Impedance Matching Techniques

Jose H Arreguin Martinez

KG5YQO

Outline

- Importance of Impedance Matching
- Matching with discrete components
- Matching with Quarter wavelength
- Stepped Impedance
- Practical Impedance Matching – Quarter Wavelength Coax

Importance of Impedance Matching

- Needed for High Power Amplifiers
  - Example:
    - VDD = 50V, Pout = 100W
    - $\frac{VDD^2}{R}$ = *2 x Pout , Consider AB Class or "Greater"*
    - $\frac{50^2}{2x100}$ *= R, R = 12.5Ω, Most likely lower impedance than this approximation*
  - GaN Amplifiers
    - MMRF5014 – Datasheet on the right
    - Narrowband Optimal at lower impedances for power gain and efficiency

f MHz	Z_{source} Ω	Z_{load} Ω
500	1.3 + j3.9	5.9 + j3.5
1000	1.0 + j0.3	5.5 + j2.9
1500	0.8 – j0.5	3.4 + j2.0
2000	1.2 – j2.0	4.7 + j0.3
2500	2.7 – j3.8	3.7 + j1.4

Z_{source} = Test circuit impedance as measured from gate to ground.

Z_{load} = Test circuit impedance as measured from drain to ground.

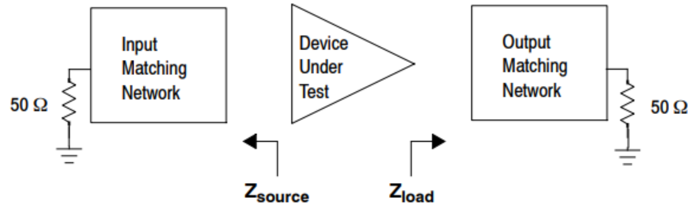


Figure 7. Narrowband Fixtures: Series Equivalent Source and Load Impedances

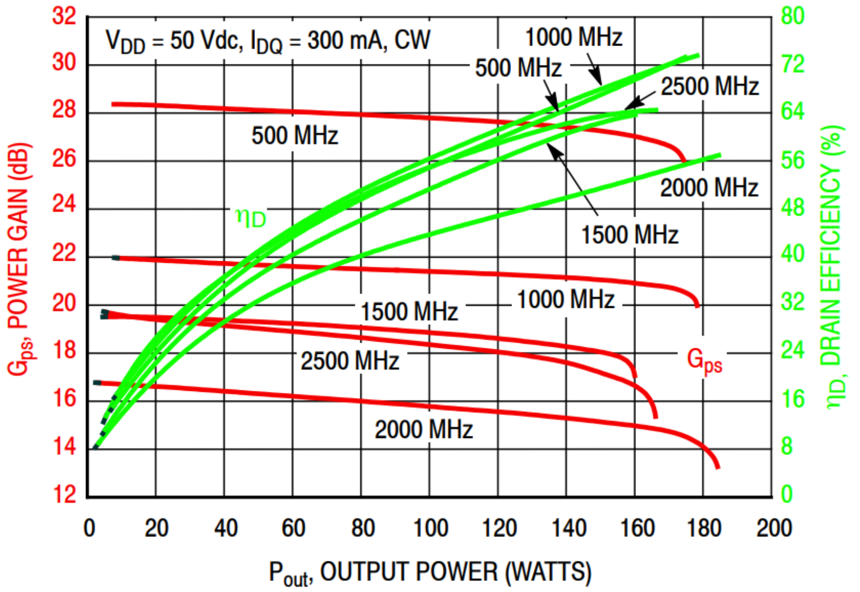
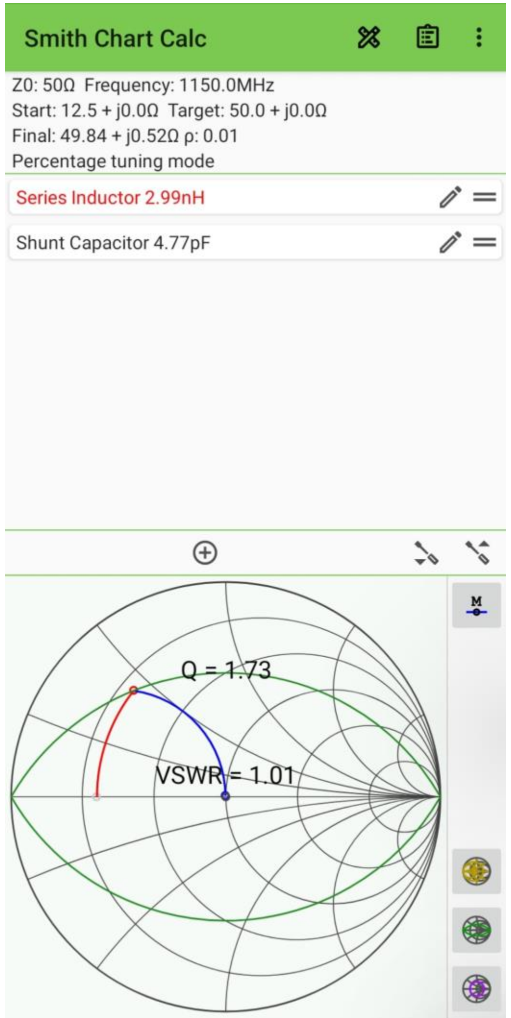
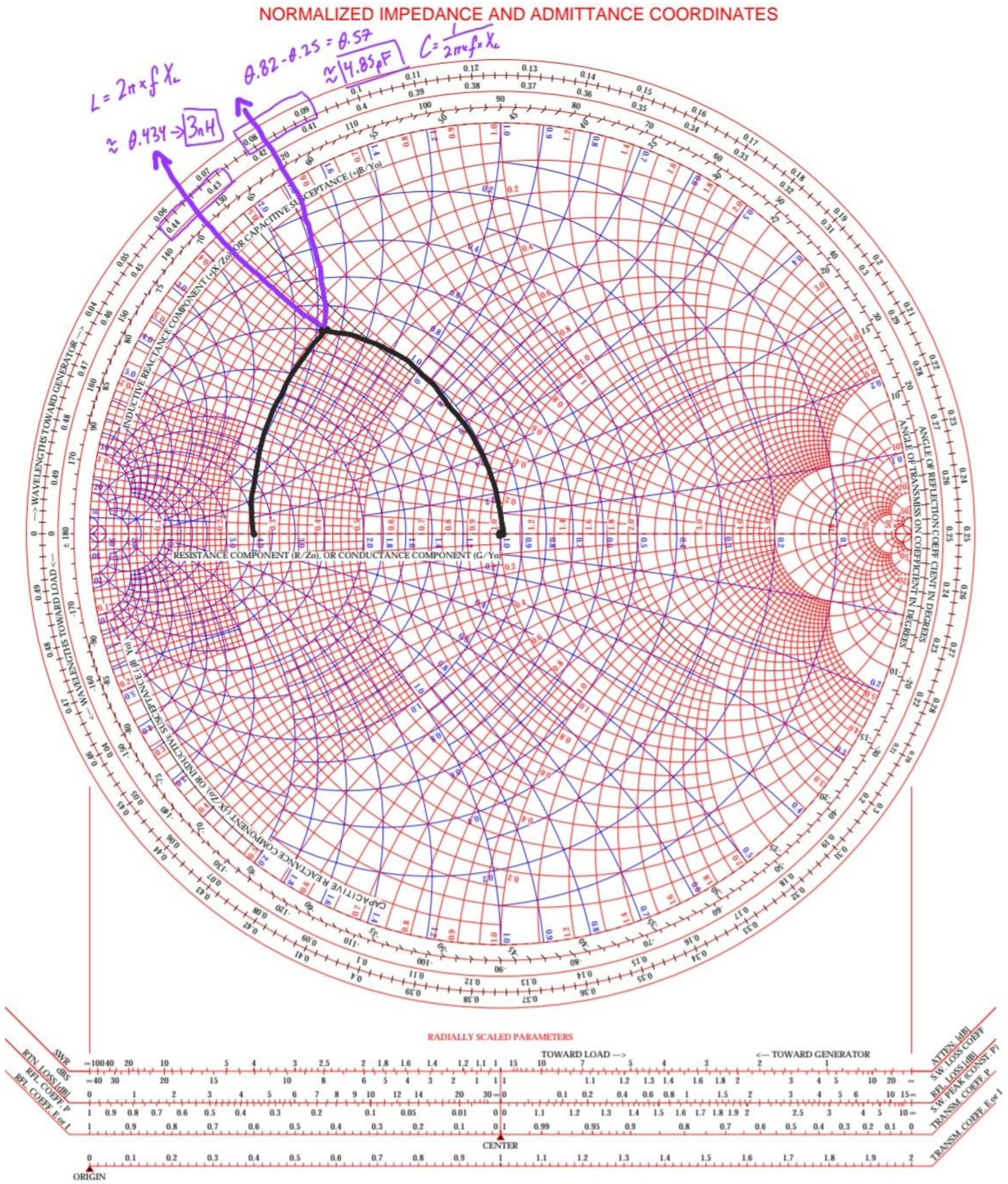


