

DATA SHEET

SKY65038-70LF: 0.25-6.0 GHz Low Noise Amplifier

Applications

- Wireless infrastructure: WLAN, WiMAX, broadband, cellular base stations
- Test instrumentation
- Cable television

Features

- Broadband frequency range: 0.25 to 6.0 GHz
- Gain = 15 dB @ 1 GHz
- Noise Figure = 2 dB @ 1 GHz
- OIP3= +40 dBm
- OP1dB = +21.5 dBm @ 1 GHz
- Wideband 50 Ω output impedance
- Single, +5 V supply
- SOT-89 (4-pin, 2.4 x 4.5 mm) Pb-free package (MSL1, 260 °C per JEDEC J-STD-020)

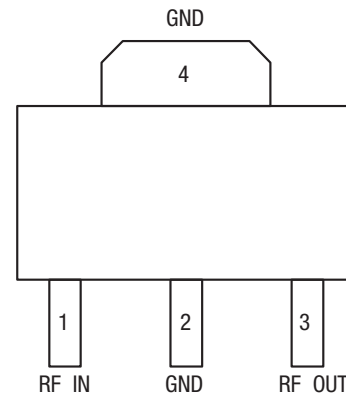
NEW Skyworks Green™ products are RoHS (Restriction of Hazardous Substances)-compliant, conform to the EIA/EICTA/JEITA Joint Industry Guide (JIG) Level A guidelines, are halogen free according to IEC-61249-2-21, and contain <1,000 ppm antimony trioxide in polymeric materials.

Description

Skyworks SKY65038-70LF is a general purpose, broadband Low Noise Amplifier (LNA). The device is fabricated from Skyworks pHEMT process and packaged in a miniature Small Outline Transistor (SOT-89) package.

The LNA's high gain, low noise, and 3rd Order Output Intercept Point (OIP3) allow the SKY65038-70LF to be used a various transmitter and receiver application. The device's 50 Ω output impedance allows it to be easily cascaded with a simple input impedance matching network. The typical useable bandwidth of the SKY65038-70LF is 0.25 to 6.0 GHz.

The device package and pinout are shown in Figure 1 and a functional block diagram is provided in Figure 2.



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Figure 1. SKY65038-70LF Pinout – 4-Pin SOT Package (Top View)

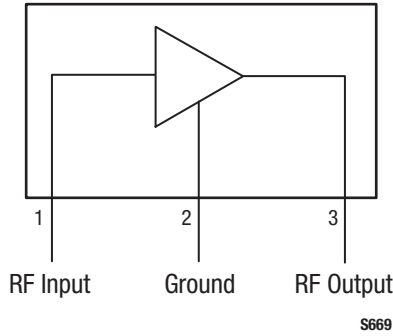


Figure 2. SKY65038-70LF Functional Block Diagram

Functional Description

The SKY65038-70LF is a single stage, low-noise LNA that operates with a single 5 V power supply connected through an RF choke (inductor L1) to the output signal (pin 3). The device is externally RF matched using surface mount components to facilitate operation over a frequency range of 0.25 to 6.0 GHz.

Electrical and Mechanical Specifications

Signal pin assignments and functional pin descriptions are described in Table 1. The absolute maximum ratings of the SKY65038-70LF are provided in Table 2. The recommended operating conditions are specified in Table 3 and electrical specifications are provided in Table 4.

Typical performance characteristics of the SKY65038-70LF are illustrated in Figures 3 through 9.

Table 1. SKY65038-70LF Signal Descriptions

Pin #	Name	Description
1	RF_IN	RF input
2	GND	Ground
3	RF_OUT	RF output
4	GND	Ground

Table 2. SKY65038-70LF Absolute Maximum Ratings

Parameter	Symbol	Min	Typical	Max	Units
Supply voltage	VDD		6		V
RF input power	P _{IN}		+10		dBm
Operating case temperature	T _C	-40		+85	°C
Storage temperature	T _{ST}	-65		+125	°C
Junction temperature	T _J		150		°C
Thermal resistance	Θ _{JC}		53		°C/W

Note: Exposure to maximum rating conditions for extended periods may reduce device reliability. There is no damage to device with only one parameter set at the limit and all other parameters set at or below their nominal values.

