Shri Vile Parle Kelvani Mandal's

DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING

Approved by AICTE and Affiliated to the University of Mumbai

Department of Electronics & Telecommunication Engineering

Case Study On

Title: ANTENNAS IN BLUETOOTH TECHNOLOGY

SUBMITTD BY:

Sr No.	Name of Students	SAP ID
1.	Atulya Kumar	60002160052
2.	Parth Mehta	60002160063
3.	Ritika Gore	60002178005
4.	Maithili Kale	60002178006

Teacher's Name: Ranjushree Pal

Shri Vile Parle Kelvani Mandal's

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CERTIFICATE

This is to certify that M/S. ________________________________,

SAP ID_________________ of TE EXTC 1 / 2: has submitted their

Case Study for Subject Name for the Academic Year 2018-2019.

Guide

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Introduction:

Bluetooth technology is a short-range wireless communications technology to replace the cables connecting electronic devices, allowing a person to have a phone conversation via a headset, use a wireless mouse and synchronize information from a mobile phone to a PC, all using the same core system. The Bluetooth RF transceiver (or physical layer) operates in the unlicensed ISM band centered at 2.4 gigahertz (the same range of frequencies used by microwaves and Wi-Fi). The core system employs a frequency-hopping transceiver to combat interference and fading. Bluetooth devices are managed using an RF topology known as a "star topology".

Any structure that is resonant at 2.45 GHz with bandwidth more than 100 MHz and efficiency >50% can be considered a Bluetooth antenna. Therefore, a countless variety of antennas can be used, and they are application-specific.

Working Principle:

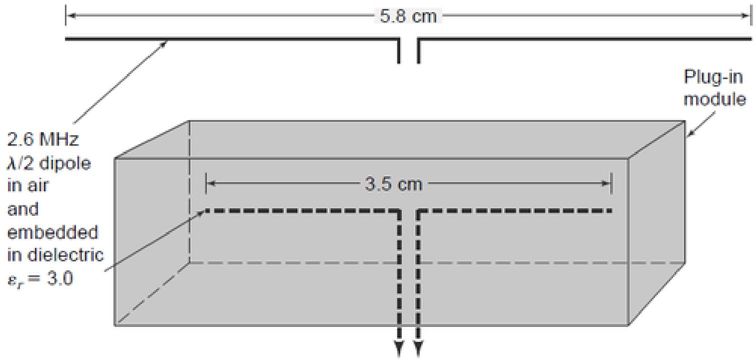
Bluetooth sends and receives radio waves in a band of 79 different frequencies (channels) centered on 2.45 GHz, set apart from radio, television, and cellphones, and reserved for use by industrial, scientific, and medical gadgets. Don't worry: you're not going to interfere with someone's life-support machine by using Bluetooth in your home, because the low power of your transmitters won't carry your signals that far! Bluetooth's short-range transmitters are one of its biggest plus points. They use virtually no power and, because they don't travel far, are theoretically more secure than wireless networks that operate over longer ranges, such as Wi-Fi. (In practice, there are some security concerns.)

Bluetooth devices automatically detect and connect to one another and up to eight of them can communicate at any one time. They don't interfere with one another because each pair of devices uses a different one of the 79 available channels. If two devices want to talk, they pick a channel randomly and, if that's already taken, randomly switch to one of the others (a technique known as spread-spectrum frequency hopping). To minimize the risks of interference from other electrical appliances (and also to improve security), pairs of devices constantly shift the frequency they're using—thousands of times a second.

When a group of two or more Bluetooth devices are sharing information together, they form a kind of ad-hoc, mini computer network called a piconet. Other devices can join or leave an existing piconet at any time. One device (known as the master) acts as the overall controller of the network, while the others (known as slaves) obey its instructions. Two or more separate piconets can also join up and share information forming what's called a scatternet.

Types of Antenna:

Bluetooth antennas are low bandwidth, resonating antennas operating at 2.4-2.485 GHz.Again PIFA, and FICA is used. Sometimes a dipole, embedded inside a dielectric is also used for high power applications.



Various microstrip geometries can be used to build Bluetooth antennas. The L-shaped, inverted F, and bow-shaped antennas are all popular designs. These antennas all transmit and receive linearly polarized radiation at 2.4 GHz and have smaller form factors than a plate antenna.

