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Antennas for Modern Wireless Communication System: A Survey

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***Abstract* - Day by day technology advances, antennas become more common in a variety of devices such as mobile phones, laptop computers, palmtop computers, smart watches, and other portable gadgets. Because of their flexible nature, antennas are now widely used in the construction of smart cities. They may be configured in a variety of sizes to meet specific needs. The radio communication technologies need the development of innovative and better organized antenna designs. This paper presents a survey on antennas for modern wireless communication and future aspects. Recent researches are examined and presented to illustrate the function and application of antennas on wireless communication systems.**

Index Terms - Communication system, Microstrip antenna, Wireless, 5G

INTRODUCTION

When used in conjunction with a transmitter or receiver, an antenna is a metallic model and also known as an aerial in broadcasting engineering. An antenna is the crossing point between radio waves peripatetic through space and electric currents flowing in the course of metallic conductors [1]. During radioing, a radio source provides an electric current to the antenna's end points and then an antenna emits radiation from the current as an electromagnetic effect. An antenna cut off the portion of a radio wave's power in order to generate an electric current at its end points, which is subsequently transferred to an amplified receiver. Antennas are required parts of any broadcasting apparatus [2].

Wireless communication system components have been created in larger quantities in recent years due to their low profile, low production cost, and simplicity of consolidation into circuit boards. Wi-MAX, GSM and Wi-Fi apps are popular because they provide services such as SMS, audio and video telephony, turbo data transmission, and internet access at any time and from any location. These applications are typically connected with mobile phones, laptop computers, and other portable devices. Various antennas are included in these devices to provide essential wireless practices. However, in present wireless communication system antennas are widely used because of their advantages, despite shortcomings such as restricted transmission capacity, low gain and low power handling capability.

In the previous fifteen years, mobile and wireless communication networks like GSM, 2G, 2.5G and 3G have grown dramatically. In cellular networks, the carrier frequency range for multimedia applications is limited from 700MHz to 2.5GHz. The worldwide spectrum transmission capacity allowance for all mobile networks does not exceed 800MHz, with each supplier receiving around 200MHz over all available cellular bands [3]. Each age group of mobile technology has brought with it a rise in data transmission speed, as well as increased connection quality and additional functions. Since 2009, fourth generation (4G) technology has been accessible worldwide. The fifth generation (5G) network will allow a variety of new facilities, together with those connected to the Internet of Things (IoT) and the notion of smart cities. 5G mobile communication technology supports a wide range of multimedia services, including teleconferencing apps and interactive games [4]. The given below table number 1 shows the different standard frequency band range.

TABLE 1
FREQUENCY BAND AND THEIR RANGE

Frequency Band Name	Range
High Frequency/(HF)	0.003 GHz to 0.03 GHz
Very-High Frequency/(V-HF)	0.03 GHz to 0.3 GHz
Ultra-High Frequency/(U-HF)	0.3 GHz to 3 GHz
Super-High Frequency/(S-HF)	3 GHz to 30 GHz

LITERATURE REVIEW AND RECENT RESEARCHES

This segment focuses on numerous predictable antennas that operate in various bands for various wireless applications.

In [5], Use of parasitic slot array antennas in a town wireless sewage sensor network is described. To illustrate the effect of a restricted beam contemplating on a genuine sensor network system, the usage of parasitic antennas is studied.

The combination of an electrically steerable beam shaping and an angular diversity method used by this antenna permitted it to modify its radio surrounding and identify optimal reception quality. The sensor measurements demonstrate that the antenna's cleverness significantly upgrade the packet response rate and receive signal strength indicator (RSSI). However, when it compared to an evenly radiated dipole antenna packet rate increased by 64% and the RSSI increased by 10dB. The sensor network findings reveal that the manholes cover antenna's tunability and angle diversity considerably enhances packet response rate by wisely adjusting to the neighbouring urban radio surroundings.

