



**T.C. YILDIZ TEKNİK ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ**

Proje Raporu

**Hazırlayan : ALİ RÜVEYCAN
No :22505108**

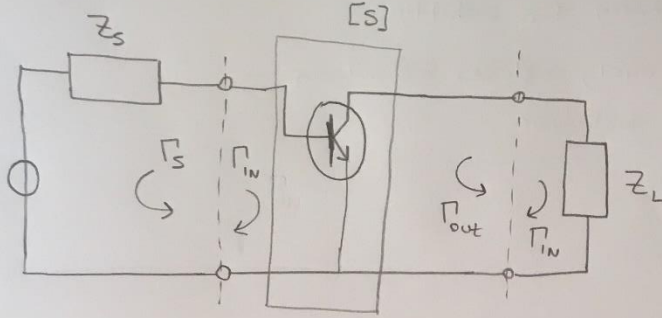
Elektronik ve Haberleşme Mühendisliği Anabilim Dalı

Haberleşme Tezli Yüksek Lisans Programı

RF Devre Tasarımı

Proje Konusu : AWR Microwave Office kullanarak Maksimum Kazanç Amplifikatörü Tasarımı ve Simülasyonu

1- Kazancı maksimize etmek



$$G_S = \frac{1 - |\Gamma_S|^2}{|1 - \Gamma_{IN} \Gamma_S|^2}, \quad G_0 = |S_{21}|^2, \quad G_L = \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \Gamma_L|^2}$$

Genel Transducer (dönüştürücü) kazancı ;

$$G_T = G_S \cdot G_0 \cdot G_L$$

2- Maksimum Kazanç için Tasarım

Verilen transistör için kazanç G_0 sabittir.
Amplifikatörün toplam kazancı, eşleşen bölümlerin G_L ve G_S 'si tarafından belirlenir.

$$\Gamma_{IN} = \Gamma_S^*$$

$$\Gamma_{OUT} = \Gamma_L^*$$

Kayıpsız eşleşen bölümleri varsayarsak;

$$G_{T,max} = \frac{1}{1 - |\Gamma_S|^2} \cdot |S_{21}|^2 \cdot \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \Gamma_L|^2}$$

3- İkili transistör için maksimum kazanç

Bir ikili transistör olması durumunda; $\Gamma_{in}, \Gamma_{out}$ 'ten etkilenir ve bunun tersi de geçerlidir.

$$\Gamma_S^* = S_{11} + \frac{S_{12} S_{21} \Gamma_L}{1 - S_{22} \Gamma_L}$$

$$\Gamma_L^* = S_{22} + \frac{S_{12} S_{21} \Gamma_S}{1 - S_{11} \Gamma_S}$$

$$\Gamma_S = \frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2C_1}, \quad \Gamma_L = \frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2C_2}$$

$$B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2$$

$$B_2 = 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2$$

$$C_1 = S_{11} - \Delta S_{22}^*$$

$$C_2 = S_{22} - \Delta S_{11}^*$$

$$\Delta = S_{11} \cdot S_{22} - S_{12} S_{21}$$

4- Maksimum Kazanç durumunda Kazanç

$$G_s = \frac{1 - |\Gamma_s|^2}{|1 - \Gamma_{in} \Gamma_s|^2} = \frac{1 - |\Gamma_s|^2}{|1 - \Gamma_s^* \Gamma_s|^2} = \frac{1 - |\Gamma_s|^2}{|1 - \Gamma_s^* \Gamma_s|} = \frac{1}{1 - |\Gamma_s|^2}$$

$$G_o = |S_{21}|^2$$

$$G_L = \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \Gamma_L|^2}$$

5- Özellikler

- Transistör Infineon BFP540
- Maksimum Kazanç Tasarımı
- Frekans : 5 GHz
- Sapma noktası $V_{CE} = 2V$ ve $I_C = 3mA$

BFP540 Touchstone File

amplifier.emp - AWR Design Environment (22.1) - [bfp540_spar (MDIF) (doc read-only)]

Project: amplifier, response, bfp540_spar (MDIF) (doc read-only)

