S^2 \frac{\delta(\varepsilon)^2}{\delta h_k} = -2S^2 PGO\varepsilon$$

S = Shaping Filter
O = Output Filter
P = Plant(Actuator to Witness Sensor)
G = Ground input

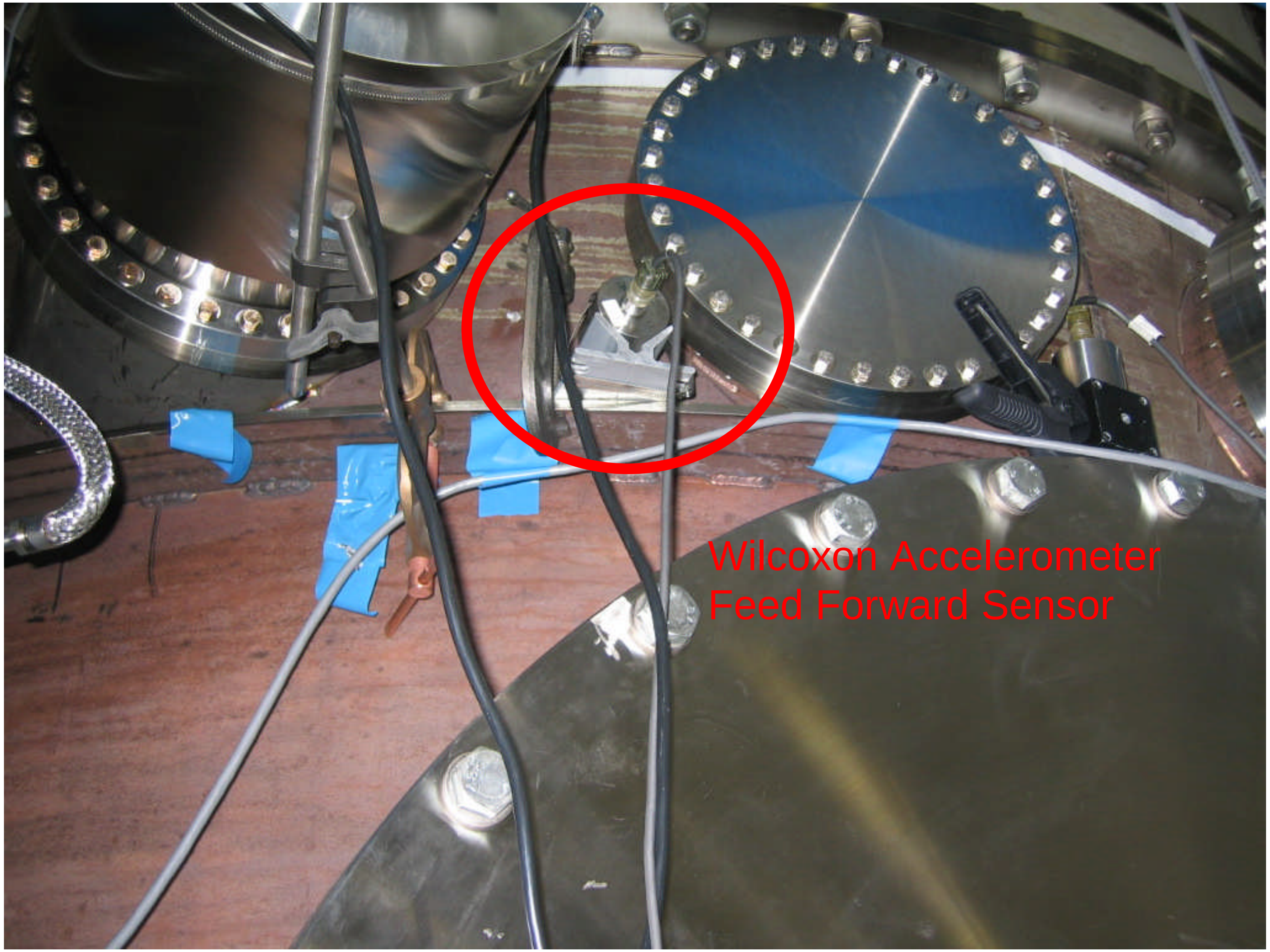


No Compensation Path

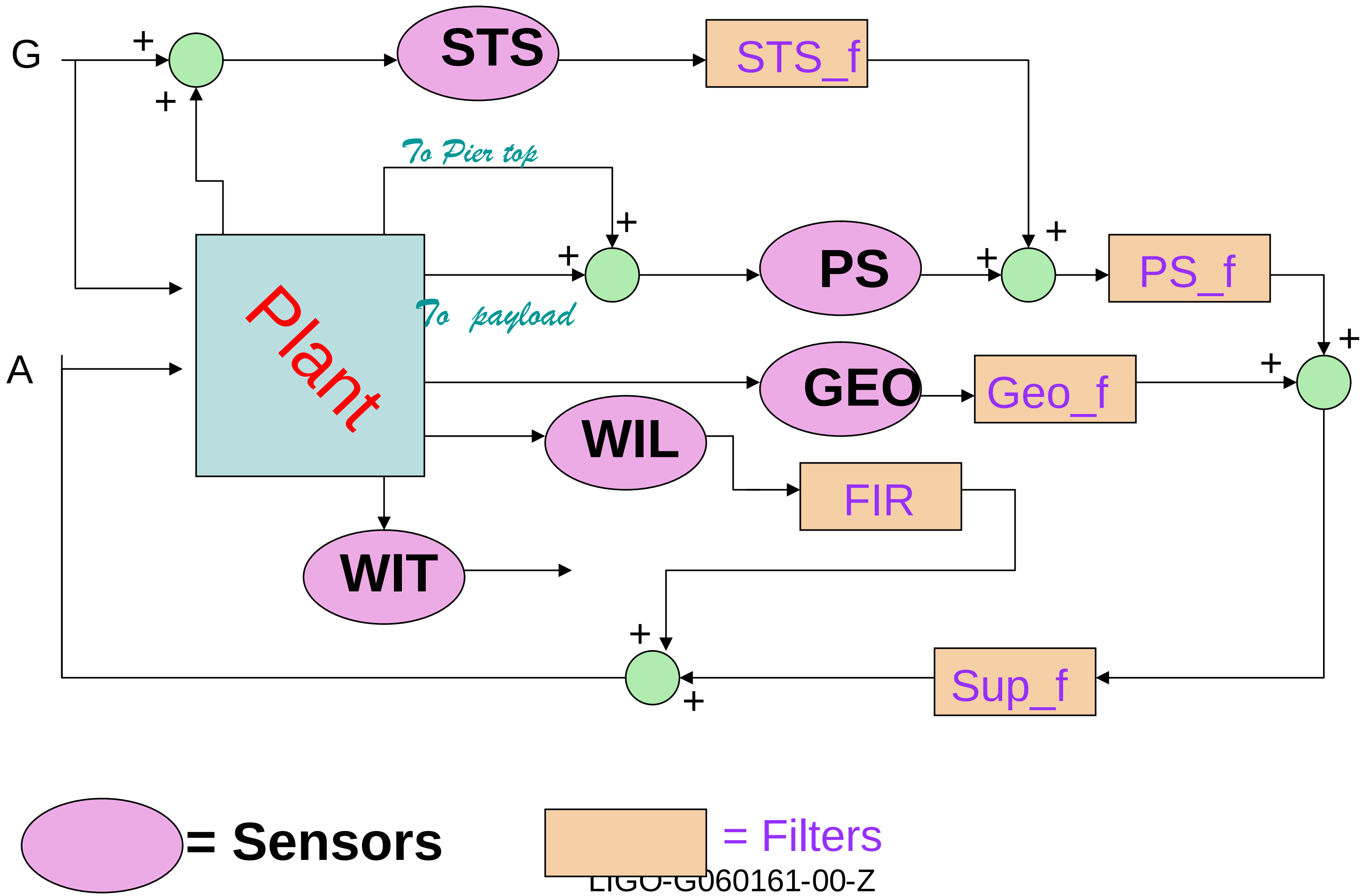


Simple Implementation

Feed Forward Sensor on the BSC



SISO BSC Model



Closed Loop Response

CLOSED LOOP EQUATION

$$A * [1 - FIR * WIL_d - Sup_f * \{Geo_f * Geo_d + PS_f * (PS_d + STS_f * STS_d)\}] =$$
$$G * [FIR * WIL_g + Sup_f * \{Geo_f * Geo_g + PS_f * (PS_g + STS_f)\}]$$

