Development Of Nano synthesised Material Antenna For Efficiency and Dimensional Enhancement

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Abstract

The performance and advantages of microstrip patch antennas such as low weight, low profile, and low cost made them the perfect choice for communication systems engineers. They have the capability to integrate with microwave circuits and therefore they are very well suited for applications such as cell devices, WLAN applications, navigation systems and many others. In this thesis; a compact rectangular patch antennas are designed and tested for GPS devices at 1.57542 GHz, and for a TV signal at 11.843 GHz and 11.919 GHz. The designed antenna with the nano matrial deposition on the surface of substrate give s effective low radiation loss and high efficiency .

Keyword : microstip antenna, single layer deposition, feed point mechanism

Introduction

The Microstrip Patch Antenna is a single-layer design which consists generally of four parts (patch, ground plane, substrate, and the feeding part). Patch antenna can be classified as single – element resonant antenna. Once the frequency is given, everything (such as radiation pattern input impedance, etc.) is fixed. The patch is a very thin ($t<<\lambda 0$, where $\lambda 0$ is the free space wavelength) radiating metal strip (or array of strips) located on one side of a thin no conducting substrate, the ground plane is the same metal located on the other side of the substrate. The metallic patch is normally made of thin copper foil plated with a corrosion resistive metal, such as gold, tin, or nickel. Many shapes of patches are designed some are shown in figure and the most popular shape is the rectangular and circular patch. The substrate layer thickness is 0.01–0.05 of free-space wavelength . It is used primarily to Provide proper spacing and mechanical support between the patch and its ground plane. It is also often used with high dielectric-constant material to load the patch and reduce its size. The substrate material should be low in insertion loss with a loss tangent of less than 0.005. In this work we have used duriod 5880 with dielectric constant of2.2- 4.7 and tangent loss of 0.003. Generally, substrate materials can be separated into three categories according to the dielectric constant [1].

1. Having a relative dielectric constant in the range of 1.0–5.0. This type of material can be air, polystyrene foam, or dielectric honeycomb.

2. Having □*r* in the range of 2.0–4.0 with material consisting mostly of fibreglass reinforced Teflon.

3. With a *between* 4 and 10. The material can consist of ceramic, quartz, or alumina.

The advantages of the microstrip antennas are small size, low profile, and lightweight, conformable to planar and non planar surfaces. It demands a very little volume of the structure when mounting. They are simple and cheap to manufacture using modern printed circuit technology. However, patch antennas have disadvantages.

The main disadvantages of the microstrip antennas are: low efficiency, narrow bandwidth of less than 5%, low RF power due to the small separation between the radiation patch and the ground plane(not suitable for high-power applications).

2.Feeding Methods

There are many methods of feeding a microstrip antenna. The most popularfeed line is.

1. Microstrip Line.
2. Coaxial Probe (coplanar feed).
3. Proximity Coupling.
4. Aperture Coupling.

Because of the antenna is radiating from one side of the substrate, so it is easy to feed it from the other side (the ground plane), or from the side of the element.

The most important thing to be considered is the maximum transfer of power (matching of the feed line with the input impedance of the antenna), this will be discussed later in the section of Impedance Matching.

Many good designs have been discarded because of their bad feeding. The designer can buildan antenna with good characteristics and good radiation parameter and high efficiency but when feeding is bad, the total efficiency could be reduced to a low level which makes the whole system to be rejected.

2.1 Microstrip Line Feed.

This method of feeding is very widely used because it is very simple to design and analyze, and very easy to manufacture. Figure (2.2) shows a patch with microstrip line feed from the side of the patch.

