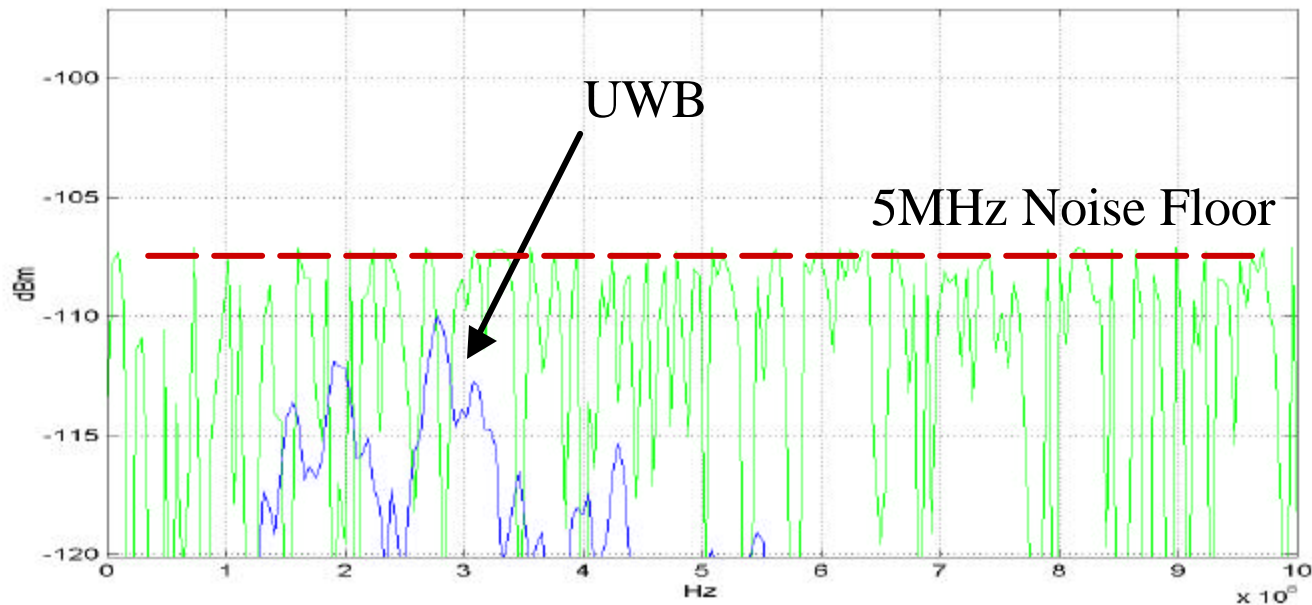


Idea: “Imperceptible” UWB

“Polite” Co-existence with Licensed Operators:

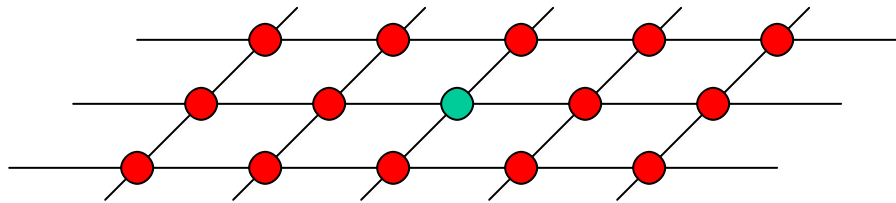
Aggregate Interference from UWB Transmissions is “Undetectable” (or Has Minimal Impact) to Narrow-Band Receivers, I.e. Power Spectral Density is at Narrow-Band Thermal Noise Floor or Below.



UWB Interference vs. Density

What is maximum allowed transmit power?