Table 3. SKY65038-70LF Recommended Operating Conditions

Parameter	Symbol	Min	Typical	Max	Units
Operating frequency	f	0.25		6.0	GHz
Supply voltage	VDD	3.0	5.0	5.5	V

Table 4. SKY65038-70LF Electrical Characteristics

(VDD = +5 V, Tc = 25 °C, Characteristic Impedance [Zo] = 50 Ω, f = 1 GHz, Tested With Unmatched Device, Unless Otherwise Noted)

Parameter	Symbol	Test Conditions	Min	Typical	Max	Units
Noise Figure	NF			2		dB
Small signal gain	IS21I	f = 1 GHz		15.0		dB
		f = 2 GHz		13.5		dB
		f = 6 GHz		8.5		dB
Input return loss	IS11I	f = 0.25 to 1.0 GHz		-15		dB
		f = 1 to 6 GHz		-8		dB
Output return loss	IS22I	f = 0.25 to 6.0 GHz		-20		dB
Reverse isolation	IS12I			-20		dB
Third order output intercept point	OIP3	10 MHz spacing, P _{OUT} = +5 dBm/tone	+37	+40		dBm
Output power @ 1 dB compression	OP1dB			+21.5		dBm
Supply current	I _{DD}		110	150	165	mA

Typical Performance Characteristics

(VDD = +5 V, Tc = 25 °C, Characteristic Impedance [Zo] = 50 Ω, I_{DD} = 150 mA, Tested With Unmatched Device, Unless Otherwise Noted)

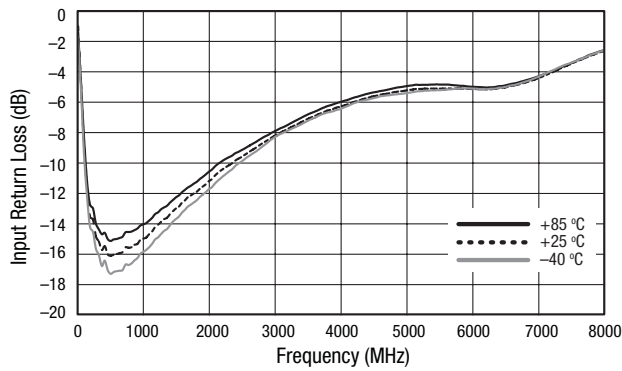


Figure 3. Input Return Loss vs Frequency Over Temperature (P_{IN} = -20 dBm)

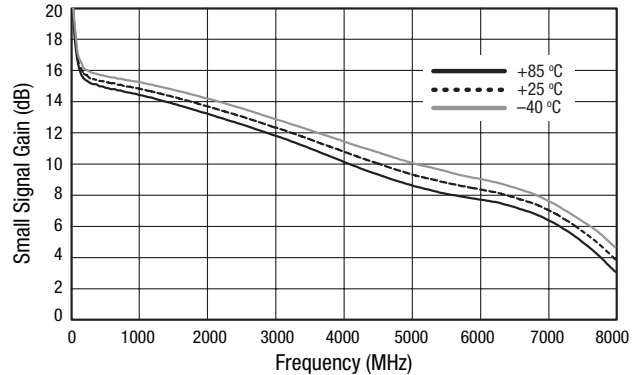


Figure 4. Small Signal Gain vs Frequency Over Temperature (P_{IN} = -20 dBm)

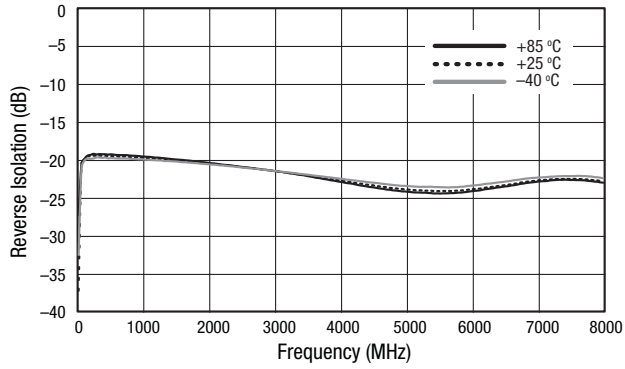


Figure 5. Reverse Isolation vs Frequency Over Temperature (P_{IN} = -20 dBm)

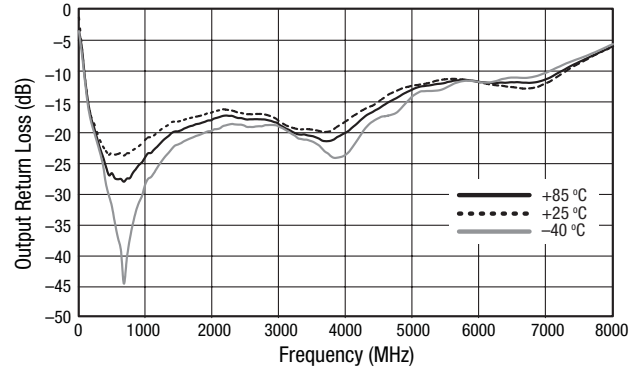


Figure 6. Output Return Loss vs Frequency Over Temperature (P_{IN} = -20 dBm)

