DATA SHEET

SKY65037-360LF: 0.7-1.2 GHz Low Noise Amplifier

Applications

- Wireless infrastructure: GSM, CDMA, WCDMA, ISM, and TD-SCDMA
- Ultra-low noise applications

Features

- Ultra-low Noise Figure = 0.60 dB @ 850 MHz
- Excellent input and output return loss
- Adjustable gain = 15 to 25 dB @ 850 MHz
- High output OIP3 = +33.5 dBm @ 75 mA
- OP1dB = +18 dBm @ 850 MHz
- Single, positive DC supply voltage
- Adjustable supply current, 30 to 100 mA
- Small, QFN (8-pin, 2 x 2 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.

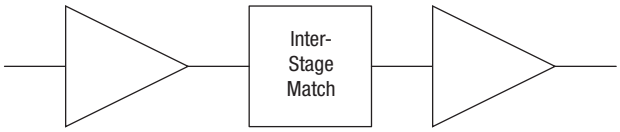


Figure 1. SKY65037-360LF Block Diagram

Description

The SKY65037-360LF is a high performance, two-stage ultra-low noise amplifier. The device is fabricated from Skyworks advanced pHEMT process and is provided in a 2 x 2 mm, 8-pin Quad Flat No-Lead (QFN) package.

The device features excellent input and output return loss, and an integrated interstage matching network. The amplifier's ultra-low Noise Figure (NF), high gain, and excellent 3rd Order Intercept point (IP3) allow it to be used in various receiver and transmitter applications.

A functional block diagram is shown in Figure 1. The pin configuration and package are shown in Figure 2. Signal pin assignments and functional pin descriptions are provided in Table 1.

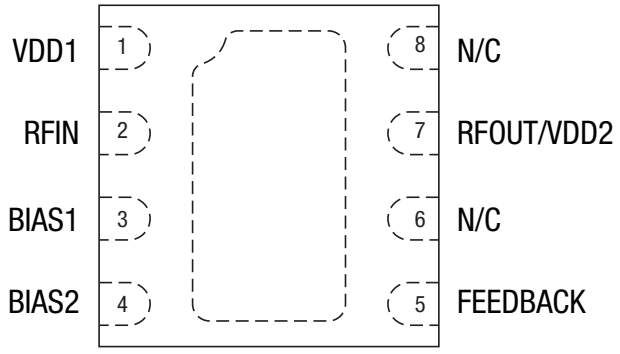


Figure 2. SKY65037-360LF Pinout – 8-Pin QFN (Top View)

Table 1. SKY65037-360LF Signal Descriptions

Pin #	Name	Description	Pin #	Name	Description
1	VDD	1st stage DC power supply	5	FEEDBACK	Connect to RFOUT to reduce gain of 2nd stage transistor
2	RFIN	RF input	6	N/C	No connection
3	BIAS1	Source lead for 1st stage transistor	7	RFOUT/VDD	RF output. Requires a DC bias using an RF choke inductor.
4	BIAS2	Source lead for 2nd stage transistor	8	N/C	No connection

Functional Description

The SKY65037-360LF is a two stage, low noise amplifier with an integrated interstage matching network. The device has a tested low NF of 0.60 dB and gain of 18.5 dB. The device allows designers to adjust current and gain without degrading the NF.

The external matching network largely dictates the RF performance of the device. The matching network is required for operation and special care should be taken when designing a circuit board layout for the SKY65037-360LF. There are four separate groups of external components: input, output, biasing, and feedback.

Biasing

To properly bias a depletion mode pHEMT, both the gate and drain of the device must be biased properly. At $V_{GS} = 0$ V and $V_{DS} > 2$ V, the amplifier stage is in its saturated state and draws the maximum amount of current, I_{DSS}. A V_{DS} of 5 V is recommended to ensure proper performance.

To eliminate the need for a negative DC supply, self-biasing should be used when a resistor is placed between one of the source leads and ground. A bypass capacitor should be placed in parallel to this resistor to provide an RF ground and to ensure performance remains unchanged at the operating frequency.

When current flows from drain to source and through the resistor, the source voltage becomes biased above DC ground. The gate pin of the device should be left unbiased at 0 V, which creates the desired negative V_{GS} value. This simplifies the design by eliminating the need for a second DC supply. Values for resistor components R1 and R2 can be changed to easily increase or decrease the bias current to a desired level.

