Ultra Low Noise Amplifiers (LNAs)

Select LNAs Available from Stock for Prototype or High-Volume Production

Skyworks Solutions offers a select group of ultra low noise, high linearity low noise amplifiers which are in stock and ready for immediate design into your demanding applications.

Pseudomorphic High Electron Mobility Transistor (pHEMT) Linear LNAs

The ultra low noise SKY67100, SKY67101, and SKY67102 are part of a LNA family which cover a frequency range from 400–2800 MHz, using a common package and application layout. The cascode architecture of these devices yields excellent linearity, bandwidth, and super low noise figure with high efficiency. Typical bias conditions are V_{DD} = 4 V and I_{DS} = 55 mA to produce 17 dB gain across the 400–2800 MHz band. A key attribute of these devices is their high active reverse isolation which results in easy input and output impedance matching, and unconditional stability up to 18 GHz and beyond. Additionally, these devices feature fully integrated active bias circuitry requiring only a single positive supply voltage, resulting in a minimal number of external components.

For less demanding applications, the low cost and lower gain SKY67014-396LF features noise figure <1.0 dB, 12 dB gain, 15 dBm $OP_{1\ dB}$, yet draws only 5 mA of current with 3.3 V supply. An OIP3 of 26 dBm @ 2.5 GHz is achievable with 15 mA supply current. Integrated active bias circuitry reduces external matching requirements and enables a wide supply voltage range of 1.8 to 5 V and operation over a broad 1500–3000 MHz frequency range. This part is ideal for use in high sensitivity battery-operated receivers.

The higher linearity SKY6700X family consists of two devices which cover a frequency range of 700–2100 MHz. These cascode pHEMT devices are essentially higher power versions of the SKY67101 and SKY67100 devices with the addition of a low current power down pin. Using larger FET devices, these parts are ideal for operating in high temperature environments up to +100 °C and provide OIP3 > 39 dBm.

Applications

- WiMAX, WCDMA, and LTE base station receivers
- WLAN enterprise access point receivers
- GPS receivers
- Public safety radios
- Test and measurement instrumentation
- ISM band receivers
- Military communications
- Smart energy

Features

- Excellent noise figure, as low as 0.50 dB
- High third order intercept
- Excellent stability
- Small form factor packages
- Broadband designs
- Low supply current
- High efficiency
- Flat gain response
- Single and two stage designs

The high gain SKY67105 and SKY67106 devices utilize the best properties of pHEMT input stages and InGaP output stages to obtain excellent noise figure and efficient linearity. These two stage designs achieve outstanding isolation and stability with high gain of roughly 35 dB. With their extremely high reverse isolation, these devices are unconditionally stable to 24 GHz and beyond.

Applications include high performance cellular infrastructure base station receivers for GSM, WCDMA, and LTE modulation schemes, as well as any other high performance LNA application in the 400–2800 MHz frequency range. These devices come packaged in a 2 x 2 mm, 8-pin, plastic DFN package or a 4 x 4 mm, 16-pin QFN package which offers excellent thermal performance.

Our amplifier solutions leverage the extensive design knowledge, technical leadership, manufacturing expertise, and superior quality of Skyworks. A select list of Skyworks' LNAs are provided in Table 1. Evaluation boards are also available.

Our application engineering team is ready to assist you with your design efforts. Application notes and block diagrams are available on Skyworks' Web site, www.skyworksinc.com.

WiFi LNAs

Skyworks offers a broad portfolio of LNAs supporting multiple WiFi markets, ranging from access points, gateways, and routers to smart phones and tablets. With industry-leading low noise figures in the 5 GHz band, the SKY65404-31 is a small form-factor, highly-integrated LNA ideal for applications requiring excellent receiver sensitivity. The corresponding device for the 2.4 GHz frequency band is the SKY65405-21, with a matched noise figure of 1.1 dB. Both are packaged in a 1.5 x 1.5 x 0.45 mm QFN package, and require a minimal number of external components, enabling ease-of-use and a fast time-to-market.

