MONARCH Antenna, Inc.

Reshaping Wireless

Frequency Tunable Antenna for LTE (4G) Handsets Operating in the 2.3-2.7GHz Global Roaming Band

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Antenna Systems 2015
Las Vegas, NV

Long Term Evolution (LTE), a.k.a. 4G

- Better spectrum efficiency,
- Higher data rates,
- Lower latencies, and
- Flatter IP core network architecture

- CHALLENGE:
  - LTE Spectrum is fragmented
  - Carrier Aggregation

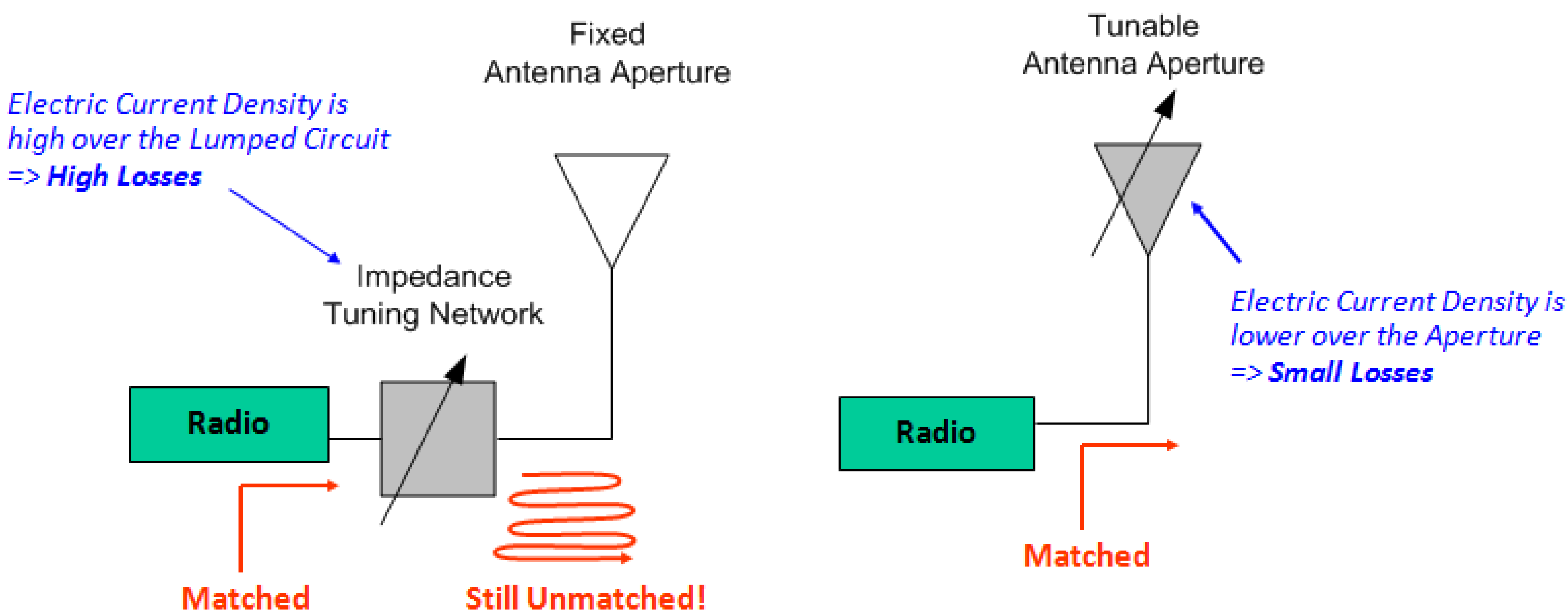
Case for Tunable Antenna

- Searching for a Global Roaming Band
- Not about having one phone to roam globally
- But about having fewer Stock Keeping Units (SKUs)
- The International Wireless Industry Consortium (IWPC) Working Group for tunable RF front-end (RFFE)
  - Architecture for an Integrated RFFE module
  - **2.3-2.7GHz** is suggested as the **global roaming band** with the potential to reach **55% of the world's population.**
  - A **Tunable RFEE** will need a **Tunable Antenna**

