LOW NOISE AMPLIFIER FOR WIRELESS COMMUNICATION SYSTEM

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***Abstract*—Nowadays, the wireless communication becomes more and more important for human life. This result with a huge demand on wireless network access increases the need to reduce the noise figure to very low level. The purpose of LNA (low noise amplifier) is to amplify the RF signals well into acceptable level and minimize the noise as much as possible**
In this paper LNA design will be introduced, discussed and explained in details.

***Index Terms*—Keywords LNA design, Low-noise amplifiers, Multi-band receivers, RF circuits, RF Satellite Communication System, noise figure(NF), Gain, Power, S-parameters, Dynamic Range.**

I. Introduction

Communication systems is the most important technology in all over the world, which makes the world connect as single home dependent of the distances. There are many technical solutions to establishing connect, one of them witch this article will take into consideration is LNA (low noise amplifier). This system (LNA) is in charge to extend the domain of the wave to make it reach to far-far away destination, but in the same time this method will amplify some unneeded signals. Here the essential imagined by remote correspondence is to trade information beginning with one spot then onto the following between any electronic systems without the use of any interfacing connection or wires. In addition, through various research it is shown that remote besides, radio repeat (RF) are eagerly associated with one another. Besides this study will shows how to remove that unneeded signals by using notch system in LAN structure model LNAs are used in applications such as industrial, scientific and Medical Band Radios, cellular telephones, Automotive Remote keyless System, and satellite communications.

II. RF spectrum frequency

The development of high-performance radio frequency (RF) transceivers or multi-standard receivers requires an innovative

RF front-end design to ensure the best from a good technology. In general, the performance of front-end and building blocks can be improved only by an increase in the supply voltage, width of the transistors or an additional stage at the output of a circuit. The objective of this work is to introduce an innovative single-stage design structure of low noise amplifier (LNA) to achieve higher performance under low operating voltage. Let's take a look on each of the RF sub bands and the areas of RF spectrum uses.

TABLE I
Radio frequency Spectrum

Designation	frequencies	wavelength
Very low Frequency	3kHz-30kHz	100Km-10Km
Low frequency	30kHz-300kHz	10Km-1Km
Medium Frequency	300kHz-3MHz	1Km-100m
High Frequency	3MHz-30MHz	100m-10m
very High Frequency	30MHz-300MHz	10m-1m
Ultra High Frequency	300MHz-3GHz	1m-10mm
Super High Frequency	3GHz-30GHz	100mm-10mm

III. lna Specifications

LNA design are under the designers control and directly affect receiver sensitivity: noise figure, gain, bandwidth, linearity, and dynamic range.

A. Noise Figure

Noise Figure (NF) describes the amount of noise a component, amplifier, or an entire radio receive chain contributes to the RF signal being received. Electrical noise is combined with the RF signal as it is generated by the RF transmitter and propagated through space. This signal is then captured by the receiving antenna and guided to the receiver input via a transmission line. In an ideal receiver, each amplifier stage would increase the desired signal and the surrounding noise floor by the same amount, or in other words, the amplifiers would not add any additional noise to the signal. This would mean that the signal to noise ratio (SNR) would remain constant throughout the stages of the receive circuit. Noise factor of a cascaded RF system is given by the Friis Equation (1), where Fn and Gn represents the Noise Factor and Power-Gain of nth stage respectively. Both Fn and Gn are

are ratios, not in decibels. A quick examination of reveals that total noise figure is minimized if F1 is low and G1 is high enough, and total noise figure does not depend on the noise

figures of next stages. That is why a low-noise, high gain amplifying stage (LNA) is used as the first stage of RF receivers.

$$FTOT = 1 + (F1 - 1) + \frac{(F2 - 1)}{tt1} + \frac{(F3 - 1)}{tt1\,tt2} + .Eq$$

B. S-Parameters

The S-Parameter examination is utilized to figure dissipating and commotion parameters for 2-port circuits that show recurrence interpretation. S-Parameter investigation is utilized for little sign and straight clamor examinations, where the circuits are linearized around the DC working point. Such circuits incorporate LNAs, blenders, samplers and other comparative circuits. For the SP investigation, it is required to indicate the info and yield ports and the scope of range frequencies. SP examination for the LNA gives gain and coordinating parameters estimations. The 2-port S-parameters have the following generic descriptions:

- S11: The Input port voltage reflection coefficient.
- S21: forward gain.
- S12: reverse gain.
- S22: the output port voltage reflection coefficient.

