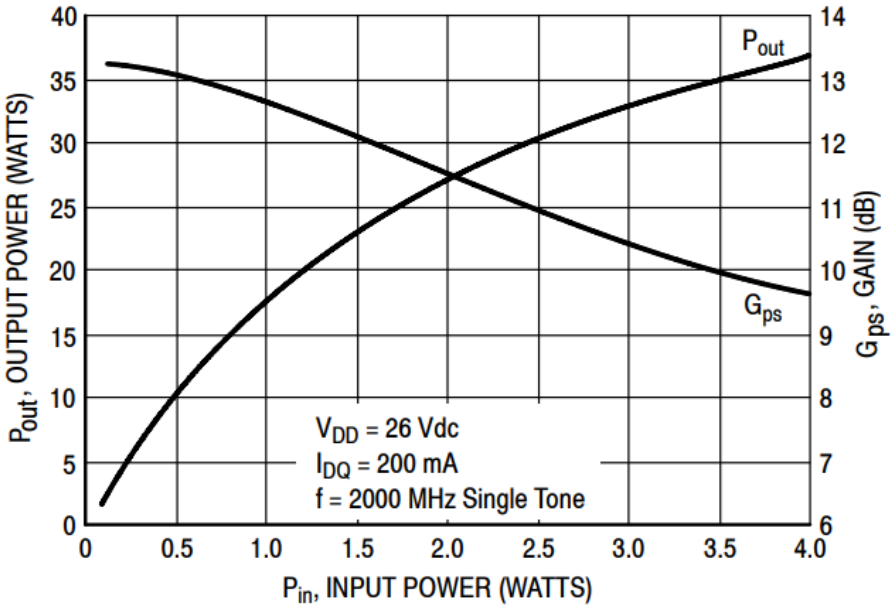
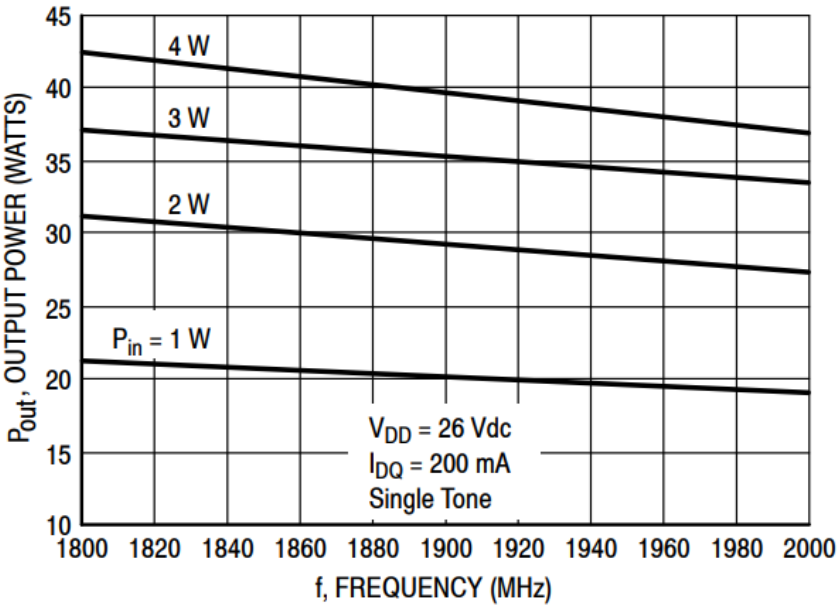
MICROSTRIP PA DESIGN

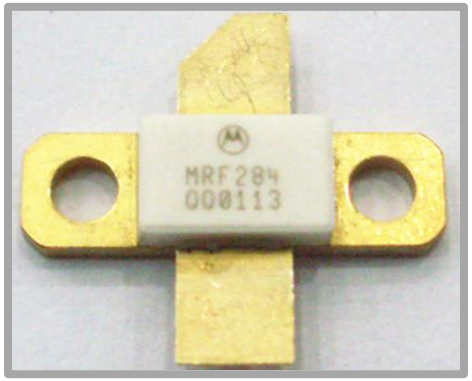
PART – I (MRF284 on 1296)

MRF284 LDMOS TRANSISTOR





- THE MRF284 IS A Si LDMOS POWER TRANSISTOR
- > 30W POWER OUTPUT AT Vdd = +26V
- MOTOROLA / NXP “OBSOLETE”
- EBAY AVAILABLE < $20



MRF284 TARGET IMPEDANCES

- OPTIMUM EXTERNAL IMPEDANCES at 1296 MHz :

  $Z_{S\ OPT} = 2.0 + j\ 2.5\ \Omega$

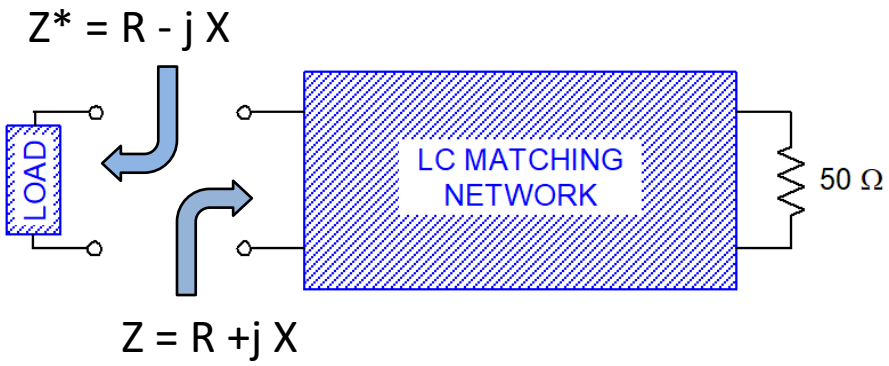
  $Z_{L\ OPT} = 3.0 + j\ 2.5\ \Omega$

- OPTIMUM MATCHING NETWORKS WILL PROVIDE A MATCH TO LOADS THAT ARE COMPLEX CONJUGATE OF THE OPTIMUMS

- SO, DESIGN MATCHING NETWORKS TERMINATED WITH:

  $Z^*_{S\ OPT} = 2.0 - j\ 2.5\ \Omega$

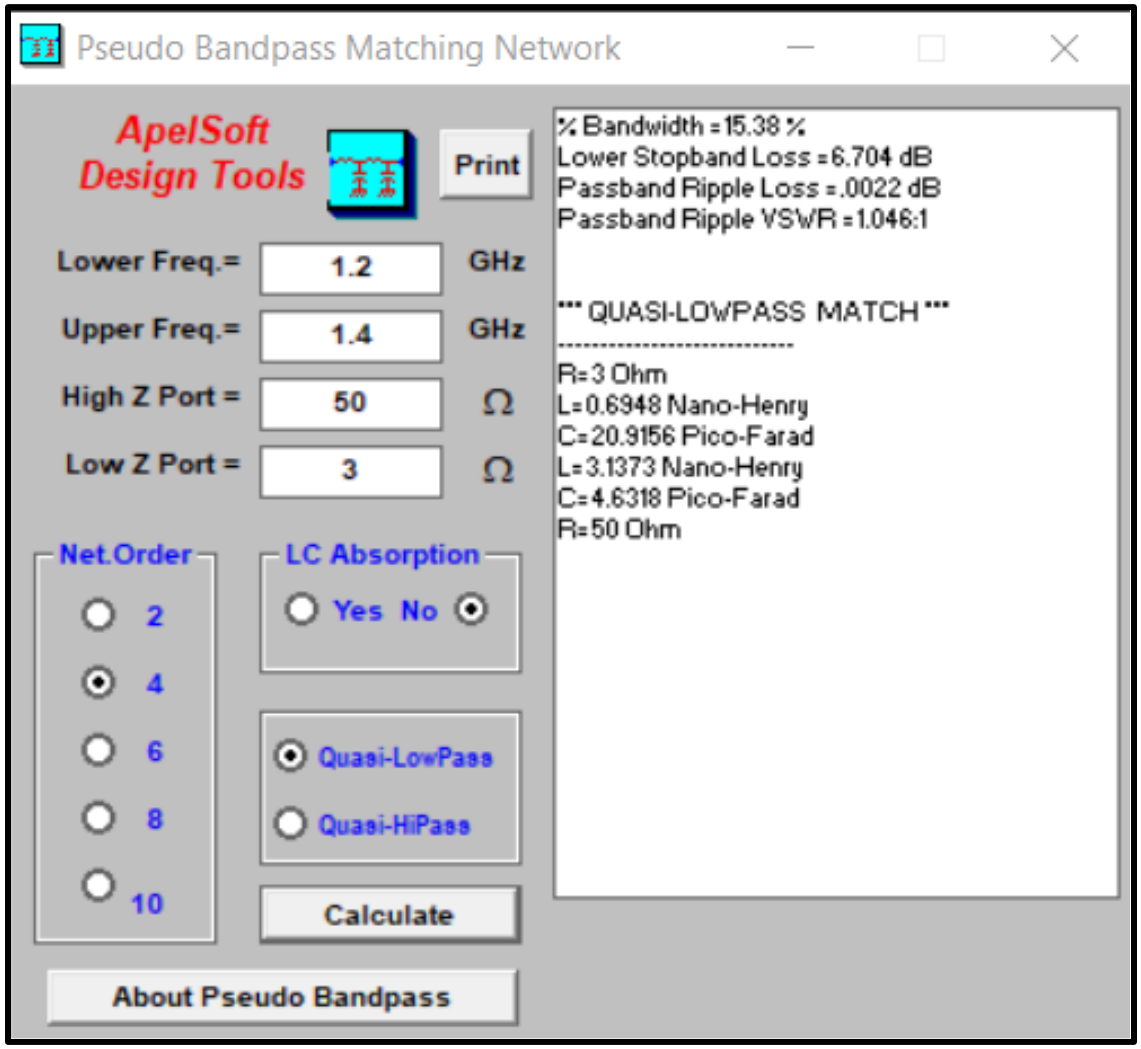
  $Z^*_{L\ OPT} = 3.0 - j\ 2.5\ \Omega$



INITIAL LUMPED LC DESIGN

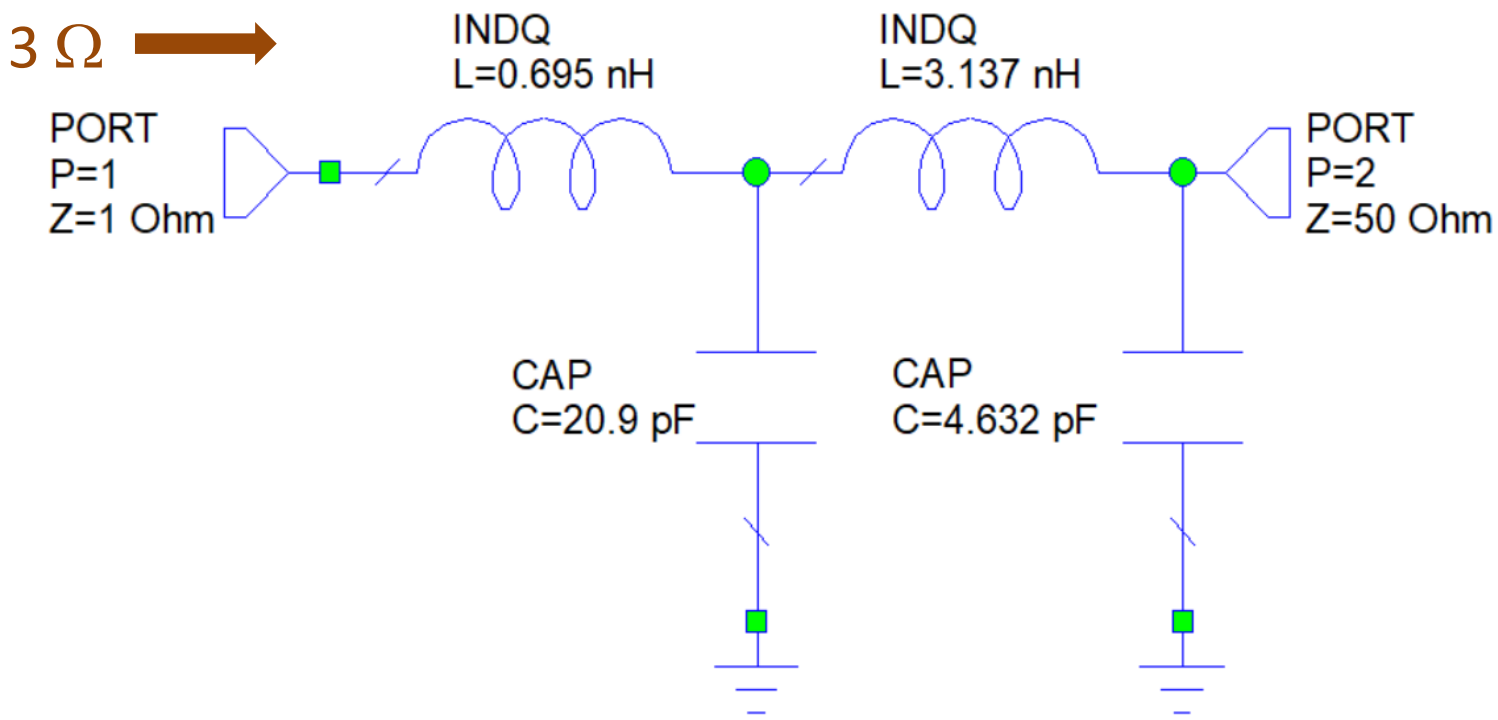
- THE FIRST STEP IN THE DESIGN IS A LUMPED LC MATCH
- THE OUTPUT MATCH WILL BE USED TO ILLUSTRATE THIS
- $Z_{L\ OPT} = 3.0 + j\ 2.5\ \Omega$
- WE WISH TO USE LOWPASS ELEMENTS (**L SERIES** & **C SHUNT**)
  - DESIGN A 4th ORDER PSEUDO BP MATCH TO 3 Ω
  - ADD 0.31 nH FOR +j 2.5 Ω

INITIAL 3 OHM MATCH

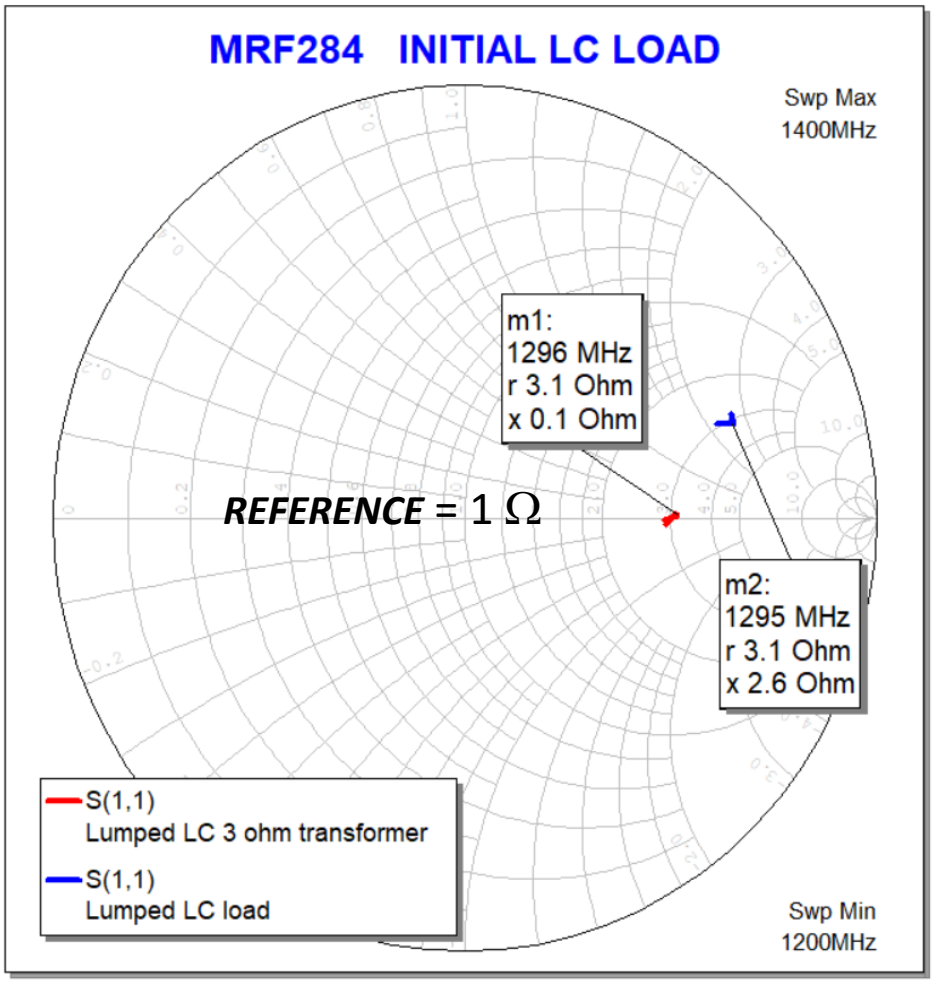


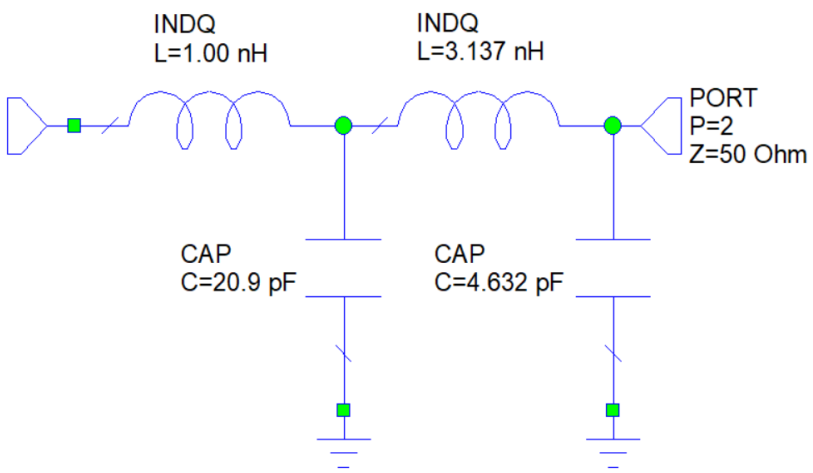
http://k5tra.net/TechFiles/PseudoBPmatch.exe