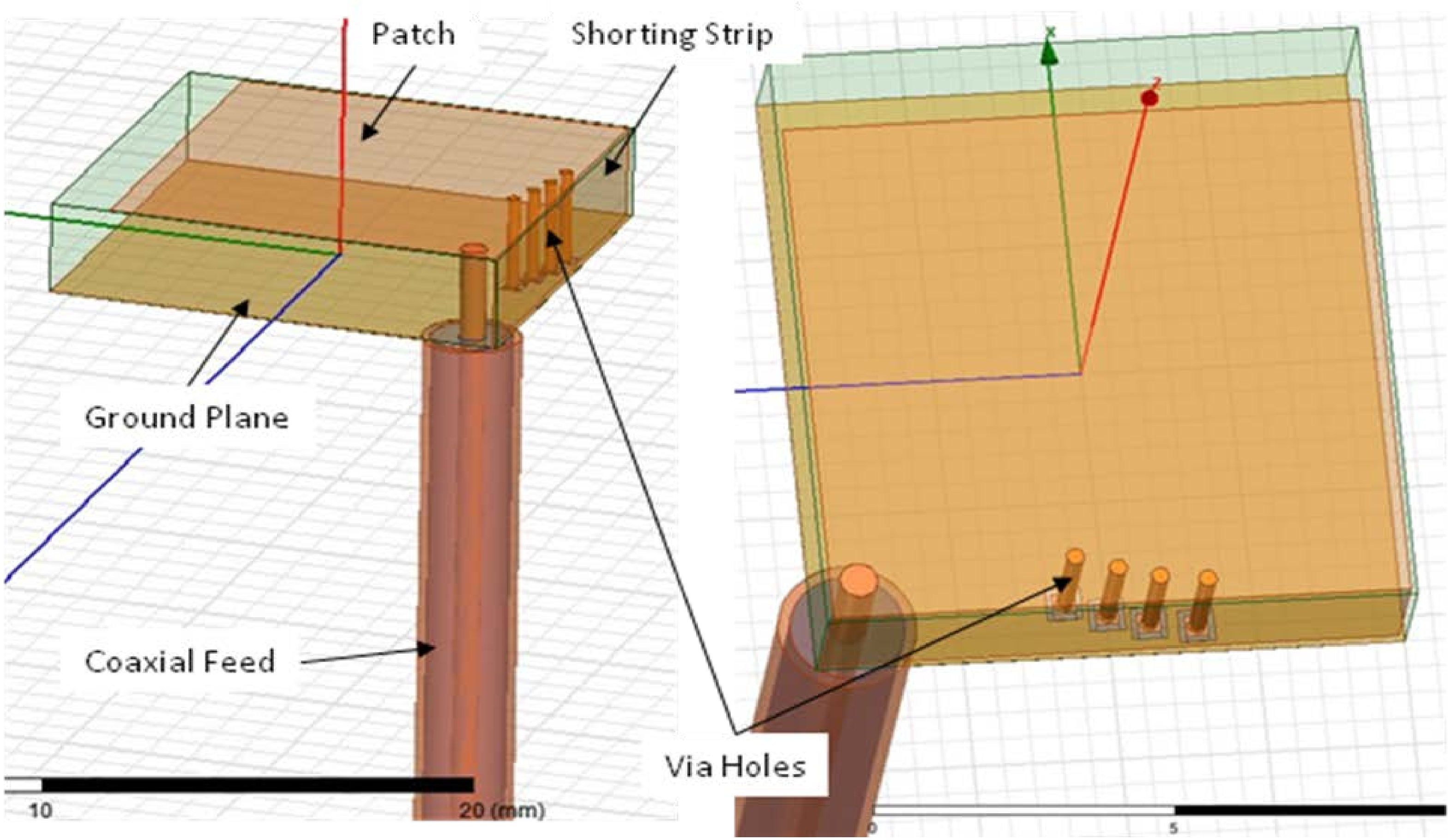
Presentation Flow

- Impedance Tuning vs. Aperture Tuning
- Design
- Manufacturing
- Measured Data

Impedance Tuning vs. Aperture Tuning

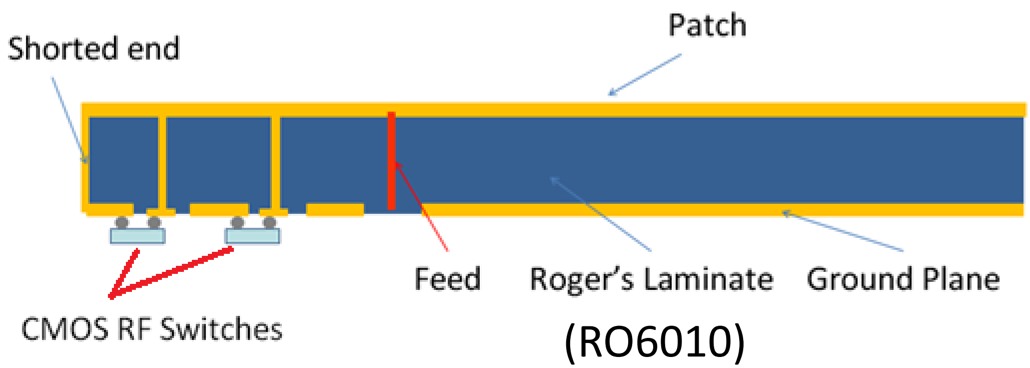


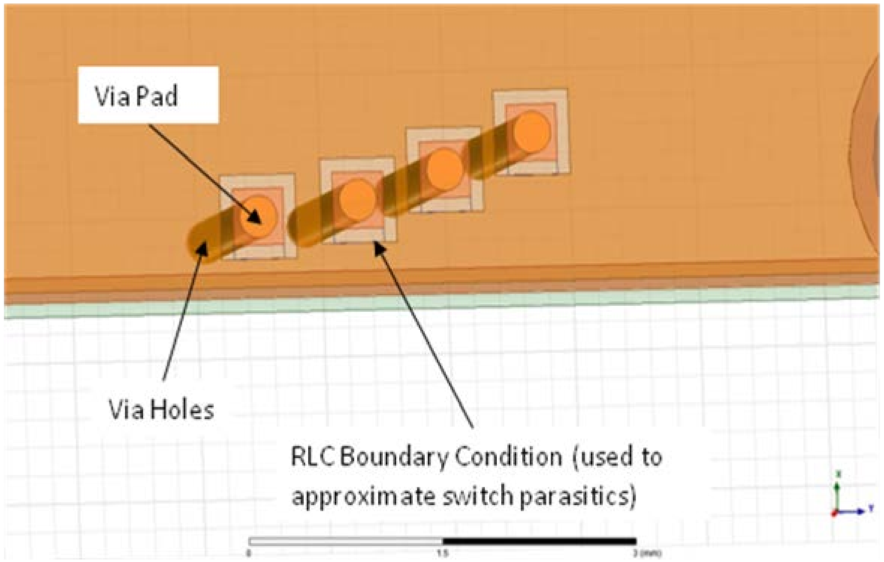
Design



Patch
Shorting Strip
Ground Plane
Coaxial Feed
Via Holes
10
20 (mm)
x
z
0
5

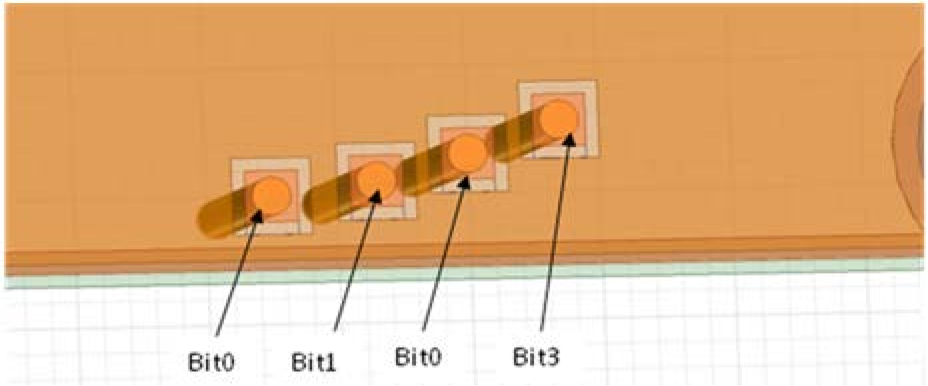
Design



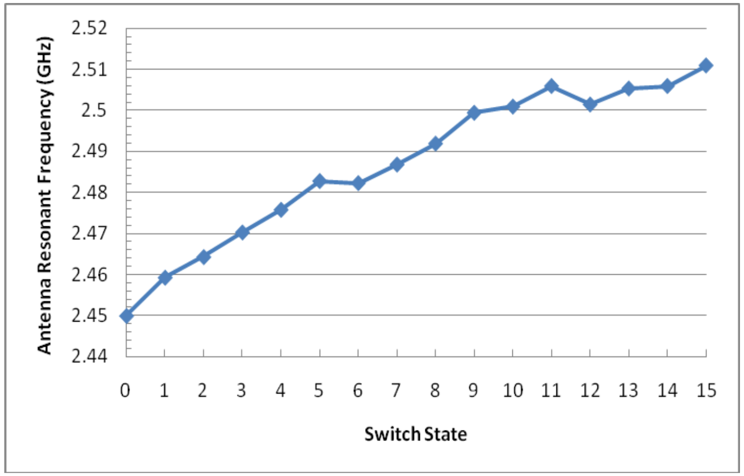


One state: 3 Ω
Off State: 10K Ω

Frequency Tuning



(LSB)



