Principles and applications of the Folded Inverted Conformal Antenna (FICA) technology

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CONVERGE 2005 – Milan, Italy, November 2005

Overview

Motivation

- Background on mobile phone antennas
- Planar Inverted-F Antenna (PIFA) technology

FICA technology

- Volume reuse concept
- FICA operation theory (**excitation mechanism and modes**)

FICA Applications

- Benchmark of FICA vs PIFA
- Integration in mobile phones

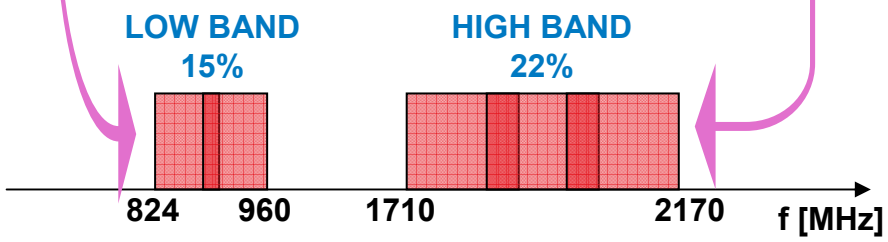
Conclusions and future directions

Background of mobile phone antennas

Cellular frequency bands

824-894 MHz (**CDMA/TDMA/GSM**)
880-960 MHz (**EGSM**)

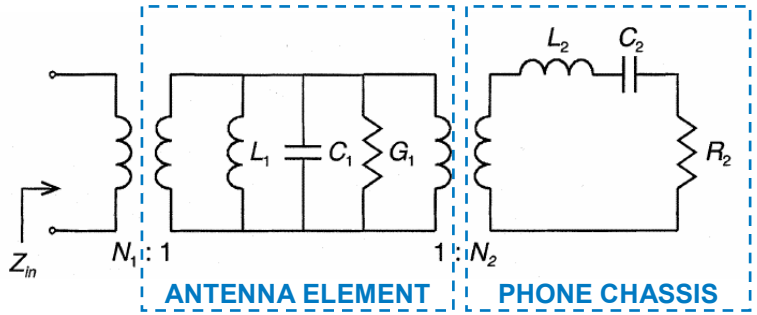
1710-1880 MHz (**DCS**)
1850-1990 MHz (**PCS**)
1920-2170 MHz (**UMTS**)



"Antenna element" = PCB exciter

Particularly in the low band, the "antenna element" mainly serves to excite radiating currents on the device chassis

Vainikainen, et al., IEEE Trans. AP, Oct. 2002



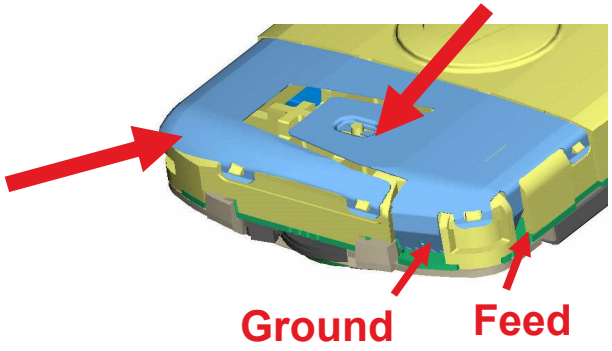
Particularly for internal antennas, bandwidth limitations are due to the narrow bandwidth of the "antenna element", i.e., exciter

Planar Inverted-F Antenna (PIFA) technology

Multi-band PIFAs are by far the most used internal antennas

Straightforward operational principle

Liu, et al., IEEE Trans. AP, Oct 1997



"volume sharing" principle

Longer arm resonates at low band

Shorter arm resonates at high band

Example

Ericsson T68i

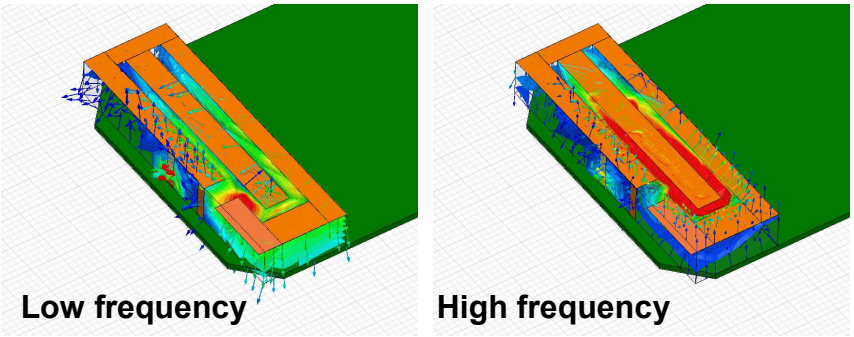
PIFA characteristics and limitations

Advantages:

- proven technology
- available from vendors
- easy to design for dual band

Drawbacks

- difficult to design for tri-band
- different resonances “compete” for space in a given volume
- hard to integrate with other components (speaker, mic,…)



Low frequency

High frequency

Antenna volume allocated selectively to each resonance

- Each resonance uses a different part of the antenna volume
  - ***Reactive energy concentrated mainly around and underneath one PIFA arm at a time***
- Multi-banding implies narrowing each individual band
  - ***Q of each “antenna element” resonance is narrow, thus the Q of the device is narrow***

PIFA should be considered a sub-optimal solution

Motivation, i.e., why still researching?

Particularly for internal antennas, bandwidth limitations of the device are due to the narrow bandwidth of the "antenna element", i.e., the exciter

PIFA is a sub-optimal solution because it implements an operation principle based on "volume sharing"

Need to provide tri-, quad-, penta-band solutions

Folded Inverted Conformal Antenna (FICA)

FICA implements a “volume reuse” principle

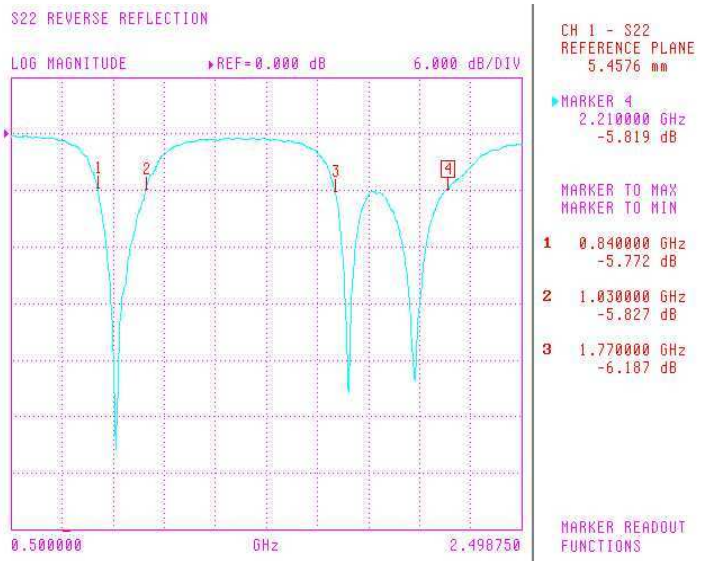
Each resonant mode uses the whole antenna volume

Structure

- **Elongated conductor mostly symmetrical with respect to PCB center line**
  - U shape mostly used
- **Slot conforming to elongated conductor**
  - Folding the slot provides extra length to enable proper tuning
- **Unbalanced feeding structure (feed,short) in mostly symmetrical location**

Three resonant modes are synthesized

- **One resonance in the low band**
  - *common mode*
- **Two resonances in the high band**
  - *differential and slot modes*

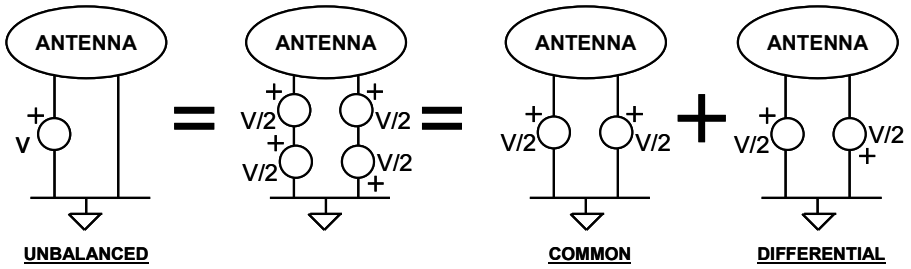


FICA excitation mechanism and resonant modes

Unbalanced feeding structure capable of exciting even and odd current configurations