The first stage is biased at 20 percent of I_{DSS} to achieve the best NF performance. The gain and current of the 2nd stage amplifier can be adjusted without degrading the overall NF. More current in the 2nd stage yields better IP3 performance.

Components L3 and L5 are the RF bias choke inductors. These are required to block RF power and pass V_{DD} to the drain of each amplifier stage. Components C5, C6, C9, and C10 are RF bypass capacitors. R5 and R6 reduce the voltage presented at the drain of each stage of the device. The resistor values are optimized for 3rd Order Output Intercept Point (OIP3) and P1dB performance.

Source Inductance

The effect of source inductance varies with frequency. Too little source inductance increases gain and high frequency stability, but at the cost of more in-band instability. Too much source inductance decreases high frequency stability and gain, but improves in-band instability. It is very important to find the optimum tuning of source inductance that balances all variables.

The trace present on the first stage amplifier (pin 3) is about 160 mils long and about 6 mils wide. The electrical length of the line is 7.3 degrees at 900 MHz. When designing a board for the SKY65037-360LF, these exact dimensions should be used. The board trace length at pin 4 should be minimized.

Input and Output RF Matching Network

The input band-pass matching network consists of four components. Component C1 serves as the input DC blocking capacitor, C2 provides high frequency stability and improved input return loss, and L1 and L2 are responsible for the best noise match looking into the gate of the first stage amplifier.

Excess board trace should be eliminated at the input of the device to minimize board losses. High-Q components should be used to achieve the best NF of the amplifier. Murata GJM series capacitors and Coilcraft HP or CS series inductors are recommended. Any excess board or component loss on the input of the device directly adds to the total measured NF.

The output matching network is band-pass network optimized for output return loss.

The SKY65037-360LF Evaluation Board assembly diagram is shown in Figure 10 and a circuit schematic is provided in Figure 11.

Feedback

Using feedback on the SKY65037-360LF is not necessary, but can be used to reduce gain without affecting other parameters. The default circuit configuration has 18.5 dB of gain, but can be increased to about 25 dB by removing feedback components. A recommended circuit that does not incorporate feedback is available upon request.

Measuring NF

Special care should be taken when making < 1 dB NF measurements. Ideally, measurements should be made in an RF shield room. An Agilent MXA N9020A spectrum analyzer with an internal pre-amp paired with an N4001A smart noise source was used for all noise measurements. The smart noise source has an internal thermocouple that automatically sets the T_{COLD} setting on the analyzer. If a smart noise source is unavailable, a standard low Excess Noise Ratio (ENR) source should be used. Use an external thermocouple to manually adjust the T_{COLD} setting to ensure accurate results.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY65037-360LF are provided in Table 2. The recommended operating conditions are specified in Table 3 and electrical specifications are provided in Table 4.

Performance characteristics for the SKY65037-360LF are illustrated in Figures 3 through 9.

Table 2. SKY65037-360LF Absolute Maximum Ratings

Parameter	Symbol	Minimum	Typical	Maximum	Units
Supply voltage	V_{DD}		5.5		V
Input power	P_{IN}		+15		dBm
Supply current stage one	I_{DS1}		100		mA
Supply current stage two	I_{DS2}		100		mA
Power dissipation	P_{DIS}		240		mW
Channel temperature	T_J		150		°C
Storage temperature	T_{STG}	–65		+125	°C
Operating temperature	T_{OP}	–40		+85	°C
Thermal resistance	Q_{JC}		47		°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 value.

Table 3. SKY65037-360LF Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units
Supply voltage	V_{DD}	4.75	5.00	5.25	V
Supply current	I_{DD}	30	75	100	mA

Table 4. SKY65037-360LF Electrical Specifications
(T_{OP} = +25 °C, Characteristic Impedance [Z_O] = 50 Ω, V_{DD} = 5 V, I_{DD} = 75 mA, F = 850 MHz, Parameters Include a Recommended 700-1000 MHz Matching Network, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Noise Figure (Note 1)	NF			0.6	1.0	dB
Small signal gain	|S21|		17.0	18.5	20.0	dB
Input return loss	|S11|			–22		dB
Output return loss	|S22|			–22		dB
Reverse isolation	|S12|			–30		dB
3rd Order Output Intercept Point	OIP3	10 MHz spacing, P_{IN} = –18 dBm per tone, I_{DD} = 75 mA		+33.5		dBm
1 dB Output Compression Point	OP1dB			+17.5		dBm
Stability		Unconditionally stable up to 18 GHz		>1		K

Note 1: Loss from input RF connector and board trace de-embedded from measurement.