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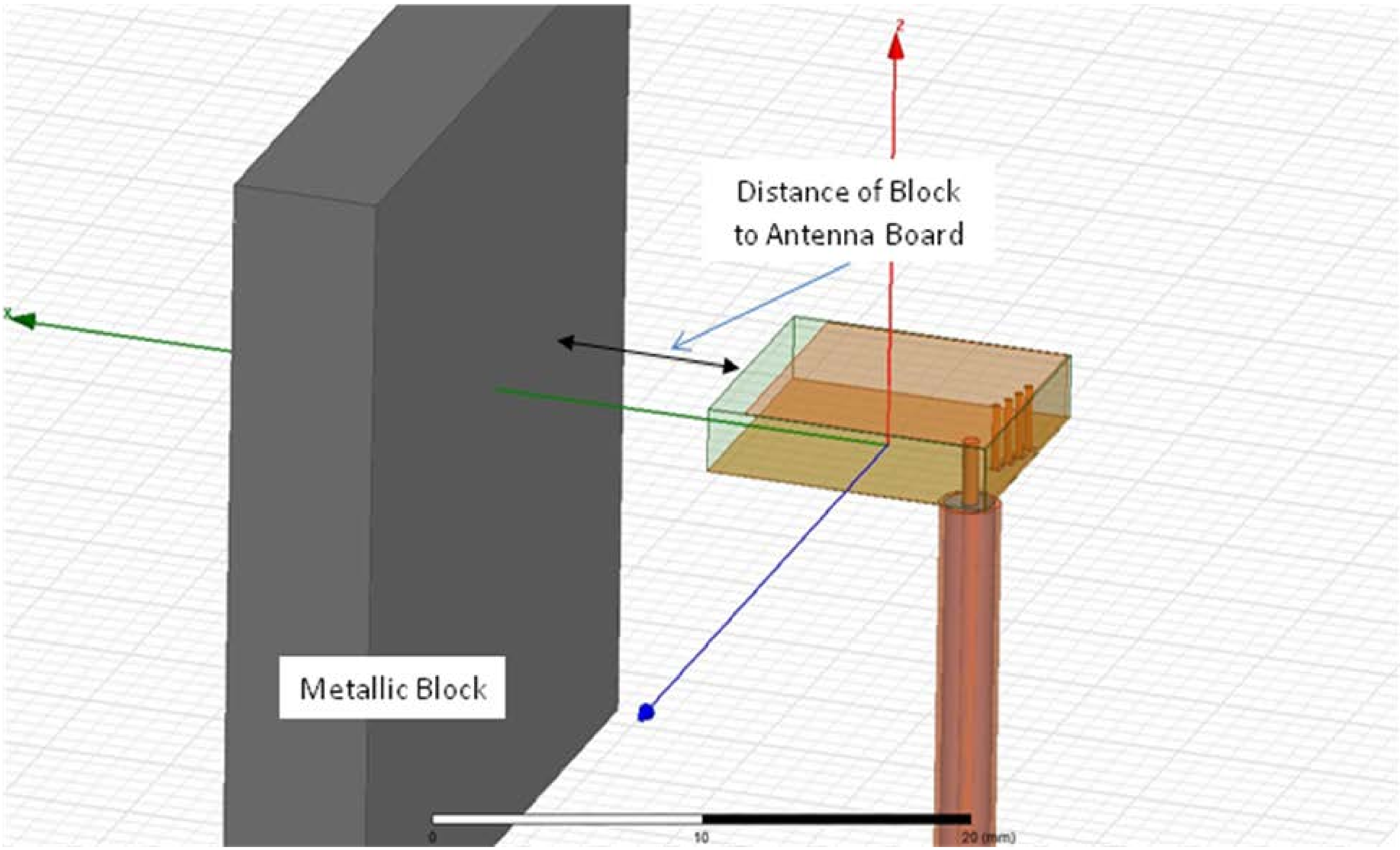
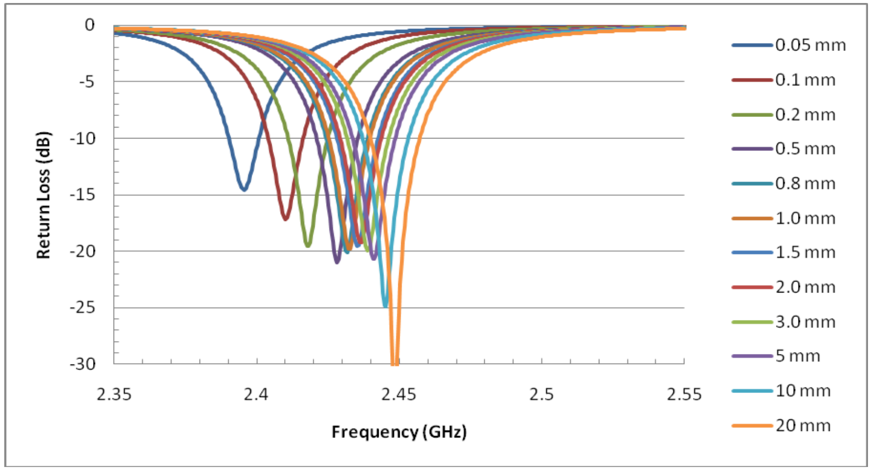
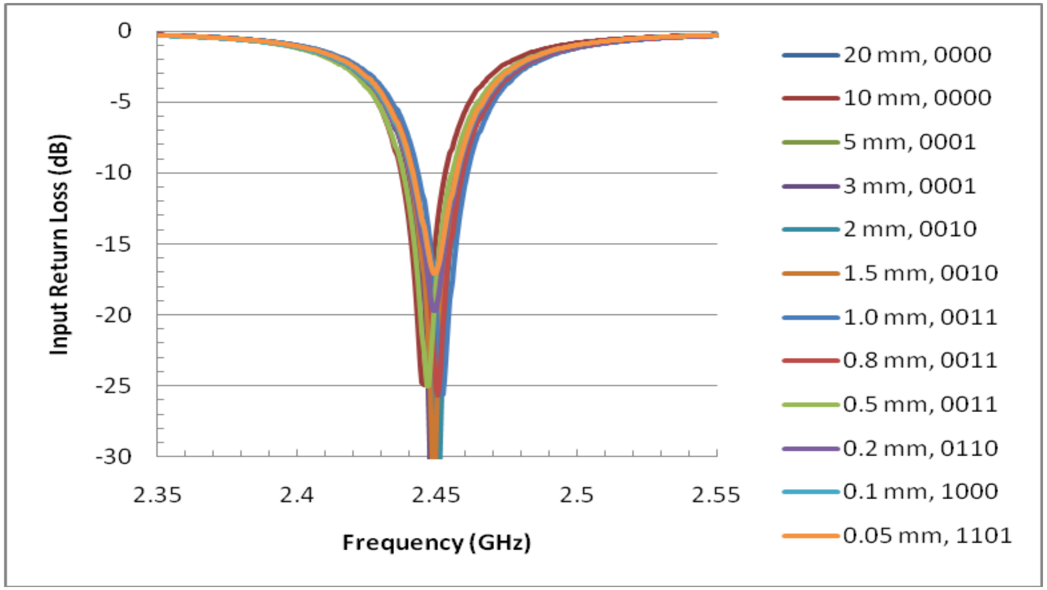
Recovering from Detuning