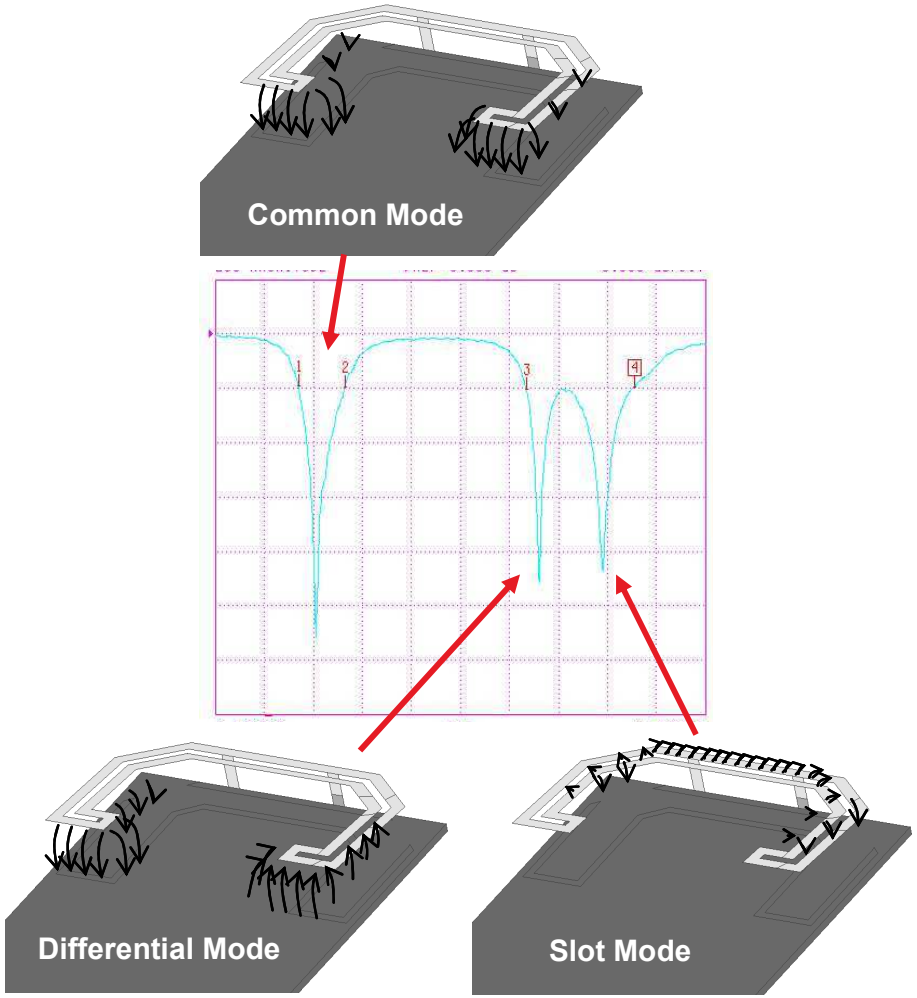
Multi-mode excitation explained by superposition principle

Even and odd current modes maximally excited at their respective resonance frequencies



