2021 International Conference on Electrical, Computer, Communications and Mechatronics Engineering (ICECCME) | 978-1-6654-1262-9/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICECCME52200.2021.9591142

A QR-based Compact Multiband Antenna for Portable Mobile Communications

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***Abstract*—A QR-based compact multi-band printed antenna is presented in this work. The QR-code was generated using a QR-generator built by "Meteor Rain" and designed in the HFSS simulator. The antenna structure is realized from a square-shaped patch. The QR-code is used as the radiating patch on an FR4 substrate of a 1.6mm thickness of a co-axial fed antenna. The proposed antenna operates at 1.63GHz, 3.34GHz, and 4.59GHz with a gain of -6.1dBi, 1.2dBi, and 2.8dBi respectively. The proposed antenna results in a 62.53% reduction compared with the conventional square-shaped patch antenna. Hence, it is suitable for portable GPS, WLAN, and WiMAX applications.**

Keywords—QR-code antenna, Multiband antenna, Portable mobile devices

I. INTRODUCTION

The compact antenna has become a major need in this era of portable wireless devices. Also, the many wireless technologies have necessitated the need for multiband antennas. Although, many researchers have worked in this area, yet, none have looked into the use of QR-code patterns as the radiating patch of a planar multiband antenna. For example, a slitting method was used by authors in [1]–[4]. For example, authors in [1] designed Isosceles triangular-shaped monopole radiating patch of size 38 x 38mm2 on which three equal widths Rectangular-shape slits were etched to produce an antenna working at 2.4/3.5/5.5GHz for WiMAX and WLAN applications with fractional bandwidth of 21.92%, 16.00%, and 18.08% and the gain of <3dB, <2dB, <1dB respectively. Also, a lumped element has been used for designing a multi-band antenna[5]. Shorting pin/plate has also been used by various authors to realize multiple bands (Multiband) and miniaturization such as[6]. In this work, the QR-Code-based patch antenna is investigated for multiband application.

II. ANTENNA DESIGN AND ANALYSIS

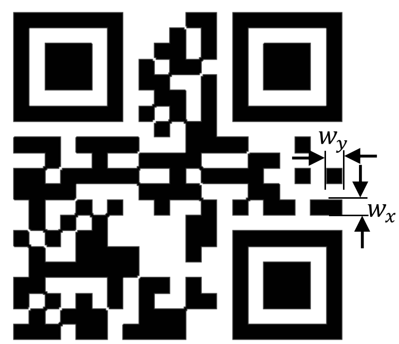
A QR-code generator was used to generate QR-code for "JESUS IS LORD". This was printed on a sheet of paper as denoted in Fig. 1(a) and then designed in the simulator (HFSS) as presented in Fig. 1(b).

This work was sponsored by the African Union through PAUSTI.

The antenna initiator is a square-shaped patch of $21\times21mm^2$ and was developed on an FR-4 substrate of dimension $29 \times 29mm^2$ with a 1.6mm thickness. The width of the a cell-strip is 1mm at both x and y axes as presented in Fig. 1(b). Fig. 1(c) denotes the front-view of the QR-antenna proposed herein.

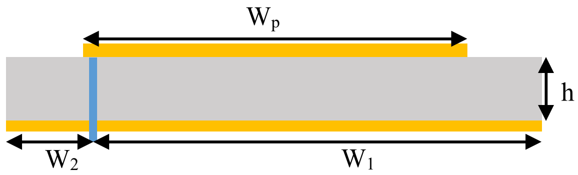
According to Eqn. 1, where W is the width of the patch, C_o is the speed of light in free space, and ε_r is dielectric constant, the resonance frequency (f_r) of a square patch of 21mm length is 4.35GHz.

$$f_r = \frac{C_o}{2W\sqrt{\frac{\varepsilon_r + 1}{2}}} \quad (1)$$



(a)

(b)



(c)

Fig. 1: The proposed QR-based antenna design (a) QR pattern, (b) Top-view (c) the front-view (Wp = 21mm, W1 =24.5mm, W2 = 4.5mm, w_x =1mm w_y = 1mm, and h = 1.6mm)

