A Survey On U-Slot Microstrip Antenna Based On Resonant Frequency

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Abstract: The objective of this paper is Implementation of a microstrip U-slot antenna based on the resonant frequency with High-Frequency Structure Stimulator. In our method, we design an antenna with a range of 1.157GHz, and we improve the gain by placing an array of the antenna. Here rectangular patch antenna is designed FR4 Glass Epoxy Substrate with a dielectric constant of r as 4.4 and a loss tangent, which is equal to 0.02, and copper is used as conducting material. This U-slot microstrip patch antenna is excited with transmission cables of respective length and width. The measurements of the gain, directivity, and efficiency of the developed microstrip patch antenna are derived from High-Frequency Structure Stimulator. There is a relation between the resonant frequency and obtained gain. If the frequency is increased, the gain is maximum. But in the proposed method, the maximum gain is derived from low frequency. The size of the antenna is proportional to frequency, gain, and bandwidth. The U-slot microstrip antenna is built with many constraints to get productive output. It is established that that two slots in U should be kept closed in a distinct patch to produce a wideband process. The u-slot microstrip antenna is made to increase the bandwidth and frequency, and it is proved. The software used here is High-Frequency Structure Stimulator and applied in a wireless local area network. It operates with high bandwidth since the structure of the antenna is too small because of its dielectric constant. It gives a maximum gain with a frequency range of above five GHz.

Index Terms: Microstrip antenna, High-frequency Structure stimulator, feeding methods, resonant frequency, value of VSWR and gain

1 INTRODUCTION

Microstrip Antenna, built-in rectangular shape is easy for construction and deployment. The simple U-slot is shown in below diagram fig 1.1. Here it is designed to operate at 1.157GHz. [1] The resonant frequency is defined precisely due to their narrow bandwidth of the patch antenna. The microstrip patch antenna is an internal antenna that is embedded mostly on printed circuit boards. These antennas mostly applied Ultra High-Frequency waves because the Antenna's size is directly proportional to resonant frequency and wavelength. This method focuses on to design an antenna with a range of 1.157GHz, and we improve the gain by placing an array of the antenna. The u-slot microstrip antenna is made to increase the bandwidth and frequency, and it is proved. The software used here is High-Frequency Structure Stimulator

1.1 MICROSTRIP ANTENNA:

Micro-strip has electromagnetically linked with a co-axial probe is an essential process for the feeding method. [2]The main component is the blot of metal foil made in any shape according to the requirement, kept in a two-dimensional array that is linked to a transmitter or receiver through the microwave transmitting cables. Micro-strip antenna is popular due to its unique usage features mainly in cellphones, because of its compact, durable, filmy, structure available at reduced cost and easy fabrication on PCB. The application of the Microstrip antenna is Aviation, bio-medical, radar, and satellite communications. Microstrip antenna has a reasonable value of return loss, bandwidth, Voltage Standing Wave Ratio. The main advantage of adopting Microstrip Antenna is for their polarization ability and its unique benchmark in the telecommunication field

1.2SHAPES AND CHARACTERISTIC OF VARIOUS MICROSTRIP PATCH ANTENNA:

The microstrip patch antenna is available in different sizes and shapes and their attributes if this antenna is analyzed. [2]Triangular patch antenna is made with glass-reinforced epoxy laminate material with a thickness of 0.6mm. The triangular patch antenna is used for the wireless communication system. The return loss is measured up to -26dB and obtained a resonant frequency of two GHz. The design and implementation are cost-effective and manageable. The software used here is Ansoft version 2.2.0. [2]The E-shaped microstrip patch antenna is made with the substrate of dielectric permittivity of 2.2 and 3.2mm of thickness. The HFSS is used here to calculate the simulation results. It works on the frequency range of 5.05GHz to 5.88GHz and has a maximum gain of 7.5dB. [3]The Rectangular Microstrip patch antenna is made with glass-reinforced epoxy laminate material deployed on High-Frequency Structure Stimulator with version 13.0 and works on the bandwidth of 3GHz to 5GHz. The resonance frequency operated is 4.3GHz and showed a return loss of -30dB. The fractal secondary microstrip antenna is made of glass-reinforced epoxy laminate material with a thickness of 1.58mm. The High-Frequency Structure Stimulator is implemented in ultra-wideband applications. The resonant frequency falls from 1 GHz to 10 GHz. The maximum return loss gained here is -23.41

1.3CONSTRUCTION OF U-SLOT MICROSTRIP ANTENNA:

.[4][5]The basic U-slot is designed in the rectangular strip antenna with L as patch length as a feed point and W as a patch width. Then slot length is denoted as Ls. The horizontal slot length is Ws.