A diamond-shaped plate-like antenna is also a popular Bluetooth antenna design that uses circularly polarized radiation. This antenna has a larger footprint on the PCB and requires an impedance matching net, but it also has better sensitivity to linearly polarized RF radiation. Getting the resonance frequency just right also requires matching the microstrip dimensions with the dielectric constant of the substrate.

Using a Printed Circuit Board substrate with a higher dielectric constant will enable smaller circuit features and allow reduced antenna size for a given frequency. Choosing substrate and microstrip materials with matching volumetric expansion coefficients is important for devices that will be used over a broad temperature range, as this will help prevent fracture or delamination.

PCB layout software like Altium Designer makes it easy to build your Bluetooth-enabled device.

Some common types are:

• *Wire Monopole* — This consists of a simple wire soldered at one end from which it is fed against a ground plane. It is trimmed to be resonant at 2.45 GHz and provides good performance and high efficiency. The disadvantage of this antenna is that it is not low profile because it projects above the PCB.

•*PIFA* — The Printed Inverted F Antenna is like a monopole printed on a PCB, but it has a ground point and feed point along the main resonant structure.

•*Helix* — Similar to the wire monopole, except that it is coiled around a central core (usually air) making the physical dimensions smaller. It provides excellent performance, but projects above the PCB.

•*Ceramic* — Surface mount dielectric antennas are the smallest types of antennas available, because they are printed on a high-dk ceramic slab, which makes the electric field concentrated allowing the antenna to be made small while keeping a high resonant frequency.

This application note only describes PIFA and ceramic antennas because they are the most common, low- profile, smallest, and inexpensive types available.