Figure 6. Power Gain and Drain Efficiency versus CW Output Power

Matching with Discrete Components

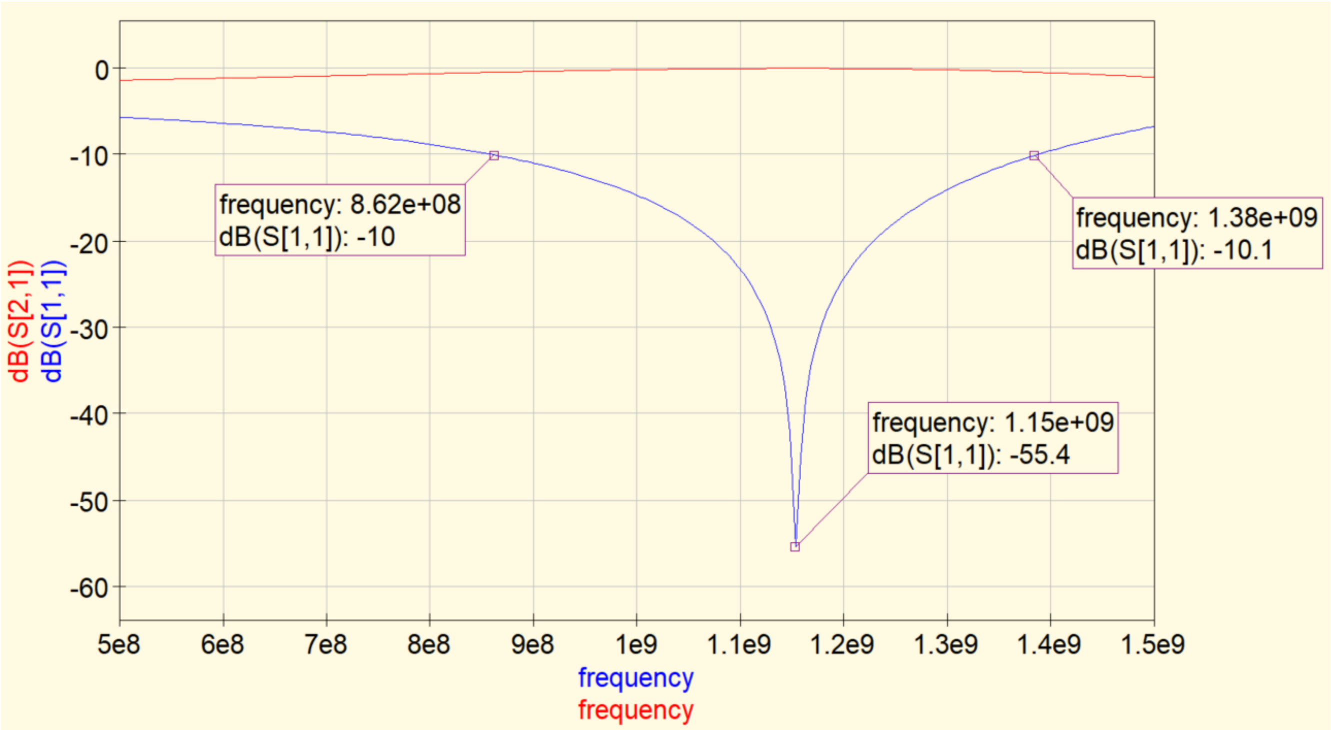
- Advantages:
  - Simple
- Disadvantages:
  - Limited to HF, VHF, UHF
  - Narrowband
    - *Note:* $Q = \frac{f_c}{BW}$
    - $BW = \frac{1150\ MHz}{1.73} = 664\ MHz$