Frequency (GHz)	Real(S11)	Imag(S11)	Real(S12)	Imag(S12)	Real(S21)	Imag(S21)	Real(S22)	Imag(S22)
3.400	0.5369	152.7	3.678	49.6	0.1013	27.1	0.1762	-113.1
3.500	0.5440	150.0	3.567	47.5	0.1029	26.6	0.1687	-117.1
3.600	0.5476	147.6	3.465	46.0	0.1041	26.1	0.1626	-121.4
3.700	0.5521	145.3	3.366	44.3	0.1054	25.5	0.1575	-126.1
3.800	0.5575	143.0	3.270	42.6	0.1066	25.0	0.1535	-131.0
3.900	0.5638	140.7	3.177	40.7	0.1078	24.5	0.1507	-136.1
4.000	0.5709	138.5	3.088	38.8	0.1091	24.0	0.1491	-141.4
4.100	0.5750	136.5	3.004	37.3	0.1106	23.3	0.1485	-145.5
4.200	0.5798	134.5	2.922	35.8	0.1121	22.6	0.1487	-149.6
4.300	0.5852	132.6	2.843	34.2	0.1136	22.0	0.1496	-153.7
4.400	0.5913	130.7	2.765	32.4	0.1151	21.3	0.1513	-157.8
4.500	0.5981	128.8	2.691	30.6	0.1166	20.7	0.1537	-161.7
4.600	0.6019	127.2	2.627	29.2	0.1180	20.3	0.1546	-164.8
4.700	0.6062	125.6	2.564	27.7	0.1194	19.9	0.1560	-167.9
4.800	0.6110	124.0	2.503	26.1	0.1208	19.5	0.1579	-171.0
4.900	0.6162	122.4	2.445	24.4	0.1222	19.1	0.1601	-173.9
5.000	0.6219	120.9	2.388	22.7	0.1236	18.7	0.1628	-176.8
5.100	0.6248	119.5	2.332	21.4	0.1252	18.2	0.1632	-179.5
5.200	0.6281	118.2	2.278	20.1	0.1268	17.7	0.1639	-177.8
5.300	0.6317	116.8	2.224	18.6	0.1284	17.2	0.1650	-175.2
5.400	0.6356	115.5	2.172	17.2	0.1300	16.8	0.1664	-172.6
5.500	0.6399	114.2	2.122	15.6	0.1316	16.3	0.1682	-170.0
5.600	0.6432	113.1	2.081	14.4	0.1332	15.8	0.1684	-167.5
5.700	0.6467	111.9	2.041	13.2	0.1348	15.4	0.1690	-165.0
5.800	0.6505	110.8	2.001	11.9	0.1364	14.9	0.1698	-162.5
5.900	0.6545	109.7	1.963	10.6	0.1380	14.5	0.1710	-160.1

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Transistörün S parametrelerine sahiptir ($Z_0 = 50 \Omega$)

$f(\text{GHz})$	S_{11}	S_{12}	S_{21}	S_{22}
5.0	$0,6556 \angle 126,9^\circ$	$0,1114 \angle 7,7^\circ$	$2,011 \angle 22,5^\circ$	$0,200 \angle -138,1^\circ$

Transistöre eşlenik eşleşme (conjugate match) şu şekilde belirlenebilir:

$$\Gamma_s = \frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2C_1} = 0,793 \angle -129^\circ$$

$$\Gamma_L = \frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2C_2} = 0,553 \angle 114^\circ$$

$$G_s = \frac{1}{1 - |\Gamma_s|^2} = 2,694 = 4,3 \text{ dB}$$

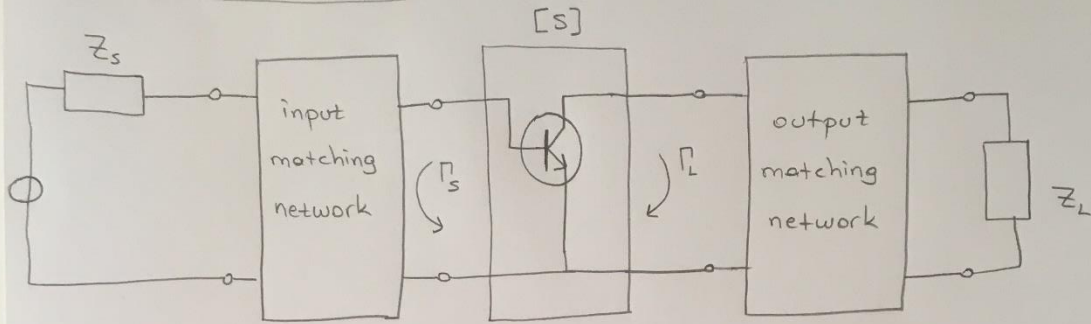
$$G_o = |S_{21}|^2 = 4,044 = 6,07 \text{ dB}$$

$$G_L = \frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2} = 0,856 = -0,67 \text{ dB}$$

Genel transducer kazancı

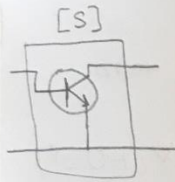
$$G_T = 4,3 \text{ dB} + 6,07 \text{ dB} - 0,67 \text{ dB} = 9,7 \text{ dB}$$

