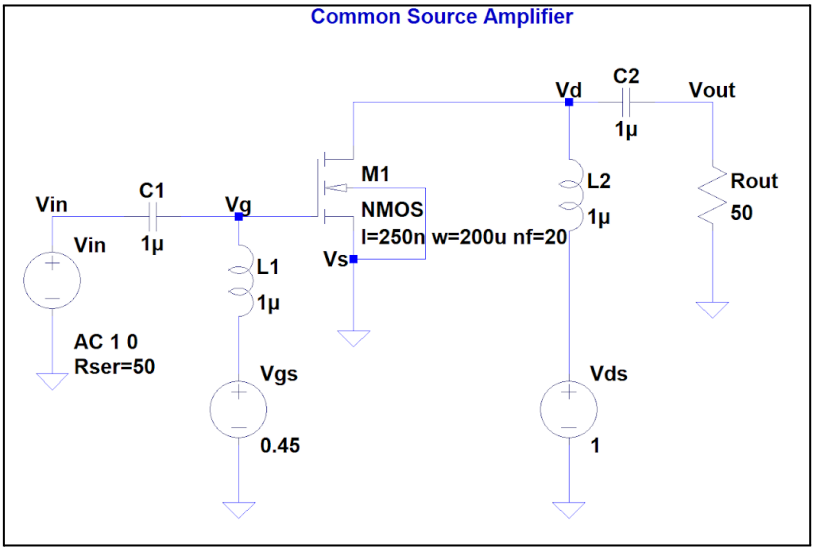
Common Source Amplifier Circuit:



Note: Used 130nm CMOS model from predictive transistor model (PTM).

Components:

Name	Components	LTspice Library	Value
M1	MOSFET	nmos4	L=250nm, W=200µm, nf=20
L1, L2	Inductor	ind	1µH
C1, C2	Capacitor	cap	1µF
Rout	Resistor	res	50Ω
Vgs	DC Voltage Source	voltage	0.45V
Vds	DC Voltage Source	voltage	1V
Vin	AC Voltage Source	voltage	Small Signal amplitude 1 and phase 0 and res 50Ω

- L1 and L2 are used to block AC signals.
  Practically, voltage divider biasing is used instead of inductors.
- C1 and C2 are used to block DC bias.

DC Simulation: Operating Point

Manual Calculation:

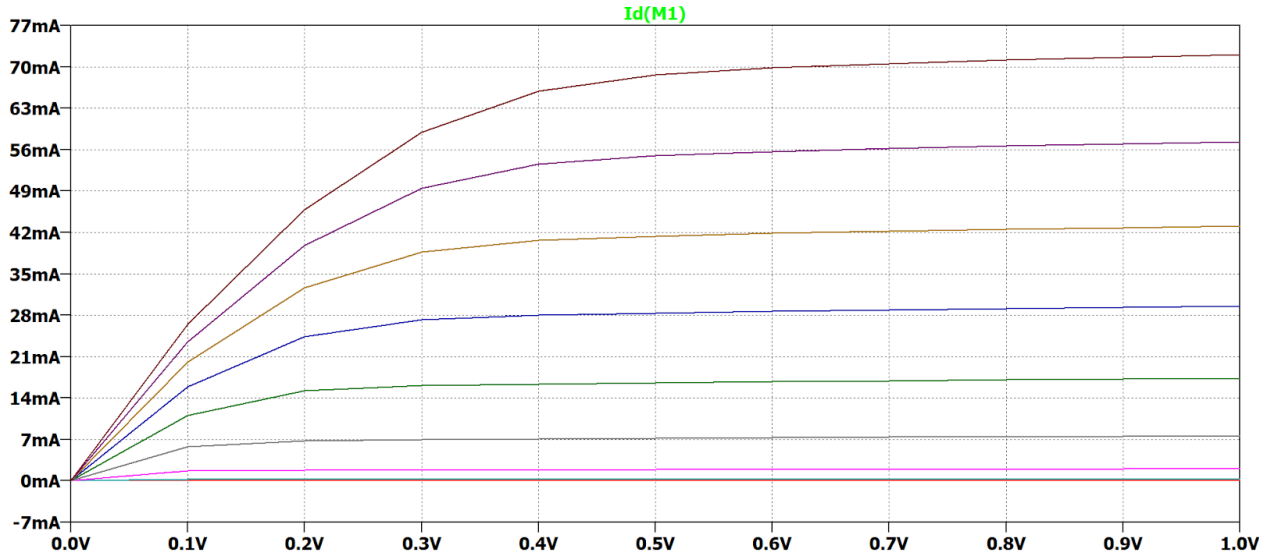
- Vg ~ 0.45V
- Vd ~ 1V
- Vs = 0V

Simulation result:

```
        --- Operating Point ---

V(vd):          0.999998        voltage
V(vg):          0.45            voltage
V(n001):        0.45            voltage
V(n002):        1               voltage
V(vin):         2.25e-17        voltage
V(vout):        4.99999e-17     voltage
Id(M1):         0.00162         device_current
Ig(M1):         0               device_current
Ib(M1):         -1.01e-12       device_current
Is(M1):         -0.00162        device_current
I(C1):          4.5e-19         device_current
I(C2):          -9.99998e-19    device_current
I(L1):          0               device_current
I(L2):          -0.00162        device_current
I(Rout):        9.99998e-19     device_current
I(Vin):         4.5e-19         device_current
I(Vb1):         0               device_current
I(Vb2):         -0.00162        device_current
```

Plotting the I-V Curve of the Transistor:



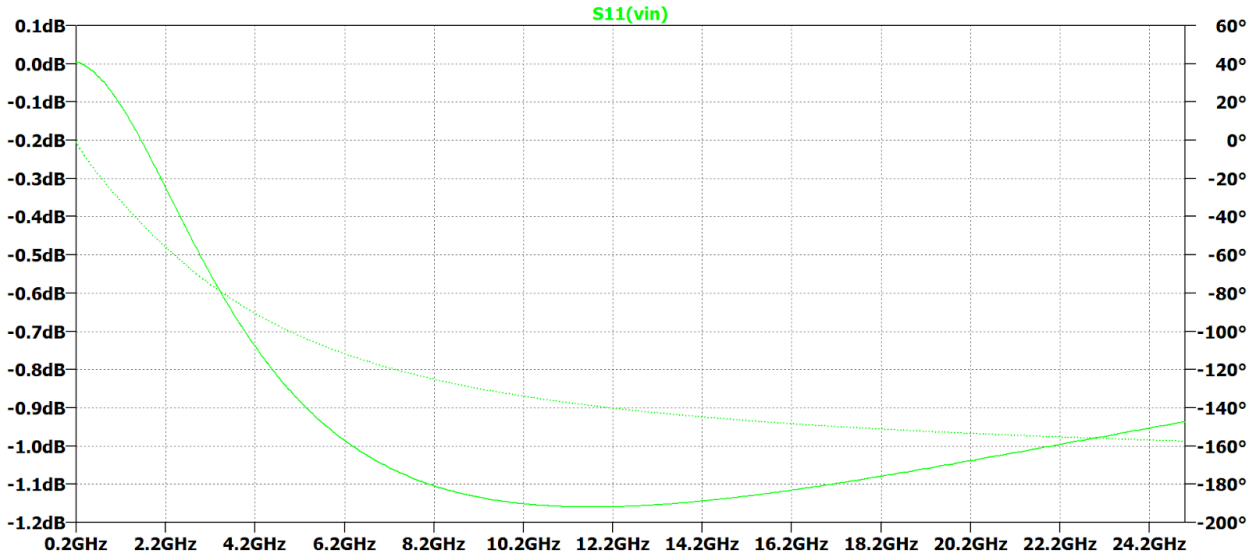
S-parameter Simulation:

Theory: A two port network has four S parameters:

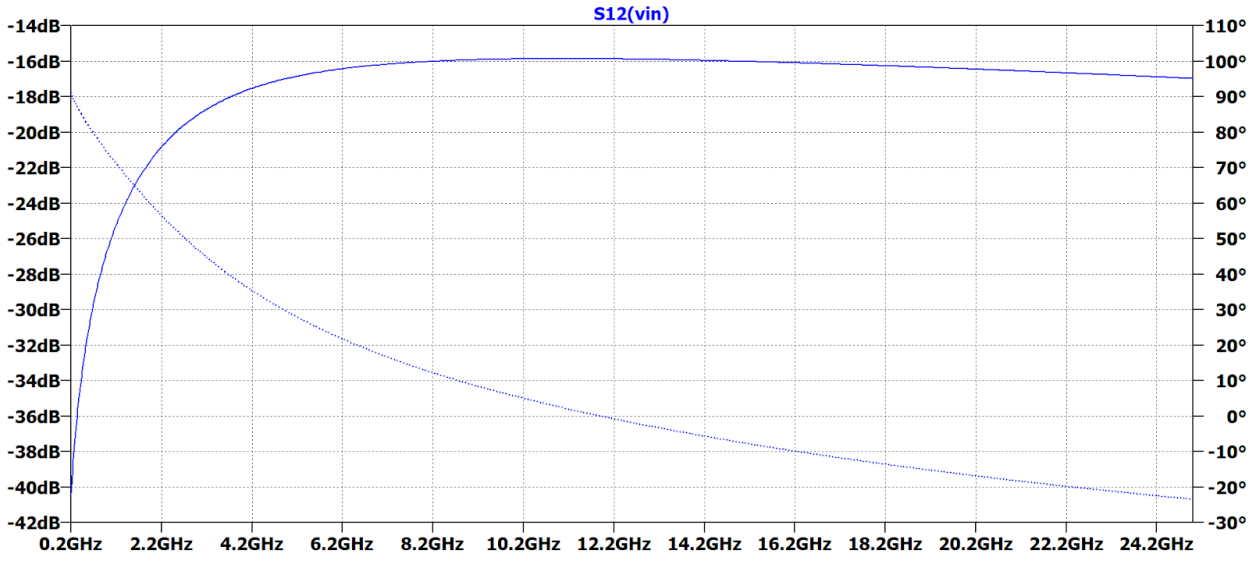
- S_{11} is the **input reflection coefficient**. It measures the portion of the input signal at port 1 that is reflected back to port 1. This parameter indicates how much of the input signal is reflected due to an impedance mismatch.

- S_{21} is the **forward transmission coefficient**. It measures the portion of the input signal at port 1 that is transmitted to port 2. This parameter indicates the efficiency of signal transmission from the input to the output.
- S_{12} is the **reverse transmission coefficient**. It measures the portion of the input signal at port 2 that is transmitted to port 1. This parameter indicates how well port 1 is isolated from signals entering port 2.
- S_{22} is the **output reflection coefficient**. It measures the portion of the input signal at port 2 that is reflected back to port 2. This parameter indicates how much of the output signal is reflected due to impedance mismatch at the output.

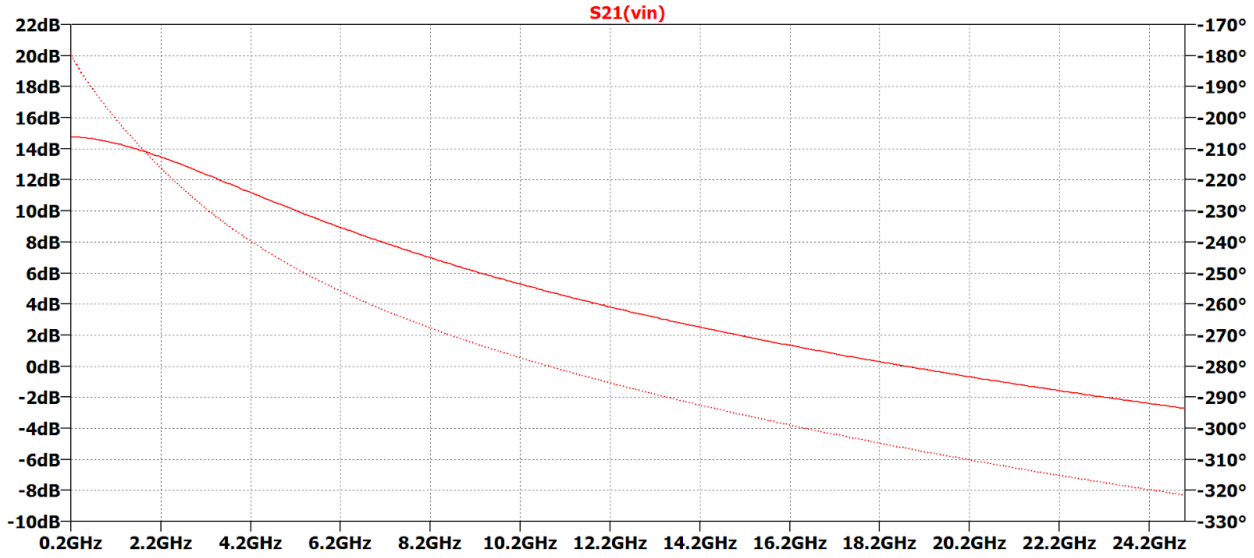
S11 plot:



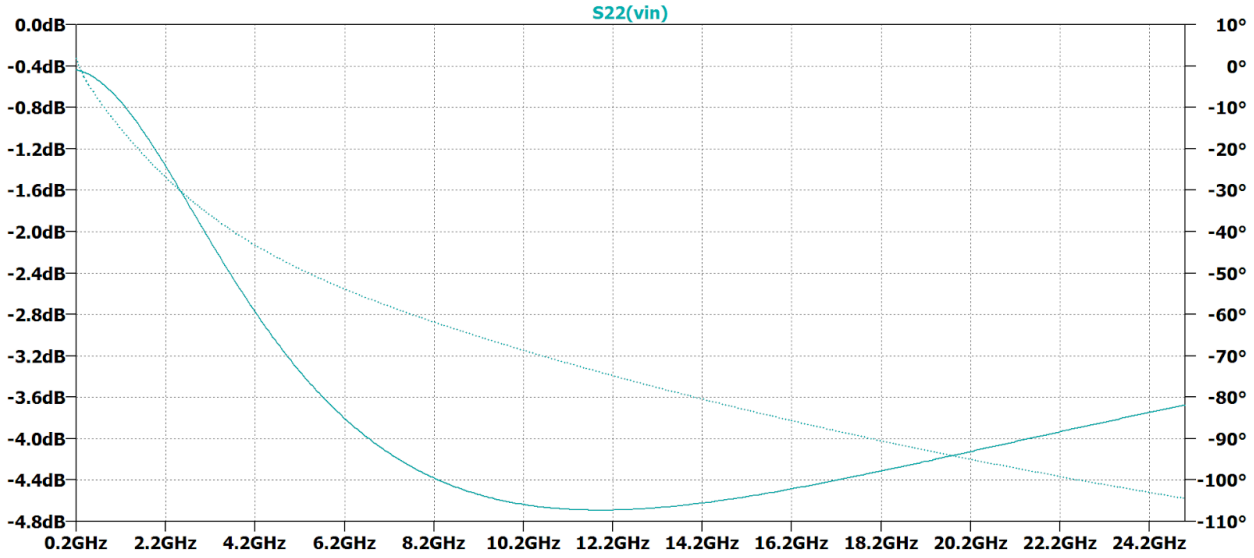
S12 plot:



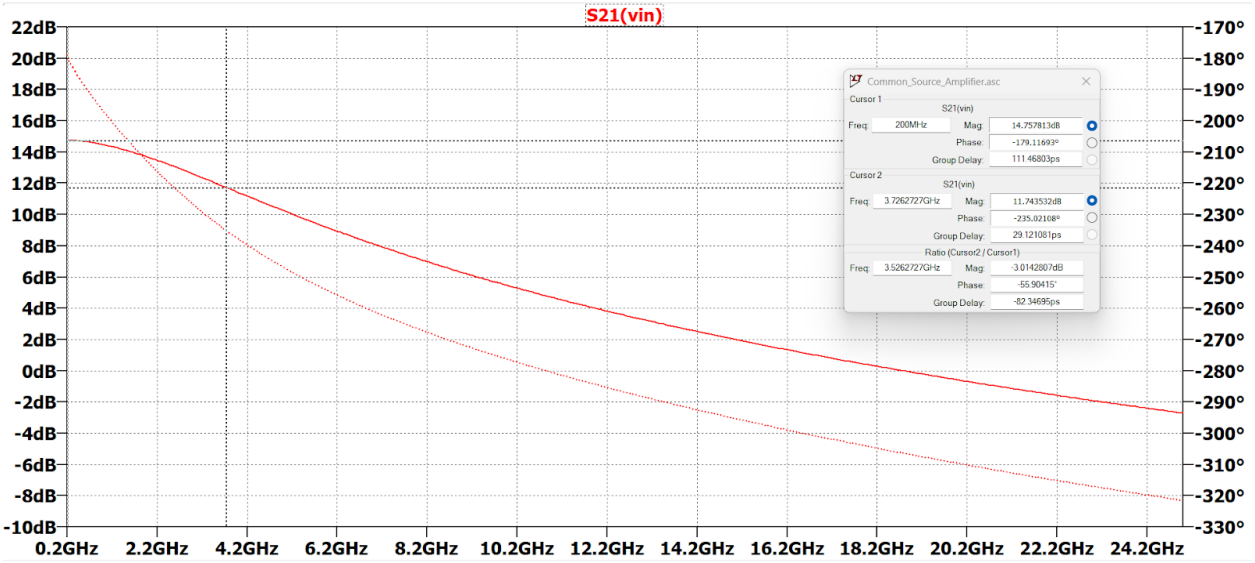
S21 plot:



S22 plot:

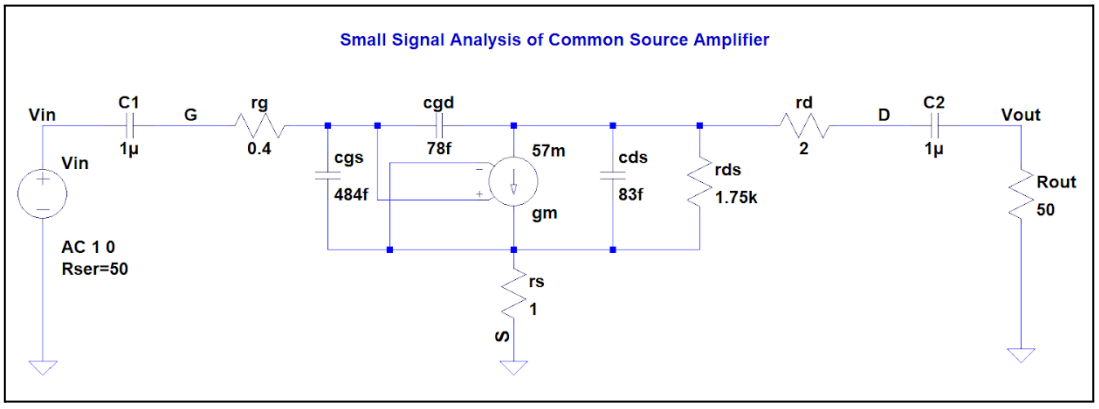


Gain-Bandwidth Product = 11.743dB × 3.726GHz = 14.401GHz



Small Signal Analysis of Common Source Amplifier:

Circuit:



Components:

Components	Value
C1, C2	1µF
rg	0.4Ω
rd	2Ω
rs	1Ω
rds	1.75KΩ
gm	57mS
cgs	484fF

cgd	78fF
cds	83fF

Transit Frequency:

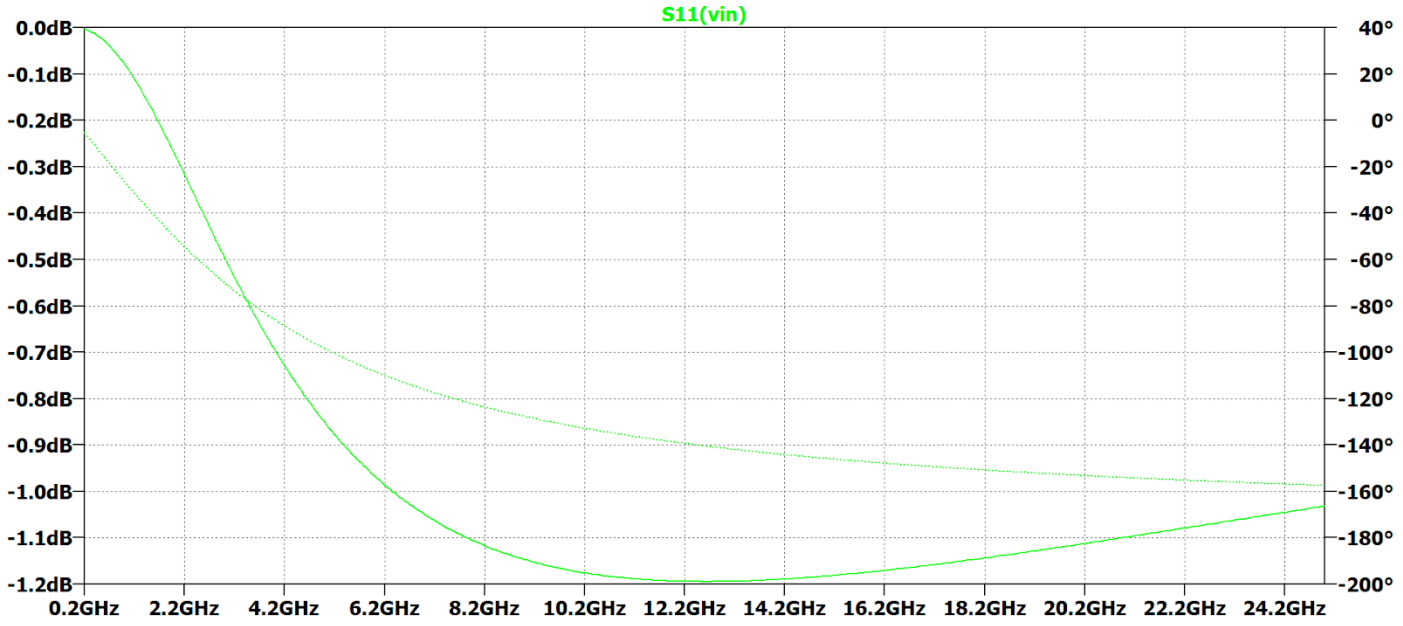
The frequency at which $i_{out}/i_{in} = 1$ (unity gain) and V_{out} is grounded, is called transit frequency.

Calculation:

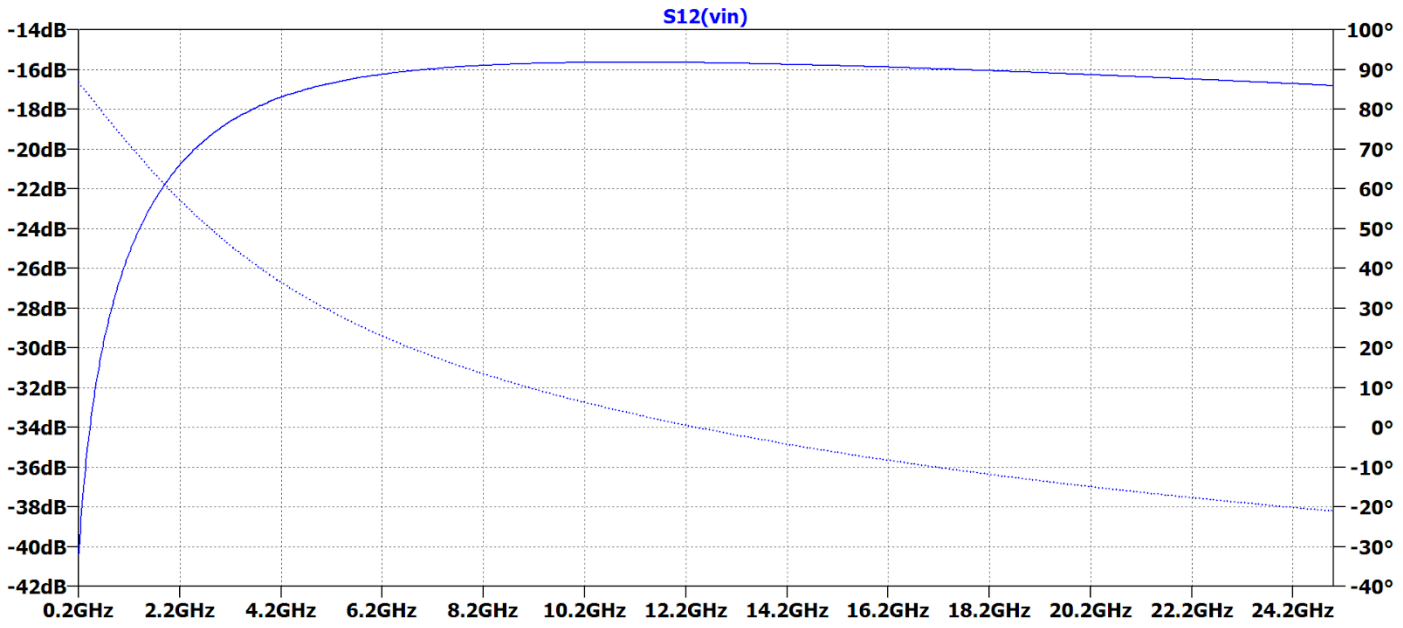
- r_g, r_s and r_d are neglected.
- c_{ds} and r_{ds} are removed because no current passes through it.
- C1 is a short circuit at high frequency.
- $f_T = g_m/2\pi(c_{gd}+c_{gs}) = 16.142GHz$