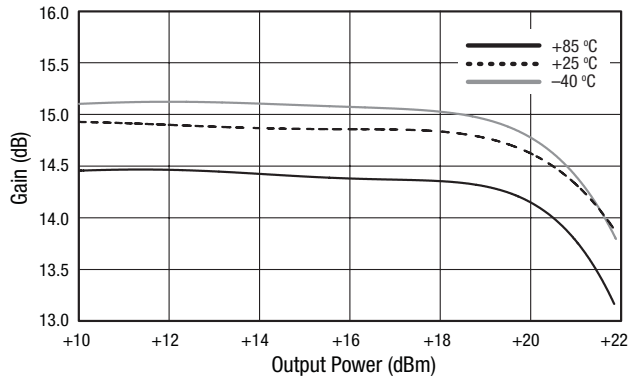


Figure 7. Gain vs Output Power Over Temperature

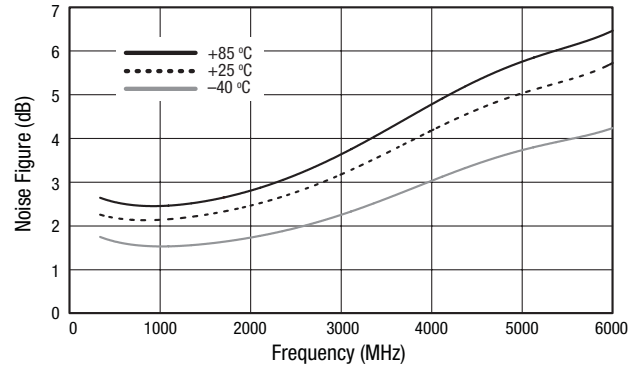


Figure 8. Noise Figure vs Frequency Over Temperature

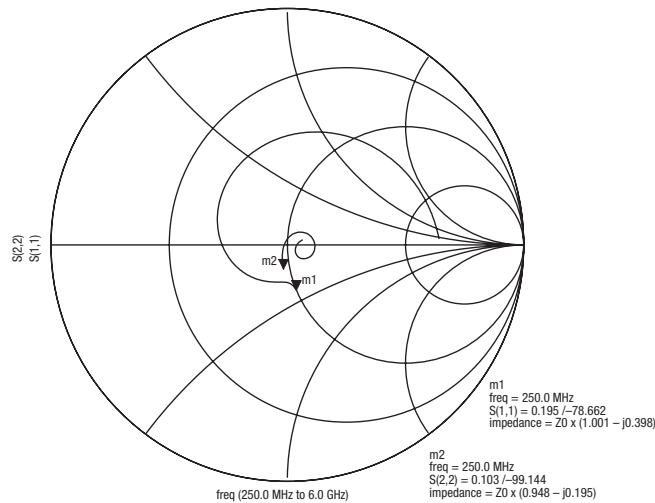


Figure 9. Input and Output Return Loss vs Frequency

Evaluation Board Description

The Skyworks SKY65038-70LF Evaluation Board is used to test the performance of the SKY65038-70LF LNA. An assembly drawing for the Evaluation Board is shown in Figure 10.

Instead of using external surface mount components to test the Evaluation Board, broadband bias Ts were used to highlight the performance of the device, itself. Evaluation Boards are available for 250 MHz, 900 MHz, 1900 MHz, and 2100 MHz. Typical reference schematic diagrams are provided in Figures 11 (250 MHz), 13 (900 MHz), 15 (1900 MHz), and 17 (2100 MHz). These are relatively wideband circuits that are useful for many applications.

The following Tables describe the S-parameter performance and provide the Bill of Materials (BOMs) for the four available Evaluation Boards:

250 MHz: Tables 5 and 6.

900 MHz: Tables 7 and 8.

1900 MHz: Tables 9 and 10.

2100 MHz: Tables 11 and 12.

Table 13 provides scattering parameters for 250 MHz up to 6000 MHz, calibrated to package leads.

Biasing

The voltage supply (VDD) should be applied to the RF_OUT pin through inductor L2. Decoupling capacitors C3 and C4 should be placed closely to L2.

If a bias level lower than +5 V is used, the feedback resistor R1 is required. Use the following equation to determine the value of R1 (do not install R1 for +5 V operation):

$$R1 = -30 \times 10^3 \times \left(\frac{VDD - 0.37}{VDD - 5} \right) \quad (1)$$

Circuit Design Configurations

The following design considerations are general in nature and must be followed regardless of final use or configuration.

1. External components should be placed close to the package pins to reduce parasitics.
2. Care should be taken to ensure that all RF traces are 50 Ω .
3. Paths to ground should be made as short as possible.
4. The ground pad of the SKY65038-70LF LNA has special electrical and thermal grounding requirements. This pad is the main thermal conduit for heat dissipation. Since the circuit board acts as the heat sink, it must shunt as much heat as possible from the amplifier. As such, design the connection to the ground pad to dissipate the maximum wattage produced to the circuit board. Multiple vias to the grounding layer are required.

5. All surface mount components are 0402-sized to reduce component parasitics. Use of 0603 or larger components is not recommended.

The different Evaluation Boards for the SKY65038-70LF are provisioned with two RF connectors and a DC launch. All boards have space for additional RF matching components. Unused series locations should be populated with 0 Ω resistors or strip lines. Unused shunt locations should be left unpopulated. Components in the feedback path from the RF input to the DC header should only be used if operating at less than +5 V.

