

HF Channel Simulator Update

W.N.Furman / J. W. Nieto

wfurman@harris.com, jnieto@harris.com

Harris Corporation

RF Communications Division

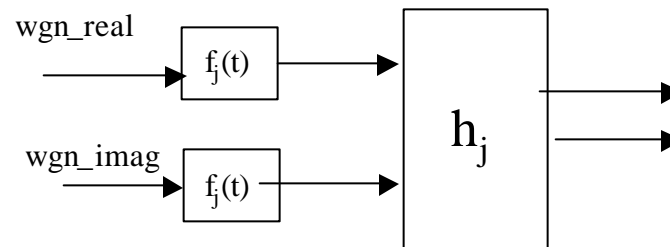
- Project Background
- Block Diagram
- Fading spectrum measurement
 - Improved measurement technique
 - Modem performance variation as a function of Gaussian filter implementation threshold
- HFIA white paper
 - Status / proposal

- Same modem or modems tested with similar channel simulators, both implemented under existing guidelines, can have different results.
- Previous work has shown that existing guidelines do not specify HF channel simulators adequately.
 - HFIA June 2000
 - Nordic HF01
 - HFIA June 2002
 - HFIA January / May 2003
- The HFIA decided to put together a working group to generate a white / position paper on this topic.

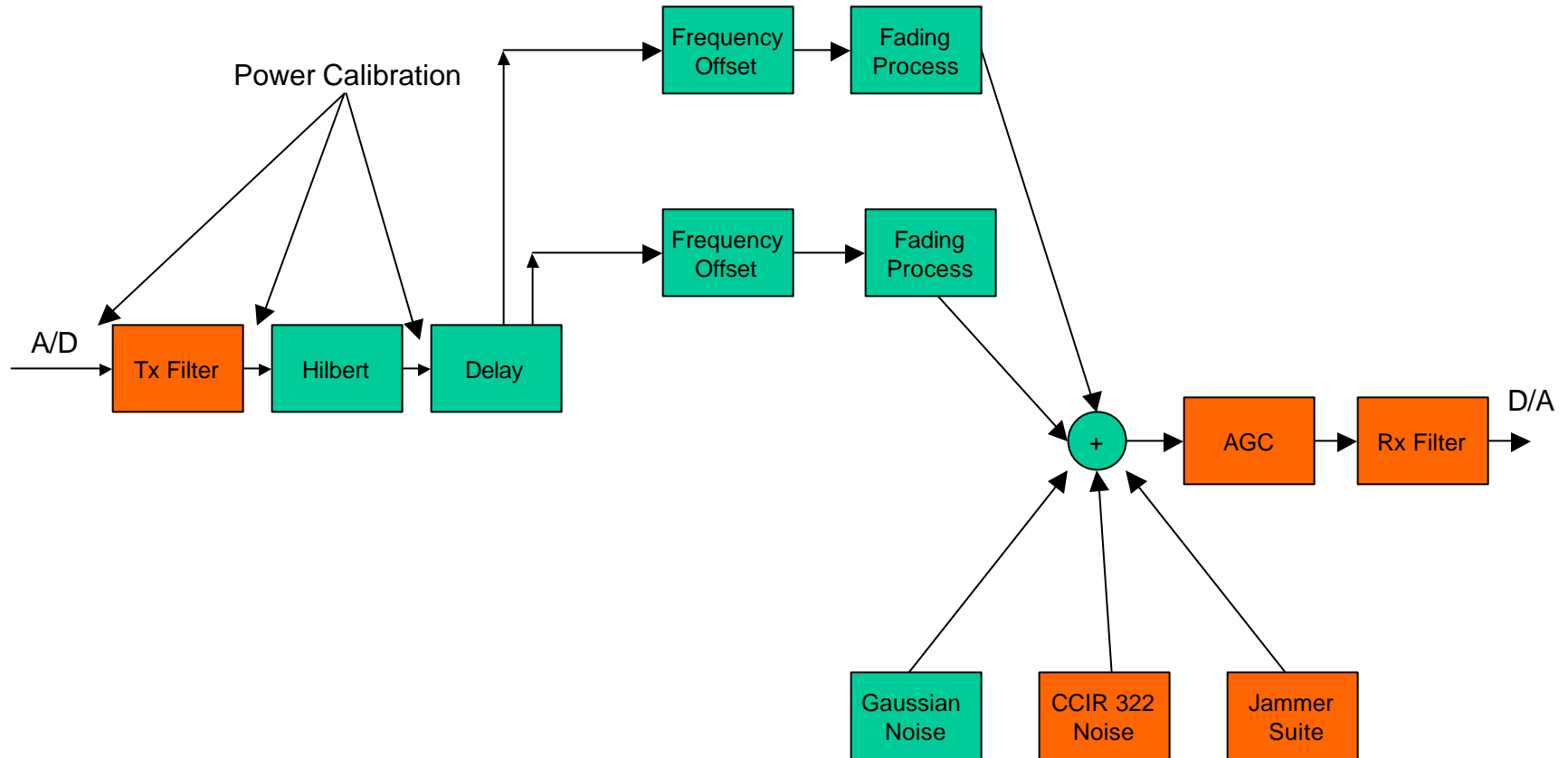
- Watterson Channel Model
 - Model proposed in 1970, experimentally validated.
 - Stationary, wrt. Doppler Spread and SNR, model valid for short durations (10 minutes) and for band-limited channels (10kHz).
 - Models the channel as a transversal filter where the taps are complex and vary with time. Includes the addition of band limited additive White Gaussian Noise.

