LTCC Chip Antennas – How to maximize performance

Outline

- Chip Antenna Characteristics
- Antenna Selection Considerations
- Circuit Design Constraints
- Layout Tips

Ultimate Goal → To Maximize Performance

Motivation

- Chip Antenna an efficient means of “connectivity” to modern portable compact electronic devices.
- Miniature portable devices requires small antennas.
- Can be internalized – i.e. “Concealed” within device.

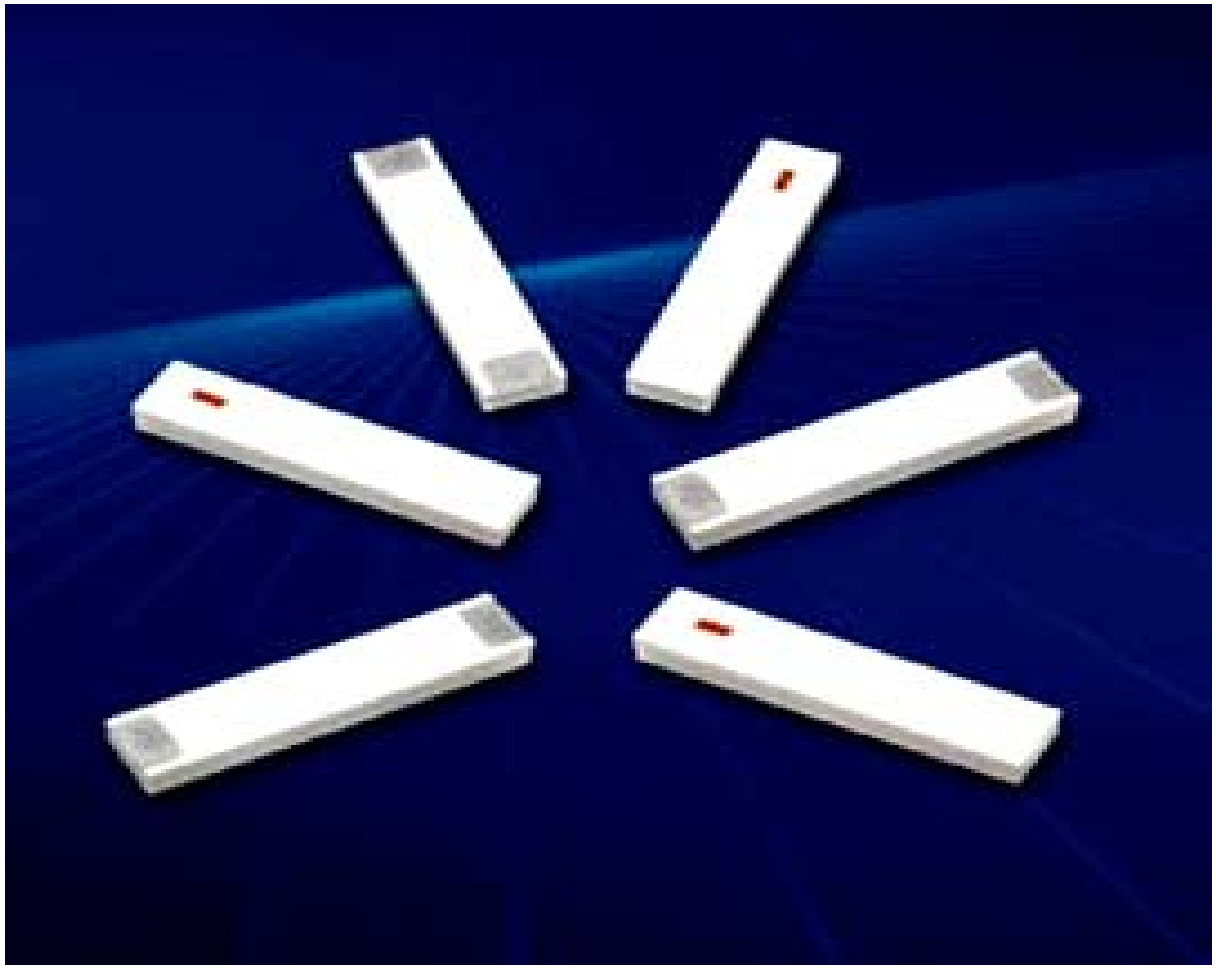
Pros

- Chip antennas are small, cheap and performs well.
- Bulky external “whip” type antennas are thing of the past.

Cons

- Must be accounted for *during initial circuit* design stage
- Interference, proximity de-tuning & degradation concerns.

LTCC Chip Antennas



Chip Antenna Characteristics -1

- Features Ag radiating element encapsulated in ceramic.
- A quarter-wave (λ /4) monopole system.
- Works with GND plane to form dipole system.
- Certain “No-GND” metal-free space necessary.
- Small form factor, thin profile & light weight

Chip Antenna Characteristics - 2

- Omni-directional radiation.
- Linear Polarization.
- Mounting configuration flexibility.
- Frequency range supported: 0.08 GHz thru 10 GHz.
- WiFi, BT, WiMAX, UWB, GSM, CDMA, GPS etc.
- Suitable for Pick & Place.