Typical Performance Characteristics

(T_{OP} = +25 °C, Characteristic Impedance [Z_0] = 50 Ω, V_{DD} = 5 V, I_{DD} = 75 mA, Parameters Include a Recommended 700-1000 MHz Matching Network, Unless Otherwise Noted)

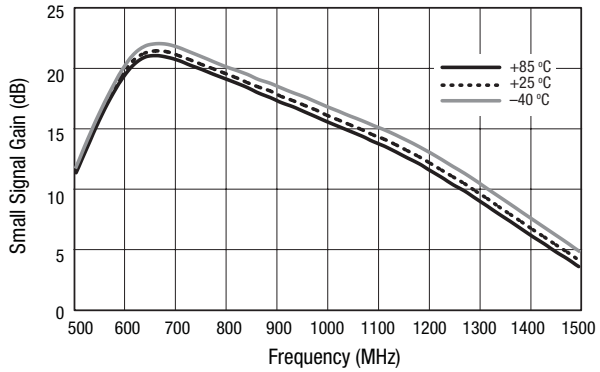


Figure 3. Small Signal Gain vs Frequency Over Temperature, P_{IN} = –20 dBm

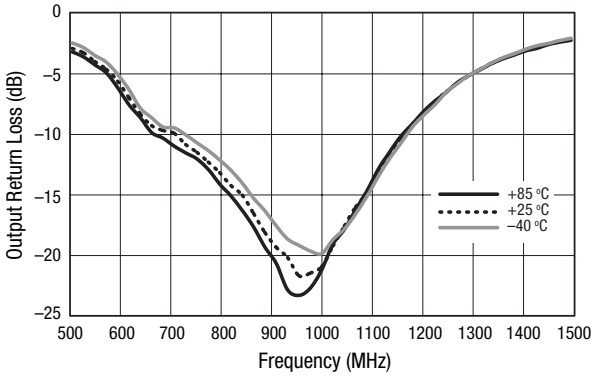


Figure 4. Output Return Loss vs Frequency Over Temperature, P_{IN} = –20 dBm

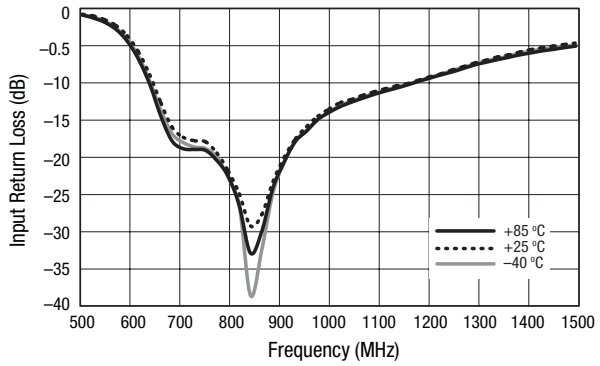


Figure 5. Input Return Loss vs Frequency Over Temperature, P_{IN} = –20 dBm

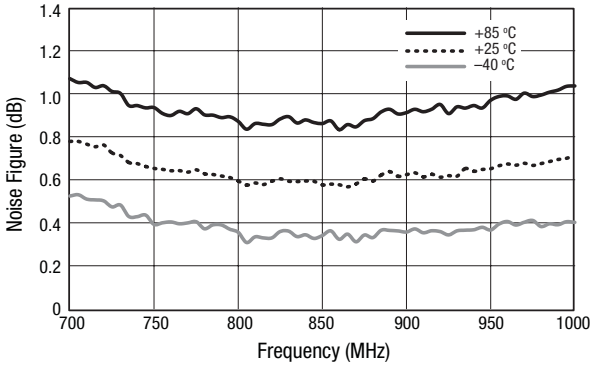


Figure 6. Noise Figure vs Frequency Over Temperature, Input RF Connector and Board Trace De-Embedded From Measurement