$$y_i = \sum_{j=0}^{L-1} h_j x_{i-j} + n_i$$

- Generation Of Fading Vector
 - Fading filter taps generated by low pass filtering of independent Gaussian random variables.
 - Magnitude of fading vector will be Rayleigh distributed.
 - Characteristics of this fading vector generation, such as filter shape, interpolation, and update rate are all very important considerations in obtaining repeatable performance measurements.



Channel Simulator Elements



Fading Spectrum Measurement



- Characteristics of this fading vector generation, such as filter shape, interpolation, and update rate are all very important considerations in obtaining repeatable performance measurements.
- The generally accepted criteria is that this spectrum should be Gaussian in shape
- This section documents a method to evaluate the fading spectrum of a channel simulator under test as a “black box”

Fading Spectrum Measurement



- Proposed Measurement Technique
 - Step 1 - Set up HF channel simulator for 1 path with a Doppler spread of X Hz.
 - Step 2 - Pass a 1 KHz tone through the HF channel simulator recording the output with a high quality DAT recorder. (44,100 sps)
 - Recommend 2 hour recording

- Step 3 - Input DAT samples into PC WAV file
 - Recommend using optical or coaxial SPDIF transfer for bit perfect transfer of digital data on DAT tape.
 - Warning not all soundcards with digital inputs give you a bit perfect transfer. We utilize the M-Audio audiophile 2496. It does. <http://www.midiman.net/>
- Step 4 - Convert WAV file from 44,100 sps to 11,025 sps (mono)
- Steps 1-4 result in a high quality digital recording of the output of the channel simulator under test. Be wary of standard sound cards and converters.

