

FIGURES FOR CHAPTER 9

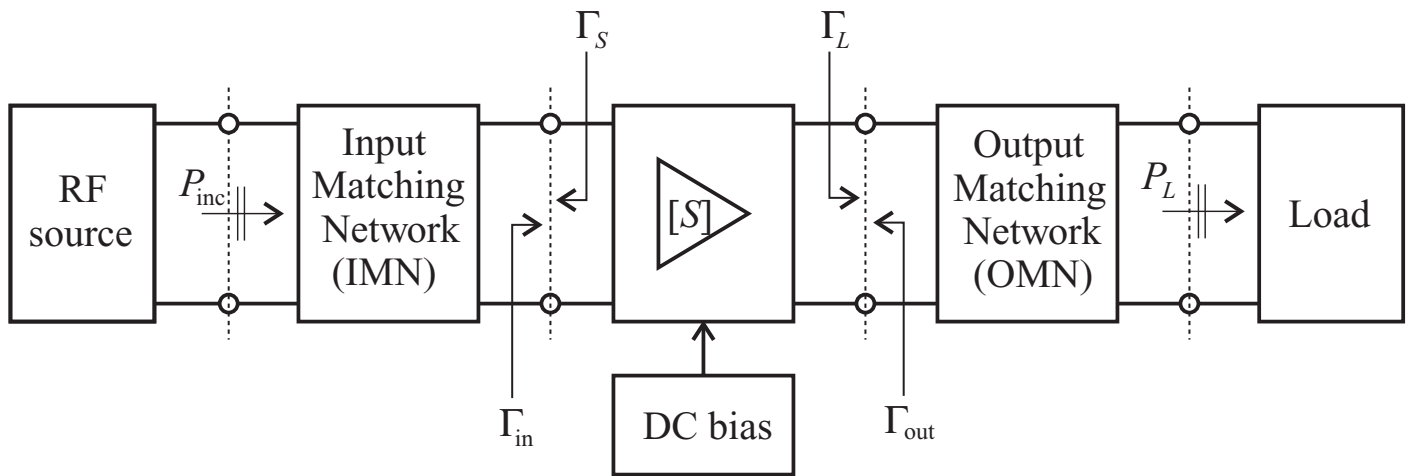
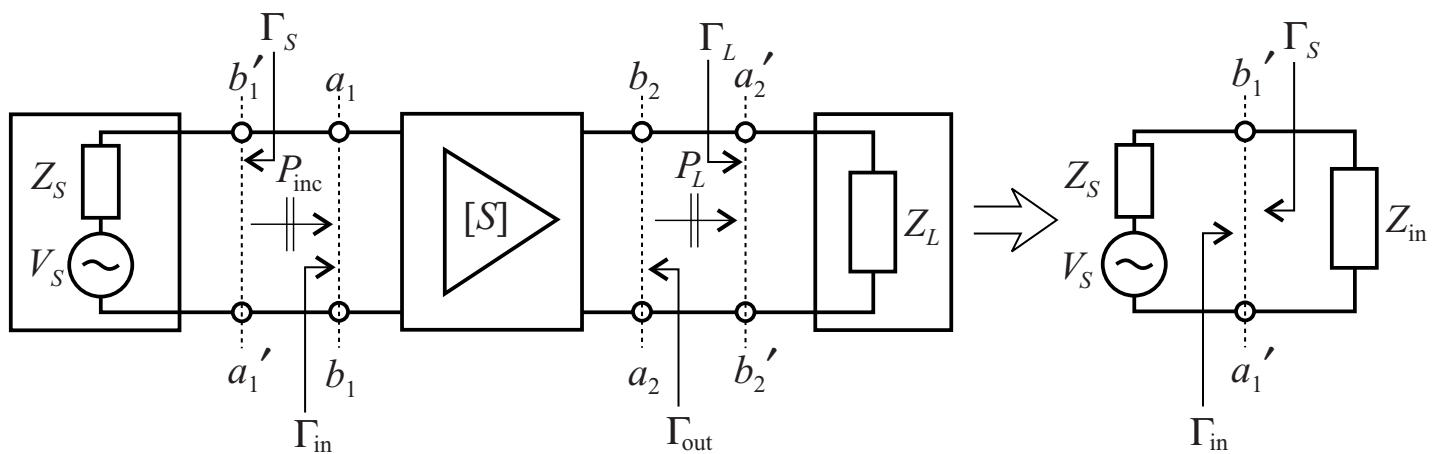
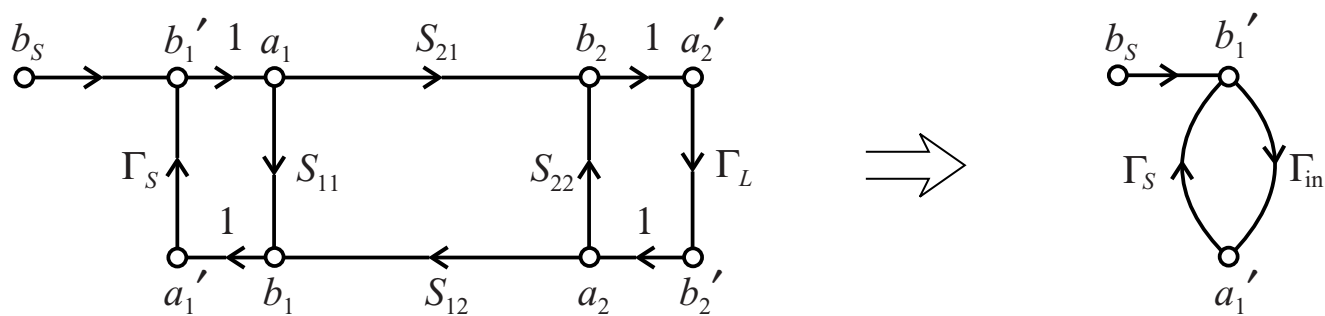


Figure 9-1 Generic amplifier system.

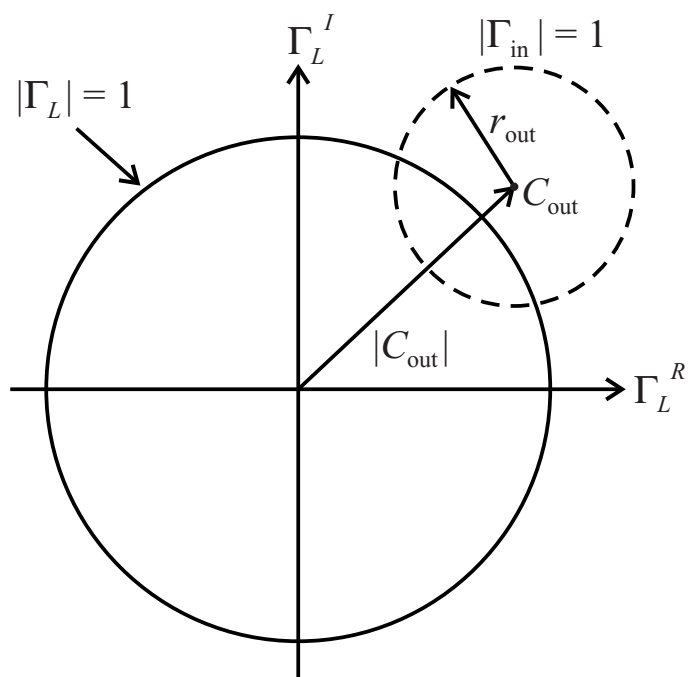


(a) Simplified schematics of a single-stage amplifier

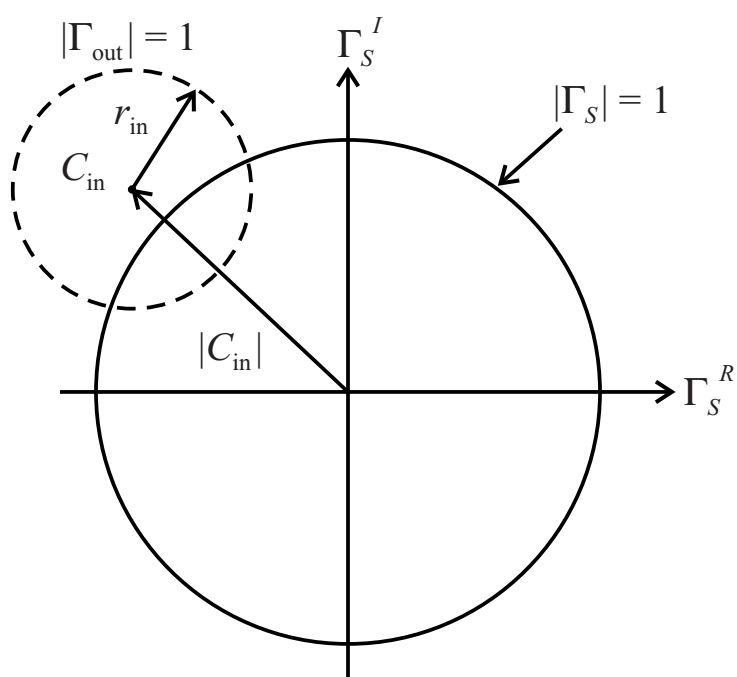


(b) Signal flow graph

Figure 9-2 Source and load connected to a single-stage amplifier network.