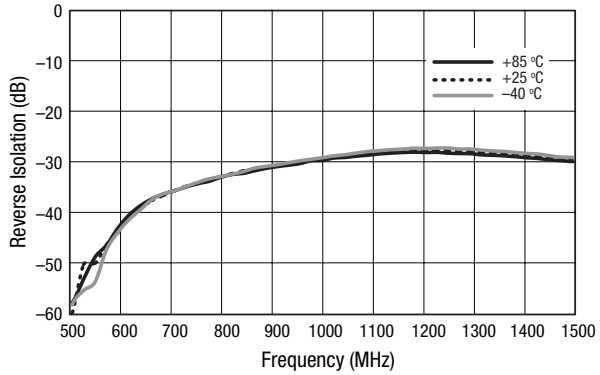


Figure 7. Reverse Isolation vs Frequency Over Temperature, P_{IN} = –20 dBm

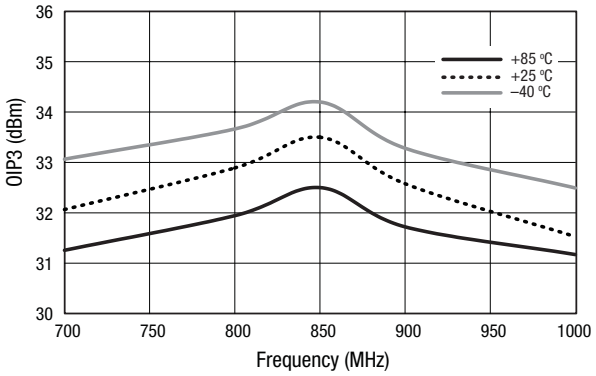


Figure 8. OIP3 vs Frequency Over Temperature, P_{IN} = –18 dBm/Tone, 5 MHz Tone Spacing

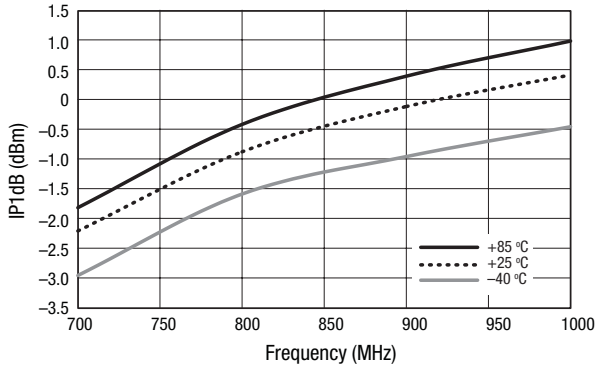


Figure 9. IP1dB vs Frequency Over Temperature

Evaluation Board Description

The SKY65037-360LF Evaluation Board is used to test the performance of the SKY65037-360LF low noise amplifier. An assembly drawing for the Evaluation Board is shown in Figure 10. The Evaluation Board schematic diagram is shown in Figure 11. Table 5 provides the Bill of Materials (BOM) list for Evaluation Board components.

Input and output trace lengths have been minimized to reduce losses. All surface mount components are 0402-sized to reduce component parasitics. The use of 0603 or larger components is not recommended. Component spacing has also been minimized. The board is provisioned with two RF connectors and a DC launch. The RF connector and board loss up to component C1 is approximately 0.05 dB at 900 MHz.

It is very important to place multiple ground vias as close to shunt components as possible. This ensures proper grounding and circuit performance.

Board material is 10 mil thick VT47 FR4 with 1 oz. copper cladding. RF input and output traces are 50 Ω with a 17.5 mil trace width and a 10 mil gap to ground.

Evaluation Board Test Procedure

Step 1: Connect RF test equipment to amplifier input/output SMA connectors.

Step 2: Connect DC ground.

Step 3: Connect VDD to a +5 V supply with a current limit of 100 mA. Verify that the board draws approximately 75 mA.

Step 4: Apply RF signal or noise source and verify performance detailed in Table 4.

Package Dimensions

The PCB layout footprint for the SKY65037-360LF is shown in Figure 12. Package dimensions for the 8-pin QFN are shown in Figure 13, and tape and reel dimensions are provided in Figure 14.