INITIAL 3 OHM MATCH



LUMPED LC MRF284 OUTPUT MATCH



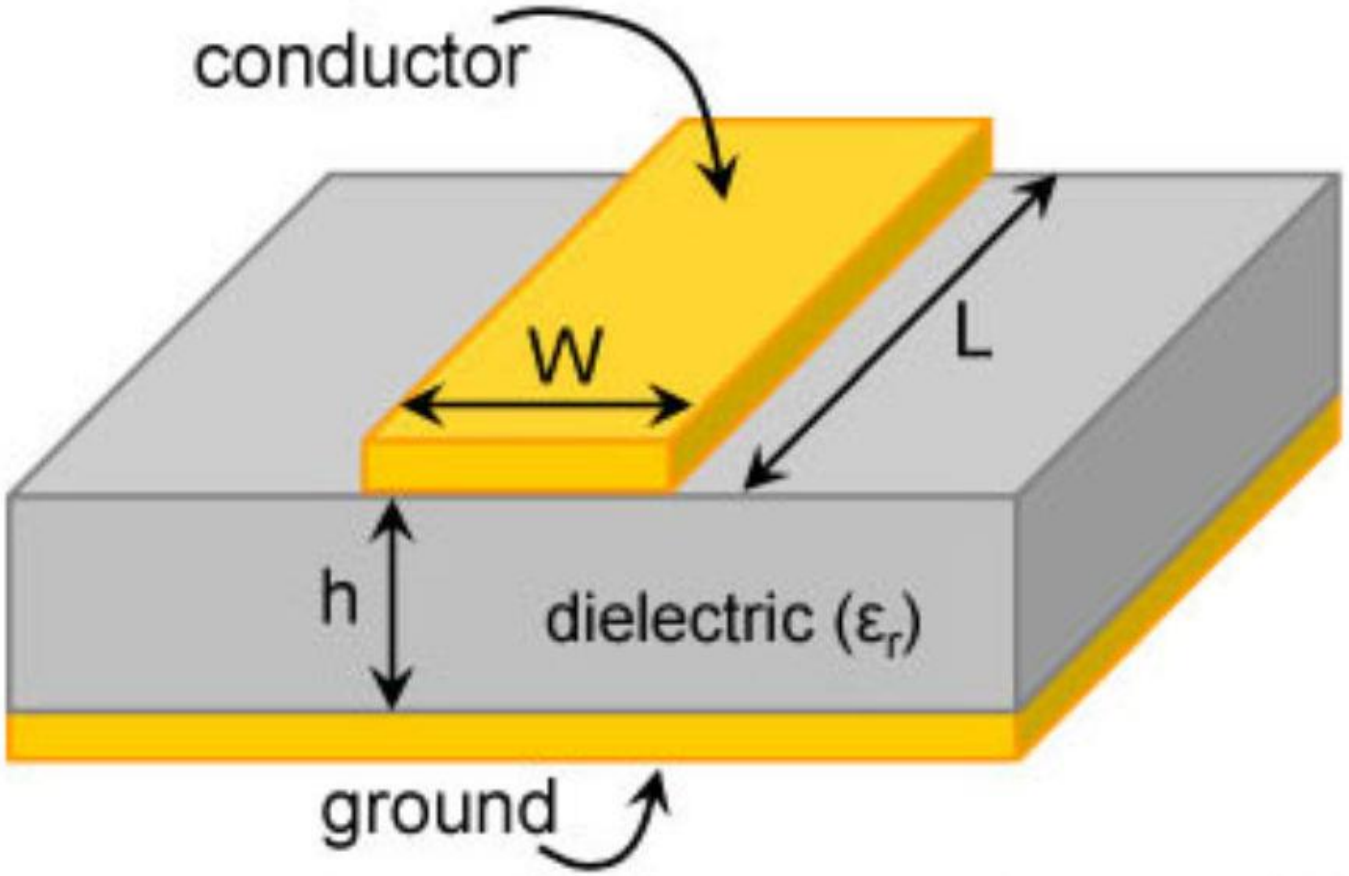


- ADD 0.31 nH to 0.695 nH
- TOTAL L SERIES = 1.00 nH

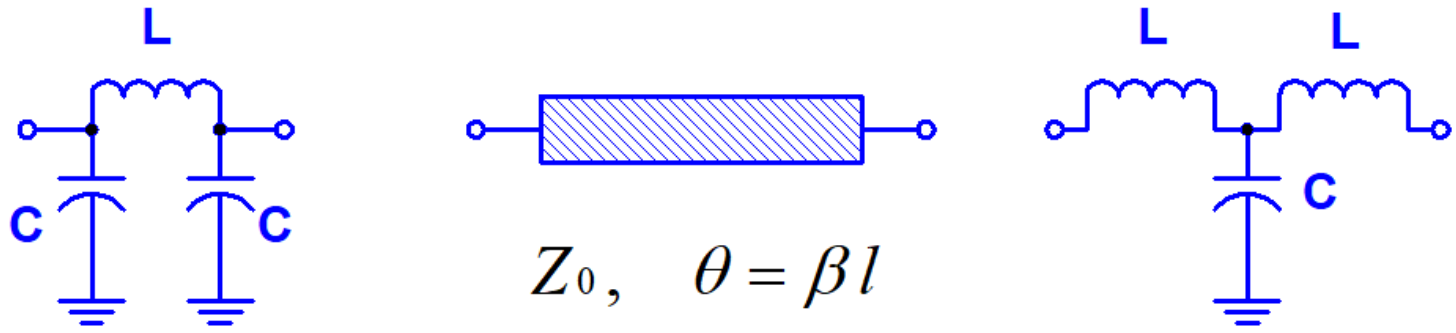
LUMPED DESIGN ON A CIRCUIT BOARD

- THERE REALLY ARE NO LUMPED ELEMENTS
  - CHIP CAPACITORS HAVE SERIES INDUCTANCE (and LOSS)
  - CHIP INDUCTORS HAVE DISTRUBUTED CAPACITNCE (SELF RESONANCE)
  - CHIP RESISTORS HAVE SERIES INDUCTANCE AND SHUNT CAPACITANCE
- CIRCUIT BOARD TRACES OVER BACKSIDE GROUND ARE MICROSTRIP TRANSMISSION LINES.
- MICROSTRIP LINES ARE QUASI-TEM; SO THEY CAN BE REPRESENTED AS A SERIES OF INCREMENTAL SERIES L AND SHUNT C ELEMENTS.
- $Z_0 = \sqrt{\frac{L}{C}}$, WHERE L AND C ARE INCREMENTAL (PER UNIT LENGTH)
- THIN TRACES:
  - HIGH Zo TRACES HAVE HIGH L/C
  - USED FOR PRINTED INDUCTORS
- WIDE TRACES:
  - LOW Zo TRACES HAVE MORE C
  - PROVIDE SHUNT C (AND SOME SERIES L)

MICROSTRIP TRANSMISSION LINES



LC REPRESENTATION OF A SHORT LINE



$$X_L = Z_0 \bullet Sin(\beta l)$$

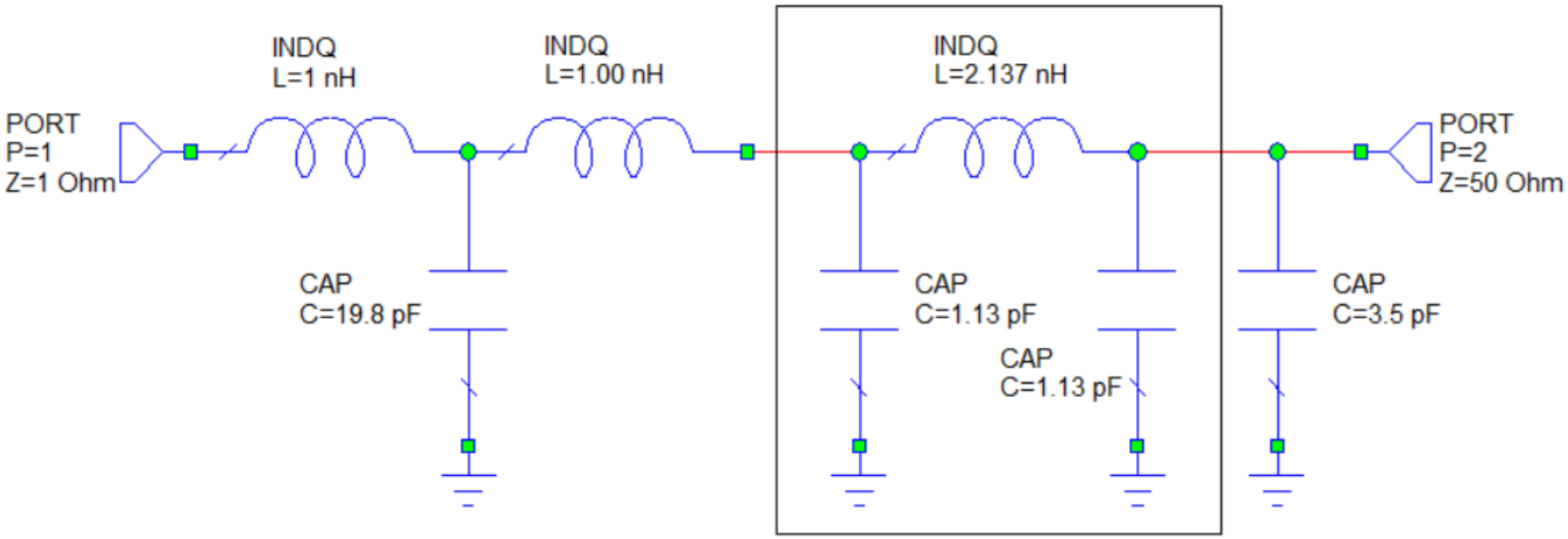
$$X_C = Z_0 \bullet Cot(\beta l/2)$$

$$X_L = Z_0 \bullet Tan(\beta l/2)$$

$$X_C = \frac{Z_0}{Sin(\beta l)}$$

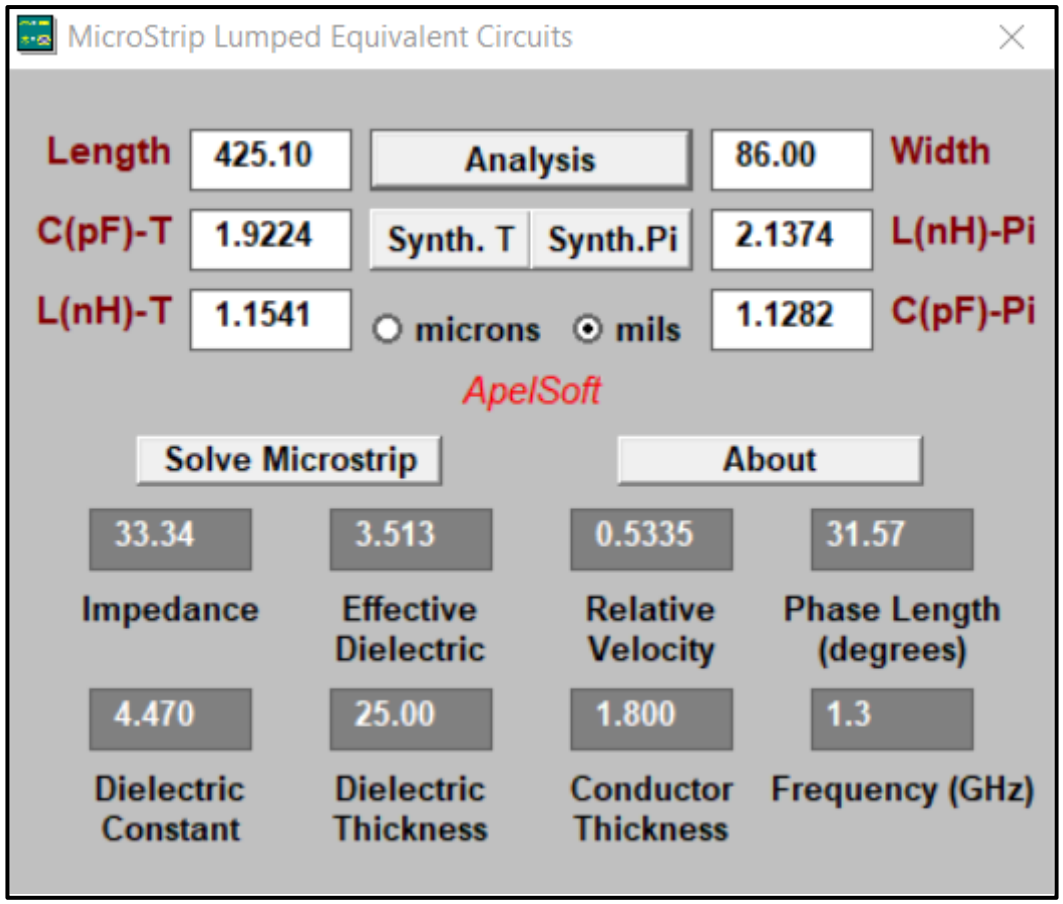
- HIGH Zo LINES USE THE π CIRCUIT FOR INDUCTOR REPRESENTATION
- THE END CAPACITANCES ARE SMALL WITH HIGH Zo LINES
- LOW Zo LINES USE THE T CIRCUIT FOR CAPACITOR REPRESENTATION
- THE END INDUCTANCES ARE SMALL WITH LOW Zo LINES

