

**APPLICATION NOTE**

# SKY65047-360LF Matching Circuits for Various Frequency Bands

## Introduction

Skyworks SKY65047-360LF is a high linearity Low Noise Amplifier (LNA) with an operational frequency of 0.4 to 3.0 GHz. The device is manufactured with an advanced SiGe process and operates with a single DC supply from 2.1 V to 3.8 V over a temperature range of -40 °C to +85 °C.

This Application Note provides S-parameter and noise parameter information needed to design application circuits using the SKY65047-360LF. Several matching schematics for various frequencies are also presented. Refer to the SKY65047-360LF Data Sheet (document #201084) for detailed specifications and additional information regarding SKY65047-360LF Evaluation Boards.

## S-Parameter and Noise Parameter Data

S-parameter and noise parameter data for the SKY65047-360LF is presented in Tables 1 and 2, respectively. A system designer can use this information to simulate the input and output impedance, and the gain and Noise Figure (NF) performance.

Figure 1 shows simulation results using the parameters in Tables 1 and 2 with the SKY65047-360LF 450 MHz Evaluation Board.

**Table 1. SKY65047-360LF S-Parameters (1 of 2)**

Frequency (MHz)	MagS11	AngS11	MagS21	AngS21	MagS12	AngS12	MagS22	AngS22
400	0.768537	-26.5748	11.83712	159.9963	0.016916	88.4548	0.496524	17.87421
450	0.744954	-29.3906	11.58071	154.9517	0.018833	85.5678	0.4843	11.4653
500	0.72065	-32.0175	11.28839	150.3434	0.020654	83.06927	0.473506	5.891828
550	0.69605	-34.4604	10.9746	146.103	0.022387	80.8882	0.463812	0.980433
600	0.67149	-36.726	10.64954	142.1797	0.024041	78.97156	0.455029	-3.39592
650	0.647229	-38.8223	10.32055	138.5336	0.025623	77.27801	0.44704	-7.33297
700	0.623463	-40.7584	9.992919	135.1325	0.027144	75.77429	0.43977	-10.9047
750	0.600333	-42.5436	9.670389	131.9495	0.028611	74.43299	0.433163	-14.1694
800	0.577936	-44.1874	9.355587	128.9618	0.03003	73.23111	0.427174	-17.1739
850	0.556335	-45.6988	9.050283	126.1496	0.031409	72.14917	0.421765	-19.9562
900	0.535564	-47.0867	8.755613	123.4956	0.032753	71.17049	0.4169	-22.5476
950	0.515638	-48.3595	8.472232	120.9847	0.034067	70.28081	0.412545	-24.9741
1000	0.496555	-49.5249	8.200447	118.6036	0.035356	69.46782	0.408668	-27.2573
1050	0.478303	-50.5902	7.940303	116.3403	0.036623	68.72094	0.405238	-29.4157
1100	0.460861	-51.5619	7.691662	114.1843	0.037873	68.03105	0.402226	-31.4645
1150	0.444201	-52.4461	7.454257	112.1261	0.039106	67.39029	0.399602	-33.4169
1200	0.428295	-53.2483	7.227729	110.1573	0.040327	66.79191	0.397341	-35.2841
1250	0.413111	-53.9735	7.011662	108.2703	0.041536	66.23011	0.395417	-37.0755
1300	0.398616	-54.6262	6.805609	106.4584	0.042736	65.69993	0.393807	-38.7993
1350	0.384778	-55.2104	6.609102	104.7154	0.043927	65.19713	0.39249	-40.4626
1400	0.371564	-55.7298	6.42167	103.036	0.04511	64.71813	0.391443	-42.0714

