Design of dual band RFID antenna reader by modified H-shaped resonator

Mahmoud Mohamed Ahmed El-Negm Yousef, Dr Adel B. Abdel-Rahman and Dr Ahmed M.montaser.

***Abstract*— A printed microstrip-fed monopole (RFID) Radio frequency identification antenna with dual bands is presented. By embedding a modified two H-shaped resonator, the first on left and the other on right of the microstrip feed line with partial ground plane. The antenna designed and simulated using CST (computer simulation technology) microwave studio software, fabricated on Rogers's 4003c substrate with dimensions 33x25 mm, dielectric constant of 3.38 and thickness of 0.813mm by etching and photolithography. The measurement showed that the designed antenna operate at (2.4 GHz & 5.8 GHz) with good return loss. Above all, the dual-band CP omnidirectional patch antenna presented is beneficial to dual-band RFID system on configuration, implementation, as well as cost reduction.**

***Index Terms*— monopole antenna, RF identification (RFID) reader, H-resonator, dual band.**

I. INTRODUCTION.

Radio frequency identification (RFID) is a technology that provides wireless identification and tracking capability and is more robust than a bar code. Now RFID system finds many applications in various areas such as electronic toll collection, asset identification inertial item management, access control, animal tracking, and vehicle security companies, logistics systems, service industries, government agencies, and public service organizations in the past few years [1],[2]. So far, several frequency bands have been assigned for RFID applications, which include 125 kHz, 13.56 MHz, 433.92 MHz, UHF 0.92 GHz, and ISM 2.45 and 5.8 GHz [3]. RFID identification is to paste tags on goods, animals, or people for the purpose of identification and tracking by radio waves [4]. This is because the bands can provide high data transfer rate and broad readable range.

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RFID system provides a wireless detection of the goods which usually consists of reader/writer and tag. Typically, the reader transmits RF power to the tag, which then sends a unique coded signal back to the reader, while the writer can change the information contained within the tag. Therefore, in the reader side the antenna needs to be carefully designed to ensure good performance of the RFID system [4-8].The system can be operated in different frequency bands in accordance to the standard regulation. Several frequency bands have been assigned to the RFID applications, such as 2.45 GHz and 5.8 GHz.

A reader is basically a radio frequency (RF) transmitter and receiver, controlled by a microprocessor or digital signal processor. An RFID reader emits electromagnetic signals where an RFID tag draws power from it. This power is then used to energize the microchip's circuits. The chip then modulates the waves and sends back this modulated wave to the reader. This process is called backscattering where the reader sees the tag. Form system requirement and application point of view, a reader antenna should have following characteristics Compact Directional with higher gain, Circular polarization, Good impedance match (normally match to 50ohms), Easily to be integrated, low-cost .In telecommunications, microstrip patch antenna is widely used because of their several advantages such as light weight, low volume, low fabrication cost and capability of dual or triple frequencies operations.

In this paper, adding two H-shaped resonator beside microstrip patch antenna with high gain for RFID reader and wireless communications are designed to resonate on the RFID bands of 2.4 GHz & 5.8 GHz. The effects of adding two H-resonators give that the proposed antenna has good impedance and radiation characteristics over the required bandwidth, (2.4: 2.48 GHz & 5.72:5.87 GHz). The return loss of the optimized microstrip patch antenna is below 10dB over the frequency bands. The theoretical simulations are performed using CST software.

II. ANTENNA DESIGN CONFIGURATION.

1) H-shape designed

H-shaped structure consists of three arms with six parameters. The H-shaped has a resonator when used beside monopole antenna and changing its parameter changing resonant frequency due to changing current disruption and the antenna surface. The H-shaped show in the Fig. (1), the parameters show the Table I.

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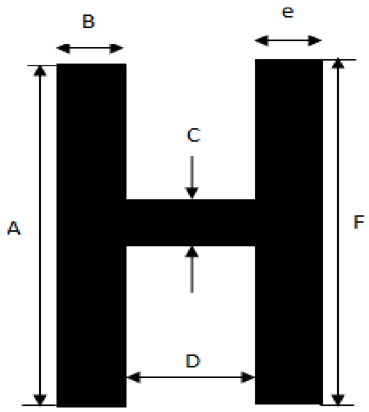


Fig. 1: H-shaped.

