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Power Amplifier and Low Noise Amplifier for WLAN Applications

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Abstract: Wireless Local Area Network (WLAN) applications operating at a frequency of 2.45 GHz are a frequently used communication method in transmission tools. The connection functions to send and receive data between access points and smart devices are also fulfilled by WLAN technology. Communication quality in data transfer gains importance for this technology at every stage. Front-end module structures are used to increase such quality affects directly the efficiency. Circuits including power amplifier (PA), low noise amplifier (LNA), antenna and filter are the most significant components that compose front-end structures. In this study, PA and LNA using PW570 gain block & BFP760 RF transistor circuit respectively are proposed. Through the usage of the proposed circuits, there will be considerable improvements in data communication speed and area of coverage, which are among the WLAN performance factors.

Keywords: front-end, amplifier module, IEEE 802.11b/g/n, IEEE UHF

Kablosuz Yerel Alan Ağları Uygulamaları için Güç Kuvvetlendirici ve Düşük Gürültülü Güç Kuvvetlendirici

Öz: 2.45 GHz frekansında çalışan kablosuz yerel alan ağları (WLAN) uygulamaları haberleşme araçlarında sıkça kullanılan bir iletişim yöntemidir. Erişim noktaları ile akıllı cihazların arasında gerçekleşen veri gönderimi ve alımı için bağlantı fonksiyonları da WLAN teknolojisi ile gerçekleşir. Veri transferindeki iletişim kalitesi bu teknoloji içinde her aşamada önem arz etmektedir. Verimi doğrudan etkileyen kaliteyi artırmak için ön-uç modül yapıları kullanılmaktadır. Güç kuvvetlendirici (GK), düşük gürültülü güç kuvvetlendirici (DGGK), anten ve süzgeç içeren devreler ön-uç yapılarının en önemli bileşenlerini oluşturur. Bu çalışmada, PW570 kazanç bloğu kullanılarak GK ve BFP760 RF transistör devresi kullanılarak DGKK önerilmiştir. Önerilen yeni devrelerin kullanılması sayesinde WLAN performans etkenlerinden olan veri iletişim hızında ve kapsama alanında önemli iyileşmeler olacaktır.

Anahtar Kelimeler: ön-uç, kuvvetlendirici modül, IEEE 802.11b/g/n, IEEE UHF

1. Introduction

Antenna-filter-switch-PA or LNA sequence is preferred as the most general circuit form for communication protocols. Along with WLAN, another communication technology such as Bluetooth can be used in this system by adding new switches [1]. Low noise figure and high linearity are important figures of merits for designing an LNA [2] which can also be used for Worldwide Interoperability for Microwave Access (WiMAX) apps [3-4]. LNA and PA designs can be with chips as well as with transistors such as Complementary Metal Oxide Semiconductor (CMOS), heterojunction bipolar transistor (HBT), field-effect transistor (FET), High-electron-mobility transistor (HEMT) and Pseudomorphic High Electron Mobility Transistor (pHEMT) [5-6]; the biasing is prominent for the selection [7]. The waves emitted from the antenna have to be

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amplified first with PA and it is essential to form a stable [8] and efficient [9] circuit according to practice. While creating the PA circuit, which class will be applied may also be selected according to the level of efficiency and linearity [10].

After the PA and LNA designs in the modules are made for WLAN applications, various optimization techniques can be applied finally to ensure that the system works at the desired level [11]. It is also requisite that the final produced product is low cost, small in volume and appeals to many fixed connectivity applications. In this research, the PA project using the PW570 RF gain block chip [12] and LNA project utilization of the BFP760 bipolar RF transistor [13] are presented; the full structure which can be integrated into many WLAN applications is small, low-cost and easy to implement.

2. Materials and Methods

A front-end module contains LNA, which captures the data from the antenna, even weak signals, amplifies them and purifies them from unwanted ones. The remarkable values pass through the LNA and continue as Rx towards the interior of the circuit. The electromagnetic (EM) waves that the circuit needs to radiate through the antenna called Tx and are amplified by the PA in advance and directed toward the antenna. The switch decides whether to use the antenna, which is only one piece for this type of circuit, with LNA or PA. A band pass filter (BPF) is also used between the antenna and switch to make signals pass at the desired frequency. In Fig. 1, an example of a structure containing all possible elements for a basic front-end module with the main circuit is given.

