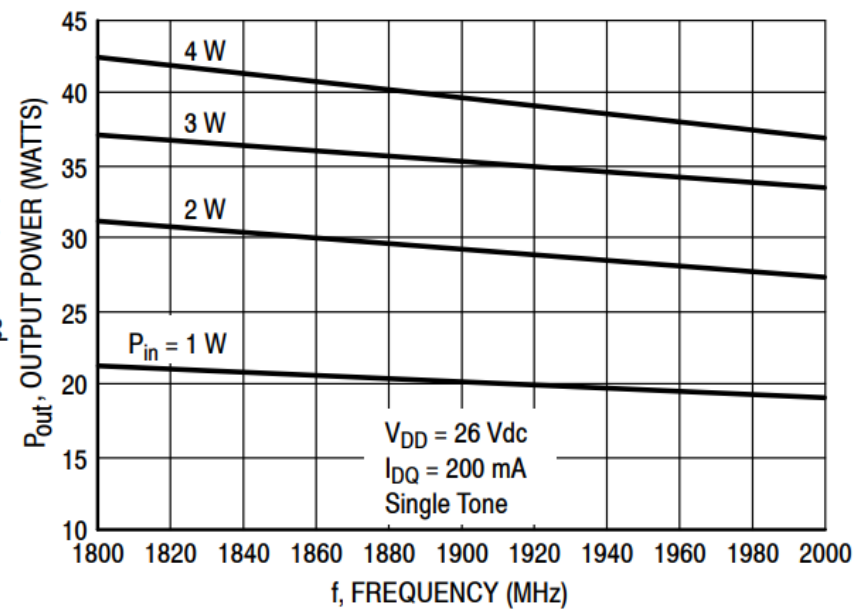
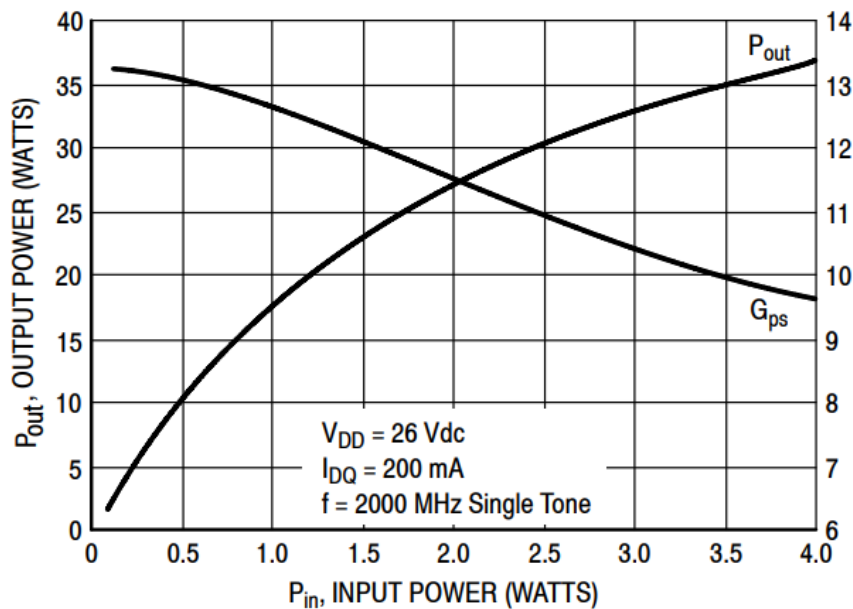


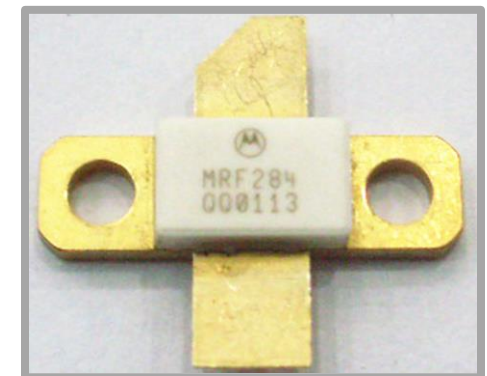
# MICROSTRIP PA DESIGN

*PART – I (MRF284 on 1296)*

# MRF284 LDMOS TRANSISTOR

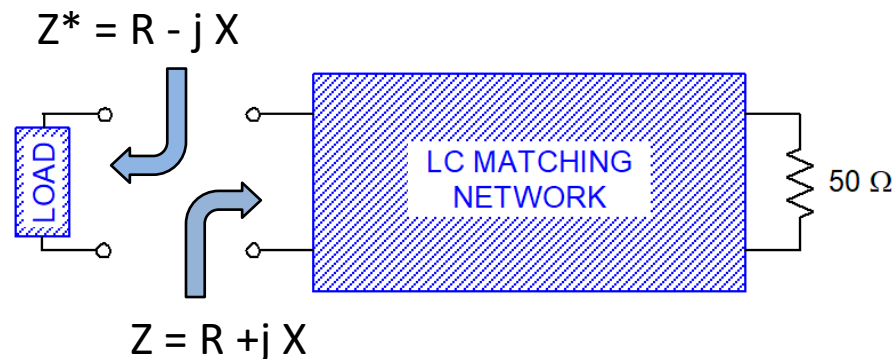


- THE MRF284 IS A Si LDMOS POWER TRANSISTOR
- > 30W POWER OUTPUT AT  $V_{dd} = +26$ V
- MOTOROLA / NXP “OBSOLETE”
- EBAY AVAILABLE < \$20



# MRF284 TARGET IMPEDANCES

- OPTIMUM EXTERNAL IMPEDANCES at 1296 MHz :  
 $Z_{S\text{ OPT}} = 2.0 + j 2.5 \Omega$   
 $Z_{L\text{ OPT}} = 3.0 + j 2.5 \Omega$
- OPTIMUM MATCHING NETWORKS WILL PROVIDE A MATCH TO LOADS THAT ARE COMPLEX CONJUGATE OF THE OPTIMUMS
- SO, DESIGN MATCHING NETWORKS TERMINATED WITH:  
 $Z_{S\text{ OPT}}^* = 2.0 - j 2.5 \Omega$   
 $Z_{L\text{ OPT}}^* = 3.0 - j 2.5 \Omega$




# INITIAL LUMPED LC DESIGN

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

# INITIAL 3 OHM MATCH

**ApelSoft**  
**Design Tools**

 **Print**

Lower Freq.=  GHz

Upper Freq.=  GHz

High Z Port =   $\Omega$

Low Z Port =   $\Omega$

**Net.Order**

☐ 2

☒ 4

☐ 6

☐ 8

☐ 10

**LC Absorption**

☐ Yes ☒ No

☒ Quasi-LowPass

☐ Quasi-HiPass

**Calculate**

**About Pseudo Bandpass**

% Bandwidth = 15.38 %  
Lower Stopband Loss = 6.704 dB  
Passband Ripple Loss = .0022 dB  
Passband Ripple VSWR = 1.046:1