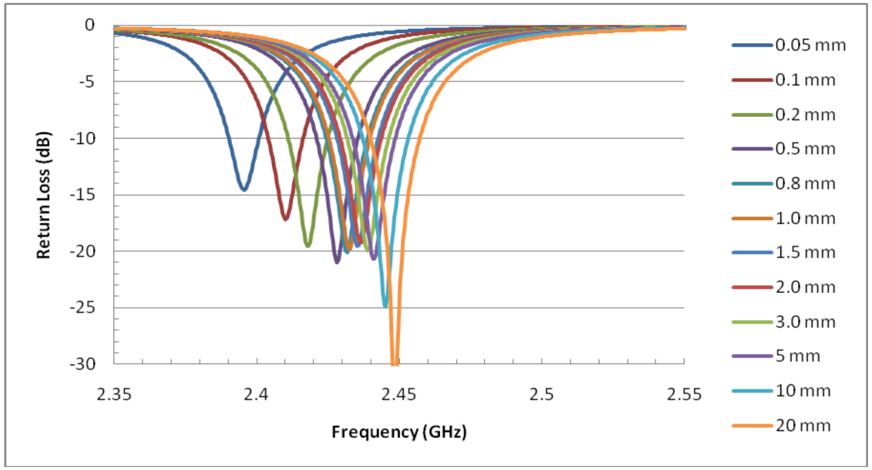


Recovering from Detuning

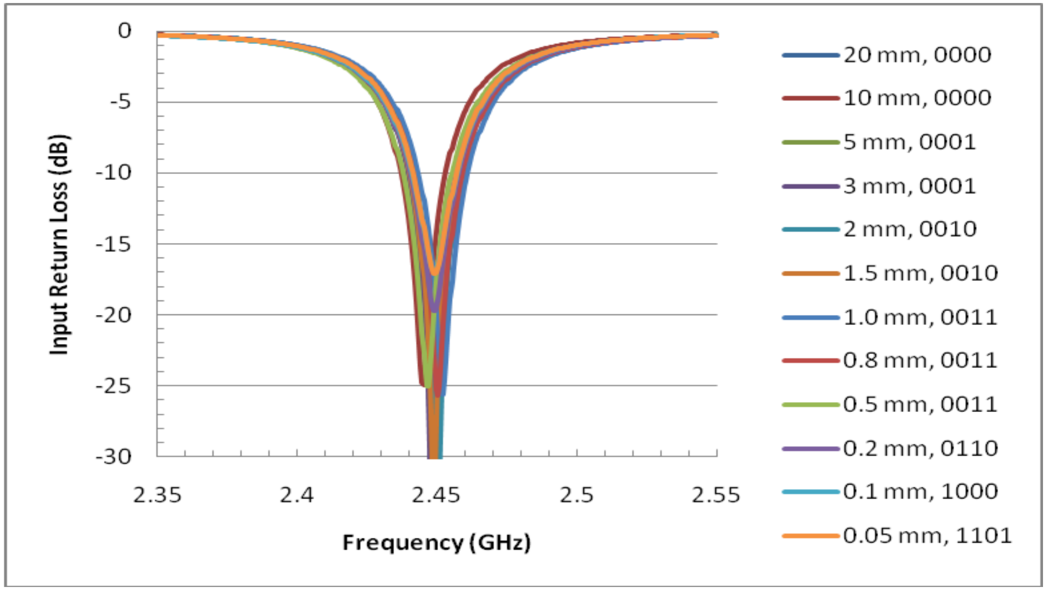




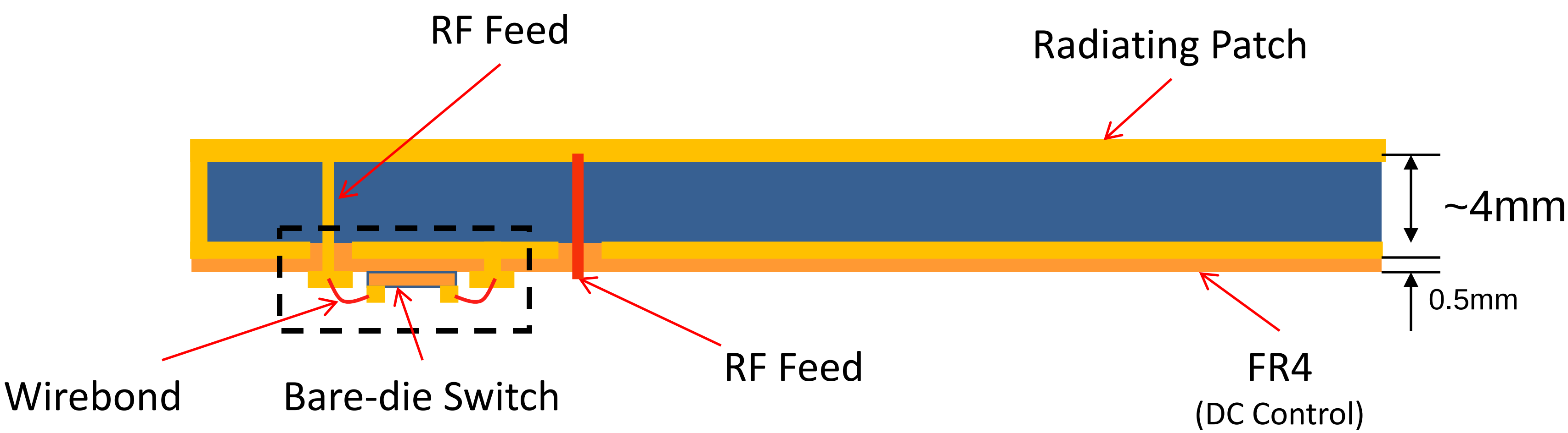
Recovering from Detuning



Block location (mm)	VSWR	Tuning State	VSWR
0.05	30.4	1101	1.3
0.1	17.2	1000	1.3
0.2	10.1	0110	1.2
0.5	5.5	0011	1.3
1.5	3.3	0010	1.1
3	2.5	0001	1.1
10	1.5	0000	1.4
20	1.1	0000	1.1



