

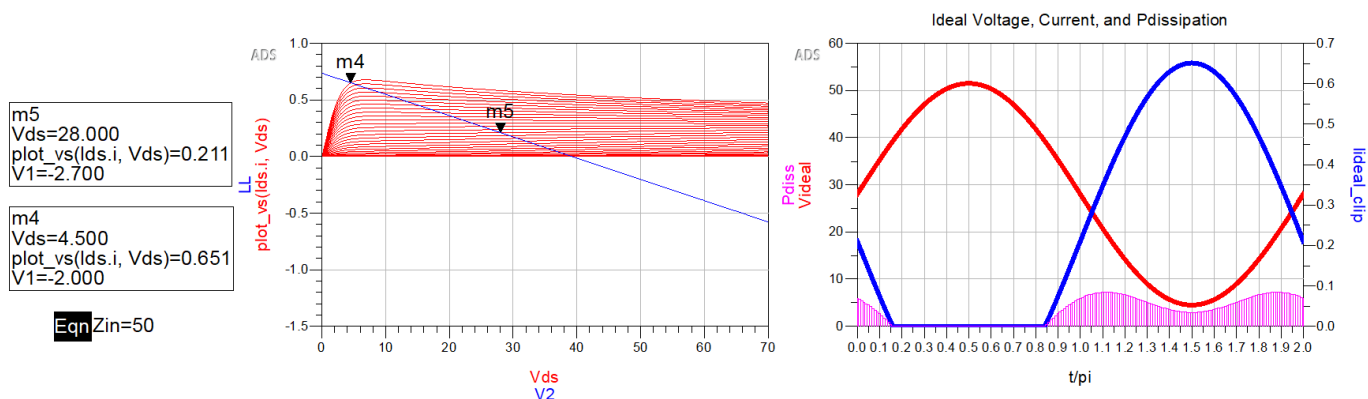
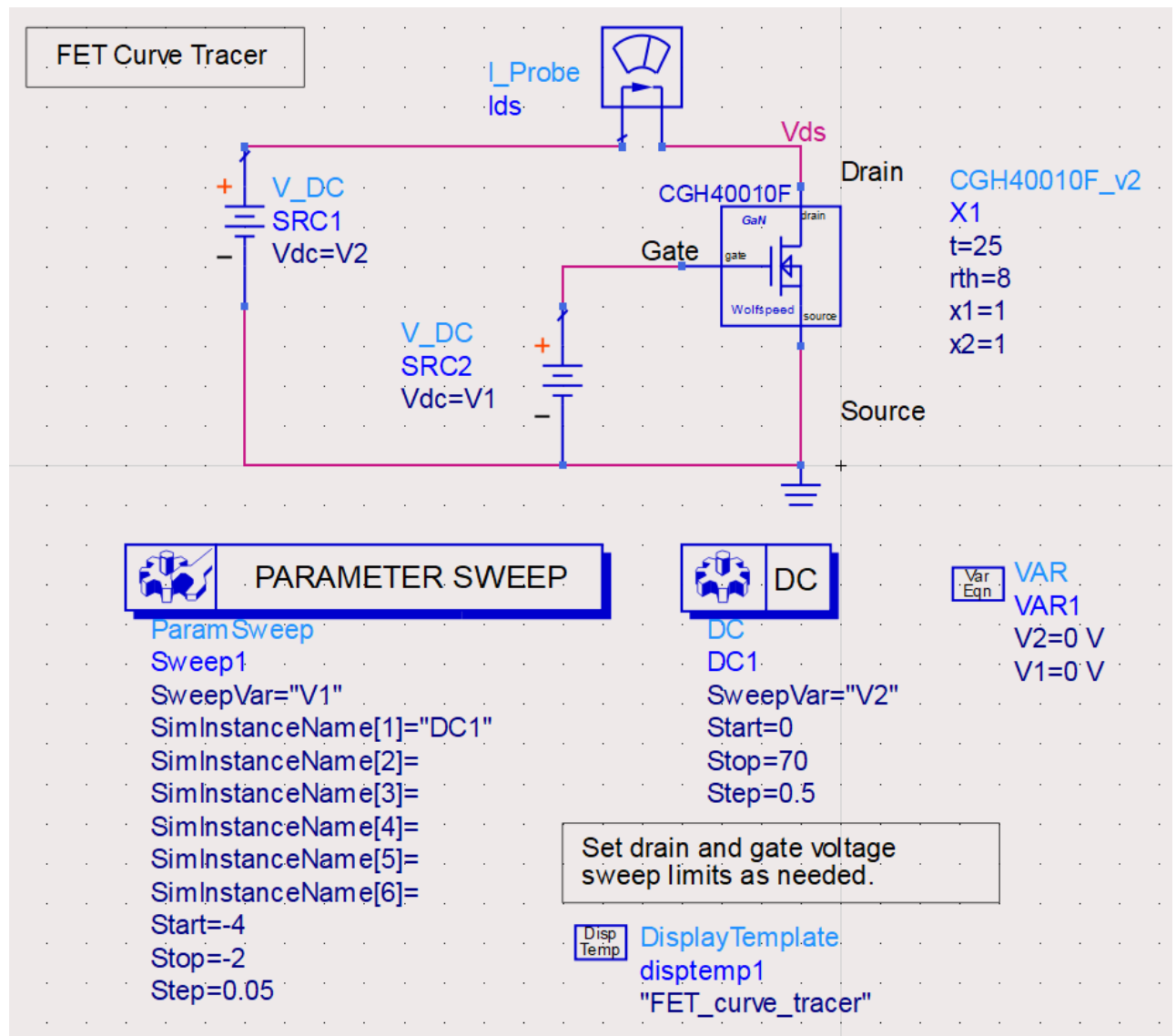
PROBLEM STATEMENT –

