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Comparative Analysis of Microstrip Patch Antenna in Various Clime

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Abstract

In the work presented here, the effect on the performance of a microstrip patch antenna due to accumulation of water and dust over its microstrip patch surface is studied. A probe-fed microstrip patch antenna is used for the experiment. The antenna is assumed to be in outdoor condition such that the microstrip patch surface lies horizontal so that water or dust particles (soil) may be accumulated over its surface during its working in the normal environmental conditions. These effects are emulated by pouring distilled water and placing dust particles (soil) over the antenna patch surface to form a dielectric layer of uniform thickness successively from 0.05 to 0.1 mm over the antenna patch surface and its effect on the working of the antenna are observed. The antenna used in this experiment is working on resonant frequency equals to 2.45 GHz.

Keywords: Microstrip Patch Antenna, Resonant frequency, Return loss, Network Analyzer.

1. Introduction

Antenna has been investigated for many years as the demand in emerging technology applications developed simultaneously. Many techniques have been proposed in various ways to suit the desired characteristics.

Now-a-days, microstrip antennas have replaced the conventional antenna because of its size and weight. In cellular communication systems conventional antenna arrays have been replaced by microstip patch antenna arrays because it is compact in size and light in weight. Microstrip patch antenna offers the advantages of thin profile low cost and conformability to a shaped surface and compatibility with integrated circuitry[1]. A system designed using any antenna should work over the desired frequency band. Effects of environmental conditions to which the antenna may be exposed in due course of its use, should to be taken into account during the design phase of the antenna. If due care is not taken during the design phase, the system may fail to work. Few of such conditions may be exposure of square microstrip patch antenna to snowfall and build-up of snow or ice over its patch surface, or exposure to rain water and accumulation of water over its patch surface. Apart from all these one phenomena which is common is the accumulation of the dust particles over the surface of the antenna when they are allowed to work in the open areas for a long course of time. If a square microstrip patch antenna is exposed to such environmental conditions, its resonant frequency gets affected as snow, water and dust are dielectrics and the antenna as a whole acts as dielectric loaded antenna, which reduces its frequency of resonance[2]. A square microstrip patch antenna is generally a narrowband device and hence, even a small shift in its resonant frequency may lie outside the intended band of use of frequency and hence may cause a system failure [3].

Water is a dielectric whose relative permittivity i.e. dielectric constant has a complex value (real and imaginary parts) and it depends on the external excitation frequency, temperature and salinity of the water [4] - [7]. However, for rain water, salinity is zero ppm. Variation in the relative permittivity of water with respect to frequency of 2.45GHz and lower (over the observed range of frequencies in this experiment) is insignificant. Also a temperature change of 1 to 20^{o}C around the room temperature of 25^{o}C does not affect the relative permittivity of water significantly. Essentially it means the relative permittivity of water is effectively constant in case of this experiment.

2. Tactic of Experiment

In the present work, a square microstrip patch antenna is fabricated on FR4_epoxy substrate ($\varepsilon_r = 4.4$). The patch is probe-fed using a coaxial pin and the antenna dimensions are optimized using 3-D Electromagnetic Simulator. The coaxial probe feed is an easy to fabricate and match, and it has low spurious radiation. Our aim is to increase the bandwidth when compared to the conventional microstrip patch antenna. The photograph of microstrip patch area along with probe-feed position is shown in the Fig. 1.

A network analyzer from Agilent Technologies is used for measurements. Before use for measurement, the network analyzer is calibrated. The effect of rain water accumulation on the microstrip patch surface is emulated by pouring distilled water over the horizontal lying microstrip patch surface to form water layer of uniform thickness successively equal to 0.05, 0.06, 0.07, 0.08, 0.09 and 0.1 mm and its effect on the resonant frequency and normal working of the antenna is observed. The water is poured such that it covers the entire microstrip patch and the dielectric substrate surface to form a water layer of uniform thickness. The temperature of water is equal to room temperature (25^{o}C) at the time of experimentation.

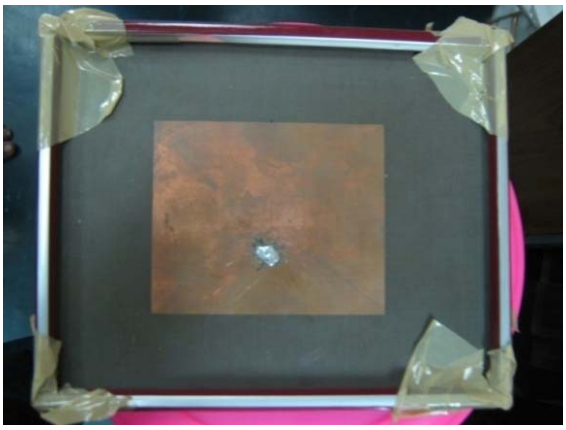

Fig. 1: Photograph of the antenna.