TABLE I
DIMENSIONS OF HE H-SHABED DESIGN

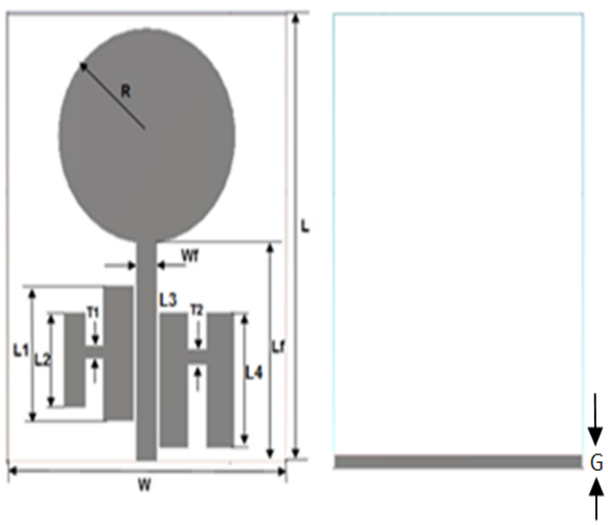
parameters	Dimension(mm)
A	10
B	2.5
C	1.15
D	1.6
E	2.8
F	10

2) Antenna design.

The geometrical configuration of the proposed antenna structure (top view&bottom view)is shown in Fig. 2. The structure has been designed on Rogeer4003c substrate 25x33 mm with a relative dielectric constant of 3.38 and a thickness of 0.813mm. The strip width of 1.866mm is chosen for a characteristic impedance of 50 Ohm. By adding two H-shaped resonator beside microstrip patch antenna (the first on the right hand side and the second on the left hand side for feed line) are designed to resonate on the RFID bands (2.4 GHz & 5.8 GHz). The effects of adding two H-resonator give that the proposed antenna has good results on mat lap after fabricated for S_{11} simulated and measured. He geometrical dimensions for the conventional structure shown in the Table II.

III. SIMULATION AND MEASUREMENTS RESULTS.

Based on the design consideration s given in section II, we used CST microwave studio software for simulation the antenna. Return loss (S_{11}) for simulation and measurements, radiation pattern for (E plane), voltage standing wave ratio (VSWR),



(a) (b)

Fig.2: Antenna geometry structure (a) Top view, and (b) Bottom view.

TABLE II

DIMENSIONS OF THE ANTENNA DESIGN

parameters	Dimensions(mm)
L	33
W	25
Lf	16.2
Wf	1.866
L1	11
L2	7
L3	12
L4	10
T1	1
T2	1.15
G	1
R	8

Directivity and gain are carried out. The results show that the proposed antenna has good impedance and radiation characteristics over the required bandwidth, (2.4 to 2.48 & 5.72:5.87 GHz).The return loss of the optimized microstrip patch antenna is below 10dB over the frequency bands. The proposed antenna is very promising for various modern communication applications. By adding two H-shaped resonator beside microstrip patch antenna are designed to resonate on the RFID bands of 2.4 GHz & 5.8 GHz. The effects of adding two H-resonator give that the proposed antenna has good results on mat lap after fabricated for S_{11} simulated and measured.

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To investigate the antenna parameters effect on the antenna performance, a parametric study was carried out. It is found that the parameters which have a significant impact and remarkably on return loss S_{11} such as: L2 along the side in the H-shaped (on the right of feed line), L3 along the side in the H-shaped (on the left of feed line).Fig. 3 (B) describes the return loss based on increasing and decreasing the long L2. It can be noticed that the long L2 affects the return loss at 5.8 GH; Fig. 3 (C) describes the return loss based on increasing and decreasing the long L3. It can be noticed that the long L3 affects the return loss at 2.4 GH. But L1 & L4 don't effect on dual band as show in Fig. 3(a) & (d). Table III show different frequencies at change in parameter sweep (L2).Table I show different frequencies at change in parameter sweep (L3).

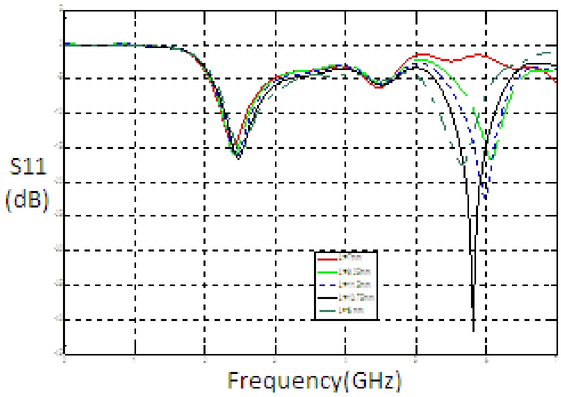

Fig.3. (A) the variation of L1 parameter on the return loss.

