A glance at

ULTRA-WIDEBAND RADIO

"*BACK TO THE FUTURE*"

L. Agarossi 16/11/01

UWB

OVERVIEW

- Impulse radio is a form of ultra-wide band signaling suitable for short range communications in dense multipath environment
- Ultra Short duration pulses which yield ultrawide bandwidth signals
- Extremely low power spectral densities
- Center frequency typically between 650 MHz and 5 GHz
- Excellent immunity to jamming from other radio systems

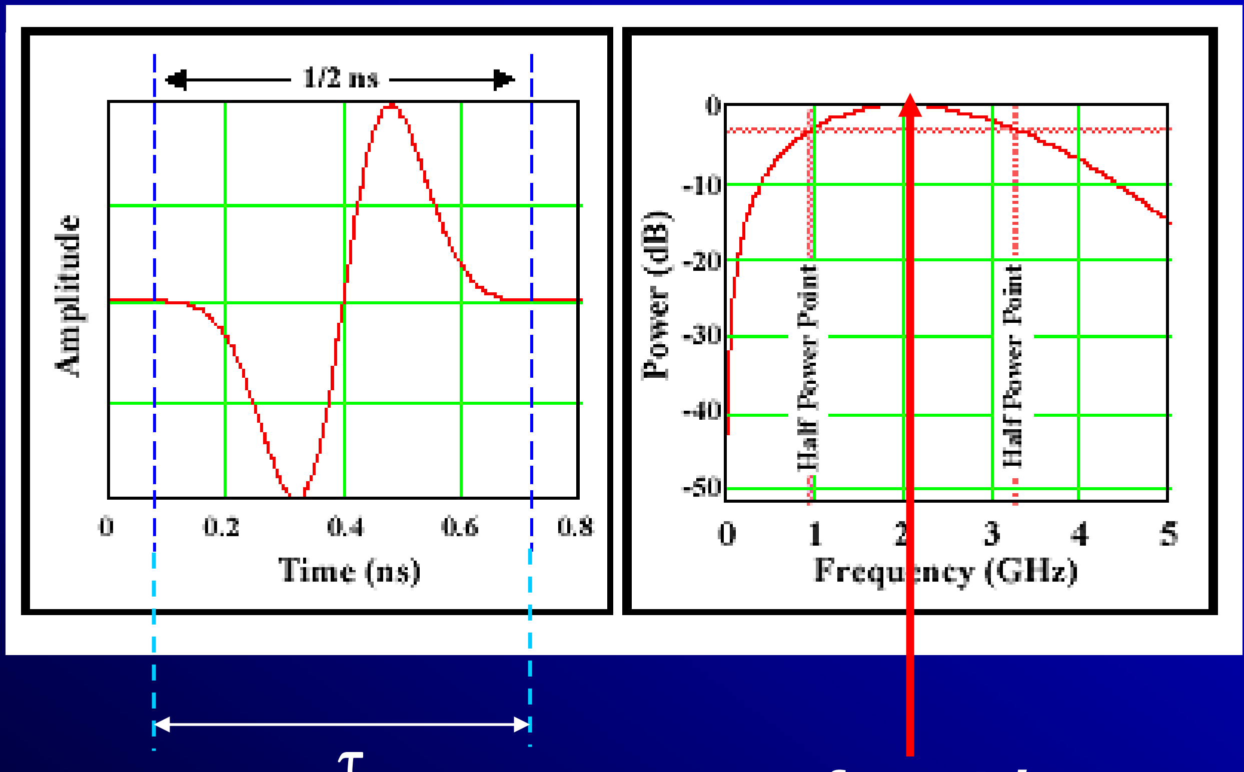
UWB

TECHNOLOGY BASICS

- Ultra-short "Gaussian" monocycle pulses
  - 0.1ns $\leq \tau \leq$ 2ns
- Pulse Position modulation
  - information signal (PPM)+ channel code (pseudo-random)
- EIRP
  - 50 μW < P< 100 mW

