MULTI-BAND ANTENNAS WITH INTEGRATED CIRCUITRY IN MOBILE PHONES

BY

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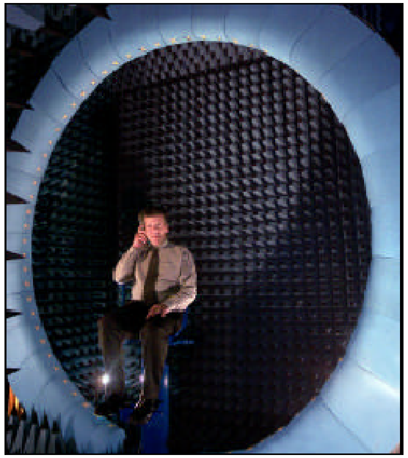
AIMS

- Work based on the co-design antennas an RF
  front-ends for portable devices in the framework of a PhD study with Philips research laboratories

- Optimal multi-band architectures are sought
  based on:
  - Component elimination
  - Re-use
  - Functionality sharing

Application(s)

- Mobile phones chosen as main application
  - –Considered most difficult due to size and SAR contraints
  - –Clear need for multi-band operation
- All parameters of importance are considered simultaneously:
  - –Bandwidth, size, efficiency
  - –User interaction
  - –SAR
  - –Cost, ease of implementation
  - –Multiple antennas (for diversity and MIMO)



OUTLINE

INTRODUCTION

GENERAL ASPECTS OF SMALL ANTENNAS
INFLUENCE OF SUPPORTING PCB
EFFECT OF PCB ON DIVERSITY PERFORMANCE
OVERVIEW CELLULAR, W-LAN AND PAN
BASICS PLANAR INVERTED F-ANTENNA (PIFA)
COMMON, DIFFERENTIAL, RADIATING AND BALANCED MODES OF PIFA
IMPEDANCE OF RADIATING AND BALANCED MODES

DUAL-BAND PIFA DESIGN

TRI-FED PIFA
S11 CHARACTERISTICS AS FUNCTION OF FREQUENCY
EQUIVALENT CIRCUIT
RESULTS CONVENTIONAL / DIFFERENTIAL FILLED PIFA
CONCLUSIONS PIFA

CIRCUIT DESIGN

USER INTERACTION & SAR CALCULATIONS

MEMS

CONCLUSIONS

GENERAL ASPECTS OF SMALL ANTENNAS (1)

Q factor

Antenna representation as series resonant circuit

as parallel resonant circuit

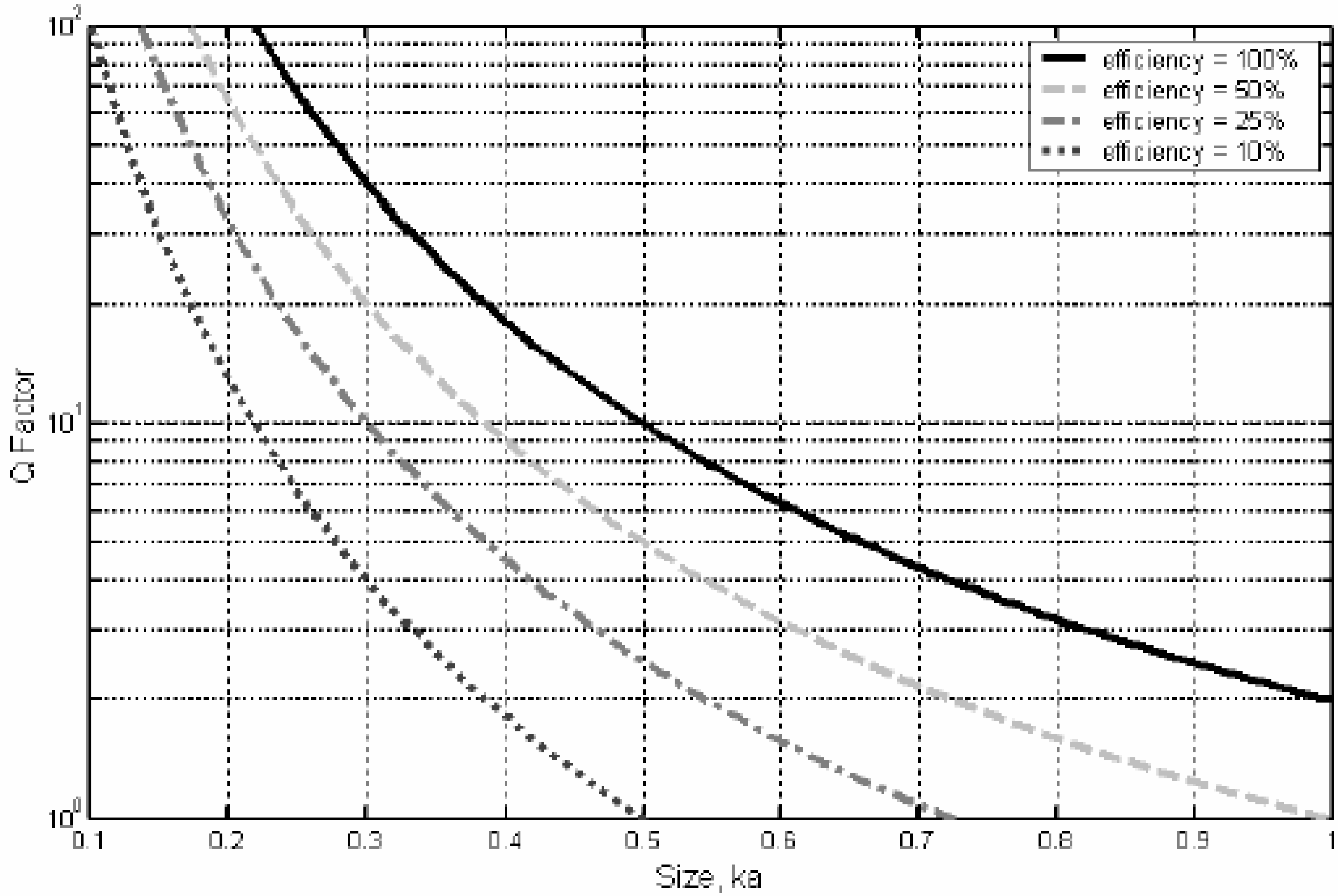
$BW = 1/Q_0$ for $P_{load}(\omega)/ P_{load}(\omega_0) = 0.5$

Impedance bandwidth

$BW = 2/Q_0$ for return loss = 0.5 (-3 dB)

$$BW_{opt} = 2\frac{|\rho|}{|\tau|^2}\bullet\frac{1}{Q_0}$$ **(optimum Z_0 for given R_a)**

GENERAL ASPECTS OF SMALL ANTENNAS (2)



The fundamental limits of antenna size, bandwidth and efficiency

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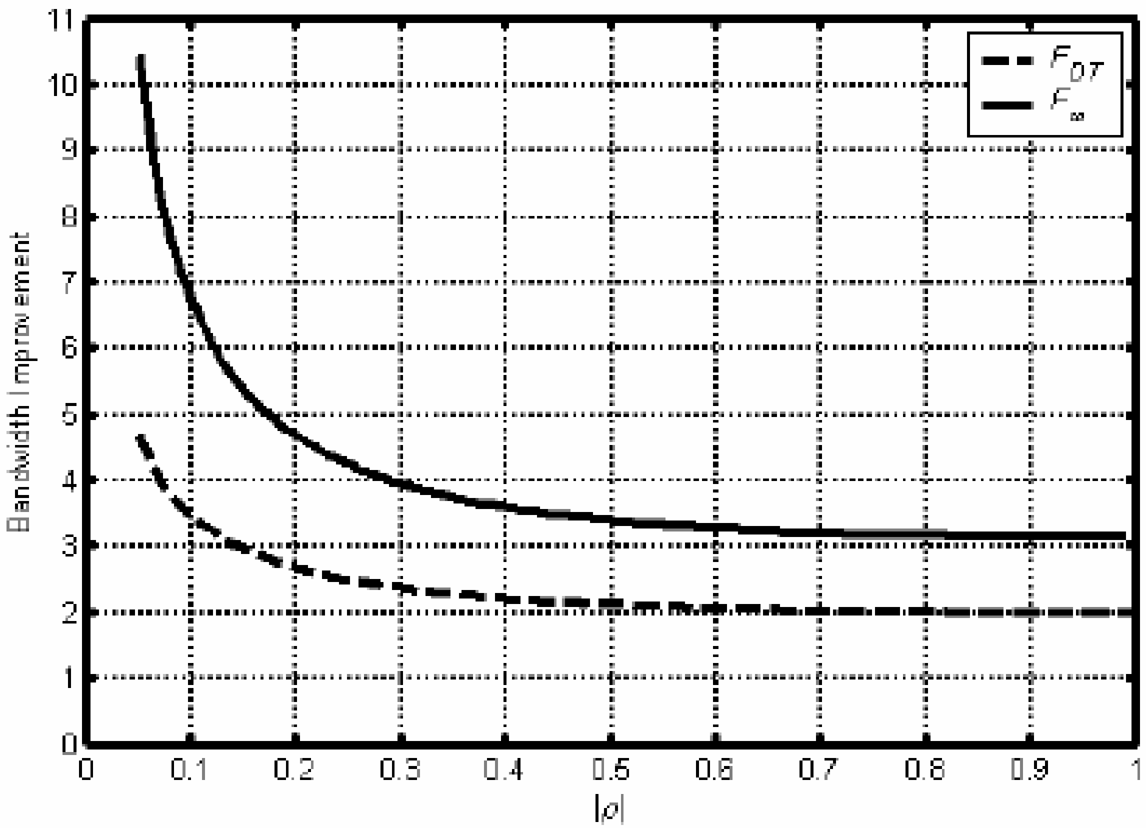
GENERAL ASPECTS OF SMALL ANTENNAS (3)

$$BW_{\max} = \frac{\pi}{Q_0 \ln\left(\frac{1}{|\rho|}\right)}$$

$$F_{\infty} = \frac{BW_{\max}}{BW_{opt}}$$



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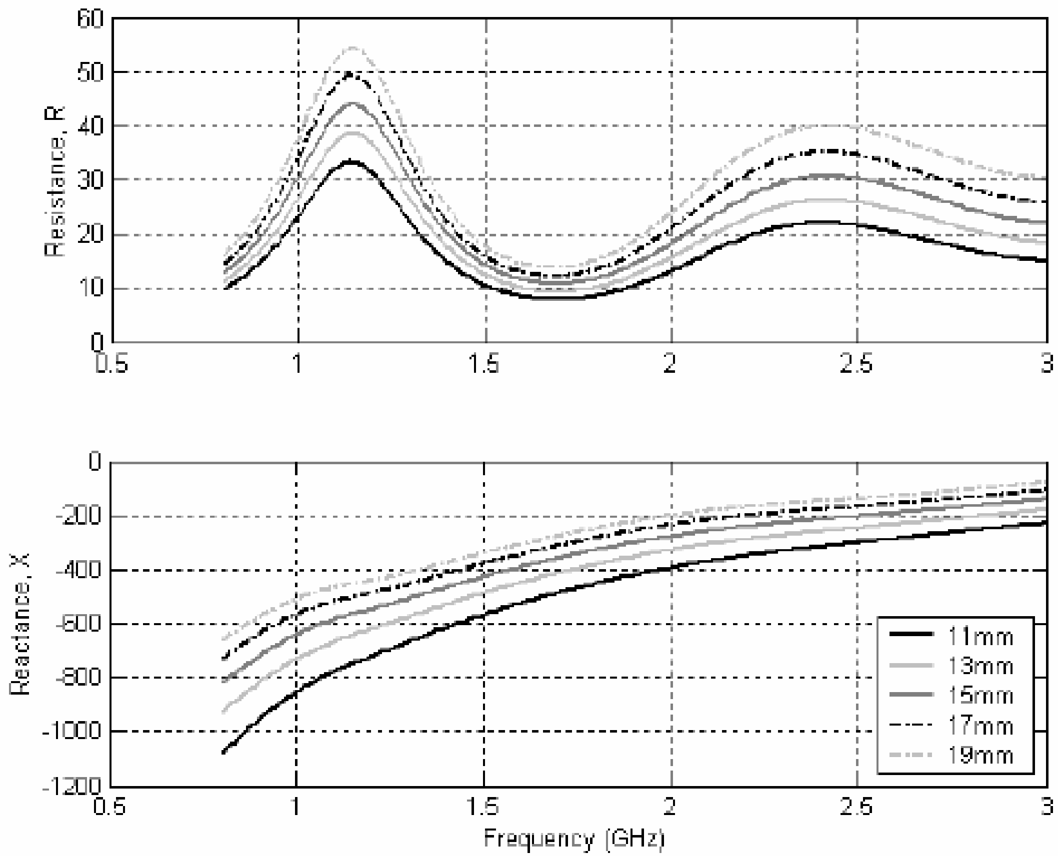
INFLUENCE OF SUPPORTING PCB (1)

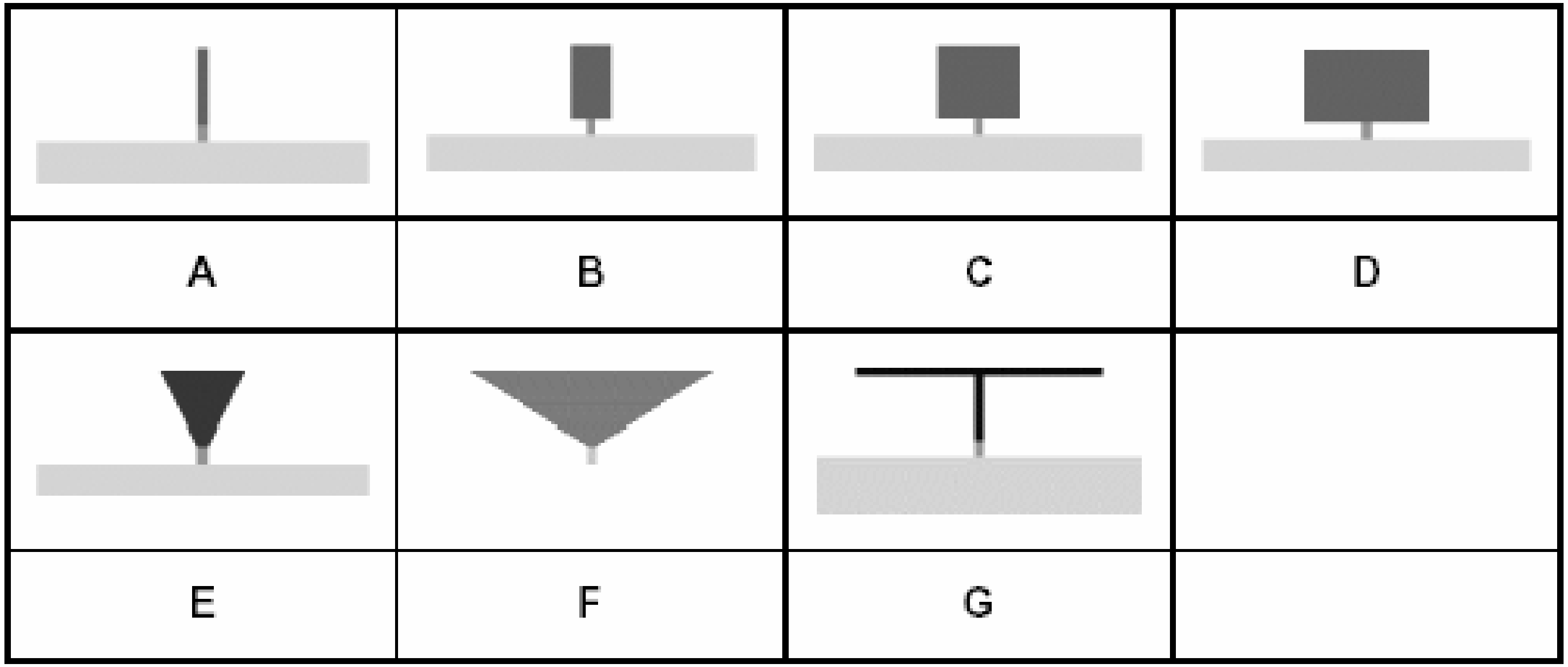
Antenna centrally at the top of PCB. Simulation HFSS



