Avrupa Bilim ve Teknoloji Dergisi
Özel Sayı, S. 304-307, Eylül 2020

Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
Special Issue, pp. 304-307, September 2020

Research Article

A Novel Electronically Reconfigurable Antenna Design for RFID and GSM 900 MHz Applications

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(1st International Conference on Computer, Electrical and Electronic Sciences ICCEES 2020 – 8-10 October 2020)
(**DOI:** 10.31590/ejosat.804511)

ATIF/REFERENCE: Danacı, H. & Palandöken, M. (2020). A Novel Electrically Reconfigurable Antenna Design for RFID and GSM 900 MHz Application. *European Journal of Science and Technology*, (Special Issue), 304-307.

Abstract

In microwave systems, frequency tunable planar antennas have become common place as it is increasingly difficult to cover all the necessary frequency bands required. These antennas are low profile, conformable to planar and nonplanar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology. The work presented in this paper proposes a electronically reconfigurable planar antenna by using only one varactor diode. Varactor diode from Skyworks Solutions Inc. (SVM1251) has been used as tuning element. It provides a tunable capacitance range from 53.65 to 2.79 pF with reverse voltages varying between 0 and 8 V. A 50 Ohm resistor as dummy load, and two 68 pF SMD capacitors are incorporated within the structure in order to protect the DC supply to Network Vector Analyzer from dc current, in addition to having an effect on the size reduction. Proposed antenna operate frequency between 400 MHz and 1116 MHz that include ultra-high frequency (UHF) for radio frequency identification (RFID) and Global Systems for Mobile Communications (GSM) applications. Proposed compact antenna having the overall physical size of 8 mm x 8 mm (0.0203λ x 0.0203 λ) is numerically modeled on FR4 substrate having loss tangent, dielectric constant and height of 0.025, 4.3, and 1.61 mm respectively in the CST Microwave Studio numerical calculation program over the frequency range from 300 MHz to 1.5 GHz. The proposed electrically tunable directional antenna has better return loss level higher than 25 dB with reduced size with novel geometrical structure in the operating frequency between 400 to 1116 MHz.

Keywords: GSM 900 MHz, RFID, Tunable antenna, Size reduction, Varactor diode.

RFID ve GSM 900 MHz Uygulamaları için Elektronik Ayarlanabilir Yeni Bir Anten Tasarımı

Öz

Mikrodalga sistemlerinde, gerekli tüm frekans bantlarını kaplamak giderek zorlaştığından, frekansı ayarlanabilir düzlemsel antenler yaygın bir yer haline gelmiştir. Bu antenler düşük profilli olup, düzlemsel ve düzlemsel olmayan yüzeylere uyumludur, modern baskılı devre teknolojisi kullanılarak üretimleri basit ve ucuzdur. Bu bildiride sunulan çalışma, yalnızca bir varaktör diyot kullanarak elekronik olarakk ayarlanabilir bir düzlemsel anten önermektedir. Skyworks Solutions Inc.'den (SVM1251) varaktör diyotu ayar elemanı olarak kullanılmıştır. 0 ile 8 V arasında değişen ters voltajlarla 53,65 ila 2,79 pF arasında ayarlanabilir bir kapasite aralığı sağlar. Kukla yük olarak 50 Ohm direnç ve Network Vector Analizörü DC akımdan korumak ve boyut küçültmek için iki adet 68 pF SMD kapasitör dahil edilmiştir. Önerilen anten, radyo frekansı tanımlama (RFID) uygulamaları için ultra yüksek frekans (UHF) ve Mobil İletişim için Global Sistemler (GSM) bantlarını içeren 400 MHz ile 1116 MHz arasındaki frekansı çalıştırır. Genel fiziksel boyutu 8 mm x 8 mm (0,0203λ x 0,0203 λ) olan önerilen kompakt anten, CST Microwave Studio sayısal hesaplama programında, değeri sırasıyla 0,025, 4,3 ve 1,61 mm'lik kayıp tanjant, dielektrik sabiti ve yüksekliği olan FR4 substratı üzerinde sayısal olarak 300 MHz ila 1.5 GHz frekans aralığında modellenmiştir. Önerilen elektriksel olarak ayarlanabilen yönlü anten, 400 ila 1116 MHz arasındaki çalışma frekansında yeni geometrik yapı ile küçültülmüş boyutta 25 dB'den daha iyi geri dönüş kaybı seviyesine sahiptir.

Anahtar Kelimeler: GSM 900 MHz, RFID, Ayarlanabilir anten, Boyut küçültme, Varaktör diyot.

