Antenna Design for Modern and Multiband Wireless Systems

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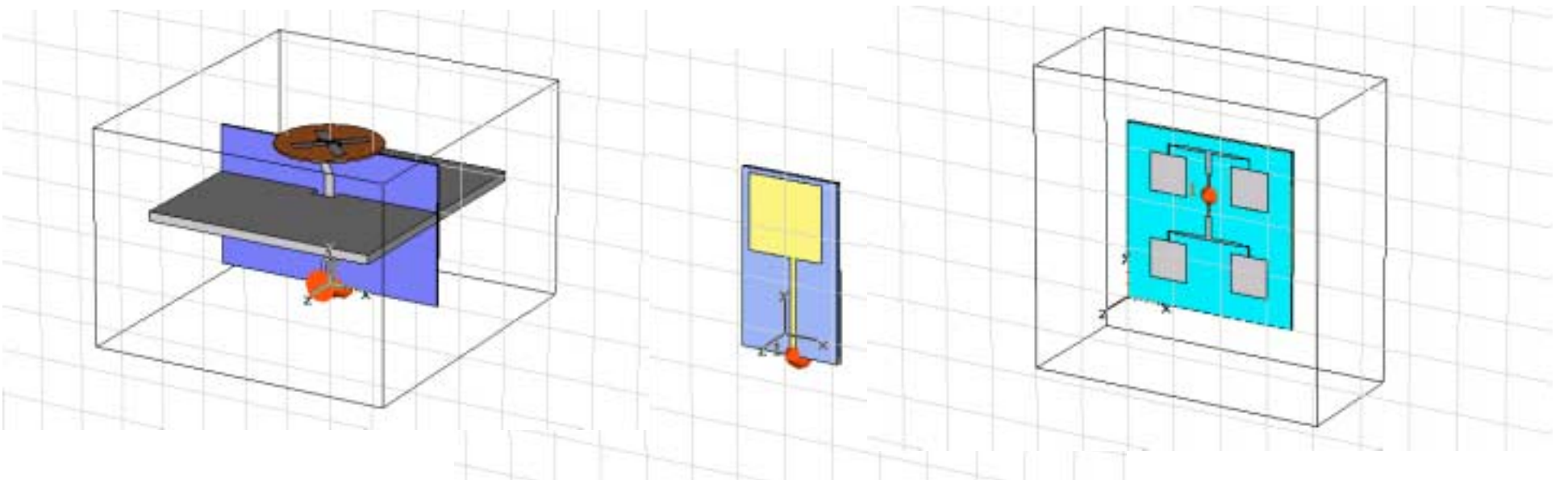
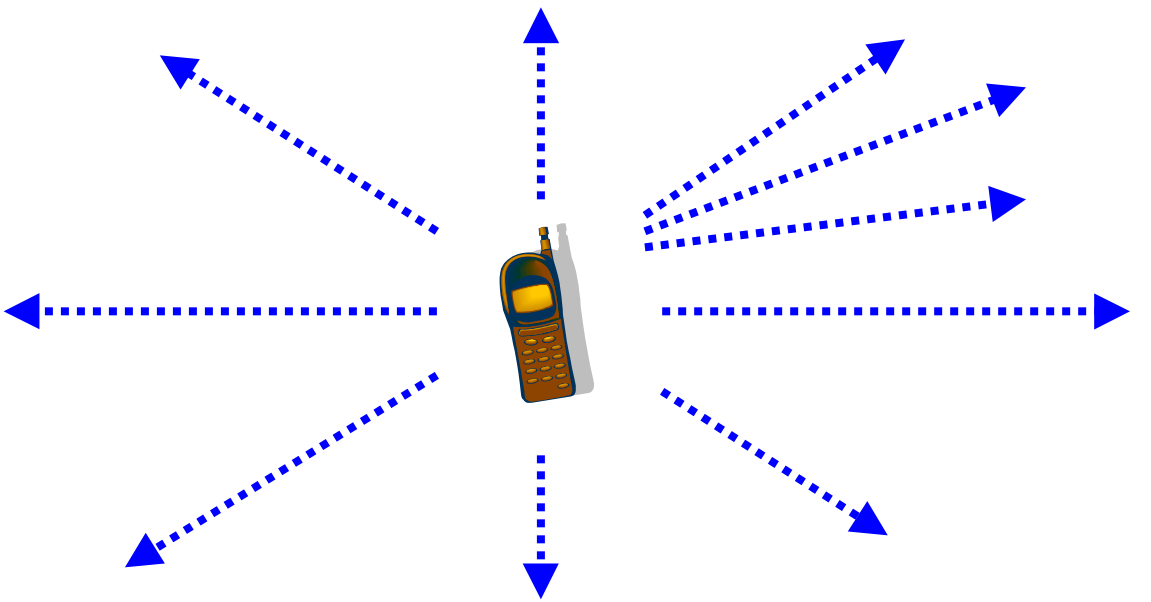


Introduction

- Introduction to antennas
- Bandwidth Requirements for Modern Mobile Systems
- Fundamental parameters
- Dualband operation
- Bandwidth Requirements for Modern Wireless Systems
- Ultrawideband systems
- Future challenges

Antenna Design Objectives

- Broadband Impedance Bandwidth
- Radiation Characteristics
- Small Size
- Low Cost



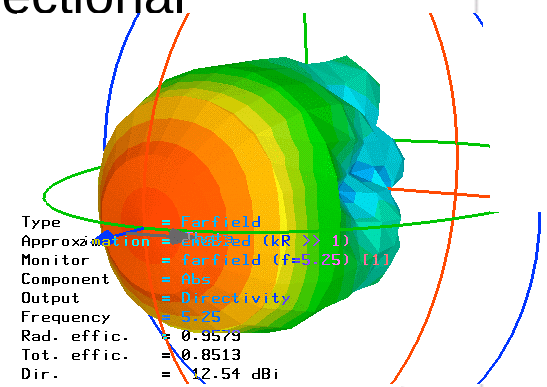
Broadband Antennas

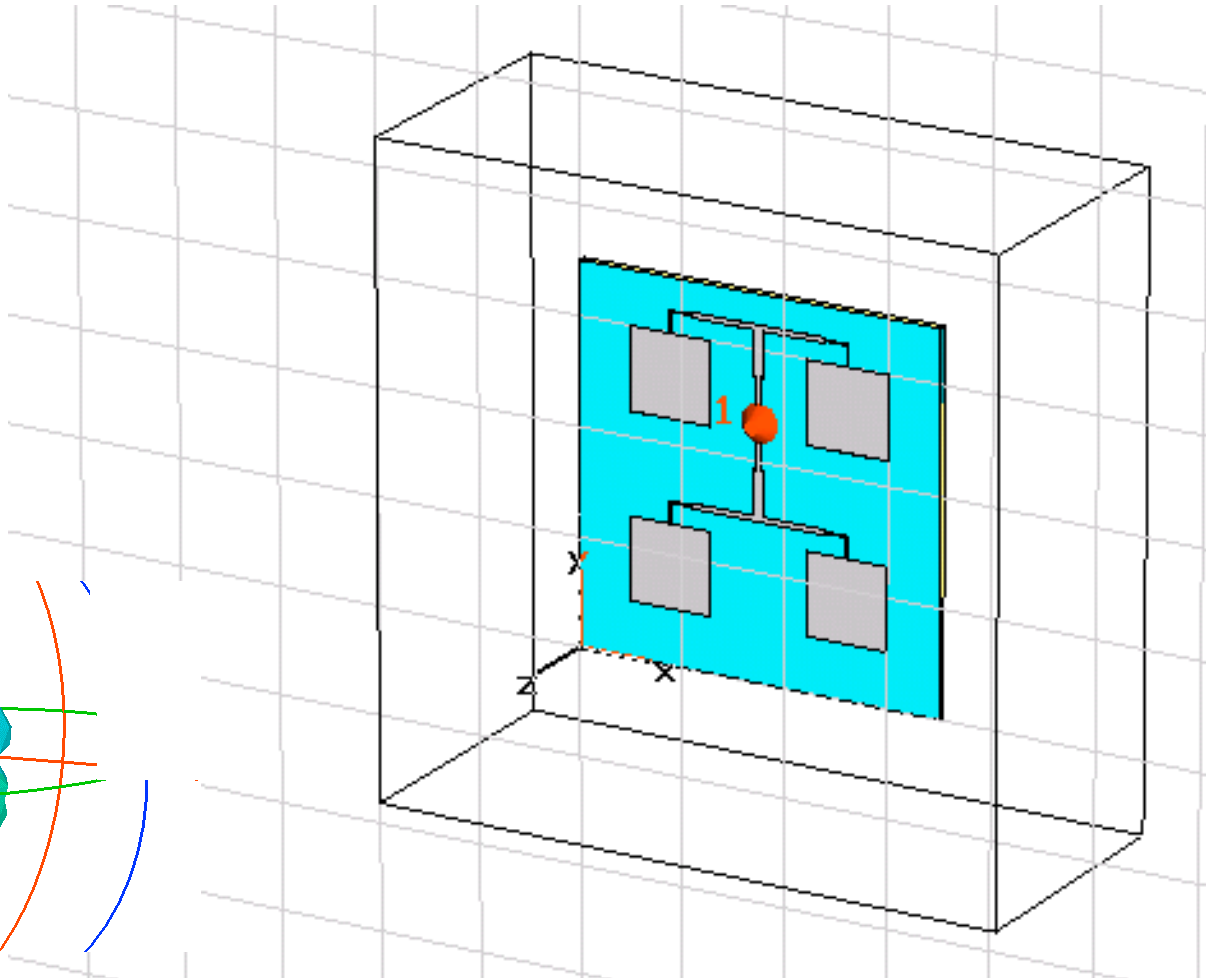
- Antenna bandwidth is a limiting factor in multiband radios