Variation of resistance and reactance with antenna height (indicated in legend) and frequency (antenna width 1mm, PCB 100x40x1mm)

INFLUENCE OF SUPPORTING PCB (2)

Antennas are planar, lossless and 11 mm high



Simple antenna test geometries (only the top part of the PCB shown)

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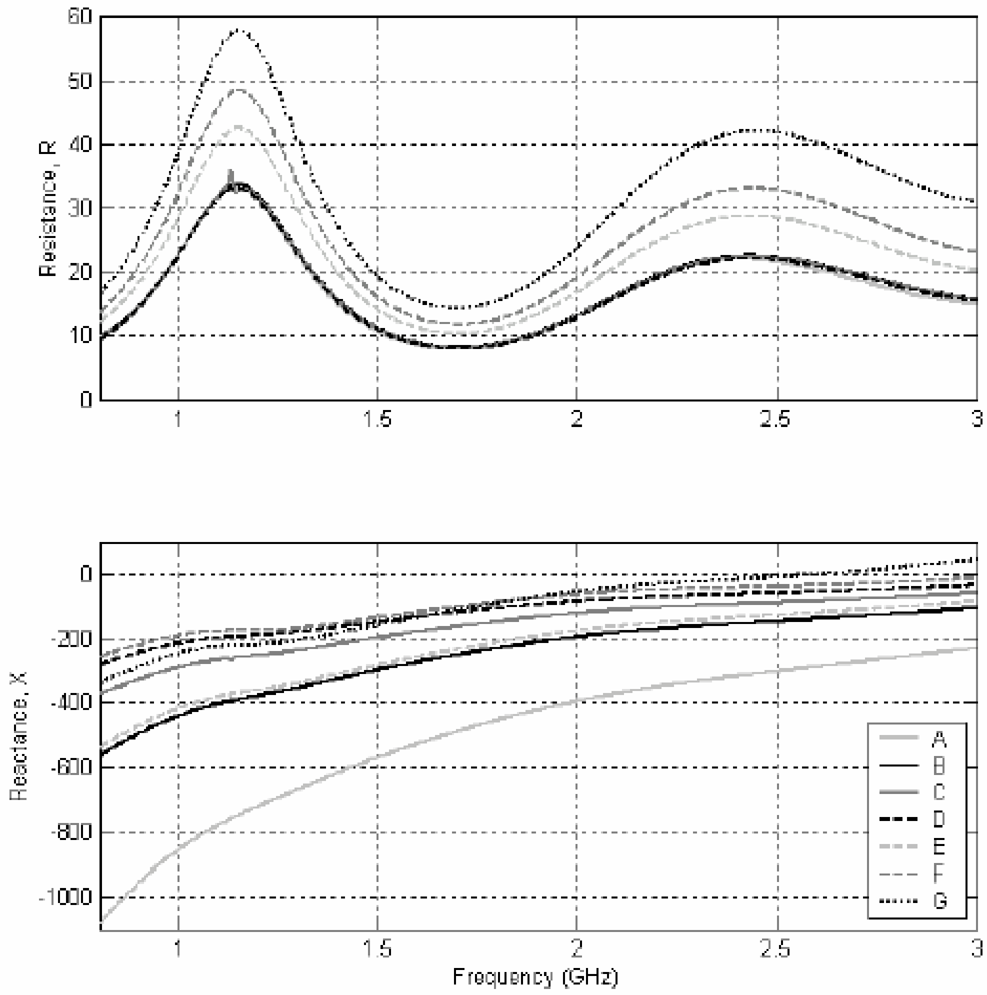
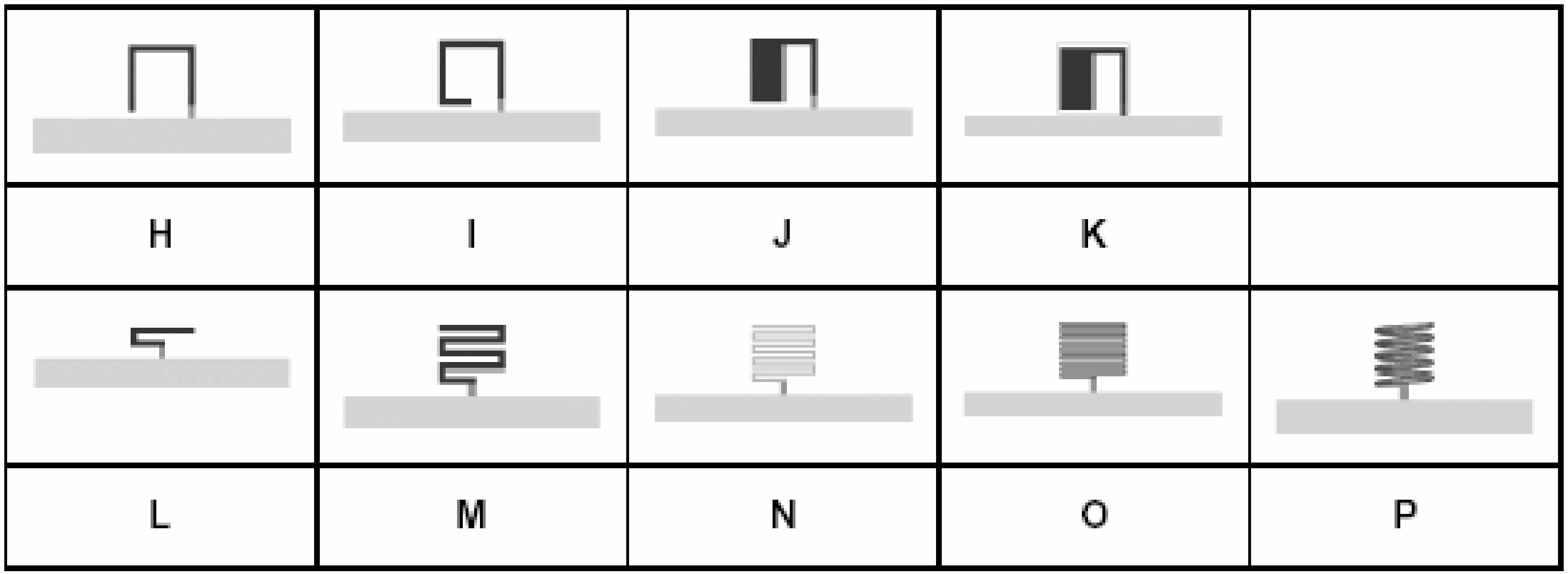
INFLUENCE OF SUPPORTING PCB (3)



Impedance variations of simple antenna geometries

INFLUENCE OF SUPPORTING PCB (4)

Antennas are planar, lossless and 11 mm high



Meandered antenna test geometries

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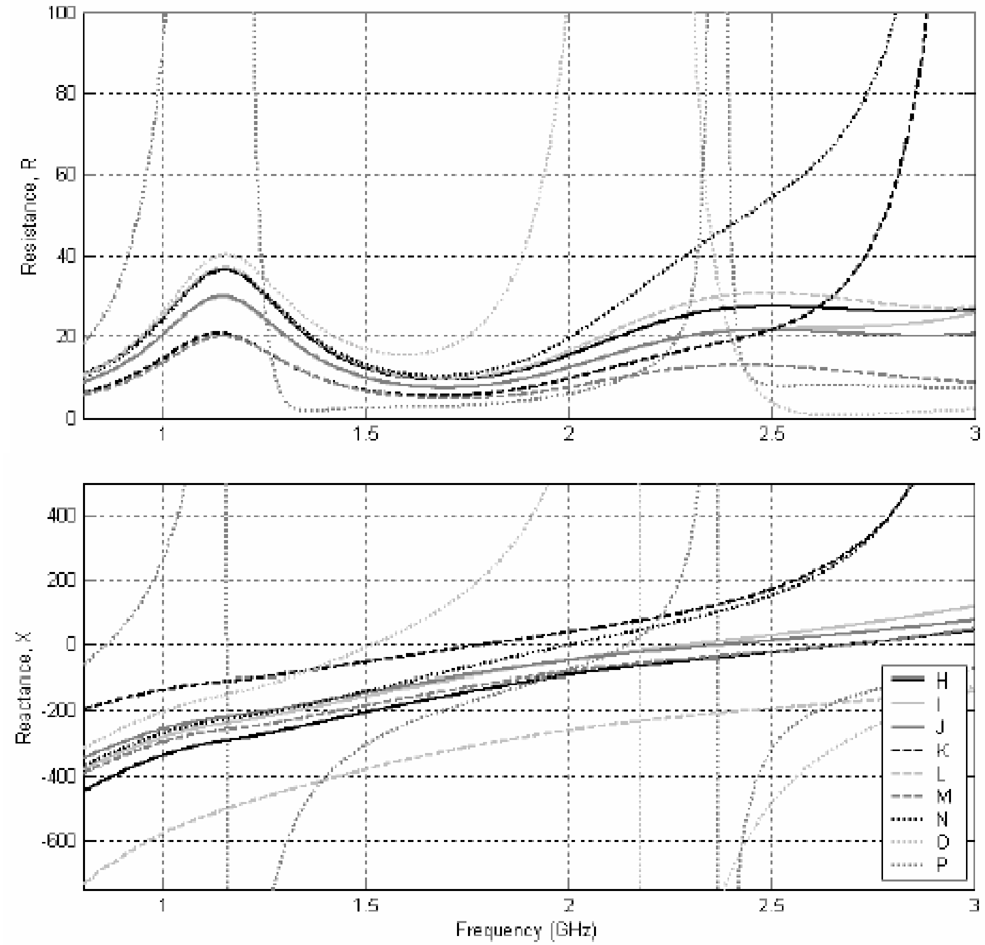
INFLUENCE OF SUPPORTING PCB (5)



Impedance variations of meandered antenna geometries

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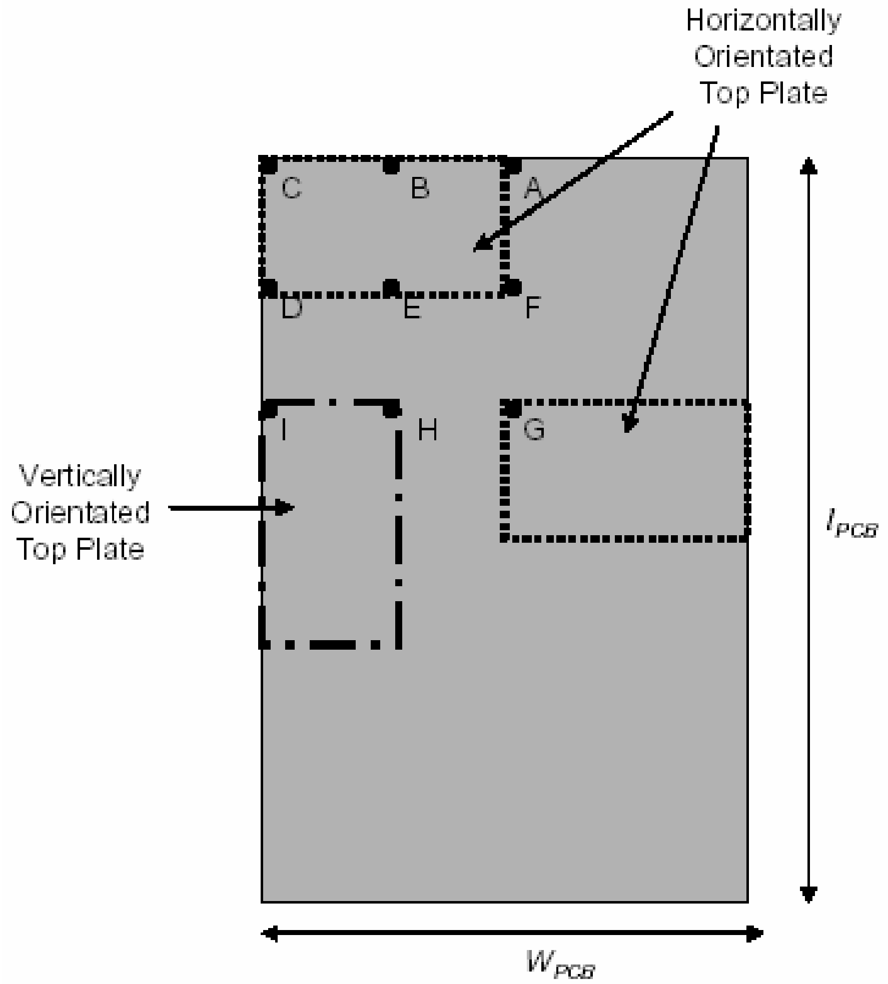
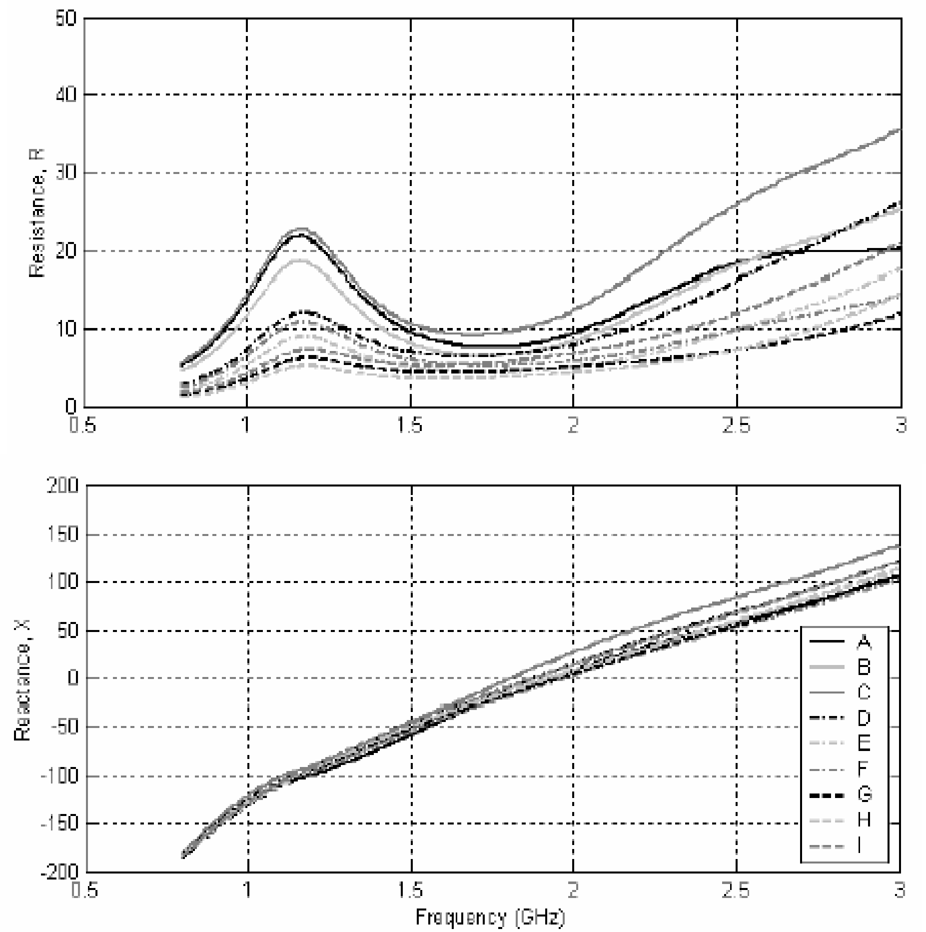
INFLUENCE OF SUPPORTING PCB (6)



