

# Exposure Aspects of New and Evolving Wireless Systems – Spectrum of Power Variations

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# Overview

Possible signal aspects of  
relevance

Spectrum of the power

## Examples

GSM

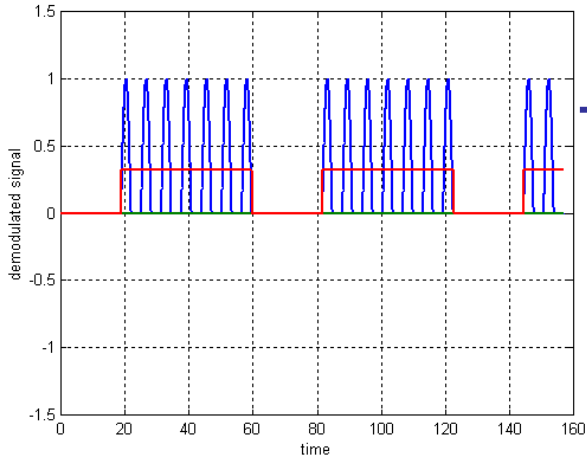
WCDMA

HSPA

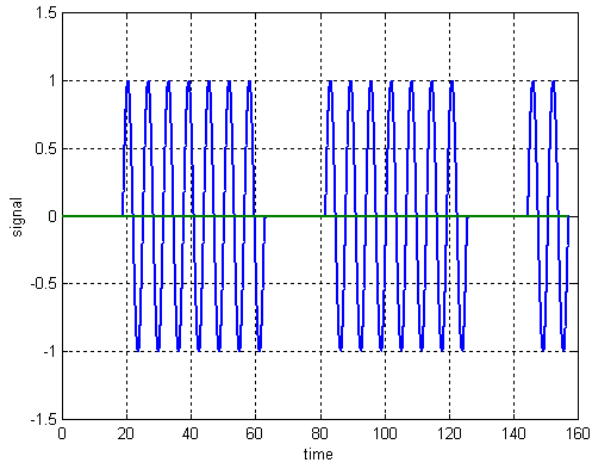
WiFi

WIMAX

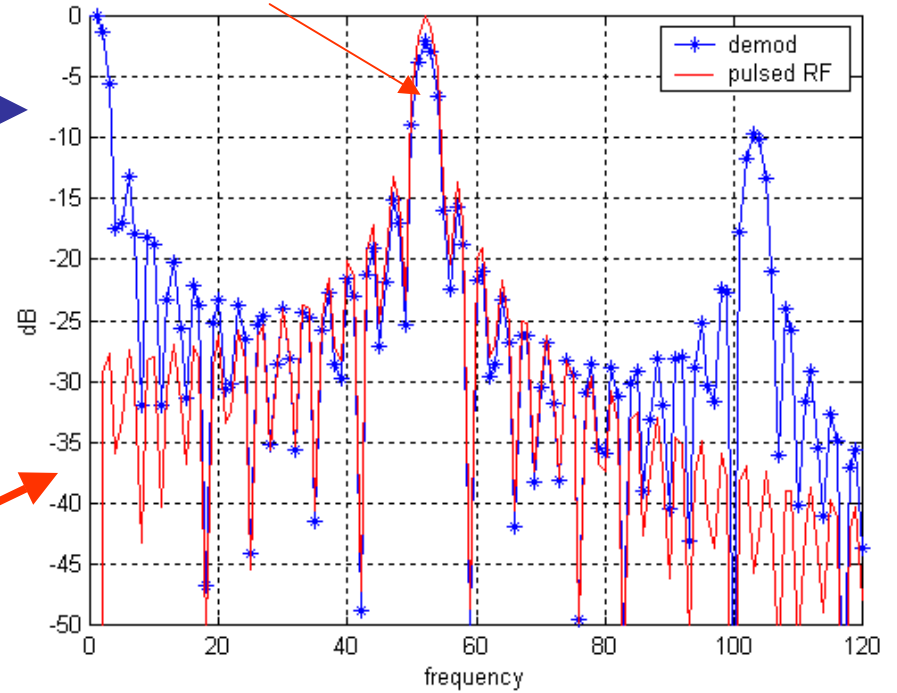