PARTITIONED LC OUTPUT MATCH



86 mil x 425 mil
MICROSTRIP

LUMPED EQUIVALENT CALCULATOR



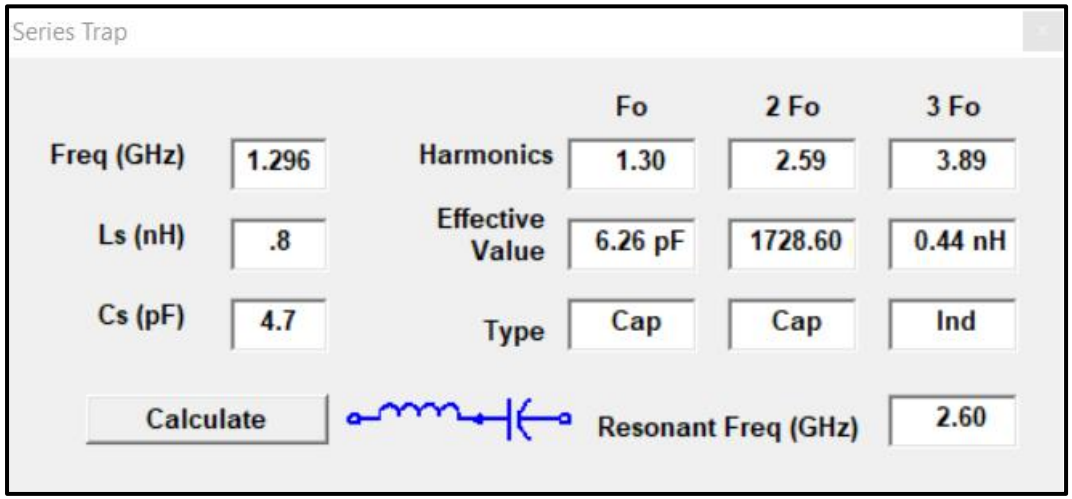
- MICROSTRIP ANALYSIS AND SYNTHESIS
- π and T EQUIVALENT CIRCUIT CALCULATION
- SELECTABLE UNITS: MILS OR MICRONS

http://k5tra.net/TechFiles/LumpEquiv.exe

SMD CHIP SERIES INDUCTANCE

SMD + PTH SERIES INDUCTANCE

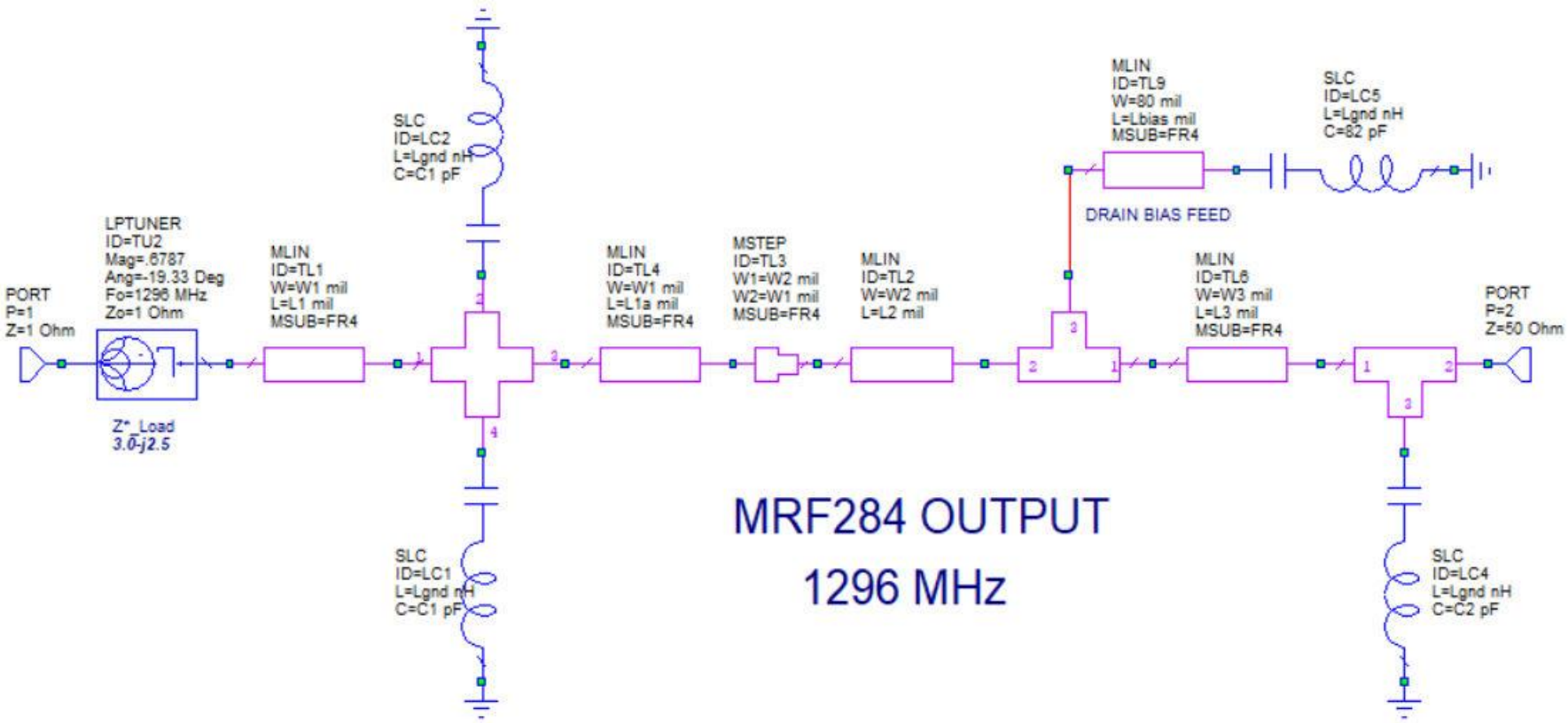
CHIP PKG	DIM (mil^2)	L(nH)
0402	40x20	0.59
0603	60x30	0.77
0805	80x50	0.84
ATC 100A	55x55	0.55
ATC 100B	110x110	0.77



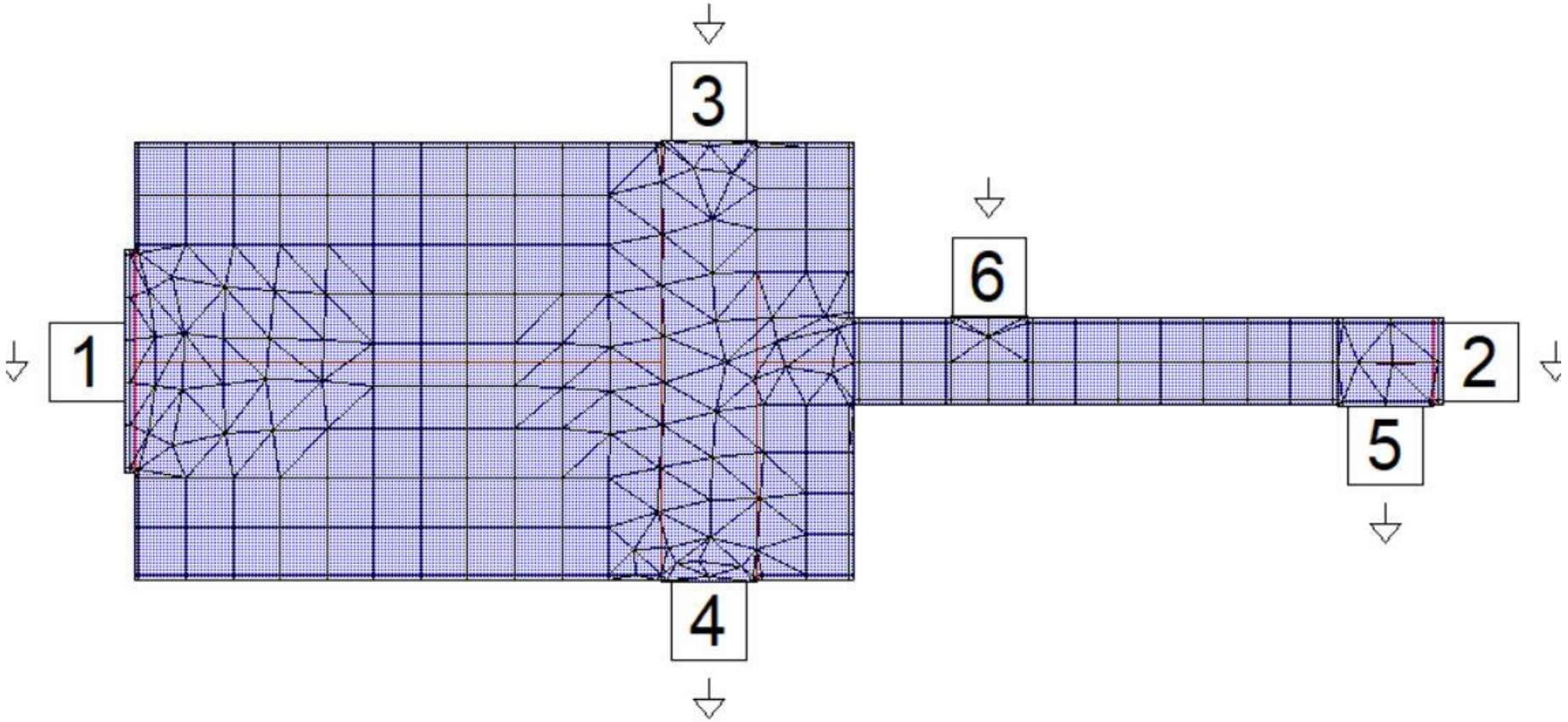
http://k5tra.net/TechFiles/SeriesTrap.exe

- AN **0805 4.7 pF** CAP ALSO HAS 0.8 nH SERIES INDUCTANCE
- SERIES RESONANT FREQUENCY IS 2.59 GHz (2nd HARMONIC SHORT)
- **EFFECTIVE CAPACITANCE IS 6.26 pF AT 1296 MHz**
- EFFECTIVE CAPACITANCE IS 1720 pF AT 2nd HARMONIC OF 1296 MHz
- EFFECTIVE INDUCTANCE IS 0.44 nH AT 3rd HARMONIC OF 1296 MHz