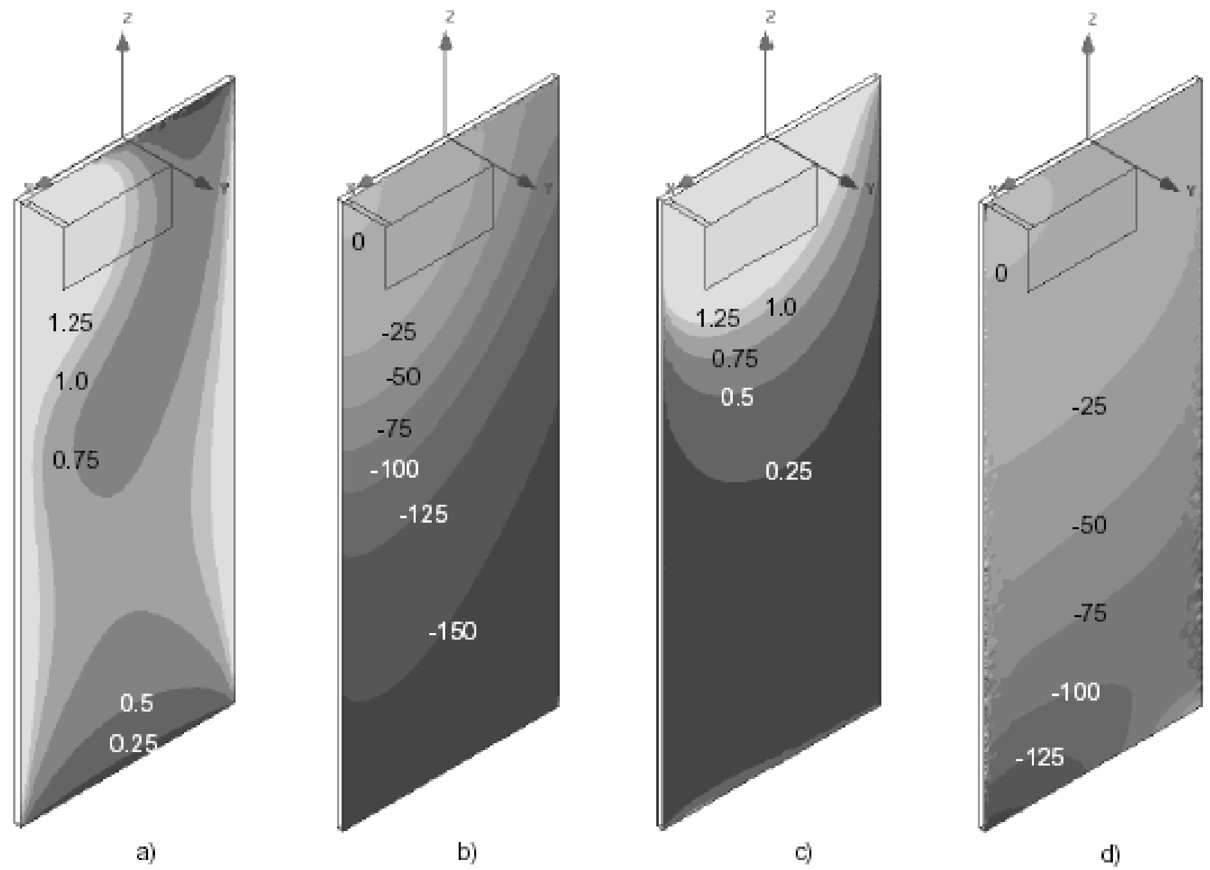
Positions of PILA "top plates" (not all positions shown)

INFLUENCE OF SUPPORTING PCB (7)



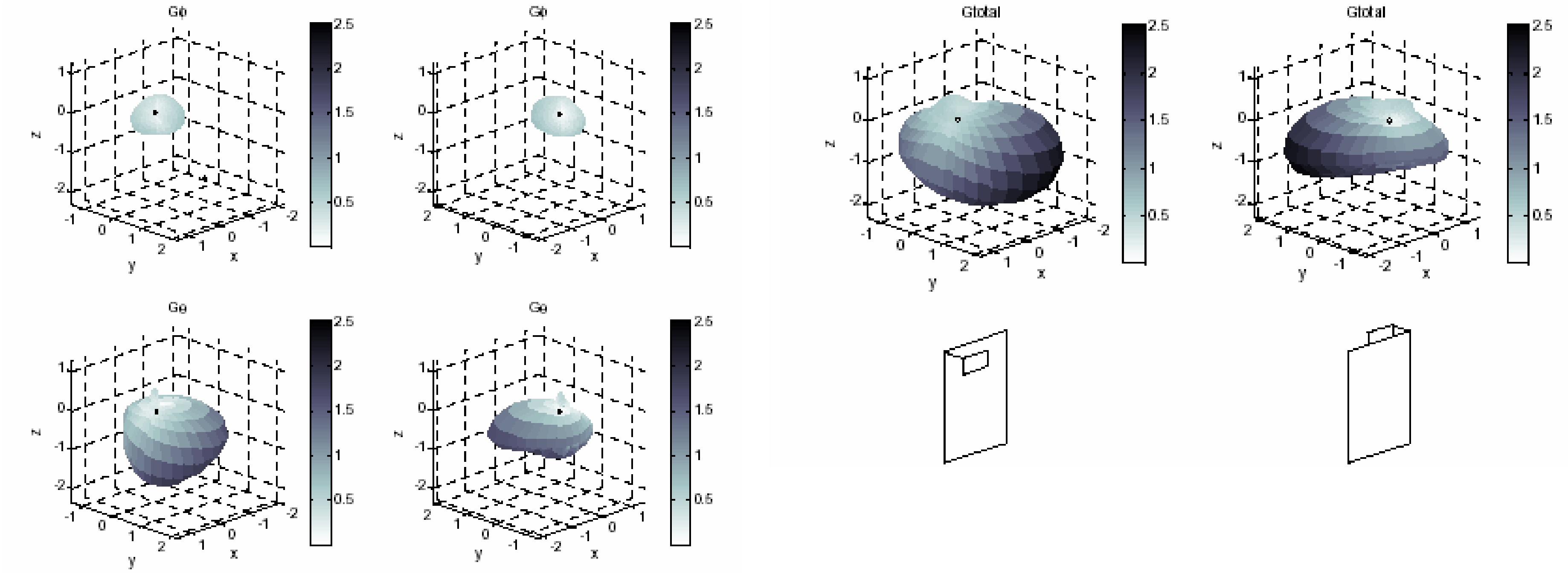
Impedance of a PILA at various positions on a 100x40x1mm PCB

EFFECT OF PCB ON DIVERSITY PERFORMANCE (1)



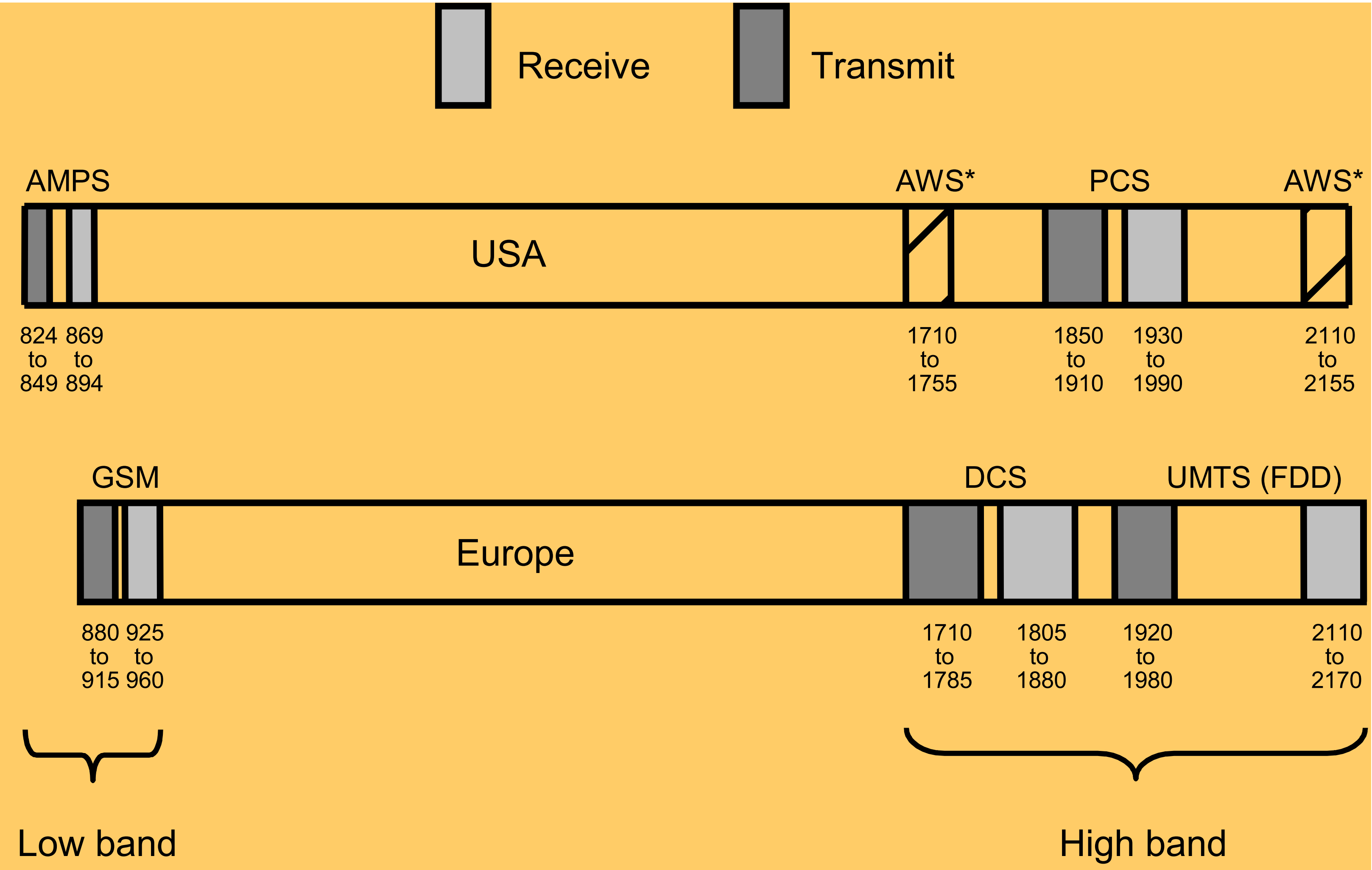
Surface current relative magnitudes and phases (degrees) at 1800MHz, a) z component magnitude, b) z component phase, c) x component magnitude, d) x component phase

EFFECT OF PCB ON DIVERSITY PERFORMANCE (2)

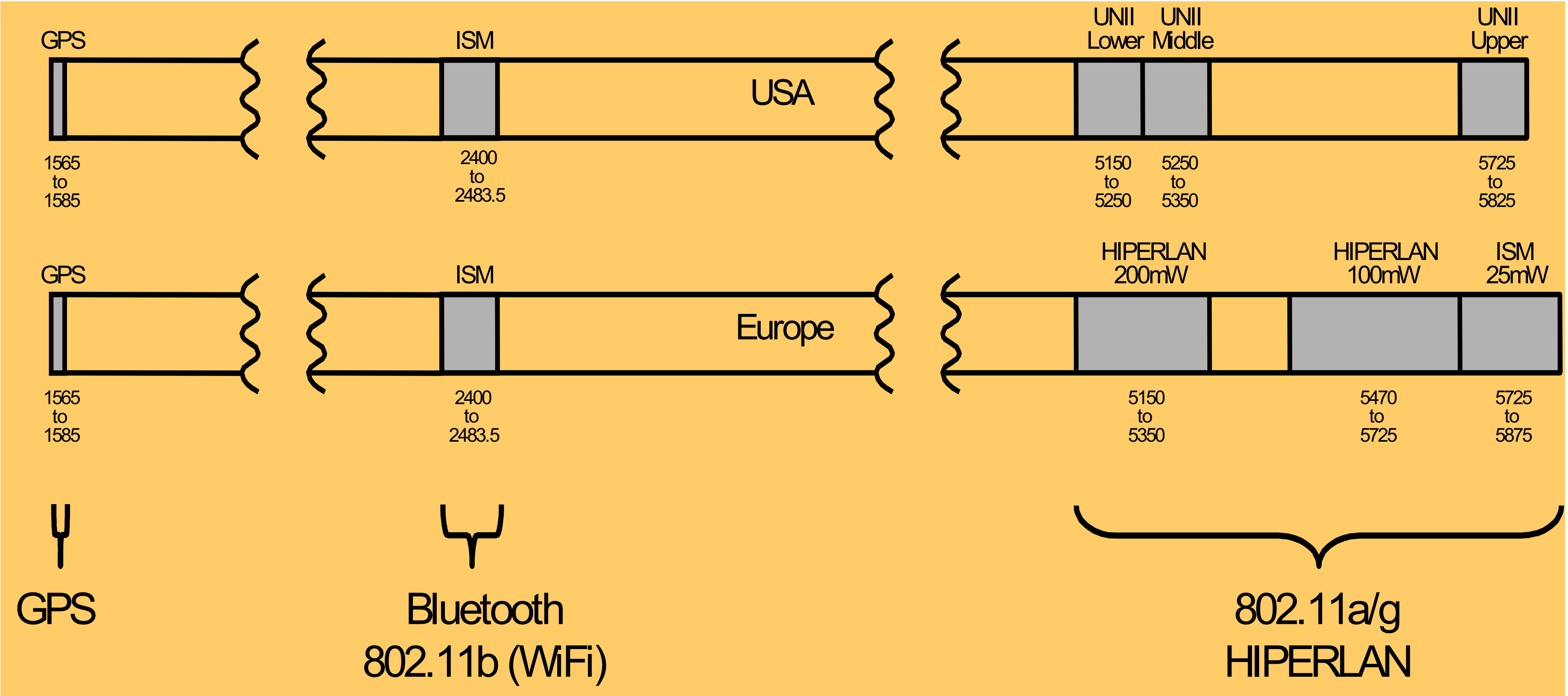


Radiation patterns at 1800MHz. Radiation patterns on first and third row are viewed from an azimuth angle of 45°, while those on the second and fourth row are viewed from an azimuth angle of -135°. The origin is marked by a small circle.

