Design of Antennas for Mobile and Vehicle Applications

October 09. 2007

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Contents

1. Introduction

1.1 Antennas and RF Devices Lab.

1.2 Ansoft Training Center

Introduction

- Antennas and RF Devices Lab., Hanyang University
  - Supervisor: Prof. Jaehoon Choi
  - Office: 605-1, Annex of Engineering Center, Hanyang University
  - Members:
    - Post-Doc: 1
    - Ph. D: 14
    - M. S: 15
    - Alumni: 61

(APLAB Members)

Introduction

- Research Areas
  - Antennas
    - Multi/Wideband Antennas for Mobile Communication
    - Multi-band Antennas for Vehicle
    - Ultra-wideband antennas
  - RF devices and Circuit design
    - Multi/Wideband LNA
    - Tunable Filter
    - Oscillator
  - EMI/EMC
    - Automotive EMI/EMC
    - PCB EMI/EMC
  - Numerical Analysis
    - FDTD/GA
    - MOM
    - UTD

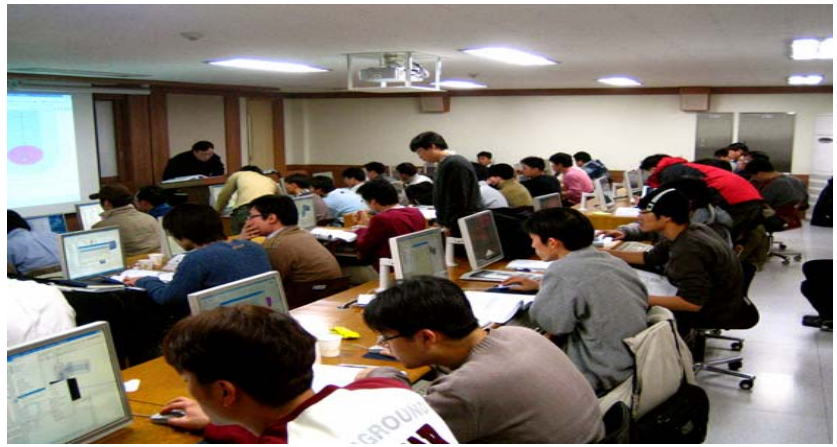
Introduction

- Ansoft Training Center
  - **Ansoft Training Center at Hanyang University: October, 2005**
  - **Course period: September 22. 2005 ~ September 21. 2007**
  - **The training course holds 7 ~ 8 times a year**
    - **Course Attendance: 440**
    - **The Number of Training Courses : 15 (2005: 2, 2006: 8, 2007: 5)**

(Ansoft training Center)

Introduction

- Ansoft Training Center
- Training Course
  - Basic training courses for beginners
  - Ansoft HFSS
    - Antenna, Filter, Connector,
    - Inductor, EMC/EMI
  - Ansoft Designer
    - Lumped LPF, Low Noise Amplifier
    - Planar EM
    - Circuit Design



(Training Course)

2. UWB

Design of Ultra-wideband Antennas with Band-stop Characteristic

UWB Wireless Communications

- Wideband antenna technology is required to satisfy the UWB system requirement
- The use of 5.15 GHz to 5.825 GHz frequency band has been limited by wireless local area network (WLAN)
- To avoid the interference between the UWB and WLAN systems, a band-notch filter in UWB systems is necessary

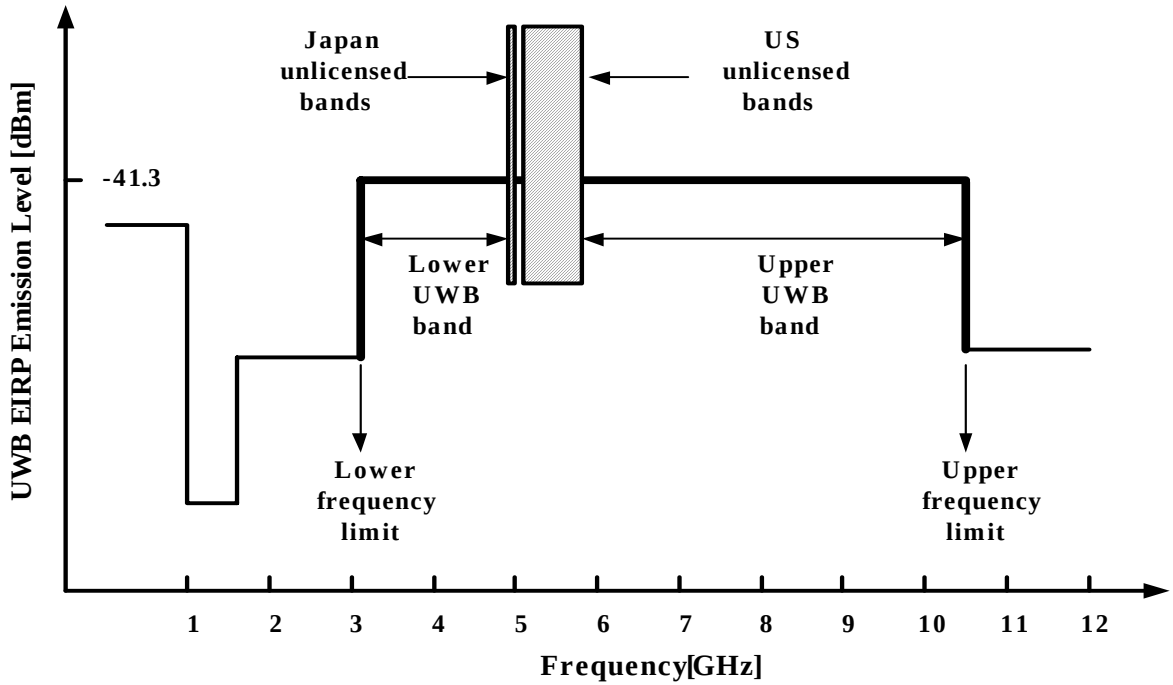


Fig. 1. UWB frequency spectrum.