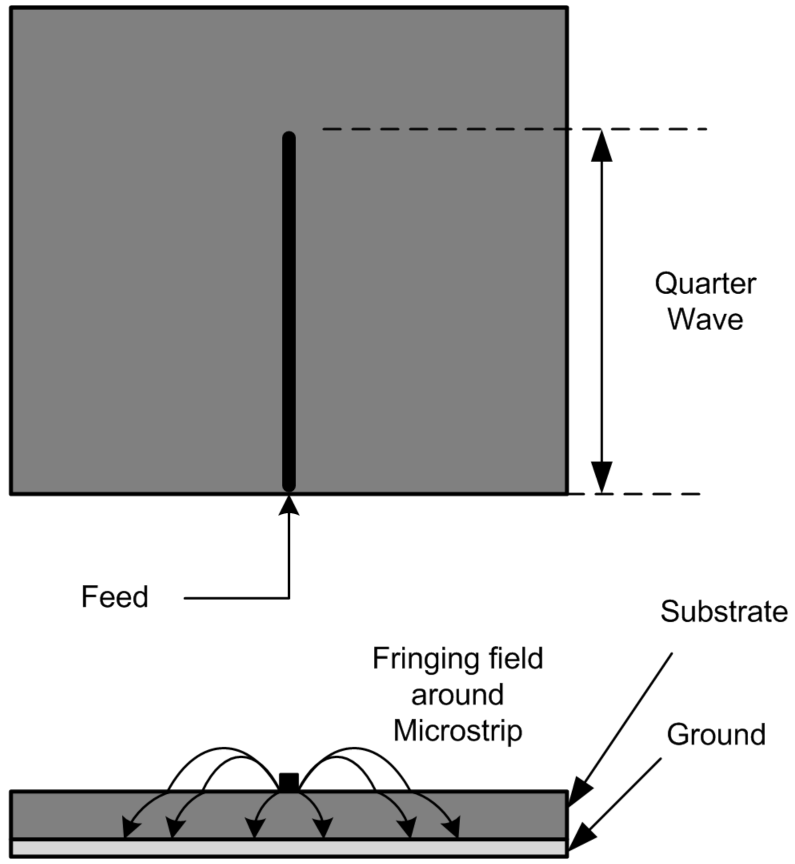
Table 4. Antenna Comparison

Antenna Type	Performance	Profile	Cost	Physical Size
Stub helix or monopole	Good bandwidth and efficiency, does not require matching network.	High: Projects from the side of the PCB	High	2.4 GHz antenna is approximately 15 mm long, but projects. Does not need ground plane to function.
Surface-mount ceramic chip	Reasonable performance on λg/4. Small bandwidth and reduced efficiency. Can become detuned during handling	Low: Can be machine mounted during assembly, no more than 0.5 mm thick	Medium	Element for 2.4 GHz is approximately 12 mm long, but needs ground area and clearance around active region.
Printed inverted-F or other printed types	Reasonable performance on λg/4. Small bandwidth and reduced efficiency. Can become detuned during handling	Lowest: Printed on PCB	Low	Element for 2.4 GHz is approximately 25 mm long, but needs ground area and clearance around active region.

Printed and surface-mount antennas have certain common properties. Area around and beneath the radiating element must be kept copper-free. The ground plane must be placed on one side of the radiating element. Bandwidth is >100 MHz with VSWR <2.5 and efficiency >60%.

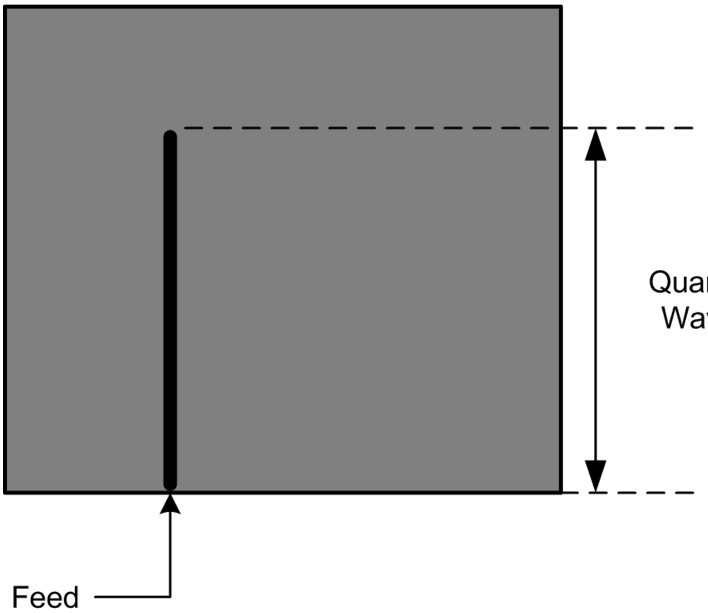
The antenna will detune if any object is placed close to it (in its near field). This has an effect of pulling the frequency, which must be returned to 2.45 GHz.

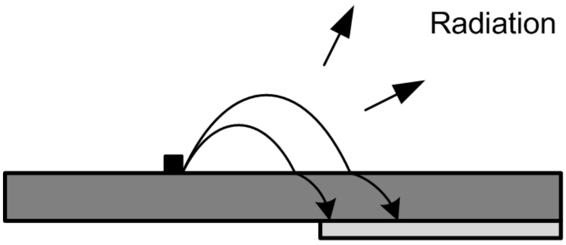
An oscillating or constantly accelerating charge is critical in producing propagating waves. A static or non- accelerating charge will result in a non-propagating electric field. But this is not the only condition for radiation. For example, consider a printed λg/4 element on micro strip, as shown in Figure 1.



The fringing field around the microstrip due to the ground plane directly underneath the substrate will be confined to a small area. If a network analyser is connected to the feed point, it would indicate a high VSWR and narrow bandwidth. This means very little radiation is being emitted from the microstrip element.

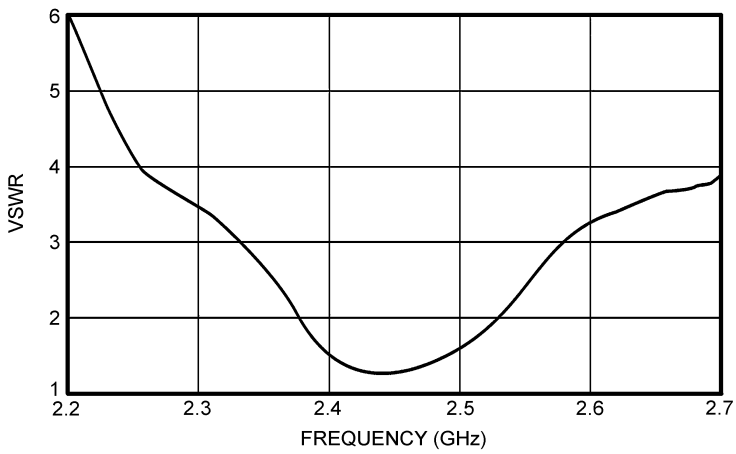
To increase the radiation emission and achieve greater bandwidth, the ground plane must be moved away from the microstrip element which makes the fringing field cover more distance, as shown in Figure 2. But it should be noted that if the ground plane is moved too far, then the fringing field stops altogether, and there is no radiation. Therefore, the position and size of the ground plane is vital in the design of a good radiator.



