Applications

- WiMAX, WCDMA, LTE base station receivers
- WLAN enterprise access point receivers
- GPS receivers
- Public safety radio
- Test and measurement instrumentation
- ISM band receiver
- Military communication
- 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

SKYWORKS®
BREAKTHROUGH SIMPLICITY

WEB 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 SKY6710X family of low noise amplifiers consists of two devices which cover a frequency range from 400–2300 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 400–2300 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, the devices feature fully integrated active bias circuitry requiring only a single positive supply voltage, resulting in a minimal number of external components. Skyworks also offers a SKY65066-360LF LNA to cover the 2300–2700 MHz LTE and ISM bands.

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 400–2700 MHz frequency range. These devices come packaged in a 2 x 2 mm, 8-pin, plastic DFN package which offers excellent thermal performance.

Discrete pHEMT Low Noise Field Effect Transistors (FETs)

Skyworks also offers low cost, discrete pHEMT FET packaged devices for those designers seeking the ultimate in application flexibility and customization. These devices are fabricated in Skyworks' proprietary pHEMT process. Their data sheets provide unconditionally-stable reference schematics covering a wide range of application frequencies. A typical device in this family is the SKY65053-377LF which achieves an outstanding 16.5 dB gain and 0.8 dB NF at 2.4 GHz. To address a wide range of linearity requirements, the device current can be set over a range of 15–100 mA with a tunable bandwidth of 450–6000 MHz. These pHEMT discretes utilize industry-standard, plastic surface-mount packages.

All 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 available.

An application engineering team is available to assist you and 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 SKY65404-21 is a small form-factor, highly-integrated LNA ideal for applications requiring excellent receive sensitivity. The corresponding device for the 2.4 GHz frequency band is the SKY65405-11, with a matched noise figure of 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 fast time-to-market.

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

Device Type	Frequency Range (MHz)	Test Frequency (MHz)	Gain (dB)	NF (dB)	OIP3 (dBm)	$OP_{1\ dB}$ (dBm)	V_{DD} (V)	I_{DD} (mA)	Package (mm)	Part Number *New Products*
Cellular Infrastructure LNA	400–1200	900	17.5	0.5	34	19	4	54	DFN 8L 2 x 2 x 0.75	**SKY67101-396LF**
Cellular Infrastructure LNA	1200–2300	1950	17.5	0.7	34	18.5	4	55	DFN 8L 2 x 2 x 0.75	**SKY67100-396LF**
Cellular Infrastructure LNA	2300–2700	2500	16.5	0.7	35.5	18	5	75	DFN 8L 2 x 2 x 0.90	SKY65066-360LF
GPS and ISM Band SiGe LNA	400–3000	1575	16.5	0.8	19.5	0	3.3	7	DFN 8L 2 x 2 x 0.90	SKY65047-360LF
Broadband Low Noise FET	450–6000	2400	15.5	0.65	23.5	10.5	3	20	SC-70 4L 2.2 x 1.35 x 1.1	SKY65050-372LF
Broadband High Linearity Low Noise FET	450–6000	2400	16.5	0.8	33.5	15.5	5	55	QFN 4L 2 x 2 x 0.55	SKY65053-377LF
5.8 GHz WLAN and ISM Band LNA	4900–5900	5800	13	1	20	9	3	11	QFN 1.5 x 1.5 x 0.45	**SKY65404-21**

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.