UWB Antenna Design

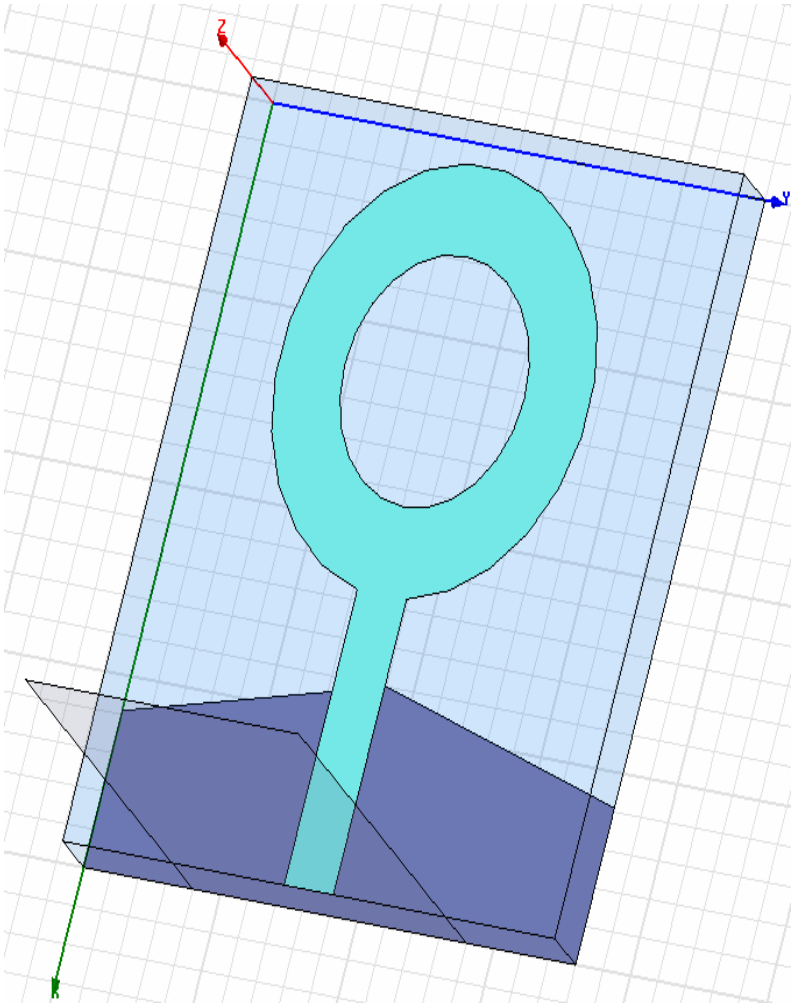


Fig. 2. Antenna Configuration

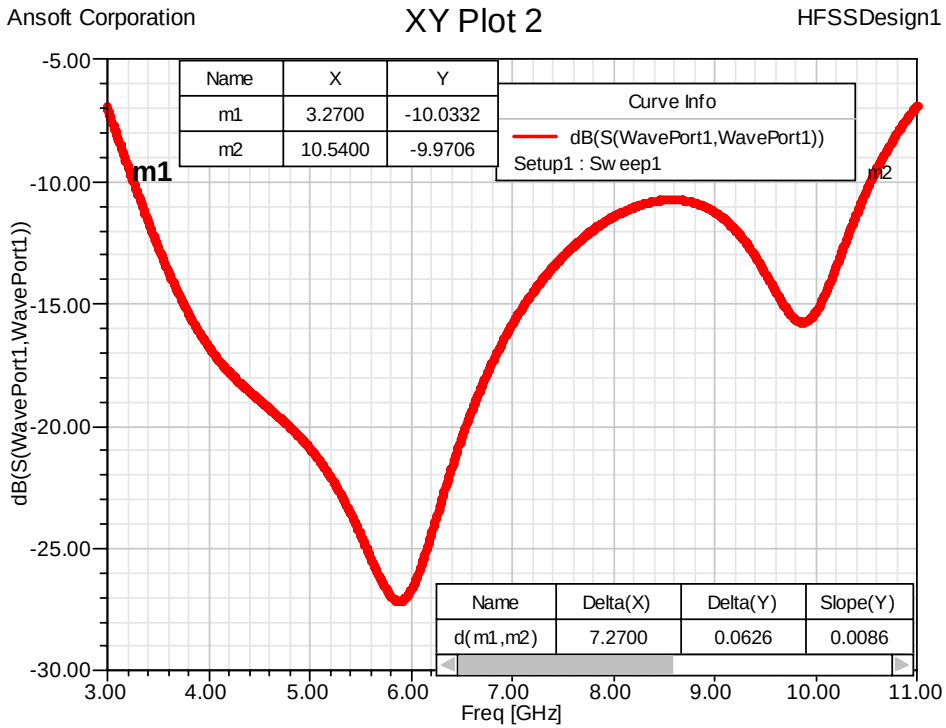
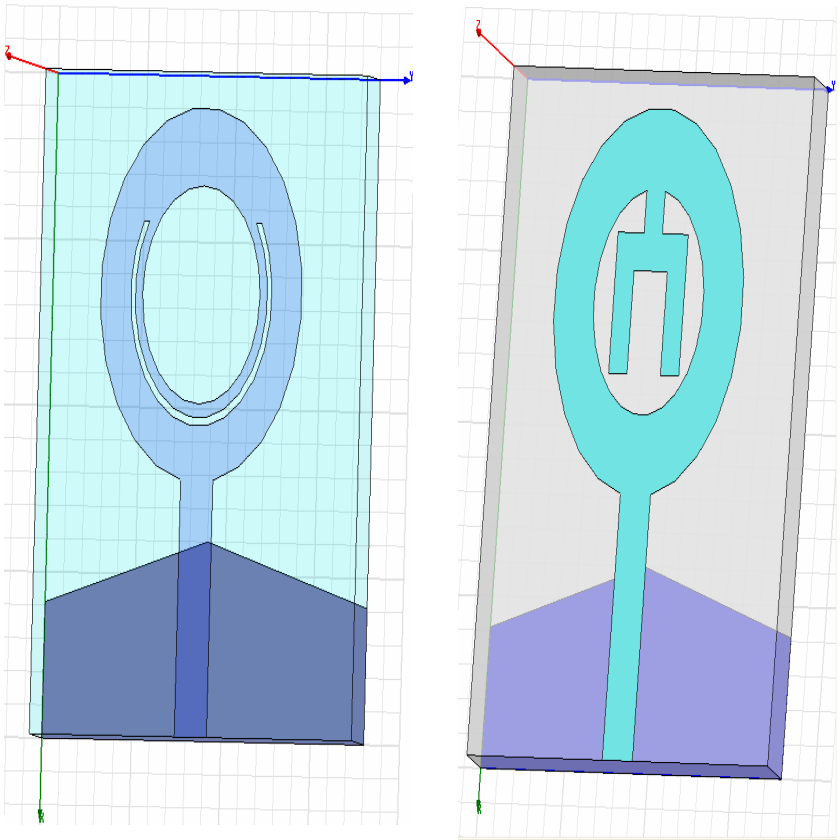


Fig. 3. Simulation Results

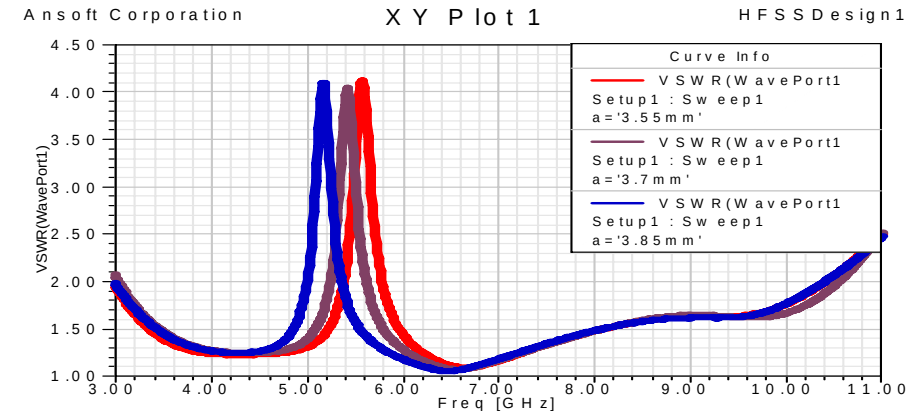
- **Excitation: Waveport**
- **Mesh length: λ/3**
- **Center Frequency: 7 GHz**
- **Sweep type: Fast (Sweep: 3 ~ 11 GHz, Step: 0.01 GHz)**