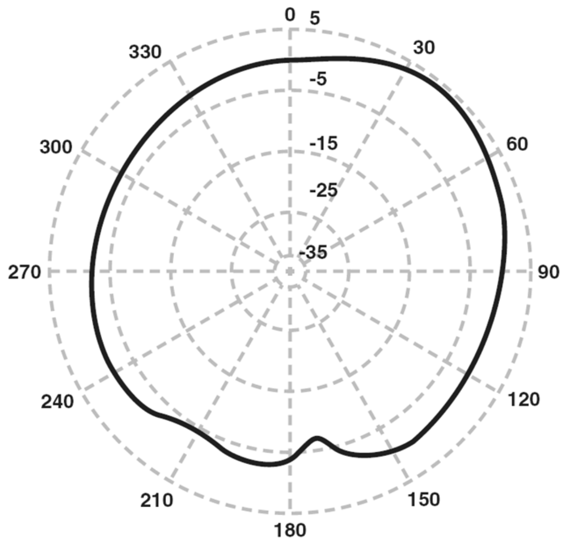


The antenna could be imagined as an impedance transformer, transforming the impedance of a microstrip line (50Ω) to that of free space (377Ω), which allows the power to be transferred from a guided wave to a free-space wave.

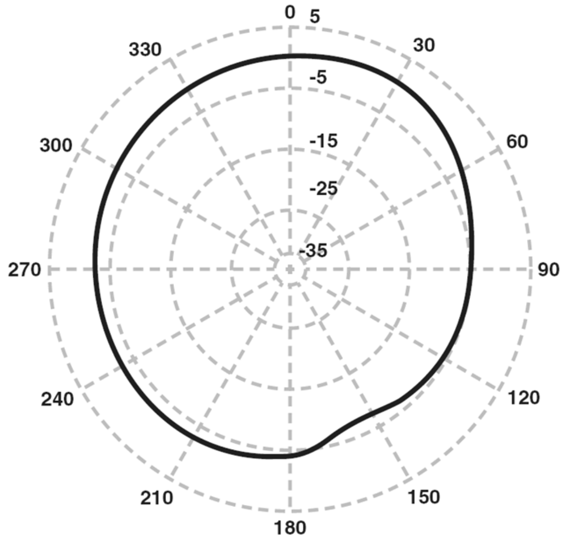
The radiation pattern from such antennas in which the physical size is much smaller then wavelength (L
<< λ) is almost symmetrical in all directions, as shown in Figure 3. The pattern can be controlled only when L is similar or greater than λ.



Radiation Pattern:



Azumith Cut



Elevation Cut

Figure 3. Antenna Radiation Pattern

Input return loss when viewed on a network analyser looks like that shown in Figure 4, with the full band covered with VSWR < 2. This gives very good matching into the antenna, however in real conditions when the antenna is detuned due to handling or placement of components close to it, a VSWR of 3 to 4 is typical.

Antenna Layouts:

1. *PIFA Antenna*

The typical length of a 2.45-GHz resonant printed antenna is 20 to 25 mm, depending on the thickness of the substrate and dielectric constant. Copper clearance is required around the radiating element which is fed from a point along it, as shown in Figure 5. The position of the feed can be used to control the input impedance into the antenna. The ground plane required on one side of the antenna is approximately 20 mm wide. If it were any smaller, it will start to reduce the bandwidth at the input. Good design practice is to have a three-element matching network going into the feed, to give some additional tuning ability if required. To obtain the exact dimensions of the design, input impedance and bandwidth would have to be simulated over the frequency band using an antenna simulation package. Alternatively an antenna manufacturer can be contacted that has the capability to make such a design.