- Options:
  - Different antennas for each frequency
  - Multiband antennas
  - Wideband antennas

Modern antennas

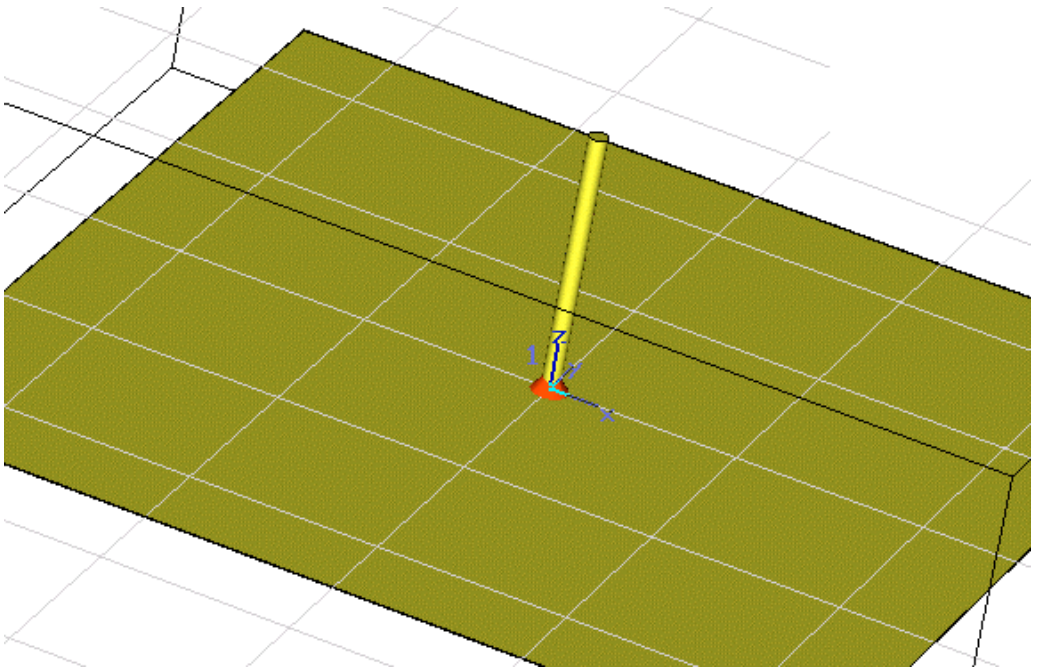
- Microstrip antennas
  - Low profile
  - Conformable
  - Narrow bandwidth
  - Costly
  - Arrayable
  - Directional





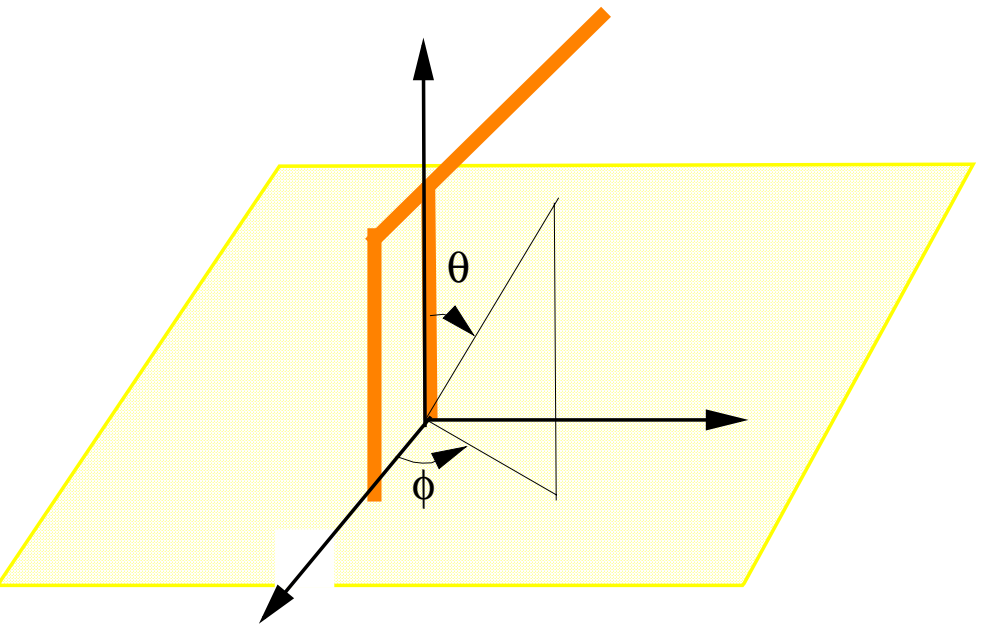
Modern antennas

- Monopole antennas
- Quarterwave
  - broad bandwidth
  - higher profile
  - ground plane dependence
  - low cost
  - onindirectional
- Dielectric-loaded
- Helical

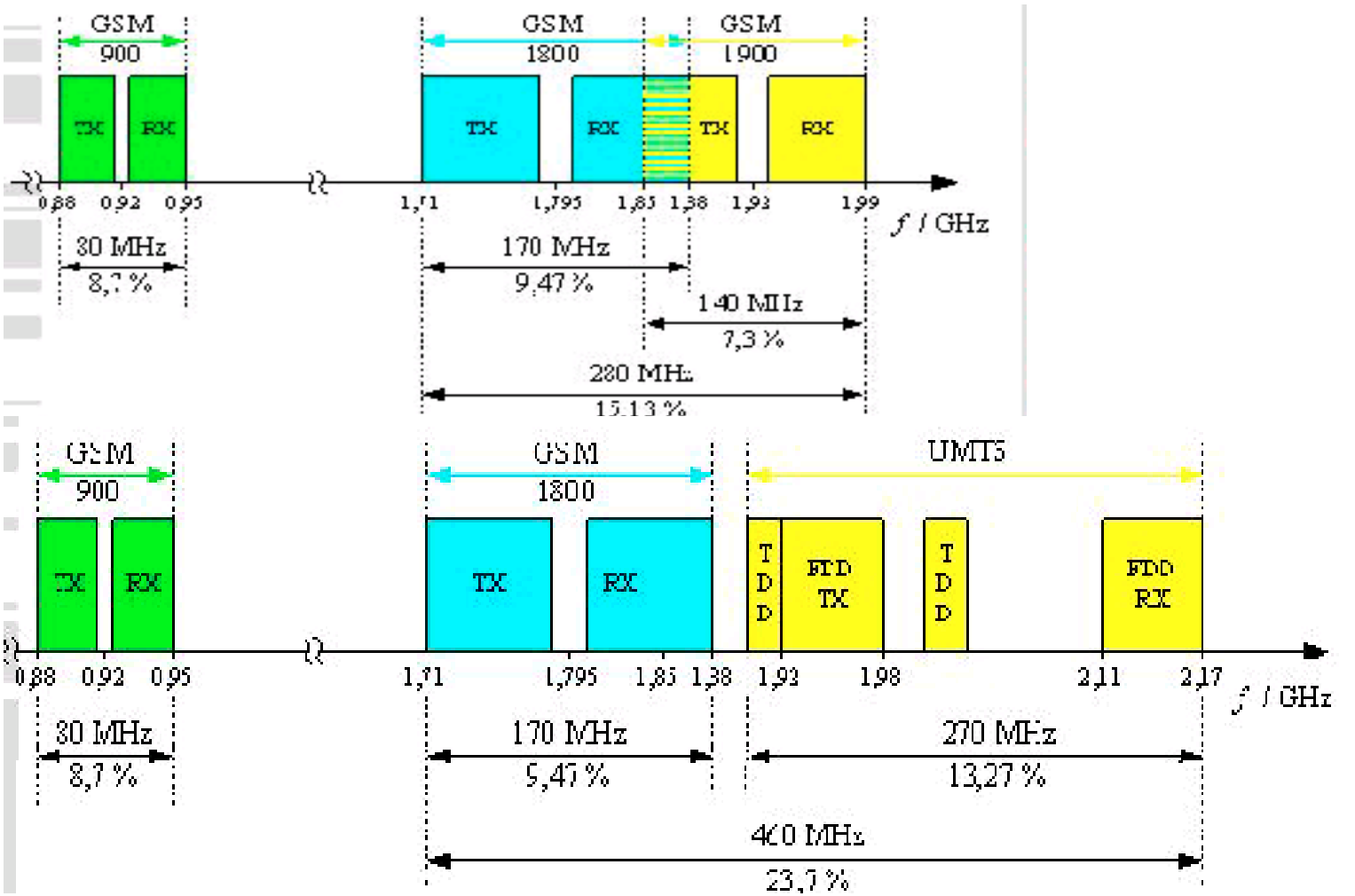


Modern antennas

- Monopole variations
  - smaller size
- Fold-over monopole
- Inverted-F, inverted-L
  - broad bandwidth
  - low profile
  - less groundplane dependence
  - low cost
  - onindirectional