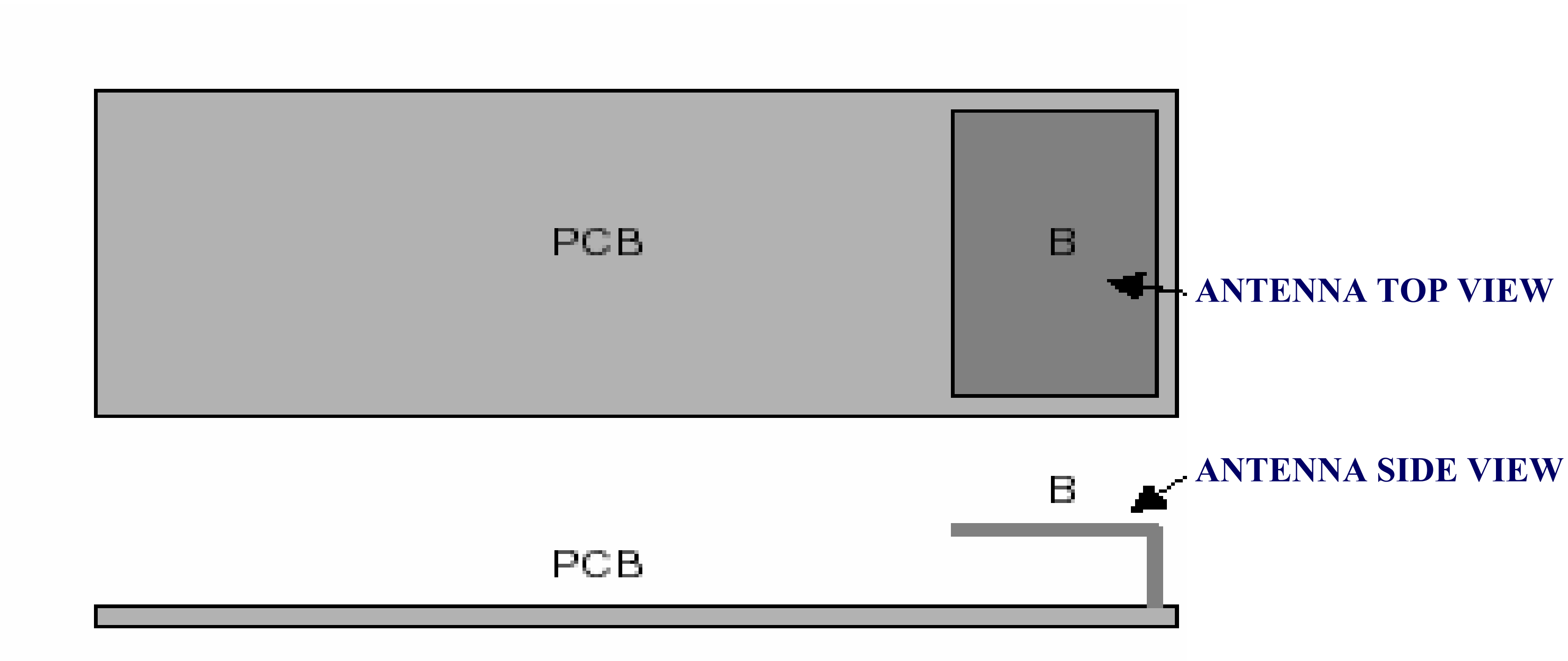
EU AND US CELLULAR FREQUENCY BANDS

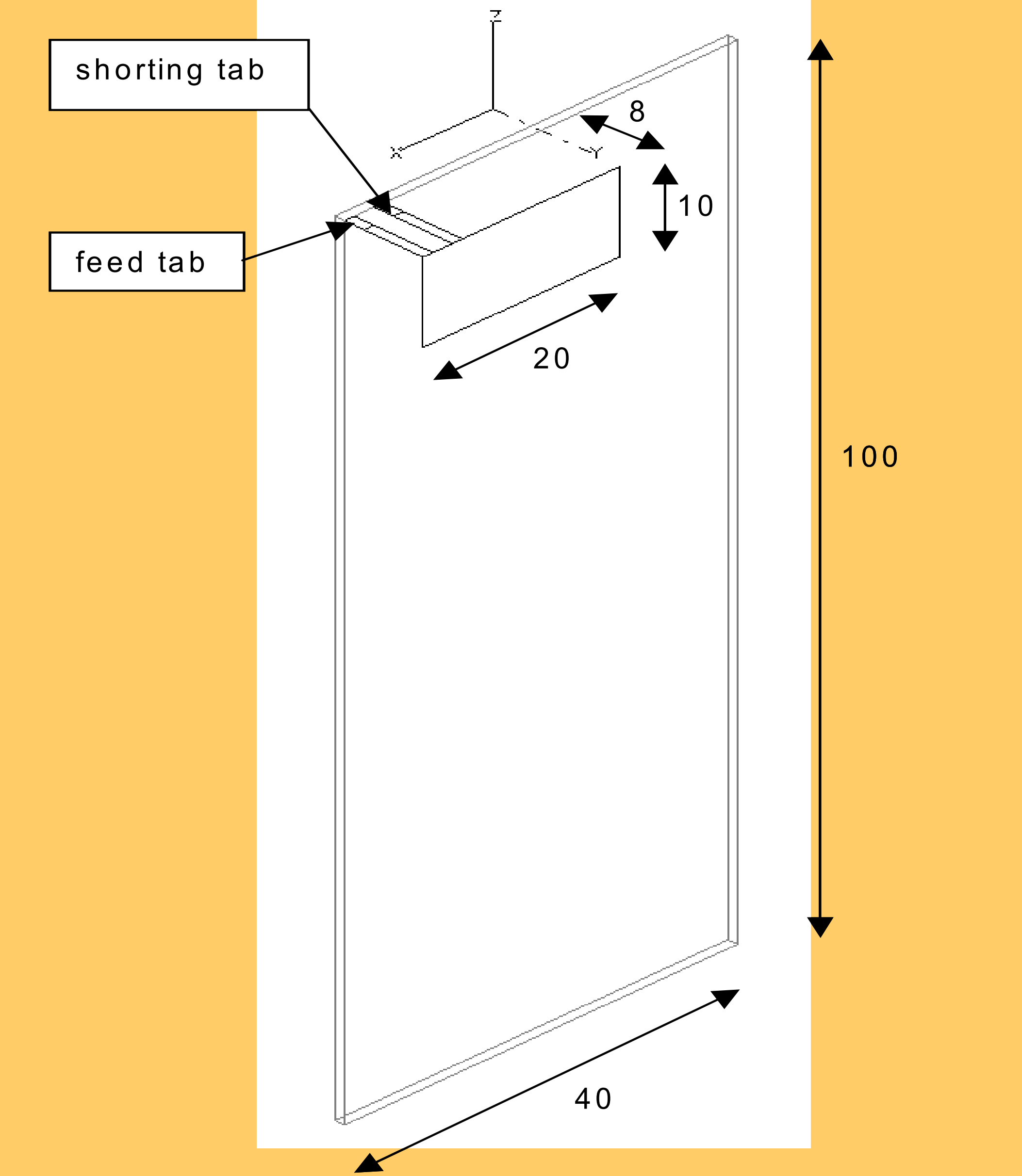


W-LAN AND PAN BANDS



BASIC ANTENNA AND PCB ARRANGEMENTS





PIFA GEOMETRY IN MM

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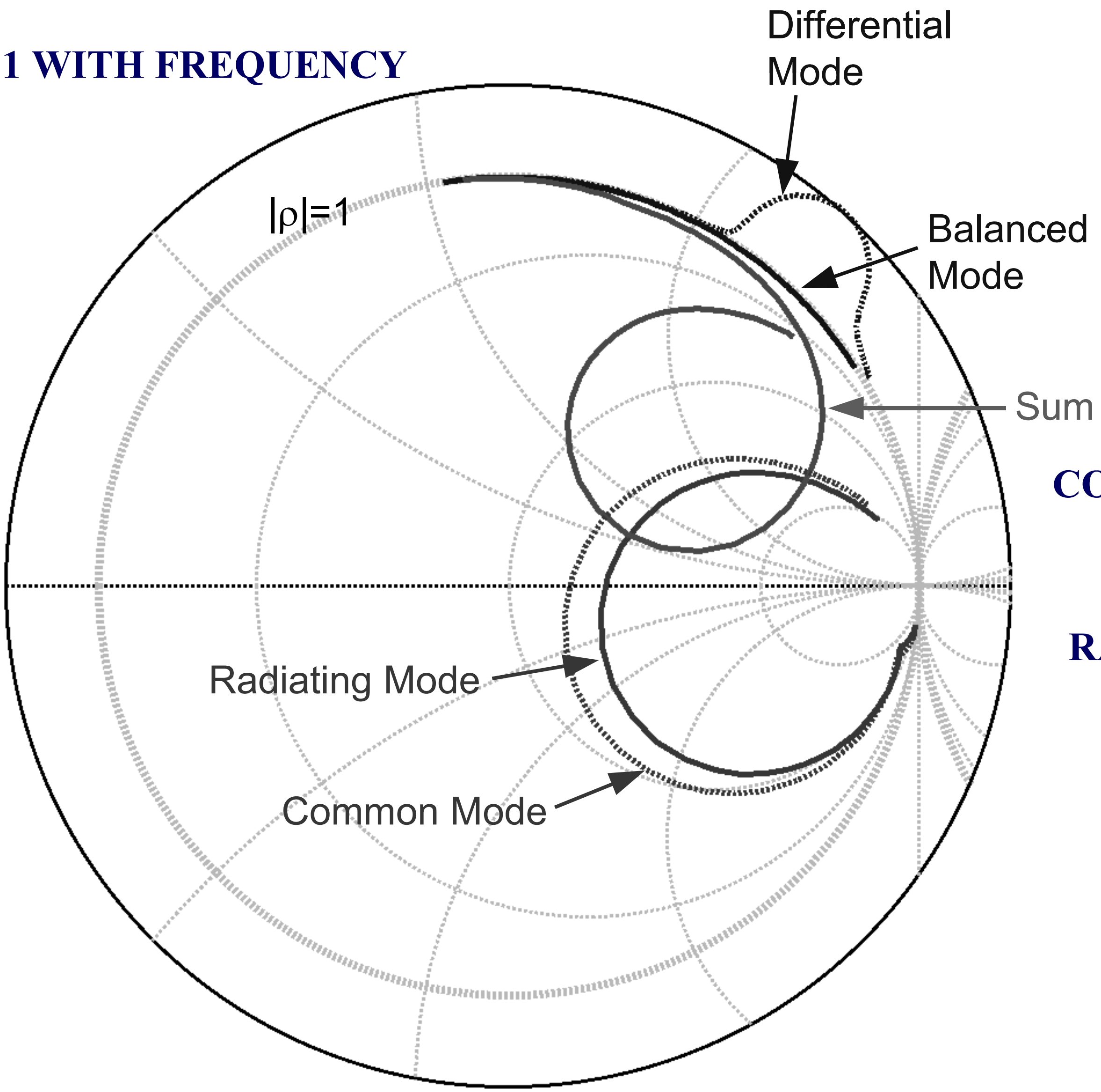
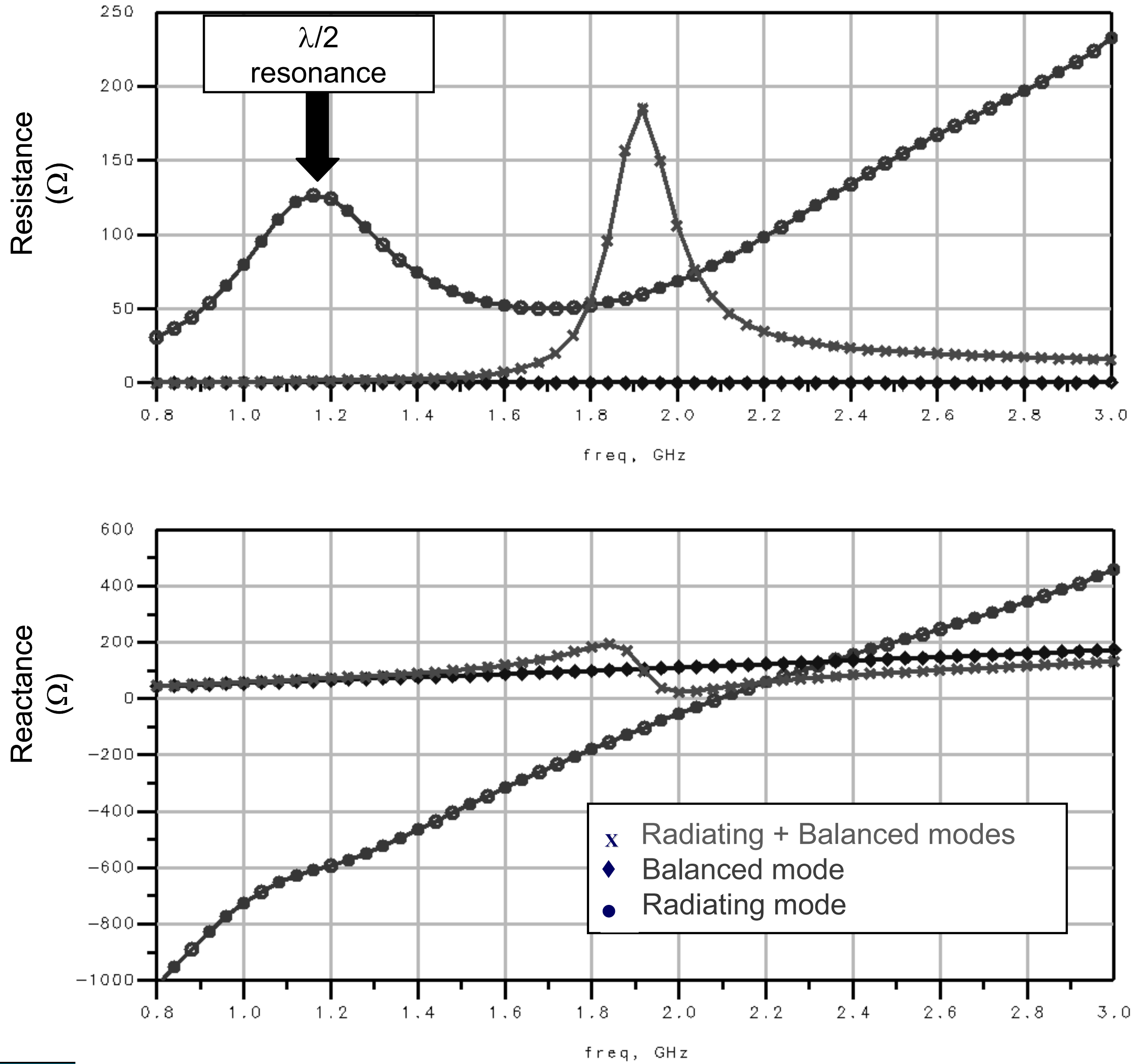
S11 WITH FREQUENCY



