Radio Detection of Meteor using Forward Scattering

Amogh Waghmare, Sheldon Fernandes, Adesh Shetty, Shraddha Thakkar, Sharad Venkataraman

Abstract— In the current scenario, it is a common practice at an amateur level to observe meteor showers through our naked eye. But many obstacles have been encountered while observing the meteor showers; such as bad weather and light conditions. In this paper, a cost-efficient method has been proposed to observe and analyze characteristics of meteor shower, based on the 'forward scattering principle'. The proposed model has been tested and results have been presented in the paper.

Index Terms— Data Logger, Forward Scattering, Meteor, Meteor Burst Communication, Meteor Shower, Yagi Uda Antenna, Zenithal hour rate.

I. INTRODUCTION

Meteor showers have not only been a subject of study and research for professional observers; but have also interested amateur astronomers. The observations made by professionals have been primarily for determining detailed qualitative meteor characteristics, some of which include velocity, path, deceleration and mass of individual meteoroids. In contrast, the work by amateur enthusiasts contributes to quantitative aspects like describing the number of meteors at and nearby the time of maxima and other parameters like daily zenithal hour rate. Although observations made by professionals are of high scientific value, but observations made by amateurs are of no less substance [1]. However, these observations are marred by a high propensity for error.

To enhance the accuracy of readings, a model has been proposed wherein a radio receiver working in the commercial Frequency Modulated (FM) signal range utilizes the 'forward scattering principle' of radio waves to record meteor showers. This principle is already in use, but the technique has been altered so as to make the receiver cost efficient and easy to implement by employing commercially available FM receivers and Yagi-Uda antenna.

In Section II, the 'Forward Scattering Principle' is explained, on which radio meteor detection is based. Section III and IV give the basic outline of the proposed and implemented radio receiver along with hardware description and discussion regarding the same. Section V and VI present the recorded observations and advantages of the implemented scheme, thus, explaining the utility of the receiver.

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II. FORWARD SCATTERING PRINCIPLE

Forward scattering [2], is the principle used for radio detection of the meteor. When a meteor enters the atmosphere, it generates a trail. This leads to ionization of atmospheric molecular content around it. The reflection of electromagnetic waves takes place due to interaction between the former and these ionized particles; and lasts as long as the meteor trail is present. Such electromagnetic waves transmitted by terrestrial sources such as radio and TV stations are used for meteor detection as they get scattered due to this phenomenon.

We have implemented the above mentioned principle using a Yagi-Uda antenna with resonating frequency of 90 MHz and bandwidth of approximately 20MHz. This particular frequency range is chosen because of its wide commercial use and availability of such FM radio receivers.

III. PROPOSED SCHEME

The basic block diagram of the Radio Frequency (RF) receiver system is shown in Figure 1. It consists of a 3 element Yagi-Uda antenna tuned at commercial FM frequency range, a 4:1 coaxial balun that converts balance end of the antenna to unbalanced one and down converts the impedance to 50 ohms is required for the impedance matching between FM detector and the antenna, FM detector with RF amplifier capable of getting tuned to all the frequencies between 87.5 -108 MHz and a computer system where received analog signal can be converted to a digital data that is logged for further processing.

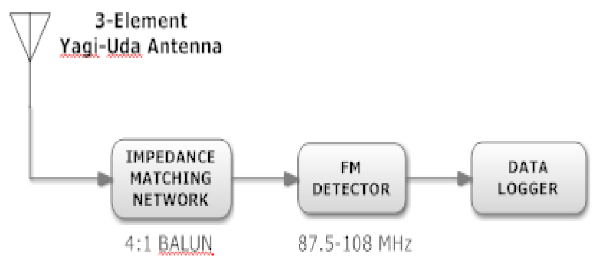

Figure 1: Block diagram of the system

IV. HARDWARE DESCRIPTION AND DISCUSSION

A. Antenna

Antenna is the major element of any RF system; the one devised for meteor detection is a 3 element Yagi-Uda antenna. It is chosen because of its high gain (approximately 11dB) and reliable frequency response. 3 elements of Yagi-Uda antenna are reflector, dipole and director. Received signal is taken from dipole which is folded in this case to achieve convenience on the ground of impedance. Reflector reflects the back lobe of the radiation pattern to forward and director directs the main front beam of the antenna leading to increase in the gain. Since radio observation of meteors requires large area of field which intern deteriorates gain of the antenna, a golden median between gain and area of field is obtained by employing 3 elements in the antenna.

Antenna was simulated using software WIPLD with the center frequency of 99MHz and fabricated. Figure 2 shows the dimensions of the designed antenna and simulated radiation pattern in Figure 3.

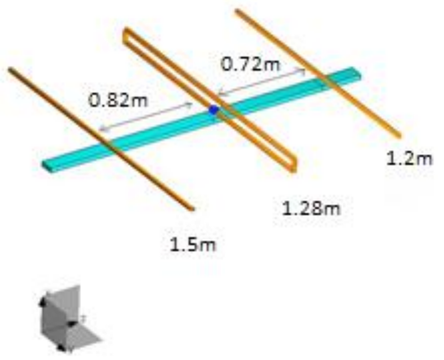

Figure 2: 3 Element Yagi-Uda antennas

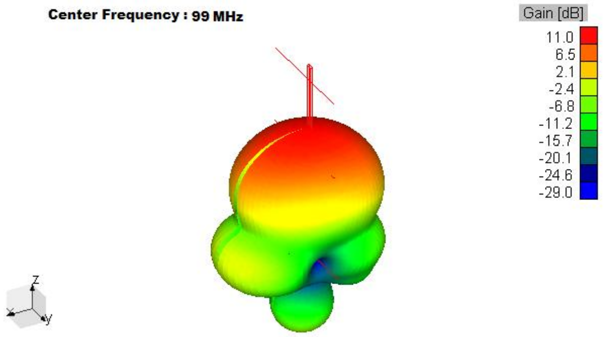

Figure 3: Radiation pattern of 3 element Yagi-Uda antenna

For making the antenna portable and light-weight, it is constructed in two parts. Aluminium is used for fabricating antenna elements because of its good electrical characteristics and light weight. The actual field setup is shown in Figure 4.