UWB

GAUSSIAN MONOCYCLE



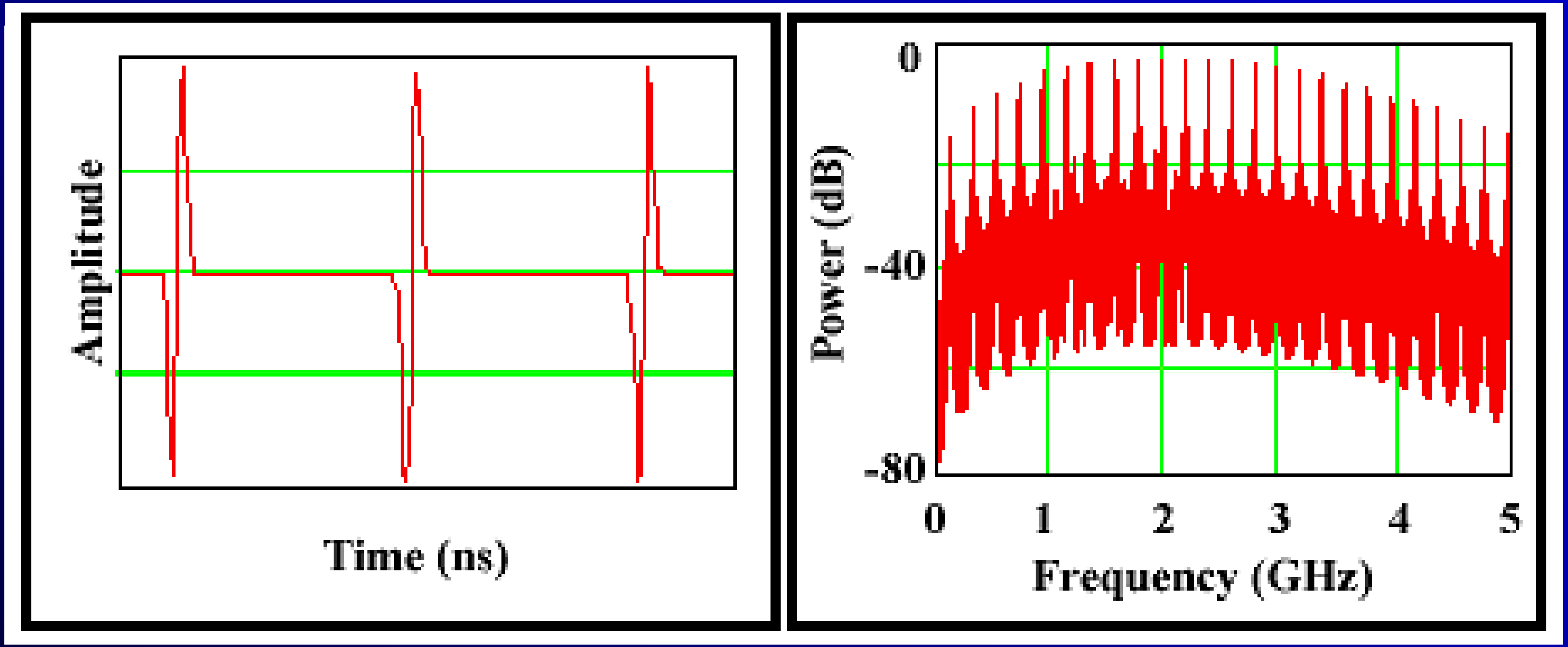
$f_c = 1/\tau$

$BW = 116\% \ f_c$

- Gaussian monocycle in time and frequency domain

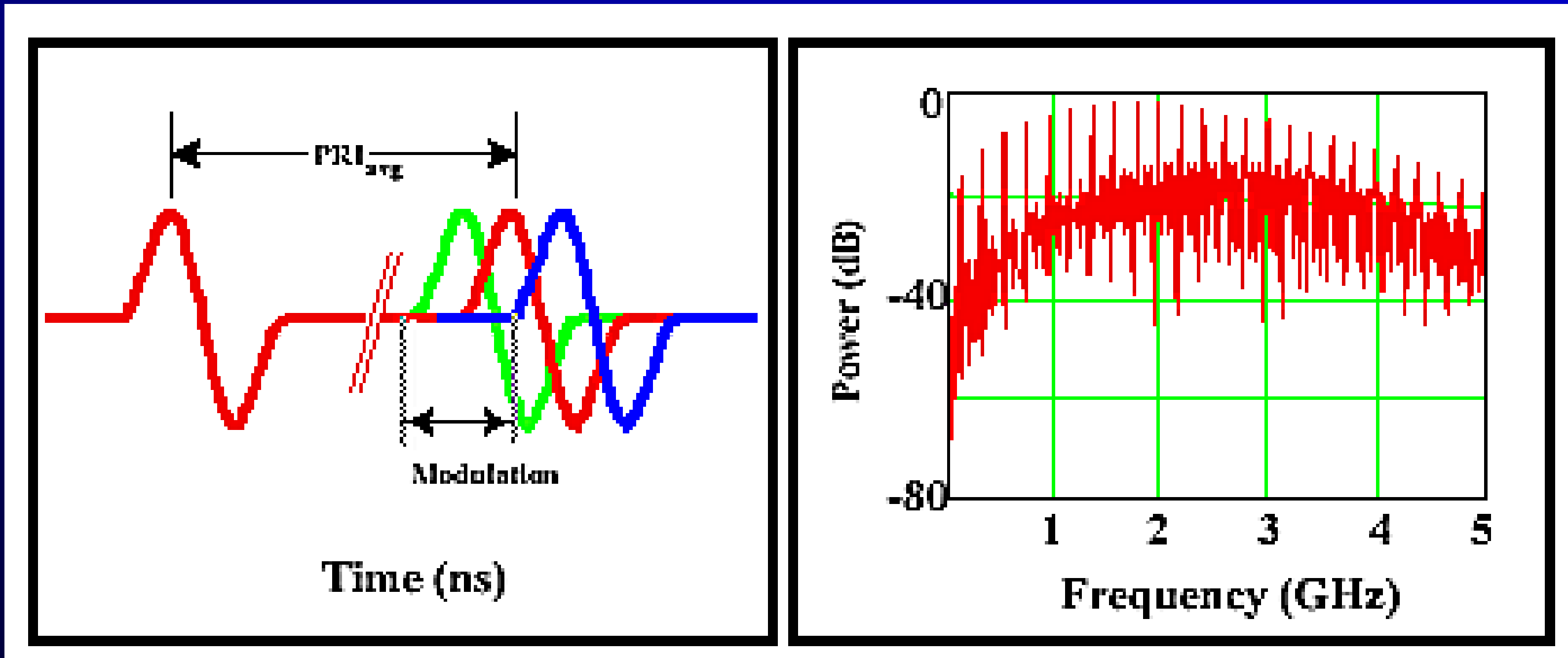