1. Introduction

Modern communication systems prefer reconfigurable and tunable planar antennas to accommodate several wireless communication applications in a handheld or portable device [1]. These antennas are low profile, conformable to planar and nonplanar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs,and when the particular patch shape and mode are selected, they are very versatile in terms of resonant frequency, polarization, pattern, and impedance [2]. Recently, several means have been used for reconfiguration of the antennas such as varactor diode [3-7], copper strip [8], pin diode [9,10], and digitally tunable capacitor (DTC) [11].

Sheta and Mahmoud [9] proposed a tunable patch antenna made of a slotted rectangular patch loaded by a number of posts close to the patch edge. The posts are short circuited to the ground plane via a set of PIN diode switches. In that study, simulations and measurements verify the possibility of tuning the antenna in subbands from 620 to 1150 MHz.

Sharif and others [8] proposed a tunable UHF RFID tag antenna design using Characteristic modes. The proposed design consists of folded-patch and a small inductive feeding loop. The folded-patch is optimized using characteristics modes to resonate around 915 MHz. This tag covers the US RFID band and can be tunable to the European band by adding two copper strips.

Cai, and Cheng [3] proposed for the first time, the design of a novel antenna with continuous control of polarization states. Polarization agility is attained by the adoption of a dual-polarized antenna and a newly developed signal control device (using varactor diodes only). The proposed circuit also features simple control circuitry, potentially wideband, almost zero DC power consumption and is amendable to antenna array realization. For experimental demonstration, the measured results of a 1.8 GHz antenna implemented on microstrip are shown.

Bai and others [11] proposed a novel tunable tri-band antenna for concurrent, multiband, and single chain radio receivers. The antenna is manufactured on a 50 × 100 mm FR4 printed circuit board, and is able to provide three concurrent, independently tunable operating bands covering a frequency range from 600 MHz to 2.7 GHz. The antenna performance is investigated for both numerical and experimental methods when using, fifirst, varactor diodes and, second, digitally tunable capacitors (DTCs) to tune frequencies, which shows that the antenna gain can be improved by up to 2.6 dBi using DTCs.

The work presented in this paper proposes a reconfigurable planar antenna by using only one varactor diode. Proposed antenna operate frequency between 400 MHz and 1114 MHz that include ultra-high frequency (UHF) for radio frequency identification (RFID) and Global Systems for Mobile Communications (GSM) applications. The antenna size is 8mm x 8mm (0.0203λ x 0.0203λ).

The paper is organized as the follows. The tunable antenna structure, principle of working are presented in the materials and methods section. In the results and discussion section, the simulation results are represented. Section conclusion concludes the paper.

2. Material and Method

2.1. Tunable Antenna Structure

The proposed tunable antenna the circuit configurations is shown in Figure 1. The tunable antenna has been designed on FR4 substrate in the CST Microwave Studio numerical calculation program having loss tangent, dielectric constant and height of 0.025, 4.3, and 1.61 mm respectively. SMD capacitor has been utilized to reduce the overall antenna size.

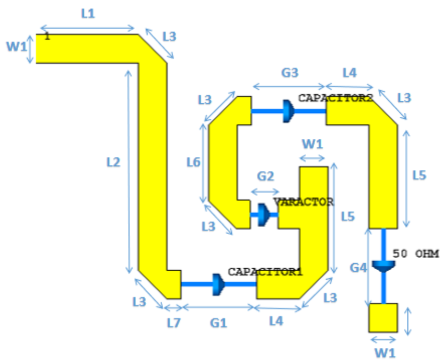

Figure 1. Configuration of the tunable antenna

The circuit parameters and main physical dimension are tabulated in Table 1.

Table 1. *Geometrical parameter of the numerical antenna structure with dimension*

Symbol	Value (mm)	Symbol	Value (mm)
L1	2	*L7*	0.28
L2	4	*W1*	0.55
L3	0.78	*G1*	1.45
L4	0.8	*G2*	0.55
L5	2	*G3*	1.45
L6	1.45	*G4*	1.45

Varactor diode is from Skyworks Solutions Inc. (SVM1251). It provides a tunable capacitance range from 53.65 to 2.79 pF with reverse voltages varying between 0 and 8 V. Varactor diode is used to ensure tunability of proposed design. One 50 Ohm resistor as dummy load, and two 68 pF SMD capacitors are incorporated within the structure in order to protect the DC supply to Network Vector Analyzer from dc current, in addition to having an effect on the size reduction.

