# O.S.C.A.R.- Orbital Satellite Communication using Amateur Radio

**Shubham Jaydeokar[1] Shubham Gohokar[2] Chinmay Kathane[3] Dr. Pradeep B. Mane[4]**
[1,2,3]Department of Electronics and Telecommunication Engineering
[1,2,3,4]A.I.S.S.M.S's Institute of Information Technology Pune, Maharashtra, India.

*Abstract*— There are many scientific experiments performed in the NASA's very own International Space Station, which is the largest Low-Earth Orbiting Satellite, till date. The results of these experiments are needed to be conveyed down to the earth station via Radio Waves. All about the current status of ISS studies and its information is broadcasted all around the globe. Access to this information does not need any licensing authorization from any of the space research organizations. This information can be publically accessed by anyone on Earth. The Project O.S.C.A.R. (Orbital Satellite Communication using Amateur Radio) focuses on the same concept as mentioned above. O.S.C.A.R. is basically one of the basic and simplest ground stations for receiving the signals transmitted from ISS. This project has been subdivided into three stages, viz. Signal Reception, FM demodulation and Audio conversion. This project shall be completed with the fabrication of a simple Yagi Uda antenna resonating at a frequency of 145.800MHz. The antenna is well receptacle to circularly polarize audio signals sent by ISS; a FM demodulator circuit and an audio conversion circuit which would convert the signals to audible sound through speakers. With the help of this project any person around the world can listen to the astronauts and can also setup a scheduled communication link for gaining the information for further explorational. Thus, O.S.C.A.R. would give one of the simplest ways to leap into the domains of modern satellite communication systems and space research.

***Key words:*** Satellite Communications, ISS Communications, Space Link setup, Amateur radio, Ground stations, Circularly Polarized Crossed Yagi-Uda antenna, Low-Earth Orbiting Satellite, etc

## I. INTRODUCTION

Amateur Radio on the International Space Station (ARISS) is a cooperative venture of the Radio Amateur Satellite Corporation (AMSAT) and the National Aeronautics and Space Administration (NASA) in the United States, and other international space agencies and international amateur radio organizations around the world. The primary purpose of ARISS is to organize scheduled contacts via amateur radio between crew members aboard the International Space Station (ISS) and organizations mentioned above. It also provides a special channel dedicated for direct communication (broadcasting) between ISS crew and a private ground station situated on Earth. The use of Amateur Radio for establishing a space communication link between orbital satellite and ground station on Earth is the main objective of the project.

The use of radio waves for the establishment of communication link between the ground station and ISS may prove to be the finest application in radio telemetry and space communication. The potential ground station is required to have a communication setup for receiving these broadcasted signals. A highly directive antenna along with some of the decoding circuits and the output device, are the basic requirements of establishing a potential ground station.

The antenna's polarization and center radiating frequency is to be selected appropriately for proper reception of the transmitted signals. A compatible decoder circuit along with pre-amplifiers and boosters are needed for processing these signals. Successfully implementing such a type of communication system is a tough challenge because of its dependency on various factors. Some of the factors affecting the aim of the project are Environmental conditions, Earth's atmosphere, Crosstalk; Frequency shift, Doppler Effect, Cosmic radiations, etc.

Studying all the technical aspects and many involuntary actions performed during working on ground, it is possible to establish the space link communication. Our project will ensure to act as a ground station privately governed and handled by using an antenna and demodulator circuit for listening to ISS Hams.

## II. PROBLEM STATEMENT

For studying the projects' aspects in detail, we need to first understand the problem statement. The problem statement of this project is stated below: -

To design an effective and portable communication setup for receiving audio signals direct from international space station using an amateur radio.

The objectives of the project are: -

1) To design a Vertically & Horizontally Polarized Cross Yagi-Uda antenna for receiving audio signals in the FM band 144MHz to 146MHz.
2) To design a super heterodyne FM Demodulator circuit for decoding the signals.
3) To integrate and test the overall setup to analyze the system performance.

