2.4GHZ Class AB Power Amplifier for Wireless Medical Sensor Network

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ABSTRACT

The objective of this research was to design a 2.4 GHz class AB Power Amplifier (PA), with 0.18um Semiconductor Manufacturing International Corporation (SMIC) CMOS technology by using Cadence software, for health care applications. The ultimate goal for such application is to minimize the trade-offs between performance and cost, and between performance and low power consumption design. This power amplifier can transmit 8.5 dBm output power to a 50Ω load. The power added efficiency is 8.2% at 1dB compression point and the power gain is 10dB, the total power consumption is 0.15W. The performance of the power amplifier meets the specification requirements of the desired.

Keywords: Two stage, class AB, power amplifier

1. INTRODUCTION

Currently, remote monitoring applications are extremely important mobile technologies, because they can detect and prevent the illness. Thus, they could reduce hospital readmission rates, saving hospital resources. Remote monitoring systems help patients effectively be aware of their physical conditions, and commute more efficiently get in touch with their physicians [1]. Wireless medical sensor networks have offered significant improvements to the healthcare industry in the 21st century. Devices are arranged on a patient’s body and can be used to closely monitor the physiological condition of patients. These medical sensors monitor the patient’s vital body parameters, such as temperature, heart rate, blood pressure, oxygen saturation, and transmit the data to a doctor in real time [1]. When a doctor reviews the transmitted sensor readings, they can get a better understanding of a patient's health conditions. The benefit for the patients is that they do not need to frequently visit the hospital, thus patients could reap time and money savings. Such wireless medical sensors will continue to play a central role in the future of modern healthcare. People living in rural areas would especially benefit, since 9% of physicians work in rural areas while almost 20% of the US population lives there [2]. A shortage of physicians and specialist is a big issue in such areas, even today. But Wireless Medical Sensor Network technology has the potential to alleviate the problem.

2. BACKGROUND INTRODUCTION

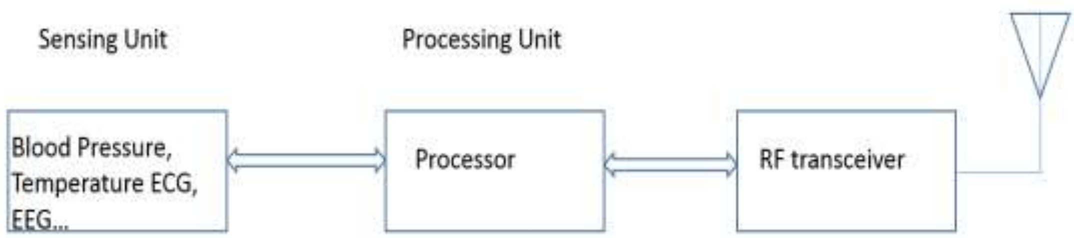


Fig.1: Block diagram of a typical sensor node.

In a wireless sensor network, as seen in the figure 1 below, each device is capable of monitoring, sensing, and/or displaying information. A sensor node is capable of gathering sensory information, processing it in some manner, and communicating with other nodes in the network.

Fig.1 shows that the basic sensing node can collect the physiological signals (e.g.: such as EEG, ECG, body temperature, blood pressure, heart beat etc.), when attached to a human body [3]. The processing unit processes all the sensed signals, then sends out the data based on communication protocols. All the processed data will be transmitted through a wireless link to a portable, personal base-station. Doctors can then obtain all the patients’ data through the network.

The main challenge for such sensor node is the high power consumption of portable devices. A solution to this challenge is the integration of the portable devices' digital and RF circuitry into one chip.

