

# Planar Antennas for WLAN Applications



---

**Kin-Lu Wong)**  
**Dept. of Electrical Engineering**  
**National Sun Yat-Sen University**  
**Kaohsiung, Taiwan**



# Outlines

---

- **WLAN Mobile-Unit Antennas**
  - Surface mountable antennas
  - Printed monopole antennas
  - Printed dipole antennas
  - Slot antennas, PIFAs
- **WLAN Access-Point Antennas**
  - Patch antennas for broadside radiation
  - Printed monopole antennas
  - Printed dipole array antennas



# Surface Mountable Antennas

---

- **Ceramic chip antennas**
- **Plastic chip or Folded strip monopole antennas**
- **Dielectric resonator antennas**



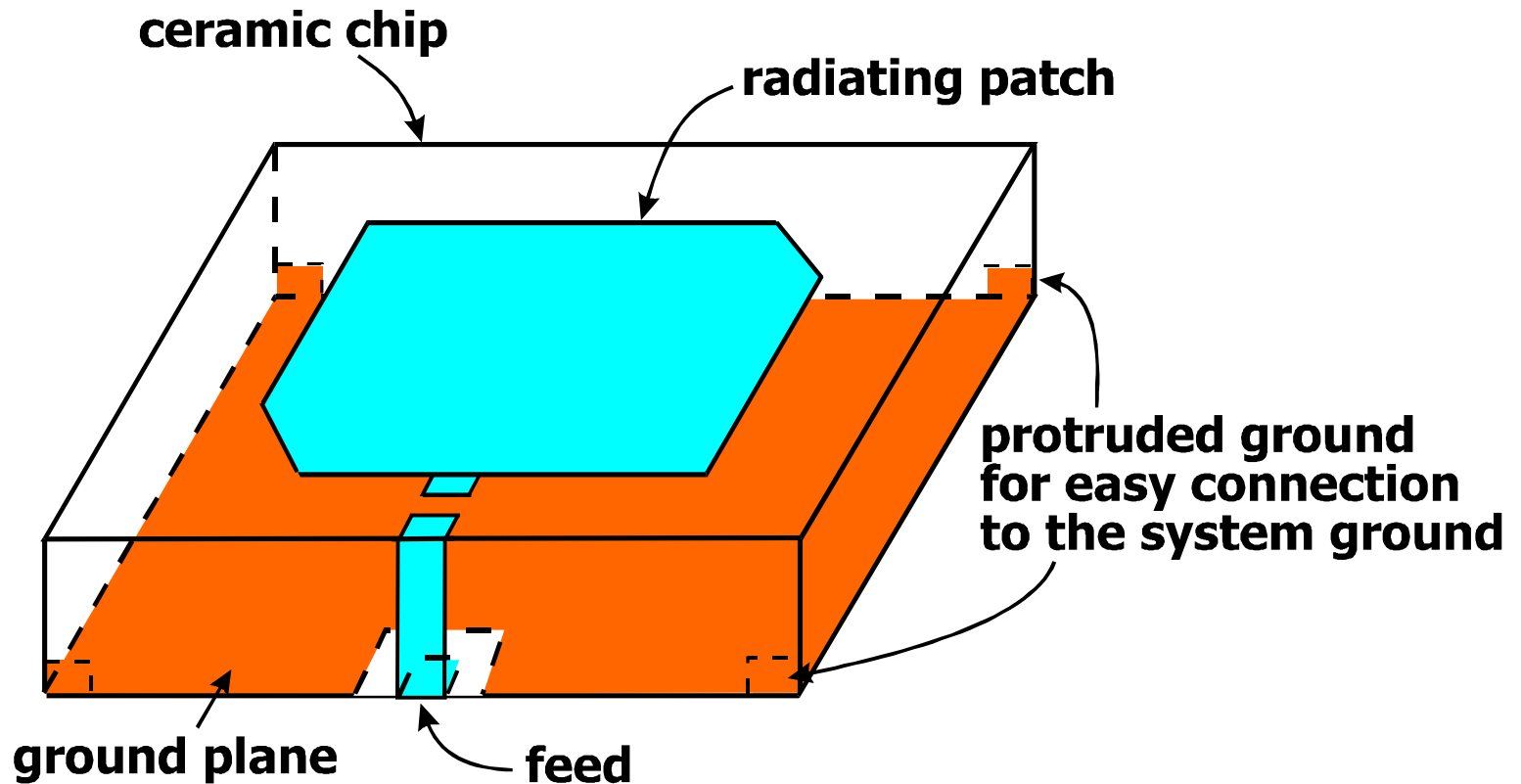
# SMA- Ceramic Chip Antennas

---

- **Regular patch antenna  
(ceramic chip as a substrate)**
- **PIFAs**
- **Monopoles (ceramic chip as a support for the monopole)**

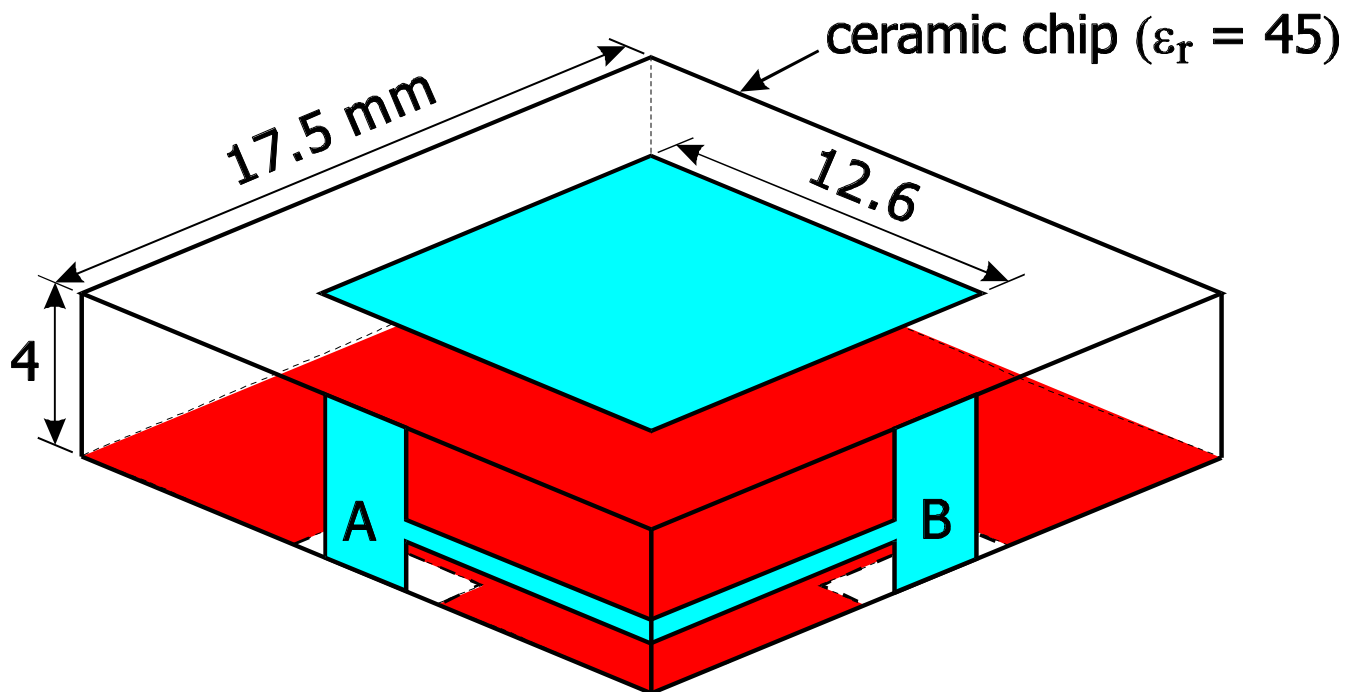
# SMA- Ceramic Chip Antenna (1)

## CP Design



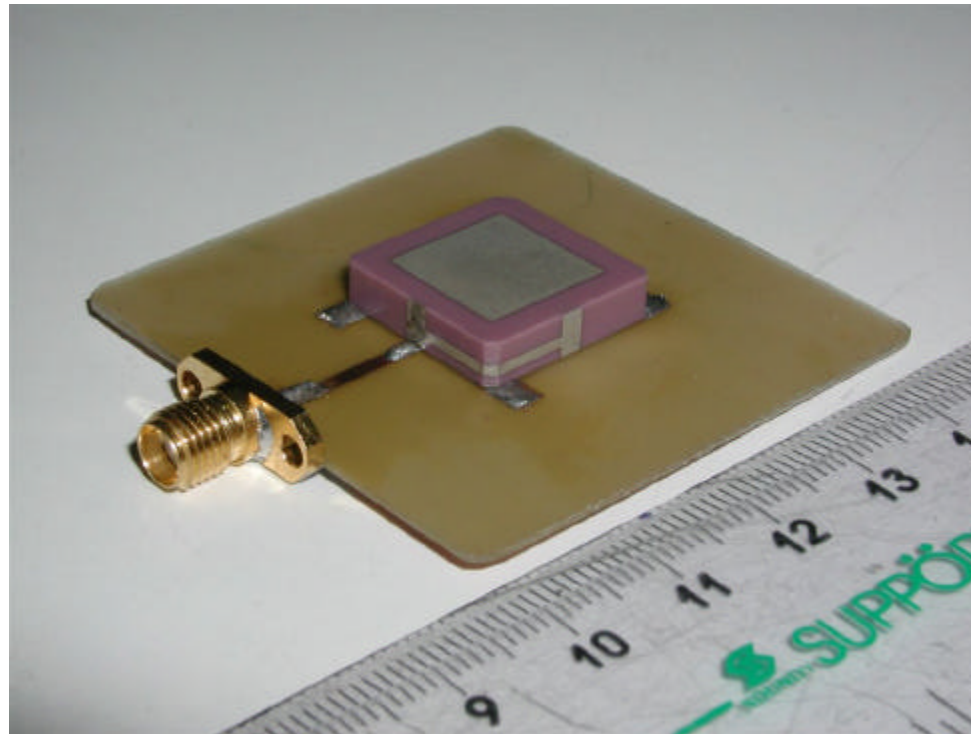
# SMA- Ceramic Chip Antenna (2)

CP Design, dual side-feed, feed at A for RHCP, feed at B for LHCP

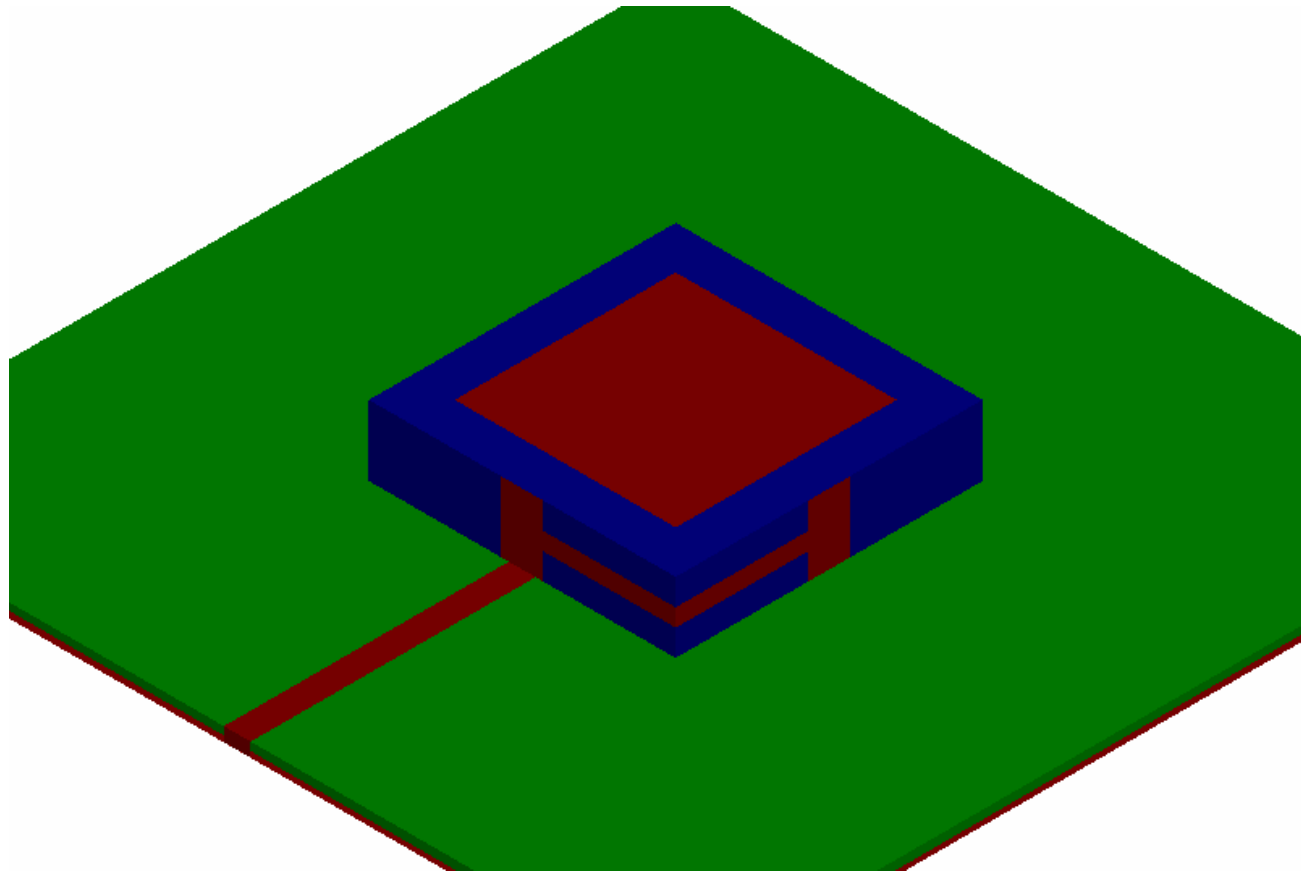


# SMA- Ceramic Chip Antenna (2.2)

**CP Design, dual side-feed ceramic chip antenna; Gain level about 3.0 dBic (test board 50 mm x 50 mm) for 1575 GHz GPS operation**



