Design of an Ultra-Wideband Monopole Antenna by Using New Nano-Composite Materials

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Abstract:
In this paper, a planar monopole antenna is introduced, also we added some new Nano fillers such as Fumed Silica and Aluminum Oxide to RT Duriod5880 and RO3003 to produce new Nano composite materials, then new Nano composite materials are used as a substrate of a ultra-wideband monopole antenna. Antenna characteristics are considered to illustrate that, by using these Nano composite materials, antenna bandwidth has significantly improved. The return loss and radiation pattern plots of the simulated planar monopole antenna show good results. Another advantage of this modification is simple fabrication and narrow substrate thickness of the proposed monopole antenna.

Keywords: Monopole antenna – Nano composite material – ultra wideband antenna

1. Introduction

In the recent years, the design and development of a conformal, flexible and lightweight antenna have received a significant consideration from microwave researcher [1]. In addition, an enhancement of antenna bandwidth, improved efficiency and gain has become the main target among researchers in antenna industries [2]. Therefore, the exploring and developing of different substrate materials for antennas have internationally increased to fulfill the above mentioned requirements.

A few approaches for reducing antenna's size are by increasing the permittivity of substrate containing the antenna [3]. Using high permittivity material for antenna substrate however suffers from narrow bandwidth and low efficiency [1]. In order to design a compact monopole antenna, substrate with higher dielectric constant must be used which are less efficient and result in narrow bandwidth. In this letter, we have used Nano composite materials as the substrate of monopole antenna. These Nano composite materials have been Nano fillers such as Fumed Silica and Aluminum Oxide composed with RT Duriod5880 and RO3003. We have investigated this triangle monopole antenna with 9 typesNano composed materials with different dielectric constant.

Another way that is proposed for increasing the impedance bandwidth of the triangular monopole antenna is changed the position of circle slot of patch and changed its radius. It has been demonstrated by adding nano composite materials of high relative permittivity and modifying the shape of monopole antenna increases the effective bandwidth and reduces the resonant frequency, so the dimension of antenna reduced.

2. Antenna Design

Figure 1 shows the configuration of the proposed monopole antenna, which consist of an inverted triangular structure with two modified stubs on the sides and a circle slot in the middle of the radiating patch [4]. The ground plane is truncated, as shown in figure 1 and envelope the feed line to the radiating patch. The ground plane includes a rectangular notch at center of its two narrow slots on both sides[4]. The conventional antenna is constructed from Rogers RO 4003C substrate with thickness of 0.813mm and relative dielectric constant of 3.38. It is tested this monopole antenna with 9 typesNano-composite material for substrate which the specifications of these materials are shown in table 1.

The selected material fumed silica is one of most important filler that used in insulting materials, integrated circuits, electric components and many other applications [11]. It has a dielectric constant is Ɛ=4.5, and the main advantages of fumed silica are costless and has a great effect on properties such as viscosity, stiffness and strength [9]. This paper has used Nano-composite materials which composite of RT Duriod 5880 with Nano-fillers (fumed silica) in triangular monopole antenna. Theother material is Aluminum oxide. Aluminum oxide is the family of inorganic compounds with the chemical formula AL_2O_3 [2]. It is commonly referred to as alumina, corundum as well as many other names, reflecting its widespread occurrence in nature and industry.

Its most significant using is in the production of aluminum metal, although it used as an abrading due to its hardness and as a refractory material due to its high melting point. It has a dielectric constant is Ɛ=9.5 [3].

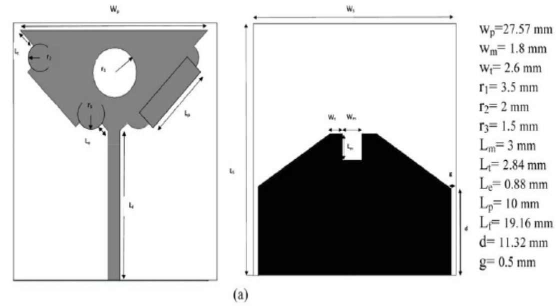

Fig.1. Configuration and parameters of proposed antenna

Tabel 1. The specification of nano composite materials used in substrate

Substrate Thickness (mm)	Relative dielectric constant	Feed line's width (mm)	Substrate materials
RT Duriod 5880	2.44	2.2	0.813
RTDuriod5880 with0.1fumedsilica	2.44	2.2	0.813
RT Duriod5880 with0.2fumed silica	2.268	2.4	0.813
RTDuriod5880 with0.3fumed silica	2.043	2.8	0.813
RT Duriod 5880 with 0.1 Aluminum oxide	1.942	3.01	0.813
RT Duriod 5880 with 0.2 Aluminum oxide	1.63	3.76	0.813
RT Duriod 5880 with 0.3Aluminum oxide	1.45	4.46	0.813
RO 3003 with 0.1 fumed silica	1.84	3	0.75
RO 3003 with0.5 fumed silica	1.64	3.52	0.5