Bandwidth Requirements for Modern Mobile Systems



Antenna fundamentals
Input Impedance

- **Antenna input impedance:** the ratio of voltage to current at the input terminals. It comprises the self and mutual impedance. The latter being due to the nearby conducting surfaces or support structures

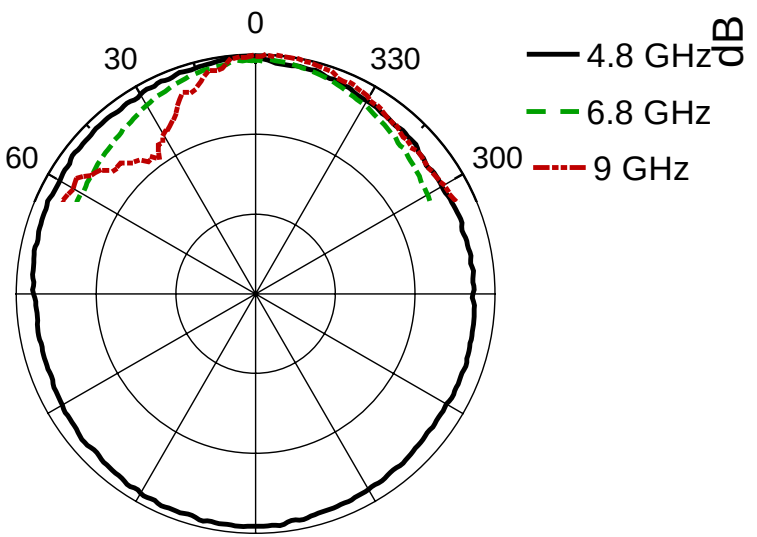
- *R+jX*

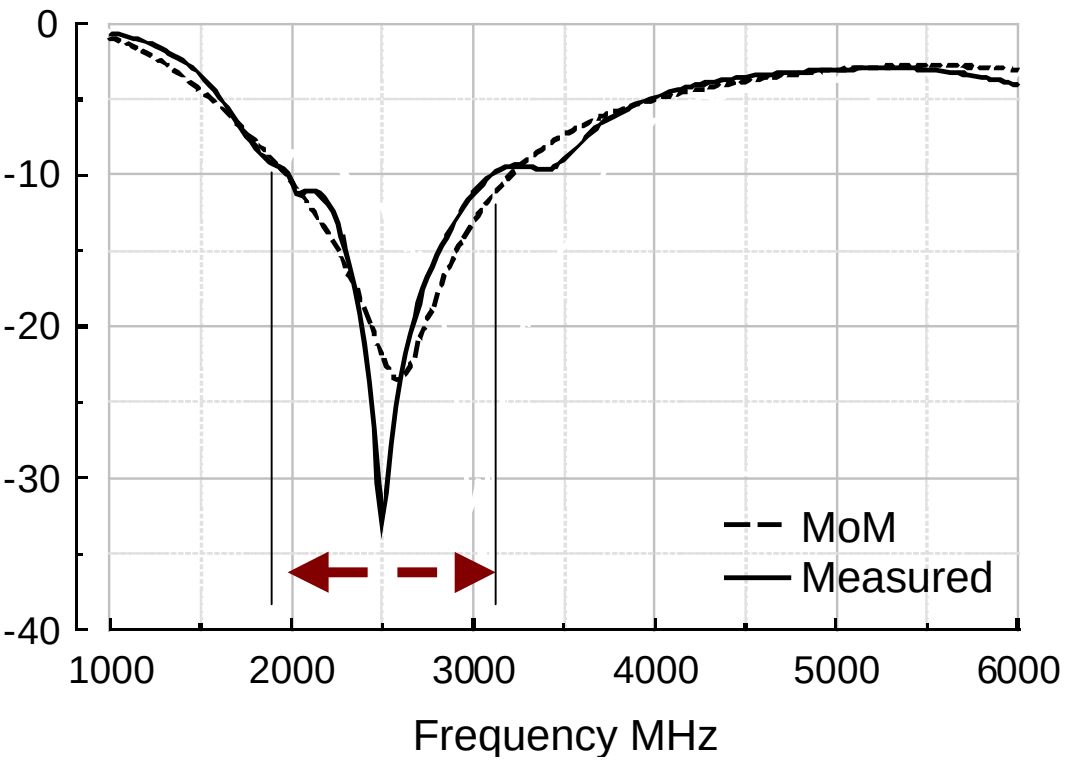
- More commonly VSWR, Return loss, which are all based on reflection coefficient

$$\mathrm{VSWR} = \frac{V_{\max}}{V_{\min}} = \frac{V_i(1+\Gamma)}{V_i(1-\Gamma)} = \frac{1+\Gamma}{1-\Gamma} \qquad \mathrm{RLoss} = -10\log\left|\Gamma^2\right| \mathrm{dB} \qquad \Gamma = \frac{V_r}{V_i}$$

Antenna fundamentals
Bandwidth

- **Impedance bandwidth:** The frequency limits for which the Return Loss (dB), VSWR at the antenna terminals remains below an acceptable value.
- Pattern bandwidth
- Gain bandwidth