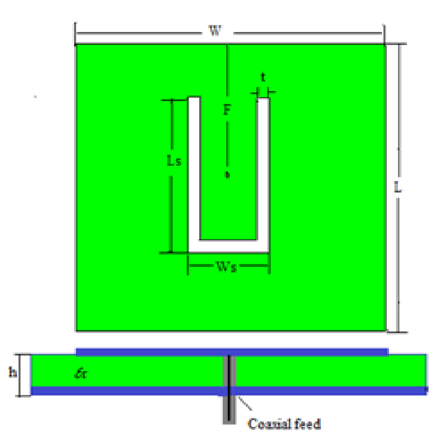

Fig 1. *Construction of U-slot in rectangular microstrip antenna[5]*

To design a light-weight antenna glass-reinforced epoxy laminate material called FR4_epoxy, since it has high mechanical strength, low loss values, cost-effective. It is designed with a dielectric constant of 4.4 and a thickness of 1.6mm. The tangent loss value equal to 0.02. [6]The parameters of gain, directivity, and efficiency is calculated in High-Frequency Structure Stimulator

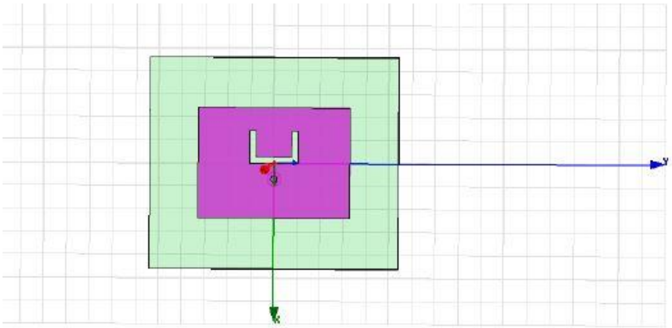

Fig 2 – *Example of High-Frequency Signal Stimulator[6]*

.[7] In this paper, the various terminology of antenna for multiple shapes and designs are studied about the U-slot microstrip antenna. The return loss is a measure of discrepancy in patch and feed cable line. It is called a reflection coefficient. It is denoted in dB, and return loss is -10dB. The voltage standing wave ratio is utilized to compute the actual impedance of the transmission line where the antenna is connected. VSWR is the ratio of maximum voltage to minimum voltage in transmitting cable line. The radiation pattern is a graphical sequence that is the properties of radiation generated from the antenna as the activity of the space coordination. The varied shapes that radiation pattern gives are a fan beam and pencil beam pattern. It provides a detailed evaluation of relative field strength reception and transmission from antenna.

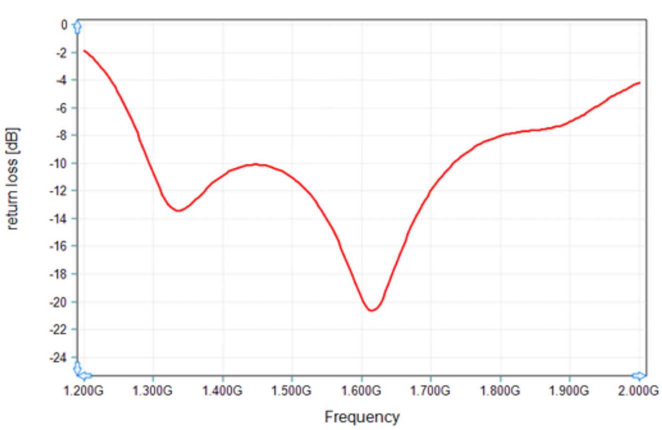

Fig 3 *– Relation between Frequency and Return loss of U-slot Rectangular Microstrip antenna[7]*