## III. BLOCK DIAGRAM OF THE SYSTEM

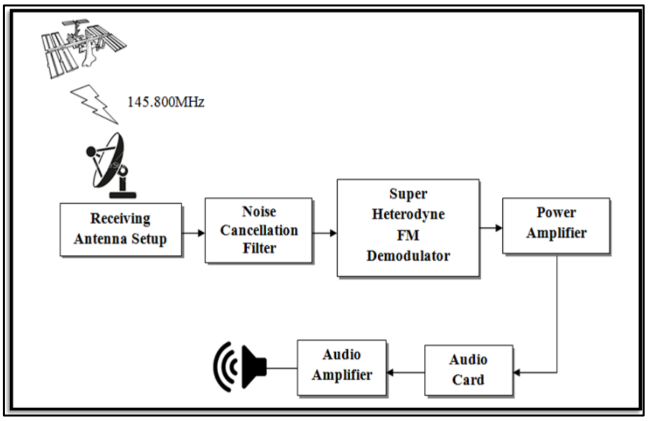


Fig. 1: Block Diagram of Project O.S.C.A.R.

### A. *Receiving Antenna setup:*

The downlink frequency of ISS Ham Broadcasting is 145.800MHz. Hams are broadcasted all over the globe at the specific frequency mentioned above. The ground stations along with telemetry and satellite tracking system receive these signals with the help of antenna similarly, by using a receiving antenna and satellite tracking system; it is also able to implement a small ground station with a dedicated channel.

An antenna radiating at 145.800MHz frequency with circular polarization, is used for receiving the signals transmitted from ISS. After receiving these signals, it is initially passed through a noise cancellation filter. All the unwanted noise interference is suppressed or attenuated and only the desired frequency band is passed on to the next circuit.

### B. *FM Demodulator:*

The signal received from ISS is FM coded. For hearing the audio line from this signal, it requires us to decode the signal. Hence, a FM Demodulator circuit is used after the noise cancellation filter. For obtaining an appropriate amount of output power for driving the speaker, it is necessary to use a High Gain High Efficiency Demodulator i.e. a Super Heterodyne FM Demodulator Circuit.

### C. *Power amplifier and Audio card:*

The average distance of ISS from Earth's surface is 220 miles. Moreover, there is a subsequent increase in space garbage all around the earth. All these factors affect the Strength of the signal transmitted from ISS. Because of this, it becomes mandatory to regain its strength after filtering, which will help in driving the output speaker. Typically, the range of output power that we require to drive the output section sufficiently is 20-100 Watts. For this purpose, we use a Power Amplifier just after the demodulator.

### D. *Audio Amplifier and Audio Card:*

The demodulated signal is now applied to a simple audio card which helps in driving the output speaker, where we can hear the commands delivered by Astronauts to various Space Organizations.

## IV. METHODOLOGY

1) Antenna Selection & Simulation: The antenna to be selected must have the following parameters so that it can be used for the project. The antenna must support Horizontal as well as Vertical Polarization and need to be highly directive. The selected antenna is portable and handheld to be simple for implementation. The antenna dimensions are calculated with the help of online RF calculator.
2) Antenna Designing: The basic material used for making the antenna is Copper Wire. By using this copper wire we have designed a Folded Dipole Antenna. The Antenna elements like reflectors and directors are also designed using this copper wire. The complete antenna is fixed on a PVC pipe which acts as the boom of the antenna.
3) PCB Designing-Power Supply: The project comprises of some of those active components which need external supply for there working. For this purpose we have built a power supply circuit which gives the output to trigger the various circuit modules in the system. The designed power supply gives the output +5Volts and +9Volts.
4) PCB Designing-Dual Balanced Mixer: The signals transmitted from the ISS are received by the antenna. For extracting the audio signals from the received signals, we need to build a Super-Heterodyne Receiver circuit. We have implemented this circuit using a dual balanced mixer which gives the output which is considered as the Intermediate Frequency.
5) PCB Designing-Audio Amplifier: The audio amplifier is then used to amplify the weak signals and give the output in the form of human audible sound signals. The audio amplifier that we have implemented uses an operational amplifier which gives the output to the loud speaker.
6) PCB Fabrication and Component Mounting: After designing all the circuit modules, we have fabricated them. After fabricating the PCBs, we have mounted the components in their respective circuits.
7) Testing: We have tested the antenna using a Ham Radio equipment and verified the antenna parameters in details. The details of these parameters are explained in the hardware section. The voltage and current ratings are tested by using a simulation software and then verified by practical means. The testing of the complete communication setup have given the near satisfactory results which were digitally recorded for the future needs.

