Ultra Wide Band Technology

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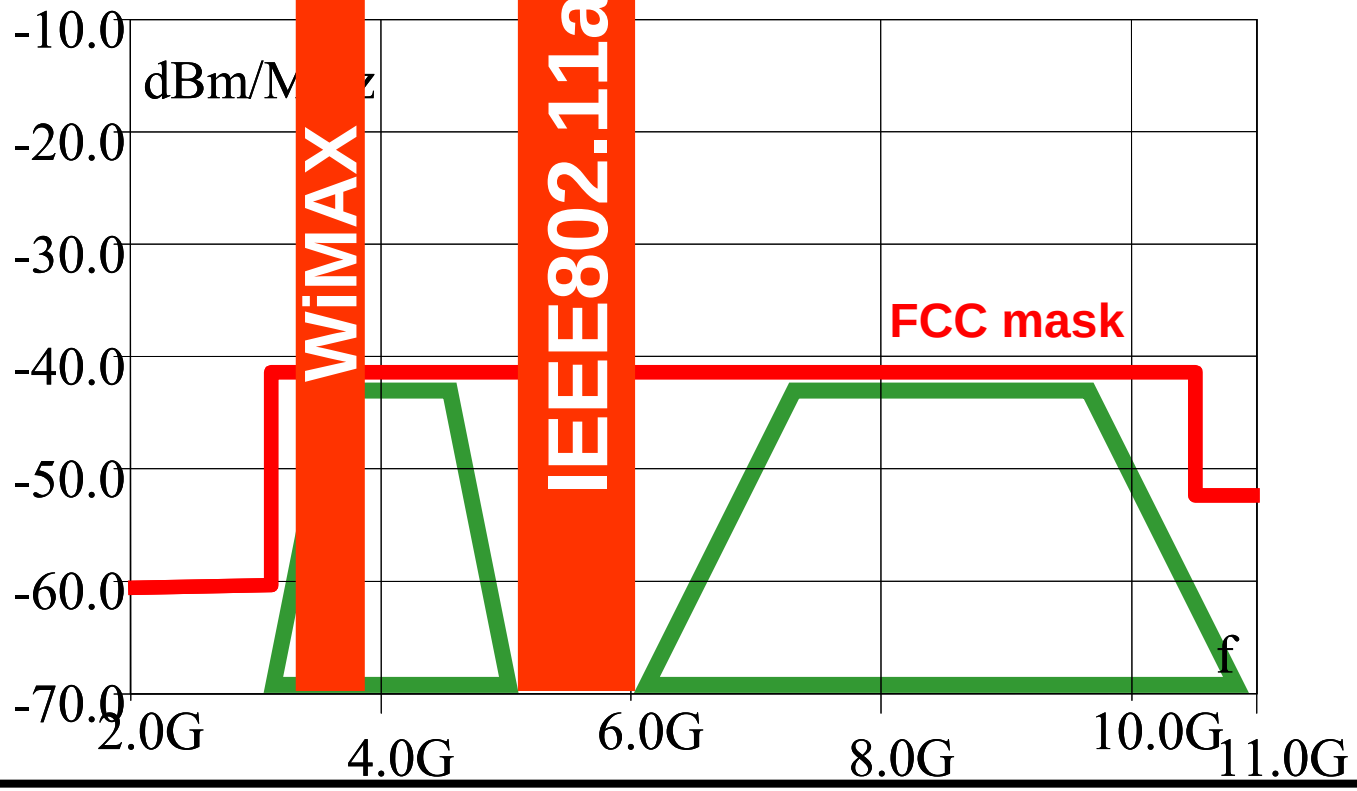
Federal Communication Commission (FCC)

- **FCC opened spectrum from 3.1GHz – 10.6GHz**
  - **Handheld missi mask : -41.3dBm/MHz**
  - **Minimum hanne ndwidth 500MHz**

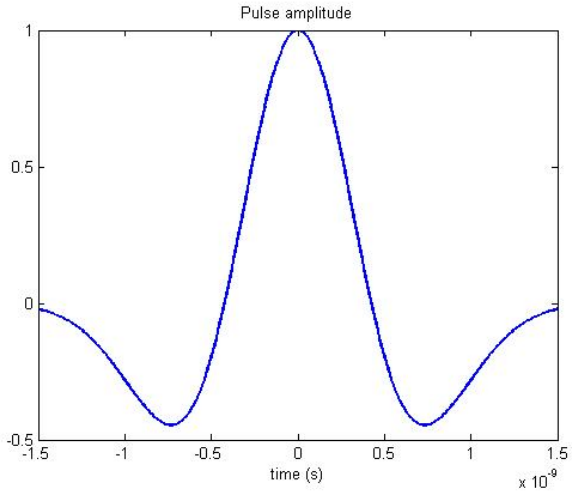


UWB communication proposals

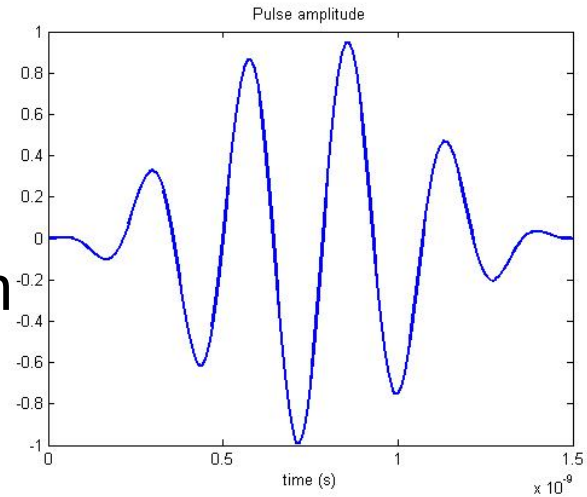
- **Time Hopped UWB (probably IEEE802.15.4a)**
  - **First proposals**
  - **Old concept (radar)**
  - **Impulse Radio (IR-UWB)**
  - ***Low/moderate data rate***
- **DS-CDMA UWB (IEEE802.15.3a)**
  - ***High data rate***
  - **UWB Forum supporting DS-UWB**
- **Multi-Band OFDM UWB (IEEE802.15.3a, ECMA-368)**
  - ***High data rate***
  - **MBOA (MBO Alliance)**

Impulse radio UWB (IR-UWB)

- Carrier-less
  - Dedicated pulse generator
  - Short Gaussian-shaped time pulse
  - Low pulse repetition