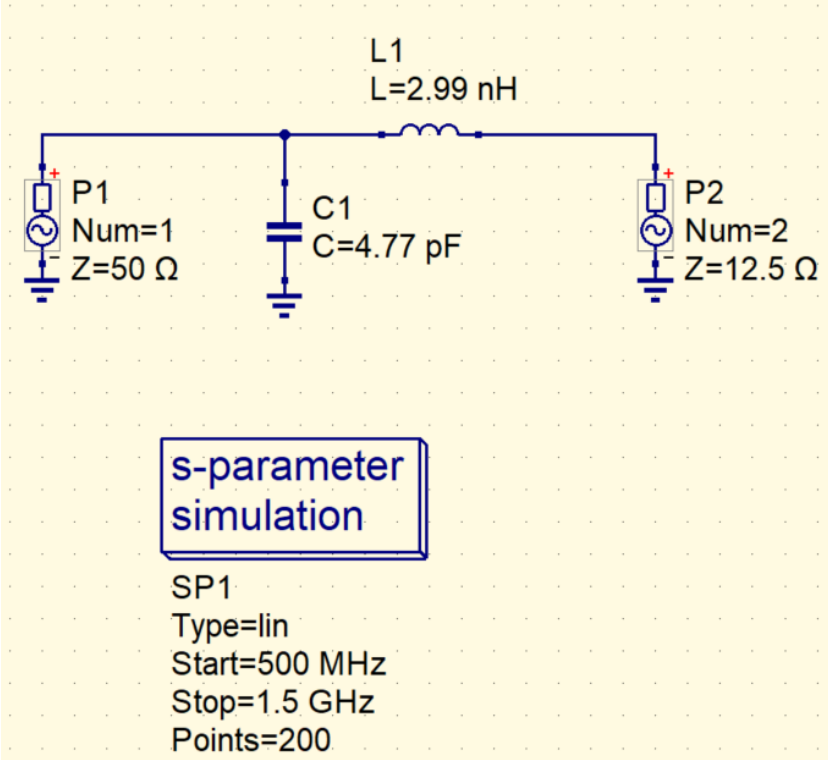




Example

- 10 dB BW = 518 MHz

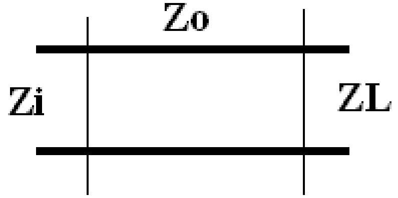


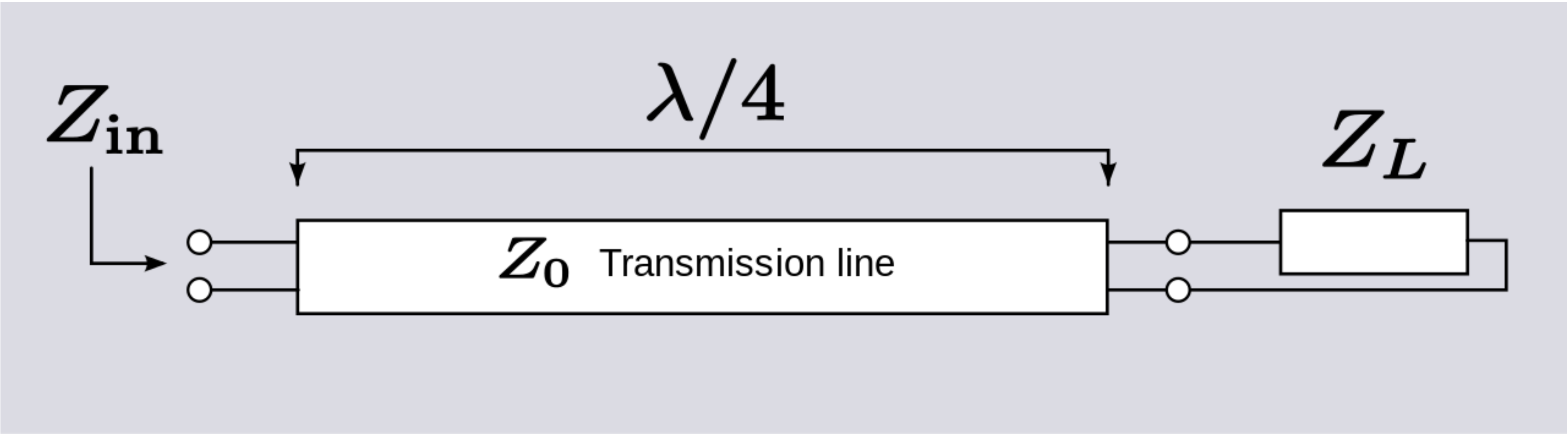


Quarter Wavelength Transformer

- Advantages:
  - “Simple”
  - Usable at higher frequencies
- Disadvantages:
  - Narrowband
  - Difficult to tune if first shot doesn’t come out as expected.