## V. HARDWARE DESIGN

The Cross Yagi Uda antenna is one of the most successful RF antenna designs for directive antenna applications. The Crossed Yagi Uda antenna is used in a wide variety of applications where an RF antenna design with gain and directivity is required. This antenna has become particularly popular for television reception, but it is also used in very many other domestic and commercial applications where an RF antenna is needed that has gain and directivity. Not only is the gain of the crossed Yagi antenna important as it enables better levels of signal to noise ratio to be achieved, but also the directivity can be used to reduce interference levels by focusing the transmitted power on areas where it is needed, or receiving signals best from where the emanate.

The crossed Yagi antenna design has a dipole as the main radiating or driven element. Further 'parasitic' elements are added which are not directly connected to the driven element.

The Crossed Yagi antenna offers many advantages for its use. The antenna provides many advantages in a number of applications.

1) Antenna has gain allowing lower strength signals to be received.
2) Antenna has directivity enabling interference levels to be minimised.
3) Straightforward construction - The Crossed Yagi antenna allows all constructional elements to be made from rods simplifying construction.
4) The construction enables the antenna to be mounted easily on vertical and other poles with standard mechanical fixings.

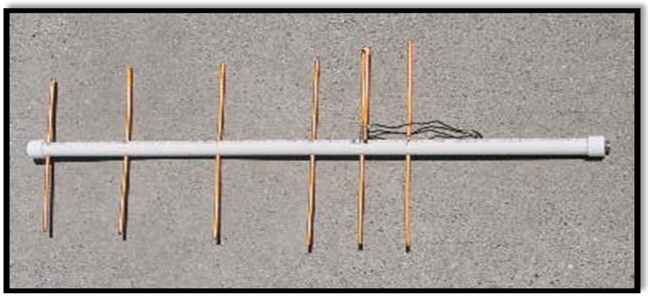

Fig. 2: Antenna for receiving signals

This project uses a simple 9Volts DC battery to be operated and does also demodulate the received signals. For demodulating, a Dual Balanced Mixer is used. For this a SA612A IC is used, which would demodulate and give the output to an Audio amplifier of 8.8 kHz. A Non-inverting amplifier is used to amplify the signals and give the output to a loud speaker from which we can hear the audio clearly.

## VI. Results

The following system parameters were established:
1) Sensitivity: 10dB Noise Figure or better. This is needed to allow receiving ISS voice with an Omni directional antenna.
2) Input impedance: 75 ohms. This allows good performance using cheap RG- 6 TV coax and an antenna but will also work fine with 50 ohm coax.
3) Intermediate frequency: 8.82 KHz. This IF is approximately in the centre of a typical sound card pass-band and is conveniently 1/5 of the max sample rate.
4) Use simple (not image-reject) mixer. With the low IF, the image is in the adjacent channel. Since the ISS and satellites are in the space sub-band, there should be little or no activity in the channel adjacent to the ISS or satellites.
5) Radio audio plays through the speakers.

## VII. Conclusion

The goal of the project OSCAR was to investigate the application of space radio technology to make a really low-cost receiver for the ISS. This is a typical application which focuses instead on high-performance or enhanced flexibility.

While this project is not sufficiently developed to consider it a construction project, it is hoped that the successful demonstration of the concept would be thought-provoking. There are many areas where limited performance might affect the system's scope of applications but really cheap radio could be useful and the basic circuit can be used. Some other versions could include an APRS monitor, a NOAA Weather radio, an aircraft receiver, or even just a monitor for a 2-meter repeater.

Most recently, there has been significant SSTV activity from the ISS. If this was expected to be continued, an SSTV demodulator could be added to allow watching these transmissions (i.e. make it into Space TV). Thus, we conclude that we have successfully implemented the satellite communication setup for receiving the signals transmitted from International Space Station.

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