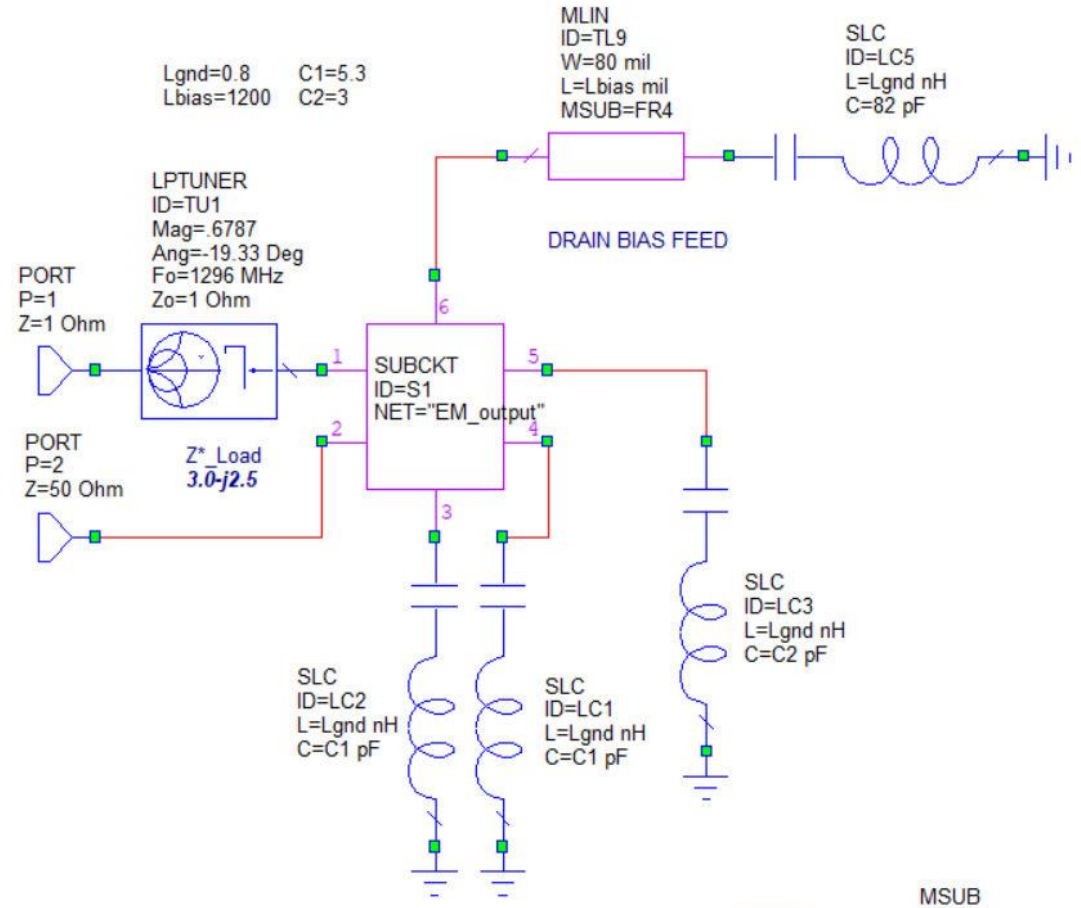
MICROSTRIP DESCRIPTION – MRF286 OUTPUT



EM SIMULATION GEOMETRY – MRF286 OUTPUT



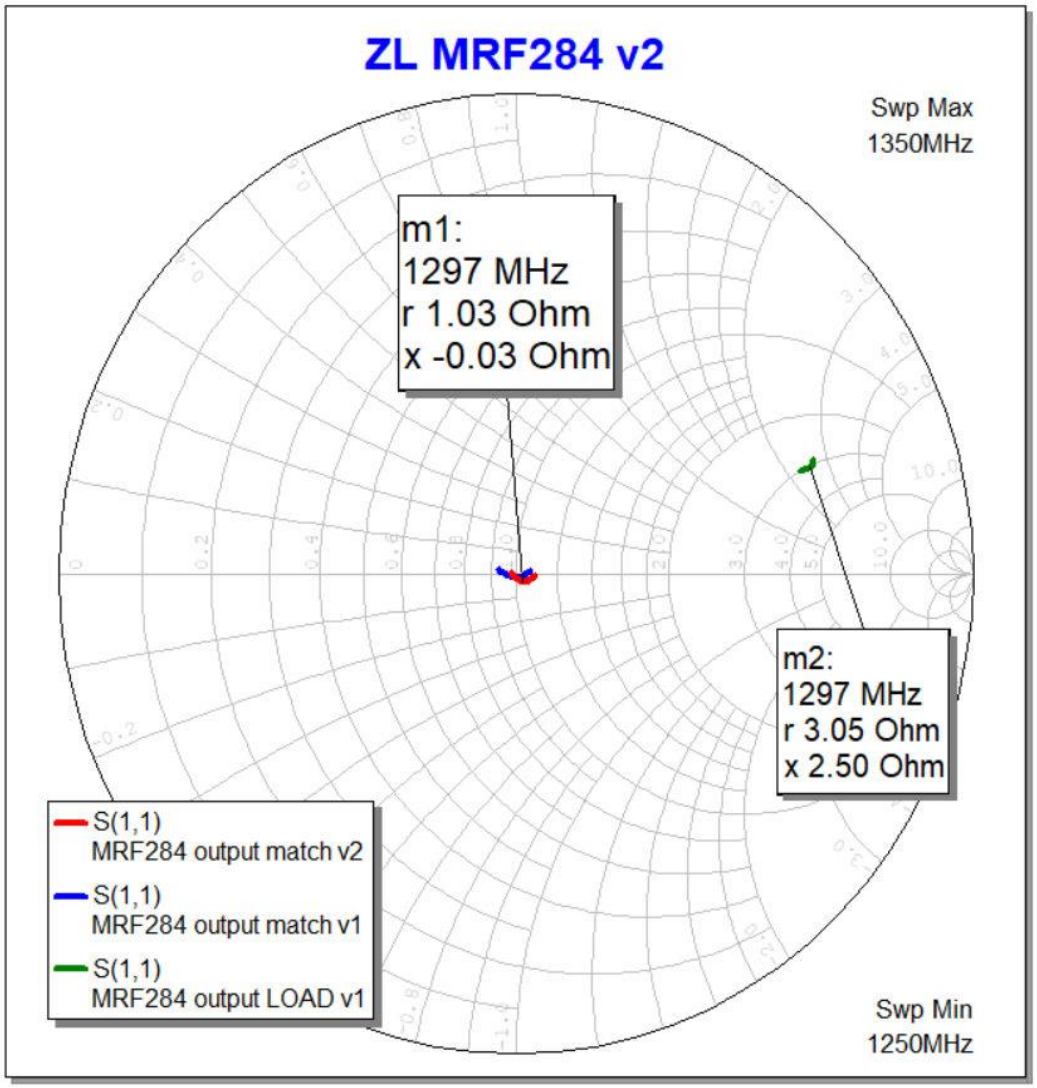
EM SIMULATION DATA IN CIRCUIT SIMULATOR



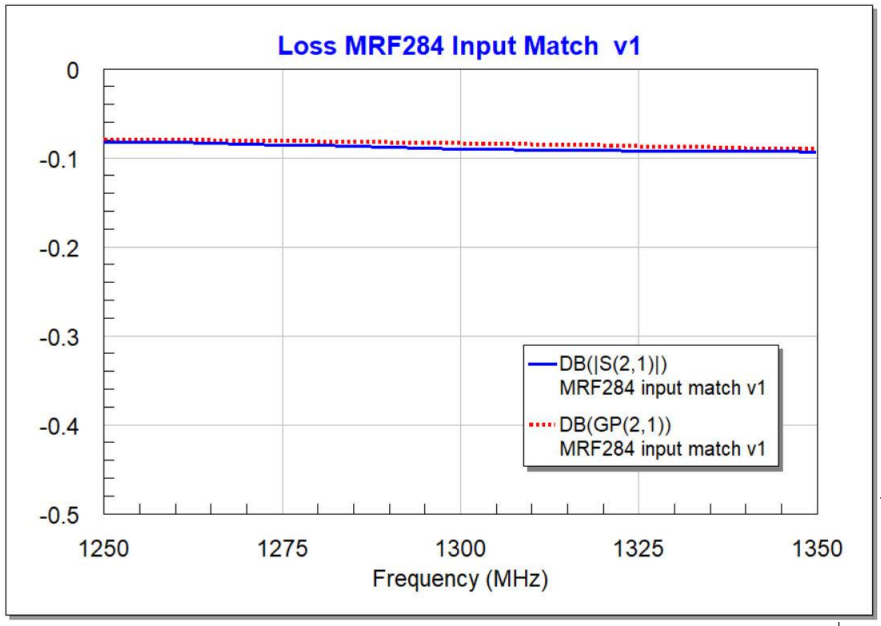
MRF284 OUTPUT

1296 MHz

EM SIMULATION DATA IN CIRCUIT SIMULATOR

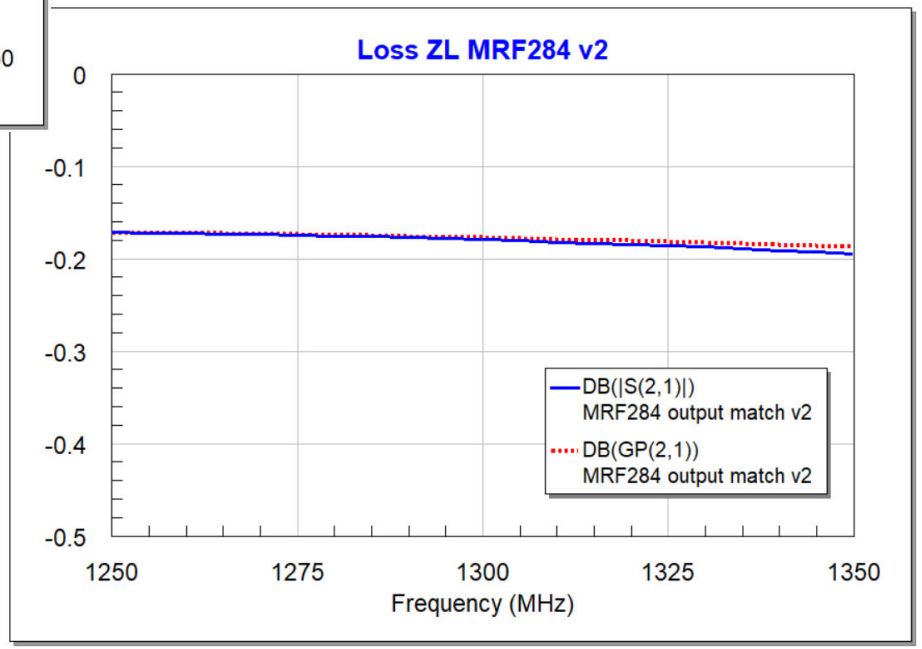


