Technion
Electrical Engineering
Department

High Speed Digital Systems Lab
Electrical Engineering Department
HS DSL

NATIONAL INSTRUMENTS™

ISCAS 2011

Sub-Nyquist Acquisition Hardware for Wideband Communication

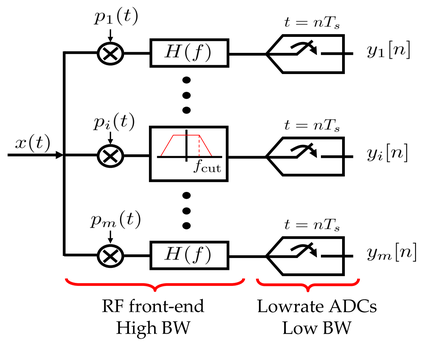
Moshe Mishali, Yonina C. Eldar, Rolf Hilgendorf, Ina Rivkin and Eli Shoshan

yonina@ee.technion.ac.il, rhilgen@ee.technion.ac.il

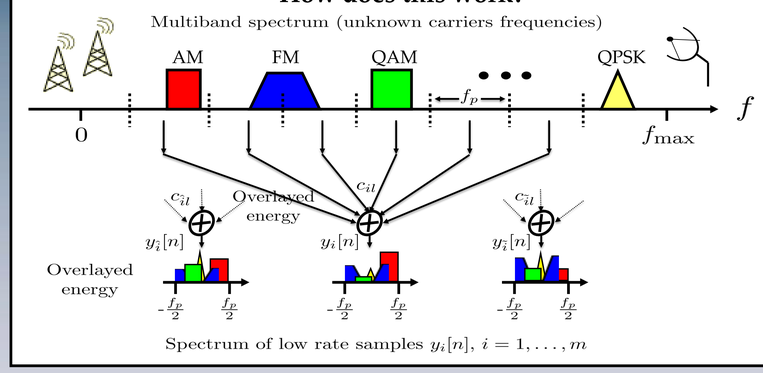
Department of Electrical Engineering, Technion – Israel Institute of Technology

Theory

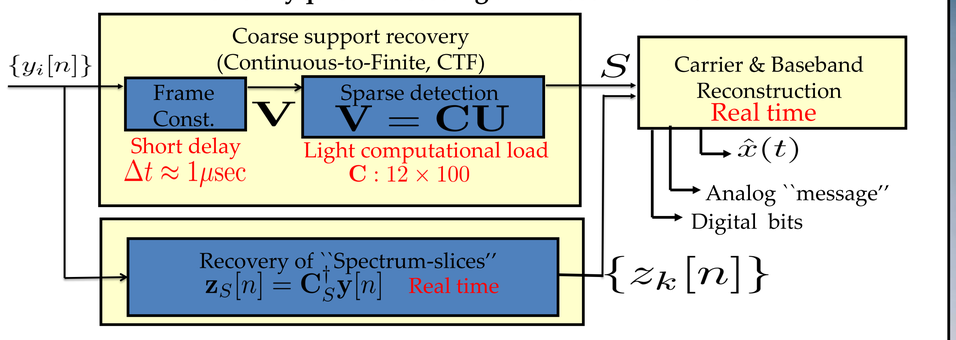
Modulated Wideband Converter



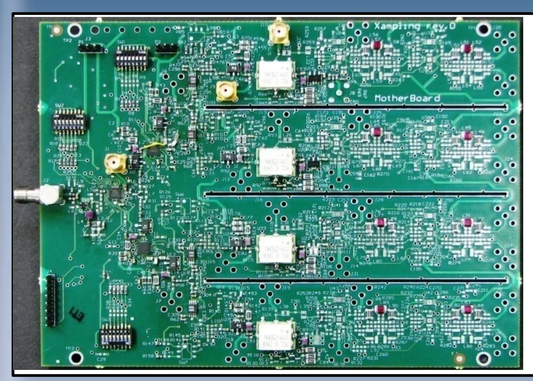
How does this work?

