Asian Journal of Electrical Sciences
ISSN: 2249-6297 Vol.11 No.1, 2022, pp.39-45

DOI: https://doi.org/10.51983/ajes-2022.11.1.3224

Design of Metamaterial Zipper Antenna for Boby-Centric Wireless Communication

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***Abstract* - It is suggested and stimulated to create a metamaterial zipper antenna that can act as an off-body antenna. The feeding point is at the bottom, namely at one of the variations, reflection coefficients, radiation patterns, or brought by excitation at a particular zipper tooth. There is some flexibility in the radiation pattern. With an increase of roughly 5dBi, a fractional bandwidth of 4.80 percent in the industrial, scientific, and medical band at 2.48 GHz has been accomplished. The metamaterial zipper antenna's matching performance and radiation characteristic show some reasonable agreement with that of stimulation, which increases the antenna's potential for body-centric wireless communication.**
***Keywords*: Body-Centric Communication, Off-Body Antenna, Wearable Antenna, Meta Material Zipper Antenna**

I. INTRODUCTION

In wireless communication, the term "SMART" stands for "World in Finger Tips," also known as IOT. The attractive potential of this technology connects human world to the technical world via virtualization. The Internet of Things (IoT) tends to advance technological as well as other management-related industries. Because it is so fascinating, we can look into its applications in more detail. There are many different educational advancements available today, along with some fascinating items. A wide range of applications in the areas of wireless communication, telemedicine, satellite communication, remote sensing, RADAR, etc. are made possible by the connectivity of antenna with IOT [1]. By integrating wireless communication and wireless biomedical sensors, the antenna is currently utilised as a safety tool as a development. These sensors enable the construction of any one of the three communication link forms, such as a link along the surface, a link near the perimeter, or an inner connection, within the human body. The current WBAN system utilises Bluetooth and WLAN at a 2.4GHz frequency. A low power, short-range, high-data-rate network designed for communication is the Medical Impact Communication system. When an antenna with UWB and WBAN is combined, results can be improved up to 10.6 GHz[2]. Direct contact (micro strip line feed and coaxial probe) and indirect contact (aperture coupling and proximity coupling) are the two different types of feeding methods. The limitations of single component fix receiving devices include poor addition, low proficiency, and limited data transmission. Many remote communication applications require wide band, and since the high addition of it cannot be supported by a single component receiving wire, a wind obstruction may be overcome by using patch array antennas. The development of remote correspondence frameworks encouraged the production of small and compact devices.

However, compared to other components, the reception apparatus will typically be very large in size. In order to reduce the amount of the radio cable, fix reception devices have been developed (antenna). The fixed receiving device (antenna) has a number of advantages, including small size, simplicity of installation, low profile, light weight, mechanical power, adaptability, and high similarity with microwave solid-state coordinated circuit construction when manufactured on resistant surfaces, among other things. This type of receiving wire is frequently used in distant communication applications, such as telemetry and exchanges, avionics, maritime communications, changed heading of sharp weaponry, satellite, radar, GPS frameworks, and biomedical. Since it is a good product to use, the programme uses a metal zipper as an antenna [3]. Here, in the second portion of this lecture, we'll discuss about the structural design and configuration of the metal antenna (zipper antenna). Then, in the third section, we'll talk about the antenna's parameters, simulations, and performance. The fourth paragraph provides the result of the measurement of the designed antenna. The order of this article is as follows. The associated work that has already been done is described in Section II, and the configuration and organisation are described in Section III.

II. RELATED WORK

The merging of a frequency-selective surface and an antenna was proposed for wireless power harvesting. A wireless alarm micro system self-powered by vibration threshold triggered energy harvester and dipole-coil-based power transfer systems were created [4]. Within the last 12 months, supportive methods have been reported, such as selective wireless power transfer for intelligent power distribution in multiple-receiver systems and a multiport RFID tag antenna for better energy harvesting of self-powered [5] wireless sensors. At the same time, wearable antennas and systems as well as antenna shrinking methods have received significant interest. The possibility of using the human body as an antenna for wireless implant communications has been explored [6]. Generally wearable antennas are operated at a frequency of about 2-2.8 GHz, printable planar dielectric antenna, a translucent and adaptable antenna for portable lens applications, a small-size dual transmitter implantable system for biotelemetry devices, and a dual band on-body repeater antenna for body sensor networks [7]. A programmable energy-efficient compressed sensing architecture with its application to on-body sensor networks, the durability of wearable PIFAs to human body proximity, and the capacity of broadband body-to-body channels between firemen wearing textile antennas have all been studied [8].