The effect of dust accumulation on the microstrip patch surface is emulated by placing the soil layers of uniform thickness successively equal to 0.05, 0.06, 0.07, 0.08, 0.09 and 0.1 mm over the horizontal lying microstrip patch surface and their effects on the resonant frequency and the normal operating conditions of the antenna are observed. The dust is placed such that it resembles the phenomenon of the accumulation of the dust particles over the antenna patch surface and creates a dielectric substrate surface over the antenna's patch surface.

3. Results and discussion

The antenna used in this experiment is made to work at a resonating frequency of 2.45 GHz. The observed experimental results are publicized below. The different experimental results plotted after accumulation of water and dust layers over the surface of the square microstrip patch antenna surface of uniform thickness successively equal to 0.05, 0.06, 0.07, 0.08, 0.09 and 0.1 mm. The graphs below define the variation on the working parameters of the environmentally affected microstrip patch antenna. The Fig. 2, Fig. 3 and Fig. 4 shown below represents the variation of resonant frequency, % change in resonant frequency and return loss versus height of superstrate layer over the microstrip patch surface respectively. The superstrate layers used in this experiment are of rain water and dust particles to represent the different environmental conditions.

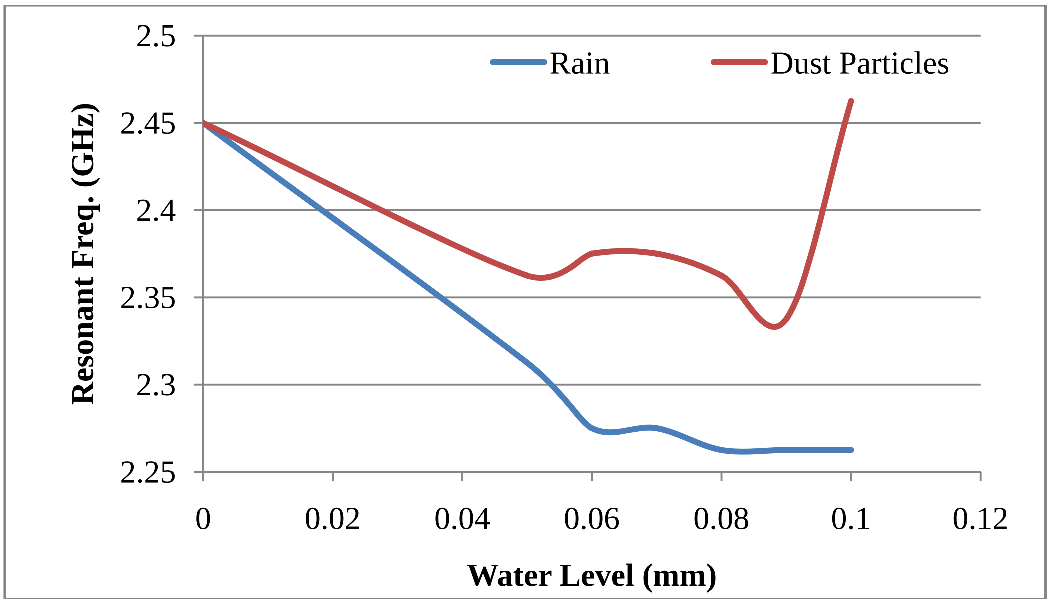

Fig. 2: Resonant frequency versus height of superstrate layers over the microstrip patch surface.