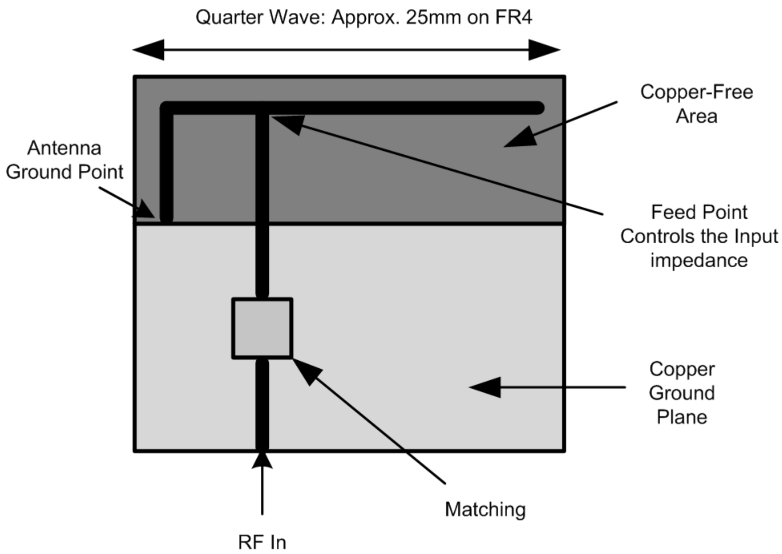


Figure 5. Printed Inverted-F Antenna (PIFA)

The PIFA is placed on the edge of the motherboard PCB, as shown in Figure 6. The area around the corner is kept copper-free, and any components such as the shielding that come close to the PIFA may pull its frequency. This can be returned by milling the end of the radiating element. The LMX5251/LMX5252 and its surrounding components do not need shielding unless they are very close to the radiating element.

2. *Ceramic Dielectric Antenna*

A ceramic dielectric antenna is smaller than a PIFA or any other PCB antenna because the active element is wound around a high-dk ceramic slab, which concentrates the electric field. As with a PIFA, a copper- cleared area and a ground plane are required, as shown in Figure 7. A smaller ground plane can be used, at the expense of bandwidth and efficiency.

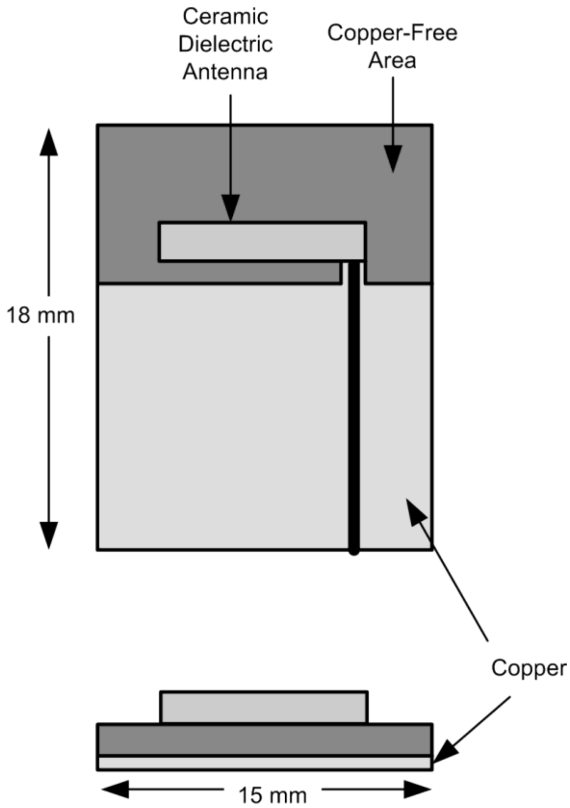


Figure 7. Ceramic Dielectric Antenna Placement

Conclusion:

The preceding discussion in the case study explains and compares various antenna layouts with their advantages and disadvantages with the radiation pattern. We have therefore understood working of Bluetooth antennas and different layouts that maximise Bluetooth efficiency like PIFA and Ceramic Dielectric antenna.

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