L. Agarossi 16/11/01

PULSE TRAIN



- Monocycle pulse train in time and frequency domain

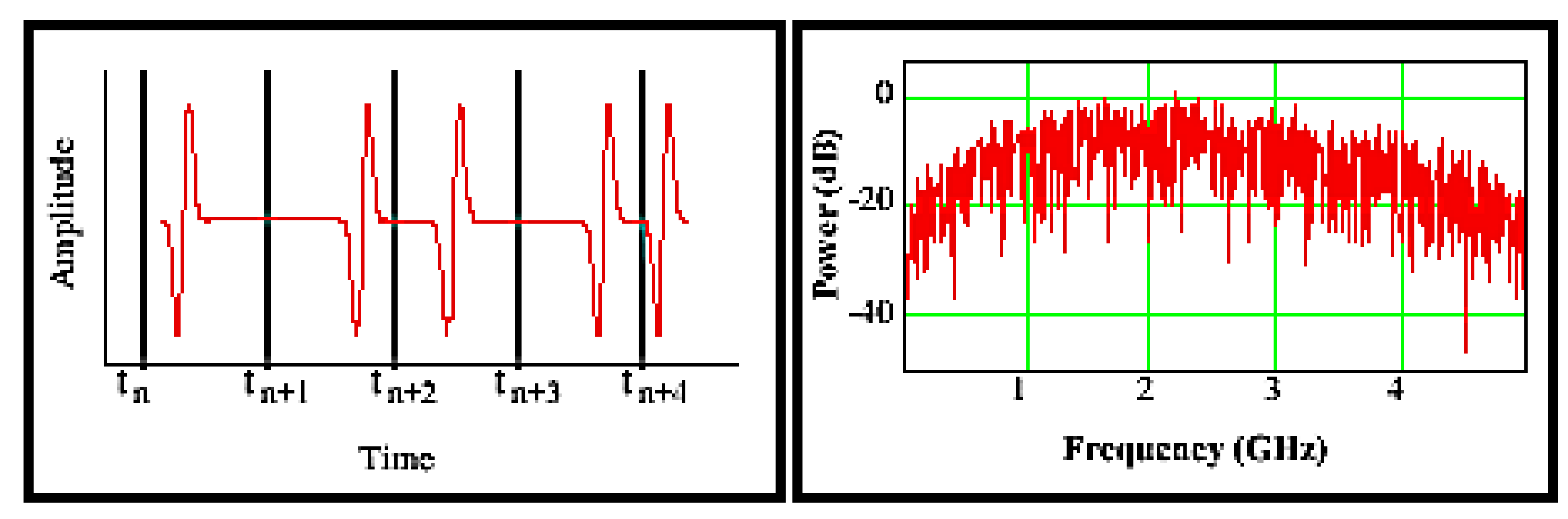
MODULATION



- Pulse Position Modulation

CODING

