Reconfigurable Components In SDR RF Front-end With Emphasis On

Reconfigurable Antennas
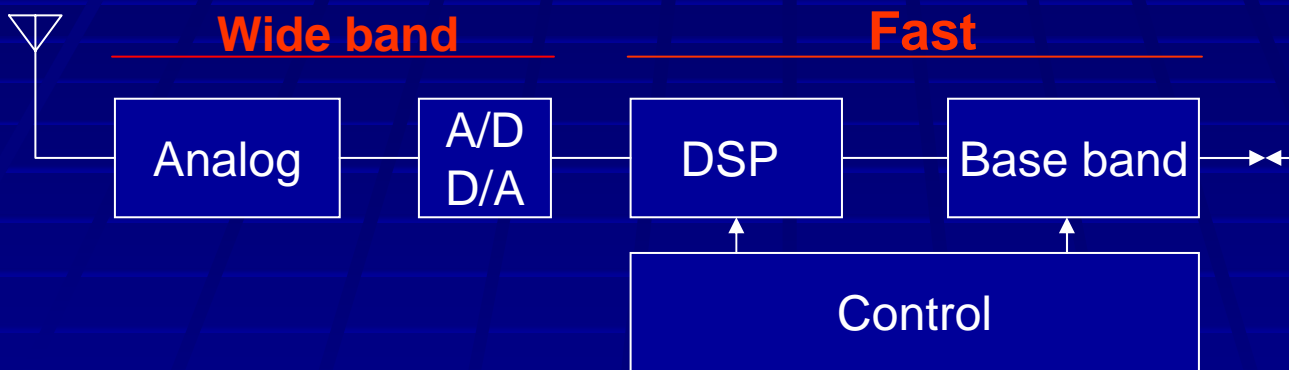
A course project for Software Defined Radio Course
Spring 2008
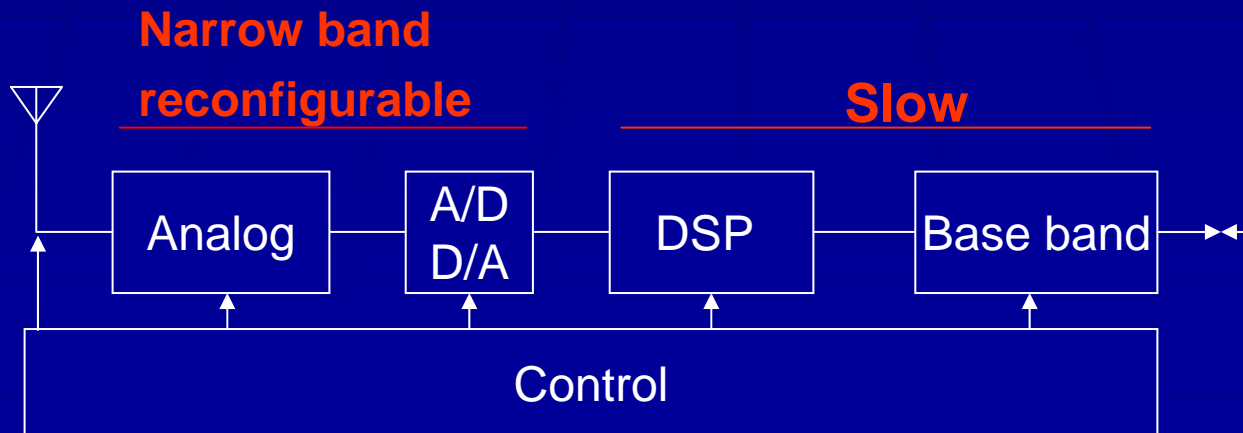
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RF front-end in SDR

❑Classical approach

Wide band   **Fast**

| Analog | A/D D/A | DSP | Base band |

Control

❑Refined approach

Narrow band reconfigurable   **Slow**

| Analog | A/D D/A | DSP | Base band |

Control

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Outline

- Reconfigurable component solutions
  - Switched elements
    - Switch Technologies
  - Electronically tunable elements
- Frequency reconfigurable antennas
  - Planar Inverted Folded Antennas (PIFA)
    - Practical examples of reconfigurable PIFA
- Conclusion

