Advanced Planar Antenna Designs for Wireless Devices

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Introduction (1)

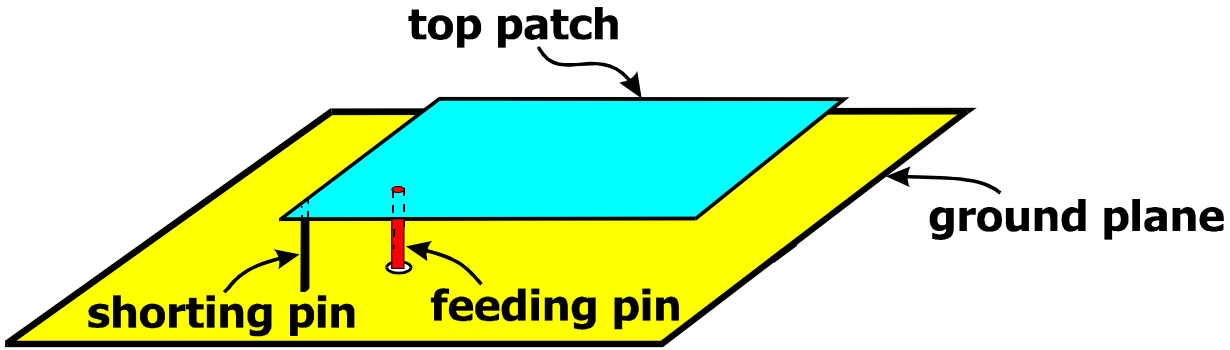
- **Wireless Communication devices**
  - **Cellular phones (bar type, folder type)**
  - **Laptops or Tablet PCs**
  - **Personal digital assistants (PDAs)**
  - **WLAN in-building access points (on-ceiling, on-wall, or-desk)**
- **Operating bands**
  - **AMPS, GSM, DCS, PCS, UMTS, etc. (850, 900, 1800, 1900, 2050 MHz bands, etc.)**
  - **WLAN band (2.4, 5.2, 5.8 GHz)**
  - **Ultra-wide band (3.1~10.6 GHz)**

Introduction (2)

- **Some Promising planar antenna types**
  - **Planar inverted-F antennas (PIFAs)**
  - **Very-low-profile monopoles (bent, folded)**
  - **Printed monopole/dipole antennas**
  - **Metal-plate antennas (constructed using line-cutting or stamping)**
  - **Slot antennas (stamped from metal or integrated with system ground plane)**
  - **folded dipole antenna**
  - **Ceramic chip antennas (SMT devices)**

Conventional PIFAs

- **Conventional PIFAs comprise: a top patch, a shorting pin, and a feeding pin.**

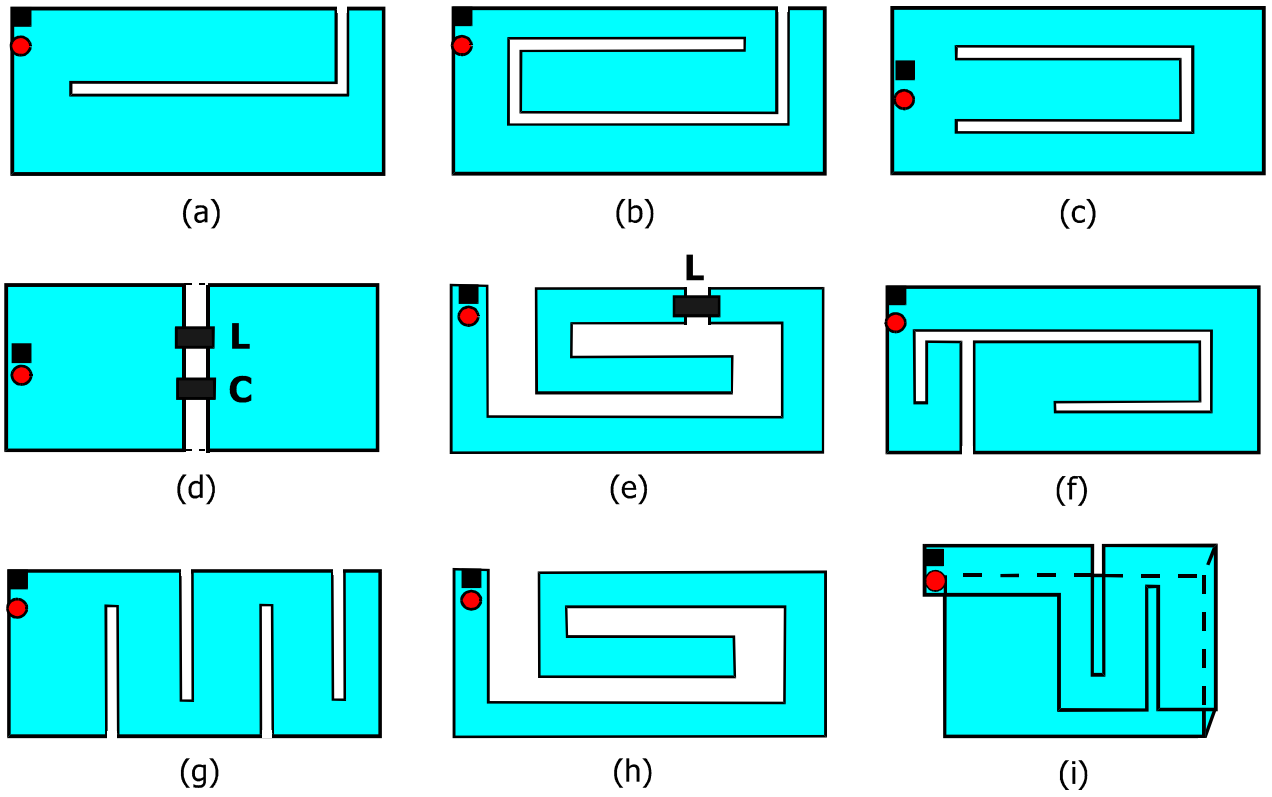


The top patch is mounted above a ground plane;

The shorting pin and feeding pin, connected at proper positions to the top patch, have the same length as the distance between the top patch and the ground plane

Some dual-frequency top patches for PIFAs

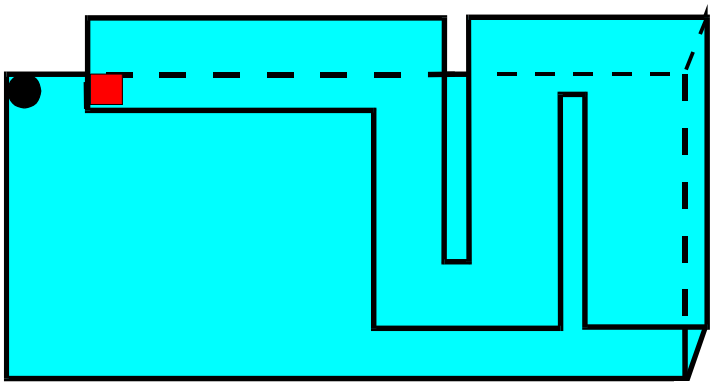
These top patches are mainly printed on a thin dielectric substrate, and then supported above a ground plane

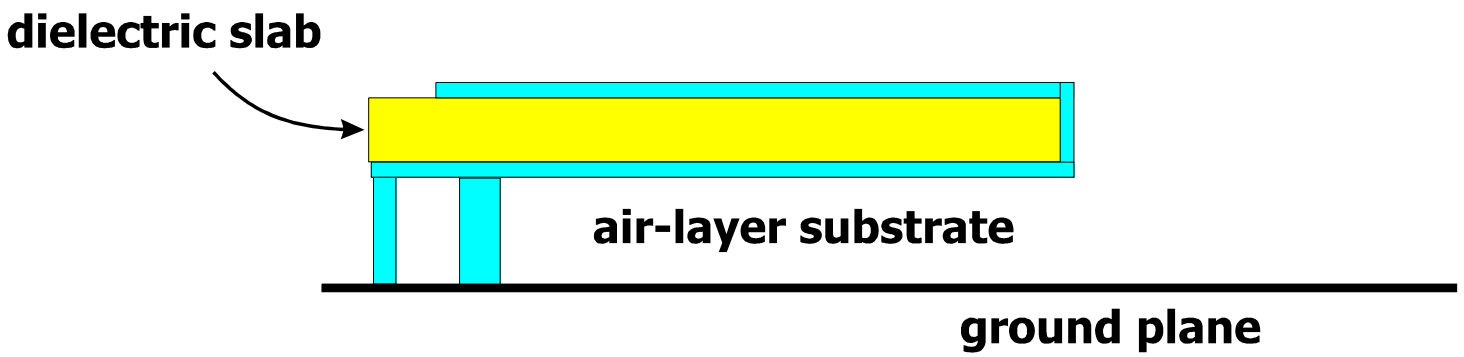


PIFA- Folded top patch, stamped from a metal plate

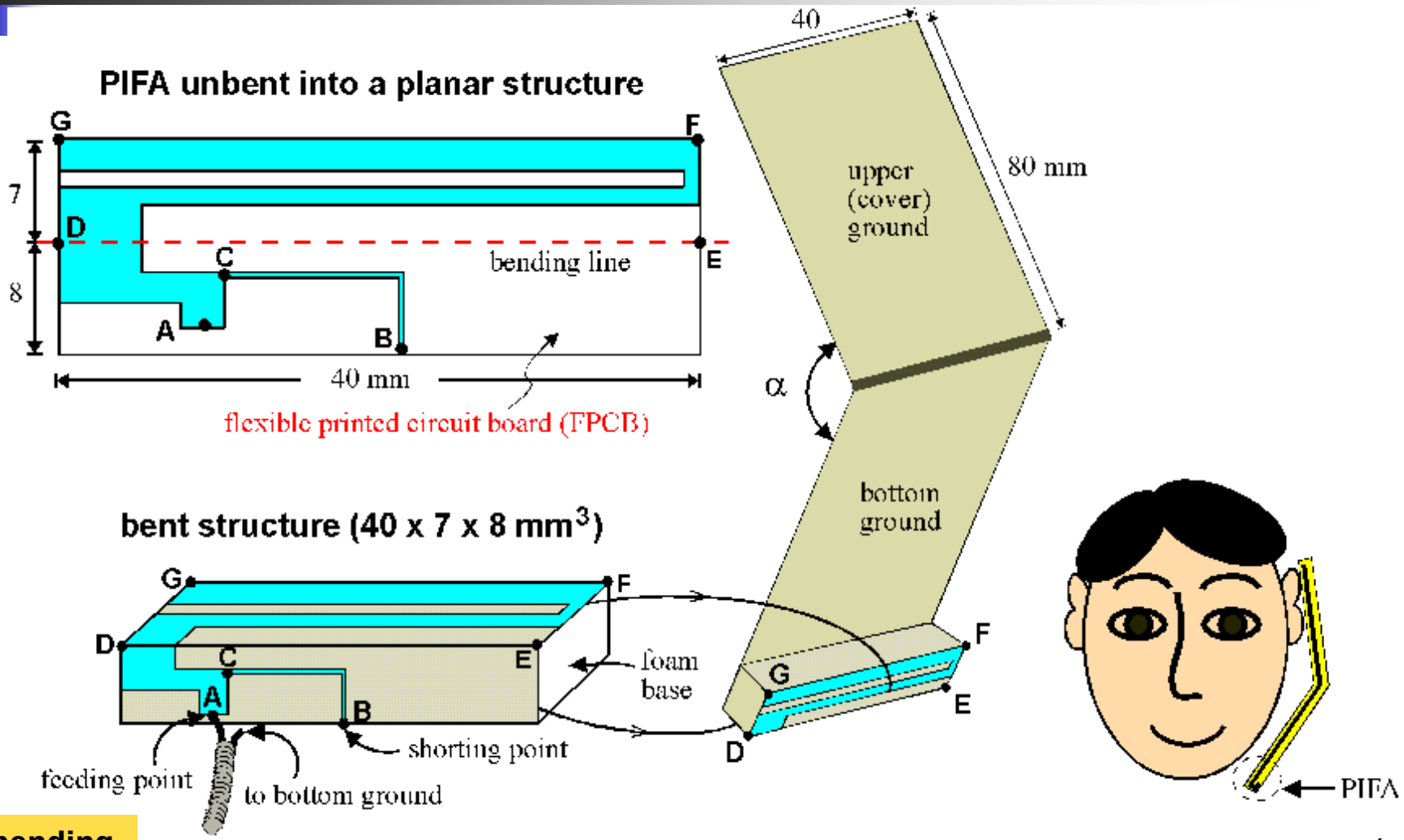
Patch stamped from a single metal plate;

