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# Review on Fully Integrated Power Amplifiers Using CMOS Technology

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**Abstract:** power amplifiers are generally used to drive the antennas in a transmitter system. Being the last block in a system like this, it increases the power of the signal, thus making it easier for the antenna to transmit over a wide area. The most basic parameters in a power amplifier are its linearity and efficiency. Over the past few decades, fully integrated power amplifiers have been designed using cmos technology. The reason for this is reduced cost, low power supply requirements, better integration and good performance. Cmos technologies have now entered the nanometer range thus making the circuits much smaller than before. In this paper we review design of fully integrated power amplifiers using cmos technology. Most of the amplifiers presented in this paper are working at different frequency bands, aiming at applications for wireless services like 5g, satellite communication etc.

**Keywords:** pa, cmos, gain, linearity, efficiency, operating point.

## I. INTRODUCTION

Power amplifier (PA) is usually the last block of a transmitter system. It amplifies a weak signal to a power level required to transmit a signal. They are also called large signal amplifiers. This is due to the fact that in order to get a large signal power at the output, the voltage of the input signal should also be very large.

Based on applications PAs can be classified into Audio Power Amplifiers and RF Power Amplifiers. The latter works with radio frequency signals amplifying a specific band of frequency and ignoring the unwanted frequency components. On the other hand, Audio PAs work with the audio frequency range like driving a loudspeaker.

Now based on mode of operations, power amplifiers are classified into various classes like Class A, B, AB, C, D to name a few. Class A amplifiers are biased in such a way that they are active for the entire input cycle. They provide an efficiency of 50% which is quite low. Class B amplifiers are active for only half the input cycle (positive half cycle). Their efficiency is over 60%. Class AB is an intermediate between Class A and B, thus remaining active for more than half of the time. Most of the designers today use Class AB amplifiers as they provide sufficient gain with relatively low input power. However the efficiency of Class C amplifiers can reach up to more than 80%. Class D amplifiers are generally use pulse width modulation and are designed to operate with digital or pulse type signals.

Design of PA is a very difficult task. Earlier BJTs (Bipolar Junction Transistor) were used for fabricating amplifiers. However with the dawn of CMOS technology, MOSFETs have found huge applications in the fabrication of analog as well as digital circuits. Alternatively, using MOSFETs has its consequences. For example, degradation mechanisms that are associated with MOSFETs like; gate-oxide break down, hot carrier effect, punch-through etc., can influence the operation of CMOS power amplifiers. This paper compares the designs of various power amplifiers using CMOS technology.

## II. LITERATURE SURVEY

Basic idea behind using CMOS technology is the reduction in cost and size and at the same time low power requirements. Many different topologies and design strategies exist that help with the designing of these amplifiers. The three most widely used topologies for designing power amplifiers are Common-Source, Cascade/Cascode and Stacked. Hai-FengWu et al used 0.18 $\mu$ m CMOS technology to design a two stage stacked power amplifier. As mentioned before it is very challenging to design a RF CMOS power amplifier which gives a good wideband frequency response and at the same time provides with good power gain <sup>[1]</sup>. The proposed amplifier 0.64mm<sup>2</sup> chip size and provides a gain of 18.4 dB. Though the design suffers from parasitic, it is countered by decoupling capacitors to ground pads <sup>[1]</sup>.

A race to provide 5G technology by the next decade is in process. 5G wireless services usually operate in Ka-frequency band (18-

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28GHz). Sherif Shakib et al in 2016 used Source degeneration for stability to design a highly linear and effective PA in 28nm technology. Byungjoon Park et al have designed a Ka-band linear PA in 28nm CMOS technology. Two stack deep class AB PA is designed to provide high gain and linearity <sup>[3]</sup>.

### III. LINEAR POWER AMPLIFIERS IN Ka-BAND

Due to congestion in the traditional communication frequency bands, a need arises to develop amplifier in higher frequency bands (Ka-band) which can serve useful for satellite communication as well as new 5G wireless applications.