Testing Procedure

Use the following procedure to set up the SKY65038-70LF Evaluation Board for testing:

1. Connect RF test equipment to the input/output SMA connectors.
2. Connect DC ground.
3. Connect VDD to a +5 V supply with a current of 200 mA. Verify that the board draws approximately 150 mA.
4. Apply an RF signal or noise source.

Package Dimensions

Typical case markings for the SKY65038-70LF are shown in Figure 19. The PCB layout footprint is shown in Figure 20. Package dimensions for the 4-pin SOT-89 are provided in Figure 21, and tape and reel dimensions are shown in Figure 22.

Package and Handling Information

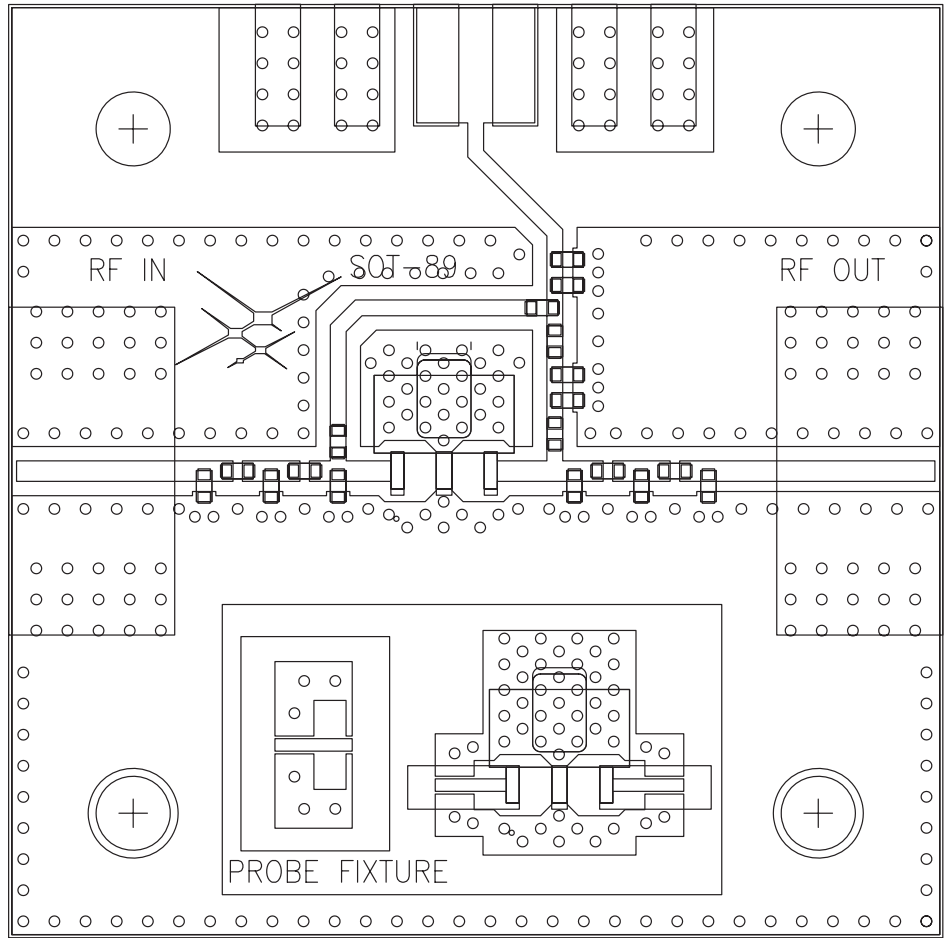
Since the device package is sensitive to moisture absorption, it is baked and vacuum packed before shipping. Instructions on the shipping container label regarding exposure to moisture after the container seal is broken must be followed. Otherwise, problems related to moisture absorption may occur when the part is subjected to high temperature during solder assembly.

The SKY65038-70LF is rated to Moisture Sensitivity Level 1 (MSL1) at 260 °C. It can be used for lead or lead-free soldering.

Care must be taken when attaching this product, whether it is done manually or in a production solder reflow environment. Production quantities of this product are shipped in a standard tape and reel format. For packaging details, refer to the Skyworks Application Note *Tape and Reel*, document number 101568.

Electrostatic Discharge (ESD) Sensitivity

The SKY65038-70LF is a static-sensitive electronic device. Do not operate or store near strong electrostatic fields. Take proper ESD precautions.