Antenna Selection Considerations -1

- Size
- Frequency Band
- Bandwidth
- Polarization
- Peak Gain
- Average Gain
- Radiation Pattern requirements

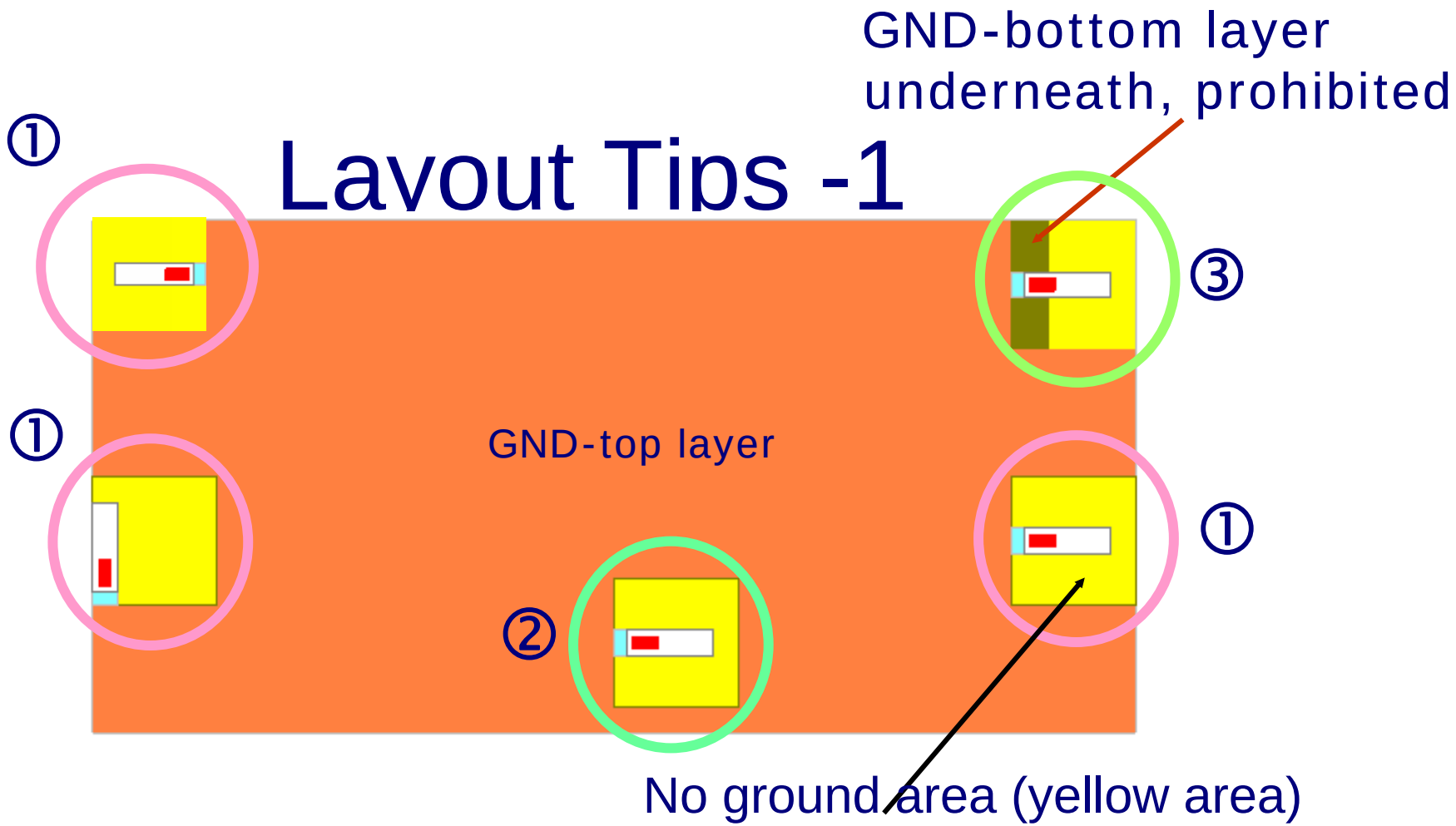
Antenna Selection Considerations -2

- Successful Antenna design means harmonious interaction of the “seven” parameters (next page)
- Additional considerations for diversity systems
  – e.g. MIMO
- Overall performance is always system dependent .