Table 1. Select LNAs for Cellular Infrastructure, GPS, Broadband, ISM Band, and WLAN Applications

Part Number New Products	Application	Frequency Range (MHz)	Test Frequency (MHz)	Gain (dB)	NF (dB)	OIP3 (dBm)	$OP_{1 dB}$ (dBm)	V_{DD} (V) (Operating Range)	I_{DD} (mA) (Operating Range)	Package (mm)
SKY67101-396LF	Cellular Infrastructure	400–1200	900	17.5	0.57	34	19	4 (3.3–5.0)	54 (20–90)	DFN 8L 2 x 2 x 0.75
SKY67100-396LF	Cellular Infrastructure	1200–2300	1950	17.5	0.7	34	18.5	4 (3.3–5.0)	55 (20–90)	DFN 8L 2 x 2 x 0.75
SKY67102-396LF	Cellular Infrastructure	2000–3000	2600	17.2	0.8	34	15	4 (3.3–5.0)	50 (20–90)	DFN 8L 2 x 2 x 0.75
SKY67001-396LF	Cellular Infrastructure	700–1000	900	17.5	0.6	40.5	21	5 (3.3–5.0)	100 (50–120)	DFN 8L 2 x 2 x 0.75
SKY67002-396LF	Cellular Infrastructure	1600–2100	1950	17.5	0.65	39.5	20	5 (3.3–5.0)	95 (50–120)	DFN 8L 2 x 2 x 0.75
SKY67105-306LF	Cellular Infrastructure	600–1100	850	37	0.7	41	26	5 (3.5–5.0)	140 (120–155)	QFN 16L 4 x 4 x 0.90
SKY67106-306LF	Cellular Infrastructure	1500–3000	1950	35	0.65	37	24	5 (3.5–5.0)	100 (80–125)	QFN 16L 4 x 4 x 0.90
SKY67014-396LF	General Purpose	1500–3000	2450	13	0.95	26	15	3.3 (1.8–5.0)	15 (5–30)	DFN 8L 2 x 2 x 0.75
SKY650047-360LF	GPS and ISM Band	400–3000	1575	16.6	0.8	19.5	0	3.3 (2.7–3.8)	7 (6.5–7.5)	DFN 8L 2 x 2 x 0.90
SKY65050-372LF	Broadband Low Noise FET	450–6000	2400	15.5	0.65	23.5	10.5	3 (2.7–3.8)	20 (5–55)	SC-70 4L 2.2 x 1.35 x 1.1
SKY65404-31	5.8 GHz WLAN and ISM Band	4900–5900	5800	13	1.2	20	9	3.3 (2.8–5.0)	11 (10–15)	DFN 6L 1.5 x 1.5 x 0.45
SKY65405-21	2.4 GHz WLAN and ISM Band	2400–2500	2450	15	1.1	24	15	3.3 (2.8–5.0)	12 (10–16)	DFN 6L 1.5 x 1.5 x 0.45

Skyworks Green™ products are compliant to all applicable materials legislation and are halogen-free. For additional information, refer to Skyworks Definition of Green™, document number SQ04-0074.

