Investigation of the Absorption Characteristics of Opuntia in Radio Frequencies

E. Delihasanlar and A. H. Yuzer

Abstract—**This paper presents the characteristics of reflection, transmission and absorption of Opuntia at 1.7 – 2.6 GHz. The measurement set-up was consisted of waveguide adaptors (WR430), an Anritsu network analyzer (MS4624B), sample holder and a computer. Measurement set-up was calibrated with Through-Reflect-Line (TRL) calibration technique. Return loss, transmission and absorption ratio in dB were calculated by S parameters and results are presented graphically.**

Keywords—**Measurement of reflection, transmission and absorption, Opuntia, S parameters.**

I. Introduction

Recently there has been a serious increase in the use of electronic devices[1]. This increase has explored the harmful effects on human and the effects on other electronic devices. It has become an essential issue to reduce electromagnetic exposure. Therefore, materials which have electromagnetic wave absorbing and shielding capacity, are being investigated. Such as textile[2], construction[3] and natural materials[4], [5].

Furthermore, properties of materials can be used in material science, military applications, communication, biomedical research, industrial production. They provide valuable information for design of remote control, monitoring and analysis[6], [7].

This paper mainly focused on the reflection, transmission and absorption measurement of Opuntia at 1.7-2.6 GHz. Opuntia, which is one of smooth surface species of cactus families, was selected. In daily life, measurements were made in the 1.7-2.6 GHz frequency range where many electronic devices were operating[8].

Contrary to other measurement systems using a waveguide do not require large sample material at low frequencies. It is much easier to prepare the material for the measurement system because of the rectangular structure of the waveguide. Waveguide measurement set-up allows for broadband measurement[9]. Because of these properties, a waveguide measuring set-up was used.

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II. Materials and Methods

A. Theoretical Analysis

The incident and transmitted waves in a two port measurement setup can be mathematically represented by S-parameters which was obtained from network analyzer[10].

Transmission ratio (T) is equal to the rate of transmitted and incident electric fields.

where E_t is transmitted electric fields, E_I is incident electric fields and transmission ratio can be defined by

$$T = \left|E_t / E_I\right|^2 = \left|S_{12}\right|^2 = \left|S_{21}\right|^2 \quad (1)$$

Return loss (R) is equal to the rate of reflected and incident electric fields.

where E_r is reflected electric fields, return loss is given by

$$R = \left|E_r / E_I\right|^2 = \left|S_{11}\right|^2 = \left|S_{22}\right|^2 \quad (2)$$

Absorption (A) can be defined by

$$A = 1 - R - T \quad (3)$$

B. Measurement Set-up

The measurement set-up was prepared with waveguide adaptors (WR430), an Anritsu network analyzer (MS4624B), sample holder and a computer and is given in Fig. 1. The smooth surface area of Opuntia was selected and the sparse spines on it were removed. Opuntia leaves were cut off by 54.61 × 109.22 mm which is the size of aperture of waveguide flanges. it was placed into the sample holder without any air gaps. Reflection coefficient (S_{11}) and transmission coefficient (S_{21}) were obtained from network analyzer.

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Fig. 1 Measurement set-up

C. Calibration

The Through-Reflect-Line (TRL) calibration technique, which is mostly preferred in literature, was used to calibrate measurement set-up, is illustrated in Fig. 2. First, through measurement is completed with two waveguides connected together. Then, the waveguide adaptors were shorted using metal plate respectively. Final, the length of waveguide adapter was extended n(λ/4) of the middle band frequency[11].

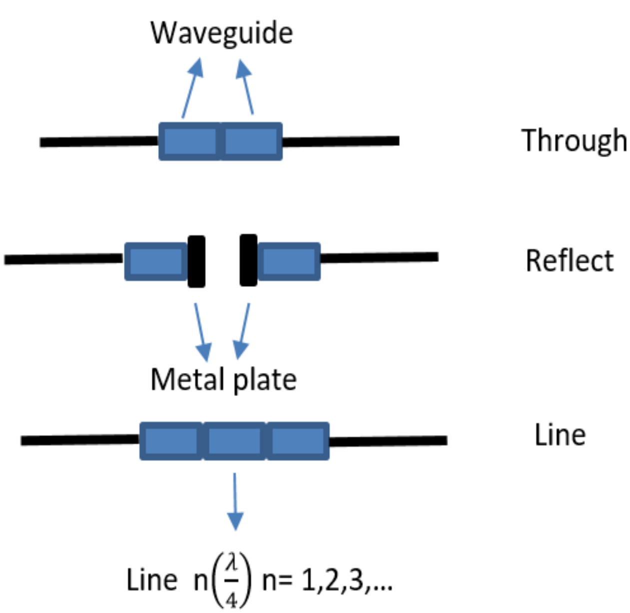

Fig. 2 TRL calibration.