Then folded and attached to two sides of a dielectric slab





PIFA- PIFA printed on an FPCB



Patent pending

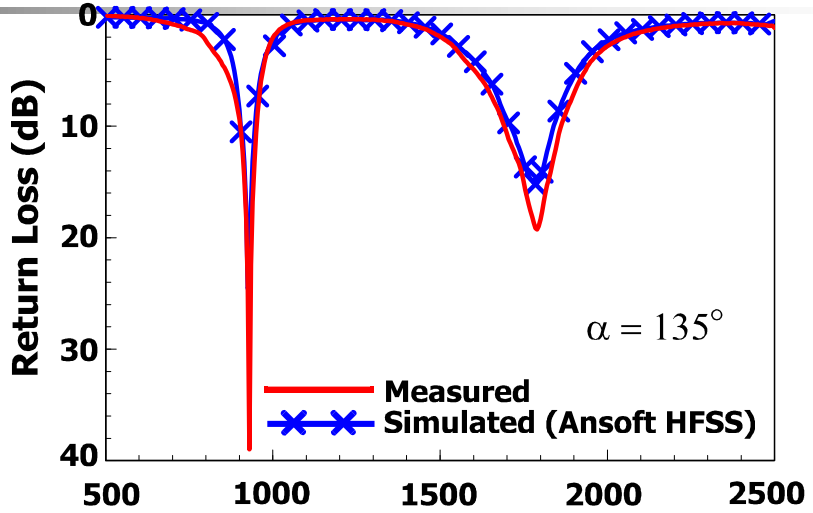
PIFA- PIFA printed on an FPCB

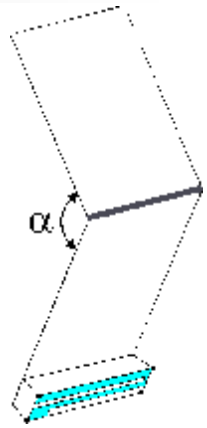
Length of the meandered radiating arm is ~ 95 mm, about 0.25λ at 900 MHz

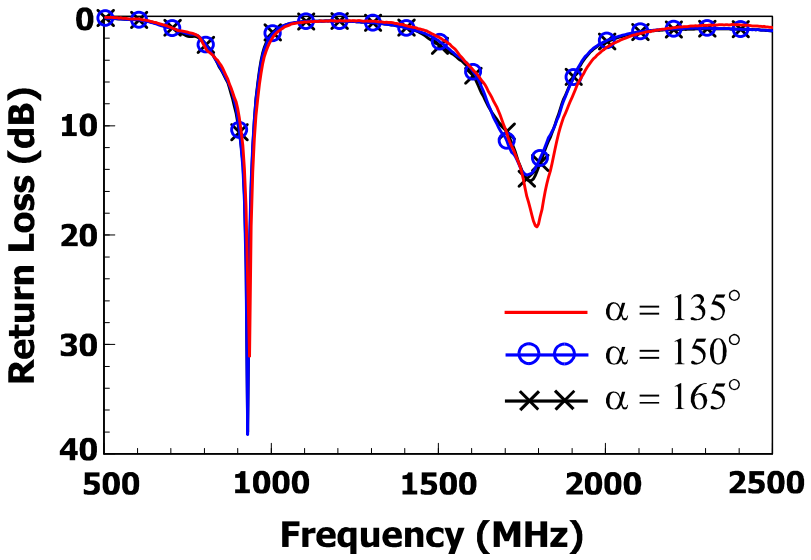
BW (2.5:1 VSWR) covers the GSM and DCS bands;

Gain about 0.5-1.4 dBi for GSM band,

and about 1.3-3.2 dBi for DCS band

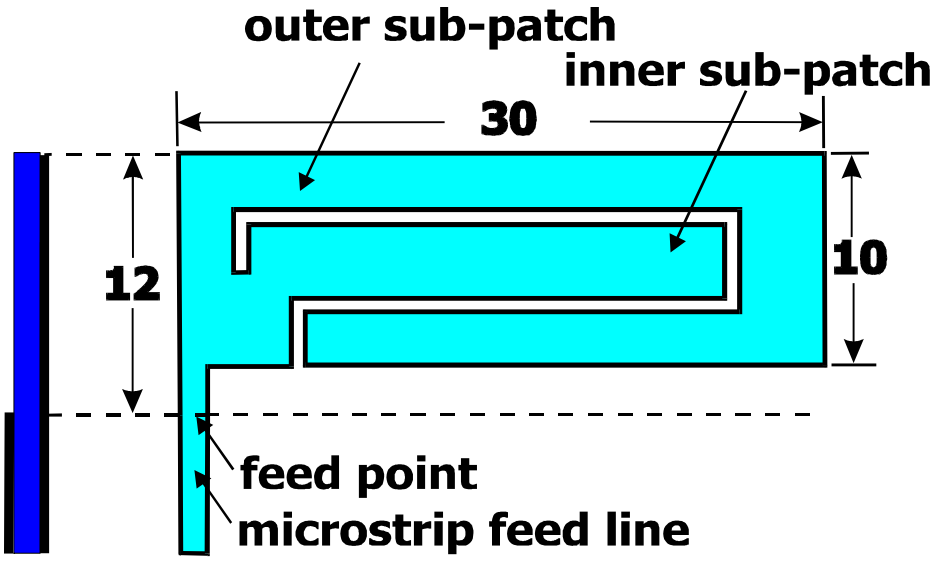


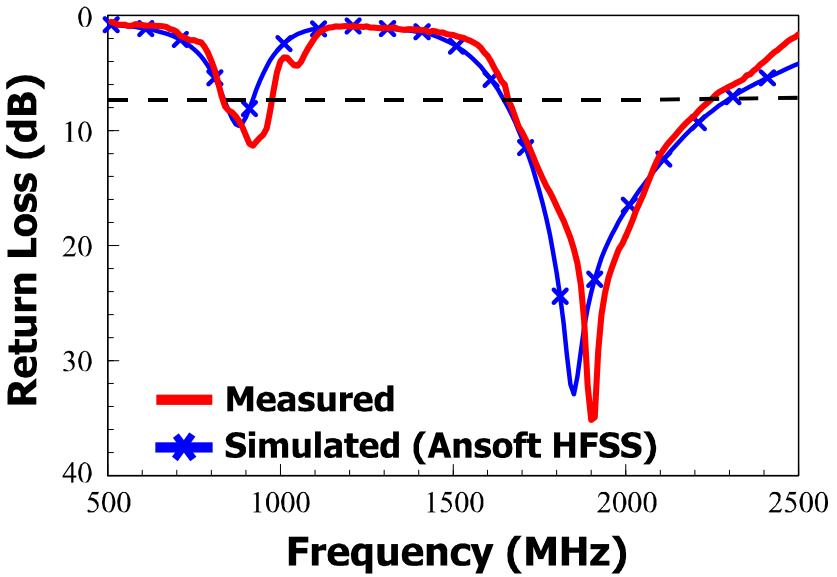




Very-Low-Profile Monopole 1-Planar monopole with slits

- **Inner sub-patch** resonates at 0.25λ for upper band; **outer sub-patch** at 0.25 and 0.5λ for lower and upper bands

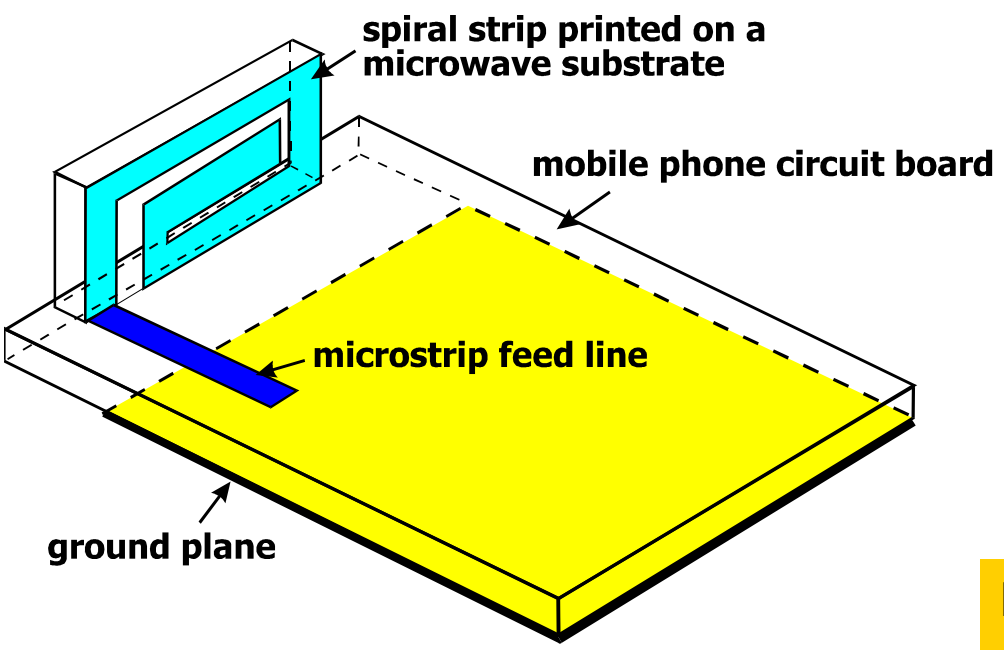


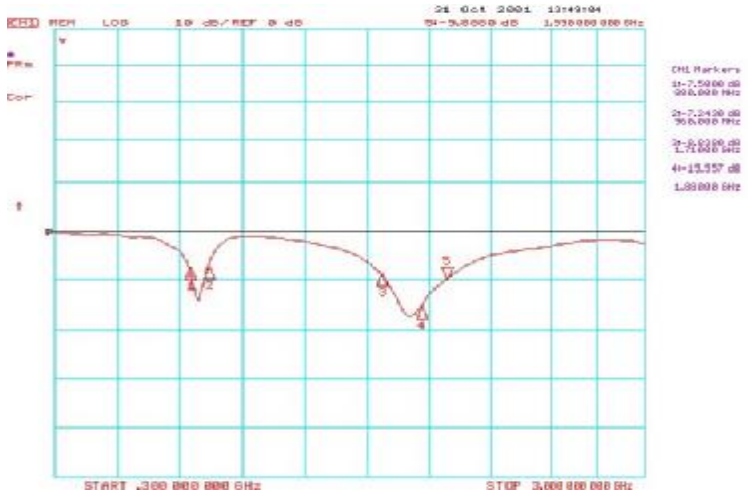


TW Patent Pub 523963

Very-Low-Profile Monopole 2-Planar spiral monopole

- Placing monopole in perpendicular to the circuit board





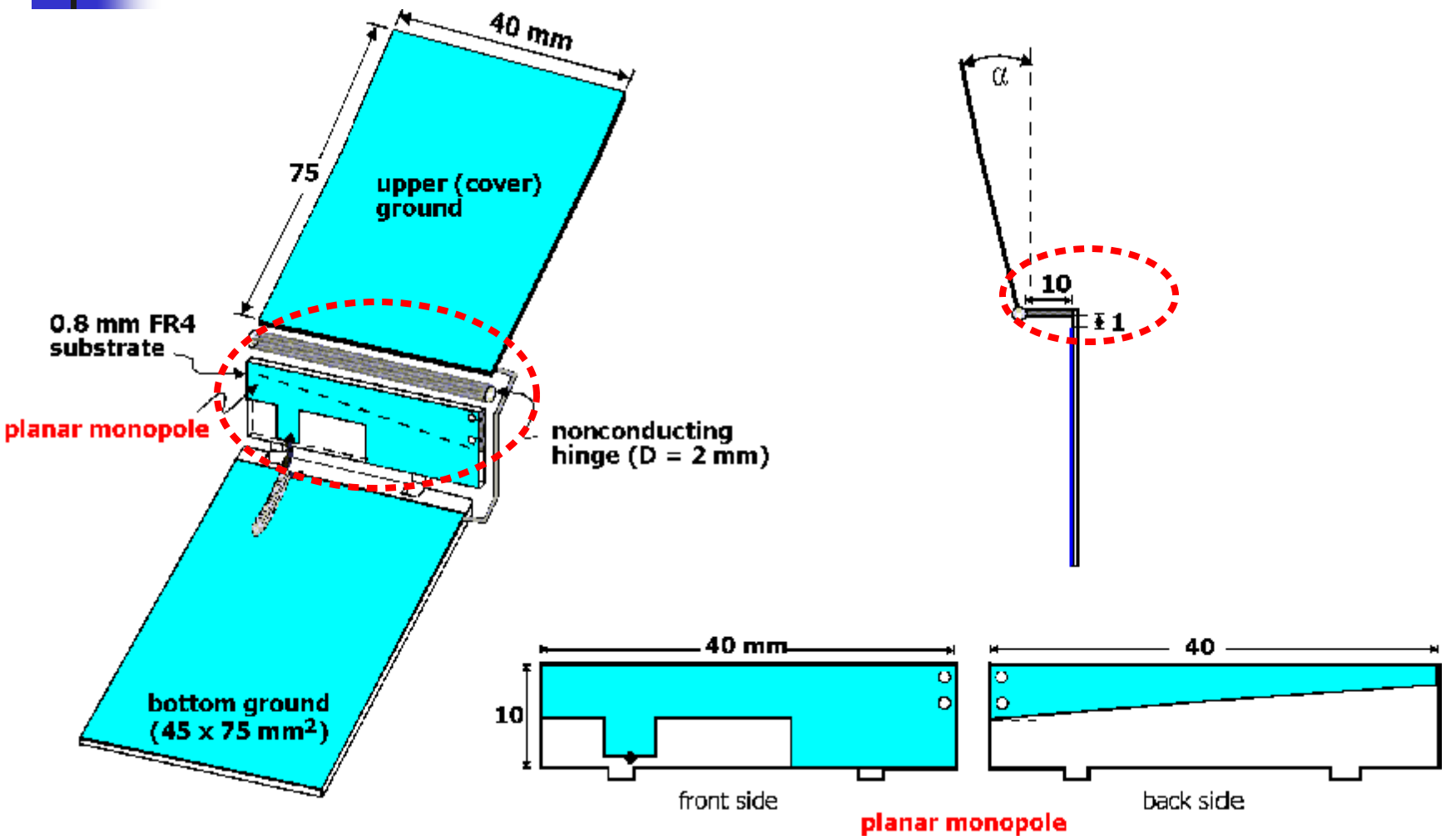
Monopole size 7 x 30 mm²;