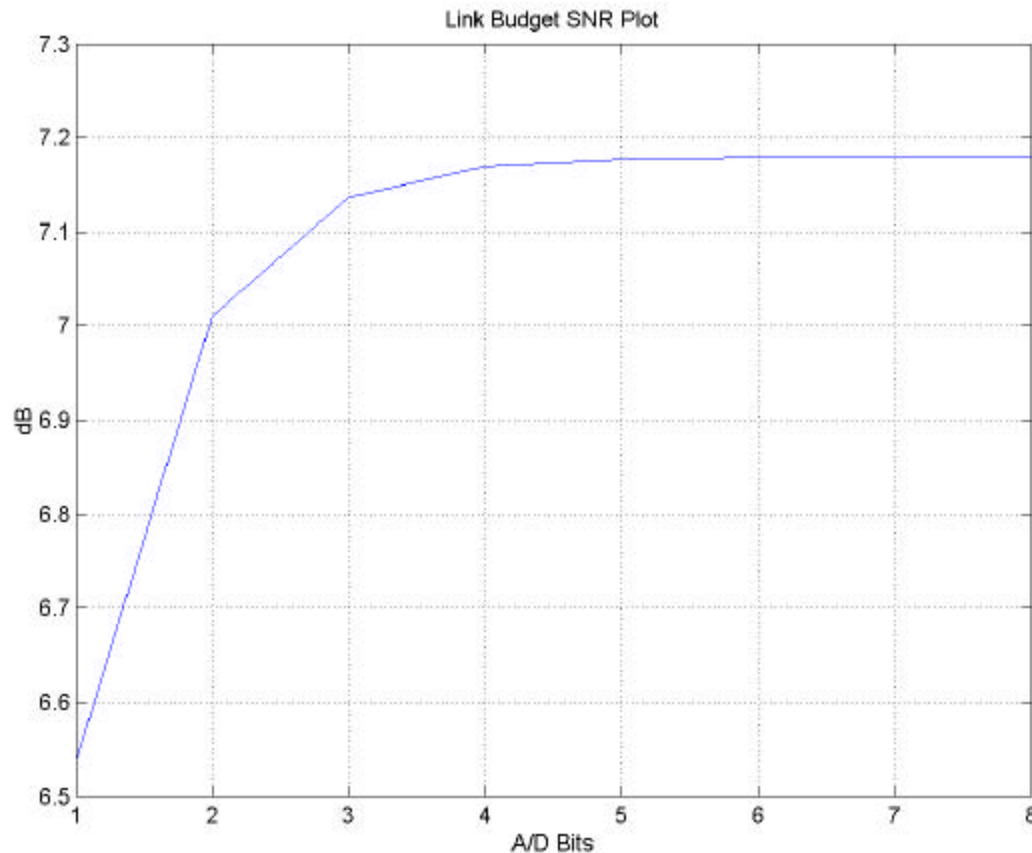
- Assume Worst-Case Jamming: Infinite 2-D Grid of UWB Aggressors Broadcasting Power= P_T Narrowband Victim at Center



- Assume Path Loss Model: $P_R = P_T(1m/d)^n$
Indoor channel measurements suggest $n \sim 2$ ($d < 10m$), $n \sim 3$ ($d > 10m$)
- Calculate Aggregate Interference from UWB Transmitters:
At 1m Grid Spacing, $P_{RX} \sim 11.5P_T$
At 3m Grid Spacing, $P_{RX} \sim 0.6P_T$

