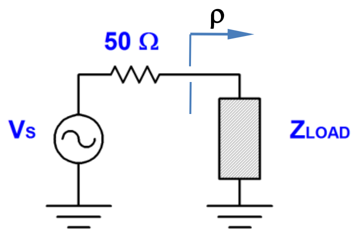
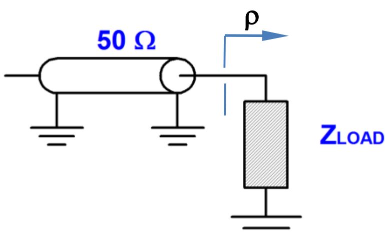
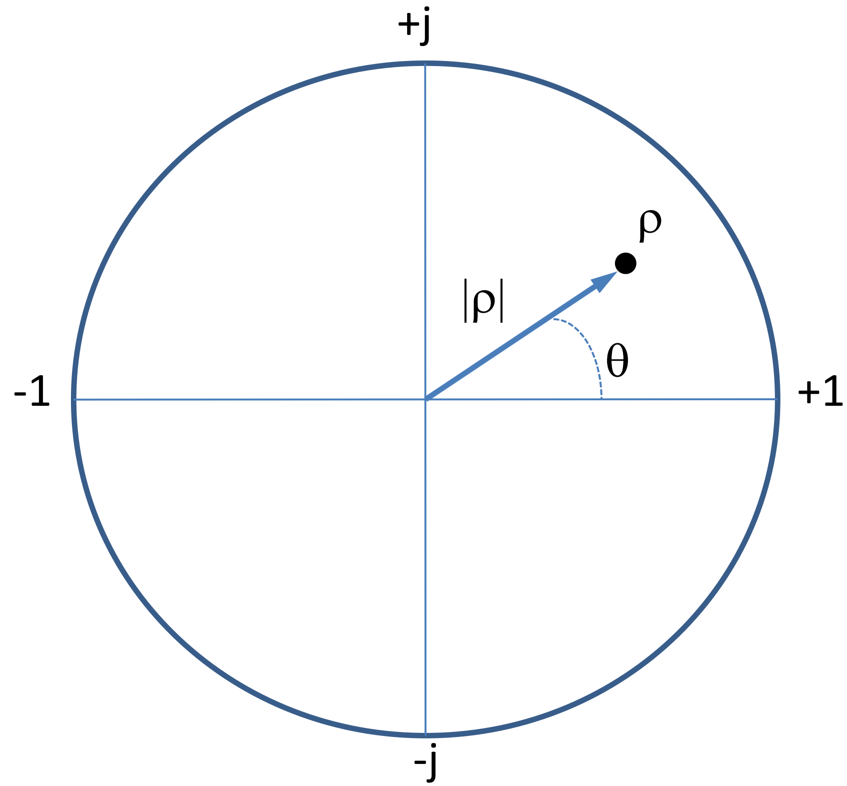
Smith Chart
Lumped Element Z-Matching

