

Design and Construction of Working Replica of Sir J.C Bose 60 GHz Experiment

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1. INTRODUCTION

Sir Jagadish Chandra Bose one of the pioneers of Radio Physics, demonstrated in Calcutta, India, the generation, transmission and reception of electromagnetic waves in 1895. So Jagadish Chandra Bose first demonstrated in Presidency College, Calcutta, India, transmission and reception of electromagnetic waves at 60 GHz, over 23 meters distance, through two intervening walls by remotely ringing a bell and detonating some gunpowder. For his communication system, Sir J.C Bose pioneered in development of entire millimeter-wave components like a spark transmitter, coherer, dielectric lens, polarizer, horn antenna, and cylindrical diffraction grating. This is the first millimeter-wave communication system in the world, developed more than 100 years ago. This is the oldest Milestone achievement from the Asian continent.

Bose chose quasi-optical, millimeter-wave frequency range. The wavelengths he used ranged from 2.5 cm to 5 mm. The reason for the choice of millimeter wave by Sir J.C. Bose was primarily due to the advantage of studies of quasi-optical properties of the radio waves within his laboratory of limited size that was available to him at the Presidency College [1]. However, the components and systems developed by Sir J.C. Bose, initially at millimeter wave and subsequently at microwave, were outstanding discoveries made more than 100 years ago, in Calcutta, India, most of which are now being used, in a modernized form for Earth/space links and remote sensing and 5G communication

Sir J. C. Bose invented the Mercury Coherer (together with the telephone receiver) used by Marconi to receive the radio signal in his first transatlantic radio communication over a distance of 2000 miles from Poldhu, UK to New found land, St. Johns in December 1901. In 1895, Sir J. C. Bose gave his first public demonstration of electromagnetic waves, using them to ring a bell remotely and to explode some gunpowder. He sent an electromagnetic wave across 75 feet passing through walls and body of the Chairman, Lieutenant Governor of Bengal. Sir J. C. Bose holds the first patent worldwide to invent a solid-state diode detector to detect EM waves. The detector was built using a galena crystal. Sir J. C. Bose was a pioneer in the field of microwave devices. His contribution remains distinguished in the field and was acknowledged by the likes of Lord Kelvin, Lord Rayleigh [2-3].

The institute of Electrical and electronics Engineering (IEEE) a professional body with members from 160 countries, wants to pay the homage to Sir J.C. Bose. In 1986 IEEE forum has recognized Sir J.C Bose mm wave experiment as a millstone experiment. In November 2012 IEEE approached Muffakham Jah College of engineering and technology (MJ CET) for making the first working model of Sir J.C Bose mm wave experiment to be installed at B.M Birla science museum at Hyderabad. In this paper we present the detail construction, design and working of Sir J.C Bose mm wave experiment working Replica designed by Muffakham Jah College of engineering and technology.

2. DESIGN AND CONSTRUCTION OF WORKING REPLICA

Bose's experiments were carried out at Presidency College, although for demonstrations he developed a compact portable version of the equipment, including transmitter, receiver, and various microwave components. Some of his original equipment still exists, currently at the Bose Institute. Figure 1. Shows the sir J.C Bose original mm wave setup and MJ CET designed working replica. The working replica was planned, designed and executed in the physics lab, MJ CET. The detail construction and working of replica as follows.