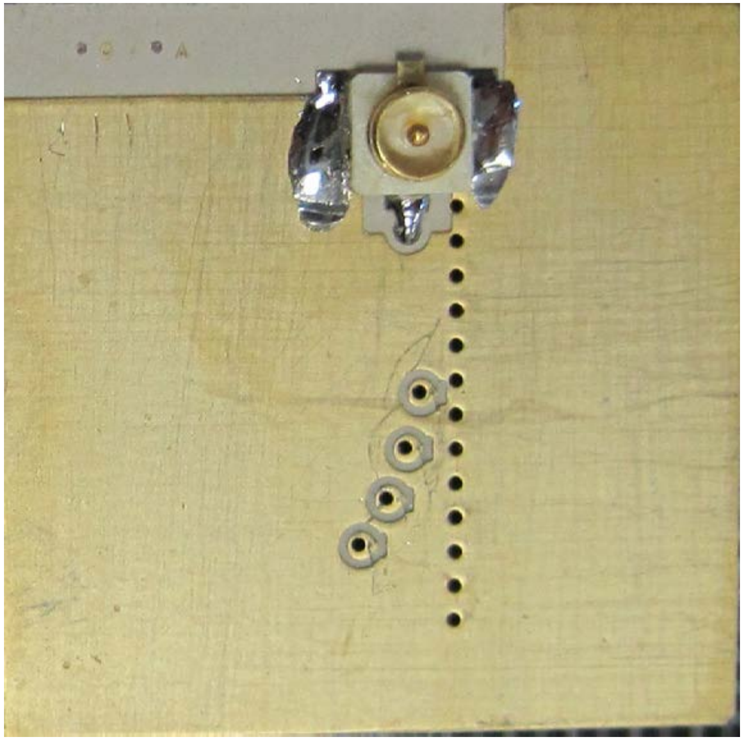
Manufacturing (*)

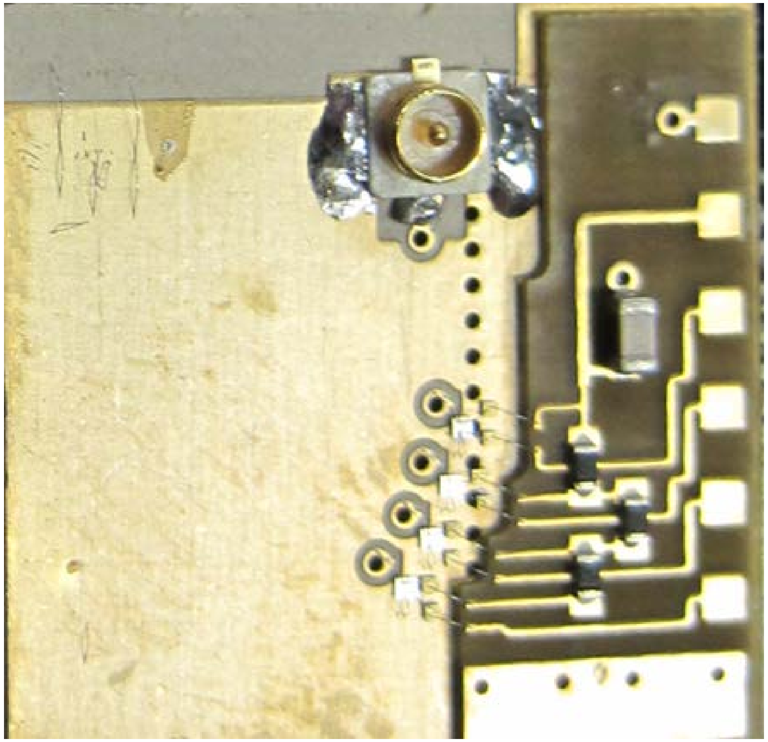


- RO3010 1/1 0.15" (3.81mm) Dk=10.2

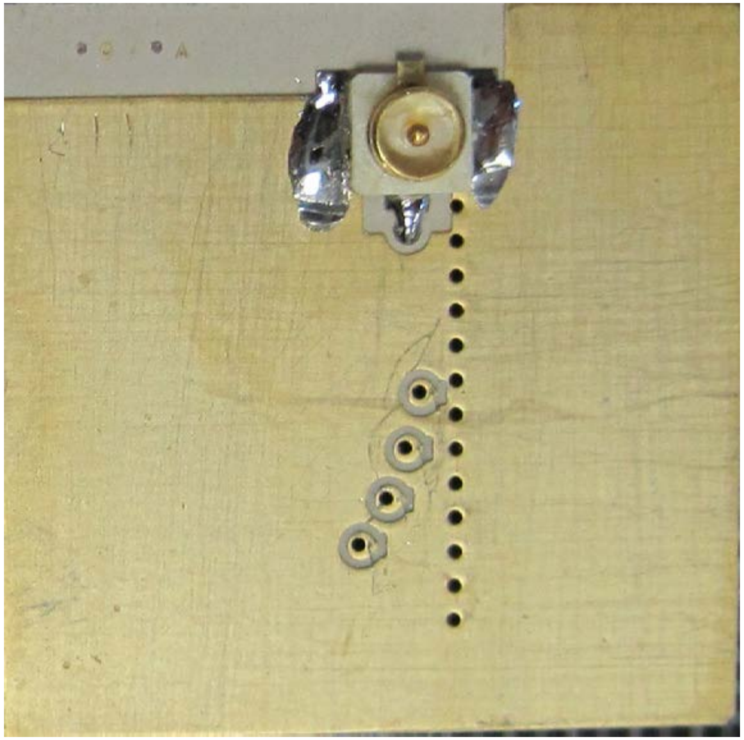
(*) US Patent Application No. 2014/0320376A1, October 30, 2014