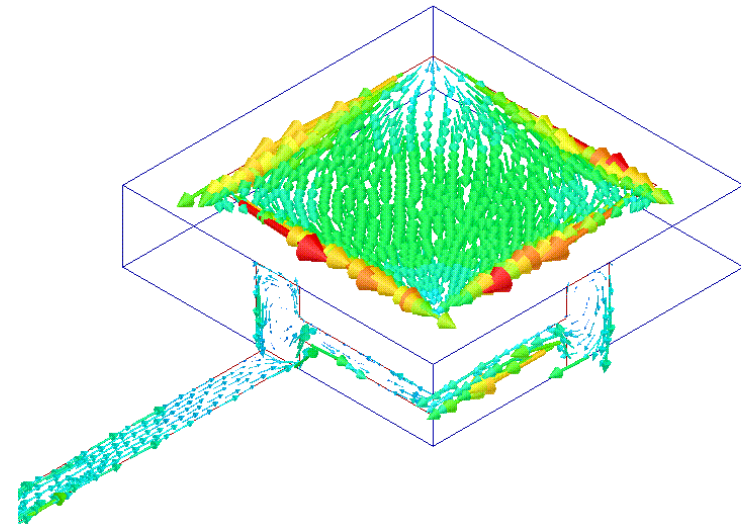
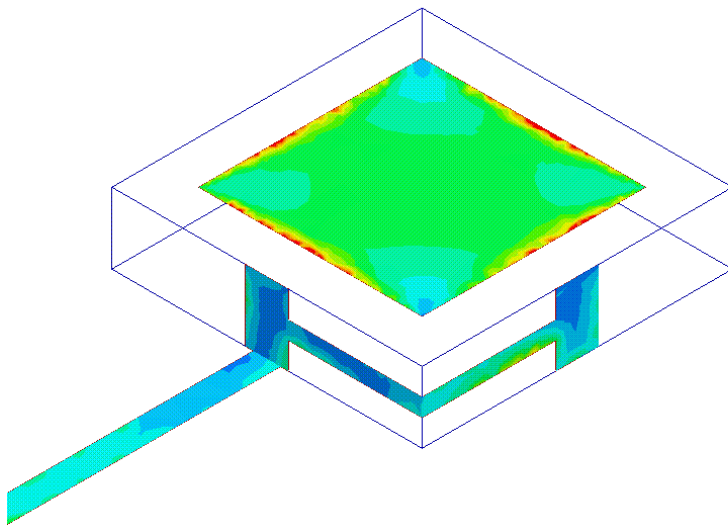
# 3D Model in Ansoft HFSS





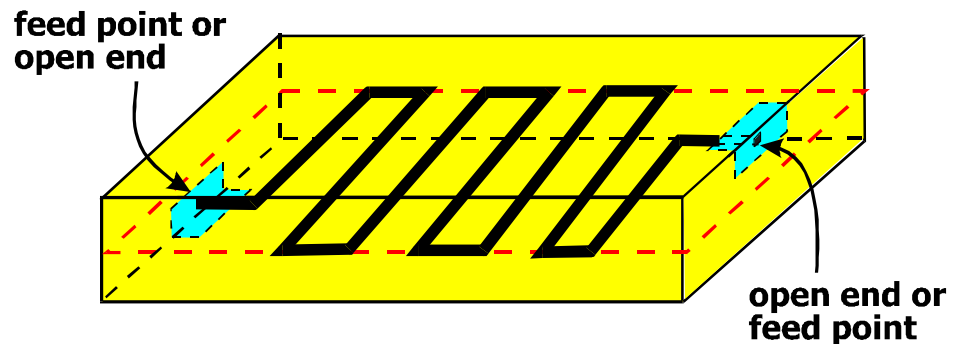
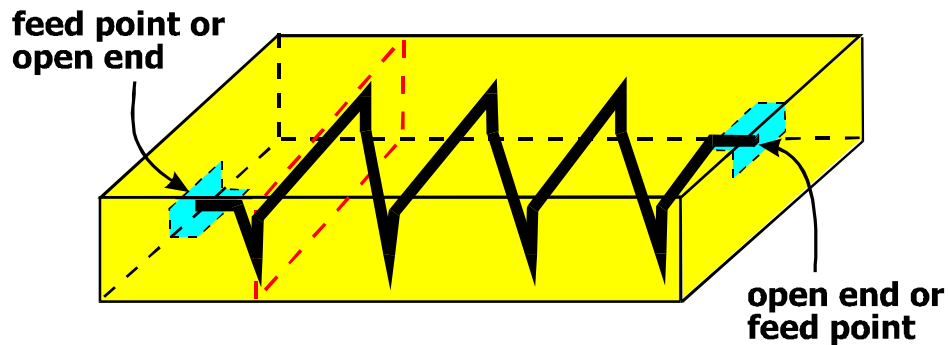
# Current Plot on Antenna

Ansoft HFSS



# SMA- Ceramic Chip Antenna (3)

**Helix monopole embedded within the ceramic chip**

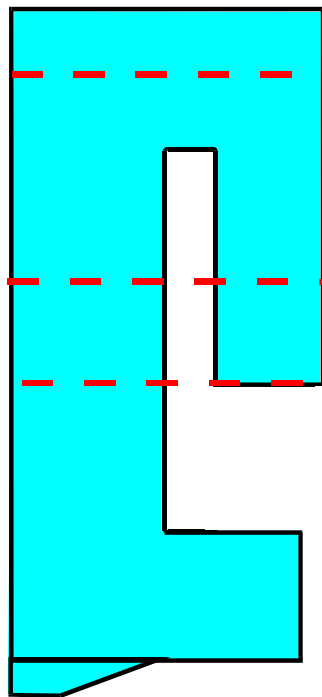


**Meandered monopole embedded within the ceramic chip**

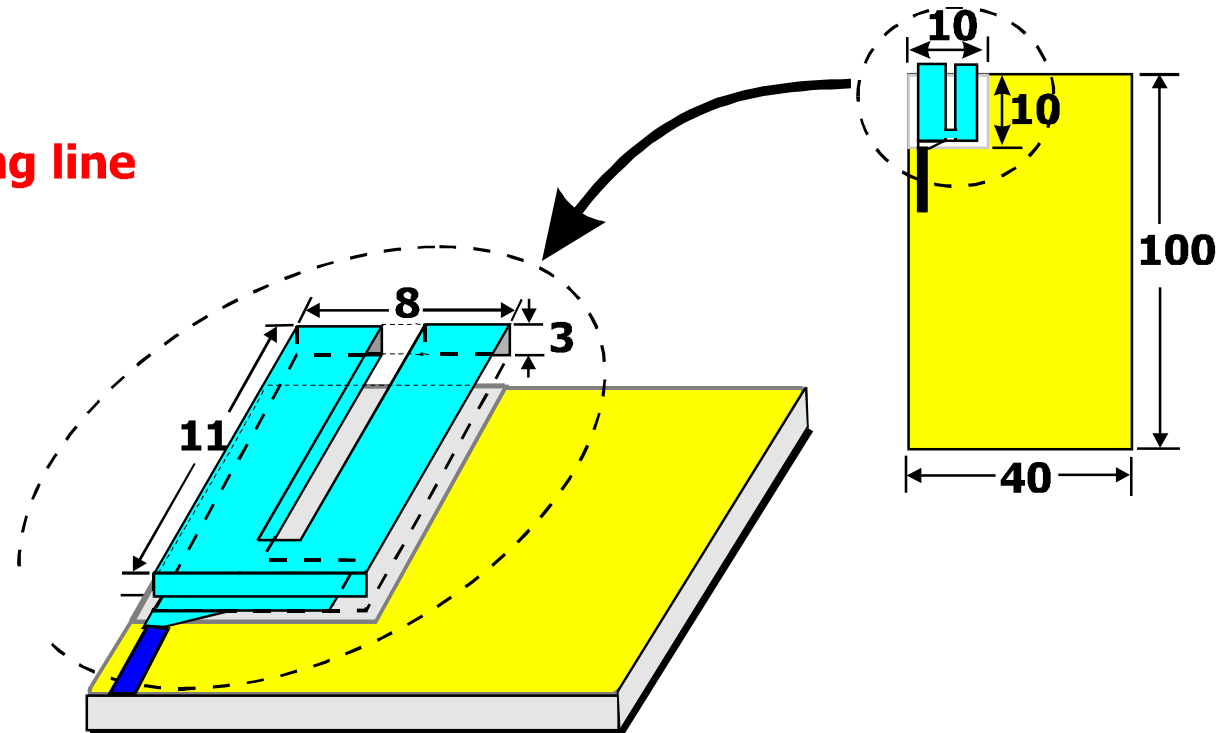
# SMA- Plastic Chip or Folded Strip Monopole (1)

Dual-band operation in 2.4/5.2 GHz WLAN bands;  
Antenna size: 12 x 8 x 3 mm<sup>3</sup>

**planar structure**



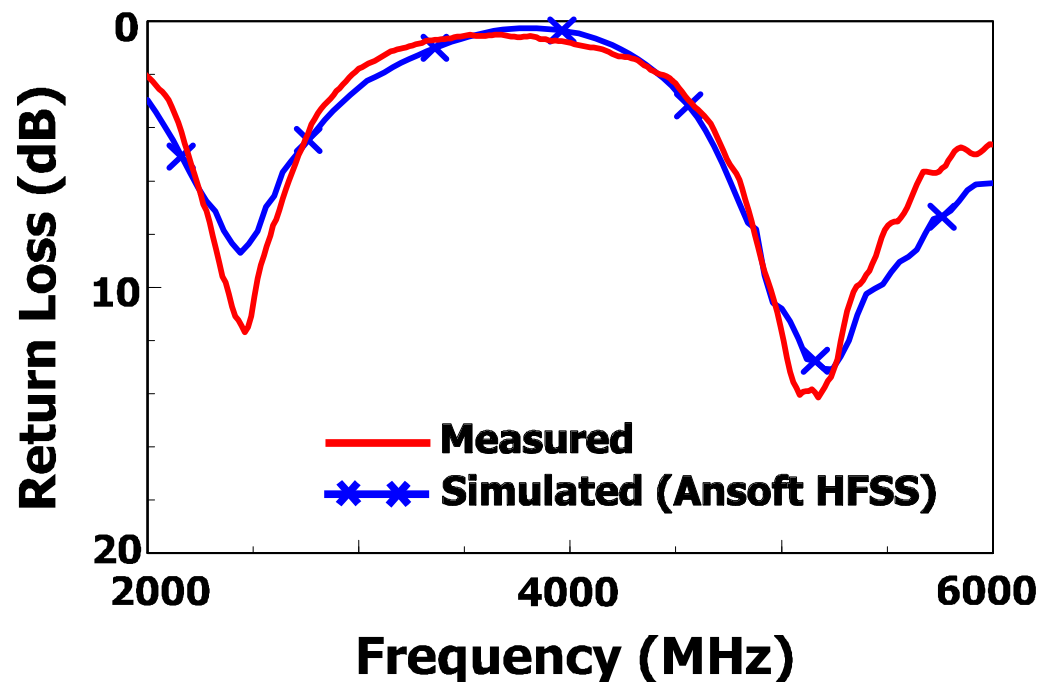
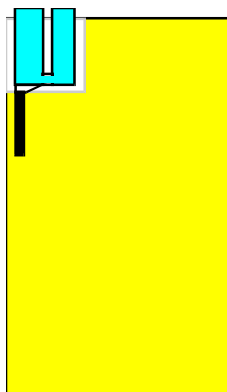
**bending line**



# SMA- Plastic Chip or Folded Strip Monopole (1.1)

10 dB RL BW: 130 MHz for 2.4 GHz band, 418 MHz for 5.2 GHz band;

Gain level about 2 dBi in the 2.4 and 5.2 GHz bands





# SMA- DR Antennas

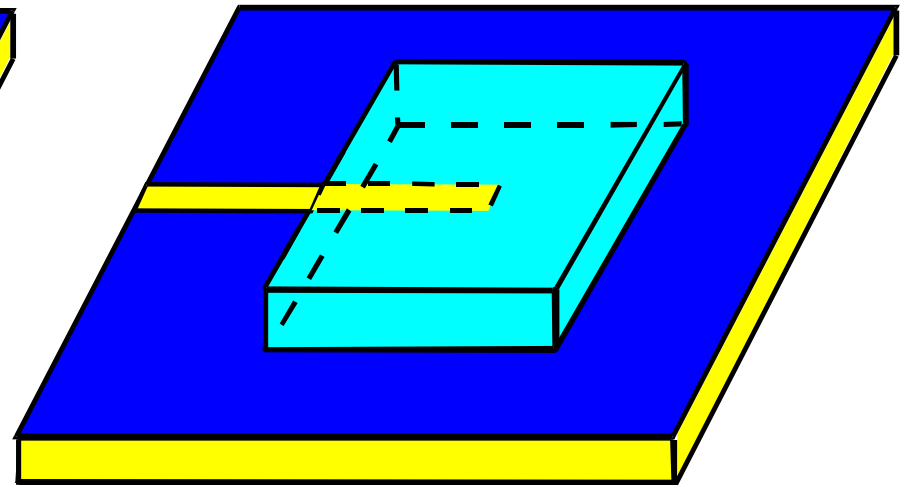
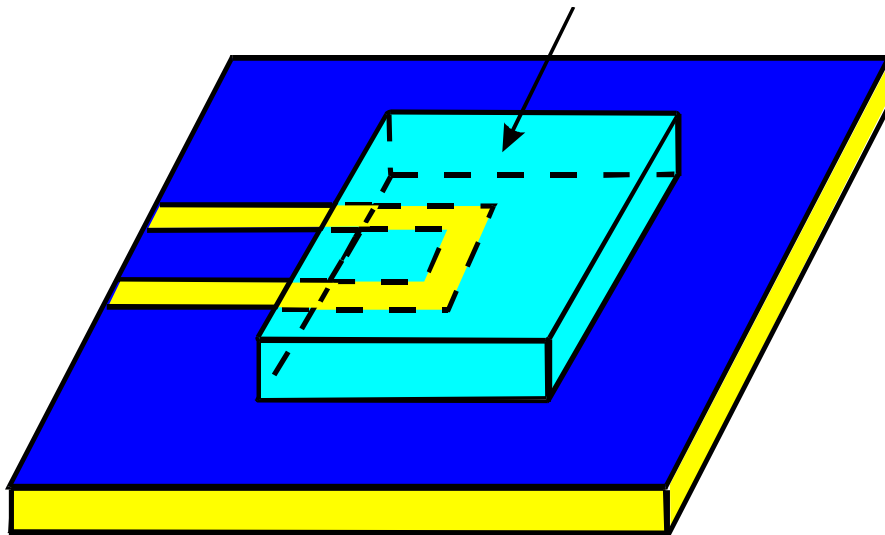
---

- **Dielectric constant = 20 ~ 100**
- **Compact size**
- **Very low dielectric loss**
- **No metallic loss, Suitable for higher-frequency operation**
- **Wider bandwidth than microstrip antennas**

