Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 2, No.4, February : 2025

A STUDY ON ANTENNA SELECTION FOR IOT (INTERNET OF THINGS) APPLICATIONS

Dr. Rekha G Nair, NSS College of Engineering, Kerala
Dr. Geetha G, NSS College of Engineering, Kerala
Dr. AnilKumar K R, NSS College of Engineering, Kerala

ABSTRACT:
The design of antennas for internet-of-things (IoT) applications is discussed in this article. In comparison with other communication and wireless devices IoT devices have very narrow bandwidth requirements. The different types of IoT antennas, key parameters to be considered for designing IoT antennas and their design challenges are also discussed.
Key words: Internet-of-Things, Microstrip antenna, Metamaterial Antennas, Latency

INTRODUCTION:

IoT connects, interacts and exchanges data amongst devices over the internet. IoT technology is used in smart homes, wearable health monitors, industrial automation, and smart cities to enhance convenience and efficiency. Antennas are used in Internet of Things systems to link wireless devices to networks. Antenna systems transmit electromagnetic signals across networked environments. So antenna design is critical to ensure the stability and efficacy of an IoT network. IoT devices, ranging from small wearable sensors to large industrial machinery, require specialized antenna systems. To meet the demand for wireless communication in healthcare, transportation, and smart homes, IoT devices utilize efficient antenna systems. Antennas with small size antennas with low power consumption and high gain, bandwidth and good VSWR are essential for IoT applications. Various antennas are required for IoT applications such as smart homes, healthcare, and agriculture. Among the different types of antennas patch antennas are tiny and are suitable for wearable healthcare devices and sensors. Metamaterial antennas are advantageous for industrial and agricultural IoT applications that demand long-range performance. Reconfigurable antennas are another important IoT antenna innovation. So as to meet the tunable frequency, power and radiation requirements of IoT systems reconfigurable antennas are required. Antenna design for IoT applications are discussed in many articles [1-5]. But still antenna selection for IoT modules is a challenging task. This prompts researchers to invent novel antenna designs, materials, and technologies to improve the performance of IoT systems. In this article section two discusses the parameters to be considered while selecting an antenna for IoT applications, section three discusses the types of antennas suitable for IoT applications and design challenges and the paper concludes in section four.

ANTENNA DESIGN FOR IOT APPLICATIONS- KEY PARAMETERS TO BE CONSIDERED:

(i). Size of Antennas: Narrow bandwidth and smaller size are required for antennas in IoT systems. This is to ensure minimum area of occupancy and isolation from other devices. This will improve the performance of the antenna.
(ii). Bandwidth: IoT systems require antennas with narrow bandwidth. The operating bandwidth of the antenna will be affected by material used for fabrication dimensions of the material used for fabrication and also by interferences. An IoT antenna should not be affected by these factors and should maintain good performance irrespective of its surroundings and interference.
(iii). Power Consumption: IoT systems collects and process data for various applications. This requires antennas with low power consumption.
(iv). Isolation: Proper isolation between different antennas used in the IoT modules should be there to ensure the proper operation of the IoT system.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 2, No.4, February : 2025

(v). Operating frequency: Different applications require antennas with different operating frequency. Antennas with resonant frequencies corresponding to Wi-Fi, Zigbee, Bluetooth etc. are required. So the antennas with resonant frequency corresponding to these applications are required.

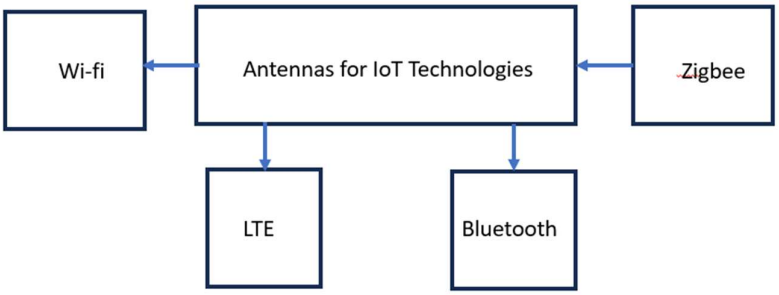


Figure:1 Antennas based on different Wireless technologies in IoT modules.

