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Design of Low Noise Amplifier (LNA) With Low Power using Predistortion Technique

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Abstract:
A Broadband CMOS LNA with predistortion technique is proposed in this project. LNA performs as the initial amplification block in the receiver path. The main mean of this project is to propose a linearization technique called predistortion to get better linearity with higher power efficiency. The proposed technique reduces signal distortion and high linearity is achieved. This proposed design is implemented on 90-nm CMOS technology and aims at achieving linearity of IIP3 greater than +14.3dbm. The predistortion is the linearization method proposed in LNA for high linearity. This minimizes the frequency interference allowing high transmission capacity in broadband communication. Scaling our technology up to 32nm is possible.

Keywords: Broadband, LNA, predistortion

I. INTRODUCTION

Development of the high-speed wireless Communication systems puts increasing request on integrated low-cost RF devices with multi-GHz bandwidth operating at the lowest power consumption and supply voltage. Ultra wide band (IEEE 802.15.3a) appears as a new technology capable for high data transfer rates (up to 1 GB/s) within short distances (10m) at low power. This technology used for some Application such as Broadband receiver for audio and video streaming, video and web conferencing and other high-bandwidth data. The amplifier that is used for this application must meet several requirements. However sufficient gain with wide band width to overtop the noise of a mixer, low noise figure to improve receiver sensitivity, low power consumption to increase battery life, small die area to reduce the cost, unconditional stability and good linearity are important parameters. The main objective of this proposed technique is to achieve high voltage gain and adequate input matching and maintaining low power consumption. It aims in obtaining high linearity and to minimize tradeoff between voltage gain and input impedance.

ULTRAWIDE-BAND (UWB) LNA

Ultra-wideband (UWB) communication systems have recently received significant attention due to the potential of transmitting data at very high rates over large band of frequencies. UWB technology may be used in imaging systems, ground and vehicular penetrating radars and many other applications. Such applications need low-noise amplifiers which have high gain and low noise figure over a large band of 3.1 – 10.6 GHz. The demand for high speed and high data rate wireless communications is increasing. The operation frequency of IEEE 802.11b and 802.11g standards is 2.4 GHz. The data rate of these standards is 11 and 54 Mbps respectively. The data rate limitation of these standards is due to their narrow bands of frequency. Other official standards for wireless communications with wider bands were needed [3]. Ultra wide band (UWB) frequency range extends from 3.1 GHz to 10.6 GHz. UWB is a new wireless technology. It produces the ability of data transmission over a wide spectrum of frequency bands. It also capable of transmitting data in high data rates with very low power. UWB technology has a lot of applications. It may be used for imaging systems. Vehicular and penetrating radars are employing UWB technology. Wireless area networks (WANs), High speed mobile area networks, personnel and asset tracking and automotive (anti-collision) radar are different applications of UWB. Through the use of UWB bandwidth (3.1 GHz to 10.6 GHz), data transmission speed achieves up to 400-500 Mbps. UWB is predicted to replace all the cables communications systems in homes or in offices.

II. EXISTING SYSTEM

In this work, fig1 represents the existing broadband noise canceling LNA where, an ultra-wideband (UWB) 3.1 - 10.6-GHz LNA is discussed. The measured noise figure is 2.66 - 3 dB over 3.1 - 10.6-GHz, while the power gain is 14 ± *0.8* dBit consumes 23.7 mW from a 1.8 V supply. The input and output return losses (S11 & S22) are less than-1l dB over the UWB band. Common-gate and Cascode configurations are two kinds of methods usually used to design the input stage of LNA in CMOS circuits, while the Common-Gate and Cascode structure provides a wide-band and narrow-band input matching respectively. However Common-gate stage has an intrinsically high noise figure versus Cascode stage and the noise-canceling techniques must be used. In the narrow band application, a shunt inductor is added in the input stage to resonate with *Cgç* to enhance impedance matching at the desired frequency. However in most CMOS narrow band applications, cascode LNA with inductive degeneration is preferable but for isolating from the input to the output and omitting of the *Cgd* path, the Common-

Gate LNA performs better reverse isolation and stability versus Common Source LNA. Numerical value for the lower bound is about 2.2 dB for long-channel devices and 4.8 dB for short channel devices.

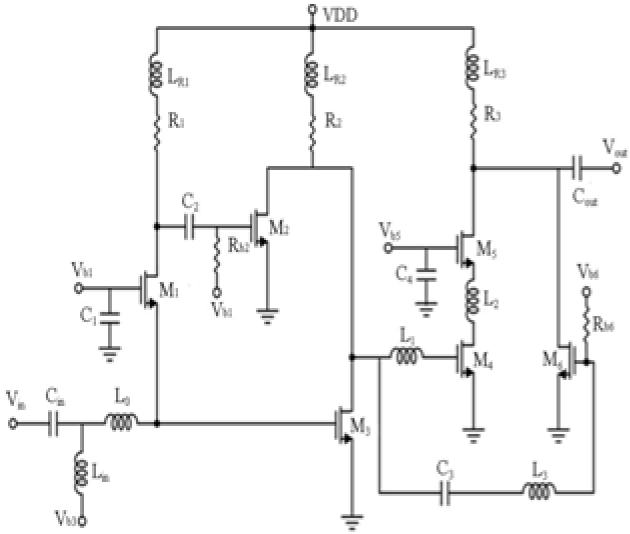

Figure.1. Existing broadband noise canceling LNA

The minimum channel length of0.18 µm is considered for all the transistors in the circuit to minimize parasitic capacitances and improve frequency performance. The Cascode stage extends bandwidth, provides better isolation and increases frequency gain. In fact the input stage and the Cascode stage support low-frequency power gain and high-frequency power gain, respectively. The combination of both frequency responses lead to a broadband power gain.