7 mm to the system ground;

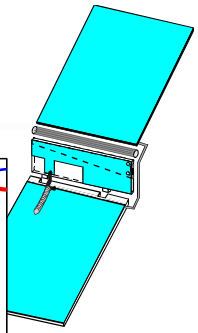
Covering GSM/DCS/PCS bands

TW Patent 171088

Very-Low-Profile Monopole 3-for folder-type handset (1)



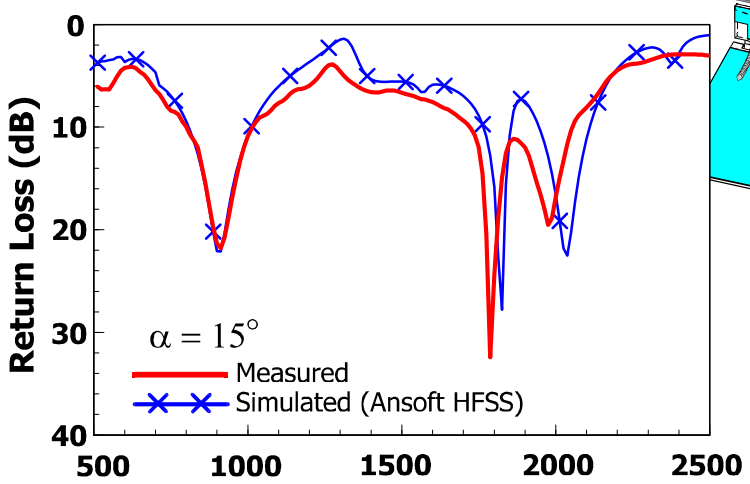
Very-Low-Profile Monopole 3- for folder-type handset (2)

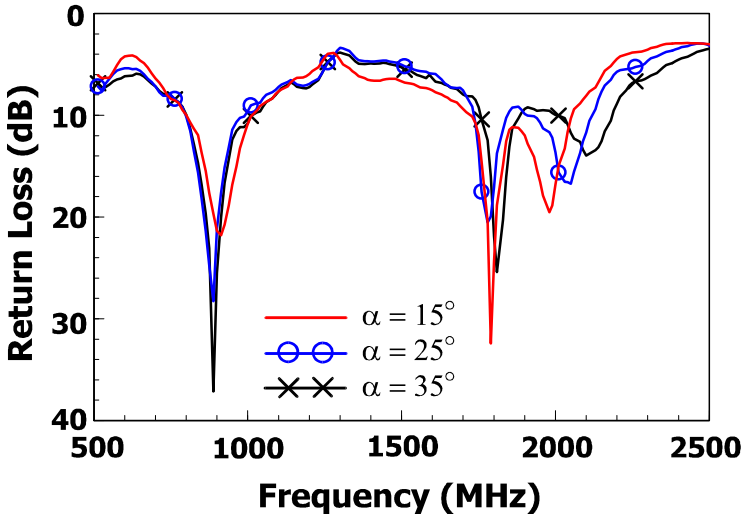


Antenna printed on two sides of a dielectric substrate; BW (2:1 VSWR) covers the GSM/DCS/PCS bands

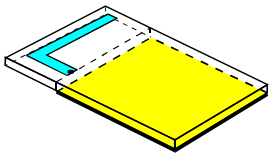
Gain level about 1 dBi for GSM band,

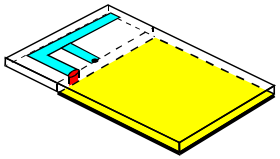
and about 2 dBi for DCS/PCS bands

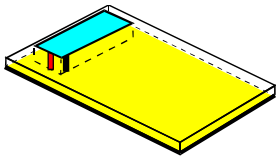




Ground plane (length) effect on antenna performance





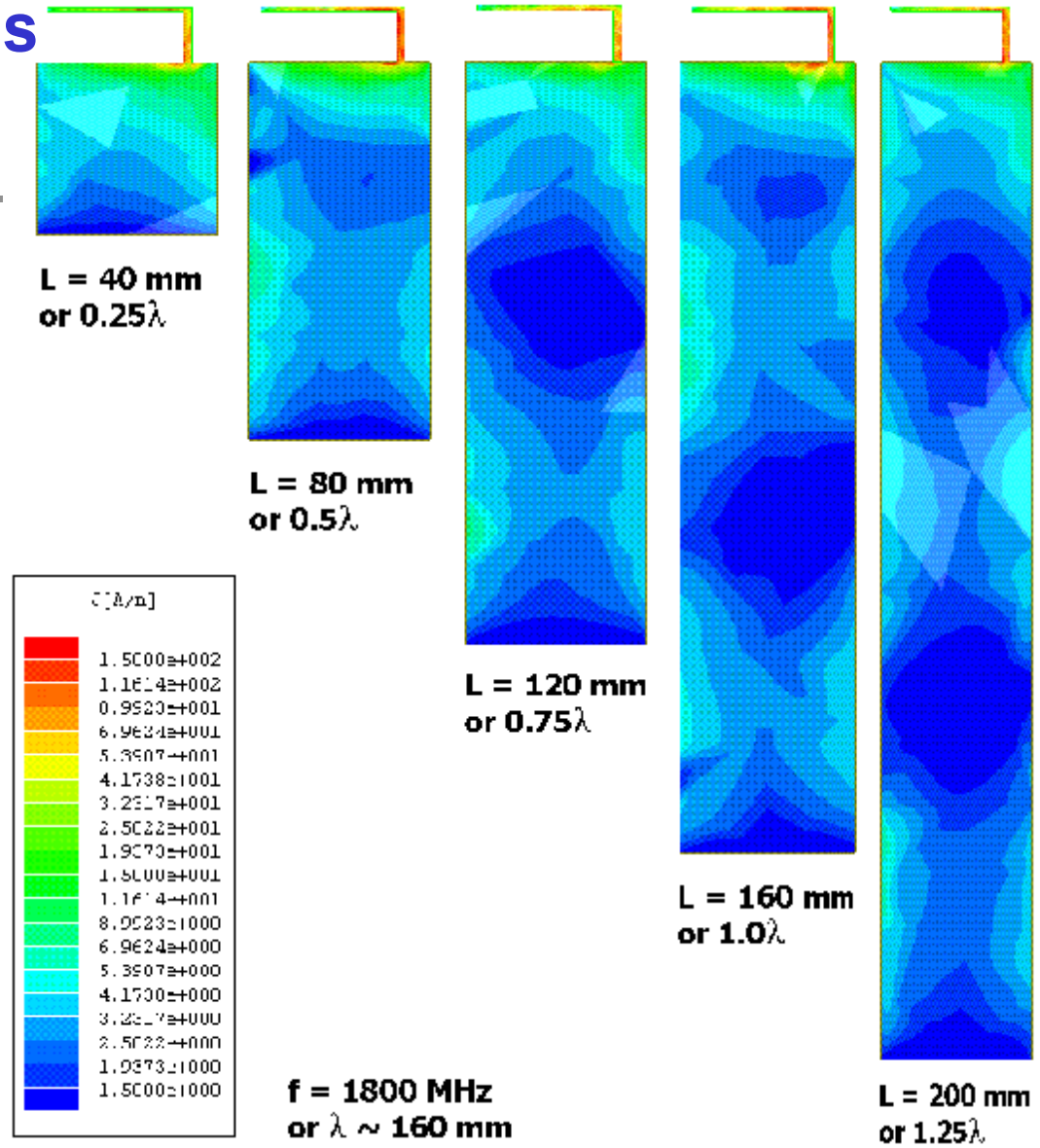


	Effect on f_r	Effect on BW	Effect on pattern
Monopole	**Large (> 15%)**	**large**	**large**
Shorted monopole	**Large (> 15%)**	**large**	**large**
PIFA	**Small (~ 5%)**	**large**	**large**

1. **GP length varies from 40~200 mm (0.25~1.25λ), f = 1800 MHz (λ~160 mm)**
2. **For PIFA, max BW occurs when GP length ~ 0.35λ (60 mm), 0.85λ (140 mm), 1.35λ (220 mm)**
3. **Period of null currents on GP is ~ 0.5λ (80 mm)**

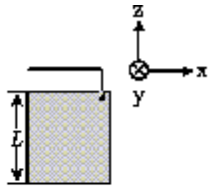
Simulated Surface Current Distributions Using Ansoft HFSS

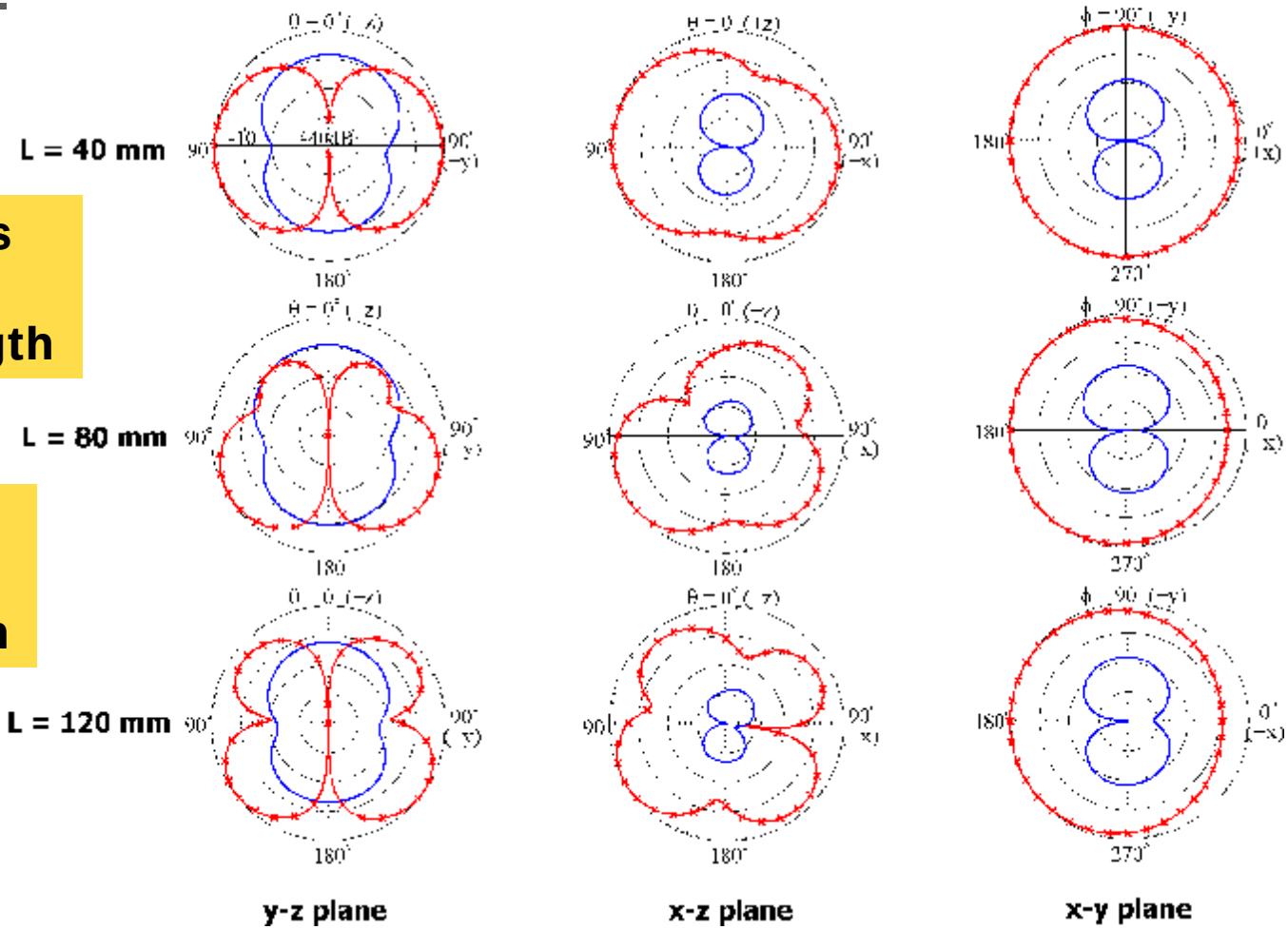
Dark regions indicate null currents and are spaced about 0.5λ