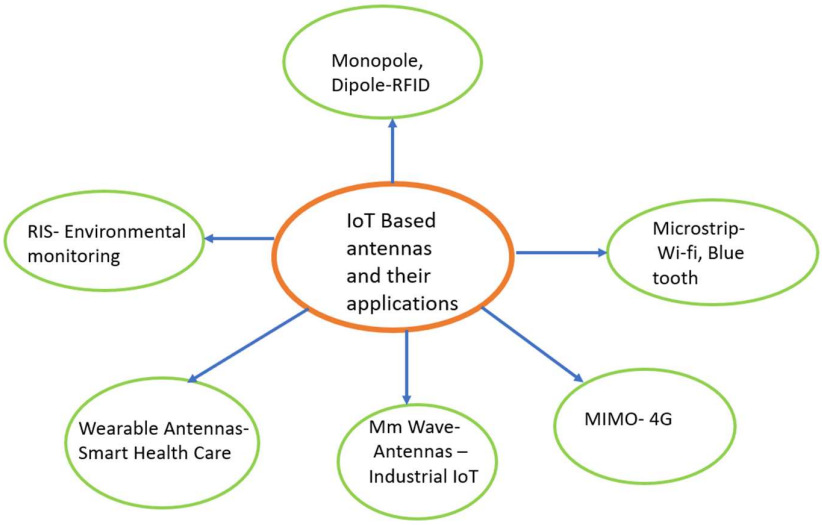
(vi). Interoperability: Inter-operability of standards and connecting devices needs to be ensured. This requires sensor networks. So energy efficient the sensor nodes are required to ensure proper communication with wireless networks.

Figure:1 shows antennas based on different Wireless technologies in IoT modules.

TYPES OF ANTENNAS IN IOT:

Internet of Things (IoT) require different types of antennas, sensors, MEMS switches, energy-harvesting techniques like SWIPT etc. Since IoT applications need different modules, we have to consider the size, resonant frequency, gain, radiation pattern, directivity and cost of the antennas used. Figure 2 – demonstrates antennas used in IOT modules and their applications

Printed antennas find IoT applications and are widely used for domestic and industrial applications like computations, sensing and creating a data-connected environment. Different types of antennas like, Monopole antenna, Dipole antenna, Vivaldi antenna, printed antennas, fractal antennas etc. can be used for IoT applications [6-10].



Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 2, No.4, February : 2025

Figure 2 – Antennas used in IOT modules and their applications

(i).Dipole antennas-Dipole antennas
are essential for IoT communication systems because they are simple and efficient. Dipole antennas have omnidirectional radiation pattern and are ideal for
Smart home automation, environmental monitoring etc., especially in low-frequency IoT devices.
(ii). Microstrip patch antennas – They are also known as microstrip antennas and are popular in IoT applications due to their small size, low profile, and easy integration. These antennas are lightweight and easy to make, with a metallic patch on a dielectric substrate and a ground plane on the other side. Their planar architecture makes them compact and suitable for space-constrained applications such as wearable electronics, smart sensors, and portable medical equipment. Patch antennas provide both linear and circular polarizations for various propagation and application conditions. So, patch antennas are ideal for IoT technologies such as Zigbee, Bluetooth, and Wi-Fi.
(iii). Spiral antennas - Spiral antennas can handle high power. This helps IoT devices to attain long distance communication. Flexible spiral antennas finds applications in wearable devices and other curved surfaces. But their gain is low , this limits the application in long distance communication. Wide bandwidth, compact nature makes spiral antennas suitable for IoT solutions. . So researches to improve their gain is going on.
(iv). Metamaterial antennas – They have peculiar electromagnetic properties. Modern IoT applications need compact antennas with enhanced gain and bandwidth. Directivity and gain of metamaterial antennas are high. This makes them suitable for applications in sensors, wearable devices and also in embedded system applications. Due to low interferences, IoT modules with these antennas can be placed in crowded places.
(v). Tunable metamaterial antennas- Antenna systems with tunable metamaterials provide real-time reconfigurability in the operational parameters like frequency, power and radiation pattern. The adaptation of antennas to variable environmental conditions is possible with the use of varactor diodes as the tuning elements. Ultra-thin, low-profile feature integrated antennas for IoT applications is possible with the use of tunable metamaterials.

