FSS Integrated Antennas for Modern Wireless Applications

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Abstract— This paper presents an extensive overview of the integration of Frequency Selective Surfaces with various antenna structures. The research presents various design parameters, including unit cell geometry, dielectric substrate, periodicity, placement of the FSS layer above and below the antenna and antenna configuration to achieve better radiation characteristics. In, this review paper the importance of FSS in improving important antenna performance in terms of gain, directivity, and bandwidth is also presented. The recent researchers also highlighted the latest applications of FSS integrated antenna structures in modern wireless communication systems.

Keywords— FSS(Frequency Selective Surface), MSPA(Microstrip Patch Antenna), ISM(Industrial, scientific and medical), DGS(Defected Ground Structure).

I. Introduction

Many investigations have been carried out throughout history to find effective antennas that can satisfy the growing need for sophisticated communication. Large bandwidth, high gain, directed radiation, ease of manufacture, and affordability are all necessary features for these antennas [1],[2]. Numerous methods have been widely employed to boost antenna gain. One such method is using epsilon-near-zero (ENZ) materials [3-5]. Alternatively, patch geometry [6],[7] or add a superstrate, such as an electromagnetic band gap (EBG) [8], [9].

A variety of techniques have been developed and implemented to enhance microwave component performance [10, 11]. The researchers used metamaterials as faulty ground structures to create patch antennas with dual bands and enhanced gain. In [12], fishnet metamaterials were used as DGS to boost the gain of a double band PIFA antenna from 3 dB to 8 dB. The researchers presented a double band patch antenna with decent gain for Ku-band applications made on both H- slotted Deflected Ground Structure and Substrate incorporated waveguide in [13]. FSS is another attractive structure that greatly enhances gain of an antenna. It was first intended to control the Tx (transmission) and Rx (Reflection) characteristics of an incident radiation wave. It is a planar, infinite unit cells array arranged consistently on a dielectric substrate [14,15]. The unit cells near the resonant element are composed of metallic patches or aperture elements that exhibit perfect transmission or reflection, respectively [16]. The FSS can be placed on top of the antenna or on its back, depending on the type of work and applications [17,18]. To improve their performance, FSS can be included into dielectric resonator antennas (DRAs) and other antenna types in addition to patch antennas [19].

For gain augmentation, the number of FSS integrated antennas is stated in literature. In the review report, a few of them are investigated and discussed. [16] describes a small wideband antenna. The FSS-loaded antenna is 46 mm by 46 mm by 28.2 mm and operates in the 2.82–19.94 GHz wideband. After loading FSS beneath the antenna, the gain increases by 3.3 dBi.

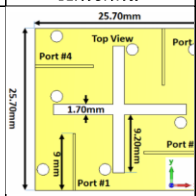
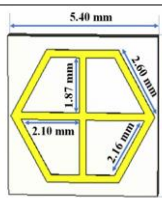
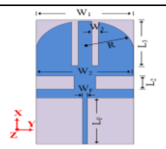
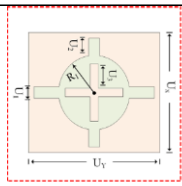
Researchers have created a number of high-gain antenna designs in order to meet the strict requirements of 5G mobile communication systems (21–26). There are several ways to increase gain, such as array layout (21, 22), an electromagnetic band gap (EBG)-based structure (23), and an FSS-equipped A four-element MIMO antenna at 38.9 GHz has been proposed in (24) to increase gain from 8 dB to 10 dB. As examined in (25), a circular patch with a circular slot and two via is used in conjunction with a partly reflecting surface (PRS) loading to produce broadband and high-gain features.