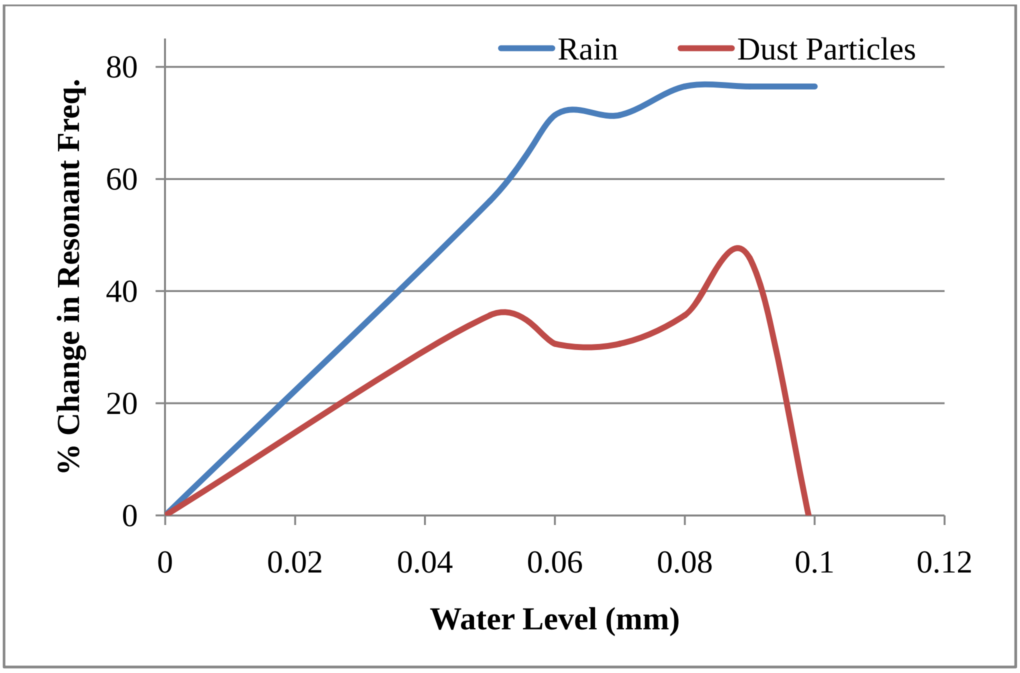

Fig. 3: Percentage change in the resonant frequency versus height of superstrate layers on the microstrip patch surface.

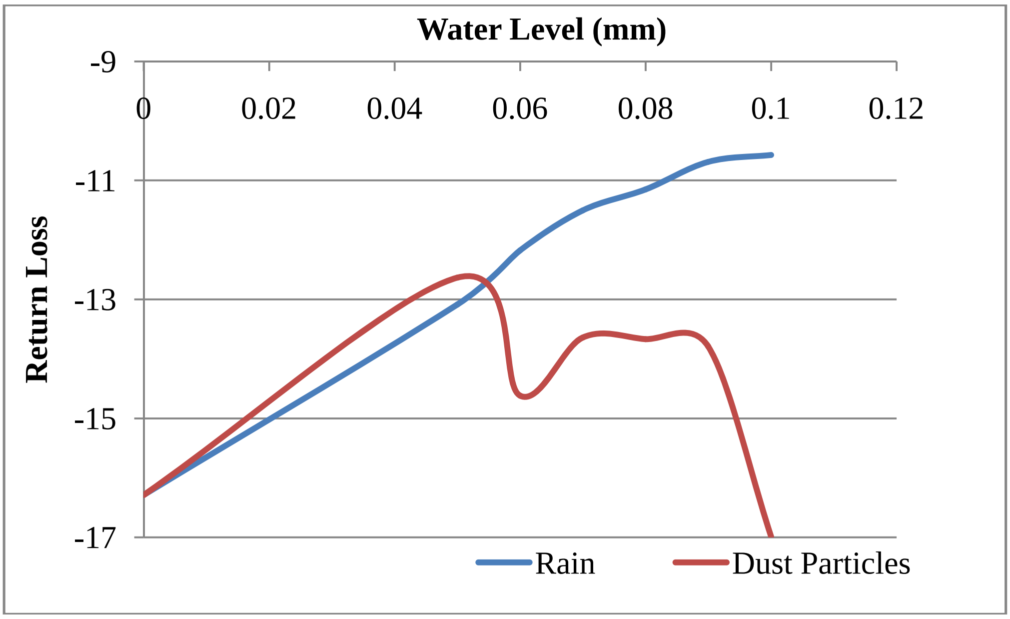

Fig. 4: Return loss versus height of superstrate layers on the microstrip patch surface.

4. Conclusion

The empirical value of effective permittivity of dust particles (soil) is derived from the experimental data on the loamy soil. The range of validity of strong fluctuation theory models and several empirical and theoretical mixing models for dust particle's effective permittivity are examined by comparing the model predictions with empirical values [8].

The resonant frequency of antenna reduces as the height of the water or dust particle layers over the surface of the square microstrip patch antenna surface increases. The resonant frequency, % change in the resonant frequency and return loss with respect to the height of water and dust layer on the microstrip patch surface, show non linear deviating relationships. The empirical relation for the percentage change in the resonant frequency with respect to the uniform height of the water and dust layer on the microstrip patch antenna surface is obtained. The empirical relation shows that the percentage change in the resonant frequency approaches saturation value as the height of water layer over the square microstrip patch antenna surface increases and simultaneously the antenna shows gradually worse impedance matching with its probe-feed, as observed from the Fig. 2, Fig. 3, Fig. 4.

Apart from this, the empirical relation shows that the percentage change in the resonant frequency varies linearly first and then shows a random fluctuating variation as the height of dust particles layer over the square microstrip patch antenna surface increases and simultaneously the antenna shows gradually worse impedance matching with its probe-feed. Also, a similar behavior is shown with the return loss variation in both the case.

We are continuing the work for standard communication frequencies viz. frequencies for 3G and Wi-Fi communications and also consider the other environmental impacts which will be reported soon.

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