Sub-Nyquist Acquisition Hardware for Wideband Communication

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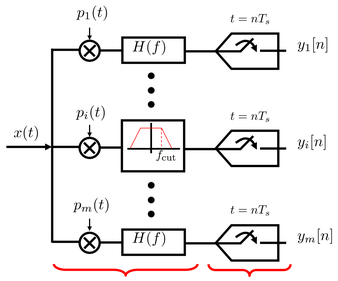
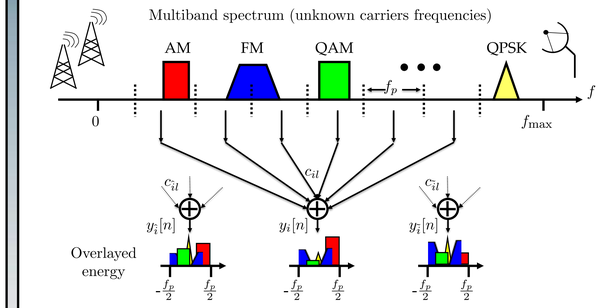
Theory

Modulated Wideband Converter



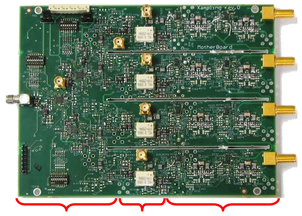
How does this work?



Spectrum of low rate samples $y_i[n]$, $i = 1, \ldots, m$

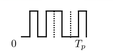
Hardware Prototype

2 GHz Wideband Receiver / 280 MHz Sampling rate



Split/Amp. Mixer Filter

$p_i(t) =$

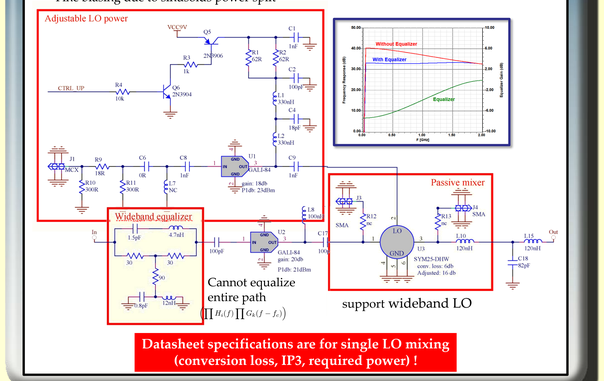


2.2 GHz Shift-Reg. (ECL Tech.)

Off-the-shelf devices, total price ~5k$, standard PCB production

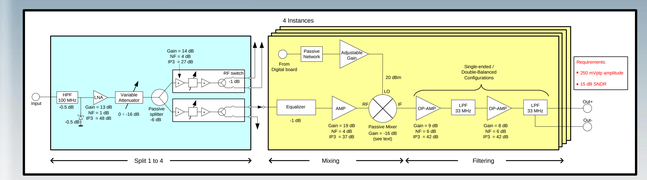
Mixing with Periodic Waveforms

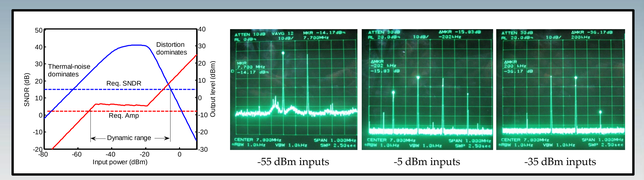
Fine biasing due to sinusoids power split



Datasheet specifications are for single LO mixing (conversion loss, IP3, required power) !

