A Single Substrate Array of Dual Bands with WPD for IoT Applications

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Abstract: With the changing trends of the communication system, less expensive, light weighted, and antennas having the characteristics of low profile are required. Microstrip antennas are the perfect fulfillment of these needs. Multiple frequencies patch, 2X1 patch antenna is designed and presented in this paper. Performance parameters of antenna parameters such as S11, gain, radiation plots, and smith chart are plotted. In this reported work two different frequencies has been used. Patches are designed on 4.5GHz and 5.1GHz. Results are obtained using High Frequency Structure Simulator (HFSS).
Keywords: S- simulated, M- measured..

1. INTRODUCTION

From the studies up till now patch antennas are made with single frequency only but in this paper array is made for two different frequencies. In this paper the frequencies used are for the IoT (internet of things) application of MIMO antenna. The two patches are connected to each other by using the Wilkinson Power Divider. As well known the microstrip antenna is composed of three layered structure, patch mounted on substrate and ground is located below the substrate. Substrate is made of dielectric material. Patch antennas can be used as arrays also instead of single element. Gain enhancement may be done by the patch arrays The important frequencies in this paper, i.e., the resonant frequencies are 4.5GHz and 5.1 GHz. Arrays are used to obtain the required pattern that is not possible with the single element.

2 ARRAY ANTENNA

Radiation characteristics are the requirement of many applications of antenna that cannot be achieved by the single element.Single element antennas radiation pattern are wide and each element has low gain.Many applications require high gain for which array is used.Arrangement of the arrays is such thatindividual elements radiation sums up which results in maximum radiation in a particular direction only.Examples of array may be

- Yagi Uda
- Aperture type
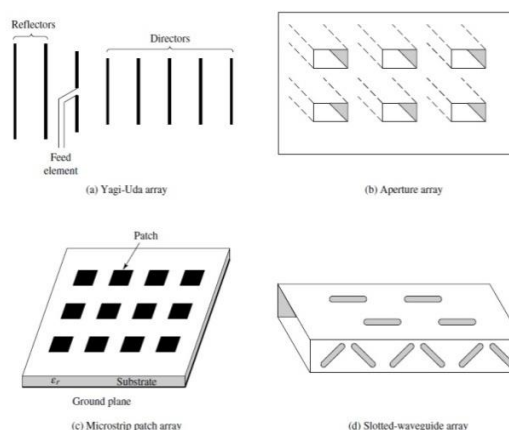- Microstrip Patch type
- Slotted Waveguide type [2]. Shown in fig.1.

Figure 1: Examples of array

3 .MICROSTRIP PATCH ANTENNA

Gained popularity in the 1970's for the space borne applications. The patch has the metallic nature and it might take different shapes, i.e., rectangular, square, elliptical, dipole, triangular, etc. From these rectangular and the circular are mostly used due to

Easy analysis, easy fabrication, low cross polarization radiation and attractive radiation characteristics. Microstrip antennas have following properties

- Economical
- Low profile
- Easy to fabricate
- Mechanically resilient

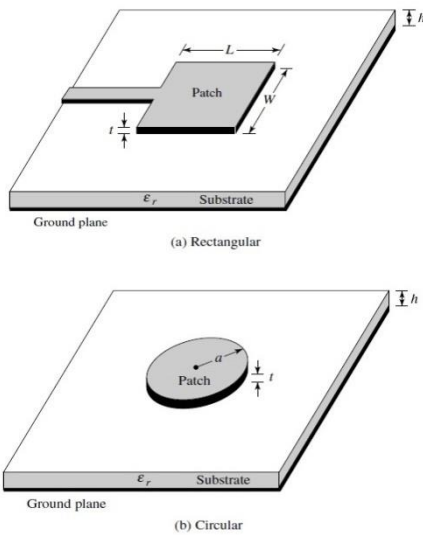- Comfortable for planar and non planar surfaces [3], [6], [7]

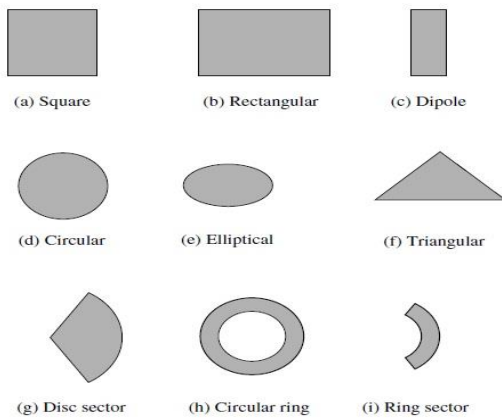**Figure 2:** Microstrip patch antenna (rectangular and circular)

Figure 3: Microstrip Antenna shapes types

A lot of substrate materials are presentto design the microstrip patch antenna the values for the dielectric materials for that deviates between $0.2 <= \varepsilon_r <= 12$.