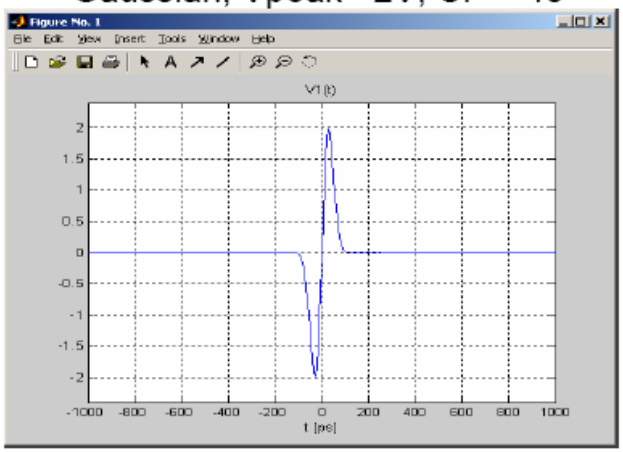
- Carrier-based
  - Quenched oscillators
  - Quench time: frequency bandwidth
  - Oscillation: carrier frequency

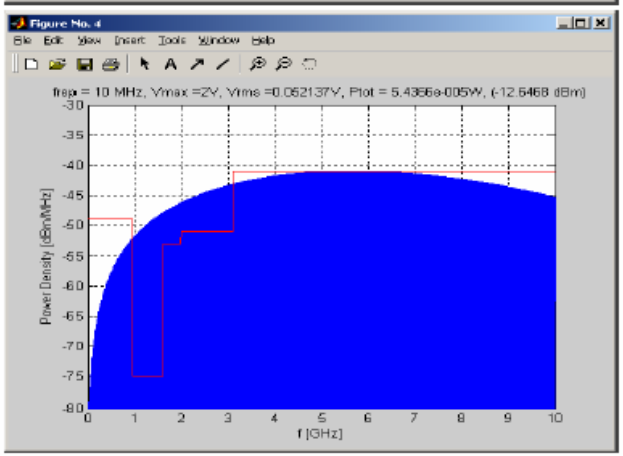


IR-UWB: pulse choice

Carrier-less

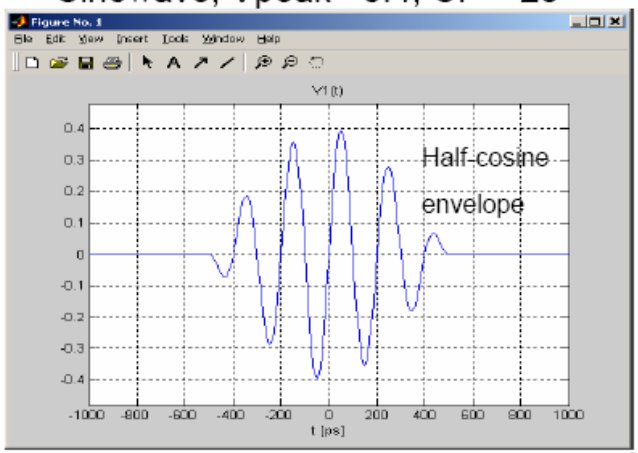
Gaussian, Vpeak =2V, CF = 40

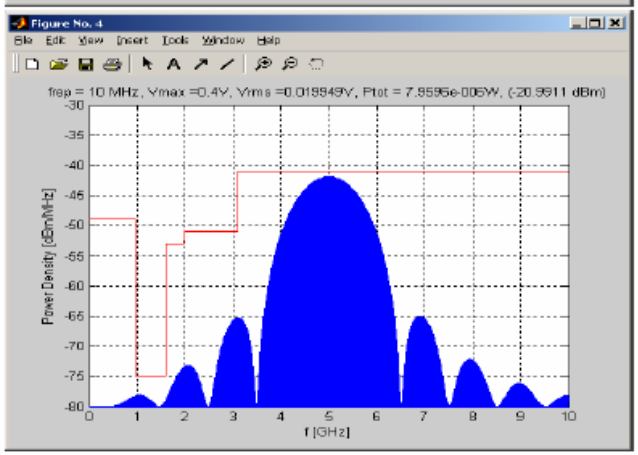