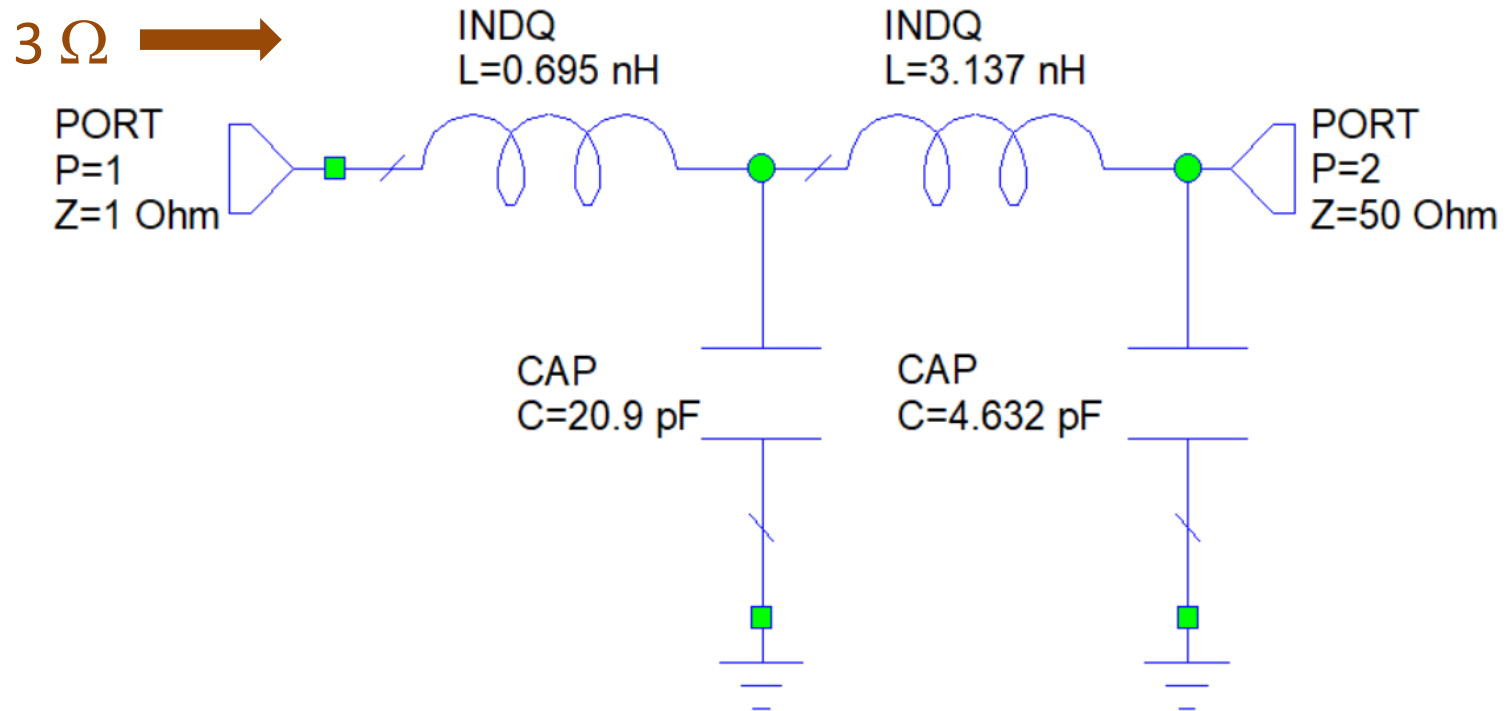
\*\*\* QUASI-LOWPASS MATCH \*\*\*

-----

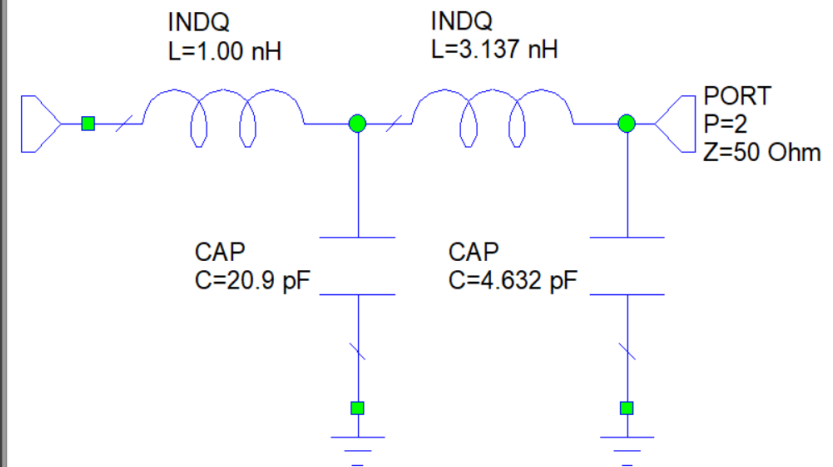
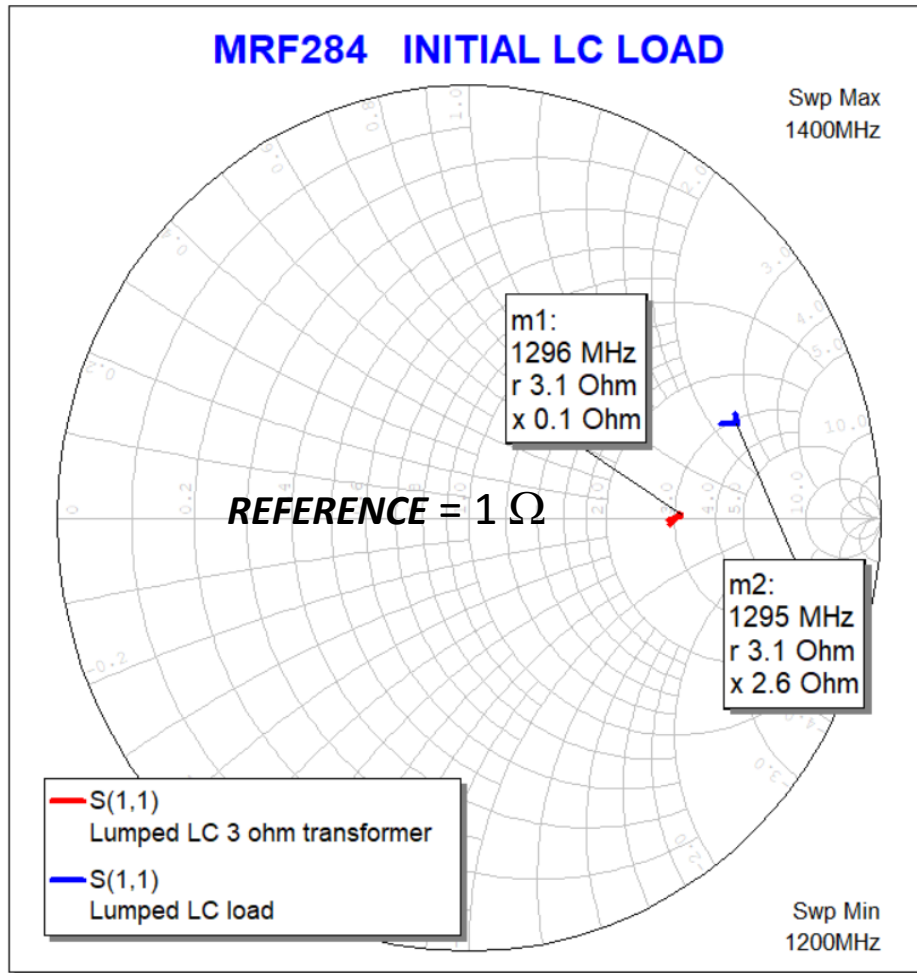
R=3 Ohm  
L=0.6948 Nano-Henry  
C=20.9156 Pico-Farad  
L=3.1373 Nano-Henry  
C=4.6318 Pico-Farad  
R=50 Ohm

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

# INITIAL 3 OHM MATCH



# LUMPED LC MRF284 OUTPUT MATCH



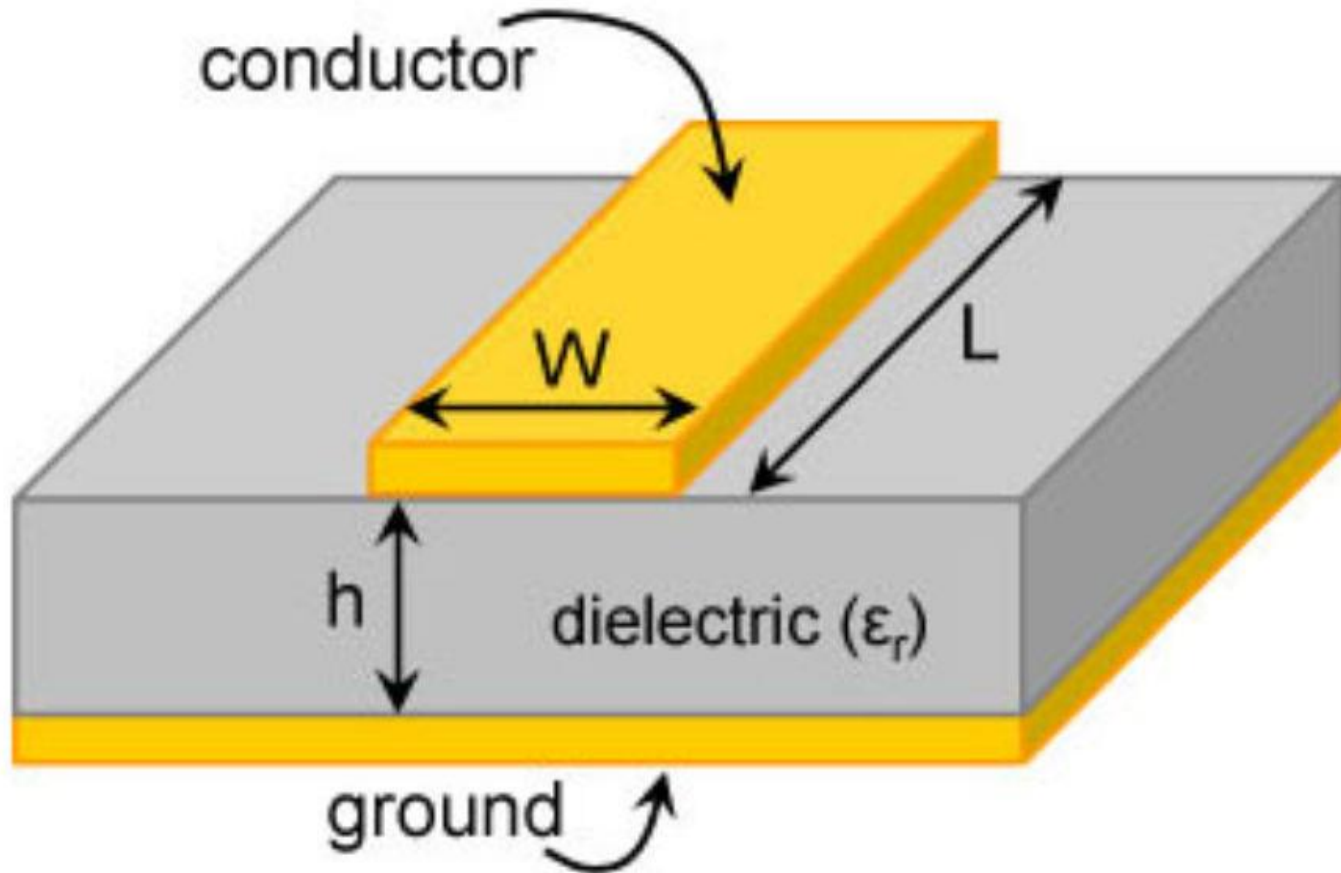
- ADD 0.31 nH to 0.695 nH
- TOTAL L SERIES = 1.00 nH