Circuit Design Constraints

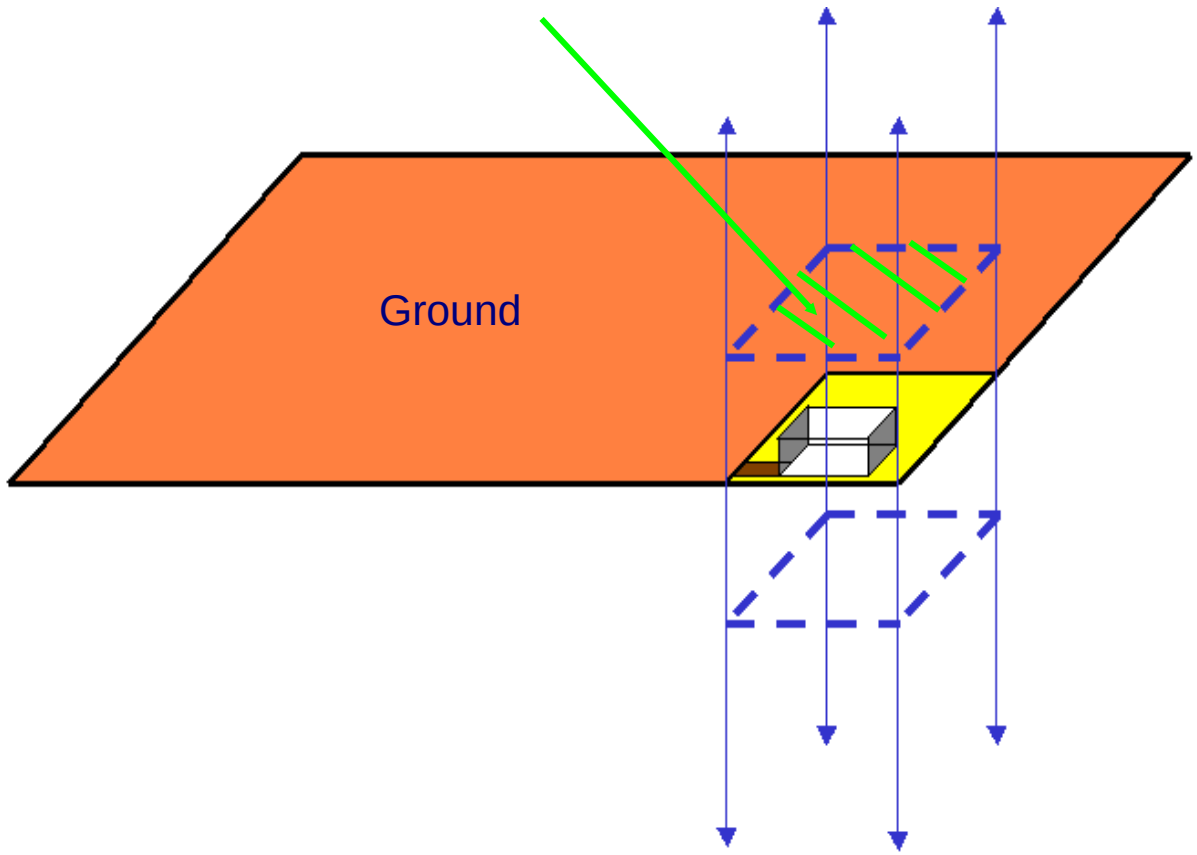
1. Size of the Circuit board.
2. Layout of other board components.
3. Complexity of circuit.
4. Proper GND/No-GND dimensions and clearances.
5. “Tuning” Matching Circuitry
6. Shielding
7. Suitable Enclosure (material)

Layout Tips -1



- Good Placements ①
- Bad Placements ② & ③

Layout Tips -2



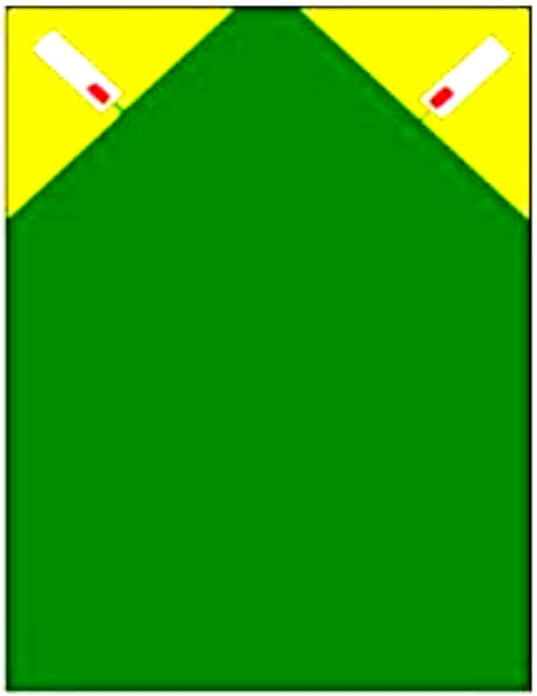
Don’t put <u>any</u> metal objects or batteries (if applicable) above or below the yellow region

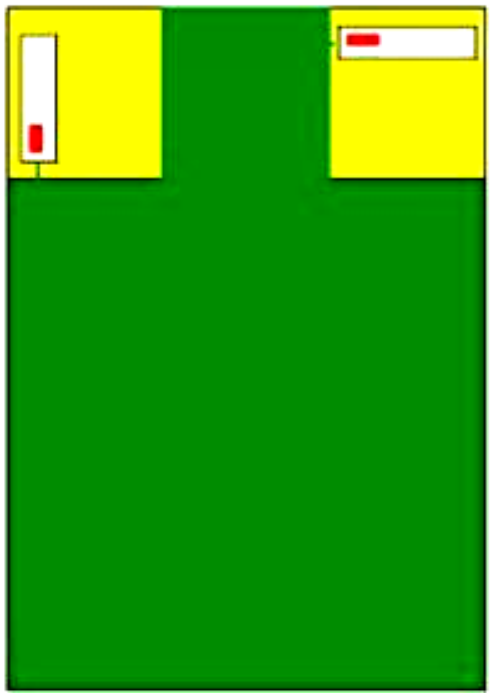
Keep away any other metals from clearance area.