$$Z_i = \frac{Z_0^{\,2}}{Z_L} \qquad Z_0 = \sqrt{Z_i Z_L}$$

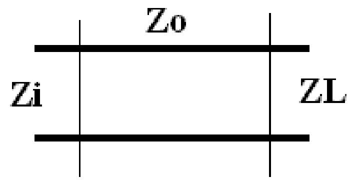


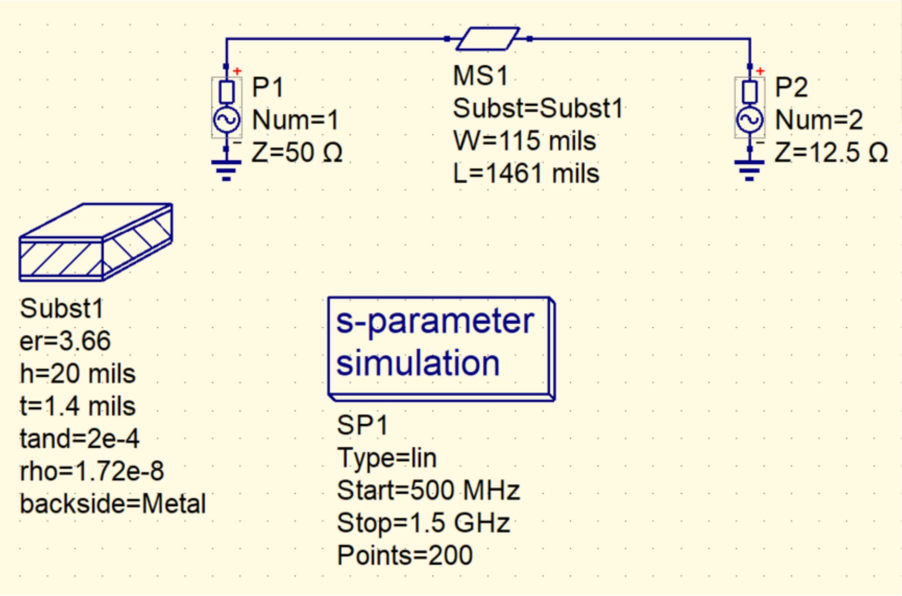


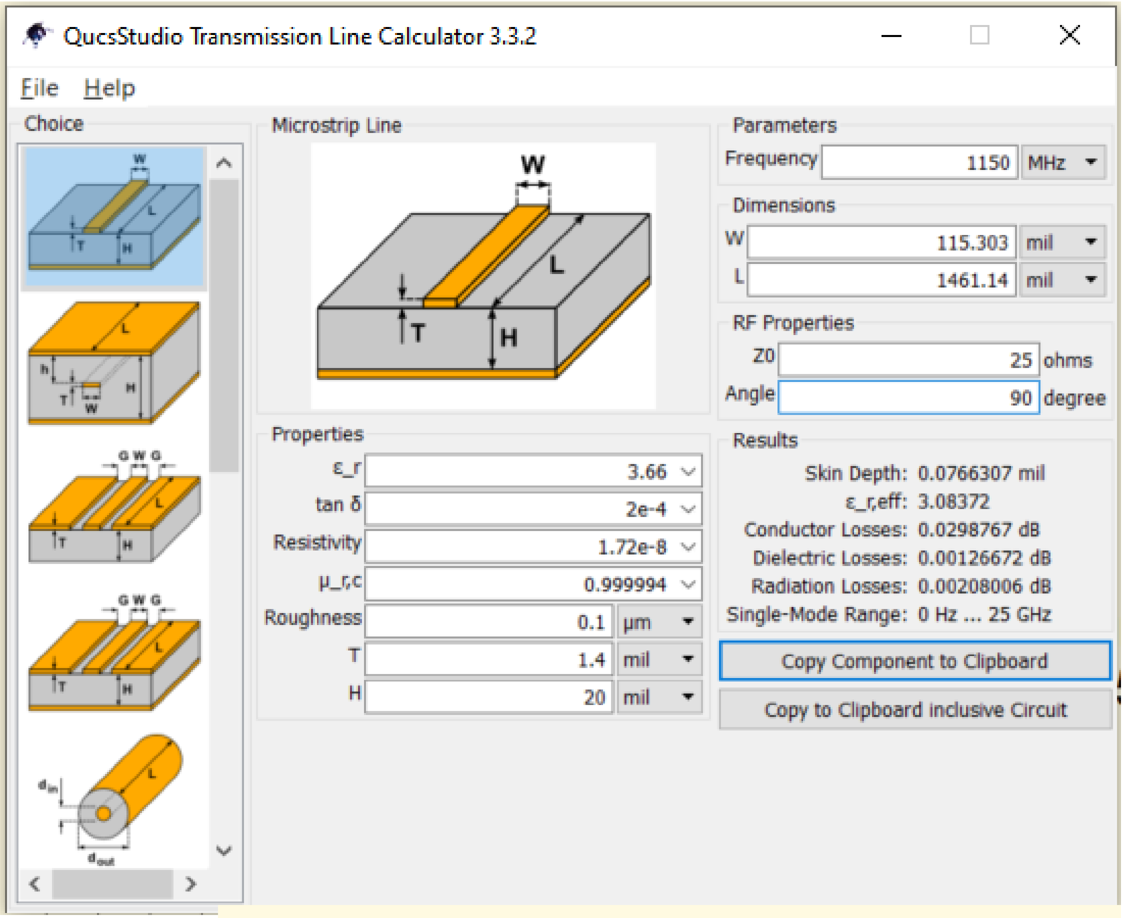
Example

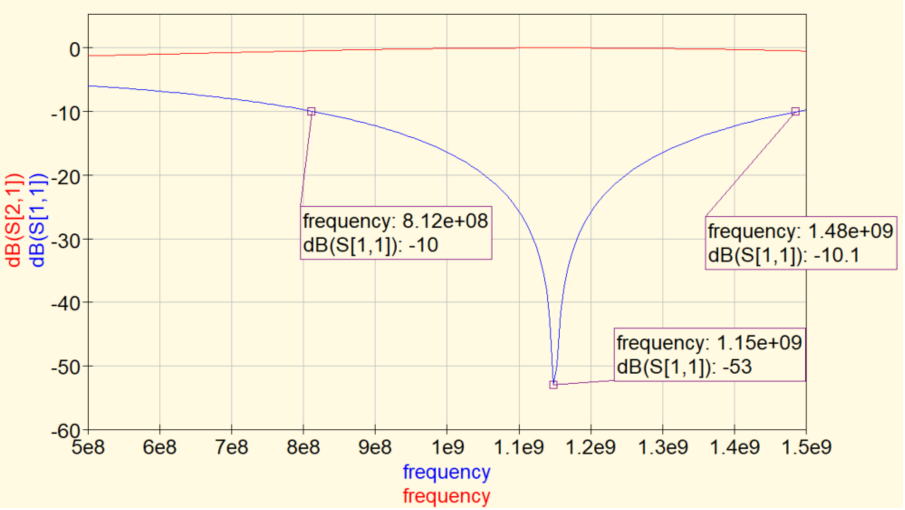
- RO4350B, 20 mil thickness, 1oz
  - $Zo = \sqrt{50 \times 12.5}$
    - $Zo = 25\ \Omega$
- BW = 668 MHz

