

Design and Simulation of Solid State Power Amplifier with ADS for Pulsed Radar Applications

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ABSTRACT: This paper proposes a design and simulation of Solid State Power Amplifier (SSPA) using ADS which will be useful for pulsed radar applications. The selection of proper device for the desired application plays a vital role. There are various steps involved in the present design such as Direct Current (DC) simulation in order to get the proper quiescent operating point under the platform. Subsequently, Stability simulations are to be carried out to make sure that the amplifier can be unconditionally stable. Load pull and Source pull simulations are required to match the load and source impedances, and finally Harmonic Balance (HB) simulations are to be carried out to verify the harmonic levels of the signals other than designed frequency of operation.

KEYWORDS: Solid State Power Amplifier (SSPA), Power Amplifier (PA), Advanced Design System (ADS), Direct Current (DC) and Harmonic Balance (HB).

I. INTRODUCTION

The key features while designing an amplifier are 10MHz bandwidth, 20% efficiency, 31dB output power, reliability, good thermal performance and 11dB gain of the amplifier. A critical element in Radio Frequency (RF) front ends is the Power Amplifier (PA). Critical specifications for PA design include linearity and output power. Linearity must be maximized in order to reduce signal distortion and minimize Adjacent Channel Leakage Ratio (ACLR). This paper describes the process of designing a single stage class AB PA for operation in the 380MHz frequency.

II. NEED OF A POWER AMPLIFIER

Power Amplifier is in the transmitting chain of T/R module of radar system and this is the final amplification stage before the signal is transmitted and therefore it must produce high output power to overcome channel losses between the transmitter and receiver.

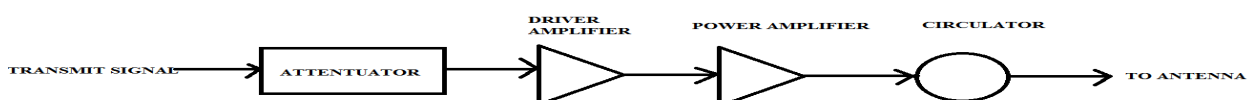


Fig 1. Transmission path of T-R Module

III. EXISTED SYSTEM

The existing Power Amplifier is the Klystron amplifier. SSPA have greater reliability than klystron amplifier. It requires high power supplies and life span is low compared with the SSPA. The mean time between failures is low in Klystron amplifier. Due to these advantages of Solid State Power Amplifier, here we are going to design Solid State Power Amplifier.

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IV. SOLID STATE POWER AMPLIFIER

An amplifier that uses transistors (BJT or FET) to provide useful amplification at Mega and Giga hertz frequencies. Power Amplifier is an integral part of modern wireless infrastructure.

V. CLASSIFICATION OF SOLID STATE POWER AMPLIFIERS

The Solid State Power Amplifier is classified into different classes based on the operating or bias point of the circuit. Power Amplifiers are mainly classified into two types Linear and Nonlinear, this can be divided based on linearity, efficiency and circuit topologies. Class A, Class B and Class AB are linear amplifiers. Class A has highest linearity. Nonlinear amplifier classes are Class C, D, E, F, G and H. In this paper, we are going to design a class AB power amplifier because it has more efficiency than class A and it reduces the cross over distortion, which is present in class B. Linearity is also the major criterion in the selection of Power Amplifier which is used for radar applications. But in radar applications the efficiency is not a criterion so we can also use class A. But the class A has a major disadvantage i.e., the transistors are on during both the cycles. Due to this the power dissipation is observed continuously which spoils the Power Amplifier circuit. This is not observed in class AB amplifier.

VI. CLASS AB POWER AMPLIFIER

A class AB amplifier is a linear amplifier, a compromise between class B and class A regarding to efficiency and linearity parameters and operates between two edges defined for these two amplifiers. For ideal case, an operating class AB mode is biased to a quiescent point, which is in the region between the cutoff point and the bias point of class A. Efficiency is improved compared to class A PA, but still less than 78.5% by virtue of conduction angle in this class is between 180° and 360° . Unlike class B amplifier, the conduction angle for a class AB amplifier being a function of drive level results in distortion of amplitude modulated signals at their peak power level.

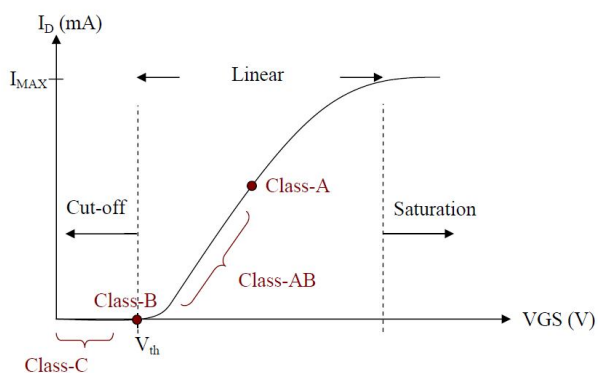


Fig 2. Transfer Characteristics of FET

VII. INTRODUCTION TO ADS

Advanced design system is an electronic design automation software for RF, microwave and high speed digital applications. It contains a variety of bundles, including PLL (phase locked loops) design, time domain and EM modelling (momentum simulator). To design a power amplifier the following steps are required.

VIII. DESIGNING STEPS WITH SIMULATION RESULTS OF A POWER AMPLIFIER

1. DC and Load line Analysis
2. Bias and Stability Analysis
3. Load pull Analysis
4. Harmonic Balance Simulation

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TYPE OF TRANSISTOR USED IN THIS PAPER

The transistor used in this design is MRF134. The MRF134 is an Enhancement mode N channel MOSFET. This transistor is used upto 400MHz frequency.