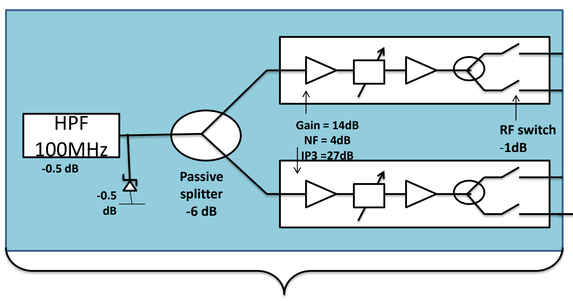


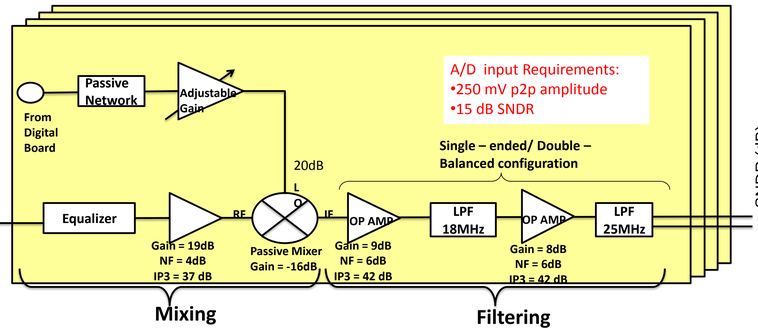
Sub-Nyquist Processing and Reconstruction