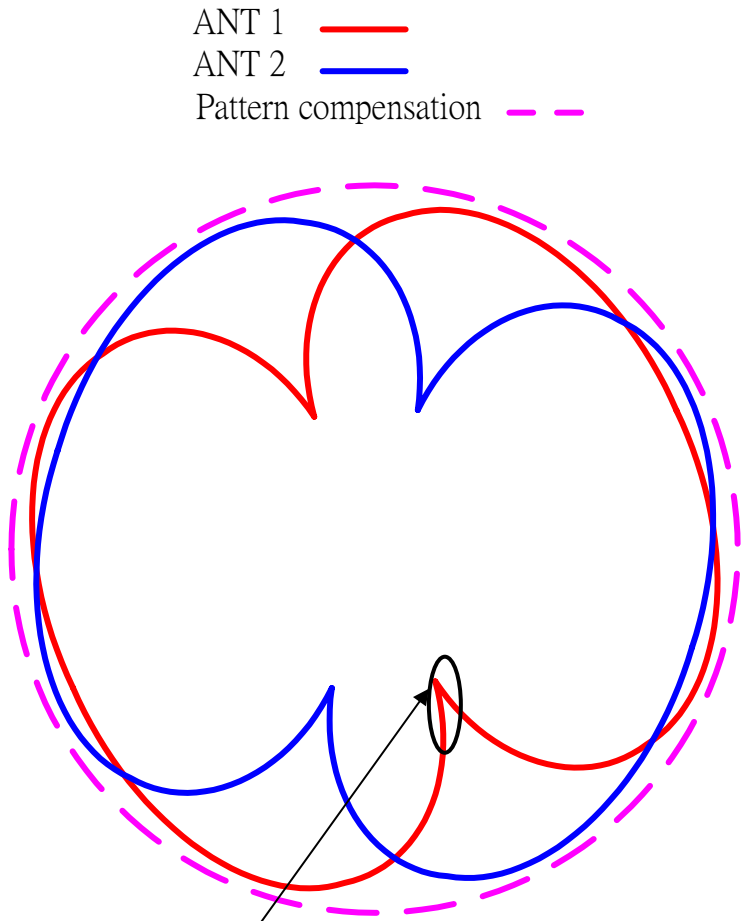
Layout Tips -3

- Further examples of good antenna placement schemes

Layout Tips -4





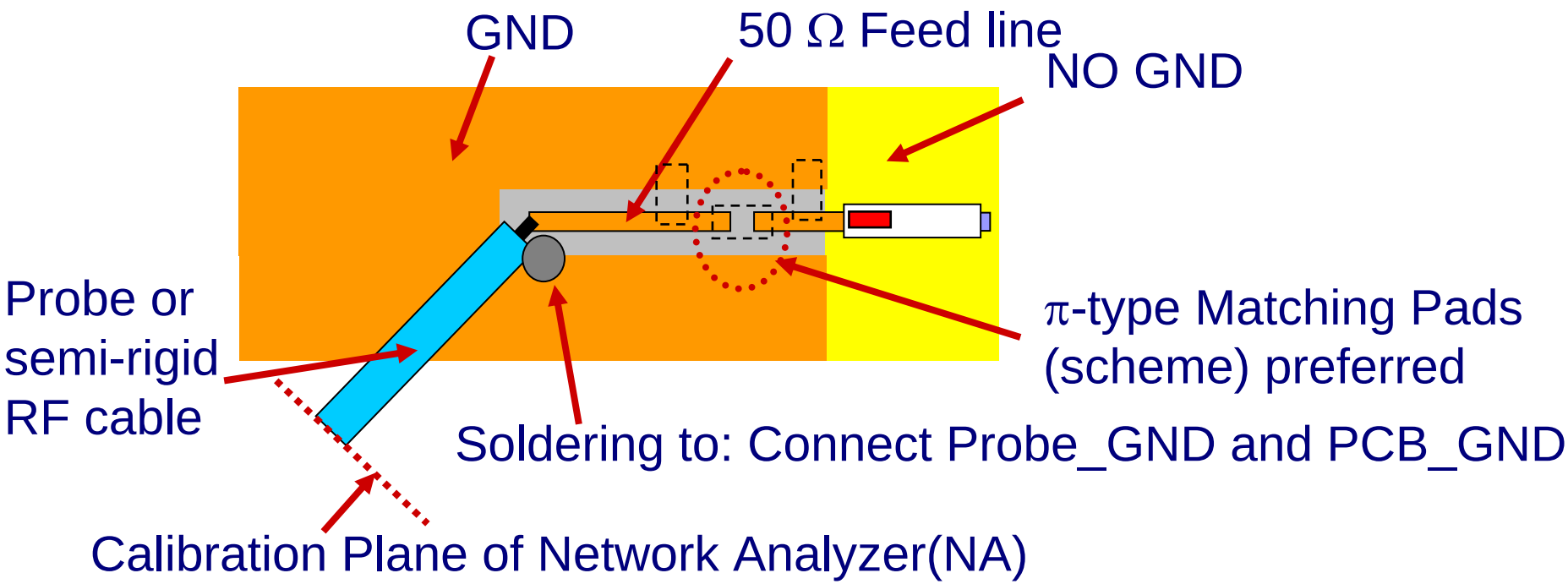


- Antenna placement schemes for antenna diversity systems

Antenna Matching -5

A. Antenna Matching Setup

Test Board matching example



B. Measuring Steps

1. One-port (S11) calibration for N.A. (Network Analyzer) Open-Short-Load for desired operating bandwidth