UWB Antenna with Band-Stop Characteristics

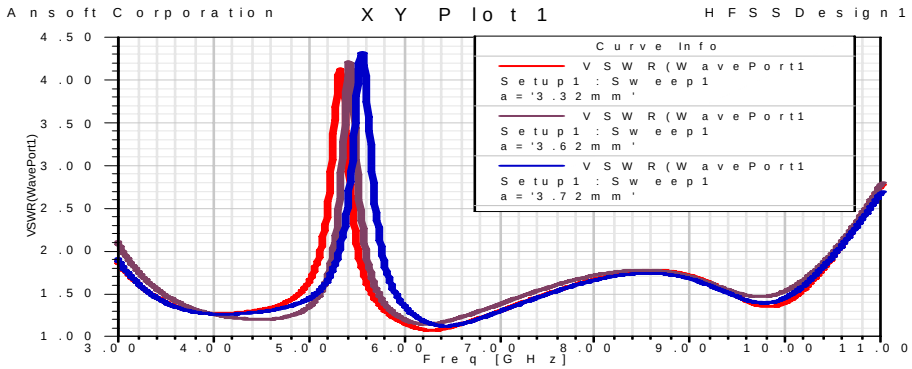


(a) slot (b) stub

Fig. 4. UWB antenna with Band-stop Characteristics



(a) slot

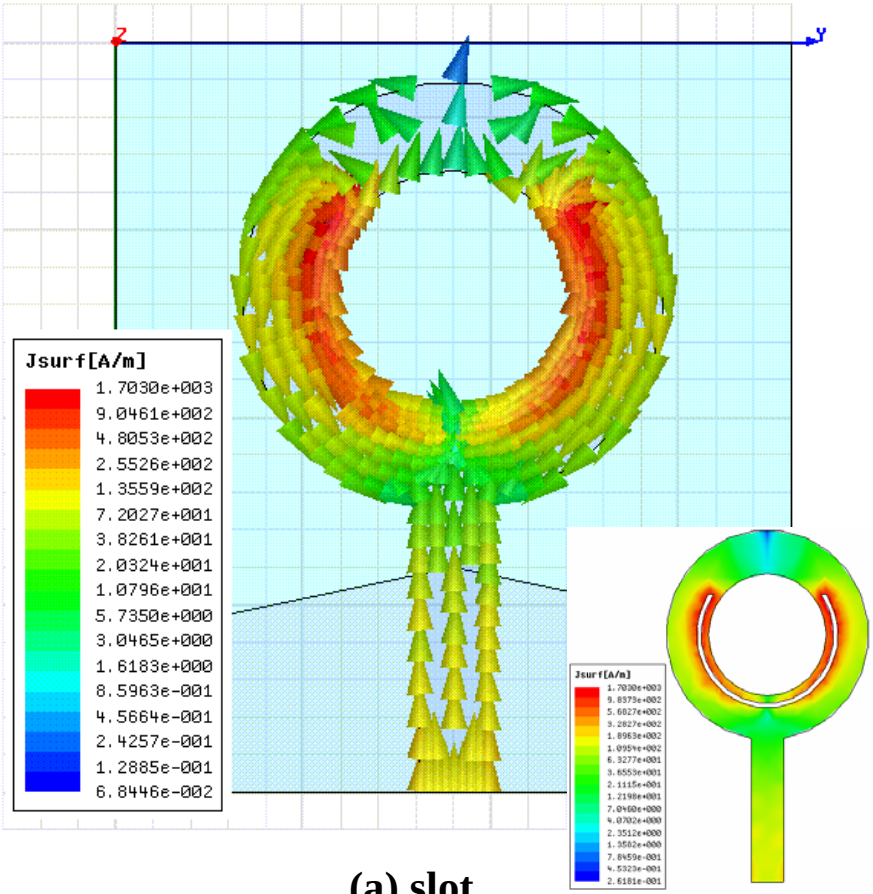


(b) stub

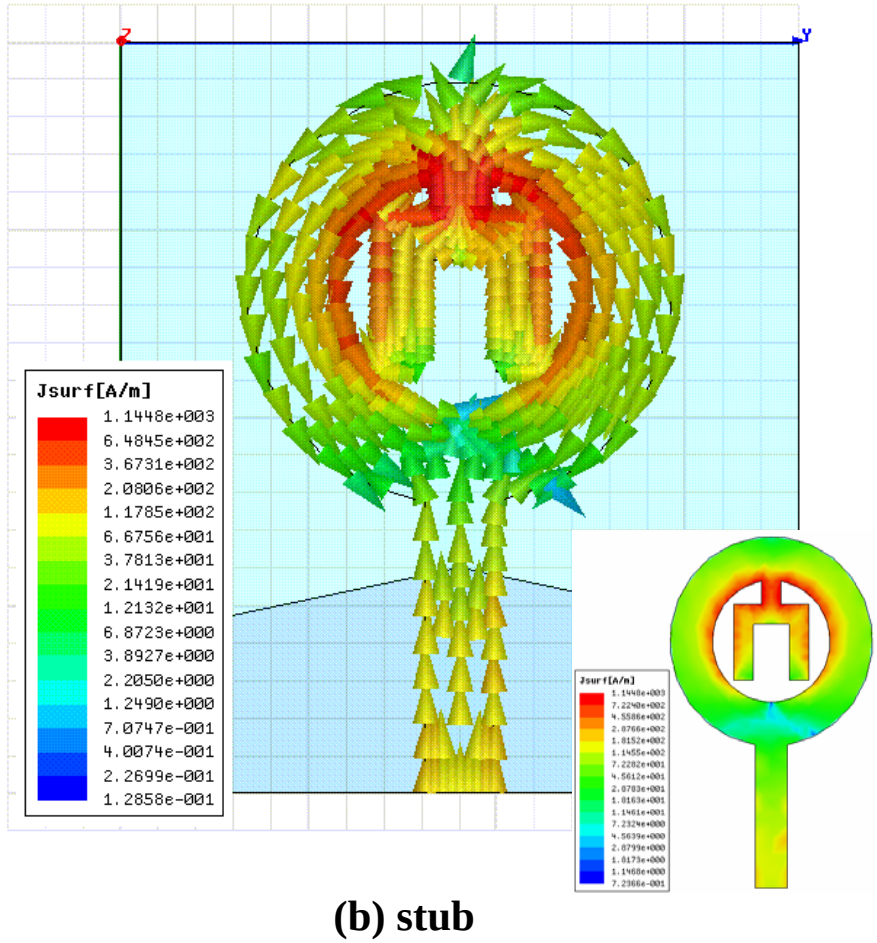
Fig. 5. Simulation Results

- **Parametric Sweep: Tuning**

Surface Current Distributions



(a) slot

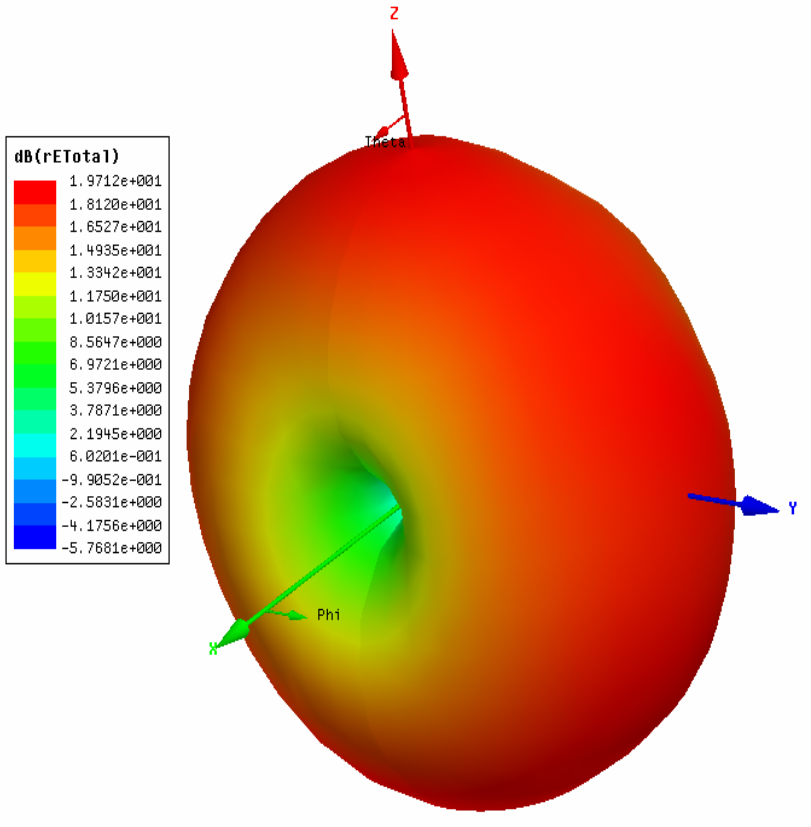


(b) stub

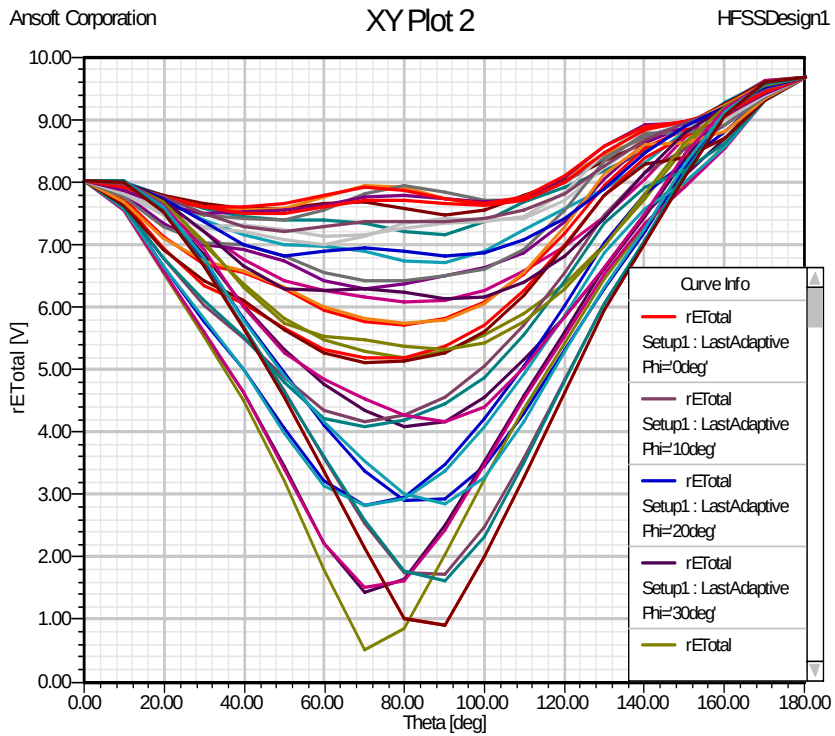
Fig. 6. Surface Current Distributions at 5.5 GHz

Radiation Patterns

- Far field: E_{total}



(a) 3D polar plot



(b) Rectangular plot

Fig. 7. Far field Distributions at 3GHz

3. PIFA

Design of a PIFA with a PIL patch having a bent feed line for GSM/DCS/UMTS/WiBro applications

Antenna Configuration

- **Applications : GSM, DCS, UMTS, WiBro**

✓ **A novel, broadband and small planar inverted F-antenna.**

✓ **The wide bandwidth characteristic is afforded by a PIL patch inserted into the PIF patch and by using a bent feed line with two contact points.**

✓ **The proposed antenna exhibits great potential for multiband mobile communication applications.**

Design of a PIFA for GSM/DCS/UMTS/WiBro applications

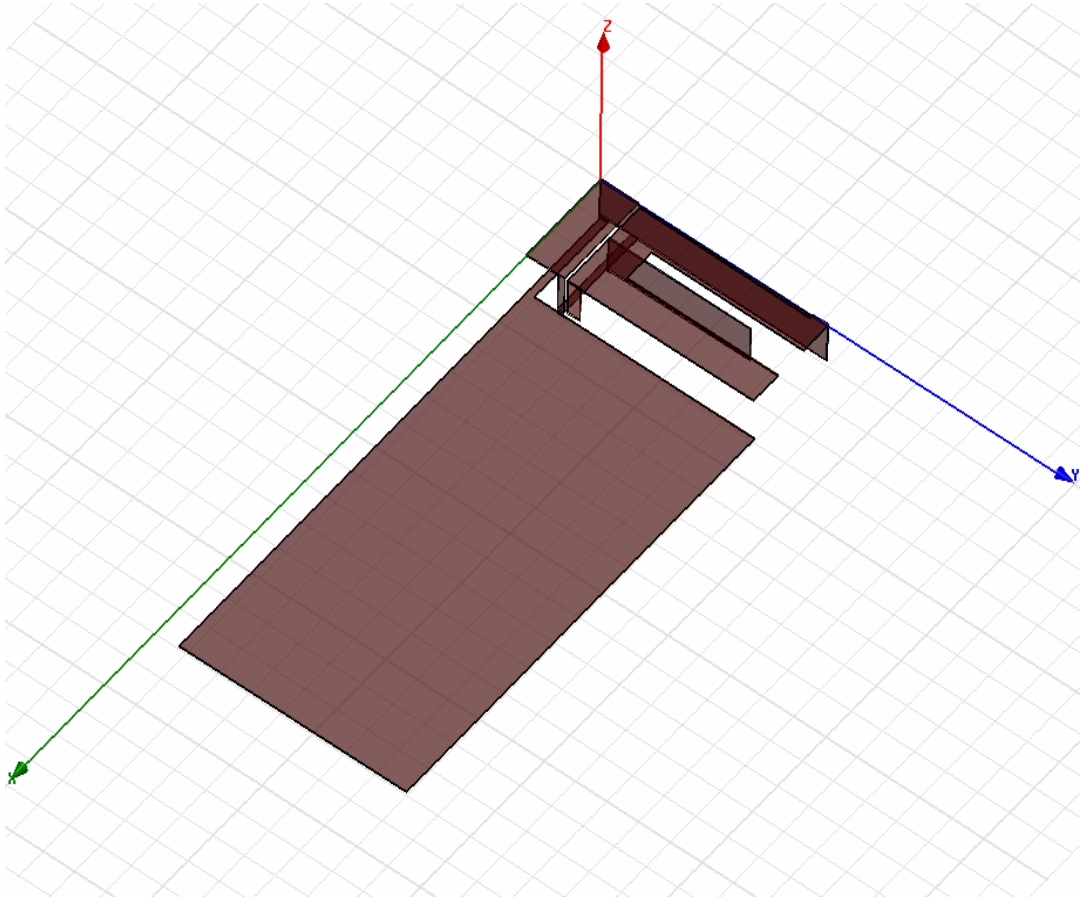


Fig. 1. Geometry of the proposed antenna

- ✓ **Service Standards:**
  - ✓ **GSM (880 ~ 960 MHz)**
  - ✓ **DCS (1710 ~ 1880 MHz)**
  - ✓ **UMTS (1920 ~ 2170 MHz)**
  - ✓ **WiBro (2300 ~ 2390 MHz)**