6- Eşlenik Eşleşme (Conjugate-Matched) Tasarımı



$$\Gamma_s = 0,793 \angle -129^\circ, \quad \Gamma_L = 0,553 \angle 114^\circ$$

Output Matching Network Tasarımı



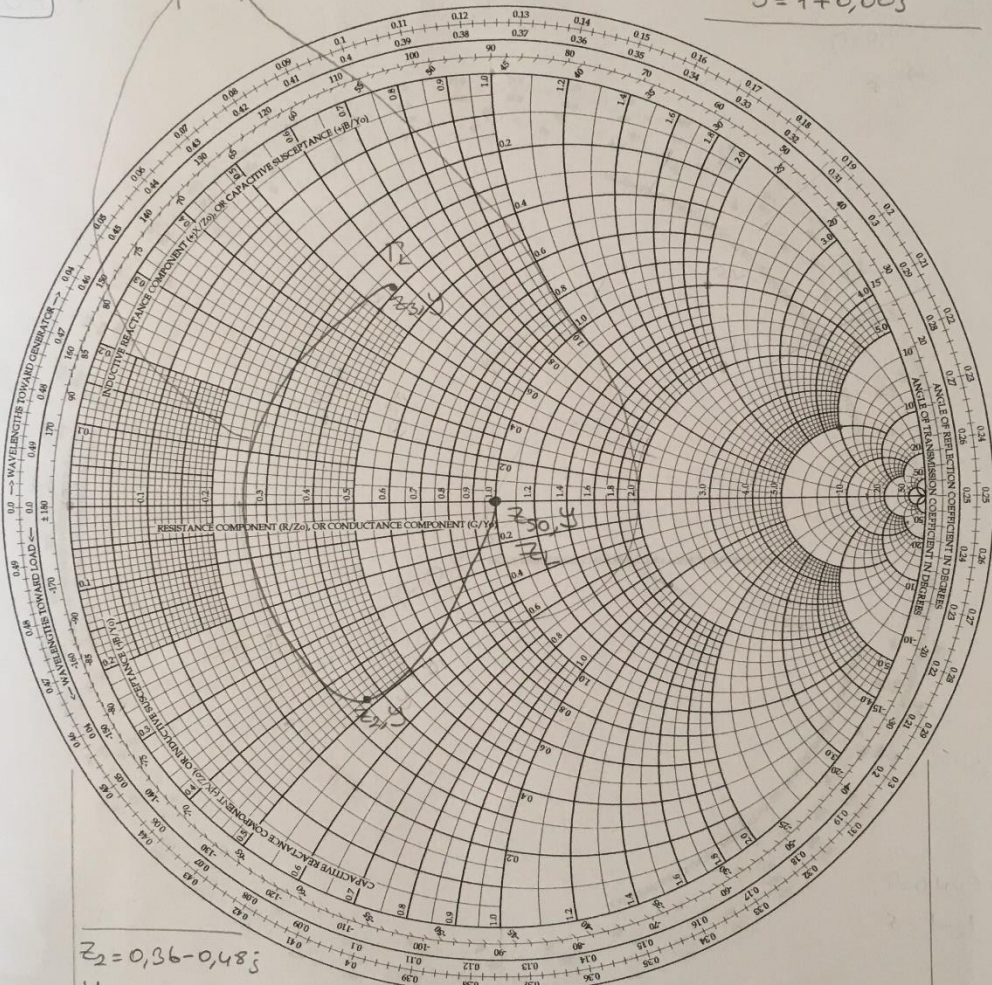
Smith Chart

$$Z_3 = 0,38 + j0,57$$

$$Y = 0,81 - j1,18$$

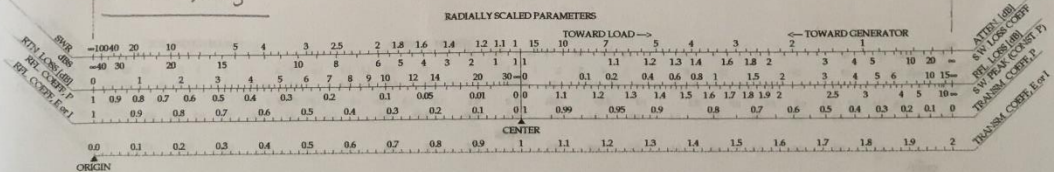
$$Z_{50} = 1,00 + j0,00$$

$$Y = 1 + j0,00$$



$$Z_2 = 0,36 - j0,48$$

$$Y = 1 + j1,34$$



Ekleler hattın hat uzunluğunu bulmak

Hat, 0,422λ'dan başlıyor.

Hat, 0,091λ'da bitiyor.

