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Tracking RF Source Location in Real-Time Applications

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Abstract

Radio waves are important and dominate most of the current modes of information transfer in technology because they are the longest wavelength in the spectrum and a faster, steeper, and less expensive way of transferring information. This project lays the foundation for building a direction-finding system that locates an RF source in a particular frequency range. This paper designs a microstrip patch antenna at 915MHz and respective results are verified through simulation in Ansys HFSS.

Keywords: Microstrip antenna, 915MHz, Ansys HFSS, RF source location

Introduction

The resonant speed of an electrical alternating current or an oscillating voltage, or of a magnetic, electrical, or electric and magnetic field or mechanical system in the range of frequency of about 30 kHz to about 300 GHz, is referred to as radiofrequency and is a form of non-ionizing radiation. When fed to an antenna, an electromagnetic field is generated that carries the signal through space. Electric and magnetic waves are emitted. This is the basis for everyday applications such as wireless transmission (radio, TV) and communication (cell phones, WLAN).

This system is used to determine the location of an RF source. It refers to a device that is used to check the position of a ship or aircraft, but it can also steer the course of a ship or be used for military or research purposes. RF detection, spectrum analysis, and address location equipment can be used to detect, identify, and locate sources of RF interference that can interfere with communications systems. The RF source used in different applications is manufactured with different types of materials which act as good conductors in tracking. This in recent times has enacted a threat to the privacy of the user of such applications such as healthcare systems, military, to an extent of cyber breach too.

To detect, identify, and locate RF interference sources that may be disrupting communications systems, RF detection, spectrum analysis, and direction-finding equipment can be used. Some of these radio frequency locators include built-in maps and spectral graph displays for data visualization, as well as internal storage devices for logging data for future analysis. These technologies can detect RF interference sources at frequencies ranging from 9 kHz to 18 GHz. [1]. A direction locator is a device that determines the destination of an unknown sensor by comparing multiple or more readings from different locations. A device's location can also be determined using two or more measurements from known transceivers. RDF is a popular global navigation satellite system, particularly on ships and aircraft.

The applications of RF tracking systems could be found in the military, health monitoring systems, radio monitoring, drone tracking systems to name a few.

The advantages of the real-time RF tracking system proposed in this project:

● High accuracy is obtained using the RSS method in short-range environments.

●Real-time location systems have received interest as a means of monitoring in health care monitoring systems.

● Low energy consumption that can be portable is also less expensive than some other wireless systems.

● RTLS would significantly reduce the time required to search for and identify equipment that is due for regular maintenance

System Overview

This system covers a frequency of 915 MHz with a current bandwidth of 1.5 GHz. It can electronically direct several scanning beams with a resolution of 0.7^0 and scanning speeds by means of digital signal synthesis. An orientation system is used to measure the direction from which a signal was sent. It uses the direction of the beam to increase the gain of the signal and avoid interference when changing the direction of the main lobe of the signal's radiation pattern. A computationally efficient implementation is given by digital beamforming, a technique that focuses a wireless signal on a specific receiving device, instead of spreading the signal in all directions from a transmitting antenna, it preserves all the information received when the set is opened[1].

The block diagram of the system is shown in Fig.1.The proposed RF source detection system needs an antenna, receivers, and processing unit, and user interface. The proposed system is an orientation system implemented and measured for the 915 MHz ISM band. The method incorporates high-speed 1-bit quantizers to adopt direct RF to digital sampling. The digital sampling oscilloscope records the quantized RF signals from the 1-bit quantizer and the sequencing clock. [2]. MATLAB is coded to get the amplitude and phase of the angle using a single point DFT Goertzen Algorithm.

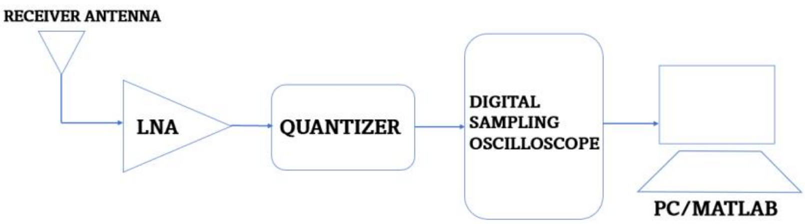

Fig.1. Block Diagram of Proposed RF Source Tracking System

Overview of Microstrip Antenna

A patch antenna is a type of flat radio antenna that can be mounted on a low surface. It's a broadband beam antenna made by etching the antenna component design onto a metal trace affixed to the material substrate, like a circuit board, and establishing a ground plane with a nonstop metal layer on the opposite side of the substrate [3].