Simulated Radiation Patterns Using HFSS

f = 1800 MHz

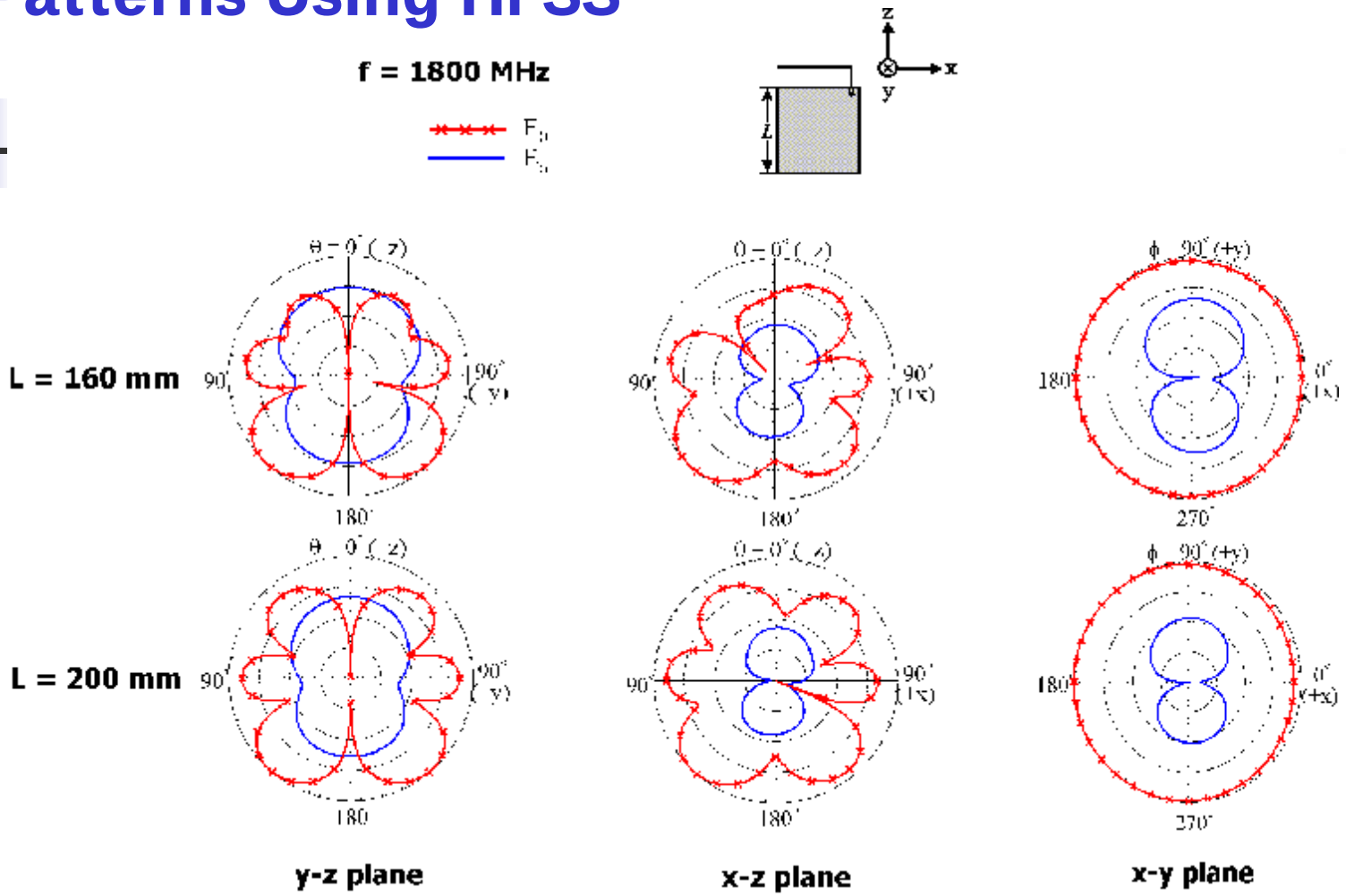




Radiation patterns dominated by the ground-plane length

L = 40 mm case shows a 0.5λ dipole-like pattern

Simulated Radiation Patterns Using HFSS



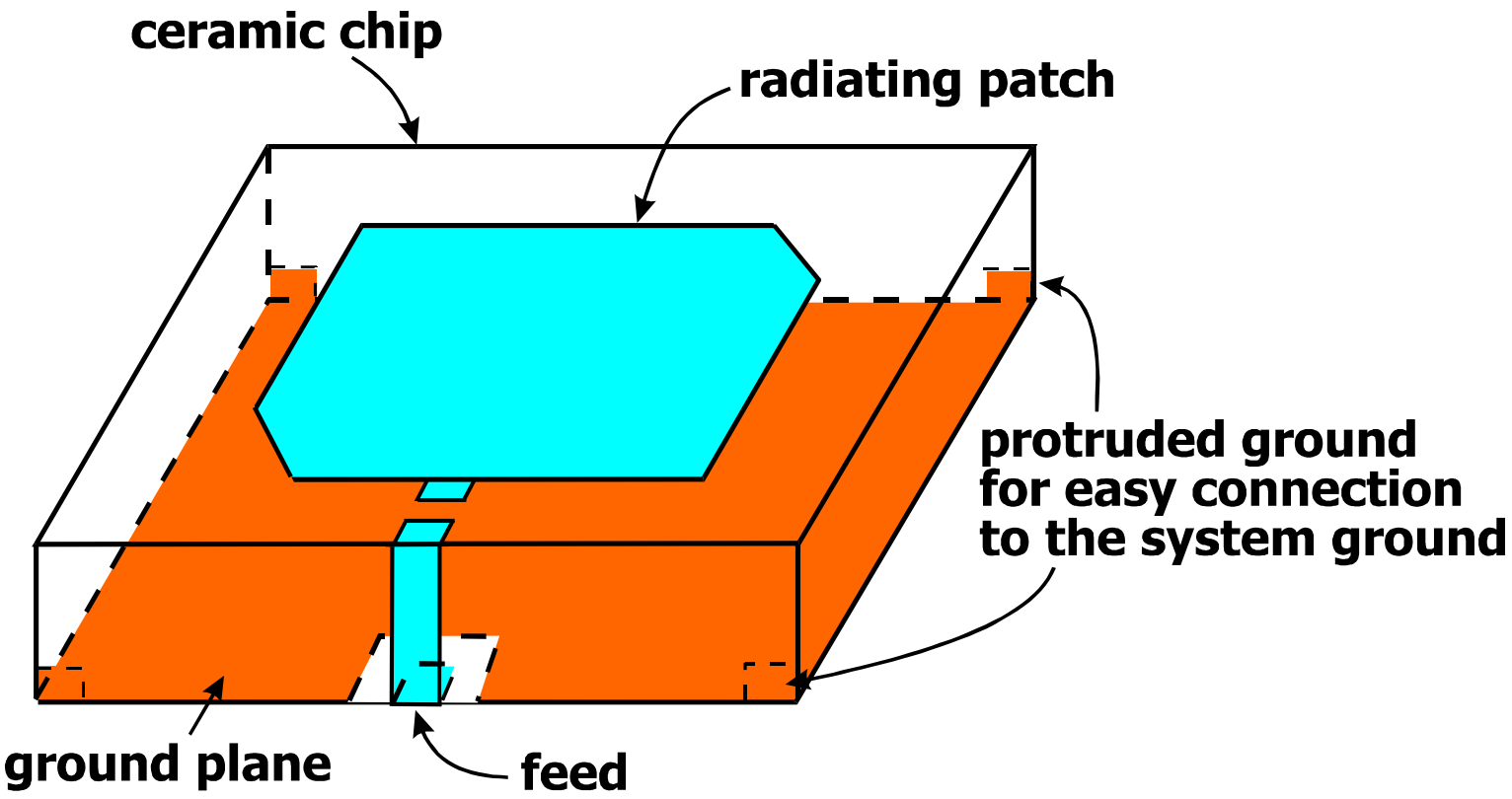
L = 200 mm case shows 1.5l dipole-like patterns

For WLAN mobile units- Surface-mount antenna

- Regular patch antennas (ceramic chip as a substrate)
- Monopoles (ceramic chip as a support for the monopole)

SMA- Ceramic Chip Antenna (1)

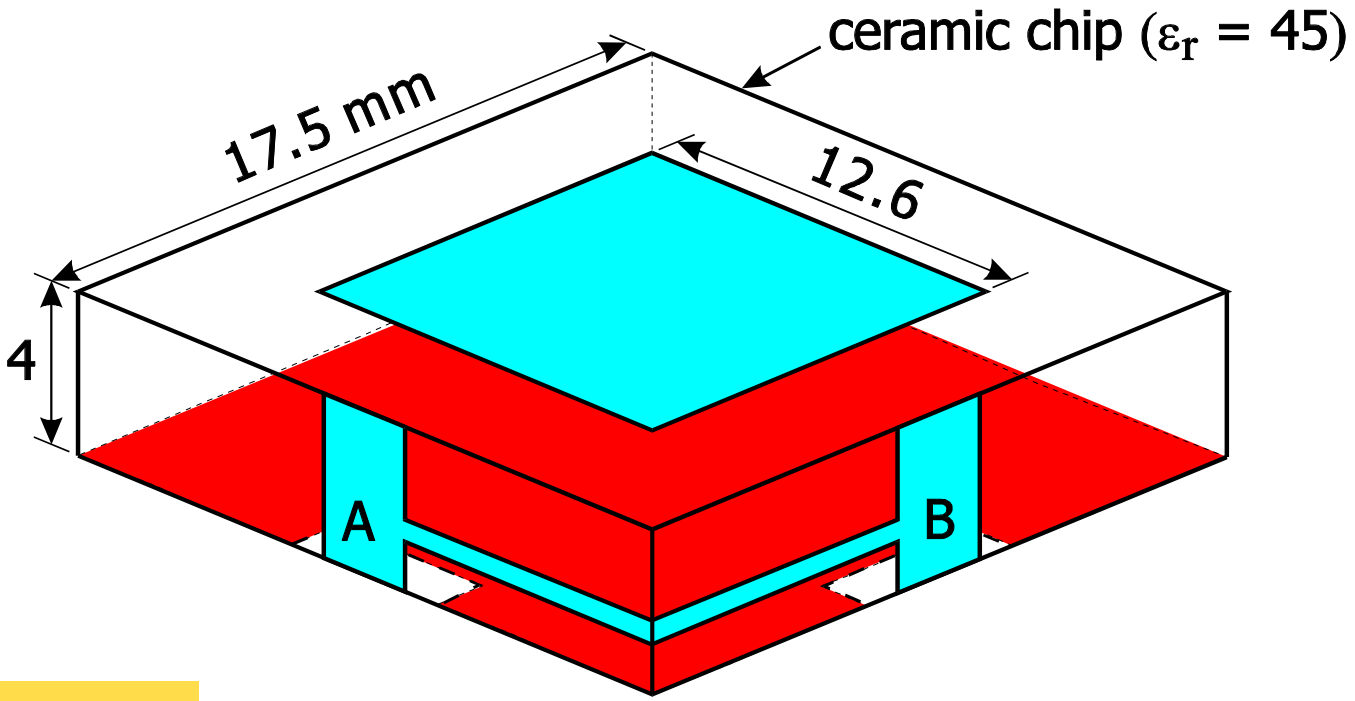
CP Design



US Patent 6140968

SMA- Ceramic Chip Antenna (2.1)