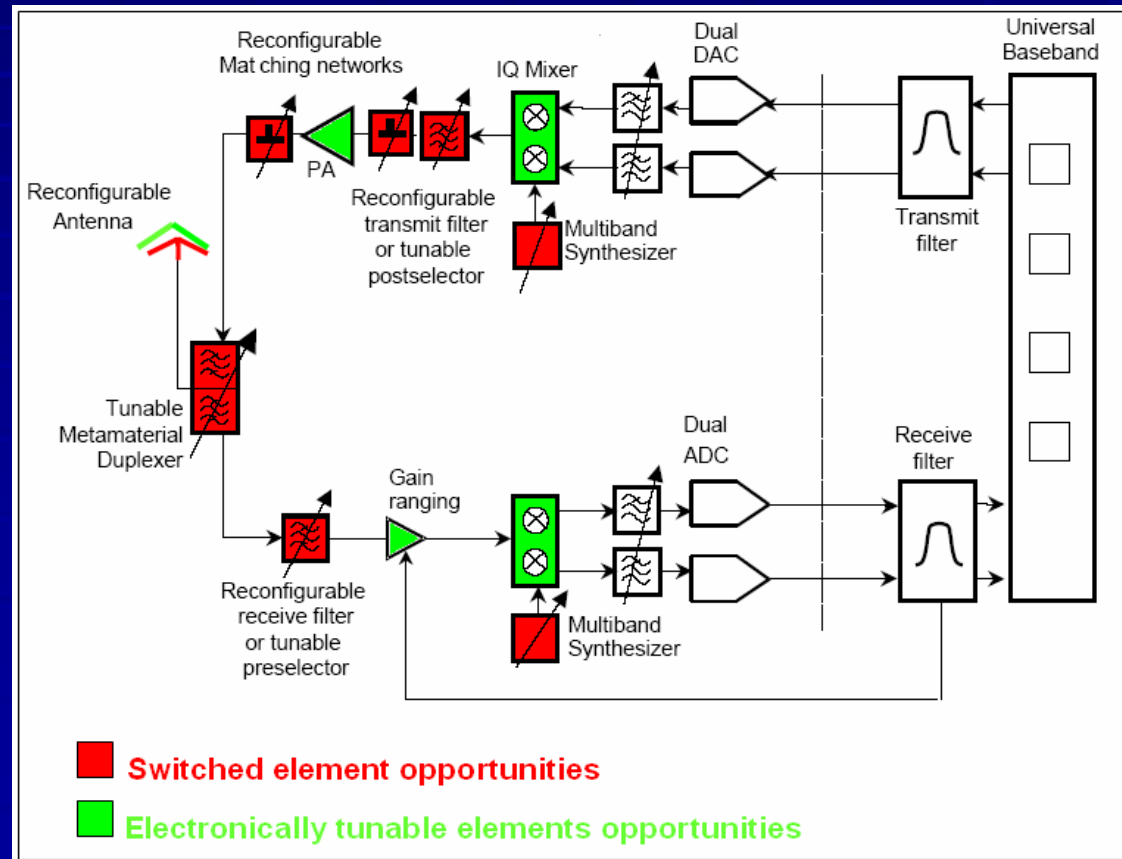# Reconfigurable component solutions

❑ Electronically tunable elements

❑ Switched elements

❑ Switches

❑ below 1 GHz
  ❑ PIN diode

❑ 1GHz to 12 GHz
  ❑ FET/HBT

❑ DC-40GHz
 ❑ MEMS

Antenna solution for SDR

- ❑ Wide band antenna
  - ❑ High cost, Trade off between size & efficiency, Weak noise and interferer blocking
- ❑ Multi-narrow band antenna
  - ❑ Difficult design, Weak noise and interferer blocking, One design per application
- ❑ Reconfigurable antenna
  - ❑ High noise and interferer blocking, There is some straightforward designs, Redesign is simple

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Reconfigurable antenna

❑Frequency and bandwidth reconfigurable antenna
  ❑Most enabling component in SDR
  ❑PIFA antenna suits for small terminal
    ❑High efficiency (Power limitation)
    ❑Compactness
    ❑Reconfigurable
❑Other reconfigurable antenna
  ❑Pattern or polarization reconfigurable
    ❑Can be used for improving performance
      ❑removing interferer, diversity, beam forming and etc

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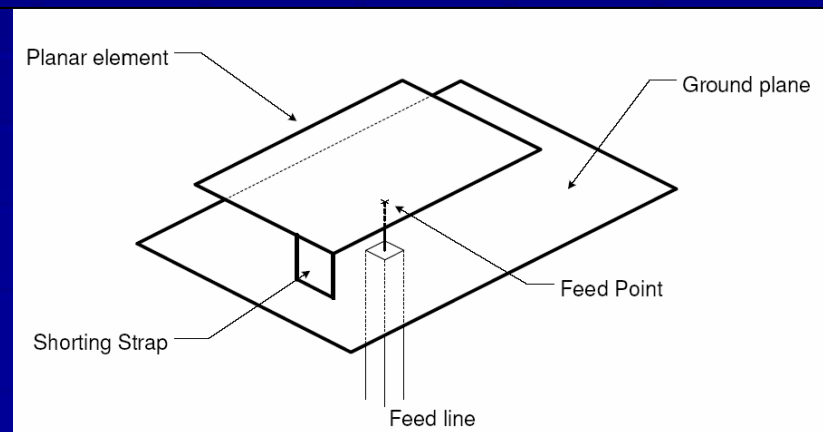# Planar Inverted-F Antennas (PIFA)

❑ The planar version of the inverted-F antenna (IFA)

  ❑ Compact height 1/20 wavelength

  ❑ Typical bandwidth of 10%

  ❑ Good relative radiation efficiency (max 40%)
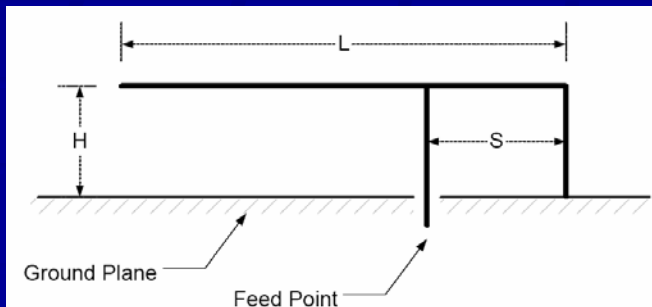
IFA
Inverted F Antenna (IFA)