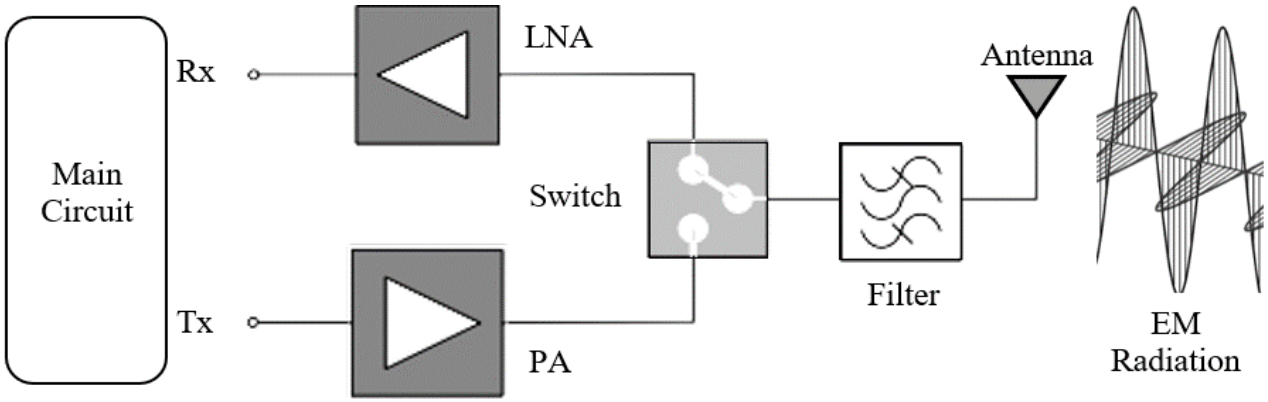

Figure 1. A basic front-end module.

2.1. Power Amplifier

The application circuit convenient for the PW570 InGaP HBT gain block as MMIC Amplifier from Prewell has been designed and built on the Rogers 4350B substrate that has 3.66 electrical permittivity via the AWR program. The MMIC chip and application of the full circuit can be seen in Fig. 2 a. the R1 is the bias resistor and the C1 capacitor is for RF decoupling. While the C4 is for input matching and DC blocking, the C2 is for output matching and stability improvement. The characteristic impedance value is 50 ohms for the power amplifier. Lumped element values, which are chosen to make the center frequency 2.45 GHz with the help of optimization and tune tools, of the amplifier are written on the circuit schematic.

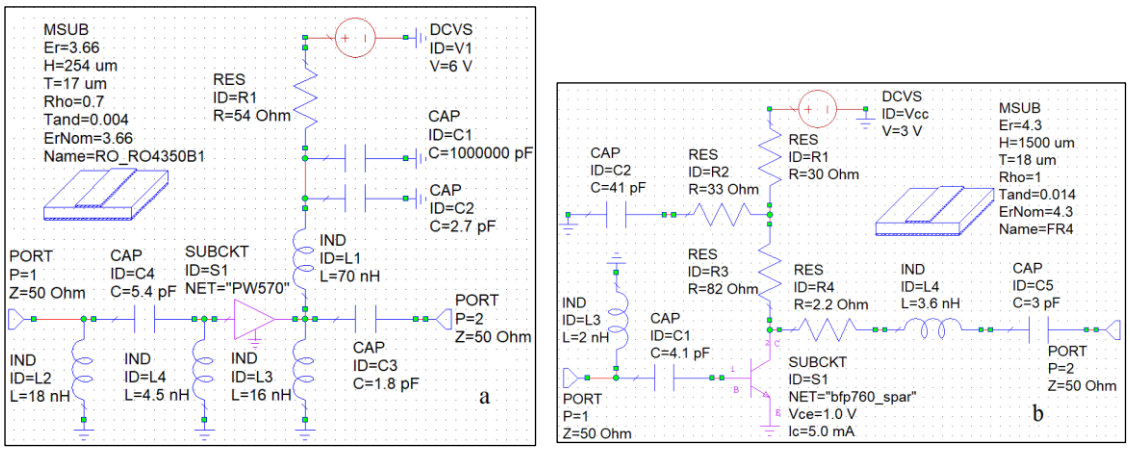

Figure 2. a. PA circuit **b.** LNA circuit.

C3, C4 capacitances and L1, L2 inductances are not connected for WLAN or WiMAX apps (emerging wireless communications) if they are performed at 2.45 GHz [14].

2.2. Low Noise Amplifier

Silicon Germanium Carbon (SiGe-C) NPN Heterojunction wideband Bipolar RF Transistors (HBT), BFP760 in this work, are widely used to design LNA. BFP760 transistor whose noise figure (NF) value is a minimum of 0.6 dB for 2.45 GHz frequency utilization of WLAN technology is appropriate for front-end LNA circuits. As shown in Fig. 2 b, C1, L3 & R4, L4, and C5 are for input & output matching, respectively. The element values are chosen with optimization and tune tools of AWR program like PA design as usual. LNA may also be cascaded according to the requirements, one LNA was used in this labor.

3. Results and Discussion

The EM waves, which will be created in the main circuit and radiate to the external environment through the antenna, will first be amplified by the PA. Therefore, the gain value of PA becomes important. In this plan, as shown in Fig. 3, the transducer power gain of the PA (S21) is close to 16 dB which is fair enough for this kind of system [15]. S11 and S22 parameters are lower than -12 dB. For PA studies, it is ordinarily around -10 dB, which is prominent for performance. The S12 (entering from outside) parameter is below -20 dB which is considered fine. Other obtained datums were found by the datasheet information [12].