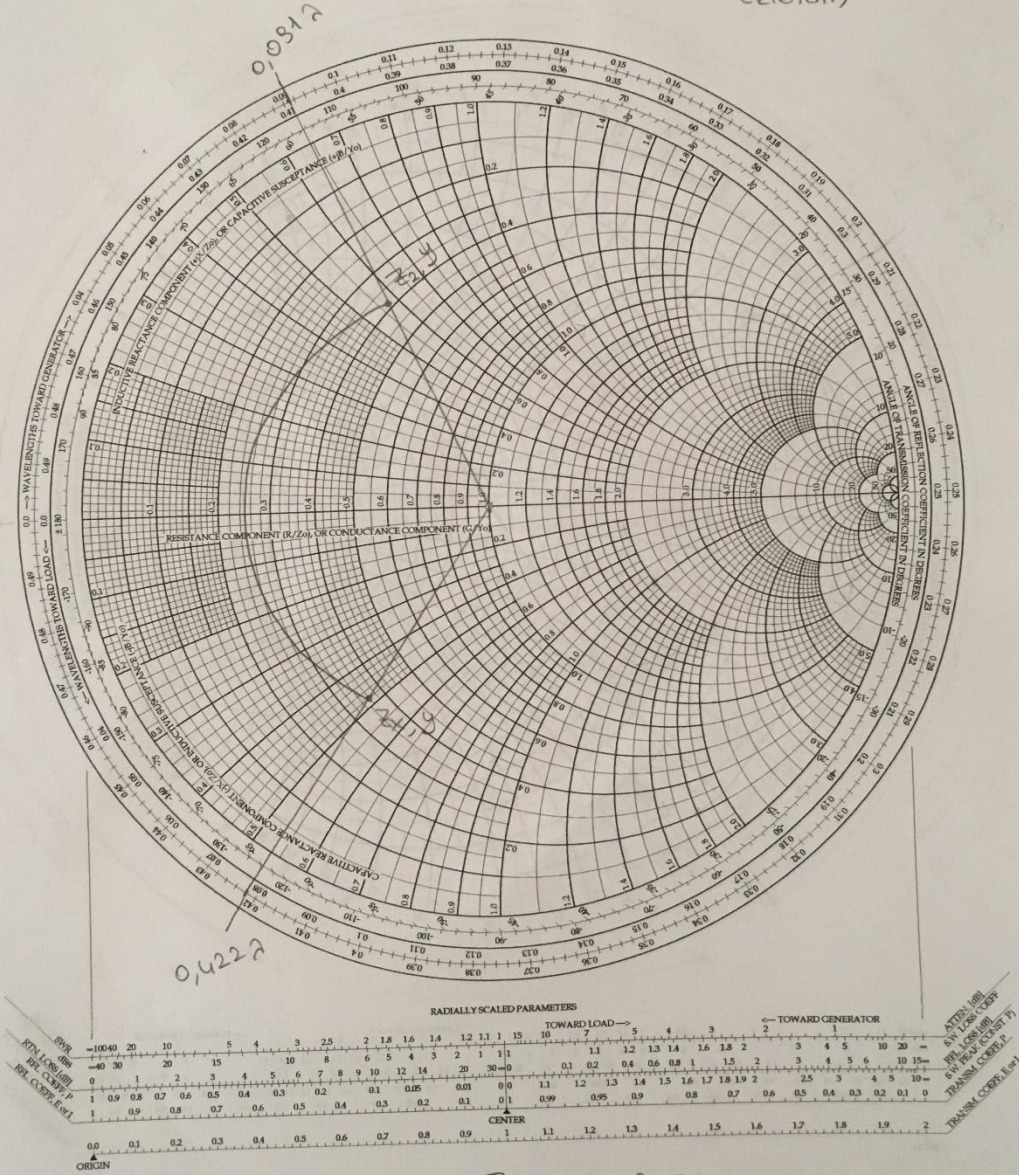
Smith Chart

Hat uzunluğu =

$$0,091\lambda - 0,422\lambda + 0,5\lambda$$

$$= 0,169\lambda$$

(0,5λ, sıfır-geçiş nedeniyle eklendi.)