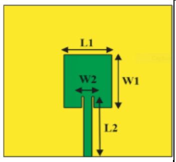
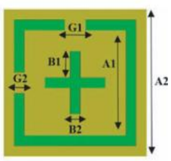
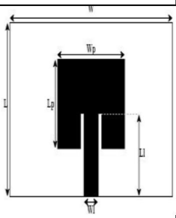
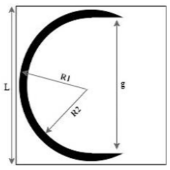
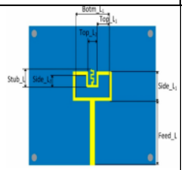
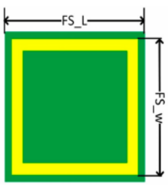
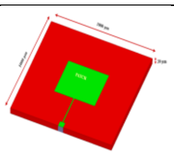
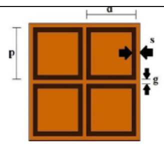
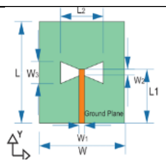
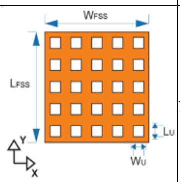
Enhanced bandwidth, better impedance matching, and the capacity to completely incorporate active or passive components are among the benefits of ground-plane slot microstrip antennas [27]. Additionally, combining antennas with FSS designs can improve specific antenna properties. In the literature, combinations of several microstrip antenna types and FSSs have been suggested [28-32]. In [28], an FSS is used to boost a patch antenna's broadside gain at the X band by about 7 dB. In [29], the use of an FSS superstrate layer increases the gain and impedance bandwidth of an aperture linked microstrip patch antenna. In [30], an EBG structure is proposed to reduce mutual interaction between meander line MIMO antennas. A conformal metamaterial lens-based radome is used in [31] to suppress surface waves, reduce side-lobes, and increase gain. A small FSS multilayer device composed of reactive impedance surfaces is used in [32] to convert linear polarization into circular polarization.

II. Literature Survey

Table 1. shows the comparative analysis of various types of Antennas Integrated FSS structures along with their design parameters, Unit cell FSS structure with its above or below the antenna, Performance of the structure and their applications.

TABLE I. COMPARATIVE ANALYSIS OF VARIOUS AUTHORS

Referen	*Structure of Antenna*	*Unit cell FSS structure*	*Performance*	Applications
[33]			The results of proposed structure show the operating bandwidth frequency of 25.5 GHz up to 30 GHz insertion loss ≤ -22 dB and maximum gain of 8dBi.	5G communication
[34]			The structure design is tailored for a particular frequency band that operates at 6 GHz (5.53 GHz to 6.36 GHz).	For 5G Sub-6 GHz applications

Referen	*Structure of Antenna*	*Unit cell FSS structure*	*Performan ce*	Applicati ons
[35]			Gain enhanceme nt with FSS layer integration from 3.18 dB to 8.98 dB.	For 5G Sub-6 GHz applicati ons
[36]			Gain enhanced from 3.9 to 5.4 dB, a 1.5-fold improveme nt. The bandwidth also increased to 230.94MH z.	Vehicle-to-vehicle commun ications
[37]			Wider bandwidth of13%at2. 45GHzand 27% at 5.8GHz and peak gain of 6.8dB at 2.45GHz and 9.0dB at 5.8GHz	ISM commun ication
[38]			Improved bandwidth from 1230 GHz to 2260 GHz in the required frequency band and improved gain and directivity by 3.73dBi	Terahertz commun ication
[39]			Increased gain and bandwidth is acheived	WLAN, WiMAX and 4G and 5G mobile commun ication system

III. CONCLUSION

Various structures of Antenna with FSS layer integrated are analysed in this review paper. On the basis of study given by various researchers, it has been presented that the performance of antenna increased with FSS layer integration either above or below the antenna in terms if gain, bandwidth, directivity and efficiency. Resultant antenna integrated FSS structures realized by various authors shows various applications in the wireless communication system. In this paper, an overview of the development of various antenna integrated FSSs that have been documented up to this point, primarily on periodic arrays. It is suggested that more antenna configurations with non-periodic FSSs be investigated. Another open research topic is antenna integrated non-periodic FSS for ultra-wideband applications.

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