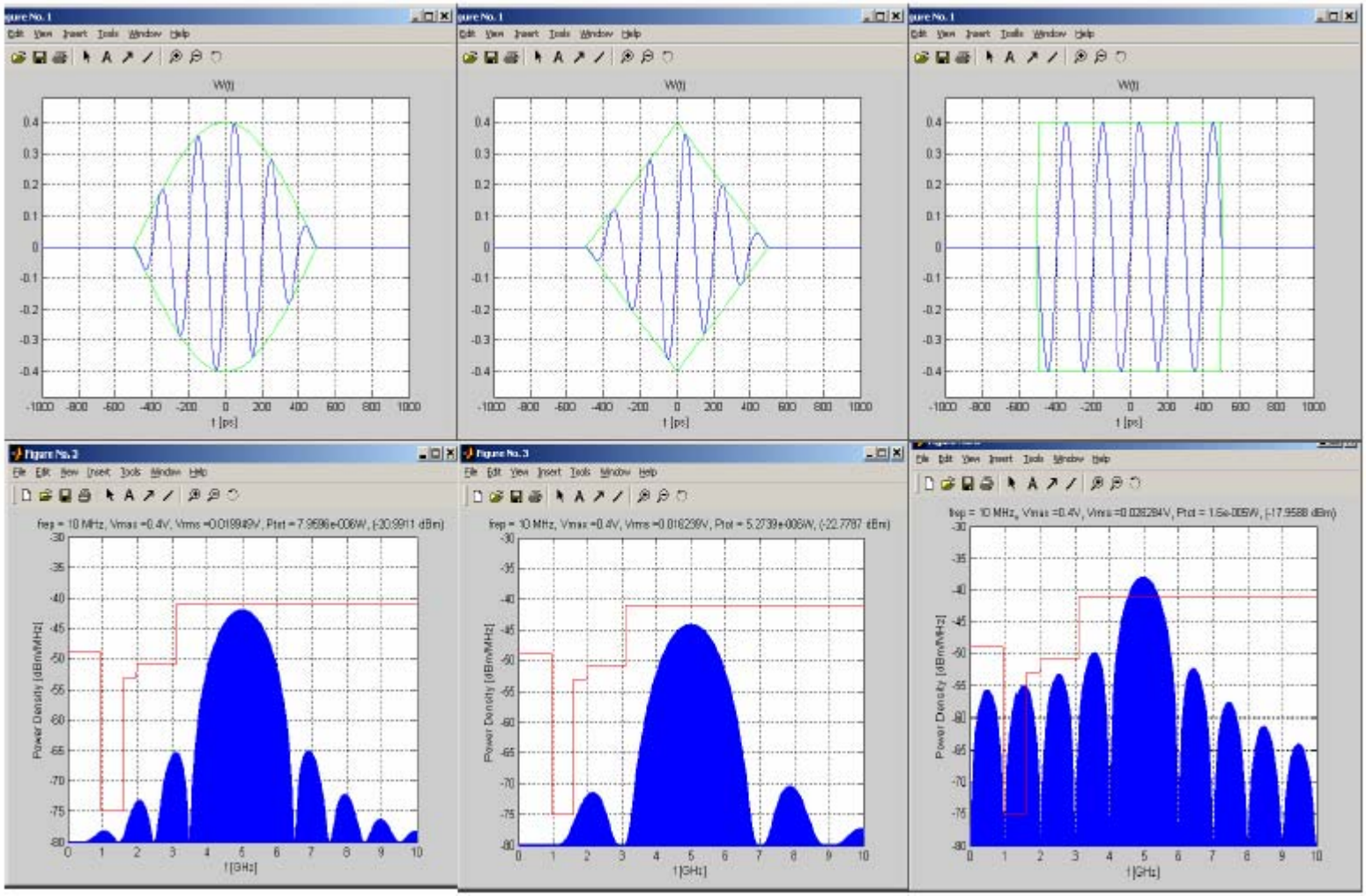
Carrier-based

Sinewave, Vpeak =0.4, CF = 20

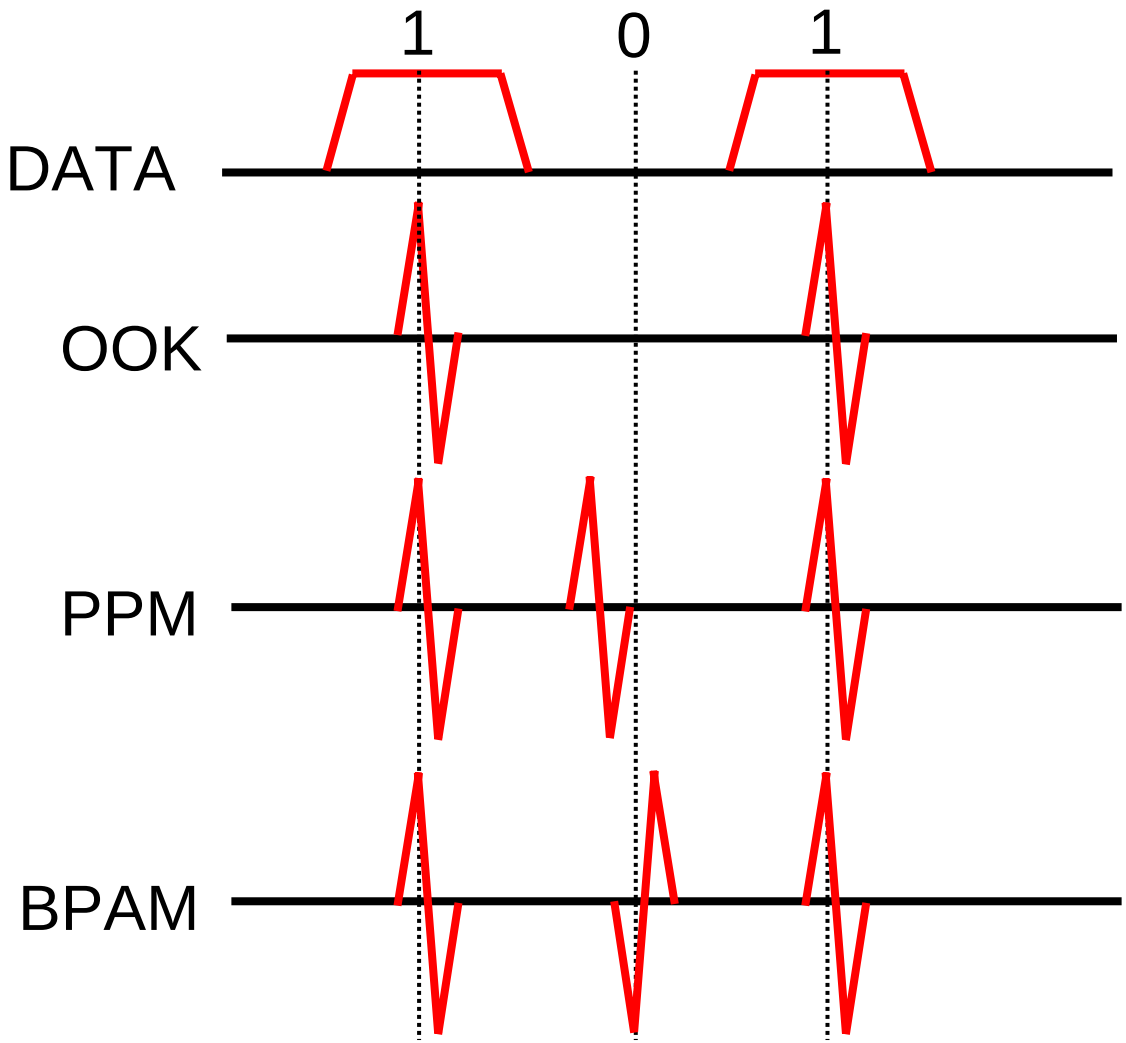




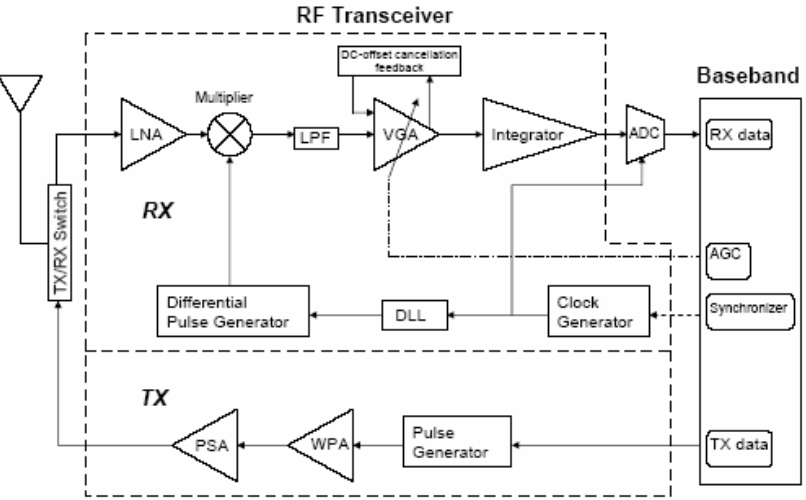
IR-UWB: envelope choice

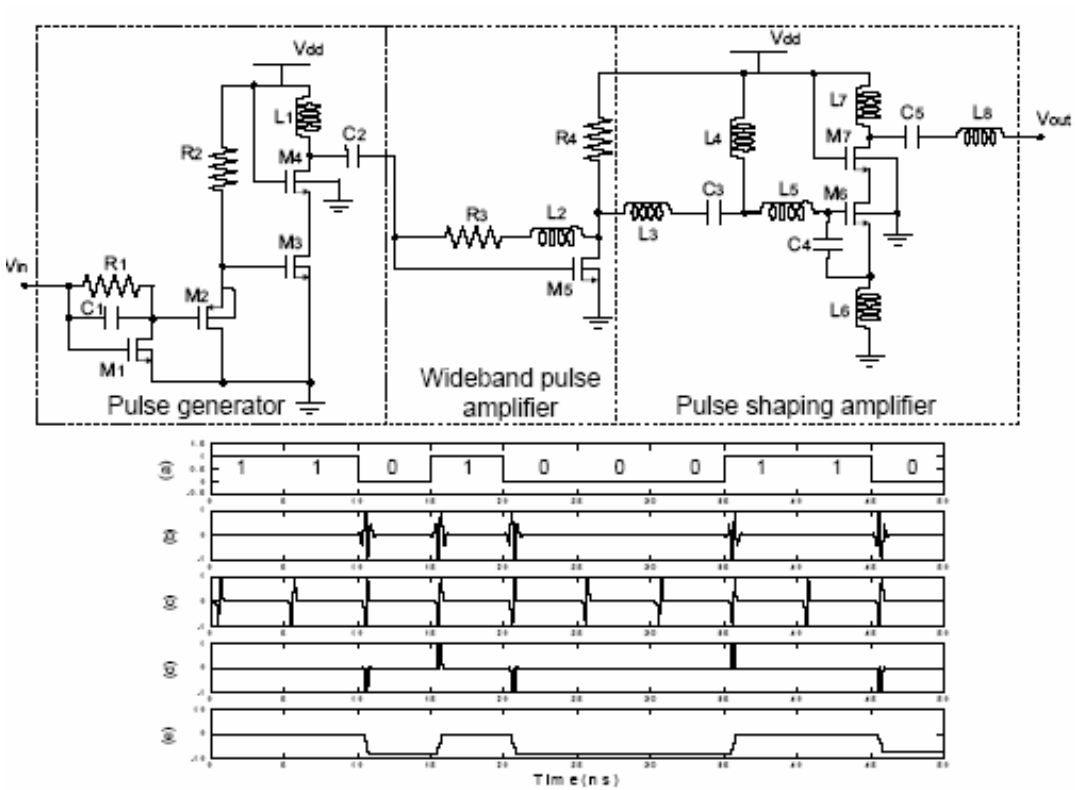


IR-UWB: modulation choice



Carrier-less IR-UWB



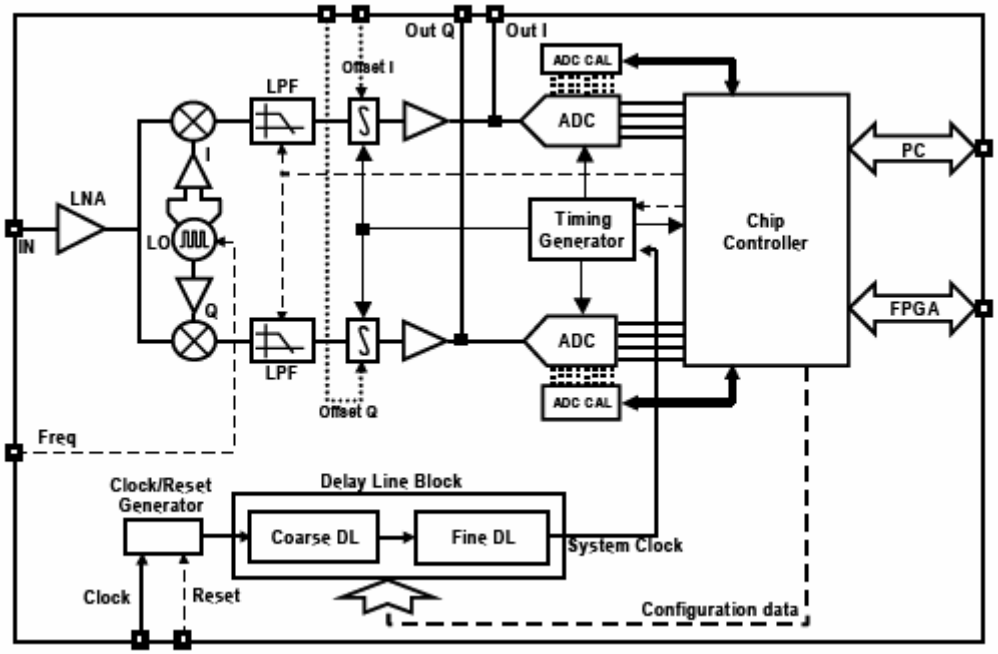


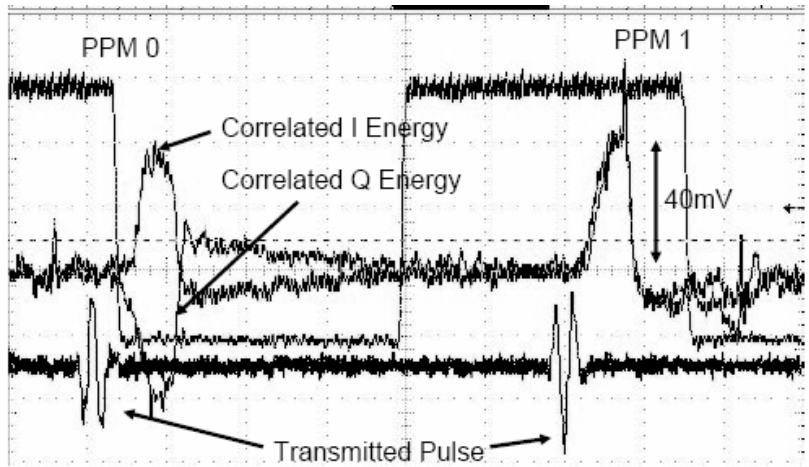