Chose P_T s.t. P_{RX} is At or Below Thermal Noise Floor

Link Budget: SNR vs. A/D Bits



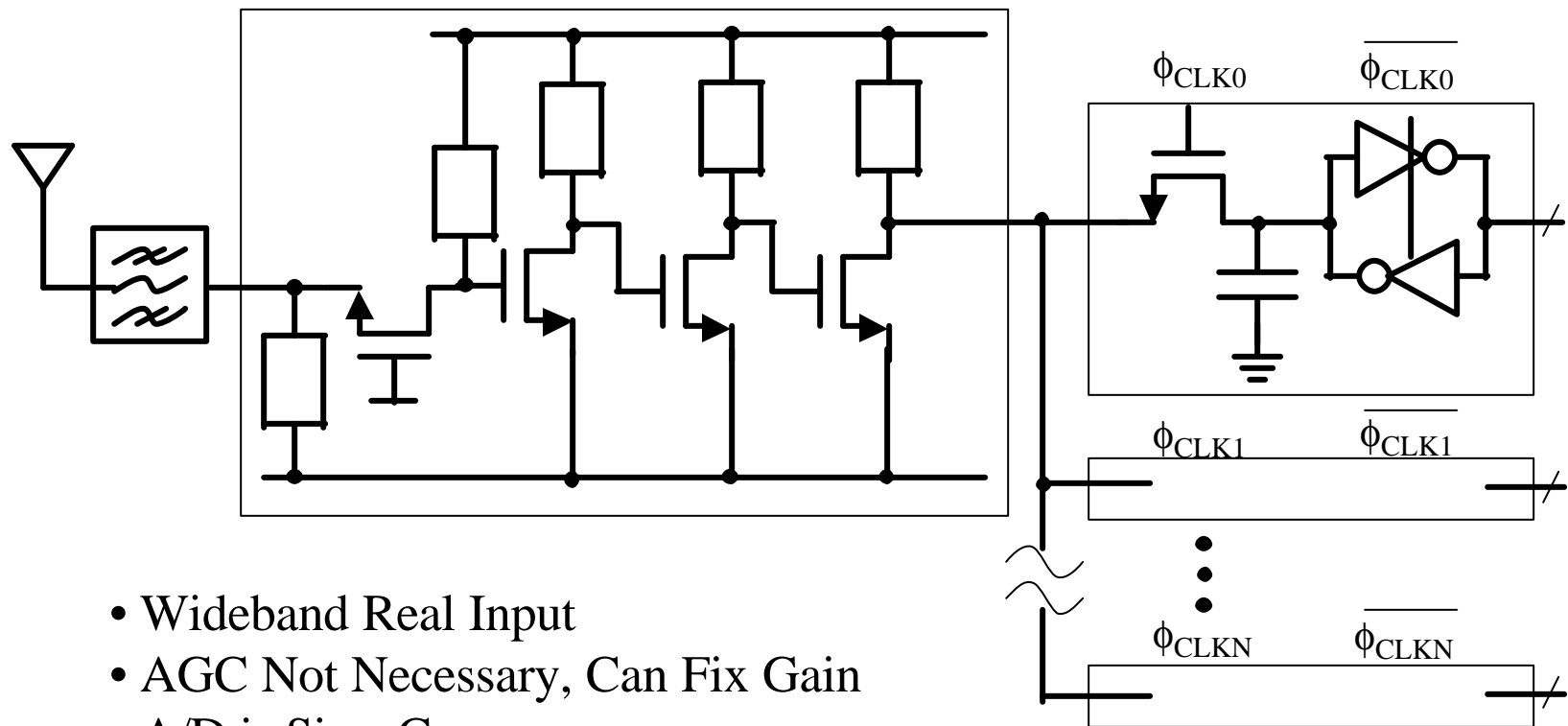
Per Pulse SNR:

- Pulse is Gaussian Derivative (1ns Edge Rate)
- Channel: 3m, 2-wall ray-traced impulse response
- NF = 10dB
- Pulse Rep = 5MHz
- Pulse PSD = Noise Floor

1-bit A/D is Adequate in Noise-Limited Case

1-bit Front-End Architecture

Conceptual Half-Circuit of Analog Front-End



- Wideband Real Input
- AGC Not Necessary, Can Fix Gain
- A/D is Sign-Compare
- Very Low Power Consumption

1-bit A/D Implications

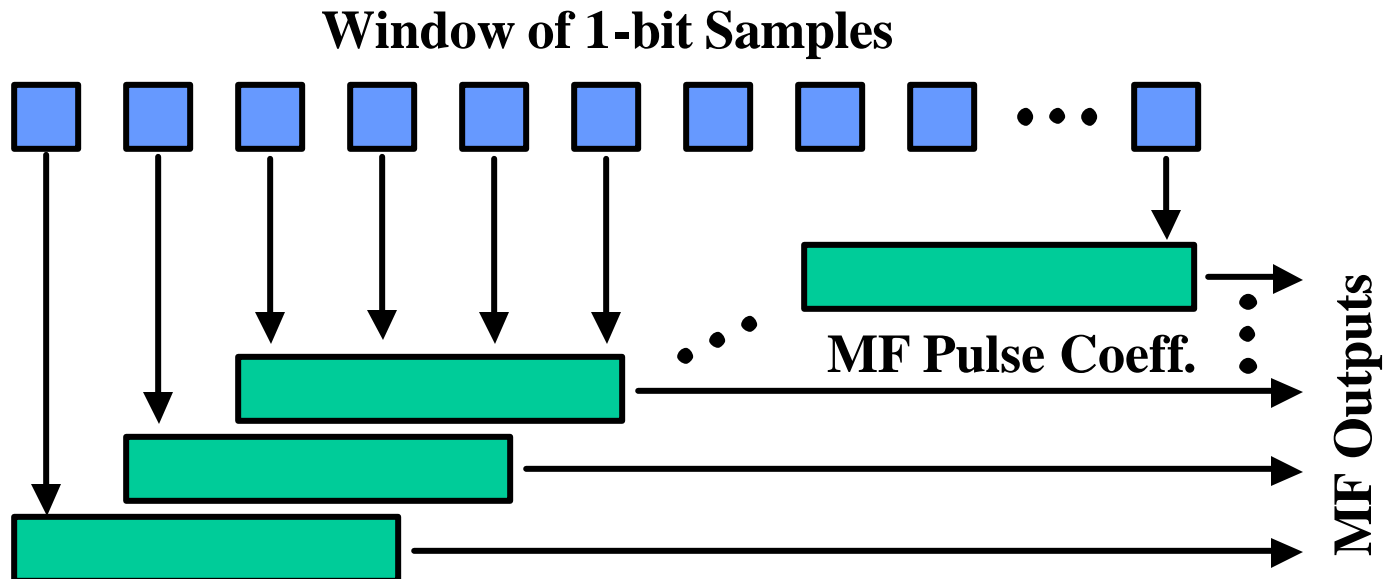
A/D Circuit Considerations:

- Tracking Bandwidth of Switch = 1GHz
- Static Sources of Error:
 - Process Variation
 - Circuit/Layout Mismatch
- Dynamic Sources of Error:
 - Clock Feed-through
 - Channel Charge Injection
 - Thermal Noise (kT/C)

Create Design Limits:

Min. C_{sample} Size, Min. Device Sizes, Min. Front-end Gain

Back-End Digital Correlator

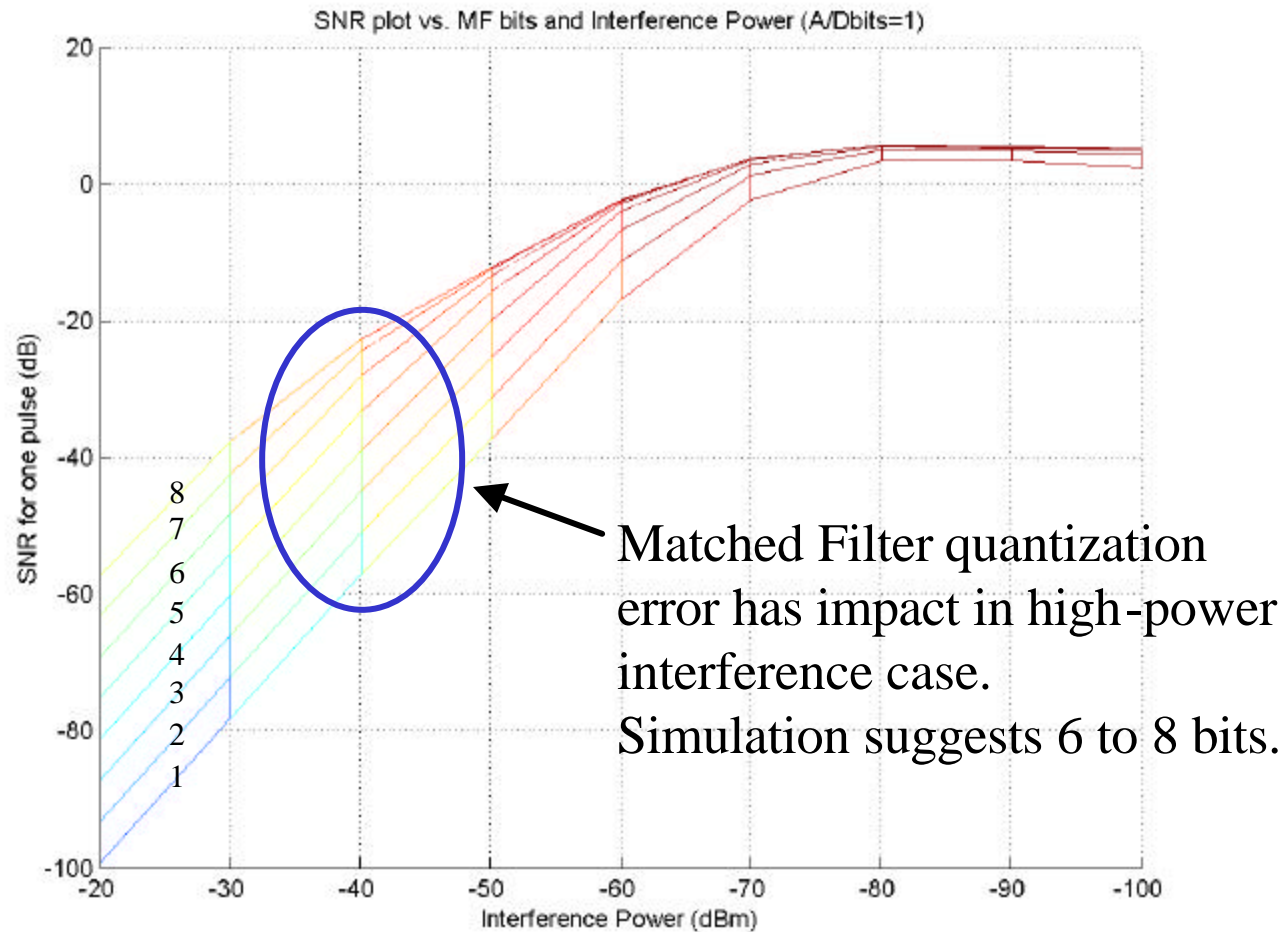


Window Size: As Large As Clocking Will Allow (for Faster Acquisition)

Pulse Length: Determine From Channel Delay Spread

Matched Filter Coefficient Quantization: Determine From Simulation

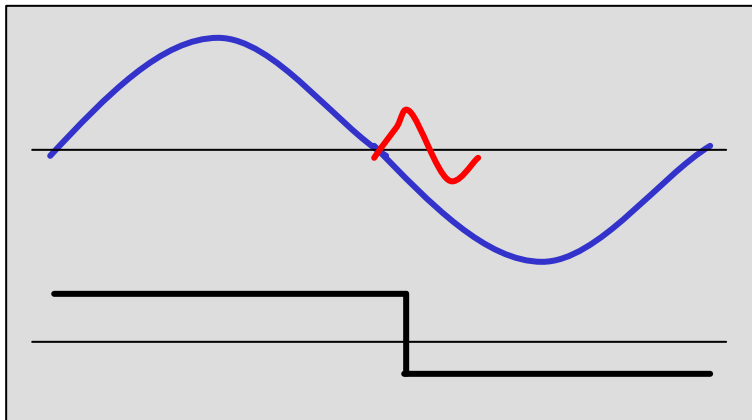
SNR vs. Interference vs. MF bits



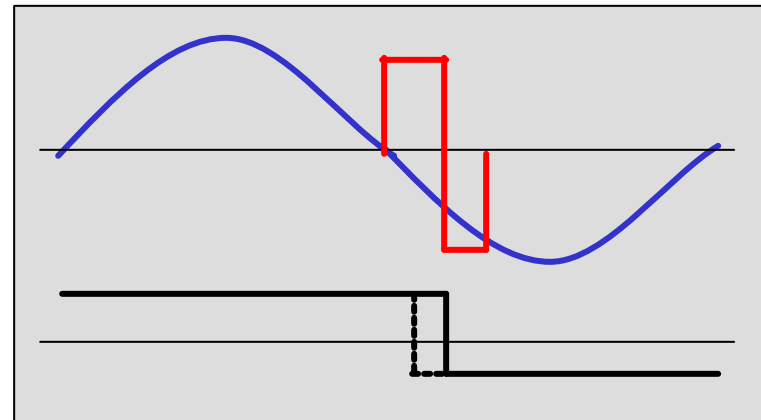
Why Need More Bits in MF?

If the Pulse Amplitude is Larger than the Interferer, a Simple Sign-Compare is Adequate; However, as Interference Power Increases, the Quantization Error in the Matched Filter Coefficients Limits the Ability to Accurately Recognize the Pulse Shape.

Ex: Large Interfering Sinusoid (Narrowband) Interferer



Full Precision Coefficients



1-bit Coeff. Misestimates Transition

MF Coeff. Quantization Limitations

How Well Do We Know the Pulse Shape?

Received Pulse Shape Changes with:

- Antenna Arrival Angle: Elevation and Azimuth
- Blocking and Multipath Contributions
- Distance (Near vs. Far Fields)
- Transmitter Variation (I.e. Edge-Rate Changes, Jitter)

How Well Do We Need to Know the Pulse Shape?

For Acquisition:

Pulse Shape Has to be “Roughly” Similar to What is Expected – This Limits the Practical Usefulness of More Finely Quantized Coefficients

Afterwards We Can Adapt:

But More Bits is Only Better if Have Large Interferers

Practical Limit May Be 6-bits or Less...