Lee, et al [6] discussed a printed slot loop antenna with tunable strips for 2.4GHz and 5.0GHz wireless practices. It has a slot design and a couple of adjustable strips with permitted impedance transmission capacity and impedance matching, and it can function in the 2.4GHz and 5.0GHz WLAN bands. The computation results of the planned antenna indicate rather high-quality omni-directional patterns in the x-z coordinate for the primary functioning frequency. The computation grades of fabricated antenna corroborate pretty well with the expected values, revealing that 2.4GHz and 5.0GHz WLAN practices work successfully.

Jin-Gang, et al [7] detailed how to build a small inner wide band antenna for the wireless USB dongle appliance. Pliable a metal plate with two bevelled edges is a simple way to make an antenna. By adding a short-circuited pin attached to the structure ground plane, the antenna achieves a broad impedance transmission capacity of about 8GHz (2.5GHz to 11GHz range). A parametric analysis is done after measuring the antenna gain and radiation shapes. The effects of a computer on radiation features are investigated.

Wu, et al [8] discussed a revolutionary low-profile scalable omni-directional antenna that may be installed beneath a solar panel. A (72x72x11.5) mm^3 solar-antenna 3-dimensional arrangement running at 2.4GHz exhibits the configuration's potential for the deployment of autonomous integrated wireless antenna junction. The antenna scale may be readily adjusted to accommodate different solar board scales dependent on the power requirements of a sensor. This research might lead to the deployment of self-sustaining ubiquitous sensors in "rugged" environments such as vehicles, highways, trains, roofs.

Guo, et al [9] discussed a novel compact wideband patch antenna. The antenna is made up of two basic patch pairs that have opposing phase feeds. An antenna of roughly (54.5x22x20) mm^3 is made and tested to account for the link between two patches in the design. In the 2.6-6GHz frequency range, this antenna has an agile reflection coefficient of less than -9.5dB. The antenna's radiation performance is excellent over the whole frequency range. This antenna can provide about 87% bandwidth along with good radiation property.

In [10], the topic of discussion is a small stacked dipole antenna with a directed radiation range for wireless practices. This antenna model has a front-to-back ratio of 15.00dB and an overall size of (44x18x4.8) mm^3. The model employs the pairing of electromagnetic resonance of the linked slabs to create directed radiation features. A new single-layered metal slab antenna construction is developed for acquiring directional radiation properties. The stacked metal plate, electric and magnetic resonances are coupled to create directed radiation coverage. The front-to-back ratio of the design is 15dB.

In [11], a 4-antenna system with good isolation for portable wireless gadget is presented. It has been recommended that a mobile terminal with 4-antennas and adequate isolation can be used. Antennas are well-planned and put on the circuit board in a handy location. Using coupling feeds, a short strip and parasitic strip, the primary antenna may productively cover the GSM1900/1800/900/850UMTS, LTE2500/2300/700 and 2.5GHz WLAN bands. Because of their vertical structure, the 3-auxiliary antennas operated successfully in the frequency band range of 1880–2690MHz while occupying a little amount of area. The observed isolation among any couple of antennas is greater than 15.00dB, and the computation effectiveness is greater than 40.00%.

He, et al [12] describes a new Vivaldi antenna for automotive wireless communication networks. For IEEE 802.11a (4.9GHz–5.935GHz) WLAN, an enhanced Vivaldi antenna with crosswise slots and planar directors is planned and produced. It upgrades the standard of IEEE 802.11a (4.9GHz–5.935GHz) WLAN and other (2.4GHz–4.9GHz) wireless systems.

Zhang, et al [13] discusses the features of a base station antenna with changeable band notch features. The initiation process involves a few window-type slits which are mounted on the radiating patches of magneto electric dipole. It has an impedance transmission capacity of 2.39GHz–2.52GHz in the 1.825GHz–2.925GHz range. It has more functions and performs better.