Many feeding techniques are present there but amongst them these four are very popular and mainly

- feed line
- Coaxial probe type
- Aperture type coupling
- Proximity type coupling

4 WILKINSON POWER DIVIDER (WPD)

The WPD means the Wilkinson power divider divides the power at the output port while maintaining the impedance matching condition among all the ports as shown in fig.4.Since the design of the Wilkinson is designed with the passive components so it can also be used as a power combiner.It consists of three ports

- Port 1: input and
- Port 2 and 3: output

If un-equal impedancesare connected to the ports 2 and 3, then asymmetric power is achieved. When characteristic impedance is Z_o, and power is splitted as P_2 and P_3, and
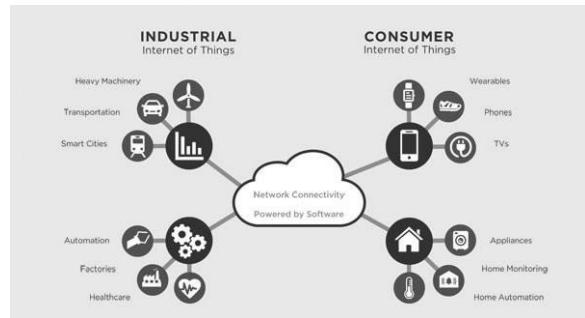
$$P_2 \neq P_3, \text{ then}$$

Figure 4: Wilkinson power divider

A new constant K is defined, where

$$K^2 = \frac{P_2}{P_3}$$

Then the design guideline is
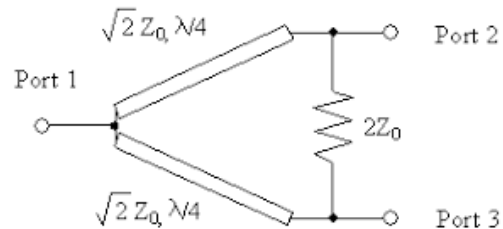
$$Z_{02} = Z_0 \sqrt{\frac{1 + K^2}{K^3}}$$

$$Z_{03} = Z_0 \sqrt{K(1 + K^2)} = K^2 Z_{02}$$

$$R = Z_0(K + \frac{1}{K})$$

For K= 1 symmetrical conditionoccurs.

5. INTERNET OF THINGS

Kevin Ashton is the one who invented the term

IoT in the MIT. Its frequency ranges from 100MHz- 5.8GHz.Interconnection of the network of devices, vehicles, and home appliances through the Internet can be achieved by the IOT. It contains electronics, software and internet connection. These

things manage the exchanging of the data as shown in fig.5, 6.

It even allows the substances to be identified and controlled remotely across present network structure, helps in makingthe more direct link between the real world and systems based on the computers, and this results in enhanced form of measuring parameters like efficiency, accuracy etc.This is the new era of thetechnology which is implementing now days that is time saving, eefficient and easily accessible.

It can be found at various aspects of day to day life such as the

- Home and Offices
- Smart Cities
- Retail
- Health Care
- Transportation

Some examples of IoT are

- The calendar can connectwith the car and give the best route to take to the meeting
- Alarm clock can connectwith thecoffee maker for turning on and off
- Alarm clock can also talk to the TV for the morning news
- Office supplies that are running low can be reordered
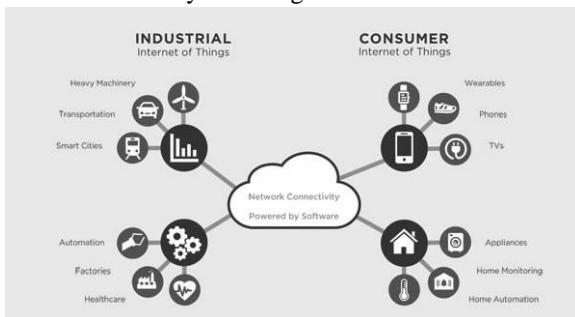- The food that has finished and you likecan be reordered by the refrigerators

