Rudimentary Study and Design Process of Power Amplifier

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***ABSTRACT* - Communication industry is currently in continuous growth..In recent time for satellite communication, spectrum at C-band and Ku band is almost congested and for various new applications Ka band is being explored. In particular the Very Small Aperture Terminal [VSAT] networks have gained wide use for business and private applications. Power Amplifier [PA] is important block in transmitter section. Various amplifier configuration were studied and suitable configuration was selected. Also design steps for power amplifier were understood. After Literature survey and studying different transistor, a suitable for Power Amplifier at centre frequency 29.5 GHz over 100 MHz bandwidth for Very Small Aperture terminal at Ka band will be designed. Its performance will be evaluated based on certain parameters like Gain, Efficiency, 1 dB compression point [P1dB], 3rd order intercept point [TOI] and it will be simulated using Advance Design System [ADS].**

***Keywords*- VSAT, PA, P1dB, TOI, ADS.**

1. INRODUCTION

An amplifier get a signal from some pickup transducer or other input source and provide a larger version of the signal to some output device or to another amplifier stage. An input transducer signal is mostly small and need to be amplified sufficiently to operate an output device. In small signal amplifier, the main factors are usually amplification linearity and magnitude of gain. Because of signal voltage and current are small in small-signal amplifier and the amount of power handling capacity and power efficiency are of little concern. On the other side Large-signal amplifiers or power amplifiers used to provide sufficient power to an output load to drive output device typically few watts to ten watts. The main feature of power amplifier is the circuit's power efficiency, the maximum output power that the circuit is capable of handling and the impedance matching to the output device. [1].

PA is designed to meet a number of indicators such as noise figure, gain and input VSWR. Because of the calculation process is more complex, we usually make it by CAD technology. In this paper, we make the simulation and optimization of the circuit through the ADS microwave circuit simulation design software which greatly help us shorten the design cycle and improve design efficiency. Due to significant R&D funding, innovations, processing advancement and electronic circuit developments, the Microwave Monolithic Integrated Circuit(MMIC) has now become commonplace, replacing many discrete circuits with individual transistors, resistors, capacitors, inductors and element interconnections. MMIC circuits show reduced size and cost with higher reliability to meet the needs of today's markets. The pHEMT has outstanding high-frequency characteristics, power characteristics and low-noise characteristics, and it is one of the most competitions in the field of microwave and millimeter-wave monolithic integrated circuits.

The low power amplifier is the key component in transmitter section, which dictates the dynamic range of the transmitter. MMIC LNAs with Low noise, high gain, good return loss, low power dissipation, high reliability and compact size are required aggressively for many system applications [2].

2. THE PRINCIPLES OF AMPLIFIER DESIGN

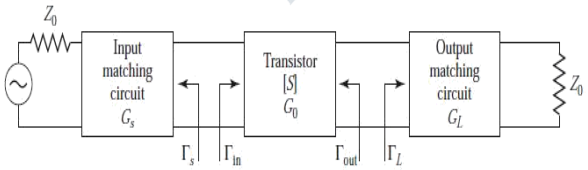

Fig. 1 Block dia. of amplifier[2]

A single-stage microwave transistor amplifier can be modeled by the fig 1. Here matching network is used on both sides of the transistor to transform the input and output impedance Z_0 to the source and load impedances Z_S and Z_L. Matching circuit is used to avoid unnecessary loss of power. Reflections are eliminated on the transmission line, this procedure is referred to as tuning.

A. DC BIASING

Biasing a Transistor amplifier is the process of setting the dc (Biasing) operating voltage and current to the correct level so that any ac input signal can be amplified correctly by the transistor. That is by setting its Collector current (Ic) to a steady state value without an input signal applied to the transistors Base, and by the values of the dc supply voltage (Vcc) and the value of the

biasing resistors connected the transistors Base terminal. The goal was to select an operating point that would give sufficient output power, have relatively low noise, and operate in the class A region. The correct bias Operating point of the transistor is generally somewhere between the two extremes of operation, that is halfway between cutoff and saturation. This mode of operation allows the output current to increase and decrease around the amplifiers Q-point without distortion as the input signal swings through a complete cycle.