Additionally, a graphene-based antenna for the creation of wireless sensors using the modulated scattering technique as well as a dual band reconfigurable Terahertz patch antenna have been introduced [9]. In 2011, a revolutionary textile zip monopole antenna on a jacket was briefly introduced. A prototype of it was made and evaluated using elementary analysis based on the return loss and the radiation pattern [10], and up to that point, it was the only antenna based on a zipper. A jacket's zipper would be tugged up and down in a real-world application scenario, changing the antenna's performance [11]. In fact, a jacket zipper frequently finds itself completely open, which is a major issue that the zip antenna must solve. We will suggest a novel antenna made of various materials based on the metal zipper of a meta material and provide a thorough analysis that takes into account the current distribution [12], the effects of the dimensions and feeding sites, as well as the impact of the human body. There are numerous accomplishments with regard to both body-centric and off-body networks [13]. For body area networks in indoor settings, an off-body channel model has been developed [14].

Recent advancements include the development of a wideband implantable antenna for body-area impulse radio transmission, a Koch fractal circularly polarised antenna for handheld RFID reader applications, and a planar reconfigurable mono-pulse antenna for indoor smart wireless access points [15]. Just now, reports of a shoelace antenna and a watch strap antenna were made [16]. Some of the studies discussed how the human body affects antenna performance, including the model of an arm and its effects on transmission [17]. The reality of making everything and everyone smart and informatics is underway, and this portends a sizable industry in the near future [18]. The aforementioned antennas as well as numerous other wearable or body-centric antennas have produced decent results, especially for certain applications [19]. To create an antenna, the majority of them must, however, manufacture extra facilities onto the body of the apparatus or onto the equipment itself, and performance enhancements are still required for a number of applications. The research on new antenna designs has realistic values as a result [20]. Use of the metal zipper that serves as the antenna on the meta material, which is already present, is a good concept.

III. STRUCTURAL DESIGN

Simulations are run with the aid of CST MWS to examine the performance of the meta-material zipper antenna. We'll give pertinent analysis on how different parameters affect things. Additionally, a concrete ground that is one year old with dimensions of 400 mm 400 mm 3 mm and a distance under the meta material of 800 mm is employed to mimic the floor. When the contact is established from the side and bottom of the tooth with tight or loose links, respectively, the different connections between the probe and the zipper tooth would produce variations of the reflection coefficients. The curves in the three scenarios show the operational frequency ranges that are available. As an illustration, loose contact from the side yields three operating bands at 1.20, 1.58, and 2.15 GHz, respectively, with an S11 lower than 10 db.

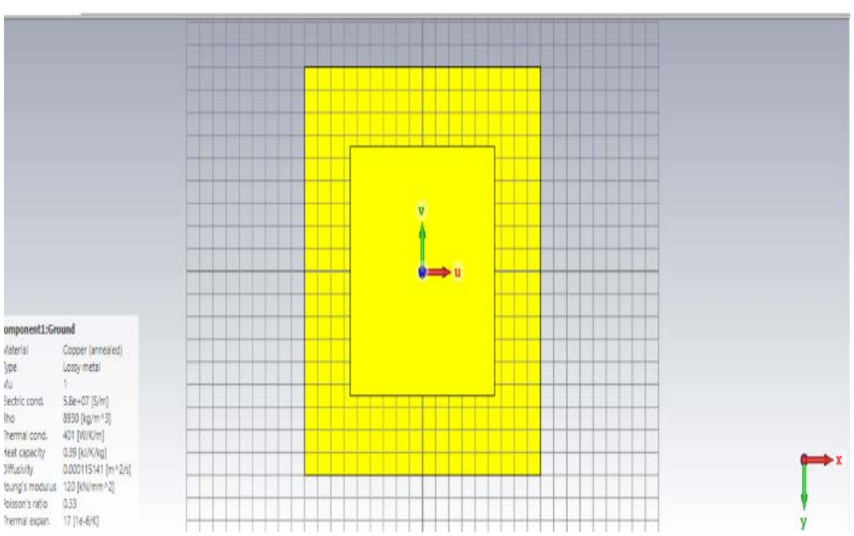

Fig. 1 Structure of Metamaterial unit cell

The circular split ring resonator (CSRR) technology and wire are used to build the metamaterial unit cell, which is then mounted as a superstrate in front of the UWB antenna and has a design layout that concurrently shows a negative magnetic permeability and a negative electrical permittivity.