# LUMPED DESIGN ON A CIRCUIT BOARD

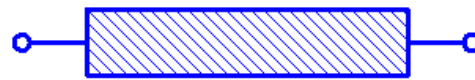
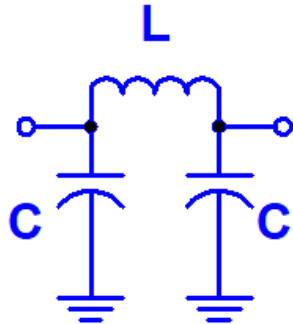
- THERE REALLY ARE NO LUMPED ELEMENTS
  - CHIP CAPACITORS HAVE SERIES INDUCTANCE (and LOSS)
  - CHIP INDUCTORS HAVE DISTRIBUTED CAPACITANCE (SELF RESONANCE)
  - CHIP RESISTORS HAVE SERIES INDUCTANCE AND SHUNT CAPACITANCE
- CIRCUIT BOARD TRACES OVER BACKSIDE GROUND ARE MICROSTRIP TRANSMISSION LINES.
- 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  $Z_0$  TRACES HAVE HIGH L/C
  - USED FOR PRINTED INDUCTORS
- WIDE TRACES:
  - LOW  $Z_0$  TRACES HAVE MORE C
  - PROVIDE SHUNT C (AND SOME SERIES L)



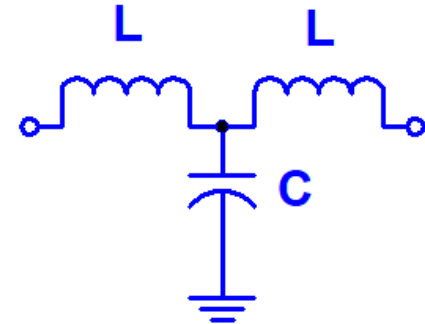
# MICROSTRIP TRANSMISSION LINES



# LC REPRESENTATION OF A SHORT LINE



$$Z_0, \quad \theta = \beta l$$



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



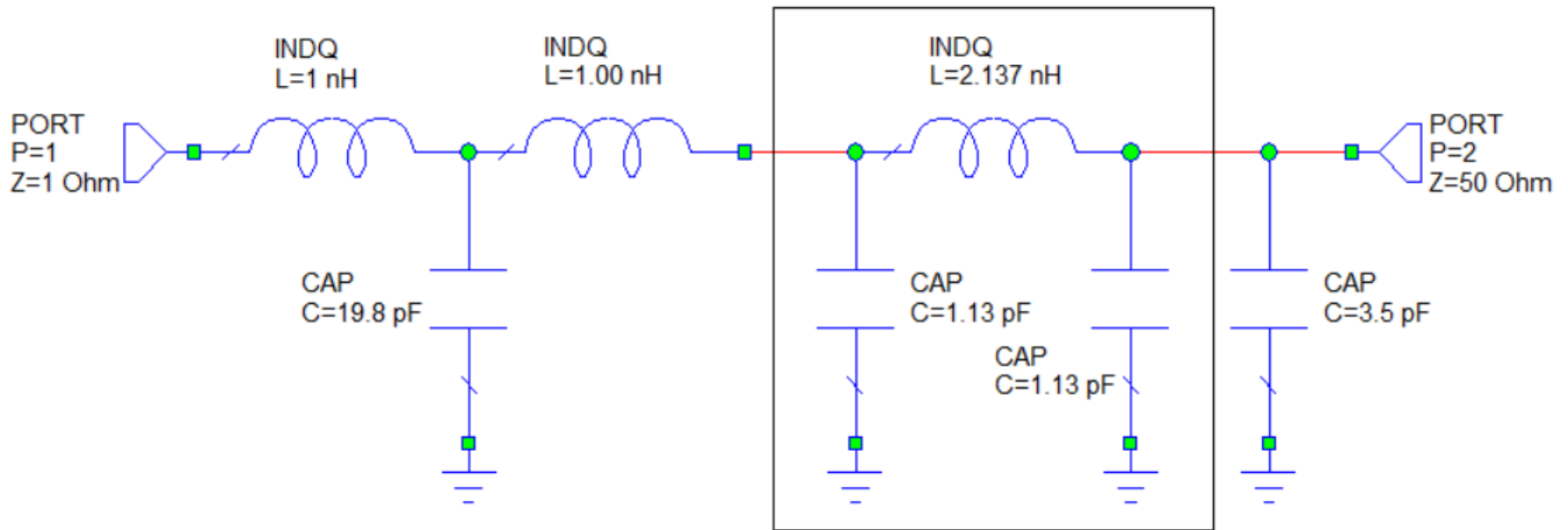
$$X_L = Z_0 \bullet \tan(\beta l/2)$$

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

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

- HIGH  $Z_0$  LINES USE THE  $\pi$  CIRCUIT FOR INDUCTOR REPRESENTATION
- THE END CAPACITANCES ARE SMALL WITH HIGH  $Z_0$  LINES
- LOW  $Z_0$  LINES USE THE T CIRCUIT FOR CAPACITOR REPRESENTATION
- THE END INDUCTANCES ARE SMALL WITH LOW  $Z_0$  LINES

# PARTITIONED LC OUTPUT MATCH



**86 mil x 425 mil  
MICROSTRIP**

# LUMPED EQUIVALENT CALCULATOR

The screenshot shows a software window titled "MicroStrip Lumped Equivalent Circuits". It features input fields for Length (425.10), Width (86.00), C(pF)-T (1.9224), L(nH)-T (1.1541), Synth. T, Synth. Pi, L(nH)-Pi (2.1374), and C(pF)-Pi (1.1282). There are buttons for "Analysis", "Solve Microstrip", and "About". A unit selector shows "mils" is selected. The "ApelSoft" logo is visible. Below the buttons, a grid of results is displayed: Impedance (33.34), Effective Dielectric (3.513), Relative Velocity (0.5335), Phase Length (degrees) (31.57), Dielectric Constant (4.470), Dielectric Thickness (25.00), Conductor Thickness (1.800), and Frequency (GHz) (1.3).

Parameter	Value
Length	425.10
Width	86.00
C(pF)-T	1.9224
L(nH)-T	1.1541
Synth. T	
Synth. Pi	
L(nH)-Pi	2.1374
C(pF)-Pi	1.1282
Units	mils
Impedance	33.34
Effective Dielectric	3.513
Relative Velocity	0.5335
Phase Length (degrees)	31.57
Dielectric Constant	4.470
Dielectric Thickness	25.00
Conductor Thickness	1.800
Frequency (GHz)	1.3

- MICROSTRIP ANALYSIS AND SYNTHESIS
- $\pi$  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 <sup>2</sup> )	L(nH)
0402	40x20	0.59
0603	60x30	0.77
0805	80x50	0.84
ATC 100A	55x55	0.55
ATC 100B	110x110	0.77

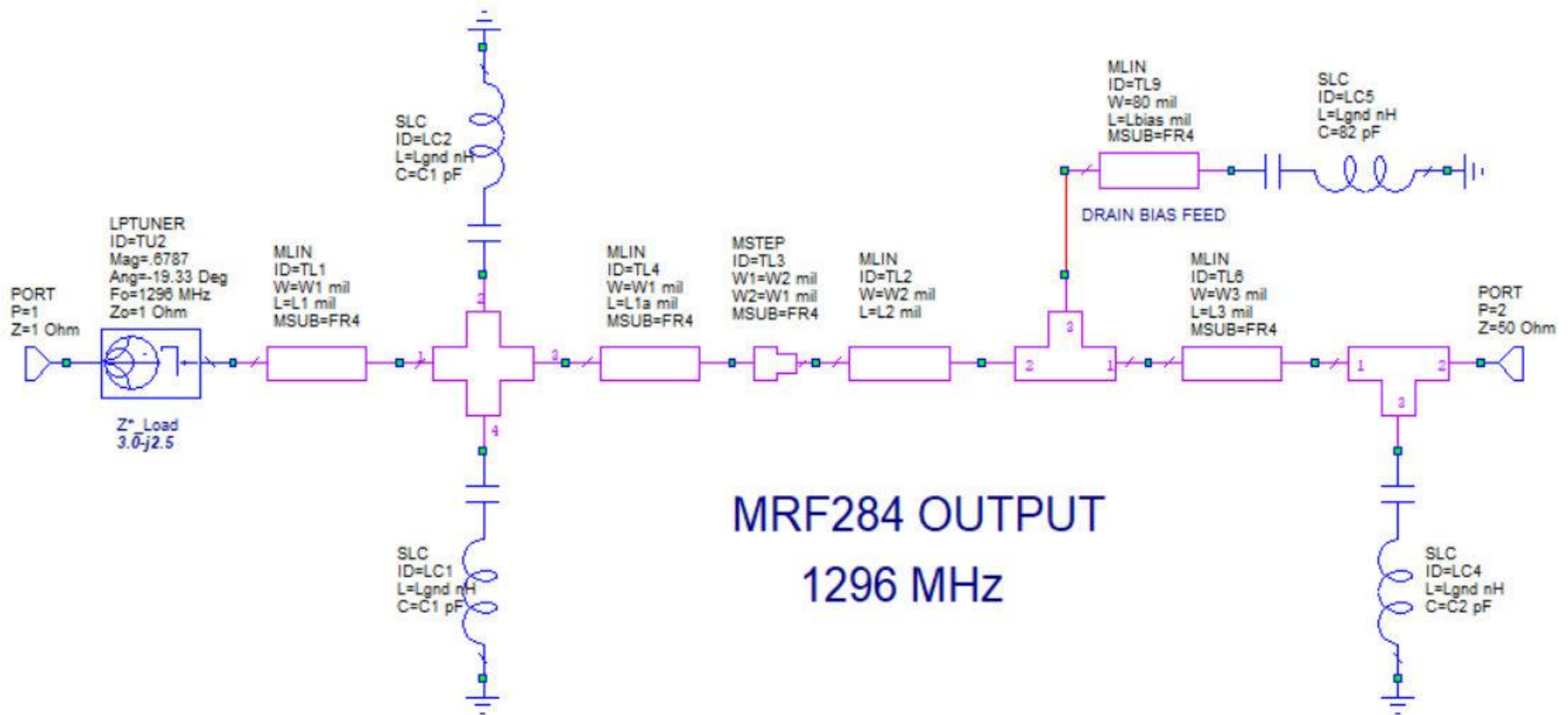
Series Trap

		Fo	2 Fo	3 Fo	
Freq (GHz)	1.296	Harmonics	1.30	2.59	3.89
Ls (nH)	.8	Effective Value	6.26 pF	1728.60	0.44 nH
Cs (pF)	4.7	Type	Cap	Cap	Ind
Calculate				Resonant Freq (GHz)	2.60

