AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electronics Engineering and Electrical Communications

DESIGN & IMPLEMENTATION OF SATELLITE RECEIVER FOR UNMANNED VEHICLE

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electronics Engineering and Electrical Communications)

by

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Statement

This thesis is submitted as a partial fulfillment of Master of Science in Electrical Engineering Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Thesis Summary

This thesis discusses one of the modern microwave receiver systems in the range of Ku-band applications as satellite receiver for unmanned vehicle and some other applications. The main objective of this thesis is conducting for a case study and design dual band receiver in the downlink and uplink carrier in Ku-band achieving multifunctional, low cost and reduced size.

- **Chapter One:** This chapter is an introduction about microwave systems, receiver architectures, the proposed RF front end receiver operating frequency and the system specifications.

- **Chapter Two:** This Chapter discusses the RF front end receiver parts. Firstly, we describe the definition of microstrip antennas, definition of basic and important antenna parameters. Secondly, we begin with the basic concept of filter and its types, then important characteristics for the microstrip filter. Finally, for a fundamental understanding of the Low Noise Amplifier procedure, we introduce a series of underlying concepts.

- **Chapter Three:** This Chapter discusses the following steps for designing the dual band RF front end receiver components separately. The first step explains the design of conventional shape for rectangular microstrip patch antenna at two different frequencies. Then, we introduce steps of design of rectangular patch with slits. The proposed antenna is fabricated and measured. We compare between the simulation and measured results which achieved the required goals.

  The second step is the procedure for designing the conventional shape of microstrip parallel coupled line bandpass filter at the uplink and downlink of Ku-band. Next, we design, simulate and fabricate the wide band filter which have good agreement results between simulation and measured results. Then, we design and fabricate the proposed dual band filter using a microstrip parallel coupled, half-wavelength resonator with tuning capacitor in series with coupled sections which achieved the required goals.

  The third step starts with features and important characteristics of the Low Noise Amplifier transistor at the Ku-band. After that, we begin the Low Noise Amplifier design with the DC analysis. Then design the biasing network, matching input/output network, and finally connect the sub networks together, to achieve the required goals. Finally, the S-parameters of each component in our system are transferred to the CAD tool, and the final results are found to meet our goals.

- **Chapter Four:** This chapter discusses the implementation of RF font end receiver in lower L-band. We started with the proposed wide band antenna specifications, and the design steps of the circular patch antenna with u-slotted and partial ground. We fabricated the proposed antenna and measured the different parameters and results are found to achieve our goals. Next, we present a wide band microstrip parallel coupled line filter. We designed, simulated and fabricated the wide band filter which have good agreement between simulation and measured results. After that, we introduced the low noise amplifier specifications with its features and important characteristics and measurements, and results are found to achieve our

goals. Finally, we measured and simulated the proposed system and the results are satisfying our goals.

- **Chapter Five:** This chapter discusses conclusion and future work for this research point.

- **Appendices & References**

Key Words:

RF Receiver, Ku-band, Microstrip antenna, Microstrip BPF, and Low Noise Amplifier.

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Abstract

This thesis discusses one of the modern microwave receiver systems in the range of Ku-band applications as satellite receiver for unmanned vehicle and some other applications .The main objective of this thesis is conducting for a case study, and design a dual band receiver in the downlink and uplink carrier in Ku-band, achieving multifunctional, low cost and reduced size. To achieve the most suitable design for the proposed system, we divide the RF front end receiver into small parts as an antenna, band pass filter and low noise amplifier.

The proposed antenna is designed to operate at dual frequencies 12.54GHz as downlink and 14.15GHz as uplink in Ku band. The proposed solution designed from a microstrip rectangular patch with three pairs of slits. The proposed antenna was designed using a ready-made software package (ZELAND IE3D-Full-Wave EM Simulation Package). Then the designed antenna has been fabricated by using thin film and photolithography technique and has been measured by using the vector network analyzer (Rohde & Schwarz ZVB20). Performance evaluation has been conducted for the simulated and measured results which determined that the designed antenna achieved the required goals at frequencies 12.5 GHz to 12.9 GHz in downlink , and from 14.1 GHz to 14.4 GHz in uplink. The VSWR is less than 2 over the planned bandwidth.