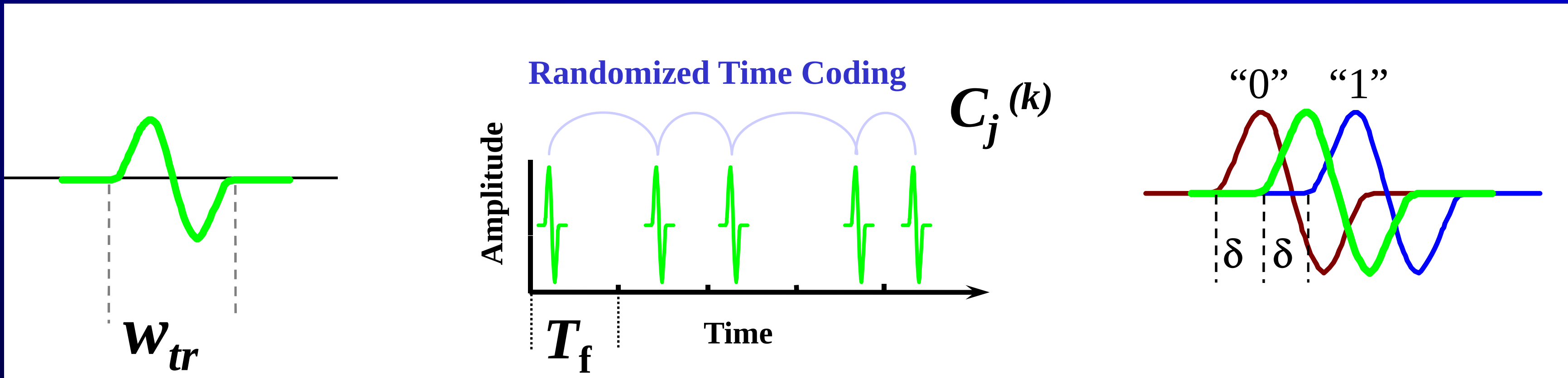
Pseudo-random Noise Coding



- Impact of Pseudo-Random Time Modulation on Energy distribution

UWB

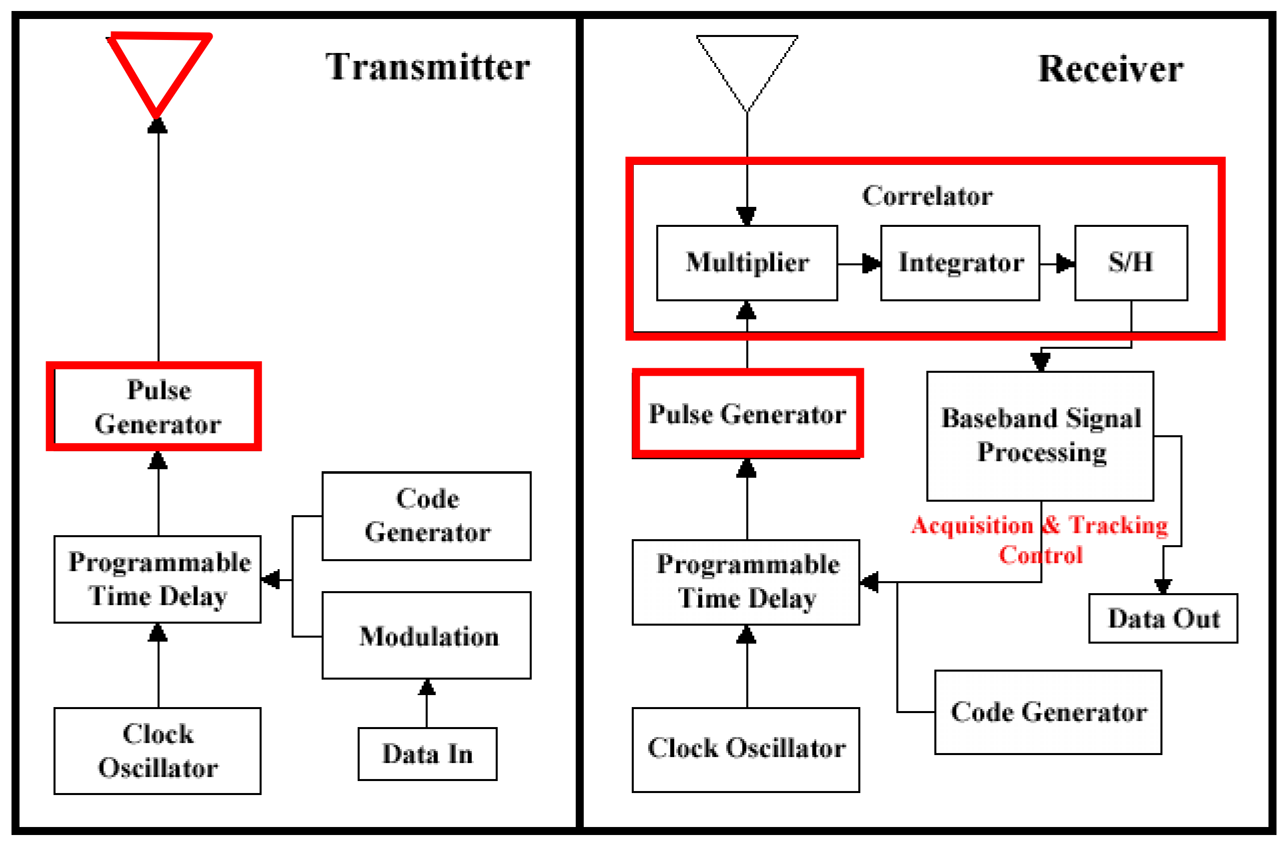
TRANSMITTER'S OUTPUT SIGNAL



