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COMPARISON ANALYSIS OF LOW NOISE AMPLIFIER BY USING FET AND BJT FOR MICROWAVE FREQUENCY BANDS

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ABSTRACT: *Simulation comparison Of Low Noise Amplifier (LNA) using FET((Field Effect Transistor) versus BJT(Bipolar Junction Transistor) LNA is proposed using different RF simulator . As Low Noise Amplifier (LNA) is the most essential block of devices in every communication RF Receiver system and its aim is to maintain the faithful gain with optimum noise figure having good linearity. So to achieve desired terms, generally FET Family is used for the design of LNA . But in today's technology formation of LNA using RF BJT with different Transistor Families with their essential characteristics can be possible. The MOSFET LNA was simulated and designed with CMOS MOSIS process. It was concluded that the use of low-cost and high integration CMOS technology results in penalty in the power dissipation and frequency response which are much better in bipolar technology [1-2].*

Keywords: *RF CMOS LNA RF BJT LNA, NF,RF BJT,S2P MODEL,ADS .*

I. INTRODUCTION

Today's industry of portable wireless communications, it is well known that the monolithic solutions Microwave/RF circuit design problems are usually the key issue to move to higher and higher levels ot integration, the size, and the useful battery life of the equipment in order to meet the aggressive cost targets associated with the commercial/consumer market. The RF functions of a typical transceiver
are now being integrated at increasingly higher levels onto a single semiconductor die, much the same way that digital IC technology is integrating more and more logic gates on a typical chip This technological trend **is** reducing the cost of the transceiver even further. The recent and largely unanticipated, explosive growth of portable wireless telecommunication systems has led to integrate it.
The wireless communication technology gets upgraded drastically in the form of design of LNA . For the advancement of the noise figure we are using LNA devices by using various High Frequency components. As one of the major suppliers in the area of High Frequency (HF) components, the NXP Semiconductors, HWELETT PACKARD, CEL etc.. provides continuous commitment to innovative Technologies and Products combined with volume strategy. The NXP Semiconductors, N.V. and Product Roadmap is directed to complete RF system solutions and device kits as well as standard and custom specific components in enhanced Si, GaAs and Hetero Materials(SiGe HBT, GaAs HEMT, GaAs HBT). A core competence is the fabrication of RF components in Surface Mounted Technology (SMT). High volume discrete in Si & GaAs, MMICs (Monolithic Microwave IC's) in Si & GaAs, and finally Fast Logic Circuits in enhanced Si technologies.[3]

Here we are using the references LNA design using RF BJT and also RF FET family for the different microwave frequency range.

B.LNA DESIGN: The design of LNA is based on the cocept of Microwave Amplifier Design and which is quite different from the normal Amplifier Design. Here we are referrig the Microwave Amplifier Design fundamentals and mathamatical calculation behind it.For Design Process following theoritical fundamentals has to be considered[4].

Typical Essential Points for LNA:

1. Stability
2. Input Matching
3. Output Matching

4. Overall Gain of the Amplifier
5.Noise Figure

1. Stability

Stability is important to consider when designing microwave transistor amplifiers. If a transistor is unconditionally stable it will not oscillate with any passive termination. On the other hand a potentially unstable transistor can be stabilized by adding resistive loadings. One way of expressing necessary conditions for unconditional stability is :

$$K = \frac{1-|S11|2-|S22|2+|\Delta|2}{2|\,S12\,S21\,|}$$

Where K>1

$\Delta = S_{11}S_{22} - S_{12}S_{21}$

Where $\Delta < 1$

When the K>1, the circuit will be unconditionally stable for any combination of source and load impedance. When K<1 then circuit is potentially unstable and oscillation may occur with a certain combination of source and /or load impedance presented to the transistor.

2. Input Matching

Input Matching is to be considered by S parameter of the amplifier where S_{11} is the input return loss it is should be S_{11}<-10dB.LNAs are typically designed to provide a 50Ω input resistance and negligible input reactance. This requirement limits the choice of LNA topologies. In other words, we cannot begin with an arbitrary configuration, design it for a certain noise figure and gain, and then decide how to create input matching.

3.Output Matching

Output Matching is to be considered by S_{22} parameter of the amplifier where S_{22} is the Output return loss it is should be S_{22}<-10dB.

Here output reflections of the amplifier is to be affected by the impedance mismatch because as the load impedance and the output impedance mismatch cause the reflections and affects the noise figure and the gain of the amplifier.

4. Overall Gain of the Amplifier

Several power gains were defined in order to understand operation of super high frequency amplifier. Figure show that power gains of 2-port circuit network with power impedance or load impedance at power amplifier. The power amplifiers represented with scattering coefficient are classified into Operating Power Gain, Transducer Power Gain and Available Power Gain [4-5].

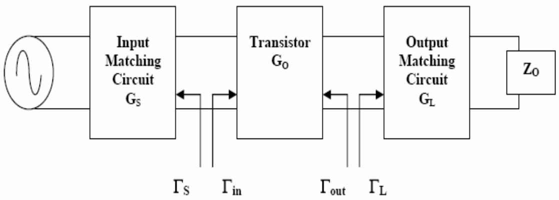

Fig.1:Impedance Matching for Overall Gain of Amplifier

5.Noise Figure

NF is one of the most important parameters to evaluate the radio performance of the communication system. It is a measurement of degradation of signal-to-noise ratio (SNR) between the input and output of the component.