2. Mount probe (semi-rigid RF cable for our example) onto PCB and connect to N.A.

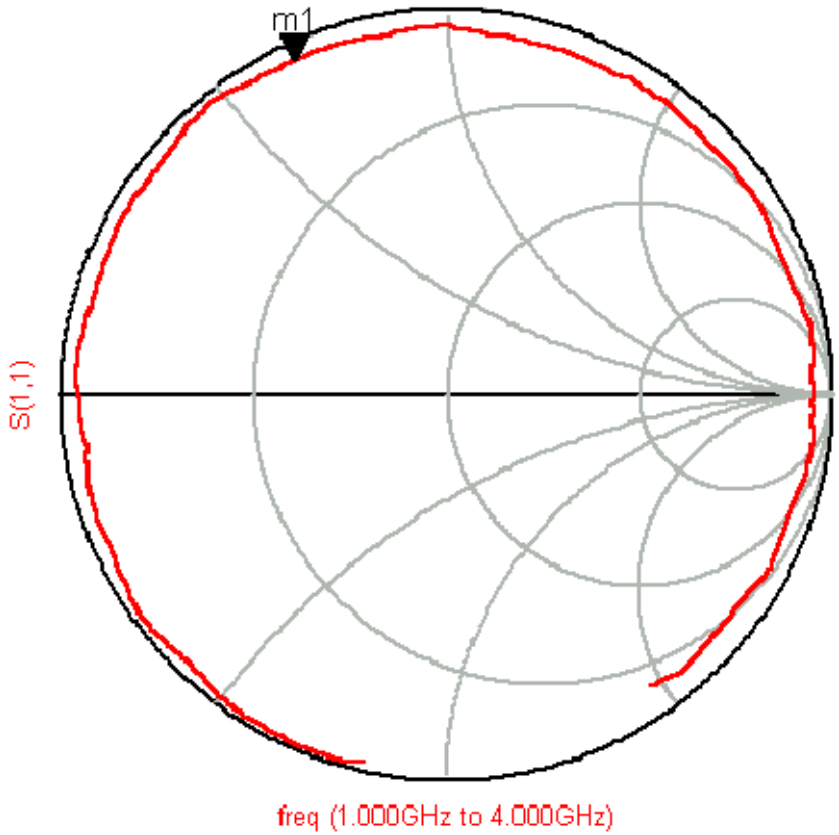
3. Measure S11 of test board **without** antenna or any matching components and save as:
   →S11_open →save trace to memory of N.A.

4. Measure S11 of test board **with antenna and series 0Ω resistor** mounted and save as: →S11_antenna

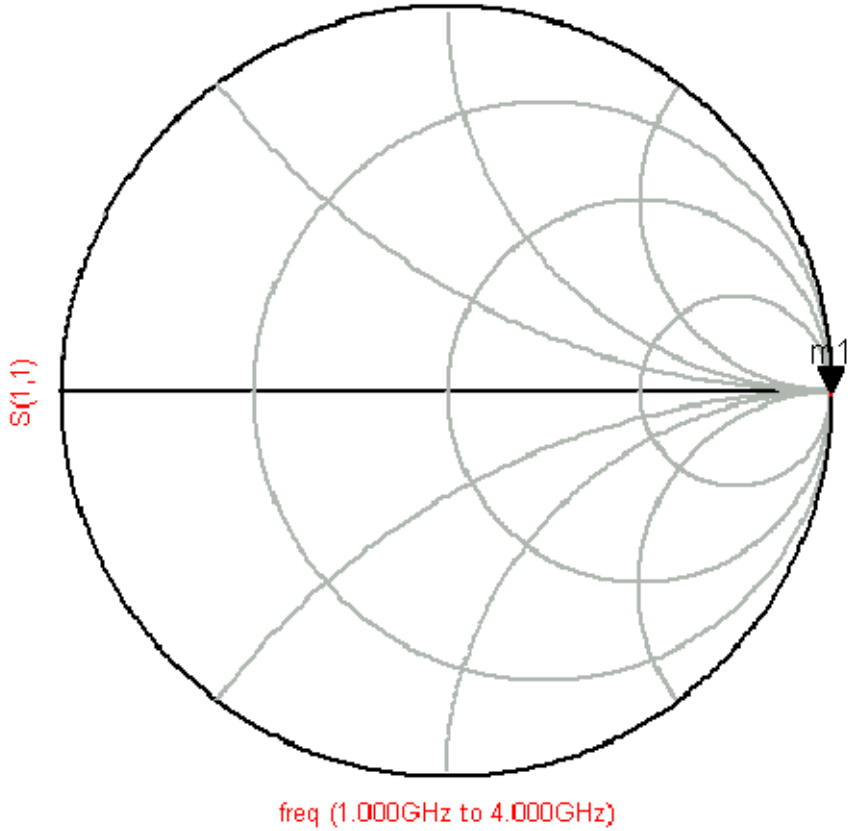
5. Set N.A. to data/memory mode (S11_antenna/S11_open) and display/save as: →S11_match