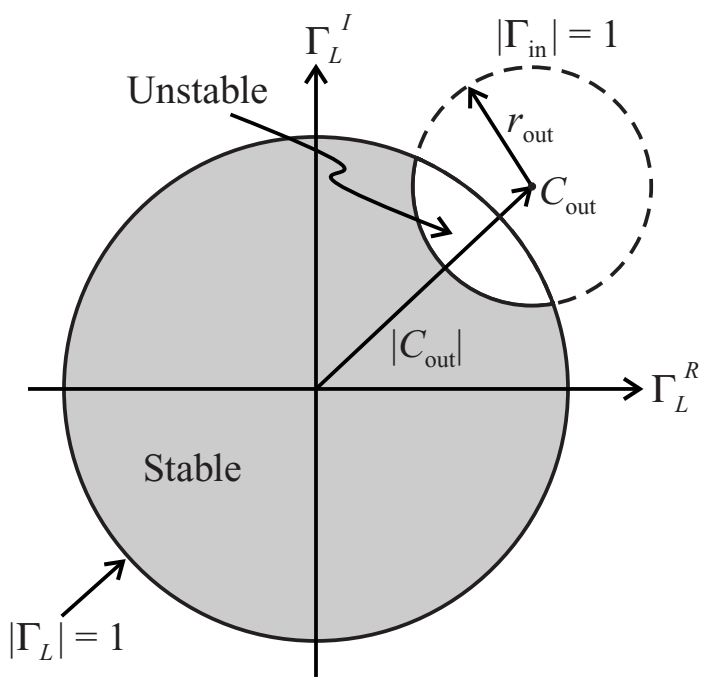


(a) Output stability circle

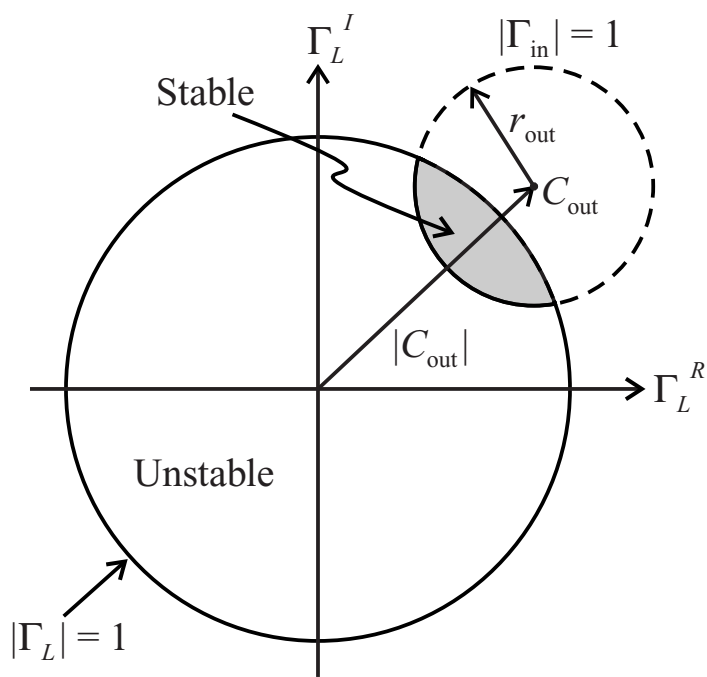


(b) Input stability circle

Figure 9-3 Stability circle $|\Gamma_{in}| = 1$ in the complex Γ_L plane and stability circle $|\Gamma_{out}| = 1$ in the complex Γ_S plane.



(a) Shaded region is stable, since $|S_{11}| < 1$



(a) Stable region excludes the origin, $\Gamma_L = 0$, since $|S_{11}| > 1$

Figure 9-4 Output stability circles denoting stable and unstable regions.

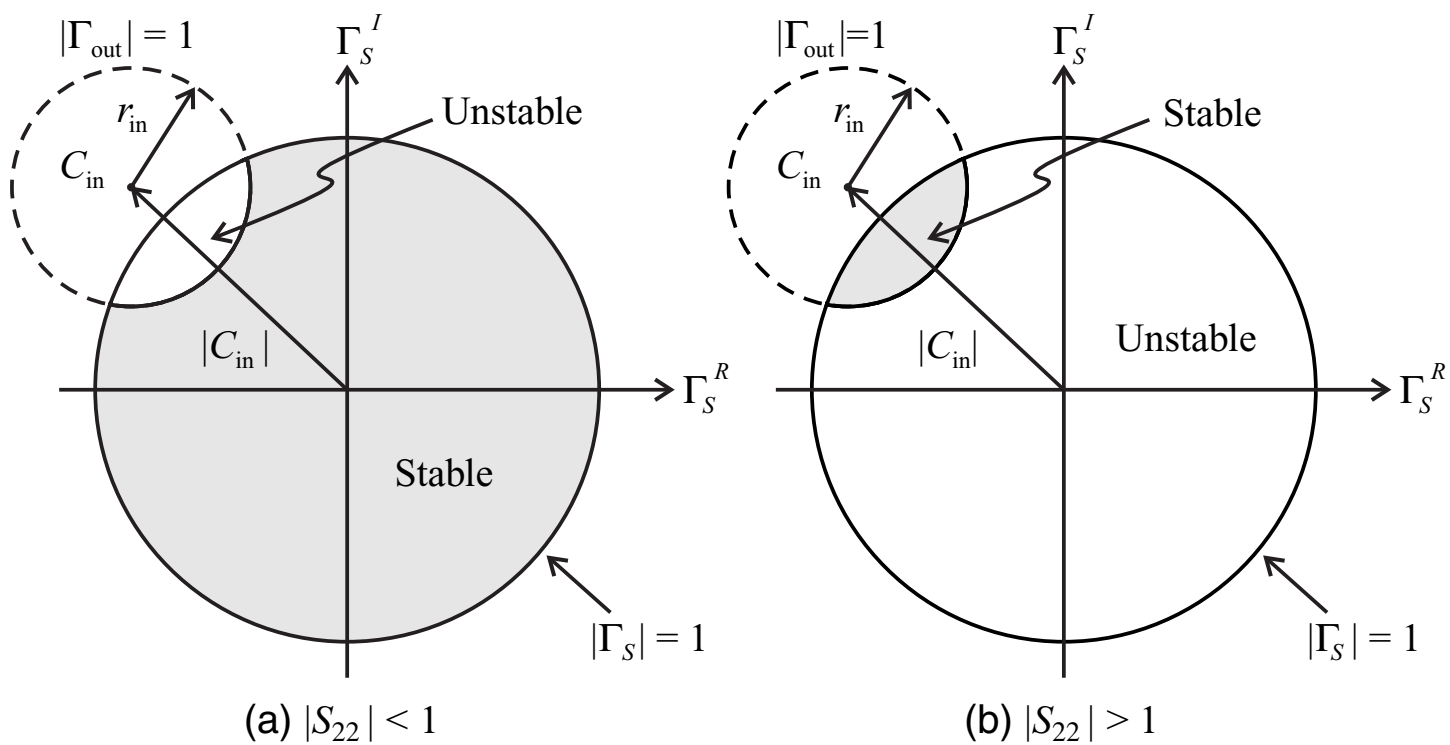


Figure 9-5 Input stability circles denoting stable and unstable regions.

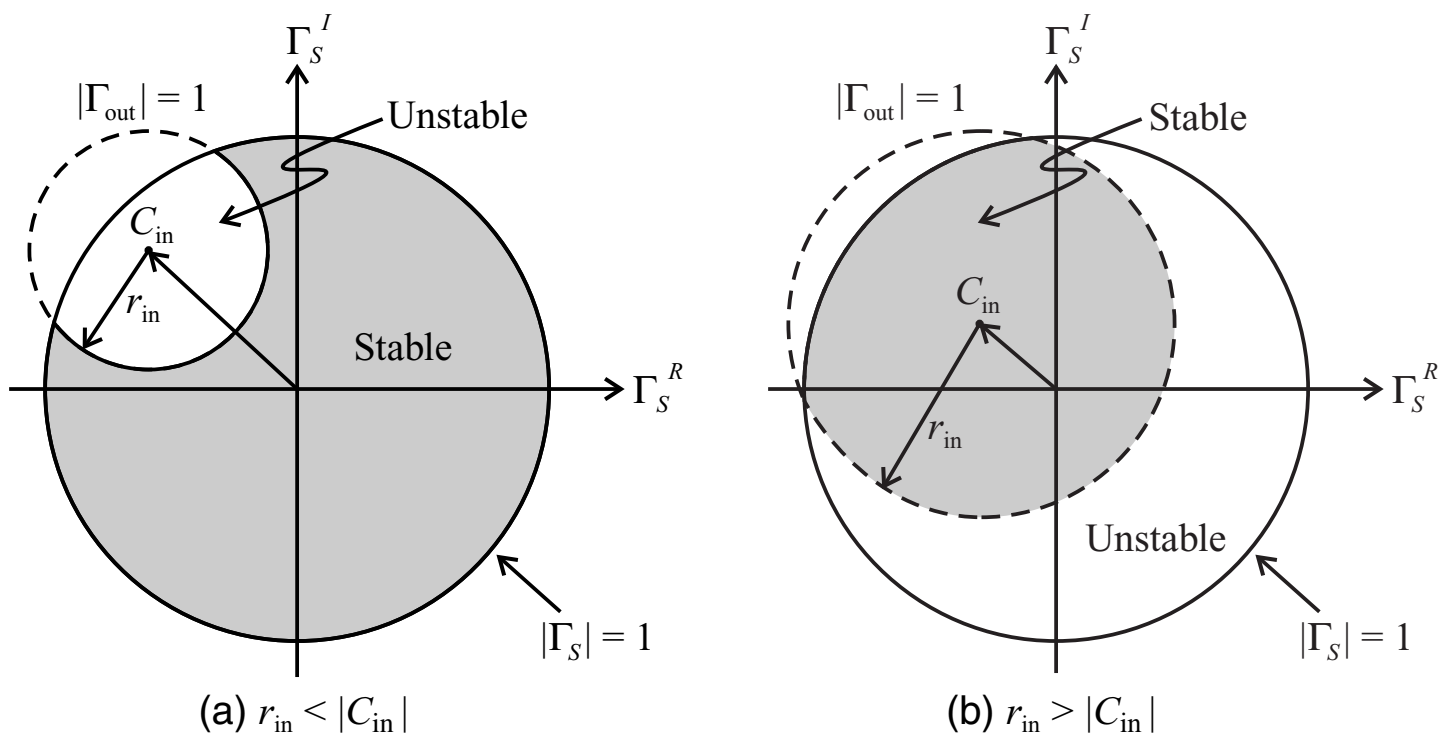
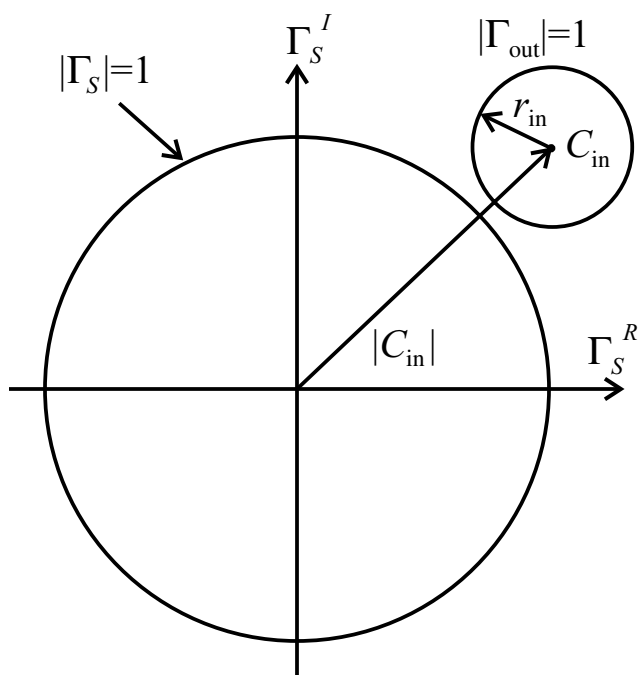
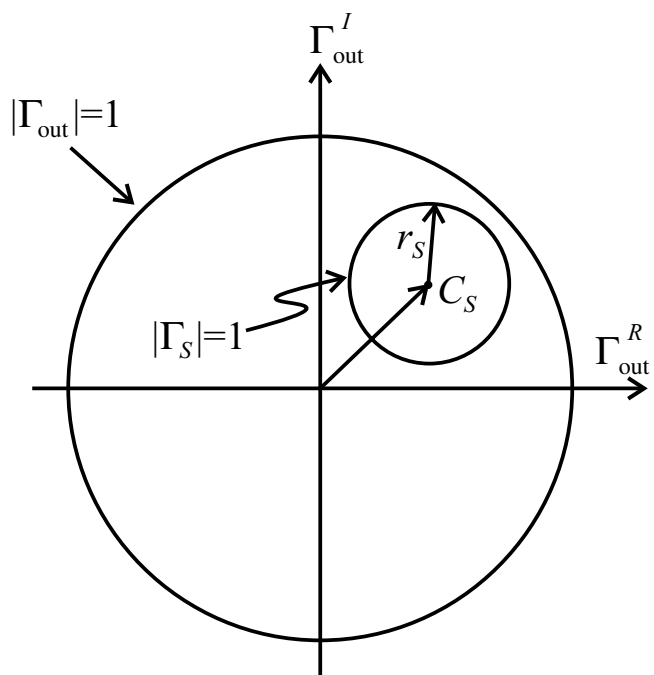


Figure 9-6 Different input stability regions for $|S_{22}| < 1$ depending on ratio between r_S and $|C_{in}|$.