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Figure 10. Evaluation Board Assembly Drawing

250 MHz Application Circuit

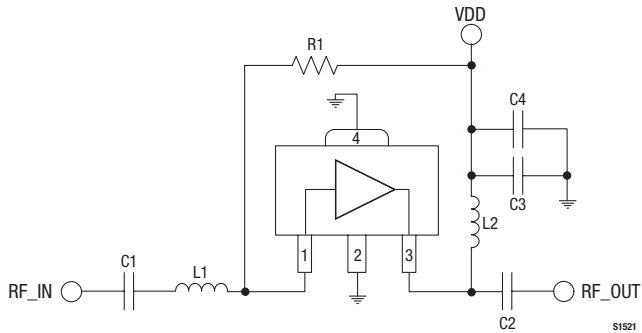


Figure 11. SKY65038-70LF Evaluation Board Schematic (250 MHz)

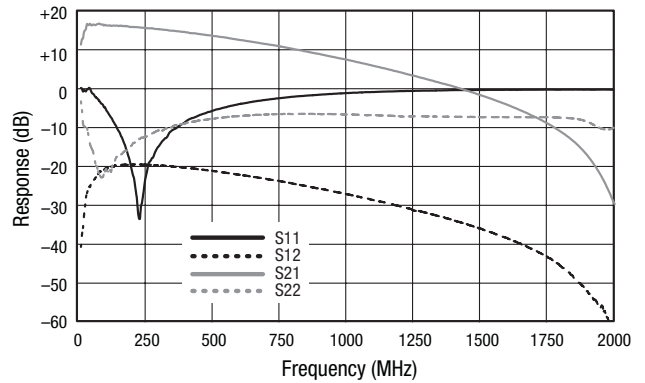


Figure 12. S-Parameters with 250 MHz External Matching Network

Table 5. Typical 250 MHz Circuit Performance

Parameter	Value
Input Return Loss IS11	-18 dB
Gain IS21	15.75 dB
Reverse Isolation IS12	-20 dB
Output Return Loss IS22	-20 dB
OIP3	+40 dBm

Table 6. SKY65038-70LF (250 MHz) Evaluation Board Bill of Materials

Component	Value	Manufacturer/Part #
C1	82 pF	Murata GRM1555C1H820JZ01
C2	82 pF	Murata GRM1555C1H820JZ01
C3	10 pF	Murata GRM1555C1H100JZ01
C4	0.1 μF	Murata GRM1555R60J104KA01
L1	15 nH	Taiyo Yuden HK100515NJ
L2	82 nH	Taiyo Yuden HK100582NJ
R1	See Equation (1)	-

900 MHz Application Circuit

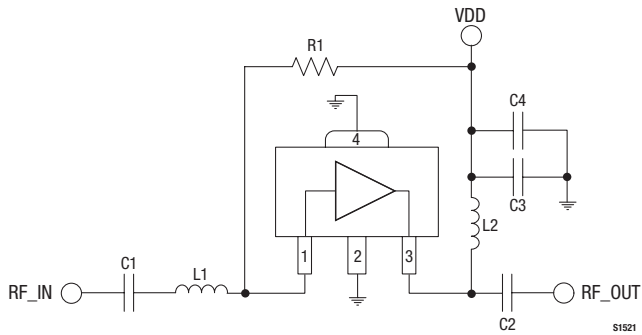


Figure 13. SKY65038-70LF Evaluation Board Schematic (900 MHz)

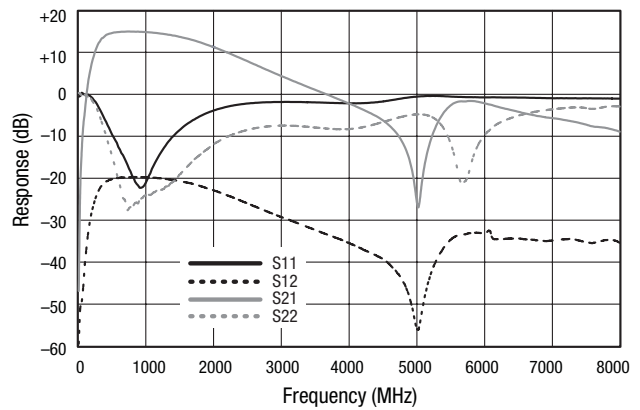


Figure 14. S-Parameters with 900 MHz External Matching Network

Table 7. Typical 900 MHz Circuit Performance

Parameter	Value
Input Return Loss IS11	-20 dB
Gain IS21	14.75 dB
Reverse Isolation IS12	-20 dB
Output Return Loss IS22	-25 dB
OIP3	+40 dBm

Table 8. SKY65038-70LF (900 MHz) Evaluation Board Bill of Materials

Component	Value	Manufacturer/Part #
C1	10 pF	Murata GRM1555C1H100JZ01
C2	10 pF	Murata GRM1555C1H100JZ01
C3	10 pF	Murata GRM1555C1H100JZ01
C4	0.1 μF	Murata GRM1555R60J104KA01
L1	5.6 nH	Taiyo Yuden HK10055N6S
L2	22 nH	Taiyo Yuden HK100522NJ
R1	See Equation (1)	-