0.18μm CMOS

Zheng, ISSCC2006

PPM/BPSK modulation,
400MPulses/s

Carrier-based IR-UWB



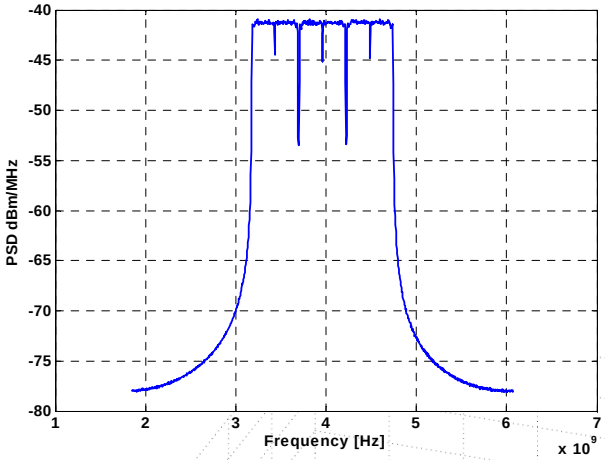


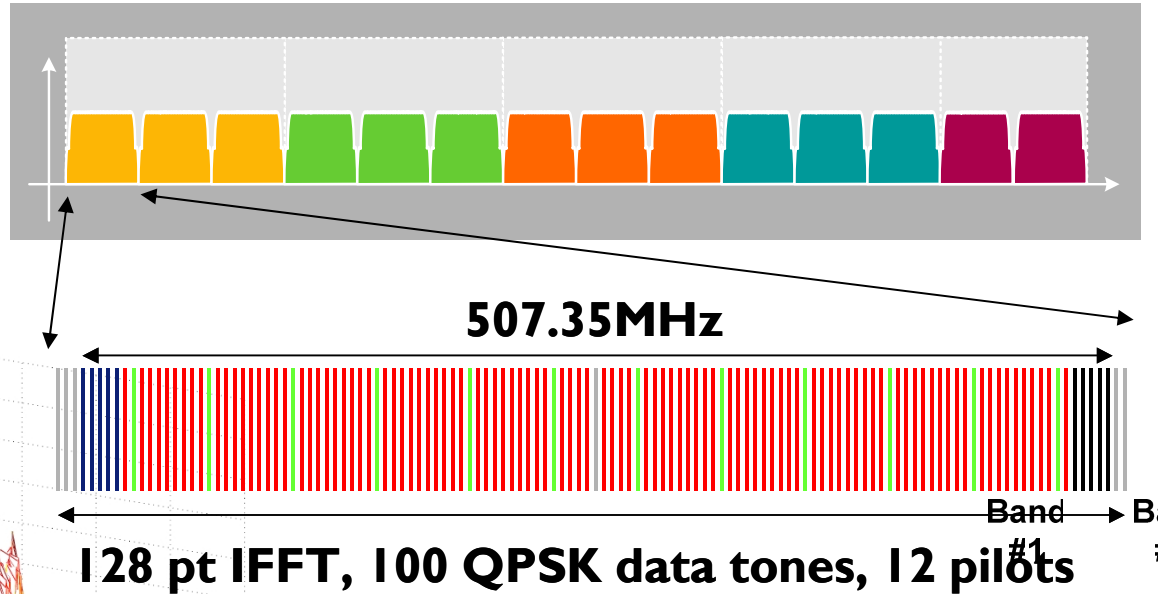
PPM/BPSK modulation,
20MPulses/s

0.18μm CMOS

Ryckaert, ISSCC2006

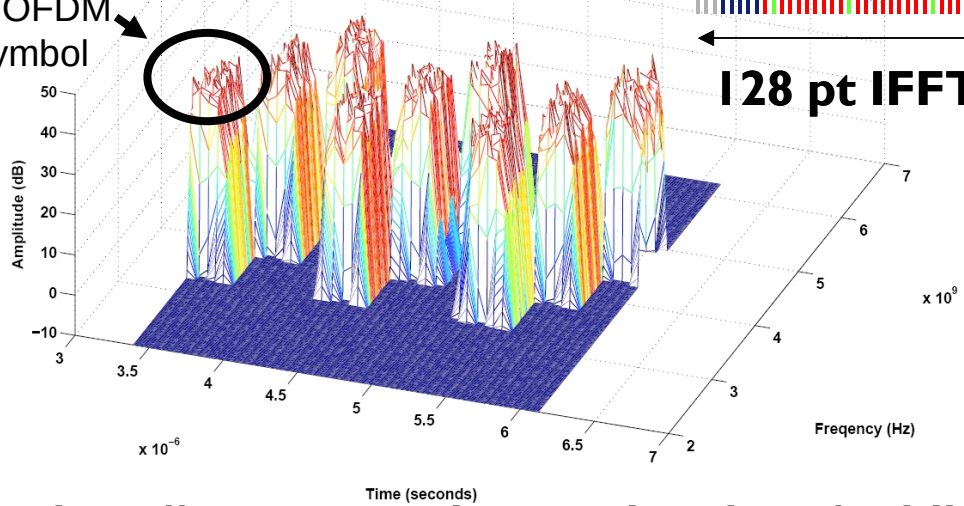
MB-OFDM UWB: system concept





128 pt IFFT, 100 QPSK data tones, 12 pilots

