Review of Linearity Enhancement and noise reduction techniques of Low Noise Power Amplifier

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Abstract— **In this paper we review and discuss the techniques that are used in the present and past decades, to improve the linearity and reduce the contents of noise. Versatile low noise amplifier is used in satellite communication Wi-Max, GSM, broadband mixer, power amplifier, active baluns and multiband amplifiers. It has important feature like amplification of the signal with rejection of noise as preferred in modern communication as a filter with amplifier. In recent scenario low noise amplifier is available in wide band, multi-band frequency application. In present days this techniques are used as transmission line to reduce the reflection of signals exists by elements and connecting interface inside the amplifier, amplifier available in high gain, less noise figure, less power consumption. Today's technology required high speed of transmission efficiency with small power consumption and less utilization of elements to construct amplifier and full-fill all the requirement of modern wireless communications. Therefore we review and discuss about the future requirement of technology, discuss the issues and its application. Recent trends to improve performance and surveyed almost all the possible work done in the past decades.**

Index Terms— **Cross capacitive coupled feedback technique, combining circuits, inductive degeneration techniques**

I. INTRODUCTION

Low noise amplifier is needed in Wi-Max, WLAN, Bluetooth, GSM application. Gain-boosting technique is inductive common-base termination. An analysis of this technique, the stability limit and an optimization methodology while maintaining stable operation is provided within this letter. The results demonstrate state-of-the-art performance; exceeding advancements in IC technologies have enabled realization of micro-systems for a variety of applications in the millimeter-wave bands. Especially, the availability of high-performance, Low-cost silicon technologies make it possible for such micro-systems to be commonly used in commercial products. Today, Si-Ge HBTs with maximum frequency of oscillation of 0.5 THz are available, the characterization and compact modeling of the high-frequency noise properties of microwave electron devices discussed from the standpoint of linear system theory. For example, in the typical application of low-noise amplifier characterization, the four classical noise parameters minimum noise figure, optimum source impedance, and equivalent noise resistance are defined and measured by implicitly assuming the linearization of the electron device around the quiescent working point of the amplifier regarded as a purely-linear system. As far as the modeling activity is concerned, the noise parameters can be predicted by means of compact (or "circuit-oriented", design (CAD) circuit simulation environment) linear model large-signal of the electron devices, connected to or including bias-dependent equivalent noise (EN) voltage and/or current generators. The relatively small amplitudes of signal usually involved in the operation of low noise amplifiers justify the standard linear approach of defining and dealing with these EN generators as controlled simply by the dc working point of the device. However, the recent literature shows a growing interest for the investigation of high frequency noise properties of circuits working in large-signal nonlinear operation [2]–[6]. In particular, by considering the example of a broad-band low noise amplifier oriented to software-defined-radio applications, characterized by high-dynamic range input requirements, it has been experimentally shown how its noise performance at a given signal frequency can degrade in the presence of a strong interferer (blocking signal) received within an adjacent channel. Other interesting fields of investigation are the influence of high-frequency noise modulation on the phase-noise in microwave oscillators, and the nonlinear high-frequency noise effects in up-conversion or non-zero-IF down-conversion mixers. Unfortunately, electron device nonlinear operation opens new scenarios and challenges in the compact modeling of high-frequency noise. In fact, although the theory of nonlinear circuit noise analysis is well developed (the corresponding algorithms and too large-signal being available in most of the commercial CAD packages), and the conventional EN generators can often be somehow re-exploited in nonlinear operation, the results suggested by the physics based investigation on noise generation and propagation mechanisms should be taken into account, in order to correctly establish the new relationships between the device large-signal regime and the characteristics of the EN generators to be used in the nonlinear analyses. More precisely, the statistical moments of the microscopic, distributed noise sources responsible for the high-frequency noise observed at the device electrical ports are found to be dependent on the carrier (electrons and holes) local concentrations. Since these quantities become large-amplitude time-varying functions under large-signal conditions, local high-frequency noise sources are definitely no longer related simply to the mean properties of the device electrical operation, but are instead controlled by its instantaneous large-signal working point. Thus, they must be described as non-stationary(in particular, cyclostationary) stochastic processes [7].From this physical standpoint, the equivalent description of the high-frequency noise in

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large-signal operation by means of mean value-controlled generators appears to be not only an arbitrary extension to large-signal regime of linear noise model large-signal, but a large-signal o theoretically in correct. The research activity on compact modeling of low-frequency (i.e., flicker and generation-recombination, G-R) noise for LARGE-SIGNAL applications [8]–[13], in which the EN generators are controlled by the time-varying operation of the device according to a number of modulation strategies. Some works deal with shot-noise in bipolar technologies in a similar way, as well [9], [12], [14]. However, as far as cyclostationary high-frequency noise in RF field-effect devices is concerned, the literature is still poor of contributions, even though very refined stationary noise model large-signal , providing size scaling features and temperature dependency, are available for both CMOS technologies [16]–[19] and typical semiconductor compounds for microwave applications[20]–[25], including the emerging Gain technology (e.g., [26]).Interesting investigation from a fundamental, thermodynamic standpoint can be found in the literature, for the description of thermal noise in nonlinear resistors, which can be a large-signal applied to channel noise in finite-element transforms(FETs). Unfortunately, these approaches are limited to operating conditions close to the thermodynamic equilibrium.