C. SFDR

The dynamic range between the fundamental tone and the largest spur is called spurious-free dynamic range (SFDR). SFDR is the measure of the ratio between the fundamental signal and the largest harmonically or nonharmonically related spur from DC to half of the sampling rate.

$$SFDR = 20 \times \log\left(\frac{Amplitudeoffundamental(RMS)}{AmplitudeoflargeSpur(RMS)}\right)$$

D. Dynamic Range

We know there is a minimum input signal power that a receiver can accurately demodulate. The ratio of the input saturation point and the minimum detectable signal (MDS)l is defined as the total dynamic range of the receiver. The Minimum Detectable Signal defines the sensitivity of the receiver:

$$TotalDr = \frac{Pin}{MDS}$$

Note dynamic range is a unitless value, therefore dynamic range is most often expressed in dB:

$$Total\ Dr = Pin(dBm) - MDS(dBm)$$

E. Power

the power of both the signal and the noise present at its input. It does not add additional noise.

$$Powerttain(dB) = 10\log\left(\frac{RFOutput}{RFInputPower}\right)$$

IV. LNA Applications

A. Digital Mobile Phones

A cellular phone that support cellular and Wi- Fi services start transmitting in the 1.9 GHz spectrum during

talks. If the Wi-Fi or Bluetooth radio goes to active and connect during this period, the 1.9 GHz cellular signals which

have larger signal strength than the 2.4 G Hz ISM band spectrum may interferes the Wi-Fi or Bluetooth signal. The high power interferes may degrade the operation of the LNA and mixer of Wi-Fi or Bluetooth receiver. Then, amplification of the Wi-Fi or Bluetooth signal may result in saturation in an Analog-to-Digital Converter.

Some existing solutions may incorporate an on-board notch filter wish is a stop-band filter in the ISM band radio. This notch filter may be located between a low noise amplifier (LNA) and the mixer in the RF parts of the ISM band radio, used to neglect the interferences from other frequency bands. Several digital mobile phone have been deployed around the world, including the Global System for Mobile communications (GSM) worldwide, the code-division multiple access in the US, the time-division multiple access in North and South America, and the personal digital cellular in Japan.

These standards have been allocated on cellular spectrum frequencies from 800 to 1000 MHz and on the Personal communications service (PCS) frequencies from 1700 to 2000 MHz.[1]

TABLE II
RF Receiver Technology Comparison.[1]

	Ideal	MESFET	RF MOSFET	Bipolar	HBT
Noise figure	L	L	H	M	L
Input IP3 capability	H	H	M	M	H
Current consumption	L	L	M	M	L
Passive component	H	H	L	L	H
Implementation	L	L	L	L	M

* LOW=L ,Moderate=M and High=H*

TABLE III
PCS LNA IC Parameters.[1]

	TQ9225	TQ9228	TQ9222	TQ9222
RF frequency (MHz)	1930 to 1990	1930 to 1990	869 to 894	1930-1990
LO frequency (MHz)	1710 to 1790	2015 to 2075	920 to 1040	200-2140
IF (MHz)	210 to 212	84 to 86	70 to 140	70-140
Gain (dB)	28	27	17	17
Noise figure(dB)	2.4	2.4	2.8	2.8
Input IP3(dBm)	-9	-9	-10	-10
Gain step(dB)	20	20	-	-

A low-noise amplifier (LNA) is an electronic amplifier. that amplifies a very low-power signal without significantly degrading its signal-to-noise ratio. An amplifier increasesss

B. satellite Communication

In a satellite communications system, the ground station receiving antenna is connected to an LNA because the received signal is weak. This received signal is usually above background noise since satellites have limited power and use low power transmitters. The satellites are also on a large distance and suffer path loss for example low earth orbit satellites might be 200 km away. A larger ground antenna would give a stronger signal, but a larger antenna is more expensive than adding an LNA. The LNA boosts the antenna signal to compensate for the feed line losses between the antenna and the receiver. In many satellite reception systems, the LNA includes a frequency block down-converter that shifts the satellite downlink frequency that would have large feed line losses to a lower frequency with lower losses. The LNA with down converter is called a low-noise block down-converter.

