A Survey: Slot Antenna and Antenna Array.

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Abstract: *Slot are generally introduced in the antenna or antenna to improve the impedance matching, improve the bandwidth and gain. Sometimes slots are introduced in the ground planes, or between antenna elements to reduce the mutual coupling between elements. The antenna being an important element in a wireless communication technology, the design of the same with different requirements is important. This paper gives the survey of the slot antenna and antenna array constructed through waveguide and microstrip lines, to meet different antenna parameters as required in various wireless communication technology.*

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Keywords: **slot antenna,slot antenna array, gain bandwidth, polarization.**

1. Introduction

Slotare produced by making a lengthened or prolonged slot cut of about 0.5 λ long and width usually very less than 0.5 λ in a conductive metal sheet and is often excited at the center or off the center. Shape of slot is usually available in the form circular or rectangular and these are in the form of width modification, due to which it is capable of being acted as a waveguide, coplanar waveguide (CPW), coaxial, slot line, or as a microstrip feeding schemes. Slot creation leads to obtaining a new resonating frequency Creating or introducing a slot in the bottom layers, of the microstrip antennasoffersincreases in antenna gain. The radiation pattern of the slot antennas is most of the omni directional, featuring omni directional gain around the azimuth plane with horizontal polarization.

Slots creation the waveguide antenna, termed slotted waveguide antenna, is basically an array of slots, offers a very high gain and are capable of operating in the frequency range 300MHz to 30 GHz. For the lower microwave frequency as well as ultra-highfrequency, a slotted-cylinder antennais used.

Slot introduction has an added advantage of getting different polarization, as a simple example , the complement of a dipole when placed in free space is a thin slot in an infinite ground plane, consider slot and dipole have same dimension , then the corresponding radiation will be same except that E- and H- fields are swapped, that is slot acts as magnetic dipole rather than an electric dipole . As a result, the polarization is rotated 90º, so that radiation from a vertical slot is polarized horizontally while aifvertical slot is introduced antenna gives the horizontally polarized signal.

Thus, slot cutting or introduction forming slot antenna and slot antenna seems to have many advantages with respect to getting desired antenna parameters such as

increase in gain, efficiency, required polarization and bandwidth. This paper gives the survey of the slot antenna and slot antenna array used in various scenarios to meet the required criteria with respect to the different application.

1.1 Slot introduction in antenna and antenna array to meet desired result.

A Dual feature, male tapered slotoperated as an antenna predefined at a frequency of 28GHz was basically used to excite dipole antenna resonating at 3.6GHz as mentioned in [7]. Slot with C shape with 50-ohm microstrip fed discussed in [15] offered left-hand polarization. In [14], bow-tie slot antenna was used to get a wide impedance bandwidth, with the three-layer groove structure to provide strong mechanical support and enhanced gain. The square ring slot radiator in [13] was designed to provide dual-polarization characteristics maintaining the performances better in terms of fundamental radiation characteristics. Design of cubic slot in [12] could switch between omni-directional and broadside radiation pattern. A compact large-declination longitudinal slot array antenna developed in [11] achieves a larger off angle[declination] and a lower side lobe level.

Circularly polarized, backed slot spiral antenna array designed in [09] and fed by PGW provides higher efficiency.Radial line slot array with Circularly polarized (CP RLSA) [8] antenna with a gradually variation of length of slot along with radius, for reducing the antenna side-lobe levels and for making uniform aperture phase distribution. It has other advantages of very good radiation efficiency, more gain and good bandwidth. substrate integrated waveguide fed open slot antenna [WOSA] array can achieve a wide bandwidth with a single-layer structure, which is attractive for millimeter-wave.

Tapered Slot Array discussed in [5] has both decoupling and radiating structure on the same the surface.For 4G/5G wireless Devices, dual-polarized crossed slot planar array antenna designed in [2] has a very simple configuration, with good radiation performance, can be fabricated easily. Circularly polarized post-wall waveguide slot array antenna in [1], has the reduction the total number of dielectric layers by a value of two, which there by greatly increases ease of mass production.

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2.1 Slot antenna/antenna array andBandwidth Enhancement

Bandwidth concerning antenna is defined in terms of radiation parameters. The Bandwidth of an antenna is defined as the range of frequency over which radiation parameters are frequency over which radiations parameters such as half-power beam width (HPBW), levels of side lobes, gain are within specified certain minimum and maximum limits then the range of frequency is defined or considered as the bandwidth. The presence of slots will greatly help in the increase of the bandwidth of the antenna. These structures are periodic that forbids the propagation of all electromagnetic surface waves within a frequency band called band gap thus permitting additional control of the behavior of electromagnetic waves other than the conventional guiding /filtering structure.

Slot antennas are used to achieve improved performances, particularly for broadband and circular-polarization applications with better gain and efficiency. This section conveys the overview of enhancement in bandwidth by the introduction of the Slot antenna/antenna array.

The type of slot and their applications are mentioned in the table below.

Table1. Application of slot arrays for bandwidth enhancement

Sl .No.	Reference No.	Type of slot array	Bandwidth	Application
1	[4]	Low-RCS slot array antenna	**7 to 40 GHz**	Radar Cross Section Reduction
2	[5]	Tapered Slot Array	28 GHz	4G/5G Wireless Devices
3	[6]	Substrate integrated waveguide fed open slot antenna	54.0 to 74.8 GHz	Millimeter-wave applications
4	[7]	The tapered slot array	28 GHz	Integrated wireless devices.
5	[10]	Taper Slot Antenna Array	0.1 to 67 GHz,	Radar Sensors
6	[14]	Bow-Tie Slot Antenna Array[	29.5 to 37 GHz	mm-wave communication
7	[6]	Substrate-integrated waveguide (SIW) cavity-backed slot	55.7-66.1 GHz	Millimeter-wave wireless systems.