COMMON, DIFFERENTIAL AND SUM MODES

RADIATING, BALANCED AND SUM MODES



IMPEDANCE OF RADIATING AND BALANCED MODES

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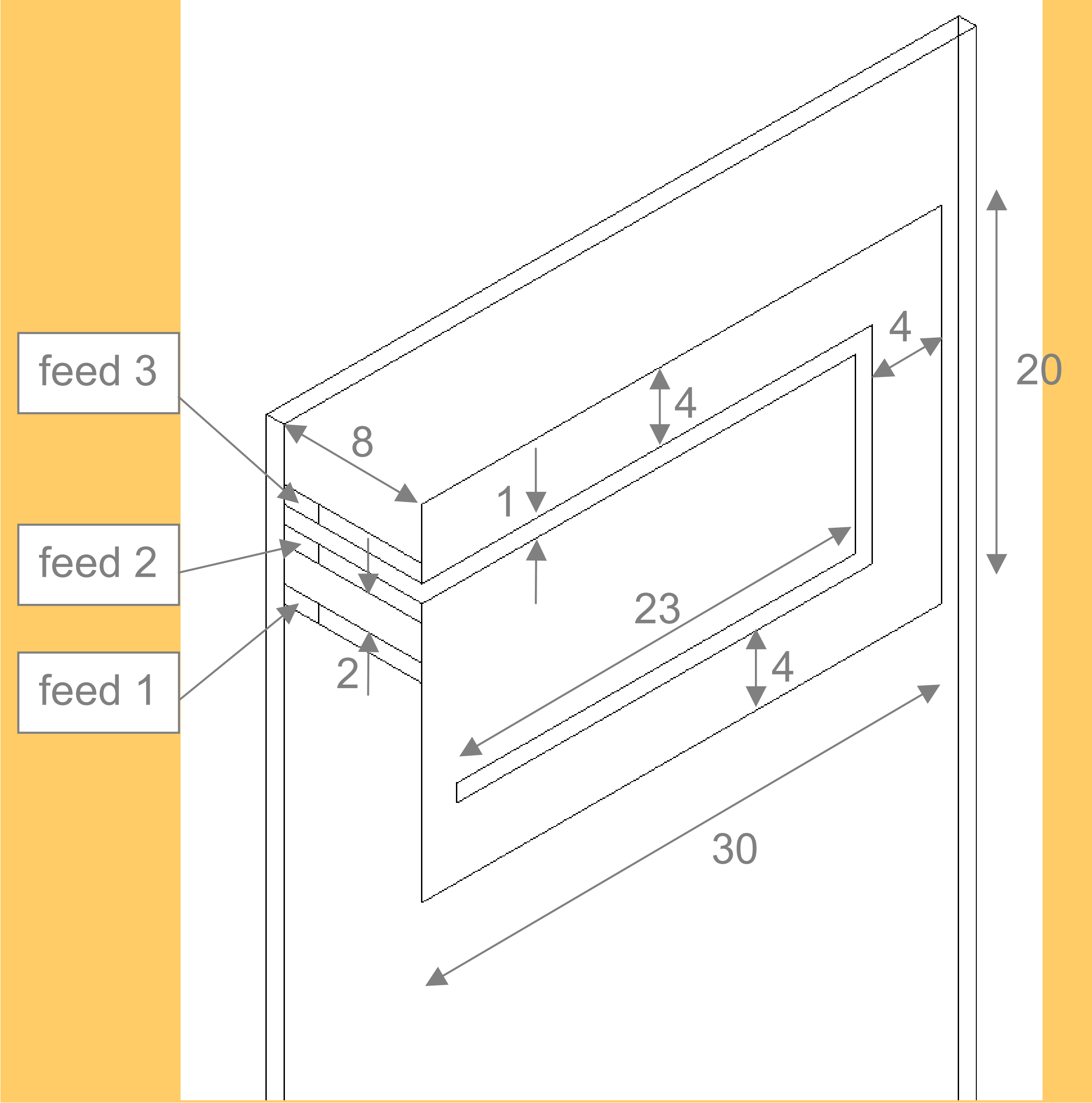

DUAL-BAND PIFA DESIGN

FEED 2 SHORTED

TRI-FED PIFA

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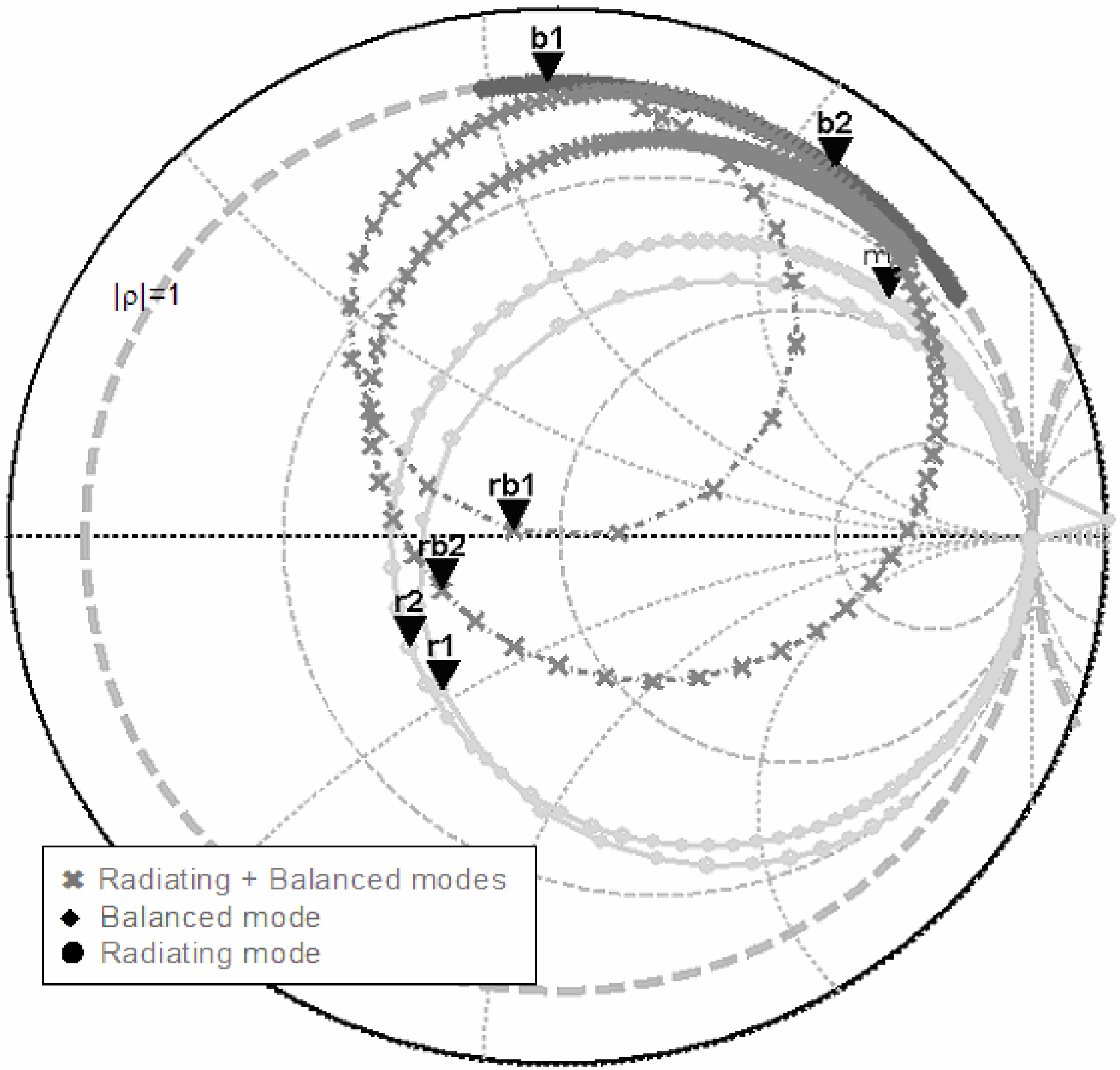

S11 WITH FREQUENCY

FEED 2 SHORTED

r RADIATING MODE

b BALANCED MODE

rb SUM MODE

1 920 MHz

2 1800 MHz

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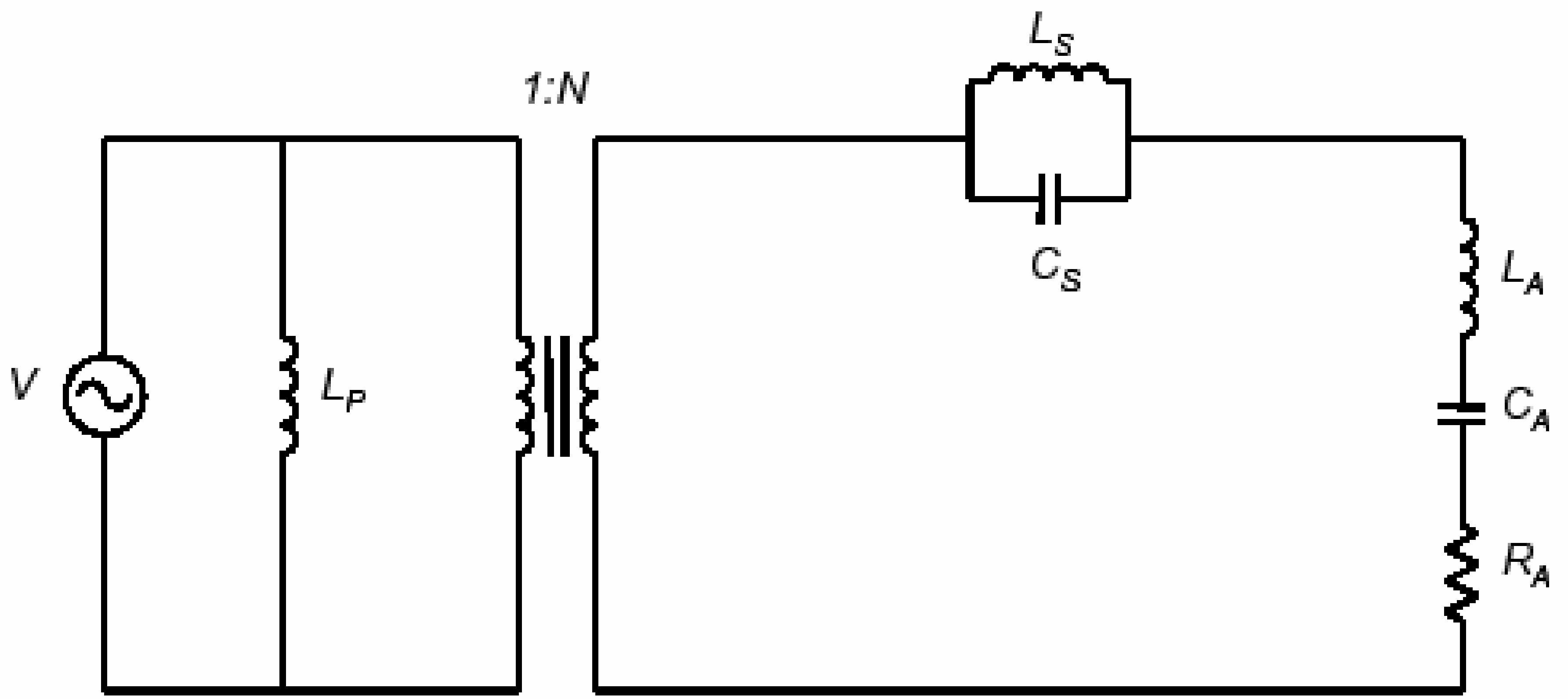
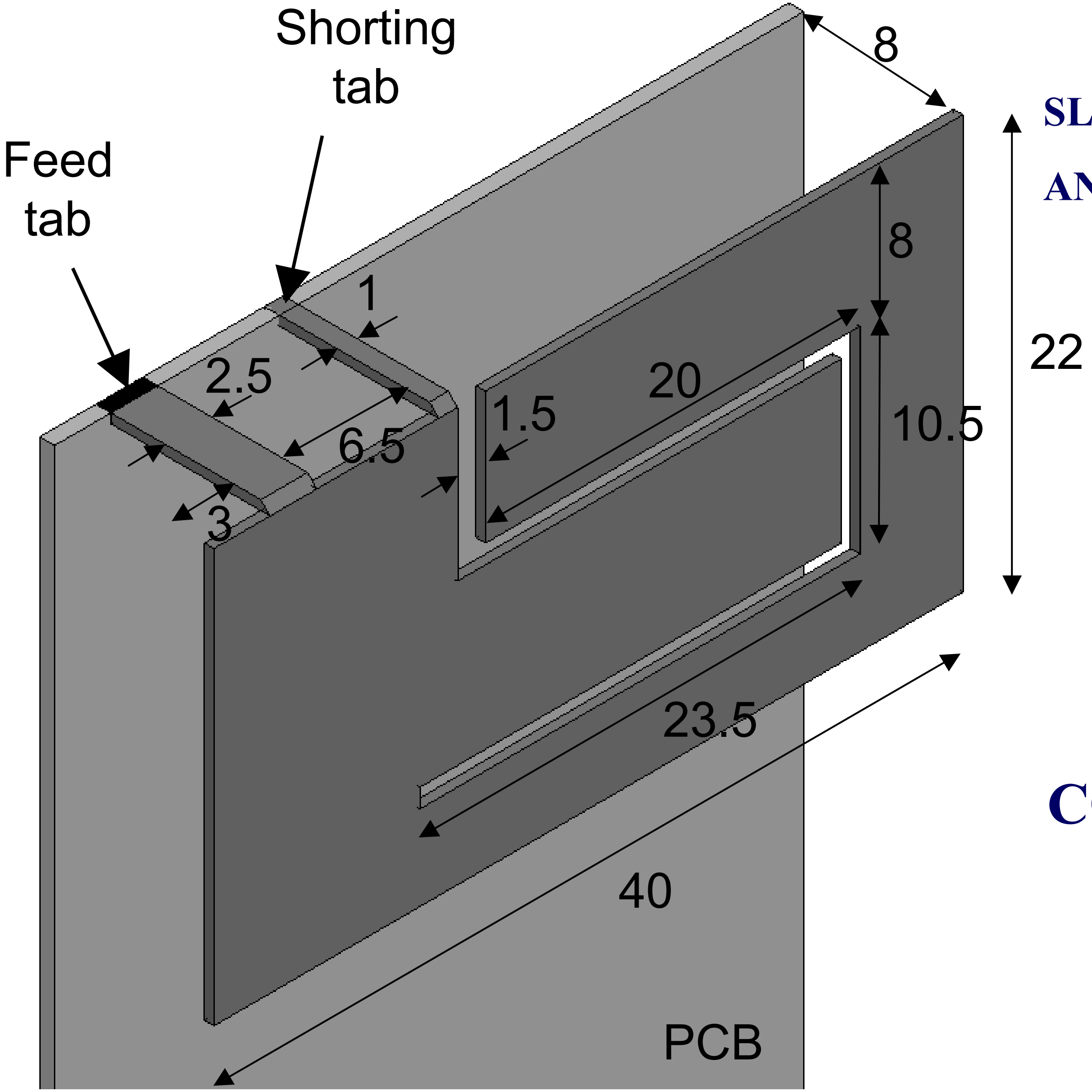
DUAL-BAND PIFA EQUIVALENT CIRCUIT





SLOT WIDTH 1.5 MM

ANTENNA THICKNESS 0.5 MM

CONVENTIONAL DUAL-BAND PIFA

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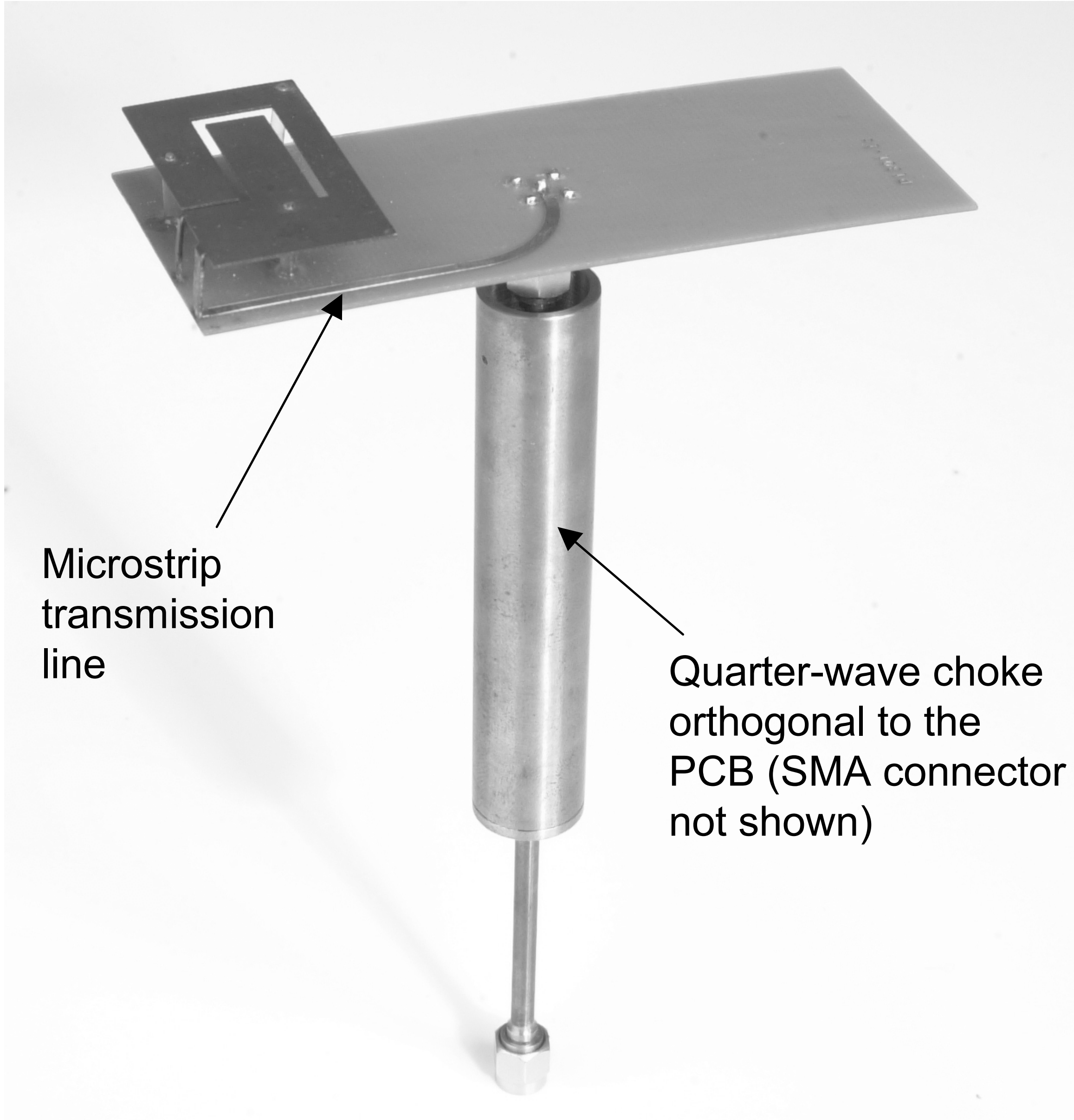