Design a harmonically tuned power amplifier to efficiently operate in S-band frequency for satellite communications.

Steps involved in designing of a power amplifier –

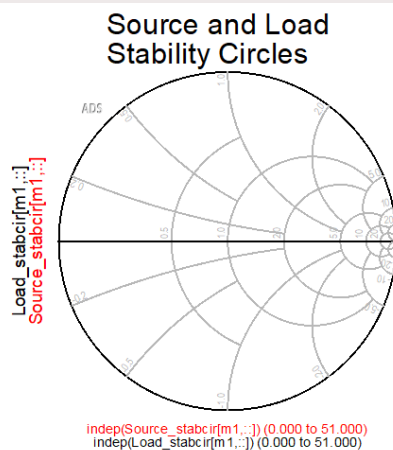
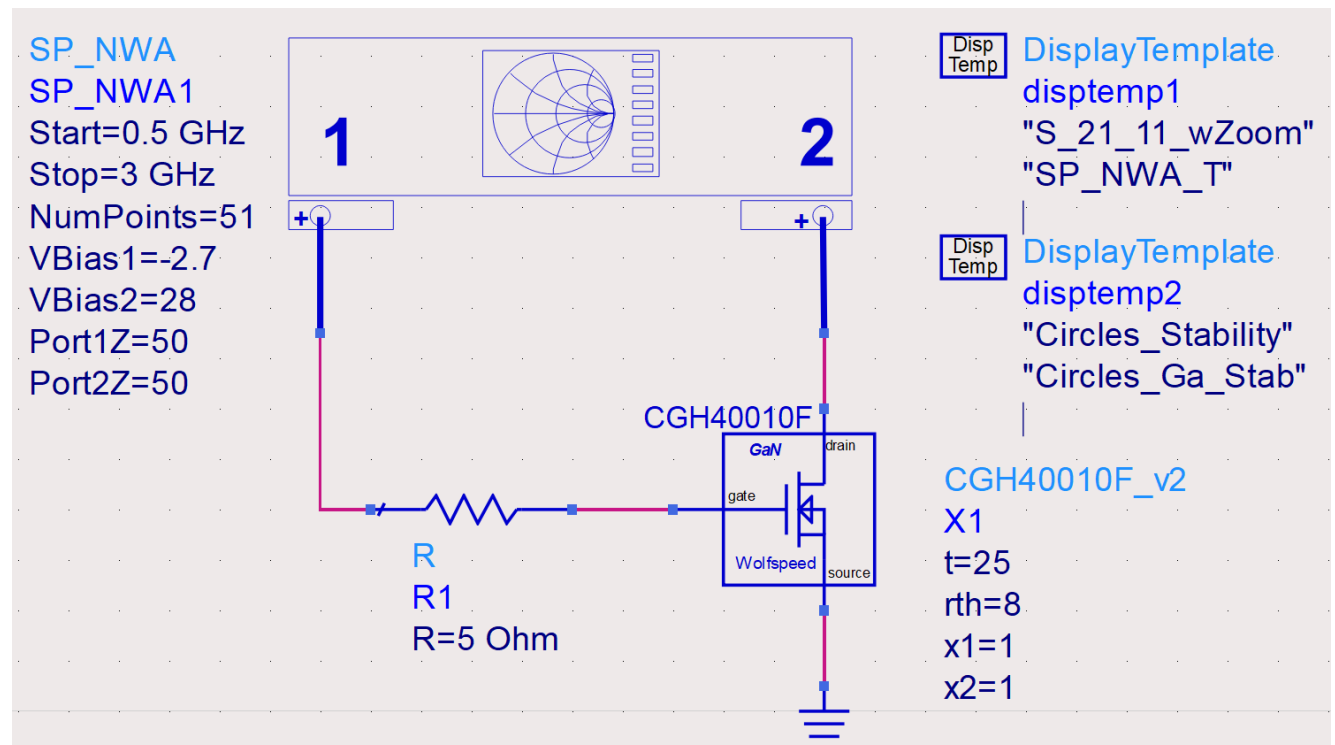
1. DC biasing
2. Stability analysis
3. Load pull analysis
4. Input and output Impedance matching
5. Optimize the design for required specifications.

