QR-Code Pixelated Antenna with Multi-Factor Authentication for Wireless and Security Applications

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***Abstract*— Quick response (QR) codes can be used for antenna applications, in addition to being used as information-sharing and security devices. QR-Code pixelated antennas present a game-changing solution for wireless communication and security applications. Their ability to facilitate efficient data transfer, compact form factor, compatibility with existing infrastructure, and enhanced security measures make them highly desirable for a wide range of applications, ranging from consumer electronics to industrial systems. The aim of this paper is to demonstrate the feasibility and success of QR code structures as antennas in wireless communication applications. It is designed on a low-cost FR4 substrate board. The suggested antenna configuration contains a modified coaxial-fed patch resonator with a QR pixelated configuration and a full ground plane providing a broad bandwidth of 8 to 9.6 GHz. The critical characteristics have been examined in simulations and sufficient return loss, radiation gain, levels are all achievable with the planned compact QR antenna design.**

Keywords*— *QR, coaxial-fed patch, dual-authentication, pixelated antenna, wireless applications.

I. Introduction

The Quick Response (QR) codes are matrix two-dimensional barcodes that were originally used in the automotive industry and then in many other industries. Codes consist of solid squares arranged on a grid and encode numeric, alphanumeric, and binary data of standardized types [1-3]. As a two-dimensional image, a QR code can be scanned with a camera, mobile phone, or other imaging devices to generate a text message, phone number, website, or other information. There are currently security applications for QR codes being considered since they can be printed with not just visible ink, but with invisible inks that can only be seen using near-IR lasers. QR codes can also be printed with polychromatic messages and symbols [4]. As represented in this research study, QR codes can also be used for antennas, in addition to being used as information-sharing and security devices. Incorporating radiating properties into QR codes (as receiving/transmitting antenna) expands their application as security devices, which are difficult to detect and reproduce. It is also possible to counterfeit QR codes without the 'key' signal transmitted by the QR code antenna [5].

QR-Code pixelated antennas are specifically designed to resemble QR codes, which are widely recognized and utilized in various industries for information encoding and decoding. This design approach allows for seamless integration of the antenna into different devices and systems, ensuring compatibility and ease of use. One of the key advantages of QR-Code pixelated antennas is their ability to facilitate efficient data transfer. The pixelated structure enables the antenna to generate complex radiation patterns, providing better signal coverage and reception. This feature is particularly beneficial in scenarios where reliable and high-speed wireless communication is crucial, such as in IoT applications, smart devices, and industrial automation systems. Moreover, pixelated antennas offer a compact form factor, making them ideal for space-constrained applications. Their miniaturized size allows for easy integration into small electronic devices and platforms without compromising performance [6-8].

This compactness enables seamless integration of wireless connectivity into a wide range of devices, including wearable technology, IoT sensors, and smart appliances. Furthermore, the unique pixelated design of these antennas contributes to enhanced security measures. By leveraging the characteristics of QR codes, which contain error correction and encryption capabilities, QR-Code pixelated antennas can provide additional layers of security in wireless communication. This helps safeguard sensitive data transmission, preventing unauthorized access and ensuring secure communication channels. Additionally, QR-Code pixelated antennas offer compatibility with existing QR-code scanning infrastructure, making them easily deployable and adaptable to different environments. This compatibility allows for seamless integration with QR code readers and scanners, enabling efficient and convenient data exchange between devices [9-10].

The paper's focus is to demonstrate the feasibility and success of QR code structures as antennas in wireless communication applications. The antenna configuration is based on the QR code depicted in Fig. 1 and contains a modified coaxial-fed patch resonator with a QR pixelated configuration providing a wide bandwidth of 8-9.6 GHz. Its characteristics were investigated using CST microwave studio 2020 [11].

Fig. 1. An example of a QR used in this study.

II. Antenna Configuration

Figure 2 shows the structural details of the suggested QR antenna. As represented, it has a modified pixelated schematic with a full ground plane designed on a low-cost FR4 with 4.4 permittivity and a thickness of 1.6 mm. The values (in mm) of the parameters are: W=80, W_1=20, and W_2=1.