Package and Handling Information

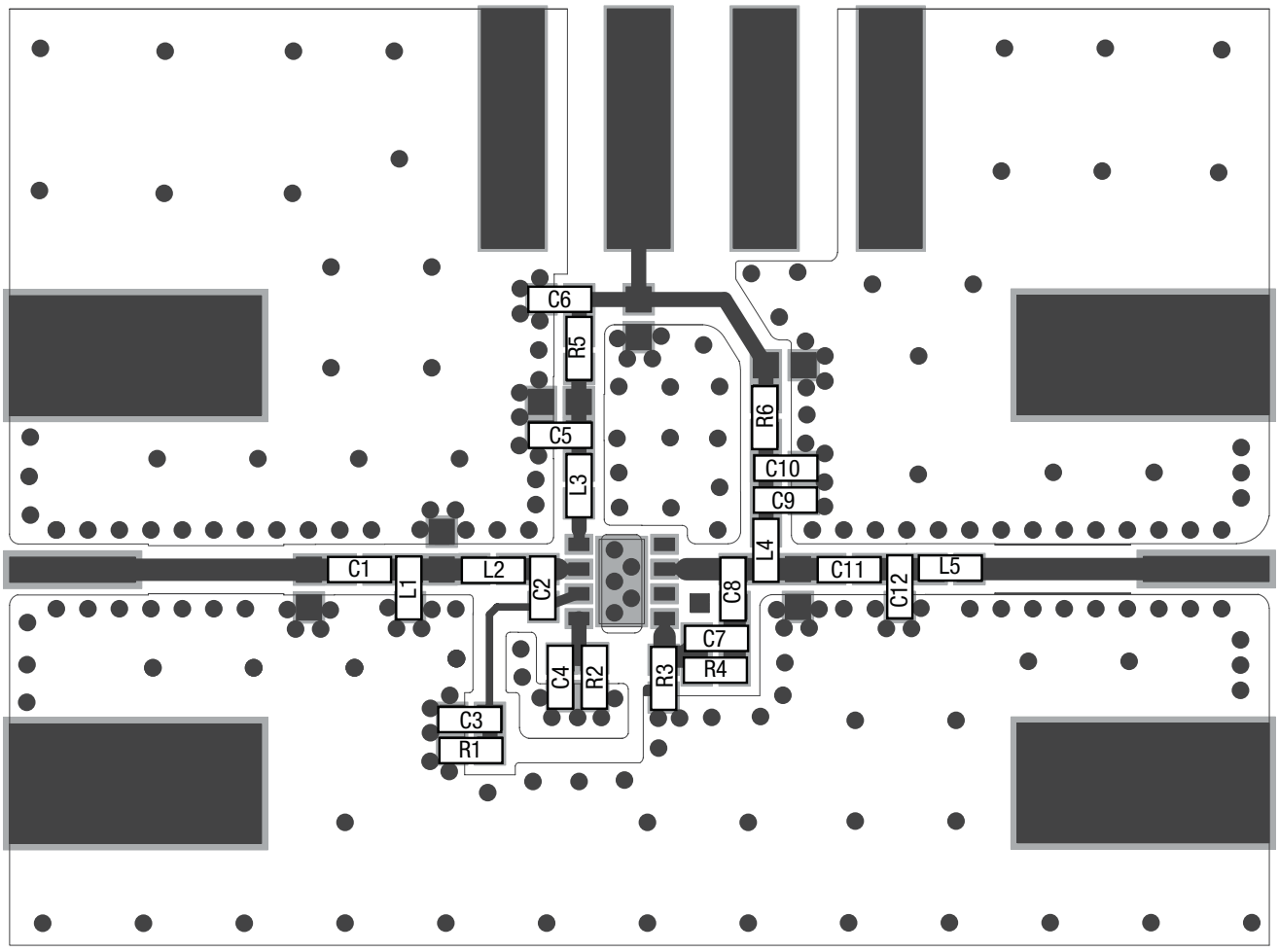
Since the device package is sensitive to moisture absorption, it is baked and vacuum packed before shipping. Instructions on the shipping container label regarding exposure to moisture after the container seal is broken must be followed. Otherwise, problems related to moisture absorption may occur when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

THE SKY65037-360LF 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, *Discrete Devices and IC Switch/Attenuators Tape and Reel Package Orientation*, document number 200083.

Electrostatic Discharge (ESD) Sensitivity

The SKY65037-360LF is a static-sensitive electronic device. Do not operate or store near strong electrostatic fields. Take proper ESD precautions.



C1, C2, L1, and L2 comprise the input matching network
C11, C12, and L5 comprise the output matching network.
R1, R5, and C3 are the bias components for the 1st stage amplifier.
R2, R6, and C4 are the bias components for the 2nd stage amplifier.
C5, C6, C9, and C10 are RF bypass capacitors.
L3 and L4 are RF choke inductors.
R3, R4, C7, and C8 are the feedback components.