Origin of the Smith Chart

REFLECTION COEFFICIENT: ρ

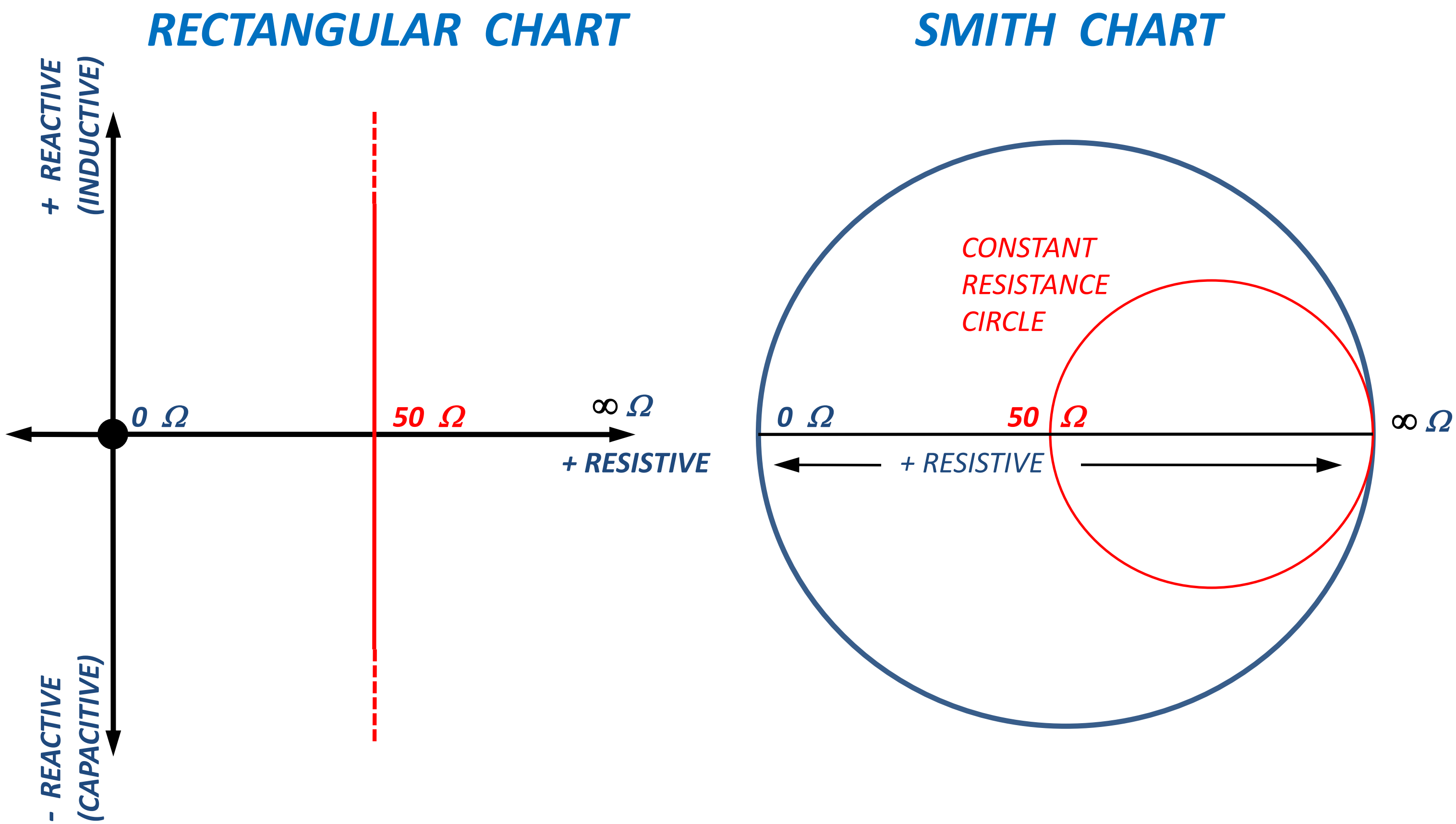






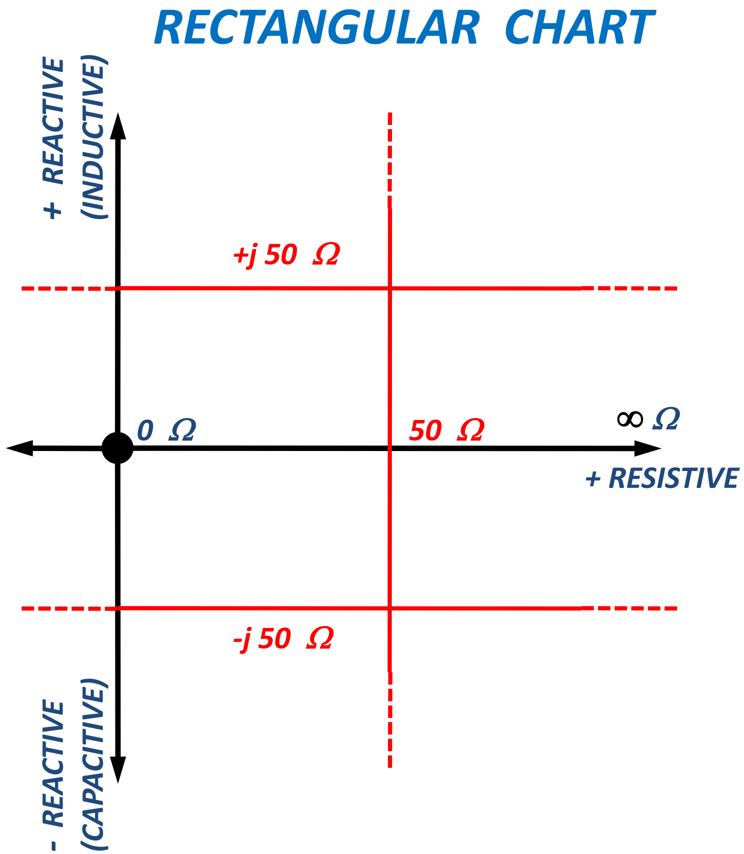
- ρ IS RATIO OF REFLECTED TO FORWARD VOLTAGE AT LOAD
- ρ IS COMPLEX NUMBER: (REAL, IMAGINARY) or (MAGNITUDE, ANGLE)
- |ρ| =1.0 IS MAXIMUM POSSIBLE WITH PASSIVE LOAD (TOTAL REFLECTION)
- |ρ| =1.0 CIRCLE IS OUTER BOUNDARY OF STANDARD SMITH CHART

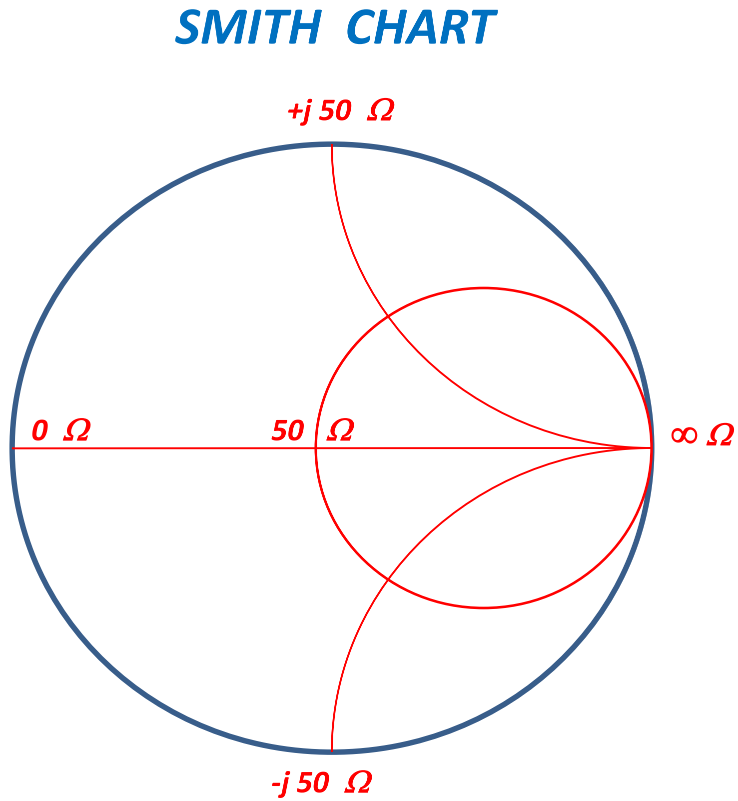
Impedance View – Constant Resistance



- **Z = R + j X**
- IMPEDANCE HAS A REAL PART AND AN IMAGINARY PART
- IMPEDANCE REPRESENTS A SERIES CONNECTION
- CONSTANT REAL LINES BECOME CIRCLES ON SMITH CHART

Impedance View – Constant Reactance



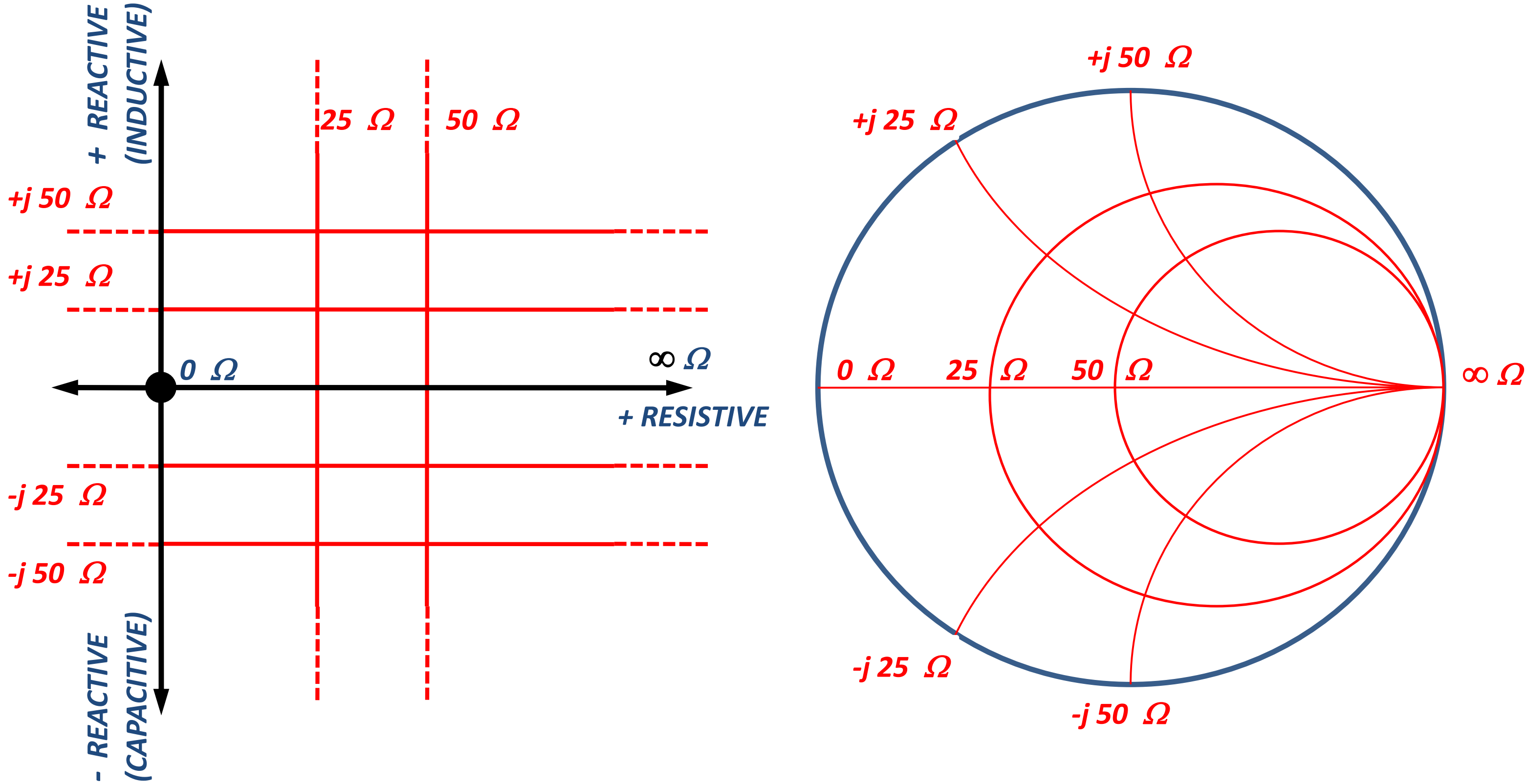


- CONSTANT REACTANCE LINES BECOME ARCS ON SMITH CHART
- UPPER HALF IS INDUCTIVE
- LOWER HALF IS CAPACITIVE
- POSITIVE REAL IS INSIDE THE SMITH UNIT CIRCLE