Feed and short placed on the same side, roughly symmetrical

Mode nomenclature



Benchmark FICA vs. PIFA

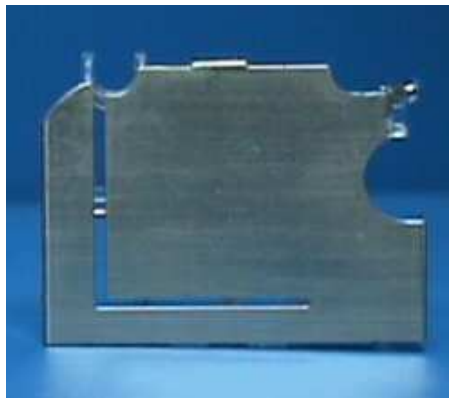
Motorola T192

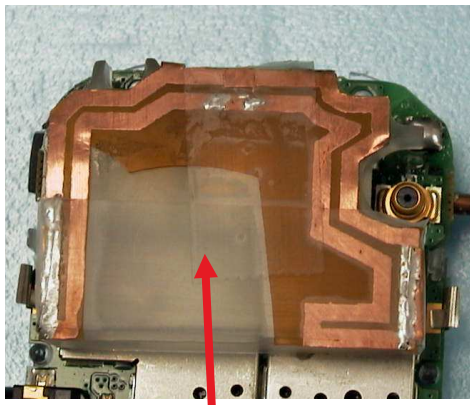
Dual band GSM

PIFA footprint:
38 X 24 mm^2

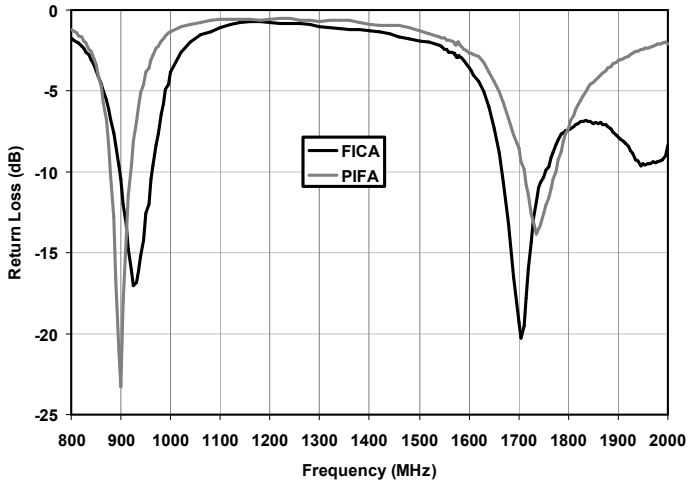
Height: 6.5 mm avg

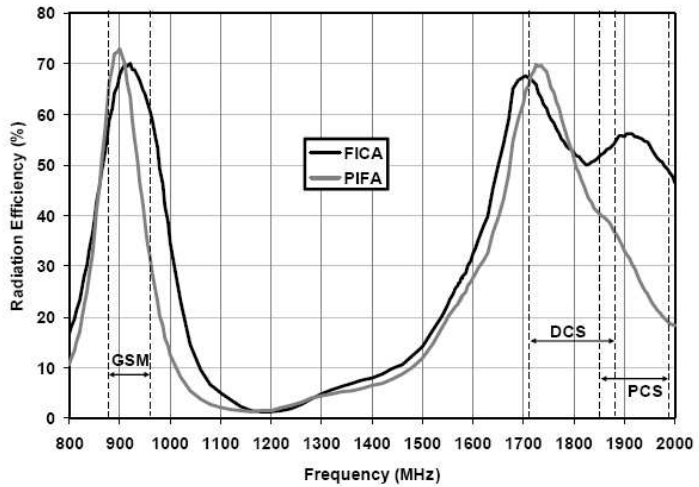
FICA etched on Kapton





Space available for component placement



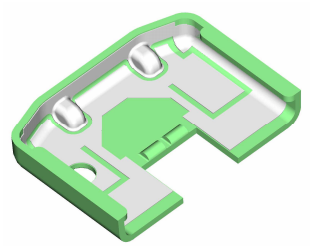


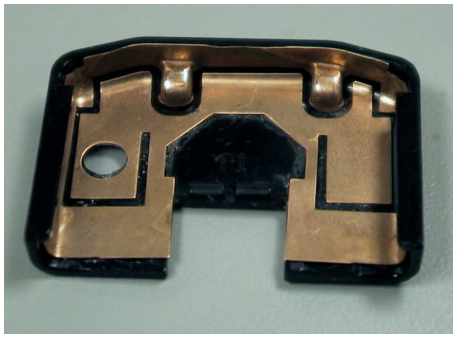
FICA yields tri-band coverage in less than half dual-band PIFA volume !

Examples of FICA Applications

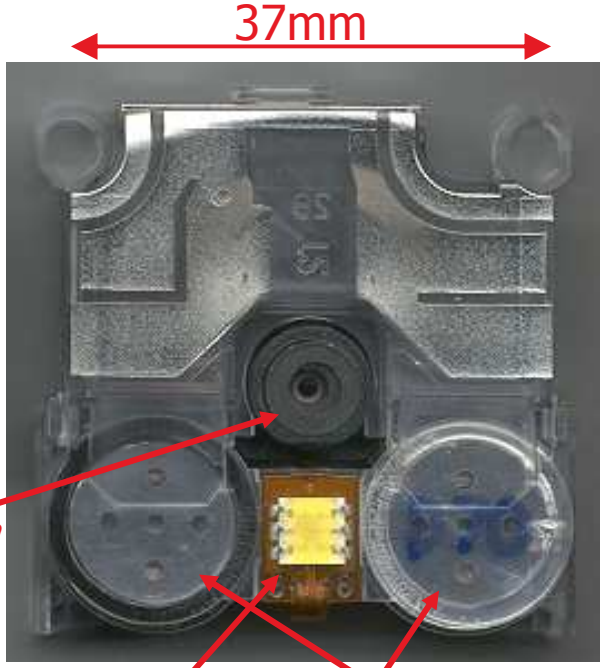
E398/E399 tri-band GSM phone (ROKR)

