**AMRITA SCHOOL OF ENGINEERING, Bengaluru**

**ELECTRONICS AND COMMUNICATION ENGINEERING**

**BTech PROJECT REPORT**
**(2018-19)**

# ADS-B air traffic monitoring and collision avoidance receiver using RTL- SDR

**DOMAIN AREA**

## RADAR communication System

**TEAM DETAILS**

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# CHAPTER 1 :

**Introduction:**

With the world making tremendous progress in technology the number of airplanes that humans are using is increasing at a rapid rate. Airplanes are the fastest way to travel around the world. There have been accidents and threats that are caused by the human errors and lack of reliable and secure communication between the airplanes. These collisions can prove to be deadly as the debris have devastating impact on the land. The existing radar systems are outdated and are not effective. ADS-B provides a cost effective and reliable way to detect the threat well in advance and provides foolproof solution to prevent mid air collisions(MAC).

ADS-B is a surveillance technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it, enabling it to be tracked. The proposed system periodically checks the parameter values with reference to the pre-set thresholds.When the value exceeds the threshold, a warning is given to both the aircrafts and necessary protocols are initiated to prevent collision.

ADS-B is replacing conventional RADAR based surveillance as the primary method for identifying and tracking aircrafts. By the year 2020, ADS-B is going to be mandatory for every airplanes and airport to have in the United States of America.

ADS-B stands for autonomous dependent surveillance- broadcast. These systems are basically present onboard aircrafts, which transmit their present GPS location and some other information (velocity, altitude, weather etc.) automatically without any interrogation by any one. Corresponding ADS-B receivers can receive, interpret and display those aircrafts locations.

ADS-B consists of two different services, ADS-B Out and ADS-B In.

ADS-B Out periodically broadcasts information about each aircraft, such as identification, current position, altitude and velocity through an onboard transmitter. ADS-B Out provides air traffic controllers with real-time position information that is, in most cases, more accurate than the information available with current radar-based systems. With more accurate information, ATC will be able to position and separate aircraft with improved precision and timing.

ADS-B In is the reception by aircraft of FIS-B and TIS-B data and other ADS-B data such as direct communication from nearby aircraft. The ground station broadcast data is typically only made available in the presence of an ADS-B Out broadcasting aircraft, limiting the usefulness of purely ADS-B In devices.

The system relies on two avionics components—a high-integrity GPS navigation source and a datalink (ADS-B unit). There are several types of certified ADS-B data links, but the most common ones operate at 1090 MHz, essentially a modified Mode S transponder or at 978 MHz.

A traffic collision avoidance system (TCAS) or traffic alert and collision avoidance system is an aircraft collision avoidance system designed to reduce the incidence of mid-air collisions between aircraft. It monitors the airspace around an aircraft for other aircraft equipped with a corresponding active transponder, independent of air traffic control and warns pilots of the presence of other transponder-equipped aircraft which may present a threat of mid-air collision (MAC).

## CHAPTER 2:

# LITERATURE SURVEY:

PAPER 1 : " **CAN SOFTWARE DEFINED RADIO BE USED TO COMPROMISE ADS-B AIRCRAFT TRANSPONDER SIGNALS ?** "

AUTHORS : **REVELS M A CIAMPAM .**

Summary: Air traffic control is moving from independent primary surveillance radar to the automatic dependent surveillance-broadcast (ADS-B) system. This holds the potential of reducing the total cost of deployment and improving the detection accuracy of aircraft. However, as currently being deployed these systems lack strong security mechanisms and are susceptible to a variety of radio frequency attacks. In this paper, a basic $200 software defined radio (SDR) transceiver was used to simulate an ADS-B replay attack to determine if a ground-based user could interfere with an aircraft in flight. It was demonstrated that using a low cost SDR transceiver, such an attack could not occur. The ability to record-and-replay ADS-B signals such that they would interfere with navigational systems is limited by two factors: low output power and poor transmitted signal quality. Despite the fact that attacks on aircraft have frequently been proffered by attackers at hacker conventions and by academic researchers, the research shows that these are only theoretical in nature and have not demonstrated a firm proof of concept.

**Ideas Obtained**: The overview of ADS-B along with its current implementation, advantages and vulnerabilities were discussed along with the implementation of its methodology.

PAPER 2 : " **KEY DISTRIBUTION SYSTEM FOR AIRCRAFT EQUIPPED WITH SECURE A D SB - IN "**

AUTHORS : **THABET KACEMAND DUMINDA WIJESEKERA**

Summary: Lists about Primary Surveillance Radar (PSR) and Secondary Surveillance Radar (SSR) and drawbacks of these old technologies. The paper suggests a cost effective and accurate way to determine GPS coordinates of the airplanes at all times. ADSB will soon replace the traditional radar methods. ADSB has a large field and has various parameters like coordinates altitude, velocity ,bearing etc due to the size of its packets.