The second part is the dual band filter, which is designed to operate at dual frequencies 12.54 GHz as downlink and 14.15 GHz as uplink in Ku band. The proposed band pass filter is designed from a microstrip parallel coupled line, half-wavelength resonator using a tuning capacitor in series with coupled sections. The design and the simulation were carried out using ready-made software Advanced Design System (ADS) electromagnetic simulation tool. To verify and ensure the design and simulation results, we fabricated and measured the dual band filter to prove the process is right. We have good agreement between the simulation and measured results except small deviation. The bandwidth of the measured result is given (70 MHz) around the center frequency at 12.53GHz and bandwidth from (12.49 GHz - 12.56 GHz) at the downlink and bandwidth (50 MHz) around the center frequency at 14.17GHz and bandwidth from (14.14 GHz - 14.19 GHz) at the uplink.

Low noise amplifier is the third part in the RF front end receiver in Ku-band. The wideband LNAs are used in different applications such as broadband and multiband systems, which provides acceptable impedance matching with higher gain and low noise figure. The proposed design of LNA uses the low noise BJT transistor DC analysis to find the biasing value required to operate in specific frequency range at Ku-band. The wideband low noise amplifier operating at 13.6GHz and bandwidth 2.1GHz has been designed using wideband biasing network and input- output matching network technique using double stub technique. The design is simulated using (ADS). The simulation results of low noise amplifier design after connecting all the sub-networks together achieve more than 11 dB gain.

After we finished the design of the RF front end components, we transferred the S-parameters for each circuit contained in our system into (ADS), and the system is simulated using (ADS). After the integrated circuits were realized the simulation results at the downlink and uplink frequencies achieved high dynamic range with minimum detectable signal less than -30 dBm and the maximum signal higher than -2 dBm, low noise figure less than 3 dB, wide rejection and high selectivity for the downlink and uplink from 12.48 GHz to 12.57 GHz and from 14.13 GHz to 14.19 GHz respectively.

Because of the difficulty in obtaining the RF components in Ku-band from the commercial markets, so it is to demonstrate our ability to design and implementation of the RF front end receiver. We proposed a method to design and implement an RF font end receiver in lower L-band. The wide band RF front end receiver is designed to operate at the lower L-band with bandwidth from 1000MHz to 1400 MHz. The lower L-band is used also in satellite applications especially GNSS Global Navigation Satellite Systems. We proposed a wide band RF front end receiver in lower L-band that can cover four different navigation systems (GPS- Galileo-Compass- Glonass), which provides multifunction receiver with low cost and reduced size.

The proposed antenna design is based on a simulation using (CST) to operate at lower L-band from (1000 MHz to 1400 MHz). The proposed antenna structure is circular microstrip patch with U-slot and partial ground. Then, the proposed antenna has been fabricated and measured. We compare between the simulation and measured results of the proposed antenna and the final results are found to meet our goals

The proposed wideband filter is also designed to operate at lower L-band. The proposed filter design methodology is the same as what was used in the previous RF front end receiver in Ku-applications. The microstrip bandpass filter was designed and simulated using (ADS). The proposed filter has a measured bandwidth from (1000 MHz to 1400 MHz) and VSWR less than 2 over the bandwidth.

The low noise amplifier in L-band (ZRL-1150LN+) with low noise figure and flatness gain was obtained and measured using vector network analyzer (Agilent N9918A).

We connect the RF front end receiver circuits together and measured the receiver performance using VNA. The simulated S-parameters data of each component in our system was transferred into the (ADS) to compare with measured result. The simulated and measured results have a good agreement except for small difference because of the RF signal propagation effects, which the simulator tools don’t take into account.

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