DC Biasing



Pout_Max	n_max	RL	Idc	Conduction_Angle	Duty_Cycle
35.83	48.35	72.15	0.28	262.50	72.92

Stability analysis - [with resistor]



RF Frequency

2.200 GHz

Stability Factor, K

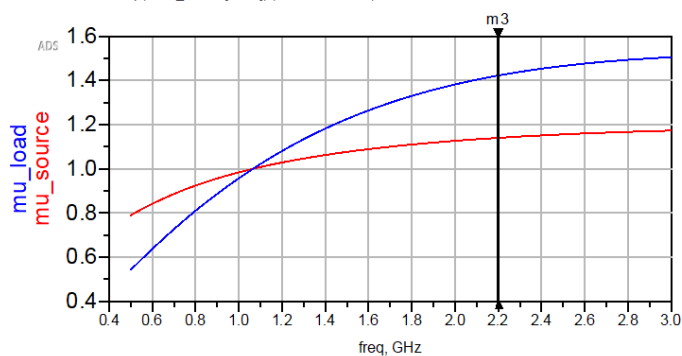
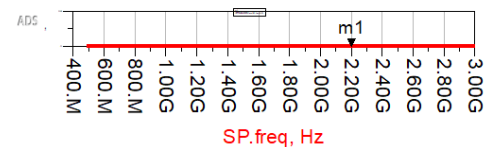
2.057

m3
freq=2.200GHz
mu_source=1.140
mu_load=1.422

Use with S_params or Spams_wNoise Schematic Templates

Move marker to desired frequency. The stability circles and stability factor, K, will be updated.

RF Frequency Selector



If either mu_source or mu_load is >1, the circuit is unconditionally stable.

Eqn mu_load=mu(S)

Eqn mu_source=mu_prime(S)

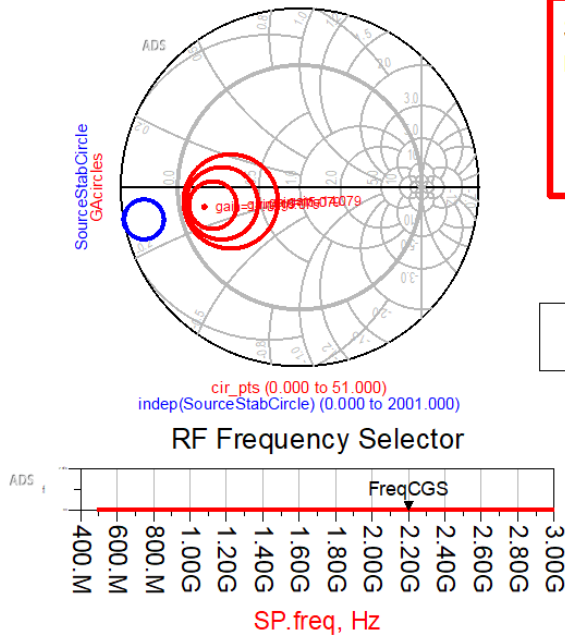
Eqn Source_stabcir=s_stab_circle(S,51)

Eqn Load_stabcir=l_stab_circle(S,51)

Eqn K=stab_fact(S(m1))

Use with 2-port S-parameter simulations

Available Gain Circles & Source Stability Circle



Set step size and
number of circles:

`Eqn num_GAcircles=3`
`Eqn GAstep_size=1`

Stability
Factor, K

2.057

MaxGain is the maximum
available gain if $K > 1$. If
 $K < 1$, it is the maximum
stable gain, $10 \cdot \log(|S_{21}|/|S_{12}|)$.

MaxGain

17.081

Source Stable Region
(inside or outside circle)

`s_stab_region(S[FreqCGS])`

Outside

`Eqn MaxGain=max_gain(S[FreqCGS])`

`Eqn GAvalue1=MaxGain-.002`

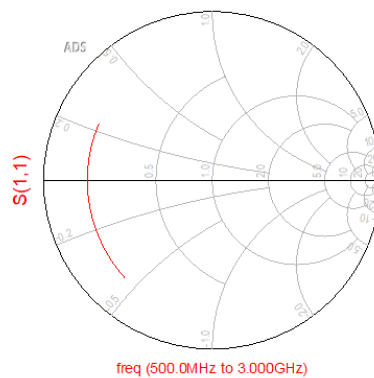
`Eqn GAcircles=ga_circle(S[FreqCGS],GAvalue1-[0:num_GAcircles]*GAstep_size,51)`

`Eqn SourceStabCircle=s_stab_circle(S[FreqCGS],2001)`

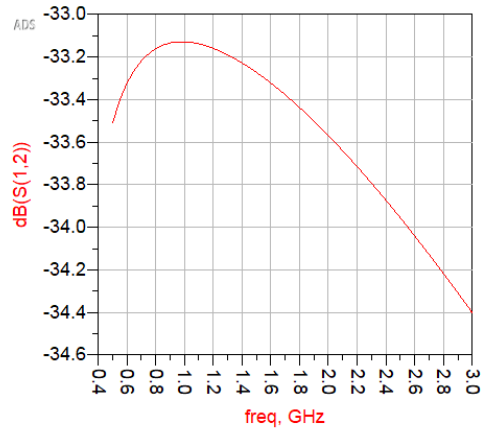
Move marker to desired
frequency to update plot.