Gain is described as the capability of the antenna to focus the power radiated from it, and also it absorbs from a particular direction. The gain of the antenna is defined as a proportion to higher intensity of the generated radiation in the noted direction of test antenna to higher intensity of the generated radiation from the isotropic antenna. The bandwidth of the antenna is measured as a range of frequencies where the antenna can work effectively. The paper presented the elements of radiating material which introduced risk factors in the fabrication process of the antenna. [8] There are different feeding techniques applied to adjust the gain and bandwidth. In this paper, they have discussed such a method to get enhance gain and bandwidth. The feeding methods are feeding of the microstrip, coaxial feeding, aperture coupled feeding, double feeding, and proximity couple feeding. In the microstrip feeding method, the conducting strip or patch is etched to the corner of the patch of microstrip. This conducting patch should be smaller to a microstrip patch. Advantage of this design is patch and feed are merged on the same substrate as the planar model. Next, it is modified to insert the cut piece. This modification is made to match the feed line and patch impedance. But it is not mandatory for additional elements. It is a simple feeding scheme that provides easy fabrication. [9]The probe feed is called as coaxial feed is a method for feeding Microstrip antennas with a patch. The interior conductor of the coaxial connector is separated from dielectric and soldered on a radiating patch. The ground plane carries the external conductor. The benefit of this feeding is it can be located at a suitable place in the patch to regulate the input impedance value. The construction of this method is a bit complex. The hole is grounded in the substrate layer, and the connector is fixed exterior to the bottom plane, which doesn't make a regular structure of a planar surface because of the substrate's thickness. This improper probe length generates impedance matching problems. The aperture coupling feed and aperture made to the ground plane is inserted between two varied substrates. It provides an electromagnetic coupling from feed to the structure of the radiation pattern. This patch, which generates radiating material, is attached to the antenna's top, and the microstrip feed layer is attached to the bottom of the feed substrate to enable aperture coupling. The width and dielectric constant of the two substrates is selected to optimize electric functions in circuits.

II RESONANT FREQUENCY OF U-SLOT MICROS TRIP ANTENNA:

The voltage standing wave ratio is correlated to a minimum magnitude of relation coefficient. The input impedance has no reactive parts, and it is near to frequency where it obtains a maximum resistance. The resonant frequency is a point where it gets a maximum strength independent of reactance value. [10] frequency-tuning effects do the change in polarization. [11]The square blotch without shorting post have both x-oriented, and y-oriented modes of planes have a similar resonant frequency. Here the probe is positioned on the slanting edges of the patch, but the x-oriented nodes and y-oriented nodes are excited with the same phase and magnitude. In addition to shorting post down the centerline of x-oriented nodes, then resonate frequency of y-nodes can be increased. A unit mode is selected by changing the resonant frequency of the following way to the actual pattern.

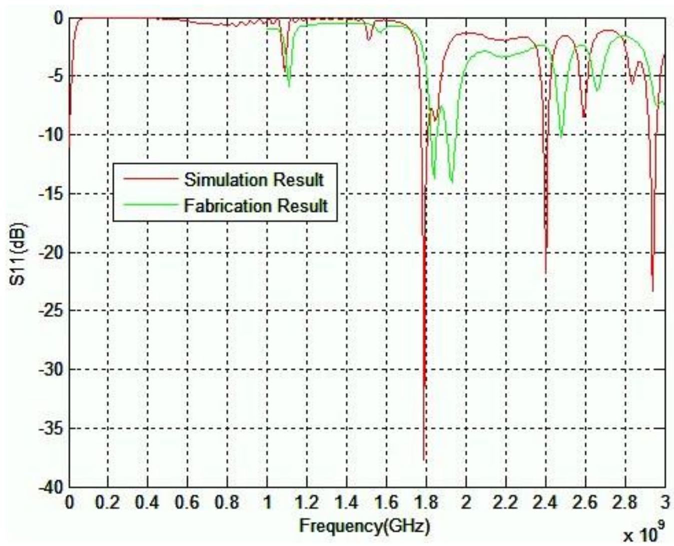

Fig 4- *Comparison between Simulation result and fabrication result of U-slot rectangular Microstrip Antenna*