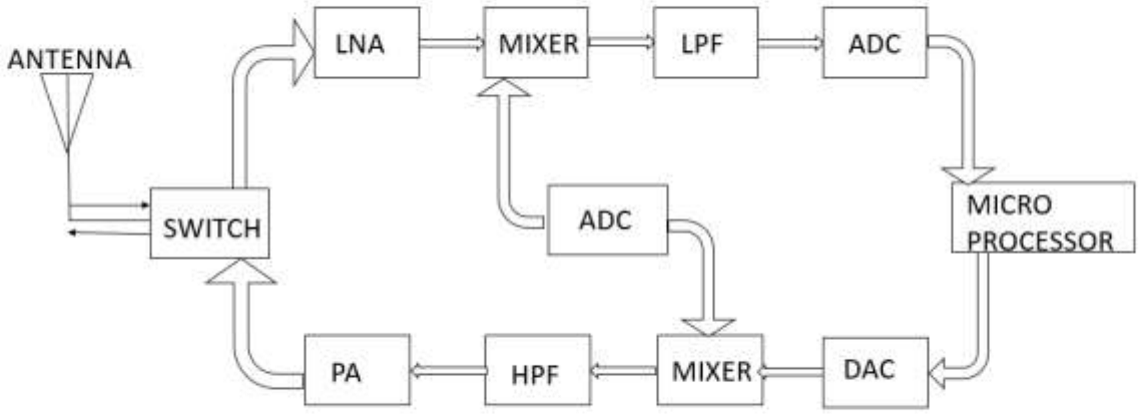


Fig.2: Block diagram of a transmitter

The receiver will receive the signal and will also perform DSP processing after the data is sent out by the transmitter [3]. Figure 2 is the transmitter diagram. It is desirable that the transmitter and receiver are low power devices. The director-conversion transmitter is very popular for such applications, because it offers versatility, flexibility, spectral efficiency, and low complexity. These features make the transmitter simpler than the super-heterodyne transmitter. Small chip and circuit size, and low power consumption can be achieved with a direct-conversion transmitter architecture. For the front-end transmitter, the major objectives are 1) transmit RF signals and 2) recover the biosignal classification. This paper proposes a low power receiver design. This paper is mainly for the power amplifier design, since other portions of the circuit design are already discussed in the paper [3]. In order to meet the standards, the PA is designed as shown in talble 1.

Table 1: PA design requirement.

Parameter	**Target**
Output Power	18dBm
PAE	30%
Stability	>1
S11	-10 dB

3. PA DESIGN

Over the past 30 years, research on CMOS radio-frequency (RF) front-end circuits has progressed extremely quickly. The ultimate goal for the wireless industry is to minimize the trade-offs between performance and cost, and between performance and low power consumption design [4].

The proposed Class AB amplifier has low output power and good linearity based on the IEEE 802.11b communication protocol. The class AB power amplifier topology is shown in figure 3. The 2.4GHz PA is a two stage common-source amplifier. The first stage is a driver stage, used for providing sufficient driving capability and a proper gain, as seen in figure 4(a), and the second stage is the power output stage which used for performing sufficient output power, as seen in figure 4(b)[5].

A. PA Deisgn

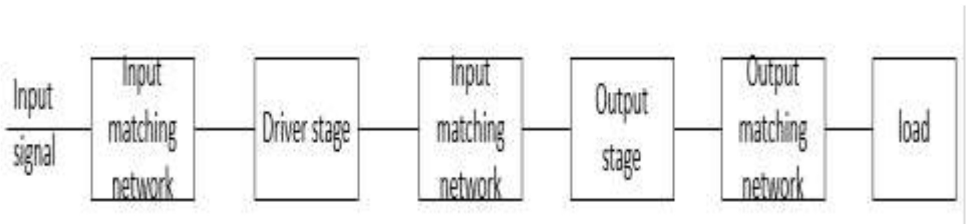
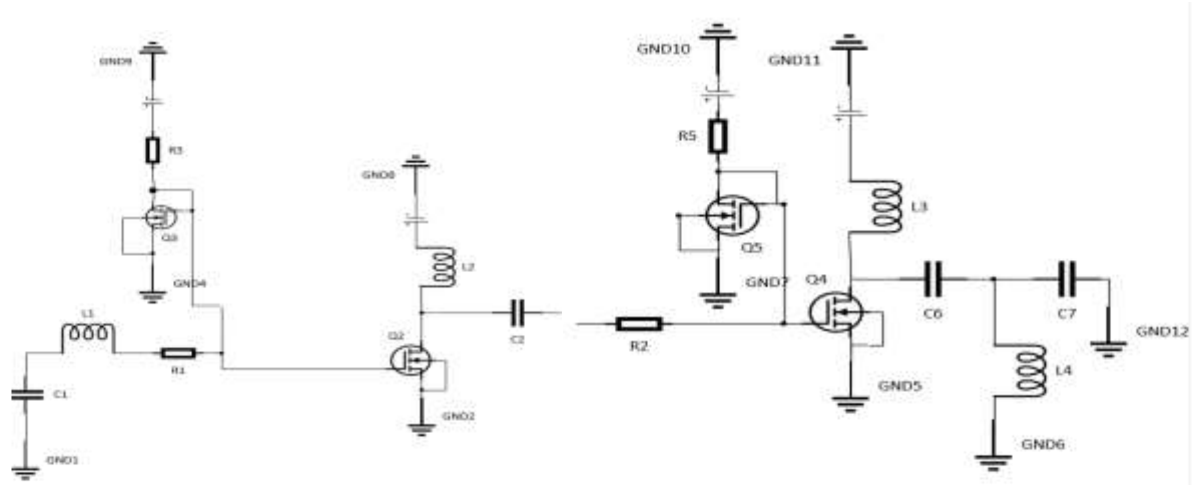


Fig.3: Block diagram of a class AB power amplifier



(a) (b)

Fig.4: (a) Schematic of driver stage. (b) Schematic of output stage.