PIFA for GSM/DCS/UMTS/WiBro applications

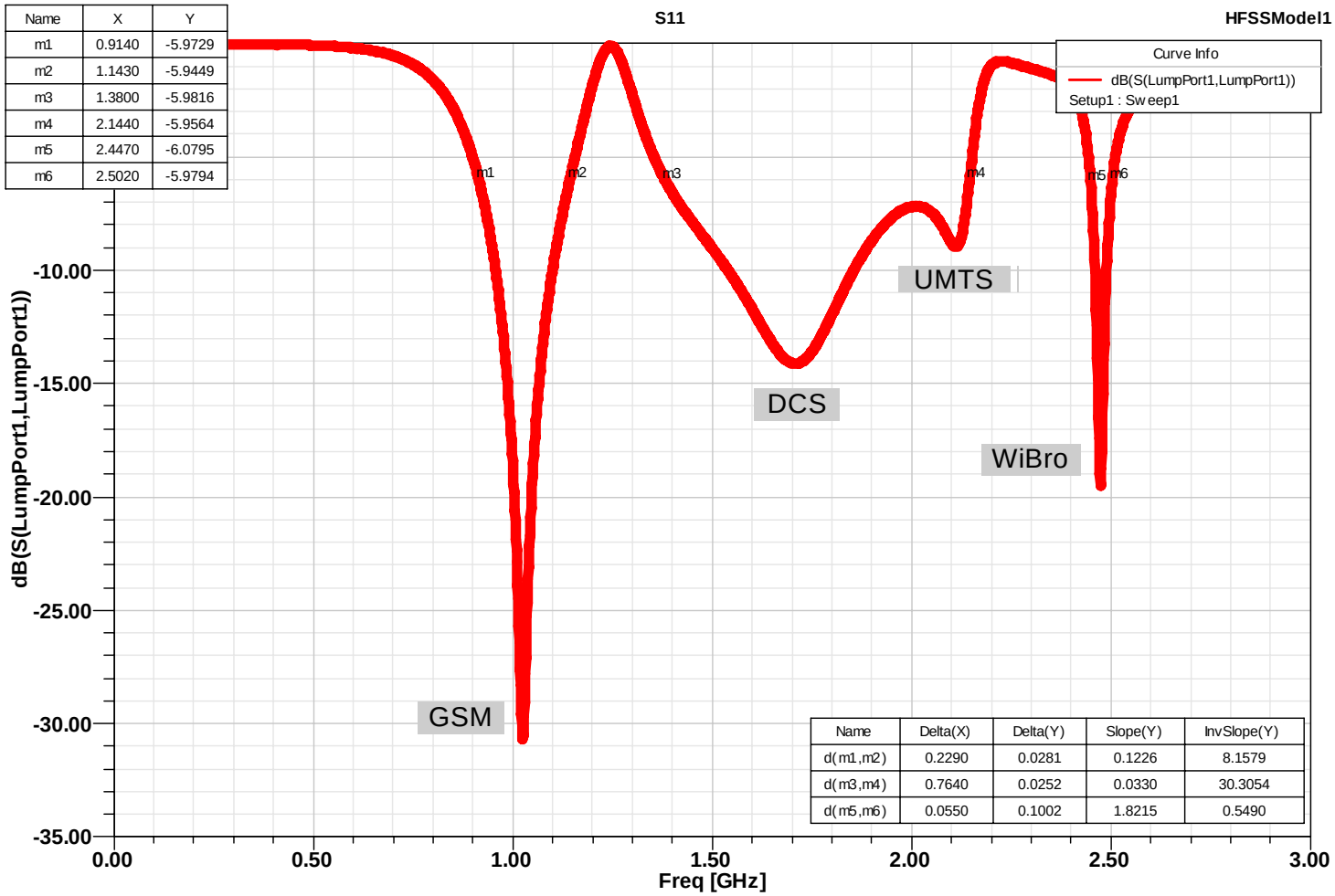
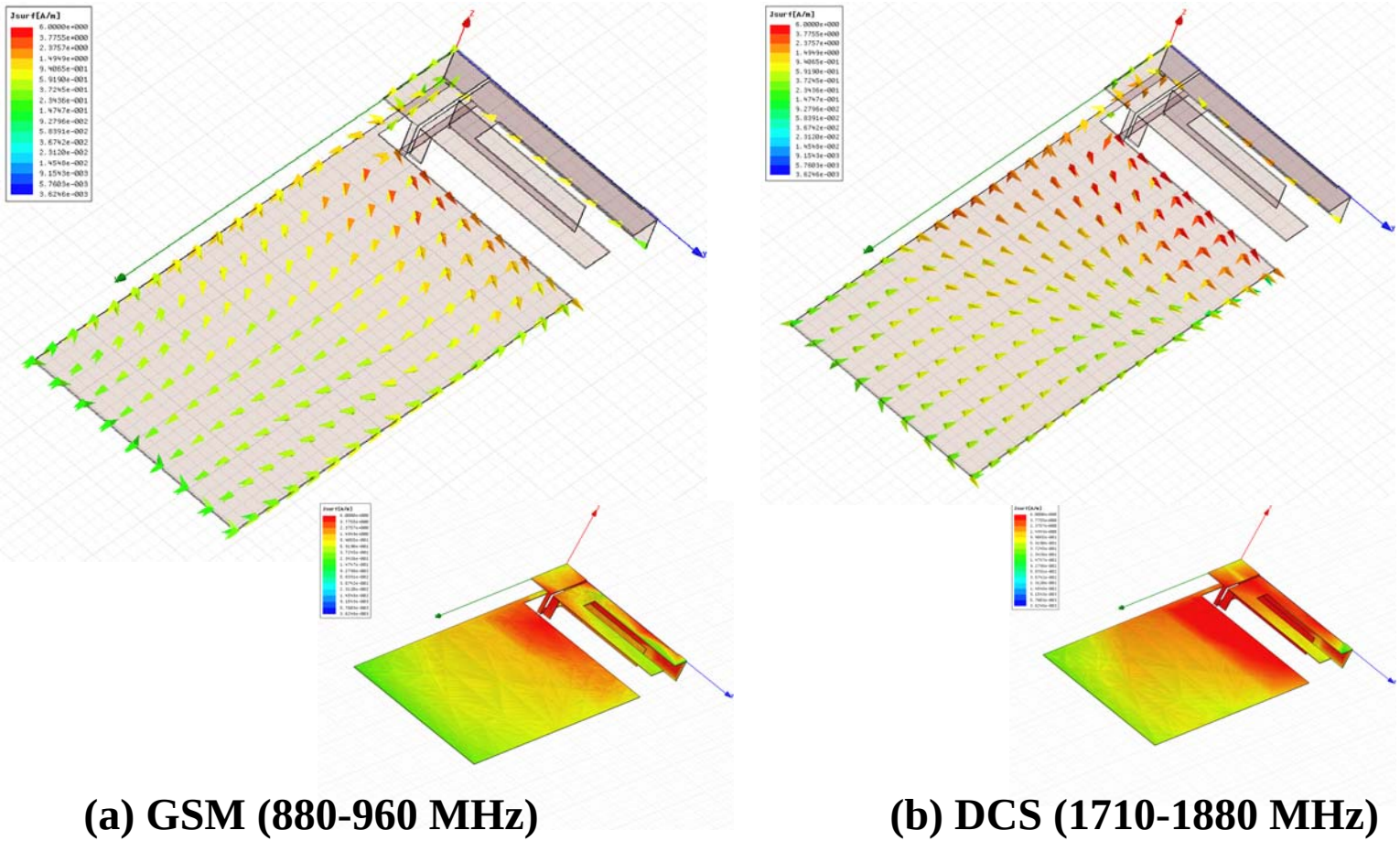


Fig. 2. Simulation Results

Surface Current Distributions

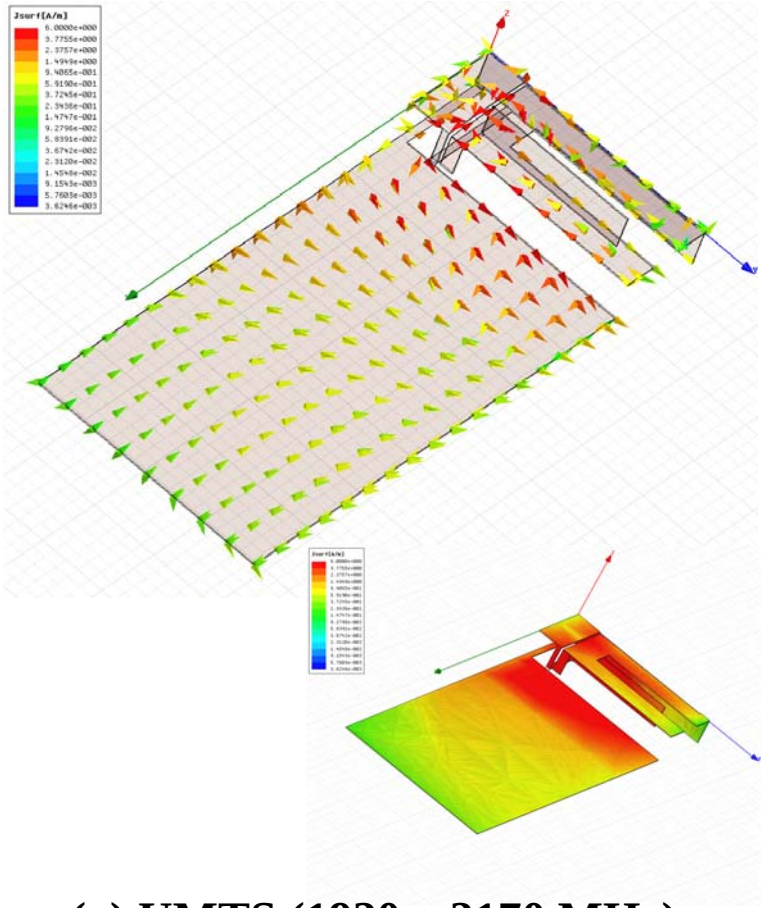


(a) GSM (880-960 MHz)