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3.1 Slot antenna/ antenna array in Gain Enhancement

Gain of an antenna, in general, can be defined as the power radiated by an antenna in the desired direction to that of the power radiated by the reference antenna or an isotropic antenna without any losses. By using a substrate with a higher value of permittivity and using slots of different shapes and sizes the gain of the antenna can be improved.
The below table gives an overview of gain enhancement with the introduction of slots of different shapes along with their applications are also mentioned in the table.

Table2. Application of slot arrays for gain enhancement

Sl.No.	Reference No	Type of slot array	Gain	Application
1	[1]	Post-wall waveguide slot array antenna	15.6-dBi gain	**mm-wave communication**
2	[2]	Crossed Slot Array Antenna	24.9 dBi	millimeter-wave applications
3	[6]	Substrate integrated waveguide fed open slot antenna	54.0 to 74.8 GHz	millimeter-wave applications
4	[3]	Cavity-backed slot antenna array	19.7-22.3 dB	mm-wave communication
5	[8]	Radial line slot array	33.8 dBi	mm-wave communication
6	[14]	Bow-Tie Slot Antenna Array	29.5 to 37 GHz	mm-wave communication
7	[9]	Slot spiral antenna array	12.3 dBi	mm-wave applications
8	[15]	C-Shaped Slot Antenna	13.4 dBi	L/S-Band Applications

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4.1 Slot antenna/ antenna array Efficiency Improvement

The efficiency in terms of radiation for an antenna is defined as the ratio of radiation in the required direction or major beam area to the radiation in an unwanted direction or minor beam area. This section gives an overview of the increase in efficiency with the introduction of the Slot antenna/antenna array also the application is mentioned in the table below. By using different shapes of slots, we can improve the efficiency of the antenna as compared to a conventional micro strip patch antenna.

Table3. Application of slot arrays for increase in efficiency

Sl. No.	Reference No	Type of slot array	Efficiency	Application
1	[1]	Post-wall waveguide slot array antenna	57.2%	mm-wave communication
2	[2]	Crossed Slot Array Antenna	76%	mm-wave applications
3	[6]	Substrate integrated waveguide fed open slot antenna	V-band array prototype is > 68.8%, W-band array prototype ranges from 41.7%to 75.7%.	millimeter-wave applications
4	[3]	Cavity-backed slot antenna array	72%	mm-wave communication devices.
5	[8]	Radial line slot array	84.4%.	mm-wave communication
6	[14]	Bow-Tie Slot Antenna Array	>80%	mm-wave communication
7	[9]	Slot spiral antenna array	57.3%	mm-wave applications
8	[10]	Tapered Slot Antenna	83%	Radar Sensors

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5.1 Slot antenna/array for getting required polarization

The type of Polarization depends on the type of slot, the shape of the slot, and the type of feeding mechanism used for feed the slot. To design an antenna with improved bandwidth and efficiency it's better to position the slots on the patch or the ground plane, particularly for broadband and circular-polarization applications.

For eg., A slot antenna in the form of a circular- fed by a strip line hybrid coupler - network gives good broadband and polarization will be circular. Square-ring slot radiators when it is fed by pairs of micro strip-line structures used to achieve Dual polarization [13] and C-shaped slot fed by a 50ohms micro strip provides left-hand circular polarization. If we consider the case of Dual-polarized antennas have often brought the exceptional performance to wireless communications systems, at the same time reducing occupied space in wireless base stations and also low cross-polarization and high isolation, enhance signal reception quality at the receiver end. This section conveys an overview of the Bandwidth Enhancement with the introduction of the Slot antenna array. Also type of slot and the application are

mentioned in the table below.

Table 4. Application of slot arrays for a different type of polarization

Sl.No.	Reference No	Type of slot array	TYPE OF FEED	Polarization	Application
1	[15]	C-shaped slot and a 50ohms	Microstrip-fed port	Left-hand circular polarization.	L/S-Band Applications
2	[12]	Cubic Slot Antenna-	Co-planar waveguide (CPW) feed	Omnidirectional and broadside radiation pattern.	WSN applications.
3	[9]	Slot spiral antenna array-	Printed Gap Waveguide (PGW) feeding network	Right-Hand Circularly Polarized RHCP	Wireless communication systems,5G
4	[8]	Radial line slot array -	Fed at the center by a coaxial probe	Circularly polarized	Wireless communication devices
5	[3]	Cavity-backed slot antenna array	SIW-fed	Dual Polarization	60 GHz communication systems
6	[2]	Waveguide slot array antenna	Fed by a rectangular waveguide	circularly polarized	mm-wave communication
7	[1]	Crossed Slot Array Antenna-	SIW-to GCPW (grounded co-planar waveguide) transitions	Dual-Polarized	mm-wave communication
8	[13]	Square-ring slot antenna array	Microstrip-line structures	Dual polarization	5G Smartphone Applications

Conclusion

Slot antenna and slot antenna array stands promising in meeting the requirement of different application with antenna perspective. Introduction of slot enhances the operating impedance bandwidth, gain and efficiency of an antenna. The dual polarization can be achieved with the slot antenna. Thus it can be concluded that slot antenna and slot antenna array can be designed keeping power, operating frequency and polarization criteria for any required wireless applications.

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