# Spectra



**PEMF  
demodu-  
lated**

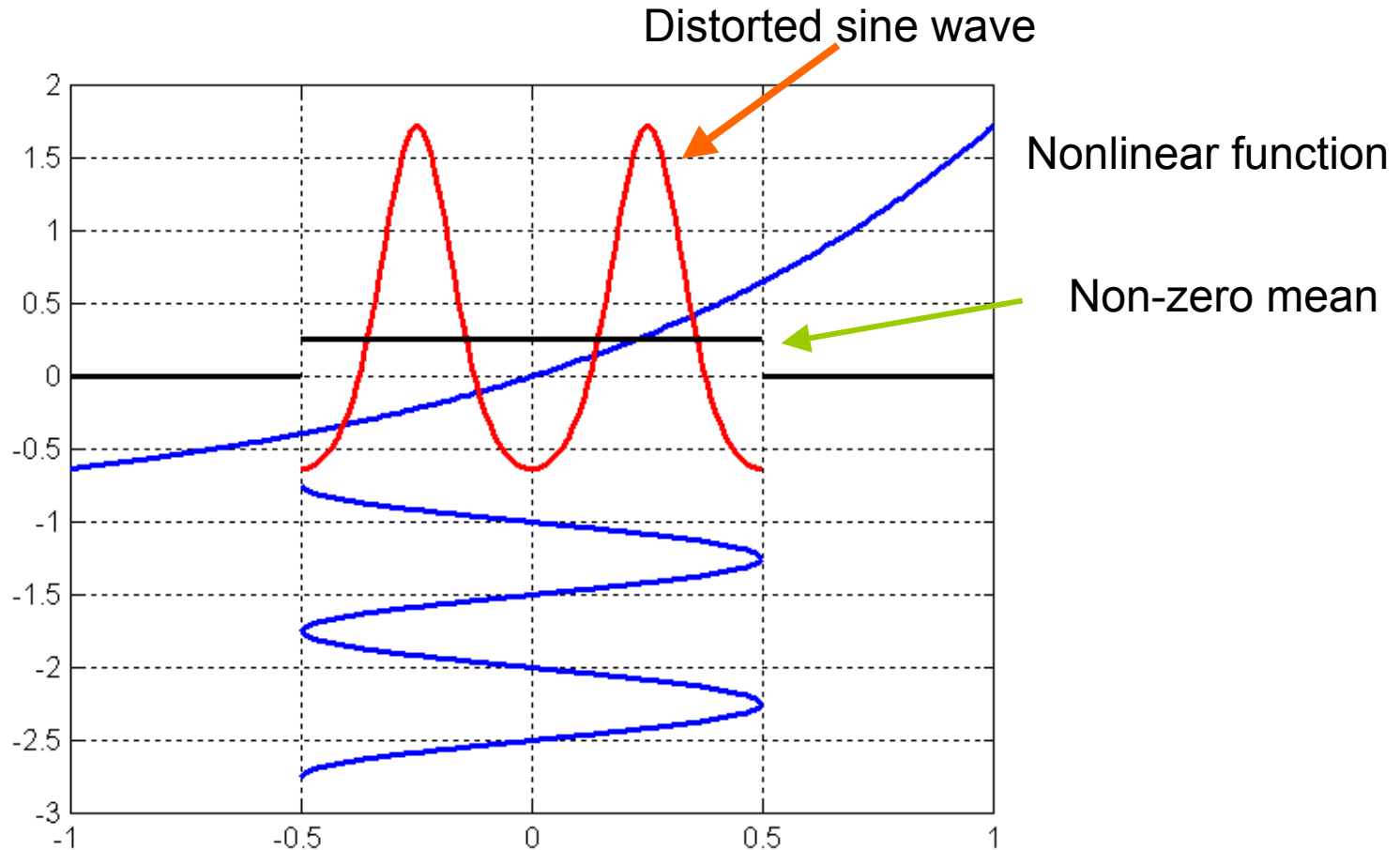


**PEMF**

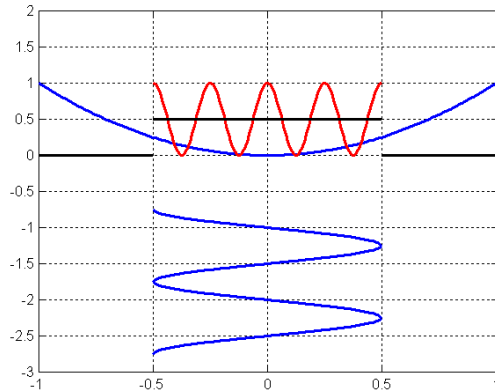


**Low frequencies 30 dB  
below carrier,  
depending on  $f_c T_p$**

# Any nonlinearity will create a non-zero mean



The power is field squared, thus a nonlinear function and will reveal what frequencies may be created through a nonlinear process (if any).