$$Z_i = \frac{Z_0^{\,2}}{Z_L} \qquad Z_0 = \sqrt{Z_i Z_L}$$



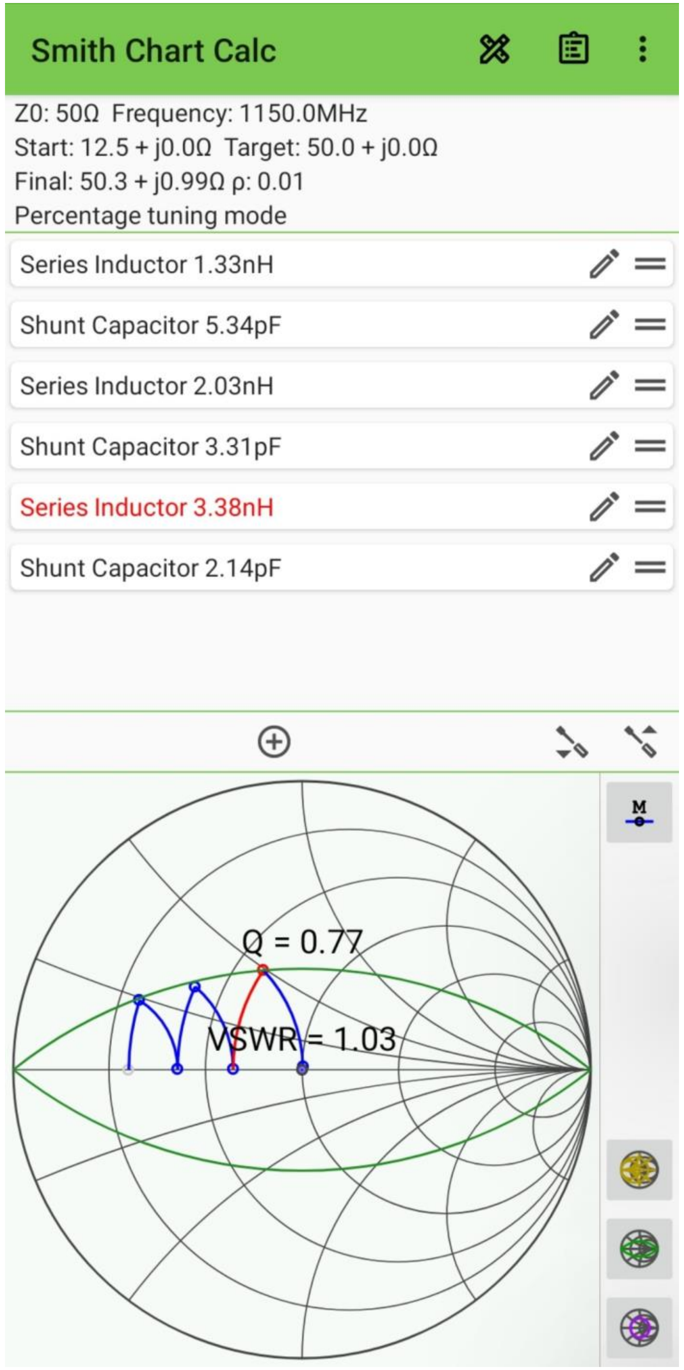






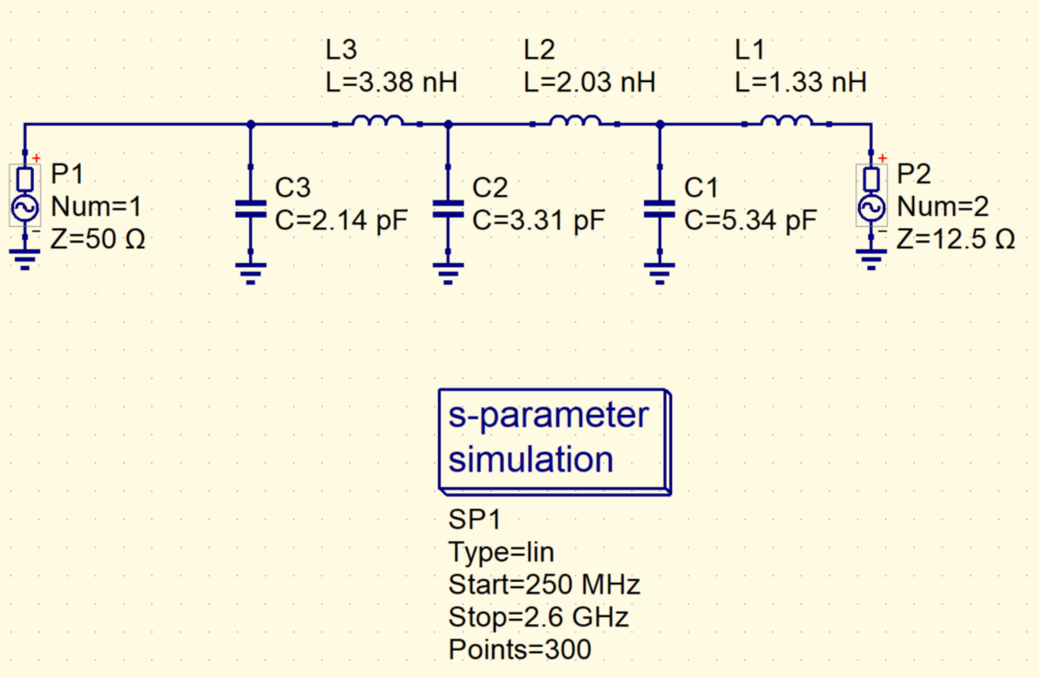
Stepped Impedance

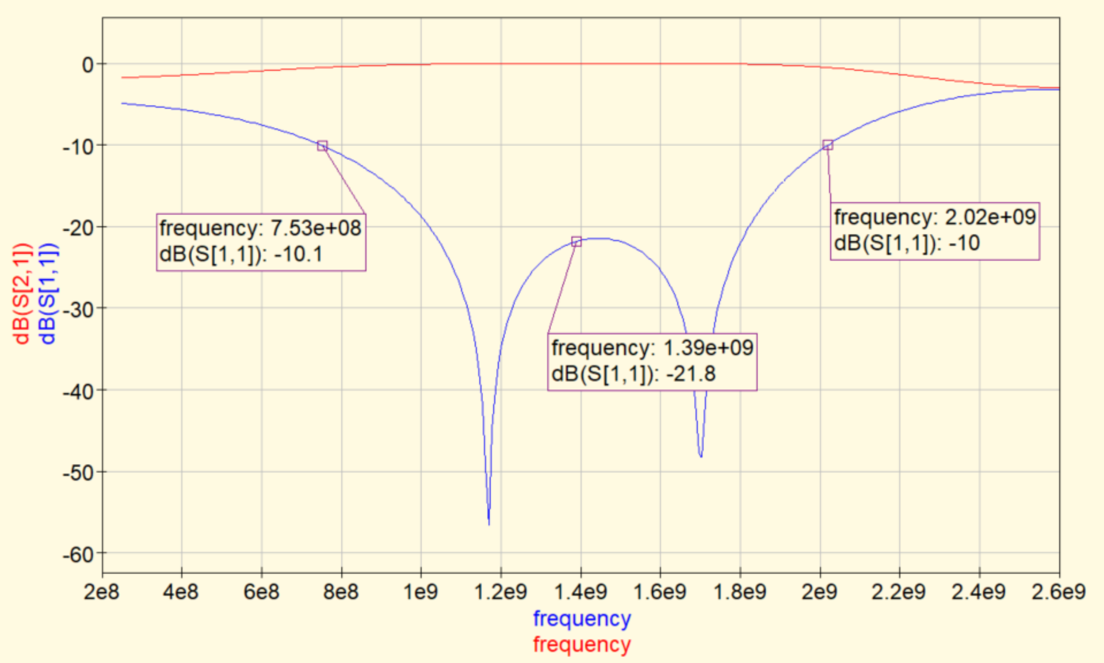
- Advantages:
  - Broadband
    - *Note:* $Q = \frac{f_C}{BW}$
    - $BW = \frac{1150\ MHz}{0.77} = 1493\ MHz$
- Disadvantages:
  - Difficult to implement and correct if board doesn’t turn out as expected.