Rather, we view and design the RF chain as one entity, performing many iterations among the stages. The NF can be calculated using the following mathematical equation. In modern RF electronics, we rarely design an LNA in isolation.

NF(dB) = 10logF (3)

Where F =(S/ N) *input* /(S/ N) *output*

We can characterize the performance of a particular receiver element by its NF, which is the ratio of actual output noise of the element to that which would remain if the element itself did not introduce noise. The total NF of a receiver system (a chain of stages) can be calculated using the Friss formula as follows:

NF=NF1 + ((NF2 -1))/G1 + ((NF3 -1))/G1G2 +…..+ ((NFn -1))/(G1…….Gn-1)

Where NF1, NF2,…NFn are the noise coefficient of each amplifier, and G1, G2… Gn are the gains of each amplifier. This result suggests that the noise contributed by each stage decreases as the total gain preceding that stage increases, implying that the first few stages in a cascade are the most critical. It is understandable that the total NF is dominated by the NF1, which is the NF of the LNA. From the Friss formula we can see what affects the cascade amplifier most is the first stage amplifier, so we should try to get an amplifier of smaller noise coefficient and larger gain in the low noise design.

So for that purpose here we are considering the overall above parameter for the development of the design aspects of Low Noise Amplifier by using the RF BJT and RF FET family and we can compare the simulation results of the LNA design for both of the active devices and make sense that in the recent area of research for the market industries we can also use the RF BJT for the design of the LNA and create a new path for the fulfillment of the industrial demand on the basis of cost reduction and other bipolar advantages of the active devices to get the competent results as we can contribute to the economical research base for the new consumer products which are on the basis of microwave and can be on the electronics market satisfactory product development of the target can be made for this competition of Mobile Handsets,GPS,etc.

COMPARISION ANALYSIS OF LNA DESIGN USING 10 DIFFERENT SET OF RF FET USING REFERENCES

SR.NO.	FET	dB(S21)	NF	dB(S11)	dB(S22)	REF.
1	CMOS 0.18um	24.92	0.5	- 23.64	≤-10	[5]
2	CMOS 0.25 µm	16.4	2.77	- 19.7	- 18.8	[6]
3	CMOS *0.5µm*	21.64	2.3	≤-10	≤-10	[7]
4	CMOS 0.18 µm	17.89	0.581	-10.65	-2.56	[8]
5	GaAs FET	20	3	≤-10	≤-10	[9]
6	CMOS ATF-54143	29.338	0.537	-32.05	≤-10	[10]
7	PHEMT	43.74	0.70	– 10.60	-18.22	[11]
8	HJ-FET NE3210S01	21.77	0.69	-23.23	≤-10	[12]
9	SuperHEMT FET	18.5	1.3	-11.5	-12.3	[13]
10	HJ-FET NE32500	20	0.334	-10.583	≤-10	[14]

TABLE 1. SIMULATION RESULTS COMPARISION ANALYSIS OF LNA DESIGN USING 10 DIFFERENT SET OF RF FET

COMPARISION ANALYSIS OF LNA DESIGN USING 10 DIFFERENT SET OF RF BJT USING REFERENCES

SR.NO.	RF BJT	dB(S21)	Nf	dB(S22)	dB(S11)	K	REF.
1	BFU710F	24.8	0.3	-8.189	-7.408	1.594	[15-25]
2	BFU910F	23.864	0.933	-10.94	-5.422	1.251	[16-25]
3	AT41411	23.55	0.35	-1.9	-1.24	0.53	[17-25]
4	NE68139R	22.857	0.3	-2.743	-1.892	3.953	[18-25]
5	BFU610F	19.722	0.36	-6.144	-8.971	2.731	[19-25]
6	BFU730F	17.986	0.36	-9.87	-1.031	2.205	[20-25]
7	BFU725FN1	16.747	0.34	-10.465	-1.173	2.095	[21-25]
8	BFU690F	11.34	7.21	-4.42	-0.35	1	[22-25]
9	AT41400	4.16	1.16	-0.81	-0.55	4.14	[23-25]
10	BFU760F	8.734	0.639	-10.133	-0.392	3.32	[24-25]

TABLE 2. SIMULATION RESULTS COMPARISION ANALYSIS OF 10 DIFFERENT SET OF RF BJT

CONCLUSION

In this paper we analyzed the comparison of LNA design using 10 different combination of RF Field Effect Transistor and combination of RF Bipolar Junction Transistor. Our simulation results show that LNA Design using RF BJT provides as competent as FET Family in terms of output. This important research output will create a new path in Microwave Research and Development and provides innovative direction that LNA can also be design using RF BJT. This research will also provide noteworthy cost effectiveness to the Microwave device Manufacturers and ultimately to the Defense, Telecom and Government Industries which will procure LNA designed with Low cost RF BJT compared FET.

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