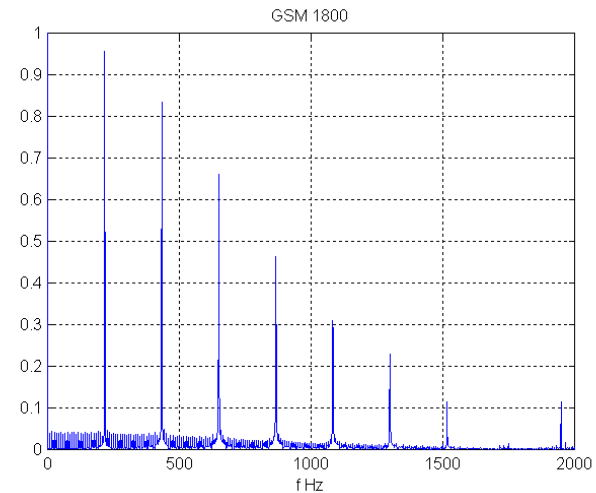
Signal:  $s(t)$

Power:  $P(t) = |s(t)|^2$

Spectrum:  $S(f) = \text{FT}(P(t))$

FT is Fourier transform

Warning: NOT POWER SPECTRUM

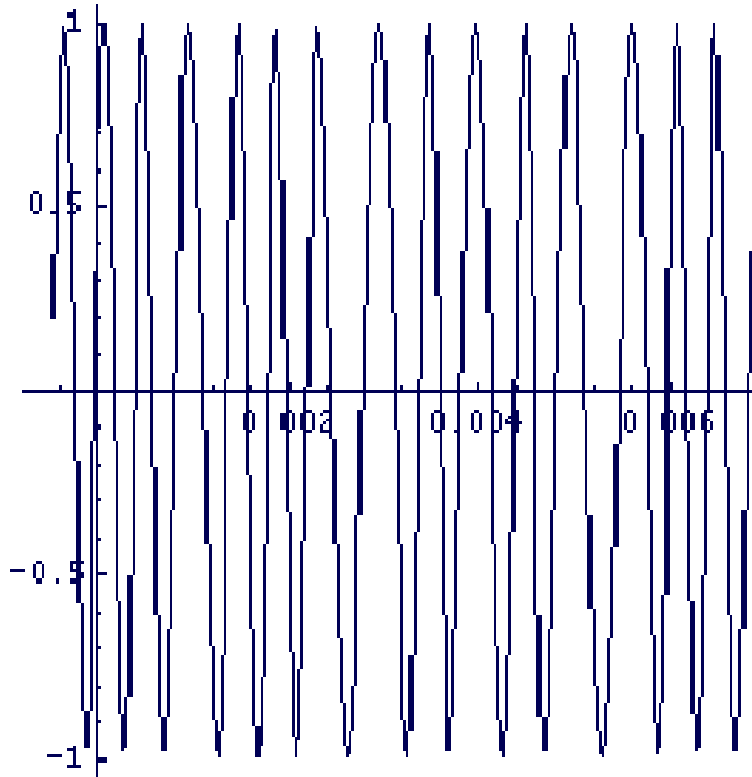


GSM handset spectrum for  $T=1$  s.

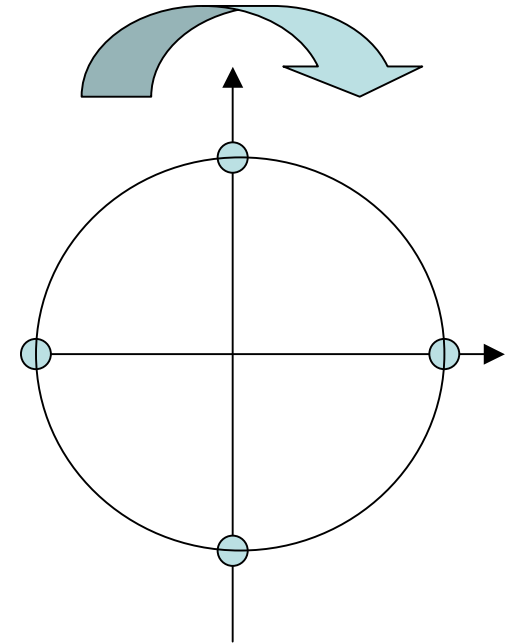
217 Hz and harmonics, 8 Hz grass.

By choosing different values of  $T$  one can focus on different frequencies. In general two sets are necessary, in the s and ms range.