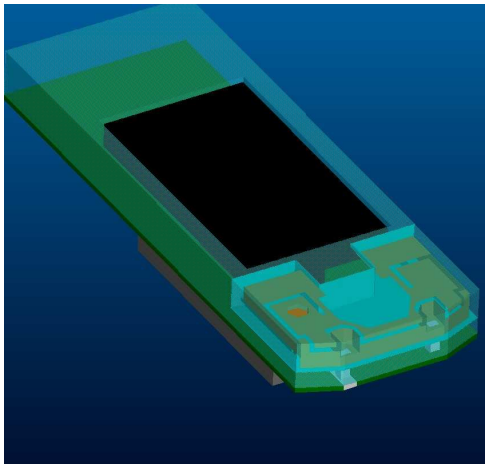
INITIAL CONCEPT





FINAL DESIGN

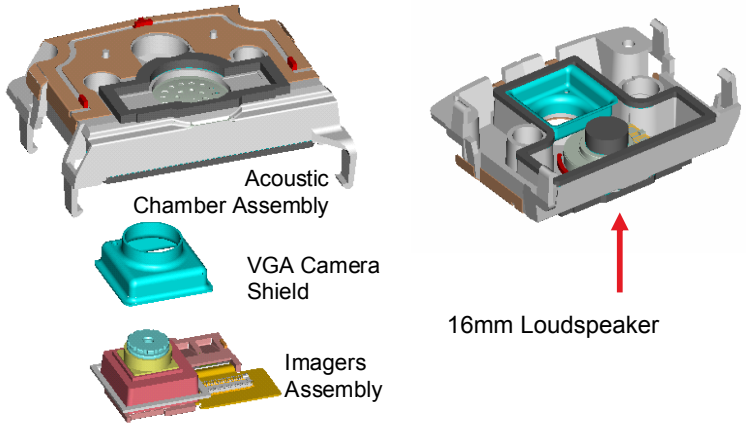




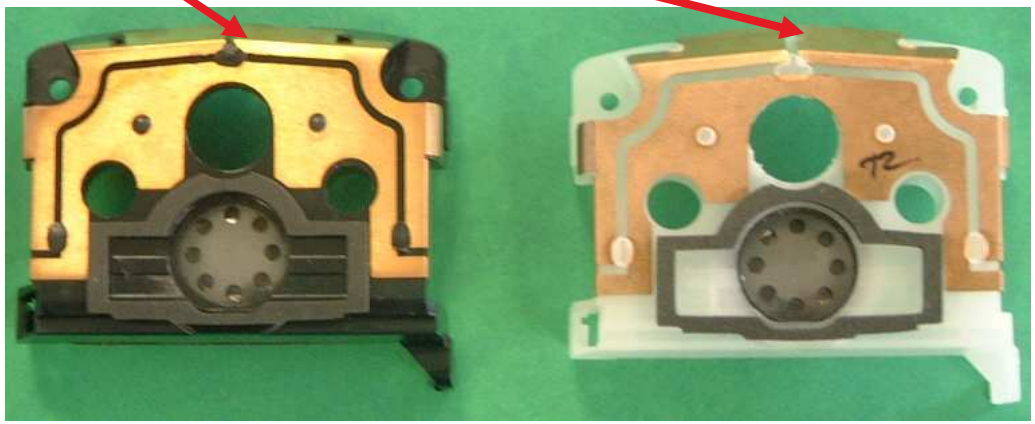
SIMULATION MODEL

Examples of FICA Applications

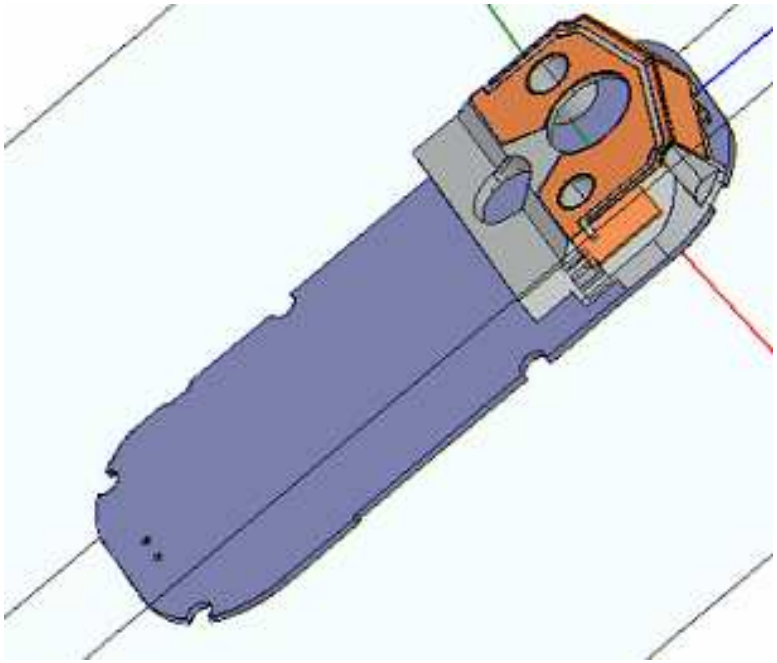
C975/C980 quad-band (GSM/UMTS)