PIFA
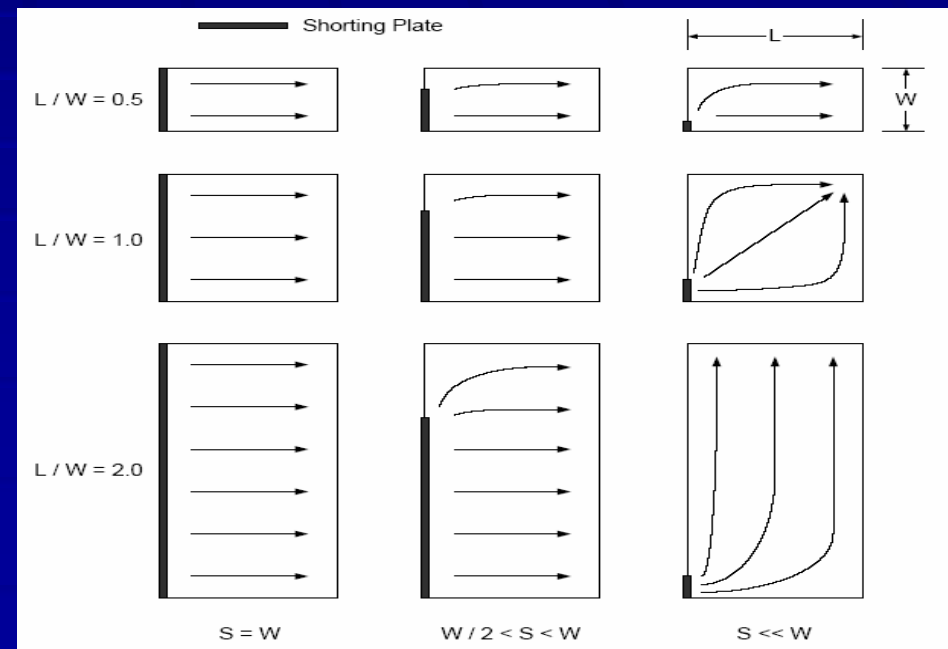Planar Inverted F Antenna (PIFA)

PIFA Resonant Frequency

❑Resonant Frequency affects by

  ❑ current distribution on top plate (below Fig)