A microstrip antenna is made up of a divergent strip on one side of an insulator substrate and a buffer layer on the other. The strip is typically made of a semiconductor device that looks like copper or gold and can take any shape. In most cases, the radiation patch and power lines are photo-etched onto the dielectric substrate. The transmitter arrays and power mesh can be photo-etched onto the substrate. Using simple techniques, microband circuits enable a variety of antenna elements. Fig.2. shows the design of a microstrip patch antenna used to generate 915MHz.

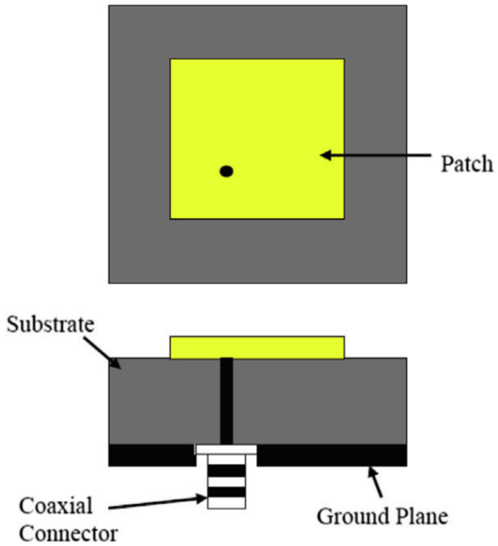

Fig.2. Design of Patch Antenna

The advantages of microstrip patch antennas are as follows:

• Lightweight and low volume.

• Low profile planar configuration which can beeasily made conformal to host surface.

•Low fabrication cost, which leads to the manufacturing of the product in bulk.

• Operates in dual and triple frequencies.

Microstrip patch antennas are the source of many uses in the latest trends. Such as in satellite communication, mobile communication, GPS systems, also have been part of healthcare monitoring systems by including hyperthermia and telemedicine.

Design of patch antenna for 915MHz

The antenna is constructed with a dielectric substrate (Rogers RT / Duroid (5880)) with the permittivity εr = 2.2. The width of the antenna patch is designed for the cut of frequency of 915MHz. The standard equation used to calculate the width of the patch antenna is as follows [1]

$$W = \frac{c}{2f\sqrt{\frac{\varepsilon r+1}{2}}} \quad (1)$$

$$\varepsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \quad (2)$$

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{reff}}} \quad (3)$$

$$\Delta L = 0.412\, h\, \frac{(\varepsilon_{reff} + 0.3)\left[\frac{W}{h} + 0.264\right]}{(\varepsilon_{reff} - 0.258)\left[\frac{W}{h} + 0.8\right]} \quad (4)$$

$$L = L_{eff} - 2\Delta L \quad (5)$$

where W is the patch width, ε_r is the substrate dielectric constant, f_r is the resonant frequency, ε_{reff} is the effective dielectric constant, h is the substrate height, ΔL is the extension in length due to fringing effect, L_{eff} is the effective length of the patch and L is the patch actual length.

The ground plane of the antenna patch is calculated using (6) and (7):

$$L_g = 6 \cdot h + L \quad (6)$$

$$W_g = 6 \cdot h + W \quad (7)$$

The position of the coaxial feed is calculated through the equation (8) and (9):

$$X_f = \frac{L}{\sqrt{\varepsilon_{reff}}} \quad (8)$$

$$Y_f = \frac{W}{2} \quad (9)$$

Table I. depicts the calculations required to design 915MHz.