**Table 1. SKY65047-360LF S-Parameters (2 of 2)**

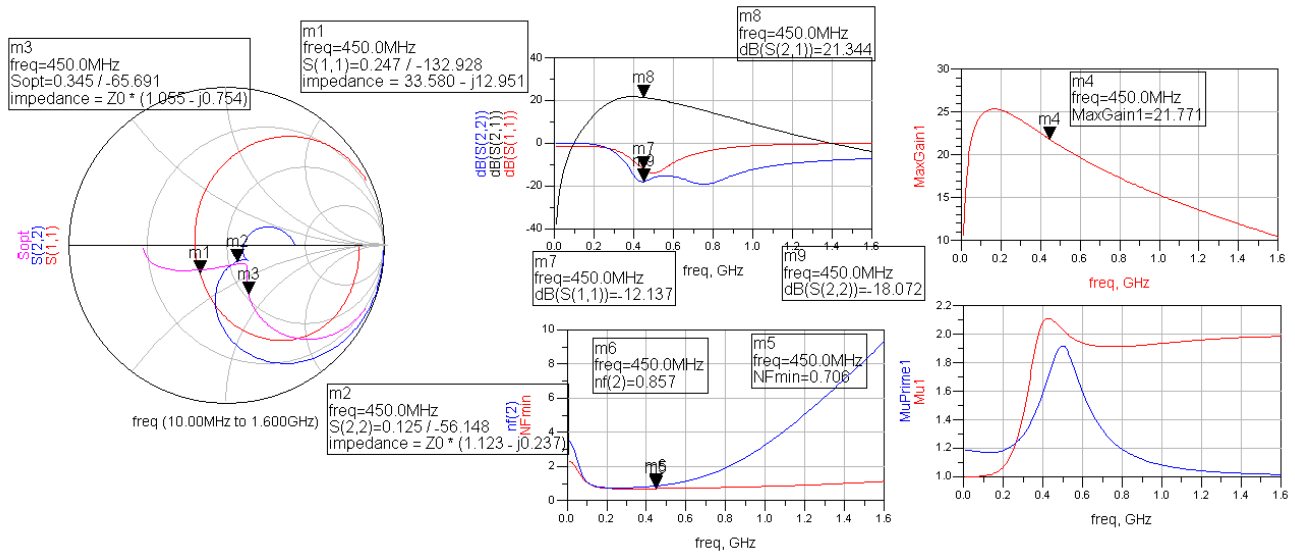
Frequency (MHz)	MagS11	AngS11	MagS21	AngS21	MagS12	AngS12	MagS22	AngS22
1450	0.358945	-56.1875	6.242848	101.4151	0.046287	64.25992	0.39065	-43.6309
1500	0.34689	-56.5865	6.07218	99.84825	0.047458	63.82003	0.390092	-45.1457
1550	0.335372	-56.9294	5.909228	98.33145	0.048622	63.39645	0.389754	-46.6198
1600	0.324366	-57.2183	5.75357	96.86102	0.049782	62.98765	0.389621	-48.0565
1650	0.313847	-57.4554	5.604805	95.43363	0.050936	62.59257	0.389681	-49.4589
1700	0.303795	-57.6425	5.462554	94.04624	0.052084	62.21064	0.389921	-50.8297
1750	0.294191	-57.781	5.326461	92.69608	0.053227	61.84184	0.390331	-52.1713
1800	0.28502	-57.8726	5.19619	91.38059	0.054363	61.48687	0.390903	-53.4857
1850	0.27627	-57.9185	5.071431	90.09744	0.055492	61.14737	0.391631	-54.775
1900	0.267935	-57.9202	4.951895	88.84442	0.056613	60.82632	0.392511	-56.0411
1950	0.260016	-57.8795	4.837321	87.61943	0.057724	60.52886	0.393542	-57.2858
2000	0.252527	-57.7989	4.727476	86.42038	0.058825	60.26366	0.39473	-58.5114
2050	0.245502	-57.6832	4.622164	85.24506	0.059915	60.04586	0.396089	-59.7208
2100	0.239009	-57.5426	4.52124	84.09072	0.060996	59.90318	0.397648	-60.9187
2150	0.23319	-57.4032	4.42463	82.95319	0.062082	59.89007	0.399467	-62.1149
2200	0.228334	-57.3427	4.33236	81.82378	0.063239	60.12157	0.401654	-63.3347
2250	0.224922	-57.6406	4.244301	80.67861	0.064781	60.8333	0.404336	-64.6584
2300	0.221853	-59.3599	4.156561	79.45196	0.068237	61.9623	0.406519	-66.3436
2350	0.205022	-62.1179	4.052027	78.29577	0.07413	59.30318	0.401508	-68.0019
2400	0.188892	-59.6401	3.962515	77.4864	0.073723	55.59007	0.399142	-68.3676
2450	0.183419	-57.4712	3.88748	76.57823	0.072901	54.67081	0.401521	-69.0279
2500	0.179318	-56.2237	3.814645	75.61817	0.073028	54.34994	0.404099	-69.9208
2550	0.1752	-55.3204	3.743376	74.65132	0.073606	54.09799	0.406469	-70.8861
2600	0.171025	-54.542	3.673928	73.69045	0.074396	53.83271	0.408697	-71.8724
2650	0.16686	-53.805	3.606435	72.73942	0.075295	53.54478	0.410845	-72.862
2700	0.162756	-53.0735	3.540925	71.79942	0.076257	53.237	0.412951	-73.8477
2750	0.158747	-52.3298	3.477378	70.87069	0.077257	52.91348	0.415036	-74.8263
2800	0.154853	-51.5647	3.415747	69.95312	0.078281	52.57764	0.417113	-75.7964
2850	0.151086	-50.773	3.35597	69.04645	0.07932	52.2321	0.419189	-76.7573
2900	0.147453	-49.9516	3.297984	68.15034	0.080368	51.87883	0.421267	-77.7086
2950	0.143957	-49.0989	3.241722	67.26445	0.081424	51.51927	0.42335	-78.6502
3000	0.1406	-48.214	3.187116	66.38843	0.082483	51.15454	0.425439	-79.5823