Impedance View

RECTANGULAR CHART

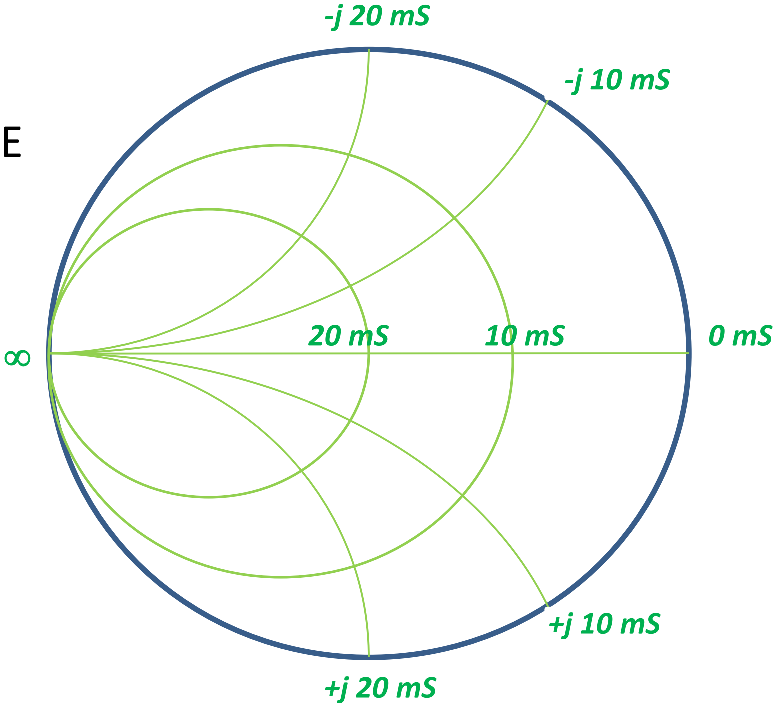
SMITH CHART



- IMPEDANCE REPRESENTATION OF THE SMITH CHART
- USUALLY IN RED
- LOWER HALF IS CAPACITIVE
- POSITIVE REAL IS INSIDE THE SMITH UNIT CIRCLE

Admittance View

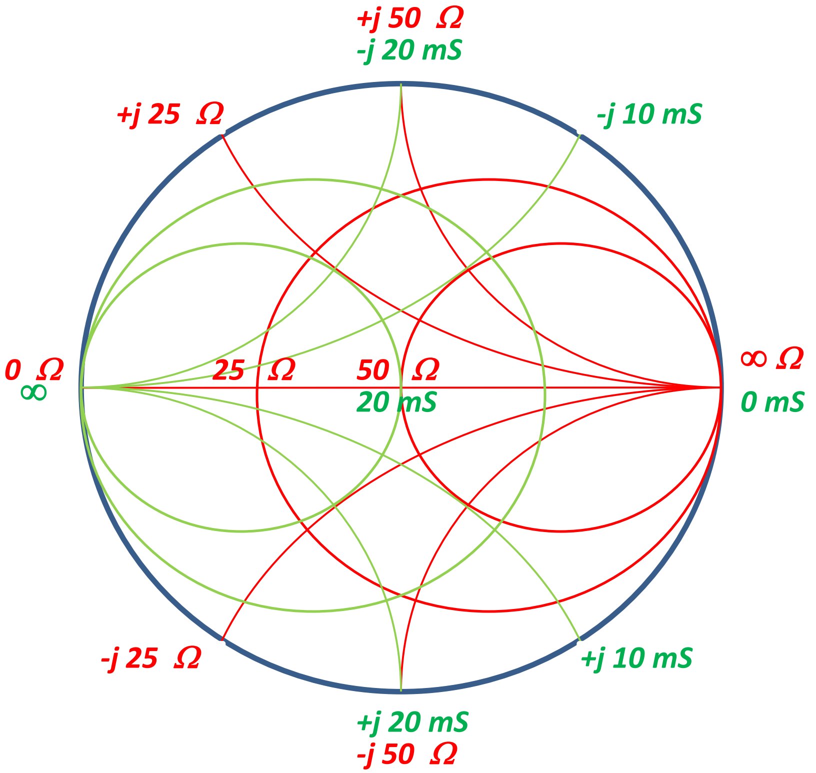
- **Y = 1/Z = G + j B**
- ADMITANCE IS RECIPROCAL IMPEDANCE
- ADMITANCE REPRESENTS A PARALLEL CONNECTION



- ADMITANCE HAS A REAL PART (CONDUCTANCE) AND AN IMAGINARY PART (SUSCEPTANCE)
- CONSTANT CONDUCTANCE IS A CIRCLE ON SMITH CHART
- CONSTANT SUSCEPTANCE IS AN ARC ON SMITH CHART

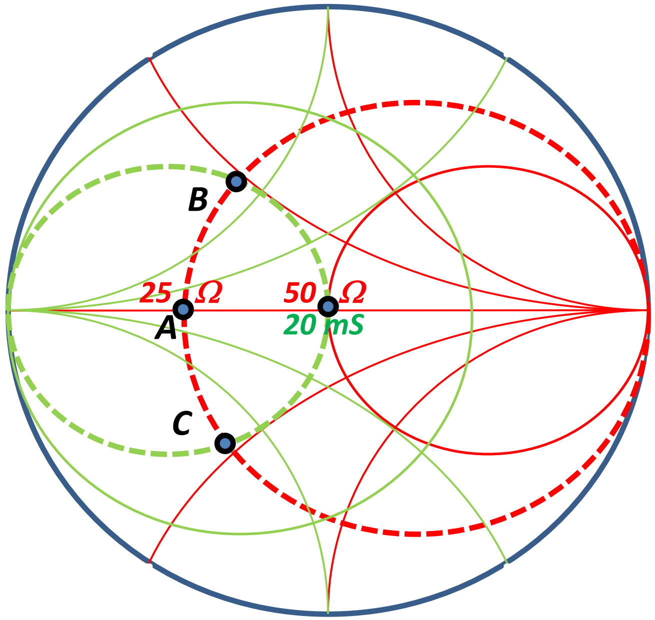
OVERLAY SMITH CHART

- BOTH IMPEDANCE AND ADMITANCE VIEWS OF SAME POINT
- SIMULTANEOUS VIEW OF SERIES IMPEDANCE OR PARALLEL ADMITTANCE
- THIS VIEW PROVIDES A CONVENIENT WAY TO DESIGN LUMPED ELEMENT MATCHING NETWORKS



Lumped Element Z-Matching

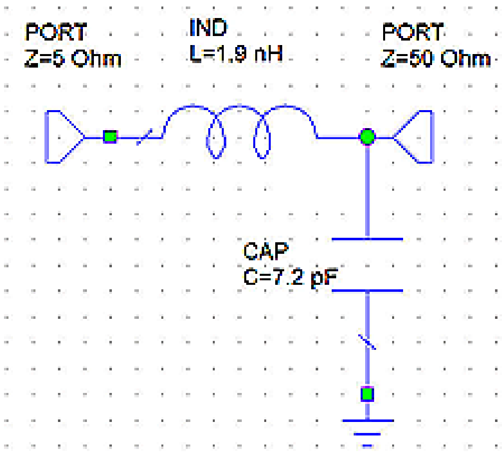
- A SIMPLE EXAMPLE IS TO MATCH BETWEEN 25 Ω AND 50 Ω
- FROM THE 25 Ω POINT WE FIRST USE THE IMPEDANCE VIEW TO MOVE TO EITHER POINT ***B*** OR ***C***
- THE (+) REACTIVE SHIFT FROM ***A*** TO ***B*** REPRESENTS A SERIES INDUCTOR
- THE (-) REACTIVE SHIFT FROM ***A*** TO ***C*** REPRESENTS A SERIES CAPACITOR
- NOTE THAT BOTH ***B*** and ***C*** ARE ON THE 20 mS CIRCLE. THIS ALLOWS US TO REACH 50 Ω WITH A SHUNT ELEMENT