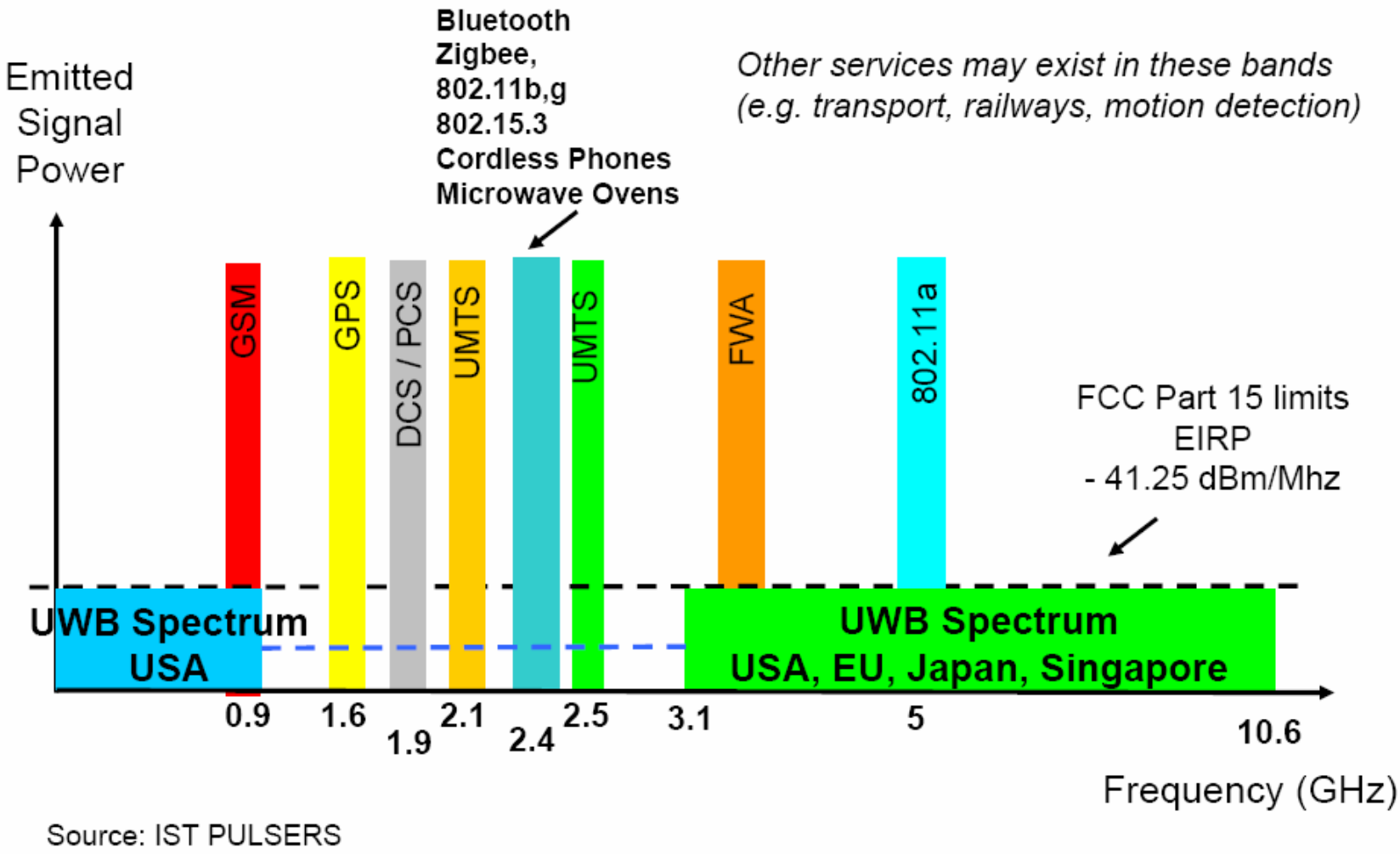
1 OFDM symbol



Time frequency coding to allow multiple access

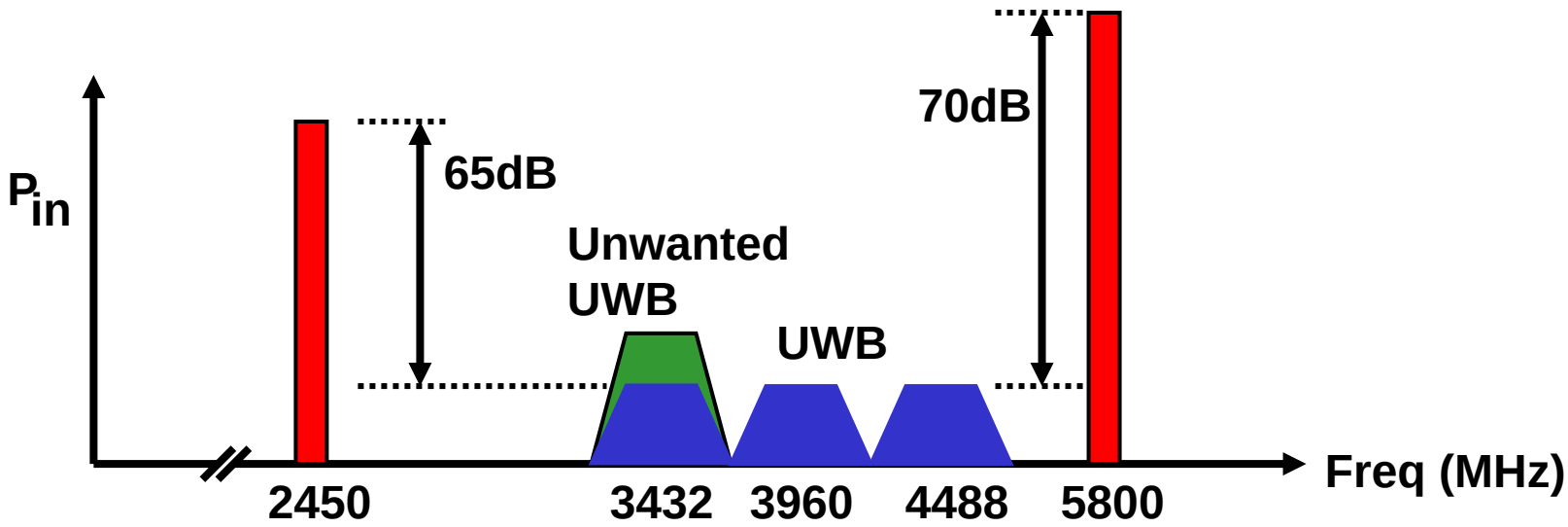
http://www.ecma-international.org/publications/standards/Ecma-368.htm

Why is linearity important?



Source: IST PULSERS

Why is linearity important?



Interferer scenario: (MBOA recommendation)