The proposed antenna is investigated by changing the substrate material at a time, while fixing other parameters.

To fully understand the behavior of the antenna structure and to determine the optimum parameters, the antenna was analyzed by using HFSS^{TM} and the S11 plot of each Nano composite material was compared with conventional material. The results are demonstrated as figure 2.

Figure 2 shows the effect of Nano composite materials on return loss S_{11} and bandwidth of suggested antenna. It has been seen that , when we changed the substrate material to RT Duriod 5880 with 0.1 fumed Silica, the band width increased to 20.7GHz, RT Duriod 5880 with 0.2 Fumed Silica increased the band width to 19.65 GHz and RT Duriod 5580 with 0.3 Fumed Silica increased the band width to 19.1GHz. The conventional model band width is about 17.5GHz. Figure 3 displays the return loss S_{11} of suggested monopole antenna with new Nano composite materials RT Duriod 5880 with 0.1 Aluminum Oxide, 0.2 Aluminum Oxide and 0.3 Aluminum Oxide. It is noticed that by using this Nano composite for RT Duriod 5880 with 0.1 Aluminum Oxide, the band width is increased to 18.7GHz, but for 0.2 Aluminum Oxide and 0.3 Aluminum Oxide band widths is decreased.

In figure 4 the S11 plots of antenna for conventional model and RO3003 with 0.1 Fumed Silica and RO3003 with 0.5 Fumed Silica are demonstrated. According to figure 4, RO 3003 with 0.1 Fumed Silica increased the bandwidth to 18.2GHz but RO3003 with 0.5 Fumed Silica decreased the bandwidth. The thickness of substrate with these Nano composite materials is lower than conventional size. The bandwidth of each material was measured and shown in table 2.

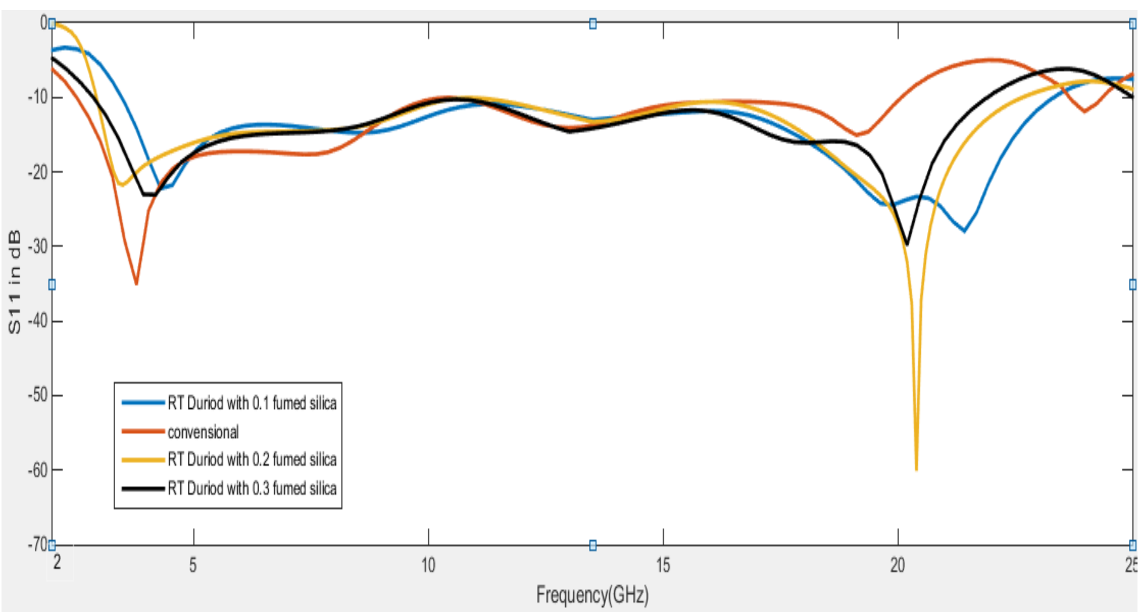

Fig.2. S11 plot of conventional antenna and antenna with substrates of RT Duriod 5880 with 0.1 Fumed Silica, 0.2 Fumed Silica and 0.3 Fumed Silica