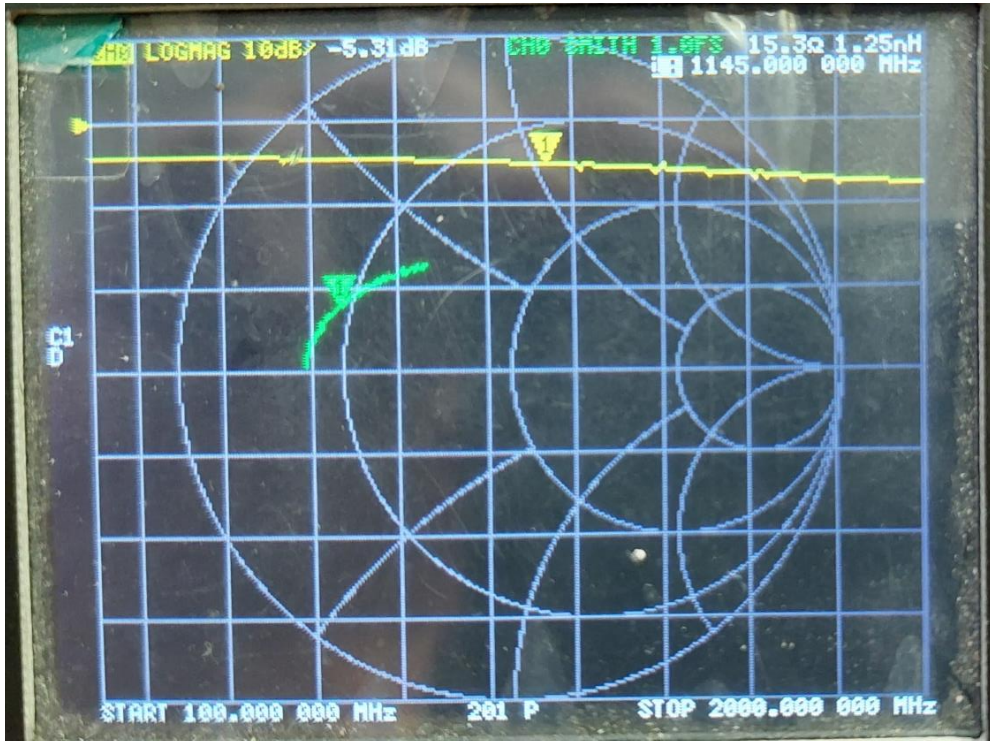
Example

- Simulated BW = 1267 MHz
- Although, impractical due to inductances/capacitances non-ideal.
- Required to design using microstrip distributed elements.



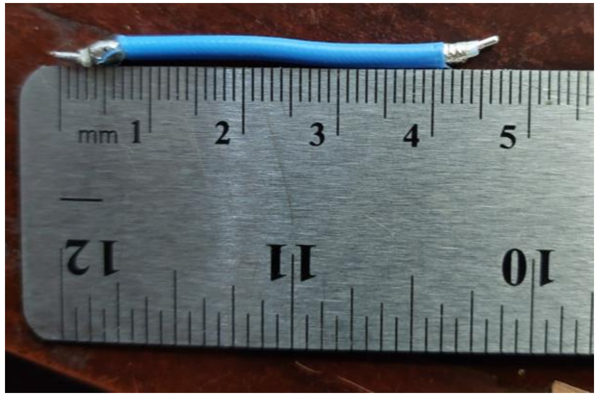


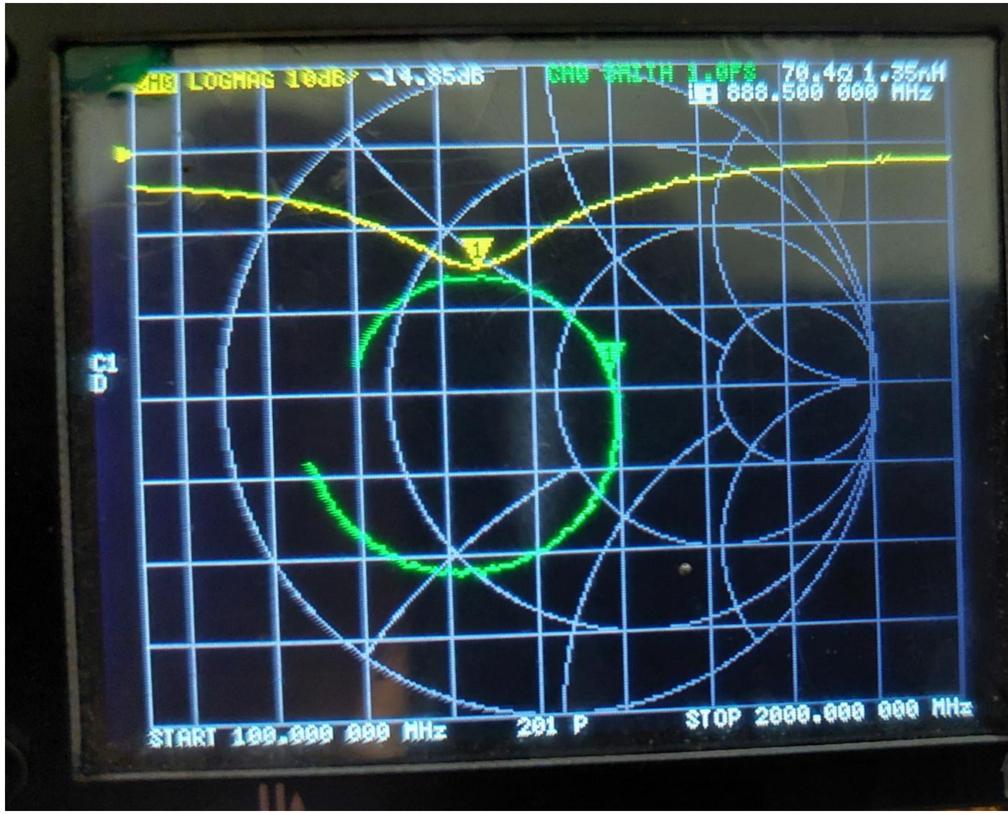
Practical Impedance Matching – Direct connection from 50Ω to 12.5Ω – no matching