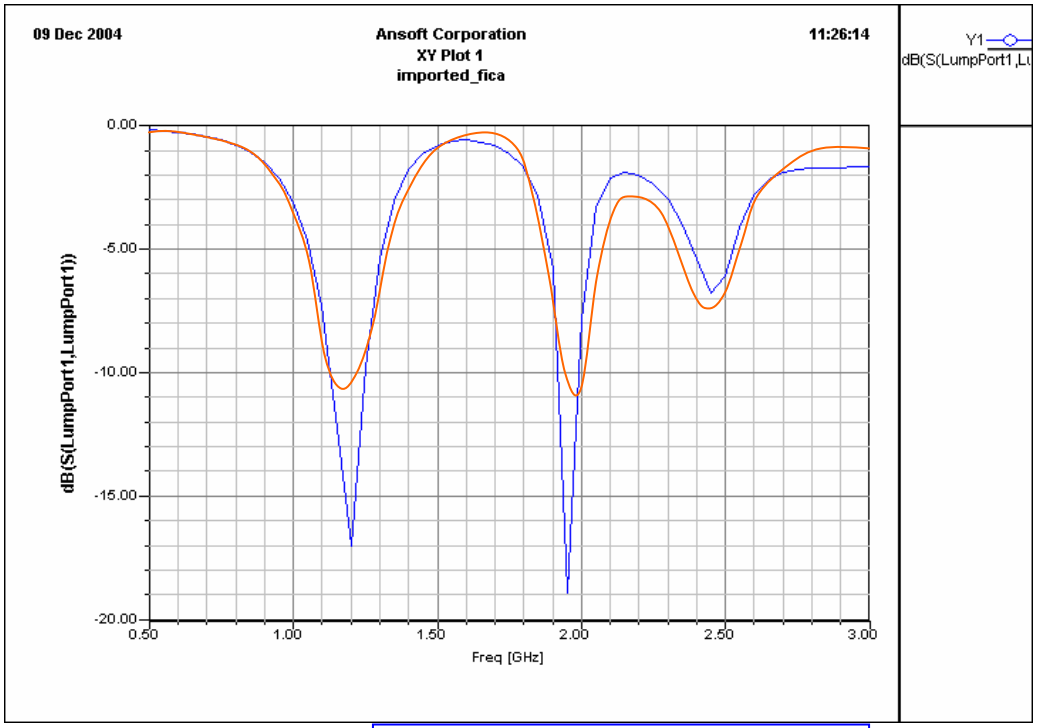


From CAD model to Prototyping



HFSS EM simulation from CAD model





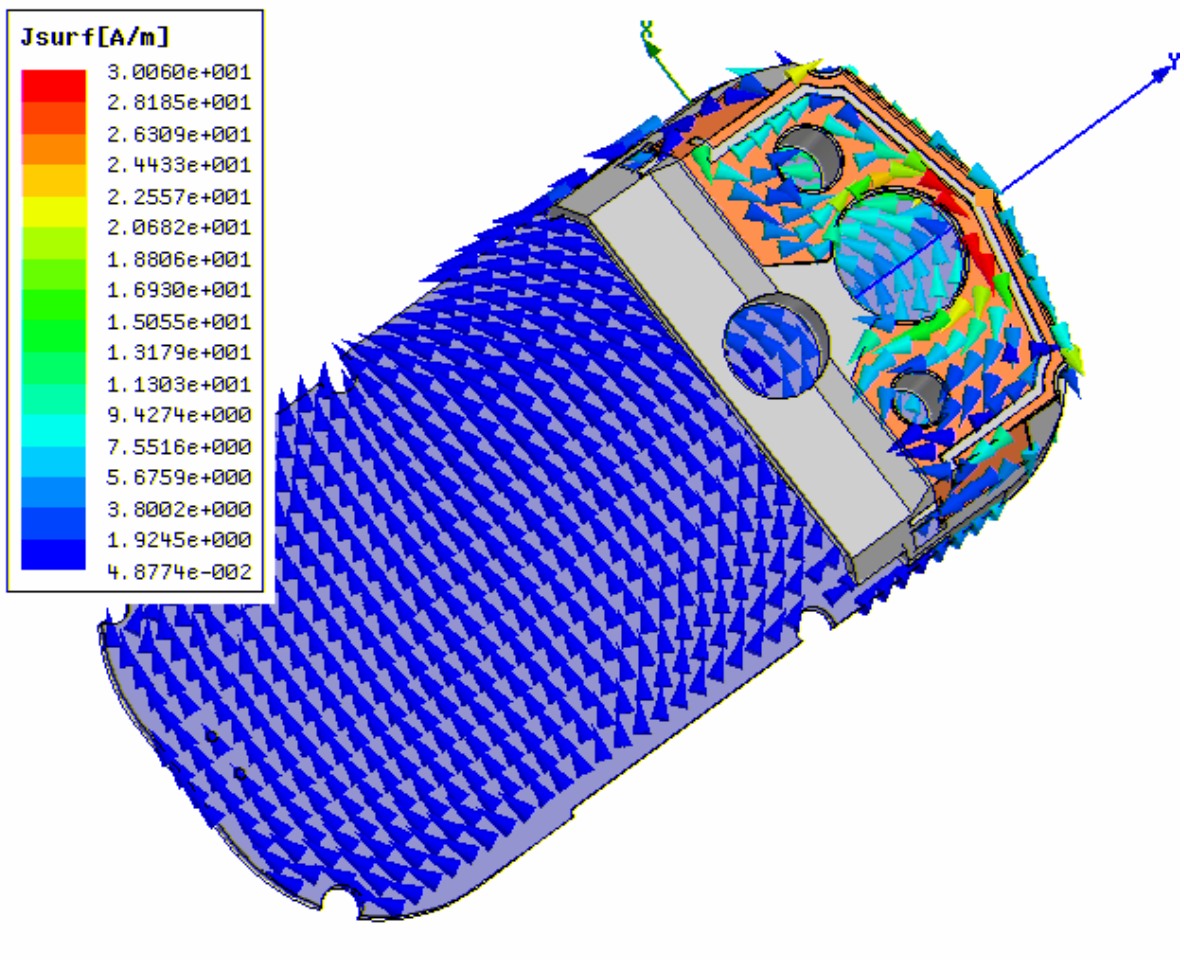
Simulation

Measurement

HFSS in the design process

- Design concept
- EM model - simulation– optimization (Optimetrics)
- CAD model – details – simulation - verification
- Prototyping - measurements

HFSS post processing to help RF insight



Conclusions and future directions

FICA technology provides a significant improvement in the state-of-the-art for multi-band integrated antennas

FICA outperforms PIFA in:

- **multi-banding**
- **volume vs bandwidth**
- **conformability and integration**

FICA design is more challenging and takes advantages from EM simulation/ optimization

FICA technology has been successfully implemented on several Motorola handsets

Future work

Extend bands beyond cellular

Reduce thickness

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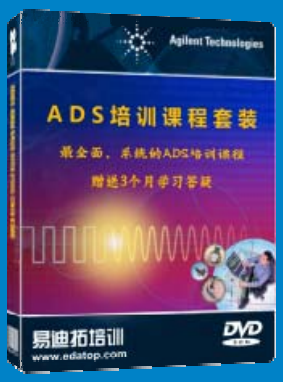

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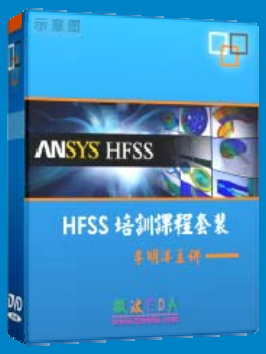

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