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Figure 10. SKY65037-360LF Evaluation Board Assembly Diagram

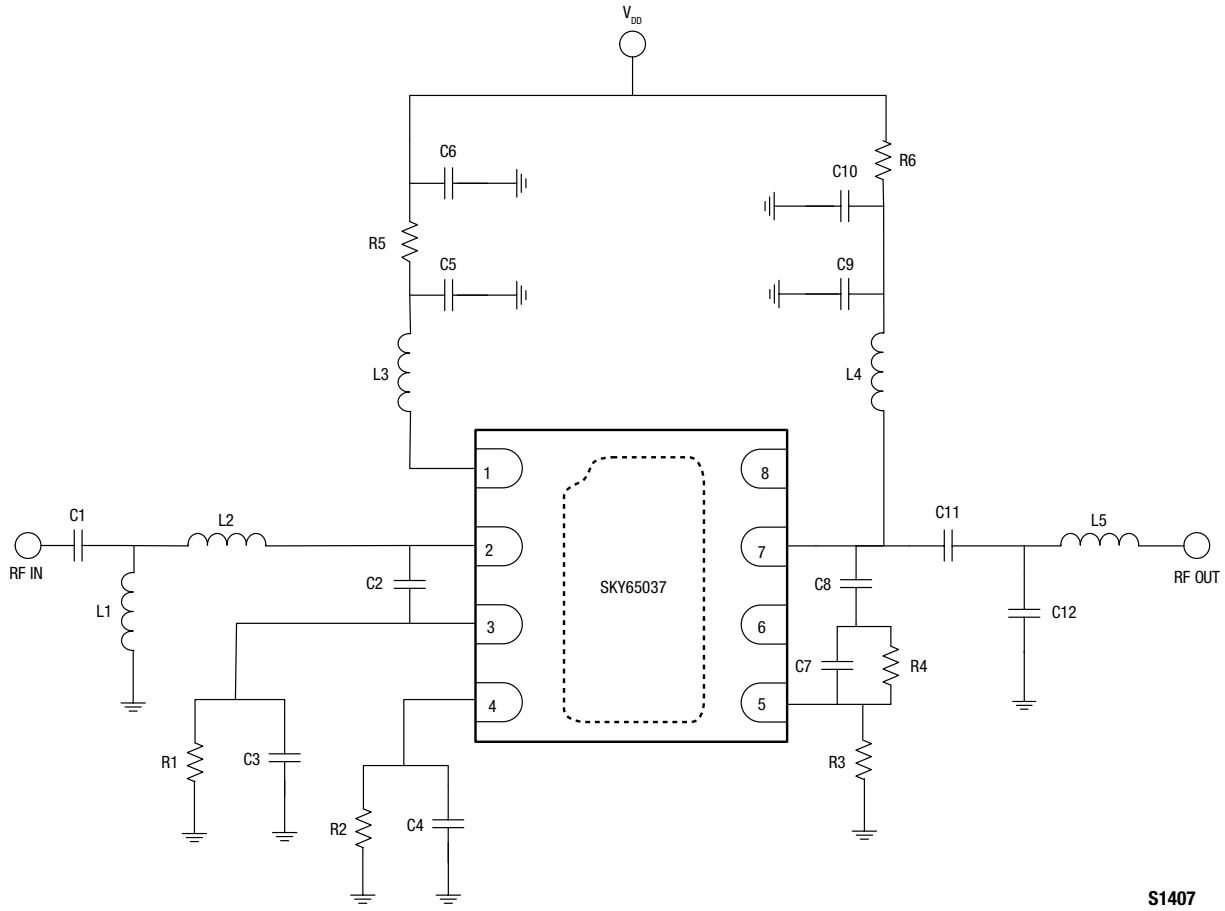
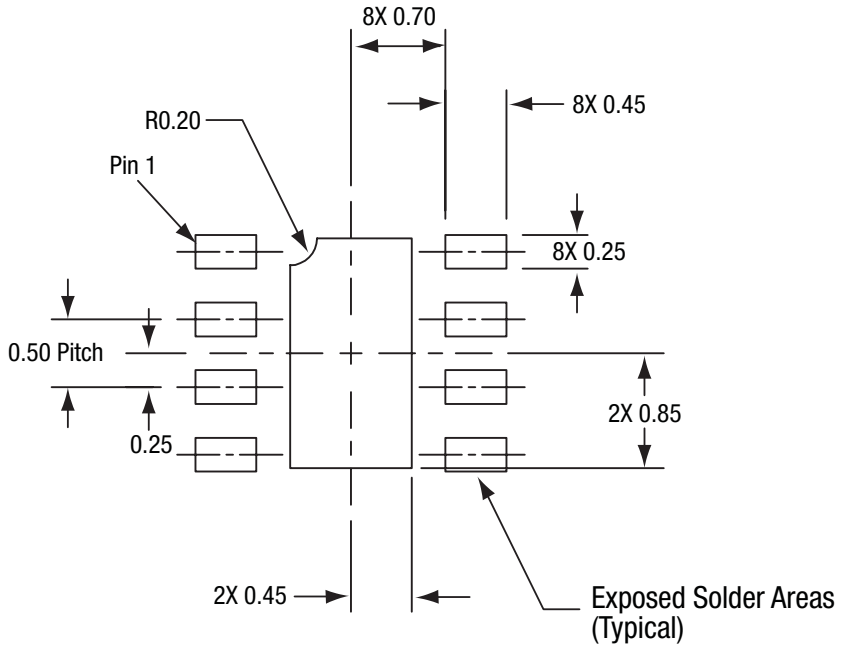