Practical Impedance Matching – Quarter Wavelength Coax

- Assumed Propagation velocity: 70% (Vp)
- $\frac{c}{f}$ x Vp = $\lambda\ in\ Coax$, $\frac{300}{1150}$ x 0.70 = 182mm
- $\lambda/4$ = 45mm
- 888.5 MHz





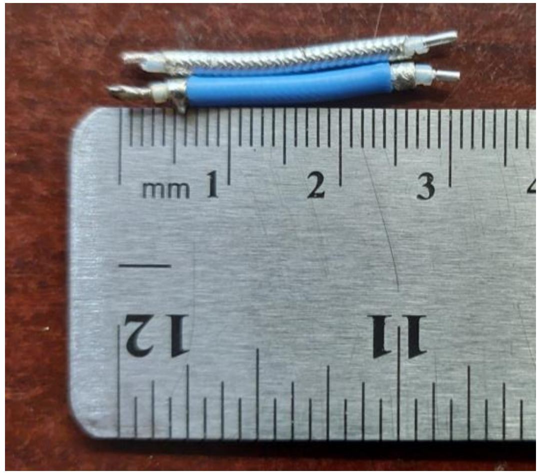
Practical Impedance Matching – Quarter Wavelength Coax - Tuning

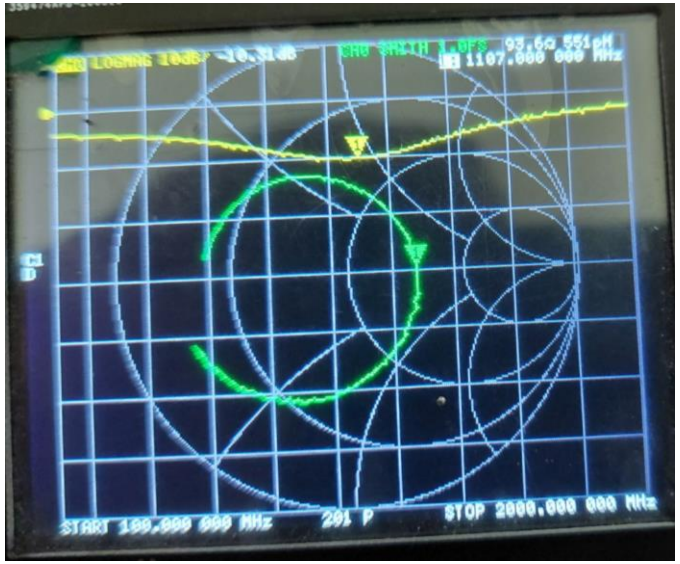
- Knowns:
  - 888.5 MHz
  - 182 mm length, λ
- Unknowns
  - Vp?
  - $\frac{c}{f}$ x Vp = λ ..... Vp = $\lambda \times \frac{f}{c}$
- Vp = 53.9%

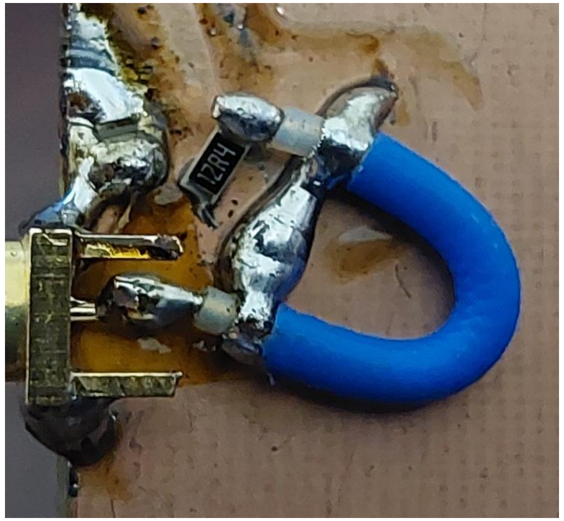
- Assumed Propagation velocity: 53.9% (Vp)
- $\frac{c}{f}$ x Vp = $\lambda\ in\ Coax$, $\frac{300}{1150\ MHz}$ x 0.539 = 140mm
- λ/4 = 35.1mm

Practical Impedance Matching – Quarter Wavelength Coax - Tuning

- Without Insulator
  - Fc = 1107 MHz, 10.3 dB Return Loss
- With Insulator
  - Fc = 1088 MHz, 13 dB Return Loss







References

- Link to the QucsStudio software download
- qucsstudio.de/download/

Questions?