# GSM

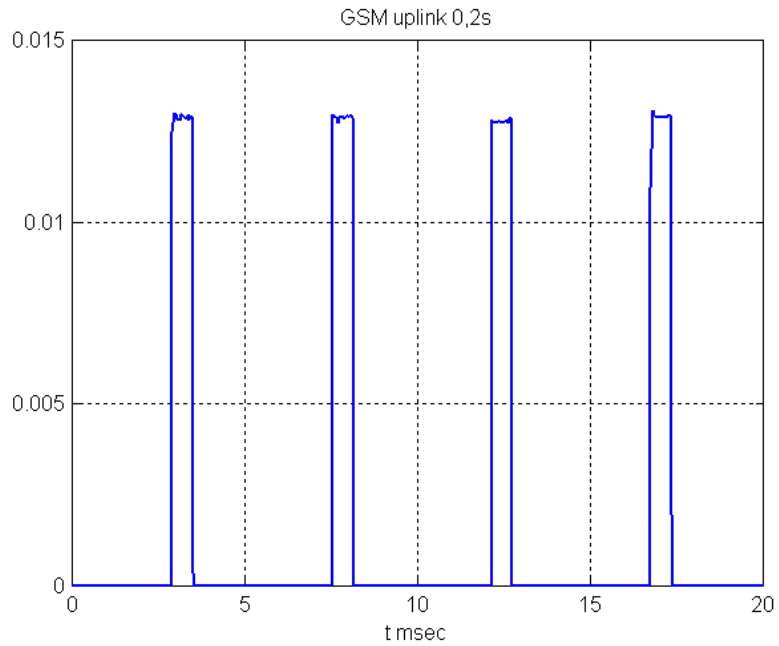


*The GSM modulated signal  $m(t)$*

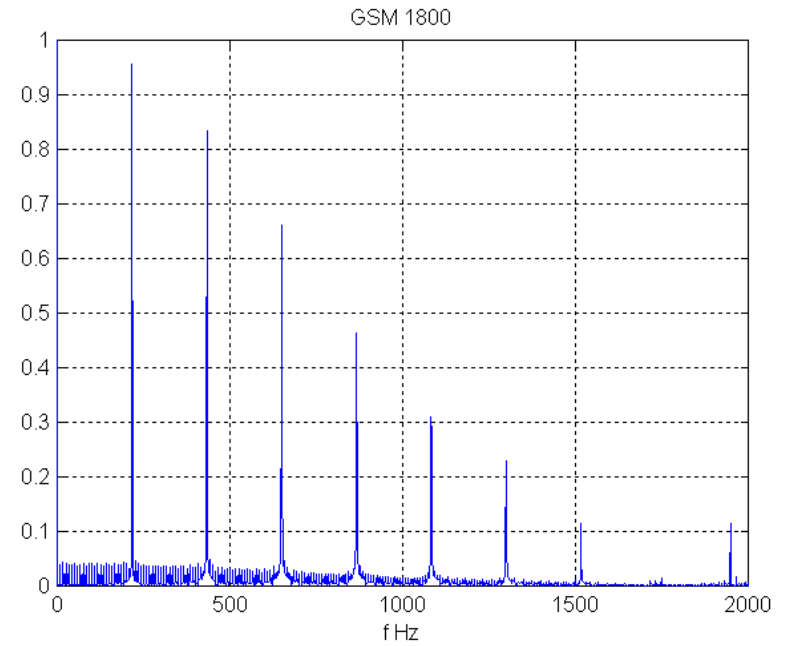


## Gaussian Minimum Shift Keying (GMSK)

**Constant envelope modulation, all the information is in the phase**



Time domain



Frequency domain

No higher frequencies in the case of GSM (except for EDGE)

In all other cases there are non-constant envelope modulations, and the information is reflected in the spectrum.

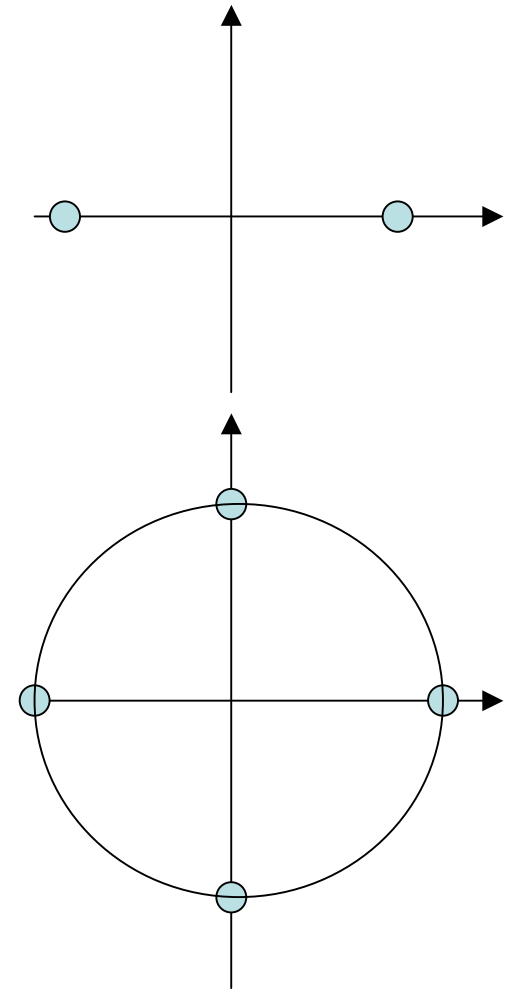
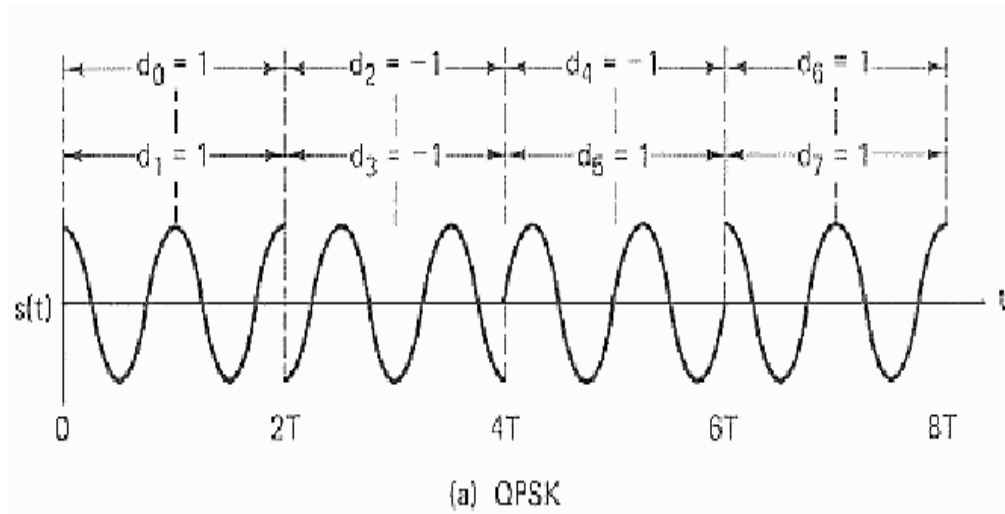
$$S_0(t) = A \cos(\omega t)$$

represents binary "0"

$$S_1(t) = A \cos(\omega t + \pi)$$

represents binary "1"