II. REVIEW OF TECHNIQUES

A. Compact Modeling Approach for High-Frequency Noise

In this technique discuss technology-independent, inherently nonlinear approach discussed for the compact modeling of noise at high-frequency under large-signal working conditions. For the formulation of nonlinear noise model, noise generation can be described by appropriate set of non-quasi-static deterministic description of the electron device and distributed stochastic processes, with respect to physics-based methods of microscopic diffusion noise sources, description of the noise generation mechanisms widely adopted in distributed numerical modeling,

B. Shunt feedback technique

In this section shunt feedback technique presented low-power, low-voltage and wideband resistive-shunt feedback low-noise amplifier. The Ultra-low voltage circuit design issues are discussed about the results of amplifier using biasing metric and series inductive peaking and feedback

C. Complementary CMOS parallel push-pull structure

To improve the linearity performance of a broadband low noise amplifier complementary CMOS parallel push-pull structure are preferred, this technique significantly reduced the contents of noise and reflection, improve the linearity of amplifier gives good linearity in amplifier design, its structure consists of complementary push pull arrangement. This technique preferred in low and high frequency application, the representation of technique is shown in figure 1

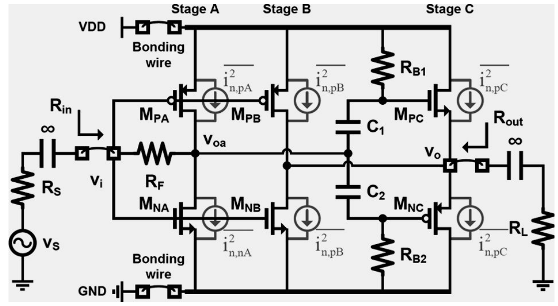

Figure 1Complementary Push Pull Arrangement

D. Cross Capacitive Coupled Feedback

The cross coupled capacitive feedback in differential mode configuration is used in modern wireless communication, this configuration initial at the starting point reduce the contents of noise and reflection and improve the linearity, this technique represents' as filter, its configured in cross coupled common gate topology with capacitive feedback. The cross coupled common gate topology boosts the trans-conductance of the design frequency and improved noise figure and gain, it is also reduces the second-order distortion.

E. Low-temperature polycrystalline silicon (poly-Si) Thin-film transistors (LTPS TFTs)

This technique suggested that transistor should be used in form of low-temperature polycrystalline silicon and Thin-film transistors, it has loss-less substrate and flexible, compare to other substrate therefore preferred in recent amplifier, this type of transistor gives high-Q and high linearity, it's very good characteristic if design as a inductors compared to Si-Substrate. The further improved is finding if appropriate change the dimension of inductors, if the dimensions of transistor is properly design then successfully reduce the poor characteristics of low-temperature polycrystalline silicon and Thin-film substrate.

F. Matching network sections

The matching networks versatile used in design of amplifier and RF devices, the matching network used in the input and output section, it is available in different shape like T-Network, pi-network, ladder network, bridge T-Network and L-network, this matching network is design using active and passive elements, for low frequency application used R-C Network and for frequency application preferred L-C Network to used, matching network gives impedance matching at design band or at specified frequency and reduce the contain of noise and reflection and improve the linearity of amplifier.

G. Differential Current-Driven Passive Mixers

Passive mixer configure in differential mode is discuss to improve the linearity and performance of amplifier, differential mode configuration significantly improve the current driving capacity of amplifier, in recent time Mobile units demand extended battery lifetime receiver. This technique used in designing of amplifier for receiver using baseband channel selection filtering that used in IEEE802.11a wireless communication.

H. Combining Technique

The idea of forward combining technique is illustrated in Fig. 3. The RF signal large-signal at the drain node and source node of the transistor are in anti-phase because they are derived from common-source and common-drain amplifications, respectively. The signal at drain node is shifted to have 90 phase advance and the signal at source node is shifted to have 90 phase lag. These two phase-shifted signal large-signal , which are in phase, are combined together before going into the next stage circuit .Since the two signal large-signal are in phase, the overall amplifier gain is boosted. The 90 phase shifts can simply be realized by an inductor and a capacitor. The noise figure of the amplifier can a large-signal o be reduced through the gain enhancement because the noise resistance Rn is inversely proportional to the square of the trans-conductance

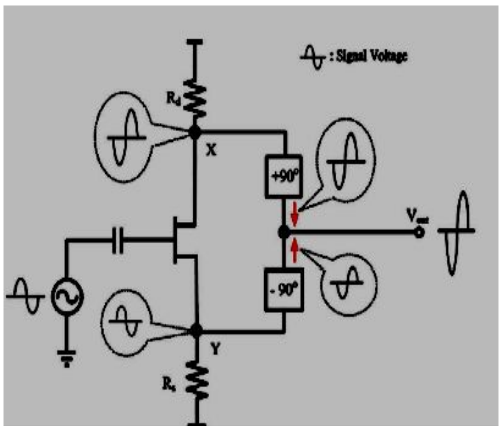

Fig. 2 forward combining technique.