SIMPLIFYING

$$A * (1 - Z) = G * Y$$

XXX_f = A filter
XXX_g = Ground to sensor TF
XXX_d = Actuator to sensor TF

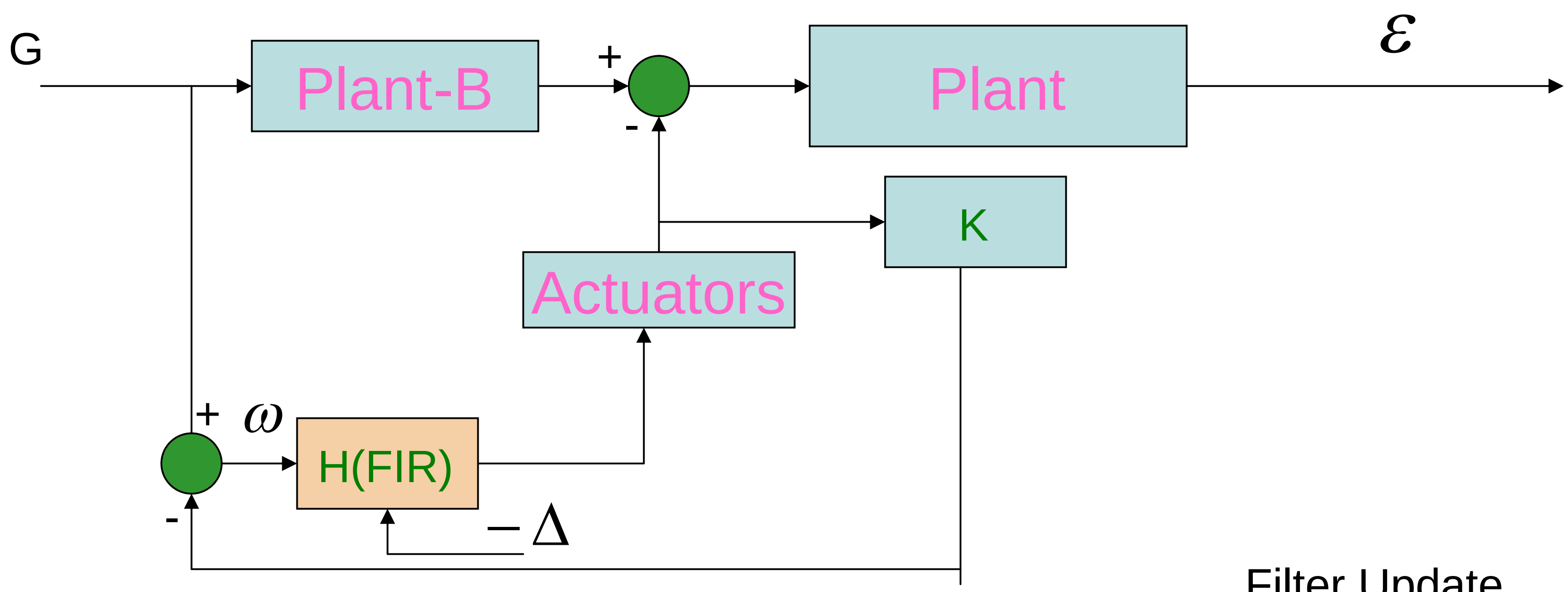
AND THE WITNESS RESPONSE IS

$$\frac{WIT}{G} = WIT_g + WIT_d * \frac{Y}{1 - Z}$$

A = Actuator Drive Signal
G = Ground Signal

Where Y has ground to sensor Transfer Functions and Z has drive to sensor Transfer Functions

Extra Feed Back Path



$-\Delta =$ Filter Update Coefficients

ω = feed forward sensor

K = feed back to feed forward senor

$$\Delta = \frac{\delta(\varepsilon)^2}{\delta h_k} = -2P\omega\varepsilon[BK-1]$$

