

Design and Analysis of Circular Patch Antenna for Determination the Moisture Content

Pankaj Kumar Mishra*

Department of Applied Physics, Amity School of Engineering and Technology, Amity University Madhya Pradesh, Gwalior, India

Abstract: The proposed circular patch antenna is designed for determination the moisture content of grains with the help of CST software. The proposed sensor has the dimensions of small size while operates at a frequency from 6GHz to 8GHz with good return loss, VSWR, polar plot, E-Field, H-field are discussed. The parameters are important for analysis the antenna before fabricating the antenna and used as a sensor for determination the moisture content. The proposed design can be fabricated on FR-4 substrate with relative permittivity 4.4 and thickness 1.676mm as well as can be used the oven drying technique due to low cost, less time consuming and the actual moisture content (MC) will be measured the vector network analyzer (VNA). It will be performed on the different samples of grains such as wheat, soil, rice, etc, important for the agricultural and industrial field.

Index Terms - Moisture Moisture Content (MC), Circular Patch Antenna (CPA), Reflection Coefficient, Grains, Microstrip patch antenna (MPA), Moisture Sensor (MS)

I. INTRODUCTION

Recently, Microstrip antenna has widely used in communication system, industrial area, etc. But now a day (MPA) as a (MS) is also using in the agricultural field, industrial field, medical, and communication etc [1]-[5]. The proposed design will be determined the moisture from the rice grains. It will be worked on dual frequency at a same time [6]-[9].

The calibration equation and regression is also the important role for detecting the moisture content. Numerically it can be detected the moisture [10]-[11]. When the highest regression value will be present then the moisture is more available [12]-[15]. The Co-axial feed technique is used in the proposed design, due to low spurious feed radiation in this technique as well as supply the signal source in the microstrip moisture sensor [16]-[18]. This feed is easy and direct contact to the patch as well as minimize the spurious radiation. The coaxial feed is important because this is influence the input impedance [19]-[22]. In microstrip patch sensor, there are many factors which is affect the performances of sensor such as size of the sensor, shape, room temperature, feed techniques, fabrication, etc.

The moist sample can be determined with the resonant frequency. When the resonant frequency is decreases with the moisture level increases [23]. It is directly proportional to moisture content. The important parameter of the sensor is insertion loss with the moisture content [24]-[26]. When the insertion loss increases then increment the moisture content. It is also directly proportional to moisture content [27]. Dielectric property is also a characteristic of plant materials and fruits mainly due to the structure of the biomaterials and the large amount of water content. A 'dielectric material' (or dielectric) is an electrically insulating material that will be polarized under an electric field and the phenomenon is called dielectric polarization [28]. The dielectric properties of the material provides valuable information about the storage and dissipation of electric and magnetic fields in materials and also provides insight into the feasibility of using the material in potential applications. Dielectric loss (loss tangent or $\tan \delta$) quantifies a dielectric material's inherent dissipation of electromagnetic energy. Dielectric losses depend on frequency and the dielectric material. The ionic conductivity of materials will contribute to the dielectric loss.

II. SENSOR DESIGN

The proposed circular patch antenna (CPA) is simulated with the help of CST software and the sensor is designed on a FR4 substrate with 1.676 thicknesses, which has a relative permittivity of 4.4 and loss tangent of 0.001. The overall dimension of the proposed sensor is 14mm and the coaxial line feed is used on sensor (6, -0) and (6, 0) are design to obtain the 50Ω characteristics input impedance. The proposed rectangular patch sensor is designed by using the computer simulation technology software with the specific dimensions as shown table 1 given below-

Table 1. Geometrical parameters of the proposed sensor

Parameters	Design measurement
Length of ground (L_g)	15mm
Width of ground (W_g)	15mm
Substrate Relative permittivity (ϵ_r)	4.3
Substrate Length (mm)	15mm
Substrate Width (mm)	15mm
Substrate Height (mm)	1.676mm

Outer radius	8mm
Inner Radius	4mm
Length of patch (P _L)	5mm
Width of patch (P _w)	5mm

The circular microstrip patch antenna is analyzed by using the CST software as shown in figure 1 with the compact size.