**Table 2. SKY65047-360LF Noise Parameters (1 of 2)**

Frequency (MHz)	Min. NF (dB)	Min. NF Source Reflection Coefficient	Reflection Coefficient Phase (deg)	Normalized Effective Noise Resistance
400	0.66854088	0.161129	21.49795	0.102482
450	0.669528092	0.16188	24.08635	0.102287
500	0.671195133	0.162201	26.70935	0.102063
550	0.673322655	0.162287	29.35811	0.101811
600	0.675801419	0.162238	32.02817	0.101532
650	0.678573564	0.162109	34.71721	0.101226
700	0.681606769	0.161933	37.42403	0.100895
750	0.684882082	0.161732	40.14802	0.100538
800	0.688387842	0.161521	42.88883	0.100156
850	0.692116514	0.161311	45.6462	0.099751
900	0.696062955	0.161112	48.41988	0.099324
950	0.700223451	0.160933	51.20955	0.098874
1000	0.704595152	0.160781	54.01476	0.098403
1050	0.709175746	0.160664	56.8349	0.097912
1100	0.713963263	0.160588	59.6692	0.097402
1150	0.71895595	0.160561	62.5167	0.096873
1200	0.724152209	0.160588	65.37622	0.096327
1250	0.729550552	0.160676	68.24642	0.095765
1300	0.73514958	0.16083	71.12572	0.095188
1350	0.740947975	0.161057	74.01241	0.094596
1400	0.746944503	0.161361	76.90455	0.093992
1450	0.753138024	0.161746	79.8001	0.093377
1500	0.759527504	0.162219	82.69684	0.09275
1550	0.766112048	0.162781	85.59251	0.092115
1600	0.772890932	0.163436	88.48473	0.091472
1650	0.779863659	0.164188	91.37116	0.090823
1700	0.787030035	0.165037	94.24945	0.090168
1750	0.794390286	0.165984	97.11739	0.089511
1800	0.801945241	0.16703	99.97296	0.088851
1850	0.809696624	0.168173	102.8145	0.088192
1900	0.817647551	0.169411	105.6407	0.087535
1950	0.825803408	0.170737	108.4514	0.086882
2000	0.834173511	0.172142	111.2477	0.086237
2050	0.842774452	0.17361	114.0335	0.085603
2100	0.851637425	0.175109	116.8181	0.084989
2150	0.86082585	0.176573	119.6235	0.084408
2200	0.870481692	0.177851	122.5033	0.083895

**Table 2. SKY65047-360LF Noise Parameters (2 of 2)**

Frequency (MHz)	Min. NF (dB)	Min. NF Source Reflection Coefficient	Reflection Coefficient Phase (deg)	Normalized Effective Noise Resistance
2250	0.880941082	0.178538	125.601	0.083556
2300	0.892559692	0.17785	129.1724	0.083685
2350	0.900648512	0.179664	131.5663	0.083613
2400	0.905880996	0.186456	132.348	0.082048
2450	0.914690749	0.190481	134.2928	0.081014
2500	0.924608037	0.193386	136.5962	0.080308
2550	0.934871997	0.196047	138.9528	0.079722
2600	0.945338035	0.198681	141.2943	0.079198
2650	0.955976638	0.201348	143.6033	0.078715
2700	0.96678279	0.204064	145.8744	0.078269
2750	0.977757187	0.206834	148.1061	0.077857
2800	0.988901749	0.209658	150.2984	0.077479
2850	1.00021849	0.212532	152.4516	0.077137
2900	1.01170924	0.215453	154.5661	0.076831
2950	1.02337567	0.218417	156.6427	0.076564
3000	1.03521925	0.22142	158.6819	0.076337