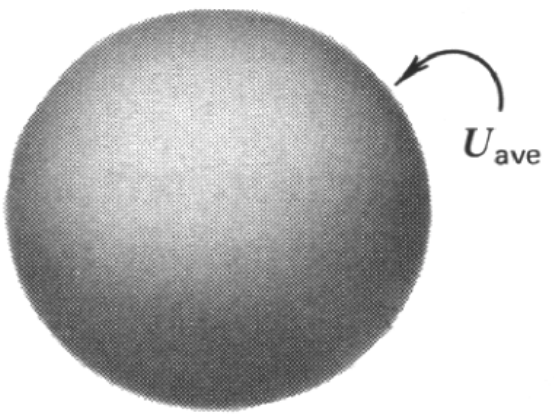


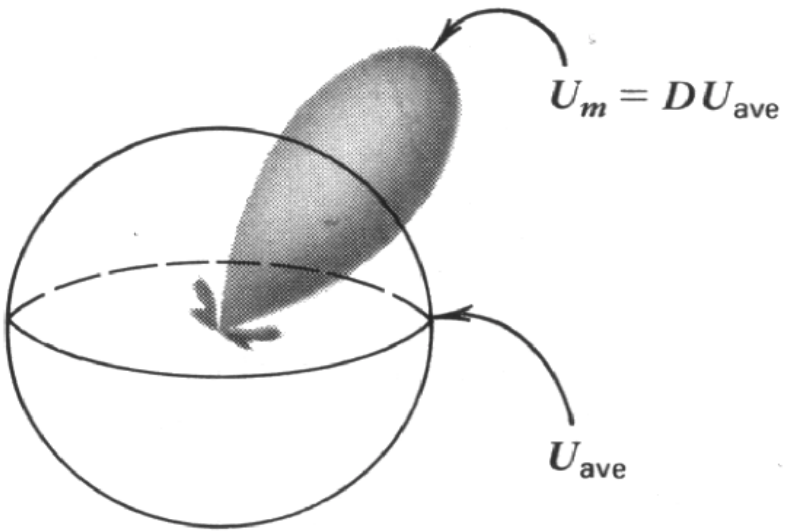


Antenna gain and directivity

Directivity $$D = \frac{U_{\max}}{U_{ave}} = \frac{4\pi U_{\max}}{P_{rad}}$$

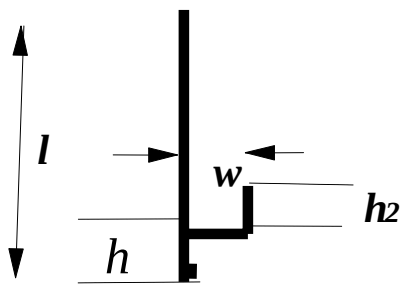
where U = radiation intensity

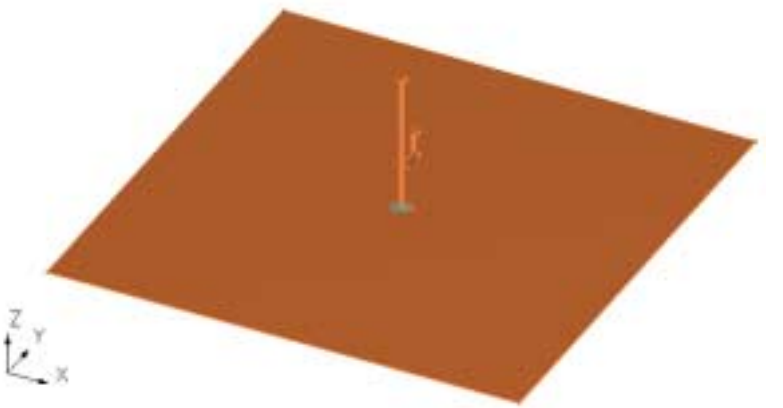




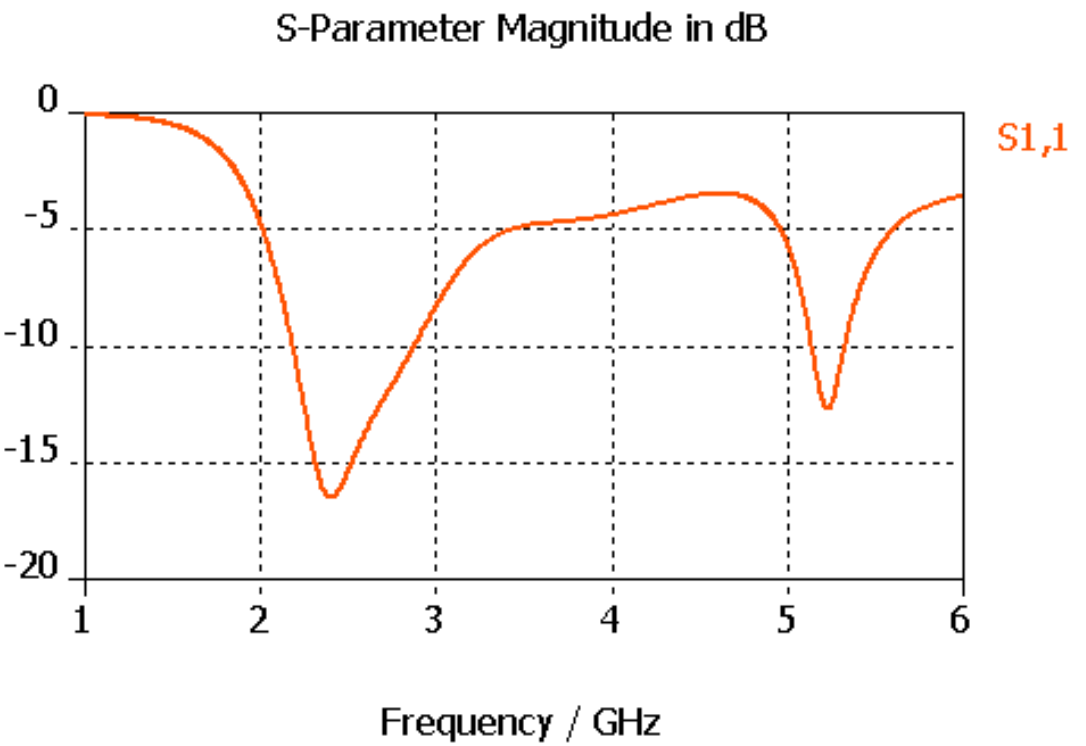
Multiband operation of antennas

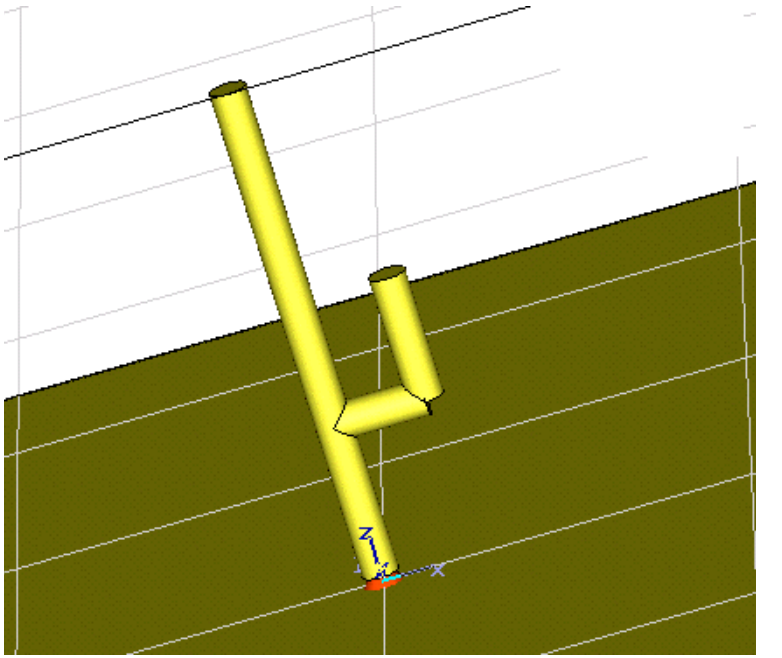
- A dual resonance must exist
- Create two paths for the RF currents
- Minimum interaction between modes
  - Impedance matching
  - Radiation pattern
- Single feed mechanism





Multiband operation of antennas

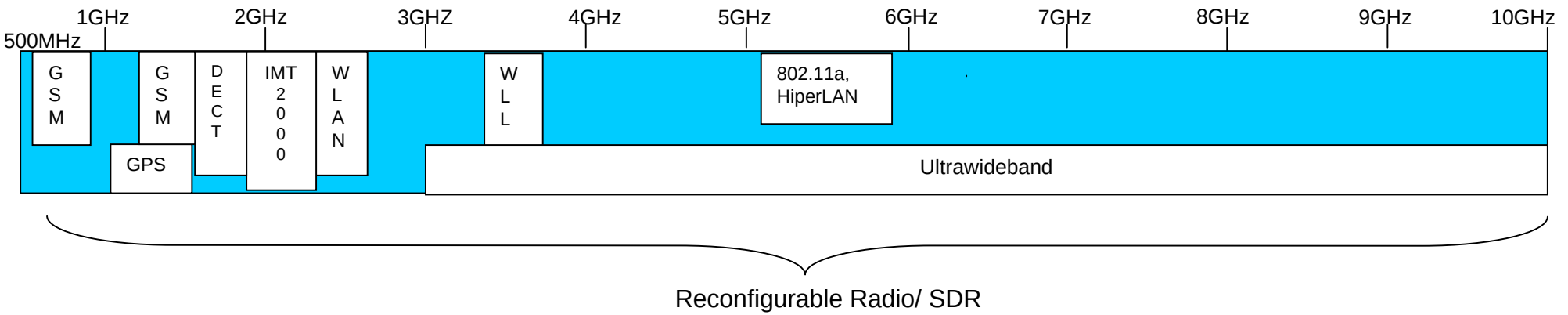




Bandwidth Requirements for Modern Wireless Systems

- Software Defined Radio:
  - Multiple different services
  - Multiple different bands

Radiocommunications Spectrum – from 500MHz to 10GHz



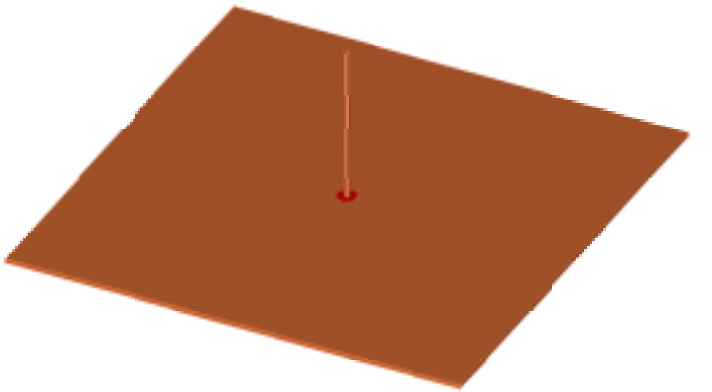
- Antenna must operate across these bands

Printed elements for integration

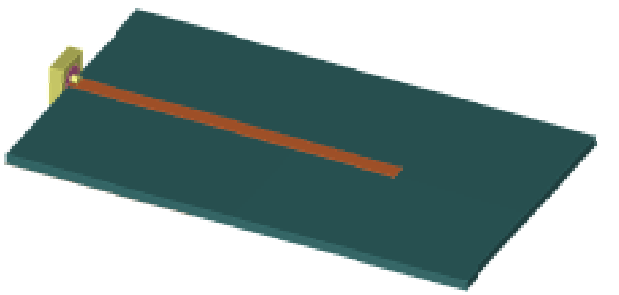
- Monopole printed on dielectric substrate,
- FR4 for low-cost, microwave laminate for high performance
- Ground plane on back of substrate
- Possible to integrate antrenna onto PA/Rx board
- Environment needs to be considered
  - case and other components
  - human proximity
  - SAR issues

Printed monopole (Single frequency)