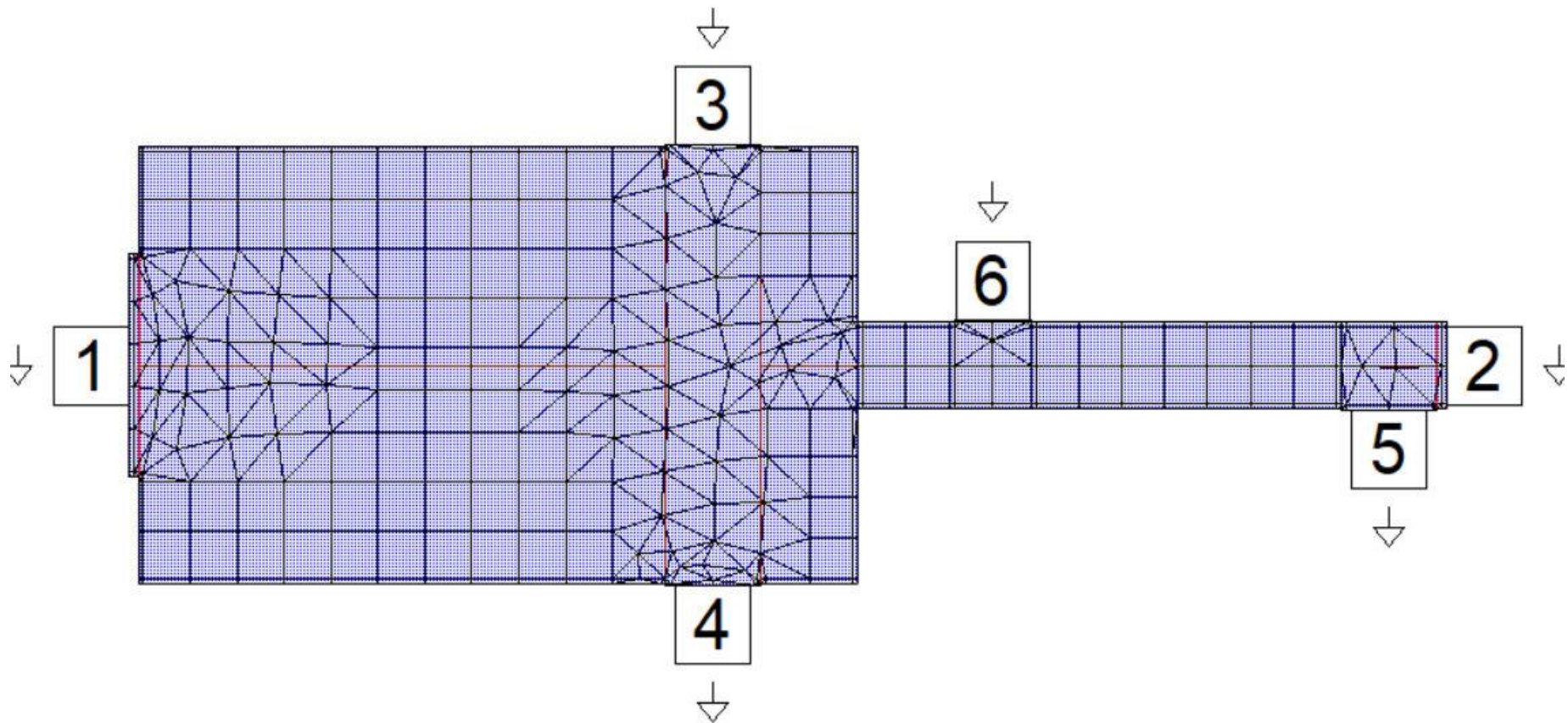
<http://k5tra.net/TechFiles/SeriesTrap.exe>