(a) $|\Gamma_{\text{out}}| = 1$ circle must reside outside



(b) $|\Gamma_S| = 1$ circle must reside inside

Figure 9-7 Unconditional stability in the Γ_S and Γ_{out} planes for $|S_{11}| < 1$.

Table 9-1 BFG505W *S*-parameters as a function of frequency

Frequency	S_{11}	S_{12}	S_{21}	S_{22}
500 MHz	$0.70\angle-57^\circ$	$0.04\angle47^\circ$	$10.5\angle136^\circ$	$0.79\angle-33^\circ$
750 MHz	$0.56\angle-78^\circ$	$0.05\angle33^\circ$	$8.6\angle122^\circ$	$0.66\angle-42^\circ$
1000 MHz	$0.46\angle-97^\circ$	$0.06\angle22^\circ$	$7.1\angle112^\circ$	$0.57\angle-48^\circ$
1250 MHz	$0.38\angle-115^\circ$	$0.06\angle14^\circ$	$6.0\angle104^\circ$	$0.50\angle-52^\circ$

Table 9-2 Stability parameters for BFG505W for frequencies listed in Table 9-1

k	$ \Delta $	C_{in}	r_{in}	C_{out}	r_{out}
0.41	0.69	39.04 $\angle$ 108°	38.62	3.56 $\angle$ 70°	3.03
0.60	0.56	62.21 $\angle$ 119°	61.60	4.12 $\angle$ 70°	3.44
0.81	0.45	206.23 $\angle$ 131°	205.42	4.39 $\angle$ 69°	3.54
1.02	0.37	42.42 $\angle$ 143°	41.40	4.24 $\angle$ 68°	3.22

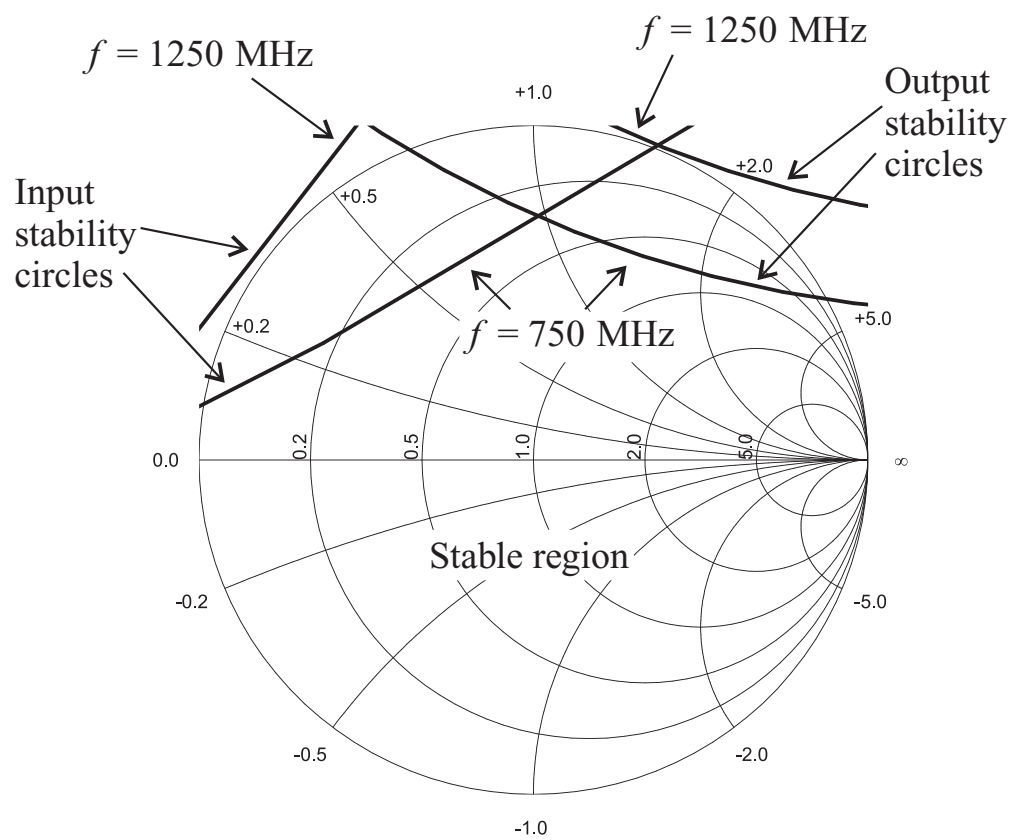


Figure 9-8 Input and output stability circles for BFG505W computed at $f = 750 \text{ MHz}$ and $f = 1.25 \text{ GHz}$.

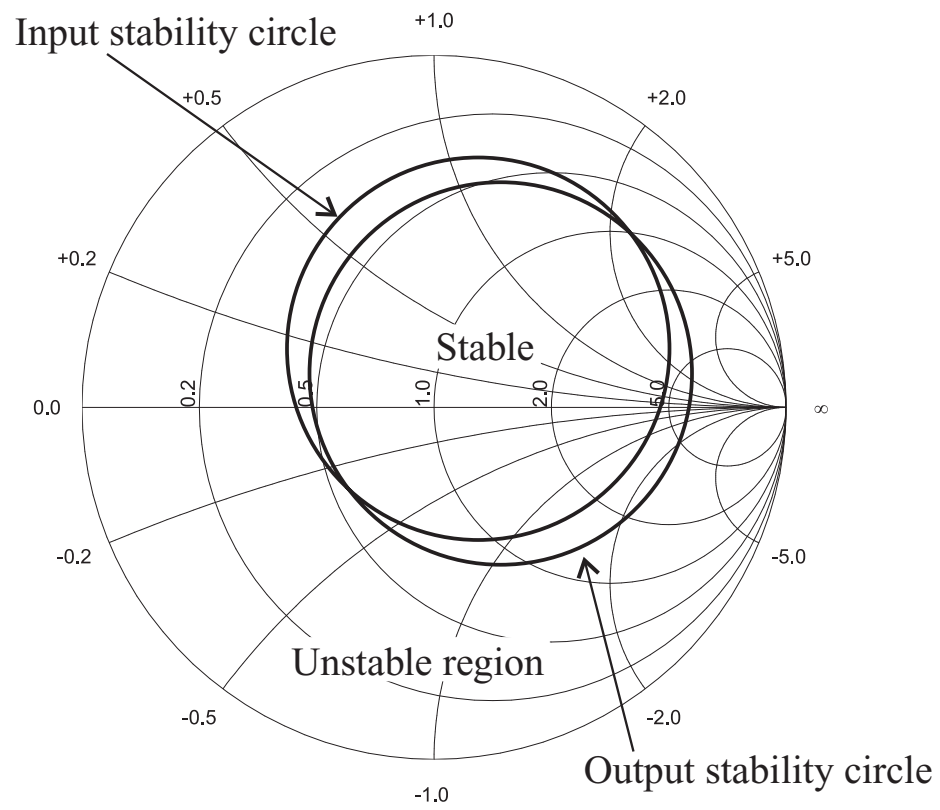


Figure 9-9 Stability circles for $k > 1$ and $|\Delta| > 1$.

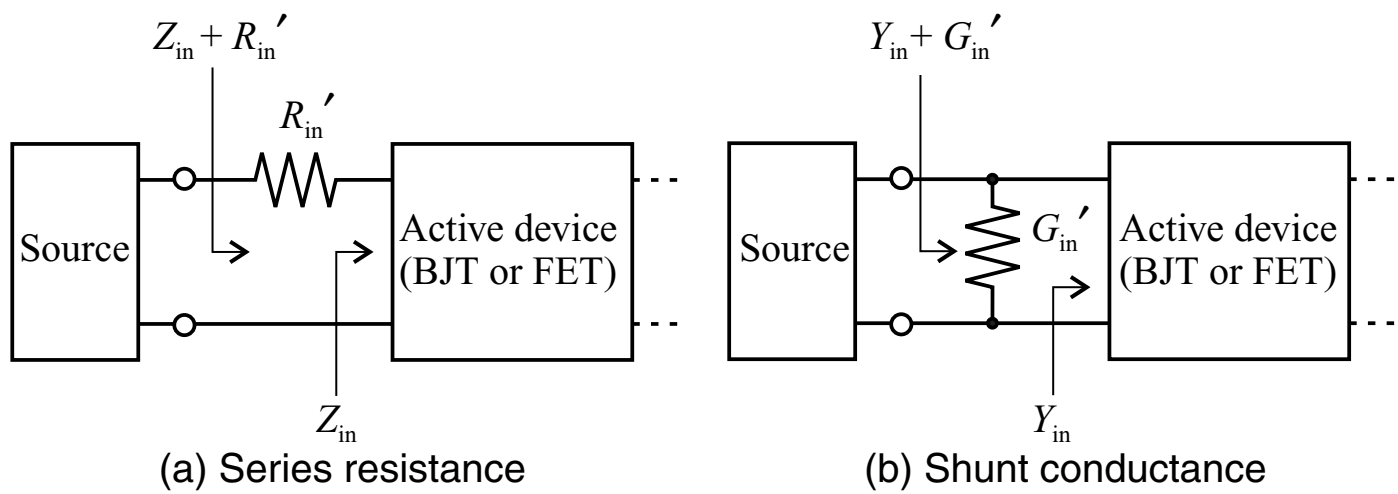


Figure 9-10 Stabilization of input port through series resistance or shunt conductance.