A typical transmitter element of a phased array system is shown in figure 1. It consists of a Phase Shifter, a VGA and a PA.

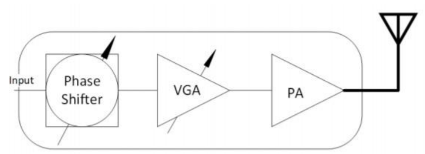

Fig. 1. Block Diagram of a Simplified Transmitter [3]

The system noise temperature consists of the antenna temperature and the noise temperature of the receiver. Note that the system noise temperature reference plane is right in front of the receiver.

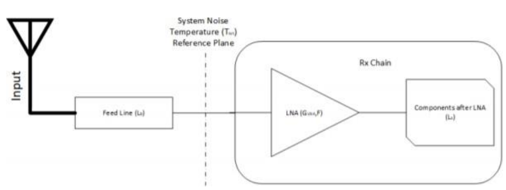

Fig. 2. Block Diagram of a Simplified Receiver [2]

TABLE IV
SPECIFICATION.[2

Parameter	Units	Values
Bandwith	GHz	28-30
Phase Shift Range	Degree	366
Power Consumption	mA	so small
Input and Output Loss	dB	≥ 10
Insertion Loss	dB	≤ 10
Insertion Loss Variation	dB	±3
Progressive Phase step	degree	≤ 5.625

C. automotive remote keyless system

The term **RKE** refers to a lock that uses an electronic remote control as a key, which is activated by a handheld device. Widely used in automobiles, an RKE performs the functions of a standard car key without physical contact. When within a few meters of the car, pressing a button on the remote can lock or unlock the doors, and the remote may also perform other functions. [4] The following table shows the RF LNA performance with RF low-power transistor BFP460 for RKE applications. The measurements are performed with network analyzer source power of -40 dBm.

TABLE V
RKE APPLICATION.[4]

Parameter	Symbol	Value	Unit
Bias Voltage	Vcc	5.0	V
Bias Current	Icc	5.3	mA
Frequency Range	f	315-900	MHz
Gain	G	16	dB
Imput return Loss	RLin	16.4-14.2-10.3	dB
Output return Loss	RLout	24.2-24.6-20.2	dB
Noise Figure	NF	1.7	dB
1 db Compression	IP1db	25.3	dBm

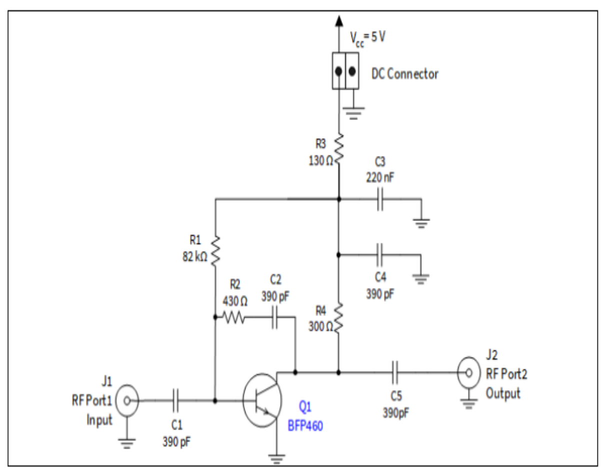

Fig. 3. LNA schematic for RKE applications.[4]