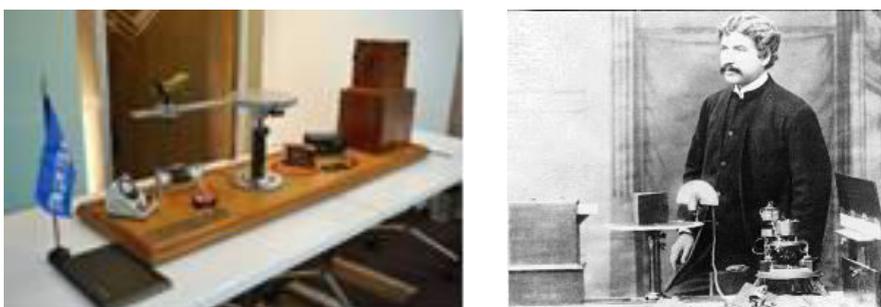


Figure 1. MJ CET designed working Replica and Original J.C Bose apparatus

2.1 The Radiator

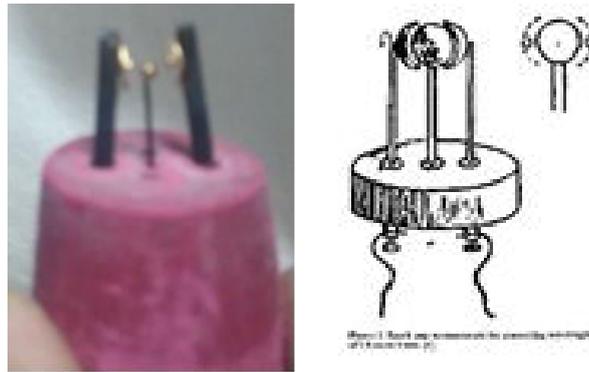


Figure 2. Sparking element of the Replica and Original Sparking element

In the working Replica the radiator consists of sparking element consist of DC power supply of 12V, 6Amps is connected across the primary of the coil, magnetic disturbances are created by applying the key which results in emission of flash of radiations form the secondary coil. The sparking elements consist of two gold spherical beads of 0.5mm diameter and one interposed sphere situated at the center of the tow beads of 1.5mm diameter. Figure 2 shows the sir. J. C Bose sparking element and MJCET designed sparking element. The working of the sparking element as follows.

- The wires of the primary coil are in connection with a small storage cell through a tapping key. The coil, a small storage cell and the key are enclosed in a tinned iron box which screens the space external from magnetic disturbances.
- Each time the key is pressed, the primary circuit of induction coil is made or broken and magnetic disturbance is produced. Therefore, pressing and releasing of key ensures flash of radiations. In front of the box the radiator tube (square). The radiating apparatus has a square tube of 1 sq. inch. cross section.

2.2 Spiral Spring receiver

Single layer of steel springs of 2 mm diameter and 1 cm length are placed in square piece of Ebonite with a shallow rectangular depression (Sensitive surface = 1cm x2 cm). Glass slide is used to prevent springs falling out. Springs are compressed by brass piece which slides in and out using screw therefore the resistance can be varied. When radiation is generated by sensitive contacts, there is sudden decrease in resistance and galvanometer was deflected. It responds (sensitive) to different types of radiations by varying the electromotive force which give rise to current that reaches receiver and galvanometer shows deflection. Figure 3 shows the design of spiral spring receiver of Sir J.C Bose and working replica.

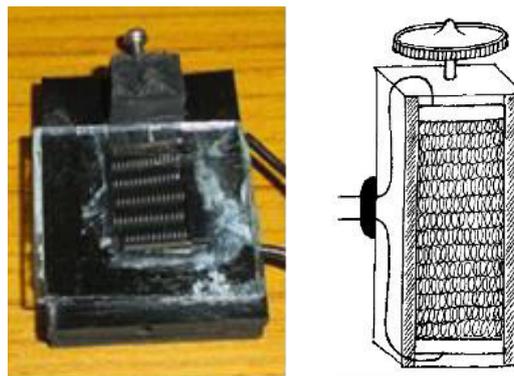


Figure 3 Spiral spring receiver of working replica and Original Sir J.C Bose receiver

2.3 Determination of Wavelength of and Cylindrical Grating

The grating made of equidistant metallic strips, which are vertical and parallel. The diameter of the cylindrical grating is 100 cm. A piece of thin sheet ebonite is bent in the shape of a portion of a cylinder and kept in that shape by screwing against upper and lower circular guide pieces of wood. Against the concave side of the ebonite are stuck strips of rather thick tinfoil at equal intervals. Figure 4 shows the design of cylindrical grating of working Replica.