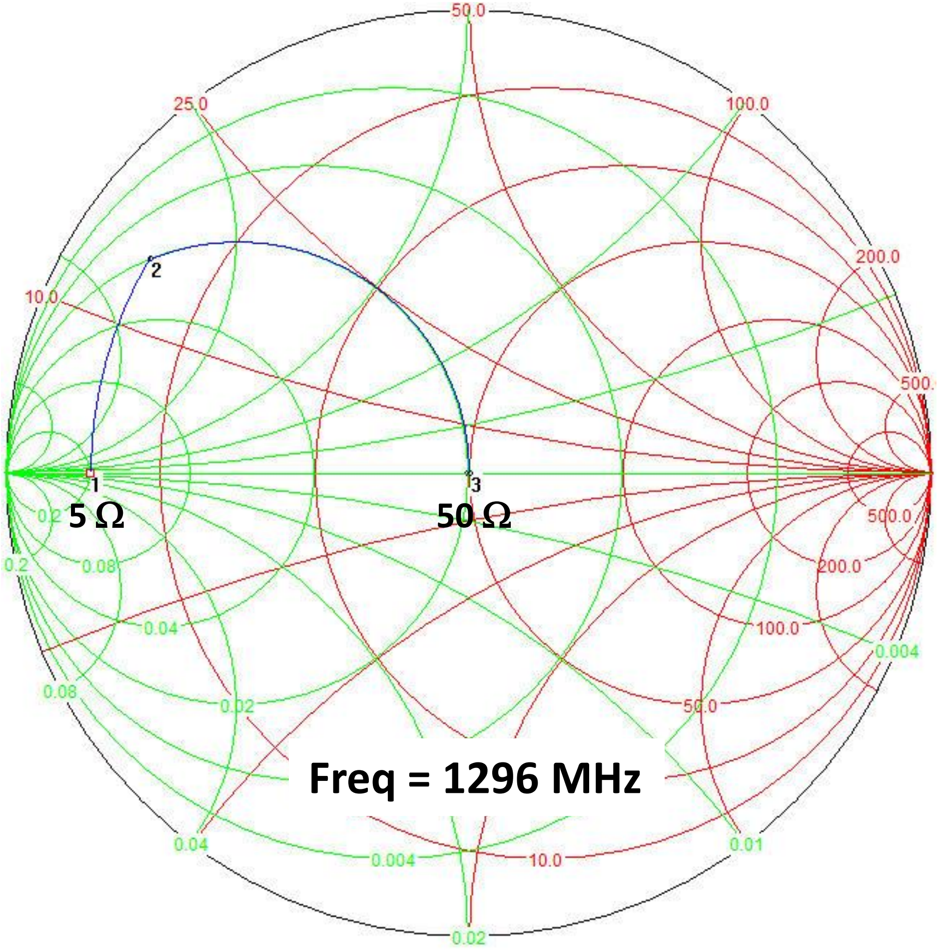


- THROUGH ***B*** REQUIRES SERIES INDUCTOR AND SHUNT CAPACITOR
- THROUGH ***C*** REQUIRES SERIES CAPACITOR AND SHUNT INDUCTOR

Examples: LP

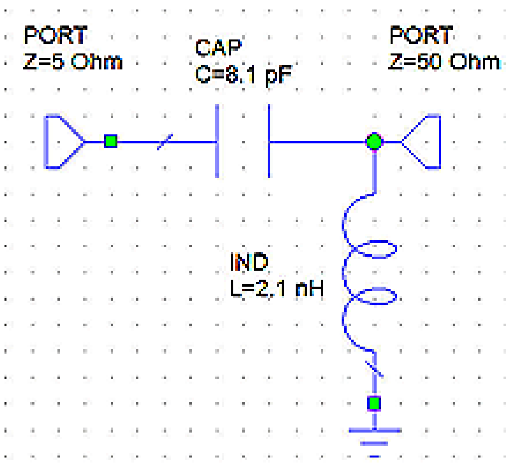
- 5 Ω to 50 Ω MATCH
- N=2 : SERIES L SHUNT C
- LOWPASS ELEMENTS

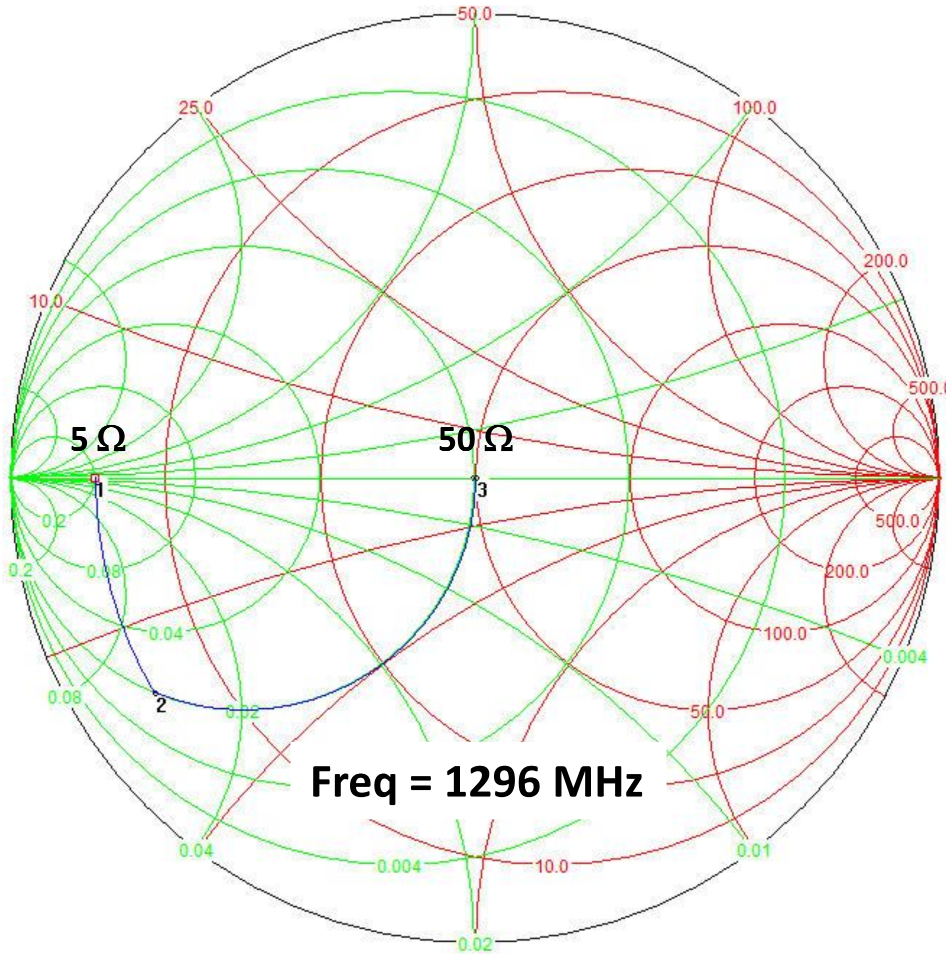




Examples : HP

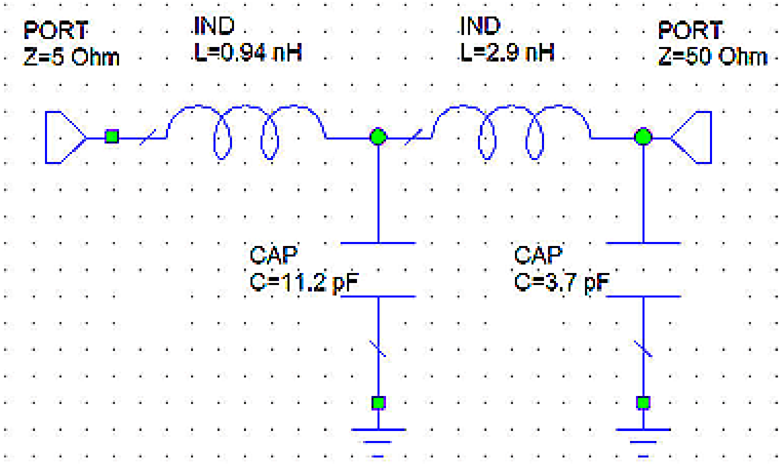
- 5 Ω to 50 Ω MATCH
- N=2 : SERIES C SHUNT L
- HIGHPASS ELEMENTS