TABLE 1 DESIGN RESULTS

Parameters	Dimensions(mm)
Patch length	104
Patch width	109.8
Substrate height	1.6
Substrate length	119.4
Substrate width	139.1
Radius of Coax	1
Radius of Probe	0.5
Height of Coax	5
Height of Probe	1.6
Radius of Pin	0.5
Height of Pin	5
Length of Radiation Box	119.4
Width of Radiation Box	139.1
Height of Radiation Box	20

Fig. 3 and Fig. 4 show the patch antennas dimensions for 915 MHz frequency.

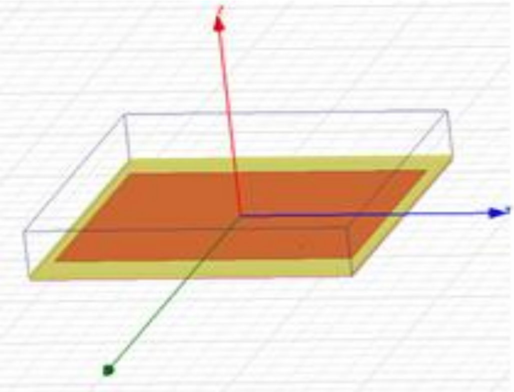

Fig.3 Dimensions of patch antenna

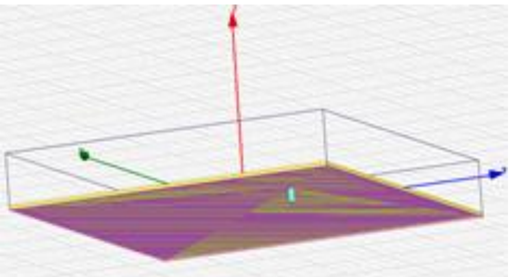

Fig. 4 Design of ground plane

Results and Discussion

For the simulation of the obtained data, HFSS software is used. Fig.5 shows that the resonance frequency obtained is 913.9 MHz and the return loss is -21.0946 dB. Fig.6 shows that the value of VSWR is 1.1934.

Fig.7 shows the 3-D radiation diagram of simulated directivity at the desired cut off frequency.

Fig.8 shows the polar radiation diagram of the simulated antenna.

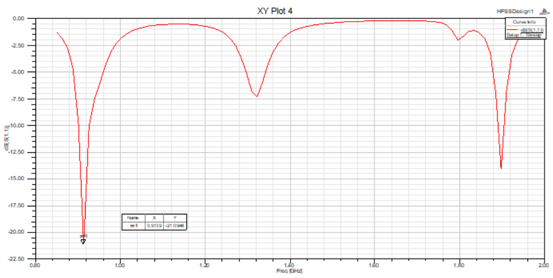

Fig.5 Resonance frequency at 913.9MHz

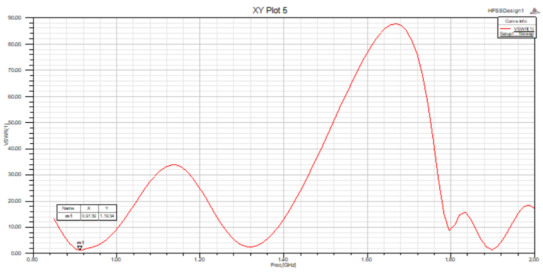

Fig.6 Return loss at -21.0946dB

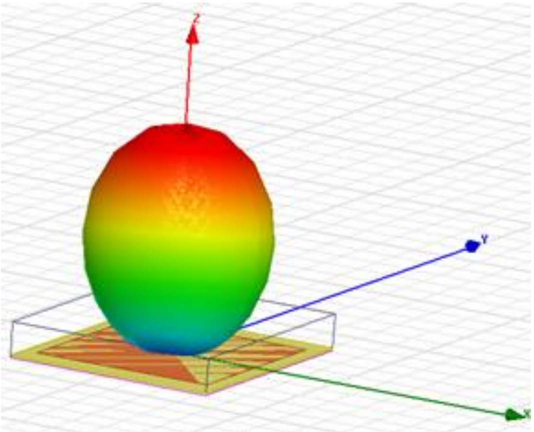

Fig.7 Radiation pattern at 915MHz

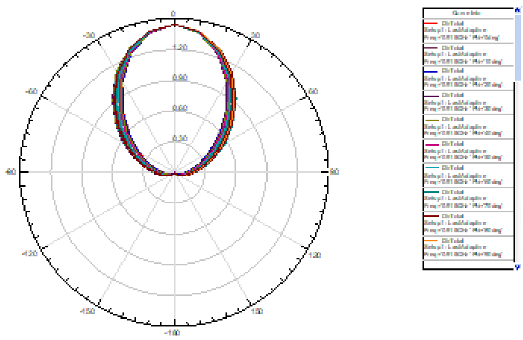

Fig.8 Polar radiation at 915MHz

Table II shows the simulation results carried out in Ansys HFSS for the 915 MHz frequency.