1900 MHz Application Circuit

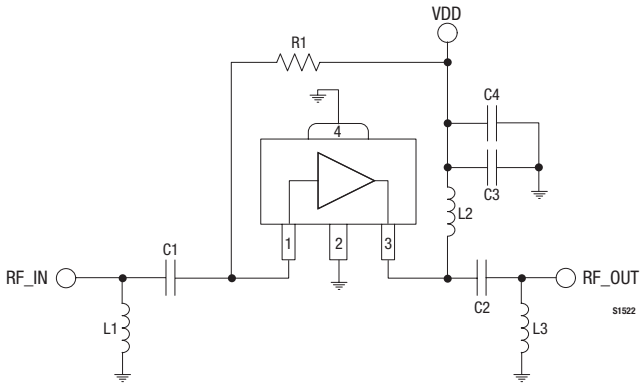


Figure 15. SKY65038-70LF Evaluation Board Schematic (1900 MHz)

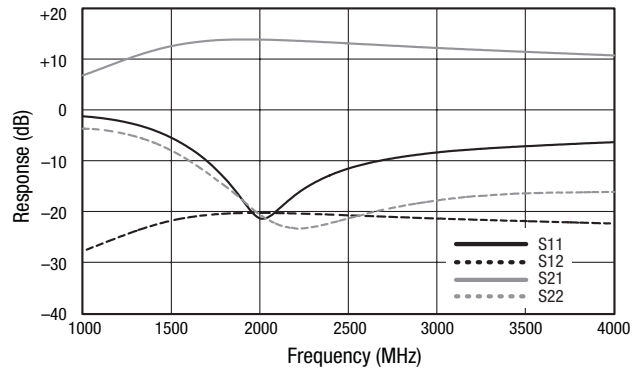


Figure 16. S-Parameters with 1900 MHz External Matching Network

Table 9. Typical 1900 MHz Circuit Performance

Parameter	Value
Input Return Loss S11	-17.5 dB
Gain S21	13.5 dB
Reverse Isolation S12	-20 dB
Output Return Loss S22	-18 dB
OIP3	+40 dBm

Table 10. SKY65038-70LF (1900 MHz) Evaluation Board Bill of Materials

Component	Value	Manufacturer/Part #
C1	2.2 pF	Murata GRM1555C1H2R2CZ01
C2	3.3 pF	Murata GRM1555C1H3R3CZ01
C3	10 pF	Murata GRM1555C1H100JZ01
C4	0.1 μF	Murata GRM1555R60J104KA01
L1	3.9 nH	Taiyo Yuden HK10053N9S
L2	22 nH	Taiyo Yuden HK100522NJ
L3	6.8 nH	Taiyo Yuden HK10056N8J
R1	See Equation (1)	-

2100 MHz Application Circuit

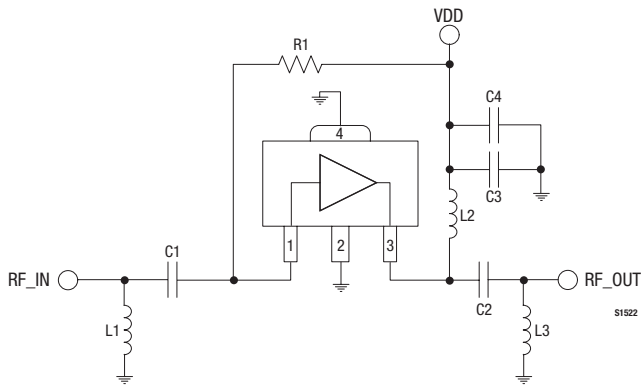


Figure 17. SKY65038-70LF Evaluation Board Schematic (2100 MHz)

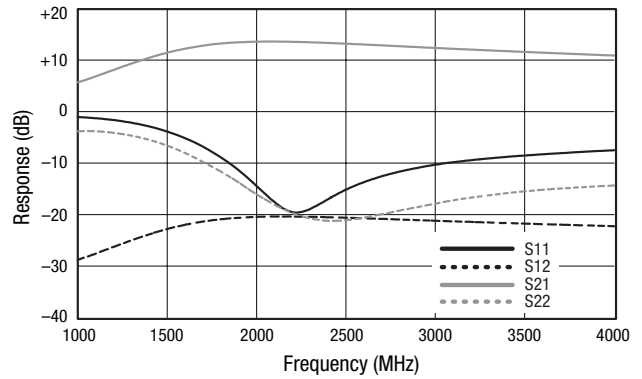


Figure 18. S-Parameters with 2100 MHz External Matching Network

Table 11. Typical 2100 MHz Circuit Performance

Parameter	Value
Input Return Loss IS11	-18 dB
Gain IS21	15.75 dB
Reverse Isolation IS12	-20 dB
Output Return Loss IS22	-20 dB
OIP3	+40 dBm