III. Result and Discussion

A. Reflection coefficient

Fig. 2 is the reflection coefficient of the QR-based antenna proposed. The antenna resonates at 1.63GHz, 3.38GHz, and 4.59GHz with a reflection coefficient of -15.48dB, -23.03dB, and -17.53dB and a -10dB fractional bandwidth of 1.23%, 2.07%, and 2.18% respectively. It can be observed that the proposed QR-based antenna results in a 62.53% reduction compared with the conventional rectangular-shaped patch.

B. Gain, current distribution and radiation pattern

h The gain of the proposed antenna at 1.63GHz, 3.38GHz, and 4.59GHz is -6.1dBi, 1.2dBi, and 2.8dBi respectively as seen in Fig. 3. It can also be observed that the proposed antenna has a directional radiation pattern in both E-Plane and H-plane as shown in Fig. 4. To understand the operation of the proposed antenna, the current distribution at 1.63GHz, 3.38GHz, and 4.59GHz are examined and presented in Fig. 5. It can be observed that different part of the antenna is responsible for each of the resonance.

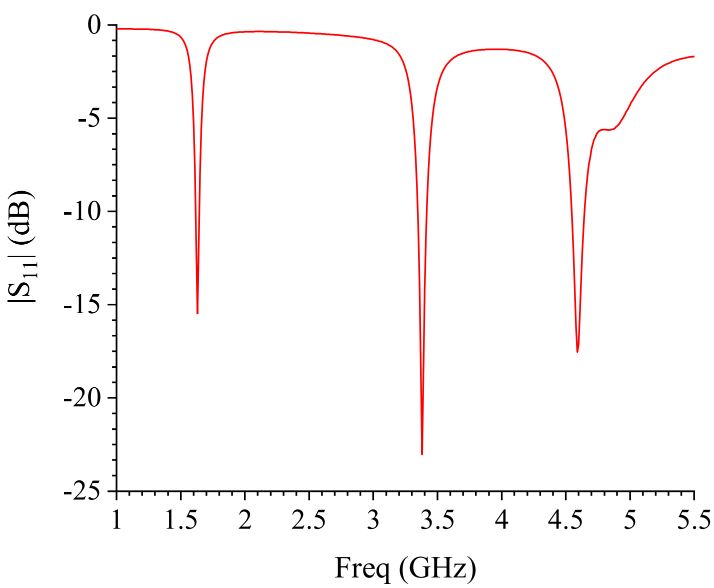
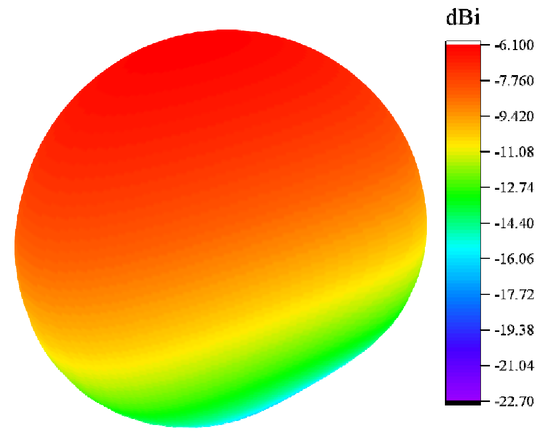
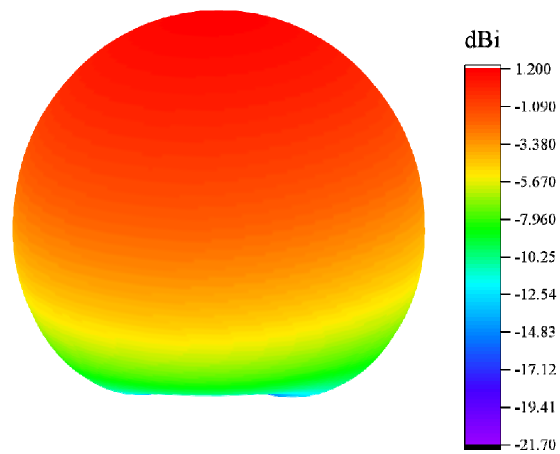