**Ideas obtained:** The protection and security of the data is highly essential in an ADS-B and can be done by two one-way hash chains of keys.

PAPER 3 : " **DESIGN APPROACH FOR WIDEBAND FM RECEIVER USING RTL - SDR AN D RASPBERRY PI** "

AUTHORS : **SATYANARAYAN A P , SYAM KUMAR M . N . V . S , KEER THIKISHANA , SURAJ , K.V. R. K .**

Summary: Software defined radio replaced majority of hardware modules like mixers, filters, modulators and demodulators etc., with Software blocks in the field of radio electronics and communication. Various SDR transceiver modules can be interfaced with digital computer and aided

with firmware like GNU radio, SDR shark, etc., allowing us to construct blocks with the help of built in components that decode and process the received data and produce required output. The main purpose of the software defined radio is to act as very cheap, multi operating system compatible RF front end for the wide range of the signals frequencies. In this paper, the implementation of an FM receiver along with a brief look of SDR based communication system with the help of RTL-SDR as an RF front end and implementation of some modulation schemes in GNURADIO with Raspberry pi as a computational device is done.

**Ideas Obtained:** The theoretical analysis of Software Defined Radio, RTL-SDR, Raspberry PI and GNU Radio is performed along with the experimental setup of the WBFM receiver implemented practically using RTL-SDR.

PAPER 4 : " **AIRCRAFT MONITORING BY THE FUSION OF SATELLITE AND GROUND D S - B DATA** "

AUTHORS : **XUANZHANG , JINGJING ZHANG , SHUFANWUA , QI ANCHENG , R UIZHU**

Summary: This paper first introduces the CubeSat mission, then discusses the integrated application of ADS-B data received from ground stations and from satellites, analyze their characteristics with statistical results of comparison, and explore the technologies to fuse these two different data resources for an integrated application. The ADS-B data received from two different resources will complement each other, such as to increase the coverage of space for air traffic and to monitor the whole space in a better way.

**Ideas Obtained**: The usage of satellites for ADS-B to increase it's coverage area, which in-turn causes better efficiency of the system and making it more cost effective.

PAPER 5 : " **SOFTWARE DEFINED RADIO BASED RECEIVER USING RTL-SDR REVIEW**'

AUTHORS : **MISHRAM , POTNISA , DWIVEDY P , MEENA S . K**

Summary: Software Defined Radio is one of the most important and latest technique for modern wireless communication. SDR is a radio which can be tuned to any frequency band which the hardware supports, implement different modulation and demodulation schemes and different signal types and standard(s) in the same device by using reconfigurable hardware and using powerful SDR systems. The main types of devices that can be implemented using SDR are only Radio Receiver, only Radio Transmitter and a Transceiver which provides function for both transmitter and receiver. The availability of low cost SDR hardware with good functional capability has reduced the overall cost of SDR system. This paper also provides a comparison between different types of radio systems developed using SDR and their performance analysis.

**Ideas Obtained:** The importance of SDR along with its working, its radio configurations, benefits and challenges have been obtained. Along with this, the working of the RTL-SDR Dongle and the interfacing of Computer and SDR is mentioned.

PAPER 6 : "**SPECTRUM ALERTING SYSTEM BASED ON SOFTWARE DEFINED RADIO AND RASPBERRY PI** "

AUTHORS : **DAVID BALL , NITIN NAIK AND PAUL JENKINS**

Summary: Inexpensive and generic Spectrum Alerting System (SAS), based on software defined radio by employing an RTL-SDR USB device, Raspberry Pi and Python. The SAS device is fully automated and the

frequency of the sweep can be configured according to the sensitivity and type of operation taking place. When the results are compared with the baseline and if a difference is detected, according to pre-set thresholds, an alert is generated and sent. Ideas Obtained: Using the sweeps to keep track of the parameters, alerts will be sent to avoid collision if any of the thresholds are crossed.

**Ideas Obtained:** Using the sweeps to keep track of the parameters, alerts will be sent to avoid collision if any of the thresholds are crossed.