Figure 5: Internet of Things

Challenges that are faced by IoT are as follows

No standards are available for the application program interface. Devices should speak the same language to get the secure communication and so that it can be managedproperly. There is a risk of the overflow of the data on the network. For the security

- No security or terrible security is expressed by many devices.
- An easy gateway can be created into the network for the malicious intent

- With the introduction of the new devices business data security can be compromised with when proper safeguards are not available
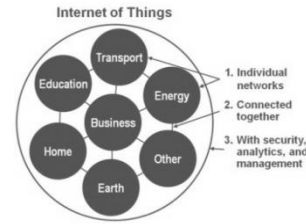
Figure 6: Internet of Things

Broadband has become more widely available. Its expenses are decreasing. It is estimated that by 2020, 50 billion devices will be present on the
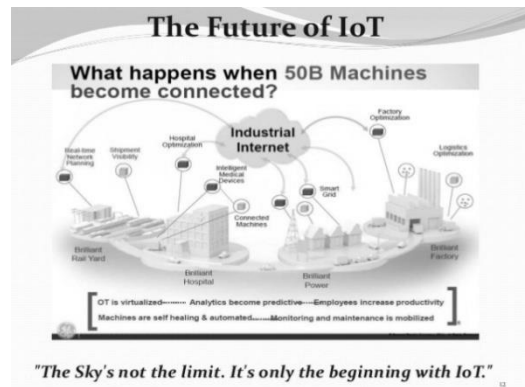
earth. It is well known that $1/3^{rd}$ of the population of the world having the facilities of
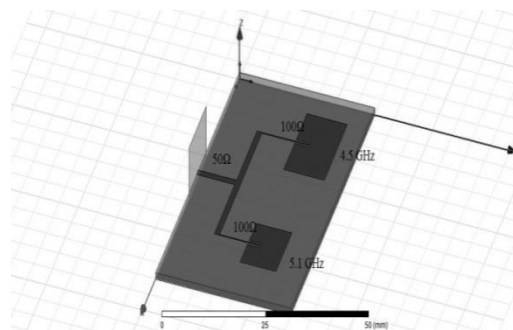
- Computers
- Smartphone
- Mobile devices

Figure 7: Future of IoT

And the remaining two third will be occupied by

- Sensors
- Actuators
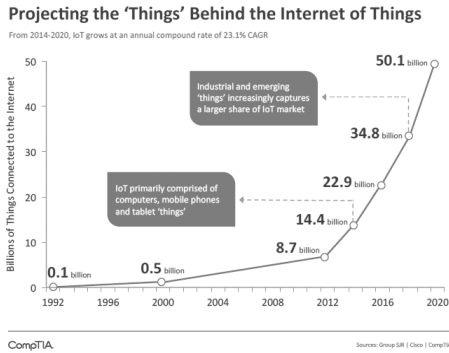- Newly upcoming Controlled devices

Figure 8: Growth of IoT

9.   ARRAY DESIGN
10.

Perfect substrate is an essential parameter while designing an antenna. For this design
- height of the substrate (h) = 1.27 mm
- dielectric constant (ε_r) = 10.2 (RT Duroid)

Dimensions of the patch antenna in this paper are as follows

Table 1: Parameters of the Designed Antenna

Parameters	Value
Length of patch (5.1 GHz)	9.21 mm
Width of patch (5.1 GHz)	12.43 mm
Length of feedline (5.1 GHz)	11.94 mm
Width of feedline (5.1 GHz)	0.16 mm
Inset length (5.1 GHz)	3.14 mm
Resonant frequency (5.1 GHz)	5.04 GHz
Length of patch (4.5 GHz)	10.43 mm
Width of patch (4.5 GHz)	18 mm
Length of feedline (4.5 GHz)	13.52 mm
Width of feedline (4.5 GHz)	0.16 mm
Inset length (4.5 GHz)	3.42 mm
Resonant frequency (4.5 GHz)	4.73 GHz

Inset length is the length of the inset feeding used in this design. It is an important part for the designing of the antenna as it is useful in impedance matching.

