Effect of Croton Leaf on the Characteristics of Λ/2 Microstrip Rejection Filter to High Frequencies

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Abstract

The dielectric properties of the leaves due to presence of water in varying quantities can be detected using microwave methods. Microstrip L – section λ/2 rejection filter can be used to investigate the effect of leaf moisture on their response. The investigations are reported in Ku band. An approximate estimate of the effective dielectric constant of the leaf has been made using overlay technique. It is felt that thin film λ/2 rejection filter can be used to monitor the moisture status of leafy vegetation in Ku band frequency range.

Keywords— *λ/2 rejection filter, overlay technique, thin film, leaf moisture, Ku band, effective dielectric constant.*

I. INTRODUCTION

The microwave part of electromagnetic spectrum can be used to study the moisture related changes occurring in the leaves. The microwaves react with the biomaterials, therefore the biophysical status of the vegetation can be studied which will be useful for management of natural resources. The microstrip component being in planer form can offer an alternative compact device for biomaterial studies. The use of overlay technique [1, 2] offers further planarization. The λ/2 L section microstrip rejection filter has a high rejection at the resonance frequency and this is very sensitive to medium above the filter. In this paper the changes in the rejection properties in the Ku band of thin film λ/2 L- section microstrip rejection filter due to leaf overlay is reported. Croton (Green leaf with yellow spots and streaks) has been used in touch overlay.

II. EXPERIMENTAL

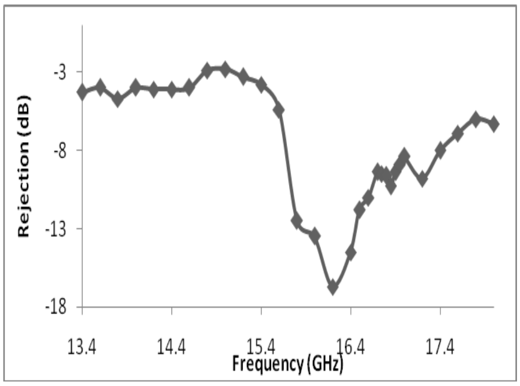
The λ/2 L section microstrip rejection filter was fabricated using thin film technology. The metallization used was copper which was deposited on precleaned alumina substrates of size 1″ x 1″ x 0.025″. Vacuum evaporation + electroplating were used to deposit copper thin film of 4 – 6 µm thickness. The rejection characteristic was measuredby point in the frequency range 13.4 – 18 GHz. For in touch overlay the leaf was cut to a size of 1.5 X 1.5 cm from the centre so that central vein was part of overlay. The experiments were conducted for fresh leaves, after 24 hours and 48 hours drying of leaves in air. Four types of measurements were done-

- ***A. USP****:* Upper surface of leaf in contact, with central vein parallel to the direction of propagation.
- ***B. LSP****:* Lower surface of leaf in contact, with central vein parallel to the direction of propagation.
- ***C. USPR***: Upper surface of leaf in contact, with central vein perpendicular to the direction of propagation.
- ***D. LSPR****:* Lower surface of leaf in contact, with central vein perpendicular to the direction of propagation.

III. RESULTS AND DISCUSSION

Figure 1 shows the frequency response of the thin film microstrip rejection filter in the Ku (13.4-18 GHz) band.

Fig.1: Characteristics of thin film λ/2 rejection filter without overlay



The filter had notch at 16.2 GHz with a rejection of -16.7 dB. The off resonance rejection was around – 5 dB.

The effect of Croton on thin film rejection filter is shown in figure 2. Two resonances are obtained for all positions of leaf except LSP position. For USP position, the notch is seen at ~ 15.8 GHz and ~ 17.2 GHz. For LSP one notch is seen at ~17.2 GHz frequency. Due to dried leaf overlay the filter shows non-overlay characteristics almost for all positions in Ku band. As the leaf dries the transmittance increases. There is not much difference between effects of 24 hours and 48 hours dried leaf. It appears the fringing fields are not able to produce sufficient interactions when only chemically bound water is present.