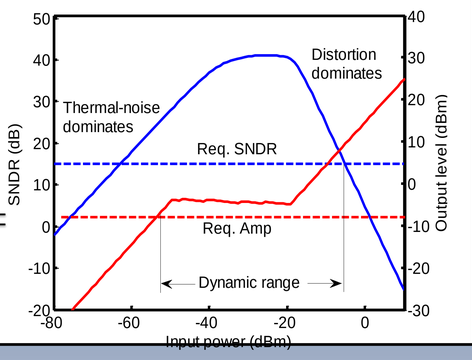


MWC – Modulated Wideband Converter
Analog Design

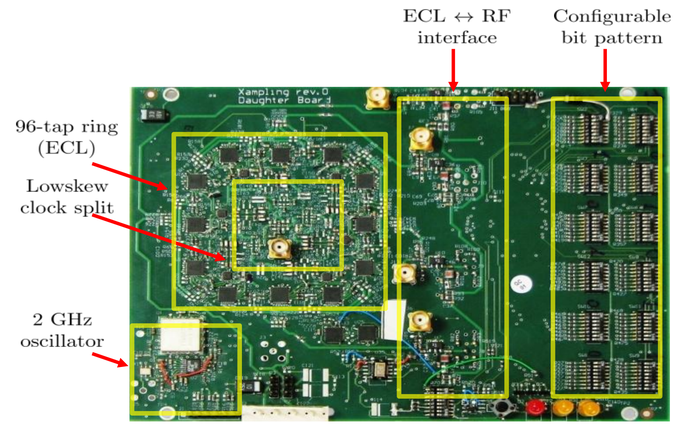


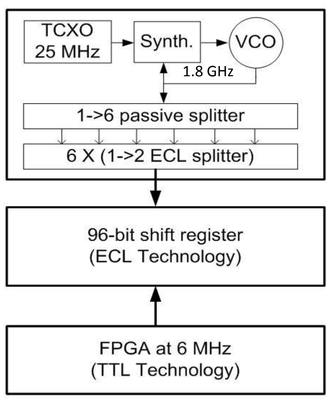


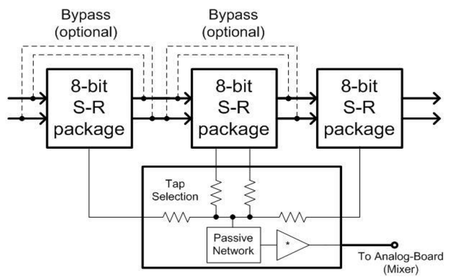


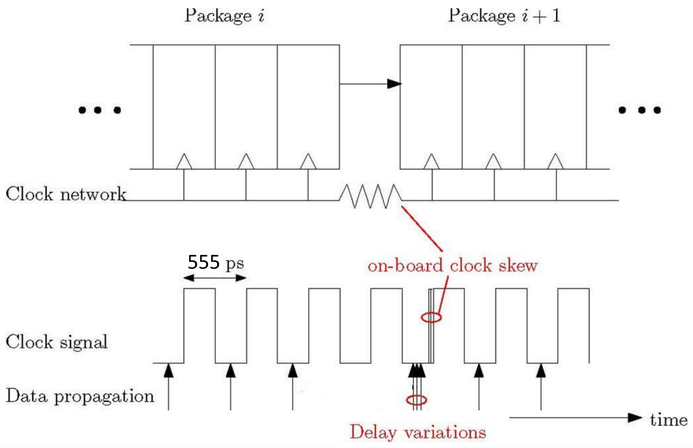


Digital Design

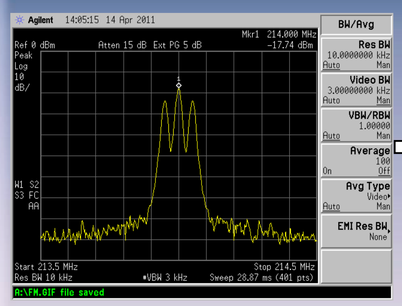






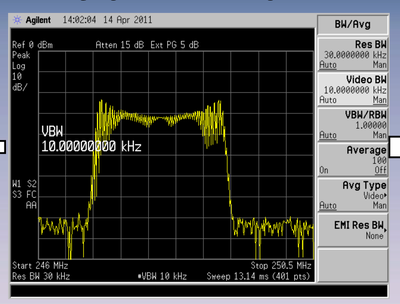


Sub Nyquist Pre processing

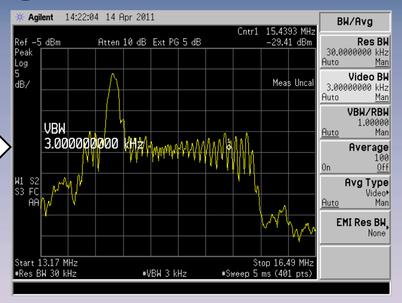


AM @ f=214MHz

+

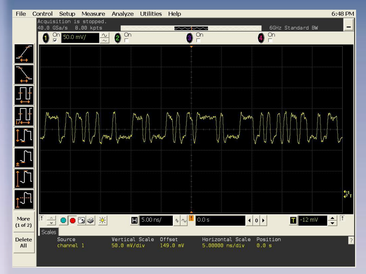


FM @ f=248MHz

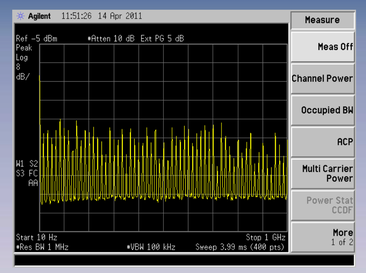


Output of MWC – combined signal @ basebend 0-25MHz

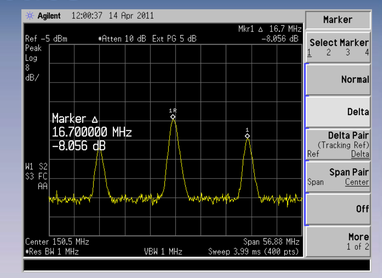
Periodic Waveforms in Practice



Time- domain Appearance
± 1 alternating @ 1.8 GHz



Frequency – domain Appearance
Uniformly spaced weighted Dirac comb



Frequency – domain Appearance
Uniformly spaced Dirac every 16.7MHz

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Sub-Nyquist Reconstruction System for Wideband Communication

Summary

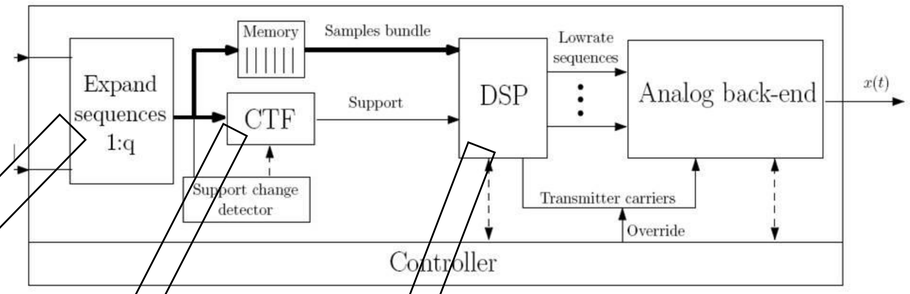
- We demonstrate the MWC which samples multiband signals with unknown carriers at sub-Nyquist rates
- The ADC converter acquires signals with bandwidth **1.8** GHz at a sampling rate of only **60** MHz per channel
- The reconstruction algorithm reconstructs the signal at baseband using NI's Flex Rio programmed in LabView