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

# MICROSTRIP DESCRIPTION – MRF286 OUTPUT

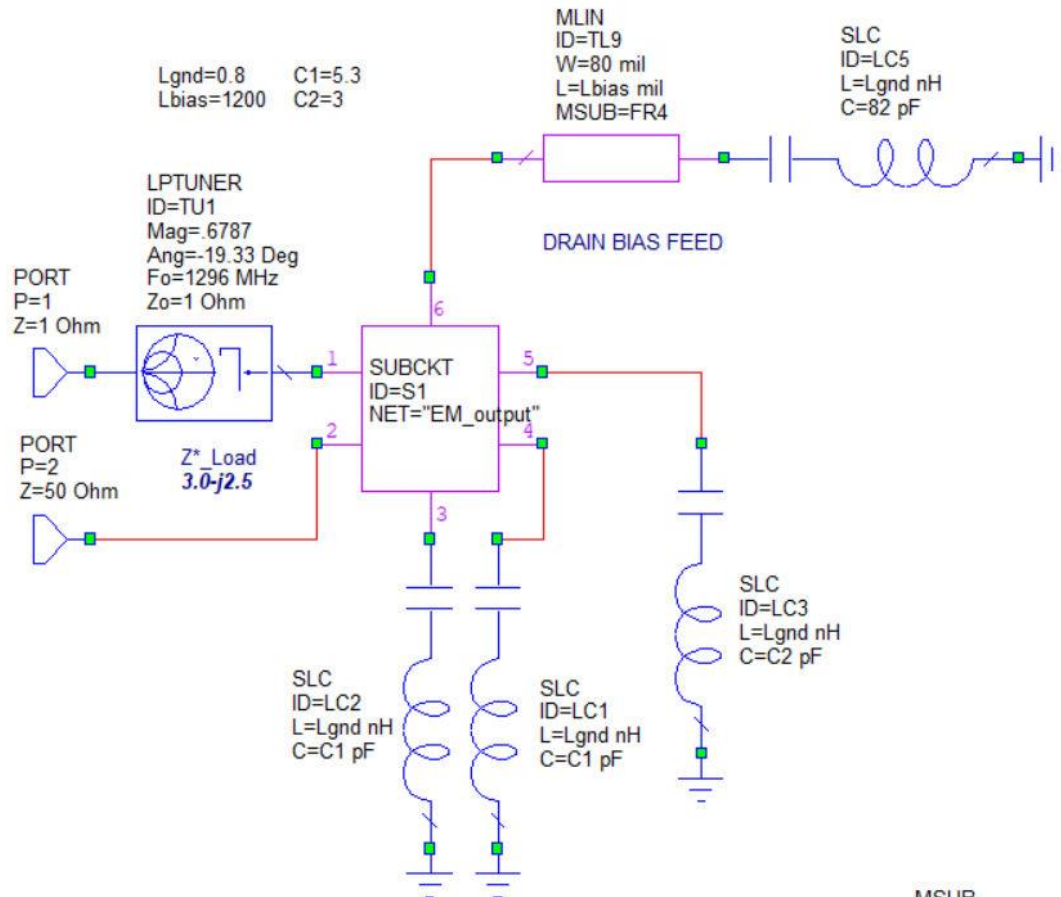


# EM SIMULATION GEOMETRY – MRF286 OUTPUT

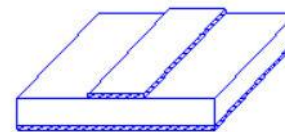




# EM SIMULATION DATA IN CIRCUIT SIMULATOR



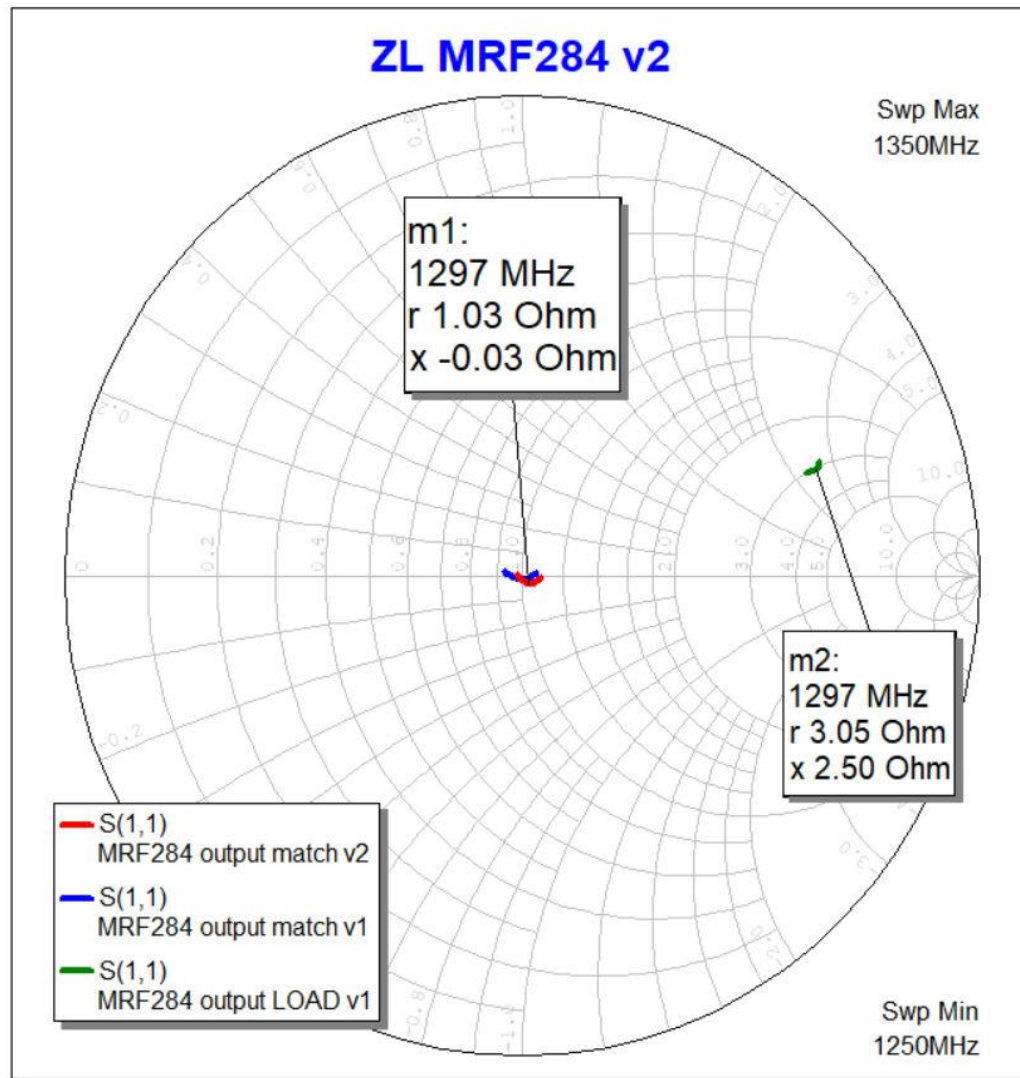
**MRF284 OUTPUT**  
**1296 MHz**



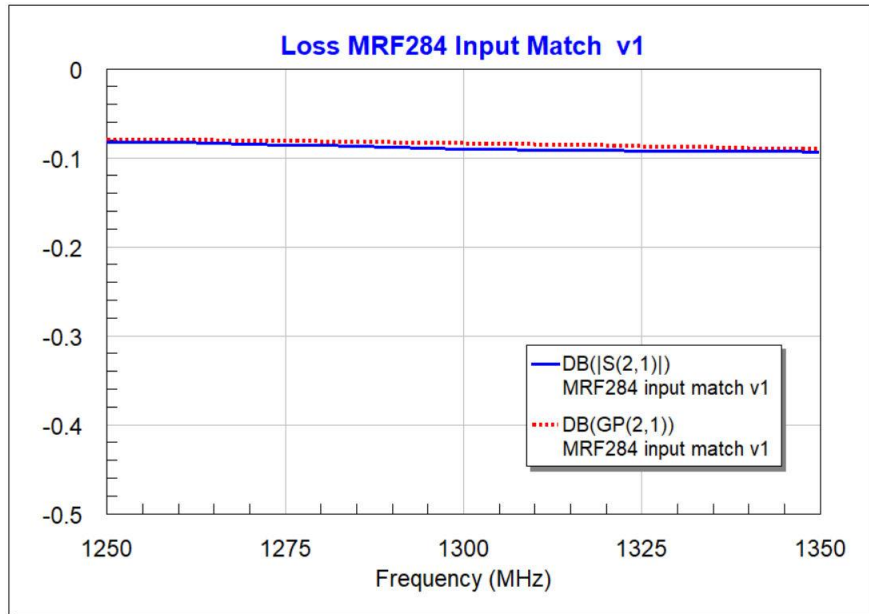
MSUB  
Er=4  
H=25 mil  
T=1 mil  
Rho=1  
Tand=0  
ErNom=4  
Name=FR4