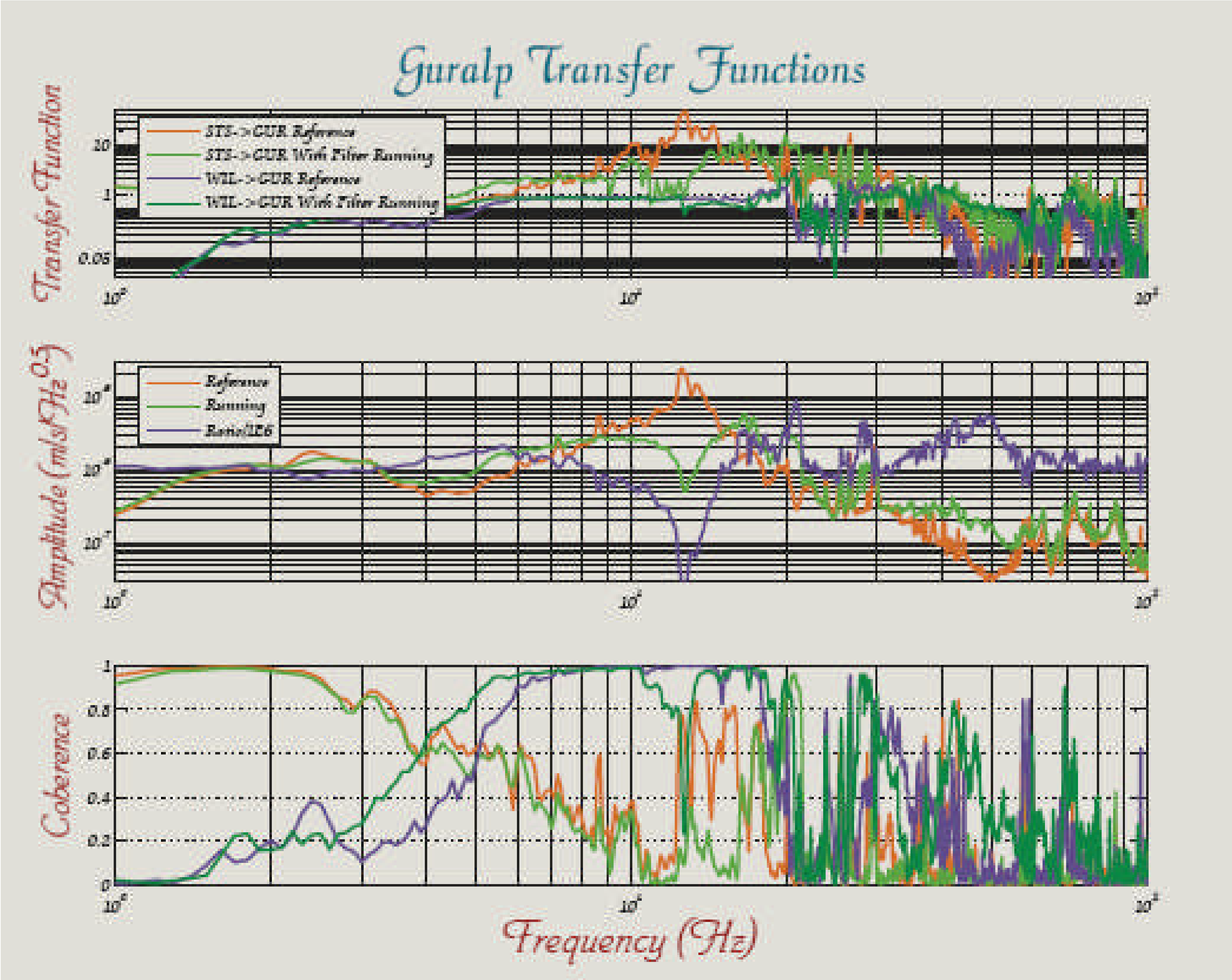
Make an approximation

Initially H = 0

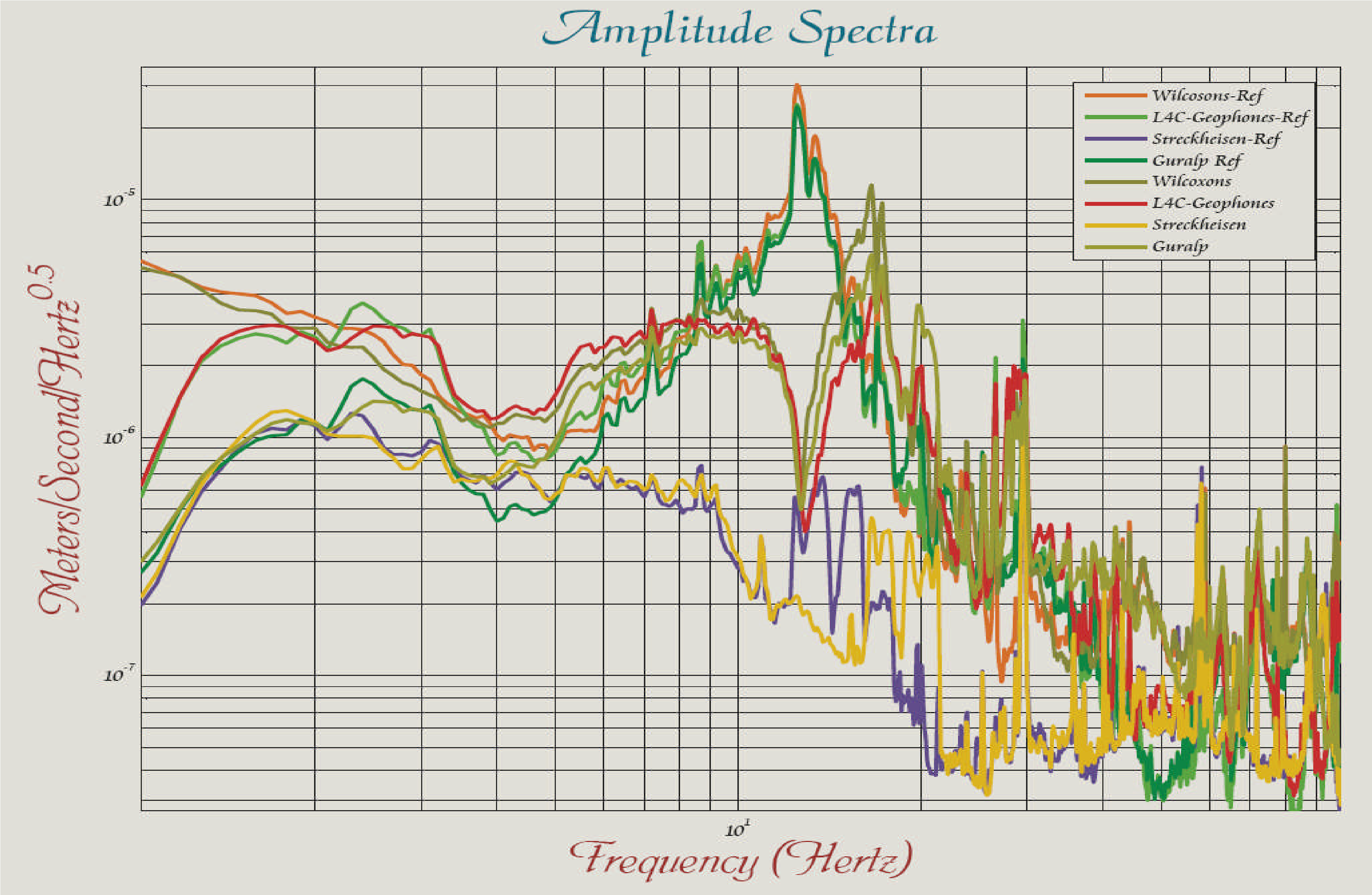
After it has converged H ~= B

So use

$$\Delta = \frac{\delta(\varepsilon)^2}{\delta h_k} = -2P\omega\varepsilon\left[HK - 1\right]$$



Guralp Transfer Functions
Transfer Function
STS->GUR Reference
STS->GUR With Filter Running
WIL->GUR Reference
WIL->GUR With Filter Running
10
1
0.05
Amplitude (m/s²/Hz^0.5)
Reference
Running
Ratio/1E6
Coherence
1
0.8
0.6
0.4
0.2
0
Frequency (Hz)