Figure 4: Antenna field setup

B. Radio Receiver

Radio receiver used in the given system is a commercially available FM receiver with input impedance of 50 ohms. Commercially available radio receiver is used because of high efficiency it provides at low cost. The receiver consists of a RF pre-amplifier, tuner circuit, mixer, band pass filter and if amplifier. RF pre amplifier amplifies the radio frequency signal received by the antenna. Since the input impedance of the receiver is 50 ohms, balun is so adjusted as to get proper impedance matching between the antenna and the receiver circuitry. Mixer down converts the RF signal to intermediate frequency (IF) signal in order to make further signal processing convenient. An IF amplifier has been incorporated to raise the IF signal strength. Tuner circuit is used to tune the receiver to the desired frequency. Automatic Gain Control (AGC) is removed from the receiver.

C. Data Acquisition

Output of the FM detector (which usually goes to the speaker) is fed to the soundcard of the computer using 3.5 mm audio jack. Soundcard of the computer converts the analog data to the digital data with the help of Analog to Digital converter present in it. The digitally converted data is viewed runtime with the help of Radio-Skypipe II software or /and saved for further processing on the hard drive. Figure 5 shows the FM receiver, Yagi-Uda Antenna and laptop with a recorded reading visible on the screen. The software used here is Spectrogram.

One of the readings taken with the help of given setup are shown in Figure 6. (The software used is Radio-Skypipe II) The prominent spikes in the figure correspond to meteor echoes.

Figure 5: System setup showing the FM detector, Yagi-Uda antenna and laptop

V. OBSERVATIONS

For the radio observations of meteor, following parameters were taken under consideration:

1. Frequency of observation:
   The RF receiver was tuned to a frequency not used by local FM stations, but transmitted by stations present at

around 500 to 2000 Km away from the receiver. Therefore, under normal circumstances the receiver cannot receive any signal, but when desired forward scatter takes place, only then does the tuned receiver receive signals from the transmitter.

2. Orientation of Antenna :
   The antenna was pointed towards zenith to avoid interference from terrestrial spurious signals.

To avoid ground reflection, it is advisable to use a sheet of conductor spread around the antenna. Alternative to this can be mounting the antenna 10-20 feet above the ground.

Date of observation :	26th October 2009
Place of Observation:	Kalyan, India
Frequency of Observation:	93.9MHz
Axes:	Time on the X axis (Universal Time) Signal Strength on the Y axis

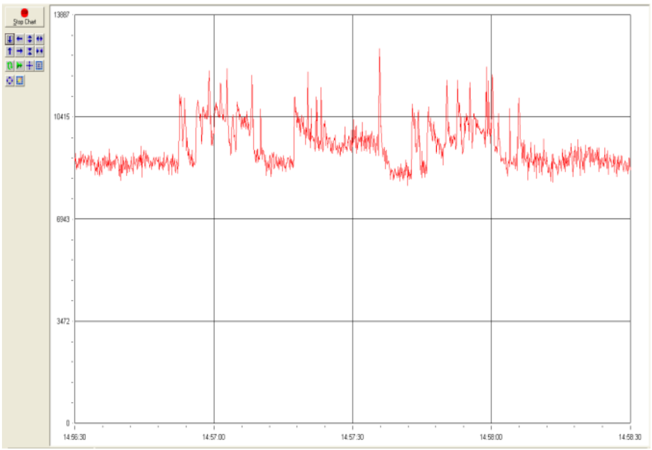

Figure 6: Time - signal strength characteristics for the observed reading (where the prominent spikes correspond to meteor echoes)

VI. ADVANTAGES OF THE PROPOSED SCHEME

Using FM spectrum for observation obviates the need of transmission as there is significant number of stations transmitting in this range. Employment of Commercially available radio receivers yields desired efficiency at low cost. Unlike visual observations which are more prone to human errors and dependent on climatic conditions, radio observations of meteors can be carried out in any season and at any time of the day.

VII. APPLICATIONS

Radio observations of meteors possess high scientific value. Various parameters of meteors such as mass, luminosity, path, velocity, etc. can be found out. Exact location of the meteor can be determined if more than one receivers are used. Forward scattering due to meteor can be used in meteor burst communication [3] to send data over a large distance in VHF range.

VIII. CONCLUSION

Observation of meteor showers has always delighted human beings, but these observations have been restricted to watching the 'shooting stars' from our naked eye. This paper intends to present a cost-efficient method for observing meteor showers. Using the proposed method will equip amateur meteor observers with a tool to observe and record meteor showers. This will not only benefit the observers, but, also help in gleaning information for scientific study of meteors.

The phenomenon of forward scattering was used for the radio detection of meteor shower. The radio detector successfully detected meteor showers and the observations made are presented in the paper.

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