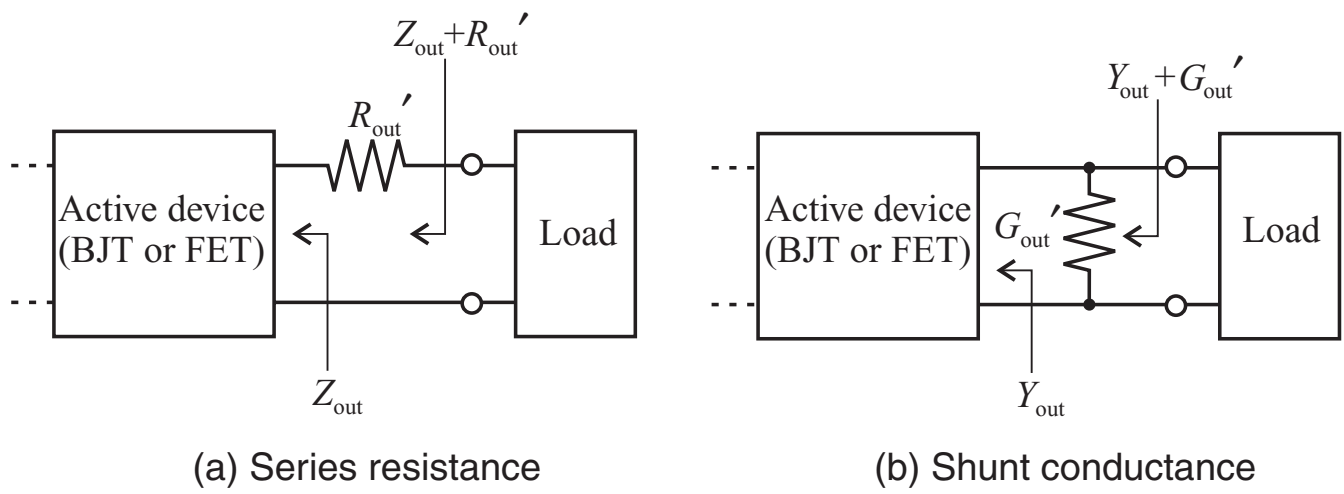


Figure 9-11 Stabilization of output port through series resistance or shunt conductance.

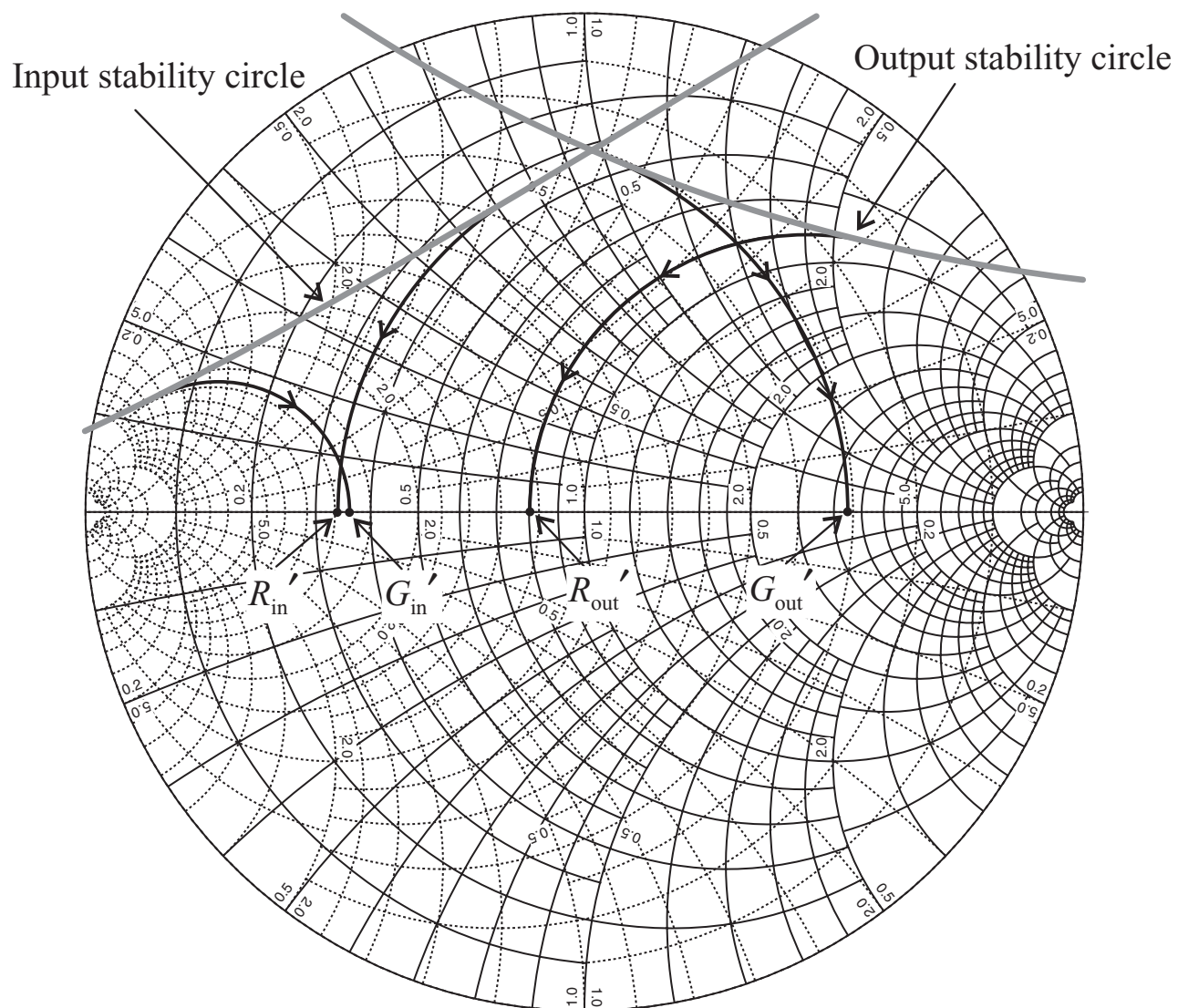


Figure 9-12 Input and output stability circles and circles for finding stabilizing series resistance and shunt conductances.

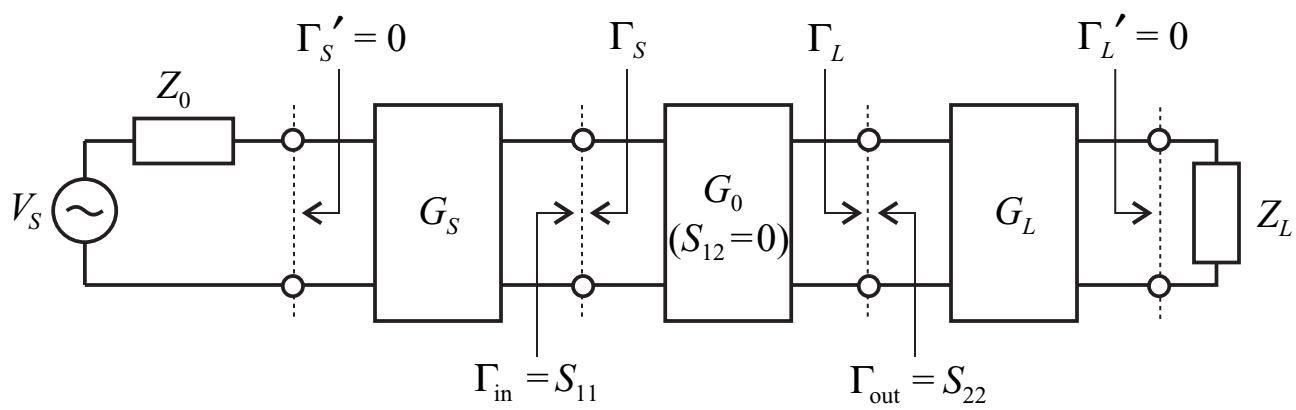


Figure 9-13 Unilateral power gain system arrangement.

Table 9-3 Parameters for constant source gain circles in Example 9-7.

G_s	g_s	d_{g_s}	r_{g_s}
2.6 dB	0.93	$0.67\angle -125^\circ$	0.14
2 dB	0.81	$0.62\angle -125^\circ$	0.25
1 dB	0.64	$0.54\angle -125^\circ$	0.37
0 dB	0.51	$0.47\angle -125^\circ$	0.47
-1 dB	0.41	$0.40\angle -125^\circ$	0.56

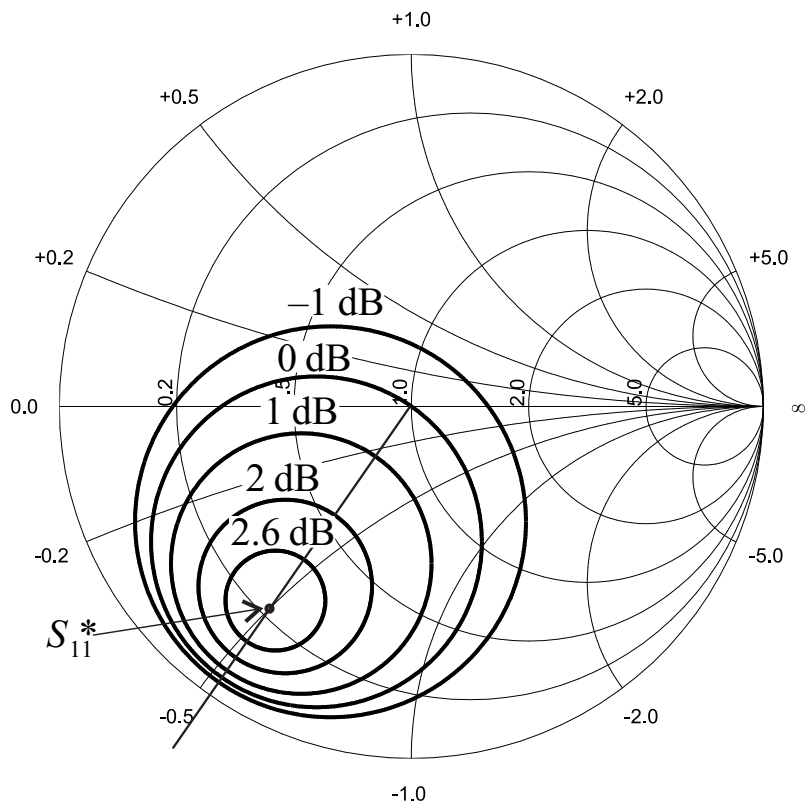


Figure 9-14 Constant source gain circles in the Smith Chart.