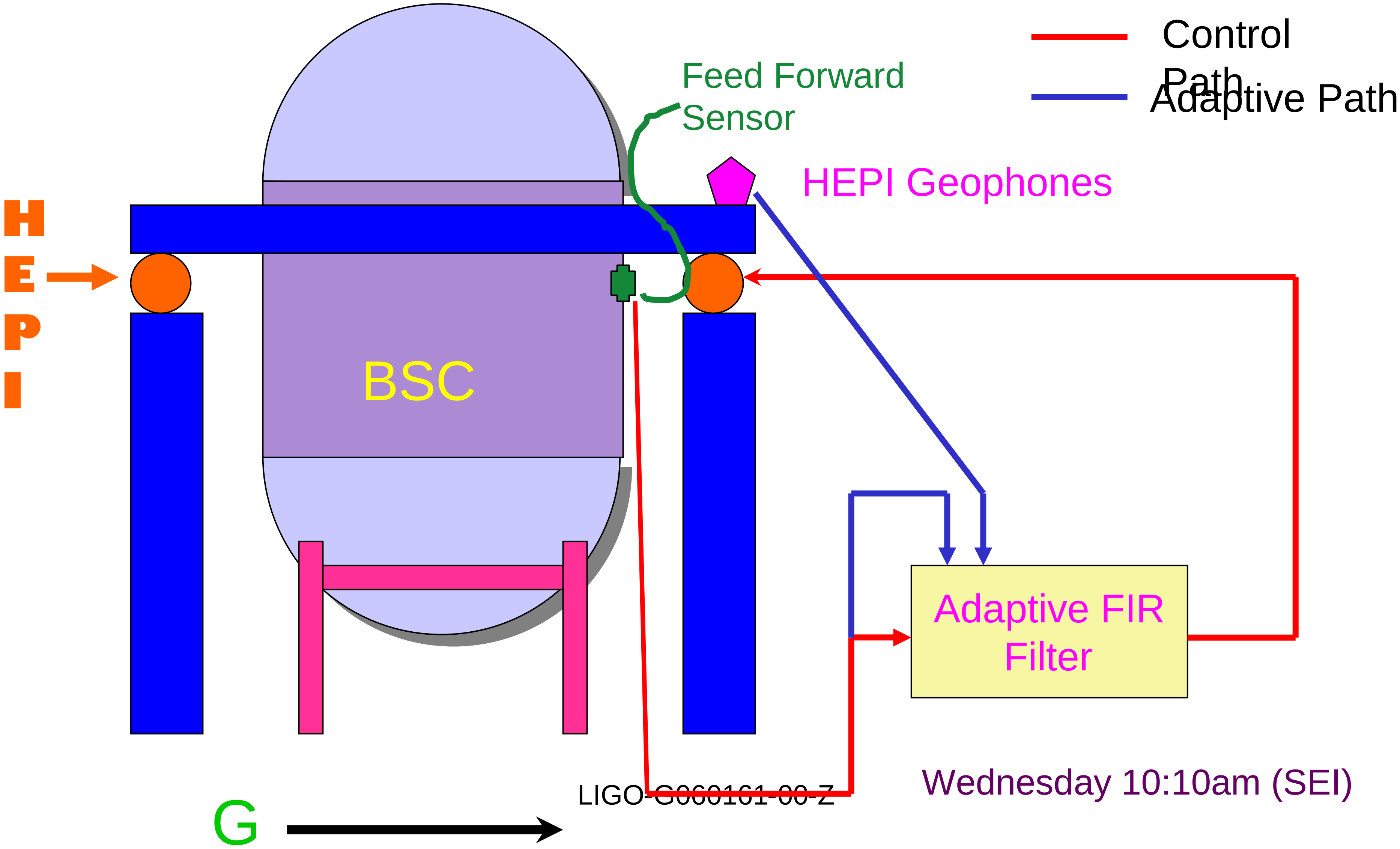
*** SENSOR CORRECTION IS OFF ***

What needs to get Done

- Work more with the Model
- Redo HEPI with 6 DOF and optimized sensor correction
  - (hopefully after the installation of the control Quad pendulum prototype in April)
- Port to LIGO controls
- Other Ideas and wonderful suggestions?

ADAPTIVE FIR FILTERS

(GRADIENT MINIMIZATION)



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Wednesday 10:10am (SEI)