The diffracted waves follow the equation. $(a+b) \sin \theta = n \lambda$

Where, $(a+b)$ is sum of breadths of strip and space in the grating. (6mm)

θ is angle of diffraction

n is order of diffraction

λ is wavelength

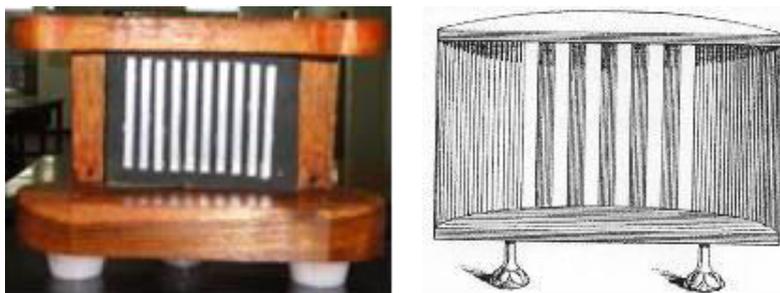


Figure 4 Design of Original cylindrical grating and working Replica

The measurement of the frequency of mm waves produced by our experimental setup has been recorded with spectrum analyzer at Research Center Imarat DRDO, Hyderabad and frequency of the replica was around 60 GHz. This frequency is similar to the frequency generated by Sir J.C Bose in his experiment. This is an achievement for the developers of the replica to attain same frequency as the original. Figure 5 shows the recording frequency spectra of working replica produced by RCI.



Figure 5 Photograph of 60GHz frequency generated by working replica

3. QUALITY TEST

The quality test of receiver was conducted at physics laboratory MJCET. The experiment repeated by pressing radiator key 50 times. For each time key press, the galvanometer reading was recorded. The report of quality test is given in figure 6 and it was found that Replica receiver absorbs radiation. It also gives the variation of signal changes recorded galvanometer which is in the range of 10 units to 30 units.

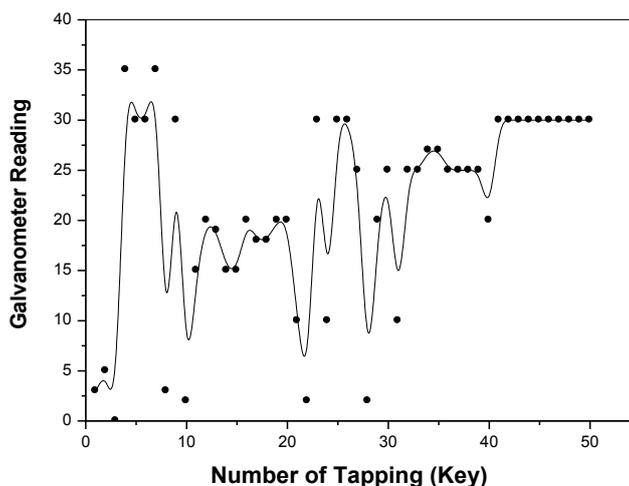


Figure 6 Variation of Galvanometer deflections with number of tapping

4. CONCLUSION

The following conclusion were drawn from the present experiment

- MJCET successfully designed and demonstrated working replica of Sir J.C Bose 60 GHz mm wave experiment
- The sparking elements consists of two spherical beads of 0.5mm diameter and one interposed sphere situated at the center of the tow beads pf 1.5mm diameter
- The spiral spring receiver designed with Single layer of steel springs 2 mm diameter and 1 cm length placed in square piece of Ebonite with a shallow rectangular depression (Sensitive surface = 1cm x2 cm). The quality test confirms the accurate signal detection of spiral spring receiver.
- The frequency of the Replica was measured and it is around 60 GHz. This frequency is similar to what Sir J.C Bose had generated in his experiment. This is an achievement for the developers of the replica to attain same frequency as the original.

5. ACKNOWLEDGEMENT

MJCET would like to thank IEEE, India for providing financial support of this project. MJCET also thank *Sri. Gopala Krishna Kuppa*, Chair, India Work Group on 1451-99 standards for valuable inputs which were incorporated to improve performance and give accurate signal detection. We wish to thank *Dr. Janhagirdar*, RCI, Hyderabad for providing spectrum analyzer for signal measurement. The authors also like to thank *Dr. Basheer Ahmed*, Advisor cum Director MJCET for encouragement and support.

6. REFERENCES

- [1] A.K. Sen, TENCON '98. 1998 IEEE Region 10 International Conference on Global Connectivity in Energy, Computer, Communication and Control Page(s):288 - 290 vol.2
- [2] Darrel T. Emerson, IEEE Transactions on Microwave Theory and Techniques, Vol. 45, No. 12, pp. 2267-2273, Dec. 1997
- [3] T. K. Sarkar, D. L. Sengupta, IEEE Antenna and Propagation Magazine, Vol. 39, No. 5, Oct. 1997

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