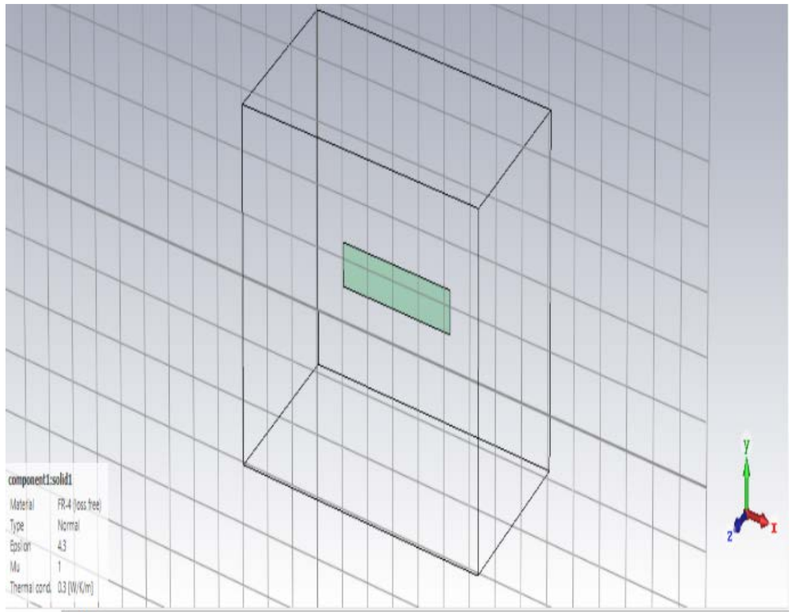

Fig. 2 Structure of FSS-Full structure

The use of an FSS is limited to frequency filtering. The surface just needs to elicit an electric or magnetic response to carry out this process. An FSS typically has little control over EM wave propagation as a result.

By stimulating both electric and magnetic responses, a meta surface can offer a wider range of control over EM wave propagation. Controlled refraction, reflection, filtration, polarization control, etc. are all possible with a meta surface. An regular FSS is unable to do out these tasks.

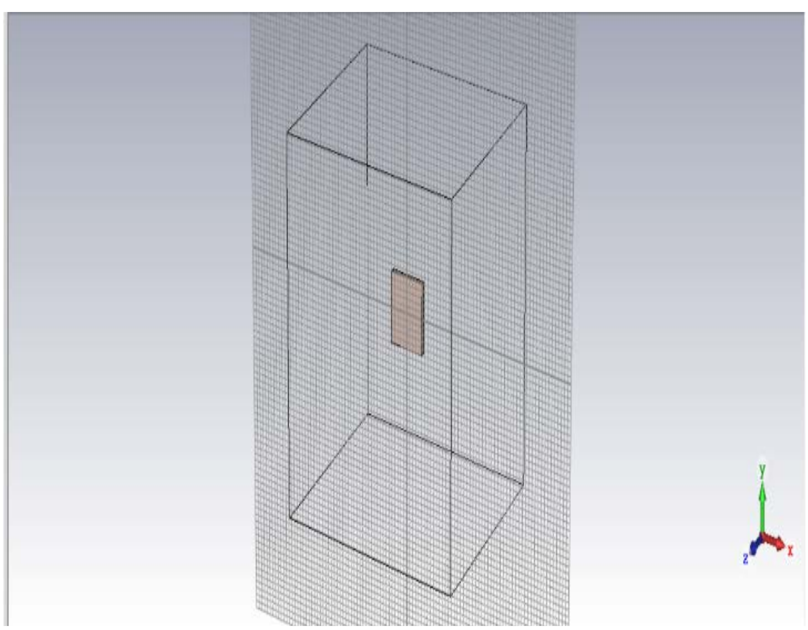

Fig. 3 Structure of Metamaterial- Full structure

In order to improve the performance of downsized (electrically small) antenna systems, a class of antennas known as metamaterial antenna uses metamaterials.