Yeoh, et al [14] presented an antenna which is a conical monopole antenna for multiple wireless practices. This antenna model proposed for ultra wideband features and other wireless practices. The recommended antenna arrangement is suitable with various wireless standards, i.e., WiMAX (2.5GHz–5.5GHz), Wi-Fi (2.4GHz), Bluetooth (4.0, V1.0–V4.0) and wireless universal serial bus (3.10GHz–10.60GHz). It also has an appropriate frequency response in the X-band (8GHz-12GHz) and Ku-band (12GHz–18GHz) for satellite communication close-range radar.

Deng, et al [15] described a MIMO antenna with increased isolation for WLAN practices. This antenna is intended to span the WLAN spectrum of 2.4GHz or 5GHz. The planned MIMO antenna is tranquil of the pair balanced meandering inverted-F antenna components separated by approximately 0.115 λ0 of the minor band. A good isolation is obtained in lower and upper bands by creating two unlinked devices, an indirect resonant branch and a reversed T-shaped slot fixed on the ground respectively. It supports both the 2.4GHz and 5GHz WLAN bands.

Zhai, et al [16] discusses a revolutionary low-profile antenna which has dual-band and dual-polarization feature for WLAN practices. The antenna can produce low-profile and unidirectional radiation pattern by adding an artificial magnetic conductor surface. At 2.4GHz, the suggested antenna has a height of 0.088 λ0. It can also deliver measured relative bandwidth of 15.5% (2360MHz-2760MHz) and 9.5% (5120MHz-5620MHz). It is feasible to attain better than the 22dB port-to-port isolation. With peak gains of 7.2dBi in the lower band and 7.3dBi in the higher band, stable radiation patterns are acquired. The antenna is suitable for usage in multi-band base stations for WLAN practices.

5G AND MICROSTRIP ANTENNA

In this section we will explore some microstrip antenna and their use in 5G technology. 5G technology is now very popular and microstrip antenna plays a vital role in it.

I. 5G Characteristic

The characteristics of 5G technology are shown in table 2:

TABLE 2
5G CHARACTERISTIC

Technology	Characteristic
5G	• Data rates are up to 10Gbps • 10 to 100 times gain in speed over 4G and 4.5G networks • The number of connected devices per unit area may be increased up to 100 times (compared with 4G LTE) • 1000x per unit area bandwidth • 1-millisecond latency • The network's energy consumption is cut by 80-90% • Battery life of a low-power IoT (Internet of things) gadget can last up to 8-10 years

II. Millimeter-Wave Microstrip Antenna for 5G Wireless system

Millimeter Wave mobile communication operates at frequencies of 28GHz and 38GHz using high dimensional antenna arrays in base stations and a small portable wireless appliance [17].

This study discusses a 5G mobile communication antenna of the future. This antenna comprises a couple of rectangular patch elements placed on a single coating 'RT 5880' substrate with a transformer connected impedance identical network that assists a high gain of 9.05dB and an efficiency of 83%. At the centre frequency of 38GHz, this antenna performs well in terms of antenna characteristics like gain, directivity, return losses, impedance, transmission capacity, and efficiency [18].

The notion of millimetre wave in mobile communication will engage in a regime change in worldwide cellular arrangements, and this may be accomplished by employing a phased array antenna or steerable directional antenna. This simple miniaturised antenna model method to phased array may aid in the development of expected 5G technologies.

This antenna can be used up to 28GHz to 38GHz range.

III. Small Microstrip Antenna for 5G Wireless Communication Systems

In this, a tiny microstrip monopole antenna capable of millimetre wave communication is used. It is built of 1.6mm thick FR4 and was organised as a planar-fed single-band by putting rectangular openings on a square patch for a simple and small structure. As a consequence, the propounded antenna was simulated in the HFSS software and several antenna properties, such as radiation patterns and gain, were deliberated across a particular frequency range. The return-loss transmission capacity was calculated to be 0.716GHz centred at 28GHz as a reference of -10dB, covering the required bandwidth of the 5G standard [19]. The antenna gain is from 23GHz to 33GHz is shown in figure number 1 given below:

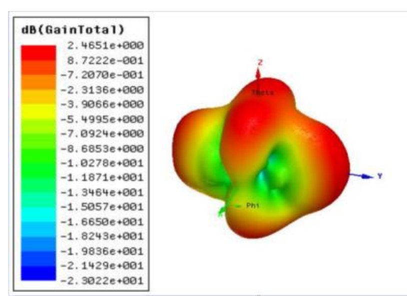

FIGURE 1
THE ANTENNA'S GAIN (ADAPTED FROM [19])

This antenna is suitable for use in current communication systems, particularly wireless communication. A compact microstrip antenna is a rectangular patch that is electrically tiny and slot-loaded to function in a single band. Gain is satisfactory and the resonance frequency is under the Ka band frequency range.

IV. Compact Wideband-Printed Antenna for 5G Wireless Communication Systems

The design technique employing the slotted partial ground plane is far more adaptable for enhancing antenna performance. A complete model instruction for estimating antenna size is provided, which is based on parametric and mathematical investigation. The consequences of changing the length of the ground and the location of the slot in the ground plane are explored. The simulation was done with the help of HFSS software.

The created antenna is intended for usage in the super-high frequency (SHF) spectrum's C band, as well as the n77 (3.30GHz-4.20GHz) and n78 (3.30GHz-3.80GHz) bands of frequency range in 5G-frequency bands. The antenna constructed has a wide transmission capacity (700MHz) and a low reflection coefficient of 31.15dB [20].

This technology may be used to extend the operational frequency band of rectangular printed antenna system in operation without changing the patch form. The HFSS programme is used to do the parametric analysis. The antenna is capable of covering 5G wireless bands such as the n77 band and n78 band. The geometry of the antenna is shown in below figure 2:

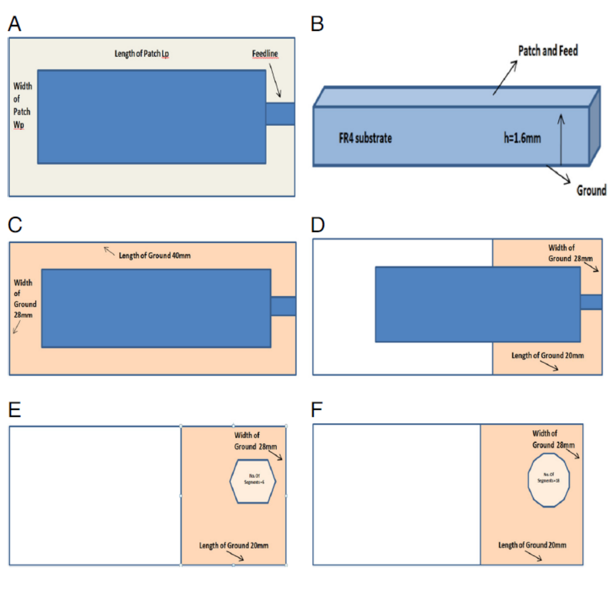

FIGURE 2
PLANNED SHAPE OF SMALL WIDEBAND-PRINTED ANTENNA (ADAPTED FROM [20])

V. Broadband Microstrip Antenna for 5G Wireless Communication Systems

In this, a latest model solution for a broadband microstrip antenna is designed for use in 5G wireless systems. The suggested antenna has a core working frequency of 28GHz and may be employed in the confined point-multipoint allocation service frequency range. The FEKO programme was used to compute, simulate and optimize the size and settings of the antenna. The antenna has a small footprint with dimensions of (6.2x8.4x1.57) mm^3 with a dielectric coefficient of 2.2 and a depth of 1.57mm, was employed as a substrate for the antenna construction [21].

In response to the increased need for mobile data and mobile devices, a rectangular microstrip antenna has been developed for 5G applications. This antenna has a resonance frequency of 28GHz and a reflectivity of 22.50dB. The suggested antenna has a radiation efficiency of 80.18% and an antenna gain of 5.06dB at the resonance frequency. The results also reveal that its bandwidth is 5.57GHz (relative operating band 19.89%), which is an excellent result.