Fading Spectrum Measurement

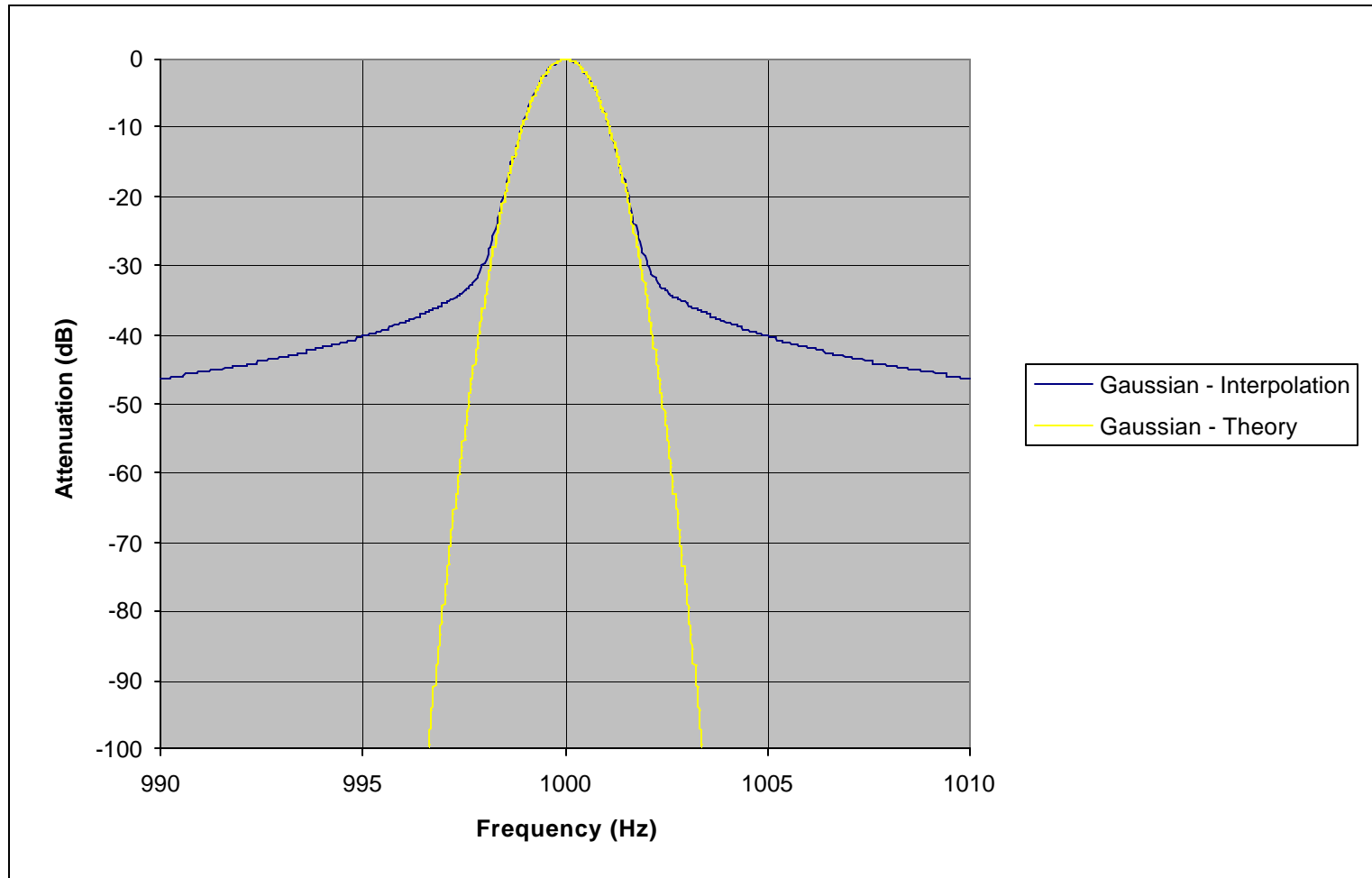


- Step 5 - Process WAV File
 - Window blocks of 131,072 samples with a Kaiser window, alpha = 5.0.
 - Take 131,072 point FFT of this windowed data
 - Take the magnitude-squared of the FFT output
 - Average the magnitude-squared output for all frames
 - Plot spectrum.
- Step 6 - Check resulting spectrum
 - Compare to ideal Gaussian Shape.
 - Close agreement from 0 to -20dB
 - Method described in [2] details how to generate the Gaussian spectrum