S-parameter Calculations result of the remote keyless system are given by graph

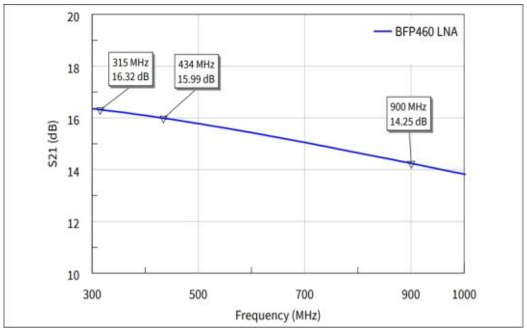

Fig. 4. Small signal gain of LNA for RKE Applications.[4]

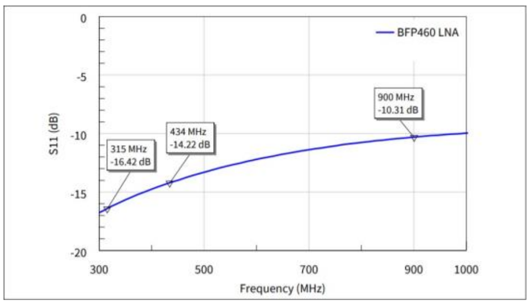

Fig. 5. Input return loss of LNA for RKE Applications.[4]

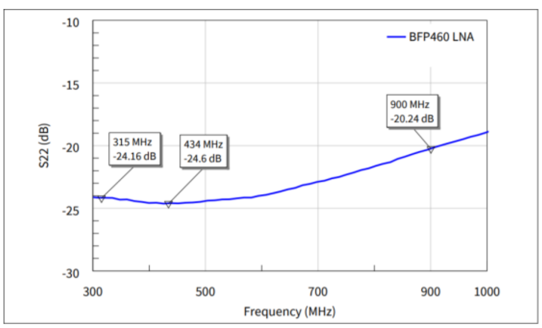

Fig. 6. Output return loss of LNA for RKE Applications.[4]

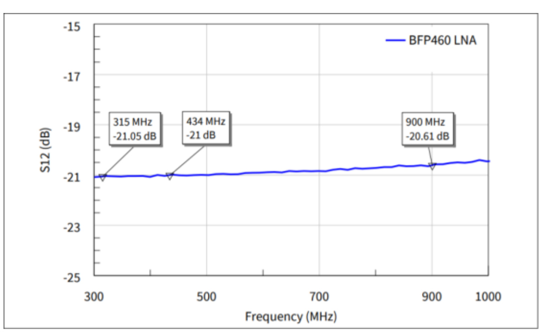

Fig. 7. Reverse isolation of LNA for RKE Applications.[4]

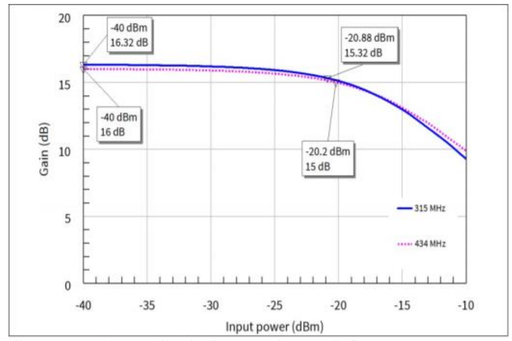

Fig. 8. Input 1 dB compression point of LNA for RKE Aapplications.[4]

V. Conclusion

The main objective of this paper is to list all the calculation steps for each LNA application with comparison of the latest technology with the future ones update the various state of low noise amplifier used in the RF receiver for wireless communication. An exclusive review of various LNA results to the conclusion that an LNA to be in RF receiver must have five major specifications, that is, gain, linearity, impedance matching, noise figure and power consumption. Different topology for planning the LNA is additionally examined here where cascade inductive source degeneration topology is the most generally utilized topology on the grounds that give great coordinating and low commotion figure when contrasted with other topology. The LNA's particular for remote correspondence is characterized relying upon various standard. The majority of the LNAs are limited band structures and this is on the grounds that, wideband LNAs give transfer speeds of the request of GHz to the detriment of expanded clamor and power utilization with moderate increase. Presently we can express that to structure LNA for a RF collector, the LNA must shows the following properties: an aggressive execution regarding gain, clamor, linearity on little size, enormous data transfer capacity and simple to control increase over a wide ranges.

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