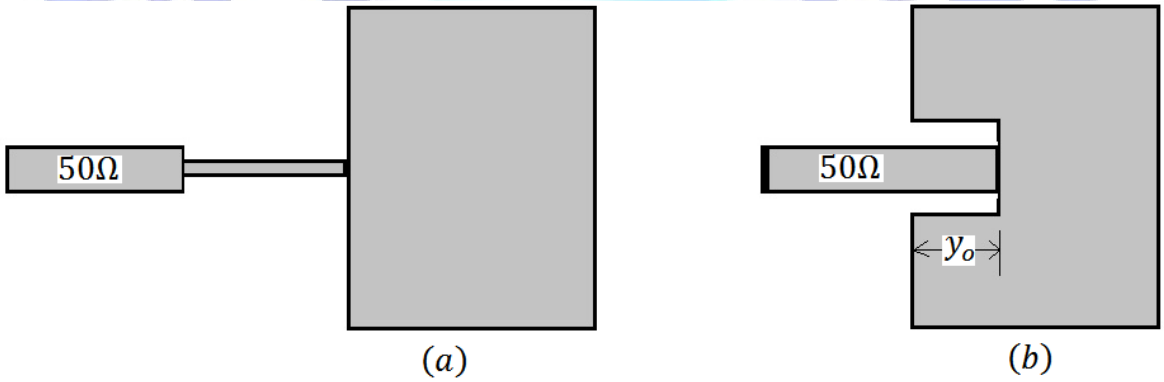

Figure 1: Microstrip patch antenna with feed from side

The position of the feed point (□0) of the patch in figure (1b) has been discussed in details in the section of Impedance Matching. Feeding technique of the patch in figure (2.3) is discussed in [7]. It is widely used in both one patch antenna and multi-patches (array) antennas.

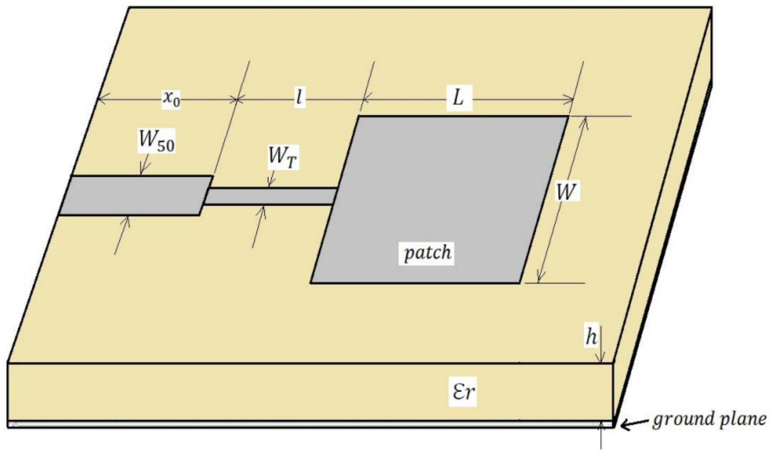

Figure 2: dimensions of patch antenna with microstrip feed line

The impedance of the patch is given by

$$Za = 90\frac{\varepsilon r+\varepsilon r}{\varepsilon r-1}\left(\frac{L}{W}\right) \quad (1)$$

The characteristic impedance of the transition section should be:

$$Zt = \sqrt{50 + Za} \quad (2)$$

The width of the transition line is calculated from

$$Zt = \frac{60}{\sqrt{\varepsilon r}}\ln\left(\frac{80d}{Wt} - \frac{Wd}{4d}\right) \quad (3)$$

The width of the 50Ω microstrip feed can be found using:

$$Z0 = \frac{120\pi}{\sqrt{\varepsilon reff}\left(1.393 + \frac{W}{h} + \frac{2}{3}\ln\left(\frac{W}{h} + 1.444\right)\right)} \quad (4)$$

The length of the strip can be found from

$$Rin = \cos^2\frac{\pi}{L}y0 \quad (5)$$

The length of the transition line is quarter the wavelength:

$$L = \frac{\lambda}{4} = \frac{\lambda}{4\sqrt{\varepsilon reffe}} \quad (6)$$

3. Design Methods

Material designing

The nano material of Aluminium, silica and graphite is prepared using sol-gel auto combustion method. The process is carried out with the nitrite group element along with the hexaferrite material.

3.1 Preparation of sample:

Nano-powder of MZN ferrite particles were prepared by sol-gel auto combustion method. By using analytical grade chemical reagents of Mn (NO3)24H2 O, Zn(NO3) 2, 6H 2 O, and Fe(NO3)O. The sample quantity is set according to its stoichiometric proportions were dissolved in deionizer water. The mixture of solution was heated at 80^0 c till the complete mixture transformed in to gel. The gel of the solution is ignited and burnt by microwave oven on 600 watt for 7-minute continuous heating to obtain ash powder. The powders were annealed slowly at 800c in a furnace for 4 hours after intermediate grinding.