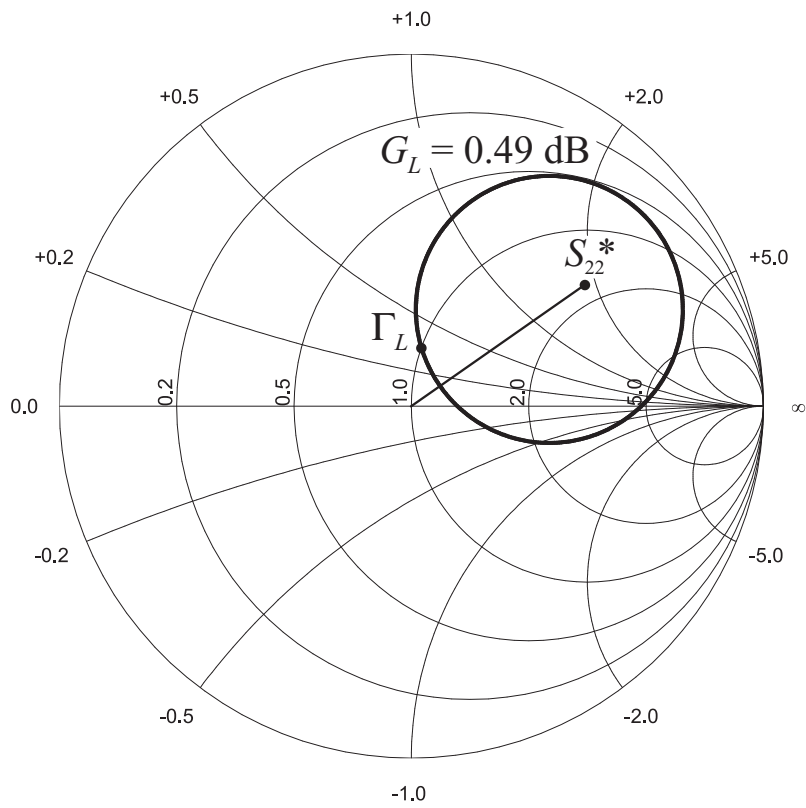


Figure 9-15 Constant load gain circle in the Smith Chart.

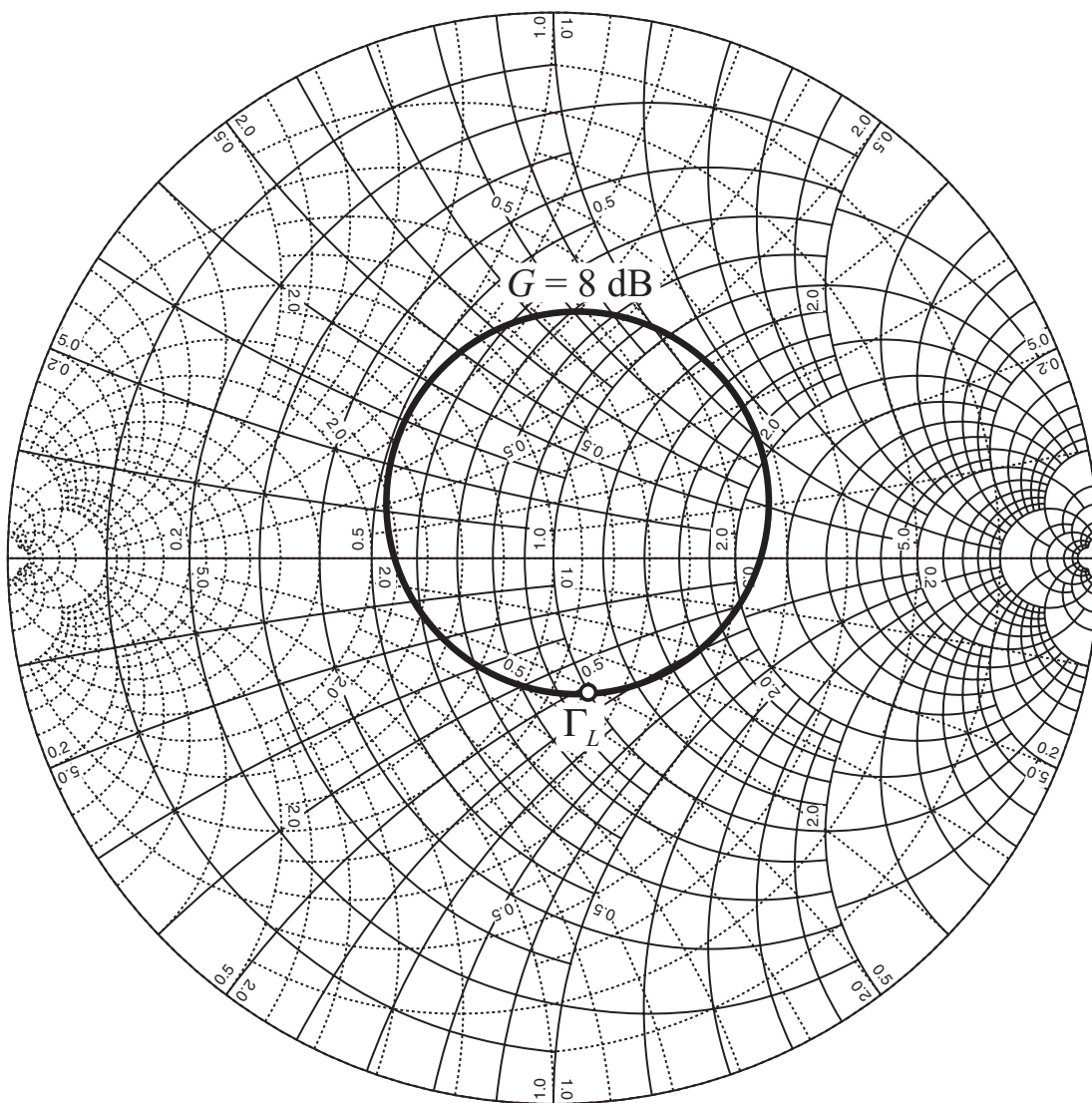


Figure 9-16 Constant operating power circle in the Γ_L -plane.

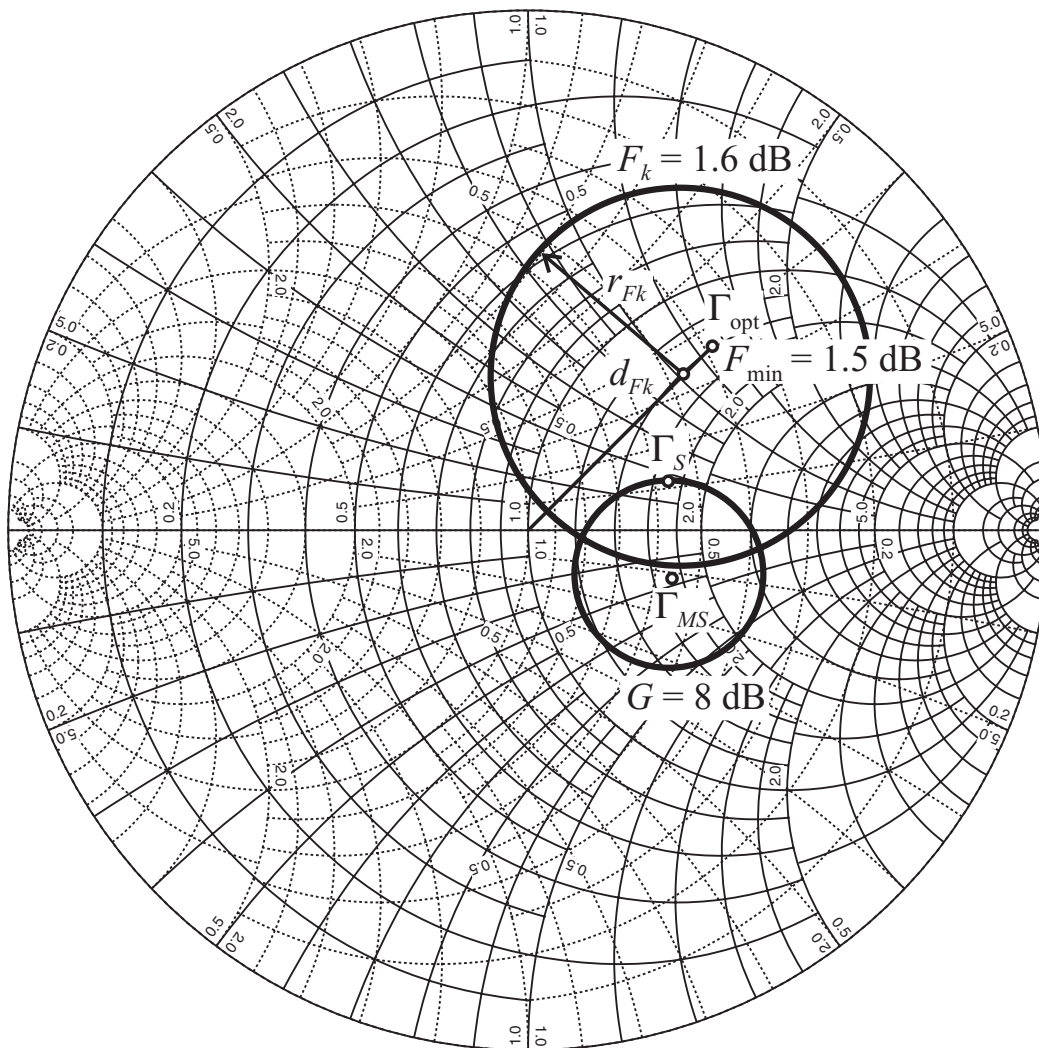


Figure 9-17 Constant noise figure circle and constant operating gain circle mapped into the Γ_S -plane.

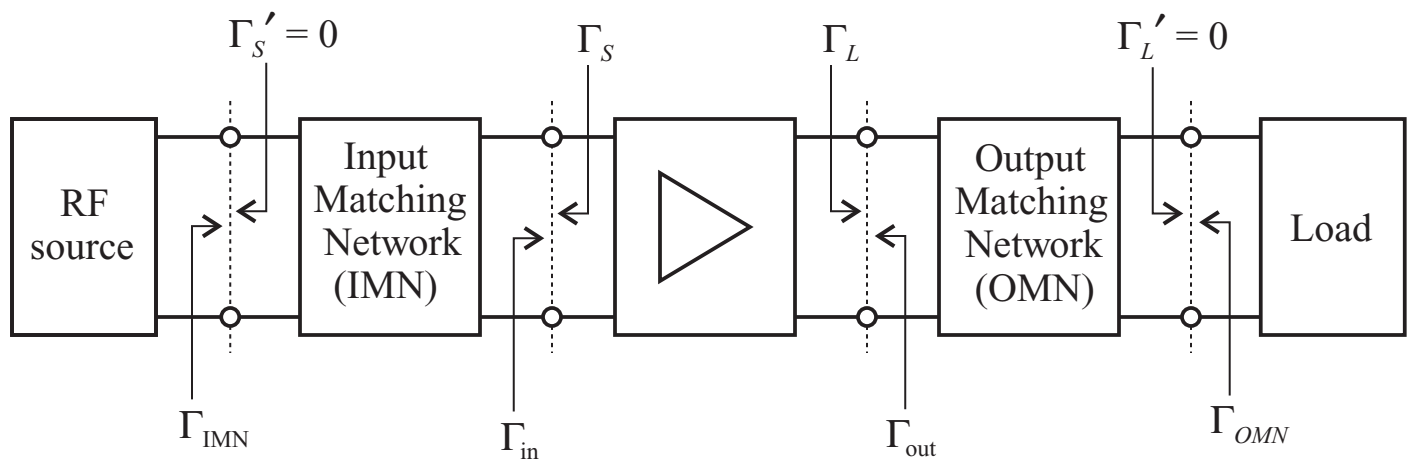


Figure 9-18 System configuration for input and output VSWR.