Fading Spectrum Measurement



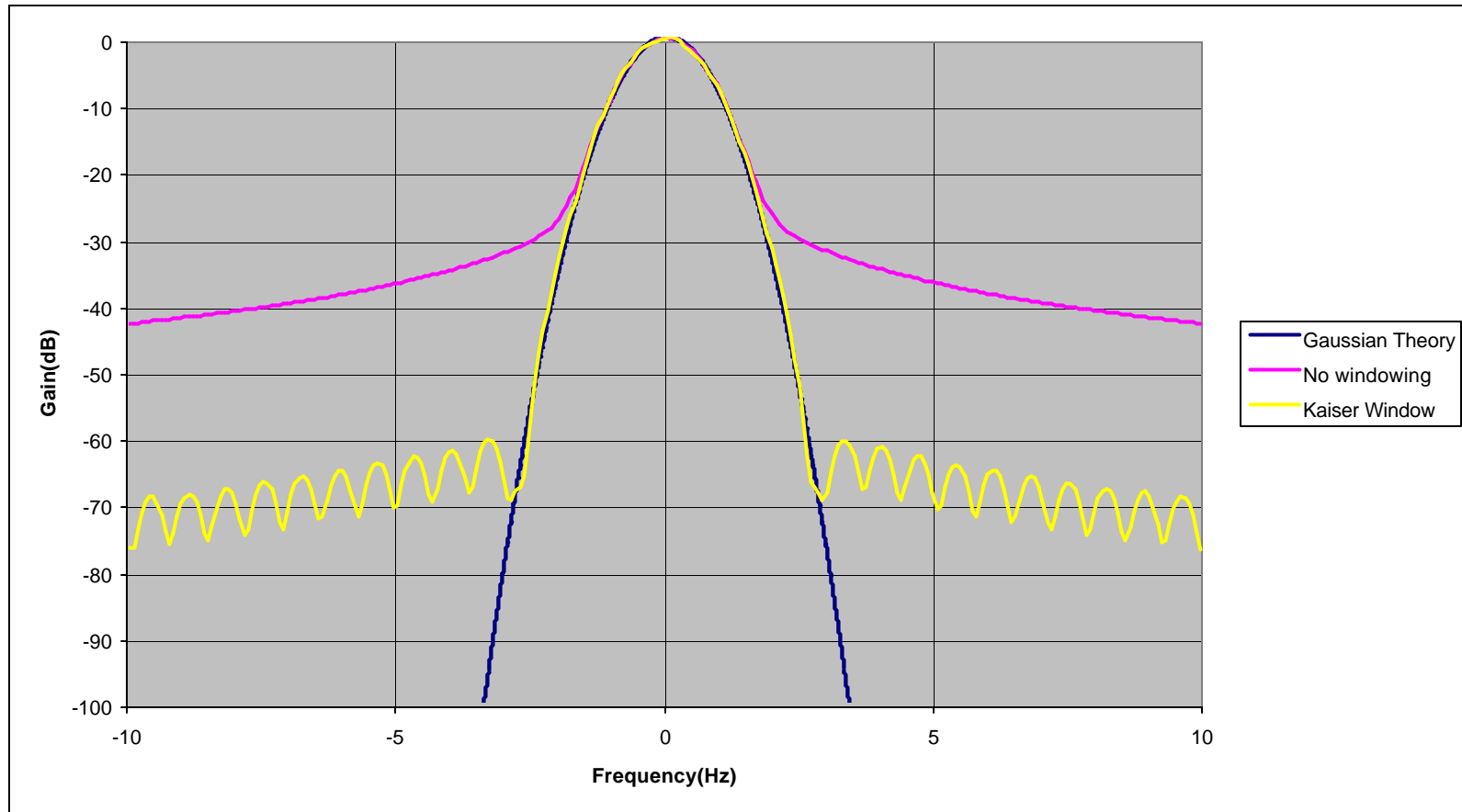
Original plot - no windowing



Fading Spectrum Measurement



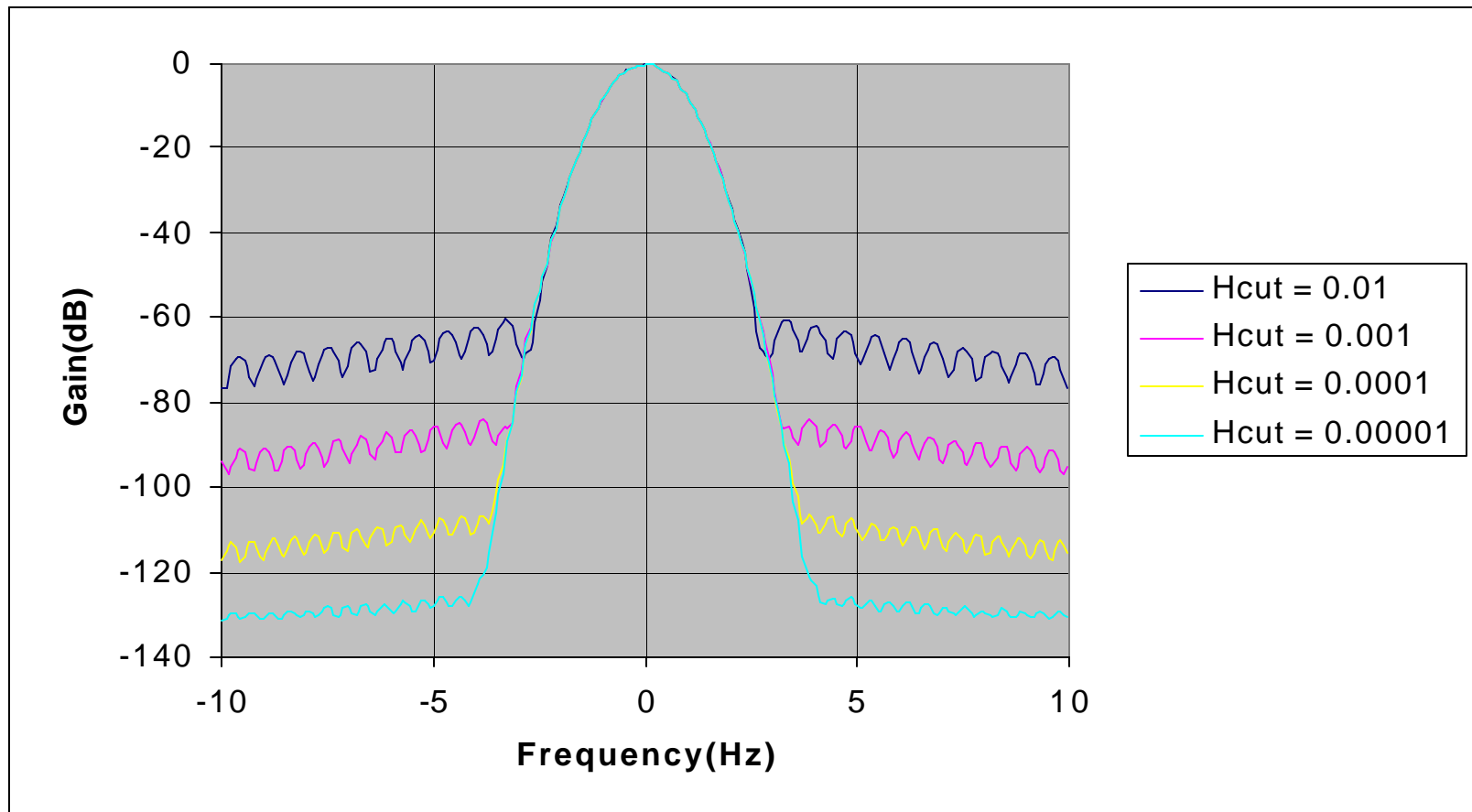
Improved evaluation using Kaiser Window



Fading Spectrum Measurement



Spectrum measurement as a function of threshold



Fading Spectrum Measurement



- Modem performance measurement as a function of threshold / No significant variation 0.01 seems adequate.

Filter Implementation Threshold	CCIR POOR	RICIAN (2Hz)
0.01 53 Taps	$9.7e^{-5}$	$7.0e^{-5}$
0.001 65 Taps	$9.4e^{-5}$	$7.3e^{-5}$
0.0001 75 Taps	$9.7e^{-5}$	$7.2e^{-5}$
0.00001 83 Taps	$9.5e^{-5}$	$7.0e^{-5}$

- Not yet complete
- Nordic HF white-paper has been used by several establishments as a guideline in simulator implementation

- Proposal
 - On the HFIA website, www.hfindustry.org, in the “Current Technical Efforts of the HFIA” place an HF channel simulator link
 - In this link include access to:
 - Nordic HF paper (approval required from NordicHF, perhaps achieved through a link to their site)
 - Table highlighting the “core” requirements
 - A 1.0 and 10.0 Hz WAV file, a downloadable exe file which performs the Gaussian Spectrum analysis