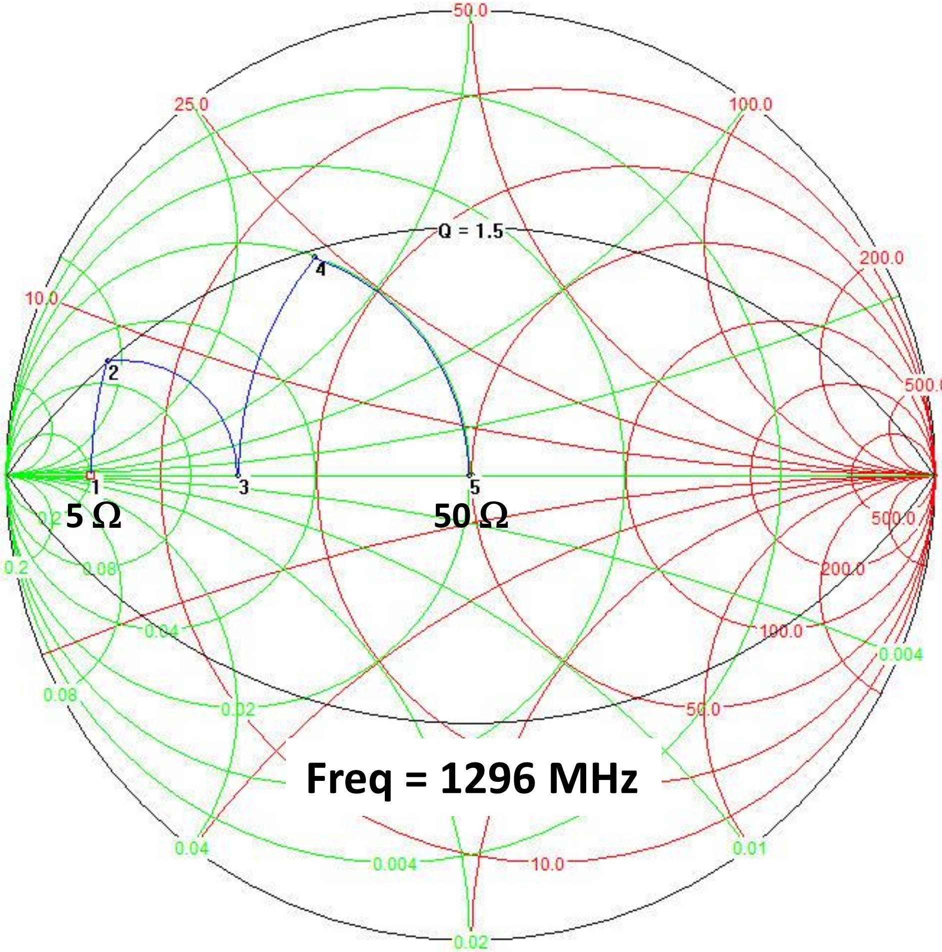




Examples : LPLP

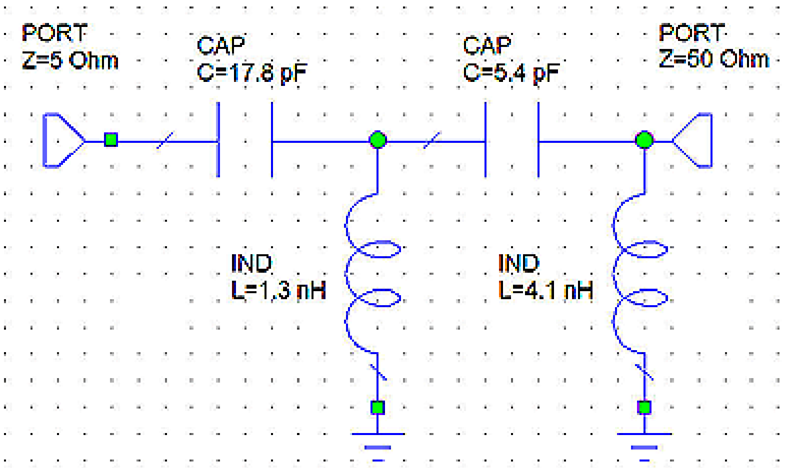
- 5 Ω to 50 Ω MATCH
- N=4 : SERIES L SHUNT C
  SERIES L SHUNT C
- LOWPASS ELEMENTS

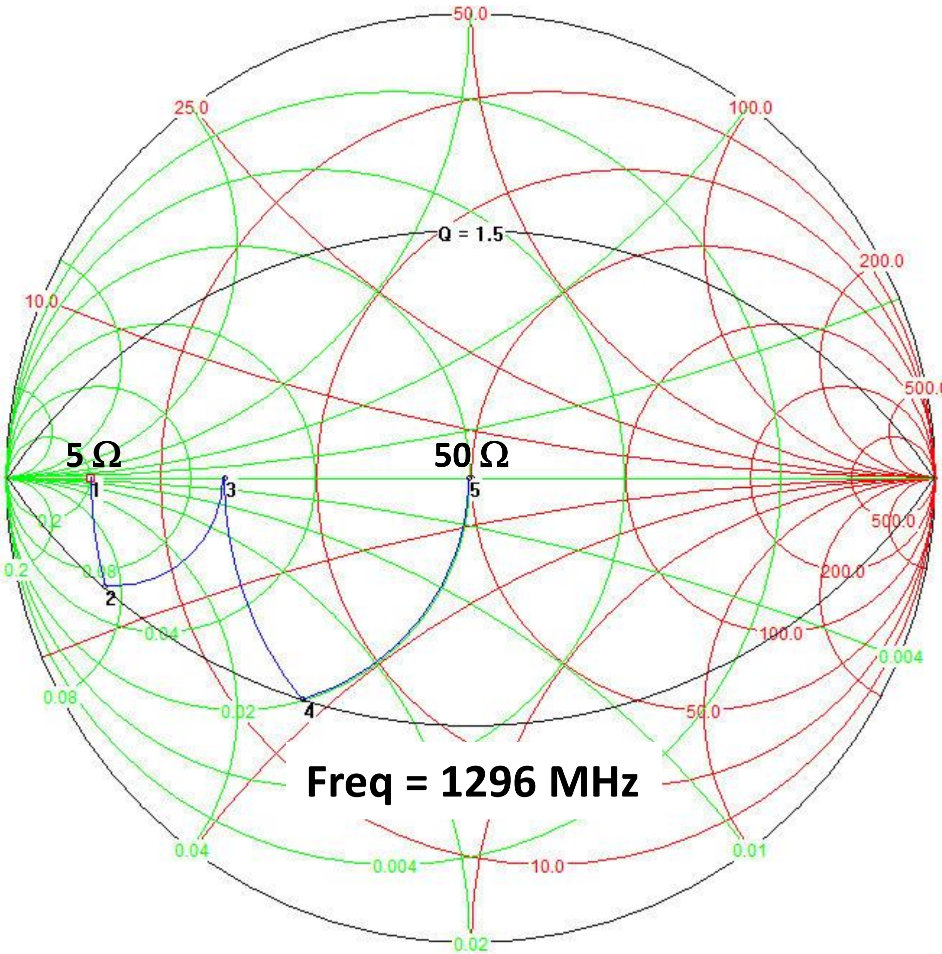




Examples : HPHP

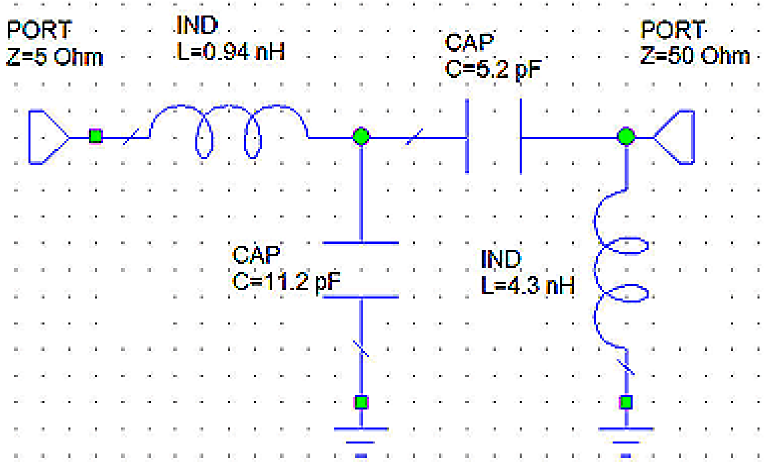
- 5 Ω to 50 Ω MATCH
- N=4 : SERIES C SHUNT L SERIES C SHUNT L
- HIGHPASS ELEMENTS