III. DESIGN SPECIFICATIONS OF EXISTING SYSTEM.

Table.1. design specifications of existing system

PARAMETERS	DESIGN VALUES.
TECHNOLOGY	180nm
S_{11}(I/P REFLECTION) in dB	< -11.5
S_{12}(REV ISOLATION) in dB	< -33
S_{21}(GAIN) in dB	13.2 – 14.8
S_{22}(O/P REFLECTION) in dB	< - 10.5
NOISE FIGURE in dB	< 3
POWER (mV)	23.7
IIP3(dBm)	-3.1 to -8.6

PROPOSED SYSTEM USING PREDISTORTION TECHNIQUE.

The predistortion is the linearization technique proposed in low noise amplifier for high linearity. Predistortion compensates the nonlinearities in the low noise amplifier. This predistortion technique minimizes the frequency interference and signal distortion and allows higher transmission capacity in broad band Communication systems. Linearization technique will allow the low noise amplifiers to have both high linearity and higher power efficiency.

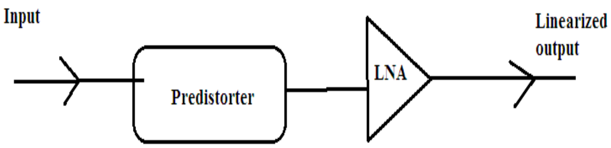

Figure.2. predistorter used before LNA

Predistortion is one of the generic terms added to the technique which seeks to linearize the low noise amplifier by making the suitable modifications to the amplitude and phase of the input signal. The output of the predistorter display a spectrum of distortion products which equal, and in most of the cases significantly it exceeds the spectral bandwidth of the uncorrected amplifier output under the same drive conditions.

PREDISTORTION CIRCUIT

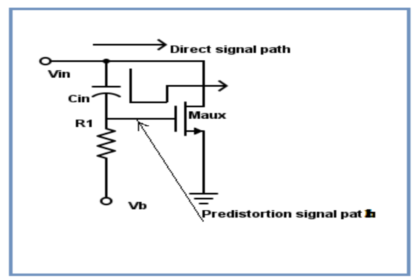

Figure.3. Predistortion circuit.

The predistortion branch is inserted at the front of the main device so as to cancel the intermediation distortion of the main device. The main key feature of this technique improves linearity in the wide range of input power without significant gain and noise figure degradation.

PROPOSED LNA WITHPREDISTORTION

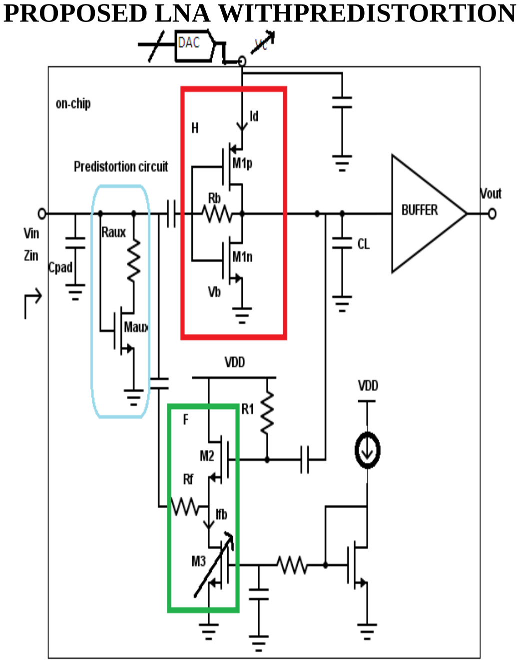

Figure.4. Proposed LNA using Predistortion technique.

The predistortion linearization employs a technique of adding an auxiliary transistor at the input of the main device to suppress the intermodulation distortion of signals resulting in linearity improvement.Auxiliary transistor added at the input of the low noise amplifier circuit to reduce the overall distortion at the output of the circuit. This technique employed in the circuit also to adjust the input matching and compensate the nonlinearity of Trans conductance. Predistortion technique is mainly preferred for low noise amplifiersbecause of its simple structure and due to its low cost.

DESIGN SPECIFICATIONS OF LNA.

Table.2. specifies the design specifications of LNA.

Parameter	Design Target
Technology	CMOS 32n
Noise Figure	<1.0dB
S_{11} (i/p ref coeff)	<-10dB
S_{12} (rev isolation)	<-20dB
S_{21} (Gain)	>15dB
S_{22} (o/p ref coeff)	<-10dB
Stability Factor (K)	>1
RF Frequency	1 GHz
Supply	1.2V
Power Consumption	≤10mW

COMPARISON TABLE

Table 3.comparision of power and speed.

	Avg Power		Delay	
Parameter	Existing	Proposed	Existing	Propo sed
180nm	$1.36*10^{-15}$	$1.03*10^{-15}$	10.8ms	9.17ms
32nm	$7.08*10^{-1}$	$4.67*10^{-1}$	8.23ms	6.5ms

Table4, comparison of existing and proposed system.

TECHNIQUE	EXISTING METHOD	PROPOSED TECHNIQUE(USING PREDISTORTION)
Distortion cancellation	LOW	HIGH
Bandwidth	LOW	HIGH
Efficiency	MEDIUM	HIGH
Size	MEDIUM	HIGH

The above table specifies the difference between the existing and proposed system (using predistortion technique)

IV. CONCLUSION

This paper presents a design of UWB LNA using predistortion technique. This technique helps in achieving high linearity by minimizing frequency interference and signal distortion. Hence it allows high transmission capacity in broadband communication system. Linearity is achieved without any significant loss in signal. Noise figure of less than 1 dB is achieved with low power consumption. This technique is highly power efficient when compared to the existing system.

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