3.2 Dimensional Design

After the discussion of the simplified formulation in previous sections, the procedure for designing a rectangular microstrip patch antenna is explained. In this procedure there are three essential parameters for the design: the frequency of operation , the dielectric constant of the substrate □r and the height of the dielectric substrate h. For a given □r and h , we design a rectangular microstrip antenna for the resonant frequency fr

3.3 Microstrip patch antenna

1. From equation we calculate W:

$$W = \frac{1}{2fr\sqrt{\mu\varepsilon}}\left(\frac{\sqrt{2}}{\varepsilon r} + 1\right) = \frac{\upsilon_0}{2fr}\left(\frac{\sqrt{2}}{\varepsilon r} + 1\right) \quad (7)$$

Now determine the effective constant of the microstrip antenna from equation (3.6):

$$\mathcal{E}reff = \frac{\mathcal{E}r+1}{2} + \frac{\mathcal{E}r-1}{2\sqrt{1-(\frac{12h}{W})}} \qquad (8)$$

Use equation to determine the extension of Δ :

$$\frac{\Delta Leff}{h} - \frac{0.412\left((\mathcal{E}reff+0.3)\left(\frac{W}{h}+0.264\right)\right)}{(\mathcal{E}reff-0.258)\left(\frac{W}{h}+0.8\right)} \qquad (9)$$

The actual length of the patch can be found:

$$L - \frac{1}{2fr\sqrt{\mathcal{E}reff}\sqrt{\mu\mathcal{E}}} - 2\Delta L \qquad (10)$$

2. Calculation of the feed point We want to match the antenna to 50Ω ;

Use equations (4.21), (4.24), (4.18), (4.23) discussed earlier to determine the feeding point Location.

$$Rin = 1/(2(G1 + G12)) \qquad (11)$$

$$Rin - \frac{1}{2(G1+G12)}(\cos(\cos\left(\frac{\pi}{L}\right)y0)) \qquad (12)$$

$$G1 = \frac{I1}{120\pi} \qquad (13)$$

$$I1 = \int\left[\sin\left(\frac{Kow}{2}\cos\theta\right] * \left[\sin\left(\frac{Kow}{2}\cos\theta\right]\sin\theta\,.\sin\theta\,.\sin\theta d\theta \qquad (14)$$

$$G12 = \frac{1}{120\pi\pi}\left[\sin\left(\frac{Kow}{2}\cos\theta\right] * \left[\sin\left(\frac{Kow}{2}\cos\theta\right] joKoLsin\theta \sin \quad \theta 3 \qquad (15)$$

3. Calculating the dimensions of the ground plane.

$$\lambda - \frac{vo}{fr}\sqrt{\square reff} \qquad (16)$$

Length of ground plane >λeff/4x2+L and Width of ground plane > λeff/4x2+W

To design a rectangular microstrip patch antenna we decide the substrate material and the thickness of it. Frequency of GPS signal is 1575.42 MHz

Set these parameters as follows: Ɛr= 4.1, h= 1.6, fr= 1.57542

W= 59.716 , L= 46.798, y0= 17.24, Ɛr=4.1 , λeff= 0.1157, λeff/4= 24.146

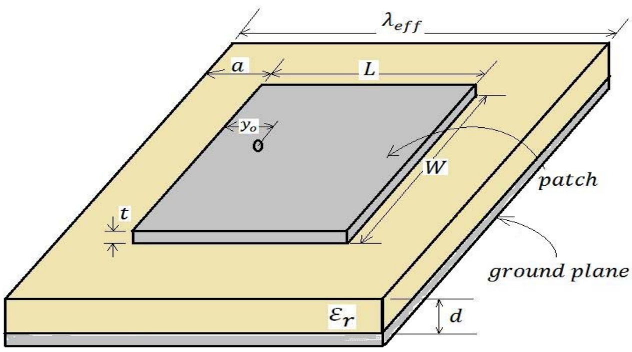

Figure 3: designed parameters of patch

3.4 Deposition methods:

the prepared sample of nano materials deposited with the spray payrolesis and the sol gel deposition. The material coated with the Si and plastic film at the 80^{0}C at constant pressure of 0.7Mbar/cm^3. The thin film prepared with the material deposited and tested on the Agilent Technology based instrument along with the simulation result.