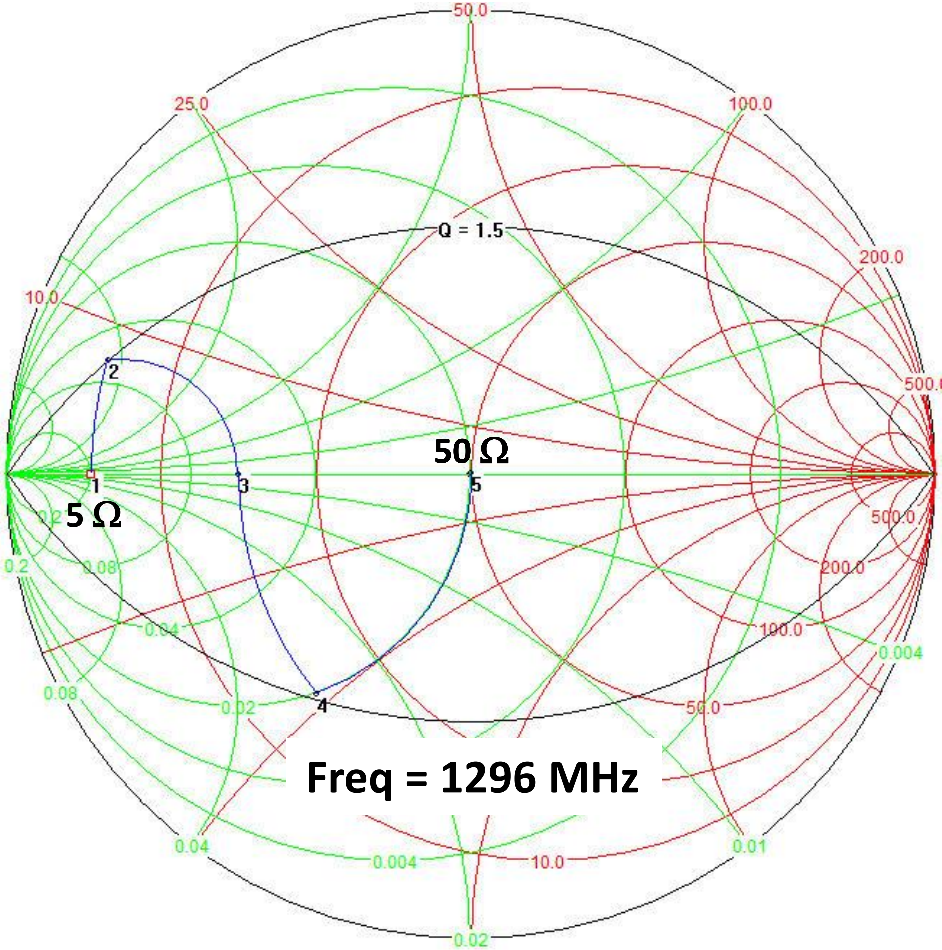




Examples : LPHP

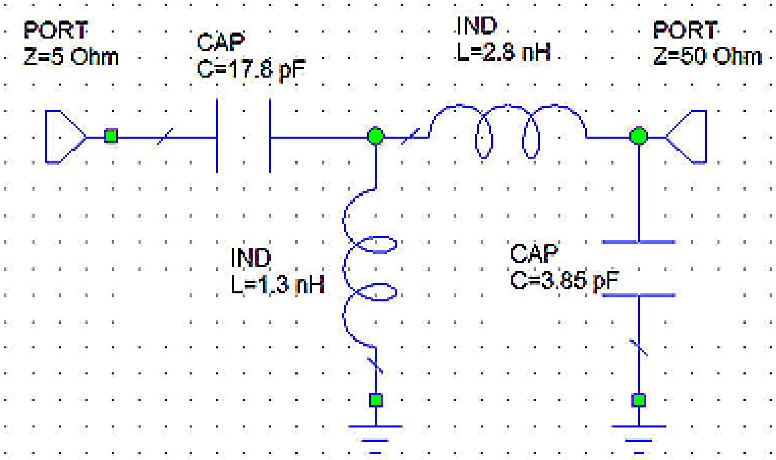
- 5 Ω to 50 Ω MATCH
- N=4 : SERIES L SHUNT C SERIES C SHUNT L
- BANDPASS ELEMENTS