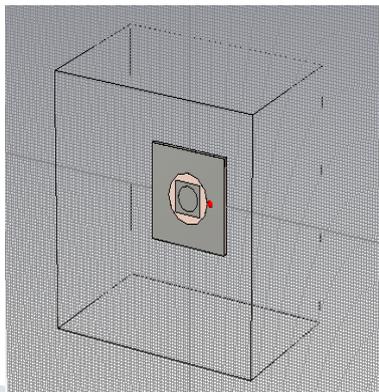


Figure 1. Circular patch antenna

III. RESULTS AND DISCUSSIONS

Figure 2 and 3 illustrate the simulated result attributed to the effect on return loss and the return loss is maximum -35dB at 5.7GHz and the VSWR is 1.03.

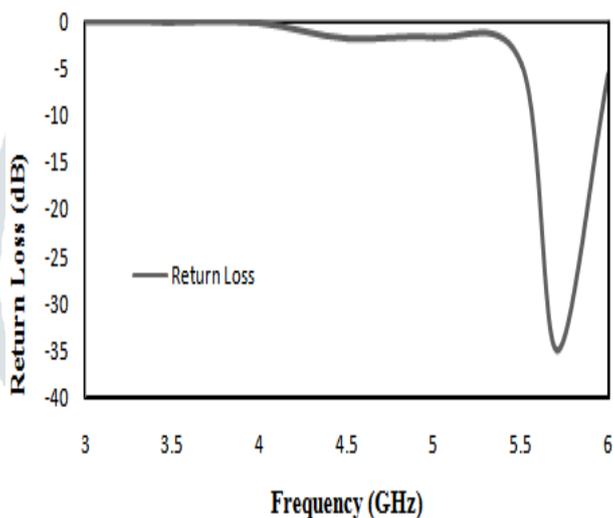


Figure 2. Return loss of circular patch antenna

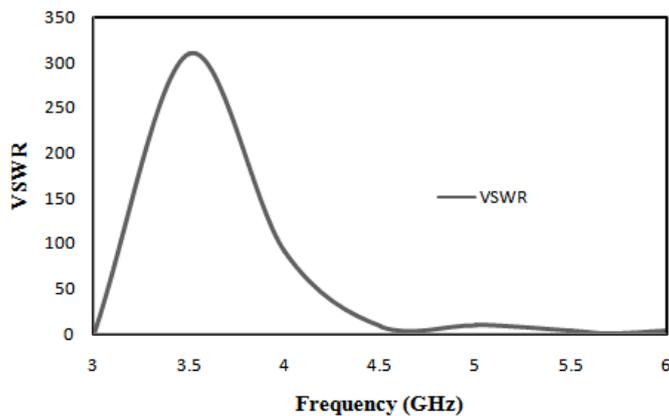


Figure 3.VSWR of circular patch antenna

Figure 4 illustrates the polar plot the circular patch antenna, it is represent the radiation goes in unnecessary direction and with the help it can be understand proposed antenna will be worked after fabricating.

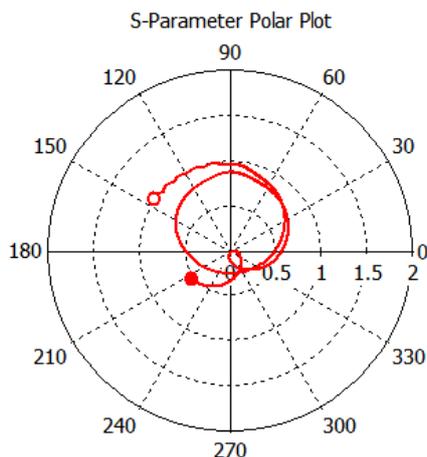


Figure 4. Polar plot of proposed patch antenna

Figure 5 and 6 show the E-Field and H-Field of the circular patch antenna, the maximum value is 9042V/m and 13.4A/m.

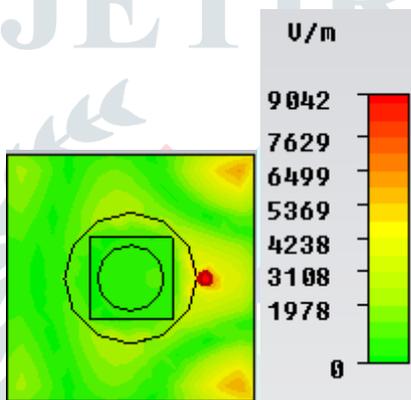


Figure 5. E-Field of circular patch antenna

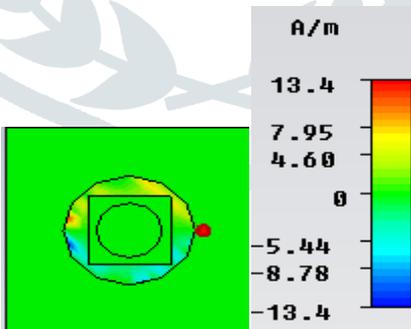


Figure 6. H-Field of circular patch antenna

Figure 7 shows the maximum current density is 64A/m², it is used to measure the density of the current.