They aim to launch energy into empty space, just like any electromagnetic antenna.

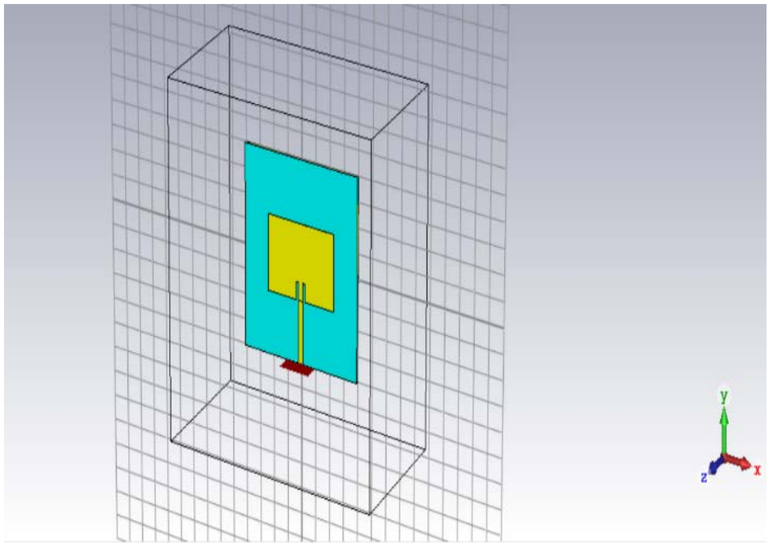

Fig. 4 Structure of Handbag in zipper antenna

Due of its appealing qualities and potential for enabling portable, lightweight, flexible, low-cost wireless communication and sensing, wearable antennas have attracted a lot of attention in recent years. These antennas must be conformal when placed on various body areas, hence they must be made of flexible materials and have a low profile design. In the case of body-worn implementation, several problems arise. When computing the reflection coefficients for feeding sites of 1.75, 2.75, and 3.75 mm along the right of the feeding area alongside the tooth and 1.75 mm on the left, the probe's precise coordinates would have an impact on the antenna's return losses.

As the probe moves from the centre to the edges, the antenna's matching performance becomes worse and worse. The antenna's best S11 value is obtained at 2.44 GHz, which is in the public Industrial, Scientific, and Medical band and has a frequency range of 2.37–2.49 GHz. With a fractional bandwidth of 4.92 percent, the width is 120 MHz.

IV. RESULTS

The substrate is fr-4 with a dimension of 20 mm, which is small and size and only slightly larger than the character to benefit the portable application. A metamaterial zipper antenna is constructed and measured for verification. A vector network analyser, Antirust 27369A, is used to feet signals for the measurement of reflection coefficient, and the results are computed.

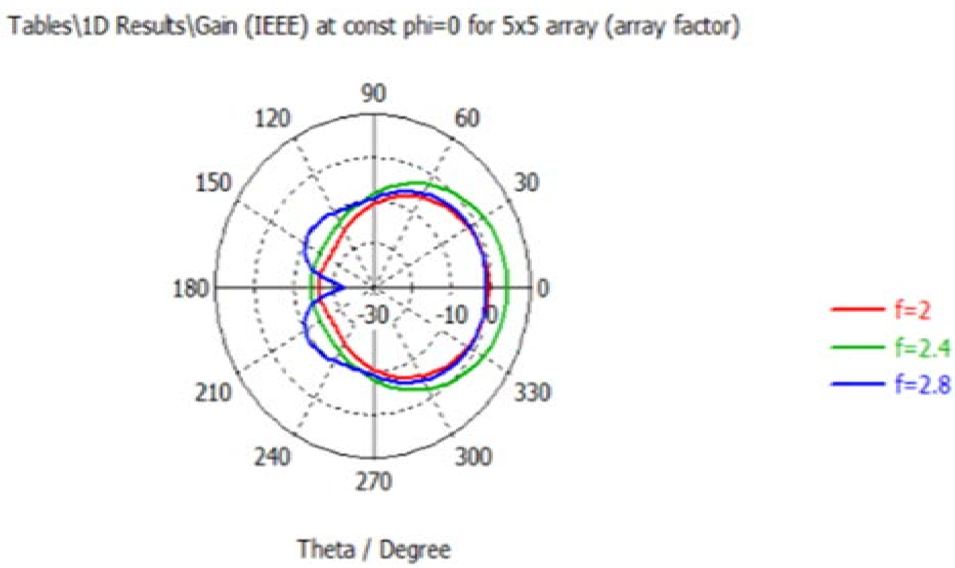

Fig. 5 Gain of metamaterial zipper antenna at frequencies f=2GHz, 2.4GHz and 2.8GHz

Gain and directivity both affect an antenna's efficiency. In terms of the power delivered by the antenna, it is the power that is radiated. The Friis equation was used to measure the gain of the metamaterial zipper antenna.