EM SIMULATION DATA IN CIRCUIT SIMULATOR

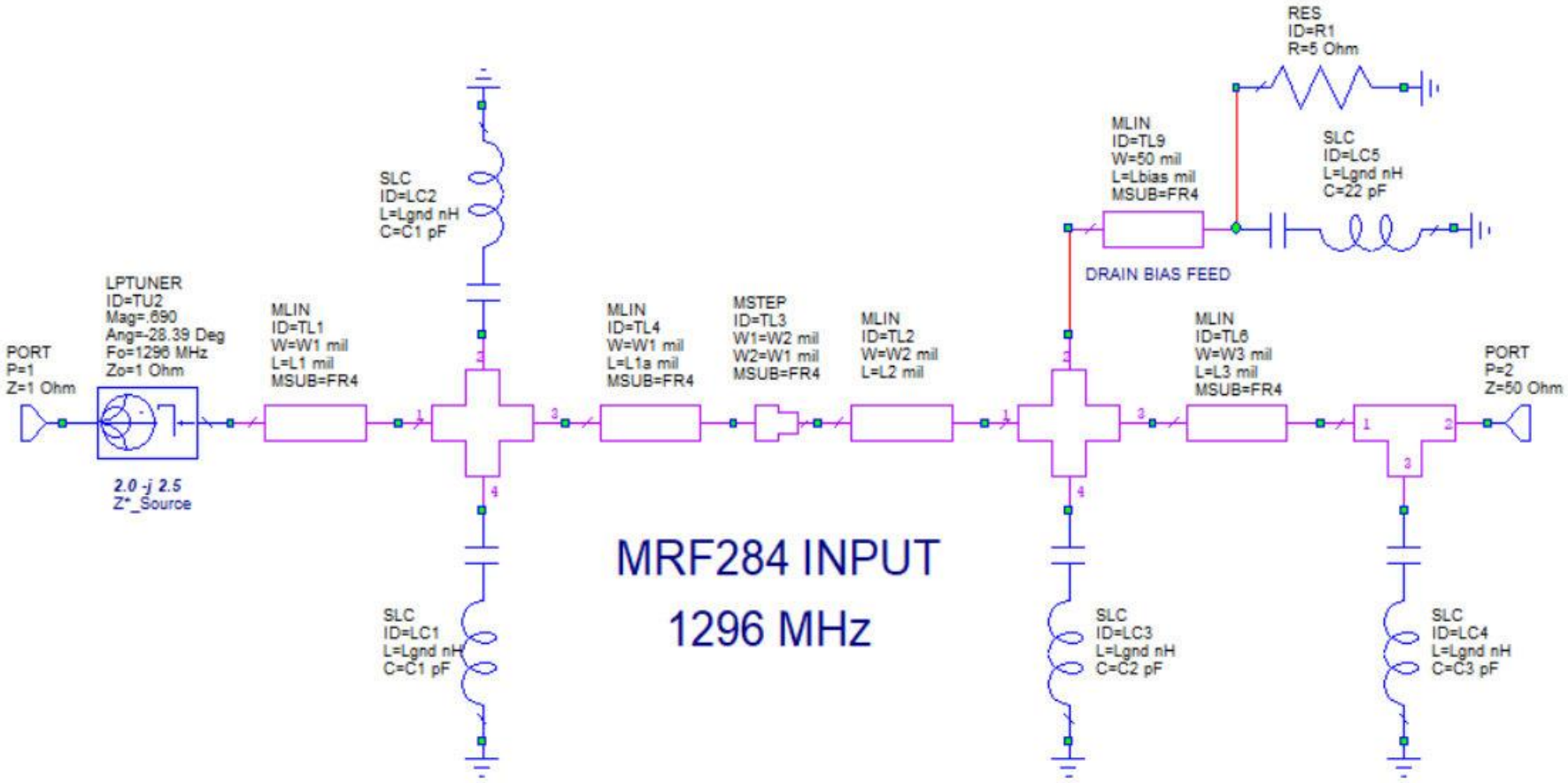


MICROSTRIP DESCRIPTION LOSS

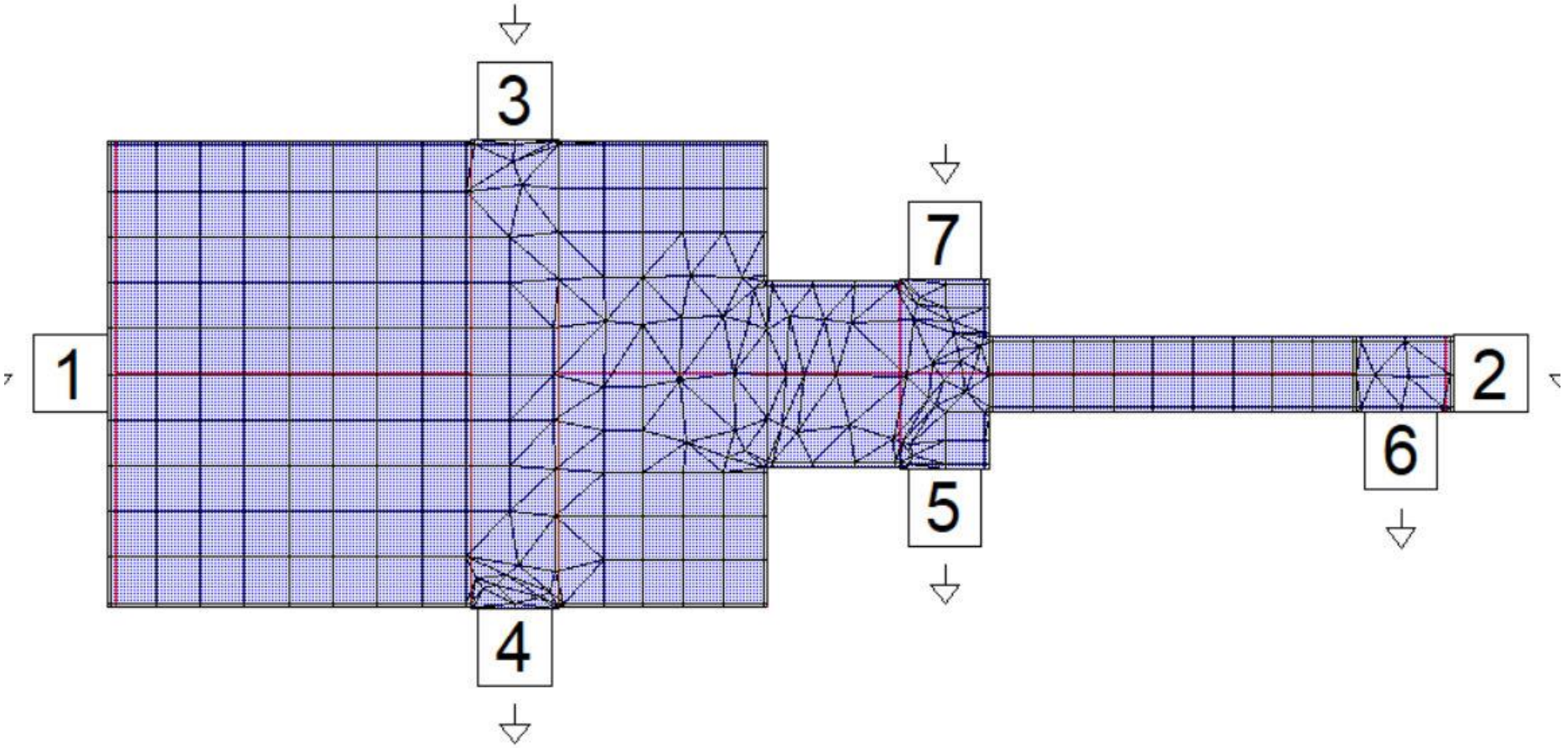
EM SIMULATION DESCRIPTION LOSS



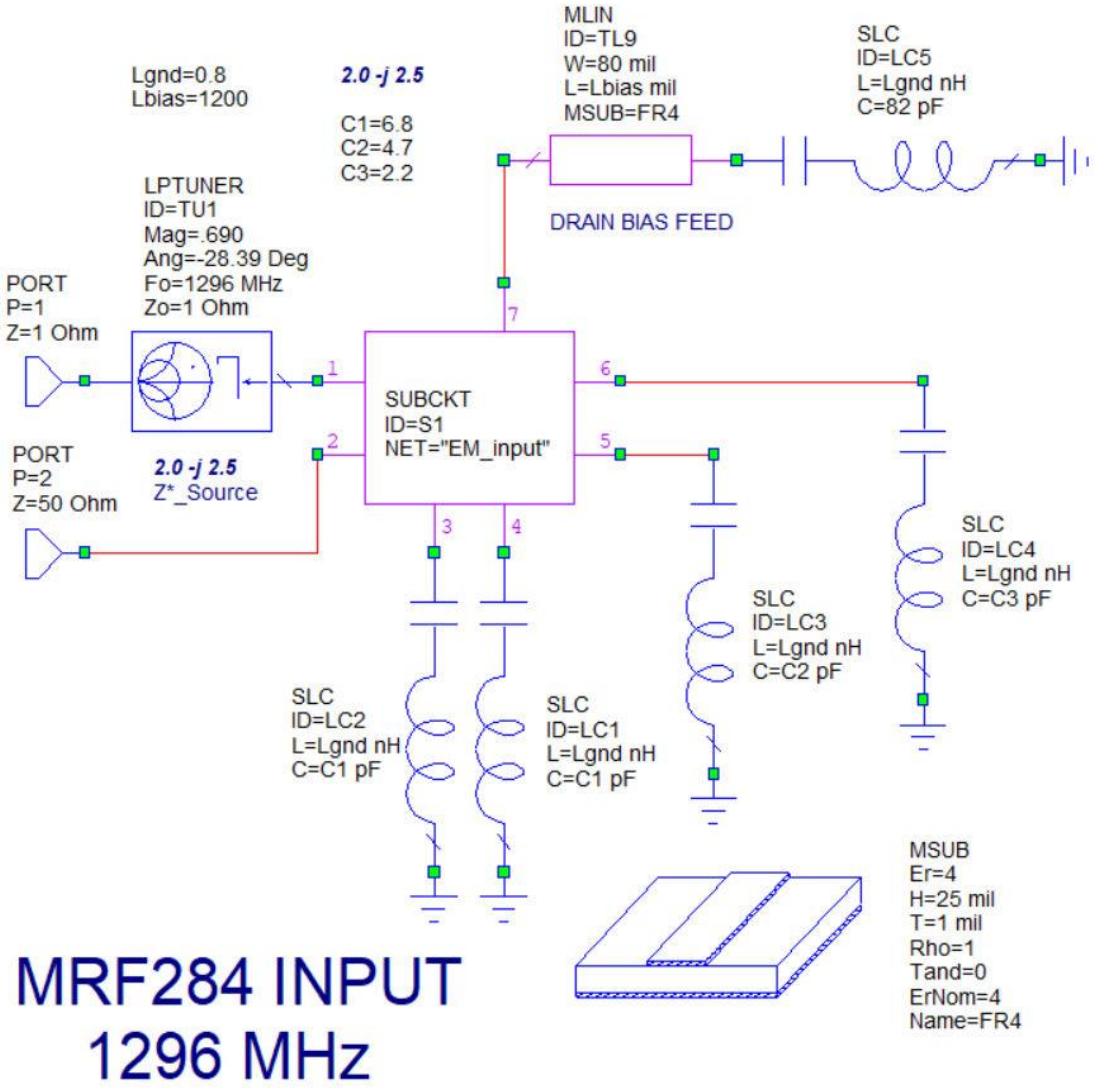
MICROSTRIP DESCRIPTION – MRF286 INPUT



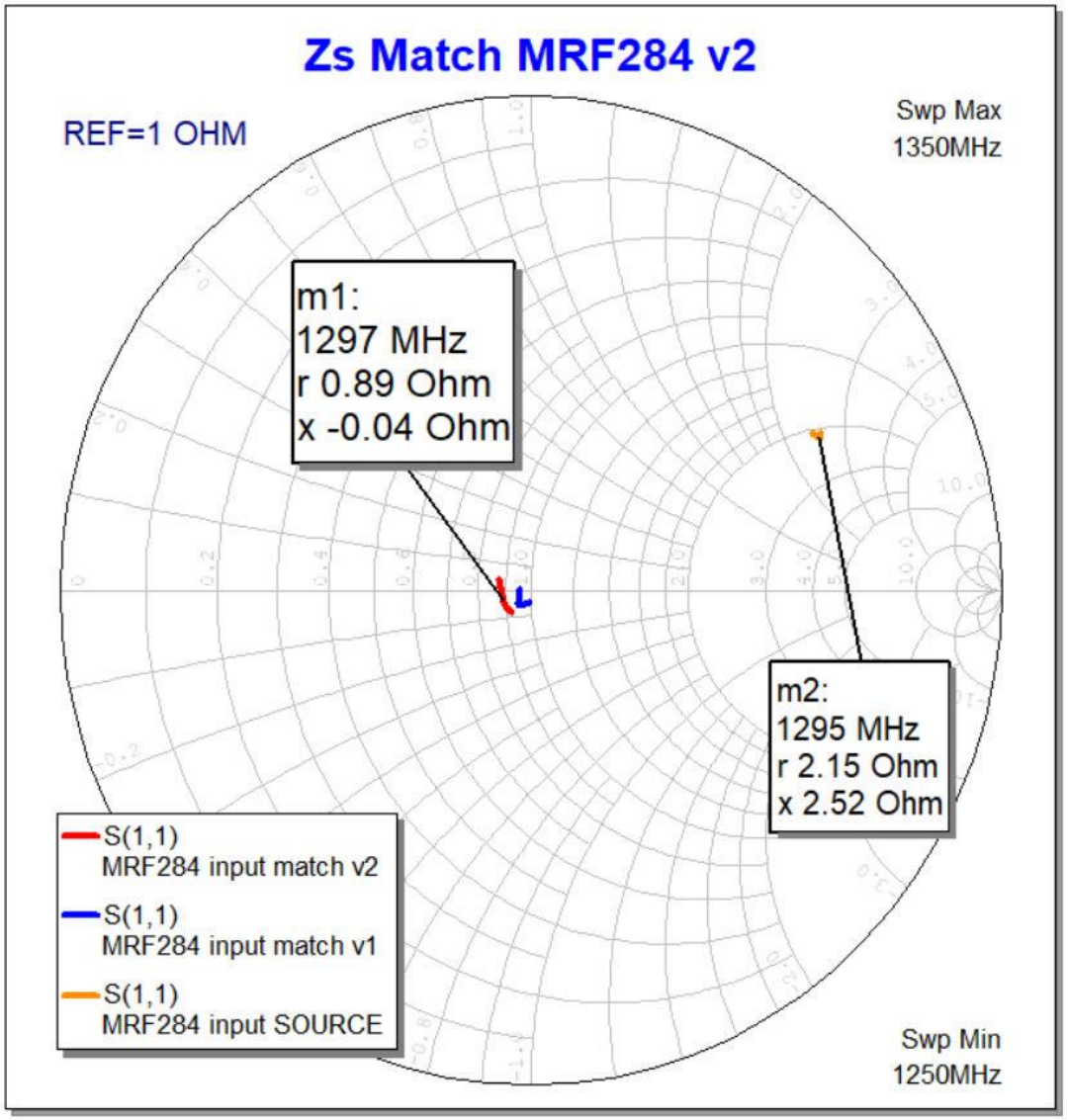
EM SIMULATION GEOMETRY – MRF286 INPUT



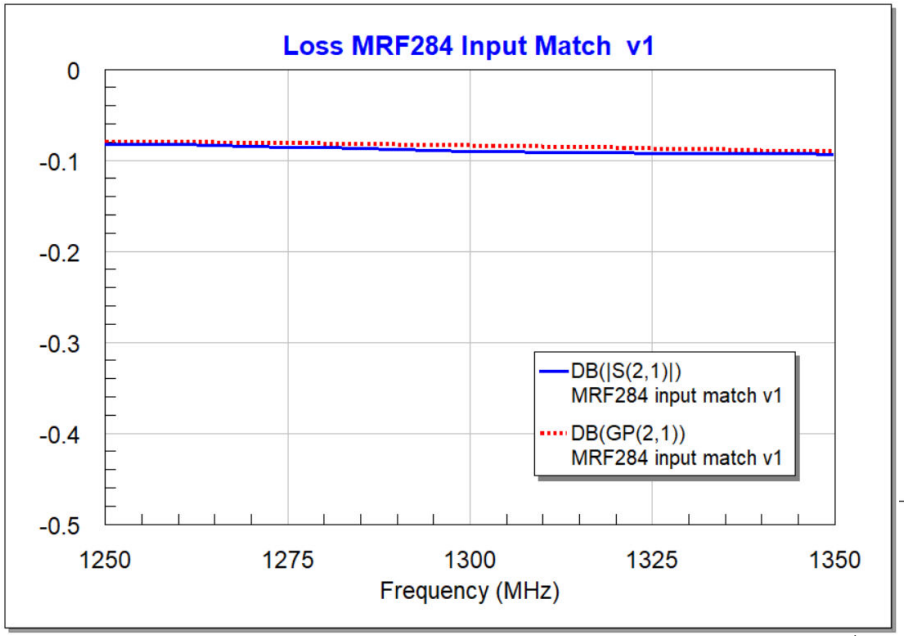