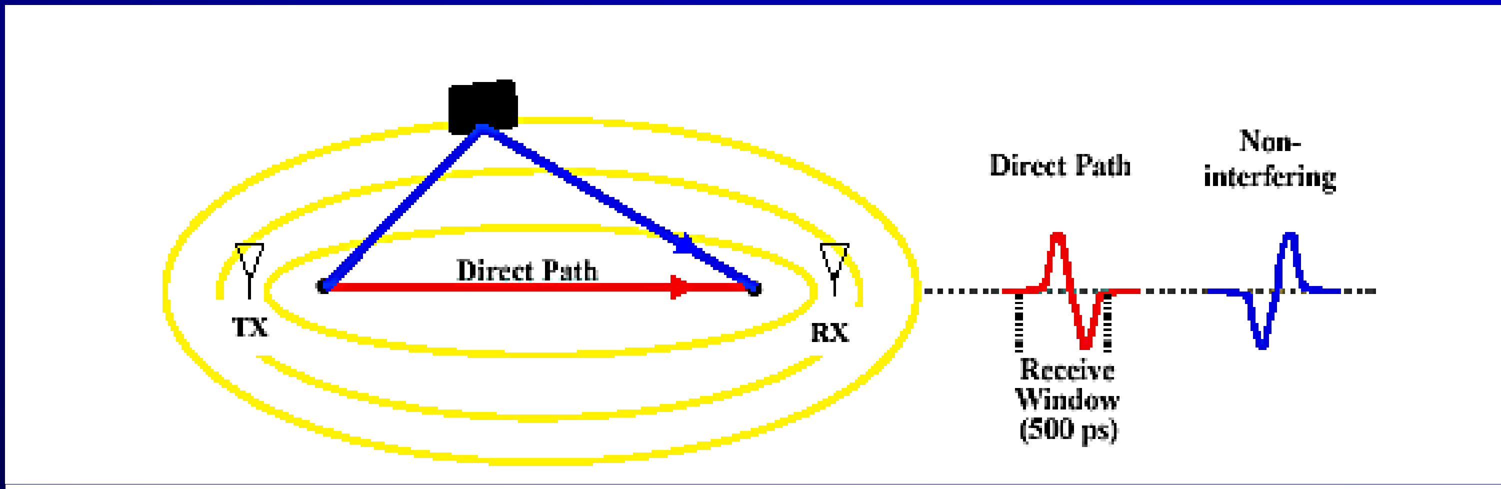
$$s_{tr}^{(k)}\left(t^{(k)}\right)=\sum_{j=-\infty}^{+\infty} w_{tr}\left(t^{(k)}-jT_f-c_j^{(k)}T_c-\delta d_{\lfloor j/N_s \rfloor}^{(k)}\right)$$