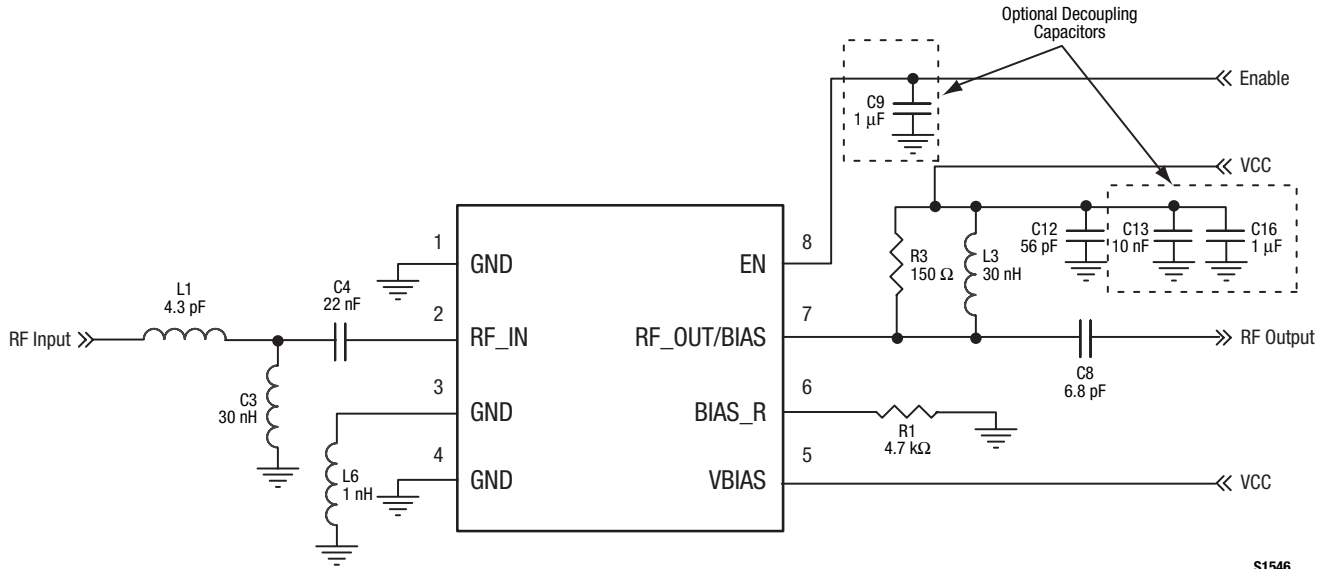


**Figure 1. S-Parameter and Noise Parameter Simulation Results for 450 MHz**

### Matching Circuits

The SKY65047-360LF LNA can be used for various 0.4 to 3.0 GHz applications such as WLANs, WiMAX systems, cellular base stations, GPS receivers, satellite receivers, remote metering, or test instrumentation.

Matching circuit schematics for 450 MHz, 915 MHz, 1227 MHz, 1575 MHz, 1730 MHz, 1960 MHz, and 2450 MHz are shown in Figures 2 through 8.