PAPER 7 : " **HOW TO PROTECT ADS-B - : CONFIDENTIALITY FRAMEWORK FOR FUTURE AIR TRAFFIC COMMUNICATION** "

AUTHORS : **EMAN HABLEEL , JOON SANGBACK , YOUNG JIBYON A ND DUNCAN S WONG**

Summary: ADS-B needs less infrastructure as they use the Global Positioning System (GPS) satellites which allows the airborne objects to be monitored with fewer ground stations, and any entity that owns transmission receivers can capture and receive ADS-B signals. ADS-B applications can be installed on any smart devices to allow users to monitor the movement of aircraft. for displaying up-to-date live monitoring of flights, airlines. Security flaws persist in this type of system and it is vulnerable to security attacks.

**Ideas Obtained:** Real time monitoring and parameters can be displayed on a mobile app, to protect the ADS-B system.

PAPER 8 : "**ADS - B SIGNAL RECEPTION AS SOFTWARE DEFINED RADIO APPROACH**"
AUTHORS : **EMILIOG . PIRACCI , GASPAR E GALATI , MARCO PAGNINI**

Summary: ADS-B systems are characterized by an easy implementation and a lower cost as compared to surveillance radars however, they are affected by problems related to security, system integrity, and system performance in high traffic density areas. The open mode S protocol does not guarantee security: actually low cost devices are available to receive the ADS-B signals and then to track the pertaining flights. It is also possible to generate false traffic (spoofing). A 1090 MHz multi-channel receiver was implemented. Transponder Data Recorder(TDR) is designed to receive and record live signals from an array antenna, useful for channel characteristics estimation, as well as to collect signals for trials and tests. It also helps to increase surveillance capacity and detect a jammer.

**Ideas Obtained:** Using this, data can be secured and ensure that no jamming or spoofing occurs thus improving the reliability of the system.

# CHAPTER 3:

## PROJECT IDEA:

The RTL-SDR can be used as a cost effective real time air RADAR. Modern planes in some parts of the world use ADS-B (Automatic Dependent Surveillance-Broadcast) Mode-S transponder, which periodically broadcasts location and altitude information to air traffic controllers. The RTL-SDR can be used to listen to these ADS-B signals to track aircrafts radar system. Compared to dedicated commercial ADS-B receivers the cost can reduce the cost by what

ADS-B broadcasts at a frequency of 1090 MHz. It has been discovered by the RTL-SDR community, that the RTL-SDR with R820T tuner has the best sensitivity at this frequency. It has an R820T tuner if which is helpful ADS-B decoding with the RTL-SDR.

# CHAPTER 4:

**The hardware was setup as per our block diagram given below. The live tracking of the flight and their parameters are displayed as shown below.**