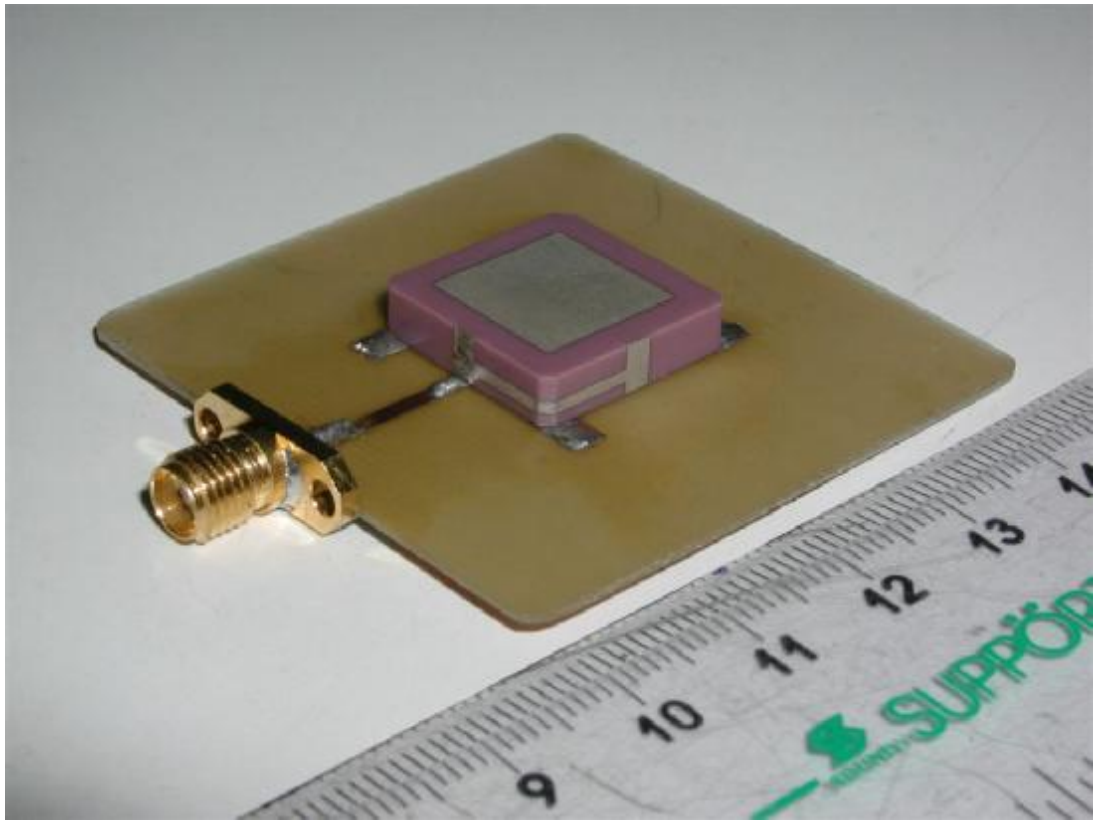
CP Design, dual side-feed, feed at A for RHCP, feed at B for LHCP; Gain level about 3.0 dBic (test board 50 mm x 50 mm) for GPS operation at 1575 GHz



TW Patent 171997

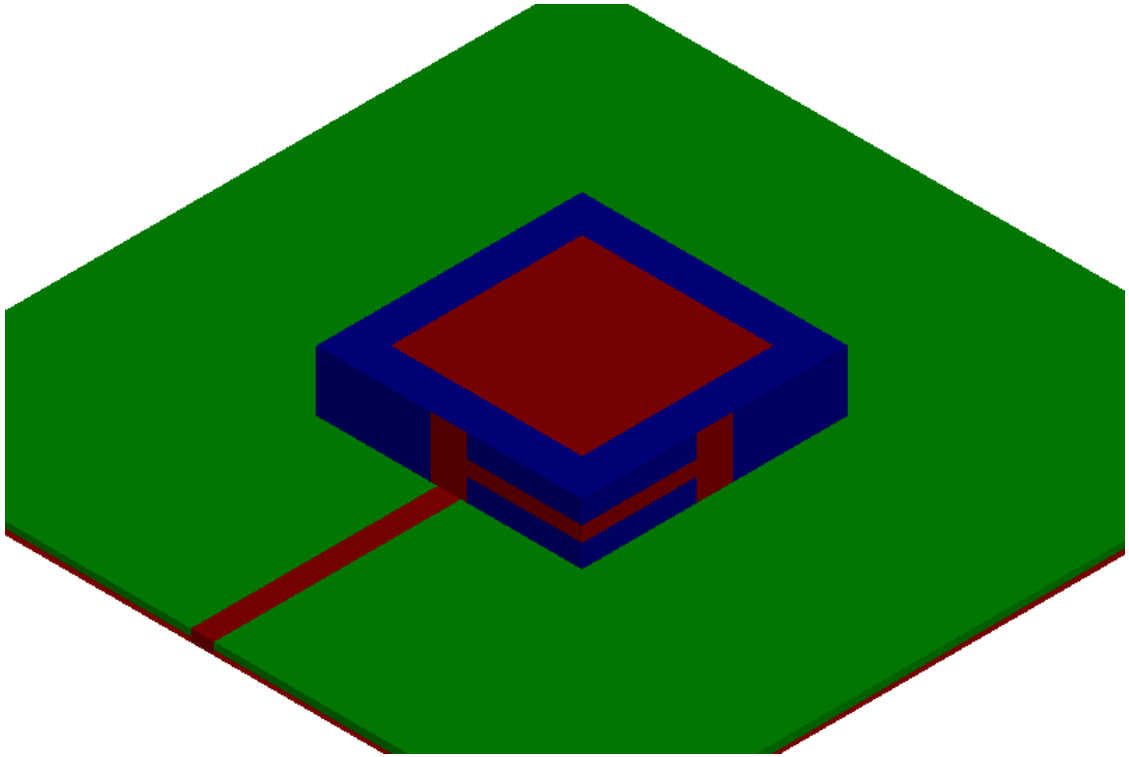
SMA- Ceramic Chip Antenna (2.2)

CP Design, dual side-feed ceramic chip antenna



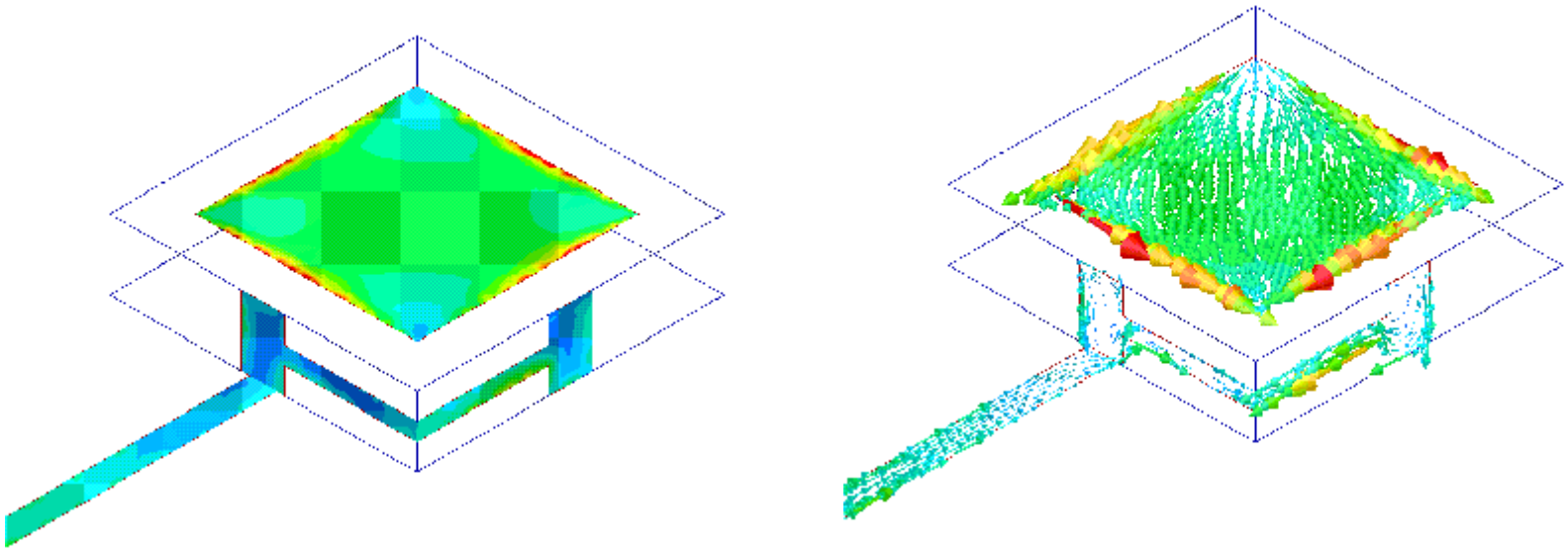
TW Patent 171997

SMA- Ceramic Chip Antenna (2.3)
3D Model in Ansoft HFSS



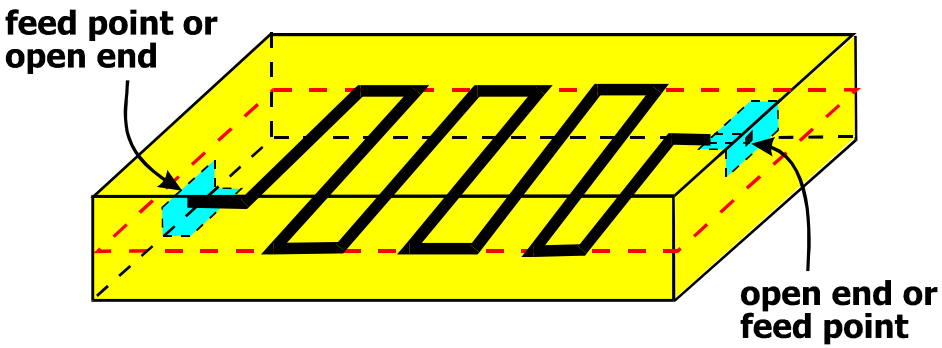
SMA- Ceramic Chip Antenna (2.4) Current Plot

Ansoft HFSS
simulation results



SMA- Ceramic Chip Antenna (3)

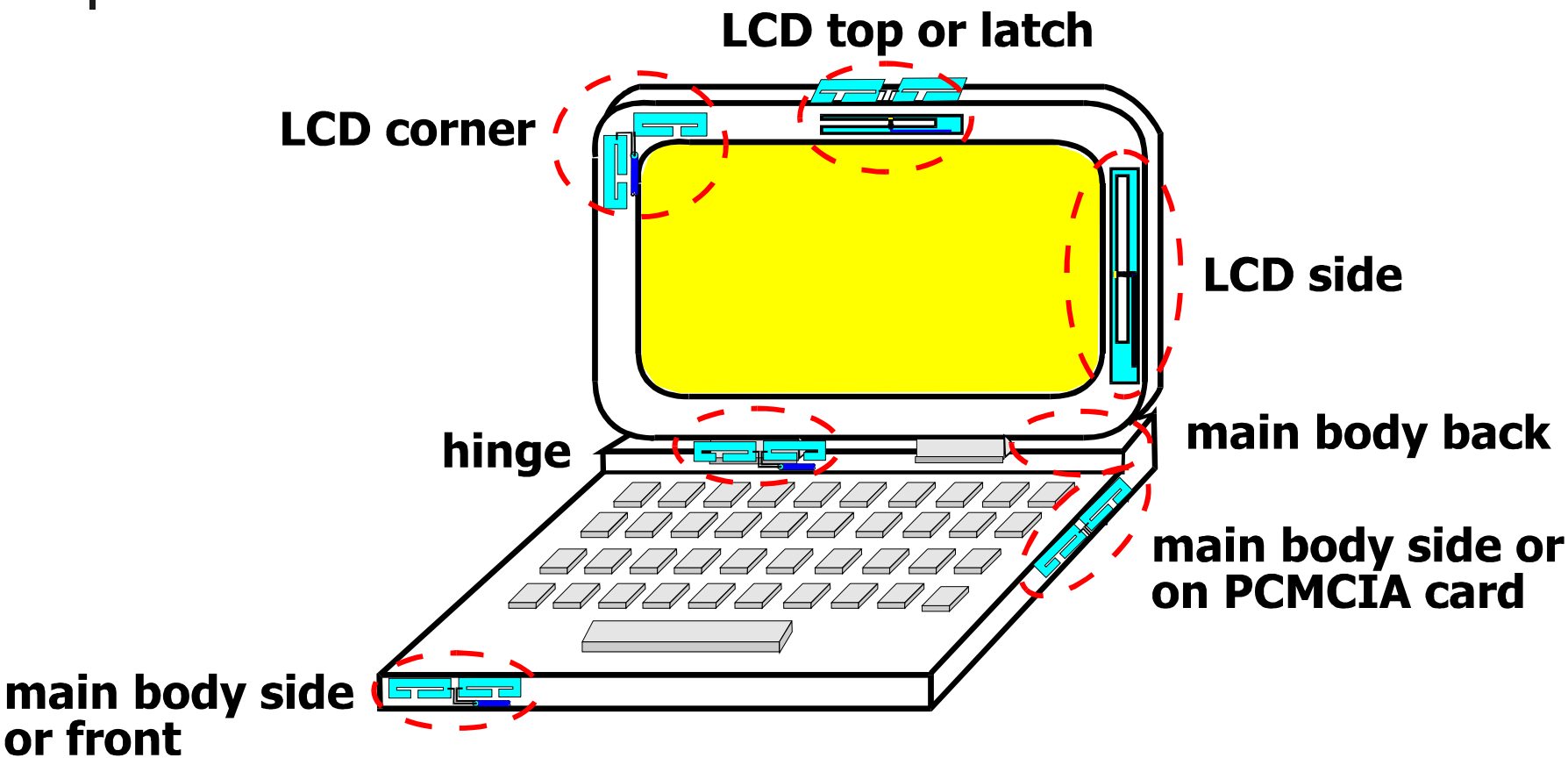
Helix monopole embedded within the ceramic chip