    ❑Top plate aspect ratio W/L

    ❑Shorting strap s

    ❑Height of top plate

❑S<<W

$$f_{res} = c/4(W+L+H)$$

❑w/2<S<W
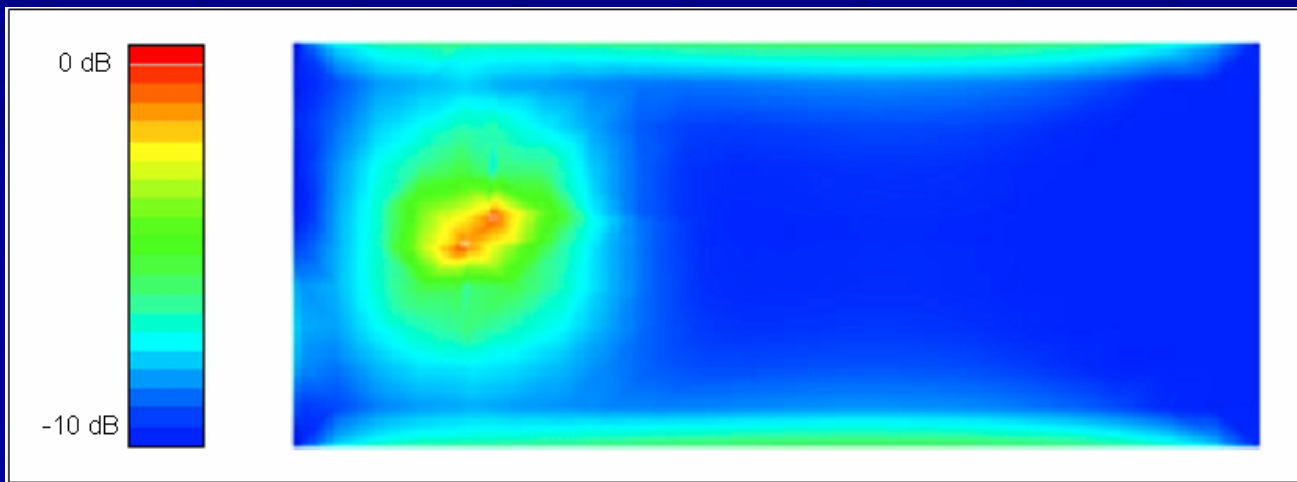
$$f_{res} = c/4(W+L)$$

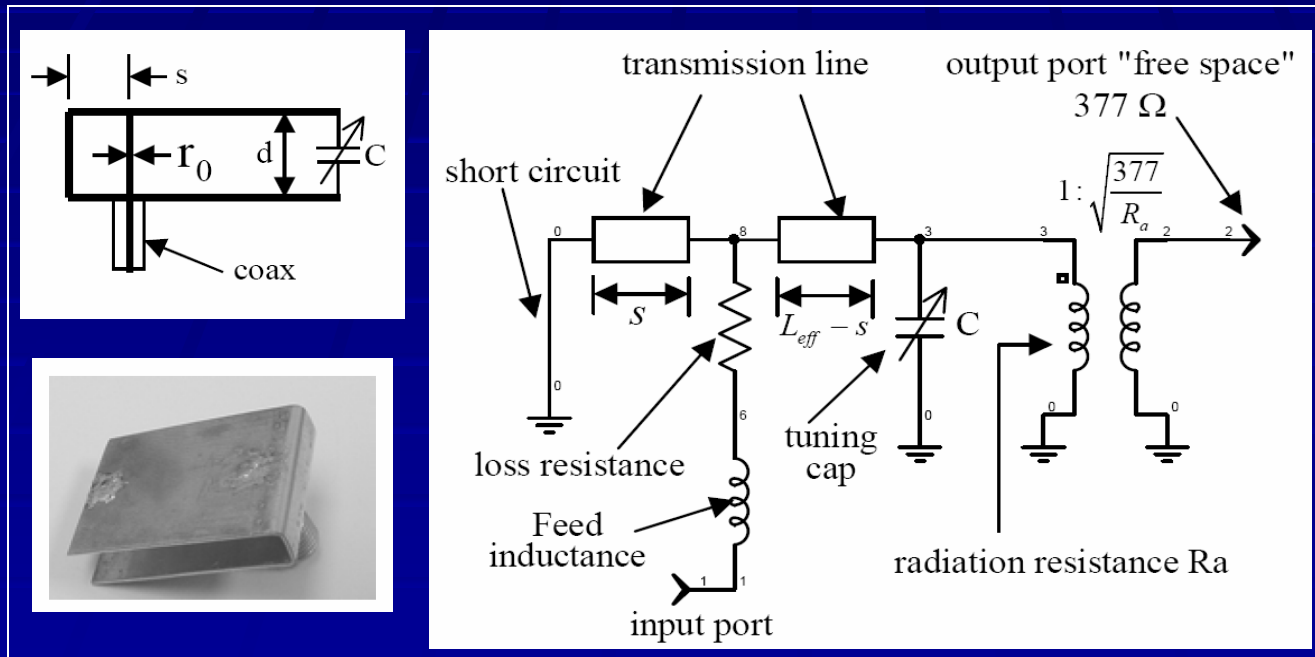# PIFA Bandwidth

❑ **Bandwidth affects by**

    ❑ Current distribution on ground plane (below Fig)

        ❑ Length of ground plane

    ❑ The bandwidth increases from **4%** for a ground plane length of 0.2λ to **10%** for a ground plane length of 1.0λ longer plane does not affect too much

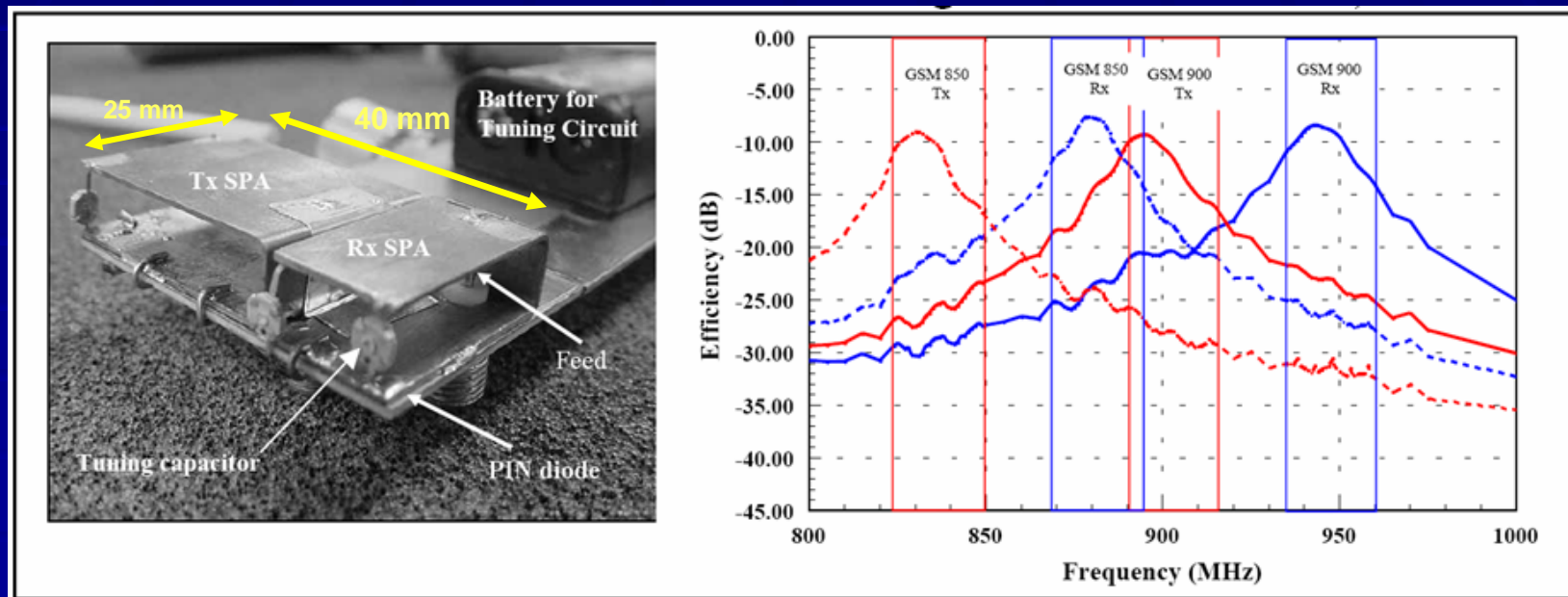# Practical examples of reconfigurable PIFA (1)

❑SPA (shorted patch antenna)