The high-frequency shift is obtained by keeping the shorting post close to the corners of the antenna's patch. [12] the technique applied to modify the [13] Reconfigurable antenna is trending in recent years, and its performance is highly achieved by installing switches, varactor diodes, variable capacitors to design the antenna. They allow the radiation sequences, gain or frequency response by combining different parameters of the antenna with being managed. [14] The dual-band antenna is constructed by inserting a capacitor chip between the slots. Because of the different capacitor values, the frequency of the impedance matching of the dual-slot antenna can be modified. The change in bias across the varactor diode establishes capacitor variance, which varies the matching frequency. The dual feed is the method that is applied to increase the bandwidth at the resonant frequency. Double feeding implementation is made to impose the vertical current mode, which stops the excitation from the horizontal and asymmetrical current pattern. There is a chance to decrease the polarization properties to gain performance and low impedance of the antenna. The used methods are formula depends on the transmission-line method, formula on cavity method, and formula on the magnetic-wall process [15]. This paper discussed the different approaches to calculate the resonant frequency on a rectangular strip of microstrip antenna in three ways. In the formula based transmission line model, the two parallel radiating slots are kept apart with desired dimensions with constant field aperture and isolated by length, which is around half of the wavelength in a layer of the substrate. In real time, the electric field located at the outer corner of the patch is disrupted by sudden closing at the edges, which leads to fringing electric fields. By using a formula based cavity model, the resonant frequency may be designed by a similar method applied to calculate cutoff in the waveguide in the region between ground plane and patch. [16]Because of the cavity bound between dielectric walls on top and bottom. The magnetic wall bounds the sides. Here the resonant frequency is calculated with patch dimensions. The magnetic wall model is the design of the antenna model with resonator, and the resonant frequency is calculated with the resonator specifications. Comparing the results from three methods, it shows -4% for an antenna with substrate elements slender than 0.066hd and -8.5% for stocky features. It has proved that resonant frequency is based on the antenna's substrate by the mentioned models.[17] The drilling of the square slot at the center of a rectangular microstrip patch gives a high gain of dual-frequency and compactness. The result shows that the size of antenna reduced by -17% using a patch without slot to obtain the dual-frequency. The square slot is drilled at mid of rectangular patch to extend the gripping surface current paths, which in turn reduces the dominant resonant frequencies. By lowering the first occurring resonant frequency, the desired size of the antenna is achieved. [21]The reduced size dual-frequency microstrip antenna is achieved by lowering the operating frequencies. It is obtained by the method of single coaxial feed. The operating frequency is controlled by the square slot and dimension of the patch to frequency ratio generated by the aspect ratio of the rectangular patch.[22] The design of antenna elements and simulation results. To implement a high gain single antenna, the superstrate of the radiating element is self-composed as a structure with a lower patch and feeding line with thickness with a minimum value of less than one mm. And the stacked patch is supported by foam. Being the entire set up is very slender, the coated film hardly impacts the radiation efficiency to wavelength. The resonant condition for maximum gain is proved that electrically between two substrates, and this case cross-polarization occurs. To reduce the effect, the optimal gain is achieved by varying the thickness of the radiating element and superstrate. The wideband behavior of microstrip patch antenna with U-slot is explained here.[19][20].The two different generated resonant frequencies combined to give wideband operation. The first resonance value is produced from the microstrip patch, and the second resonance is generated from the U-shaped slot. The equations are derived by computing surface-current distribution on the patch. The accuracy is measured with five percent, and this is compared to the simulation by Ansoft ENSEMBLE based on the moment method. The paper designed about method about increment in the operating frequency bandwidth in microstrip patch antenna by application of varactor diodes on the radiating corners of the structure.[23] This method delivers thirty percent accuracy to two percent of the unloaded patch radiator. But this method has two significant problems; one is the antenna size becomes large. It is not applicable for understanding the vast arrays of active control over the local maxima of field pattern, and radiation behavior are mandatory to be noted. But they are not adaptable for geometries of microstrip antenna. It is easy for integration to the circuit, providing a reasonable control. The varactor diodes are operating in reverse bias, so when the capacitance is added at radiating corners, it changes in the electrical length of the patch, which increases resonant frequency. The simple implementation of ultra-wideband microstrip antenna placed at mid of rectangular slot.[24].. The parametric measures would help to design the microstrip antenna for wireless communication in the ultra-wideband.The radiating element in the stacked microstrip antenna provides high gain and substantial bandwidth.[18][27]The Stacked microstrip patch antenna comprises of four similar patches with equal spacing are arranged evenly in the rectangular aperture. It is driven electromagnetically by a patch of microstrip lines attached on a lower substrate. The benefit of this method is simple in construction. Still, the multiple feeds of this network are minimized by rectangular patch's parameter, which usually doesn't affect the character of the antenna but slightly varied with the coupling amount with upper patches. It is not possible to increase the spacing between the patches, and it should be placed corresponds to the bandwidth value. The advised spacing value is 0.8 between patch centers, which is possible with PFTE dielectric using a conventional substrate. The stacked microstrip antenna shows a reliable increase in input impedance of bandwidth. In comparing to the electromagnetic compatibility of coplanar parasitic sub-array. [28]The advantage of the proposed method lies in its radiation sequences. Similar to the stacked microstrip antenna, the five arrays of patches are placed to increase its bandwidth. Still, here, patches are coplanar, which results in distortion becausenon-uniform field radiation, but the insertion of five patched arrays generates scraping lobes. But this is rectified in the proposed method by the stacked parasitic sub-array way because of its interception of parasitic elements and patch radiation. Still, it doesn't change regularly on the antenna aperture efficiency. The slit cut on a microstrip antenna is made and also shared the analysis of an established multiport series inductance network.[29]. The two-slit application's design a small microstrip antenna that is used to tune the resonant frequency. For mobile phones and smartphones, microstrip antenna is too big to suit, so a small-sized microstrip antenna is designed and implemented, which is trending. The vital three methods proposed here are the addition of shorting posts, usage of high-permittivity components, and choosing of twisting microstrip patch. The addition of a shorting position to probe-fed antenna tends to give a sensitive input impedance that corresponds to distance between shorting post and feeding probe. The usage of high permittivity components produces a low gain. From the review, the resonant frequency of the H-slit on microstrip patch antenna gives of sixty percent of the initial frequency. Drilling of H-slit minimizes the antenna size from half to quarter wavelength. The H-slit antenna is designed that made to be resonated at 910 MHz by length parameters of sixty to seventy millimeters. Hence cutting of H-slot reduced the antenna's size and beam width of three decibels and cross-polarization less than ten decibels is obtained