4. Result and conclusion

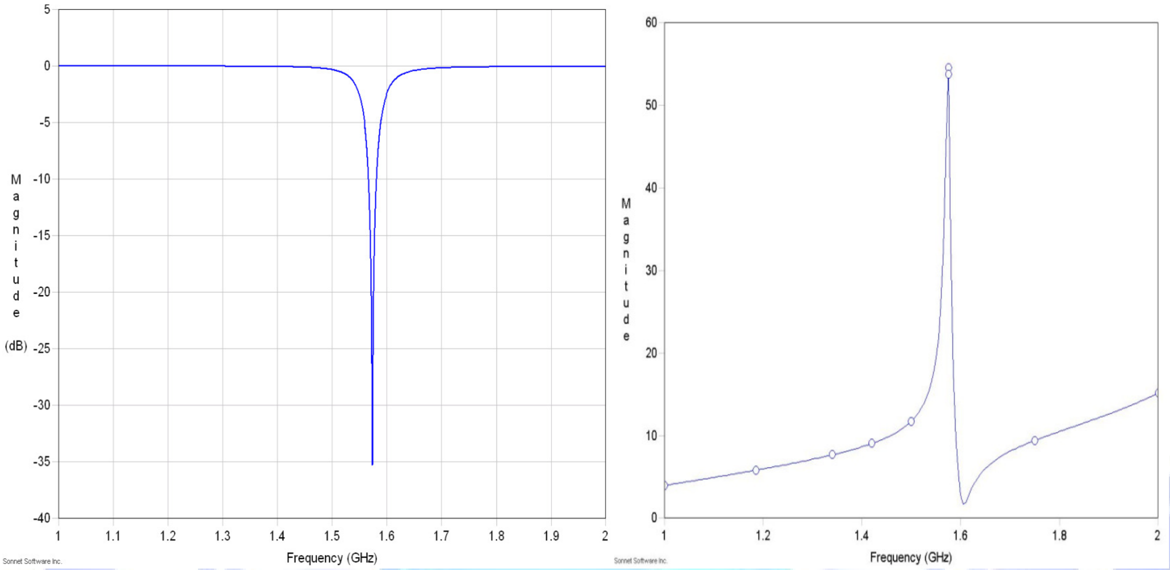

Figure 4: frequency response of patch antenna and input impedance of patch antenna

Table 1: dimensional parameter with dielectric constant

Ɛr	D mm	W mm	L mm
1	1.6	95	92.9
2	1.6	77.3	66.4
4.1	1.6	57	46
8	1.6	44.5	33.8
10	1.6	40.6	30
12	1.6	37.4	27.9
16	1.6	32.5	23.5
20	1.6	29.4	21.2

If we want to see the effect of changing the dielectric constant on the dimensions of the antenna we can keep the thickness of the substrate at 1.6 mm and change the dielectric from 1to 20 using equations (5.1) to (5.10) as follows: We can see that changing the dielectric constant will change the dimensions of the antenna strongly while the change of the thickness will change the length of the antenna slightly but no change on the width, see equations (3.2), (3.5), and (3.6). We can also redesign the microstrip patch antenna in example 1 using substrate with dielectric constant of 16, the dimensions are:

W= 31, L= 22.8 , Y0=8.7

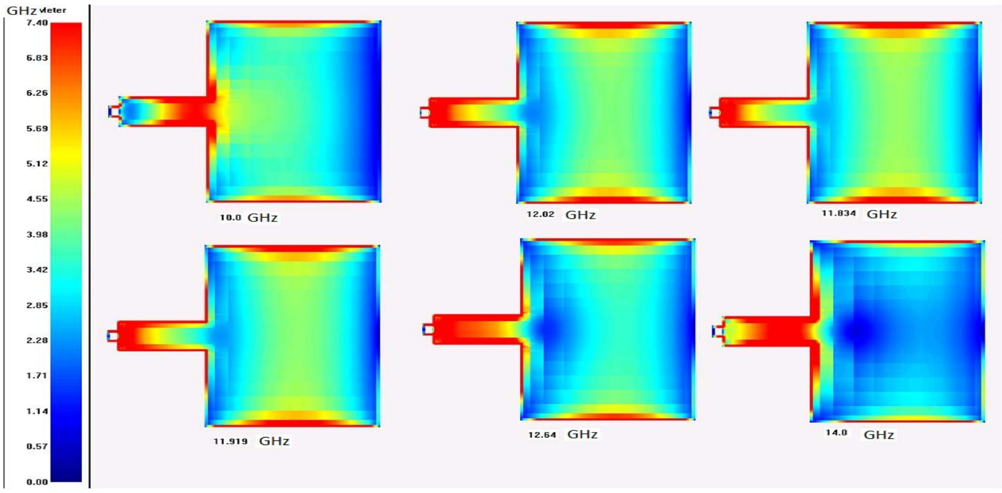

Figure 6: current distribution along the patch

5. Conclusion

We have successfully synthesized single-phase simple cubic spinal polycrystalline of MZN ferrite and particles with an average crystalline size of 28 nm by sol-gel route. These newly developed material and fabricated antenna in this paper is to design a rectangular patch Microstrip antenna and to study the responses and the radiation properties of the same. The two antennas have been designed with 2 different design parameters. Taking all this into consideration we can say that there are many aspects that affect the performance of the antenna. Dimensions, selection of the substrate, feed technique and also the Operating frequency can take their position in effecting the performance. A rigorous analysis of the problem begins with the application of the equivalence principle that introduces the unknown electric and magnetic surface current densities on the dielectric surface. The formulation of the radiation problems is based on the numerical solution of the combined field integral equations.

The radiation resistance of the designed patch is improved with the nano ferrite material depositions which enhances the performance of the antenna and give the tangential loss parameter with less radiation loss.

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References'

[1] C. A. Balanis, *Antenna Theory Analysis and Design*, Jhon Wiley & Sons, Inc., Second Edition, 1996.

[2] Manik Gujral, Tao Yuan, Cheng-Wei Qui, Le-Wei Li and Ken Takei, "Bandwidth Increment of Microstrip Patch Antenna Array with Opposite Double- E Ebg Structure for Different Feed Position", *International Symposition on Antenna and Propagation*, Inc. NY, USA, ISP- 2006.

[3] Richard C. Johnson, Henry Jasik, "Antenna Engineering Handbook" Second Edition, pp. 7-1 to 7-14, McGraw Hill, 1984.

[4] Pozar, D. M., and D. H. Schaubert (Eds), "The Analysis and Design of Microstrip Antennas and Arrays", *IEEE Press*, New York, 1996.

[5] D. Urban and G. J. K. Moernaut, "The Basics of Patch Antennas" *Journal, Orban Microwave Products*.

[6] Y T Lo and S W Lee, editors, ''Antenna Handbook Theory, Applications & Design'', Van Nostrand Rein Company, NY, 1988.

[7] Franco Di Paolo, ''Networks and Devices using Planar Transmission Lines'', pp 71, CRS Press, LLC, NY, 2000.

[8] Antenna theory: analysis and design / Constantine A. Balanis, third edition, Hoboken, NJ: Wiley, 2005, ISBN 047166782X (hbk.)

[9] Antenna Engineering Handbook/ Richard C. Johnson, second edition, New York: McGraw-Hill, cop. 1984, ISBN 0070322910

[10] RF circuit design: theory and applications / Reinhold Ludwig, Pavel Bretchko,

Prentice Hall, 2000, ISBN 0-13-095323-7

[11] Advanced engineering electromagnetic / Constantine A. Balanis, New York:

Wiley, cop. 1989, ISBN 0-471-62194-3

[12] Millimeter- Wave Microstrip and printed circuit Antennas/ P. Bartia, Artech

House 1991, ISBN 0-89006-333-8