Meandered monopole embedded within the ceramic chip

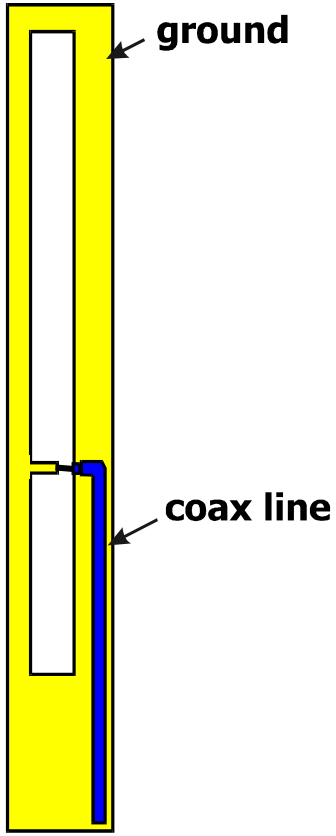
US Patent 5977927, 5892490

Printed Dipoles/Monopoles/Slot Antennas/ PIFAs Applied to Notebook Computer



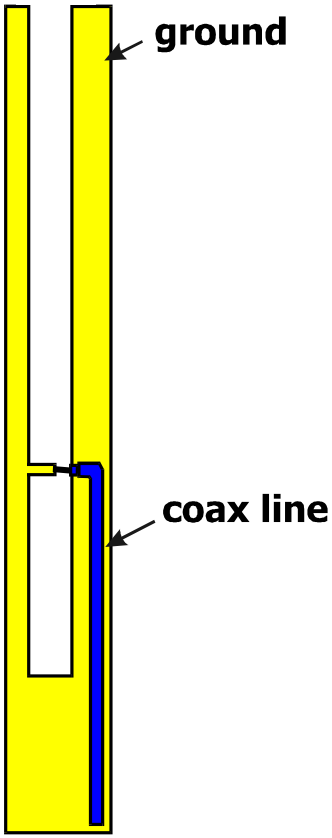
US Patents 6344825, 6297779, 6008774, 6295029, 6339400, 2001/0040529, 2002/0021250

WLAN Slot Antennas/PIFAs Applied to Laptops



slot antenna

0.5 wavelength in length

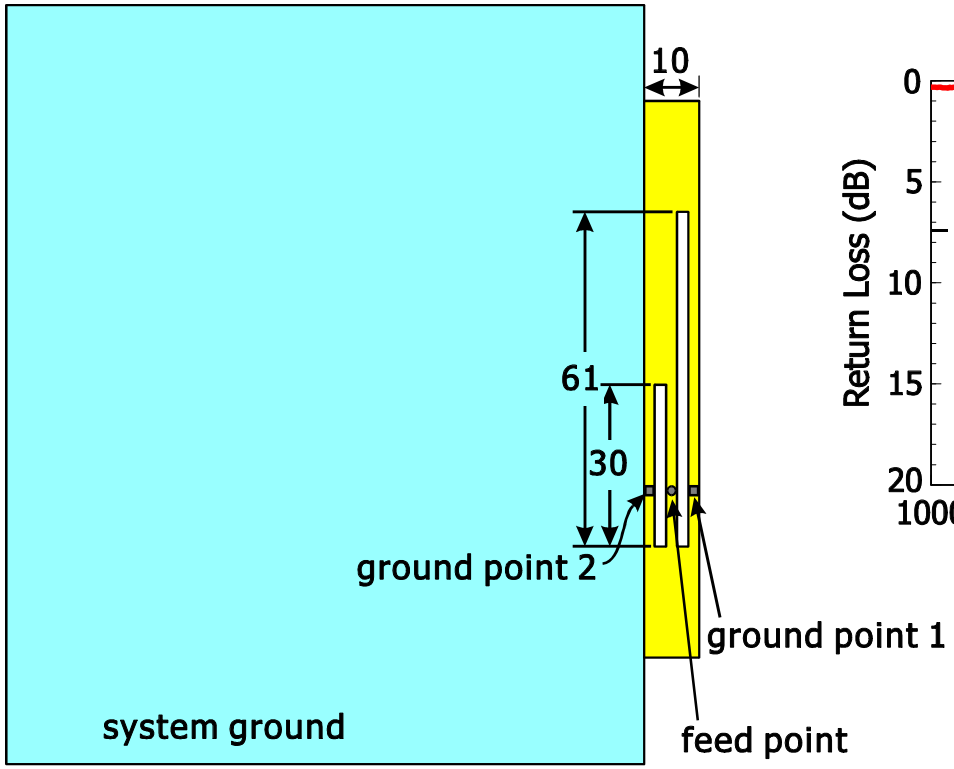


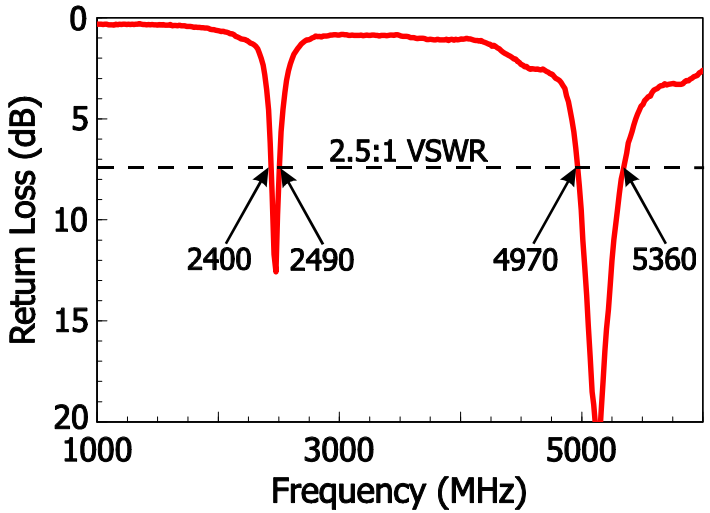
PIFA

0.25 wavelength in length

WLAN 2.4/5.2 GHz Dual-Band Dual-Slot Antenna

Antenna gain level in both 2.4 and 5.2 GHz about 6.0~7.0 dBi

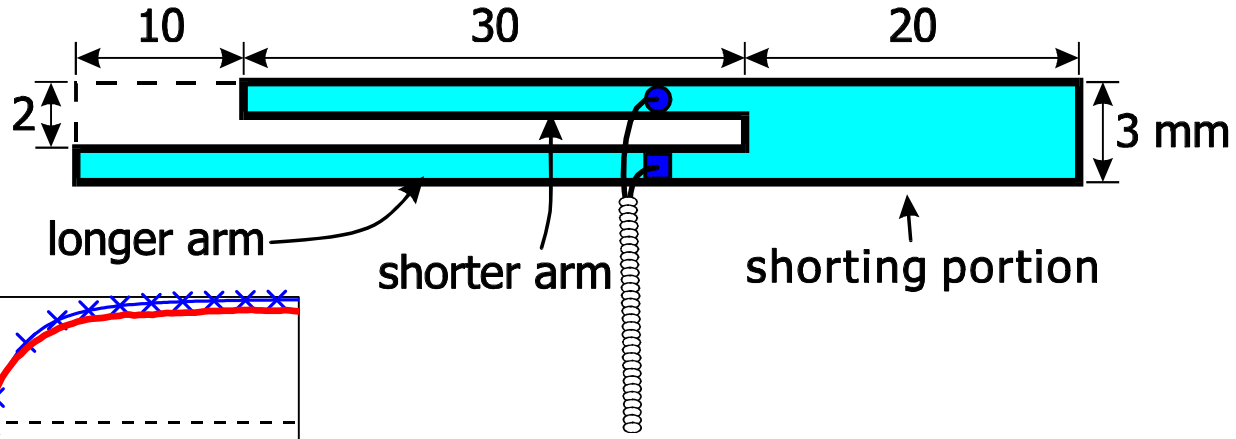


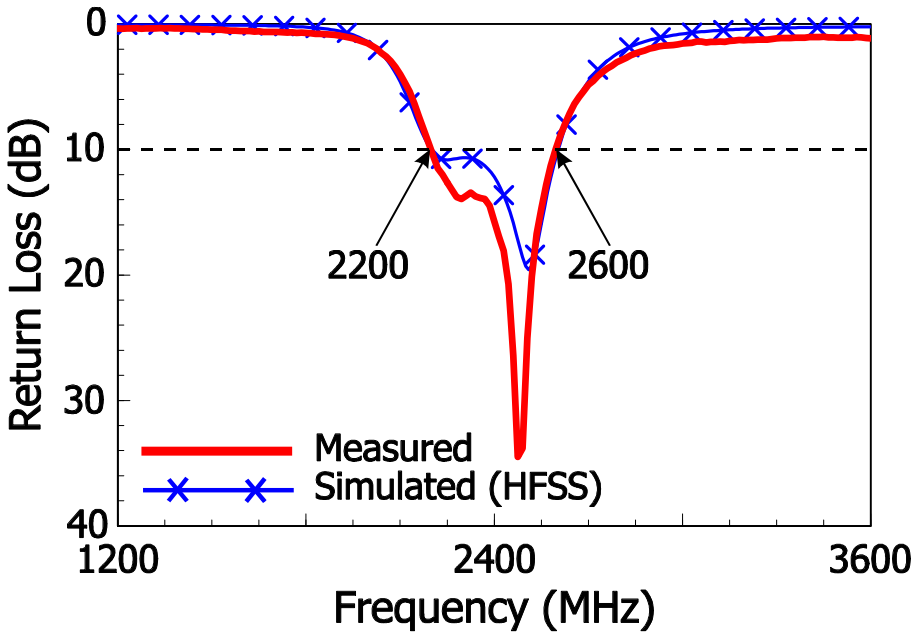


Patent pending

WLAN Metal-Plate Antenna (1)