A Reconstruction System Based On NI Flex Rio and LabView

High-level architecture

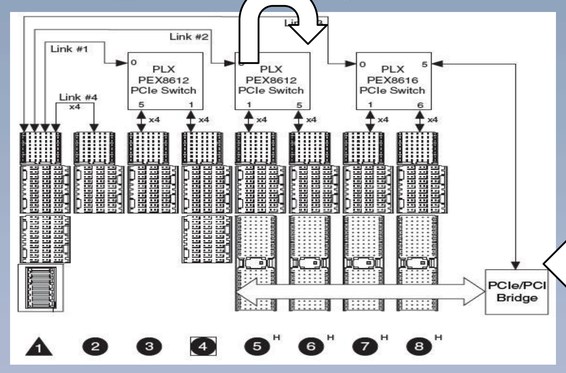
Main functions:

- **Expand:** Decode 4 input streams to 12 channels, by frequency slicing
- **CTF:** Recover spectrum support (at f_p resolution)
- **DSP:** Recover the contents of each active spectrum slices

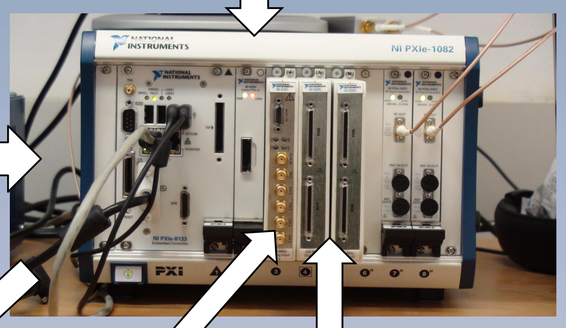


NI Flex Rio

P2P
@ 800MB/sec



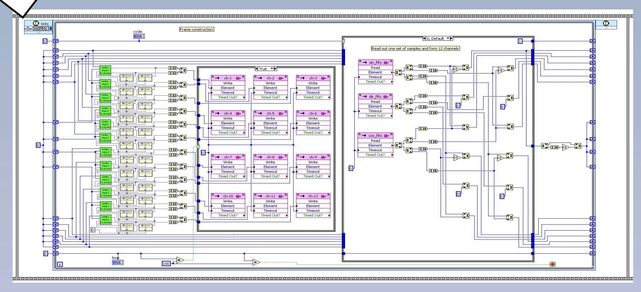
NI chassis back plain



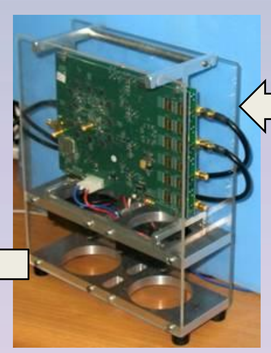
Implementation in

VHDL

LabVIEW Certified Developer



MWC
Xampler

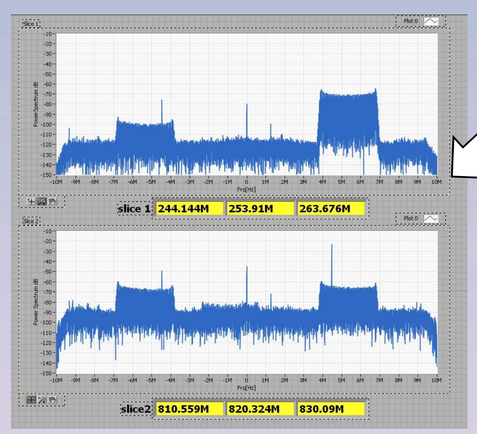


Original signal

$x(t)$

LVDS @
800MB/sec

Digitizer
fs=62.5 MHz



Reconstructed signal

More Information

[1] http://webee.technion.ac.il/Sites/People/YoninaEldar

[2] M. Mishali, Y. C. Eldar, O. Dounaevsky and E. Shoshan, "Xampling: Analog to digital at sub-Nyquist rates," I*ET Journal of Circuits, Devices and Systems*, vol. 5, no. 1, pp. 8–20, Jan. 2011.