Yong Huang et al (2017) presents a 28.5GHz Ka-band PA in 130nm CMOS technology. Proposed design shows a power gain of 22.6 dB and a PAE of 19%. To increase stability, an inter-stage inductor is used between the common source transistors. Cascode configuration has higher output impedance than CS topology which brings a higher gain. Furthermore, the cascode configuration increases the maximum tolerable voltage between drain and source by a factor of 2 <sup>[4]</sup>.

Sometimes we need to increase the number of stages as we move to higher frequency ranges to maintain the required gain. Jong-Wook et al designed a three stage common-source Ka-band PA using 180nm technology. By using a substrate-shielded microstrip-line, accuracy was achieved upto 40GHz. A maximum gain of 14.5dB and PAE of 13.2% was achieved. <sup>[5]</sup>

Hamed Alsuraistry et al designed power amplifier at two different technologies i.e. 180nm and 150nm. PA designed using 150nm showed higher gain and PAE.

Results from other researchers are listed in the table below.

Table 1

FREQUENCY (GHz)	28.5	28	27	29	29
TECHNOLOGY (nm)	28	130	180	180	130
TOPOLOGY	stacked	CS & CG	CS	CS	CS
GAIN (dB)	11	22.6	14.5	12.6	16.3
POWER ADDED EFFICIENCY (%)	16.5	19	13.2	25.3	25.7

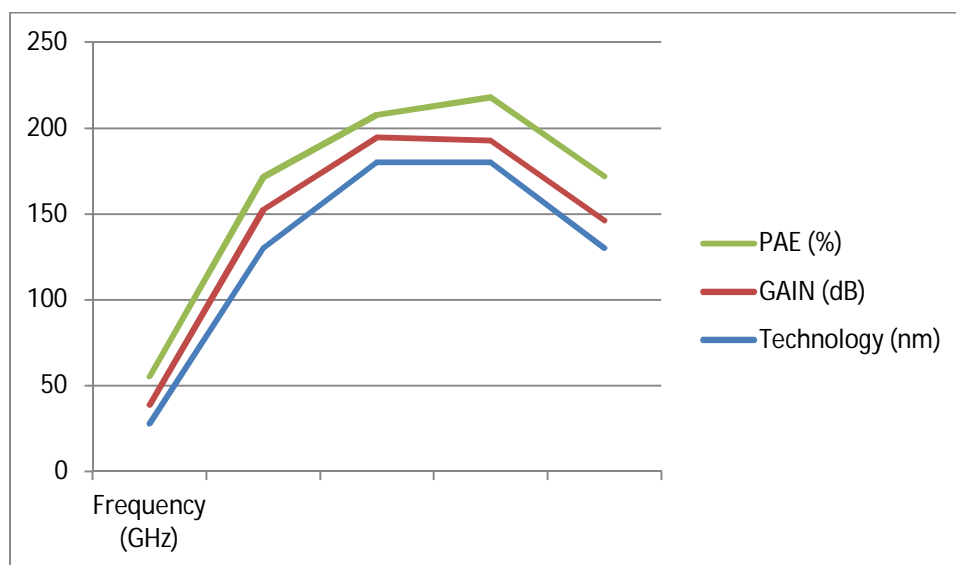


Figure 1

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## IV. CONCLUSION and FUTURE WORK

As we move deeper into the nano range for gate channel length, there is a huge shift in properties. Moreover short channel effects come into play. However, shorter channel length increases the gain and power efficiency and reduces the chip area considerably. Higher frequency bands require more number of transistors, hence, number of stages increases.

It is observed that in most of the cases common-source topology is best suited for amplification purposes.

Satellite transponders need power amplifiers to raise the power of the signal before transmitting. At the same time these transponders are being designed in Ka-band for communication applications. Hence, we can design a CS amplifier in CMOS technology for satellite transponders.

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