`FreqCGS`
`indep(FreqCGS)=2.200G`
`vs([0:sweep_size(SP.freq)-1],SP.freq)=34.00`

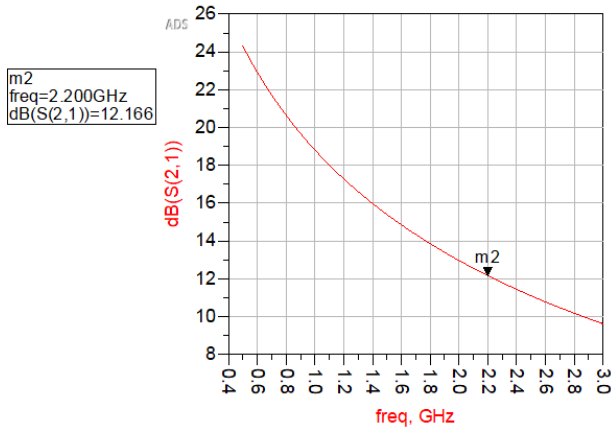
Input Reflection Coefficient



Reverse Transmission, dB

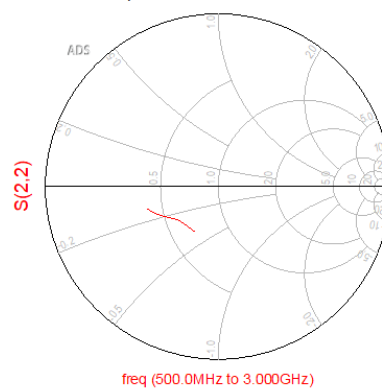


Forward Transmission, dB

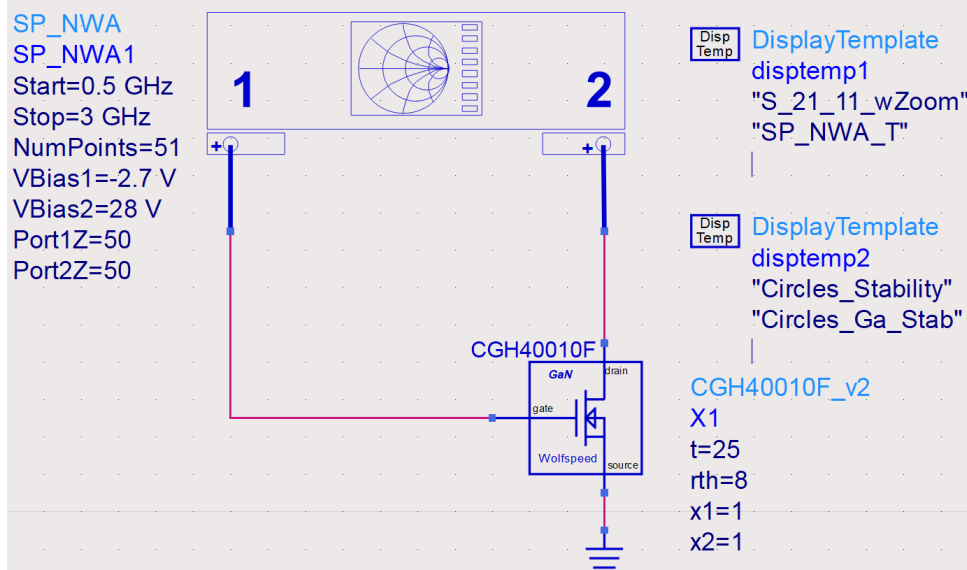


m2
freq=2.200GHz
 $\text{dB}(S(2,1))=12.166$

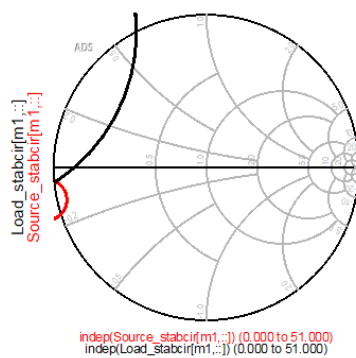
Output Reflection Coefficient



Stability analysis – [without resistor]

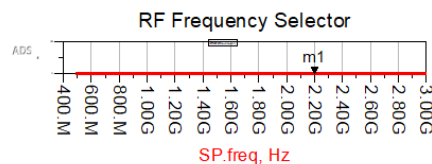


Source and Load Stability Circles

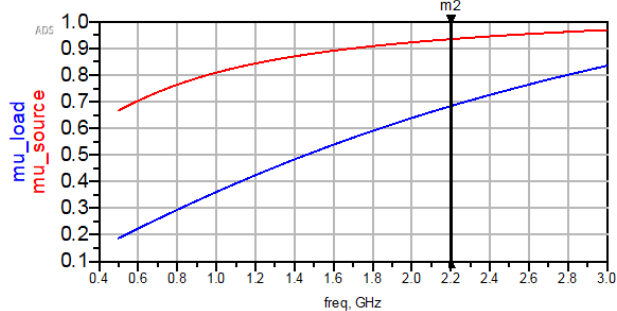


Use with S_params or Sparms_wNoise Schematic Templates

Move marker to desired frequency. The stability circles and stability factor, K, will be updated.