CONVENTIONAL DUAL-BAND PIFA

MEASUREMENT SET-UP

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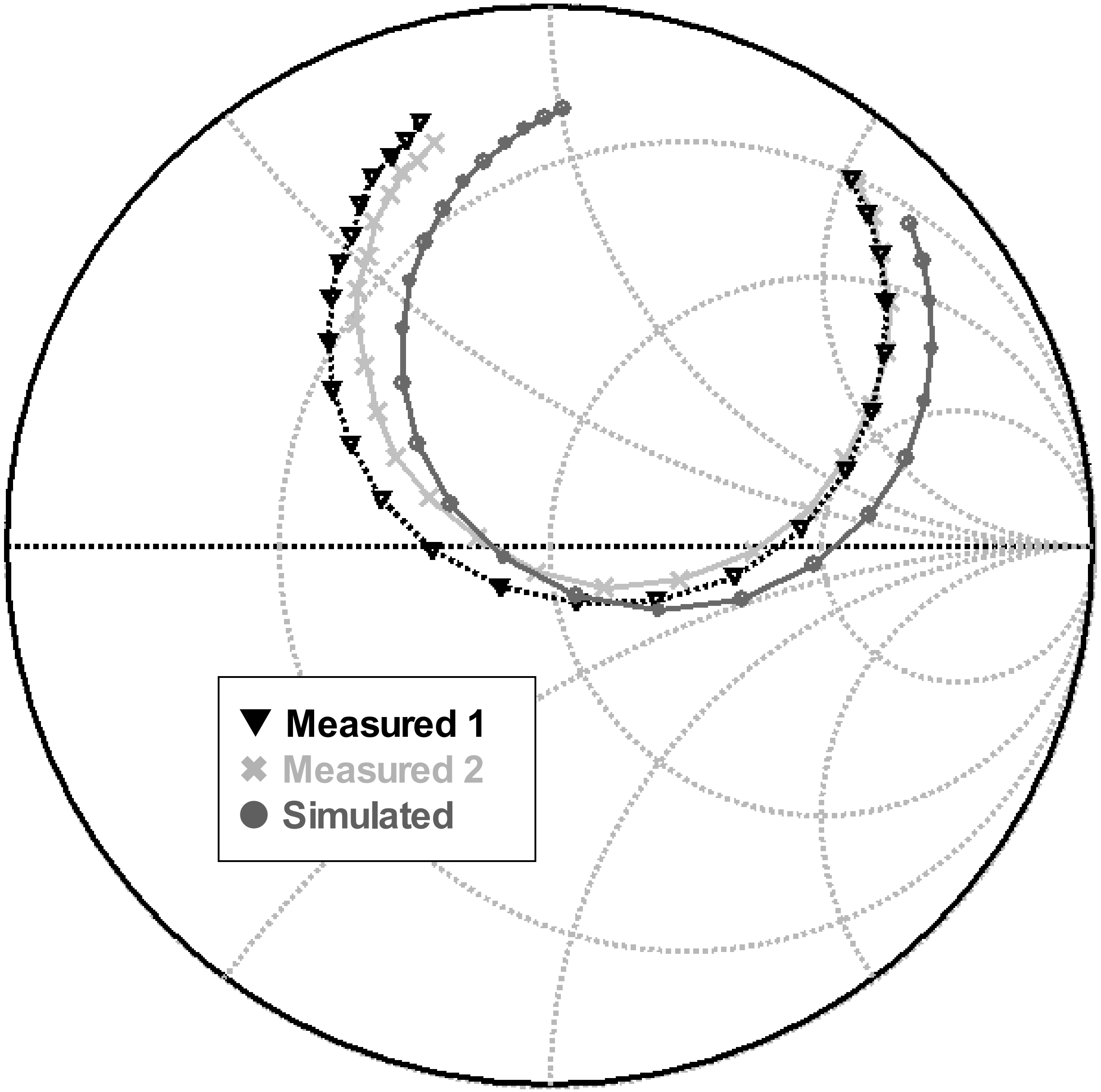
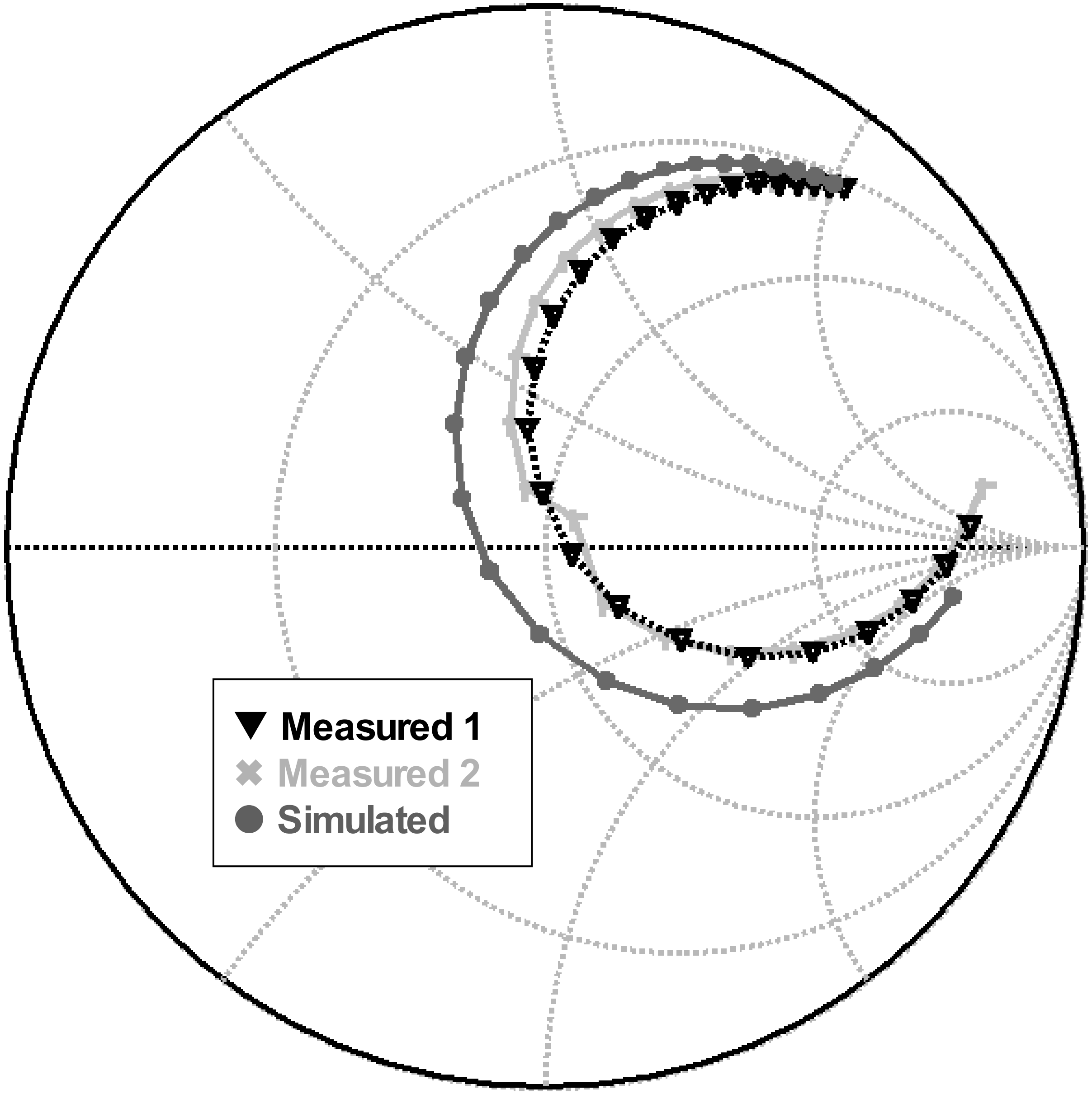
S11 OF CONVENTIONAL PIFA



800-1040 MHz

MEASUREMENT 1 AND 2 FOR REPRODUCIBILITY



S11 OF CONVENTIONAL PIFA

1610-2090 MHz

MEASUREMENT 1 AND 2 FOR REPRODUCIBILITY

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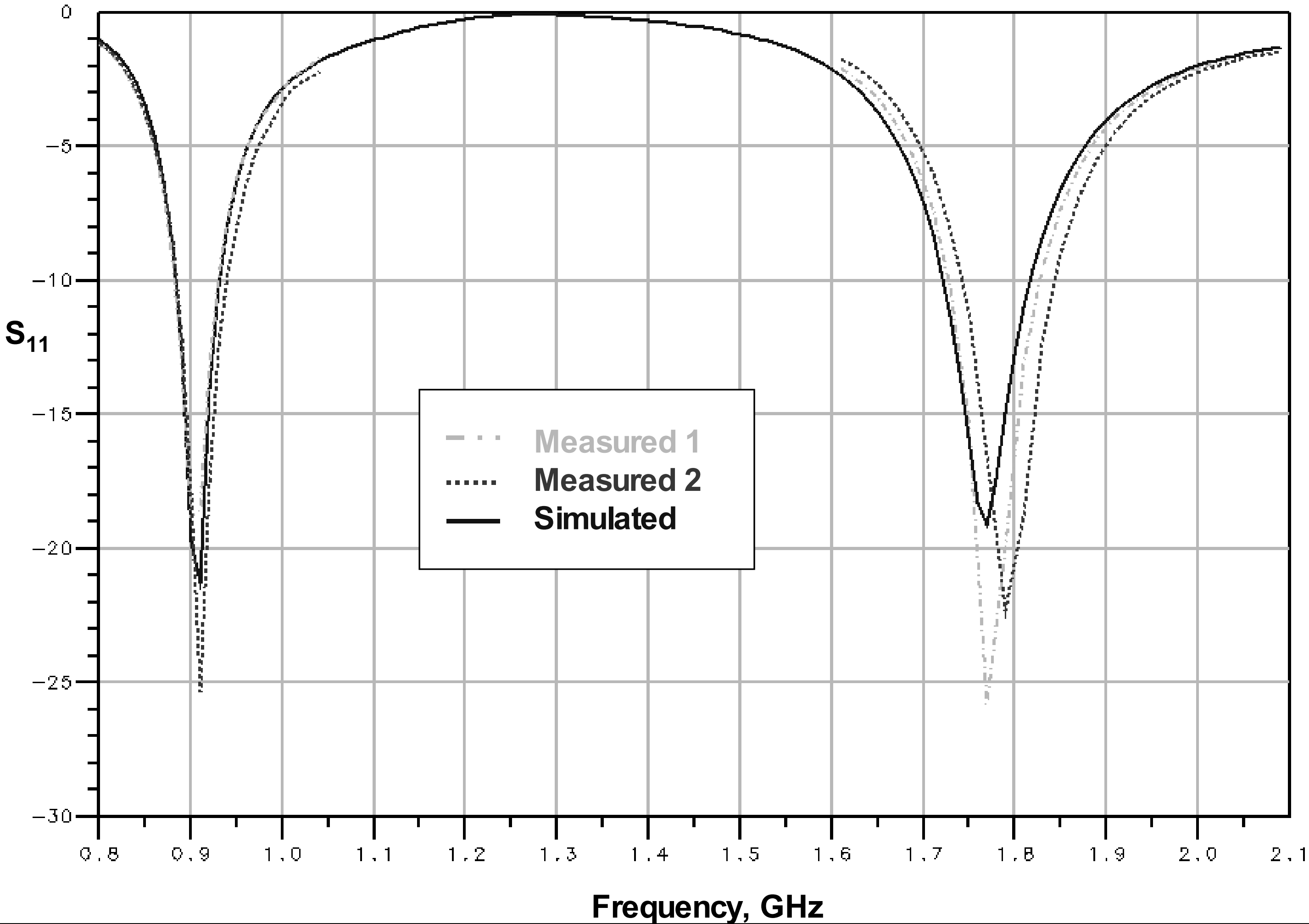
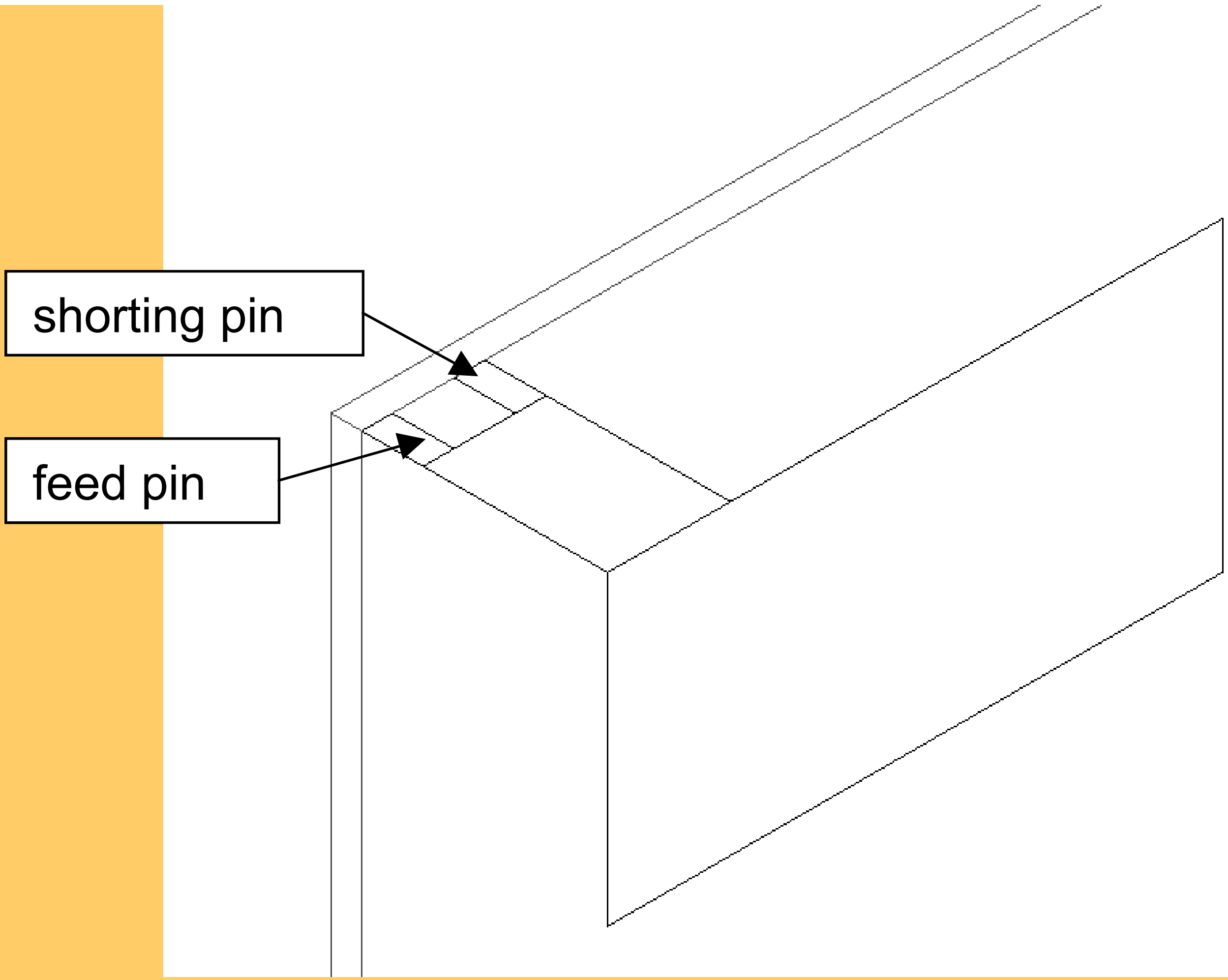
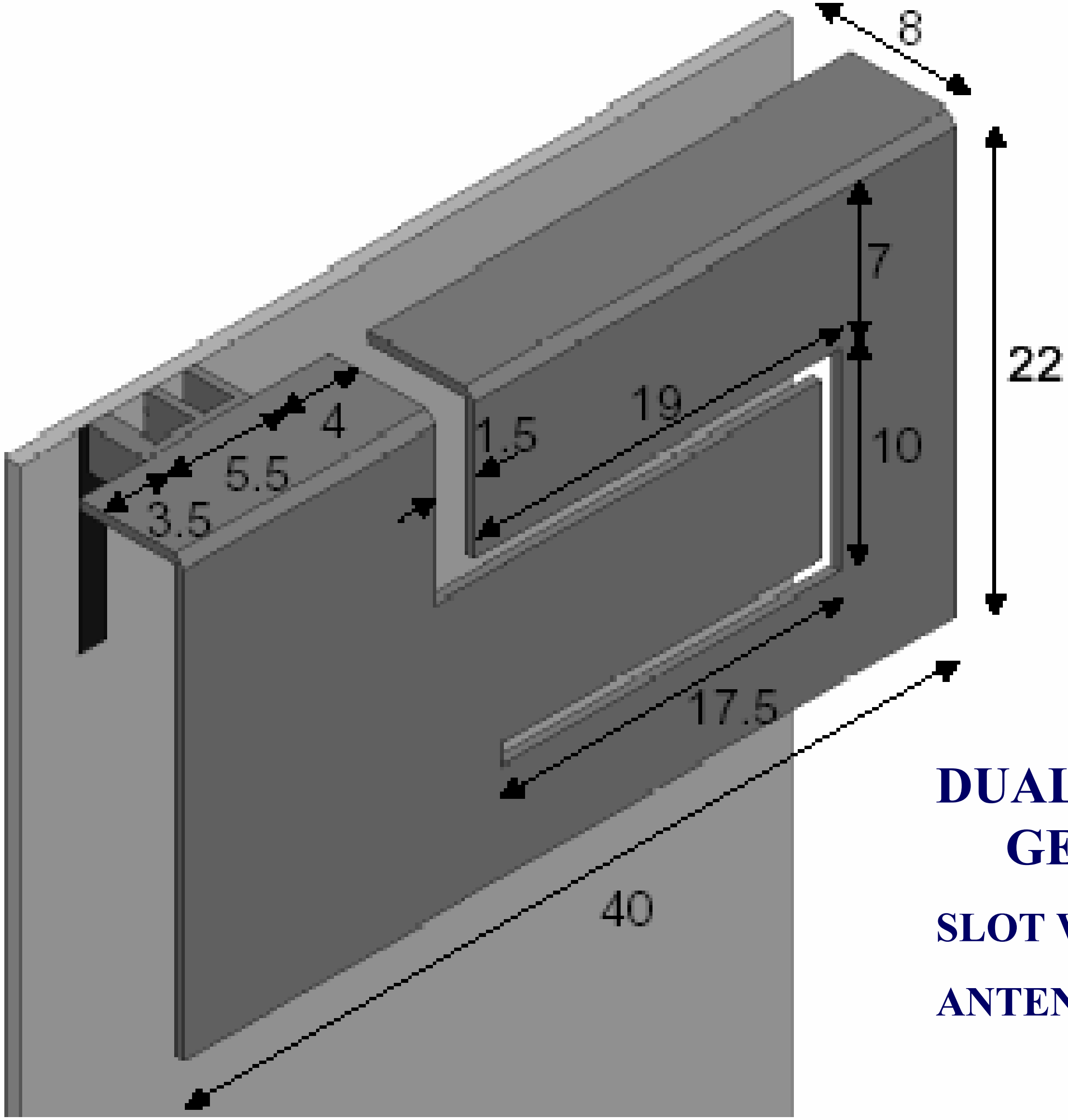
RETURN LOSS OF CONVENTIONAL PIFA