# SMA- DR Antenna with a CPW feed or a microstrip-line feed

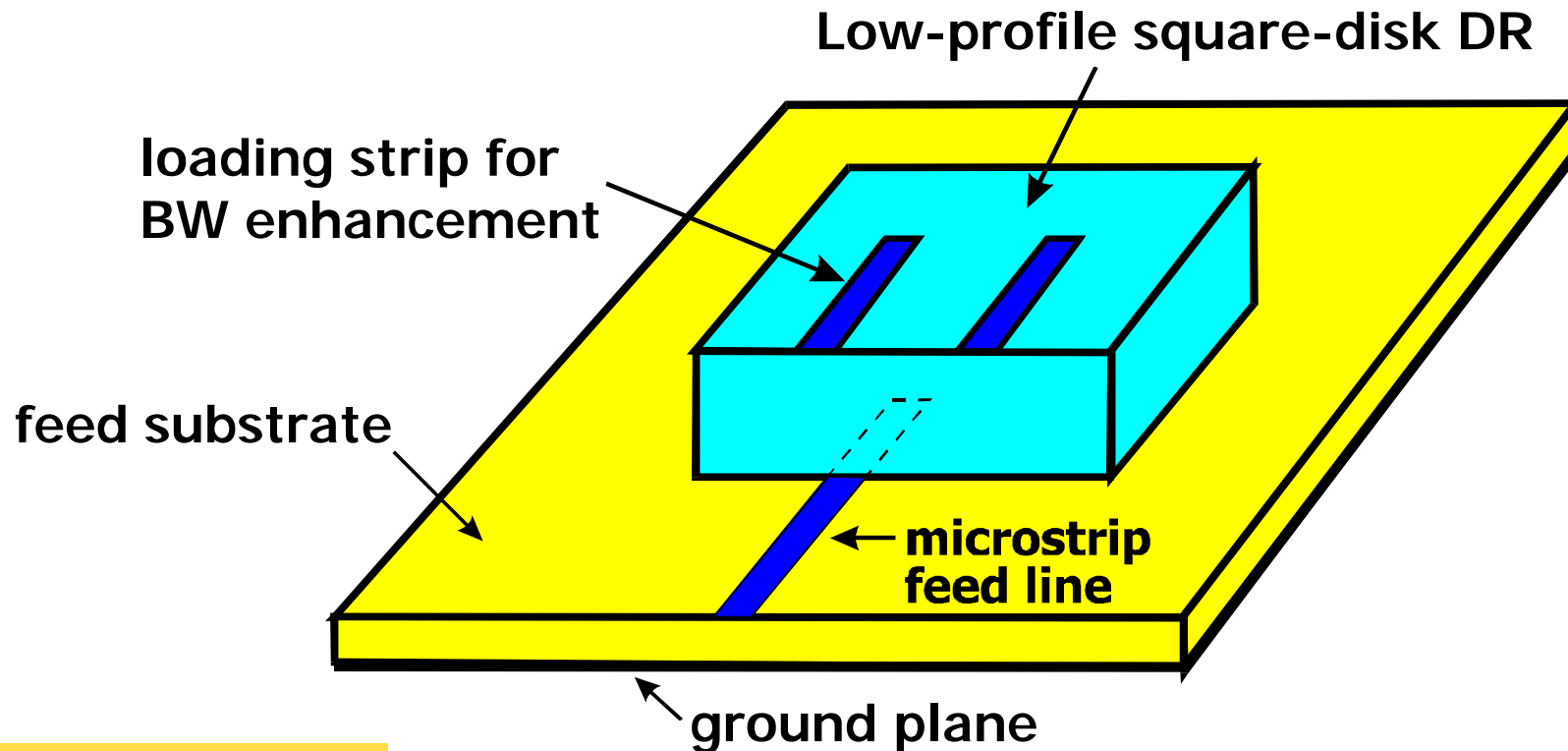
**DR antenna can be easily excited by a CPW line or a microstrip line**

Low-profile square-disk DR



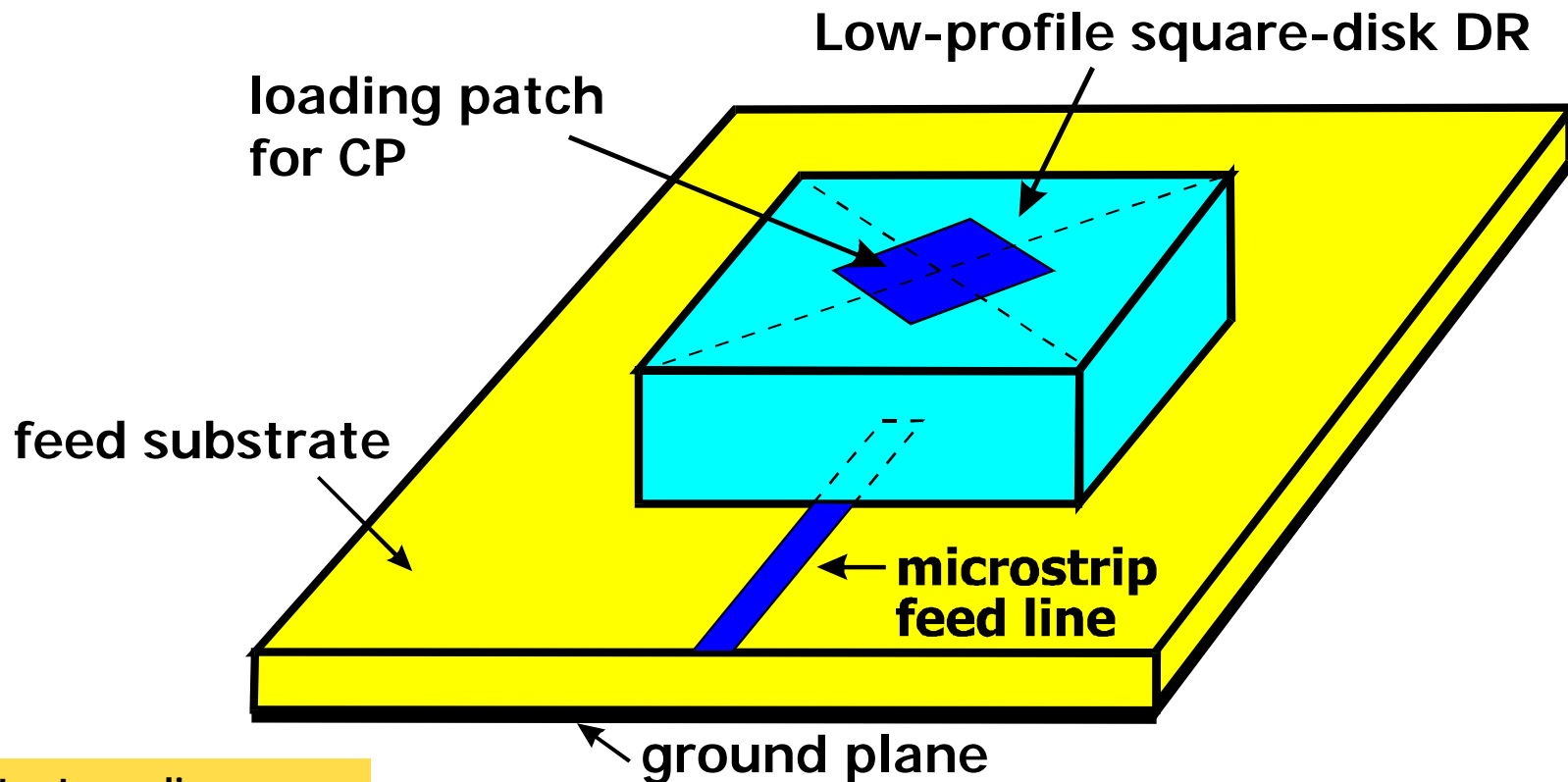
# SMA- Broadband DR Antenna with a Microstrip Feed (1)

DRA with size  $1.6 \times 10 \times 10 \text{ mm}^3$  and  $\epsilon_r = 90.5$  has a 250-MHz BW for WLAN operation in the 5.2 GHz band



# SMA- DR Antenna for CP Radiation (1) using a loading patch

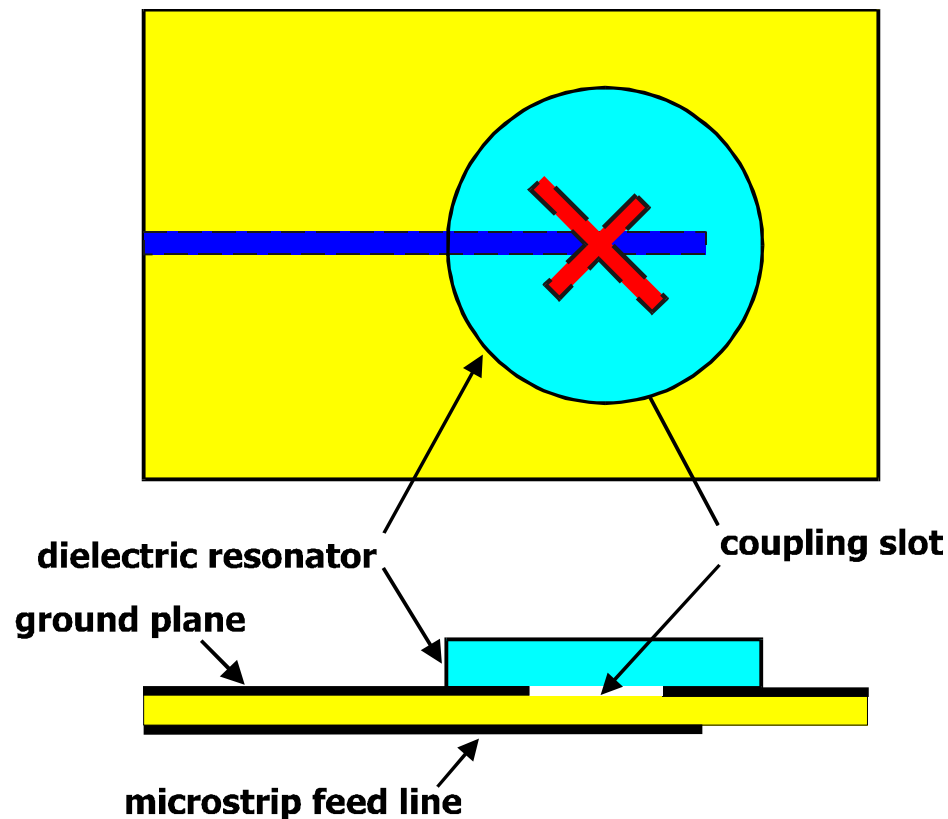
DRA with size  $28 \times 28 \times 4.9 \text{ mm}^3$  and  $\epsilon_r = 79$   
has a 1.1% CP BW@2 GHz





# SMA- DR Antenna for CP Radiation (2) using a cross-slot-coupled feed

DRA with radius 14.7 mm, height 5.1 mm, and  $\epsilon_r = 79$  has a 3.9% CP BW@2 GHz



# WLAN Printed Monopole Antennas



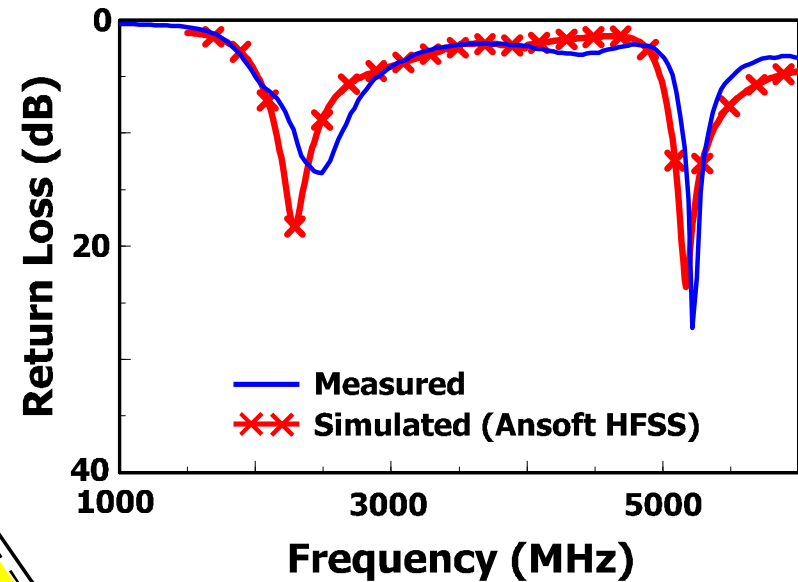
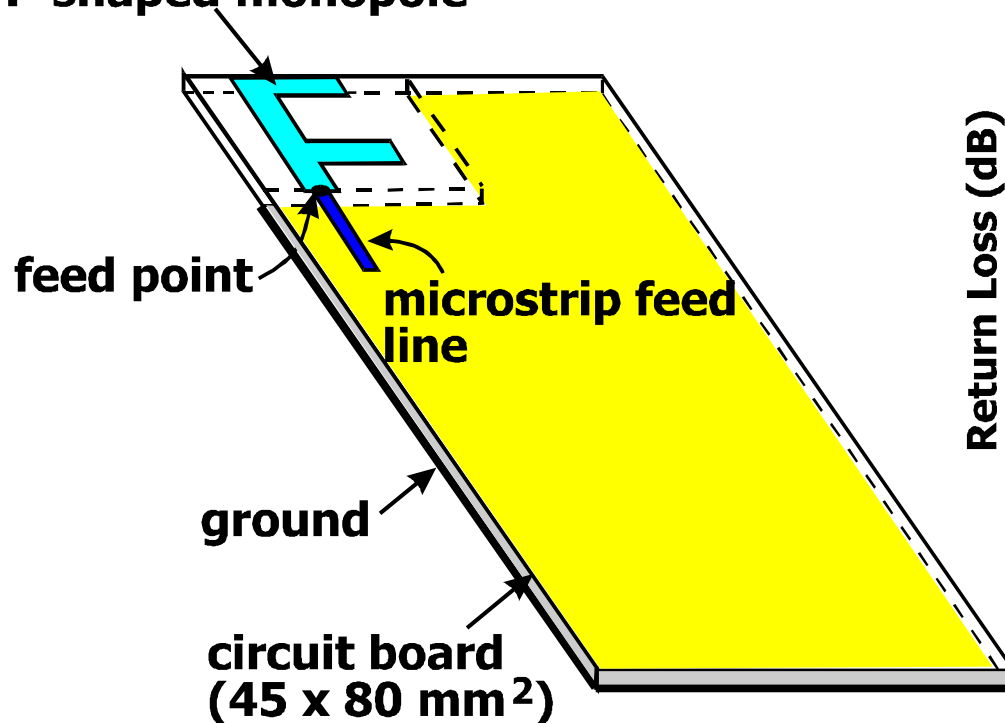
---

- **Integrated design with the system circuit board**
  - Dual-band monopole antenna
  - Diversity monopole antenna
  - Diversity dual-band monopole antenna
- **Printed monopole with a coaxial feed line**