Superheterodyne Radio Receiver

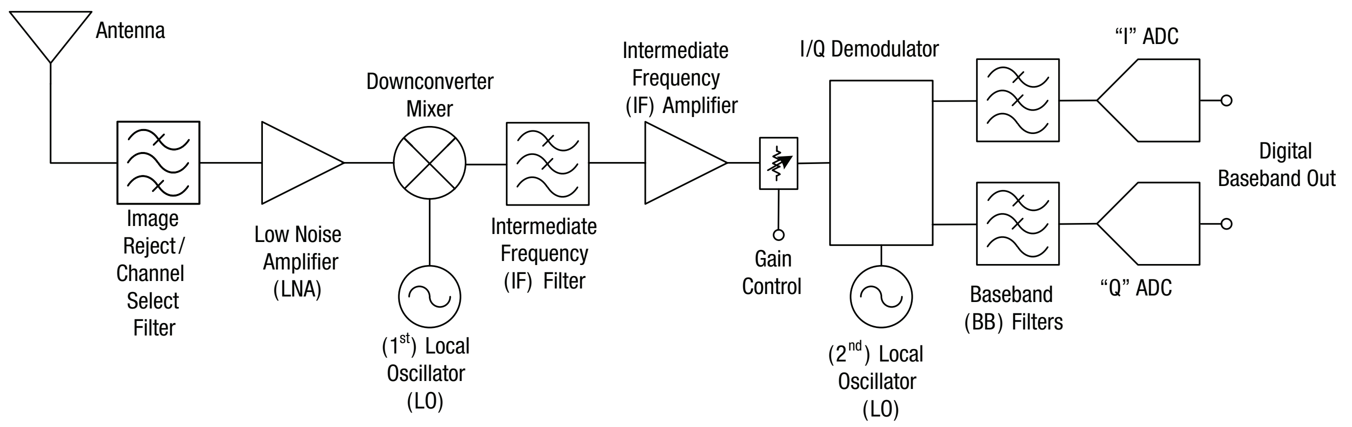

Figure 1. Typical Superheterodyne Radio Receiver Block Diagram

Applications

Radio receivers, such as the superheterodyne receiver shown in Figure 1, typically must process weak signals in the presence of extraneous received signals as well as internally-generated noise and distortion products. A well-designed receiver must have optimal sensitivity to the desired signal while producing minimal internally generated noise and distortion.

The amount of noise produced in a receiver is expressed as its noise factor (F) or noise figure (NF). The noise factor of a cascade of components is given by

$$F_{casc} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \ldots + \frac{F_n - 1}{\prod_{N=1}^{n-1} G_N}$$

where

G_n = gain of stage n, expressed as a ratio (i.e., not expressed in dB)

F_n = noise factor of stage n, expressed as a ratio (i.e., not expressed in dB). F is the ratio of the input signal-to-noise ratio to the output signal-to-noise ratio for each stage

Noise figure is F expressed in dB

$$NF = 10 \log (F)$$

The equation for cascaded noise factor shows that the noise performance of the stages nearest to the input of the cascade set the lower bound for the noise figure of the entire cascade, which must be minimized to optimize receiver sensitivity. Also, the gain of the first stage is very important since it strongly affects the noise contribution of the following stages.

In order for the receiver to have optimal sensitivity, the production of distortion products within the cascade must be minimized while simultaneously minimizing noise figure. In most systems, distortion performance is described by the third order intercept (IP3) of the cascade, which is given by

$$IP3_{casc} = \frac{1}{\frac{1}{IP3_n} + \frac{1}{IP3_{n-1} \times G_n} + \frac{1}{IP3_{n-2} \times G_n \times G_{n-1}} + \ldots + \frac{1}{IP3_1 \times \prod_{N=1}^{n} G_N}}$$

where

G_n = gain of stage n, expressed as a ratio (i.e., not expressed in dB)

$IP3_n$ = third order intercept of stage n, expressed as power in watts, not in dBm. IP3 is the theoretical power level at which the power of desired signal is equal to that of the third-order distortion products.

Additionally, IP3 may be referred to power level at the input of a stage, in which case it is called input third order intercept (IIP3), or it may be referred to power level at the output of a stage, in which case it is called output third order intercept (OIP3). When performing analysis of a cascade, it is necessary to use either IIP3 or OIP3 for each stage in the cascade.

Typically, IP3 is expressed in dBm (dB relative to 1 mW) for radio receivers as

$$\text{IP3 (dBm)} = 10 \log \left(\frac{IP3}{10^{-3}} \right)$$

Optimal Circuit Design

Skyworks offers several application notes from our Web site (www.skyworksinc.com) which show suggested circuit designs for each LNA product at many frequency bands. Important factors include, but are not limited to, optimal impedance matching for noise figure and distortion performance, selection of operating current and the prevention of oscillation.