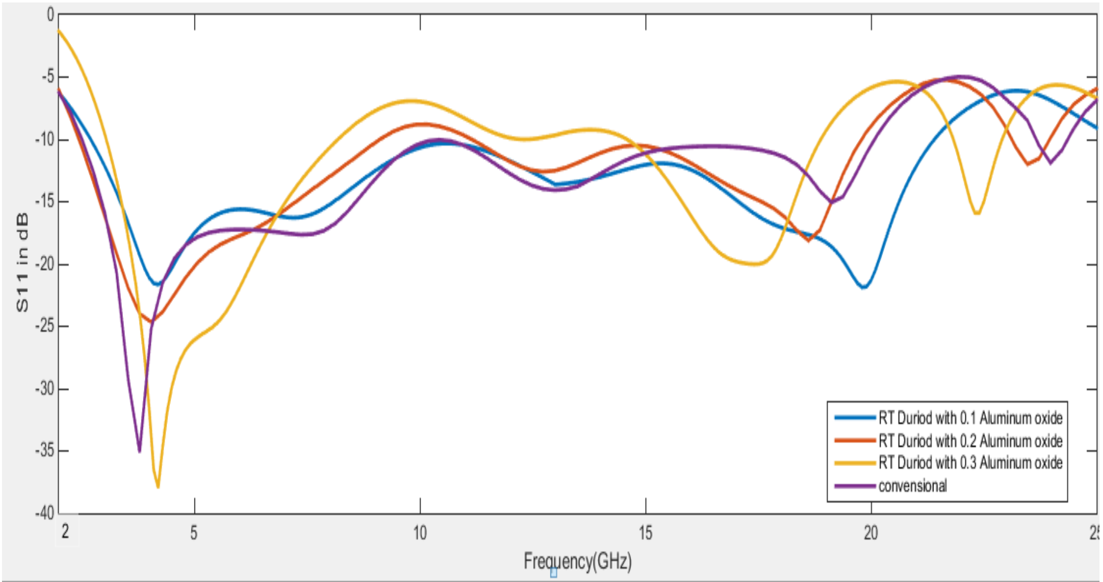

Fig.3. S11 plot of conventional antenna and antenna with substrates of RT Duriod 5880 with 0.1 Aluminum Oxide, 0.2 Aluminum Oxide and 0.3 Aluminum Oxide