For this design two different types of impedance matching are used, one for the input from the external environment to the antenna and the other inside the circuit for the two patch antennas.
- Input impedance matching**:** 50Ω
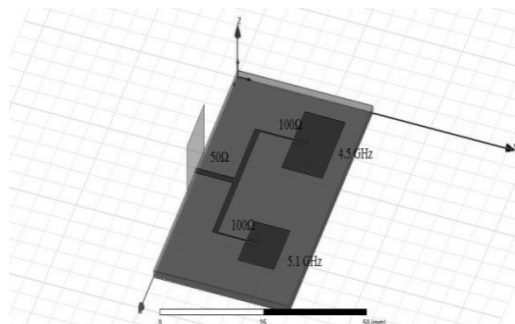- Patch impedance matching**:** 100Ω as shown in

fig.9.
- **Figure 9:** Impedance Matching

Dimensions of the antenna for the design are calculated by these formulas. See fig.10 [5].
- **Length of feedline (L_f)**
-
-

$$\frac{\lambda}{4\sqrt{\varepsilon_{eff}}}$$

- **Width of feedline (W_f)**

$$\frac{7.84}{\exp\left[\dfrac{Z_o\,[\varepsilon r + 1.14]^{1/2}}{87}\right]}$$

- **Inset length (y_o)**

Fabricated structure is shown in fig.11 and

$$R_{in}(y=y_o) = R_{in}(y=0)\cos^2\left(\frac{\Pi}{L_p}\,y_o\right)$$

$$y_o = \frac{L_p}{\Pi}\cos^{-1}\left(\frac{R_{in}(y=y_o)}{R_{in}(y=0)}\right)$$
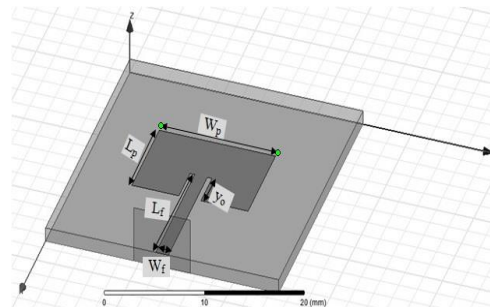
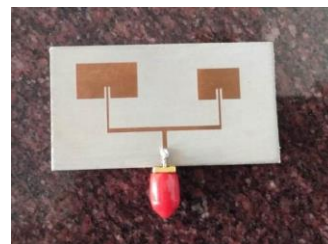measured results in fig.12.

Figure10: Dimension Calculation

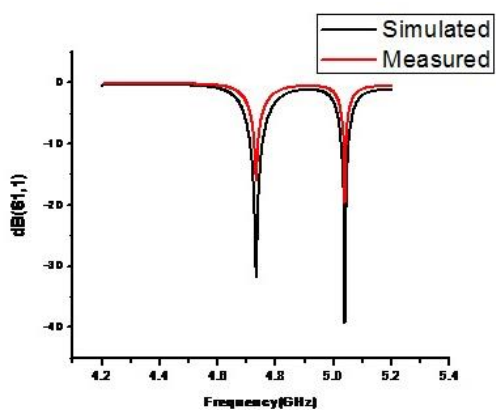

Figure 11: Fabricated Structure

Figure12: Measured Results

11. RESULT AND ANALYSIS

Table 2: Summarized Results

S.No	Parameters	Value
1	Return Loss (4.5GHz)(S)	-31.73 dB
2	Return Loss (5.1GHz)(S)	-39.32 dB
3	Gain	1.84 dB
4	Smith Chart	Nearly passes through 1.
5	Resonant Frequency (4.5GHz)	4.73 GHz
6	Resonant Frequency (5.1GHz)	5.04 GHz
7	Return Loss (4.5GHz)(M)	-18.865 dB
8	Return Loss (5.1GHz)(M)	-23.66 dB

12. CONCLUSION

IOT is the latest trends for smart controlling of the devices. In this paper an antenna is reported that will be work for two frequencies for controlling these IOT devices wirelessly and smartly. With the help of the result we can conclude that Array is an assembly of antennas which is required to get high gain, good radiation pattern and high directive characteristics. The literature available for the array specifies that it works on one frequency only due to the reason of easy and practical construction. But in this paper the innovation is that the array is made for two different frequencies

- 5.1 GHz (Wi-Fi)
- 4.5 GHz (WLAN)

In this paper the antennas are connected to the input by using the Wilkinson power divider. This is also one of the novel approaches.

The IOT devices are able to provide the connection among the network of devices, vehicles, and home appliances that can be connected to the internet and they contain the electronics, software, actuators, and internet connectivity that provides the exchanging of data. 5.1GHz and 4.5 GHz frequency have been used for the work which belongsto the IoT range.

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