S1546

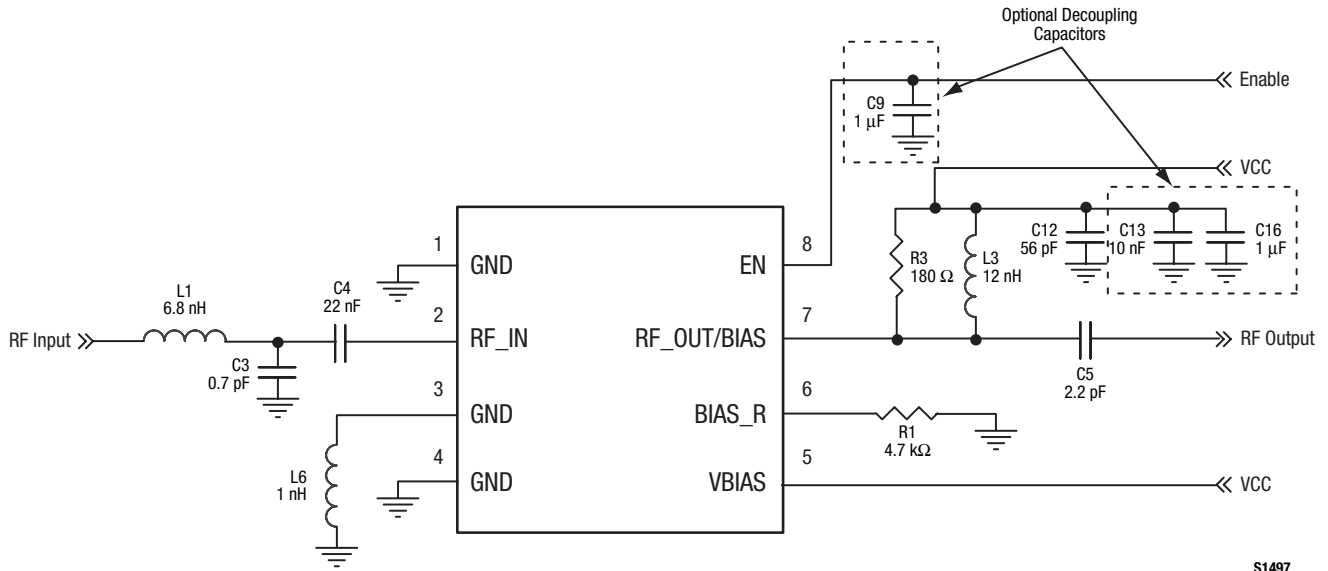
Figure 2. 450 MHz Matching Circuit

### 450 MHz

The 450 MHz matching circuit connects a 1 nH degeneration inductor to pin 3.

Test results:

- Gain: 21.44 dB
- NF: 1.34 dB
- IIP3: -4 dBm
- Current: 6.47 mA



S1497

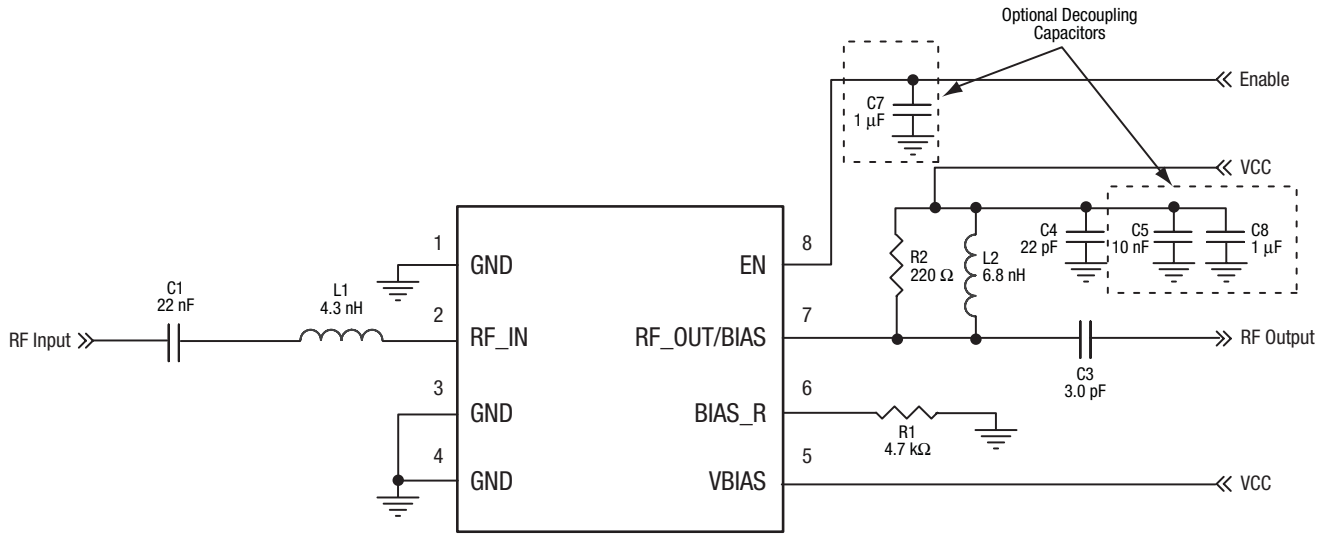
Figure 3. 915 MHz Matching Circuit

**915 MHz**

The 915 MHz matching circuit connects a 1 nH degeneration inductor to pin 3.

