ENHANCEMENT OF BANDWIDTH AND GAIN OF MICROSTRIP PATCH ANTENNA

NEHA GUPTA

M.TECH. STUDENT, ELECTRONICS AND COMMUNICATION, INVERTIS UNIVERSITY, BAREILLY, INDIA

---***---

ABSTRACT: *The research in wireless communication has spurred to development of extra ordinary range of antennas each with its own advantage and limitations. There are many applications where space is at premium and where these are urgent need for an antenna with the flexibility of efficient combine the capabilities of multiple antennas. In fact rapidly developing market in personal communication system (PCS), Mobile satellite communication, direct broadband television (DBS) wireless local area networks (WLANS) suggest the demand of microstrip antenna and array will increase even further.Conventional microstrip patch antenna has some drawbacks of low efficiency; narrow bandwidth (3-6%) of central frequency, its bandwidth is limited to a few % which is not enough for most of wireless communication system nowadays. In this paper we are going to enhance gain and bandwidth of microstrip patch antenna.*

Keywords: *Microstrips patch antenna, bandwidth, gain, VSWR.*

1-INTRODUCTION TO MICROSTRIP PATCH ANTENNA: A microstrip patch antenna is basically a very thin metallic patch placed above a ground plane. Such antennas are low weight, highly compact and efficient and are widely used at microwave frequencies for low power applications. Out of different available patch rectangular and circular patch are simpler and also common. However microstrip antennas inherently have a narrow bandwidth enhancement is usually demanded for practical applications.

2-BANDWIDTH: In terms of VSWR (voltage standing wave ratio) or input impedance variation with frequency or in terms of radiation pattern.

The VSWR or impedance bandwidth of microstrip patch antenna is defined as the frequency range over which it is matched with that of feed line within specified limits. The bandwidth of microstrip antenna is inversely proportional to its quality factor Q is given by

$$\text{Bandwidth} = (\text{VSWR}-1)/\ (Q\sqrt{\text{VSWR}})$$

The bandwidth is usually specified as frequency range over which VSWR is less than 2 (which corresponds to a return loss of 9.5 dB or 11% reflected power) sometimes for stringent application the VSWR requirement is specified to be less than 1.5. Conversion of bandwidth from one VSWR level to another can be accomplished by

$$BW1\ /BW2 = (VSWR1-1)\ \sqrt{VSWR2}\ /\ \sqrt{VSWR1}\ (VSWR2-1)$$

Where BW1 and BW2 corresponds to VSWR1 and VSWR2. The expression for approximately calculating the % of bandwidth of rectangular microstrip patch antenna in terms of patch dimension and substrate parameters is given by

$$\%\ BW = Ah/\lambda\sqrt{\varepsilon}\ \sqrt{(W/L)}$$

Where $A=180$ for $h/\lambda\sqrt{\varepsilon} < 0.045$

A=200 for $0.045 < h/\lambda\sqrt{\varepsilon} < 0.075$

A=220 for $h/\lambda\sqrt{\varepsilon} > 0.07$

W and L are width and length of microstrip patch antenna with increase in width bandwidth also increases. The bandwidth can also be defined in terms of antenna radiation parameters .It is defined as the frequency range over which radiation parameters such as gain, half power bandwidth and side lobes level are within the specified minimum and maximum limits. This definition is more complete as it also takes care input impedance mismatch, which also takes contribute to change gain.

Above definition for linearly polarized antenna, for circularly polarized. Bandwidth depends on axial ratio. The bandwidth is frequency range over which axial ratio is less than maximum limit.

2.1-TECHNIQUES TO IMPROVE BANDWIDTH

1. MODIFIED SHAPE PATCHES: The regular microstrip patch antenna configuration such as rectangular and circular patches have been modified to rectangular ring and circular ring to enhance the bandwidth. The larger bandwidth is because of reduction in the quality factor Q of the patch resonator, which is due to less energy stored beneath the patch and higher radiation. When a U shaped slot is act inside the rectangular patch, it gives a bandwidth of approximately 40% for VSWR. Similar results are obtained when U slot is cut inside a circular or a triangular microstrip antenna.