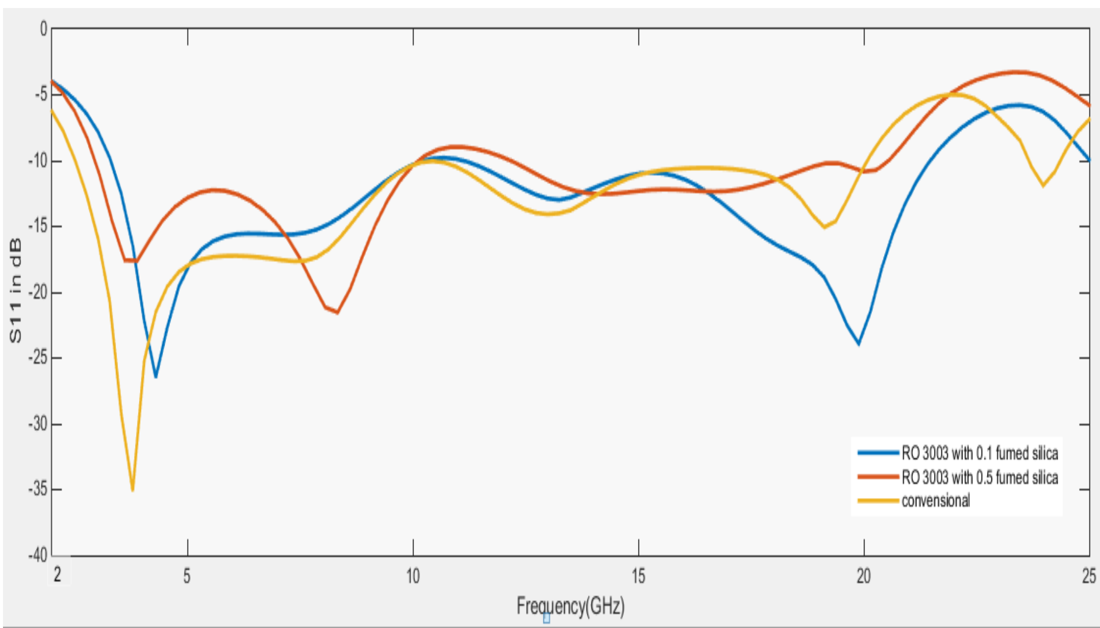

Fig.4. S11 plot of conventional antenna and antenna with substrate of RO3003 with 0.1 and 0.5 fumed silica

Table 2. The bandwidth of the antenna using each different Nano composite substrate

Substrate materials	Band Width (GHz)
RT Duriod 5880	2.5-20
RT Duriod 5880 with 0.1 fumed silica	3.3-24
RT Duriod5880 with 0.2 fumed silica	3-22.65
RT Duriod 5880 with 0.3 fumed silica	2.9-22
RT Duriod 5880 with 0.1 Aluminum oxide	2.7-21.4
RT Duriod 5880 with 0.2 Aluminum oxide	2.5-8.9 and 11.2-19.7
RT Duriod 5880 with 0.3 Aluminum oxide	3.05-8.2 and 14.6-18.9
RO 3003 with 0.1 fumed silica	3.3-21.5
RO 3003 with0.5 fumed silica	2.5-10.28 and 11-20.56

3. Result and Discussion

The proposed antenna is a triangular monopole antenna that was investigated, as shown in figure 1 [1]. The conventional antenna has impedance bandwidth matching (S11<-10) about 2.5-20GHz as shown in figure 2. the proposed antenna is a triangular monopole antenna that was investigated, as shown in figure 1 [1]. The conventional antenna has impedance bandwidth matching (S11<-10) about 2.5-20GHz as shown in figure 2. In this study we have investigated 9 types materials and have used in this monopole antenna. Figure 2 shows the return loss response for conventional antenna and antenna with RT Duriod 5880 with 0.1, 0.2 and 0.3 fumed silica and compared with each other. The impedance bandwidth (S11<10 dB) for RT Duriod 5880 with 0.1 fumed silica was enhanced to 3.3-24GHz, for RT Duriod 5880 with 0.2 fumed silica was enhanced to 3-22.65 and for RT Duriod 5880 with 0.3 fumed silica was enhanced to 2.9-22 as shown in figure 2. according to figure 3 the impedance bandwidth for RT Duriod 5880 with 0.1 aluminum oxide was enhanced to 2.7-21.4GHz and for RT Duriod 5880 with 0.2 Fumed Silica and RT Duriod 5880 with 0.3Aluminum Oxide was decreased. Figure 4 shows the return loss response for conventional antenna and antenna with RO3003 with 0.1 Fumed Silica and RO3003 with 0.5 Fumed Silica and compared with each other, the impedance bandwidth for RO3003 with 0.1 Fumed Silica was enhanced to 3.3-21.5GHz and for RO3003 with 0.5 Fumed Silica the bandwidth was decreased. There for, for 5 types of Nano-composite substrates we achieved a wider bandwidth in comparison conventional structure. The proposed antenna radiation pattern was measured and shown in figure 5.

4. Conclusion

In this article, a triangular monopole antenna with different Nano-composite substrate materials was simulated. The measured results show that the impedance antenna bandwidth with substrate of RT Duriod 5880 with 0.1, 0.2 and 0.3 Fumed Silica and with 0.1 aluminum oxides and RO3003 with 0.1 Fumed Silica is significantly improved the range of bandwidth. The maximum range of bandwidth that measured is about 3.3-24GHz with returnloss better than-10dB. The measured results show good radiation patterns within the UWB frequency range. Using of Nano-composite materials for proposed monopole antenna was enhanced the radiation efficiency and bandwidth with easy fabrication high performance and low cost.