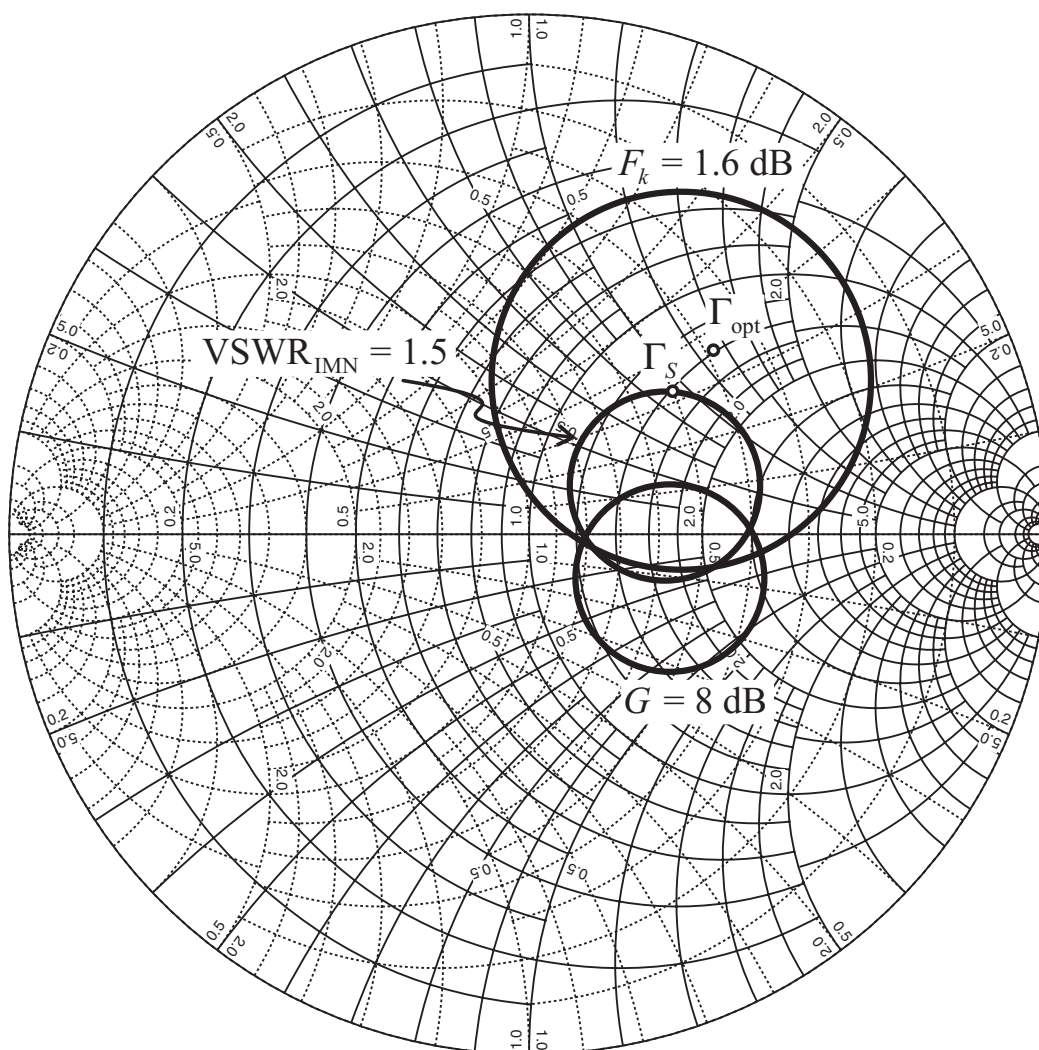


Figure 9-19 Constant operating power gain, noise figure, and input VSWR circle in Γ_S -plane.

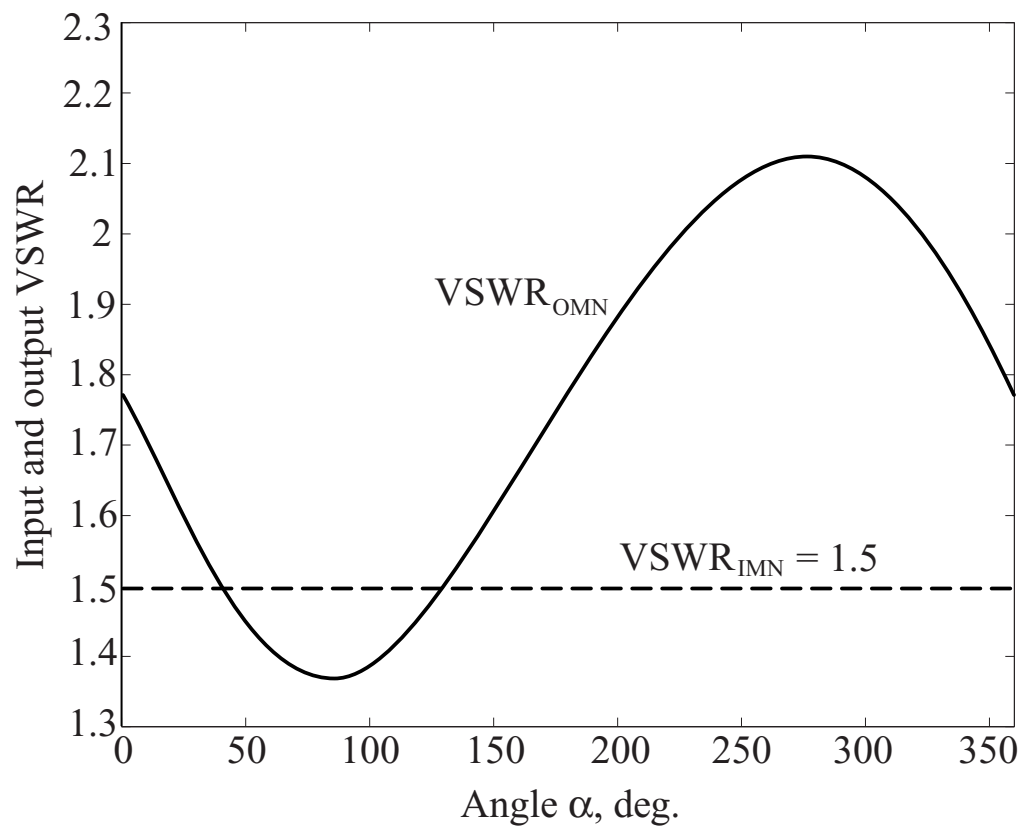


Figure 9-20 Input and output VSWR as a function of angle α .

Table 9-4 S-parameters of AT41410 BJT ($I_C = 10 \text{ mA}$, $V_{CE} = 8 \text{ V}$)

$f, \text{ GHz}$	$ S_{21} $	S_{11}	S_{22}
2	3.72	$0.61 \angle 165^\circ$	$0.45 \angle -48^\circ$
3	2.56	$0.62 \angle 149^\circ$	$0.44 \angle -58^\circ$
4	1.96	$0.62 \angle 130^\circ$	$0.48 \angle -78^\circ$

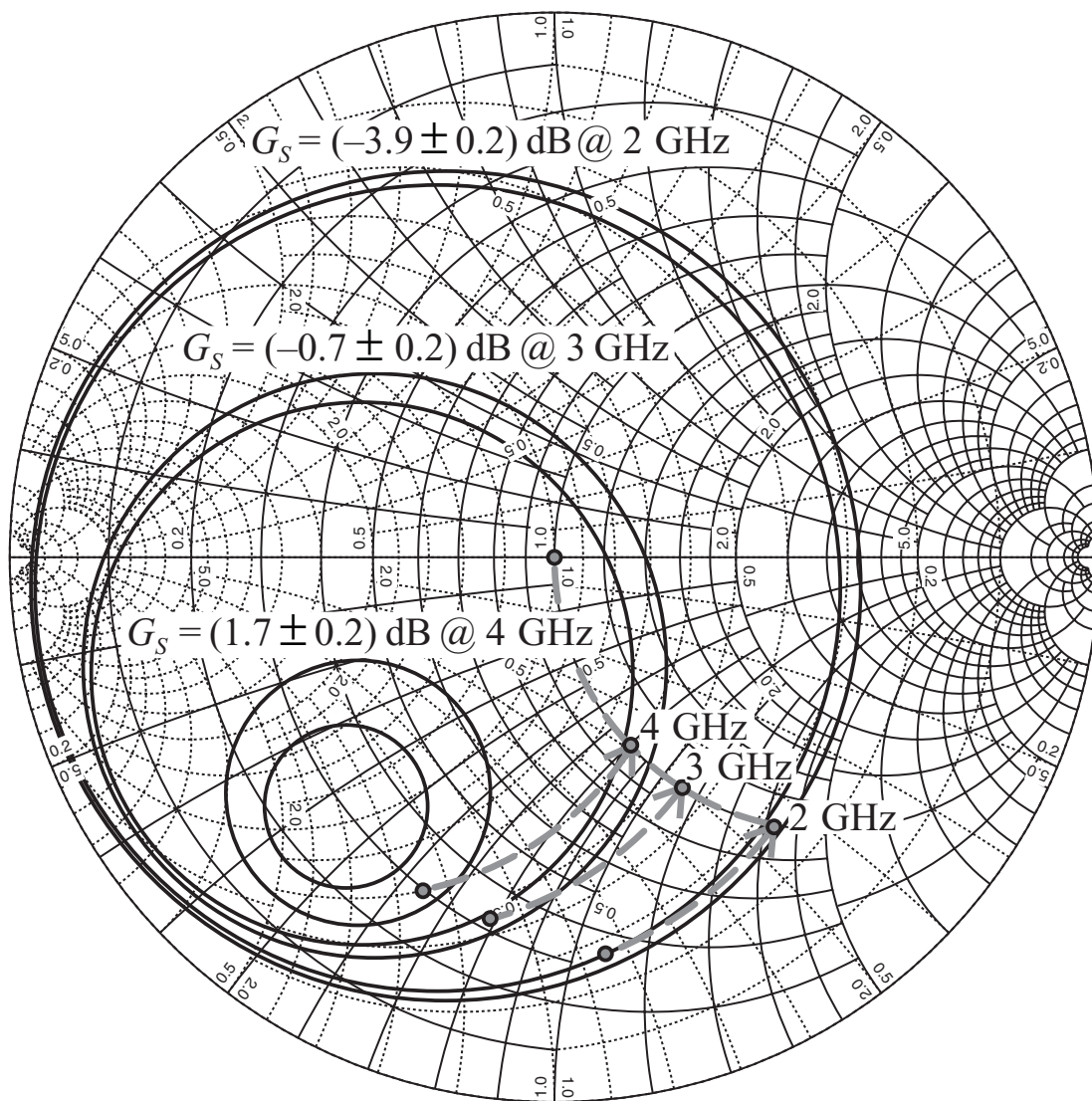


Figure 9-21 Smith Chart design of a broadband amplifier in Example 9-16.