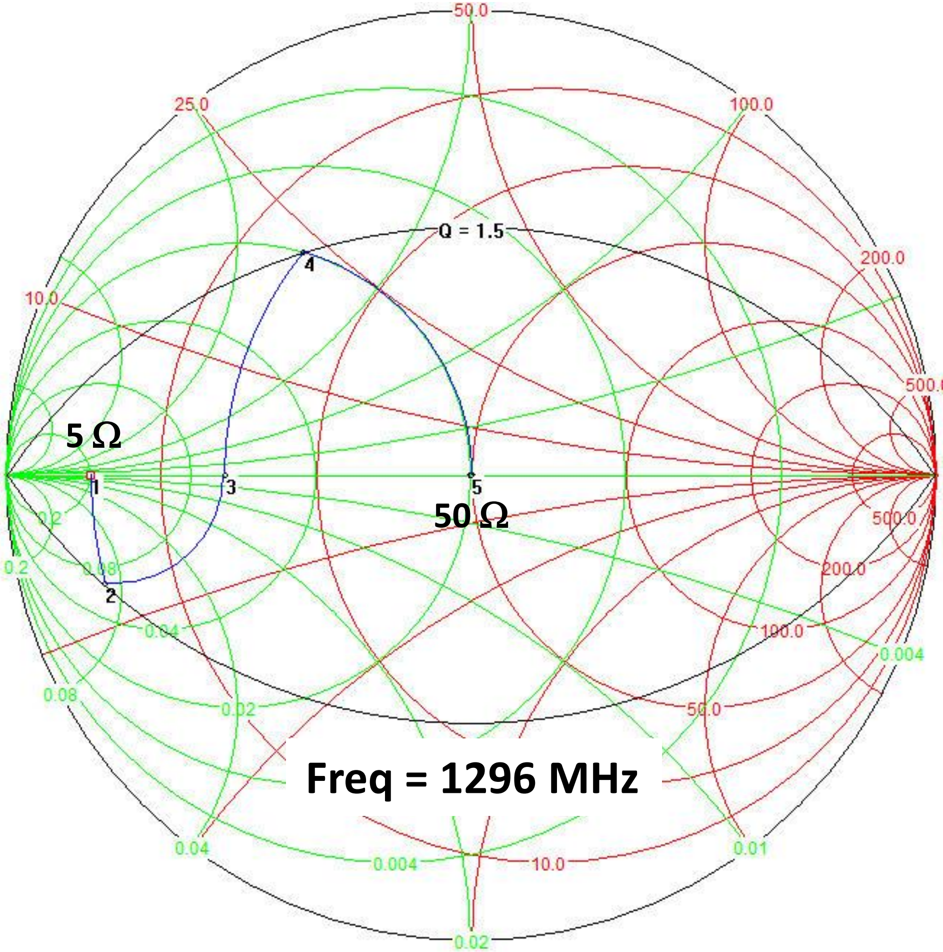




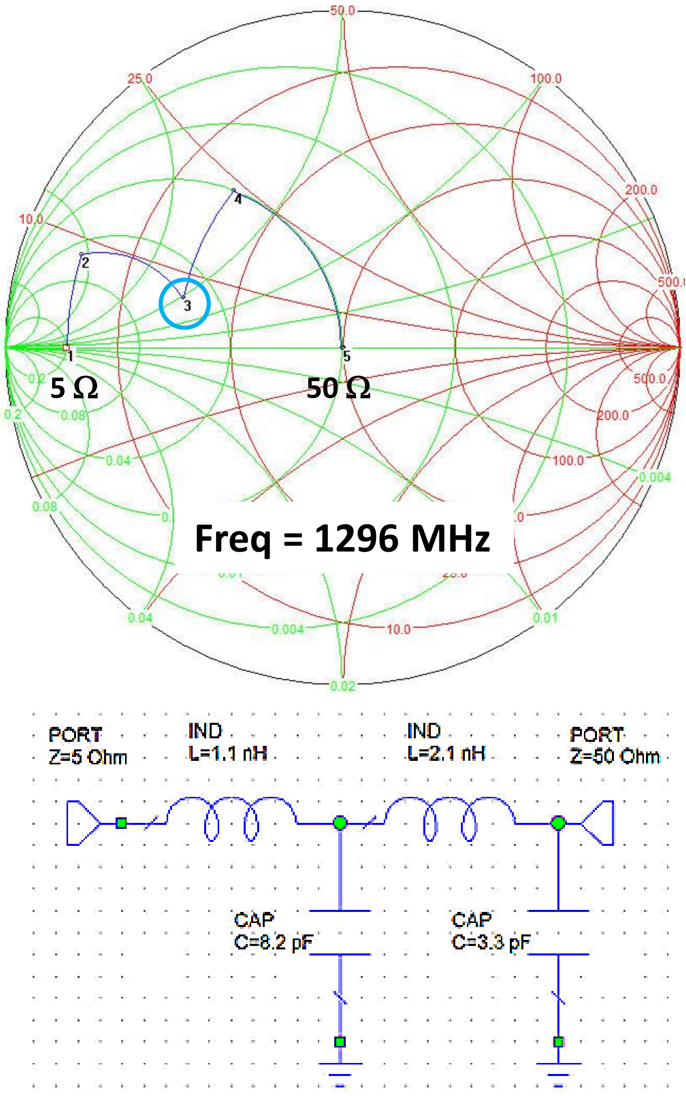
Examples : HPLP

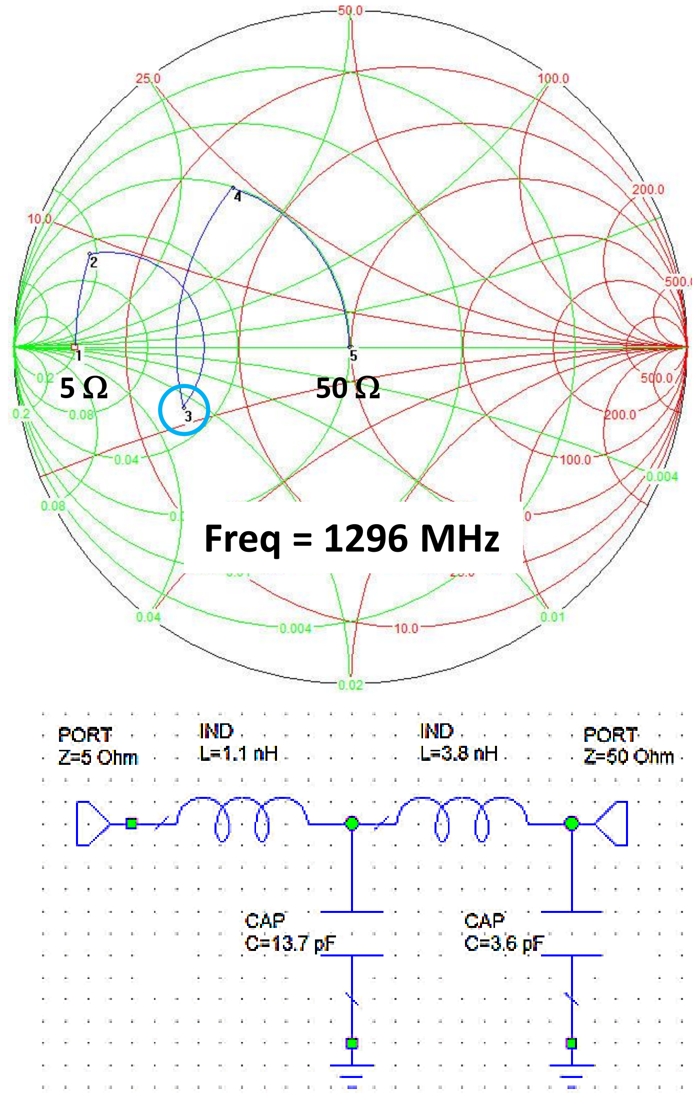
- 5 Ω to 50 Ω MATCH
- N=4 : SERIES C SHUNT L SERIES L SHUNT C
- BANDPASS ELEMENTS