$$Z_x = 0,36 - 0,48j$$

$$Y = 1 + 1,34j$$

$$Z_2 = 0,39 + 0,57j$$

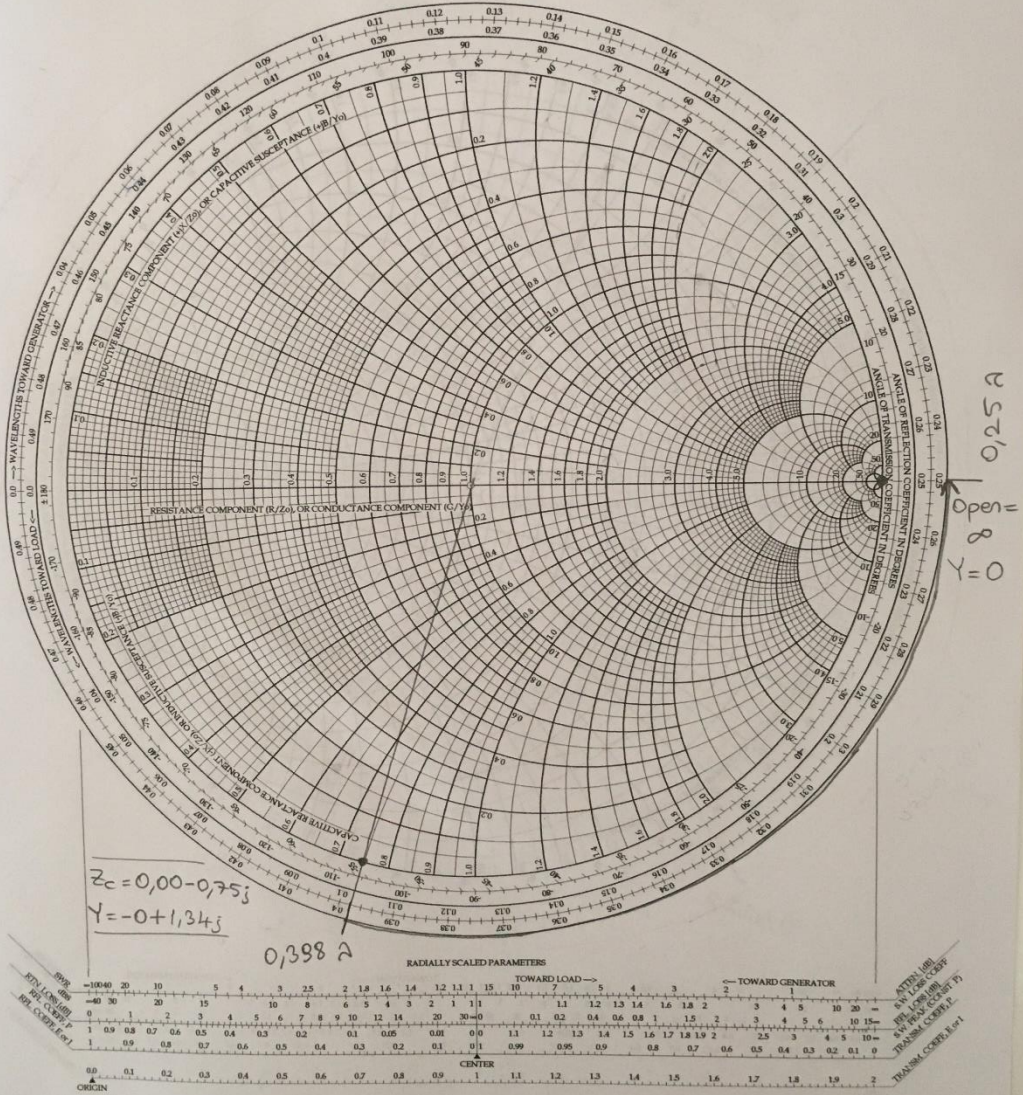
$$Y = 0,82 - 1,19j$$

Kapasitörü açık Stub Line ile değiştirmek
Kapasitör, $Y_c = 1,34j$ admitansa sahip.

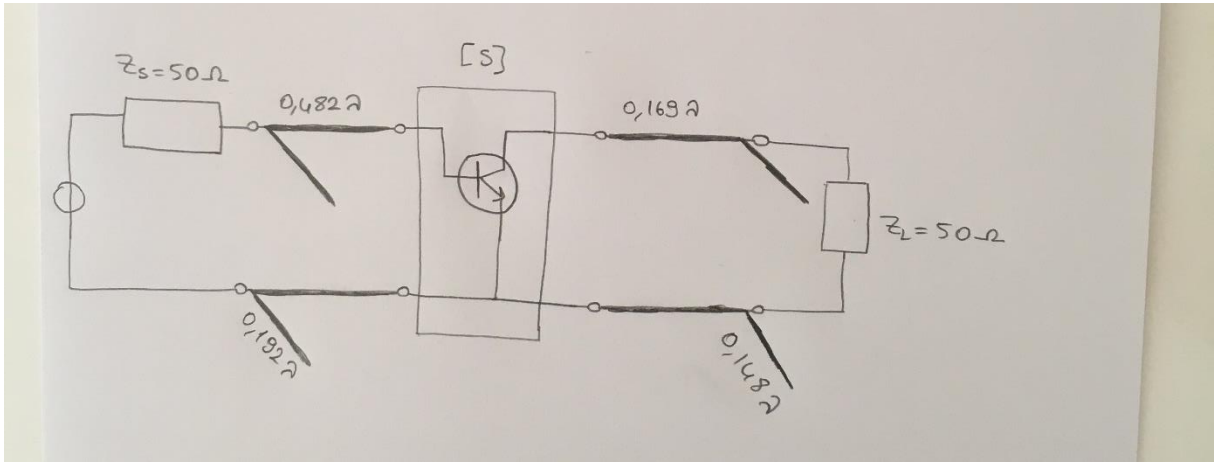
0,25 λ başla, 0,398 λ sınır
girisinde dur.