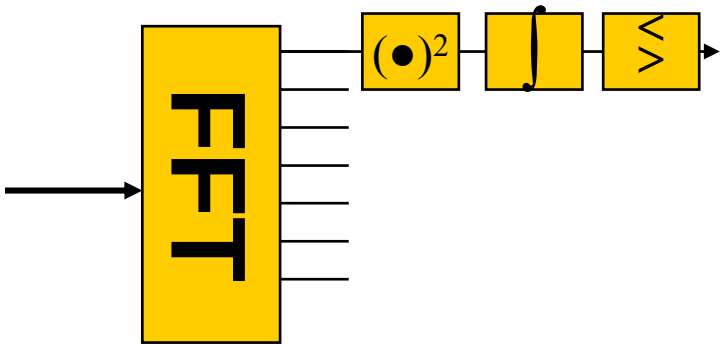
- Distance wanted UWB : 10.0m → -73 dBm
- Distance WLAN interferer: 0.2m → -3 dBm
- Distance 2.4GHz ISM interferer: 0.2m → -8 dBm
- Distance GSM1900 interferer: 1.0m → -8 dBm
- Distance unwanted UWB interferer: 2.0m → -60 dBm

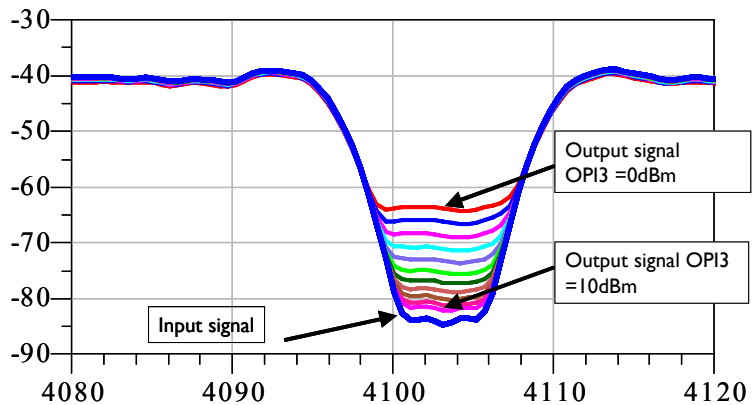
Why are linearity/spurs important?

