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DESIGN OF K BAND PATCH ANTENNA FOR SATELLITE APPLICATION

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Abstract:

In proposed antenna, a square patch with pi (***π***) shape meander line radiator antenna was designed using ARLON AD 1000 (tm) substrate. This antenna is used to transmit and receive the signal of k band frequencies. The dimension of patch antenna is 4.6×4.6mm and pi (***π***) shape meander line radiator is 5.3×0.5mm, 0.5×5.5mm and 0.5×6mm. The design and simulation of the antenna is done by using ANSYS HFSS software tool. The resultant antenna return losses are -28dB at 18.1GHz and -25dB at 22GHz. The measured gain is 3.9dB at 18.1GHz, 22GHz and the corresponding efficiency is 89.68% respectively. The proposed antenna has the potential application in naval satellite applications.

Index Terms—***Square patch, Pi (π) shape radiator, Naval satellite application***

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I. INTRODUCTION

The systematic investigation involves patch antenna with pi (***π***) shape meander line radiator designed for k (kurtz) band. This design was introduced for the Naval satellite applications. The patch antenna is a low profile radio antenna mounted on the flat surface, is mainly practical at microwave frequencies at which its wavelengths are short. Because of the ease fabrication on PCB it is widely used as portable wireless devices. Microstrip antennas are named because of multiple patch antennas are mounted on the same substrate, can be used to make high gain electronically steered phased arrays antennas.

The demand of developing RF & microwave communication equipment, the research of antenna focuses on some particular aspects for instance how to reduce the size of antennas while maintaining higher radiation efficiency. Meanwhile, with the improvement of small scale integrated circuits, the size of communications equipment is also getting smaller and smaller. The meander line antenna is indisputable antenna plays a significant part in RF & microwave communication system that provides the largest size reduction at a given frequency at the expense of a narrow bandwidth.

Therefore, an increasingly number of technicians begin to do some research and development of antenna. However, with rapid development of the communication industry, the requirement of antenna will be achieved with high quality. The meander line antenna is relatively easy

to catch larger relative bandwidth compared with PIFA antenna.

A satellite navigation is a system that uses satellites to provide autonomous geo-spatial positioning and allows small electronic device to determine their location (longitude, latitude, and altitude/elevation) to high precision time signals transmitted along a line of sight by radio from satellites. The system can be used for providing position, navigation for tracking the position using antenna (satellite tracking). The signals also allow the electronic transceiver antenna to calculate the current local time to high precision, which allows time synchronisation. Satnav systems operate independently of internet transmission and reception, though these technologies can enhance the usefulness of the positioning information generated. Satnav system provides enhanced accuracy and integrity monitoring.

A satellite navigation system with global coverage may be termed a global navigation satellite system (GNSS). GNSS civil navigation is classified as GNSS-1 & GNSS-2 is the first generation and second generation system. GNSS-1 is the combination of GPS and GLONASS navigation systems, with Satellite (or) Ground Based Augmentation Systems (SBAS) or (GBAS). The Wide Area Augmentation System (WAAS) is the satellite based component in United States, European Geostationary Navigation Overlay Service (EGNOS) in Europe and Multi-Functional Satellite Augmentation System (MSAS) in Japan. Ground based augmentation is provided by systems like the Local Area Augmentation System (LAAS).

GNSS-2 is the system that independently provides a full civilian satellite navigation system, exemplified by the European Galileo positioning system. This will provide the accuracy and integrity monitoring necessary for civil navigation including aircraft. This system consisted of frequency of k band (18GHz to 27GHz).

By their roles the navigation systems can be classified as: Core Satellite navigation systems, currently GPS, GLONASS, Galileo and Beidou. Global Satellite Based Augmentation Systems (SBAS) such as Omnistar and StarFire. Regional SBAS including WAAS, EGNOS, MSAS and GAGAN. Indian Regional Navigation Satellite Systems (IRNSS) such as India's NAVIC, it is an autonomous regional satellite navigation system that provides accurate real-time positioning and timing services. Continental scale Ground Based Augmentation Systems (GBAS) for example the Australian GRAS and the joint US Coast Guard, Canadian Coast Guard, US Army Corps of Engineers and US Department of Transportation National Differential GPS (DGPS) service. Regional scale GBAS such as CORS networks. Local GBAS typified by a single GPS reference station operating Real Time Kinematic (RTK) corrections.

II. ARLON AD 1000(TM) MATERIAL AND LUMPED PORT

2.1 ARLON AD 1000(TM) Material

Arlon AD 1000(tm) is a high dielectric constant substrate that permits circuit miniaturization, compared to traditional low loss materials. It is especially beneficial for power amplifiers, filters, couplers and other components using low impedance lines. AD 1000 is a woven glass reinforced laminate. This allows miniaturized circuitry without requiring a complicated processing or special handling associated with brittle pure ceramic or ceramic hydrocarbon materials. Thermal conductivity is best in class, High copper peel strength allows for thinner etched line widths, Lowest insertion loss available, Larger panel sizes available, Low moisture absorption are the important features of the material.