2. PLANAR MULTI-RESONATOR CONFIGURATIONS: The planar stagger tuned coupled multiple resonators yields wide bandwidth in same way as in case of multistage tuned circuit. Several configurations are available yield bandwidth of 5-25%.Various parasitic patches like narrow strips, shorted quarter –wavelength rectangular resonator patches and rectangular resonator patches have been coupled to the central fed rectangular patch. These planar multi resonator configuration yield broad bandwidth but have the following disadvantages.

They are of large size which makes them unsuitable as an array element. There is variation in radiation pattern over the impedance bandwidth.

3. MULTILAYER CONFIGURATION: In the multilayer configuration two or more patches on different layers of the dielectric substrate are stacked on each other. Based on coupling mechanism these configuration are categorized as electromagnetically coupled or aperture coupled microstrip antenna.

Various direct coupled multi resonators are:

a. Rectangular direct coupled along radiating edges.

b. Rectangular microstrip antennas direct coupled along non radiating edges.

c. Direct coupled rectangular microstrip antennas.

4. ELECTROMAGNETICALLY COUPLED MICROSTRIP ANTENNAS: In the electromagnetically coupled microstrip patch antenna one or more patches at the different dielectric layers are electromagnetically to the feed line located at the bottom dielectric layer. Alternatively, one of the patches is fed by a coaxial probe and other patch is electromagnetically coupled. Either bottom or top patches is feed with coaxial probe. The patches can be fabricated on different substrate and accordingly the patch dimensions are to be optimized so that the frequencies of the patch are close to each other to yield broad bandwidth.

5. STACKED MULTIRESONATOR MICROSTRIP ANTENNAS: The planar and stacked multiresonator techniques are combined to further increase to bandwidth and gain. A probe fed single rectangular or circular patch located on the bottom layer has been used to excite multi rectangular or circular patches on top layer respectively. Besides increasing the bandwidth there configuration also provide an increase in gain as well.

2.2- DESIGN METHODOLOGY TO ENHANCE BANDWIDTH: Microstrip patch antenna is low profile antenna with light weight and low cost. As compare to conventional antenna they have many advantages so they are used for various applications ranging from mobile communication to satellite, air craft and other applications.

Similarly different structure shapes of slots in microstrip antenna have attracted much attention in recent years in microwave community for its unique properties. These structures are periodic in nature that forbids the propagation of all electromagnetic surface waves within a particular frequency band called the band bandgap-thus permitting additional control of the behaviour of electromagnetic waves other than conventional guiding and/or filtering structures.

1. LOW BANDWIDTH OF PATCH ANTENNA: In spite of many advantages that patch antennas have in comparison to conventional antennas, they suffer from certain disadvantage. The major drawback of such antenna is narrow bandwidth. This problem is solved by taking a reference antenna and efforts are made to improve its bandwidth by etching the feed line connecting the patch using two square slots type patterns across side surface of rectangular microstrip patch antenna.

2. CHOICE OF SUBSTRATE: Substrate itself is part of antenna and contributes significantly to its radiative properties. Many different factors are considered in choosing a substrate such as dielectric constant, thickness stiffness as well as loss tangent. The dielectric constant should be as low as possible to encourage fringing and hence radiation. A thicker substrate should also be chosen. Since it increases the impedance bandwidth. However using thick substrate would incur a loss in accuracy. Since most microstrip antenna models use a thin substrate approximation in the analysis. Substrate which is lossy at higher frequencies should not be used for obvious reasons. The choice of a stiff or soft board basically depends on the application at hand.

3. INPUT IMPEDANCE MATCHING: Impedance matching is critical in microstrip antennas since the bandwidth of the antenna since the bandwidth of the antenna depends upon it. Beside this a poor match results in lower efficiency also. Line fed rectangular patches may be fed from the radiating or non radiating edge. To find an impedance match along the non radiating edge w may use the transmission line model. The input impedance along the non radiating edge is lowest at the centre since two equally high impedance at the two ends are transformed into a low value at centre and connected in parallel. Matching along the edge is also symmetrical about the midpoint of the length.

3-ANTENNA GAIN: It relates the intensity of an antenna in a given direction to the intensity that would be produced by

a hypothetical ideal antenna that radiates equally in all directions or isotropically and has no losses. Since the radiation intensity from a lossless from isotropic antenna equals the power into the antenna divided by a solid angle of 4 л steradians we can write the following equations.