- WiMAX (Worldwide interoperability for Microwave ACCess)
  - IEEE802.16
  - Operates in 3.3-3.8GHz band
  - Therefore WiMAX covers sub-band #1 and #2 (Band Group 1)
  - Consequently: a detect and avoid (DAA) scheme needs to be implemented in UWB

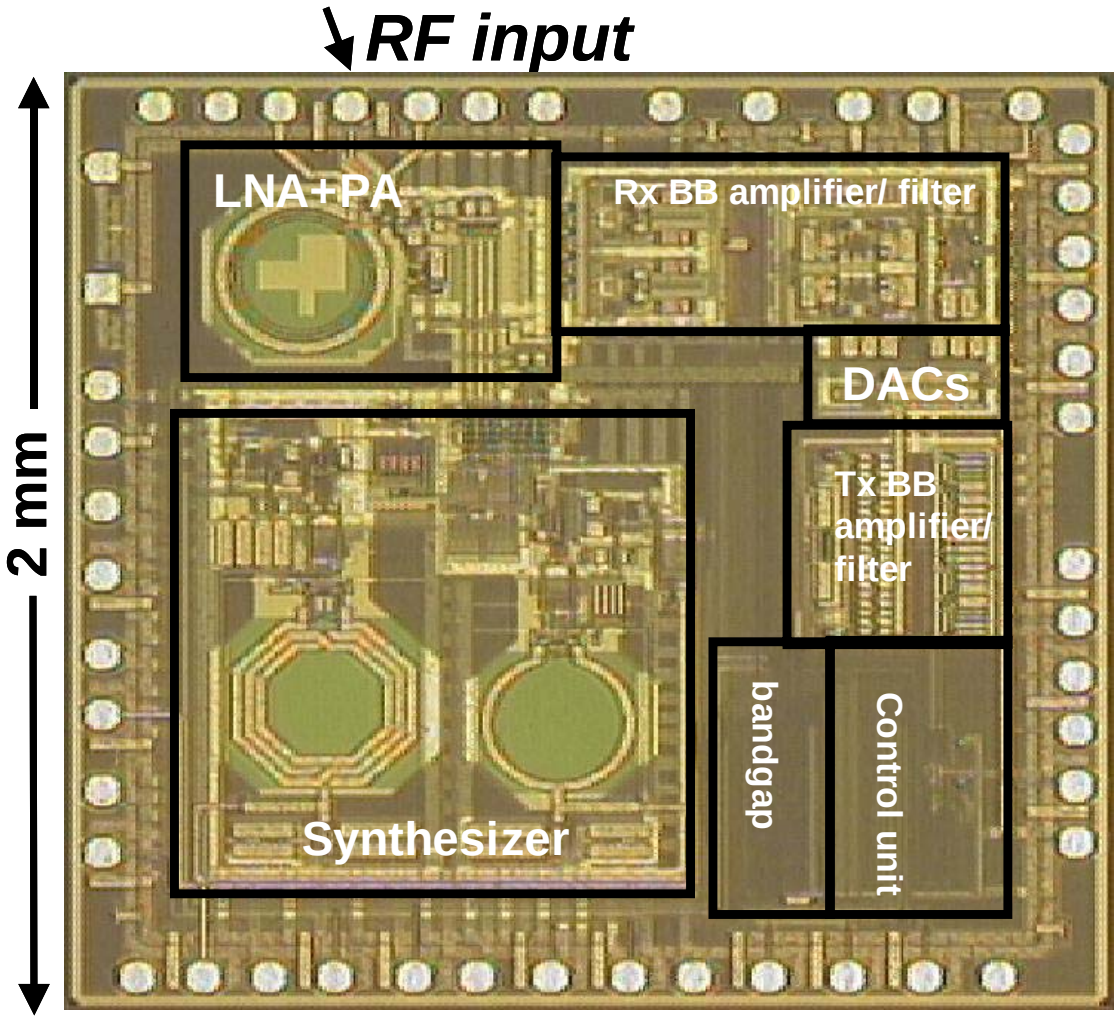
Why are linearity/spurs important?

- Detect and Avoid (DAA)
  - Detect using channelized radiometer
  - Avoid using 5 nulling tones as replacement for OFDM data tone #24 - #28
    - Requires linear TX and higher DR of DAC
  - Avoid using skipping sub-band
    - Lower transmit power