For the drive-level circuit, the first design concern was ensuring the input and output conjugate match to different sizes of CMOS transistor. To get the optimum bias, small-signal simulation and 1dB compression point simulation are completed by their power output capability. Resulting design values can be shown in Table 2 and Table3.

Table 2: PA driver stage component.

Parameter	Size (Unit)
Q1	W/L=0.6um/0.6um (f=56,m=16)
Q2	W/L=0.3um/0.6um (f=88,m=36)
Q3	W/L=0.3um/0.6um (f=2,m=6)
R1	14.5 Ohm
R2	10K Ohm
R3	80 Ohm
L1	36 nH(Q=20)
L2	15 nH (Q=20)
C1	240fF
C2	10 pF
C3	100pF

After the output stage and driver stage, the inter-stage matching circuit is more challenging. If the input of second stage and output of the first stage are all conjugate matched to 50Ω, the two stages can be connected directly. The complete optimized circuit is shown in Figure 5.

Table 3: 2.4GHz PA output stage component.

Parameter	Size (Unit)
Q4	W/L=0.3um/0.6um (f=66,m=24)
Q5	W/L=0.3um/0.6um (f=4,m=2)
R4	5 Ohm
R5	80 Ohm
L4	30 nH(Q=20)
L5	10 nH(Q=20)
L6	10 nH(Q=20)
L7	1 nH (Q=20)
C4	800 fF
C6	390 pF
C7	1.1 pF

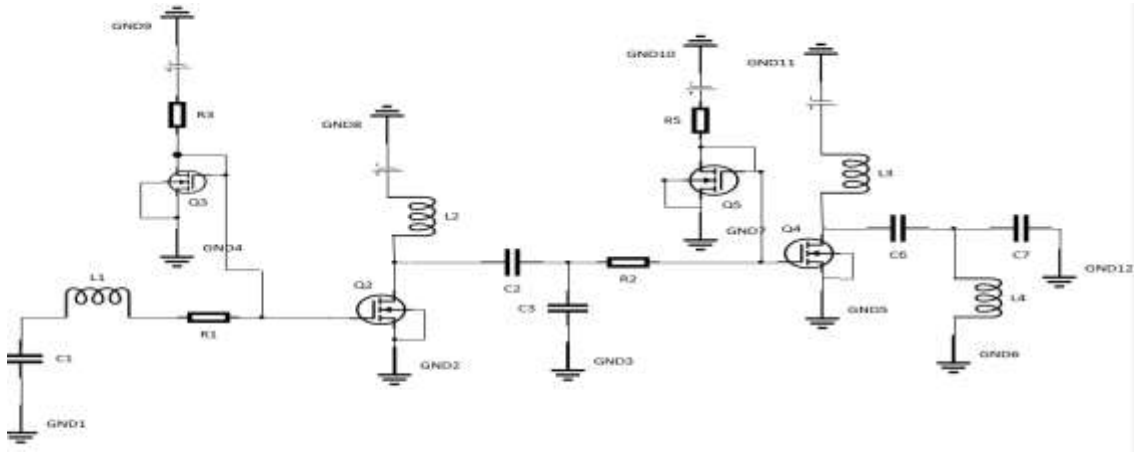
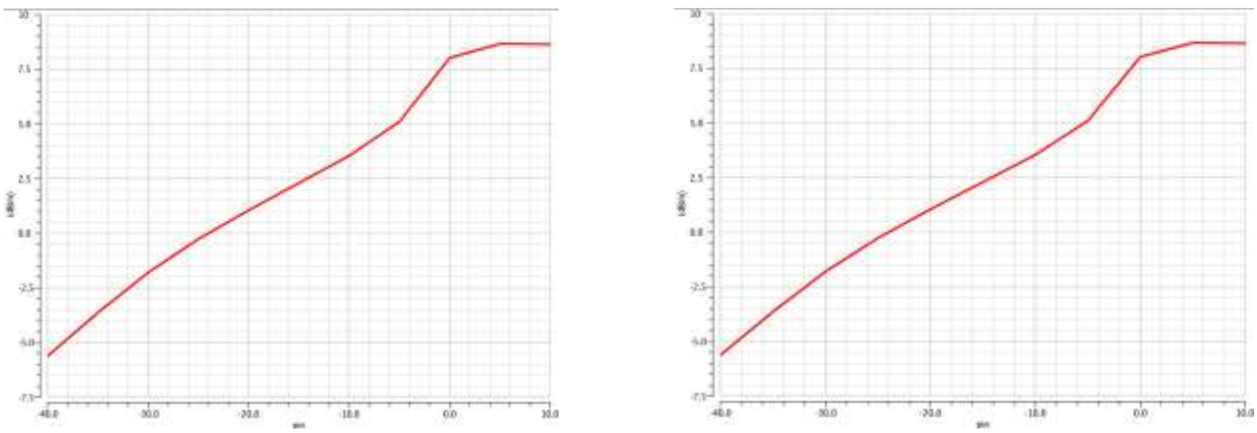