Table 12. SKY65038-70LF (2100 MHz) Evaluation Board Bill of Materials

Component	Value	Manufacturer/Part #
C1	1.8 pF	Murata GRM1555C1H1R8CZ01
C2	3.3 pF	Murata GRM1555C1H3R3CZ01
C3	10 pF	Murata GRM1555C1H100JZ01
C4	0.1 μF	Murata GRM1555R60J104KA01
L1	3.9 nH	Taiyo Yuden HK10053N9S
L2	22 nH	Taiyo Yuden HK100522NJ
L3	6.8 nH	Taiyo Yuden HK10056N8J
R1	See Equation (1)	-

Table 13. Device S-Parameters Calibrated to Package Leads (VDD = +5 V, IDD = 150 mA)

Freq (MHz)	S11 (dB)	S11 (ang)	S21 (dB)	S21 (ang)	S12 (dB)	S12 (ang)	S22 (dB)	S22 (ang)
250	-14.32	-79.08	15.77	156.66	-19.33	1.19	-20.04	-100.02
500	-16.02	-93.74	15.39	147.98	-19.33	-10.54	-32.87	-140.85
750	-15.51	-110.59	15.19	136.65	-19.40	-19.14	-32.61	92.85
1000	-14.52	-127.62	14.98	124.78	-19.51	-26.89	-26.30	65.55
1250	-13.48	-143.76	14.74	112.73	-19.66	-34.19	-23.28	50.90
1500	-12.43	-159.87	14.47	100.20	-19.81	-41.57	-21.41	38.39
1750	-11.50	-174.51	14.19	88.34	-19.98	-48.37	-20.18	28.05
2000	-10.67	171.57	13.89	76.59	-20.16	-55.04	-19.45	18.39
2250	-9.93	158.31	13.57	65.05	-20.37	-61.37	-18.93	9.50
2500	-9.23	145.00	13.22	53.17	-20.57	-68.04	-18.70	0.40
2750	-8.62	132.83	12.89	41.96	-20.78	-74.24	-18.67	-7.95
3000	-8.07	121.02	12.54	30.91	-20.97	-80.10	-18.75	-15.52
3250	-7.55	109.65	12.20	20.03	-21.21	-86.03	-19.07	-23.18
3500	-7.08	98.74	11.85	9.29	-21.39	-91.71	-19.53	-29.87
3750	-6.62	87.70	11.48	-1.84	-21.62	-97.49	-20.23	-36.11
4000	-6.21	77.37	11.14	-12.33	-21.86	-102.95	-21.16	-41.42
4250	-5.83	67.27	10.79	-22.73	-22.08	-108.07	-22.22	-45.74
4500	-5.47	57.47	10.45	-33.07	-22.30	-113.24	-23.66	-47.75
4750	-5.13	47.48	10.08	-43.78	-22.52	-118.11	-25.38	-46.29
5000	-4.83	38.15	9.74	-53.93	-22.75	-122.70	-27.22	-38.86
5250	-4.55	28.99	9.39	-64.06	-22.90	-127.21	-28.56	-22.36
5500	-4.30	20.01	9.03	-74.03	-23.05	-131.10	-28.10	-0.97
5750	-4.06	10.76	8.67	-84.43	-23.22	-134.97	-25.81	13.20
6000	-3.85	2.15	8.31	-94.37	-23.22	-138.54	-23.40	18.50

Note: S-parameters for additional frequencies are available. Refer to the Designer Info S2P file posted on www.skyworksinc.com (see Technical Documents or the SKY65038-70LF product page).