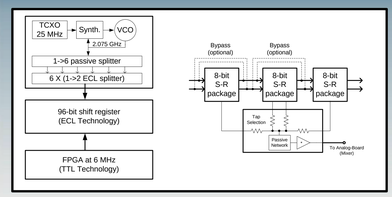
Analog Design

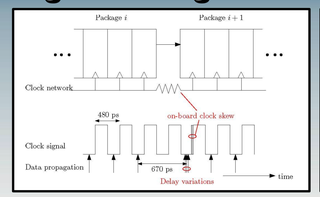


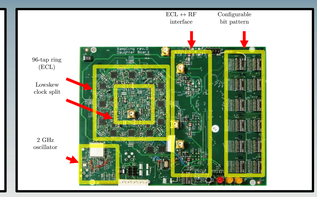


-55 dBm inputs -5 dBm inputs -35 dBm inputs

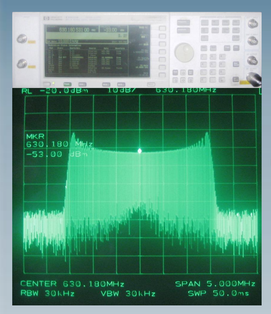
Digital Design



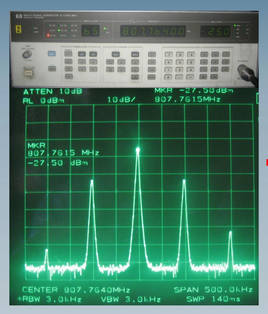




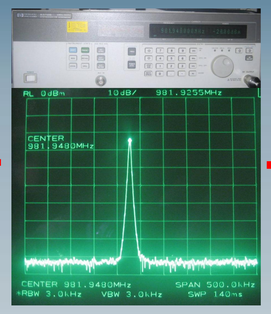
Sub-Nyquist Reconstruction



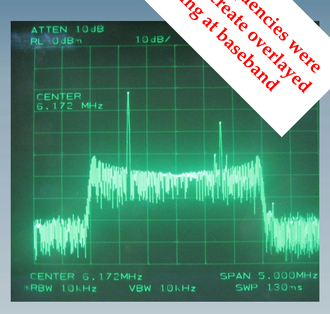
FM @ 631.2 MHz



AM @ 807.8 MHz



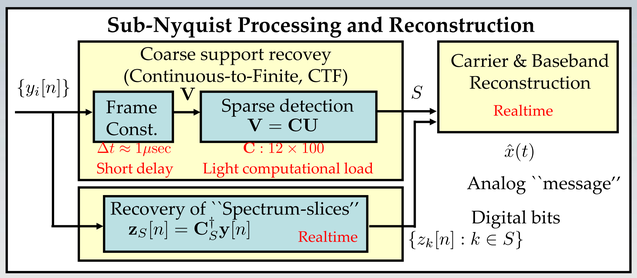
Sine @ 981.9 MHz

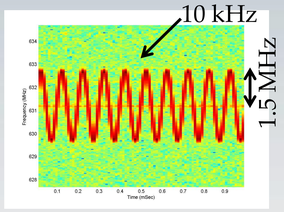


Carrier frequencies were chosen to create overlayed aliasing at baseband

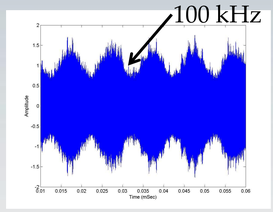
Overlayed **sub-Nyquist** aliasing around 6.171 MHz

Sub-Nyquist Processing and Reconstruction



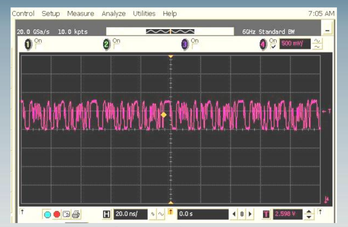


FM @ 631.2 MHz

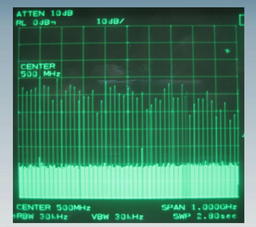


AM @ 807.8 MHz

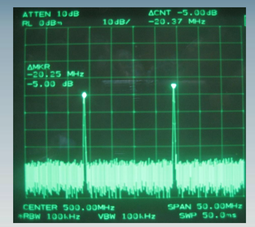
Periodic Waveforms in Practice



Time-domain Appearance
± 1 alternating at 2 GHz



Frequency-domain Appearance
Uniformly-spaced weighted Dirac comb



$\frac{f_{\text{NYQ}}}{108} = 20.37$ MHz

More Information

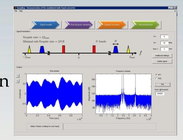
[1] M. Mishali and Y. C. Eldar, "From theory to practice: Sub-Nyquist sampling of sparse wideband analog signals," *IEEE J. Sel. Topics Signal Process.*, vol. 4, no. 2, Apr. 2010.

[2] M. Mishali, Y. C. Eldar and A. Elron, "Xampling: Signal Acquisition and Processing in Union of Subspaces," CCIT Report no. 747, EE Dept., Technion; *arXiv.org 0911.0519*, Oct. 2009.

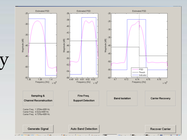
[3] M. Mishali, Y. C. Eldar, O. Dounaevsky and E. Shoshan, "Xampling: Analog to digital at sub-Nyquist rates," to appear in *IET Journal of Circuits, Devices and Systems*; [Online] *arXiv 0912.2495*.

Online demonstrations: **http://webee.technion.ac.il/Sites/People/YoninaEldar/**
http://www.technion.ac.il/~moshiko/

Sub-Nyquist Sampling & Reconstruction (GUI)



Carrier Recovery (GUI)



Lab experiments (Video)

and more…