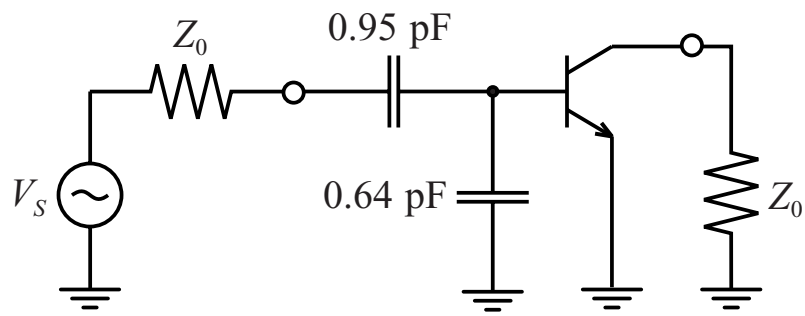
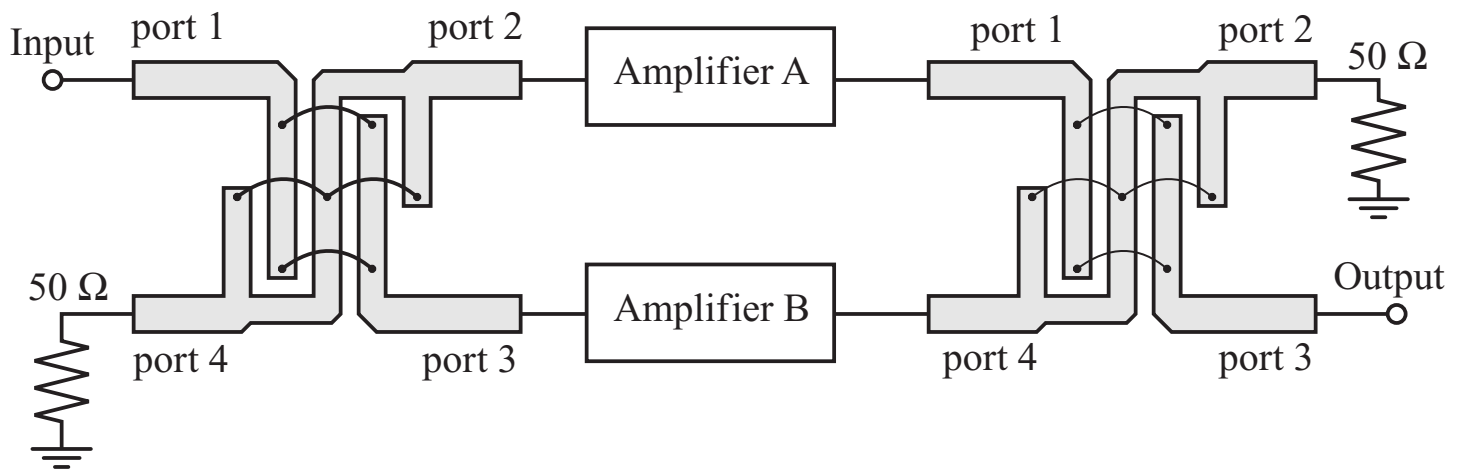


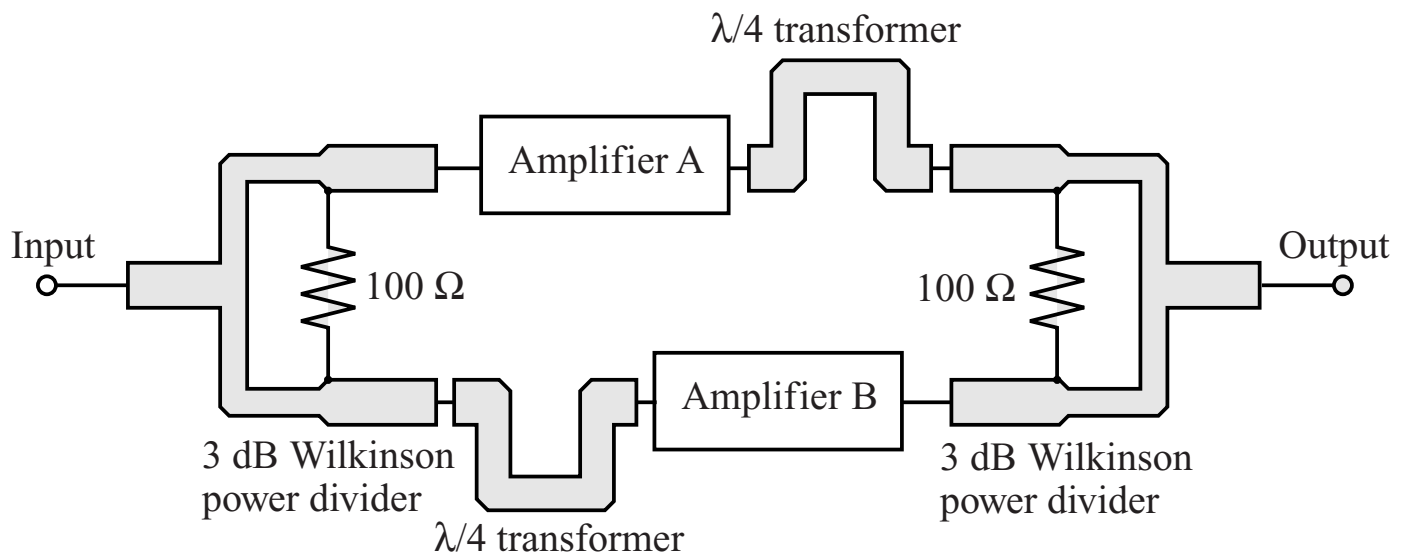
Figure 9-22 Broadband amplifier with 8.7 dB gain and ± 0.2 dB gain flatness over a frequency range from 2 to 4 GHz.

Table 9-5 Parameters of a broadband amplifier

f , GHz	Γ_S	G_T , dB	VSWR _{IMN}	VSWR _{OMN}
2	$0.74\angle-83^\circ$	7.65	13.1	2.6
3	$0.68\angle-101^\circ$	7.57	5.3	2.6
4	$0.66\angle-112^\circ$	7.43	2.0	2.8

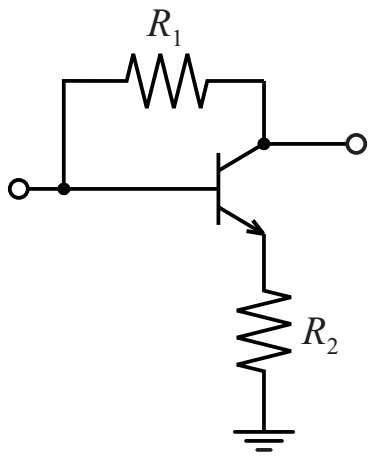


(a) Balanced amplifier using 3 dB coupler

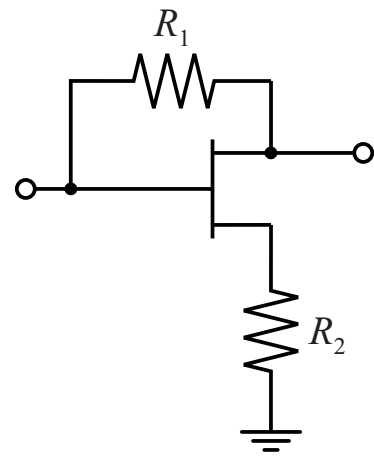


(b) Balanced amplifier using 3 dB Wilkinson power divider and combiner

Figure 9-23 Block diagram of a balanced broadband amplifier.



(a) Feedback in BJTs



(b) Feedback in FETs

Figure 9-24 Negative resistive feedback circuits.

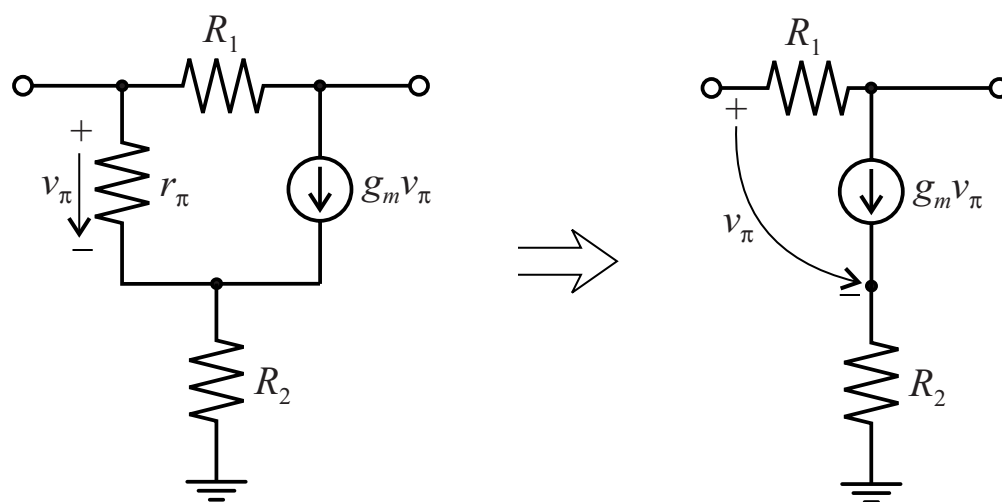


Figure 9-25 Low-frequency model of negative feedback circuit.