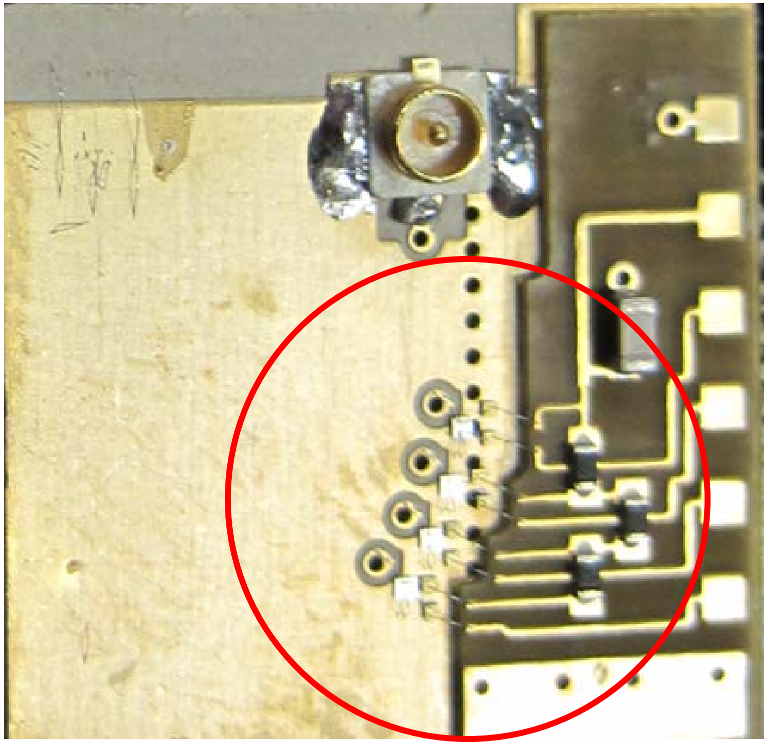
Manufacturing



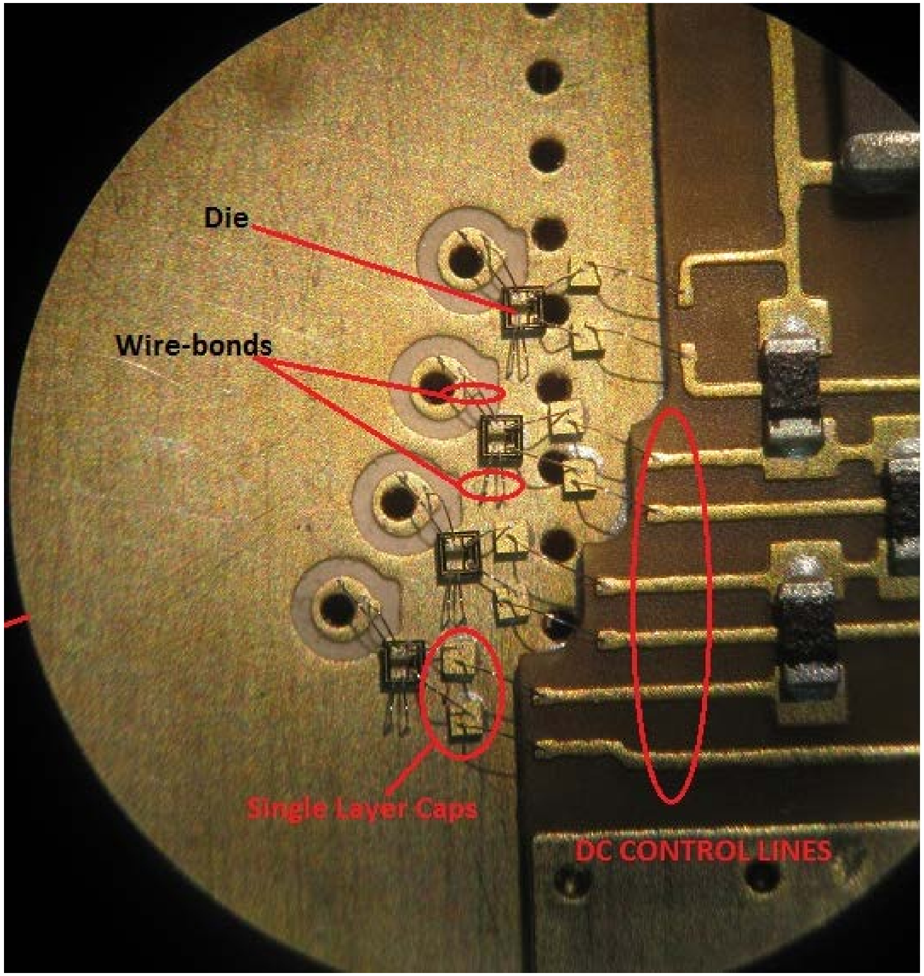


Manufacturing

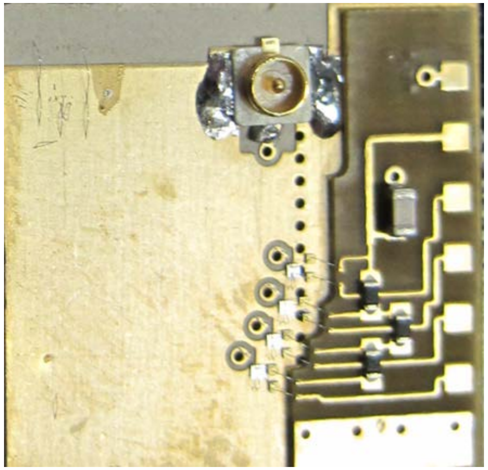




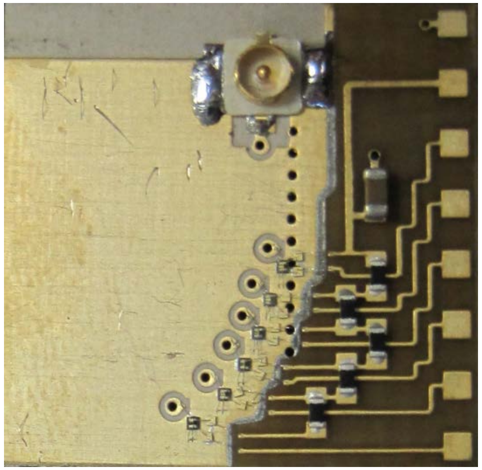
Manufacturing



4-bit and 6-bit versions



2.3 - 2.7 GHz
(16%)



2.2 - 2.9 GHz
(27%)