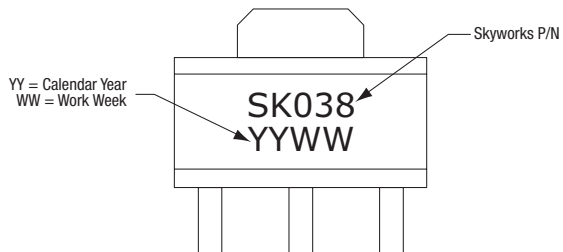
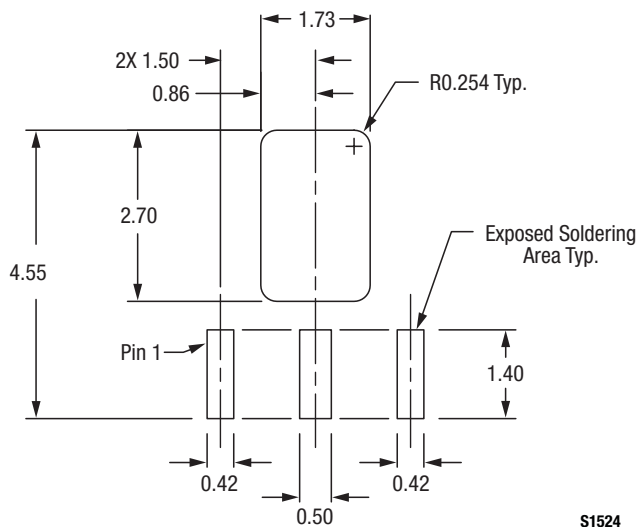
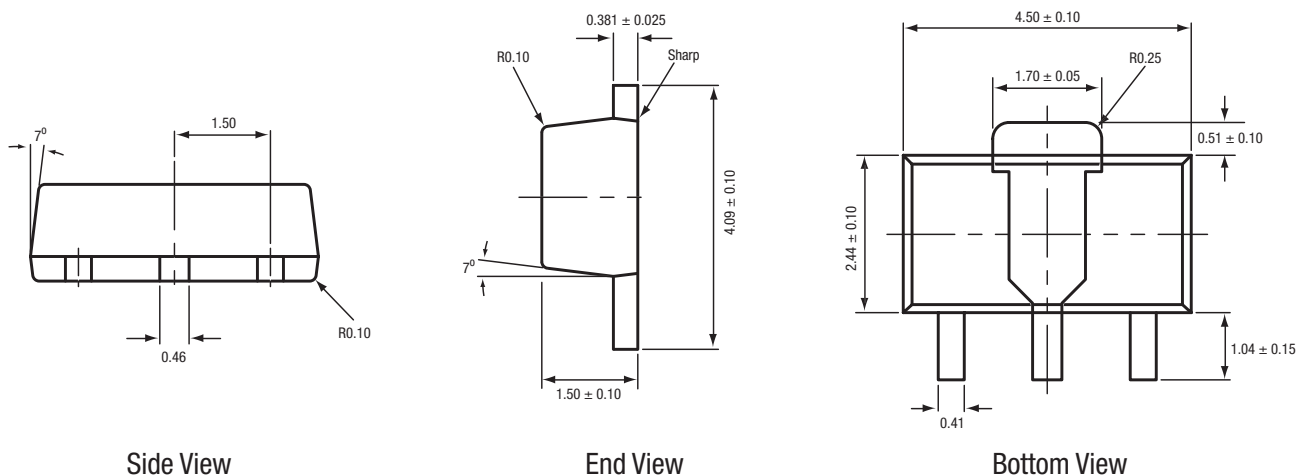


Figure 19. SKY65038-70LF Typical Case Markings



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Figure 20. SKY65038-70LF PCB Layout Footprint



Side View

End View

Bottom View

All measurements are in millimeters

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Figure 21. SKY65038-70LF 4-Pin SOT-89 Package Dimensions

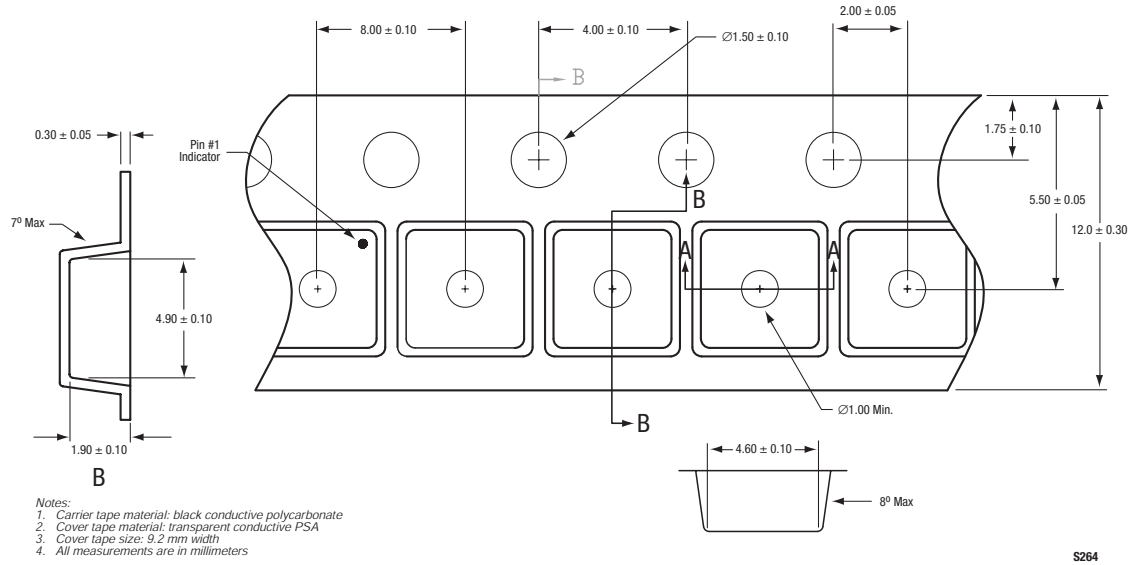


Figure 22. SKY65038-70LF Tape and Reel Dimensions

Ordering Information

Model Name	Ordering Part Number	Evaluation Kit Part Number
SKY65038-70LF Low Noise Amplifier	SKY65038-70LF (Pb-free package)	SKY65038-70LF (250 MHz) SKY65038-70LF (900 MHz) SKY65038-70LF 1900 MHz) SKY65038-70LF (2100 MHz)

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