B. STABILITY FACTOR

Amplifier is not reliable when it is instable condition. The stability of a circuit is characterized by stern stability factor. The circuit is stable only when K > 1 and Δ< 1. When the input and output reflection coefficients are less than one then we determined the absolute stability factor:

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{|S_{12}S_{21}|} > 1 \qquad (1)$$

$$|\Delta| = S_{11}S_{22} - S_{12}S_{21} < 1 \qquad (2)$$

C. IMPEDANCE MATCHING

Impedance matching at input and output port done by using smith chart technique, by properly adjusting the value of inductance and capacitance at input and output side, we have managed to match impedance with the terminating resistance of 50 Ω. Γ_S and Γ_L is the source and load reflection coefficient respectively. Input and output reflection coefficient is Γ_{in} and Γ_{out} respectively shown in following equations:

$$\Gamma_{in} = S_{11} + \frac{S_{12}S_{21}\Gamma_L}{1 - S_{22}\Gamma_L} \qquad (3)$$

$$\Gamma_{out} = S_{22} + \frac{S_{12}S_{21}\Gamma_s}{1 - S_{11}\Gamma_s} \qquad (4)$$

D. S-PARAMETERS

It is refers to RF output voltage verses input voltage in the RFIC and describes the relationship between the two or more port network.

In the term of RFIC, S_{11} and S_{22} is called reflections coefficient. S_{21} and S_{12} are called transmission coefficient. S_{11} and S_{22} are used to calculate the input and output reflection in the circuits. S_{21} and S_{12} are used to calculate the forward and reverse voltage gain in dB as shown in the figure 2.

S-parameter is one of the important parameter of low noise amplifier.

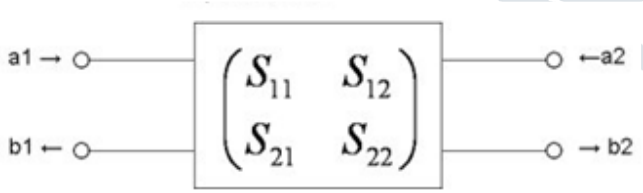

Fig. 2 S-parameters of two port network[2]

E. Efficiency:

The power amplifier is generally the primary consumer of DC power in most hand-held wireless devices, thus amplifier efficiency is an essential consideration. One measure of amplifier efficiency is the ratio of RF output power to DC input power,

η =Pout/PDC

One drawback of this definition is that it does not account for the RF power delivered at the input to the amplifier. Since most power amplifiers have relatively low gains, the efficiency of this equation tends to over rate the actual efficiency. A better measure that includes the effect of input power is the power added efficiency, given as

ηPAE=PAE=(Pout−Pin)/PDC= (1 −1/G)Pout/PDC = (1 −1/G)η

F. RETURN LOSS

The characterization of the input and output signal can be shown in more convenient way in the form of return loss when a load is mismatched. This means that all the source power is not delivered to the load. This loss of power is known as "return loss" and can be represented as:

$$RL = -20 \log|\Gamma| \text{ dB} \quad (7)$$

G. LINEARITY

Linearity of LNA is most important in a wireless receiver to reduce the inter-modulation distortion. The linearity is expressed by the 1 dB compression point and inter-modulation product (IP3). When the input signal is increased, a point is reached where the power of the signal is not amplified by the same amount as the smaller signal at the output. At this point where the input signal is amplified by an amount 1 dB less than the small signal gain, these are called 1 dB compression point. IIP3 (input inter-modulation product) is proportional to the ratio of the first and third derivatives of the transfer characteristic.

3. ADS OVERVIEW

Advanced Design System (ADS) is an electronic design automation software system produced by Keysight EEsof EDA, a division of Keysight Technologies. It provides an integrated design environment to designers of RF electronic products such as mobile phones, pagers, wireless networks, satellite communications, radar systems, and high speed data links. ADS supports every step of the design process schematic capture, layout, design rule checking, frequency-domain and time-domain circuit simulation, and electromagnetic field simulation.

4. CONCLUSION

After studying literature of Power Amplifier and its different parameters it can be concluded that Power Amplifier is a device which delivered maximum power at output for this purpose transistor should be selected as its gain, efficiency, 1dB compression point and 3rd order intercept point are as large as possible, for this purpose different manufacturer companies transistor datasheet and its s parameter are compared for VSAT application at ka band then using that design of target specified Power Amplifier will be done. .

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6. REFERENCE

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