## Binary Phase Shift Keying, BPSK

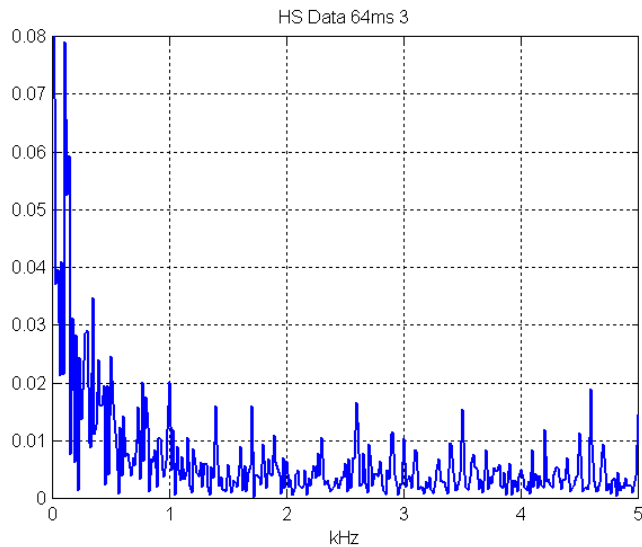


## Quadrature Phase Shift Keying, QPSK

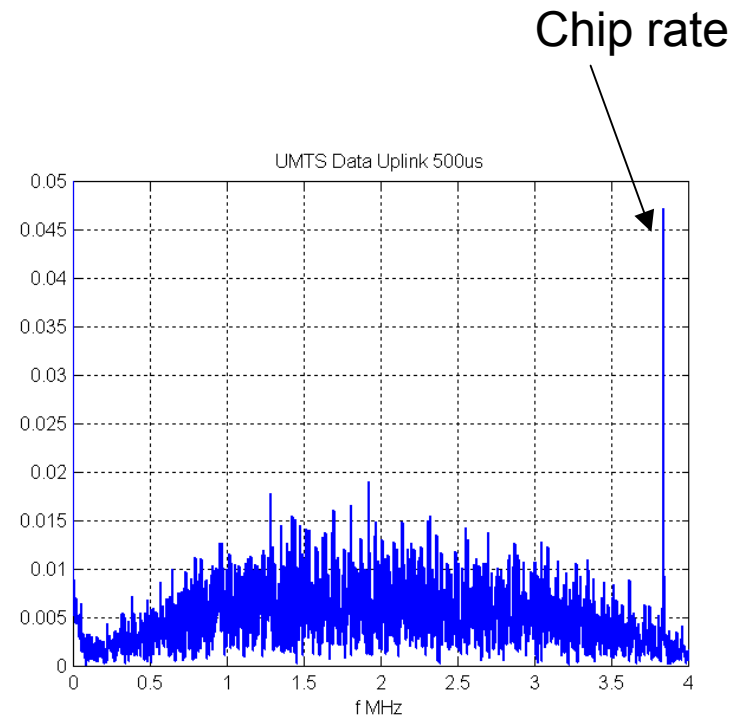
# WCDMA (UMTS) 3G

- multiple access is controlled by code division
- rapid power control at 1500 Hz
- non-constant envelope modulation

## Uplink. Browsing with a handset

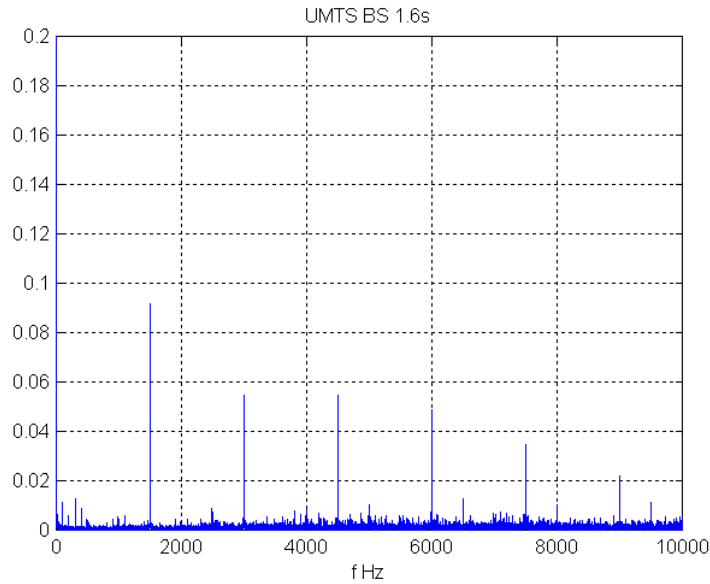


T=64 ms  
(0-5 kHz)