1. DC LOADLINE ANALYSIS

DC simulation is used for finding the bias point and operating characteristics of the transistor. Below circuit shows characteristics for MOSFET.

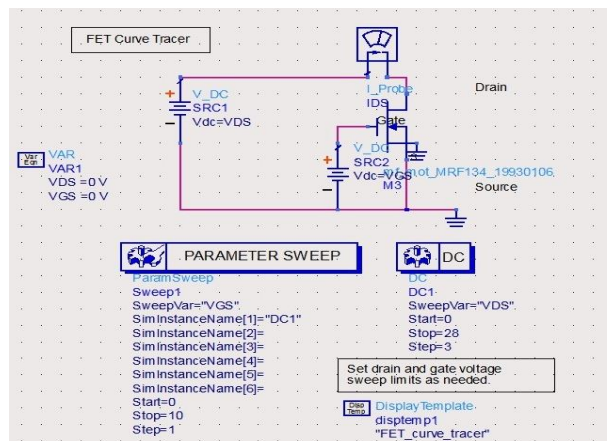


Fig 3. FET Curve Tracer circuit in ADS

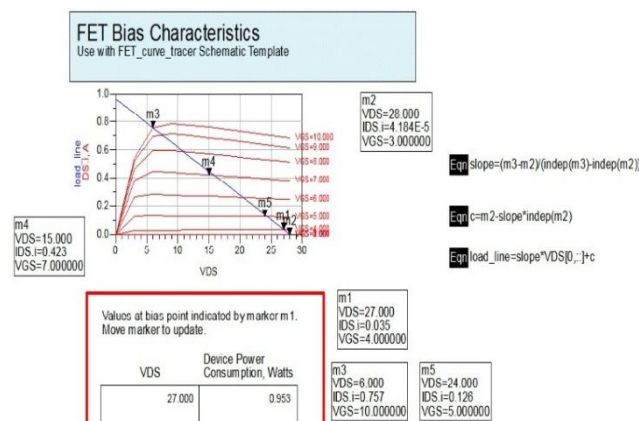


Fig 4. FET Curve Tracer simulation in ADS

2. BIAS AND STABILITY ANALYSIS

Stability analysis is a very important aspect of any active circuit design and it is equally important in Amplifier design too. Below shows the circuit that was obtained after adding potential divider bias networks. The stability should be less than or equal to 1 for unconditionally stable. Insert stability fact component from the palette simulation for calculating the S-parameters and stability factor.

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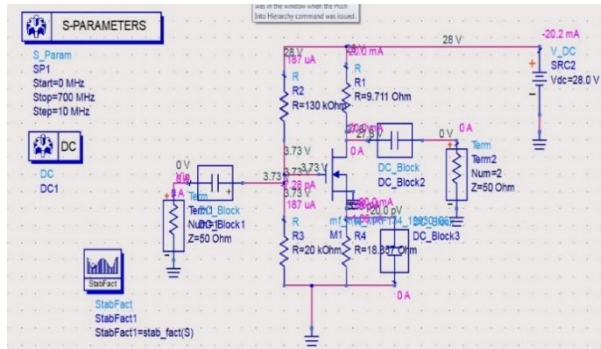


Fig 5. Bias and Stability circuit of FET in ADS

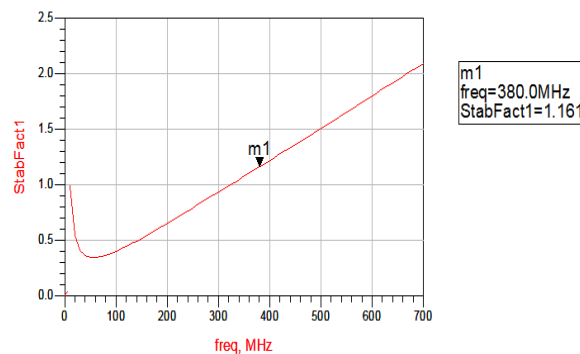


Fig 6. Bias and Stability circuit simulation of FET MRF134 in ADS

3. LOADPULL SIMULATION

Load pull simulation is utilized to find the optimal load value that will maximize the output power and the efficiency, or achieve a compromise between both of them. This analysis utilizes the built-in ADS load-pull circuit simulator. Different values of load impedance are applied to find out the optimum one, which meets the required value of gain, output power and efficiency. Before running the simulation, some parameters like frequency, V_high and V_low have to be set. The load pull circuit is shown below.

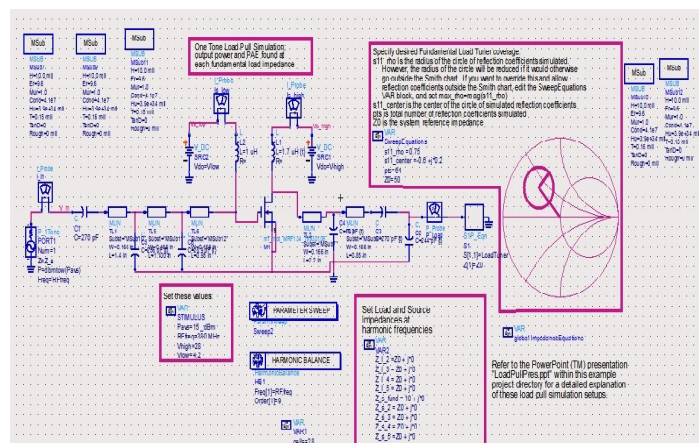


Fig 7. Load pull circuit of FET MRF134 in ADS



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IX. CONCLUSIONS

This paper proposes design of Solid State Power Amplifier for radar applications using ADS software. Here we are designing a power amplifier by using MRF134 and performing DC simulation, S-parameters simulation, Loadpull simulation and Harmonic Balance simulation.

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BIOGRAPHY



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