MEASUREMENT 1 AND 2 FOR REPRODUCIBILITY



DIFFERENTIALLY-FILLED (DF) PIFA



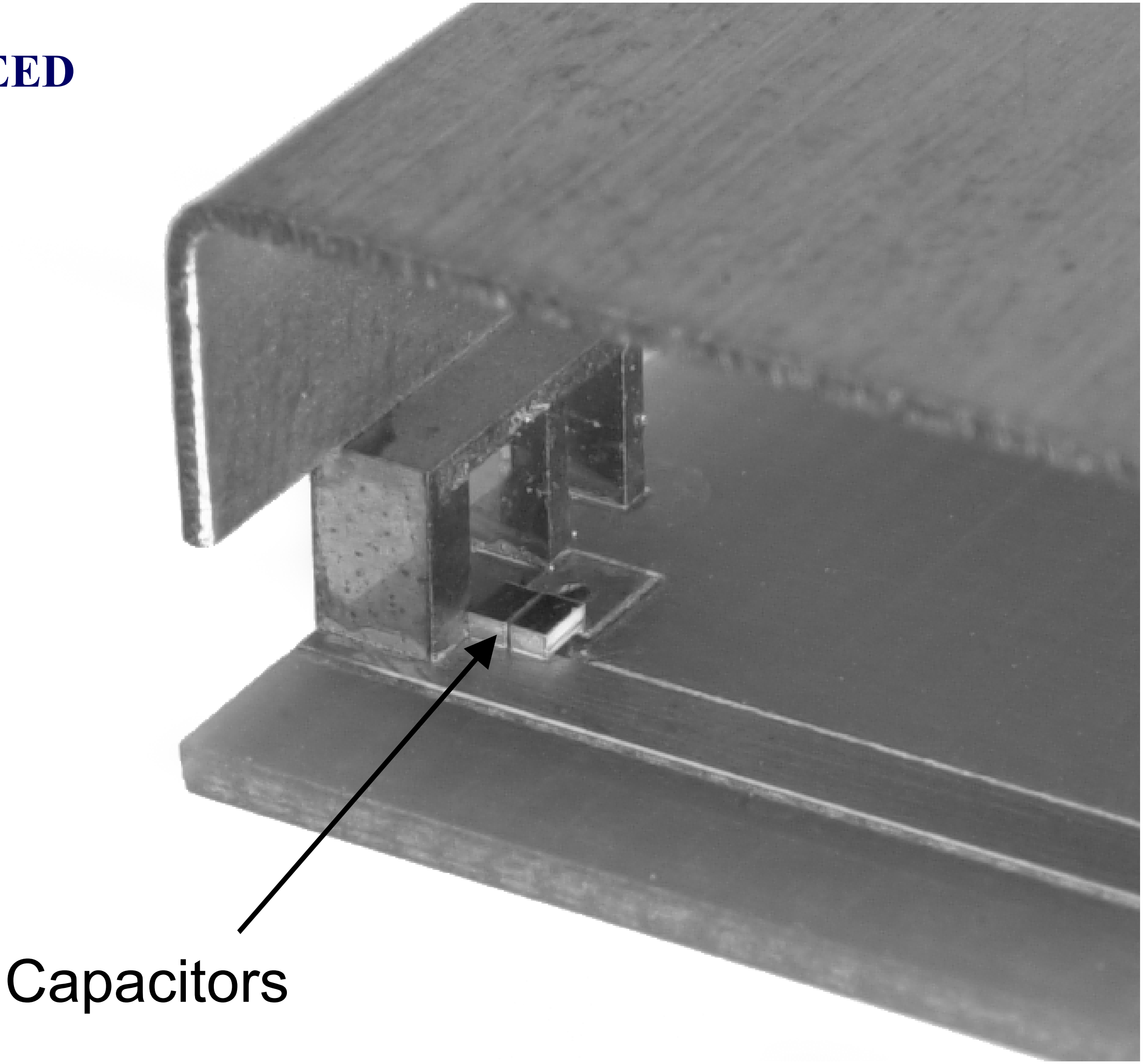


DUAL FED DF PIFA GEOMETRY IN MM

SLOT WIDTH 1 MM

ANTENNA THICKNESS 0.5 MM

DUAL-FED DF PIFA FEED



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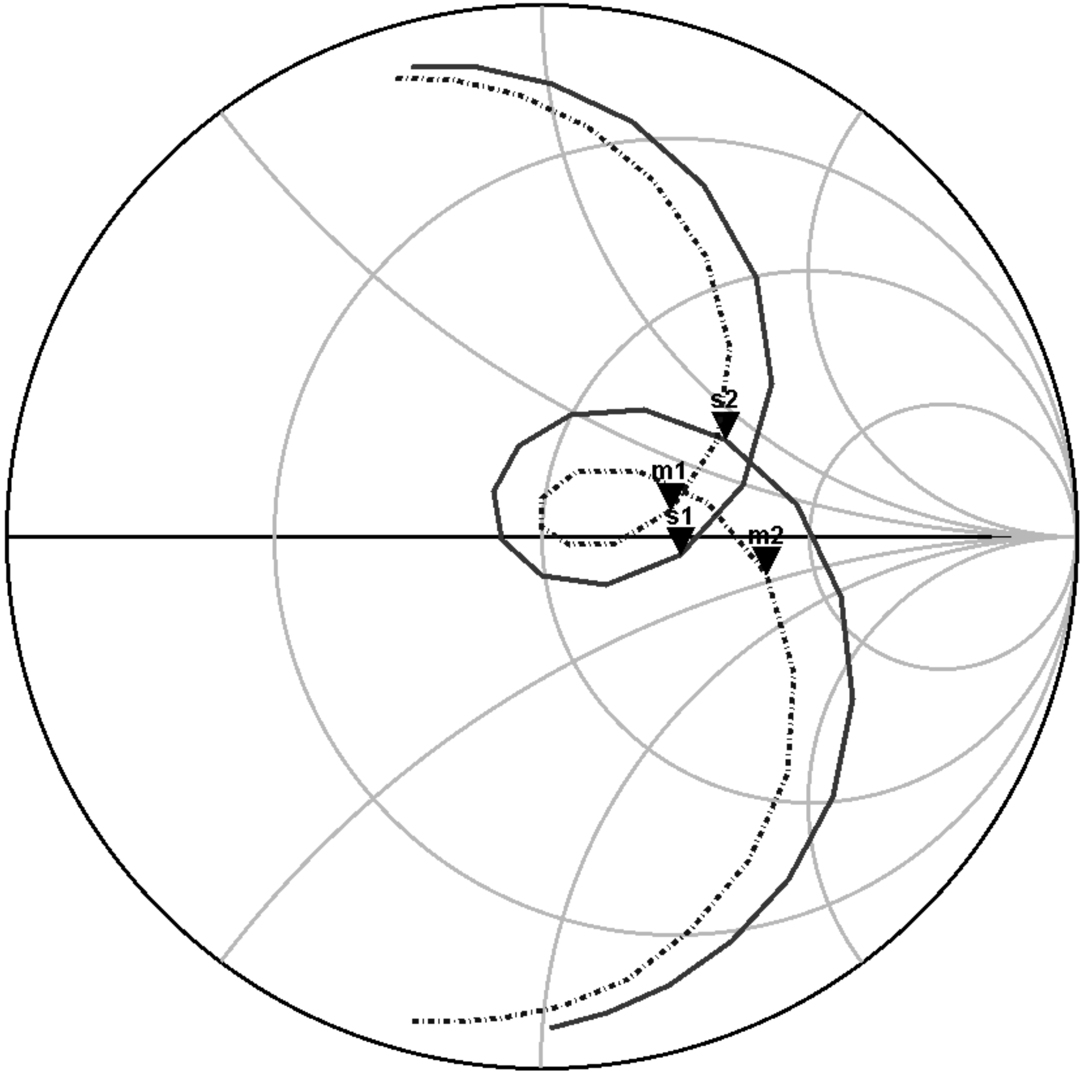
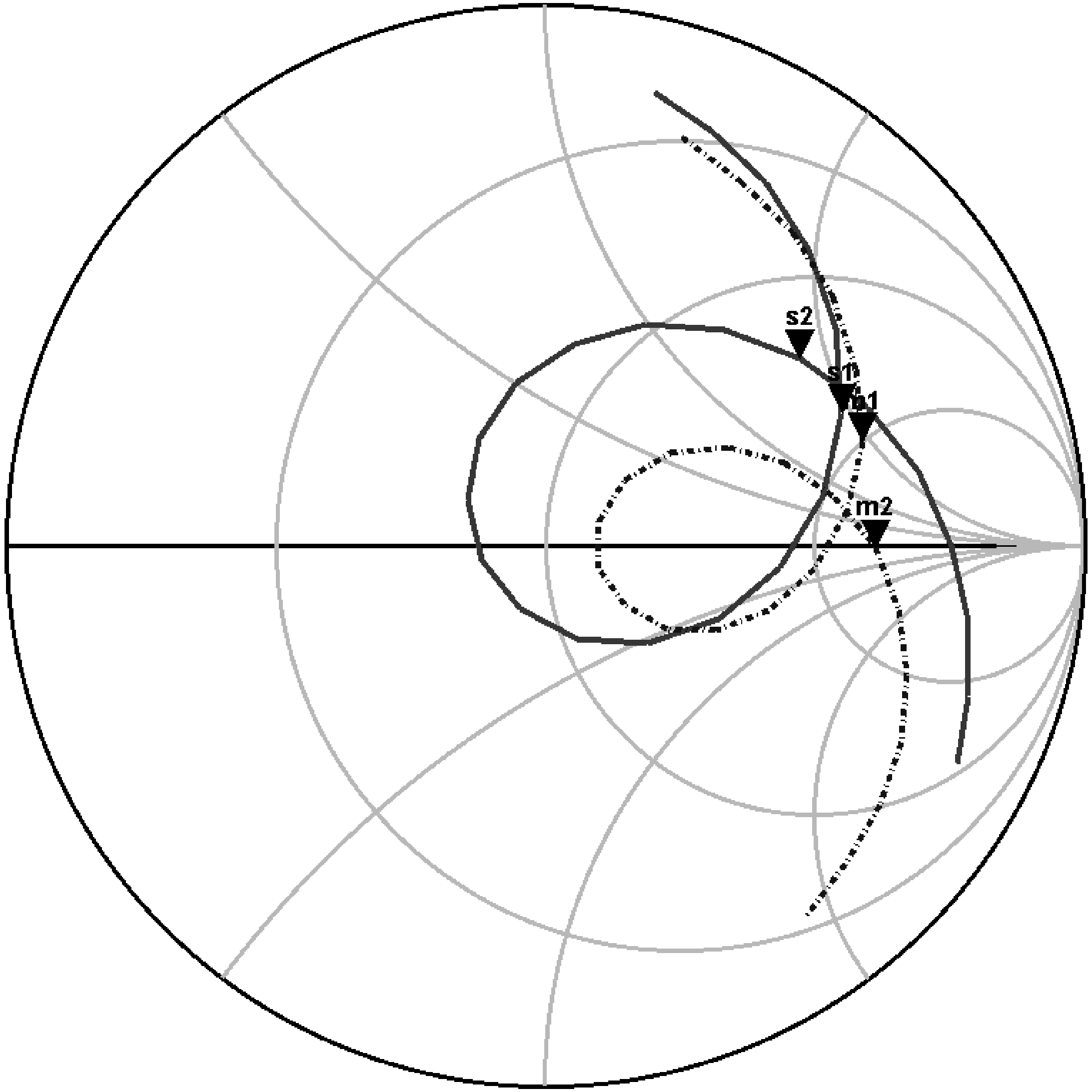
S11 OF DUAL FED DF PIFA IN GSM BAND