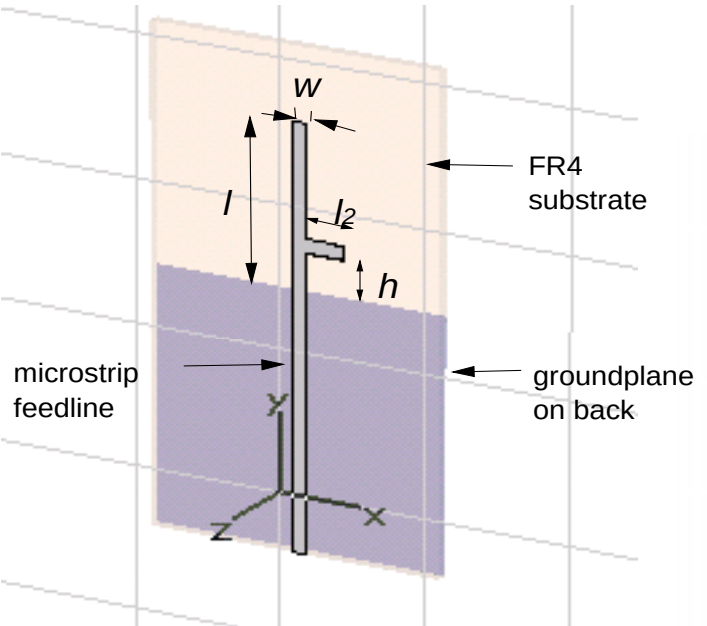
- Thick-wire monopole antenna

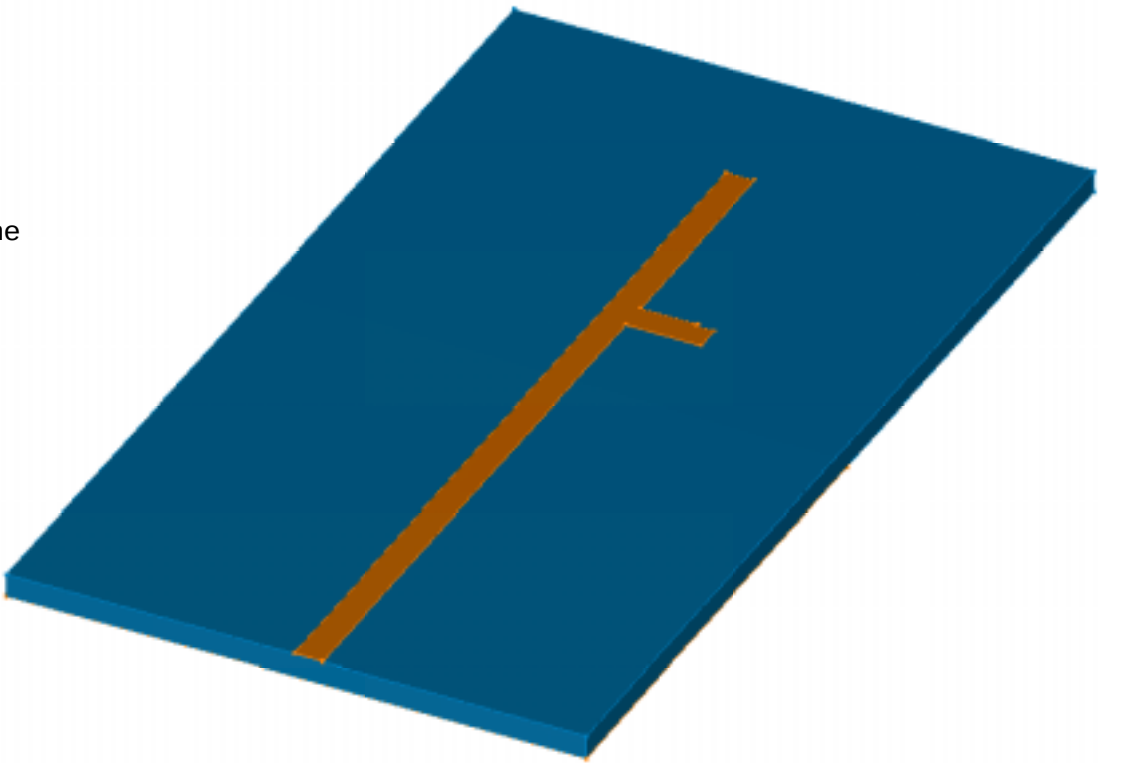


- Printed monopole antenna



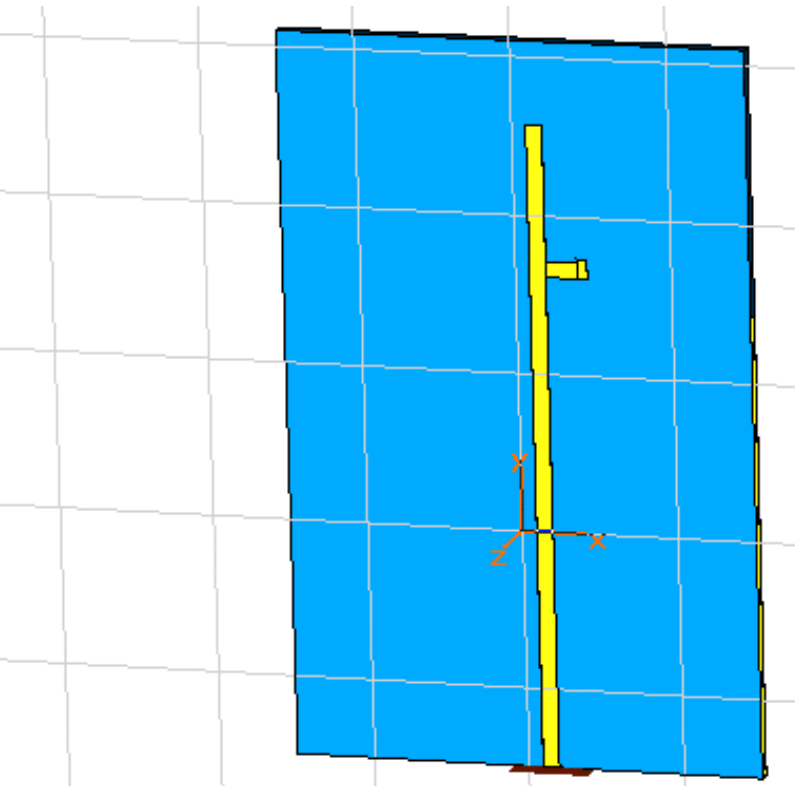
Printed Dual-band Monopole Antenna

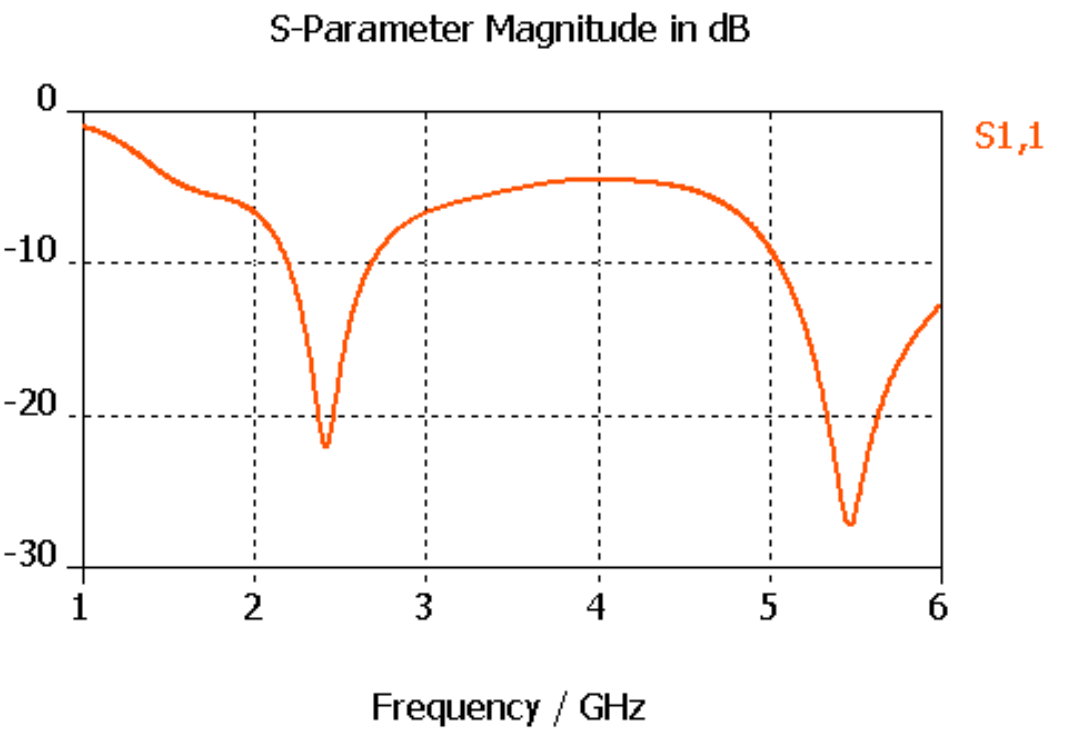




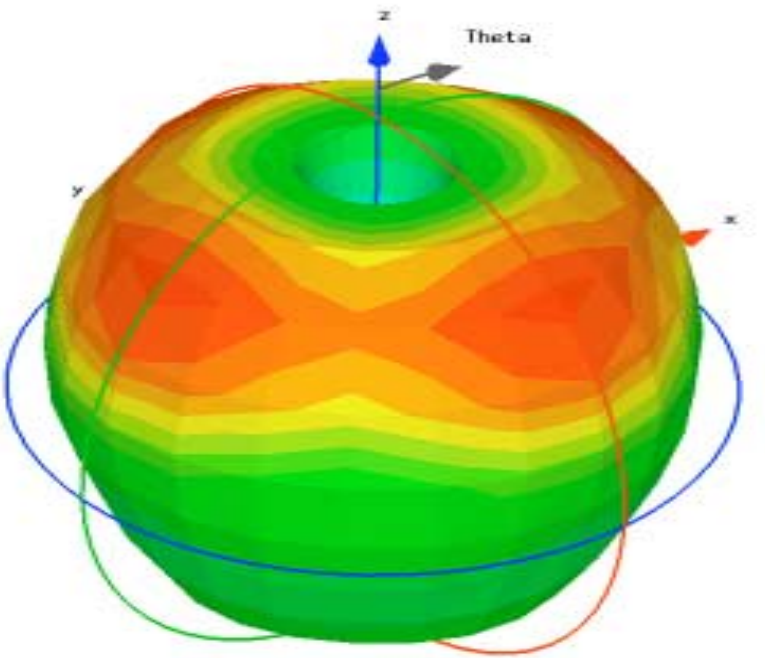
Dual band monopole for integration

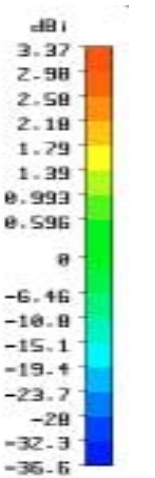
- Covers 2.2 - 2.6 GHz and 5.0 - 6.1 GHz,
- IEEE 802.11a, b, g, + ISM band