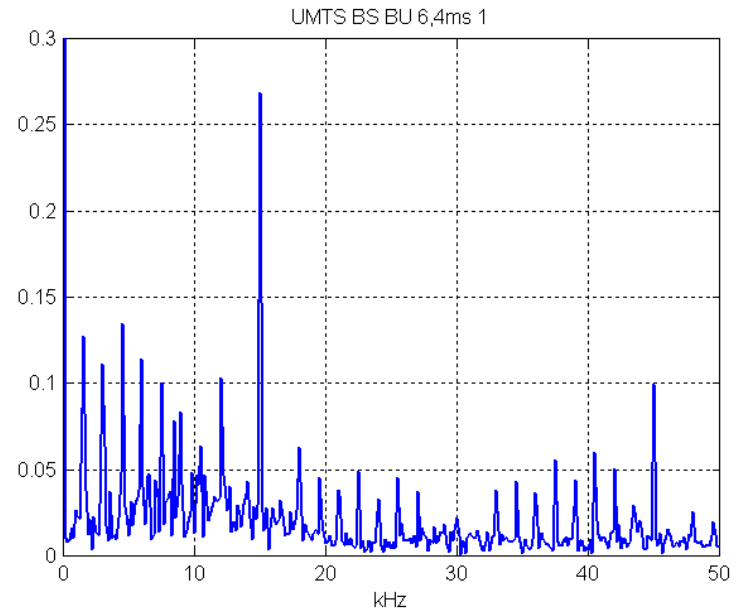


T=0.5 ms  
(0-4 MHz)

# Measured spectrum from WCDMA base station



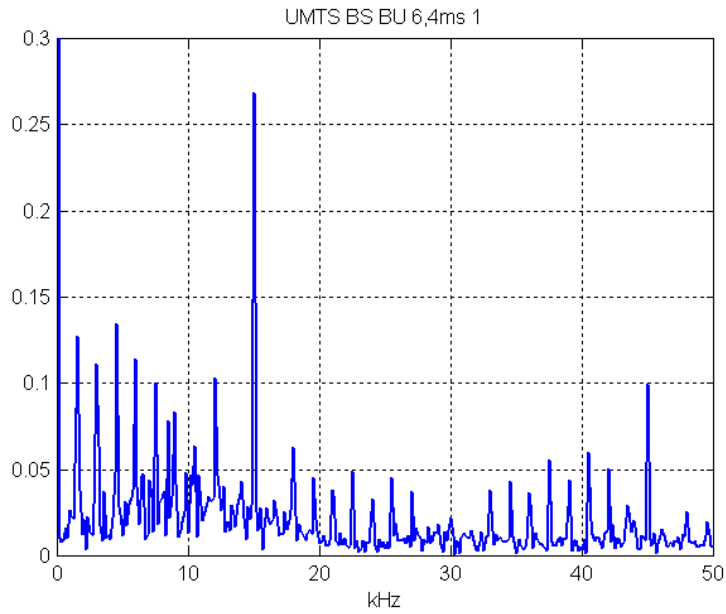
0-10 kHz



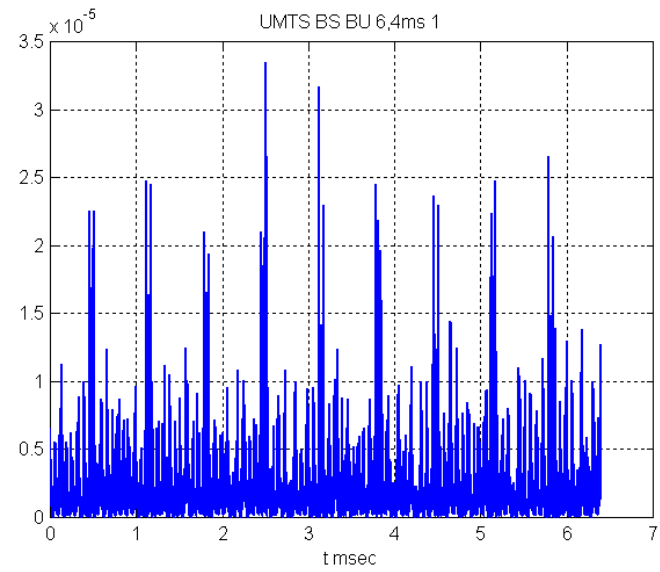
0-50 kHz

Note the dominant 15 kHz common pilot signal, different from the 1500 Hz power control component. Also a weak 100 Hz.