Gain=4л (radiation intensity/antenna input power)

Gain=4л (U (ɵ, ϕ))/Pin dimensionless units

The gain of a rectangular microstrip patch antenna with air dielectric can be very roughly estimated as follows. Since the length of the patch, half a wavelength is about the same as the length of resonant dipole, we get about 2db of gain from the directivity relative to vertical axis of patch. If the patch is square the pattern in the horizontal plane will be directional, somewhat as if the patch were a pair of dipoles separated by a half waves this counts for about another 2-3 db. Finally the addition of the ground plane cuts of most or all radiation behind the antenna reducing the power averaged over all direction by a factor of (2 and thus increasing the gain of 3db). Adding this all up we get about 7-9 db for a square patch in good agreement with more sophisticated approaches.

3.1-METHODS TO ENHANCE GAIN IN MICROSTRIP PATCH ANTENNA: Most compact microstrip patch antenna designs show decreased antenna gain owing to the antenna size reduction. To overcome this disadvantage and obtain an enhanced antenna gain. Several designs for gain enhanced compact microstrip antenna with the loading of high dielectric superstrate or the inclusion of an amplifier type active circuitry have been demonstrated .Use of high permittivity superstrate loading technique gives an increase in antenna gain of about 10 dbi with a smaller radiating patch. An amplifier type active microstrip antenna as a transmitting antenna with enhanced gain and bandwidth has also been implemented.

4-CONCLUSION: Bandwidth is enhanced by inserting slots on patch of microstrip patch antenna. This improved characteristic is satisfactory for most of wireless communication. This improve characteristic is satisfactory for most of wireless communication. The proposed antennas have good gain. Mobile communication wireless computer links remote control, satellite, mobile phones and wireless internet has shown a tremendous growth in present days. Now a days the size of electronic need for mobile applications have decreased drastically where as their functionality has increased.

REFERENCES

1- R. G. Voughan. 1988. two-port higher mode circular microstrip antennas. IEEE, Trans. Antennas Propagat.36 (3): 309-321

2-WL. Stuntman and G.A. Thiele, Antenna Theory and Design, 2nd Ed. New York: Wiley, 1998

3- C.A. Balanis, Antenna Theory, 2nd Ed. New York: John Wiley & Sons, Inc., 1997.

4- H. F. AbuTarboush, H. S. Al-Raweshidy, "A Connected E-Shape and U-Shape Dual-Band Patch Antenna for Different Wireless Applications", the Second International EURASIP Workshop on RFID Technology, July, 2008.

5- Nashaat DM, Elsadek H. Miniturized E-shaped dual band PIFA on FR4 substrates. Radio Science Conference, 2006 NRSC 2006 Proceedings of the Twenty Third National. 2006; 0:1-6.

6- Lin S-, Row J-. Bandwidth enhancement for dual-frequency microstrip antenna with conical radiation. Electronics Letters. 2008; 44(1):2-3.

7- Anguera J, Cabedo A, Picher C, Sanz I, Ribo M, Puente C. Multiband handset antennas by means of ground plane modification. Antennas and Propagation International Symposium, 2007 IEEE.2007:1253-6.

8- G. A.Deschamps, "*Microstrip microwave antennas*", presented at the 3rd USAF Symp. On antennas, 1953.

9- R. E. Munson, "*Single slot cavity antennas assembly*", U.S. patent No. 3713 162, January 23, 1973.

10- K.P. Ray and G. Kumar, "*Broadband Microstrip Antennas*", Archtech House, ISBN: 1-58053-244-6, 2003.

11- James, J. R. and G. Andrasic, "Super dichroic microstrip antenna arrays," *Proc. IEEE*, 135 H, 304–312,1988.

12- Long, S. A. and M. D. Walton, "A dual frequency stacked circular disc antenna," *IEEE Trans. Ant. Prop.*,Vol. AP-27, No. 2, 270– 273, 1979.

13- Legay, H. and L. Shafai, "New stacked microstrip antenna with large bandwidth and high gain," *IEE Proc.Micro. Ant. Prop.*, Vol. 141, No. 3, 99–204, 1994.

14- Zurcher, J. F. and F. E. Gardiol, *Broad-band Patch Antennas*, Artech House, Inc., London, 1995.