

“Multidisciplinary Approach towards Indian Knowledge System”

Recent Trends in Arts, Humanities, Management & Science

JANUARY 2023



Chief Editor

Dr. S. R. Kattimani

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Sir Jagadish Chandra Bose: Pioneering Contributions to Radio Waves and Wireless Communication

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Abstract:

Sir Jagadish Chandra Bose demonstrated the electromagnetic wave capabilities with generation, transmission and reception of electromagnetic waves at 60 GHz frequency in Calcutta, India about 130 years back during 1890s. He developed delicate and precise equipment's such self-recovering coherer detector, spark transmitter, rectangular waveguide, horn antenna and microwave absorber in India more than 130 years ago when there were no modern laboratory facilities available anywhere in the world. Highlighting the contributions of Sir J. C. Bose in Microwaves, millimetre waves, and their contemporary applications in wireless application is very significant work. The purpose of this article is to present scientific contribution of J.C. Bose in the field of wireless communication.

Keyword: Electromagnetic wave, Semiconductor diode detector, millimetre wave.

1. Introduction

The history of Wireless Communications explicitly involves experimentation, observation, understanding and formulating equations on magnetic and electric phenomena of electromagnetic signals. Scientists worldwide contributed to pioneering advancements, shaping the evolution of wireless technology from its inception [1]. In the year 1864, Scottish scientist James Clerk Maxwell (1831–1879) presented his “Dynamical Theory of the Electromagnetic Field”, wherein he gives only theoretical observed that electromagnetic wave moves at the speed of light in free space. He suggested light as a transverse electromagnetic wave. While Maxwell's equations hinted the idea of electromagnetic waves and he focused mostly on light and didn't explore their generation through electrical or magnetic means [2]. In 1888, Heinrich Hertz (1857–1894) validated Maxwell's theory by generating, radiating, and receiving electromagnetic waves at 60 cm wavelength along free space. Hertz's experiments not only confirmed Maxwell's electromagnetic theory, but also initiated the discipline of microwaves communication technology [3].

2. Sir J.C. Bose Research on millimetre wave

The millimeter-wave (mmWave) frequency spectrum in telecommunications ranges 30-300 GHz, which correlating with 10-1 mm wavelengths [4]. J.C. Bose developed the World's first wireless communication link remote control at 5-millimeter wavelength (at 60 GHz) during the last 3 years of 1894. In 1895, he demonstrates the experiment on

electromagnetic waves by ringing a bell remotely and to explode some gunpowder at Calcutta in front of the Lt. Governor Sir Wdham Mackenzie. With invitation of Prof. Lord Rayleigh in 1897, he delivered the public lecture with demonstration of to the Royal Institution in London. For this work, he used spark generator, waveguides, horn antennas, dielectric lenses, polarizers, and a Galena detector up to 60 GHz for diverse applications in high-frequency technology. He used circular waveguide, pyramidal electromagnetic horn antenna, and used semiconductor diode device first time [5] [6].

3. Sir J.C. Bose Research on Semiconductor Device

On December 12, 1901, G. Marconi achieved a revolutionary transatlantic wireless communication experiment at Signal Hill, St. John's, Newfoundland. He sent the signal of successive Morse code letter "S" from Cornwall in England to Newfoundland across the Atlantic Ocean using a temporary makeshift receiving system consisting of a wire antenna flown 400 ft. In this communication, he used a new "mercury coherer" detector in series with a telephone headset. This revolutionary diode detector device was invented by Sir J. C. Bose in the April 27, 1899, Royal Society meeting, London [7]. Sir J.C. Bose developed Galena (lead sulphide, PbS) crystal detector for microwave, the first semiconductor device, for which he applied US patent "Detector for electrical disturbances" in 1901 and sanctioned in 1904. He used it to detect microwaves (range 12-60 GHz) generated by a spark transmitter from his first historic experiments with millimetre waves. This was semiconductor diode detector. Up to this time the terminologies such as "diode" and "semiconductor" were unknown. Later this detector was used as a receiver for demodulation of continuous wave radio signals. In 1954, W.H. Brattain (co-inventor of the transistor and Nobel Prize in Physics 1956) and G.L. Pearson gave priority to J.C Bose for the use of a semiconducting crystal as a detector of radio waves [8]. Also, Neville F. Mott, Physics Nobel Laureate in 1977 for his contribution in the electronic structure of magnetic and disordered systems remarked that "J.C. Bose was at least 60 years ahead of his time" and "In fact, he had anticipated the existence of P-type and N-type semiconductors" [5].

4. Impact of Sir J.C. Bose's on Modern Electronics Communication

In 1895, Pioneering physicist J. C. Bose laid the groundwork for mmWave technology by publicly demonstrating wireless signalling at 60 GHz. His innovations included the use of early versions of microwave components like horn antennas and detectors [4]. Millimeter wave (mmWave) communications in mobile networks especially for 5G and beyond has attracted significant research attention, since the huge available bandwidth holds promise for achieving multiple Gbps rates per user. Recently, intensive research focuses on mmWave wireless local area networks (WLAN) technology, particularly Wi-Fi (IEEE 802.11ad) operating at 60 GHz. In May 2013, Samsung achieved 1 Gbps data transmission at 28 GHz. Google also put substantial research efforts to explore mmWave technology for faster communication [9].

5. Conclusion

Sir J.C. Bose's pioneering work in radio waves marked a breakthrough in microwave devices and wireless communication, shaping the foundation of modern technology. J.C. Bose significantly contributed in millimetre-wave technology, creating spark transmitter, coherer, polarizer, dielectric lens and horn antenna components for groundbreaking advancements. Bose developed a Galena-based solid-state detector for highly sensitive millimetre waves and infrared waves, which will be pioneering work on wave detection technology. This was the first semiconductor device and first patent on semiconductor device. Bose's notable contributions in this field were recognized by eminent figures like Neville F. Mott, W.H. Brattain and Lord Rayleigh, highlighting his distinction.

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