Applications

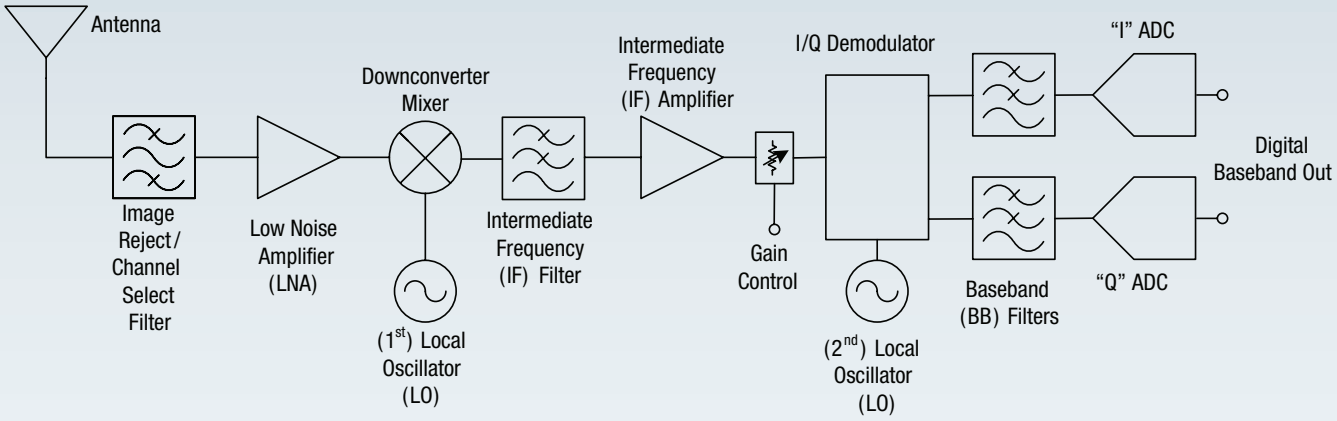

Figure 1. Typical Superheterodyne Radio Receiver Block Diagram

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

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

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 low noise amplifier, 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 listed 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.

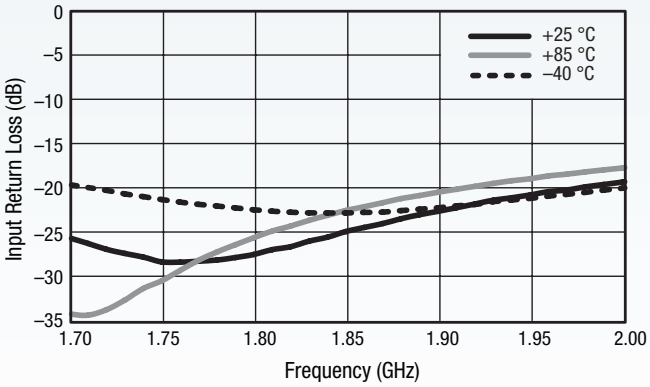

Figure 2. Narrowband Input Return Loss vs. Frequency
SKY67100

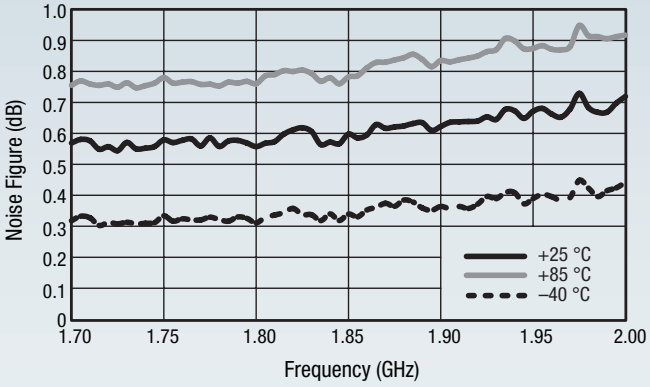

Figure 3. Noise Figure vs. Frequency
SKY67100

This 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.

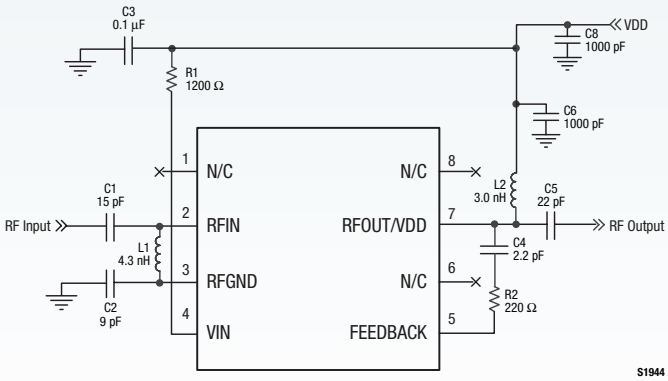

Figure 4. SKY67100-396LF Evaluation Board Schematic

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 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

WEB Application Notes:

SKY65050-372LF: Low Noise Amplifier Operation

SKY65047-360LF Matching Circuits for Various Frequency Bands

Low Noise, High Linearity Amplifier Circuit Using the SKY65053-377LF Low-Noise Transistor

Green Initiative™

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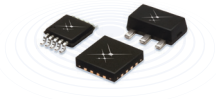

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