Smith Chart

Stub Line uzunluğu =
 $0,398\lambda - 0,25\lambda =$
0,148 λ



Son Amplifikatör Devresi



$$Z_2 = 0,13 - 0,33j$$

$$Y = 1 + 2,62j$$

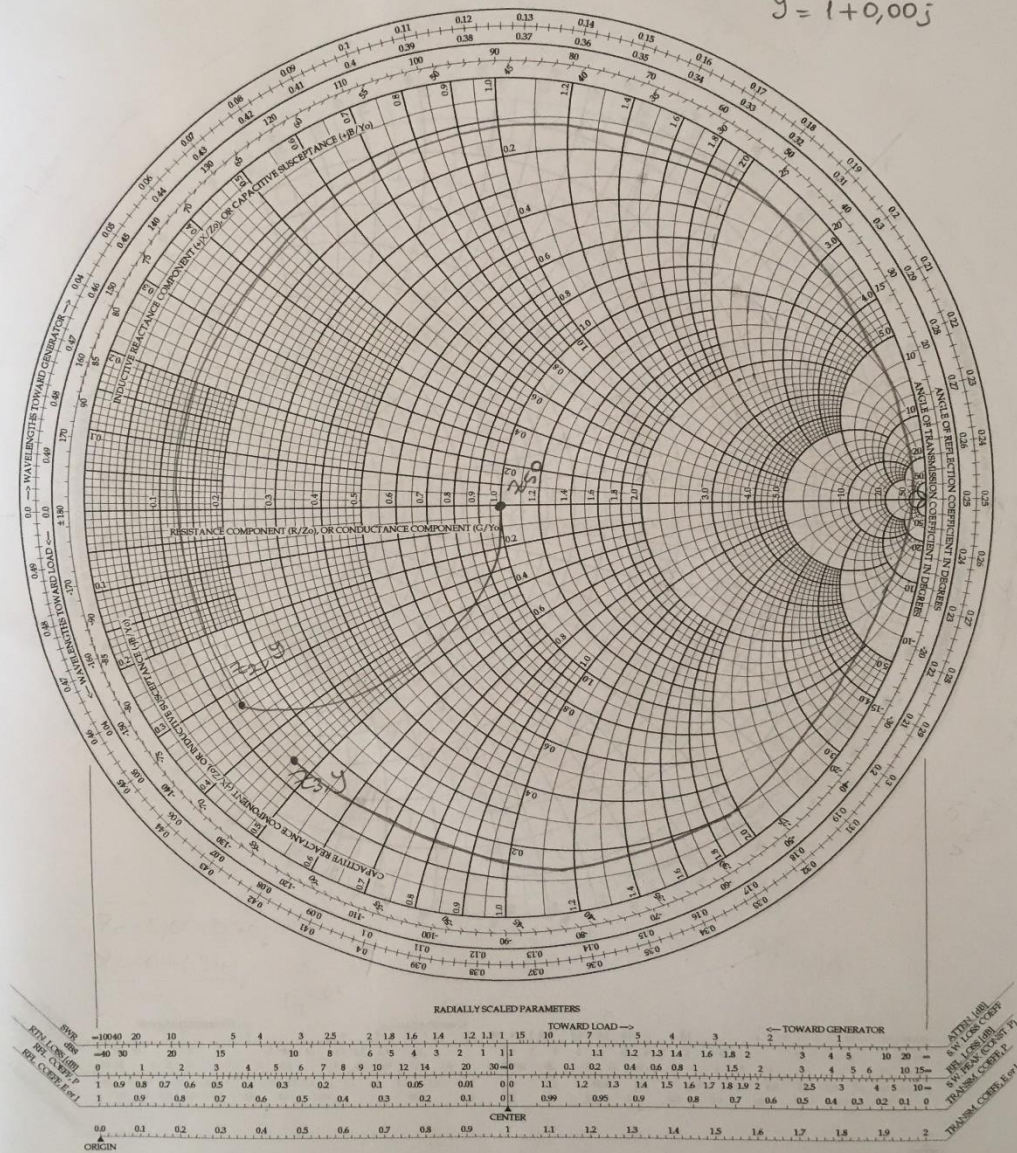
$$Z_3 = 0,14 - 0,46j$$

$$Y = 0,59 + 1,98j$$

Smith Chart

$$Z_{50} = 1,00 + 0,00j$$