6. Match the trace of S11_match to **50Ω**
   (center of Smith chart at the desired frequency)

1. Probe+Feed Line Smith chart display from 1-4GHz (not-normalized)



2. Probe+Feed Line (normalized)

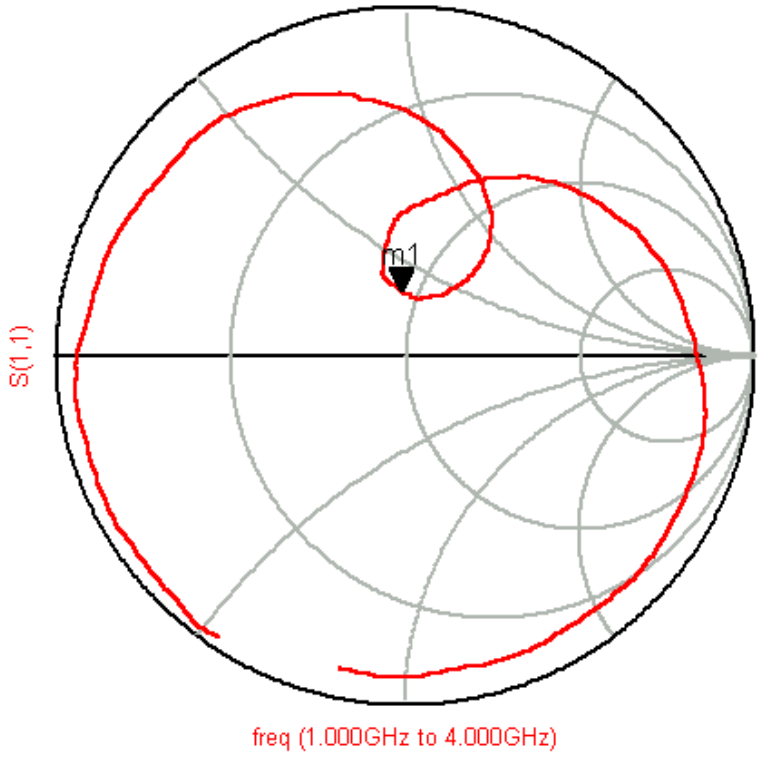


Test Board matching example

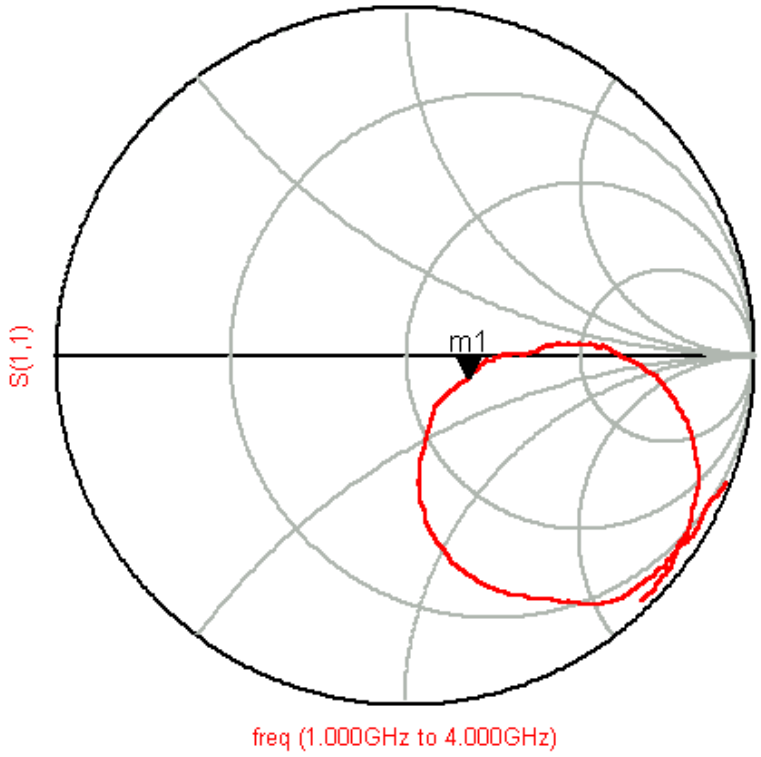
1. Probe + Feed Line + Antenna
Smith chart display from 1-4GHz
(not-normalized)

2. Probe + Feed Line + Antenna
(normalized)

(not normalized)