If either μ_{source} or μ_{load} is > 1 , the circuit is unconditionally stable.



m2
freq=2.200GHz
 $\mu_{\text{source}}=0.935$
 $\mu_{\text{load}}=0.684$

RF Frequency

2.200 GHz

Stability Factor, K

0.457

Eqn $\mu_{\text{load}}=\mu(S)$

Eqn $\mu_{\text{source}}=\mu_{\text{prime}}(S)$

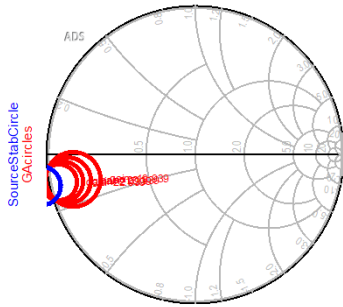
Eqn Source_stabcir=s_stab_circle(S,51)

Eqn Load_stabcir=l_stab_circle(S,51)

Eqn $K=\text{stab_fact}(S[m1])$

Use with 2-port S-parameter simulations

Available Gain Circles & Source Stability Circle



Set step size and
number of circles:

`Eqn num_GAcircles=3`

`Eqn GAstep_size=1`

Stability
Factor, K

0.457

MaxGain is the maximum
available gain if $K > 1$. If
 $K < 1$, it is the maximum
stable gain, $10 \cdot \log(|S_{21}|/|S_{12}|)$.

MaxGain

22.941

Source Stable Region
(inside or outside circle)

`s_stab_region(S[FreqCGS])`

Outside

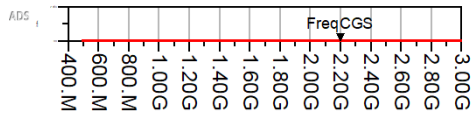
`Eqn MaxGain=max_gain(S[FreqCGS])`

`Eqn GAvale1=MaxGain-.002`

`Eqn GAcircles=ga_circle(S[FreqCGS],GAvale1-[0::num_GAcircles]*GAstep_size,51)`

`Eqn SourceStabCircle=s_stab_circle(S[FreqCGS],2001)`

RF Frequency Selector

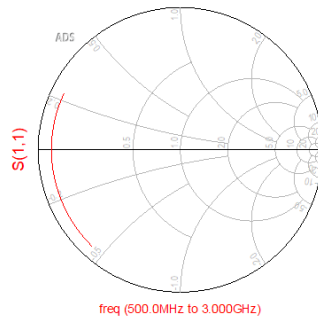


SP.freq, Hz

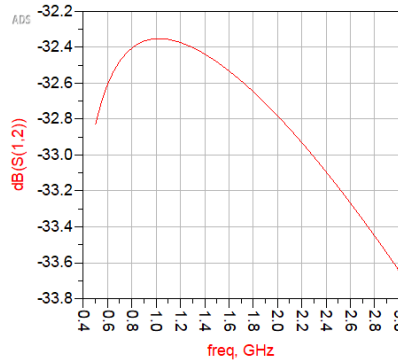
Move marker to desired
frequency to update plot.