UWB RF Transceiver Design



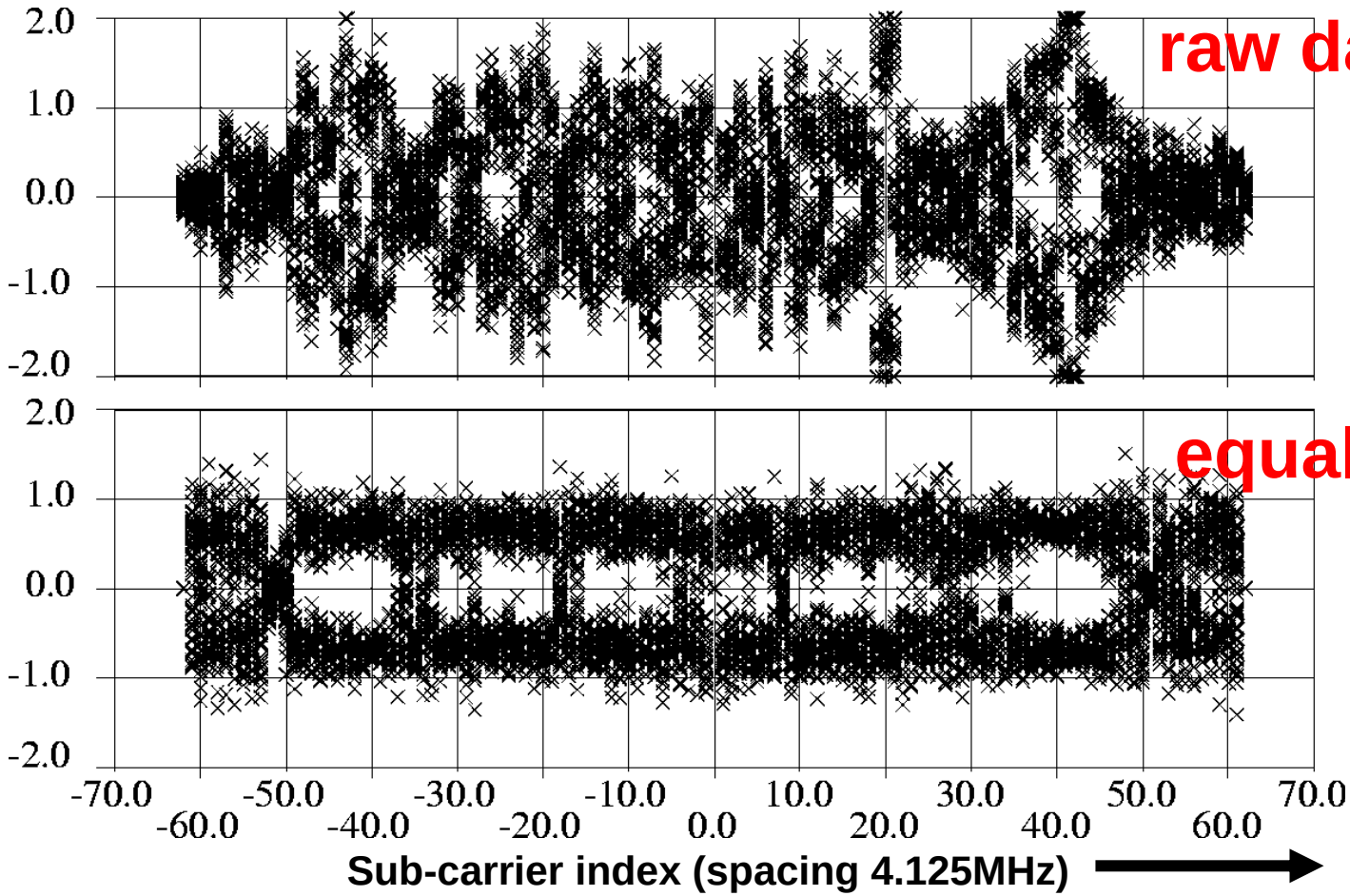
IF outputs

IF inputs

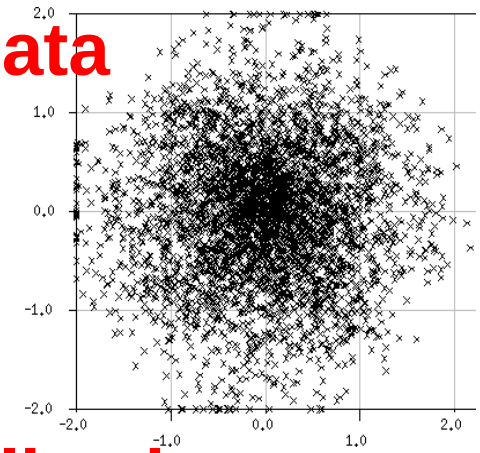
Bergervoet, Leenaerts

ISSCC2005/JSSC2005/RFIC2006

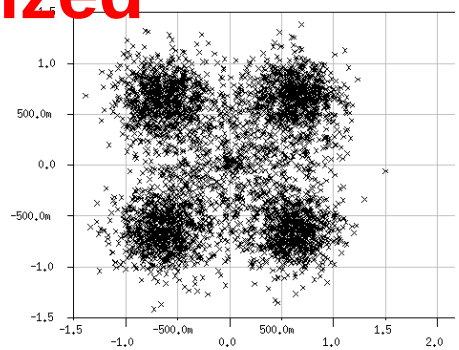
Measurements: 5m distance, 480Mbps, non line of sight



raw data



equalized



EVM=45%, not coded BER=4.6%

UWB RF Transceiver Design

Parameter	required	measured	info
Current consumption		47mA @ 2.7V 43mA @ 2.7V 27mA @ 2.5V	Receiver Transmitter Synthesizer
Noise Figure	< 6.6dB	4.5dB	On PCB, center of IF band, LO is 3960MHz
Input IP2	> +20dBm	+25dBm	f_{in1}: 5GHz ISM f_{In2}: GSM1900
Input IP3	>-9dBm	-6dBm	f_{in1}: 5GHz ISM f_{in2}: 5GHz ISM
Maximum Gain		59dB	power gain from RF input to base-band output
VCO phase noise	<-100dBc/Hz	-104dBc/Hz	At 1MHz offset
Integrated phase noise rms	< 3.5 degrees	1 degrees	Integrated from 0-50MHz
In-band spurs	<-30dBc	<-30dBc	
Out-of band spurs	<-50dBc <-45dBc	<-50dBc <-45dBc	For 5GHz ISM For 2.4GHz ISM
Hopping speed	< 9.5ns	<1ns	all hopping sequences
EVM	<10%	<8%	loop back mode test
Output power	-9.5dBm	-6dBm	
OIP3	10dBm	12dBm	

UWB RF Transceivers : comparison

	[1]	[2]	[3]	[4]	This work
Technology	0.13μm CMOS	90nm CMOS	0.13μm CMOS	0.18μm CMOS	0.25μm SiGe BiCMOS
NF (dB)	6-7	6.9	4.1	4.7	4.5
iIP3 (dBm)	-15	-16	-22	-0.8	-6
iIP2 (dBm)				+22	+25
EVM (dB)	-19.5	-28	-27	-28.6	-24
P_{out} (dBm)		-3.8	+5	-12.6	-6
TX OIP3		8.6		11.8	12
P diss Rx (mW) Pdiss Tx (mW)	100mA @ 3.3/1.5V 70mA @ 3.3/1.5V	224 131	237 284	412 397	199 190
Chip area (mm^2)	2	4.5	6.6	16	4

[1] Aytur, ISSCC2006
[2] Tanaka, ISSCC2006
[3] Sadner. ISSCC2006
[4] Lo, ISSCC2006

Concluding remarks

- **IR-UWB: interesting research field as no standard yet**
  - **Mostly CMOS technology**
  - **Big debate between carrier-less / carrier-based impulse radio**

- **MB-OFDM UWB**
  - **W-USB is the ‘killer’ application**
  - **SiGe implementations dominate, but it is to be expected that CMOS (130nm, 90nm) will take over**
  - **Challenging is the combination of broad-band design with low NF and high linearity.**