TABLE II SIMULATION RESULTS

Resonance Frequency	913.9 MHz
Return Loss	-21.0946 dB
VSWR	1.1934
Radiation Efficiency	93.71%
Gain	1.3506

Conclusion

In this paper, a 915MHz patch antenna is designed with coaxial feed which is used to track RF source location in real-time applications. The microstrip patch antenna for 915MHz was successfully designed and simulated in the Ansys HFSS software. The values were adjusted to get a better resonance frequency of 915MHz. In addition, the antenna can be manufactured and the simulated results and the experimental results from the manufactured microstrip patch antennas are compared and then used to design an RF source location system.

REFERENCES

J. D. Popp and J. Lopez, "Real-time digital signal strength tracking for RF source location," 2015 IEEE Radio and Wireless Symposium (RWS), 2015, pp. 218-220, DOI: 10.1109/RWS.2015.7129768.

Keriee, Hussam& Rahim, MKA &Zakaria, Zahriladha& Al-Gburi, Ahmed & Al-Dhief, Fahad&Jawad, Mustafa Mohammed. (2020). High gain antenna at 915 MHz for off-grid wireless networks.Bulletin of Electrical Engineering and Informatics. 9. 2449-2454. 10.11591/eei.v9i6.2192.2020.

M. Mathur, A. Vats and A. Agarwal, "A new design formulae for feed line dimensions of the rectangular microstrip patch antenna by using equivalent design concept," 2015 International Conference on Signal Processing and Communication (ICSC), 2015, pp. 105-110, DOI: 10.1109/ICSPCom.2015.7150629.

Rathod, Jagdish. (2010). Comparative Study of Microstrip Patch Antenna for Wireless Communication Application.International Journal of Innovation, Management, and Technology. 1. 4.

H. Matsumoto et al., "Variable Beamwidth Shorted Patch Antenna Array for Indoor Positioning", IEEE RWS, pp. 64-66, 2014.

H. Liu et al., "Survey of wireless indoor positioning techniques and systems", IEEE Trans. Syst. Man Cybernet., vol. 37, no. 6, pp. 1067-1080, Nov. 2007.

Z. Xiao, H. Wen, et al., "Identification and mitigation of non-line-of-sight conditions using received signal strength", IEEE WiMobConf, pp. 667-674, Oct. 2013.

J. Chicharo and M. Kilani, "A sliding Goertzel algorithm", Jrnl. of Signal Processing Elsevier, vol. 52, pp. 283-297, 1996.

Y. Xiao, C Li and J. Lin, "A portable non-contact heartbeat and respiration monitoring system using 5-GHz radar", IEEE Sensors J., vol. 7, no. 7, pp. 1042-1043, July 2007.

B. Razavi, "RF transmitter architectures and circuits," Proceedings of the IEEE 1999 Custom Integrated Circuits Conference (Cat. No.99CH36327), 1999, pp. 197-204, doi: 10.1109/CICC.1999.777273.

K. Kurokawa, "Injection locking of microwave solid-state oscillators," in Proceedings of the IEEE, vol. 61, no. 10, pp. 1386-1410, Oct. 1973, doi: 10.1109/PROC.1973.9293.

G. Irvine, S. Herzinger, R. Schmidt, D. Kubetzko and J. Fenk, "An up-conversion loop transmitter IC for digital mobile telephones," 1998 IEEE International Solid-State Circuits Conference. Digest of Technical Papers, ISSCC. First Edition (Cat. No.98CH36156), 1998, pp. 364-365, doi: 10.1109/ISSCC.1998.672531.