A low noise amplifier will produce minimum noise figure when it is driven from a specific impedance (Z_{opt}), which generally is not 50 Ω. Noise figure will degrade when driven by any other impedance. Since the characteristic impedance (Z_0) of most radio receivers is 50 Ω, the circuit designer must provide an input impedance matching network which transforms Z_0 to Z_{opt}. Since this impedance matching network is at the input of the LNA, its loss will have significant impact on cascaded NF, so the designer must trade off optimal impedance match for NF performance while also paying careful attention to the quality factor of each component in the matching network.

IP3 performance is significantly affected by operating current (I_{DS}), as well as by output impedance matching and the architecture of the LNA. Suggestions for optimal values of these parameters are also contained in the application notes described above.

Stability is an important factor in any amplifier design. Skyworks offers complete stability data to 18 GHz for all LNA products, along with suggestions for printed circuit board design that will prevent the possibility of oscillation.

SKY6710X Highlights:

With discrete low noise transistors, the source impedance that yields best noise figure (Z_{opt}) often differs greatly from that which offers best impedance match: the conjugate impedance of the active device which produces the complex conjugate input reflection coefficient, S_{11} conjugate. This can result in difficult matching tradeoffs to obtain an acceptable compromise for NF, gain, and input return loss.

The SKY6710X monolithic microwave integrated circuit (MMIC) LNAs are designed such that Z_{opt} and S_{11} conjugate are nearly equal. This allows the circuit designer to simultaneously achieve excellent NF, gain and input return loss.

The SKY67100 standard application circuit is optimized for performance from 1700 to 2000 MHz, as shown in the performance plots in Figures 2 and 3.

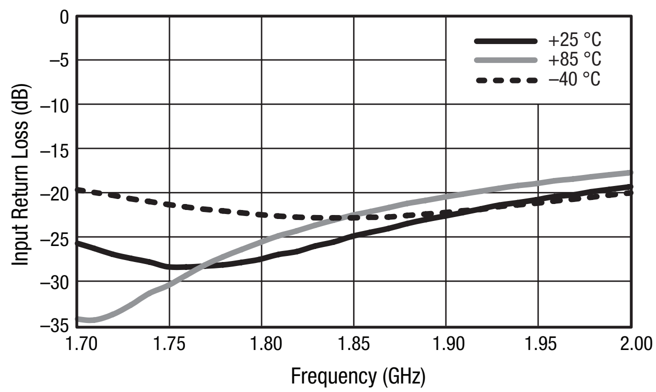

Figure 2. Narrowband Input Return Loss vs. Frequency
SKY67100

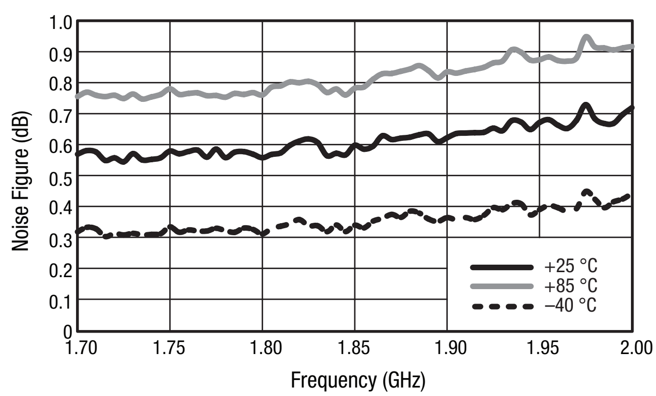

Figure 3. Noise Figure vs. Frequency
SKY67100

This design offers exceptional LNA performance without compromise. The SKY67100 application schematic shown in Figure 4 highlights the simple matching requirements for this family of LNAs, which all use the same application layout.