Table 9-6 S-parameters for the transistor in Example 9-17

f , MHz	$ S_{11} $	$\angle S_{11}$	$ S_{21} $	$\angle S_{21}$	$ S_{12} $	$\angle S_{12}$	$ S_{22} $	$\angle S_{22}$
10	0.877	-0.3	7.035	179.6	1×10^{-4}	66.8	0.805	-0.1
100	0.876	-2.4	7.027	176.1	7×10^{-4}	85.9	0.805	-1.4
250	0.870	-5.9	6.983	170.2	0.002	84.3	0.803	-3.4
500	0.850	-11.5	6.834	160.6	0.003	80.5	0.797	-6.6
750	0.820	-16.9	6.607	151.4	0.004	76.0	0.789	-9.8
1000	0.783	-21.7	6.327	142.8	0.005	68.2	0.777	-12.7
1500	0.700	-29.6	5.711	127.2	0.007	74.1	0.755	-18.1
2000	0.619	-35.7	5.119	113.8	0.007	74.1	0.735	-23.0

Table 9-7 Insertion gain of the feedback amplifier

f , MHz	$ S_{21} ^2$, dB		
	$R_1 = 208 \, \Omega$, $R_2 = 4.1 \, \Omega$	$R_1 = 276 \, \Omega$, $R_2 = 1.4 \, \Omega$	$R_1 = 276 \, \Omega$, $R_2 = 1.4 \, \Omega$, $L_1 = 4.5 \, \text{nH}$
10	7.50	10.01	10.01
100	7.50	10.01	10.01
250	7.50	10.00	10.01
500	7.50	9.97	10.00
750	7.50	9.93	10.00
1000	7.50	9.88	10.00
1500	7.51	9.75	9.99
2000	7.54	9.59	9.99

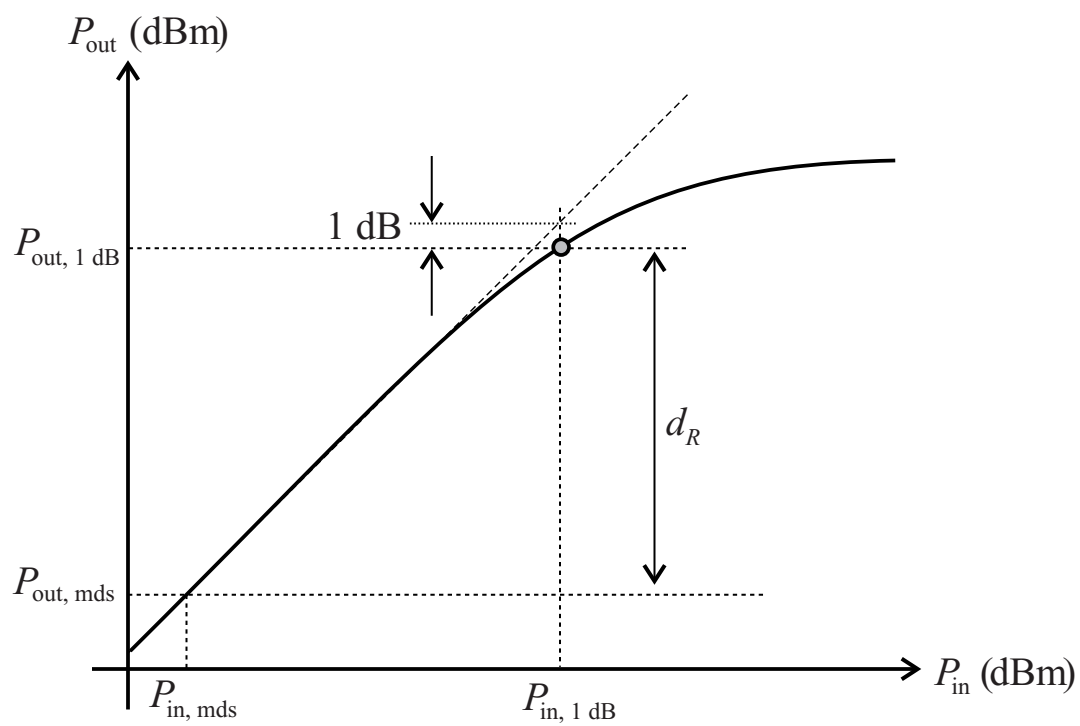


Figure 9-26 Output power of the amplifier as a function of input power.

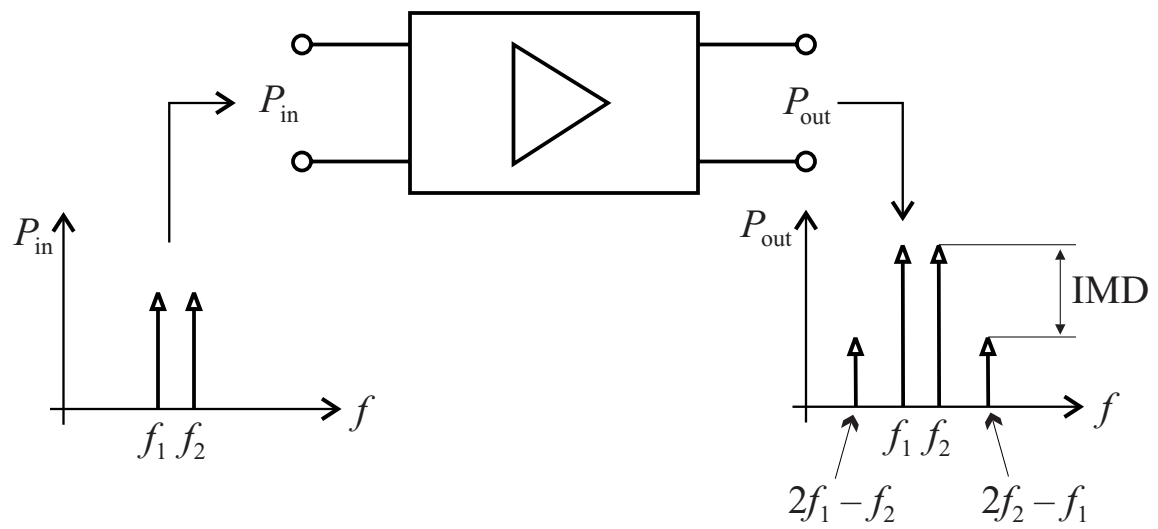


Figure 9-27 Observing the intermodular distortion of an amplifier.

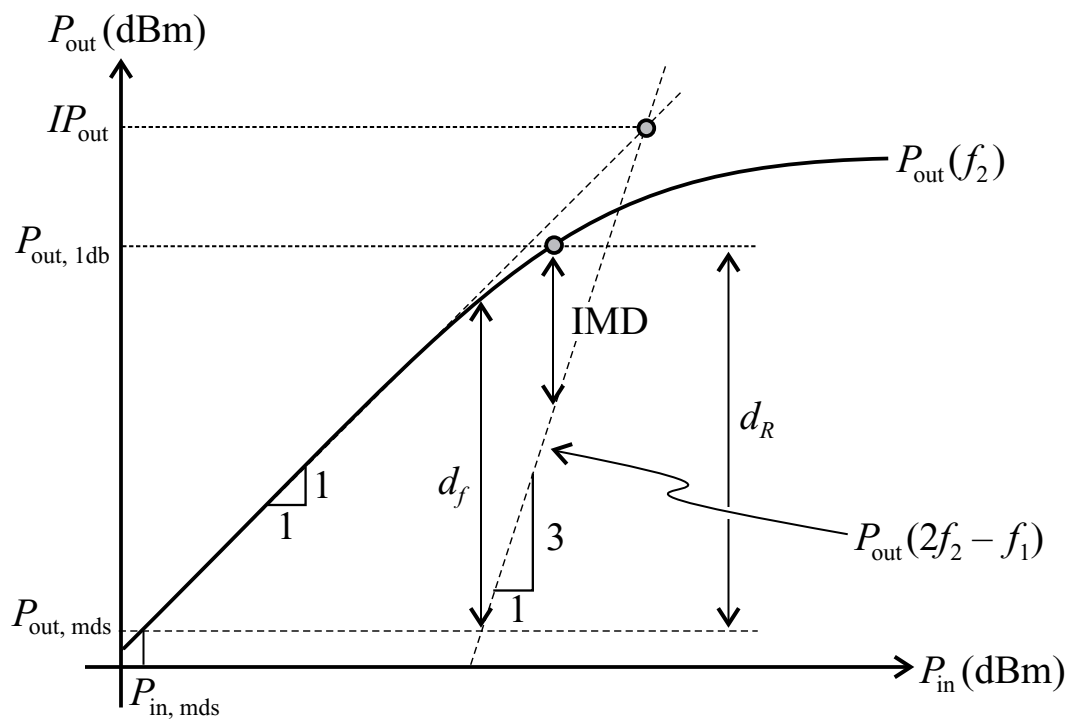


Figure 9-28 Recording of IMD based on input-output power relation.

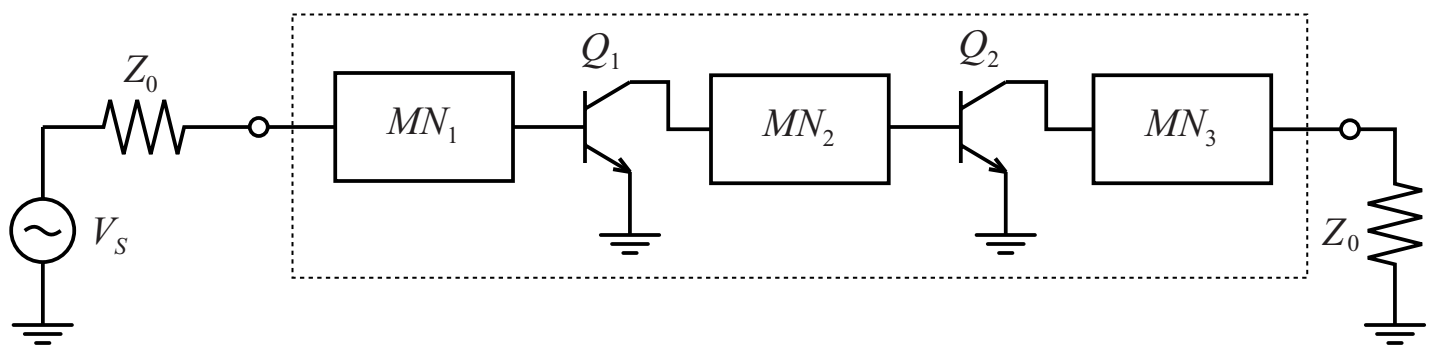


Figure 9-29 Dual-stage transistor amplifier.

Table 9-8 Transistor characteristics for Example 9-18.

Transistor	$F[\text{dB}]$	$G_{\max}[\text{dB}]$	$P_{\text{out}, 1\text{dB}}[\text{dBm}]$	$IP[\text{dBm}]$
BFG505	1.9	10	4	10
BFG520	1.9	9	17	26
BFG540	2	7	21	34

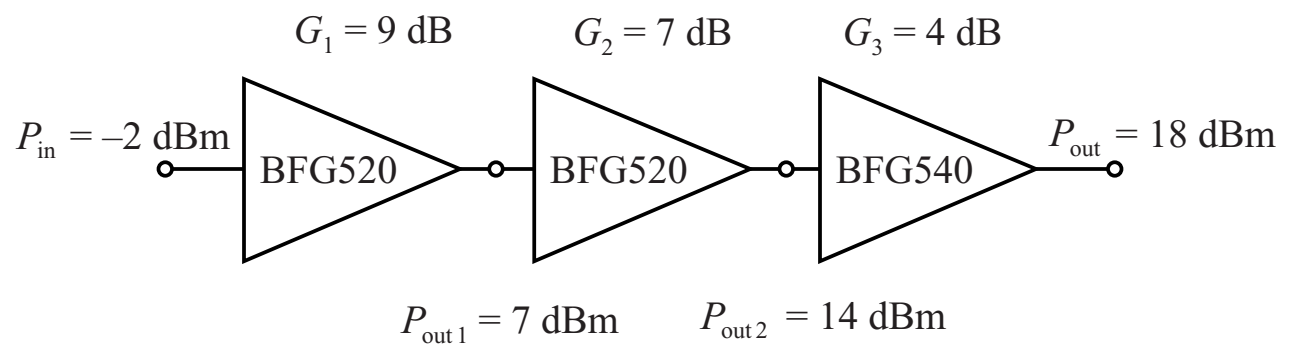


Figure 9-30 Block diagram of a three-stage amplifier.