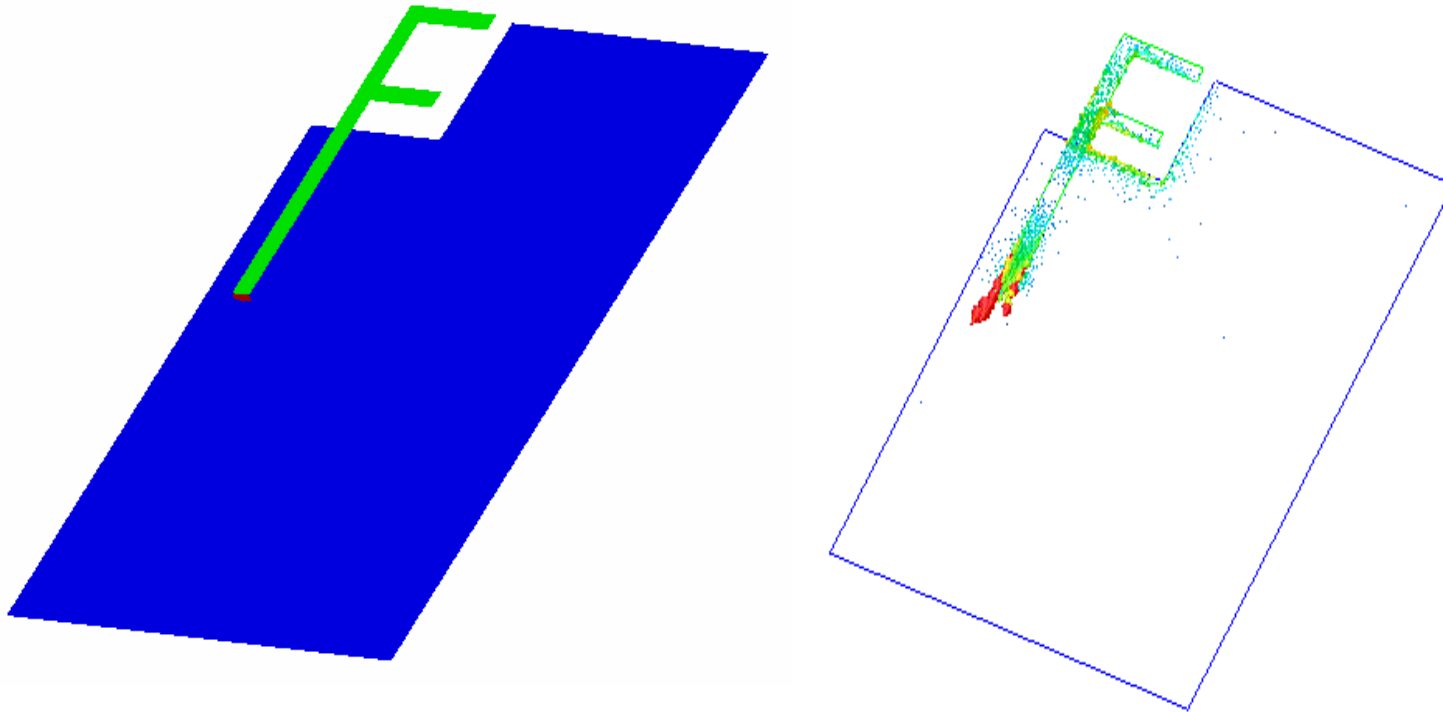
# WLAN Printed Monopole-Dual-band monopole (1)

Dual-band F-shaped monopole for 2.4/5.2 GHz WLAN bands; antenna size: 10 x 15 mm<sup>2</sup>

F-shaped monopole

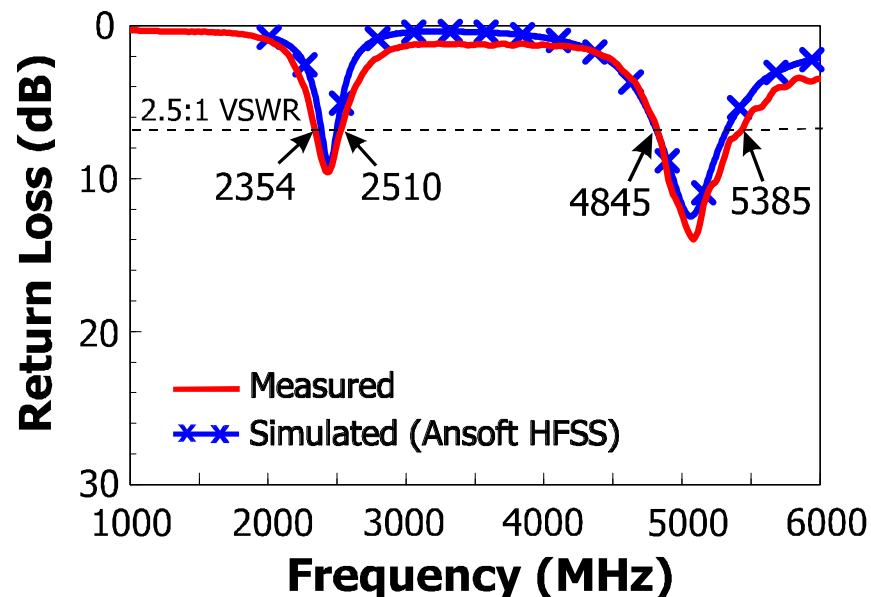
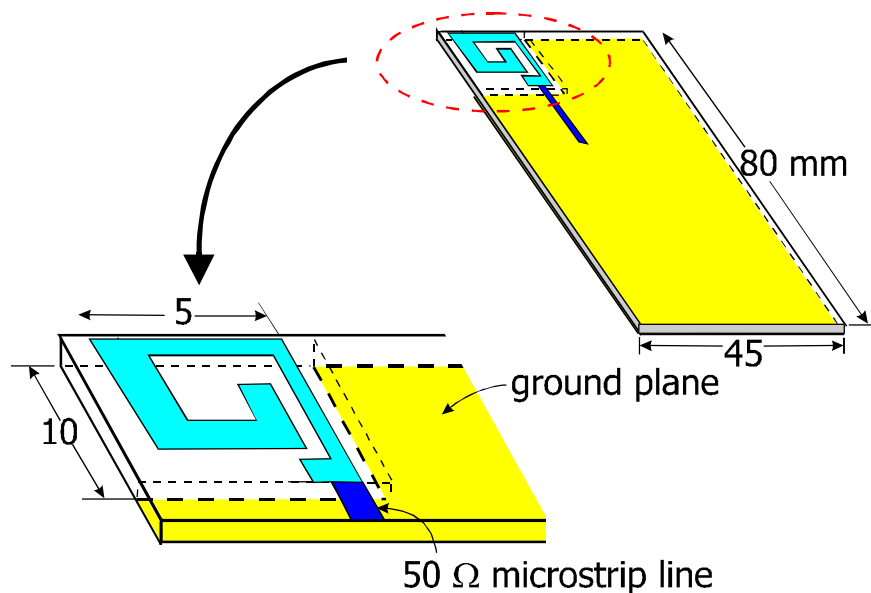


# 3D Model in Ansoft HFSS & Vector Current Plot

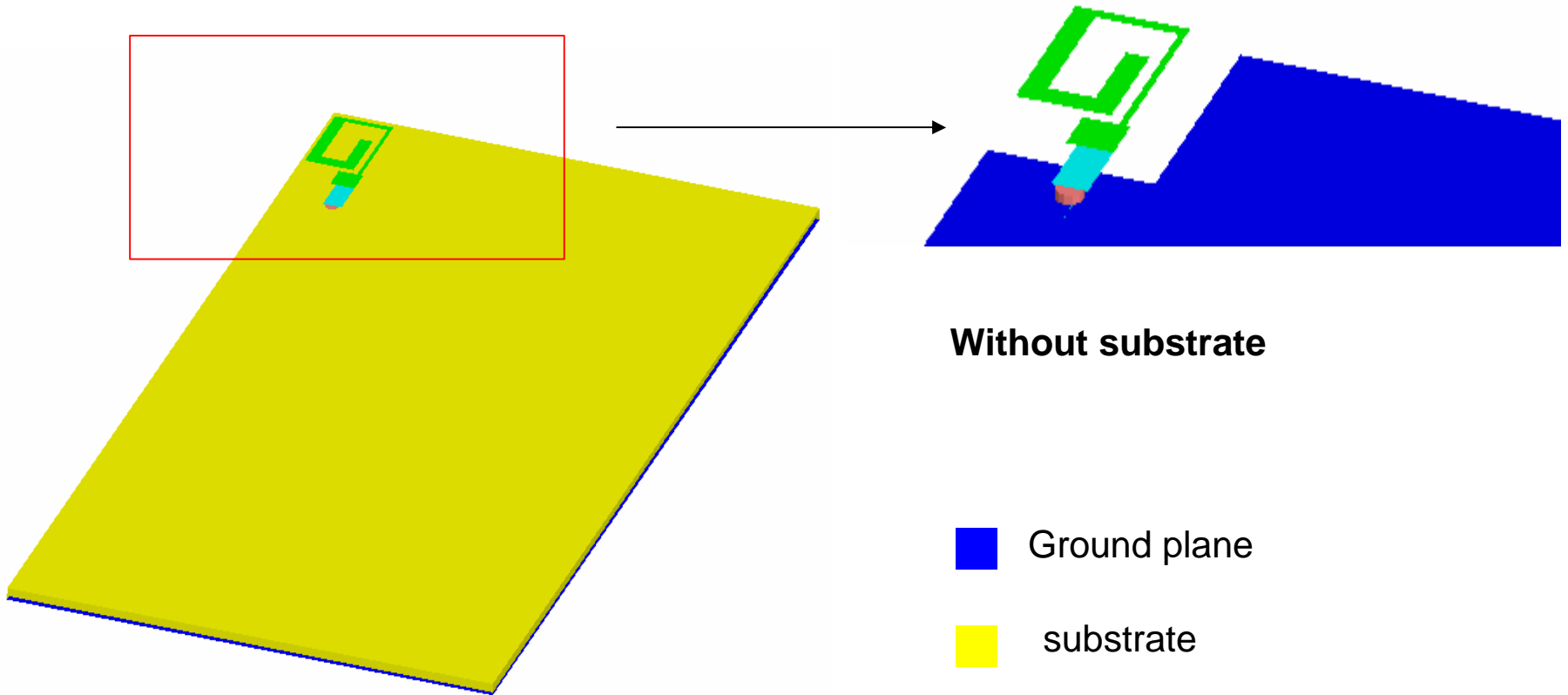


# WLAN Printed Monopole-Dual-band monopole (2)

Dual-band spiral monopole for 2.4/5.2 GHz WLAN bands



# 3D Model in Ansoft HFSS



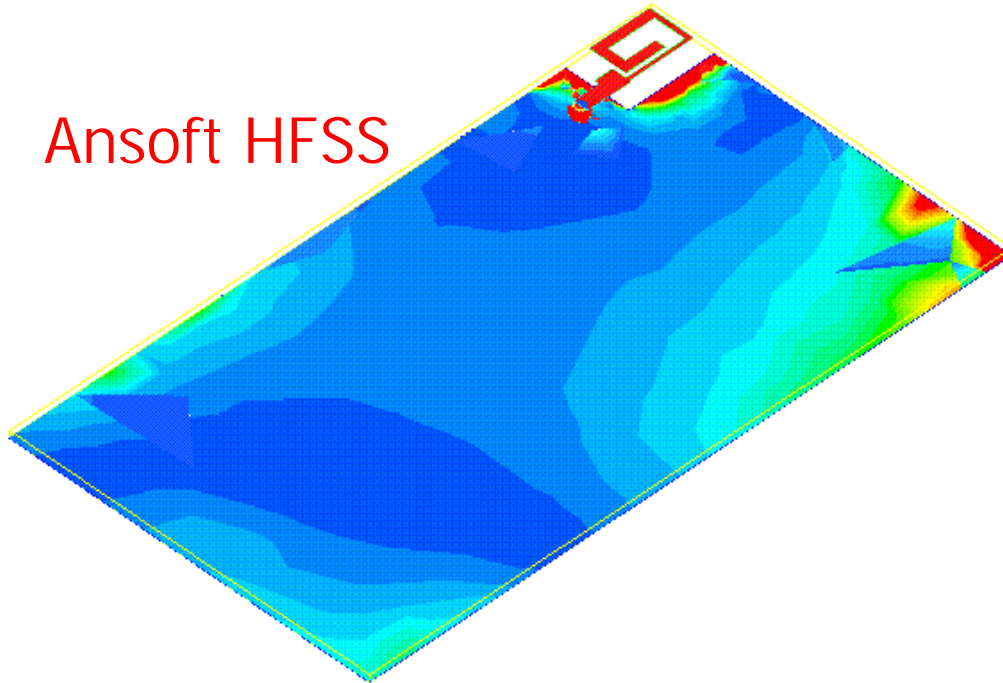
**Without substrate**

■ Ground plane

■ substrate

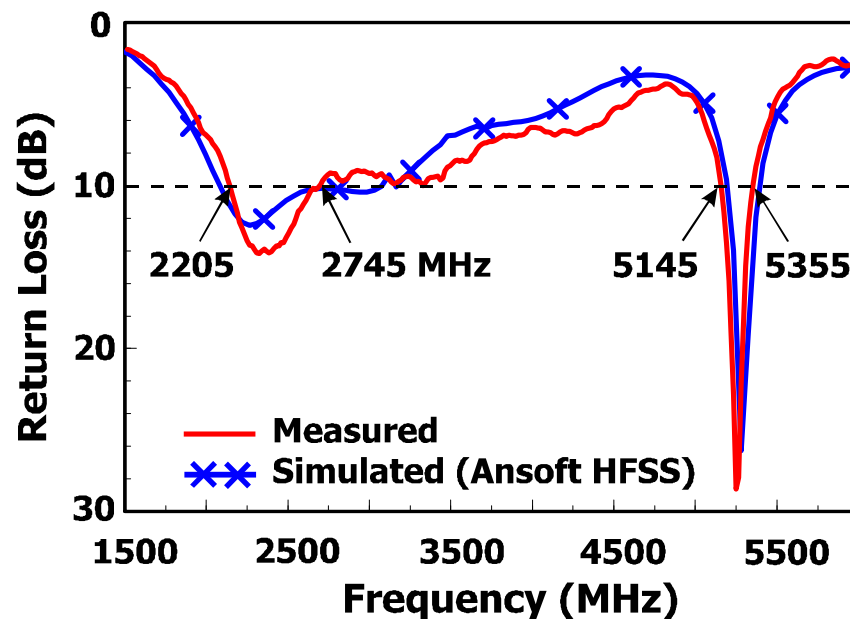
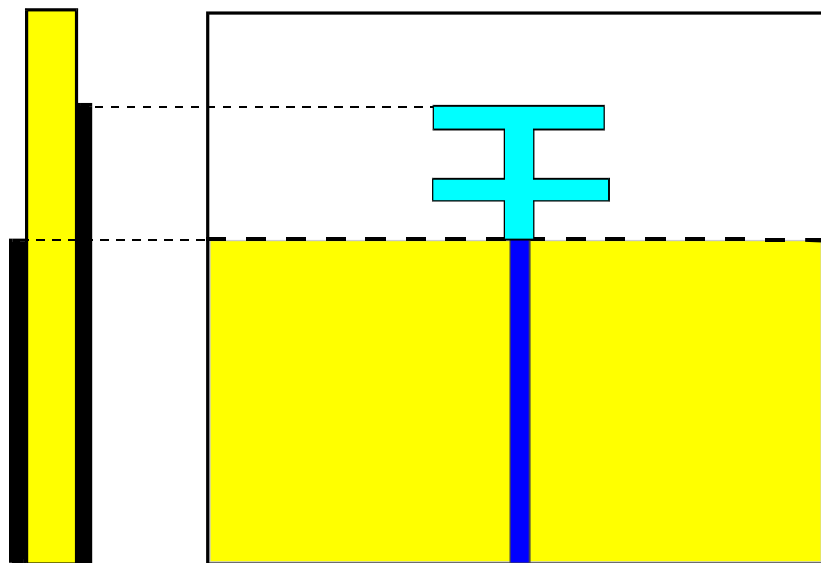
# Magnitude Current Plot on Antenna