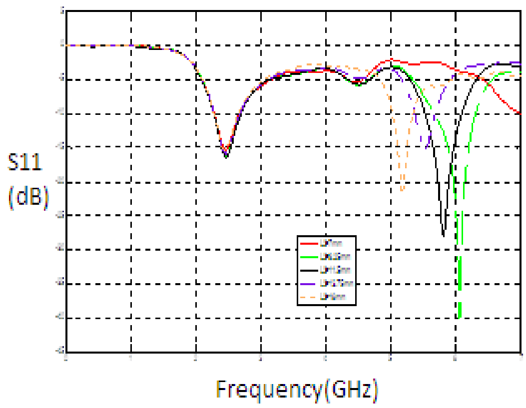

Fig. 3. (B) the variation of L2 parameter on the return loss.

TABLE III

PARAMETER SWEEP (L2) WITH DIFFERENT FREQUANCIES.

Par.Sweep(L2)(mm)	7	9	11.25	13.75	16
Frequency(GH)	7.5	6 4	5.8	5.5	5.2

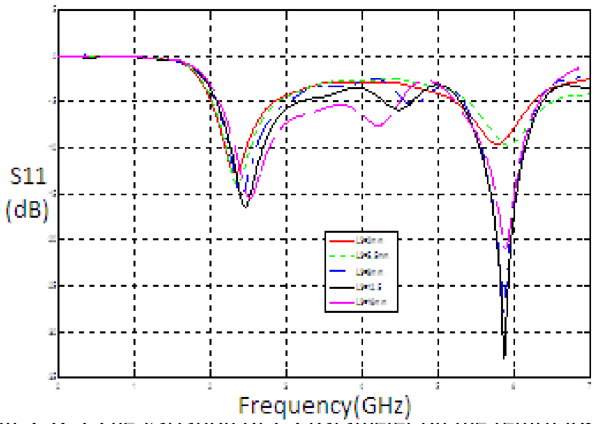

Fig.3. (C) The variation of L3 parameter on the return loss.

TABLE IV
PARAMETER SWEEP (L3) WITH DIFFERENT FREQUANCIES.

Par. Sweep (L3) (mm)	2	5.5	9	12.5	16
Frequency (GH)	2.37	2.39	2.42	2.46	2.53

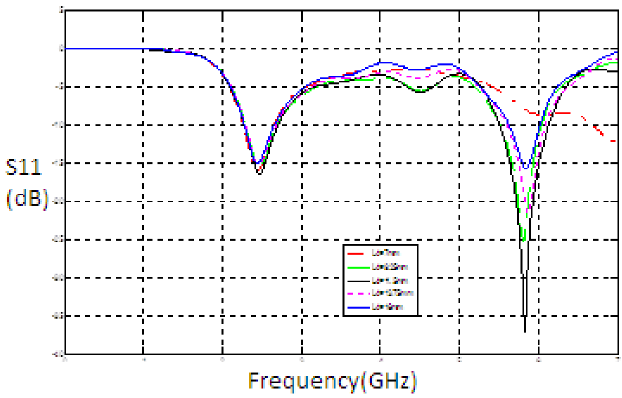

Fig.3. (D) The variation of L4 parameter on the return loss.

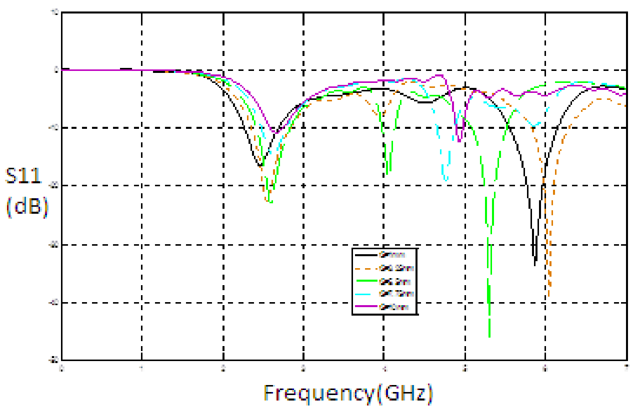

Fig.3. (E) The variation of Ground (G) parameter on the return loss.