III. CHALLENGES

A high electric dielectric material is applied at the bottom of the substrate to optimize the patch's radiation. The major problem is the alignment of multiple layers leads to complex fabrication. This coupling aperture placed at the center of the surface under the patch to have less cross-polarization because of the symmetrical structure.[9] The coupling percentage from patch and feed line is defined by the shape, position, and size of the aperture. The ground plane connected with an external layer of antenna isolates the patch from the feed line to have low radiations [8]The major disadvantage is the thickness or intensity of the built substrate boost up the feed radiation and surface waves that in turn affect the antenna's bandwidth[26]The parasitic H-plane surface elements give double the bandwidth with regular optimization results in triple bandwidth. The addition of E-plane coupling can increase the bandwidth value. But here, the bandwidth is not increased by fifteen percent as the coupling is weaker. [23] The twisting patch antenna doesn't generate an active radiation pattern. So to overcome all these negativities, the building of new antenna design is introduced by drilling H-slit[25] The performance of UWB microstrip antenna effects of different shapes and sizes of the slot. The addition of slots impacts the characteristics of the microstrip antenna but to increase the bandwidth, the slot should be inserted on the planar structure which creates a complex fabrications [26] The paper shows the observation of wideband antenna, which is feasible for proper utilization of patch dimensions to obtain suitable feed impedance and an appropriate geometric structured substrate with a correct thickness and minimal permittivity. Then the partial plane surface of the ground helps in the decrease of the quality factor, which in turn increases the bandwidth.