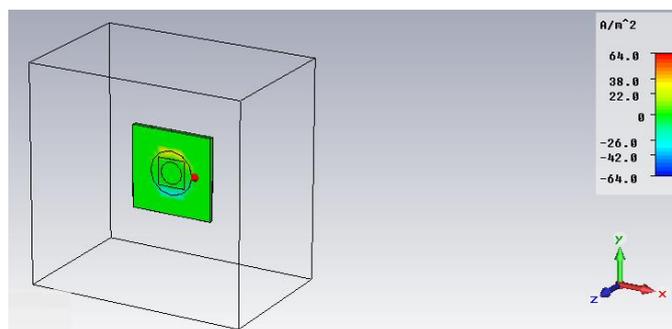


Figure 7. Current Density of circular patch antenna

IV. CONCLUSION

The circular MPA used as a sensor for determination the moisture content with the better results such as return loss, VSWR, polar plot, E-Field, H-Field discussed in this paper for analysis the moisture sensor will be better with high sensitivity. The proposed antenna is designed with compact size. The calibration equation can be determined for determination the predict moisture content and oven drying technique will be used for actual moisture content and this sensor will be very helpful for agricultural field and industries.

To summarize, the proposed sensor will be very useful for detecting the moisture of rice owing to its marked properties of simple topology, compact size, easy to install, low insertion loss, excellent performance and able to achieve the high sensitivity and accuracy.

REFERENCE

- [1] K. B. Khalid, T. S. M. Maclean, M. Razaz, P. W. WEBB. 1988. Analysis and optimal design of microstrip sensors: IEE proceedings, 135(3):187-195.
- [2] Muhammad Taha Jilani, Wong Peng Wen, Mohd. Azman Zakaniya, Lee Yen Cheong, Muhammad Zaka Ur Rehman. 2014. An improved design of microwave biosensor for measurement of tissue moisture: IEEE.
- [3] Sweety Jain, Pankaj Kumar Mishra, Vandana Vikas Thakare. 2017. A Rectangular microstrip moisture sensor based on microwave measurement technique: SKIT Research Journal, 7(1): 30-33.
- [4] K. K. Joshi, Mahesh Abegaonkar, R. N. Karekar and R. C. Aiyer. 1997. Microstrip ring resonator as a moisture sensor for wheat grains, IEEE, 1679-1682.
- [5] Pichitpong Soontornpipit, Cynthia M. Furse, Youchung Chung and Bryan M. Lin. 2006. Optimization of a buried microstrip antenna for simultaneous communication and sensing of soil moisture: IEEE Transactions on antennas and propagation, 54(3): 797-800.
- [6] Sweety Jain, Pankaj Kumar Mishra, Vandana Vikas Thakare. 2016. Design and Analysis of microstrip moisture sensor for the determination of moisture content in soil: Indian journal of science and technology, 9(43):1-6, DOI: 10.17485/ijst/2016/v9i43/101065.
- [7] Mohamed Mustafa Ghretli, Kaida Khalid, Ionel Valeriu Grozescu, Mohammad Hamami Sahri and Zulkifly Abbas. 2007. Dual frequency microwave moisture sensor based on circular microstrip antenna: IEEE Sensors journal, 7(12):1749-1756.
- [8] Thomas J. Jacson, Albin. J. Gasiewski, Anna Oldak, Marian Klein, Eni G. N joku, Aleksander Yevgrafov, Sven Christiani and Rajat Bindlish. 2002. Soil moisture retrieval using the C-Band polarimetric scanning radiometer during the southern great plains 1999 experiments: IEEE Transactions on geosciences and remote sensing, 40(10): 2151-2161.
- [9] Sweety Jain, Pankaj Kumar Mishra, Vandana Vikas Thakare. 2016. Design and analysis of dual-frequency microwave moisture sensor based on rectangular microstrip antenna: 4th International workshop/conference on computational condensed matter physics and materials science (IWCCMP-2016), at IITM, Madhya Pradesh.
- [10] Wobschall, D. 1978. A Frequency Shift Dielectric Soil Moisture Sensor: IEEE Transactions on Geoscience Electronics: 16(2):112-118.
- [11] A.F. Ahmad, Z. Abbas, Suzan J. Obaiys, M.A. Jusoh and Z.A. Talib. 2012. Analysis and optimal design of a microstrip sensor for moisture content in rubber latex measurement: Adv. Studies theory Physics, 6(2):49-62.
- [12] K. K. Joshi, Mahesh Abegaonkar, R. N. Karekar and R. C. Aiyer. 1997. Microstrip ring resonator as a moisture sensor for wheat grains: IEEE, 1679-1682.
- [13] Haiying Huang. 2013. Flexible wireless antenna sensor: A Review: IEEE Sensors journal, 13(10): 3865-3872.
- [14] Sweety Jain, Pankaj Kumar Mishra, Vandana Vikas Thakare. 2016. Analysis of moisture sensor based on microstrip patch antenna: A review: International conference on futuristic trends in engineering science, humanities and technology (FTESHT-16), 3(1): 64-67.
- [15] Sweety Jain, Pankaj Kumar Mishra, Vandana Vikas Thakare. 2016. The analysis and design of circular microstrip moisture sensor for rice grain: 4th International workshop/conference on computational condensed matter physics and materials science (IWCCMP-2016), at IITM, Madhya Pradesh.