Ansoft HFSS



# WLAN Printed Monopole-Dual-band design (3)

Dual-band double-T monopole for 2.4/5.2 GHz WLAN bands

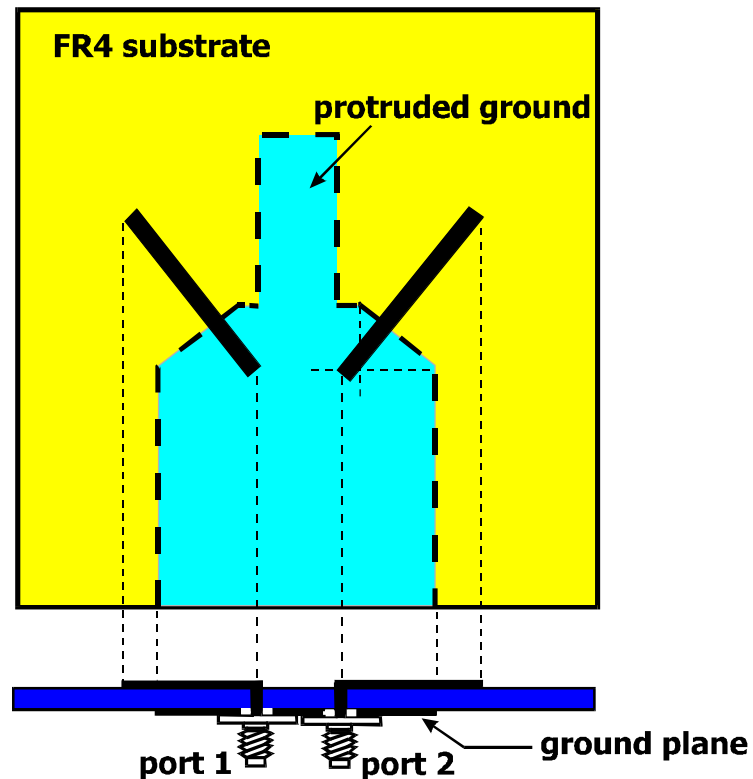




# WLAN Printed Monopole- Diversity monopole design (1)

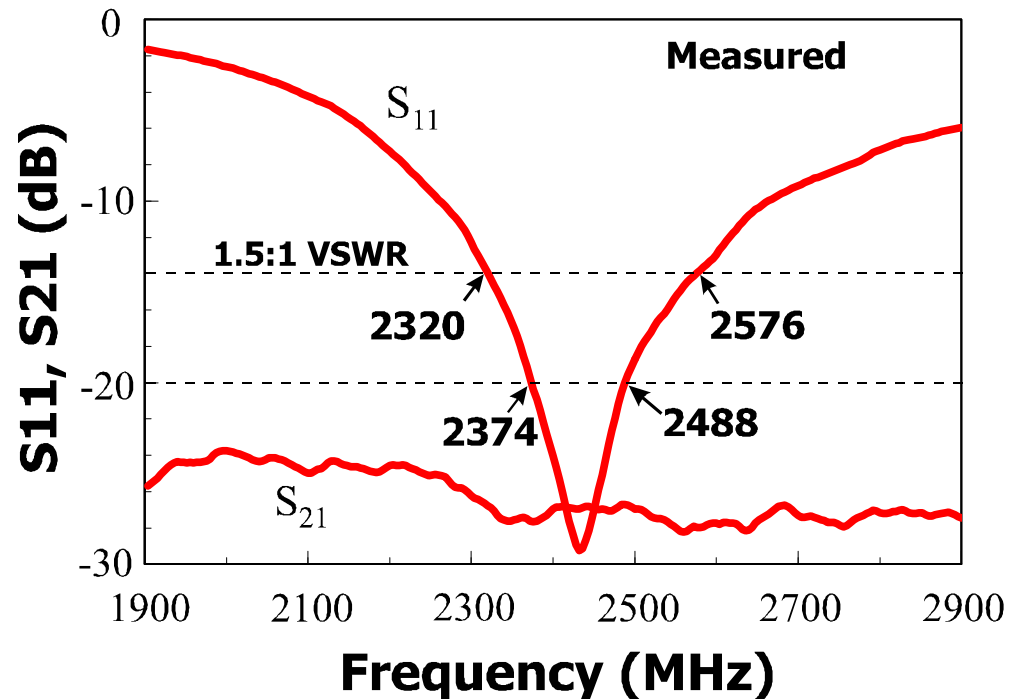
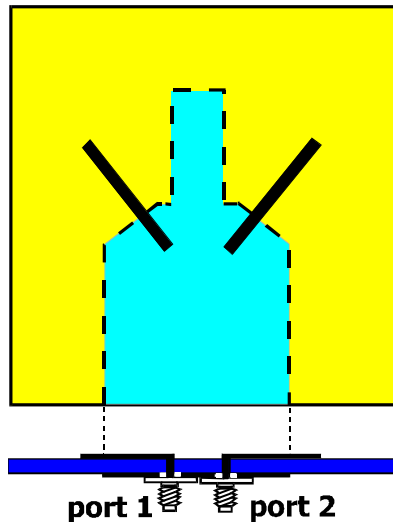
Spatial/polarization diversity in the 2.4 GHz band

Protruded ground plane improves port decoupling between ports 1 and 2



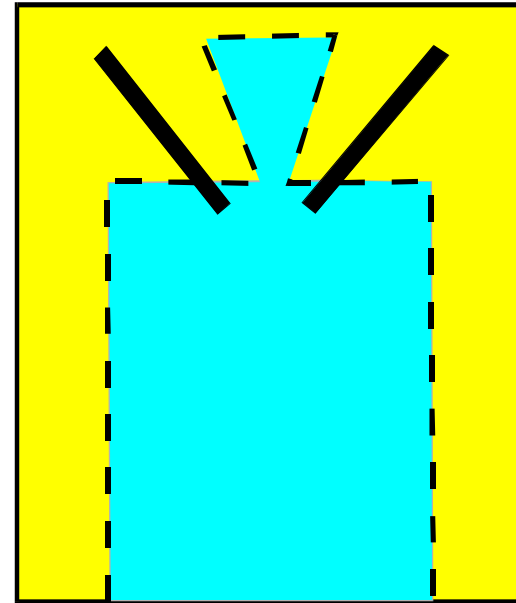
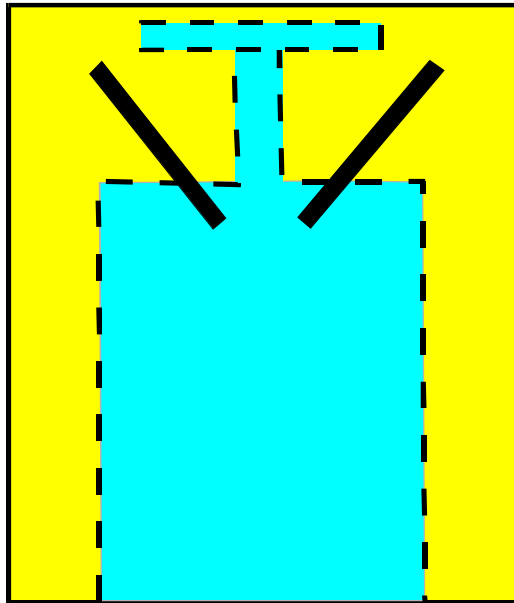
# WLAN Printed Monopole-Diversity monopole design (1.1)

Gain level ~ 1.8 dBi for ports 1 and 2



# WLAN Printed Monopole-Diversity monopole design (1.3)

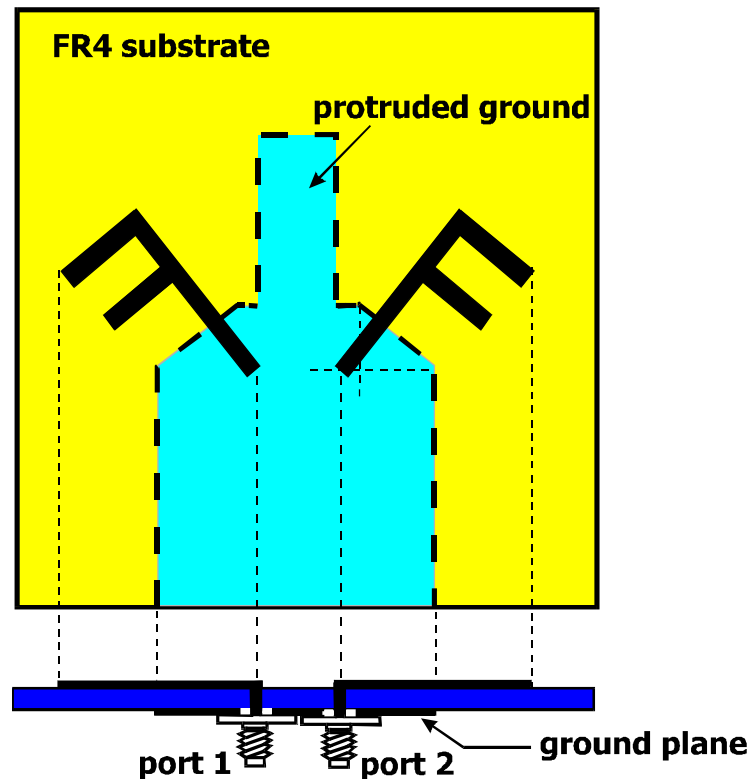
Other promising diversity monopole antennas with highly decoupled feeding ports



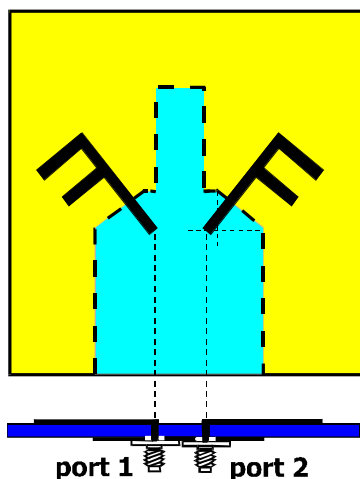
# WLAN Printed Monopole-Diversity dual-band monopole (1)

Diversity monopole antenna for 2.4 and 5.2 GHz dual-band operations

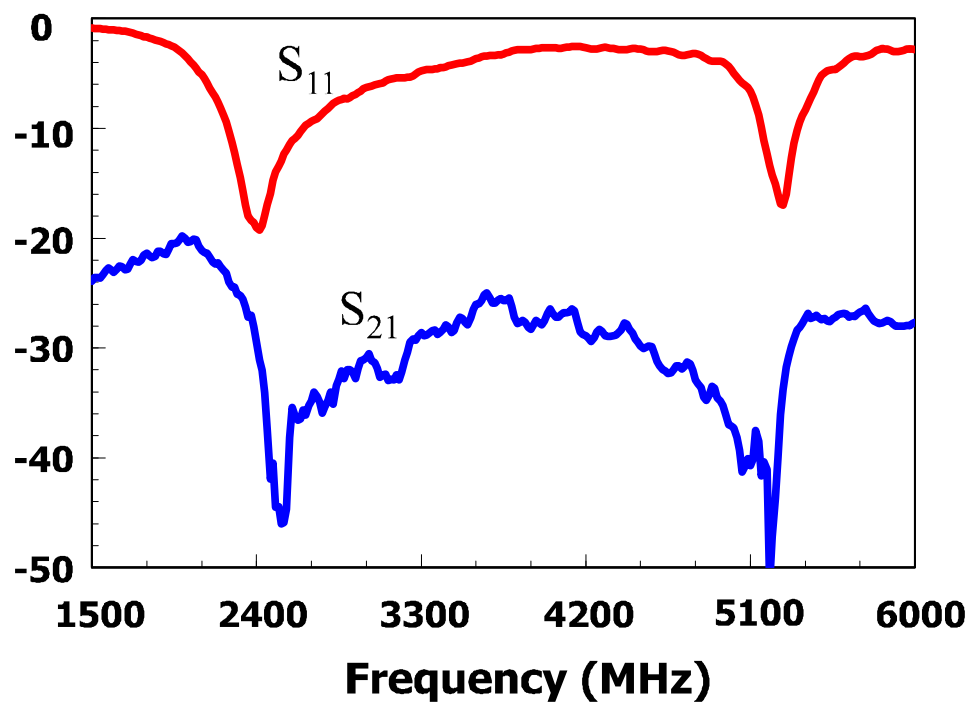
Protruded ground plane improves port decoupling between ports 1 and 2