$$Y = 1 + 0,00j$$



$$Z_3 = 0,39 + 0,57j$$

$$y = 0,81 - 1,19j$$

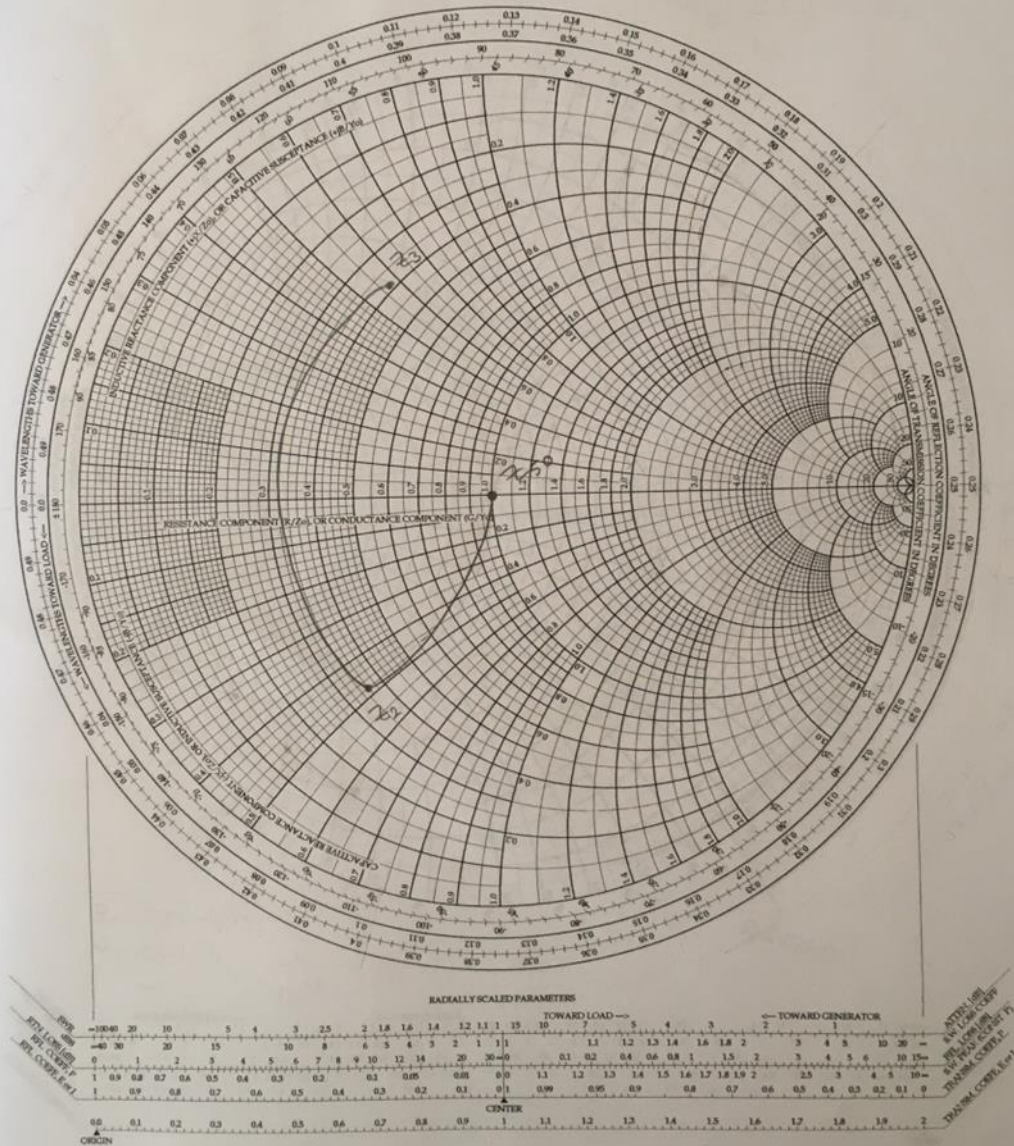
$$Z_2 = 0,36 - 0,48j$$

$$y = 1 + 1,34j$$

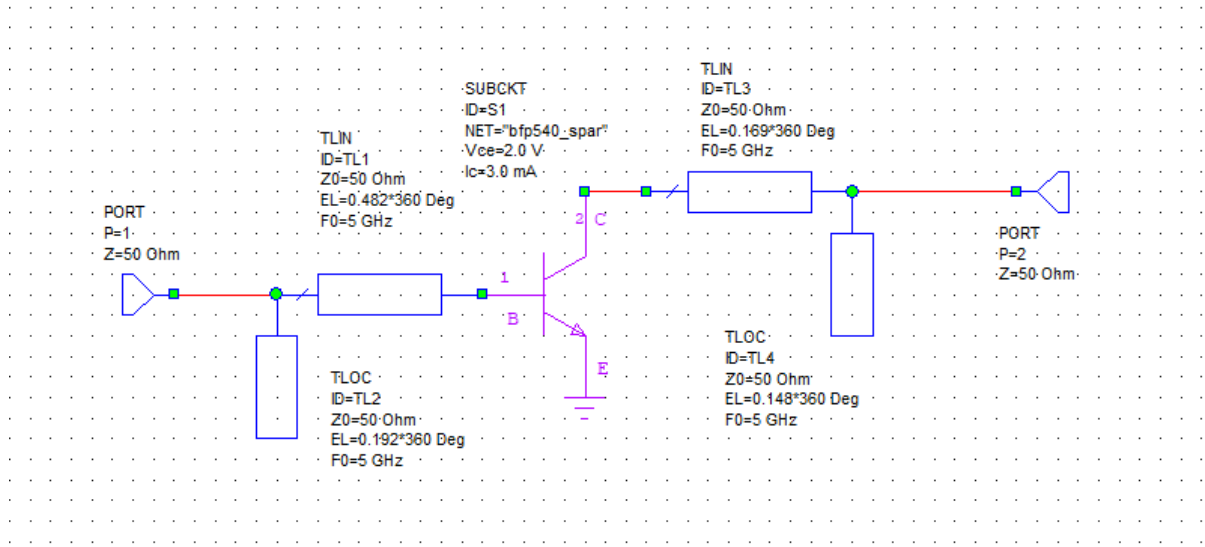
Smith Chart

$$Z_{50} = 1,00 + 0,00j$$

$$y = 1 + 0,00j$$