After the EM waves are taken from space by the antenna and eliminated by the filter, they come to the LNA using a switch. LNA, according to its degree, amplifies even weak signals and sends them to the main circuit. In Fig. 3, LNA has 17.85 dB gain and approximately -5 dB input and output reflection coefficients. It has a -18 dB S12 scattering coefficient value at the operating frequency of 802.11b/g/n. A similar circuit design with the same transistor [16] was carried out with Infineon Designer powered by TinaCloud and Fig. 4 was found. The S parameters of the graph of Fig. 4 are very close to the LNA side (right) in Fig. 3. Amplifier design circuits (PA or LNA) are exemplified by handling a withal chip or transistor.

The use of RO4350B substrate for the chip and FR4 substrate for the transistor makes it impossible to integrate the circuits on the same board, which is the weak side of this work, on the other hand, it is the strength of the work to run each active element by the datasheet, therefore the factory data. The ultimate circuits work stably (K and B1 factors).

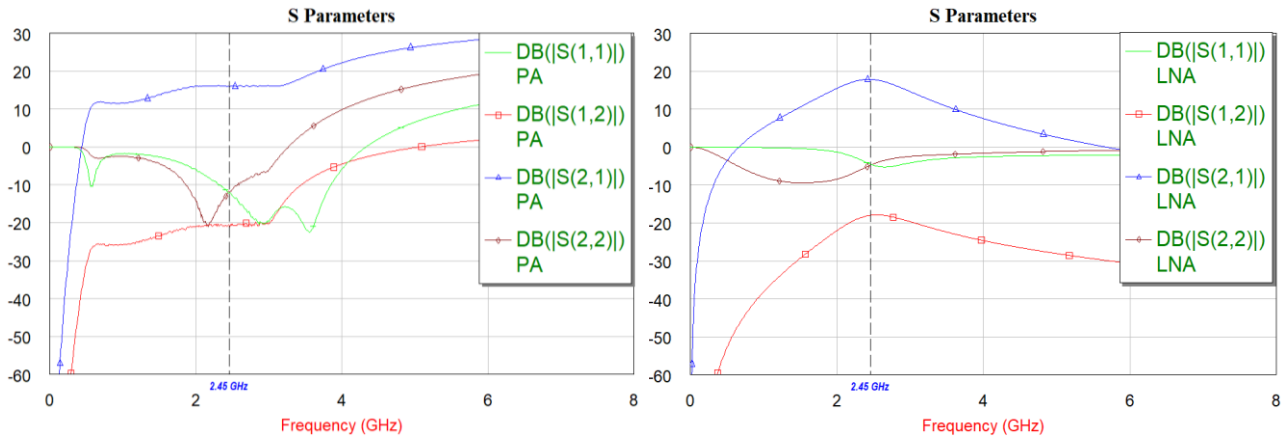

Figure 3. S Parameters of the PA & LNA circuits.

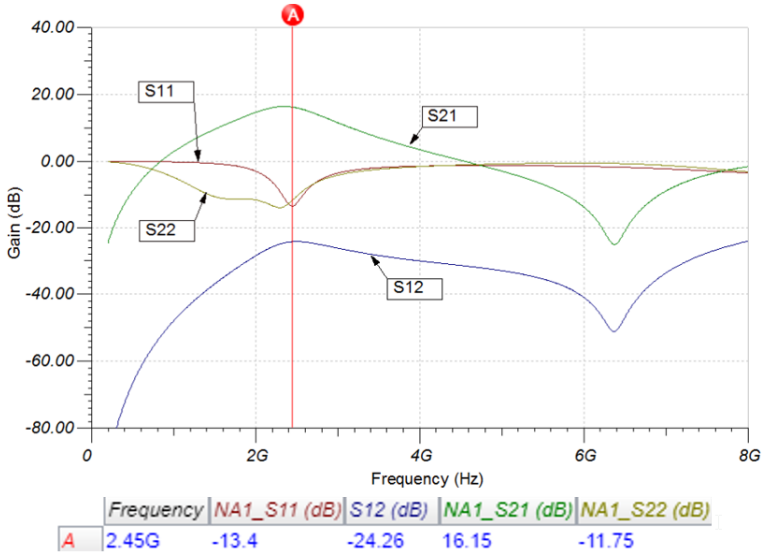

Figure 4. S Parameters of the LNA circuit via Infineon Designer powered by TinaCloud.

4. Conclusion

PA and LNA design that can function in S-band and take part in pioneering techniques such as WLAN and WiMAX has been proposed. As a result, the main circuit will be able to benefit from the front-end circuit with maximum efficiency in the operating region called UHF according to IEEE. For 802.11b/g/n, a high gain will be achieved when data transmission or reception is implemented with the recommended circuits [15, 17].

5. Future Works

The possibility of processing on the same circuit board will be investigated. Band pass filter will be designed with a microstrip patch antenna or dipole wire antenna and printed circuit processes will be started with the implementation of the manufacturer components.

Author's Contributions

MD conducted literature searches, designed circuits, analyzed and interpreted results, calculated theoretical notations and wrote the article. The author read and approved the final manuscript.

Conflict of Interest

The author declares that there is no conflict of interest.

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