# WLAN Printed Monopole- Diversity dual-band monopole (1.1)

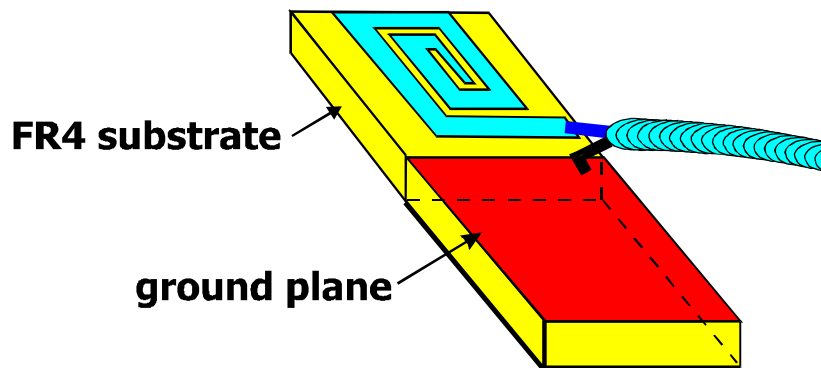
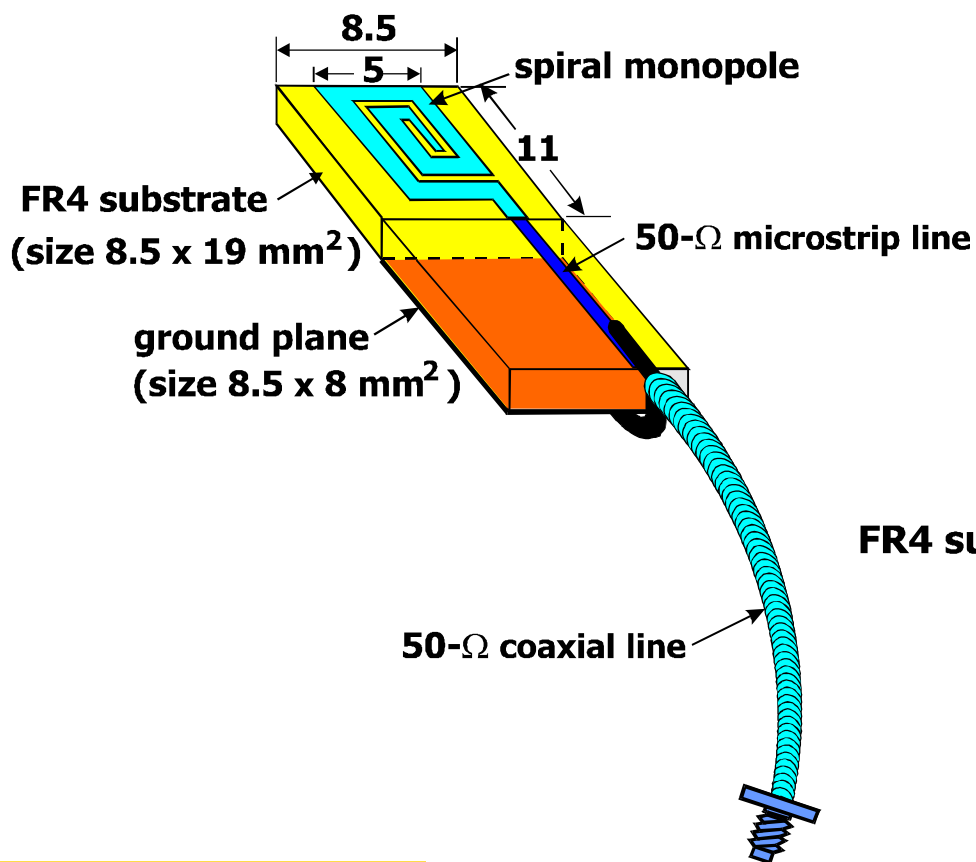


Within the 2.4 and 5.2 GHz bands,  
 $S_{11} < -10$  dB and  $S_{21} < -28$  dB



# WLAN Printed Monopole- using a coaxial feed line

Dual-band spiral monopole for 2.4/5.2 GHz WLAN bands



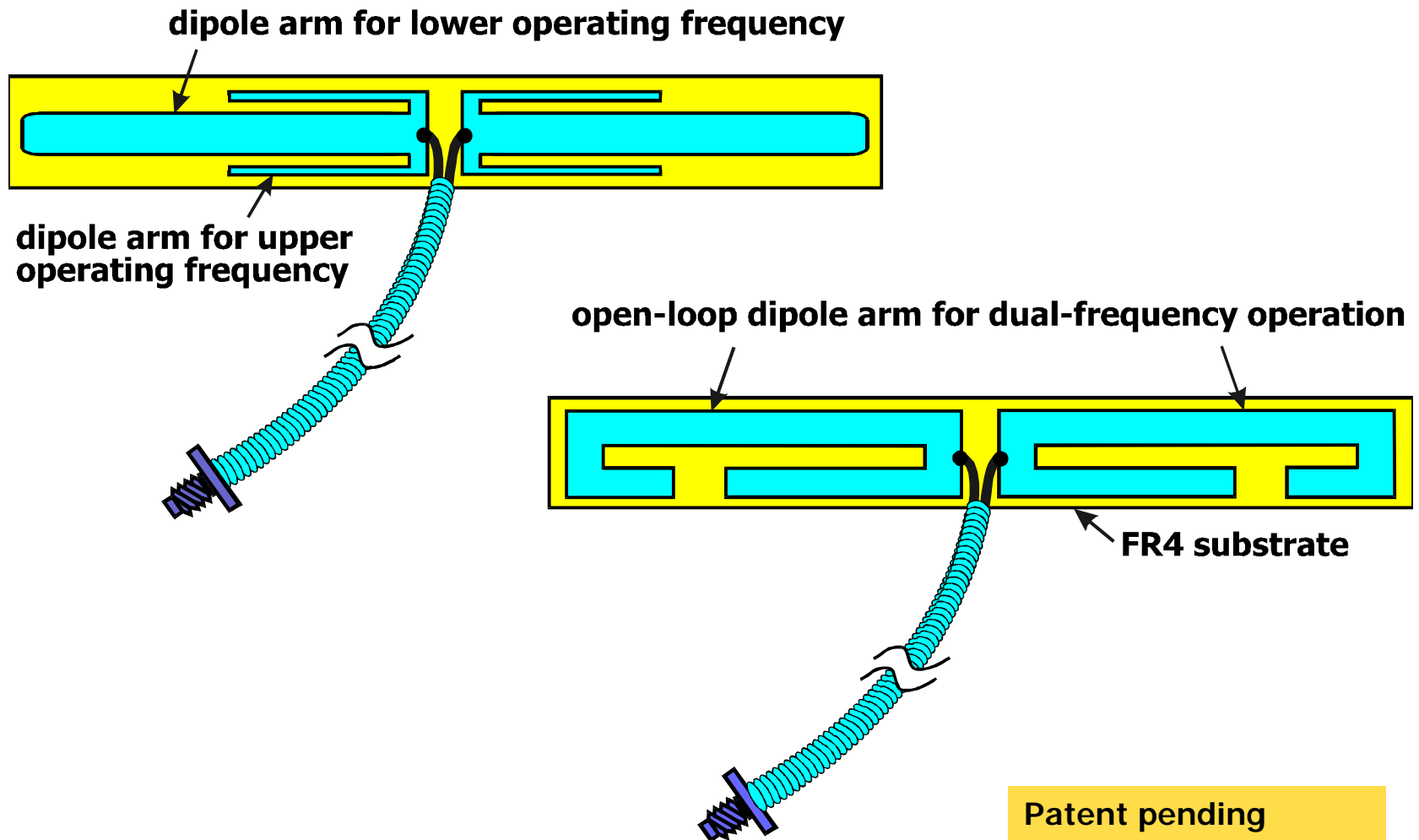
# Dual-Band Printed Dipole Antennas



---

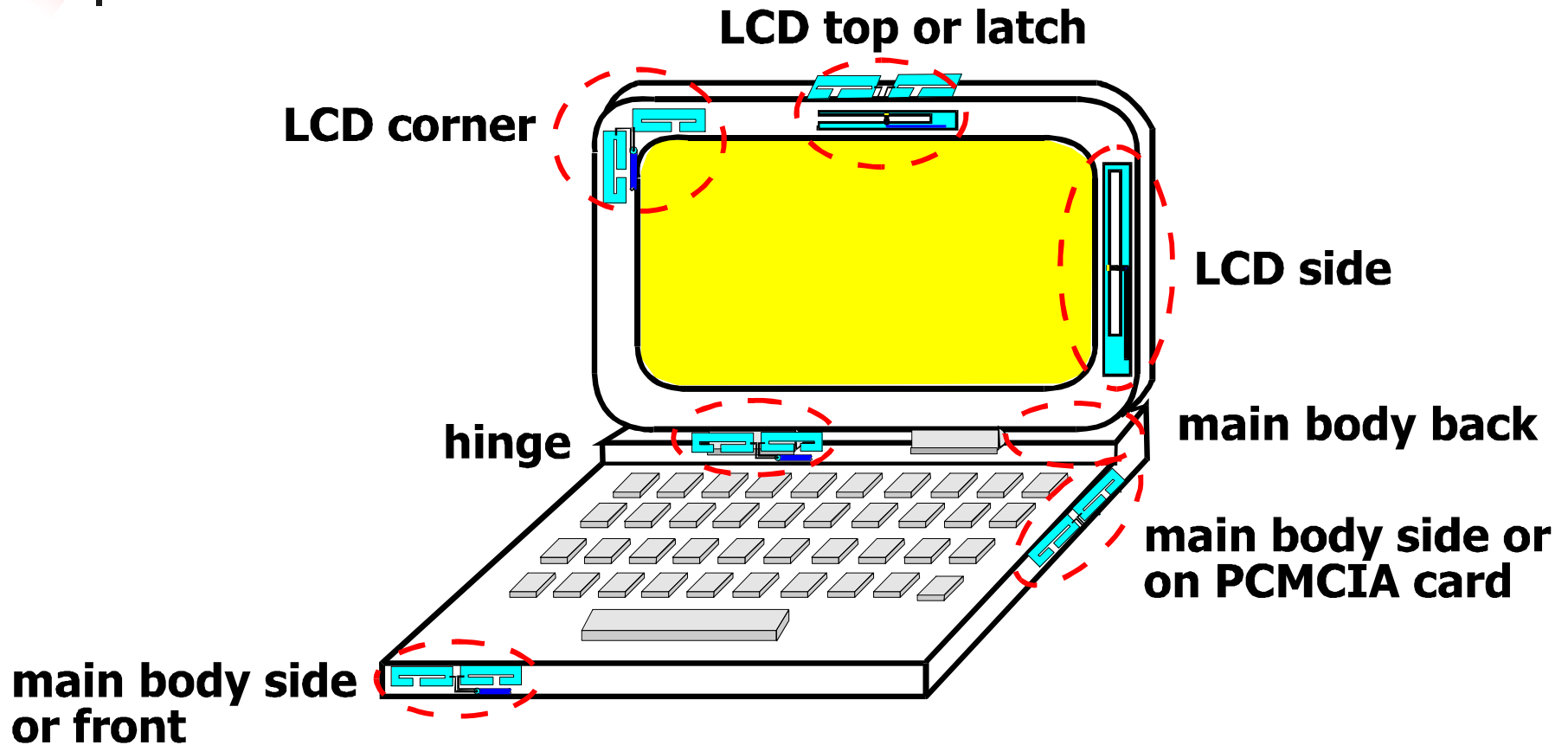
- **With trident arms**
- **With open-loop arms**
- **With L-slit-loaded arms**
- **With U-slotted arms**
- **With folded arms**

# Dual-Band Printed Dipole-Fed by a Coaxial Line (1)

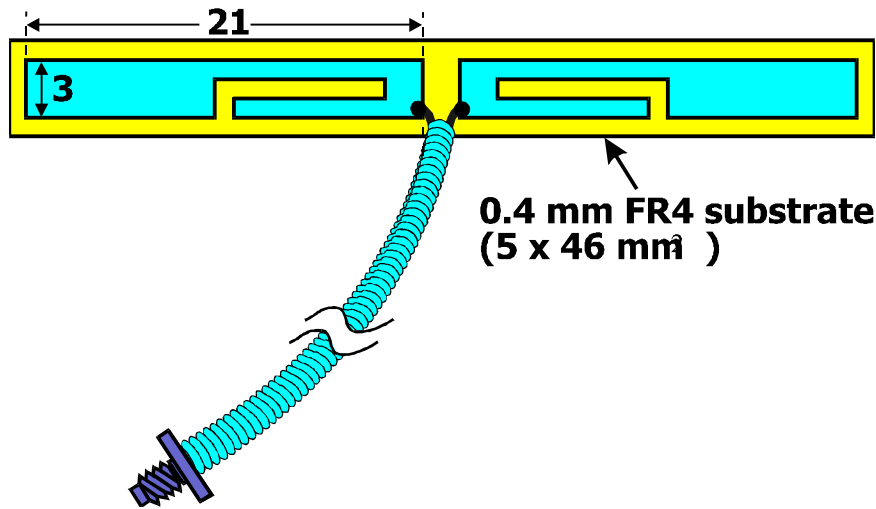




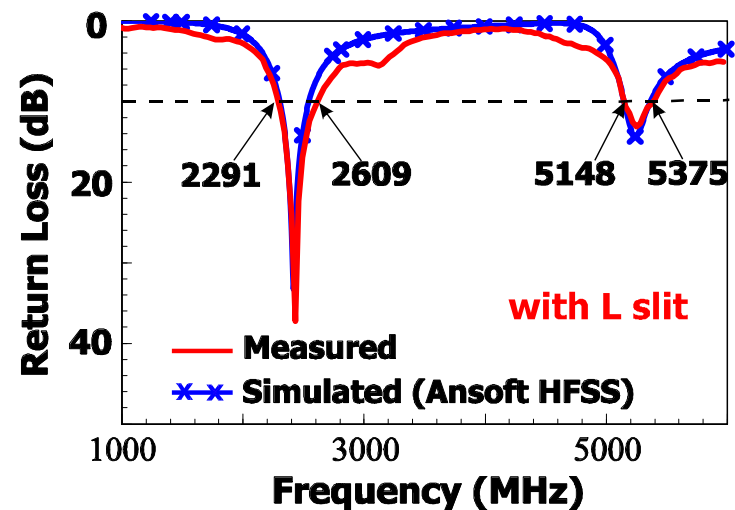
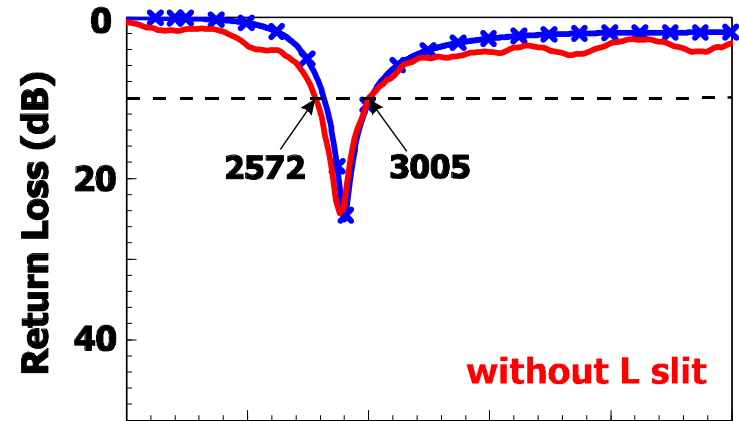
# Printed Dipoles/Monopoles/Slot Antennas/ PIFAs Applied to Notebook Computer