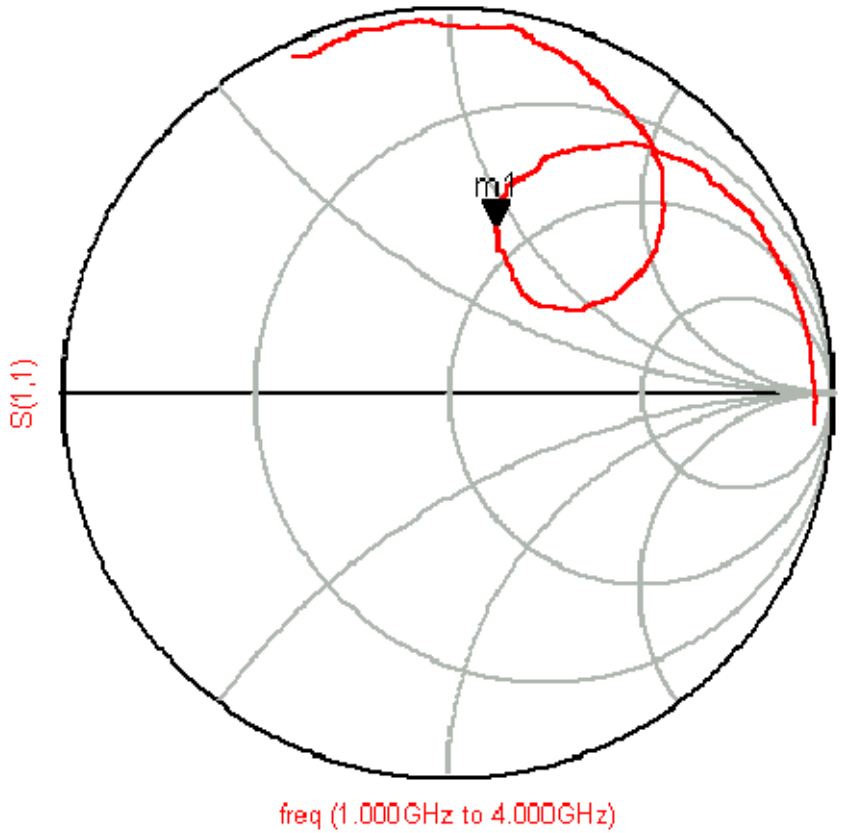
(normalized)



Test Board matching example

Step 1 in matching:

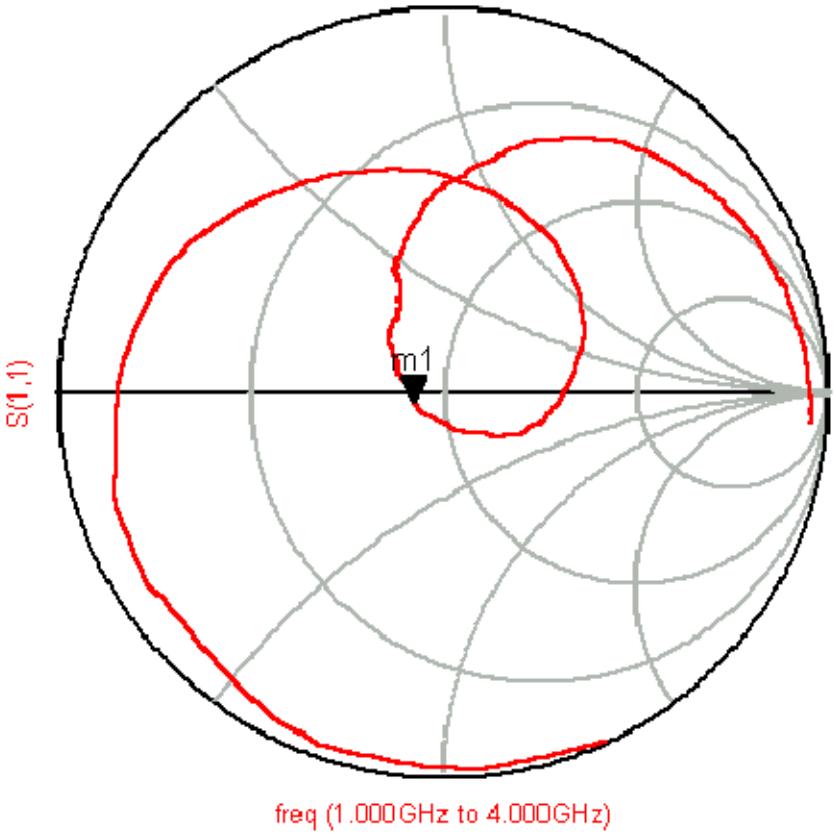
Ant + shunt 3.9nH (normalized)