I. Gain-boosting Technique

In this section gain boosting technique is discusses, utilize the gate-inductive gain-peaking scheme for the enhancement of maximum gain of amplifier. Inductor connects in series and shunt of proposed amplifier. This inductor gives very low resistance for designing and increase flow of current in output section of amplifier and improves linearity and performance of amplifier, in this technique number of component required is very less to achieved linearity, reduction in noise and reduction in power consumption. For further improvement in linearity, noise performance of amplifier next technique is discussed in next section.

J. switched multi-tap transformer

In this technique implementing a transformer-based multimode that can be configured to operate in single-band, concurrent dual-band, or wideband frequency of application. In the conventional narrowband low noise amplifier, shown a series gate inductor, is used to achieved narrowband matching and high value of current,

K. SiGe BiCMOS technology

In this technique SiGe BiCMOS configuration is used to improve linearity, reduce the contain of noise and power consumption, The first stage is cascade chosen for its higher power gain and improved input-to-output isolation and improve impedance matching for input and output section. By using such configuration, the noise performance and maximum power gain at high frequency are improved when compared with the higher single-base device (CBE) and larger parasitic capacitance triple base finger device (CBEBEBC). Common emitter (CE) with double-base finger device is used in the second stage to improved linearity and broader output matching bandwidth

Review of all parameters of amplifier shown in table -1, comparison has done between different techniques

III. Design Parameters

The four most important parameters in LNA design are: gain (A), noise figure (NF), and non-linearity and impedance matching (Z). The steps required in designing a LNA are as follows:

A. Design of low noise amplifier

There are two widely used types of devices the S-parameter and normal device. In designing a LNA, the S-parameter design is the most used, designing of amplifier included appropriate selection of transistors, appropriate designing of input output matching network and appropriate designing of intermediate stage, many researcher design low noise amplifier in different aspects, the demand of research continuously carried out in the appropriate and acceptable design of low noise amplifier, low noise amplifier design from low frequency band to high frequency band.

B. Operating requirement of low noise amplifier

Operating voltage of low noise amplifier is very less 2 - 10 V. LNA require supply current in the range of mA, The Frequency Range of low noise amplifier is very broad. They can be used from 400 kHz to 100 GHz, low noise amplifier, like other semiconductor devices, the temperature range of low noise amplifier in the range of -30 to +50 C.

C. Noise Figure

Noise figure is also one of the key parameter in the designing of low noise amplifier, how much density of noise in amplifier by transmission of signal and used components is represent by noise figure, noise figure should be low for effective and useful design of low noise amplifier for a particular application. A low noise figure result is better for reception of signal.

D. High Gain

High gain is the key requirement of amplifier design, for linearity enhancement work on unity gain bandwidth, unity gain bandwidth should be high to represent low losses of amplifier, many aspects used in amplifier designing to enhance the gain of amplifier,

Table 1 Review of Techniques

Technique Used	Power Consumption	S-Parameter	Broad impedance bandwidth	Noise Figure	Linearity Bandwidth	Gain Boosting
Compact Modeling Approach for High-Frequency Noise						
Matching network sections						
Complementary CMOS parallel push-pull structure						
Derivative Superposition						
Coupled Amplifier Topology						
shunt feedback topology						
Combining Technique						
Si-Ge Bi-CMOS technology						
switched multi-tap transformer						

CONCLUSION

Versatile Low noise amplifier is used and needed for recent technology like GSM, Wi-Max, Mobile communication etc. For improvement of the performance and linearity of amplifier many number of techniques used in past decades discussed like Resistive shunt feedback topology, matching network sections, combining Technique, cross capacitive feedback, differential current driven passive filter, Si-Ge Bi-CMOS technology, switched multi-tap transformer and inductively degenerated, all techniques are discussed in detail and concluded that this technique is frequently used in modern application. Discuss about the techniques to improve noise figure, reduce power consumption, gives good impedance matching in input and output section of amplifier. Discuss about the gain boosting technique, inductive peaking is a best technique to improve the gain of amplifier, all techniques are used to improve low noise amplifier , improve gain ,noise rejection capability and impedance bandwidth over single band, dual band, multi-band and broad band, but recent technology demand and needed so that more discussion and research required infield of low noise amplifier, discuss recent techniques in table-1, reviewed low noise amplifier from origin and discuss development and find Different technologies are used for implementing the different designs in the different aspects

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