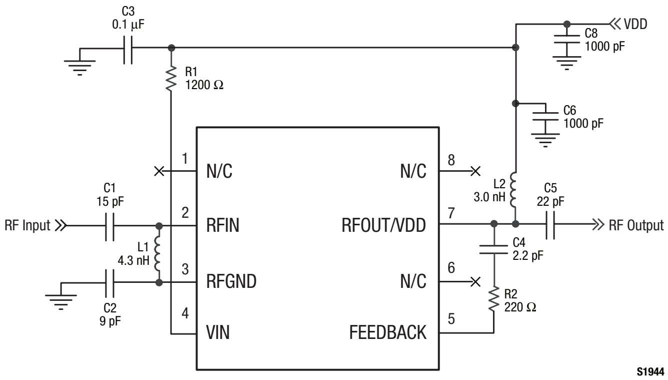

Figure 4. SKY67100-396LF Evaluation Board Schematic

SKY6700X Highlights:

This family consists of the SKY67001 and SKY67002 cascode e-pHEMT LNAs. These devices are higher power versions of the SKY6710X with higher compression and intercept points (OIP3 > 39 dBm). Using larger FET devices, these parts operate at very low maximum channel temperatures making them suitable for operation up to 100 degrees Celsius. The devices are unconditionally stable to 24 GHz and beyond.

SKY67014 Highlights:

The first device in this new family of low-cost, high-performance pHEMT LNAs is the SKY67014-396LF. The device offers NF < 1.0 dB with easy matching, unconditional stability to >24 GHz, and flexible biasing options. Depending on application linearity requirements, this device can be operated with V_{DD} values from 1.8 to 5.0 volts and with I_{DDQ} values from 5 to 30 mA. The SKY67014 is specified over a broad 1500 to 3000 MHz frequency range.

The SKY67014 is just the first in a new family of efficient, cost-effective and high-performance LNAs for broad market applications. New devices covering 300 to 600 MHz and 700–1500 MHz will be available soon. All devices in this family will utilize a common package and application layout. The device package is a 2 x 2 mm, 8-pin, plastic DFN.

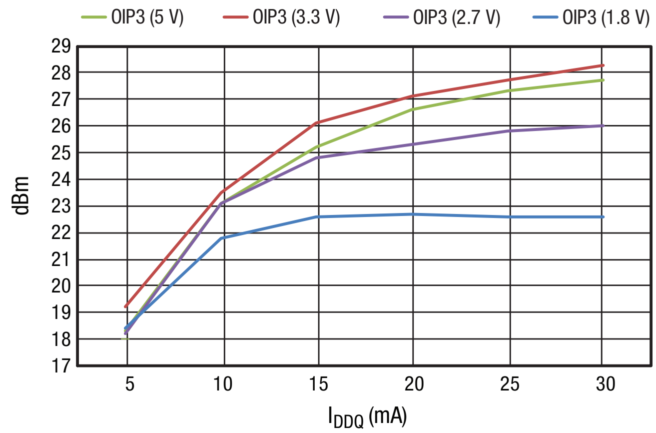

Figure 5. OIP3 vs. I_{DDQ} at 2.45 GHz
SKY67014-396LF

SKY67105 and SKY67106 Highlights:

These are high-gain, high-linearity LNA with outstanding isolation characteristics. Utilizing an e-pHEMT cascode first stage and an InGaP HBT output stage, these devices offer high gain of typically 35 dB. These devices obtain < 0.75 dB noise figure from the pHEMT input stage and efficient linearity (OIP3 > 37 dBm) from the HBT output stage. With outstanding isolation, these devices are unconditionally stable to 24 GHz and beyond.

White Papers, Application Notes, Published Articles

For additional information, please refer to the following:

WEB White Papers

Designing Ultra Low Noise Amplifiers for Infrastructure Receiver Applications

Ultra-Low Noise Figure, High Gain Amplifier with High Linearity

Skyworks De-embedded Scattering Parameters

WEB Application Notes

SKY65050-372LF: Low Noise Amplifier Operation

SKY65047-360LF Matching Circuits for Various Frequency Bands

WEB Published Articles

Make Accurate Sub-1 dB Noise Figure Measurements Part 1: Noise Concepts

Make Accurate Sub-1 dB Noise Figure Measurements Part 2: The Measurements

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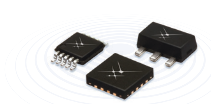

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