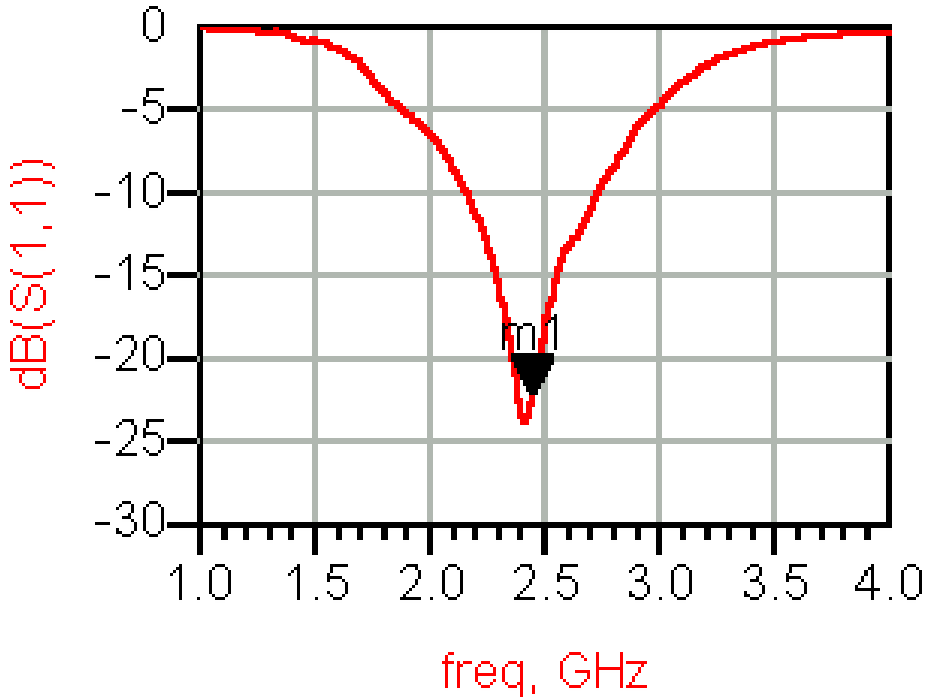
Test Board matching example

Step 2 in matching:

Ant + shunt 3.9nH + series 1.5pF (normalized)



Test Board matching example

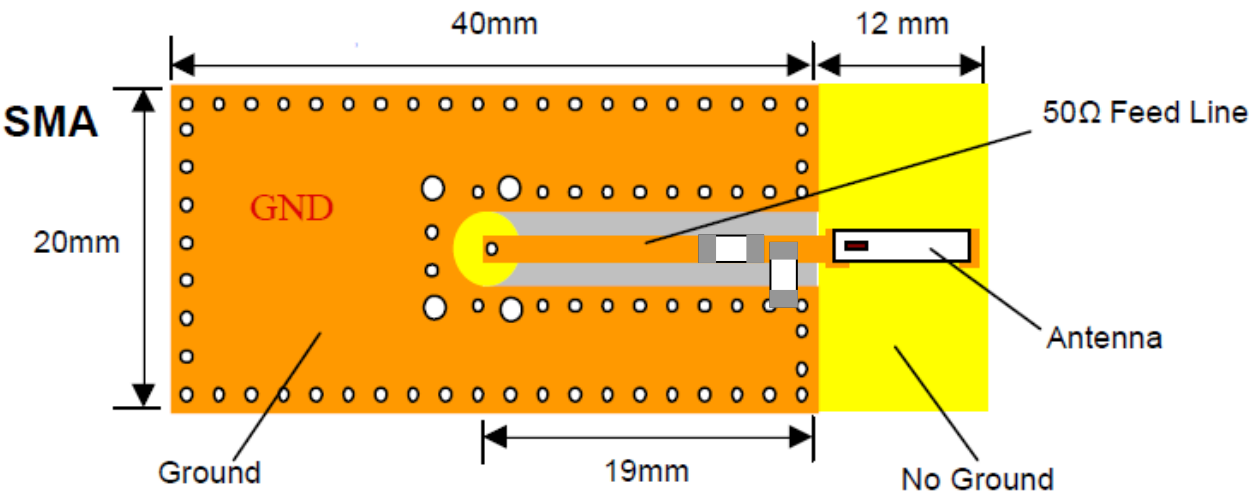


Matched Return Loss chart

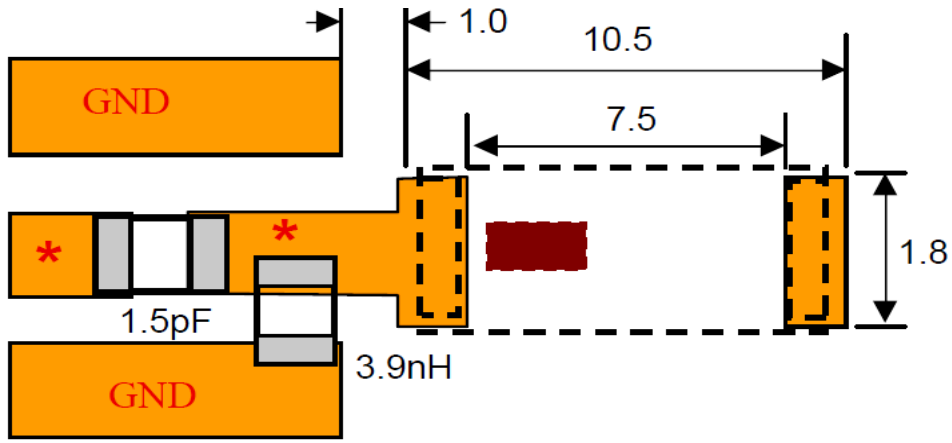
Matched Antenna Example

Test Board

EVB p/n:
2450AT45A100-EB1SMA



Return Loss



b) With Matching Circuit* (wide bandwidth)

* matching circuit and component values will depend on PCB layout, thickness, material, etc.

General Specifications

Part Number	2450AT45A100
Frequency Range	2400 - 2500 Mhz
Peak Gain	3.0 dBi typ. (XZ-V)
Average Gain	1.0 dBi typ. (XZ-V)
Return Loss	9.5 dB min.

JTI P/N for Matching Circuit:
Cap (1.5pF): 500R07S1R5BV4T
Inductor (3.9nH): L-07C3N9SV6T

Conclusion – How to design

- 1st – Determine the antenna location and space available on board
- 2nd – Select the most appropriate antenna model
- 3rd - Implement antenna in conformance with design rules
- 4th – Match antenna to your system