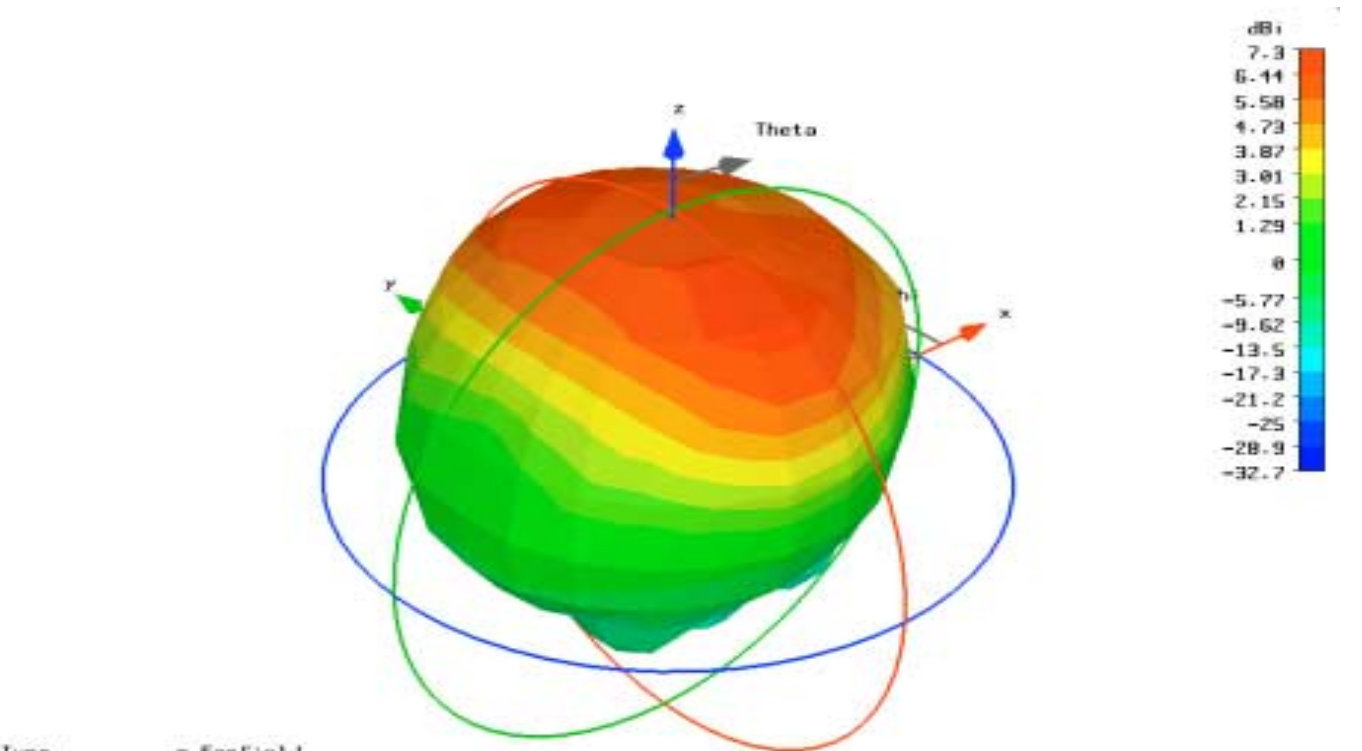
Radiation characteristic for dual-monopole at 2.45 GHz





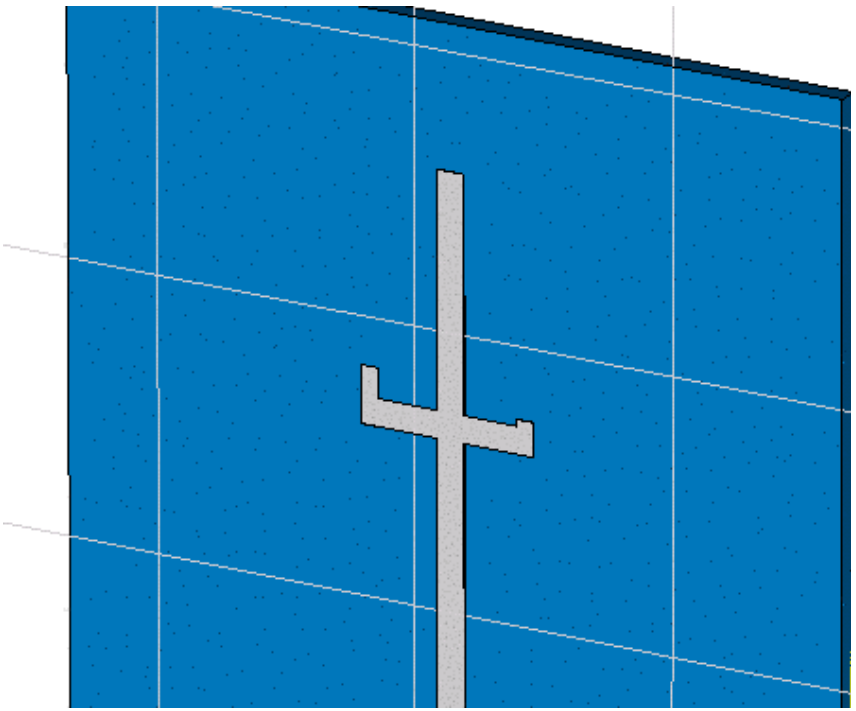

```
Type           = Farfield
Approximation  = enabled (kR >> 1)
Monitor        = farfield (f=2.45) [1]
Component      = Abs
Output         = Directivity
Frequency      = 2.45
Rad. effic.    = 0.9959
Tot. effic.    = 0.9719
Dir.           =  3.375 dBi
```

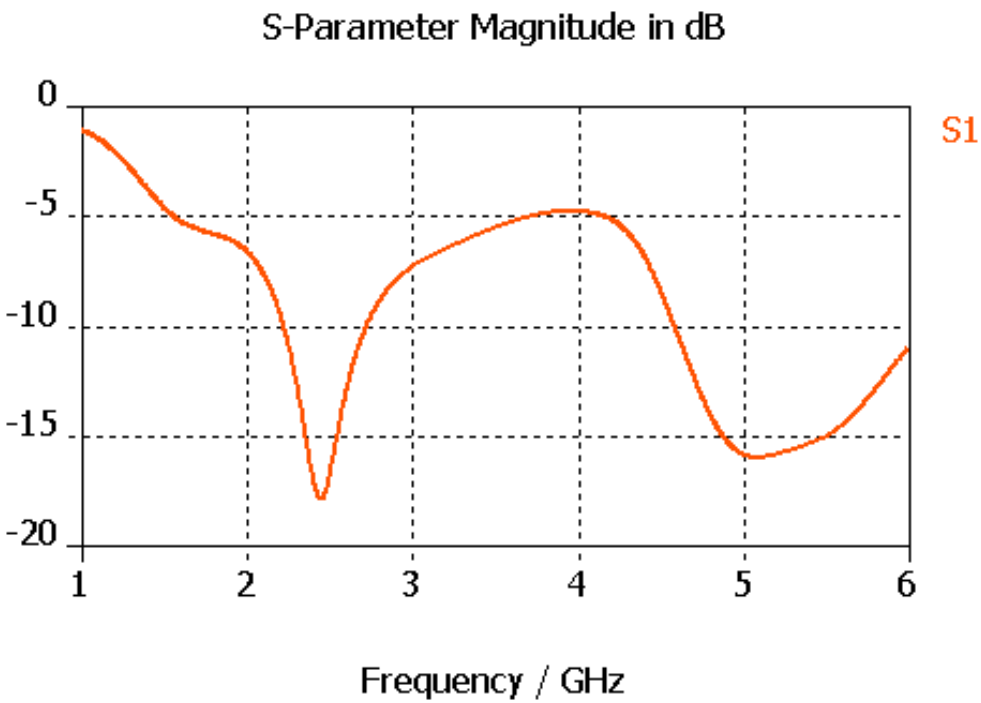
Radiation characteristic for dual-monopole at 5.25 GHz