Fig.5: Overall circuit schematic

B. Class AB PA Design Simulation

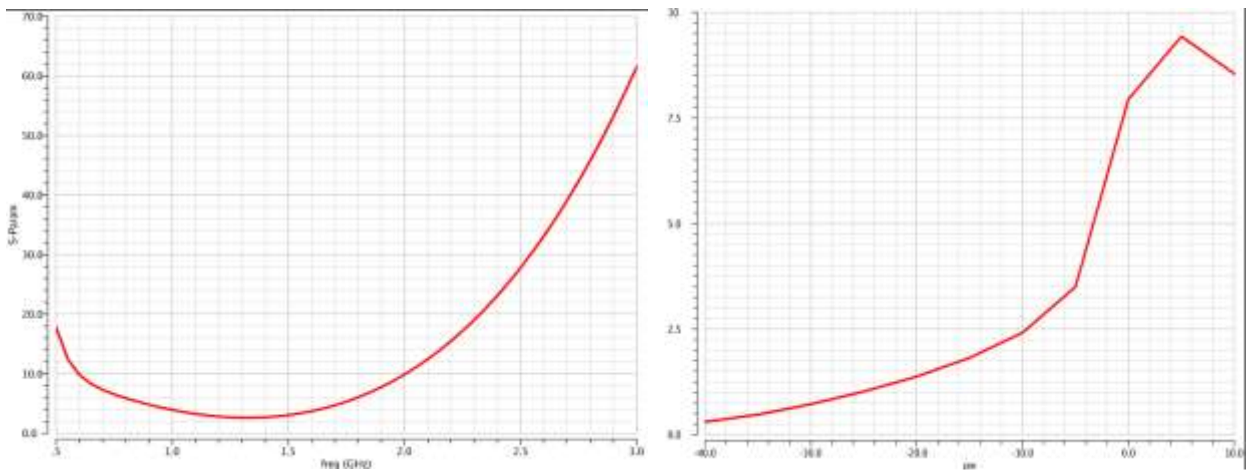
As seen in figure 6 (a), the output power is 8.5 dBm. As seen in figure 6(b), the frequency is at 2.4 GHz the S11 is less than -10 dB, also, the total power of the PA is 0.15 W.

As seen in figure7 (a), Kf is larger than 1 for all frequencies from 1 to 3 GHz, so this circuit is totally stable. And the PAE is 8.2% at input power 0 dB.



(a) (b)

Fig.6: (a) PA output (b) S11



(a) (b)

Fig.7: (a) Kf (b) PAE

CONCLUSION

In hospital healthcare, the monitoring system can help doctors to monitor the patient's physiological parameters. Using proposed technology, a pregnant woman can be checked for such parameters as Blood Pressure (BP) and heart rate of the woman and heart rate and movements of fetal to control their health condition. In her proposed system, a coordinator node can be attached to a patient's body to collect all the signals from the wireless sensors and sends them to the base station. The attached sensors on a patient's body form a wireless body sensor network and they are able to sense the heart rate, blood pressure and so on. The main advantage of this system in comparison to previous systems is to reduce the energy consumption to prolong the network lifetime, speed up and extend the communication coverage to increase the freedom for enhance patient quality of life. Patients can reduce the cost of staying hospital, and doctors can monitor patients' conditions at any time. Thus, poor people can receive better healthcare, and do not have to worry about money. This technologies are extremely important, because they can detect and prevent illness without a patient ever leaving their home. Thus, they could reduce hospital readmission rates, save hospital resources and save patients money. Remote monitoring systems help patients be aware of their physical conditions, and communicate more efficiently with their physicians. For this design includes LNAs, mixers and VCOs that build a low-power, compact, reliable and fully-integrated 2.4GHz heterodyne receiver. I discuss such issues, as design trade-offs, input matching, output matching, and tuning techniques.

This paper describes the method of designing and simulating power amplifier using cadence software based on SIMC CMOS process 180nm technology. This PA is used for sensor networks. This research is still in the early stages of development of a low cost and low power device. In order to reach the performance that is needed, the PA process uses group III and IV elements. This circuit meets the scheduled requirements for the CMOS process, but it still has room to improve performance metrics. When the sensor is coupled with communications technologies such as mobile phones and the Internet, the sensor network constant information flow between individuals and their doctors. Such low cost and low power device can save a lot of hospitalization resources. To realize this, future improvement is needed.

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