## BLOCK DIAGRAM:

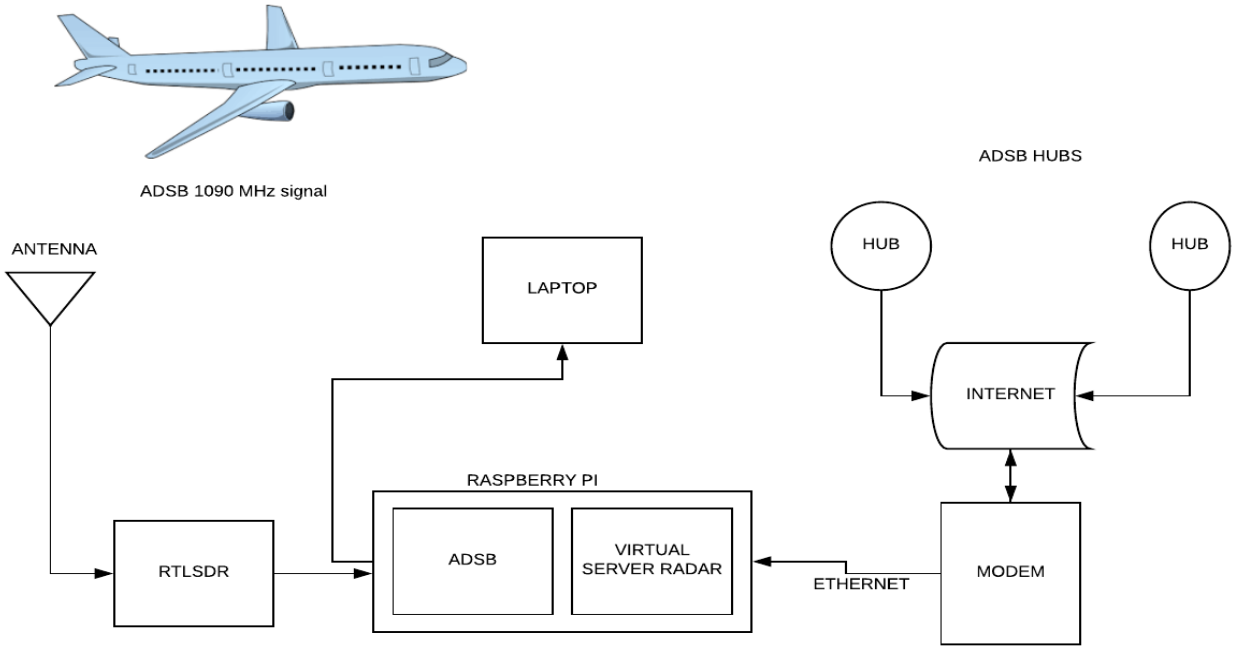


**Figure 4.1**

The antenna receives the 1090 MHz signal and it is then sent to the RTL-SDR.
The Raspberry Pi acts as a mini computer to help process the signals and track/monitor the flight path.In order to run the Pi, ethernet connections are required and this has been shown in the figure.
The RTL-SDR radio is capable of using a sampling rate in the range [200e3, 2.8e6] Hz. When RTL-SDR radio is the source, the example is used and interpolation is carried out.