❑ In the case that operating frequency should be sweep on a narrow range and on discrete values. SPA is a good choice
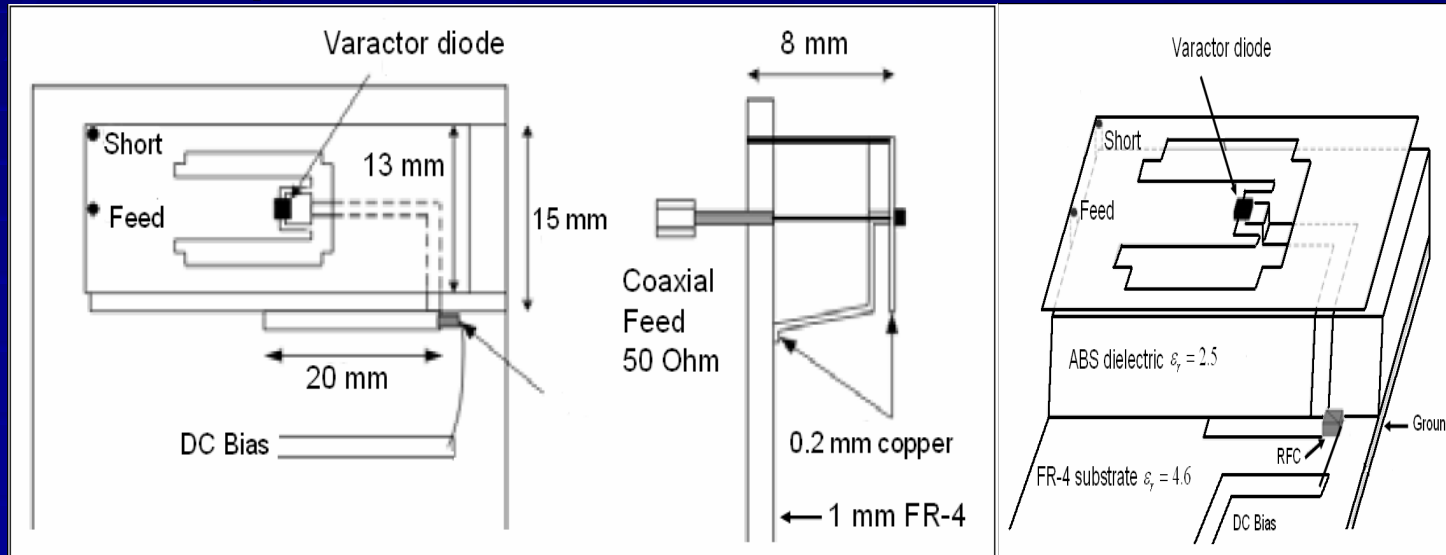
Implemented SPA

☐ It can switch between GSM850 & GSM900
  ☐ By switching the capacitor to the ground

☐ Maximum antenna cross talk -20 dB

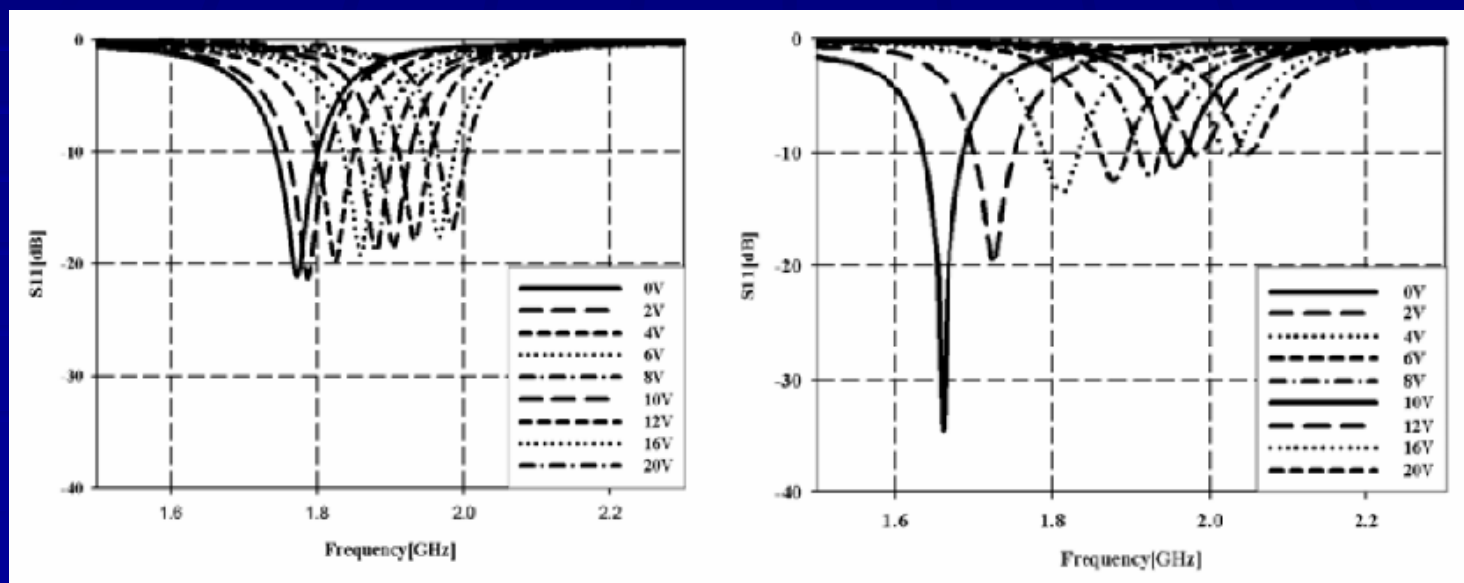# Practical examples of reconfigurable PIFA (2)