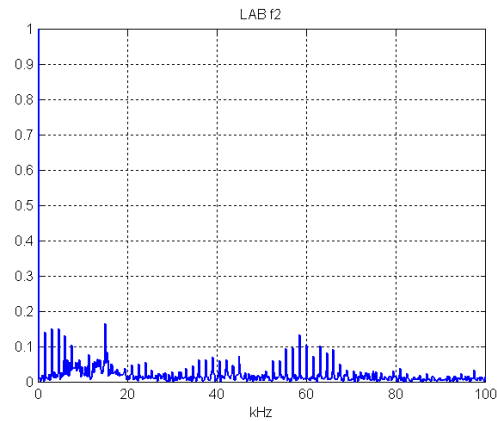
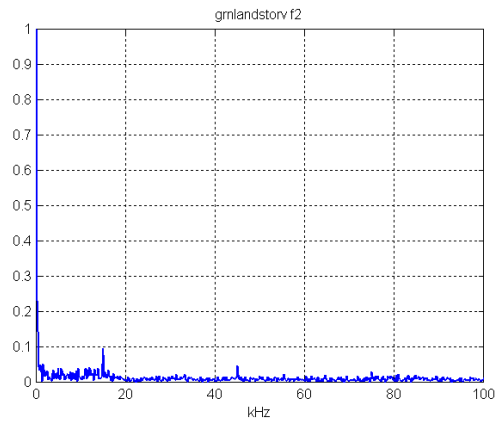
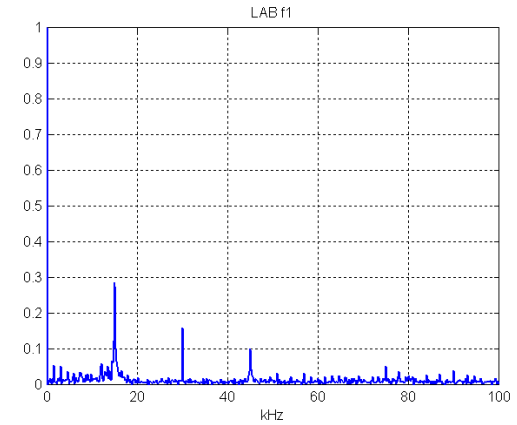
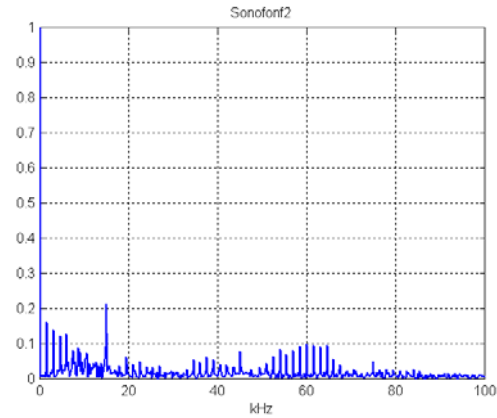
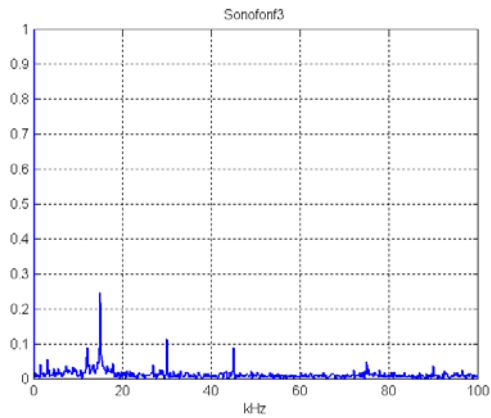
# Base station power in frequency and time domain



f= 0-50 kHz



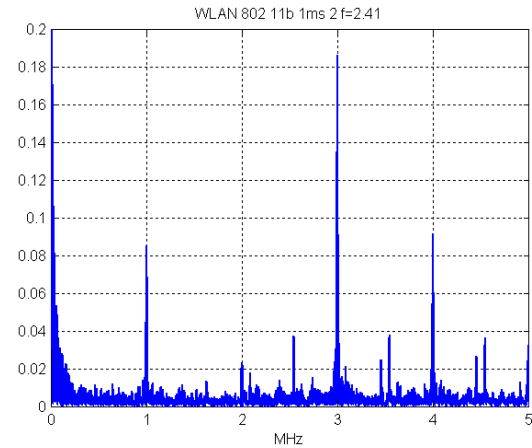
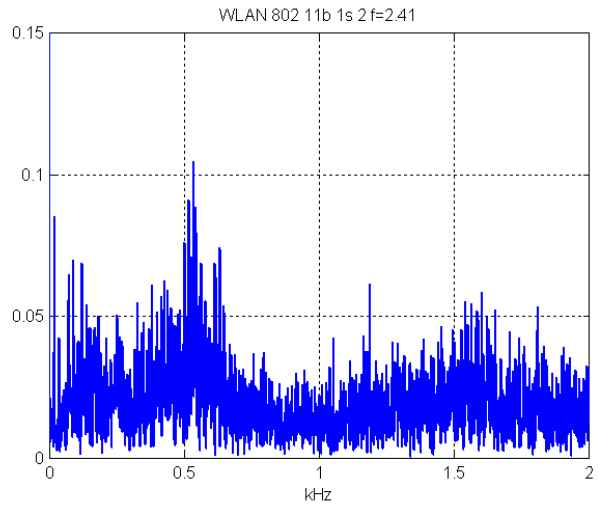
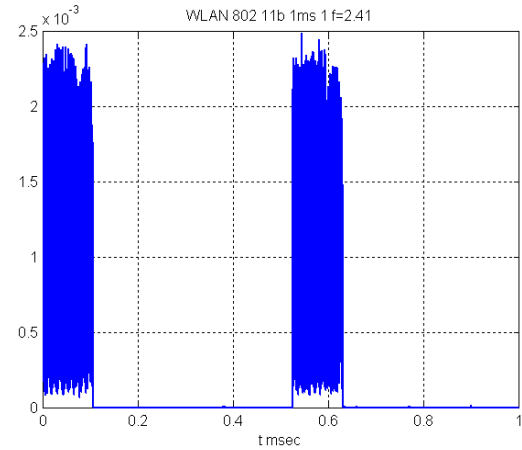
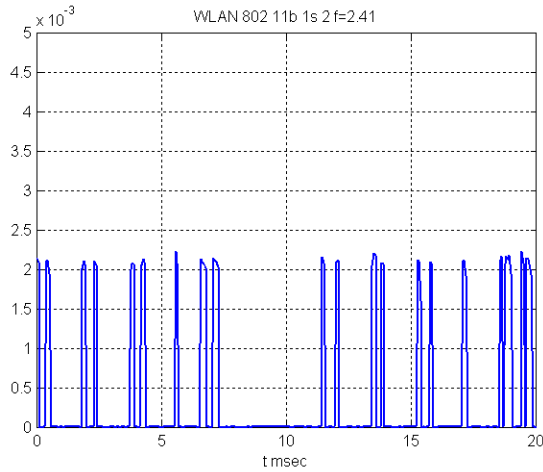
t=0-6,4 ms



The spectrum varies depending on the traffic situation  
Different antenna sites, different time of day.