`FreqCGS`
`indep(FreqCGS)=2.200G`
`vs([0::sweep_size(SP.freq)-1],SP.freq)=34.00`

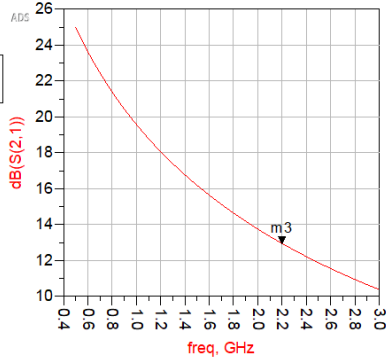
Input Reflection Coefficient



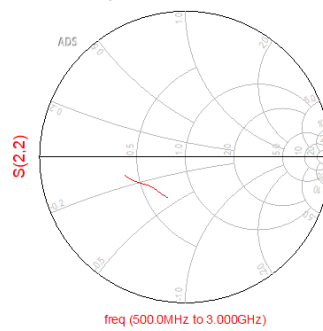
Reverse Transmission, dB



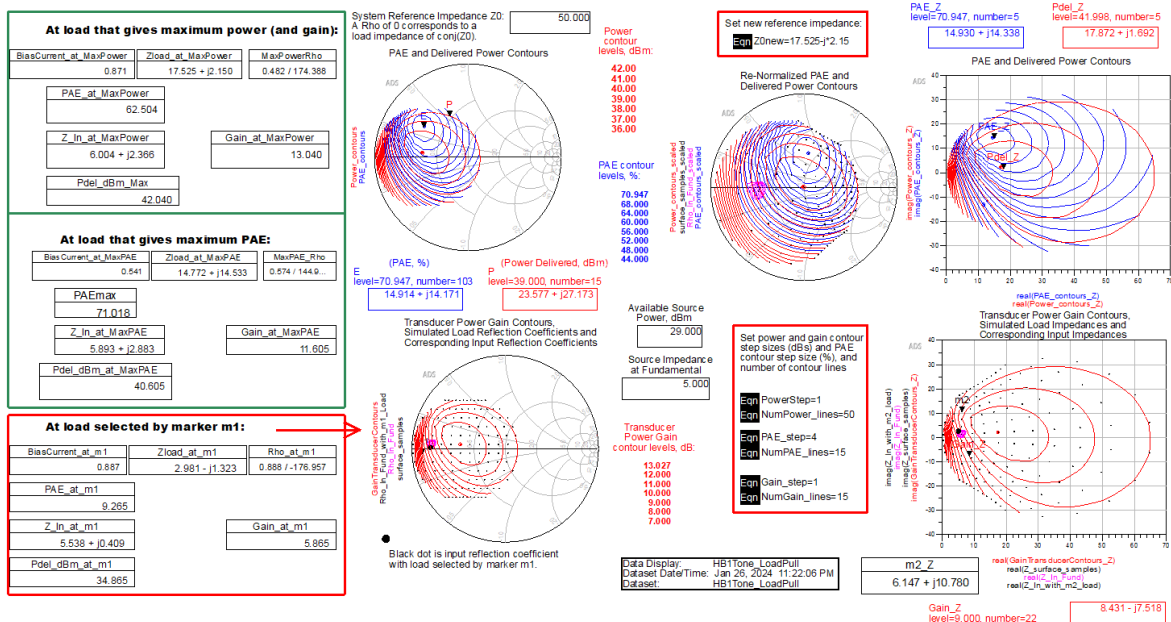
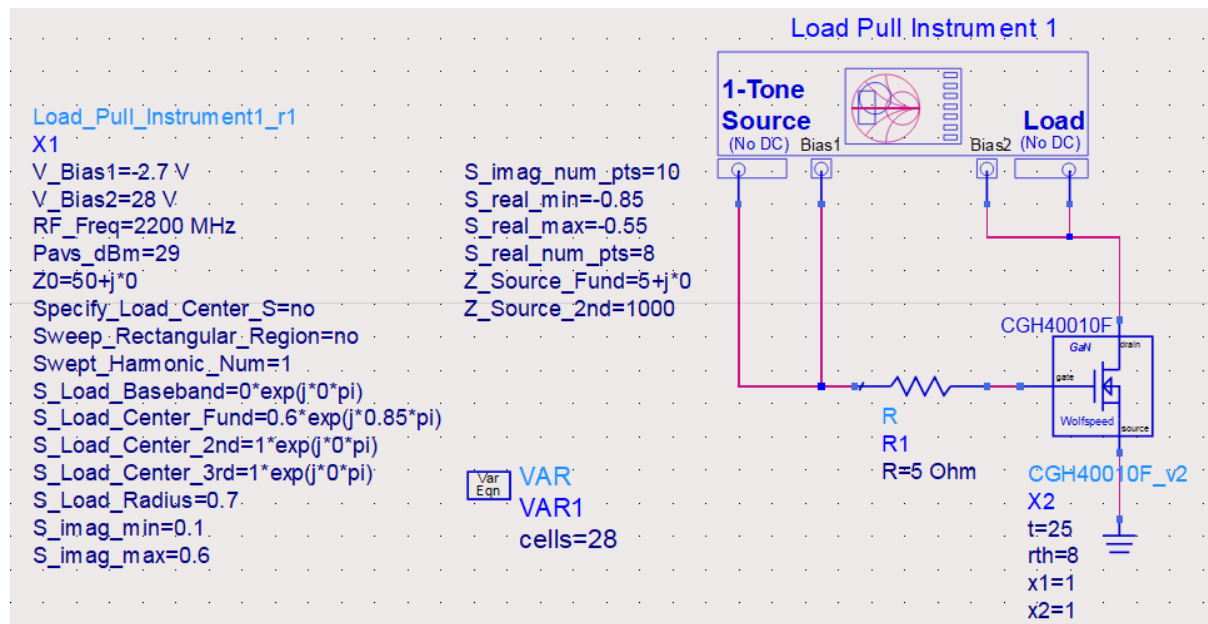
Forward Transmission, dB



