ECE 233 Project Presentation – Spring 2020

Subsampling Architecture for Ultra-Wideband (UWB)

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System Model and Problem Statement

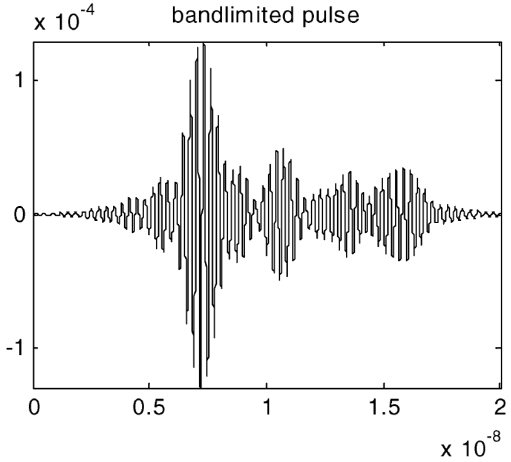
Objective: Exploit wideband nature of UWB signal

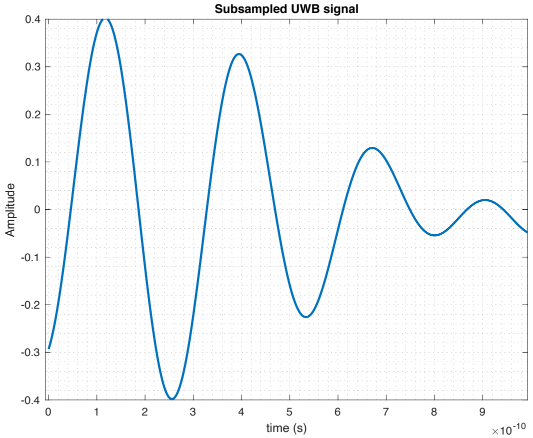
Low Power → Low Complexity → Less Costly → Less sensitive to timing offsets → Sufficient ADC throughput

Subsampling Analytic UWB Architecture

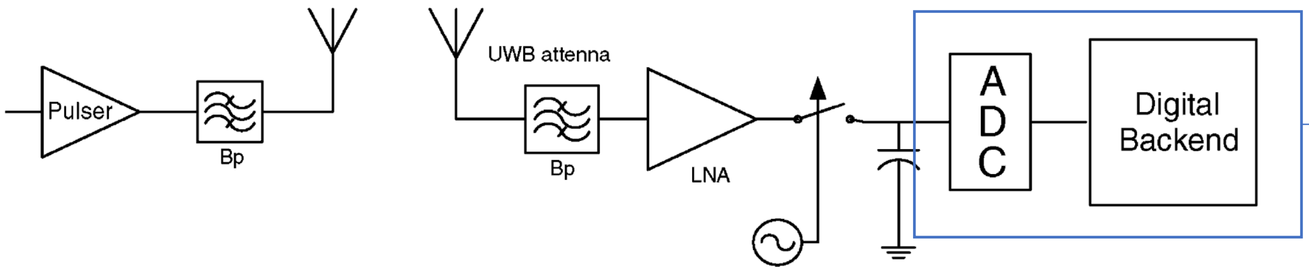
$$s_{TX}(t) = \sqrt{\frac{E_s}{2N_f}} \sum_{j=-\infty}^{\infty} d_j[w_{tx}(t - jT_f - c_jT_c) + b_{\lfloor j/N_f \rfloor} w_{tx}(t - jT_f - c_jT_c - T_d)] \approx \sqrt{\frac{E_s}{2N_f}} \sum_{j=-\infty}^{\infty} d_j\, b_{\lfloor j/N_f \rfloor} w_{tx}(t - jT_f)$$

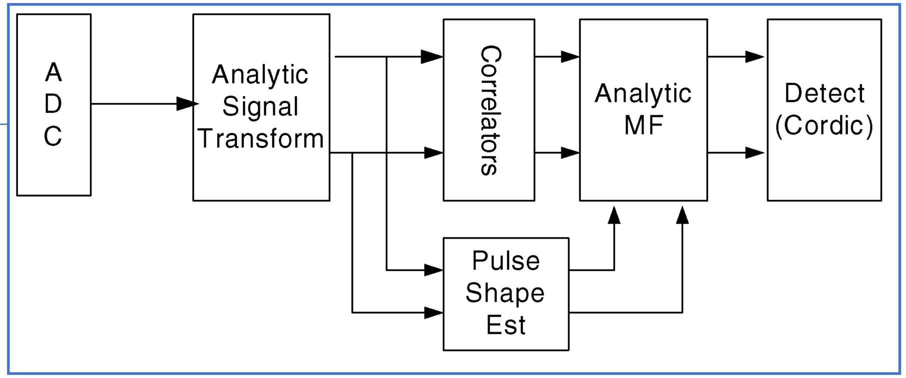
N_f = number of frames per symbol = 10
E_s = signal energy = assumed to be unit energy
d_j = pseudo-random sequence pf +1 and -1, mean 0 (useful for pulse shaping)
w_{tx} = unit energy transmit waveform (gaussian modulated RF pulse), B = 1 GHz, f_c = 3.5 GHz
$b_{\lfloor j/N_f \rfloor}$ = BPSK information signal
T_f = frame duration = T_s / N_f , where T_s is the symbol duration
Channel used: IEEE CM-1 (Residential LOS)