2.2 Lumped port

The proposed antenna is fed by a Lumped port “applies a uniform electric field between two

metallic boundaries" and that "the excitation at the port can be expressed as a voltage or as a current, or via the connection to the circuit interface". Lumped ports are categorized by their geometric shape are Uniform, Coaxial, Multi-element uniform, User defined. The user defined lumped ports, if the shape of a lumped port boundary cannot be defined by a coaxial, multi-element uniform, or uniform lumped port, then you can use the User Defined type, as long as the height and width of the lumped port boundary are constant and the polarization is definite. The lumped port uses the constant 50 ohm resistance.

III. ANTENNA DESIGN AND CHARACTERISTICS

A square patch antenna is designed for k (kurtz) band. The antenna is designed by multiple layers of ground, substrate, radiating layer, feed, user defined lumped port, radiated air box. For the proposed patch antenna is designed utilizing a Arlon AD 1000 (tm) substrate. The permittivity of substrate ε_r =10.2 and the thickness is 1.6mm. To improve the performance of the antenna, a square patch length is 4.6mm and the width is 4.6mm. The pi ($\boldsymbol{\pi}$) shape meander line radiator formed by three different rectangular slots, whose dimensions are 5.3×0.5 mm, 0.5×5.5 mm, 0.5×6 mm respectively. The feed and their user defined lumped port dimensions are 1×2.7mm and 2×1.6mm respectively. The radiation air box is 15.4×15.4×8mm.

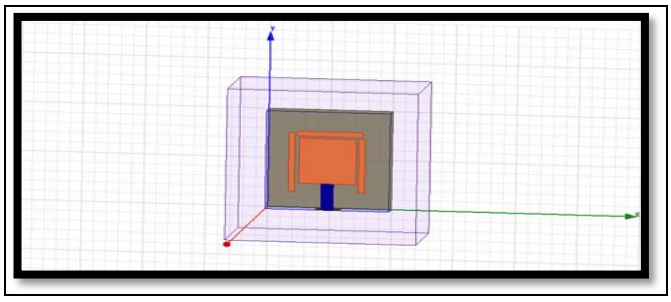

Fig.1. Design of proposed antenna, square patch with pi ($\boldsymbol{\pi}$) shape radiator

Each radiator (2-Dimensional rectangle) had different sizes because of meander line antenna is the step like meander line antenna. The stepwise meander line antenna act as a timely invariant antenna or it otherwise called as a lift based antenna. It covers three side of the square patch and it is separated from a very small distance. In which the gap act as a capacitor as well as it performs in an inverse fast action transfer mode and the radiator act as an inductor. These radiators will make a return loss more negative; improve the antenna performance like VSWR, gain and directivity. The antenna is designed mainly for high frequency naval satellite application.

The pi ($\boldsymbol{\pi}$) shape radiator act as a reflector is a stand-alone device used for reflecting the electromagnetic waves (or) redirecting the radio frequency (RF). The most common stand-alone reflector types are corner reflector and flat reflector. Here we are using flat reflector will act as a mirror, reflect the radio signal and is used as a passive repeater.

Table.1. Dimensions of proposed antenna

ITEM	POSITION	AXIS	X	Y	Z
Ground	0,0,0	Z	10	10	-
Substrate	0,0,0	-	10	10	1.6
Patch	2.7,2.7,1.6	Z	4.6	4.6	-
Rad slot 1	2,7.5,1.6	Z	5.3	0.5	-
Rad slot 2	7.5,2,1.6	Z	0.5	5.5	-
Rad slot 3	2,2,1.6	Z	0.5	6	-
Feed	4.5,0,1.6	Z	1	2.7	-
Lumped port	4.5,0,0	Y	2	1.6	-
Air box	-2.7,-2.7,-2.7	-	15.4	15.4	8

IV. SIMULATION RESULTS

We had designed an antenna for wide band operation, it could achieve multiple frequencies.

The solution frequency is 16GHz and the maximum number of passes is 6 are used for simulating the antenna performance. But here we are using fast sweep setup and there are two different frequencies used in the frequency setup they are start and stop frequency. The start and stop frequencies are 16GHz and 26GHz respectively. The step size used for this is 0.01GHz.The return loss should keep below -10dB and for proposed antenna return loss will be very low as -28dB and -25dB at the frequencies of 18.1GHz, 22GHz respectively.

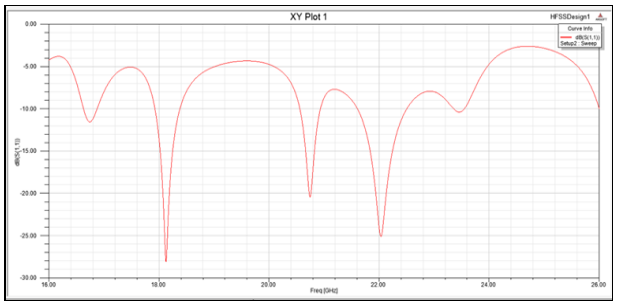

Fig.2. Return loss of the proposed antenna

The VSWR of an antenna is nearly equal to 1 for the frequencies of 18.1GHz and 22GHz.