❑Varactor tunable PIFA antenna with U-shaped slot

- In the case that operating frequency should be change in a relative wide range with continuous values Varactor tunable PIFA can be a good choice.
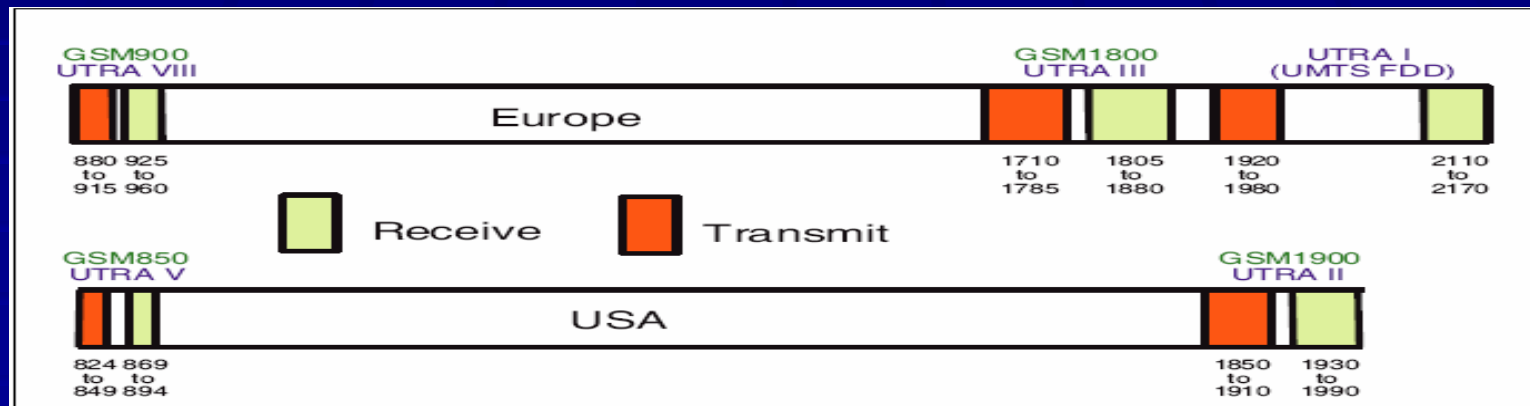
Varactor tunable PIFA antenna

❑ L-shape structure suppresses the first resonance frequency by the outer element and create another new resonance frequency
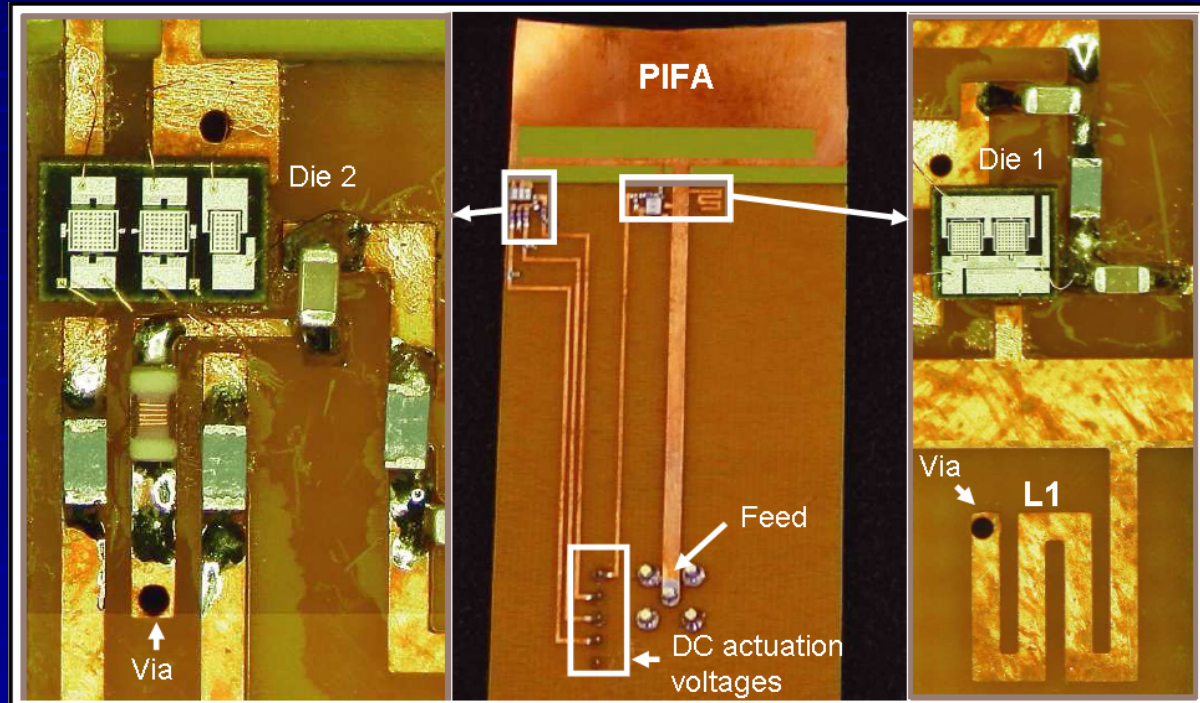
Practical examples of reconfigurable PIFA (3)

❑ In most cases operating frequency should be changed in a relatively wide rage
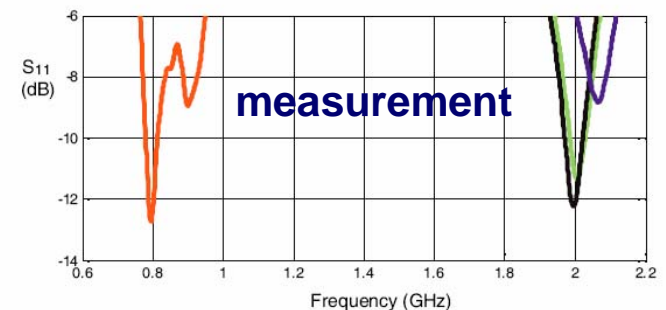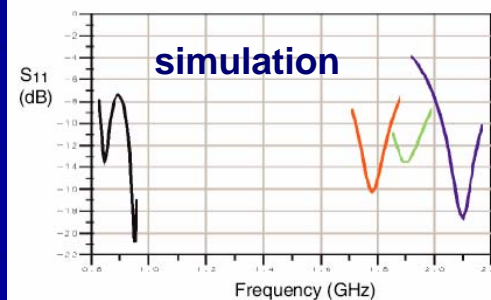
  ❑ Common cellular band in Europe and USA