TABLE 1: *Various surveys of various feeding techniques and design of microstrip patch antenna*

Author	Design	Methodology	software used	Advantage/ disadvantage
[2]	Implementation of Triangular Microstrip patch antenna	It is made of glass-reinforced epoxy laminate material with a density of 0.6mm respect to the relative permittivity This antenna can be deployed in Wi-Max that is a wireless communication system	The software used is Ansoft Version 2.2.0	The design is simple and cost-effective The return loss is measured as -26 dB with two GHz of the resonant frequency
[18]	Design of E-shaped Microstrip patch antenna	The substrate of thickness is 3.2mm and has a dielectric permittivity of 2.2 The application is in WLAN that is Wireless Local Area Network	High-Frequency Structure Stimulator	It has high bandwidth range and size of the antenna is small because of its minimum dielectric constant The achieved gain is 7.5dB The frequency The range of this antenna varies from 5.05GHz to 5.88GHz.
[19]	Plan of U-slot rectangular patch antenna	It is fed through a coaxial probe with 2.33 as a dielectric constant of the substrate It is applied in Low profiles	The three-dimensional EDTD technique is used to obtain the antenna's performance	It enhances the quality factor of the antenna. The gain is about 6.5dB, and high bandwidth of twenty-seven percent is achieved
.[18]	Design of E-shaped patch antenna	This antenna is made of glass-reinforced epoxy laminate material The antenna is deployed in cognitive radio	High-Frequency Structure Stimulator 13.0 is used	Mounting is easy with lightweight and minimum fabrication cost The radiation efficiency is ninety-six percent, and frequency varies for 1.6GHz to 3.8GHz
[21]	Implementation of the fractal-based microstrip patch antenna	It is made of glass-reinforced epoxy laminate material with 1.58mm thickness It is widely used in UWB Ultra Wide Band applications.	High-Frequency Structure Stimulator	This antenna produces linear and circular polarization and can be mounted as mechanically robust in rough planes The antenna generates a resonant frequency that varies one GHz to twenty GHz with resonance at six. In 7.03 GHz, It gives a high return loss value of 23.41
[20]	Design of U-shaped parasitic patch antenna	It is built with a glass-reinforced epoxy laminate material It is applied in condensed transreciever. It is mainly applied in industrial applications for commercial use	It works on High-Frequency Structure Stimulator	The antenna size is too small with dimensions of 25*30mm Twenty-seven percent of bandwidth is obtained.
[9]	Method of Coaxial feeding	It is a method of feeding in where the internal layer conductor of the coaxial cable is etched to radiation patch of the microstrip antenna, and the external layer is attached to the bottom surface plane	In Coaxial feed, Drilling and soldering is mandatory to obtain the expected result	The range of VSWR varies from 1.4 to 1.8 The Coaxial feed reflects more return loss The coaxial feed gives a poor polarization value The bandwidth value ranges from 2-5% The reliability is Poor because of soldering The coaxial feed provides a low resonant frequency
[15]	The technique of	In this feeding method, it forms the	The Alignment	Aperture feed gives an

	Aperture feeding	*feed circuitry; the transmission line is encapsulated from the antenna by aperture or hole built-in conducting plane to transfer the energy to the microstrip antenna* *The aperture feed has an excellent reliability*	*should be proper to give an effective result.*	*excellent polarization value.* *The Aperture feed has a low return loss* *This feed has VSWR value which is equal to 2* *The bandwidth was 21%* *The impedance matching is done in a fundamental way to get the expected value with the low resonant frequency*
[16]	*Implementation of Line feeding*	*Here the transmission cable or line is connected to the antenna with a radio receiver or transmitter and again sends the radio frequency that is RF current from the transmitter and fed as input to microstrip antenna to generate radiation of radio waves*	*The line feed has a simple fabrication process*	*The Line feed has a minimal return loss* *The value of VSWR is low than 1.5* *The line feed gives a poor polarization value* *The bandwidth ranges from 2-5%* *The line feed has a more resonant frequency* *The line feed has better reliability needs to be improved*

IV CONCLUSION

[30]The U-slot rectangular patch antenna made of the dielectric constant of 2.33, and it works on a three-dimensional EDTD method to measure the performance of the antenna. It increases the quality factor. The maximum bandwidth was twenty-five percent, and the calculated gain is 6.5dB. Hence there are various methods applied to boost up the gain of U-slot rectangular microstrip patch antenna to the frequency. So in this proposed method, the gain is increased in the frequency of 1.157 GHz by placing an array of microstrip antennas.

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