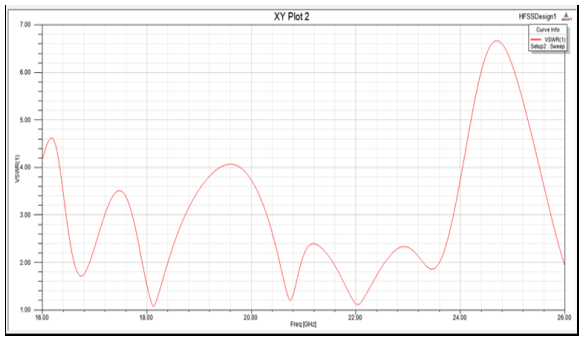

Fig.3. VSWR of the proposed antenna

The Smith chart can be used to solving problems with transmission lines and matching circuits, simultaneously display various parameters including impedances (Z-parameters), admittances (y-parameters), reflection coefficients (Γ), scattering parameters.

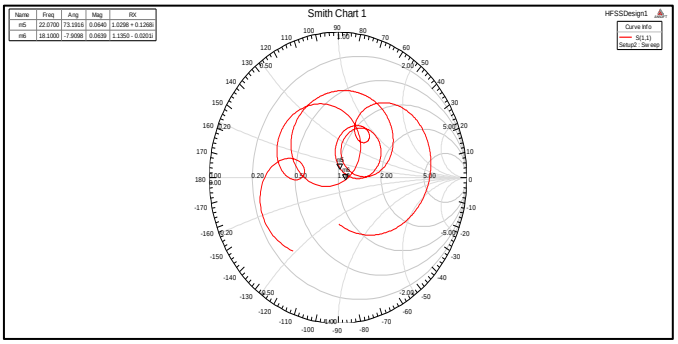

Fig.4. Smith chart of the proposed antenna

Radiation pattern refers to the strength of the radio waves from the antenna or other source depends on direction (front end, back end).

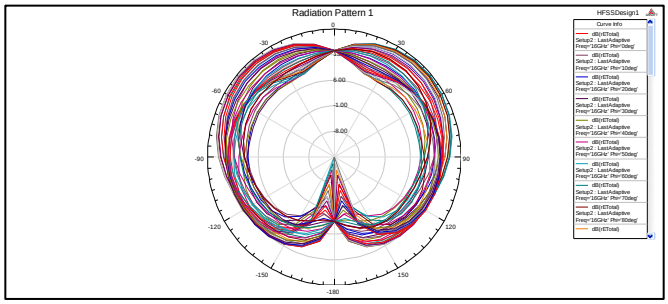

Fig.5. Radiation pattern of the proposed antenna

When no direction is specified "gain" is understood to refer to the peak value of the gain, the gain in direction of the antennas main lobe. A plot of the gain as a function of direction is called gain pattern or it otherwise called as radiation pattern. Here the gain of the proposed antenna 2 is 3.95dB and is measured by using 3D polar plot.

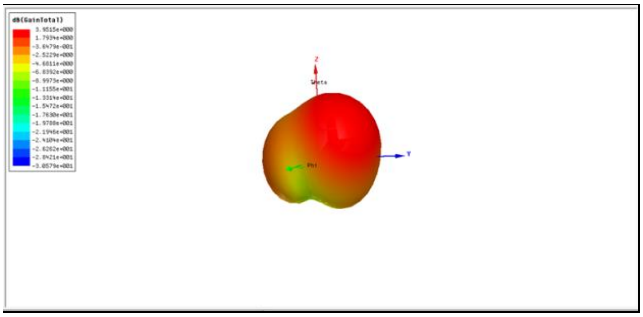

Fig.6. Gain of the proposed antenna

Directivity of an antenna is expressed in decibels (dB) and is plotted in the 3D polar plot using HFSS. The directivity of an antenna is 4.40dB.

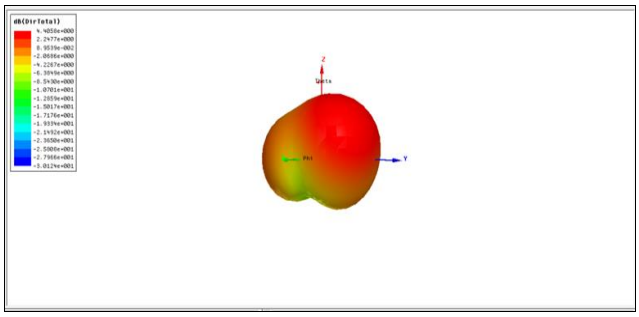

Fig.7. Directivity of the proposed antenna

From those results the efficiency is calculated by the ratio of gain and directivity. The efficiency is expressed in terms of percentage (%). The antenna efficiency is 89.68%.

V.CONCLUSION

Our proposed antenna shows the advantage of both antenna size, frequency usage for live broadcasting and naval satellite application. The frequency of k band is efficiently utilized in this antenna. From the simulation results, the VSWR is less than two (<2), the gain is 3.9dB at k band and the resultant efficiency of the proposed antenna is 89.68%. The comparison result shows that proposed antennas has achieved better gain and efficiency with comparatively smaller dimension than some of the reported antennas. To further enhance the performance of an antenna by changing the size of radiator using the circular patch.

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