Output Reflection Coefficient

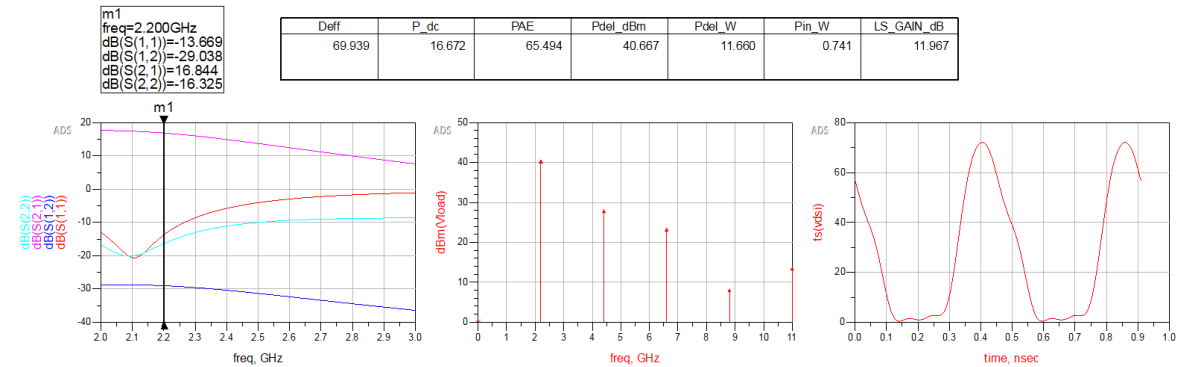
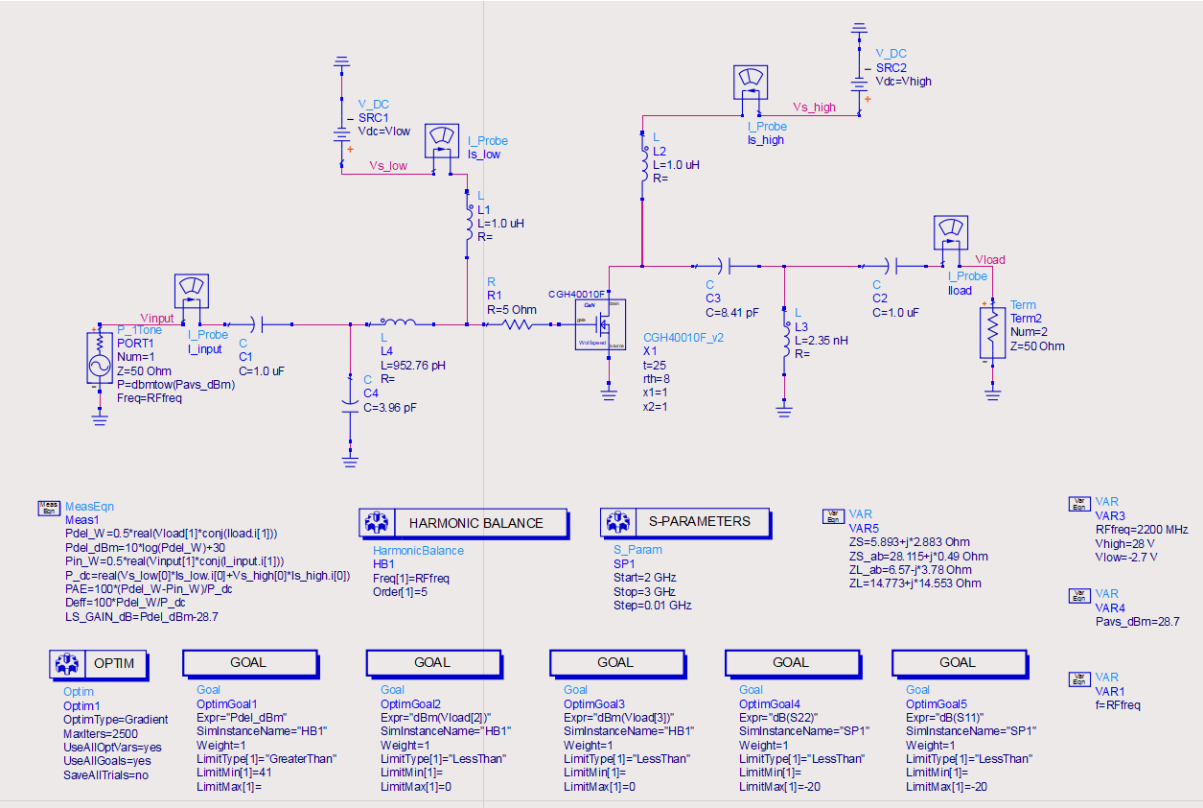