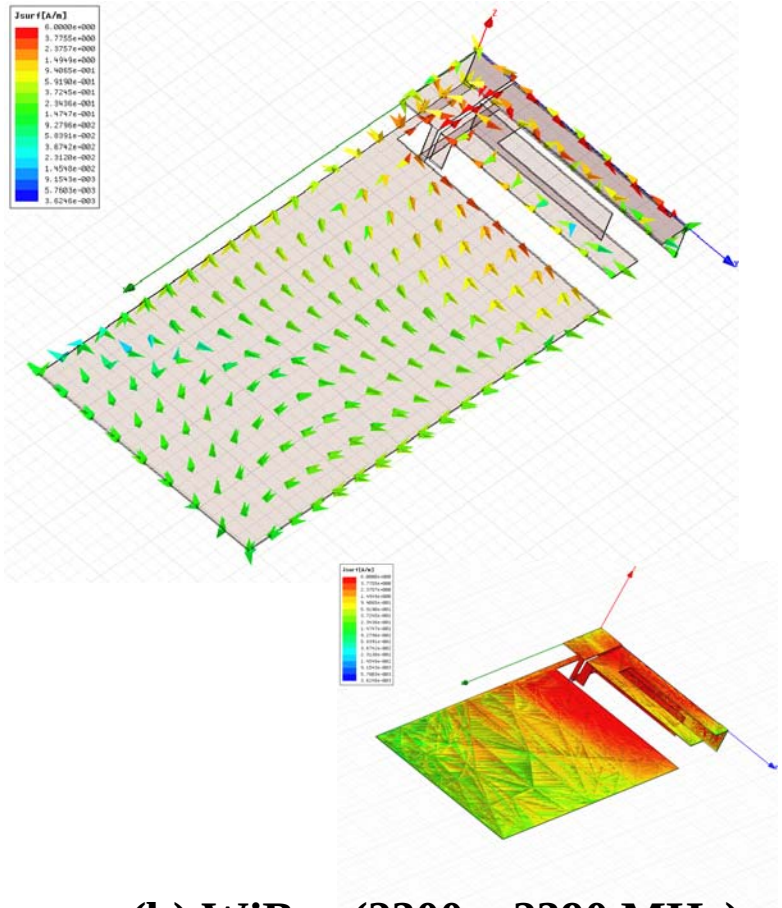
(b) DCS (1710-1880 MHz)

Fig. 3. Surface Current Distributions GSM and DCS band

Surface Current Distributions



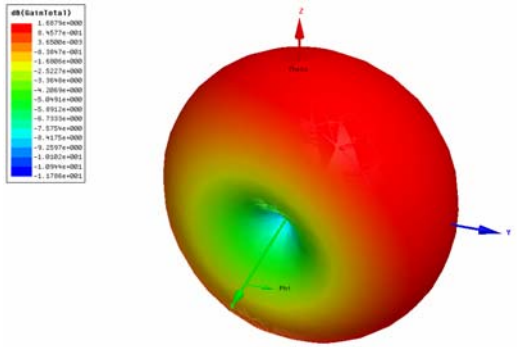
(a) UMTS (1920 ~ 2170 MHz)



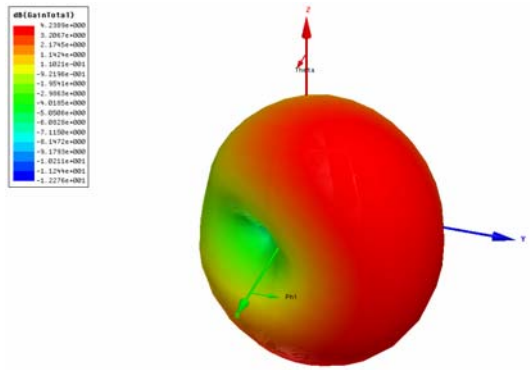
(b) WiBro (2300 ~ 2390 MHz)

Fig. 4. Surface Current Distributions at UMTS and WiBro band

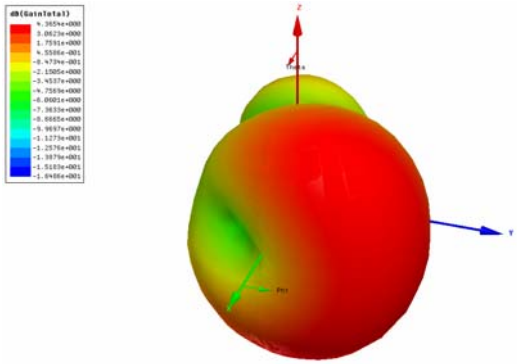
Radiation Patterns



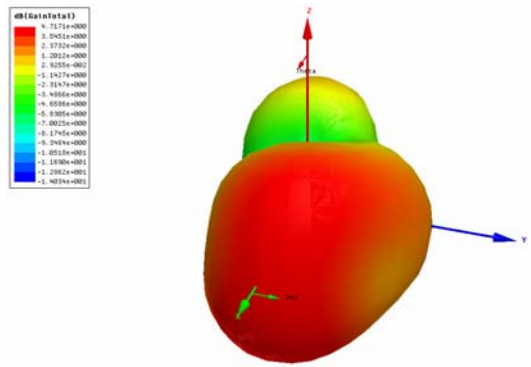
(a) GSM



(b) DCS



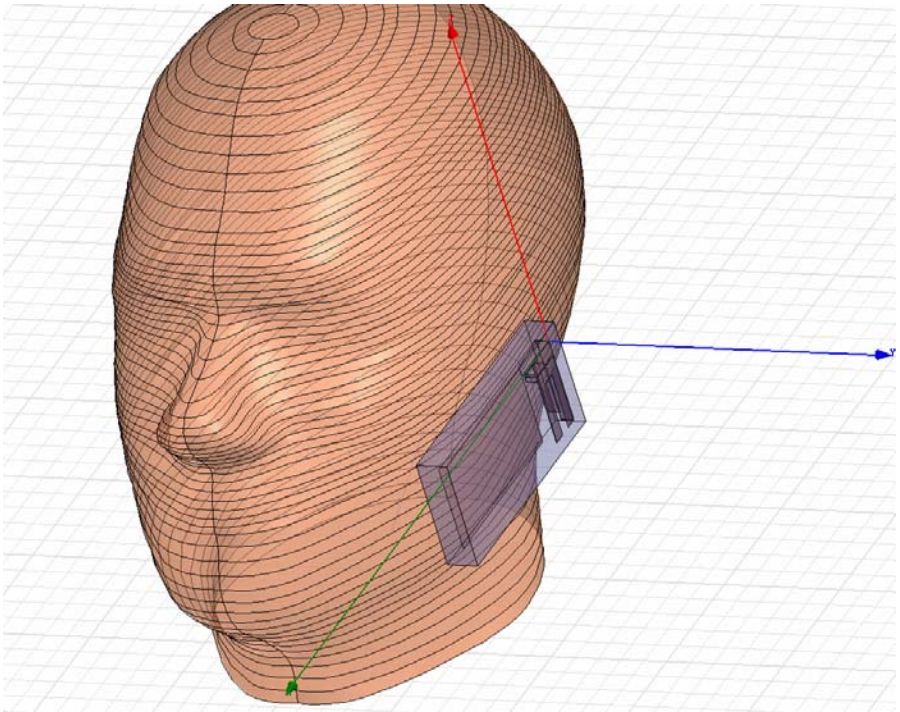
(c) UMTS



(d) WiBro

Fig. 5. Far field Distributions at GSM, DCS, UMTS and WiBro Band

SAR (Specific Absorption Rate)



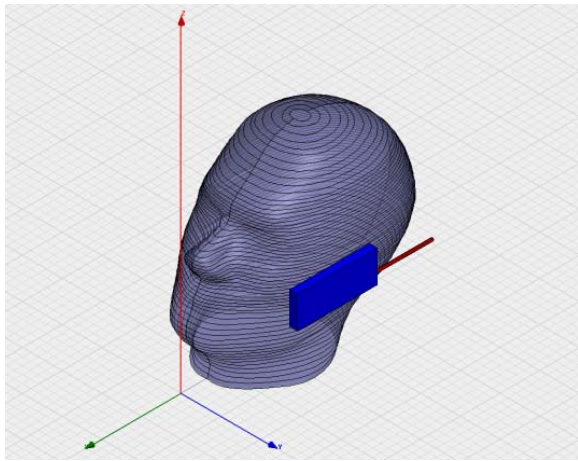


Fig. 7. HFSS SAM-Phantom model

Fig. 6. SAM-Phantom model of the proposed PIFA

✓ **HFSS SAM-Phantom model can compute local and average SAR values and simulate results for SAR distributions.**

4. Automotive

Design of Antenna Module

Design Object

Antenna Type	Patch type (GPS/DMB signal reception) Planar monopole type (PCS/DMB signal reception)		
Service	GPS	DMB	PCS
Frequency band	1575.42 MHz	2630~2655 MHz	1750~1870 MHz
Return Loss	≤ -10 dB	≤ -10 dB	≤ -10 dB
Gain	30 dBi (with LNA)	25 dBi (with LNA): Satellite 2.15 dBi : Gap filler	2.15 dBi
Axial Ratio	≤ 3 dB	≤ 3 dB	-
Polarization	Circularly Polarized	C.P. : Satellite L.P. : Gap filler	Linear Polarized

ITU-R BO. 1130-4

Antenna Configuration

- Applications : PCS, GPS, Satellite DMB
  - Planar Type Monopole Antenna : PCS, DMB (Gap filler)
  - Rectangular Patch Type Antenna : GPS, DMB (Satellite)
  - Configuration : Separated or Integrated configuration
- Low noise amplifier
  - GPS, DMB (Satellite) signal reception