# WiFi

## 2.45 GHz. Uploading a file, two different time resolutions



T=1 s

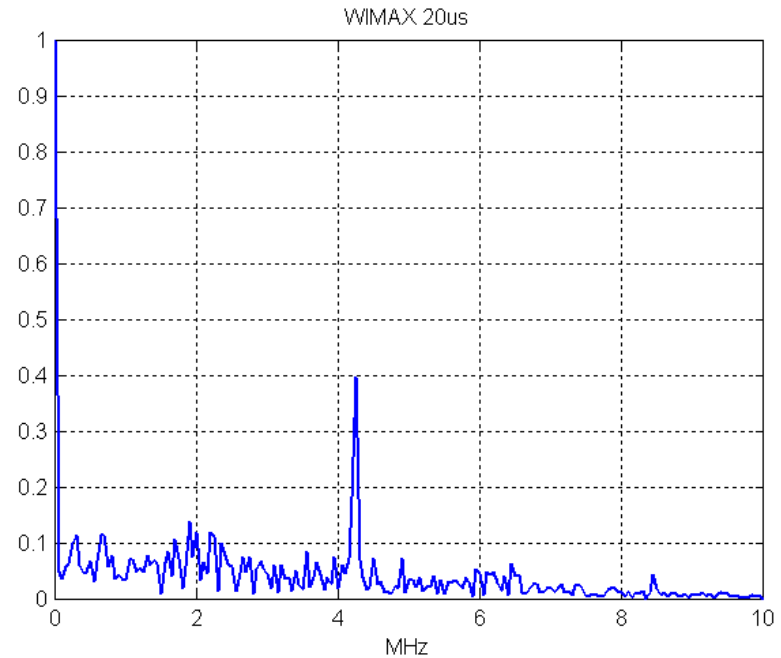
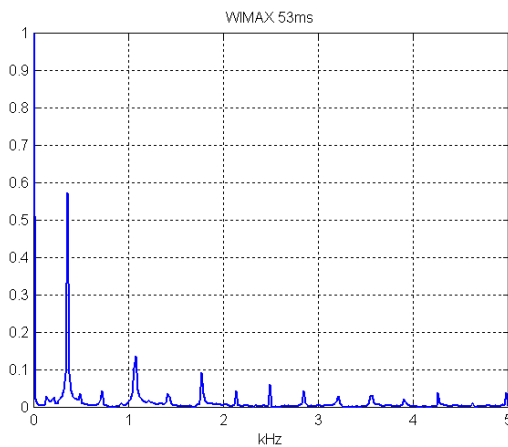
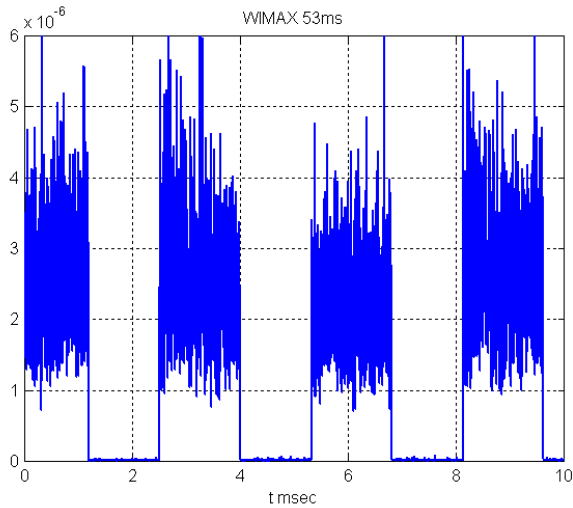
T=1 ms

# WIMAX

20  $\mu$ s window. Frequencies from 0.1 – 7 MHz.

53 ms window, TDD with 350 Hz.

$f=3.5$  GHz, OFDM modulation



	Access	Modulation	Line spectrum	Continuous spectrum
GSM	FDD,TDMA	GMSK	n*(8, 217)	null
WCDMA	FDD,CDMA	QPSK	3.84 MHz	0-3.8 MHz
uplink			1,5 k	
downlink			1,5 k, 15k	
HSPA	CDMA	QPSK, 16QAM		0-3.8 MHz
uplink			1,5k , 500 Hz	
downlink			500 Hz, 15 k	
WiFi	TDD	SS	n*1 MHz	
WIMAX	TDD	OFDM	350 Hz ≈4 MHz	0-6 MHz

## **Conclusion**

**Showing the spectrum of the power is revealing for comparing experimental exposures.**

**Except for GSM the spectral components are increasing in frequency, like 100 Hz, 1.5 kHz ,15 kHz and 3.8 MHz for WCDMA partly due to higher control and pilot frequencies, and non-constant envelopes**

**Similar trends in WiFi and WIMAX**

**Biological significance unknown!**

A more complete report will soon be available from GSMA.