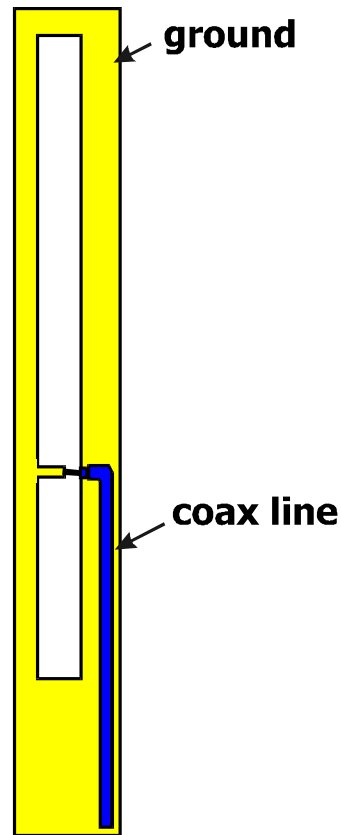
# Dual-Band Printed Dipole-Fed by a Coaxial Line (2)



Radiation patterns across the 2.4 and 5.2 GHz bands are stable and close to those of a simple dipole antenna

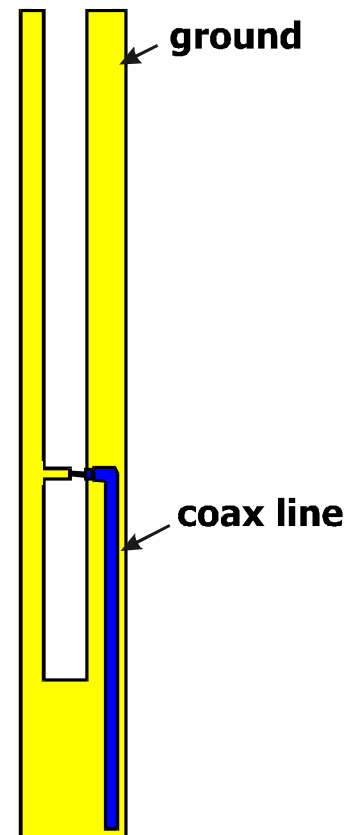


# WLAN Slot Antenna/PIFA Applied to Notebook Computer



**slot antenna**

**0.5 wavelength in length**

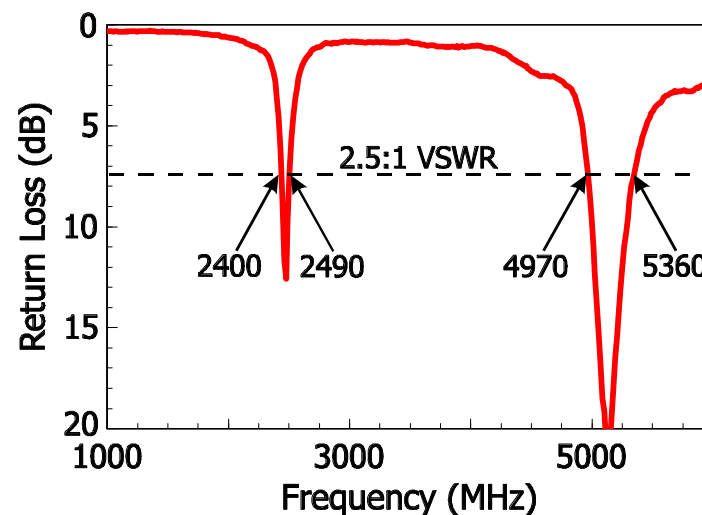
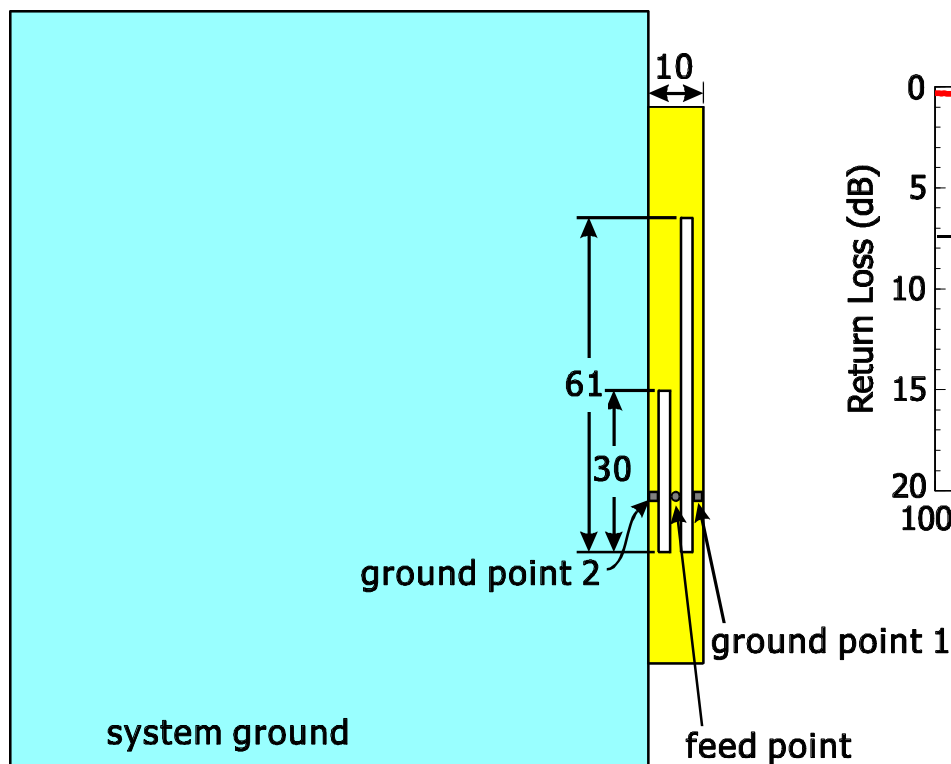


**PIFA**

**0.25 wavelength in length**

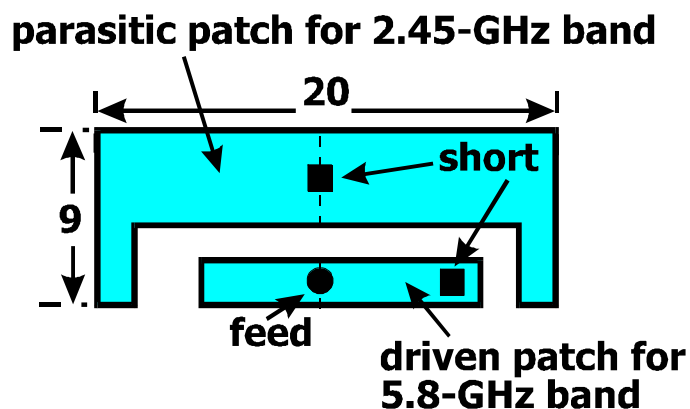
# WLAN 2.4/5.2 GHz Dual-Band Slot Antenna

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

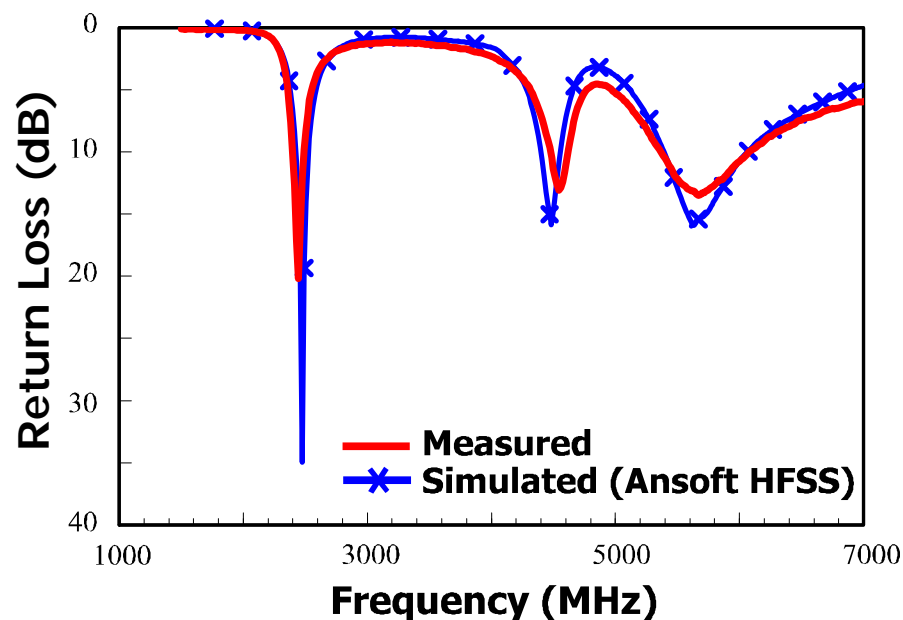


# PIFAs for WLAN Operation- PIFA with a parasitic shorted patch

Antenna operates at the first resonant frequency of the driven and parasitic patches (2.4/5.8 GHz dual band)



Patch 5 mm above ground





# WLAN AP Antennas

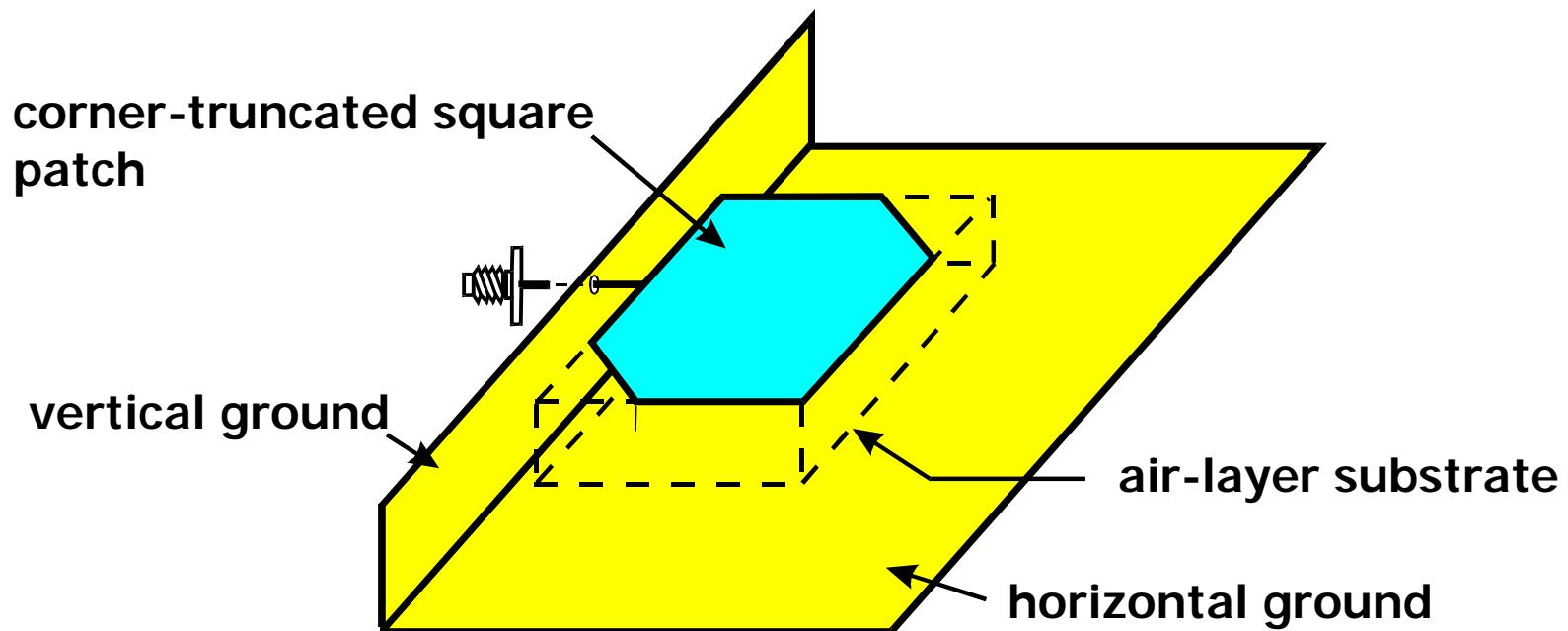
---

- **Broadband CP design**
- **Dual-polarized design**
- **Dual-band design**
- **Printed dipole array for omnidirectional radiation**

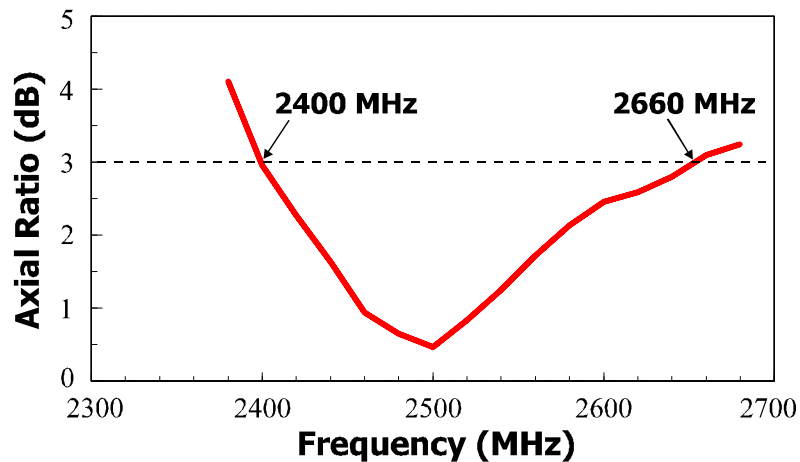
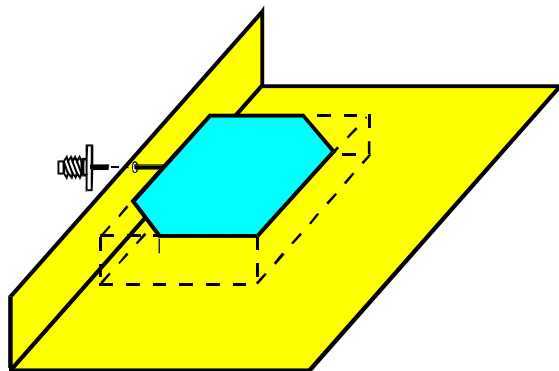
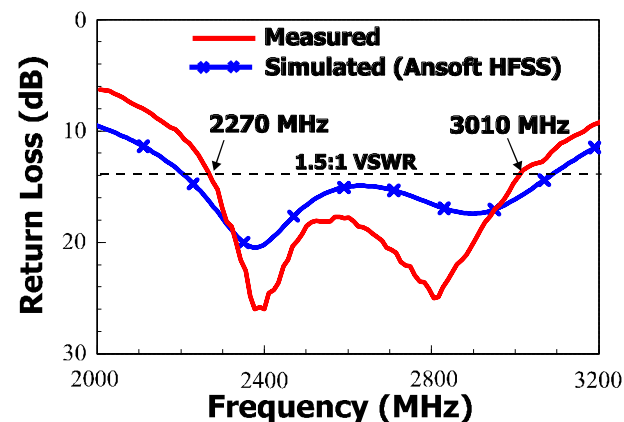
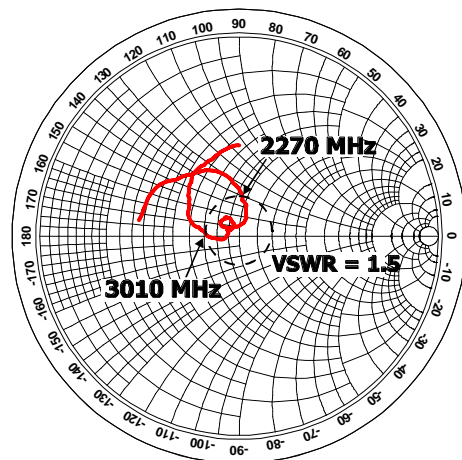
# WLAN AP Antenna- Broadband CP design (1)