s1, s2 SIMULATED BAND-EDGE FREQUENCIES

m1, m2 MEASURED BAND-EDGE FREQUENCIES

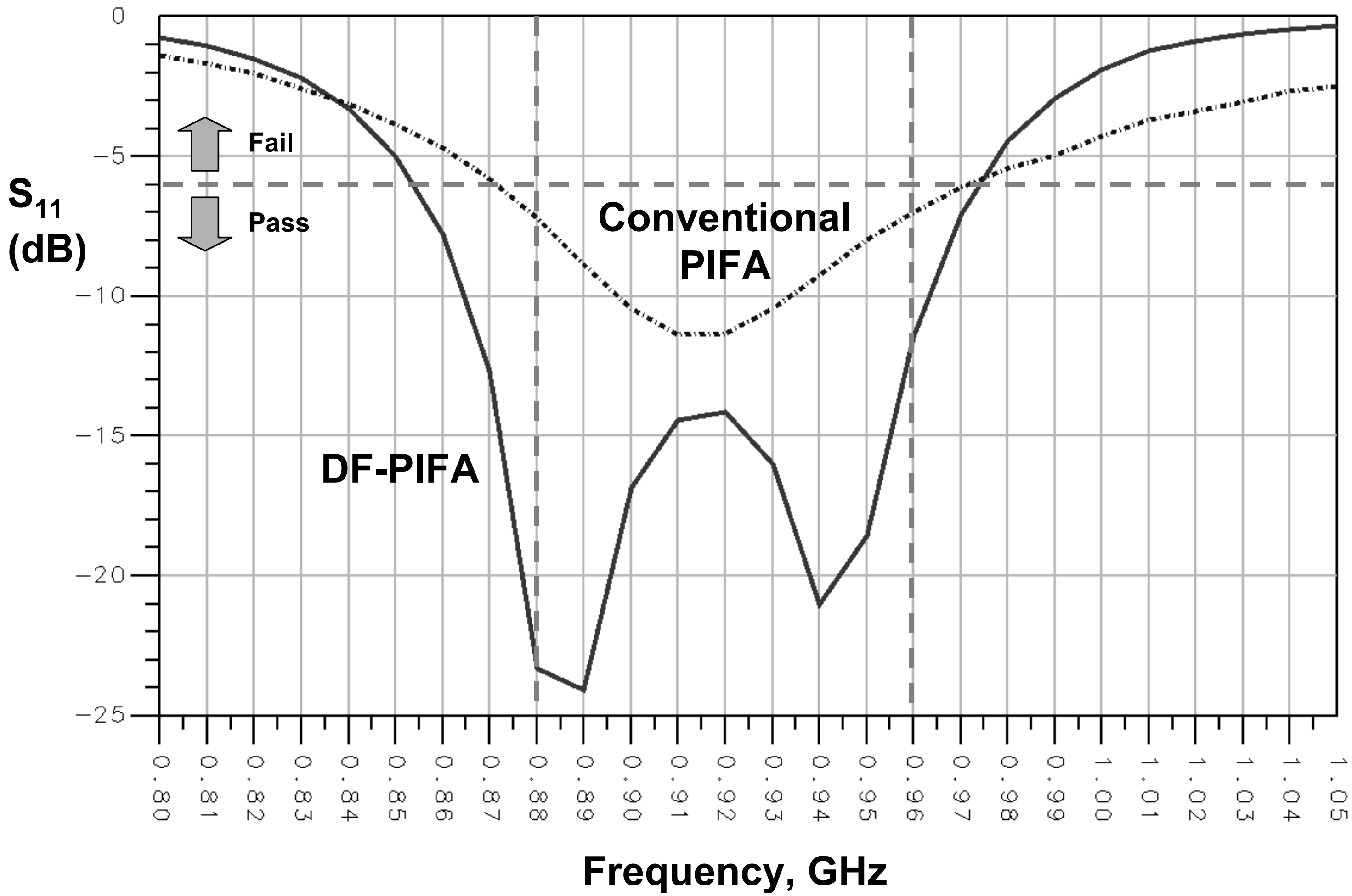
S11 OF DUAL FED DF PIFA IN DCS/PCS BAND



s1, s2 SIMULATED BAND-EDGE FREQUENCIES

m1, m2 MEASURED BAND-EDGE FREQUENCIES

RETURN LOSS OF CONVENTIONAL AND DUAL FED DF PIFA OVER GSM BAND AFTER MATCHING



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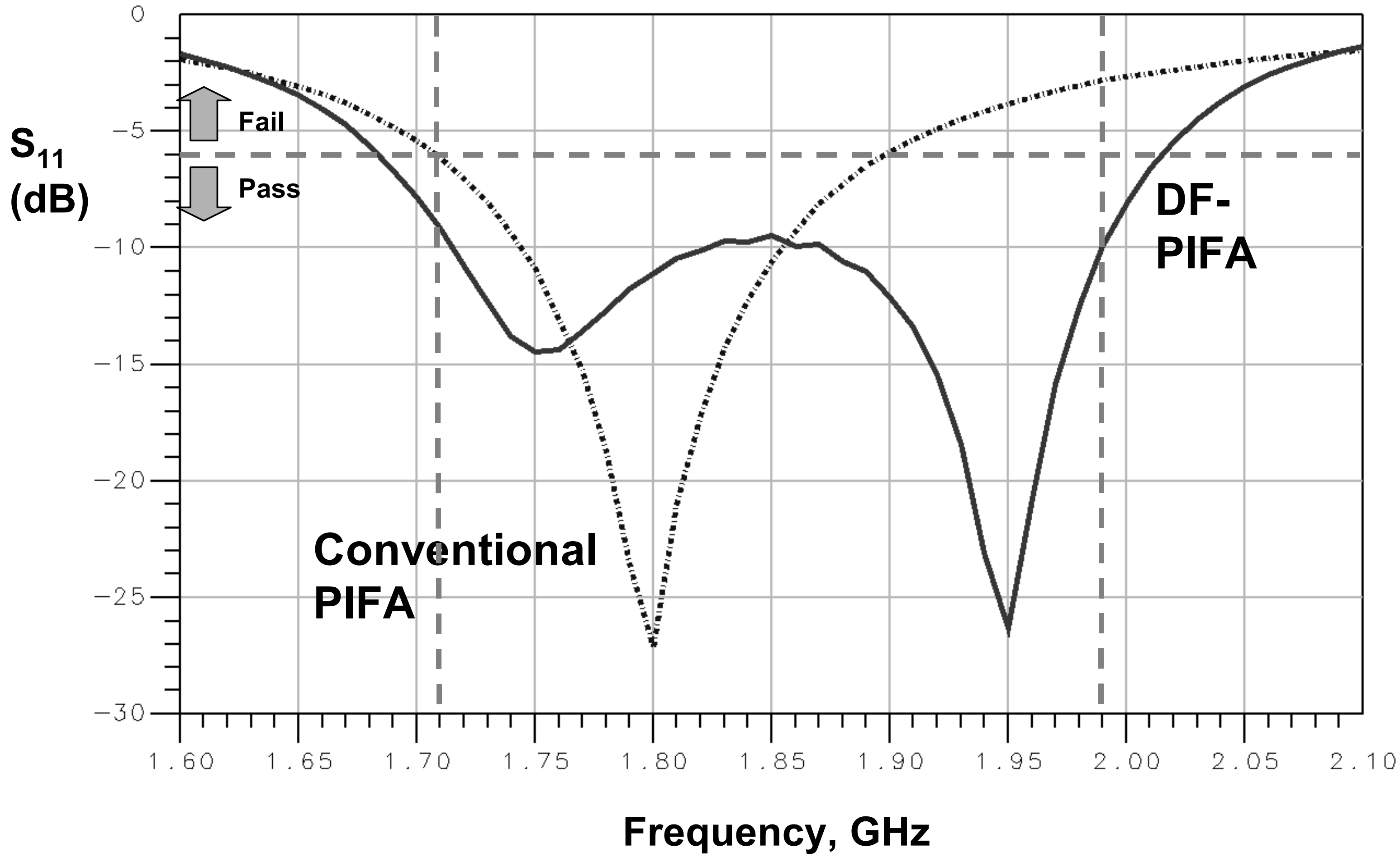
RETURN LOSS OF CONVENTIONAL AND DUAL FED DF PIFA OVER DCS/PCS BAND AFTER MATCHING



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CONCLUSIONS PIFA

1. PIFA DESIGN SHOWN IS NEW
2. PIFA IMPEDANCE CHARACTERISTICS CAN BE DECOMPOSED IN RADIATING AND NON-RADIATING MODES
3. SIMPLE EQUIVALENT CIRCUITS REPRESENT PIFA
4. SLOT EFFECT WITH OPENING CLOSE TO FEED AND SHORTING PIN IS REACTIVE
5. SINGLE-BAND AND DUAL-BAND DESIGNS ARE SHOWN

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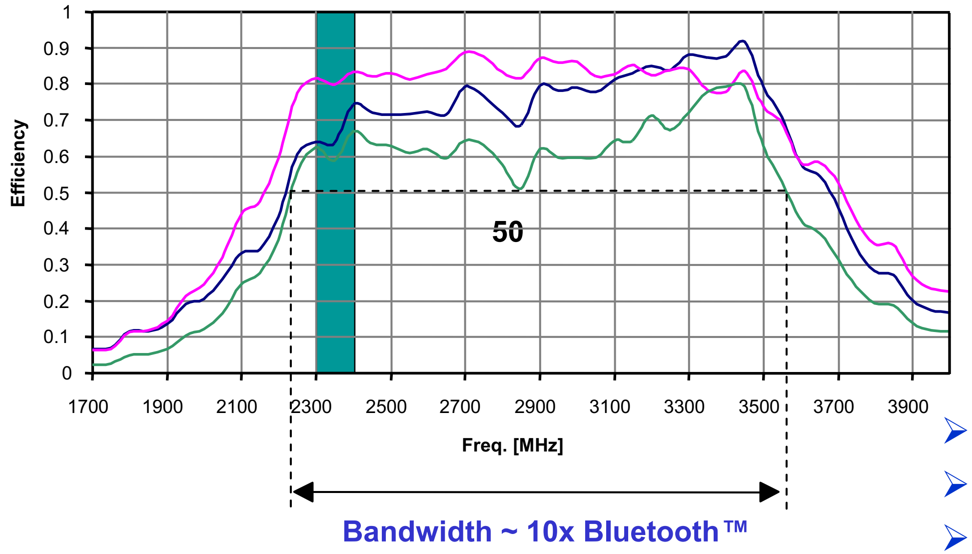
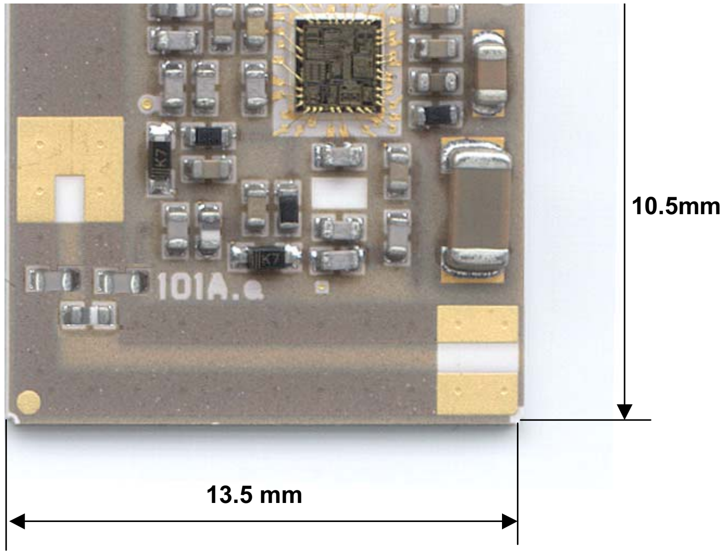
CONCLUSIONS PIFA WITH INTEGRATED CIRCUITRY

PIFA PARAMETERS (BANDWIDTH, SIZE, EFFICIENCY, USER INTERACTION, SAR, COSTS, EASE OF IMPLEMENTATION, MULTIPLE ANTENNAS FOR DIVERSITY) CAN BE CONSIDERED SIMULTANEOUSLY

EXAMPLE

Bluetooth RF module





- Very small antenna (<60mm2) integrated in substrate
- Very low cost
- Good efficiency (~70%)
- Very wideband (typically 10x that of Bluetooth)
- *Hence, truly “drop-in”*

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CST 学习培训课程套装

该培训套装由易迪拓培训联合微波 EDA 网共同推出，是最全面、系统、专业的 CST 微波工作室培训课程套装，所有课程都由经验丰富的专家授课，视频教学，可以帮助您从零开始，全面系统地学习 CST 微波工作的各项功能及其在微波射频、天线设计等领域的设计应用。且购买该套装，还可超值赠送 3 个月免费学习答疑…

课程网址：http://www.edatop.com/peixun/cst/24.html

HFSS 天线设计培训课程套装

套装包含 6 门视频课程和 1 本图书，课程从基础讲起，内容由浅入深，理论介绍和实际操作讲解相结合，全面系统的讲解了 HFSS 天线设计的全过程。是国内最全面、最专业的 HFSS 天线设计课程，可以帮助您快速学习掌握如何使用 HFSS 设计天线，让天线设计不再难…

课程网址：http://www.edatop.com/peixun/hfss/122.html

13.56MHz NFC/RFID 线圈天线设计培训课程套装

套装包含 4 门视频培训课程，培训将 13.56MHz 线圈天线设计原理和仿真设计实践相结合，全面系统地讲解了 13.56MHz 线圈天线的工作原理、设计方法、设计考量以及使用 HFSS 和 CST 仿真分析线圈天线的具体操作，同时还介绍了 13.56MHz 线圈天线匹配电路的设计和调试。通过该套课程的学习，可以帮助您快速学习掌握 13.56MHz 线圈天线及其匹配电路的原理、设计和调试…

详情浏览：http://www.edatop.com/peixun/antenna/116.html

我们的课程优势：

※ 成立于 2004 年，10 多年丰富的行业经验，

※ 一直致力并专注于微波射频和天线设计工程师的培养，更了解该行业对人才的要求

※ 经验丰富的一线资深工程师讲授，结合实际工程案例，直观、实用、易学

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