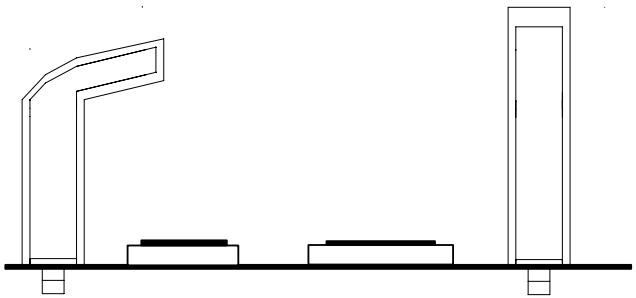


Fig. 1. Separated type

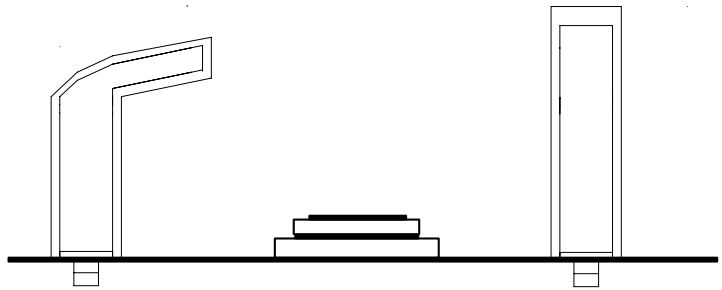
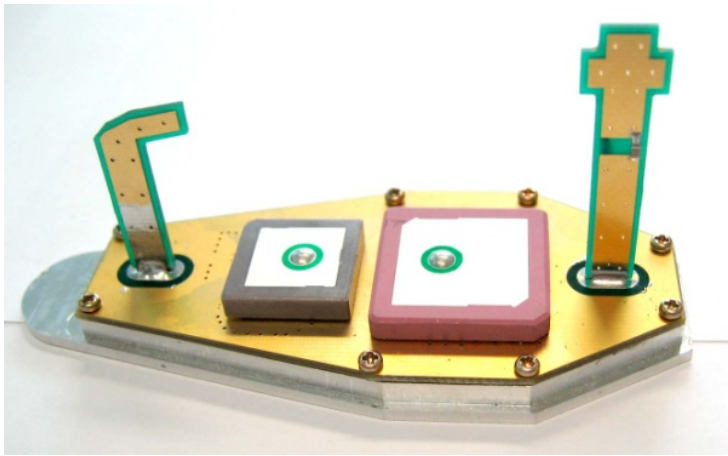
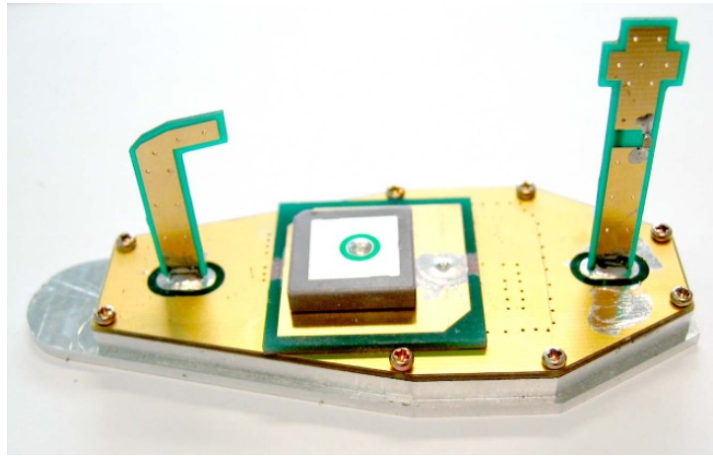


Fig. 2. Integrated type





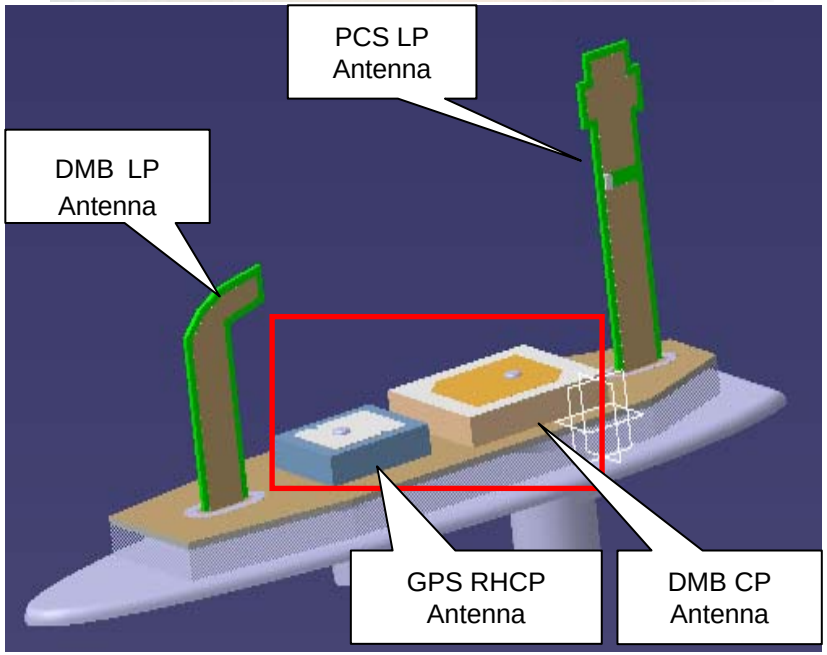


Fig. 3. GPS/DMB/PCS separated type

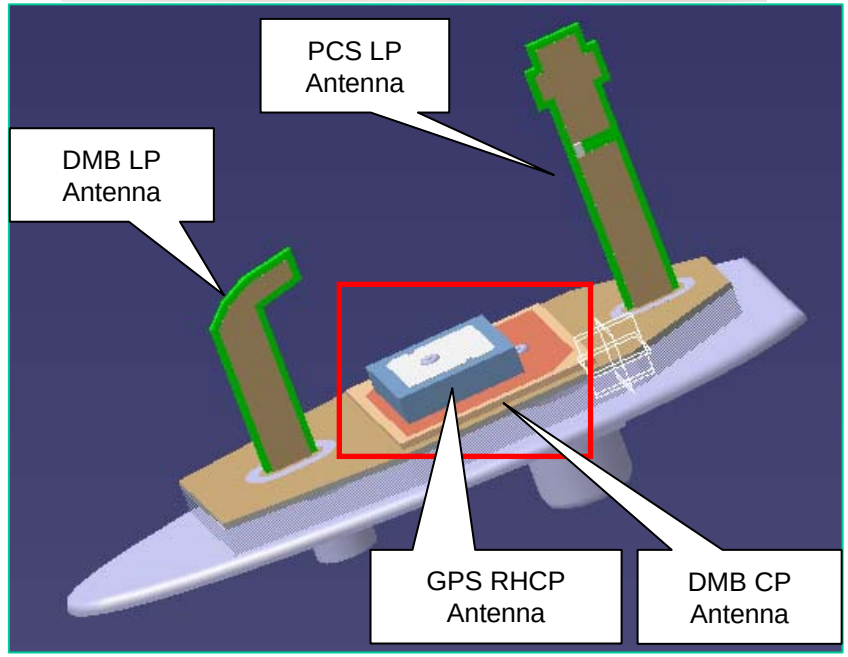


Fig. 4. GPS/DMB/PCS integrated type

Patch Antenna (DMB)

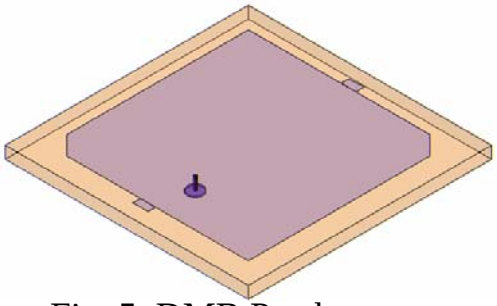
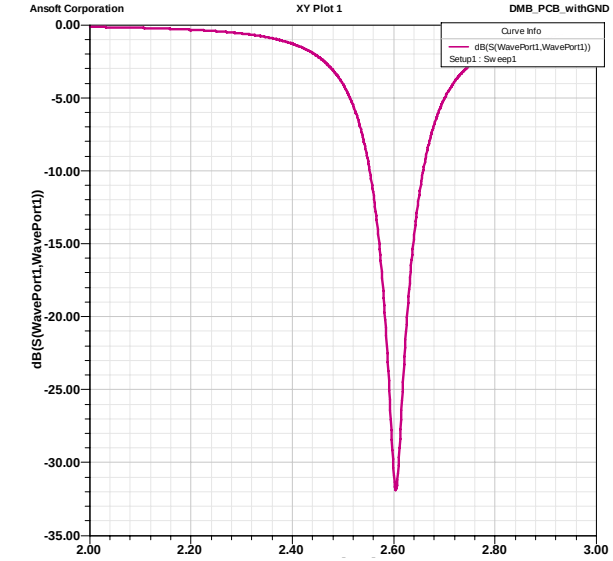
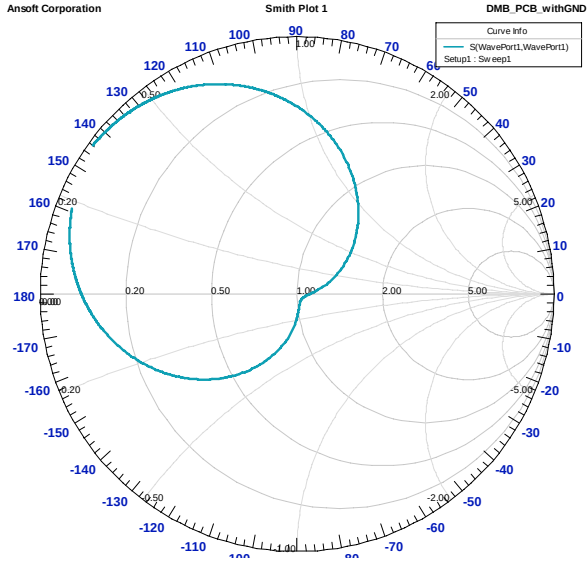


Fig. 5. DMB Patch antenna

- Truncated corner: 2.4 mm
- 32 mm X 32 mm X 1.6 mm
- Permittivity: 4.4(FR-4)





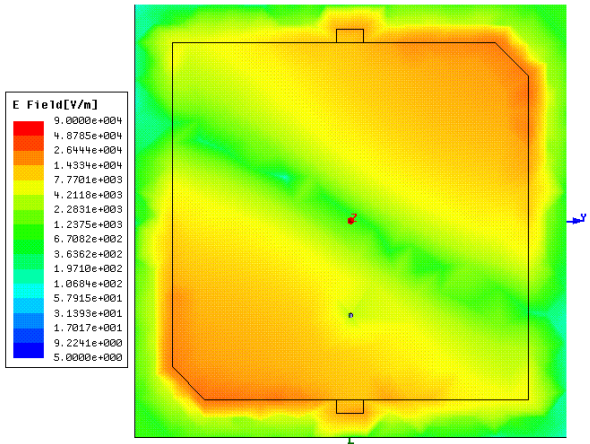


Fig. 6. E-field

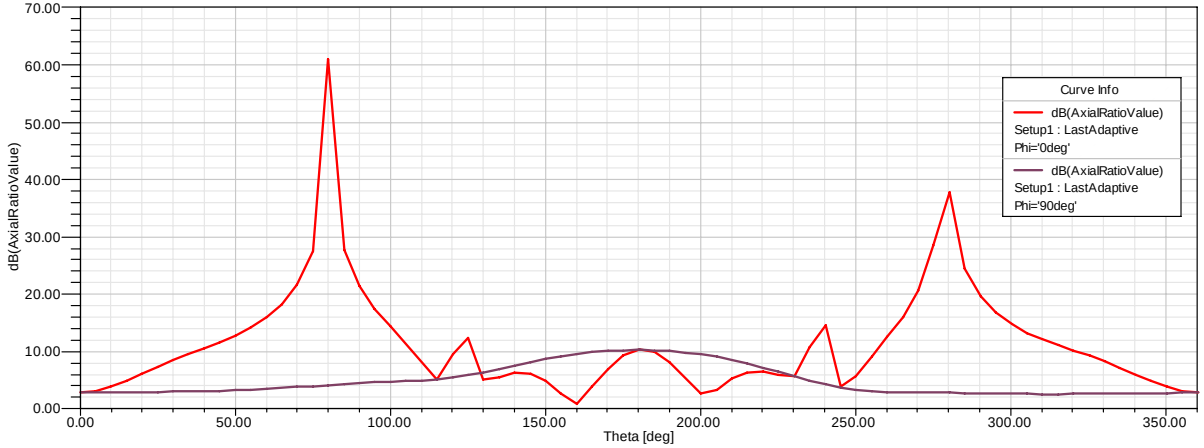


Fig. 7. Calculated performance

Patch Antenna (integrated)