❑ In such cases use of MEMS switched PIFA antenna can offer wide range tunability

Implemented MEMS switched PIFA

Implemented antenna

Simulation and measurement Results of S11

Practical examples of reconfigurable PIFA (4)

❑Reconfigurable bandwidth PIFA

Implemented antenna
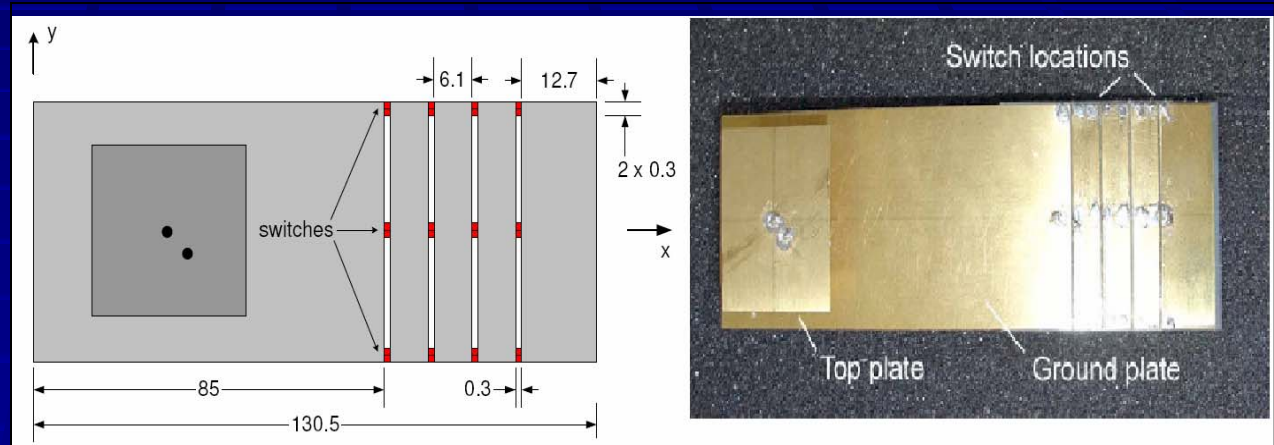
measurement Results of Return loss And pattern
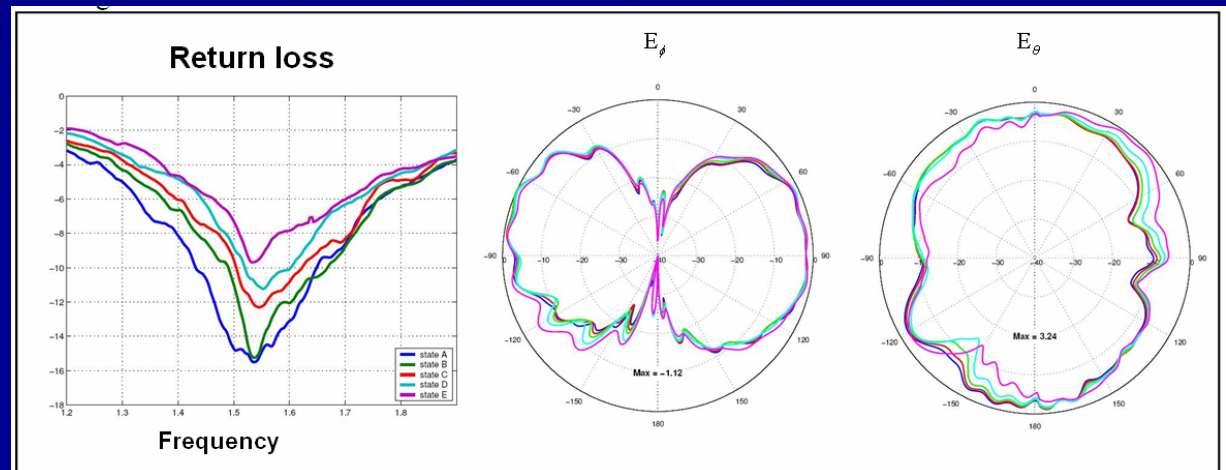
Conclusion

- For successful implementation of a multi-standard transceiver
    - reconfigurable architecture and reconfigurable component design technique are essential
- Reconfigurable antenna offers good characteristics
    - PIFA antennas suit for small terminals
        - Reconfigurable, low power consumption, relative high efficiency, compact, high noise and interferer blocking

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[10] Design of MEMS based triple band antenna, Zahirul**,** Dept. of ECE, Faculty of Engineering, Dept. of ECE, Faculty of Engineering,2004

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Question ?