Load pull Analysis



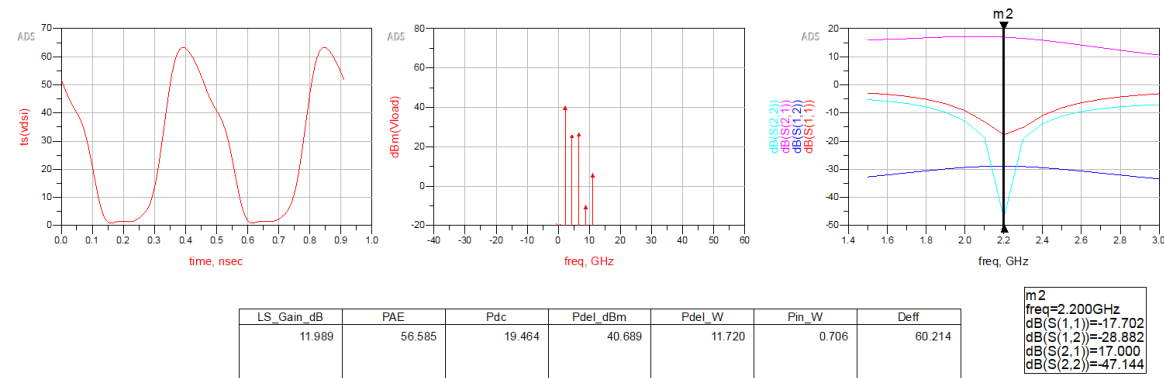
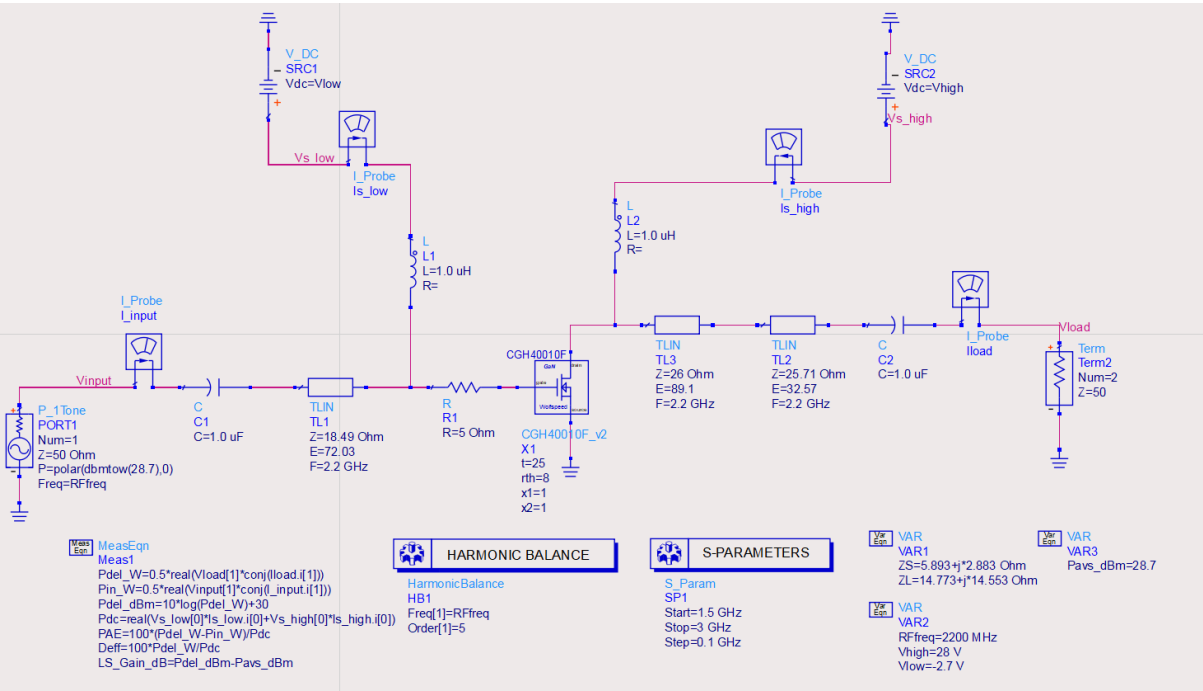
Matching network with Lumped components.

Textbook



Matching network with Transmission lines.

Complex impedance matching Journal.



The image displays a circuit schematic for a power amplifier, likely a Class AB or B PA, using a CGH40010F transistor. The circuit includes a matching network (TL1, TL2, TL3), a load network (C2, Term), and various measurement points (V_s_low, V_s_high, V_load, I_s_low, I_s_high, I_s_input). The schematic is annotated with component values and simulation parameters.

MeasEqn

```

Meas1
Pdel_W=0.5*real(Vload[1]*conj(Iload.[1]))
Pin_W=0.5*real(Vinput[1]*conj(Iinput.[1]))
Pdel_dBm=10*log(Pdel_W)+30
Pdc=real(Vs_low[0]*Is_low.[0])+Vs_high[0]*Is_high.[0])
PAE=100*(Pdel_W-Pin_W)/Pdc
Deff=100*Pdel_W/Pdc
LS_Gain_dB=Pdel_dBm-Pavs_dBm

```

HARMONIC BALANCE

Harmonic Balance
HB1
Freq[1]=RFfreq
Order[1]=5

S-PARAMETERS

S_Param
SP1
Start=1.5 GHz
Stop=3 GHz
Step=0.1 GHz

OPTIM

Optim
Optim1
OptimType=Random
MaxIters=5000
UseAllOptVars=yes
UseAllGoals=yes
SaveAllTrials=no

GOAL

Goal
OptimGoal1
Expr="PAE"
SimInstanceName="HB1"
Weight=1.0

GOAL

Goal
OptimGoal3
Expr="dB(S(2,2))"
SimInstanceName="SP1"
Weight=1.0

GOAL

Goal
OptimGoal2
Expr="dB(S(1,1))"
SimInstanceName="SP1"
Weight=1.0