Stagger-tuned Dual band monopole for integration

- Covers 2.2 - 2.7 GHz and 4.6 - 6.2 GHz,
- IEEE 802.11j also - triple band





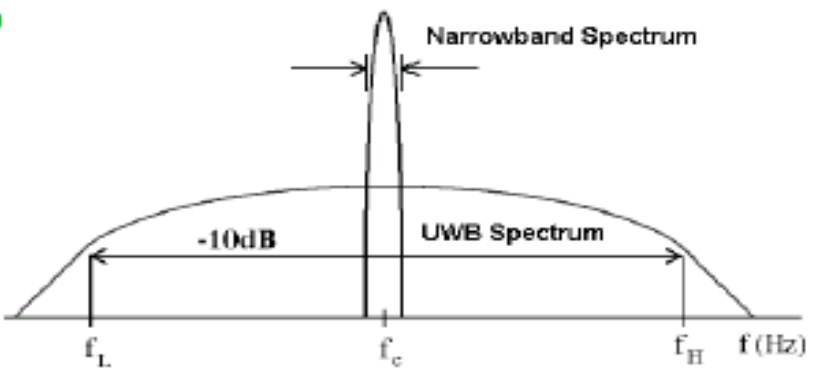
UltraWideBand systems

- Definition

⇩ **A radio-communication system with:**

- A fractional Bandwidth ≥ 25%

$$2\frac{f_H - f_l}{f_H + f_l} \geq 0.25$$

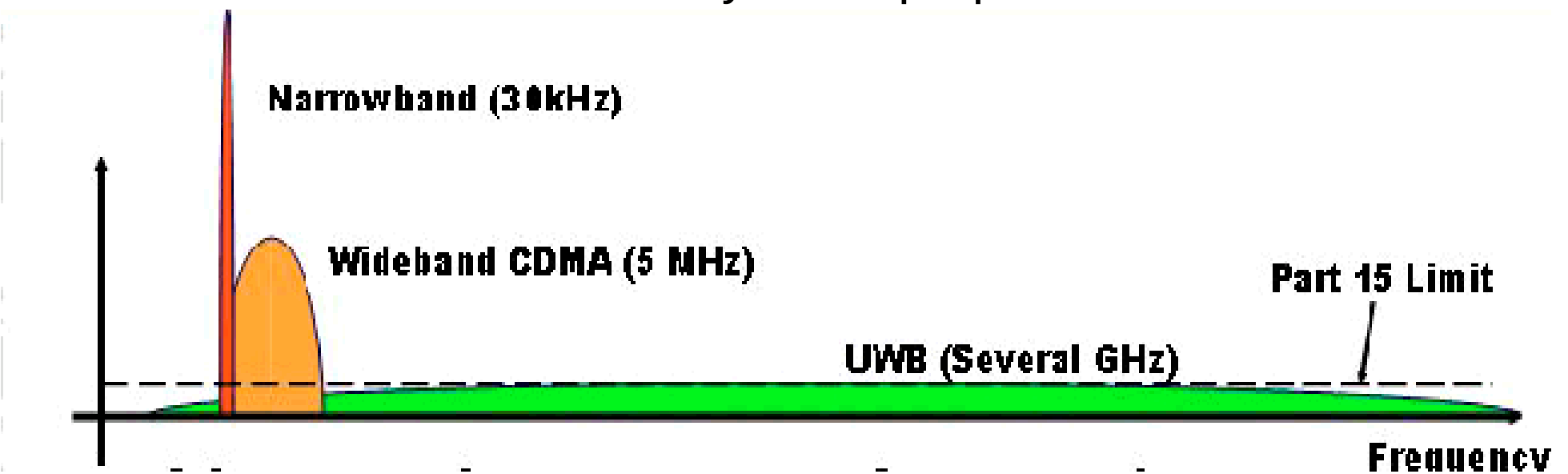


- Or, a Bandwidth ≥ 500 MHz

→ UWB is a means of accessing 7500 MHz of unlicensed spectrum

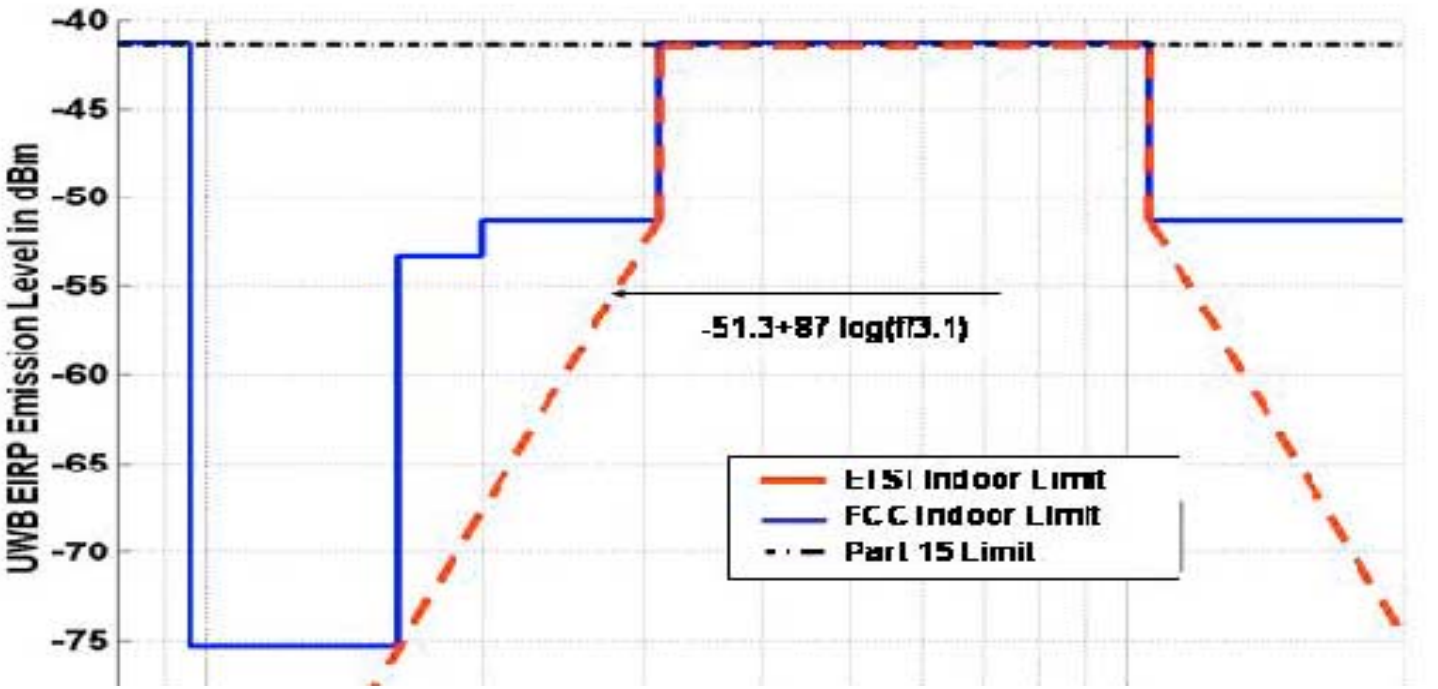
UltraWideBand systems

- RF energy spread over many GHz of spectrum
- Wider than any NB system by orders of magnitude
- Look like random noise by conventional systems
- Pulse based and OFDM systems proposed