This antenna is appropriate for use in modern communication systems, notably 5G wireless communication systems.

ANTENNA'S FEATURE AND DISCUSSION

In this section we will discuss the antenna features. The table 3 and table 4 are given below:

TABLE 3
ANTENNAS AND THEIR FEATURE

S.No.	Year	Author	Type of Antenna	Feature
1	2009	Jeong, et al [5]	Parasitic Slot Array Antennas	• Controlled by a sensor mote • Packet receiving rate is good
2	2009	Lee, et al [6]	Slot Loop Antenna	• WLAN operation bands : 2.4GHz and 5GHz • Good omni-directional patterns
3	2010	Jin-Gang, et al [7]	Internal Wideband Compact Antenna	• Provides large transmission capacity up to 8.5GHz • Can be employ in a USB dongle appliances due to its very small size feature
4	2011	Wu, et al [8]	Scalable Solar Antenna	• Low-profile omni-directional antenna • Reconfigurable as per requirement
5	2011	Guo, et al [9]	Patch-Pair Crescent Moon-Shape Antenna for Broadband	• Provides about 87% bandwidth • Radiation property is good for band 2.6–6 GHz

S.No.	Year	Author	Type of Antenna	Feature
6	2013	Sarin, et al [10]	Stacked Dipole Compact Antenna	• Provides better directional radiation characteristics
7	2013	Guo, et al [11]	4-Antenna System With High Isolation	• Operated at 1.8GHz–2.69GHz with a small occupied space and 2.4GHz WLAN bands • Antenna efficiency reached 40% or above
8	2014	He, et al [12]	Vivaldi Antenna	• Operated at 4900-5935 MHz WLAN band and other wireless (2400-4900 MHz) WLAN band • It provides resistance to polarization distortion
9	2015	Zhang, et al [13]	LTE Base-Station Dipole Antenna	• MIMO system application is present • Multi-operational and improved performances such as unidirectional radiation, low back radiation, cross-polarization and high gain
10	2015	Yeoh, et al [14]	Ultra-wideband Conical Monopole Antenna	• Provides better performance than traditional monopole antenna
11	2017	JingYa Deng, et al [15]	MIMO Antenna with dual-band inverted-F	• Operated at either 2.4GHz WLAN band or 5GHz WLAN band • Lower envelop correlation coefficient • Compact size
12	2017	Huiqing Zhai, et al [16]	Low-Profile Dual-Band Dual-polarized Antenna	• Operated at a lower band (2360MHz to 2760MHz) and higher band (5120MHz to 5620MHz) • Better use for a base antenna model in wireless local area network communication appliances

TABLE 4
MICROSTRIP ANTENNAS AND THEIR FEATURE

S.No.	Year	Author	Type of Antenna	Feature
1	2014	Chauhan, et al [18]	Millimeter-Wave Microstrip Antenna	• Working range is 28 GHz and 38GHz frequency • Provides the gain of 9.05dB and efficiency 83% • Compatible for 5G wireless communication systems
2	2019	Tahir, et al [19]	Compact Microstrip Antenna	• Small and compact • Operated at 28 GHz • Compatible for 5G wireless communication systems
3	2020	Kapoor, et al [20]	Compact Wideband-Printed Antenna	• It provides 5G wireless application bands such as n77 band and n78 band • Compatible for 5G wireless communication systems
4	2020	Przesmycki, et al [21]	Broadband Microstrip Antenna	• Operated at 28 GHz • Compatible for 5G wireless communication systems

CONCLUSION AND FUTURE WORK

This research paper provides a comprehensive survey of some recent initiatives in antenna technology and towards small and compact microstrip antenna and enhancement of their characteristics. The 5G wireless technology is now on boom. The Internet of Things, in conjunction with integrated and intelligent sensor systems and in-home sensor networks, will transfigure how people live their lives. Microstrip antenna operating at 28GHz-38GHz range will help to achieve new smart life style.

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