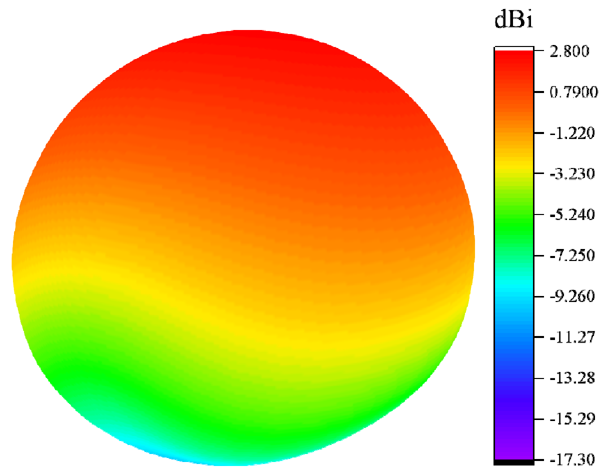
Fig. 2: Simulated reflection coefficient



(a)



(b)



(c)

Fig. 3: The gain of the proposed QR-based antenna at: (a)1.63 GHz, (b) 3.38 GHz, and (c) 4.59GHz

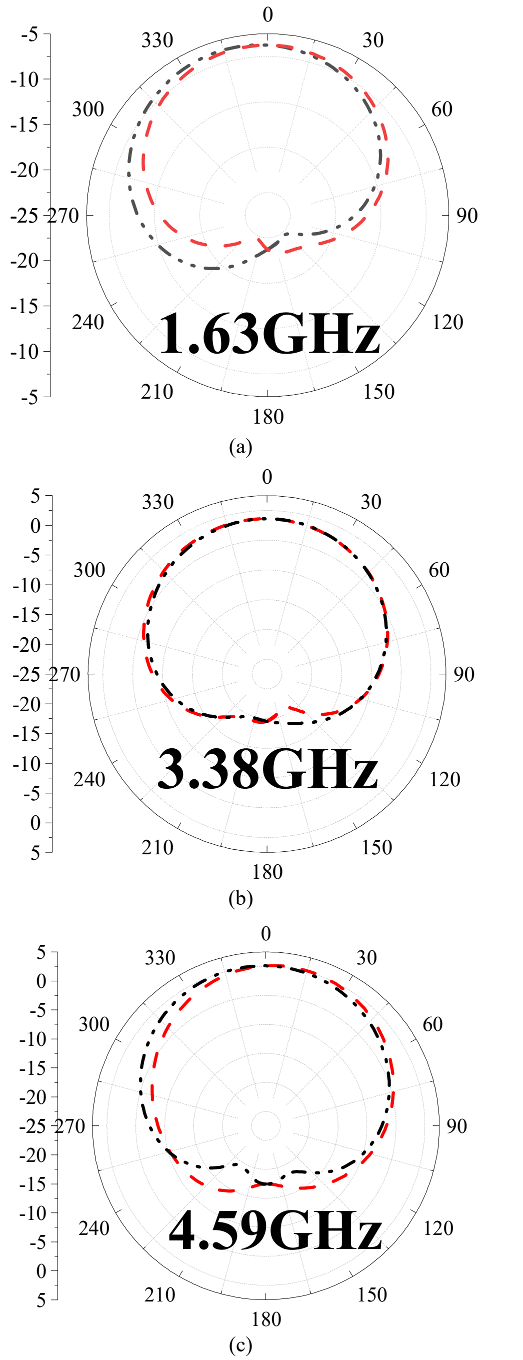


Fig. 4: The 2D radiation pattern of the proposed QR-based antenna

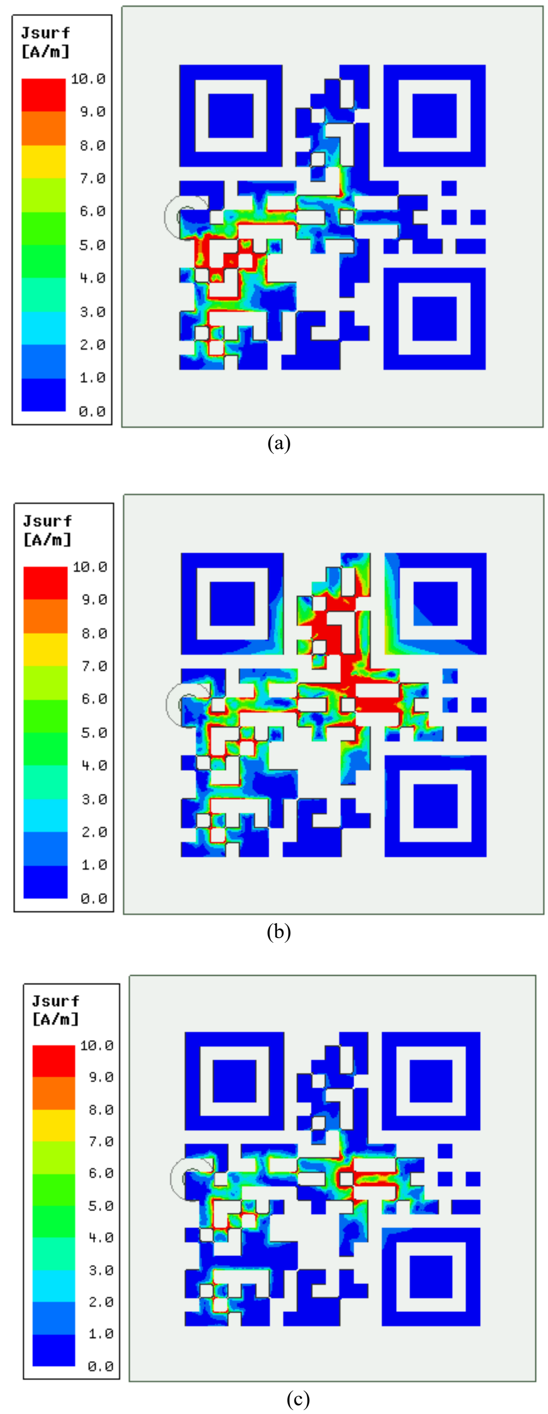


Fig. 5: The current distribution at (a) 1.63GHz, (b) 3.38GHz, and (c) 4.59GHz

IV. COMPARATIVE ANALYSIS

The proposed antenna comparison against recently works in open literature is presented in Table I. It can be seen that the QR-based antenna is comparatively small compared with recently reported works.

TABLE I. COMPARATIVE ANALYSIS FOR PROPOSED ANTENNA VALIDATION

REF	Year	Size (λ_d)	Freq. (GHz)	Gain (unit)	No of Band
[7]	2020	0.7 x 0.7	3.47/5.61 /7.5/8.02	2.65/2.97 /6.61/4.31(dB)	Quad-Band
[8]	2020	0.3x 0.4	2.45/3.5/ 7.3/11.5	1.2/1.92/3.17 /5.13(dB)	Quad-Band
This Work	___	0.3 x 0.3	1.63/3.38 /4.59	-6.1/1.2/2.8 (dBi)	Tri-Band

V. CONCLUSION

In this work, a QR-based multiband antenna is presented. The proposed antenna operates at 1.63GHz, 3.38GHz, and 4.59GHz with a peak gain of 2.8dBi. The QR-based antenna demonstrated a 62.53% miniaturization compared with the conventional square-shaped patch antenna. The proposed antenna is a suitable candidate for GPS, WLAN, and WiMAX applications.

ACKNOWLEDGMENT

Abolade J. O. thanks Abolade O. A., Abolade T. D., and Abolade T. M. for their support in the course of this research. All the authors also thank the PAUSTI EEE Laboratory Technologist for their support during this research.

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