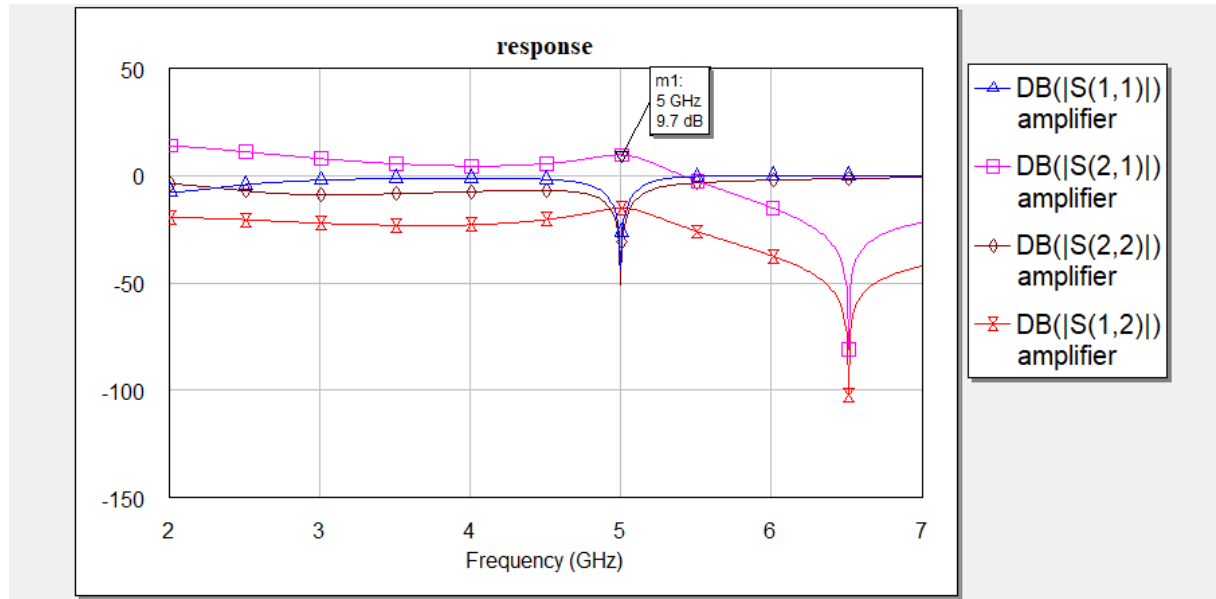
AWR Microwave Office Devre Kurulumu Şeması



Add New Graph > response

Add Measurement to "response" > S11,S12,S21,S22 'yi oluşturun.

>Analyze ile simülasyon sonucunu görüntölüyoruz.



Rectangular Plot Properties > Min : -50 Max: 20 ayarlarsak;