Figure 11. SKY65037-360LF Evaluation Board Schematic

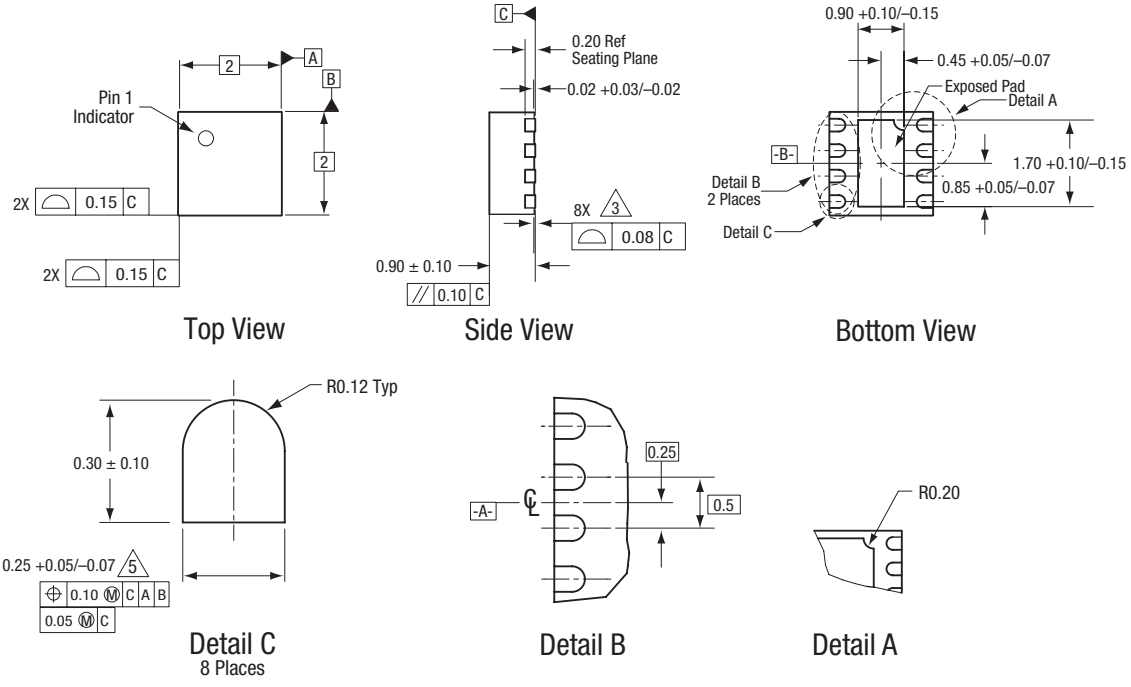
Table 5. SKY65037-360LF (QFN Package) Evaluation Board Bill of Materials