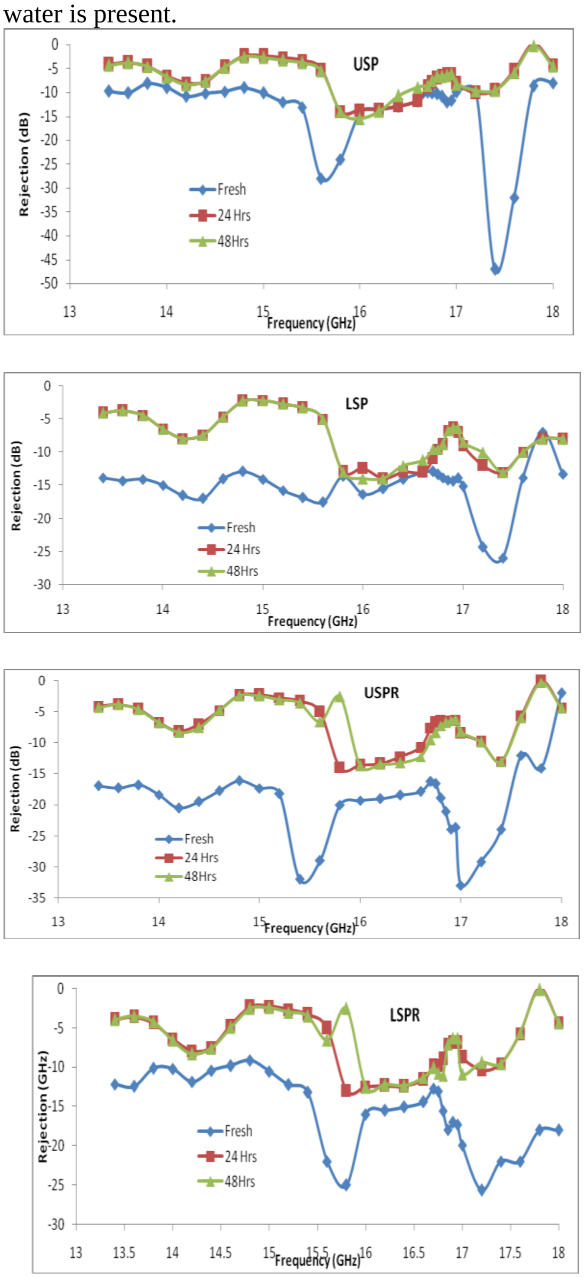


Fig.2 Characteristics of thin film λ/2 rejection filter with croton leaf overlay.

Leaves are a major constituent of many types of plants. Leaf is heterogeneous media consisting of components with different dielectric behaviours. Leaves are basically water loaded materials. The amount of water in the leaf is a dominant factor dictating the dielectric behaviour of the leaf. Water has the complex permittivity, therefore the permittivity of the leaf is the effective complex permittivity of the mixture $\varepsilon^* = \varepsilon_r' - j\,\varepsilon_r''$. The complex permittivity is a measure of the ability of a material to polarize when subjected to an electric field. At microwave frequencies moisture in most substances plays a major role in the polarization phenomenon. The water in the leaves can be either in free state or in bound state. Water in its free liquid state appears very rarely in agricultural products. It is mostly physically absorbed in the capillaries or cavities or chemically bound to other molecules of the material [3]. In the Ku band, the water dominates the dielectric properties of the leaves. Water in the vegetation material is generally found at different binding modes depending on the intensity and nature of the forces acting on water molecules. The propagation of bound and free form is very difficult to determine. The physically bound water is present with leaf throughout its volume either in absorbed or in adsorbed state. It is possible to excite rotational energy level in the water molecule and achieve an energy based attenuation of the microwave signal proportional to the amount of water present. The chemically bound water forms part of the crystal lattice or its hydrogen bonds to another charged species. In this case the microwave beam is not able to make the molecule spin and is not of sufficient energy to break the molecule free from its bond.

The real part of permittivity of pure water is ~60 at 10 GHz but the imaginary part increases in the microwave range and attains maximum value at ~ 20 GHz. The leaves have complex dielectric constant, with real part depending on the phase and imaginary part on amplitude change, the formula suggested by Gouker et al [4] was used to calculate the amount of phase change due to overlay. Using the expression of Kim et al [5], the values ε_{eff}' and ε_{eff}'' have been calculated.

The real part ε_{eff}' indicates the ability of the material to store energy from the field of the electromagnetic wave and the imaginary part ε_{eff}'' indicates the ability of the material to dissipate energy. Both entities are dependent of frequency, bulk density, moister content, temperature and composition.

The data of ε_{eff}' and ε_{eff}'' for the various leaves after keeping as overlay on λ/2 rejection filter are given in table 1.

Table 1. Data of Permittivity

ε_{eff}	Δφ	ε_{eff}'	Leaf condition	ε_{eff}'' at 16 GHz
76.6	126.5	130.8	**Fresh** USP,LSP, USPR,LSPR	0, 44, 107.1, 66
28.2	91.3	72.9	**24 Hrs.** USP,LSP, USPR,LSPR	29.8,12.1, 38.1, 11.16
17.5	68.6	44.4	**48 Hrs.** USP,LSP, USPR,LSPR	26.8, 32.7, 22.5, 4.5

The microstripline circuit changes its effective dielectric constant with overlay. The changes are highly dependent on the dielectric constant and thickness of the overlay[6]. The dielectric constant of most of the dry biomaterials is very low whereas dielectric constant of water is very high. In a fresh leaves due to water content being very high the resultant permittivity of the matter – water mixure increases considerably causing a major change in the resonance frequency of the filter. As the leaf dries the filter behaves similar to no overlay situation since the permittivity of the dried leaf ~ 2 which is nearer to that of air.

As expected the ε_{eff}' (real part) is more for fresh leaf. Since our experimental parameter is the attenuation, this effect is observed in the ε_{eff}'' (imaginary part). The circuit has become very lossy because of fresh leaf.

IV. CONCLUSION

The response of the leaf overlaid thin film $\lambda/2$ microstrip rejection filter changes due to condition of the leaf overlay. It is seen that thin film microstrip rejection filter is sensitive to deficiency of chlorophyll.

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