Antenna size = 3 x 60 mm²; gain level ~3.6 dBi in 2.4 GHz band

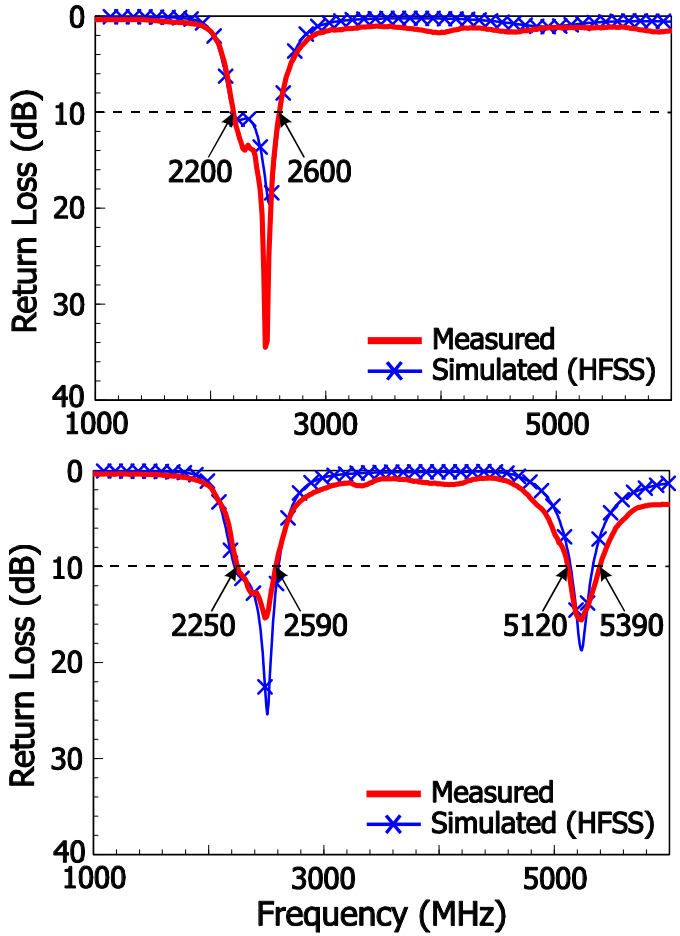


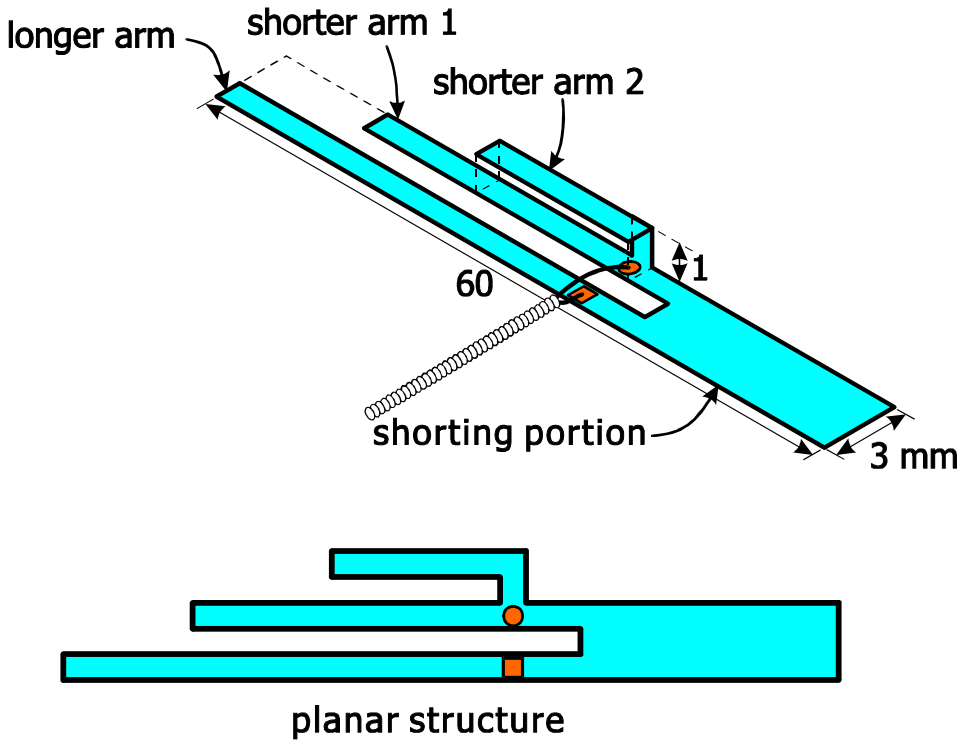


Patent pending

WLAN Metal-Plate Antenna (2), dual-band operation

Antenna size = 1 x 3 x 60 mm³; gain level ~3.0/3.6 dBi in 2.4/5.2 GHz bands



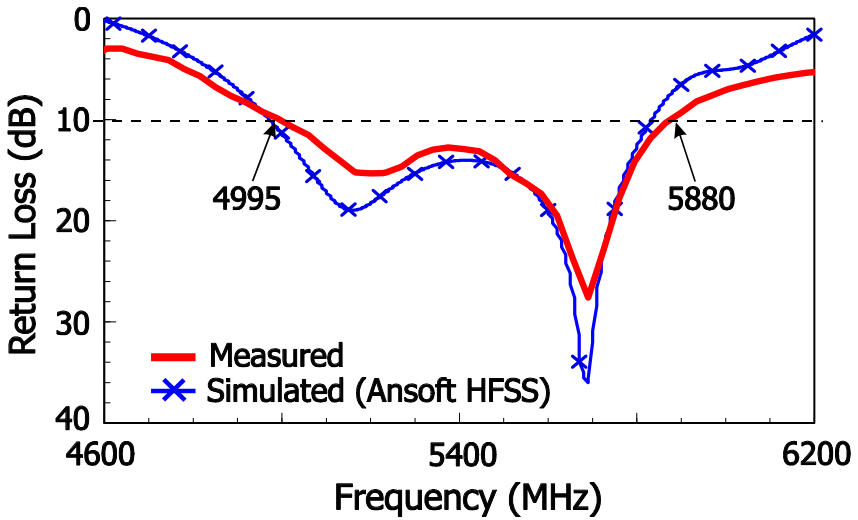


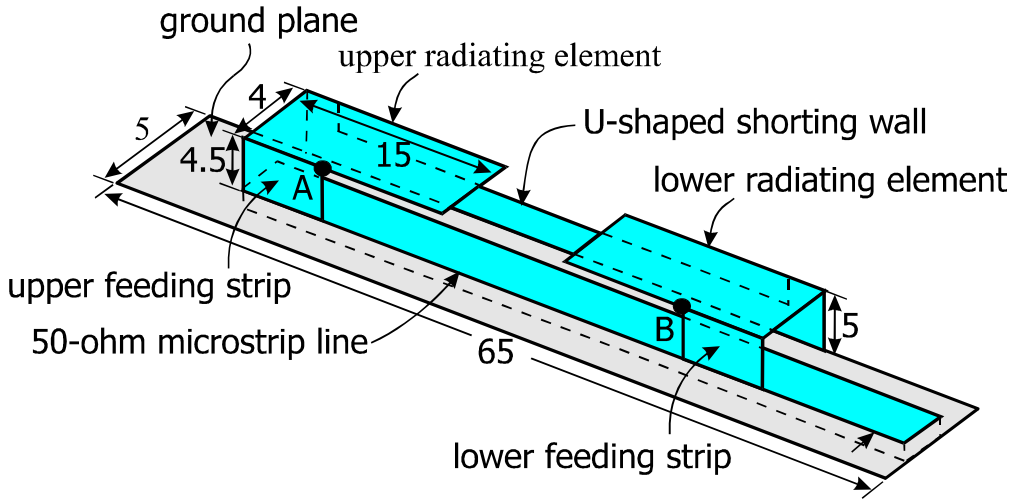
WLAN Metal-Plate Array Antenna

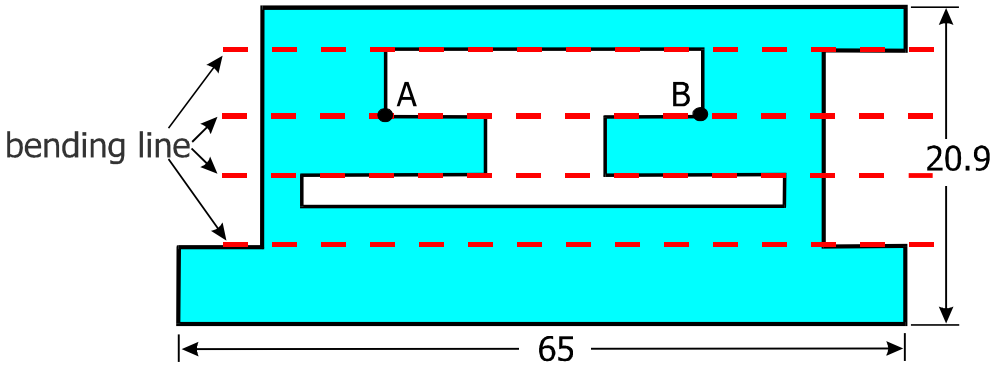
Antenna size = 5 x 5 x 65 mm³;

Gain level > 4 dBi in 5 GHz band;

Antenna constructed from a single metal plate







WLAN Access-Point Antennas

- On-wall, on-ceiling, on-desk designs
- Printed dipole array for omni or diversity radiation
- Printed folded dipole (or loop) array for omni or diversity radiation

WLAN AP Antenna-Omnidirectional dipole array (1)

5 GHz AP dipole array:

1.5:1 VSWR: 5.15-5.35 GHz

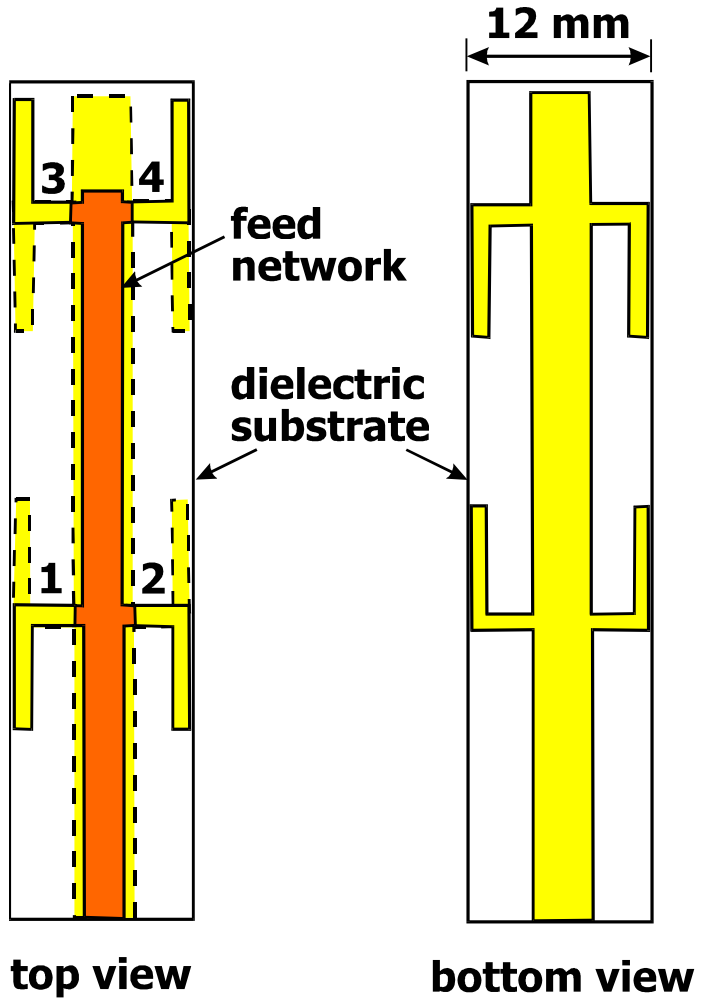
Peak gain: > 5.5 dBi (Duroid sub)

Omnidirectional ripple: < 2 dBi

Size: 12 mm x 90 mm

Ports 1, 2: 0°, 1/4 power

Ports 3, 4: 180°, 1/4 power



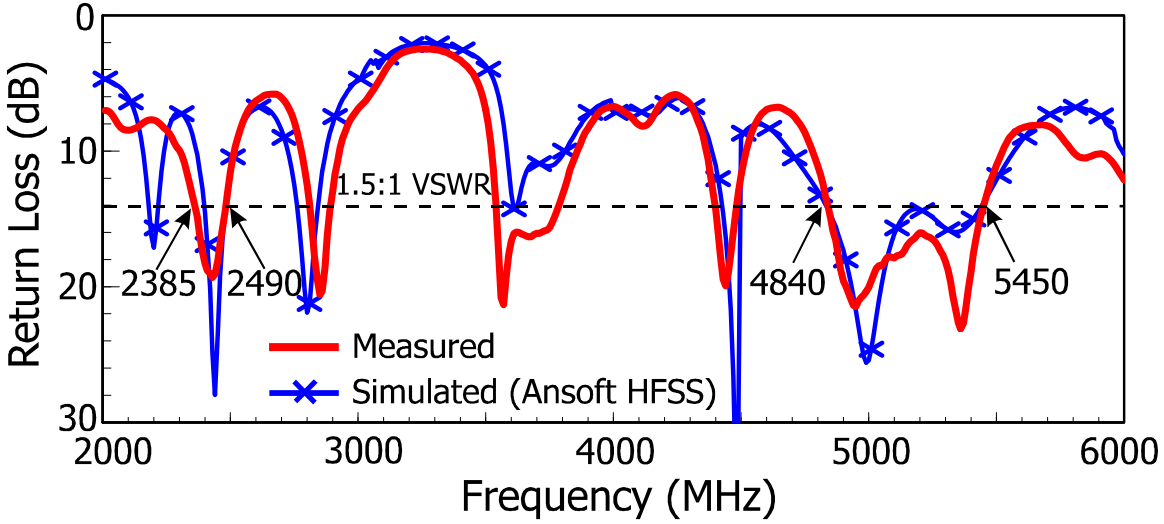
WLAN AP Antenna-Omni dipole array (2)