III. RESULTS AND DISCUSSION

The return loss, transmission and absorption properties of Opuntia have been calculated by using measured S_{11} and S_{21} parameters at 1.7-2.6 GHz. Results were calculated in dB.

The following Fig. 3, the return loss were calculated using measured S_{11}.

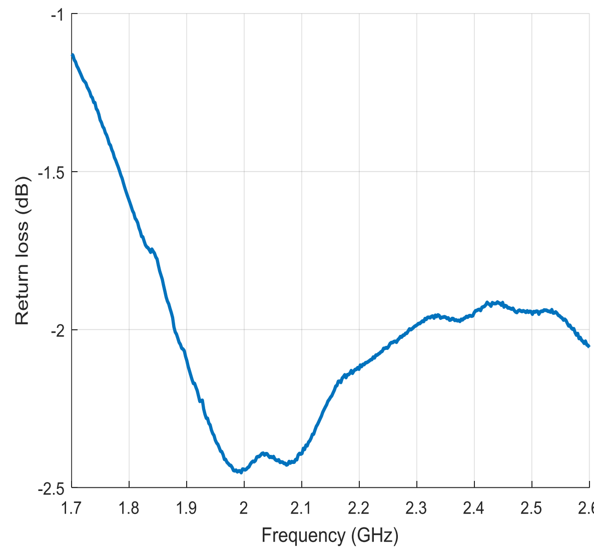

Fig. 3 Return loss

The transmission ratio was calculated using measured S_{21} and illustrated in Fig. 4.

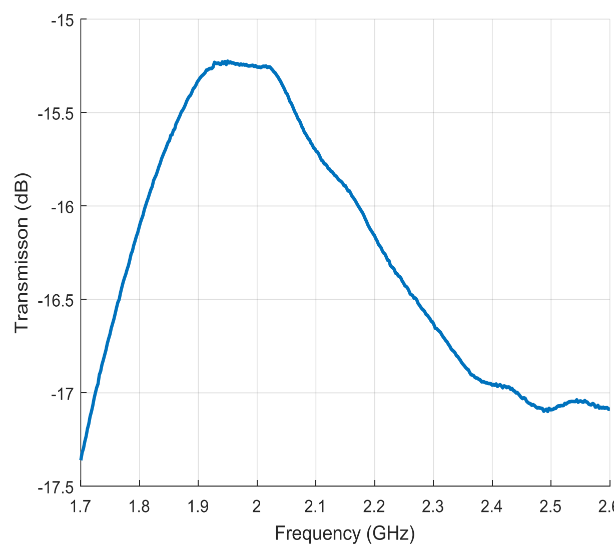

Fig. 4 Transmission

The absorption was derived by using reflected power and transmission power using equations (3) and given in Fig. 5.

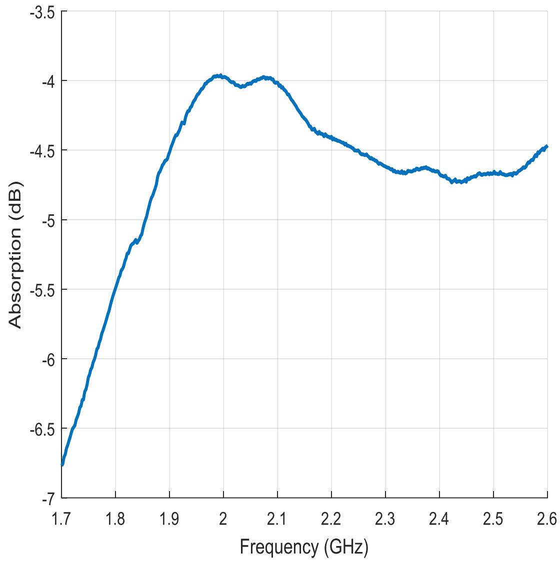

Fig. 5 Absorption

IV. CONCLUSIONS

In this paper the reflection, transmission, absorption characteristics of Opuntia was investigated at 1.7-2.6 GHz. The results obtained can be concluded as the following aspects. Fluctuations in the measurement results are considered due to the non-uniform structure cross section of Opuntia.

Results indicate that the Opuntia is a highly loss medium in the 1.7-2.6 GHz. It has a fibrous structure and high-water content, resulting in high absorption and low transmission. Because of fibrous structure, it acts like multi-layer material like metamaterials.

High reflection shows that the dielectric constant of Opuntia could be high.

Other of Cactus species will be investigated in further studies to determine their behavior and effect on absorption.

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