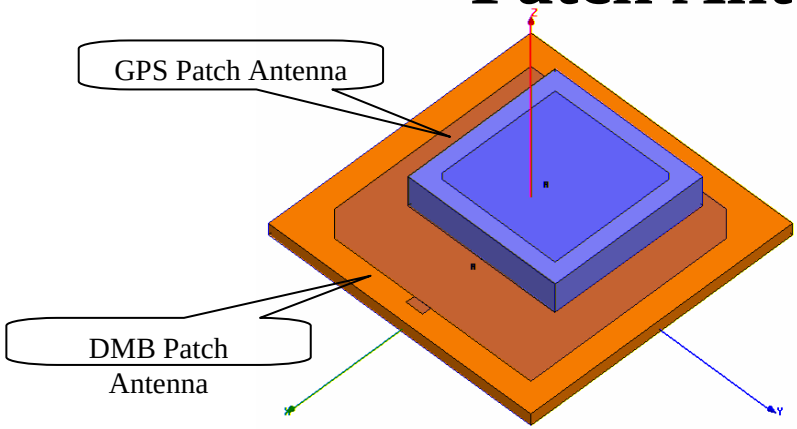


Fig. 8. Integrated Patch antenna

- Two patch antennas are integrated.
  - Operation frequency shifts.
  - Axial ratio is increased.

➔ Antenna is arranged.

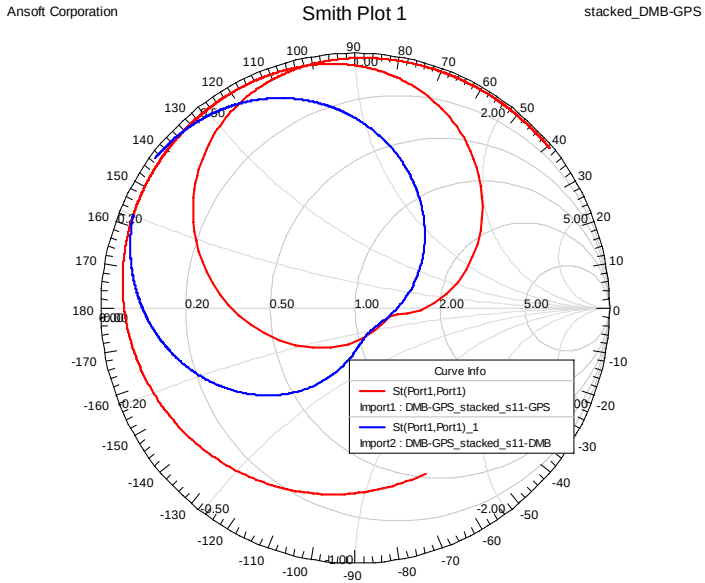


Fig. 9. Port impedance

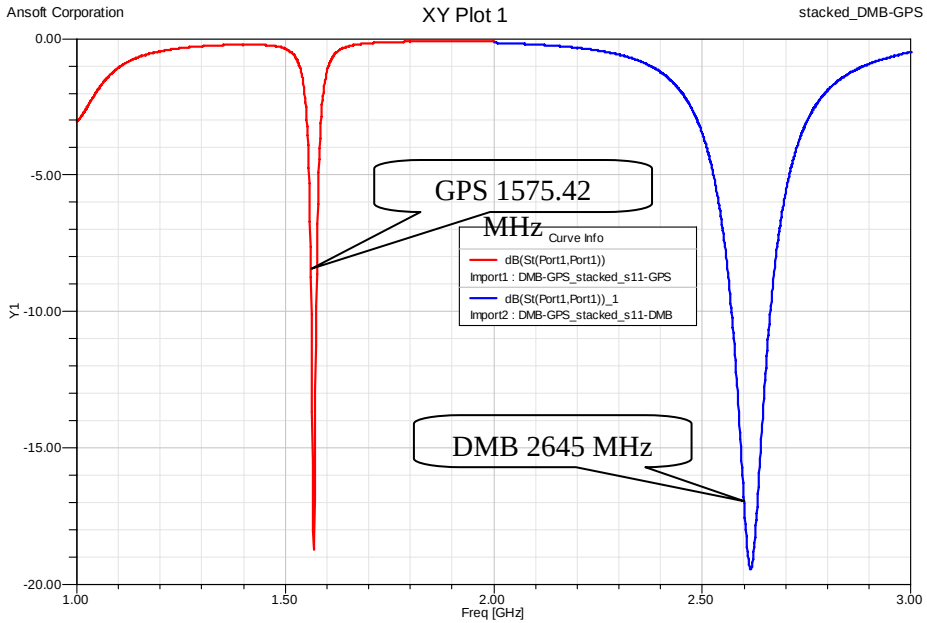


Fig. 10. Return loss

Interference (separated type)

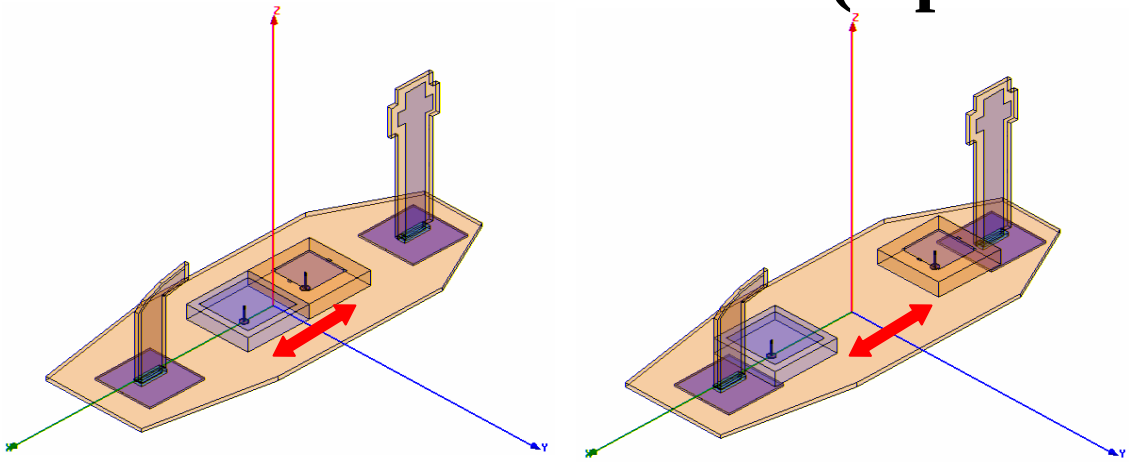


Fig. 11. Variation of the gap distance

- Both patch and monopole antenna for DMB application are sensitive to the variation of gap distance.
- Gap distance : 0, 10, 20, 30 mm

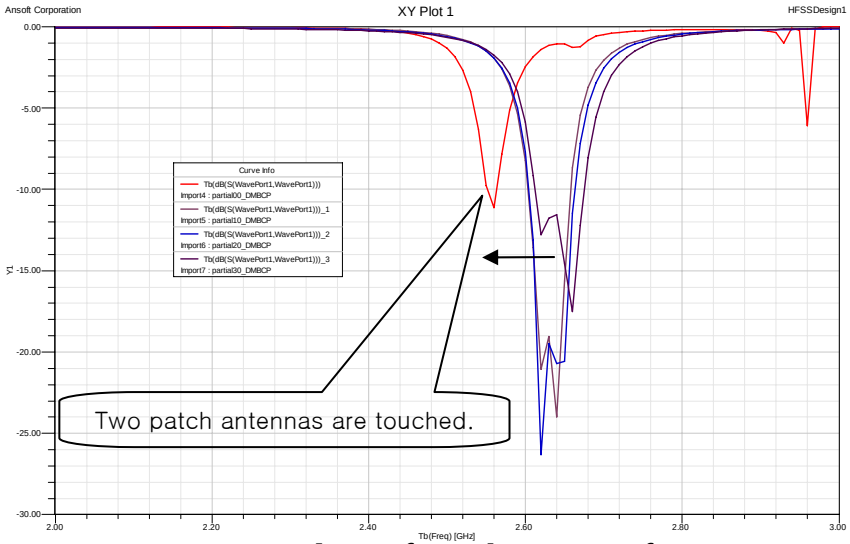


Fig. 12. Return loss of Patch antenna for DMB

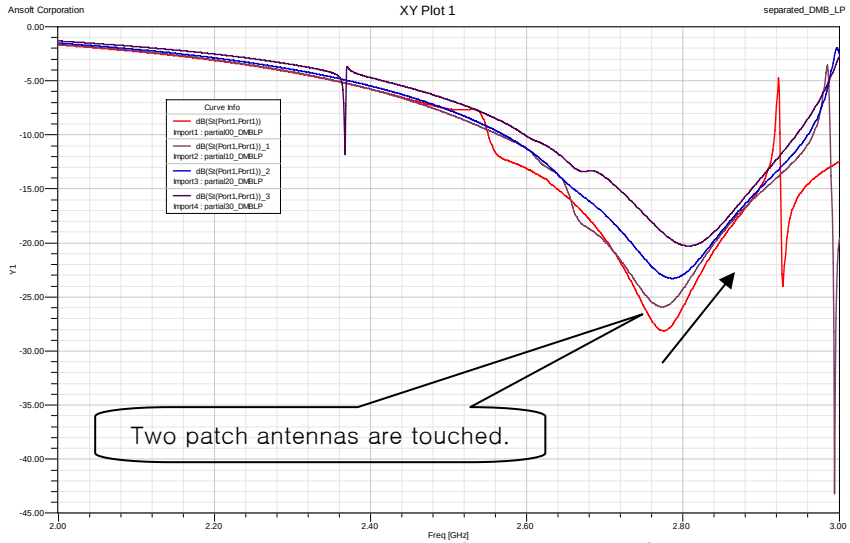


Fig. 13. Return loss of Monopole for DMB

Interference (integrated type)