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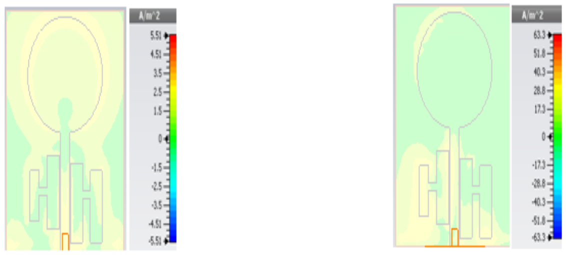
Fig. 4show S11 simulated and measured return losses of proposed antenna. The simulated *E*-plane of the antenna are shown in Fig.5 and photograph of the fabricated Antenna (top view and bottom view) is show in fig 6.

For better understanding the role of each monopole antenna on the antenna performance, the surface current distributions for the dual band antenna at different working frequencies 2.4 GHz and 5.8 GHz are calculated and plotted in Figure 8.



(b) f=2.4 GHz (b)f=5.8GHz

Fig. 8.simulated current distribution at different frequencies(2.4 GHz & 5.8 GHz)

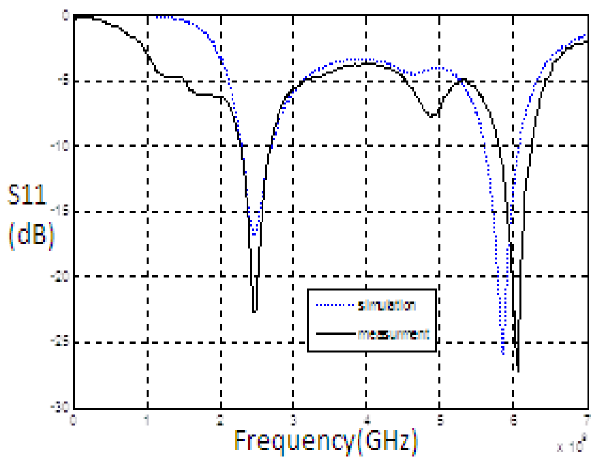
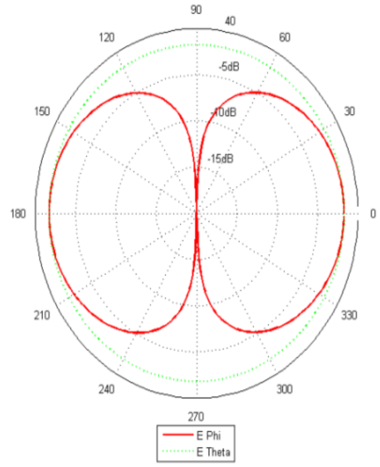
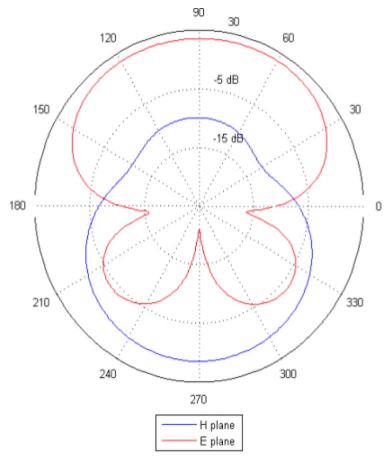


Fig. 4: S11 simulated and measured return losses of proposed antenna.

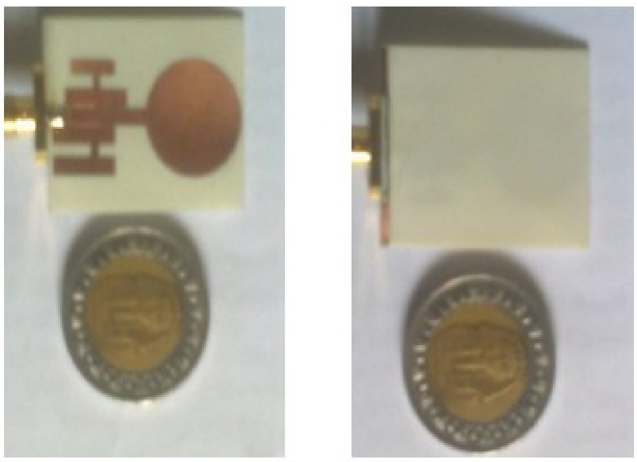


F= 2.4 GHz



F=5.8GHz

Fig.5: (a) Simulated Radiation pattern of the proposed antenna at (2.4 GHz & 5.8GHz) for E-H plane.