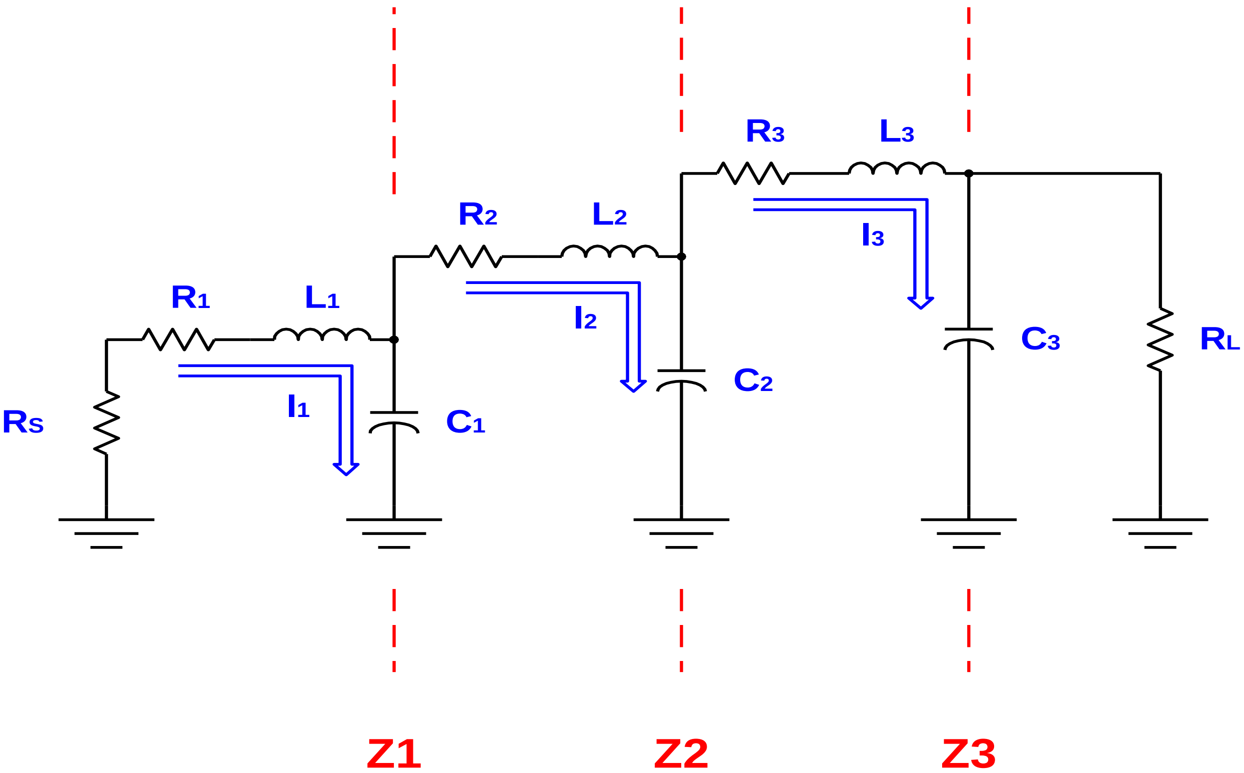


Different Internal Z





LOSS CONSIDERATIONS

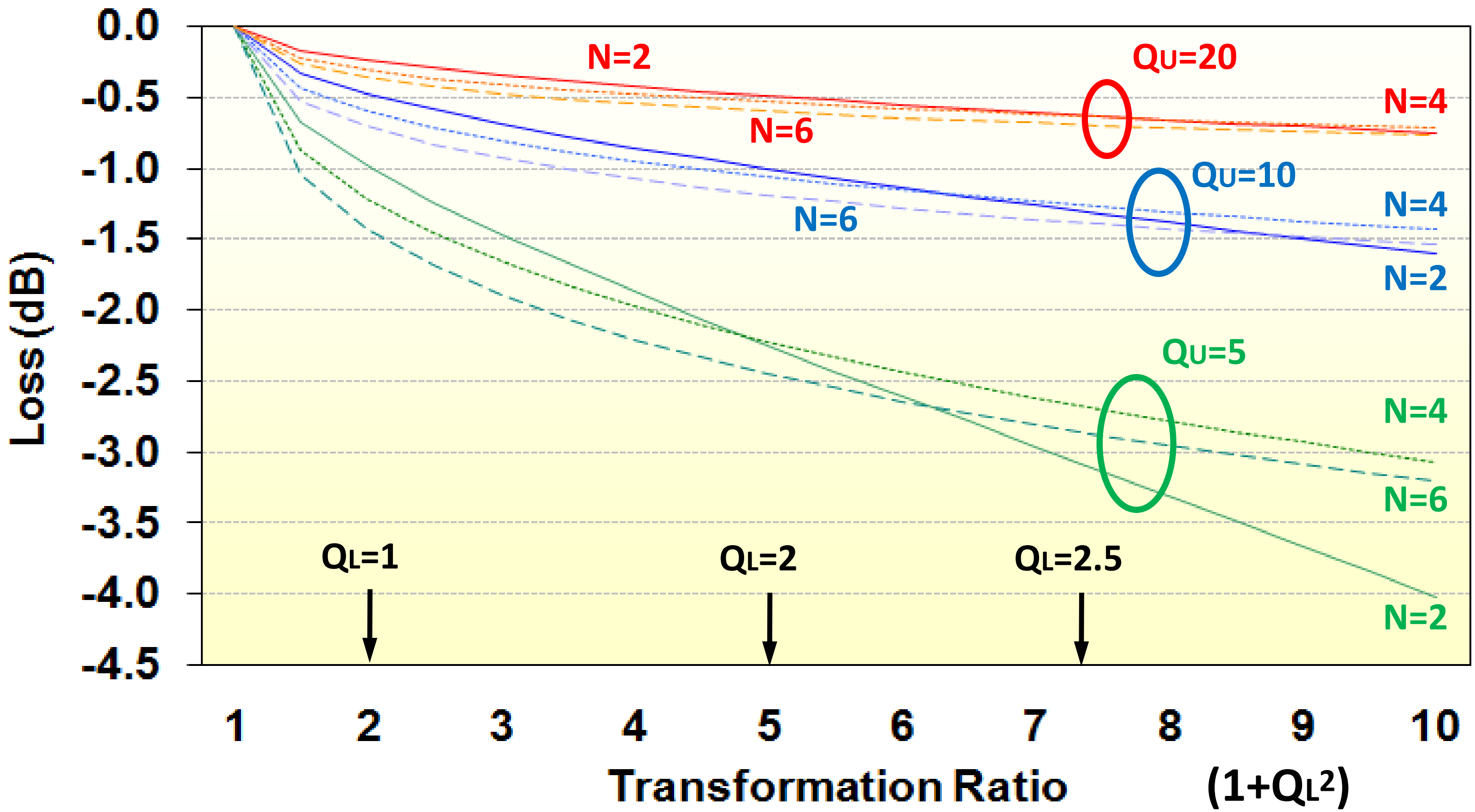


I1 > I2 > I3

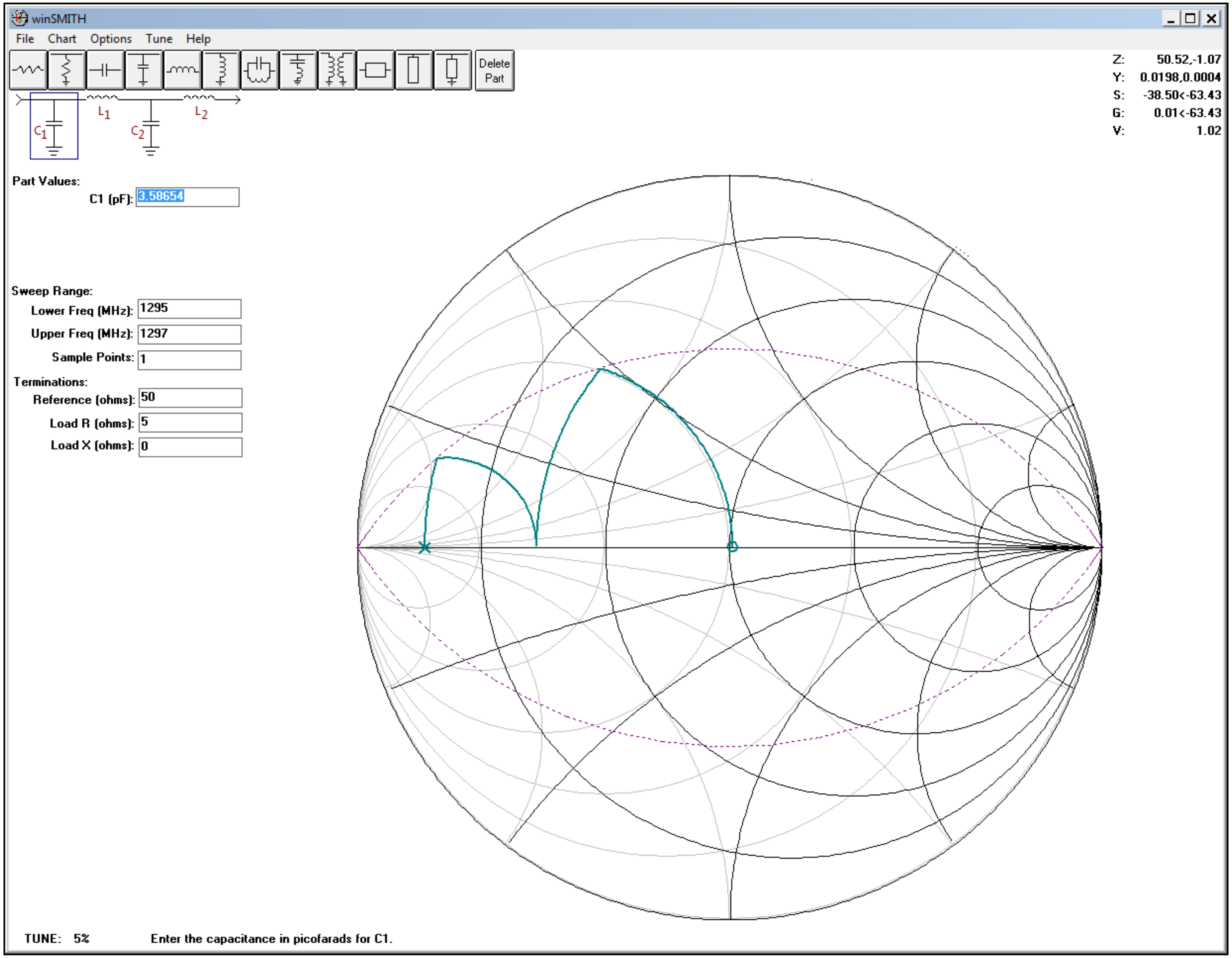
Z1 < Z2 < Z3

- Power transfer of each section is $(Q_U - Q_L) / Q_U$
- Impedance transformation requires $Q_L > 1$
- Z transformation per section is $1 + Q_L^2$
- $I^2 R$ losses (primarily in inductors) produces insertion loss

LOSS TRADE-OFFS



Software Tools: *WINSMITH*



Software Tools: ***SMITH***