UWB

TRANSCEIVER SCHEMATICS



MULTIPATH



$$d_{min} = c\tau = 3\ 10^{-8} \times 0.5\ 10^{-9} = 15\ cm$$

UWB

RESISTENCE TO JAMMING

- **Huge process gain**
  - $G = BW/B_s$

  (BW = RF bandwidth, B_s = information bandwidth)

Example

Qualcomm's SS system

BW = 1.25 MHz

B_s = 8KHz

G= 22 dB

UWB system (same capacity, with τ = 0.5 ns)

BW = 2 GHz

Bs = 8KHz

G= 54 dB

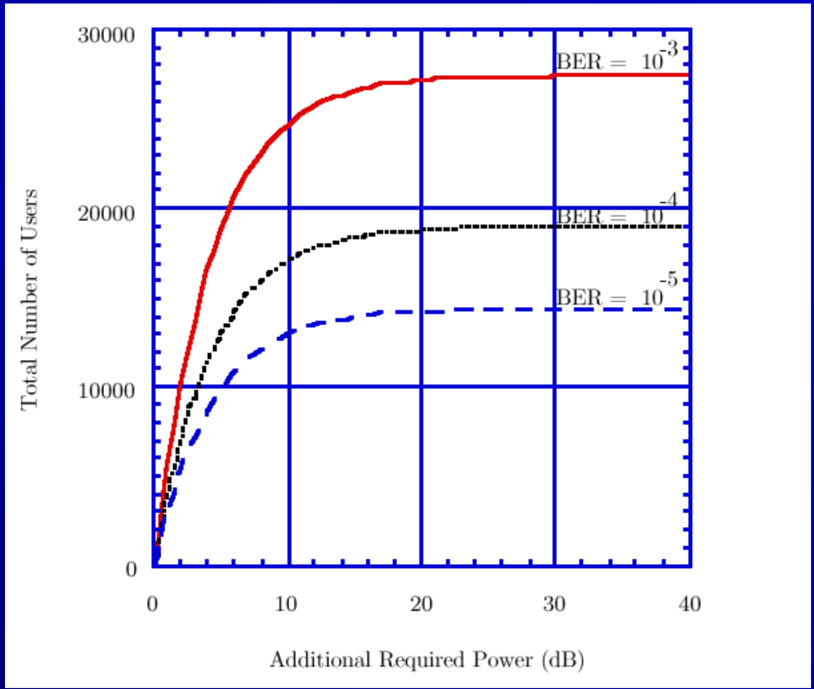
UWB

ACCESS CAPABILITY

27488 / 10^{-3}

19017 / 10^{-4}

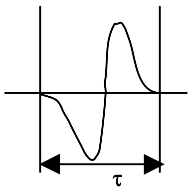
14426 / 10^{-3}



L. Agarossi 16/11/01

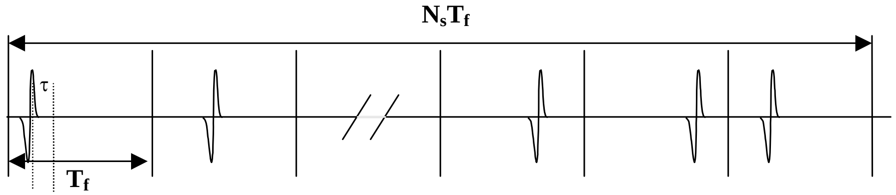
CAPACITY ESTIMATION

Gaussian monocycle



$0.1ns = \tau = 2ns$

Time-hopping format



T_f = Pulse repetition time
Ns = Number of monocycles per symbol
$10^{-2} = \tau / T_f = 10^{-3}$

Max /min pulse frequency F_{pMAX}

$\tau / T_f = 10^{-2}$
$\tau = 0.1$ ns
$T_f = 10.1$ ns
$F_{pMAX} = 1/T_f \sim$ **100Mpps**

$\tau / T_f = 10^{-3}$
$\tau = 2$ ns
$T_f = 2002$ ns
$F_{pmin} = 1/T_f \sim$ **500Kpps**

One bit spread over many monocycles so Br << Fp that means for UWB systems

Br << 100Mbps

Ex: 10Mpps/8kbps ratio > 1000!

UWB suitable for multi users system with low/mid bitrate.