3. Results and Discussion

3.1. Numerical Calculation Results

The tunable antenna has been numerically modeled on FR-4 substrate over the frequency range from 300 MHz to 1.5 GHz by using CST Microwave Studio. Figure 2 exhibit the S-parameters and illustrates good performances for the antenna. The return loss values of electronically tunable antenna are greater than 25 dB as shown in Figure 2 in the entire frequency band between 0.4 to 1.116 GHz as shown in Figure 2.

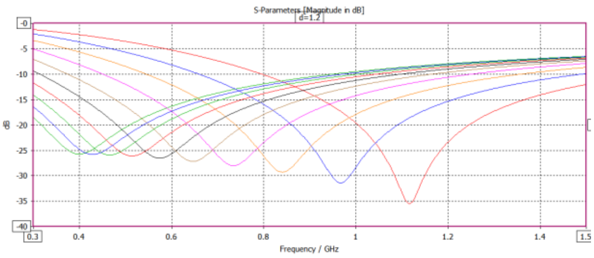

Figure 2. *Simulated S11 results of the proposed antenna with*

3.1. Discussion

Table 2 compares the RF performance parameters between the proposed antenna structure and referenced antennas. As deduced from Table 2, the proposed electrically tunable directional antenna has better return loss level higher than 25 dB in more reduced size with novel geometry. The proposed antenna utilized only one varactor diode to obtain tunability of frequency.

Table 2. Comparison of RF performance parameters between the proposed antenna structure and proposed antenna

Items	**[9]**	**[8]**	**[3]**	**This Work**
Tuning Elements	Pin Diode	Copper Strips	Varactor Diode +DTC	Varactor Diode
Return Loss (dB)	>20	>10	>6	>25
Frequency (GHz)	0.62-1.15	0.905-0.928	0.6-1.1	0.4-1.116
Size (mm x mm)	20x24	200x200	50x100	8x8

4. Conclusions and Recommendations

A simple varactor-tuned balanced antenna structure was presented ultra-high frequency (UHF) for radio frequency identification (RFID) applications and Global Systems for Mobile Communications (GSM) applications. The tunable antenna successfully was designed. In this paper, only one tuning element, and single voltage operation is used.

The proposed antenna has a compact size 8 mm x 8 mm (0.0203λ x 0.0203λ), and low return loss higher than 25 dB.

References

[1] Balanis C. A. (2008). Modern Antenna Handbook. New Jersey, USA: John Wiley & Sons Inc.
[2] Balanis C. A.,(2005). Antenna Theory: Analysis and Design. New Jersey, USA: John Wiley & Sons Inc.
[3] Cai L., & Cheng K. M. (2016, November). Continuously Tunable Polarization Agile Antenna Design Using a Novel Varactor-Only Signal Control Device, IEEE Antennas and Wireless Propagation Letters, 16, 1147 - 1150.

[4] Maharsh D., & Pandit N., Pathak N. (2017, November). Design, Analysis and Characterization of Tunable Dual Band Planar Antenna for WLAN Applications. 2017 IEEE International Conference on Antenna Innovations & Modern Technologies for Ground, Aircraft and Satellite Applications.
[5] Ghaffar F. A., Shamim A., & Bray J. R. (2014, July). Design Strategy for a Tunable Antenna on a Partially Magnetized Ferrite LTCC Substrate. 2014 IEEE Antennas and Propagation Society International Symposium (APSURSI).
[6] Rahola J. (2018, March). Design of Frequency Tunable Antennas for Mobile Devices. 2018 International Workshop on Antenna Technology (iWAT).
[7] Bouezzeddine M., & Schroeder W. L. (2016, July). Design of a Wideband, Tunable 4-port MIMO Antenna System with High Isolation Based on the Theory of Characteristic Modes. IEEE Transactions on Antennas and Propagation. 64(7).
[8] Sharif A., Ouyang J., Chattha H. T., & Abbasi Q. H. (2018 July). Tunable Folded-Patch UHF RFID Tag Antenna Design using Theory of Characteristic Modes. 2018 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting.
[9] Sheta A., Mahmoud S. F., & Member L. S. (2008, March). A Widely Tunable Compact Patch Antenna. IEEE Antennas and Wireless Propagation Letters. 7.
[10] Sharma S. K. (2013, December). Design Considerations of Reconfigurable and Tunable Planar Antennas. 2013 IEEE Applied Electromagnetics Conference (AEMC).
[11] Qiang Bai, Ravinder Singh, Kenneth Lee Ford, Timothy O'Farrell, Richard J. Langley, (2017, December). An Independently Tunable Tri-Band Antenna Design for Concurrent Multiband Single Chain Radio Receivers", IEEE Transactions on Antennas and Propagation. 65(12). 6290 - 6297.