- [16] Abegaonkar, M.P., R.N. Karekar and R.C. Aiyer. 1999. A microwave microstrip ring resonator as a moisture sensor for biomaterials: Application to wheat grains. *Meas. Sci. Technol.*, 10: 195-200, DOI: 10.1088/0957-0233/10/3/014
- [17] Sweety Jain, Pankaj Kumar Mishra, Vandana Vikas Thakare. 2017. Bandwidth and Gain enhancement in microstrip moisture sensor for agricultural applications: *Indian journal of science and engineering research*, 1(1):37-40.
- [18] Sweety Jain, Pankaj Kumar Mishra, Vandana Vikas Thakare. 2017. Design and development of microstrip sensor with triple frequency for determination of rice grains moisture content: *International journal of mechanical and production engineering research and development (IJMPERD)*, 7(5): 375-380.
- [19] K.C. Lawrence, S.O. Nelson, P.G. Bartley Jr. 1998. Flow-through coaxial sample holder design for dielectric properties measurements from 1 to 350 MHz: *IEEE Trans. Instrum. Meas.*, 47(2):354-361.
- [20] S. Trabelsi, A.W. Kraszewski, S.O. Nelson. 1998. New density-independent calibration function for microwave sensing of moisture content in particulate materials: *IEEE Trans. Instrum. Meas.*, 47(3): 613-622.
- [21] Meyer W, Schilz W. 1981. Feasibility study of density-independent moisture measurement with microwaves. *IEEE Transactions on Microwave Theory and Techniques*, 29(7): 732-739
- [22] Trabelsi S, Kraszewski A, Nelson S O. A microwave method for on-line determination of bulk density and moisture content of particulate materials. *IEEE Transactions on Instrumentation and Measurement*, 1998; 47(1): 127-132
- [23] K. Sarabandi, E.S. Li, "A microstrip ring resonator for soil moisture measurements", *IEEE Transaction on Geosciences and Remote Sensing* 35, pp 1223-1231, 1997.
- [24] Trabelsi S., Kraszewski A.W., Nelson S.O., "A new density independent function for microwave moisture content determination in particulate materials", *Proc. IEEE Instrumentation & Measurement Technology Conference sensing, processing, networking*, vol.1, pp 648-652, 1997.
- [25] Sweety Jain, Pankaj Kumar Mishra, Vandana Vikas Thakare. 2018. Determination of moisture content in soil based on oven drying method using a microstrip patch sensor: *International journal of engineering technologies and management research (CINSP-2018)*, 5(2):233-239, DOI: 10.5281/zenodo.1202501.
- [26] Sweety Jain, Pankaj Kumar Mishra, Vandana Vikas Thakare. 2018. Rice Moisture Detection Based on Oven Drying Technique using microstrip ring sensor: *Engineering Vibration, Communication and Information Processing lectures in electrical engineering*, 99-109.
- [27] Sweety Jain, Pankaj Kumar Mishra, Vandana Vikas Thakare. 2018. Analysis and Optimal design of moisture sensor for rice grain moisture measurement: *American Institute of physics*, doi: 10.1063/1.5028775, 060005 (1-3).
- [28] Elen Semouchkina, Wenwu Cao, Raj Mitra, and Wenhua Yu. 2001. Analysis of Resonance Processes in Microstrip ring Resonators by the FDTD Method: *Microwave and optical technology letters*, 28(5):312-321.