# EM SIMULATION DATA IN CIRCUIT SIMULATOR

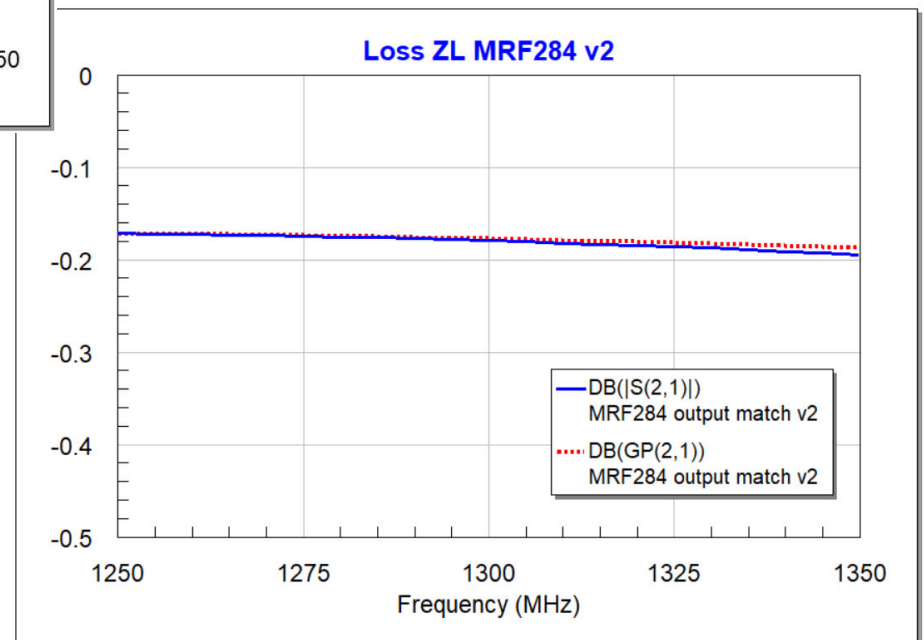


# EM SIMULATION DATA IN CIRCUIT SIMULATOR

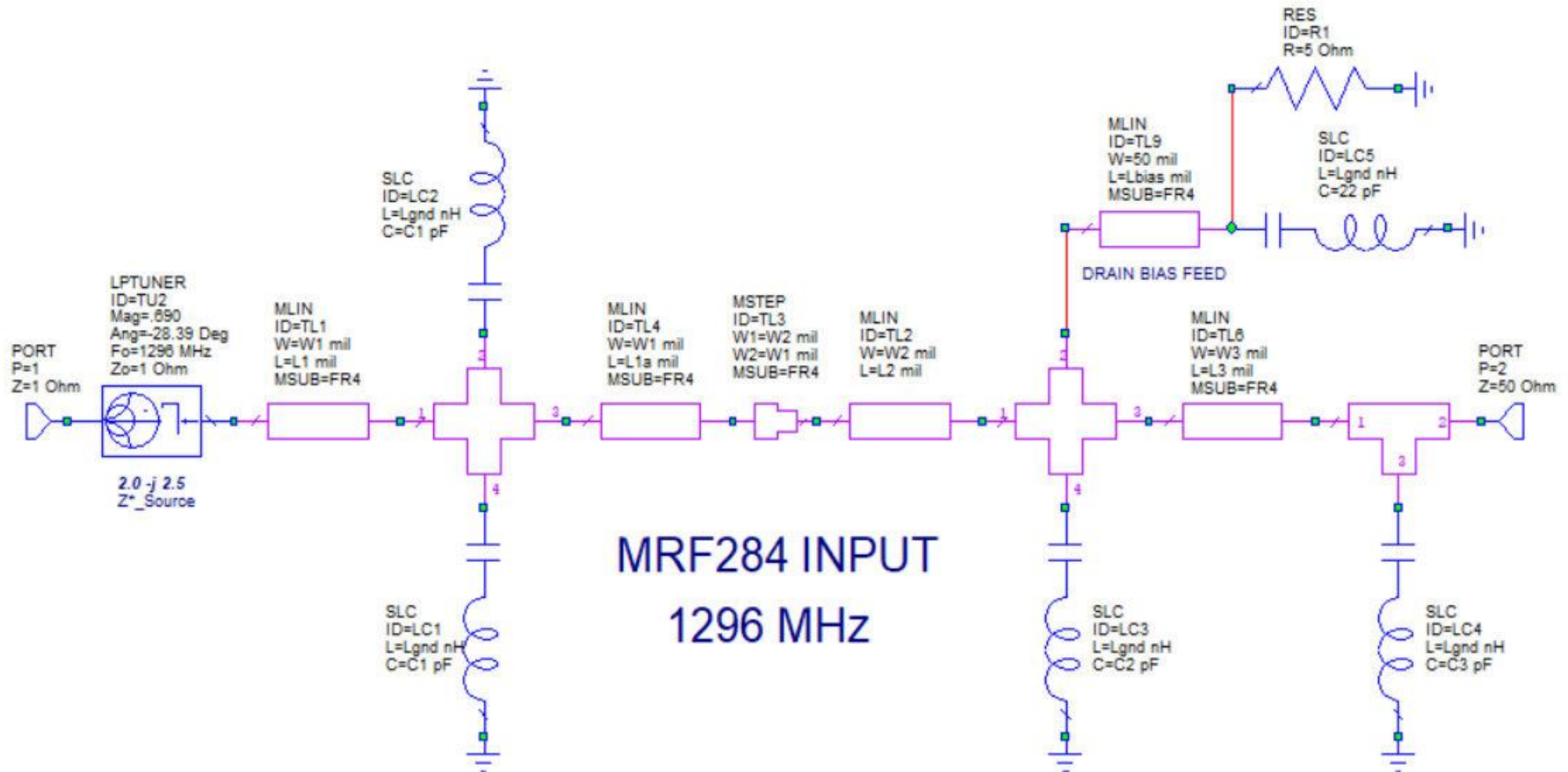


**MICROSTRIP DESCRIPTION LOSS**

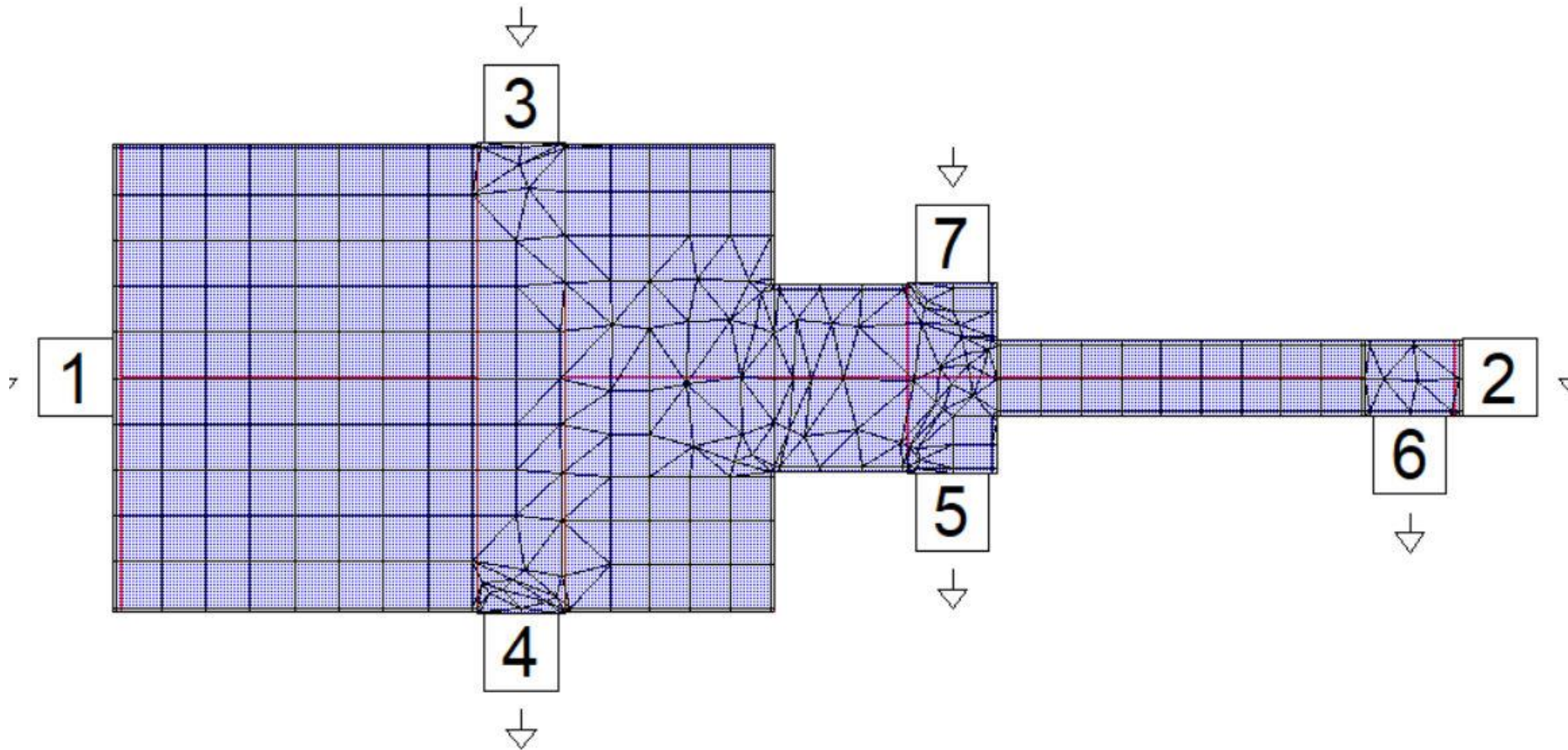
## EM SIMULATION DESCRIPTION LOSS



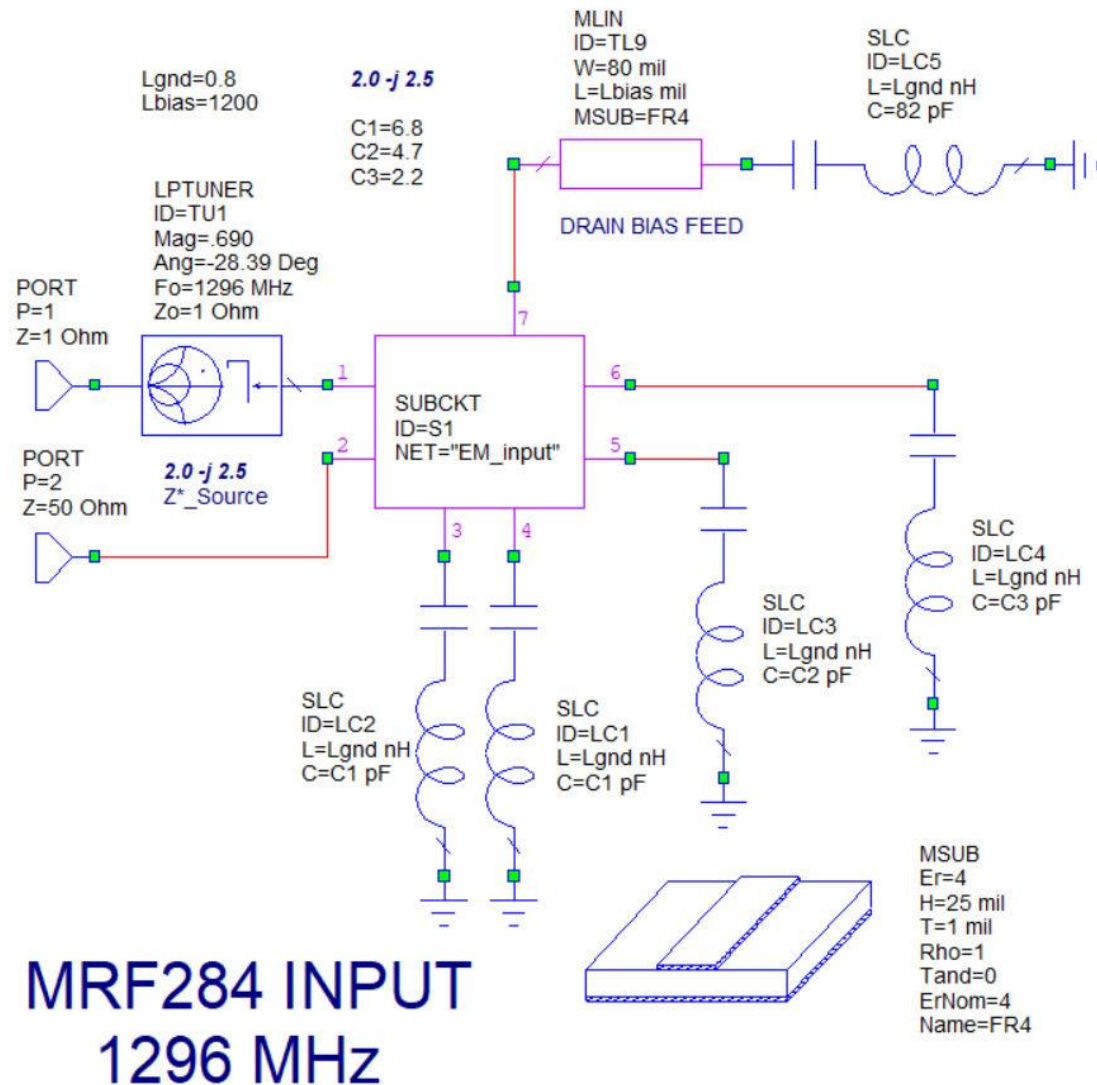