- Single-feed design with low cost in construction

**3dB AR CP bandwidth > 10% @ 2.45 GHz,  
gain level ~ 8.5 dBi**

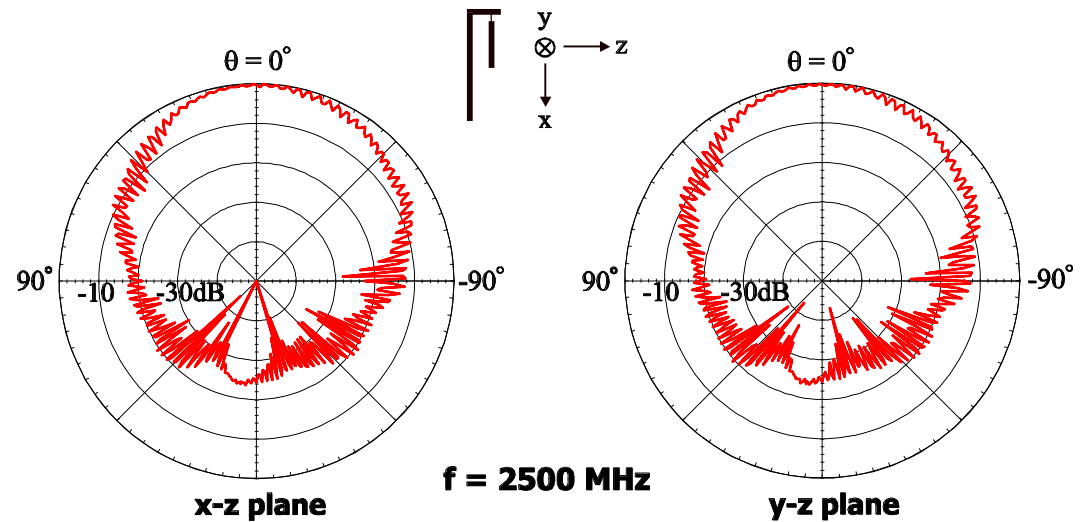
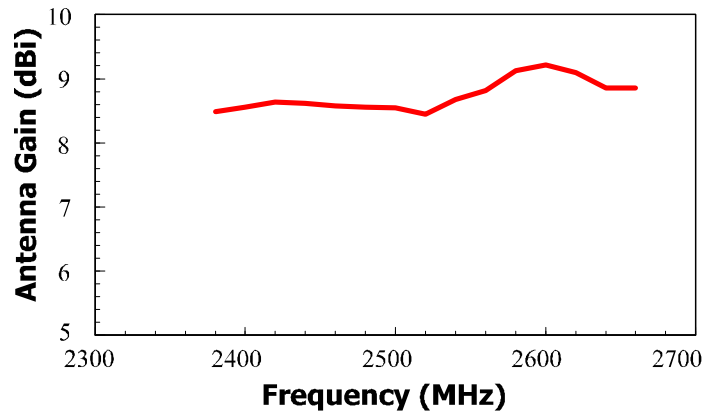


# WLAN AP Antenna- Broadband CP design (1.1)

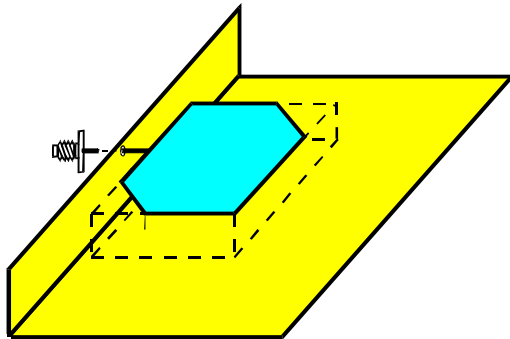




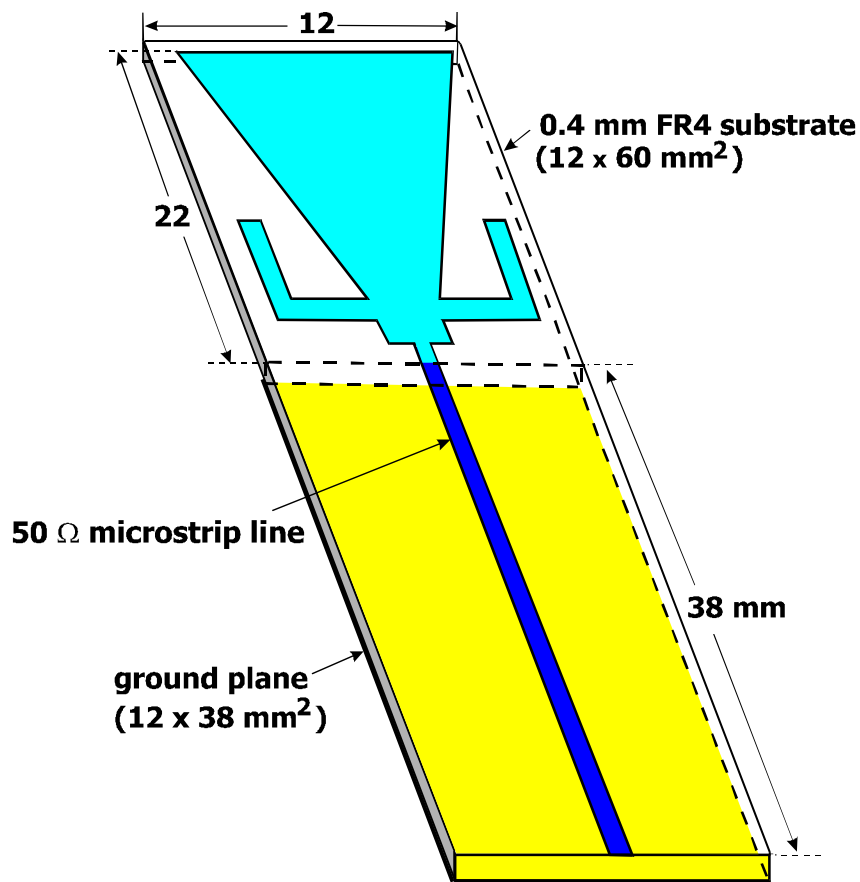
# WLAN AP Antenna- Broadband CP design (1.2)



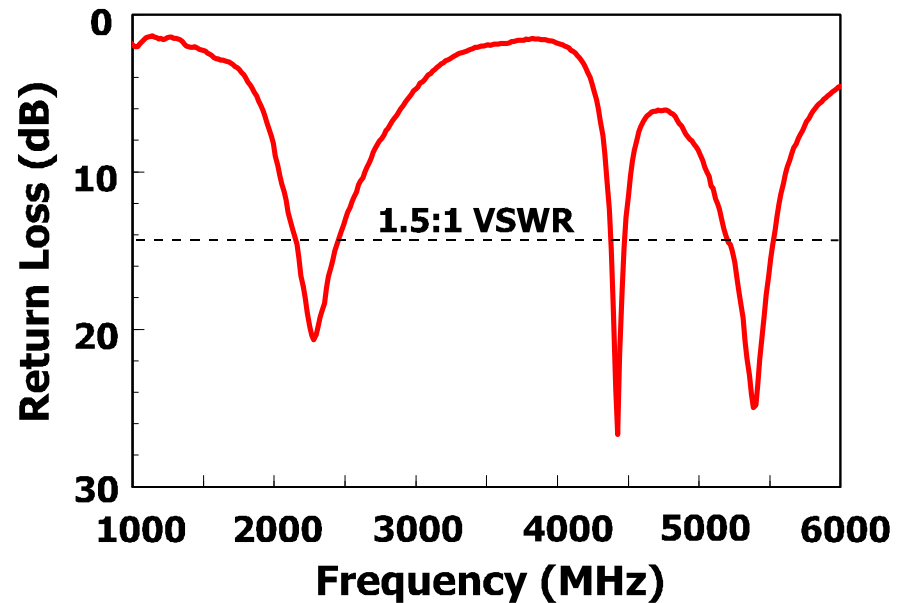
**Spinning linear radiation patterns**



# WLAN AP Antenna- Dual-Band design- Printed monopole



2.4 GHz band: 3.5-4.0 dBi  
 5.2 GHz band: 4.0-5.5 dBi  
 Omnidirectional radiation



# WLAN AP Antenna-

## Omnidirectional printed dipole array (1)

5 GHz AP dipole array:

1.5:1 VSWR: 5.15-5.35 GHz

Peak gain: > 5.5 dBi

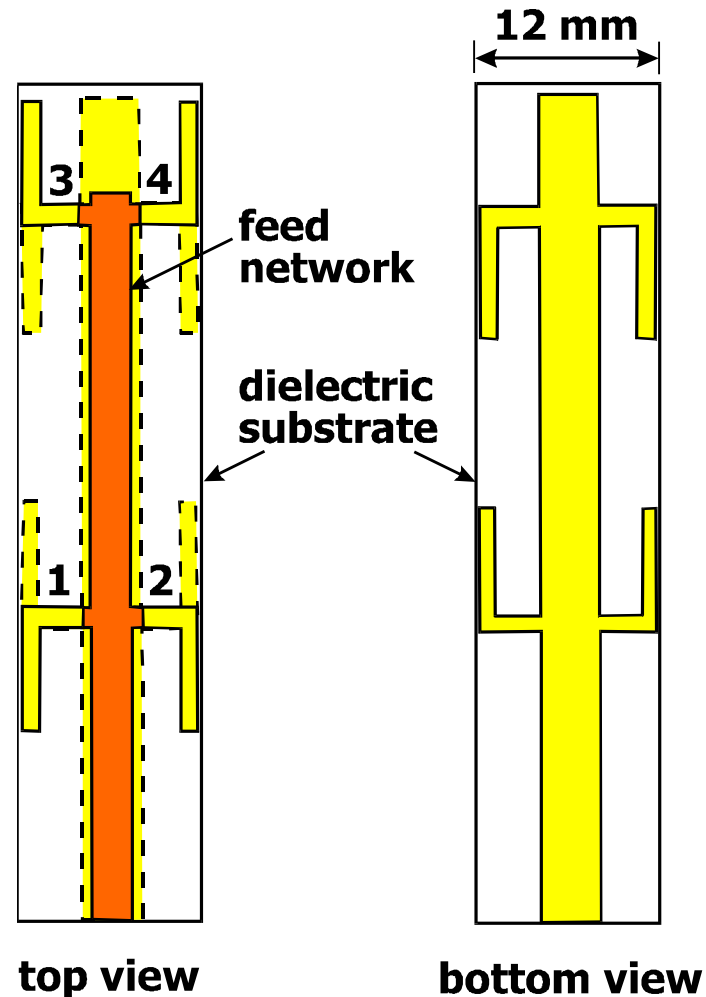
Omnidirectional ripple: < 2 dBi

Size: 12 mm x 90 mm

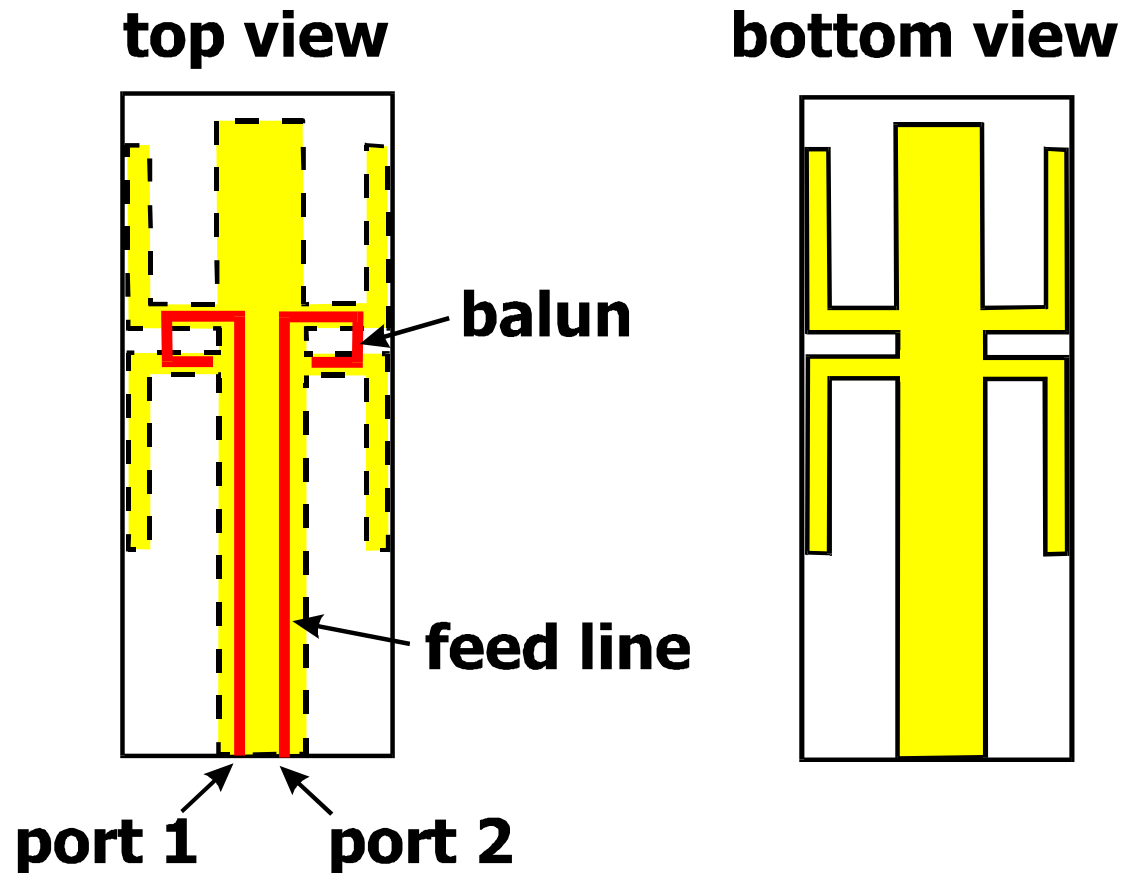
Omnidirectional pattern

Ports 1, 2:  $0^\circ$ , 1/4 power

Ports 3, 4:  $180^\circ$ , 1/4 power



# WLAN AP Antenna- Diversity printed dipole





# Conclusions

---

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