Component	Value	Size	Manufacturer	Part Series
C1	3 pF	0402	Murata	GJM
C2	0.5 pF	0402	Murata	GJM
C3	4700 pF	0402	Murata	GRM
C4	1000 pF	0402	Murata	GRM
C5	15 pF	0402	Murata	GRM
C6	1000 pF	0402	Murata	GRM
C7	0.5 pF	0402	Murata	GJM
C8	1.8 pF	0402	Murata	GRM
C9	1 pF	0402	Murata	GRM
C10	1000 pF	0402	Murata	GRM
C11	30 pF	0402	Murata	GRM
C12	3.9 pF	0402	Murata	GRM
L1	11 nH	0402	Coilcraft	HP
L2	1.9 nH	0402	Coilcraft	HP
L3	15 nH	0402	Taiyo Yuden	HK
L4	8.2 nH	0402	Taiyo Yuden	HK
L5	1.5 nH	0402	Taiyo Yuden	HK
R1	12 Ω	0402	Panasonic	–
R2	9.1 Ω	0402	Panasonic	–
R3	3 kΩ	0402	Panasonic	–
R4	51 Ω	0402	Panasonic	–
R5	5.1 Ω	0402	Panasonic	–
R6	7.5 Ω	0402	Panasonic	–



All dimensions are in millimeters S1413

Figure 12. SKY65037-360LF PCB Layout Footprint



All measurements are in millimeters.
Dimensioning and tolerancing according to ASME Y14.5M-1994.
Coplanarity applies to the exposed heat sink slug as well as the terminals..
Plating requirement per source control drawing (SCD) 2504.
Dimension applies to metalized terminal and is measured between 0.15 mm and 0.30 mm from terminal tip.

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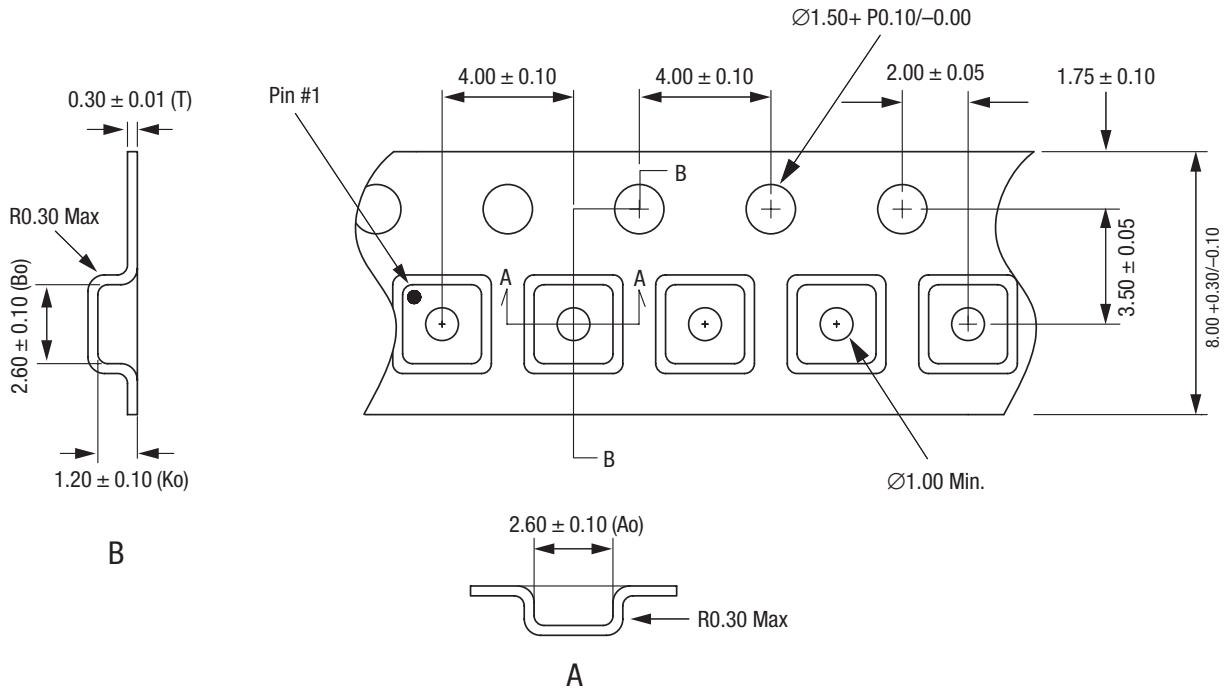
Figure 13. SKY65037-360LF 8-Pin QFN Package Dimensions



Notes:
1. *Carrier tape: black conductive polystyrene.*
2. *Cover tape material: transparent conductive HSA.*
3. *Cover tape size: 5.40 mm width.*
4. *All measurements are in millimeters.*

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Figure 14. SKY65037-360LF Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Kit Part Number
SKY65037-360LF Low Noise Amplifier	SKY65037-360LF (Pb-free package)	SKY65037-360LF (700-1000 MHz)