# MICROSTRIP DESCRIPTION – MRF286 INPUT



# EM SIMULATION GEOMETRY – MRF286 INPUT

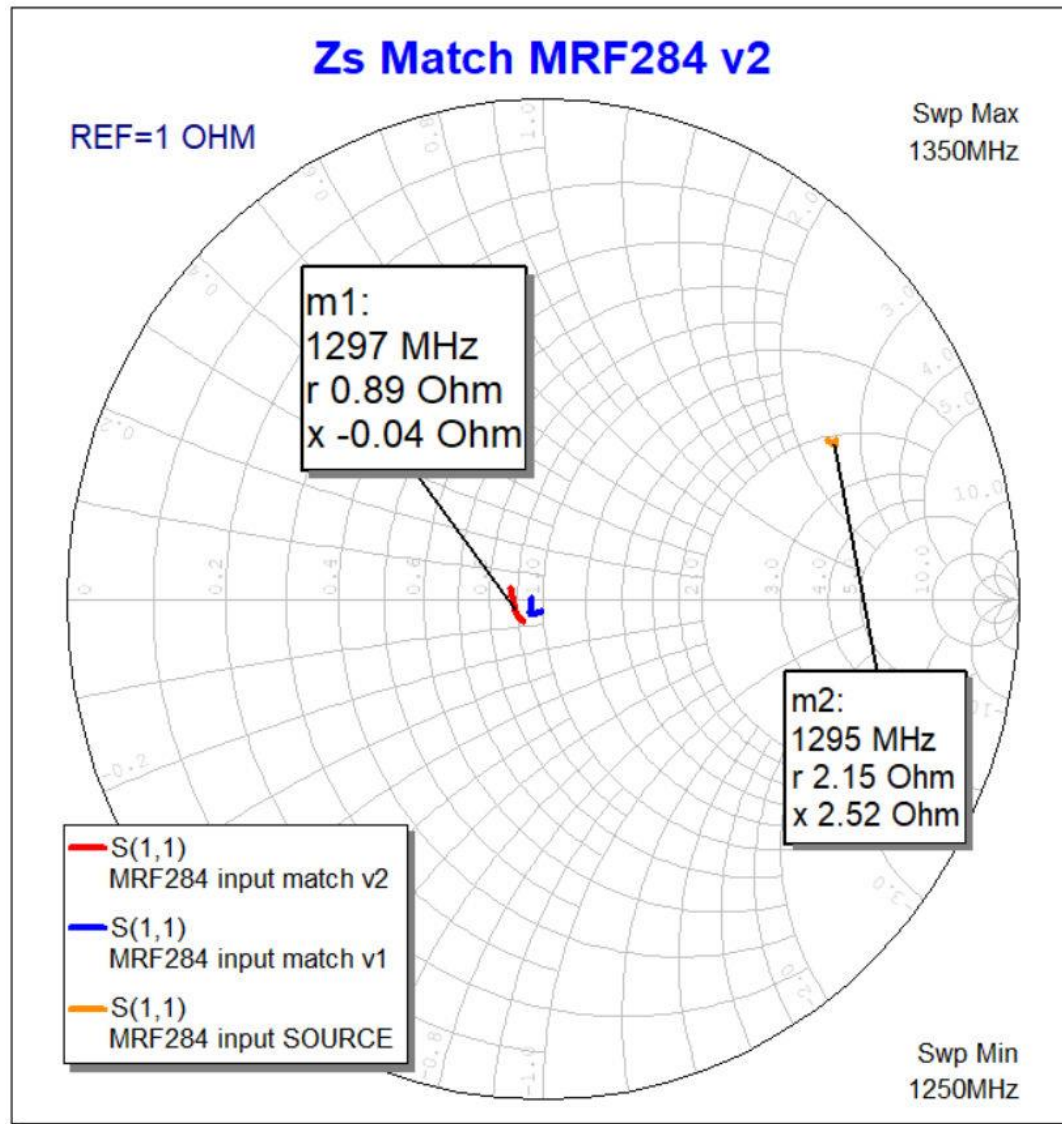


# EM SIMULATION DATA IN CIRCUIT SIMULATOR

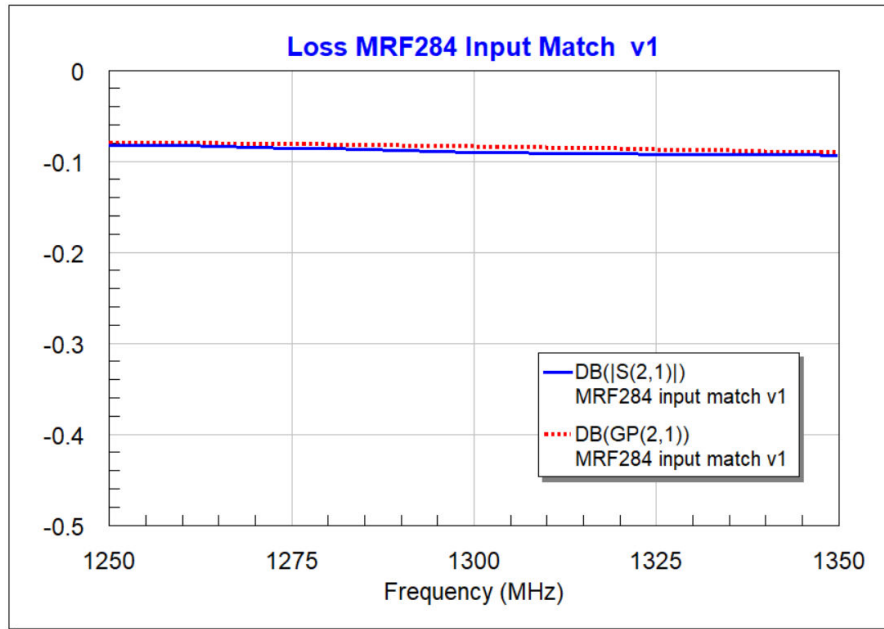




# EM SIMULATION DATA IN CIRCUIT SIMULATOR

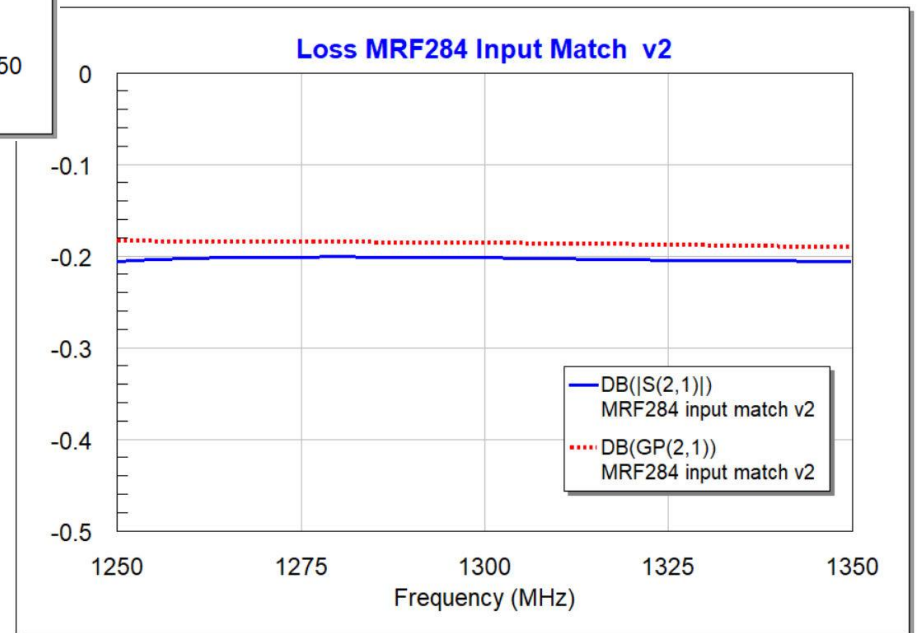


# EM SIMULATION DATA IN CIRCUIT SIMULATOR

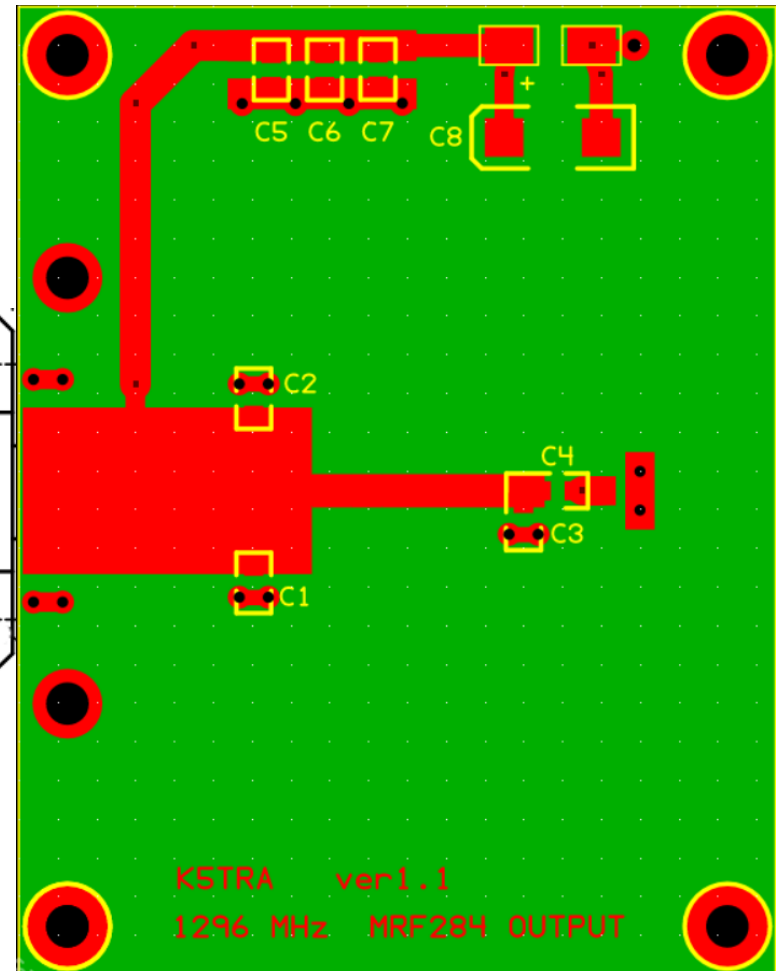