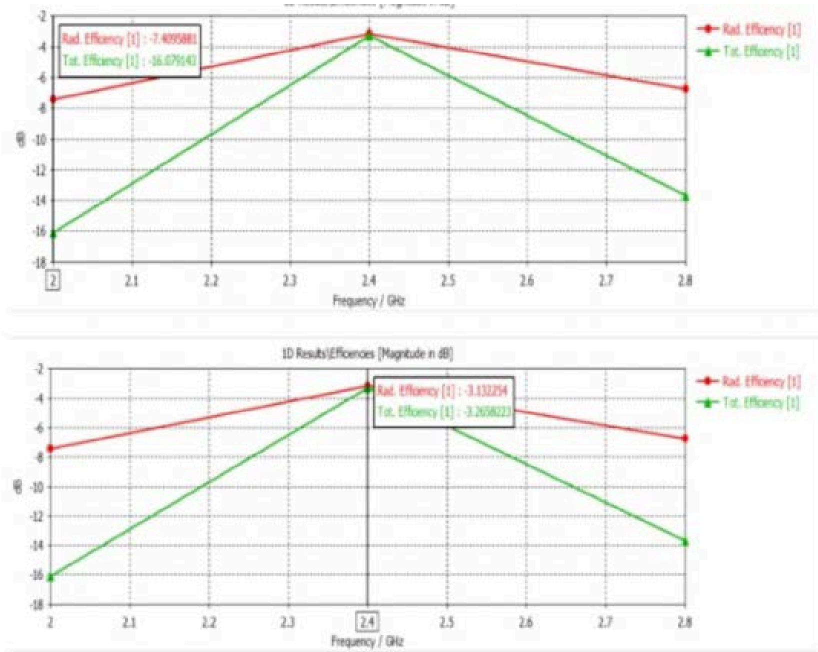

Fig. 6 shows Total efficiencies at minimum and maximum

The above figure displays the radiation and total efficiencies of the meta material zipper antenna, with the lowest radiation efficiency is 97% at 2.90 GHz and the highest total radiation efficiency is 97.4% at 2.70 GHz, respectively. The radiation efficiency is defined as the gain to directivity ratio, or alternatively the ratio of the antenna's radiated power to its accepted (input) power, whereas the total efficiency is defined as the antenna's radiated power to its stimulated power.