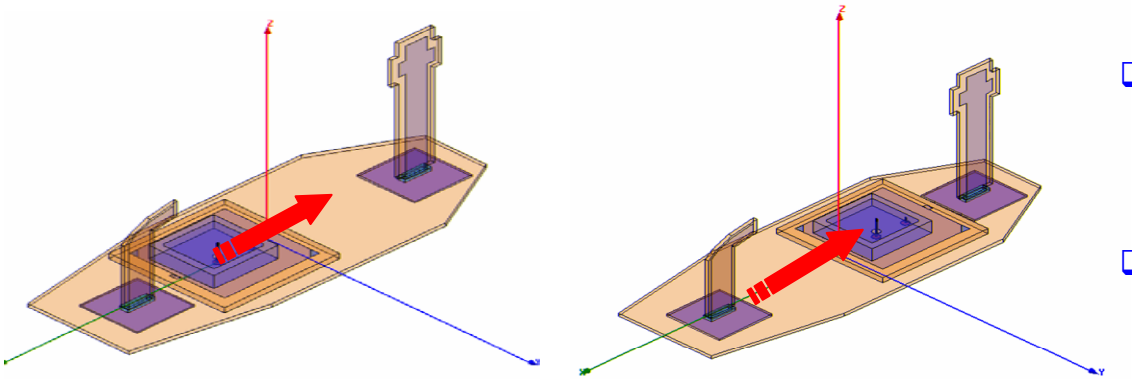


Fig. 14. Variation of the gap distance

- Both patch and monopole antenna for DMB application are sensitive to the variation of integrated path antenna's location.
- The integrated patch antenna is moved by 5 mm each time.

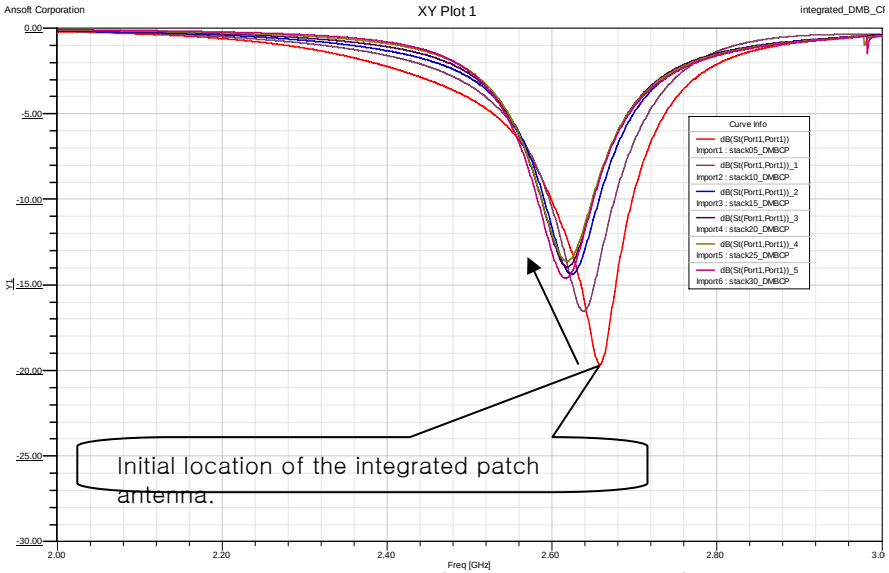


Fig. 15. Return loss of Patch antenna for DMB

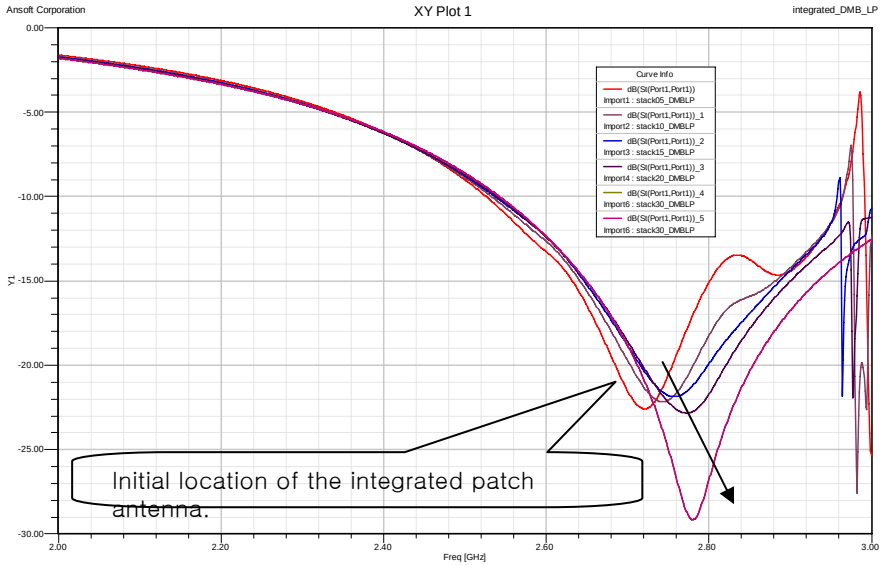


Fig. 16. Return loss of Monopole for DMB

Case effect

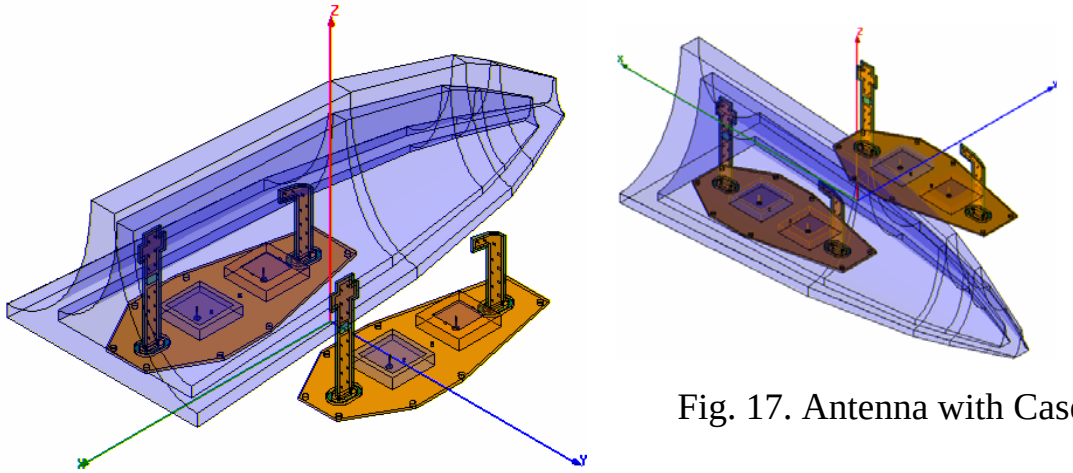


Fig. 17. Antenna with Case

- Antenna cover (BMW)
- Permittivity: 3.0 (Rubber hard)
- Monopole antenna for DMB application is sensitive to antenna cover.

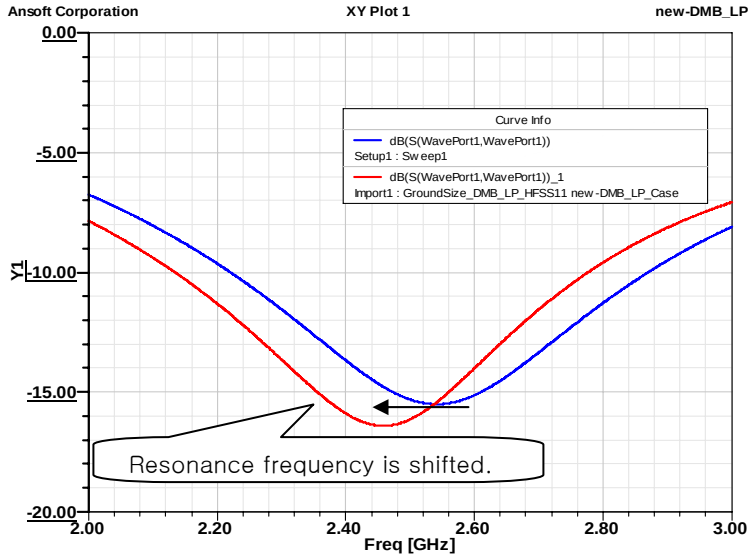


Fig. 18.Return loss of Monopoleh antenna for DMB

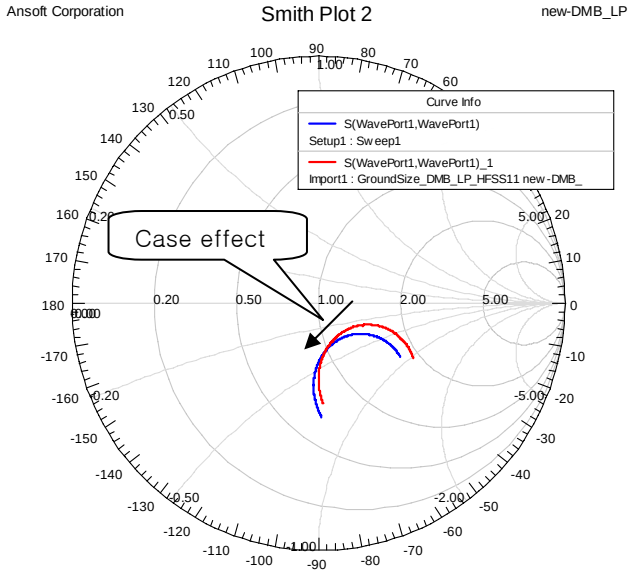


Fig. 19. Port impedance