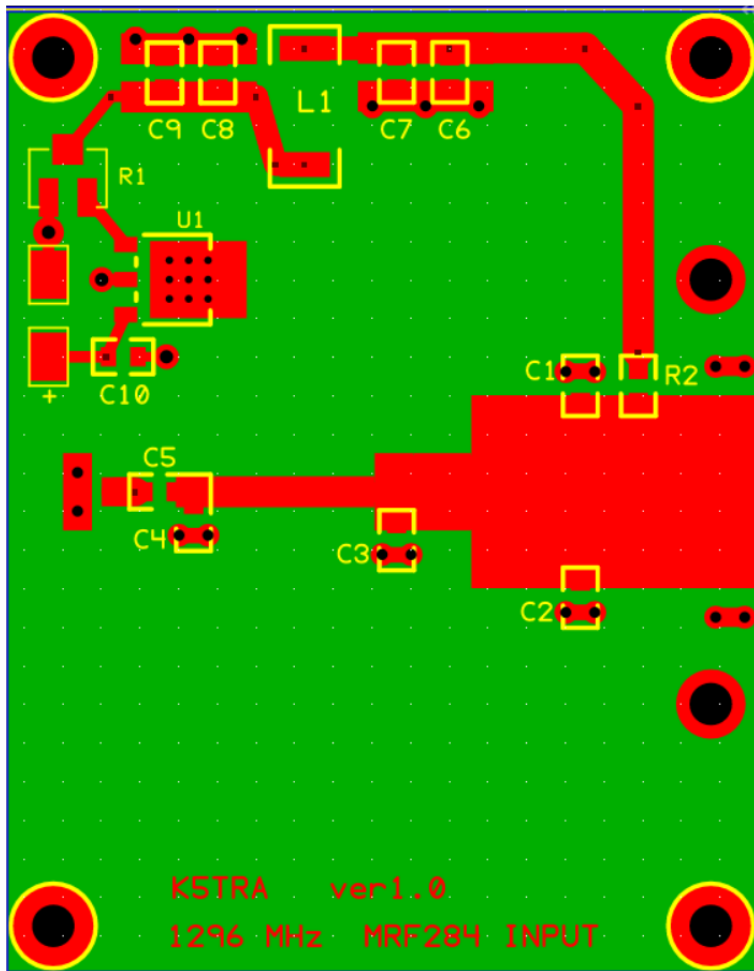


**MICROSTRIP DESCRIPTION LOSS**

## EM SIMULATION DESCRIPTION LOSS

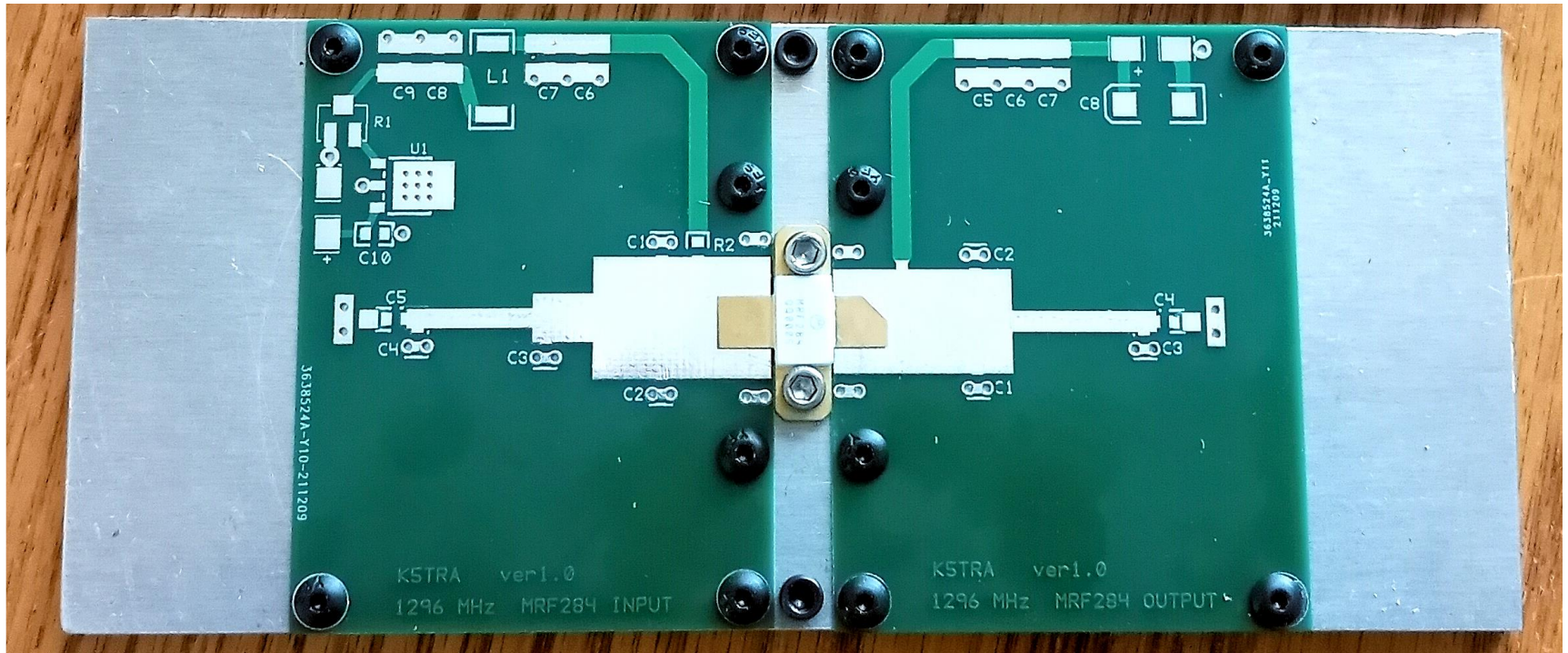


# 1296 MHz MRF284 30W PA

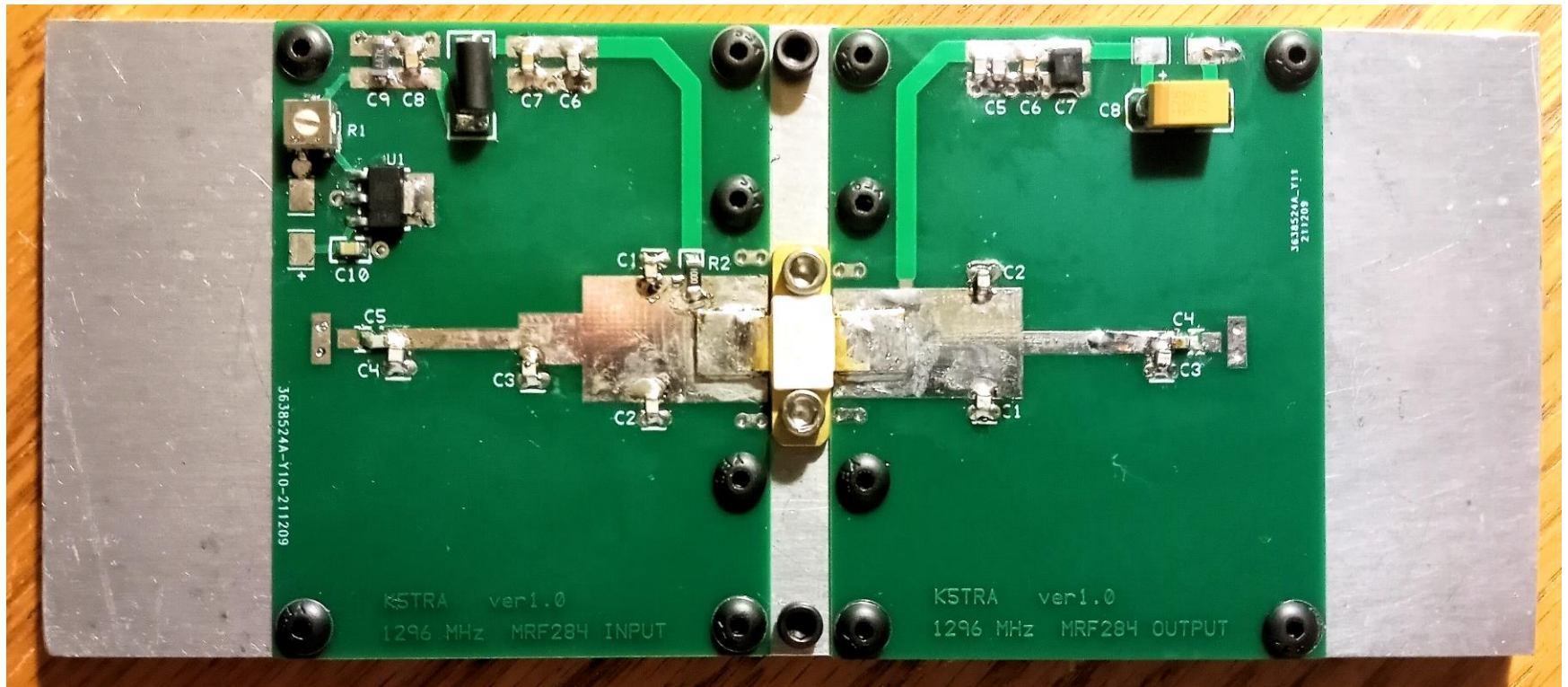




1296 MHz MRF284 30W PA



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>