MAJOR CHALLENGES IN ANTENNA DESIGN:
Implementation of IoT for applications like smart cities faces challenges like, latency, level of consumption of energy, issues related to connectivity, latency etc. . Figure-3 explains the major challenges in antenna design.

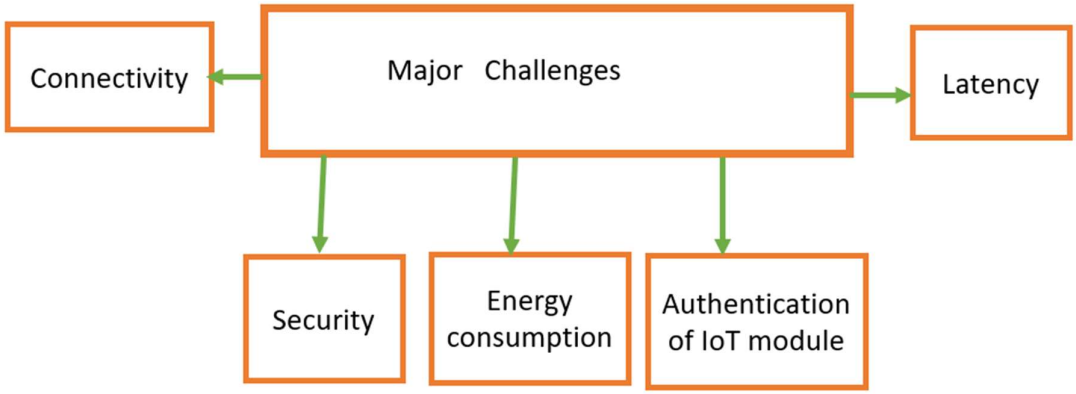


Figure-3 Major challenges in antenna design

Security and privacy risks will be there since the server has to deal with data from numerous devices. Also care should be taken so that unauthorized devices are not connected with IoT server. Proper error correction schemes are also required

CONCLUSION:

The Internet of Things (IoT) is now widely used for data collecting and long-distance wireless communication. Highly efficient antennas enable wireless connectivity across all IoT applications. The function of the antenna is thus extremely crucial and should not be overlooked. The rising demand for IoT applications necessitates continuous improvements in antenna technologies, including new designs, to enhance performance.

REFERENCES:

[1]. Khan, Sunawar, et al. "Antenna systems for IoT applications: a review." Discover Sustainability 5.1 (2024): 412.

[2]. Planar Antenna: Design, Fabrication, Testing, and Application, Nova Science Publishers Inc, New York, Oct 15, 2021, ISBN: 9781536198980.

[3].. Smart Antennas: Latest Trends in Design and Application, Malik, P., Lu,J., Madhav, B.T.P., Kalkhambkar, G., Amit, S. (Eds.), Springer, 2021. ISBN:, DOI: 10.1007/9783030766368.

[4]. Roges, R., Malik, P.K. Planar and printed antennas for Internet of Things enabled environment: Opportunities and challenges. Int J Commun Syst.
2021; 34(15): e4940. https://doi.org/10.1002/dac.4940, ISSN: 1099-1131.

[5]. Mohamed, H.A. and Sultan, K.S., 2018, July. Quad band monopole antenna for IoT applications. In 2018 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting (pp. 1015-1016). IEEE.

[6]. Anchidin, Liliana, et al. "The design and development of a microstrip antenna for internet of things applications." Sensors 23.3 (2023): 1062.

[7]. Karami Farzad, Halim Boutayeb and Larbi Talbi, "Directive Millimeter-Wave End-Fire Diplexing Antenna for IoT Applications", IEEE Internet of Things Journal (2023).

[8] Palanisamy Prabhu and Malarvizhi Subramani, "Design of metallic via based octa-port UWB MIMO antenna for IoT applications", IETE Journal of Research, vol. 69, no. 5, pp. 2446-2456, 2023.

[9]. Nair, Rekha G., et al. "Dual wide band patch antenna for WLAN/WiMAX and X-Band operations." materials today: proceedings (2023).

[10]. Cheng, Jiangfeng, et al. "Industrial IoT in 5G environment towards smart manufacturing." Journal of Industrial Information Integration 10 (2018): 10-19.

[1] . 12, no. 1, pp. 23–28, 2017.