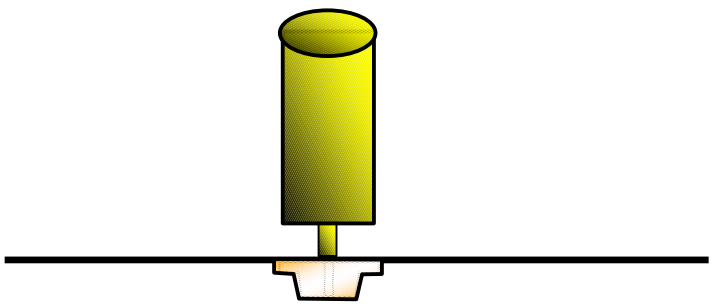
UWB Mask

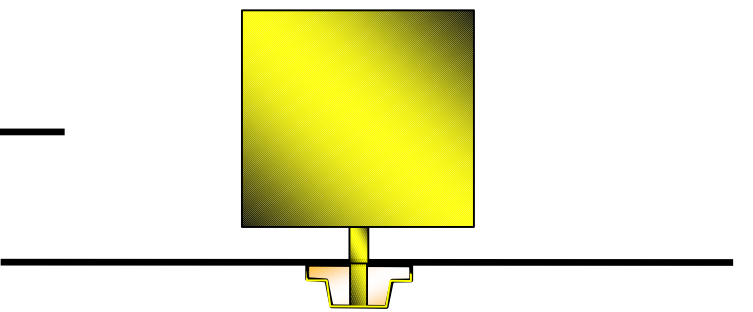
- Frequency range
- Draft Spec Mask (Europe)

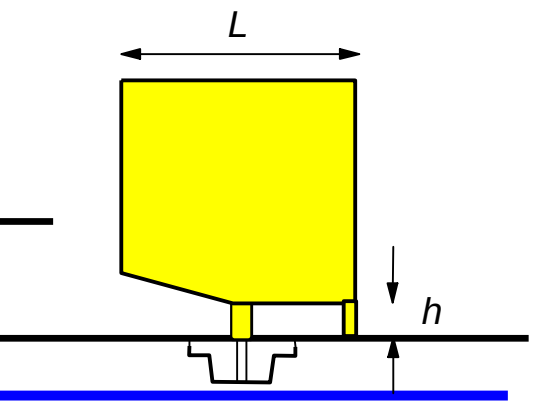


UltraWideband systems

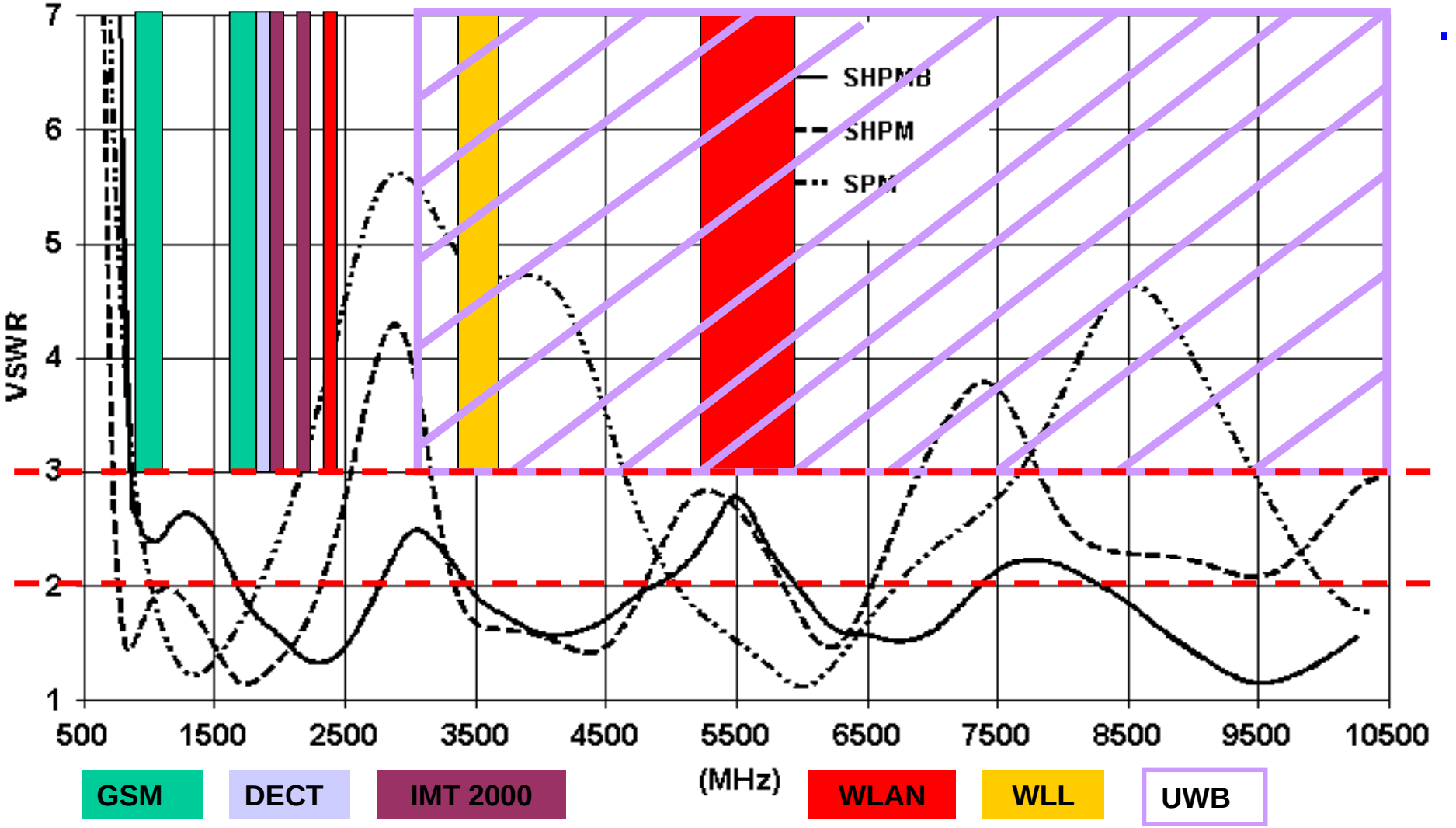
- Planar monopole antenna
  - Broadbanding techniques
  - Ultrawide impedance bandwidth
- Time domain (ringing) must be also considered
- IEEE 802.11 a,b,g,j IEEE 802.15.3a, 4a (3.1-10.5 GHz)



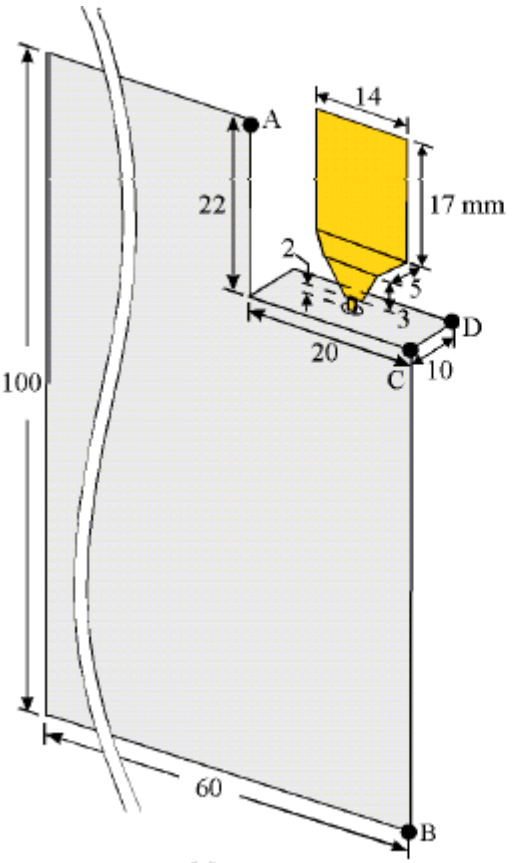




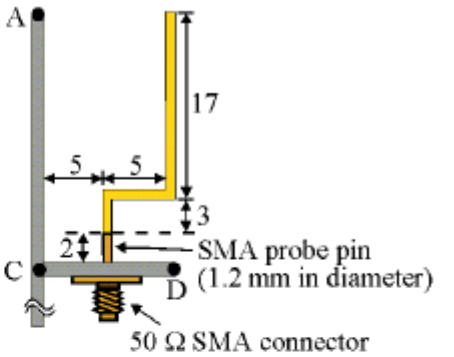
Planar monopole performance



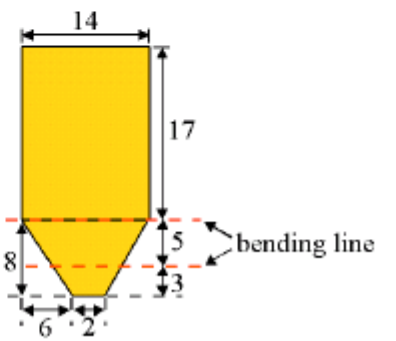
Planar monopole on handset



(a)



(b) side view from $\overline{BC}$



(c) planar structure

SIMO / MIMO / Future Challenges

- MIMO : Parallel transmission of several data streams at the same time and frequency, only separated by the spatial domain.
- As well as improving capacity, MIMO may also improve the SAR issue for handsets.

- Handset / portable device
- To develop small antennas, positioned in a small space
- To have low correlation of radiation patterns
- To have isolation between elements in excess of 20 dB

Thank You

Danke Schoen

Go raibh maith agaibh