Test results:

- Gain: 17.3 dB
- NF: 0.9 dB
- IIP3: +3 dBm
- Current: 7.0 mA



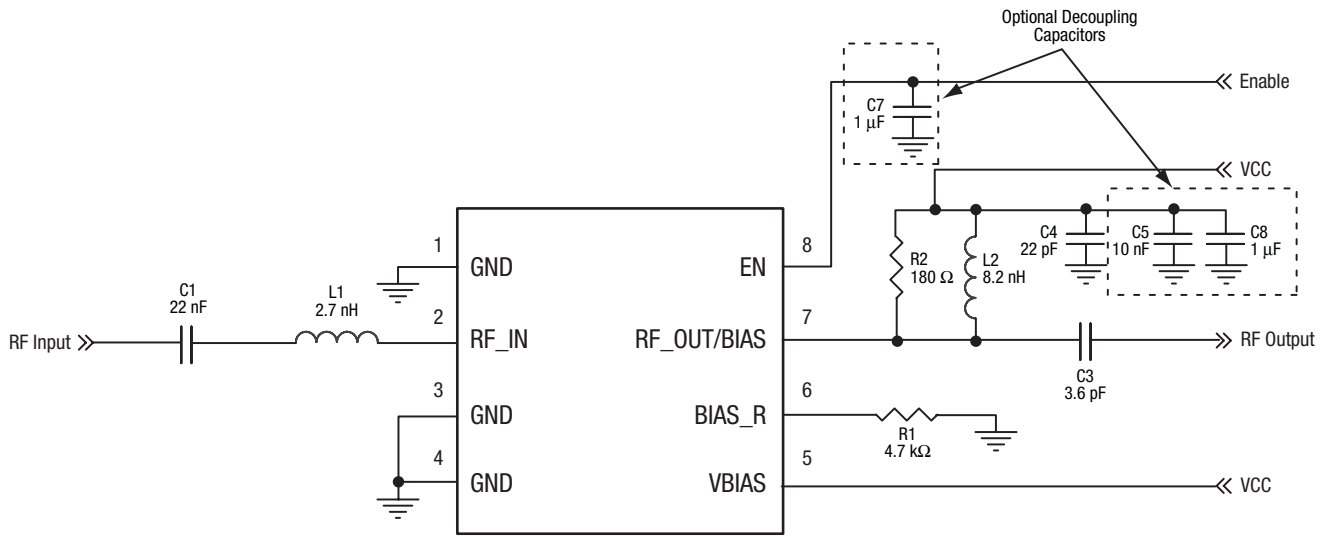
S1547

Figure 4. 1227 MHz Matching Circuit

**1227 MHz**

Test results:

- Gain: 19.5 dB
- NF: 0.92 dB
- IIP3: +1.6 dBm
- Current: 6.1 mA



S1498

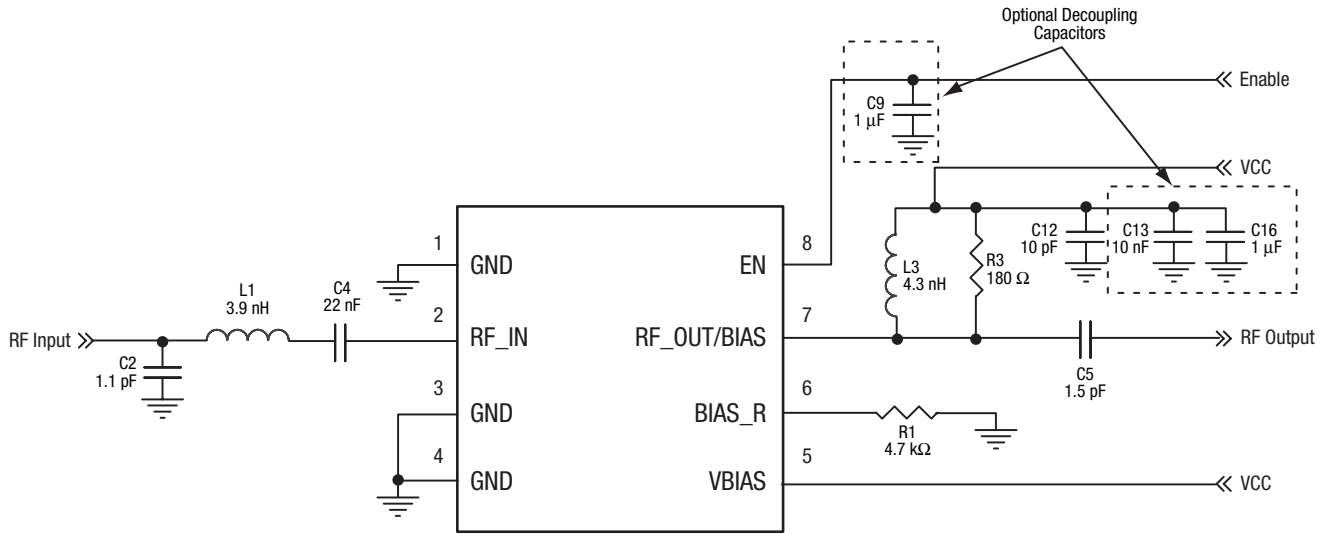
Figure 5. 1575 MHz Matching Circuit

**1575 MHz**

Test results:

- Gain: 16.5 dB
- NF: 0.75 dB
- IIP3: 0 dBm
- Current: 6.7 mA





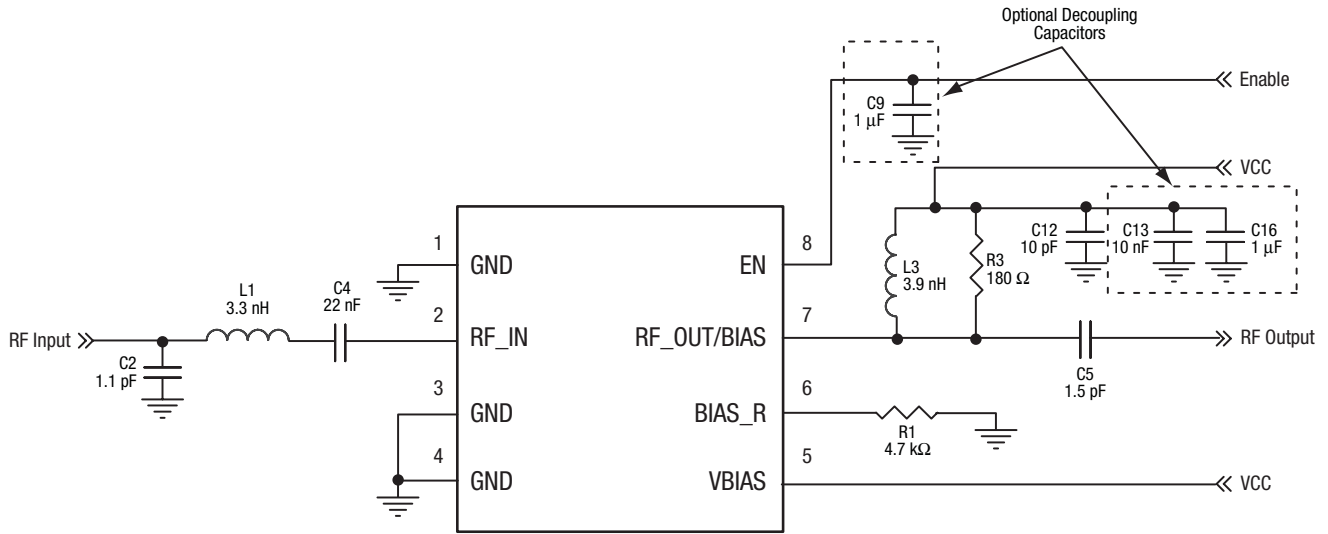
S1548

Figure 6. 1730 MHz Matching Circuit

**1730 MHz**

Test results:

- Gain: 16.8 dB
- NF: 0.82 dB
- IIP3: +3.4 dBm
- Current: 5.8 mA



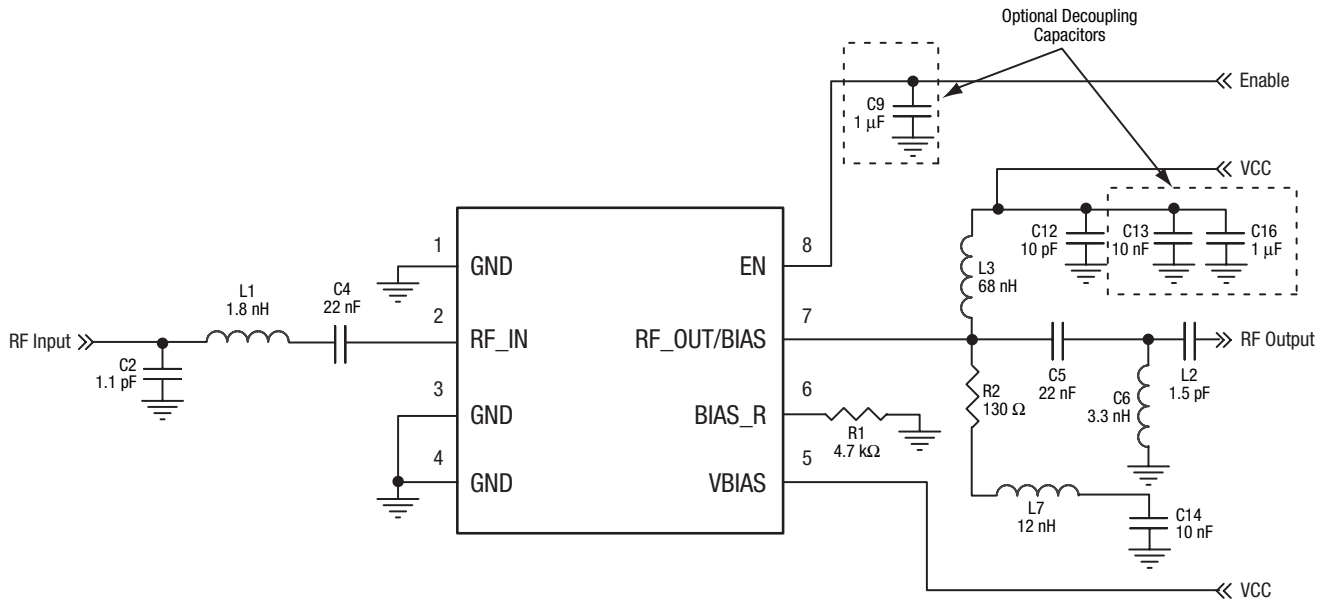
S1549

Figure 7. 1960 MHz Matching Circuit

**1960 MHz**

Test results:

- Gain: 15.7 dB
- NF: 0.92 dB
- IIP3: +5.5 dBm
- Current: 5.7 mA



S1550

**Figure 8. 2450 MHz Matching Circuit**

**2450 MHz**

The 2450 MHz matching circuit includes optional components R2, L7, and C14. These components could help to maintain stability and allow a higher gain at this high frequency.

Test results:

- Gain: 15.7 dB
- NF: 0.95 dB
- IIP3: +6.5 dBm
- Current: 6.8 mA

## Bias Reference Setting

Pin 6 of the SKY65047-360 LF, BIAS\_R, should connect to resistor R1 to set the bias reference voltage. Normally, a 4.7 kΩ resistor is used. This value sets the current to about 6.8 mA, which can be increased or decreased by changing the value of this component.

The Table below provides a sample list of R1 values and corresponding currents.

**Table 3. R1 Values vs Current**

Resistor R1 Value (kΩ)	Current (mA)
5.6	5.8
4.7	6.8
3.0	9.8
1.8	17.0

## Evaluation Boards

The SKY65047-360LF Data Sheet (document #201084) provides assembly drawings for the following three Evaluation Boards:

1. 915 MHz
2. 1575 MHz
3. 2450 MHz

For each of these test boards, connector P1 is for the DC power supply. Pin 1 of this connector (the leftmost pin looking from the top of the board) enables the LNA. This is normally 3.3 V DC. Pin 2 of this connector (the middle pin) is ground, and pin 3 (the rightmost pin looking from the top of the board) is the VCC supply (3.3 V).

There are two internal circuits for each Evaluation Board. One circuit is from SMA connector J1 (LNA input) to connector J2 (LNA output). This circuit is used to measure the fully matched LNA performance, which includes all the needed matching components.

The second internal circuit is from SMA connector J3 (LNA input) to J4 (LNA output). This circuit only has a DC supply and biasing components but no matching components for input and output. Use this circuit to measure the LNA impedance or the full S-performance data if needed.

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