S-parameter Simulation:

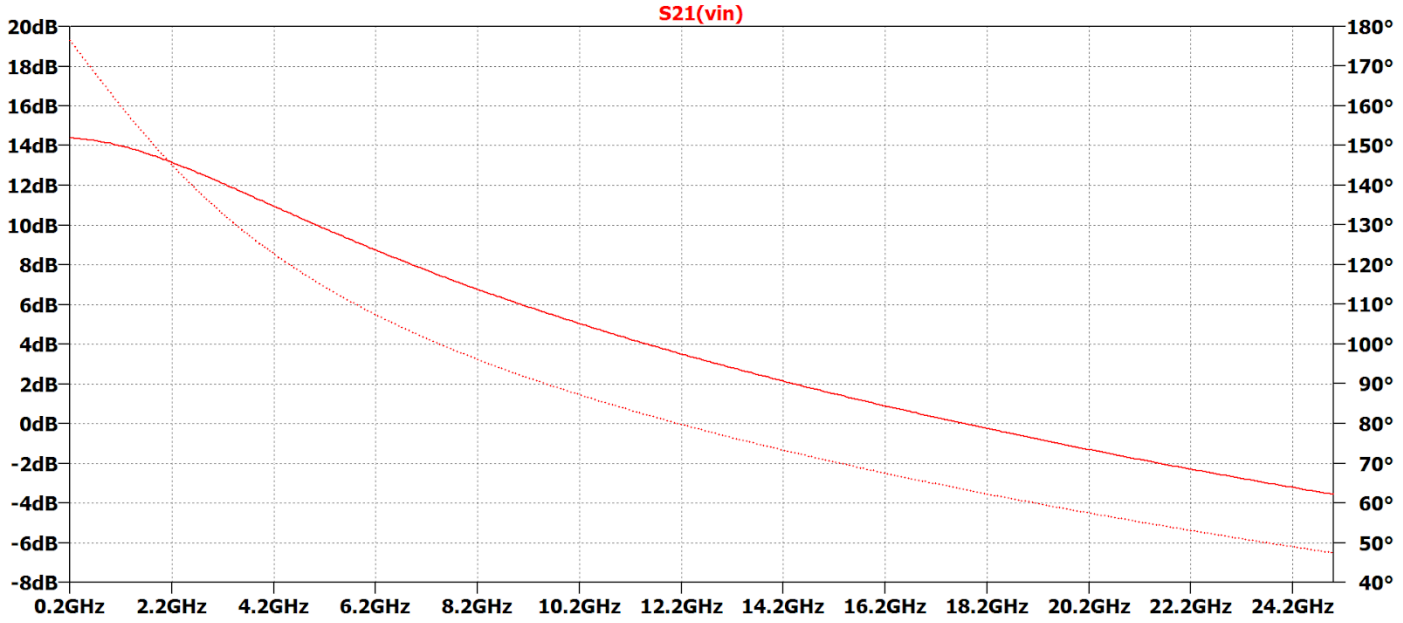
S11 plot:



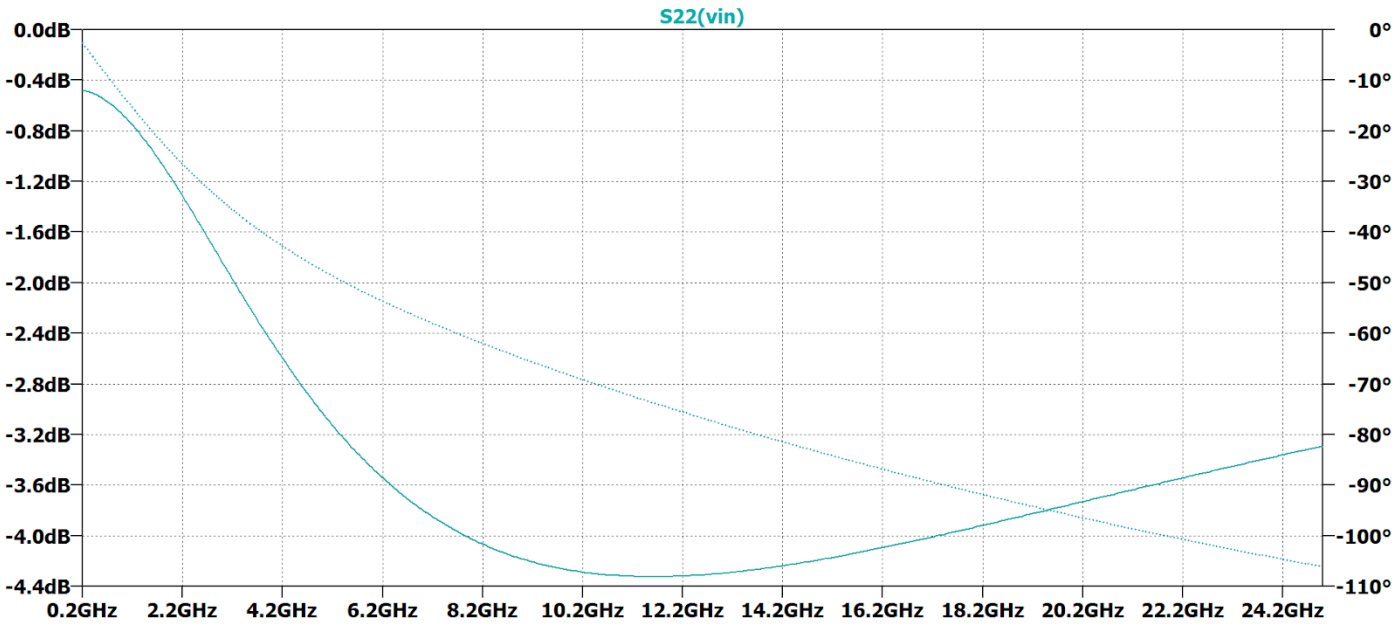
S12 plot:



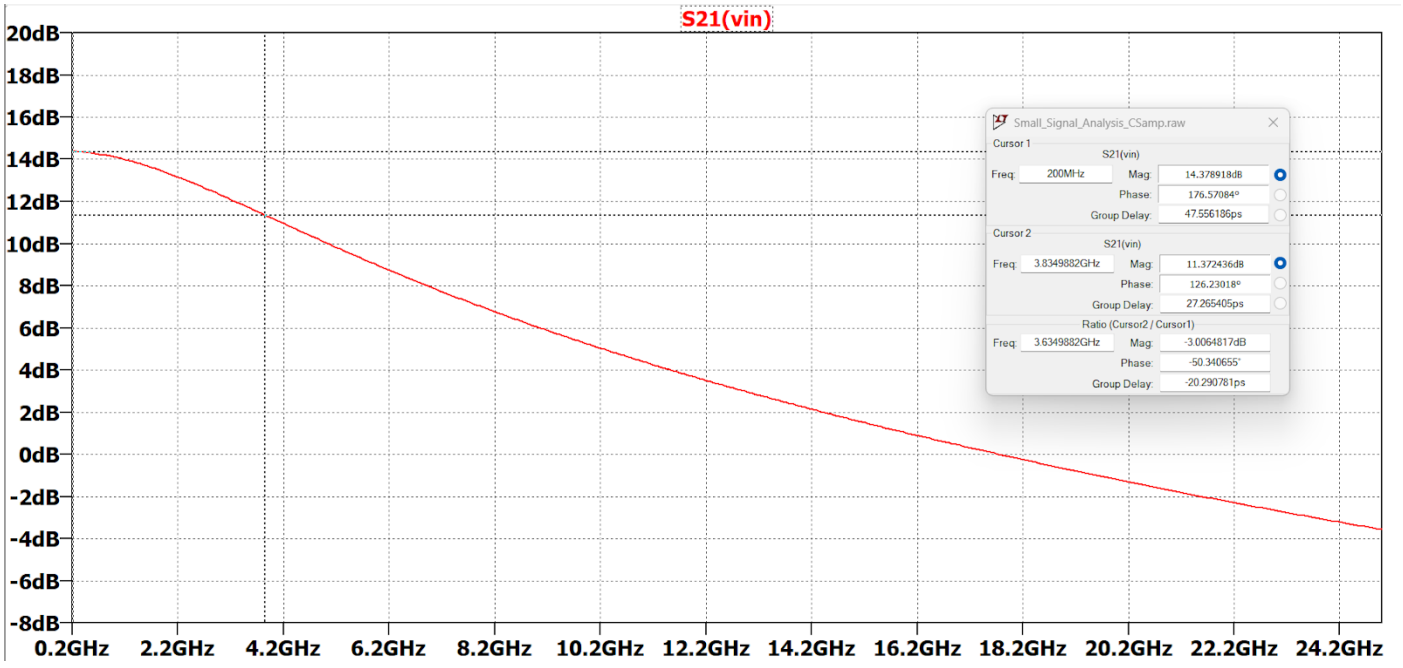
S21 plot:



S22 plot:

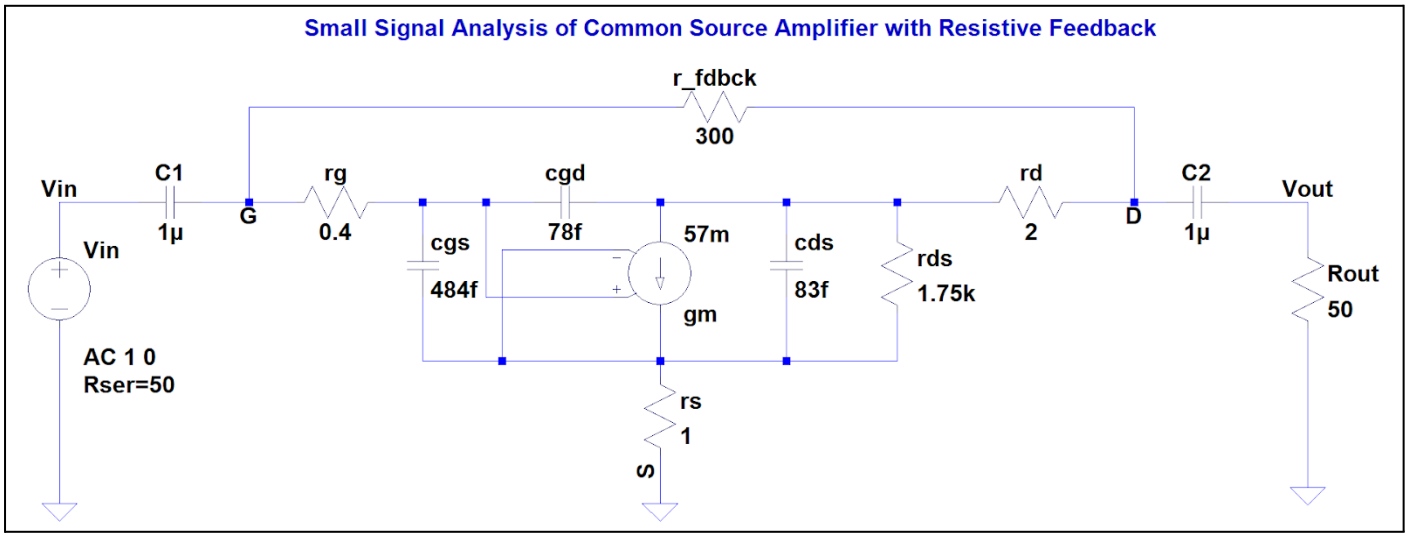


Gain-Bandwidth Product = 11.372dB ×3.834GHz = 14.198GHz



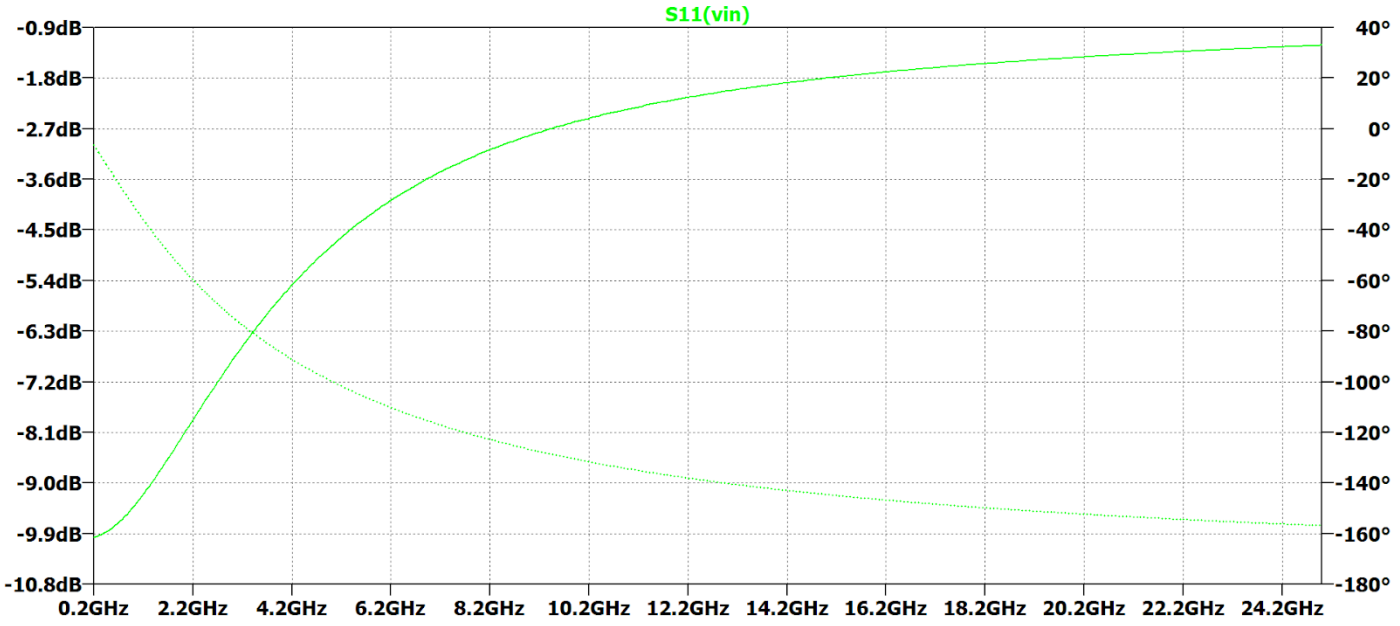
Small Signal Analysis of Common Source Amplifier with Resistive Feedback:

Circuit:

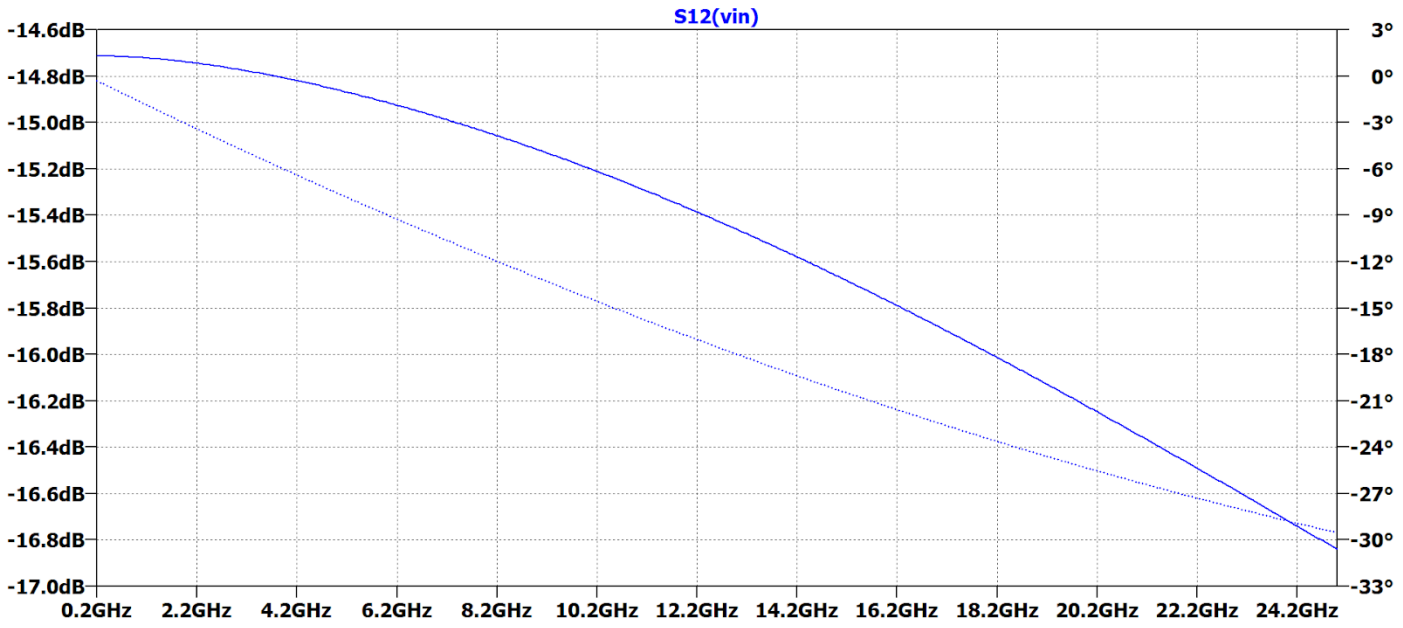


S-parameter Simulation:

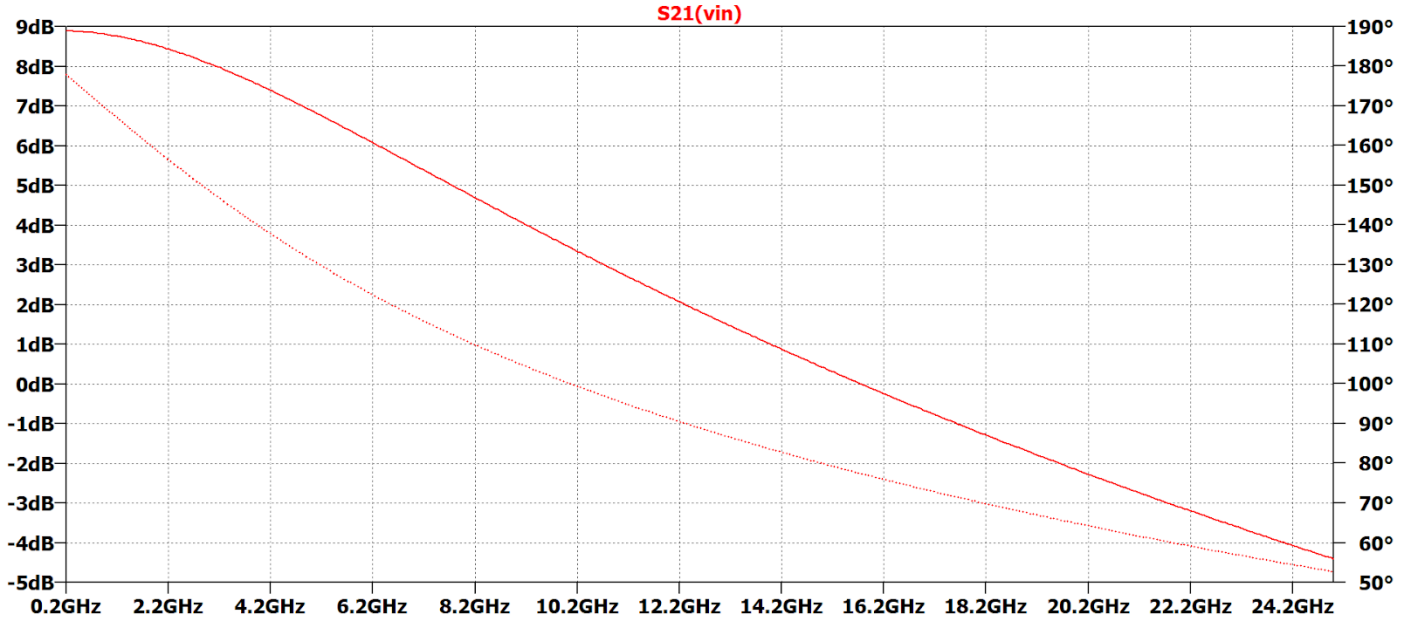
S11 plot:



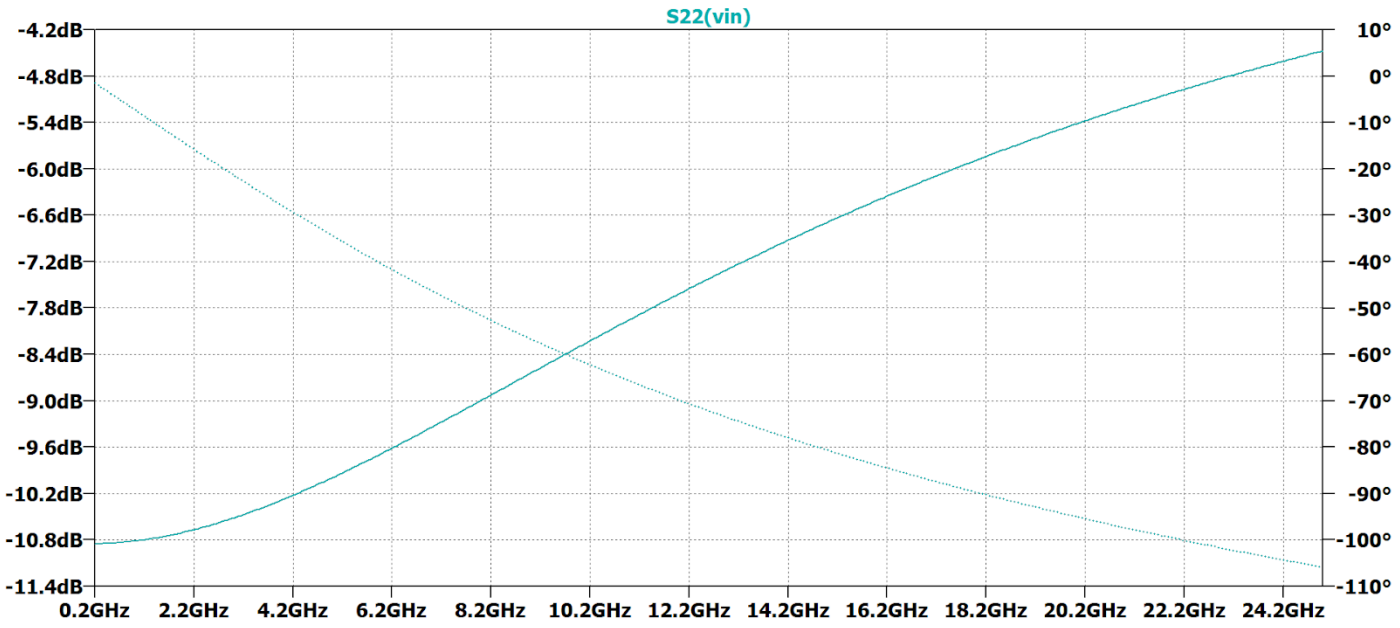
S12 plot:



S21 plot:



S22 plot:



Gain-Bandwidth Product = 5.886dB ×6.469GHz = 12.739GHz