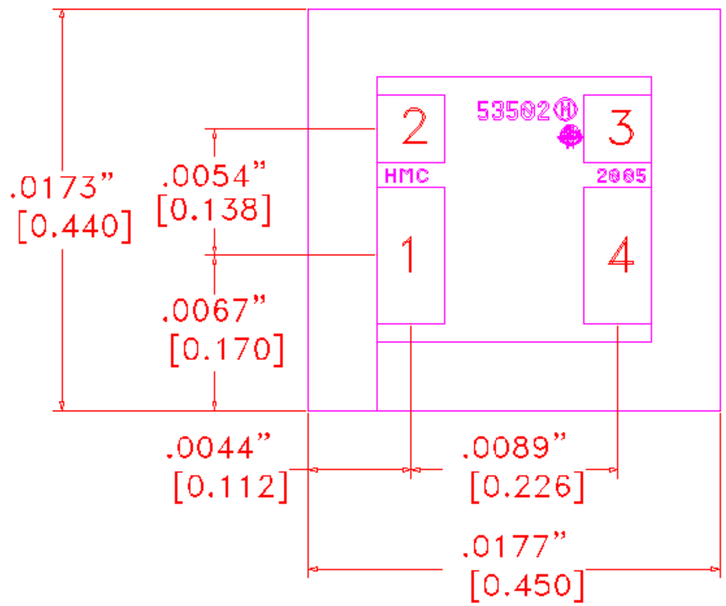
Finished Assembly:
16mm x 16mm x 5mm

Patch Antenna:
10mm x 7mm x 4mm

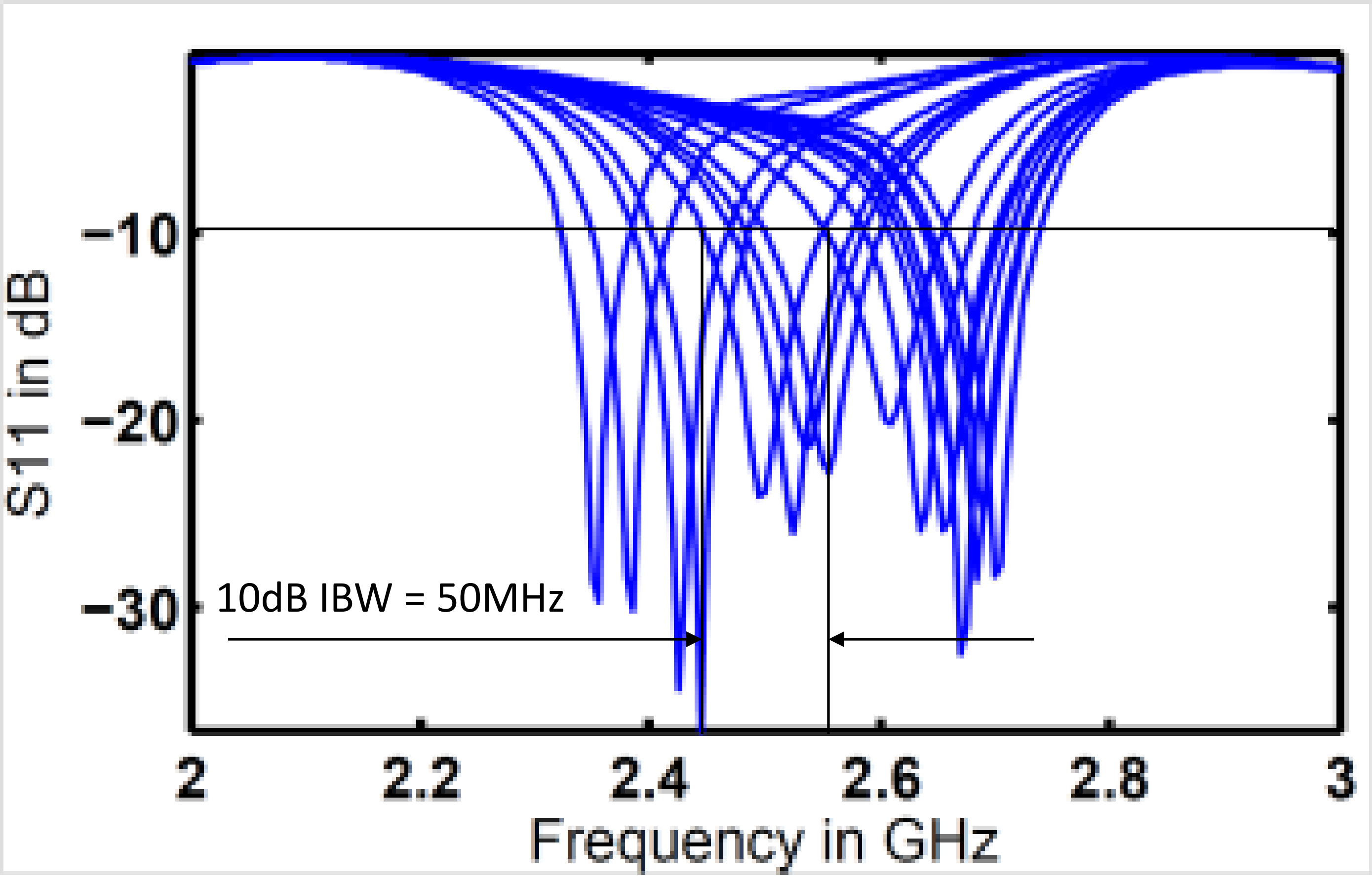
GP:
13mm x 10mm

Manufacturing

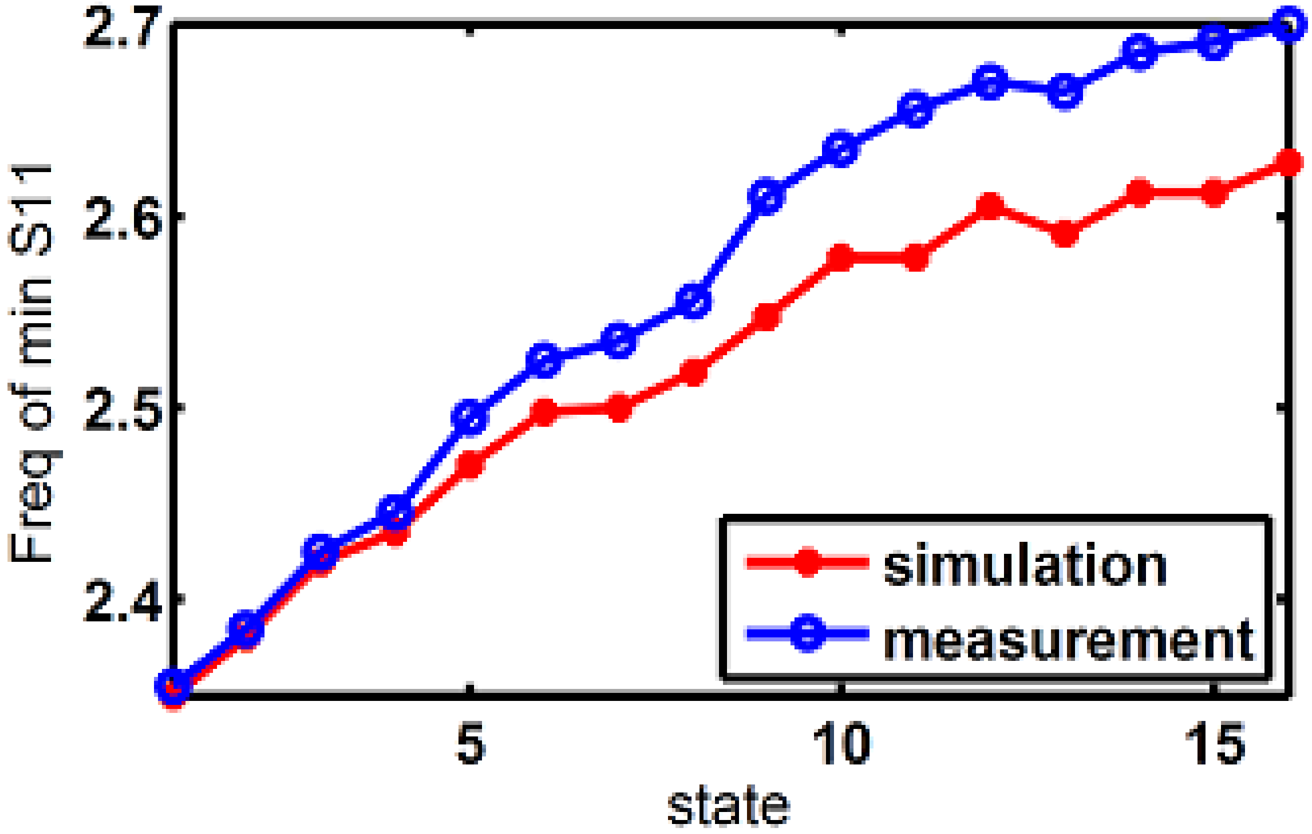
- HMC550, Hittite Microwave
- Bare Die 53502, SPST Reflective, Floating Ground
- Ron=5.9 Ohms, Coff=0.09pF
- 0.44mm x 0.45mm