## SIMULATION:


**Figure 4.2**

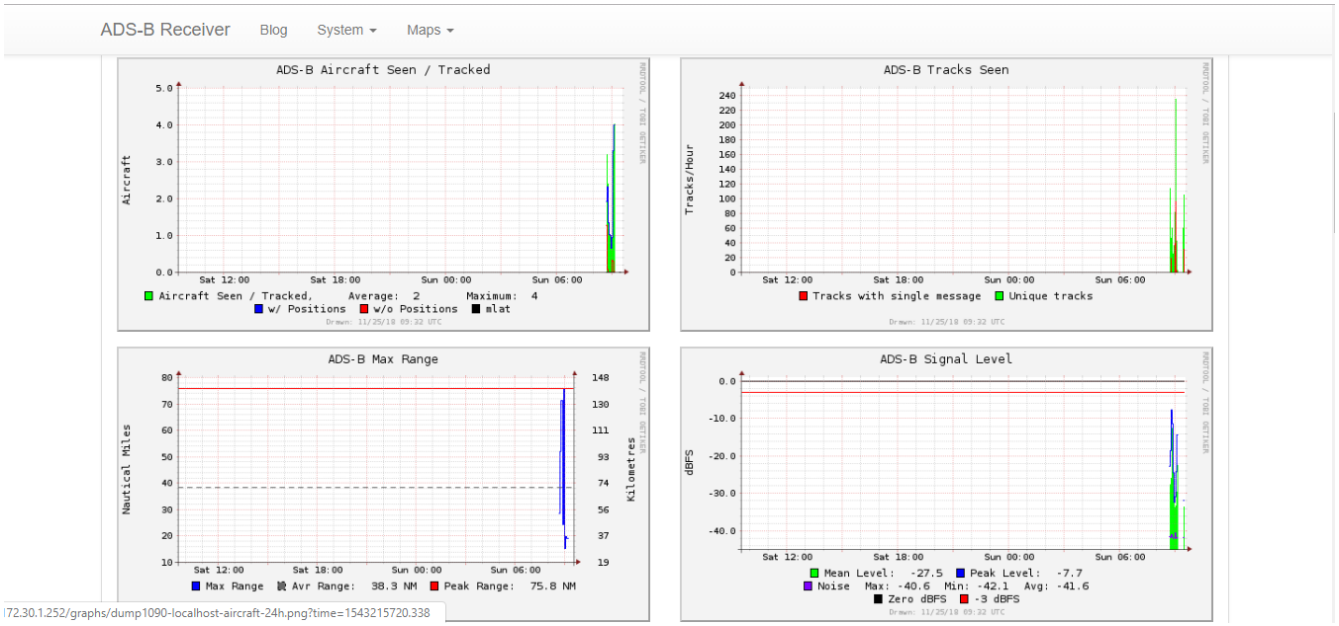


**Figure 4.3**

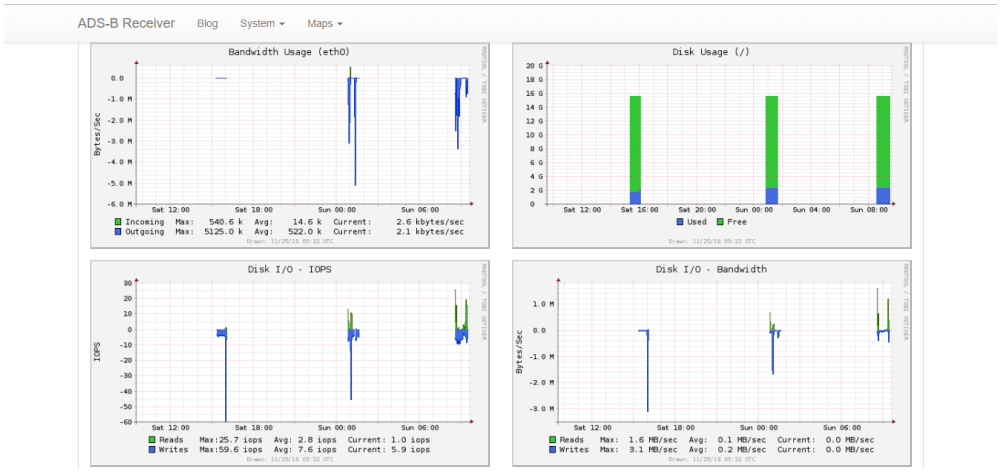


**Figure 4.4**

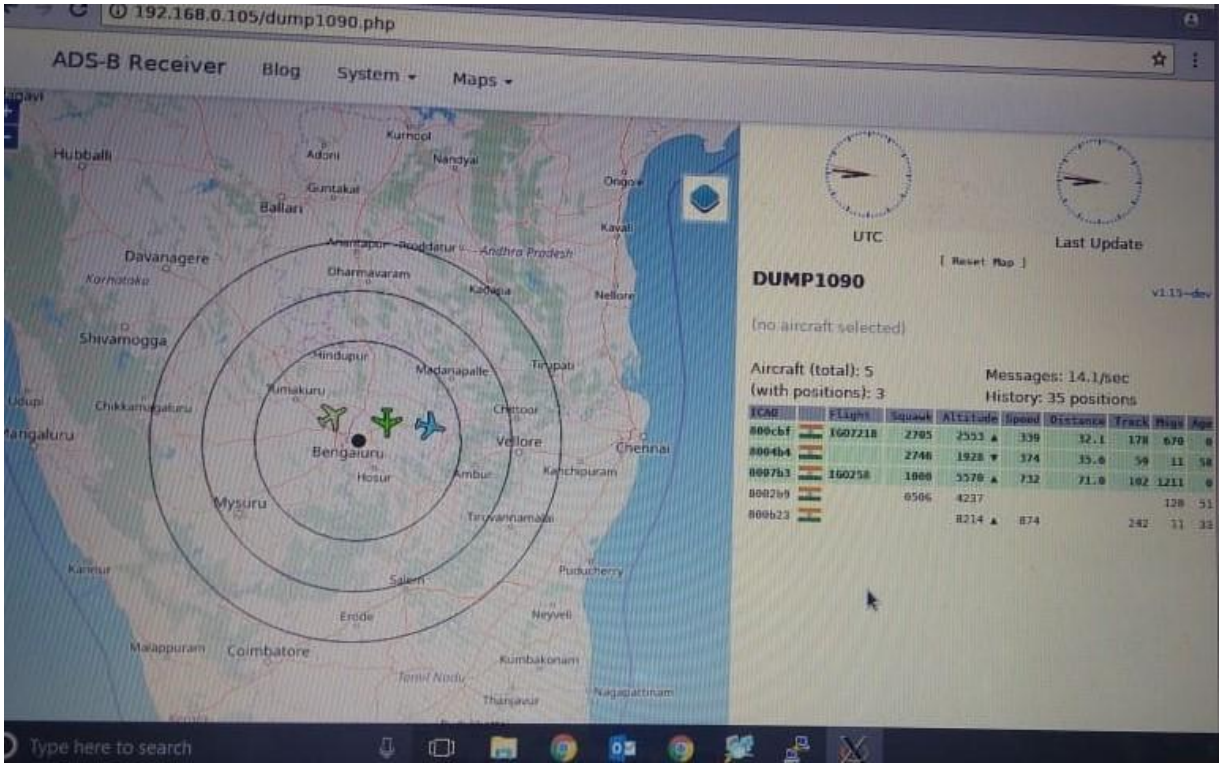


**Figure 4.5**

## CHAPTER 5:

## FUTURE SCOPE:

The hardware setup and simulation helps us track dynamically track the flight and its parameters (altitude,speed,distance,etc).We are going to employ TCAS(Traffic collision and avoidance detection) into this RTL-SDR based ADS-B system.By setting thresholds and actively processing the parameters involved resolution advisories will be designed. These resolution advisories will be conveyed to the flights so as to help avoid collision.The system will be able to track more flights in the future with the addition of another SDR antenna system. The tuning of the other SDR to 978MHz(UAT). 978 UAT

transponders are permitted below 18,000 ft. UAT will be using weather updates as well and flights below 18,000ft will be tracked as well. This will give us a better perspective and all flights irrespective of altitudes will be tracked.

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