Receiver Architecture and Techniques



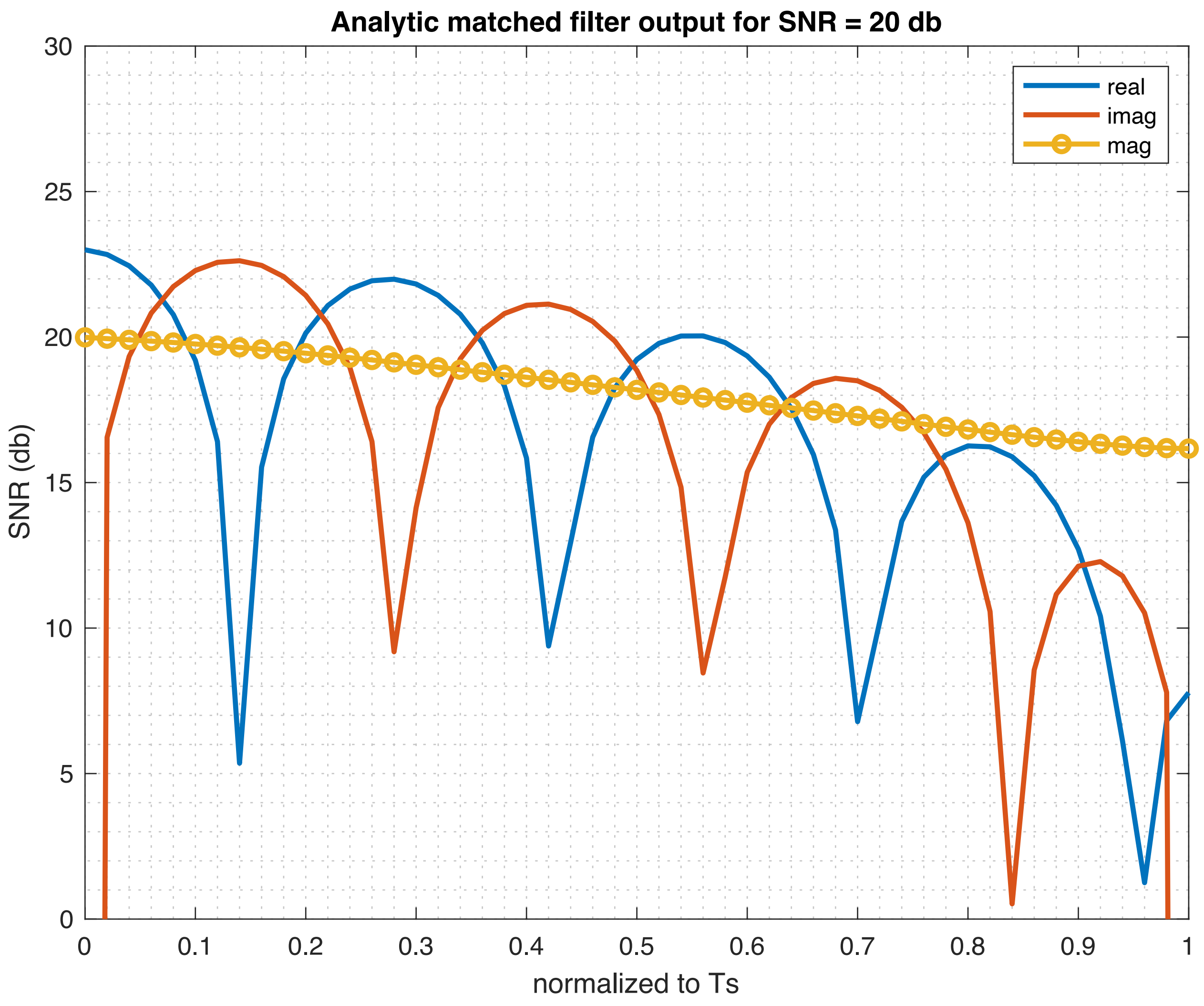


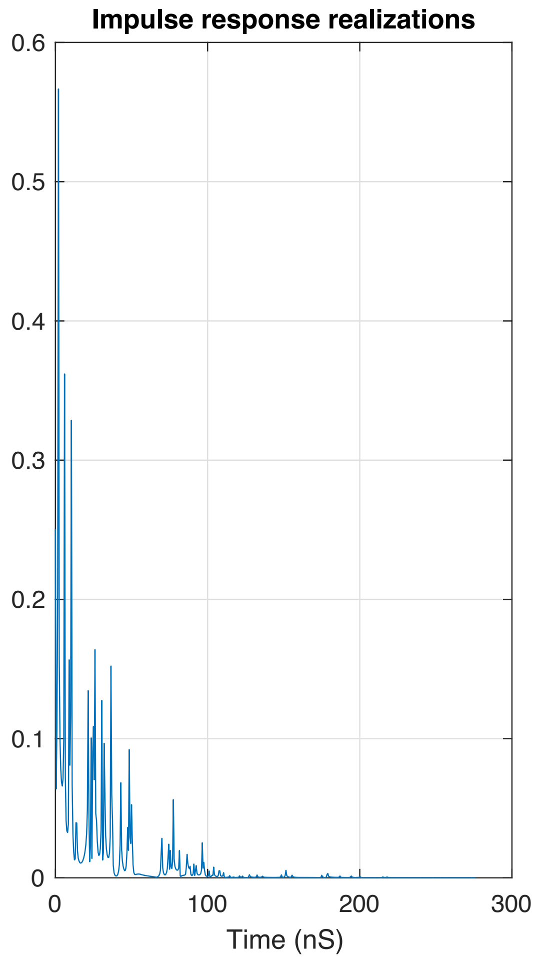
- **ADC** samples at twice the bandwidth instead of maximum frequency
  - Maintains high bandwidth till sampling circuitry
  - More resistant to aliasing / folding
  - Overall system performance degradation due to small sampling capacitance is negligible (quantization noise dominates thermal noise)

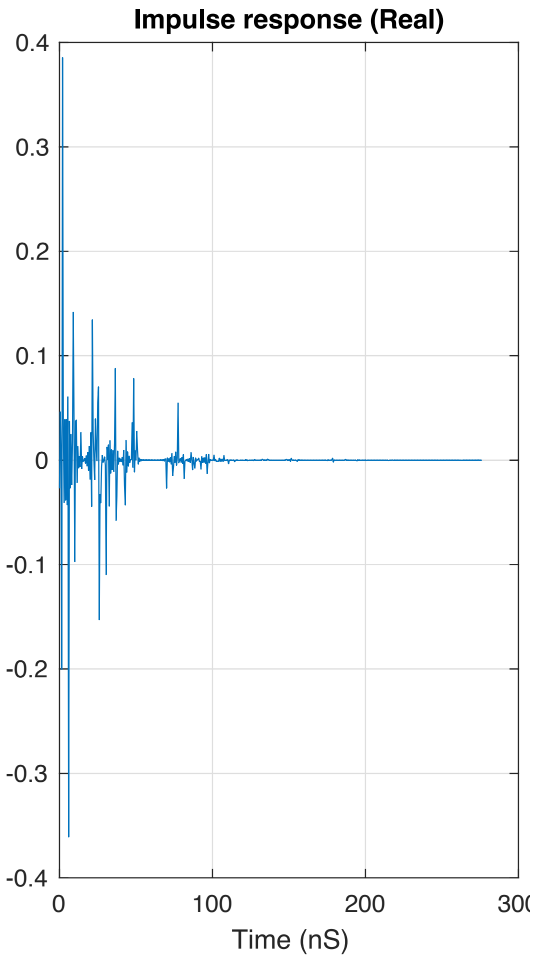
- **Analytic signal transform**: 21-tap Hilbert transform for signal analysis in appropriate domain (lower SNR degradation than differentiator)
- **Correlators:** De-spreading of modulated code and gain
- **Pulse shape estimator**: Uses maximum likelihood (running average) over a PN sequence (within coherence time) for optimal detection
- **Analytic matched filter:** "Signal detector" in presence of AWGN
- **Detector:** Decode data or timing information (assumption: ISI mitigated with complex equalizer)

1. $\mathbf{m_r + jm_i = \langle y_r, h_r \rangle + \langle y_i, h_i \rangle + j(-\langle y_r, h_i \rangle + \langle y_i, h_r \rangle)}$
2. $\langle x, y \rangle = \int_a^b x(t) \cdot y(T-t)dt \qquad T = b - a$
3. $h(t) = s_r^*(T-t) + s_i^*(T-t),$ $\qquad \boxed{\tilde{s} = H(s(t))}$
4. $y(t) = F^{-1}(F(\tilde{s} \cdot \boxed{e^{-jk\frac{2\pi}{T_s}T_0}})) + N(t)$

Preliminary Results







Future Work

Explore BER vs SNR plot

Couple channel model with the system

Complete project report

THANK YOU