EM SIMULATION DATA IN CIRCUIT SIMULATOR



EM SIMULATION DATA IN CIRCUIT SIMULATOR

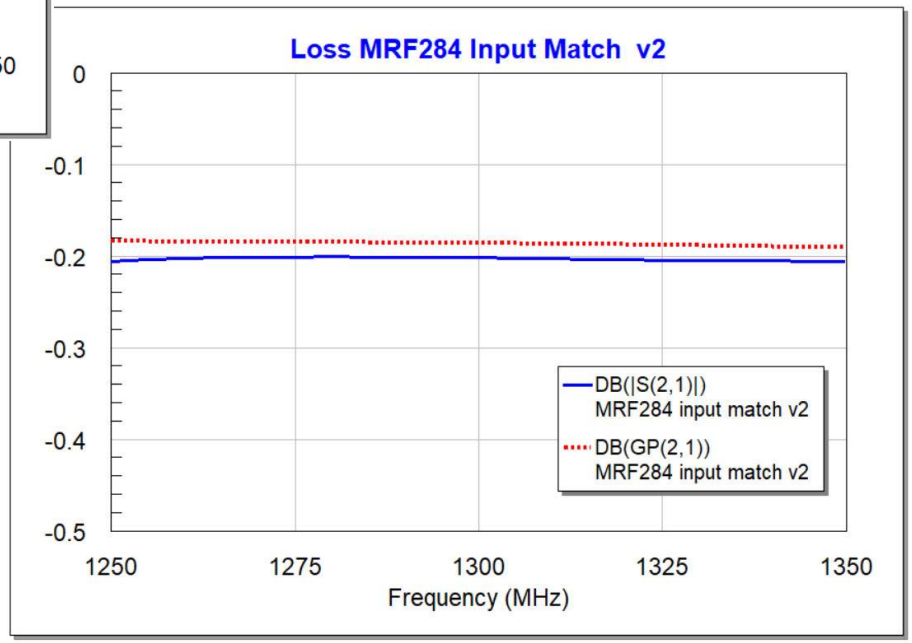


EM SIMULATION DATA IN CIRCUIT SIMULATOR

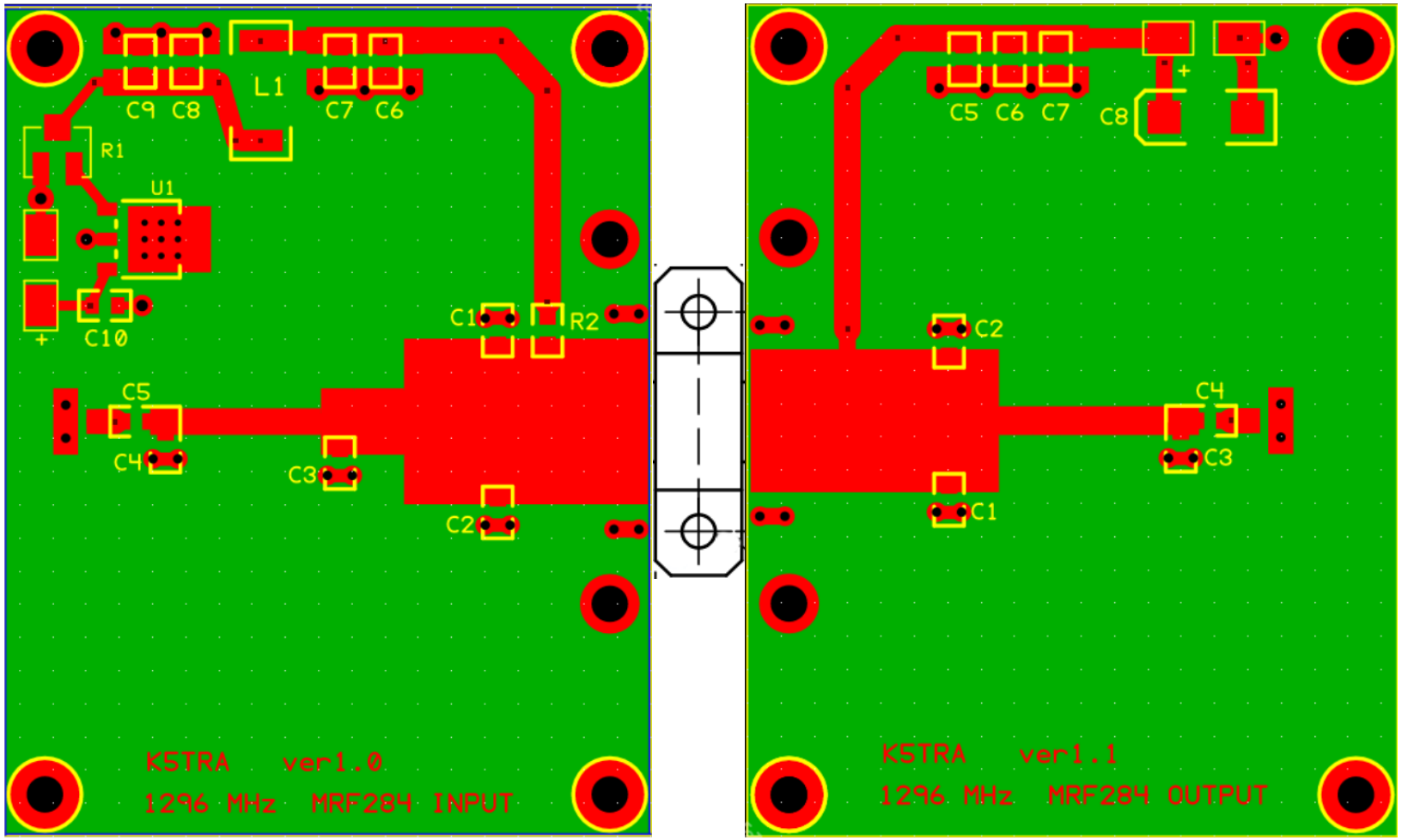


MICROSTRIP DESCRIPTION LOSS

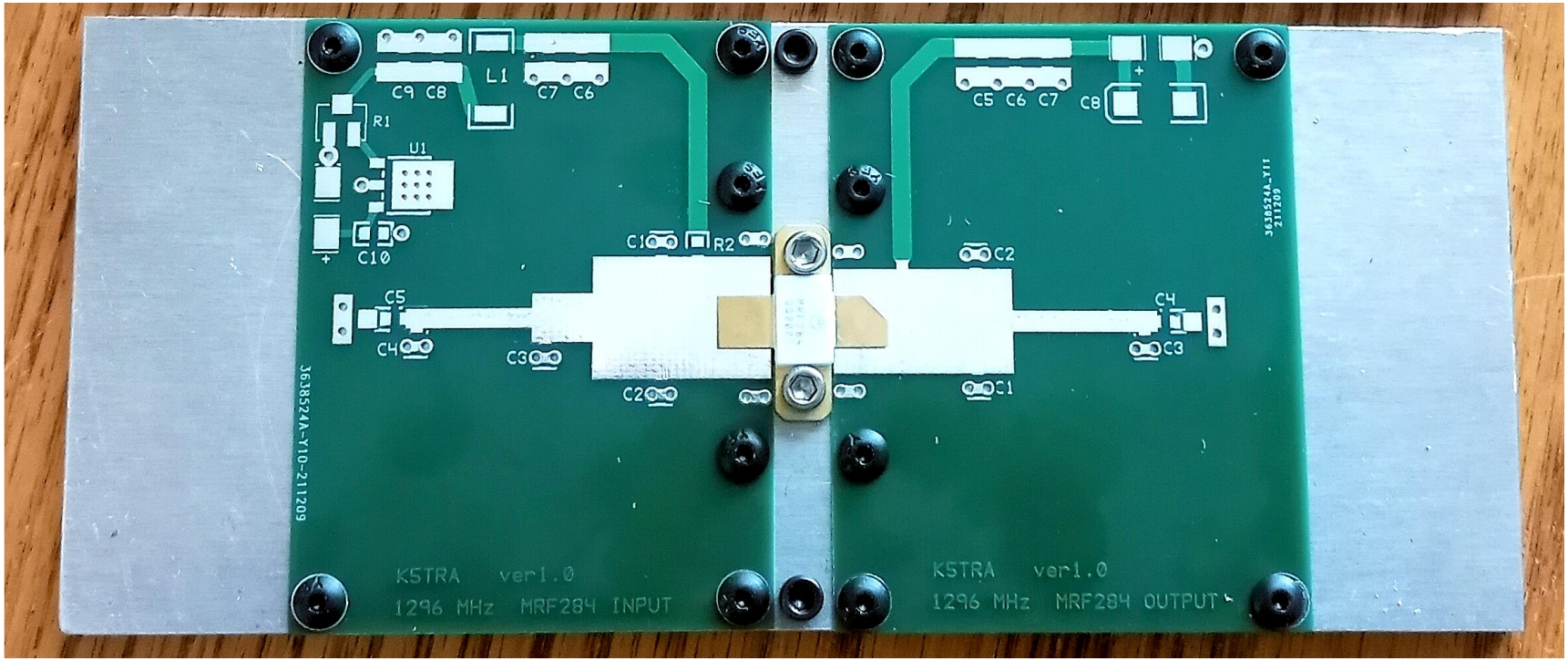
EM SIMULATION DESCRIPTION LOSS



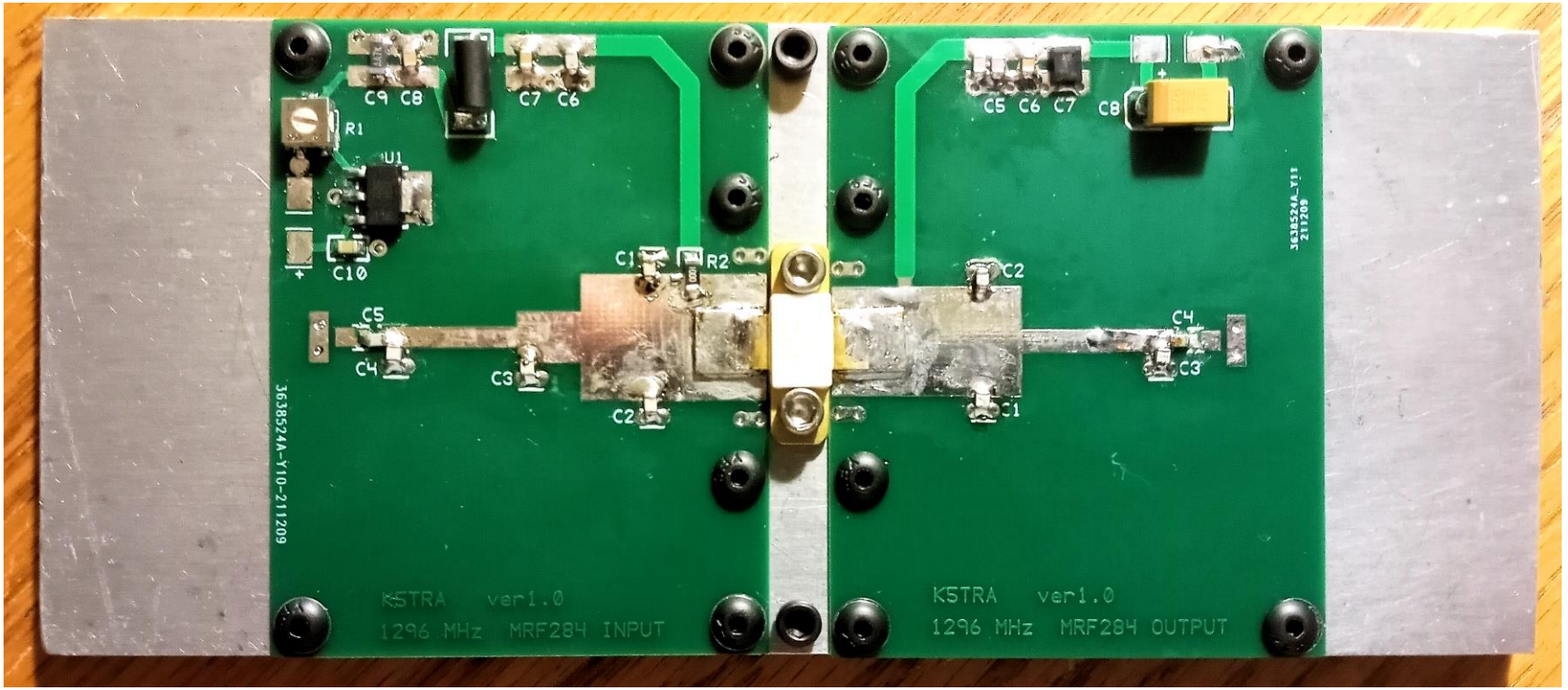
1296 MHz MRF284 30W PA



1296 MHz MRF284 30W PA



1296 MHz MRF284 30W PA



SOFTWARE TOOLS

- SMITH:
  http://www.fritz.dellsperger.net/smith.html
- PSEUDO BP MATCH:
  http://k5tra.net/TechFiles/PseudoBPmatch.exe
- MICROSTRIP LUMPED EQUIVALENT:
  http://k5tra.net/TechFiles/LumpEquiv.exe
- SERIES TRAP:
  http://k5tra.net/TechFiles/SeriesTrap.exe
- SHUNT TRAP:
  http://k5tra.net/TechFiles/ShuntTrap.exe