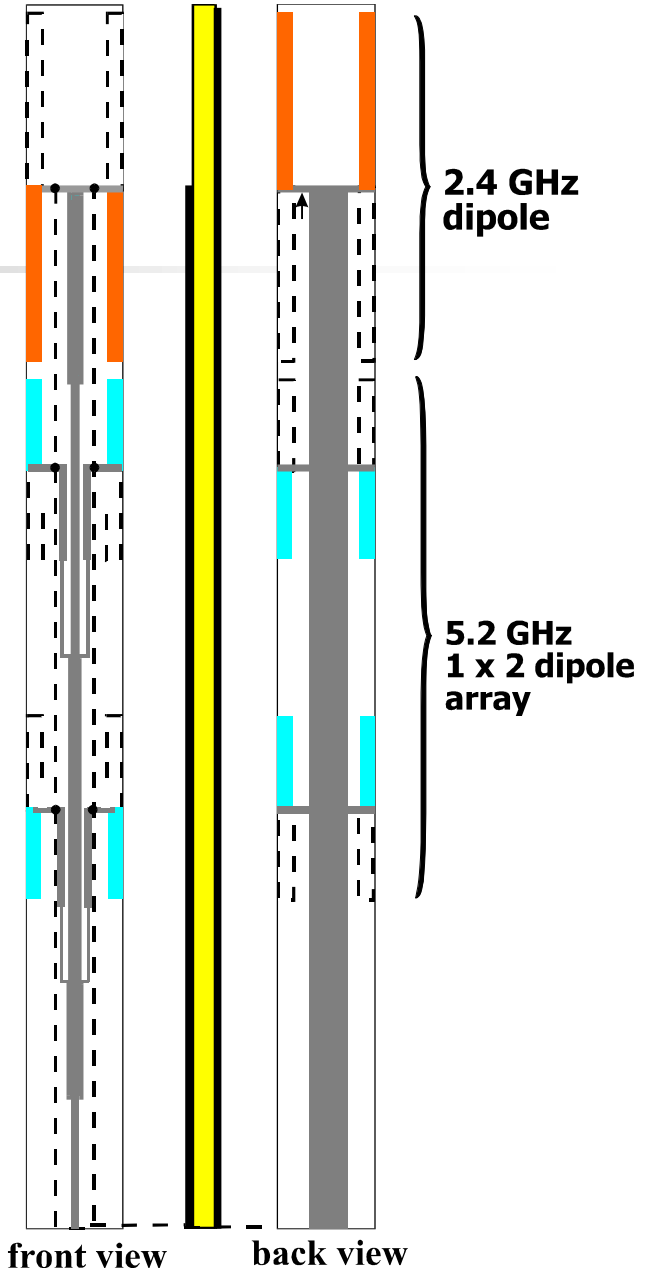
BW covers 2.4/5.2 GHz bands

Gain level: ~ 2.5 dBi for 2.4 GHz band; ~4.0 dBi for 5.2 GHz band (FR4 sub)

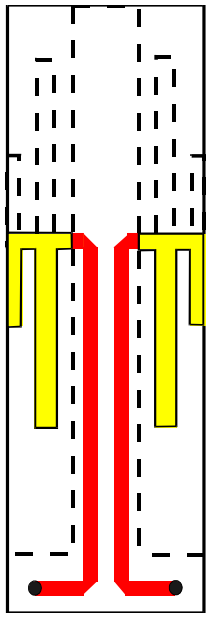
Omnidirectional ripple: < 2 dBi

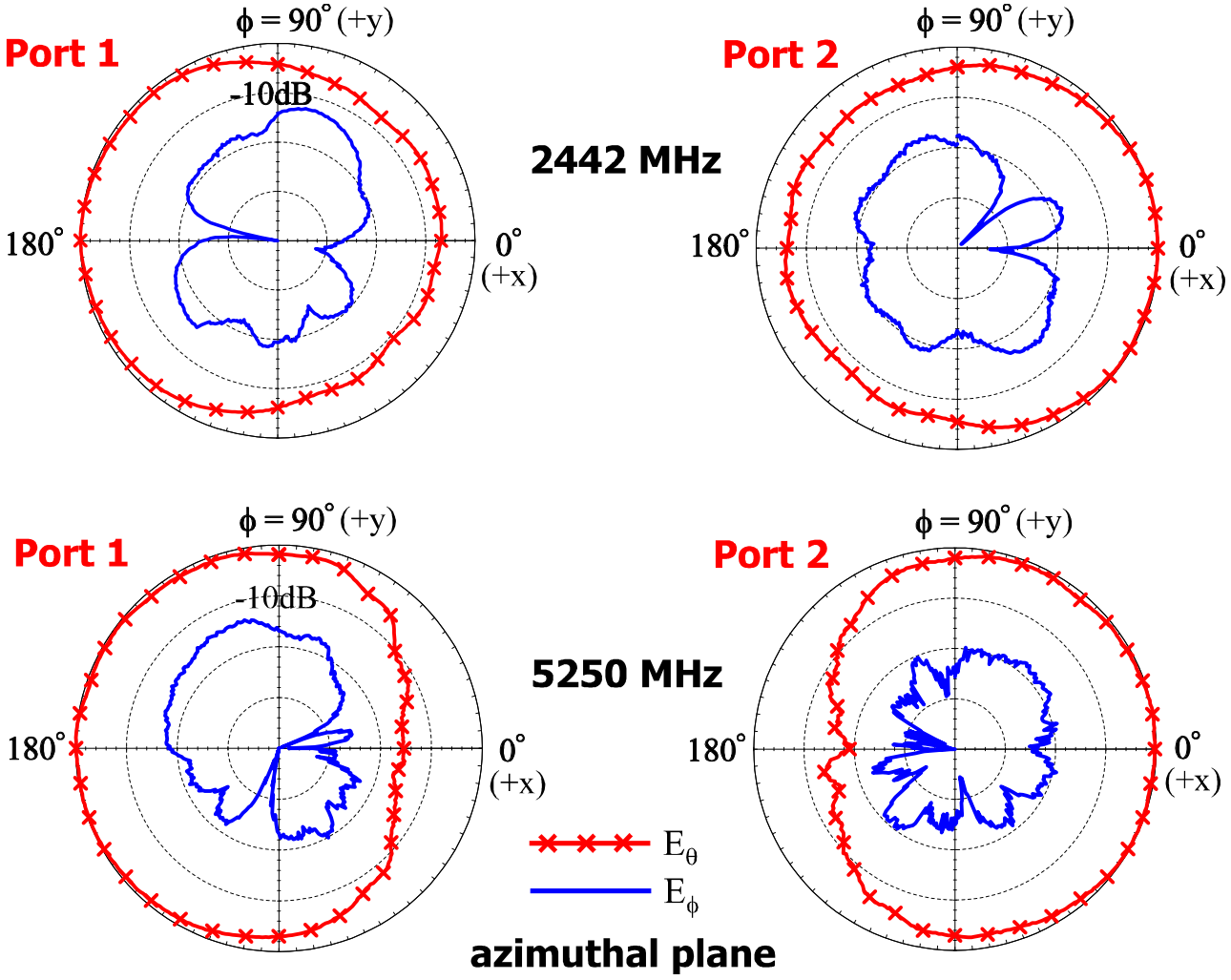
Size: 12 mm x 160 mm





WLAN AP Antenna-Diversity dual-band dipole





WLAN AP Antenna-Omnidirectional folded dipole

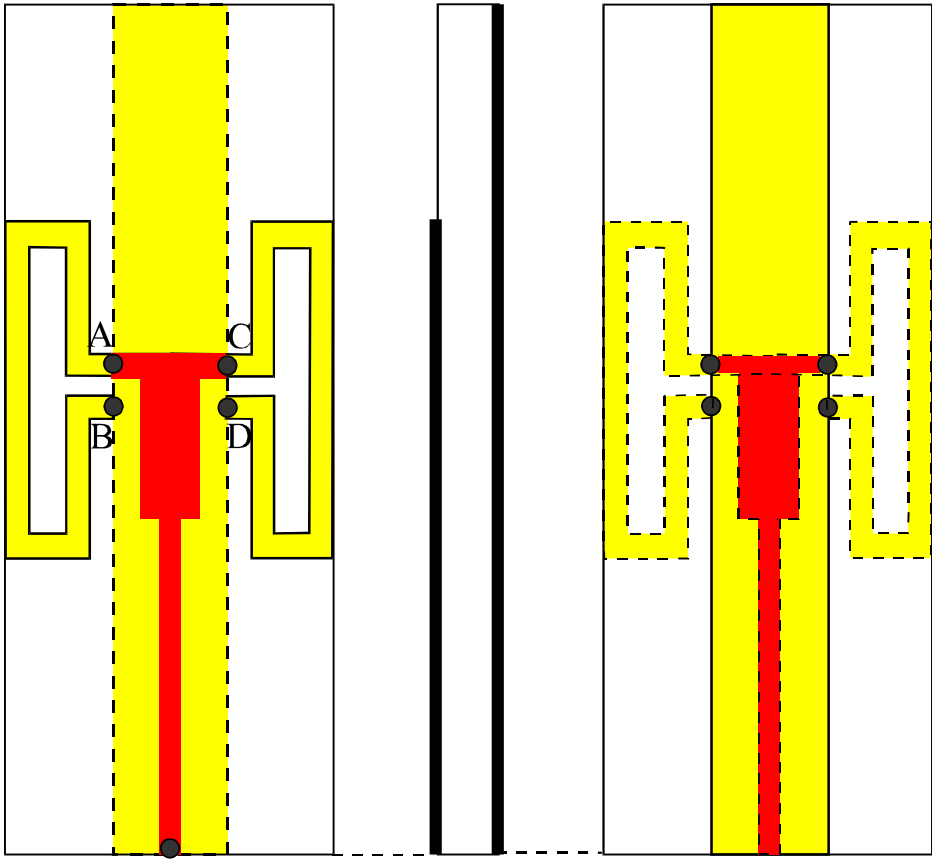
5 GHz AP dipole array:

2:1 VSWR: 5.0-6.1 GHz

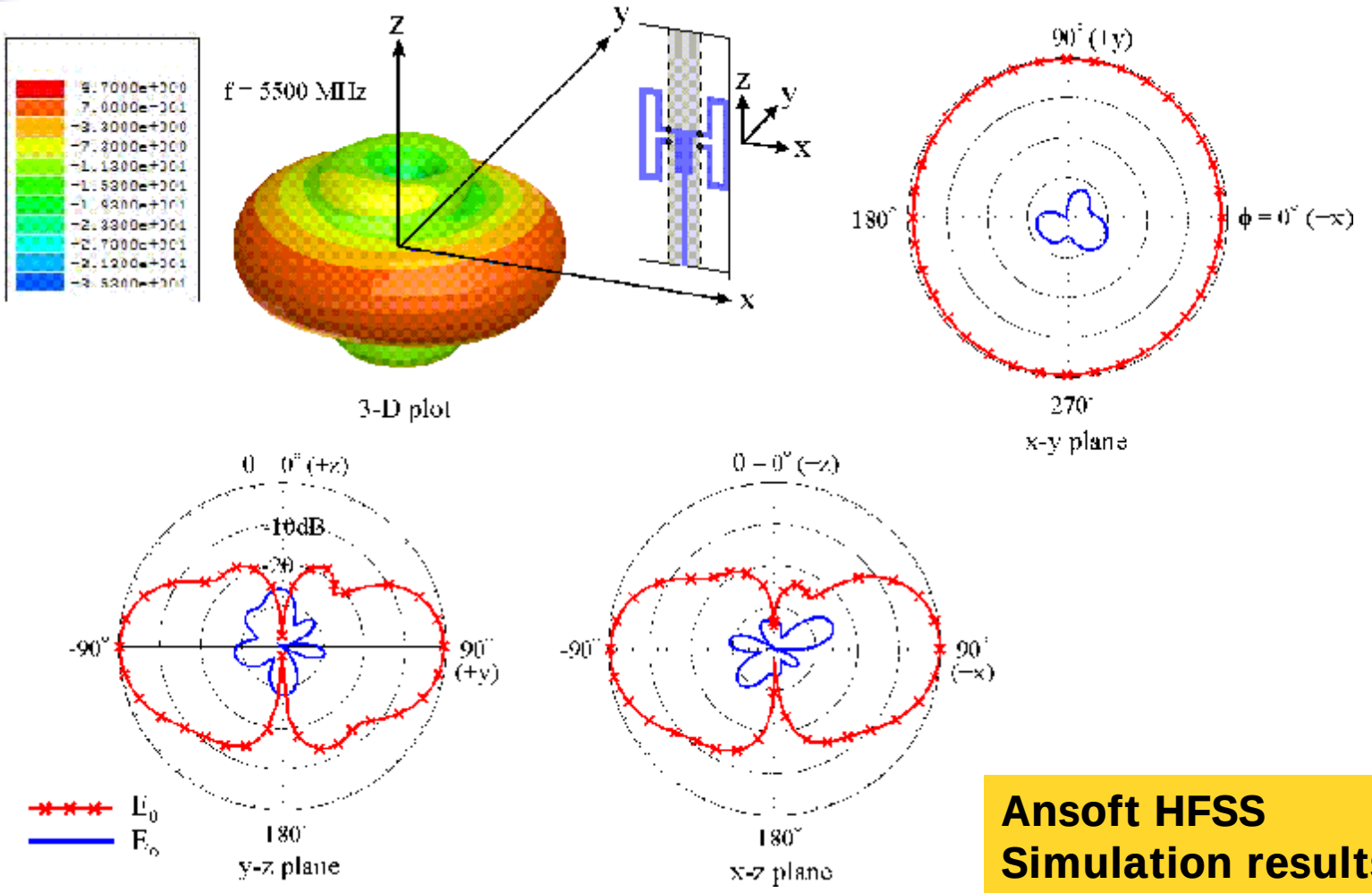
Peak gain: > 4.5 dBi (FR4 substrate)

Omnidirectional ripple: < 1.8 dBi

Size: 18 mm x 68 mm



WLAN AP Antenna-Omnidirectional folded dipole



Ansoft HFSS Simulation results

Conclusions

- **Planar antennas are good candidates for wireless devices applications**
- **More promising planar antenna designs and applications are in progress**