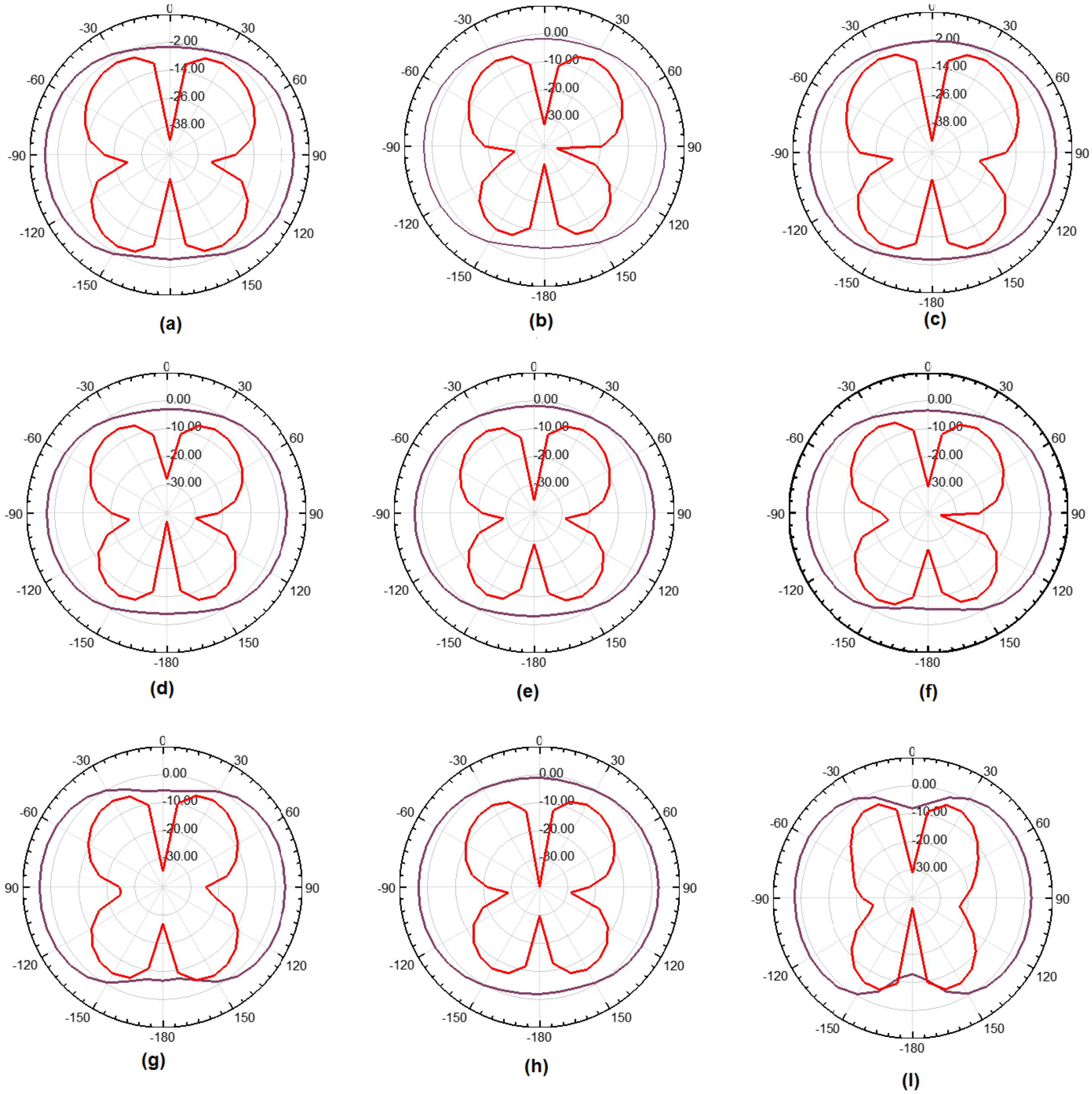

Fig.5. Radiation pattern of the antenna in E- plane a) conventional antenna (b) antenna with substrate of RT Duriod 5880 with 0.1 fumed silica (c) RT Duriod 5880 with 0.2 fumed silica (d) RT Duriod 5880 with 0.3 fumed silica (e) RT Duriod 5880 with 0.1 Aluminum oxide (f) RT Duriod 5880 with 0.2 Aluminum oxide (g) RT Duriod 5880 with 0.3 aluminum oxide (h) RO3003 with 0.1 fumed silica (I) RO3003 with 0.5 fumed silica at 12 GHz.

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