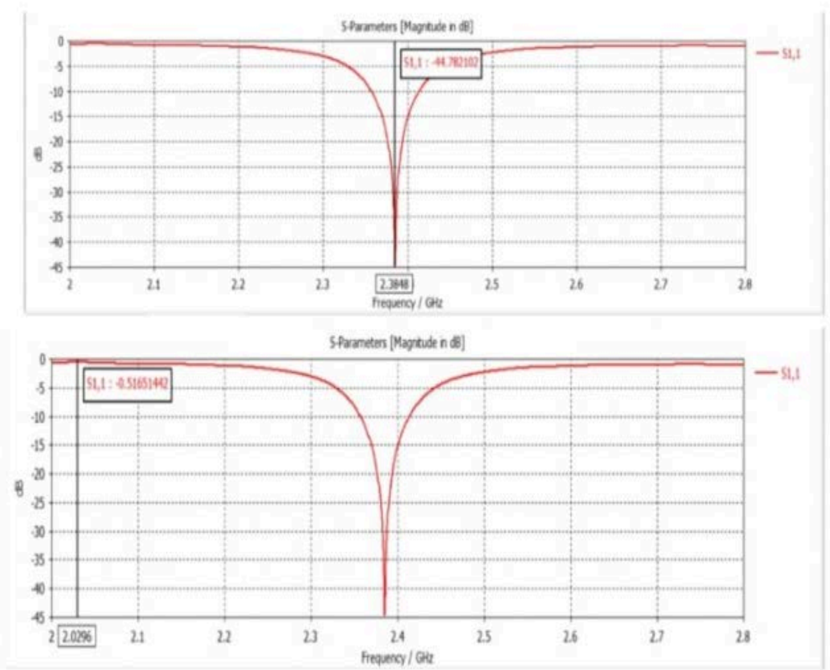

Fig. 7 Return loss at minimum

According to a ratio of rejected to accepted radio waves, the return loss of an antenna shows what percentage of radio waves arrive at the antenna input. In relation to a short circuit, it is specified in decibels (dB) (100 percent rejection).

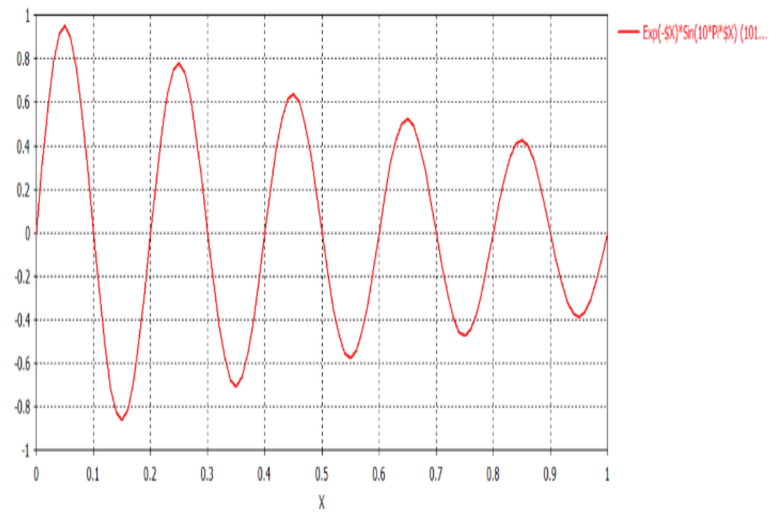

Fig. 8 shows the Plot function of Metamaterial

This figure depicts the Plot of Metamaterial structure using 1D results. The maximum no. of curves possible to plot is 25.

TABLE I PARAMETERS AND RESPONSES

Frequency (GHz)	Directivity(dB)	Gain(dBi)	Efficiency(dB)	Return Loss (dB)
2	6.596	-0.8139	-16.08	-25.5687
2.4	7.142	4.010	-3.266	-44.7821
2.6	6.189	-0.978	-14.76	-35.7649
2.8	5.656	-1.113	-13.66	-38.4932

The above shown table compares the analysis of parameters and responses of Handbag in zipper antenna. For the frequency 2.4GHz, we obtain maximum gain compared to other frequency ranges. The directivity and efficiency attained was comparatively higher than gain in 2.4GHz. The return loss we achieved for S_{11} parameter is -44.7821dB. From 2-2.8GHz frequency ranges we gained parameters for 2.4GHz.

V. CONCLUSION

The results of the modelling and the measurements demonstrate the efficacy of the suggested zipper antenna. At 2.5 GHz, gain of nearly 1.98 dB, which is roughly equivalent to 2 dB, is attained. The modelling and measurement outcomes proved that the metamaterial zipper antenna is valid. At 2.44 GHz, an increase of roughly 5 dbi might be achieved. It is a good idea to use the zipper in the meta material for the advantage of the off-body systems. The standard zipper doesn't need to be altered or destroyed**.** The key benefits of the presented method include improved operating frequency bandwidth, wider downsizing, and ease of design. Extra impedance converting structures can be modelled when specific frequency ranges or values are anticipated. When compared to other types of wearable antennas and body-centric networks, it is larger in size and exhibits the advantages of high gains and radiation patterns. There is no need for an additional installation space in order to mount over, approach, or adhere to any material. By simply changing the feed position, the proposed antenna can be used at several frequency bands. By switching the feeding location, the meta material zipper antenna may operate in a variety of frequency bands. It can also get various radiation directivities by dragging the zipper's handle open or shut. Using GPS and embedded system components, we will track the location of the person using this form of antenna in the future application of our concept. The antenna can only be connected wirelessly to embedded modules in order to accomplish this.

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