(a) (b)

Fig. 6: photograph of the fabricated Antenna prototype (a) topview (b) bottom view.

IV. Conclusion.

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Microstrip antenna has become a rapidly growing area of research. Their potential applications are limitless, because of their light weight, compact size and ease of manufacturing. In this paper, a circularly polarized (CP) H-shaped microstrip single layer patch antenna been designed for RFID reader. The return loss was below -10dB for (2.4 GHz& 5.8 GHz) bands. The antenna is thin and compact with the use of low dielectric constant substrate material. These features are very useful for worldwide portability of wireless communication equipment. The antenna was designed, fabricated and measured. Good agreement between simulated and measured results has been achieved.

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REFERENCES

[1] *Y. Sung., "Triple Band-Notched UWB Planar Monopole Antenna Using a Modified H-Shaped Resonator," in IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 61, NO. 2, FEBRUARY 2013.*

[2] *Qiang Liu, Junyu Shen , Hongli Liu, and Yuanan Liu, " Dual-Band Circularly-Polarized Unidirectional Patch Antenna for RFID Reader Applications ," IEEE Trans , Manuscript received March 1, 2014; revised August 18, 2014; accepted September 20, 2014. Date of publication, 2014; data of current version, 2014.*

[3]*I. Ismail, S.M. Norzeli., "UHF RFID Reader Antenna with High Gain,"in INTERNATIONAL JOURNAL OF ELECTRICAL AND ELECTRONIC SYSTEMS RESEARCH, VOL.6 JUNE 2013.*

[4] *Z. N. Chen, X. M. Qing, and H. L. Chung, "A universal UHF RFID reader antenna," IEEE Trans. Microw. Theory Tech., vol. 57, no. 5, pp. 1275−1282, May 2009.*

[5] Z. B. Wang, S. J. Fang, S. Q. Fu, and S. L. Jia, "*Single-fed broadband circularly polarized stacked patch antenna with horizontally meandered strip for universal UHF RFID applications,*" *IEEE Trans. Microw. Theory Tech.,* vol. 59, no. 4, pp. 1066−1073, Apr. 2011.

[6] M. I. Sabran, S. K. A. Rahim, A. Y. A. Rahman, T. A. Rahman, M. Z. M. Nor, and Evizal, "*A dual-band diamond-shaped antenna for RFID application,*" *IEEE Antennas Wireless Propag. Lett.,* vol. 10, pp. 979–982, 2011.

[7] ShinChul, K., et al. A novel design of an UHF RFID reader antenna for PDA. in Microwave Conference, 2006. APMC 2006. Asia-Pacific. 2006.

[8] Ankang, R., et al. A novel design for UHF near-field RFID reader antenna based on traveling wave. In Communication Technology ICCT) , 2010 12th IEEE International Conference on.

[9] Finkenzeller, K., *RFID Handbook*, 2nd Edition, Wiley, New York, 2003.

[10] Hend A. Malhat, Saber H. Zainud-Deen and Kamal H.Awadalla, "*Circular Polarized Dielectric Resonator Antenna for Portable RFID Reader Using a Single Feed,"International Journal of Radio Frequency Identificationand Wireless Sensor Networks* 2011.

[11] http://www.rfid4u.com/glossary.asp

[12] Balanis, Constantine A. "*Antenna Theory - Analysis and Design*", published by John Wiley & Sons, (3rd Edition) 2005.

[13] J.-S. Yoon et al., "*A new DGS resonator and its application to band pass filter design*," in Proc. IEEE Microwave Theory Techniques-S Dig.,2004, pp. 1605–1608.

[14] http://www.cst.com/content/products/mws/overview.

[15] http://www.antenna-theory.com/definitions/fronttobackratio.php

[16] Haoshi Jiang, Jiangyu Lin, "The application and development trends of RFID technology," Application of Elecrtonic Technique, 30(5),pp. 4-7, Jannuary 2009.

[17] M.T. Zhang,Y.C. Jiao, F. S.Zhang, "Dual-band CPW-fed folded-slot monopole antenna for RFID application," Electronics Letters, 42(21), pp.1193-1194, Oct 2006 (Sung, 2013).

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