Measured Data



Measured Data



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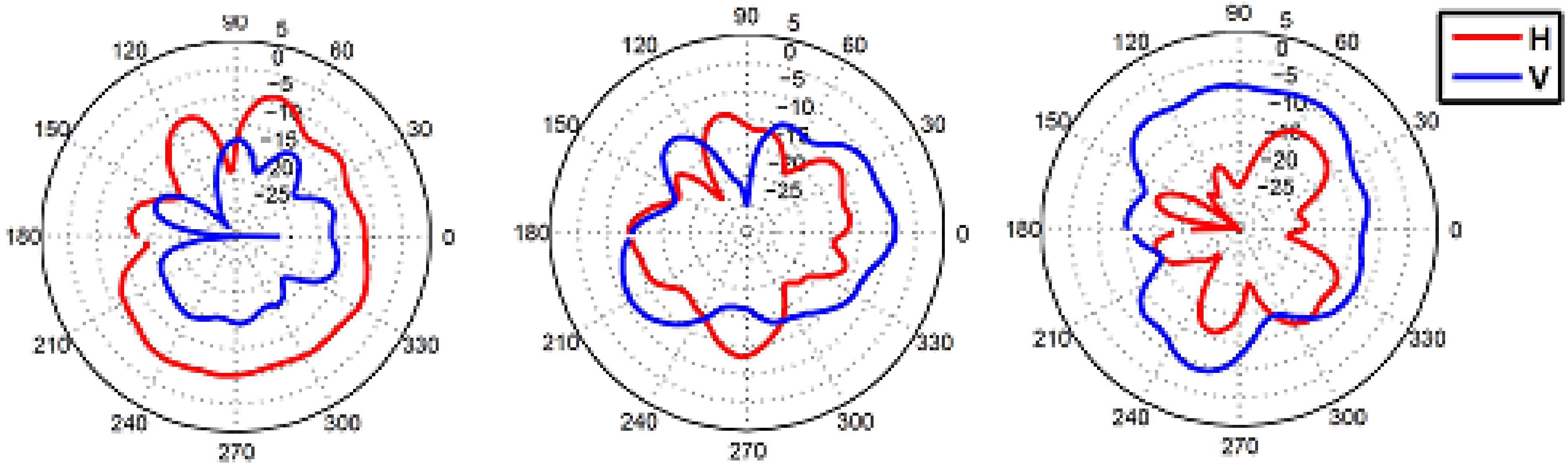
Measured Data

- Average Peak gain = -4.7 dBi
- High R_{on} resistance (5.9 Ω) is to blame.



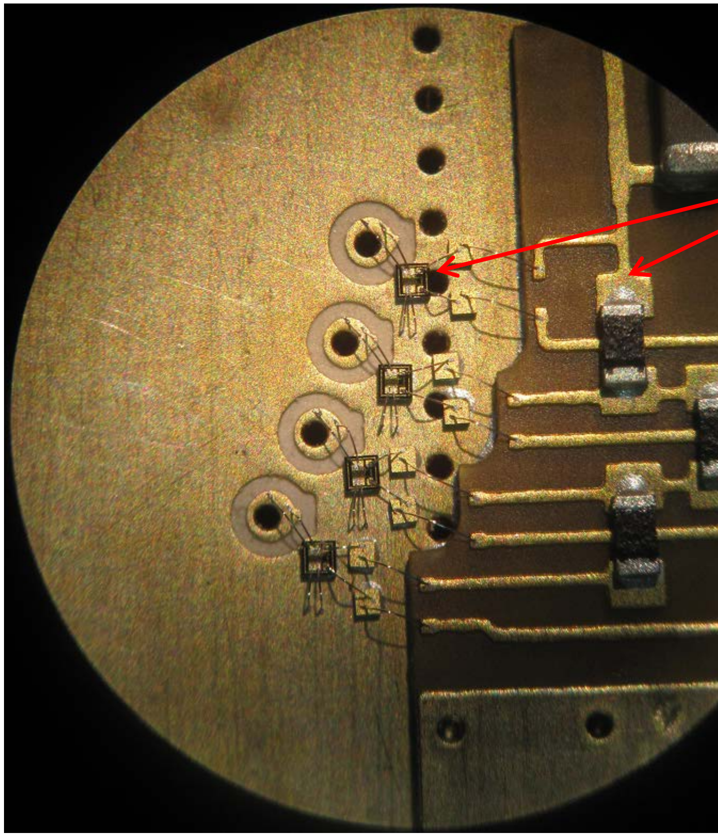
Enabling Technology: SPST Switches

- Solid State (GaAs or others)
  - HMC550: R_{on} x C_{off} = 531 fSec
  - Current State of Art: 240 fSec
  - 60fSec – Desired (4x Improvement)
  - Non-linearity
- MEMS
  - Yield
  - Cost
  - Speed (µs)
  - Hot-switching

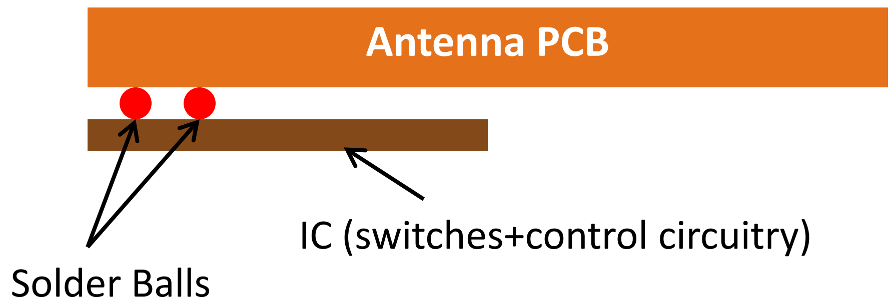
DESIRED SPECS

Switch Type	Bare Die, SPST, Reflective, Floating Ground
Size (mm)	0.4 x 0.4
Pad Configuration	2 DC bottom/RF opposite side (preferred)
Frequency (GHz)	0.6 – 3.0
Ron ()	2.0
Coff (Pf)	.03
RF Power (watts)	1.0
Non-Linearity (IP3)	50 dBm

Manufacturing Option: Integrated CMOS IC



Switches and the control circuitry are integrated into a thin IC



- More expensive parts but
- Less parasitics and
- Cheaper manufacturing