Thank you

Trade offs

❑ Classical approach

- Wide band analog
- Fast digital system
- High level of blockers at A/D, high dynamic rage is required

- Linearity in both digital domain and analog domain is critical

- Fixed analog front-end

❑ Refined approach

- Narrow band analog
- Slow digital system
- Blockers shall be filtered at analog domain, so lower dynamic range is required at digital domain

- Linearity at digital domain is not critical, spurious signals shall be filtered

- Reconfigurable analog front-end

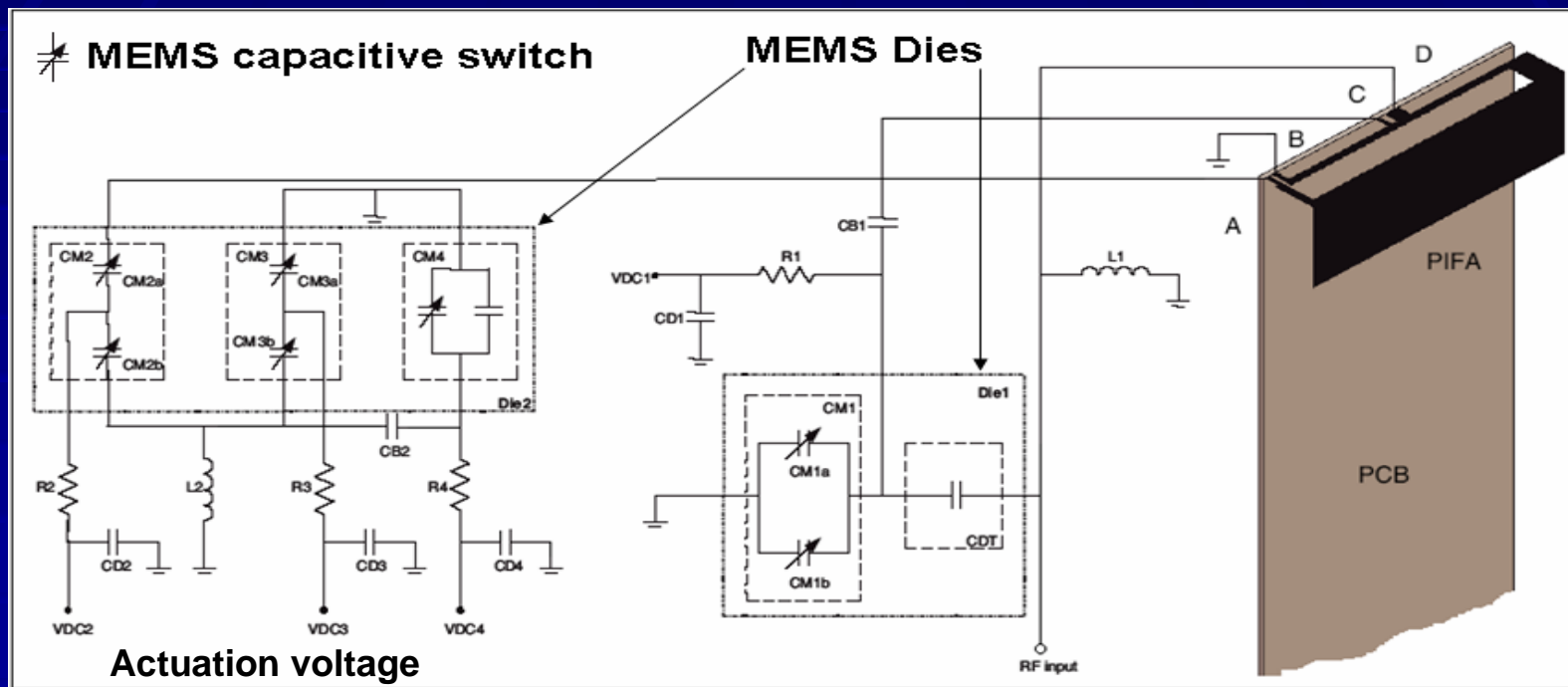Back up Silde

SPA design considerations

- ❑ Quality factor of tuning capacitor has significant effect on efficiency and bandwidth
- ❑ Proximity of external lossy objects like a human operator's head or hand decreases the efficiency
  - ❑ In implemented SPA efficiency decreased by 15% instead of 30-40%
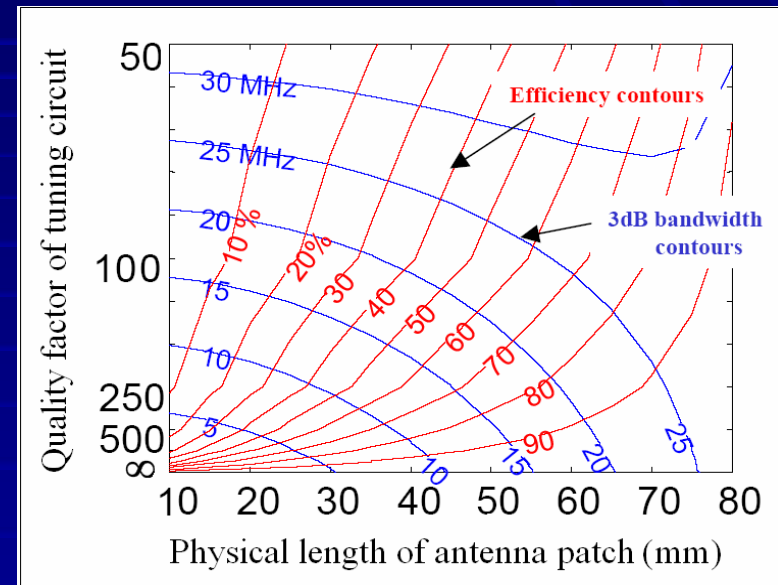
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MEMS switched PIFA

❑MEMS switched PIFA and its circuit

A: switch connection for frequency tuning
C: switch connection for impedance matching
D: antenna feed

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