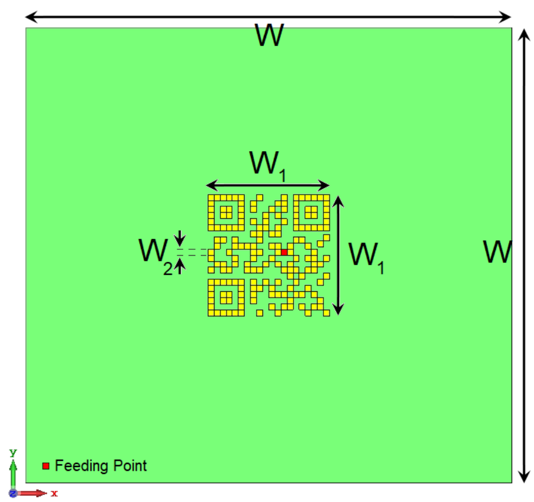

Fig. 2. Schematic of the suggested QR antenna.

III. Characteristics of The QR Pixelated Antenna

This section investigates the critical characteristics of the introduced design for wireless applications. The S_{11} (return loss) feature of the designed QR pixelated antenna is shown in Fig. 3. As represented, for RL≤- 10, the antenna is offering a wide impedance bandwidth ranging from 8 GHz to 9.6 GHz. The impact of the substrate on the antenna operation band is discussed in Fig. 4. As shown, by increasing the FR4 substrate thickness, the antenna isolation can be improved to cover a wider band [12-16].

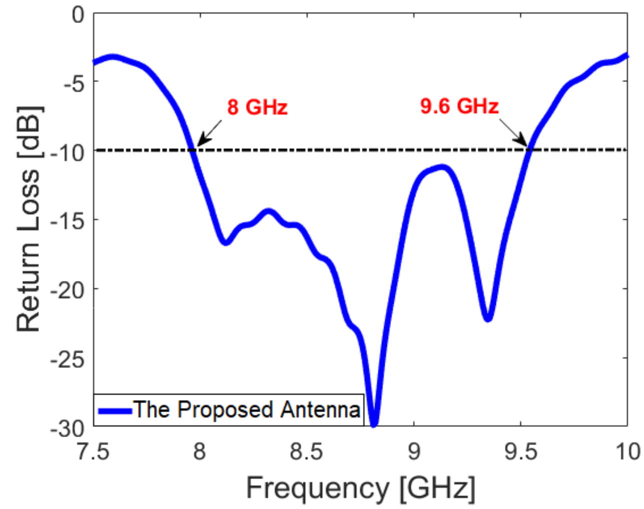

Fig. 3. The Simulated return loss.

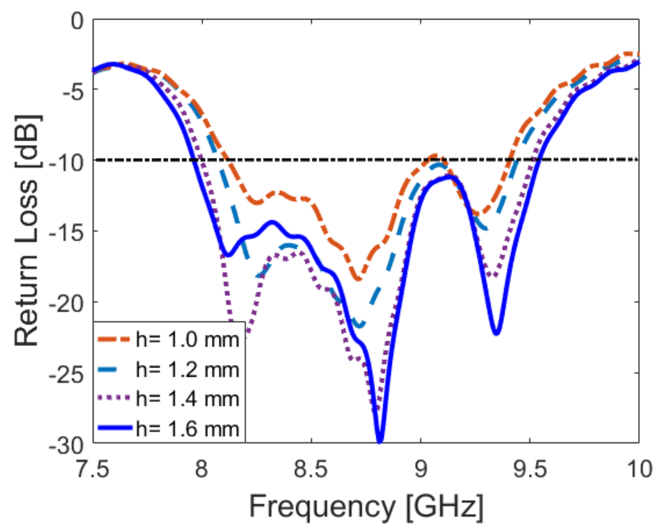

Fig. 4. The return loss variation for different substrate thicknesses.

The surface current distribution of the designed QR pixelated patch antenna at its resonances including 8, 8.8, and 9.4 GHz have been studied and represented in Fig. 5. It can be clearly observed that different parts of the suggested pixelated radiation patch actively have impacts on generating the resonances and improving the antenna impedance bandwidth [17-21]. As shown in Fig. 5 (a), the largest area coverage with high current densities is representing the lower band and vice versa.

The 2D view of the antenna radiation at different resonating frequencies (including 8, 8.8, and 9.4 GHz) are illustrated in Figs. 6 (a-c), respectively. As shown, the suggested QR antenna offers bi-directional radiation patterns which make it suitable for wider radiation coverage in wireless applications [22-24]. In addition, for a better representation, the 3D view of the antenna radiation at 9.5 is shown in Fig. 7 which verifies the well-defined and bi-directional radiation of the suggested antenna [25-30].

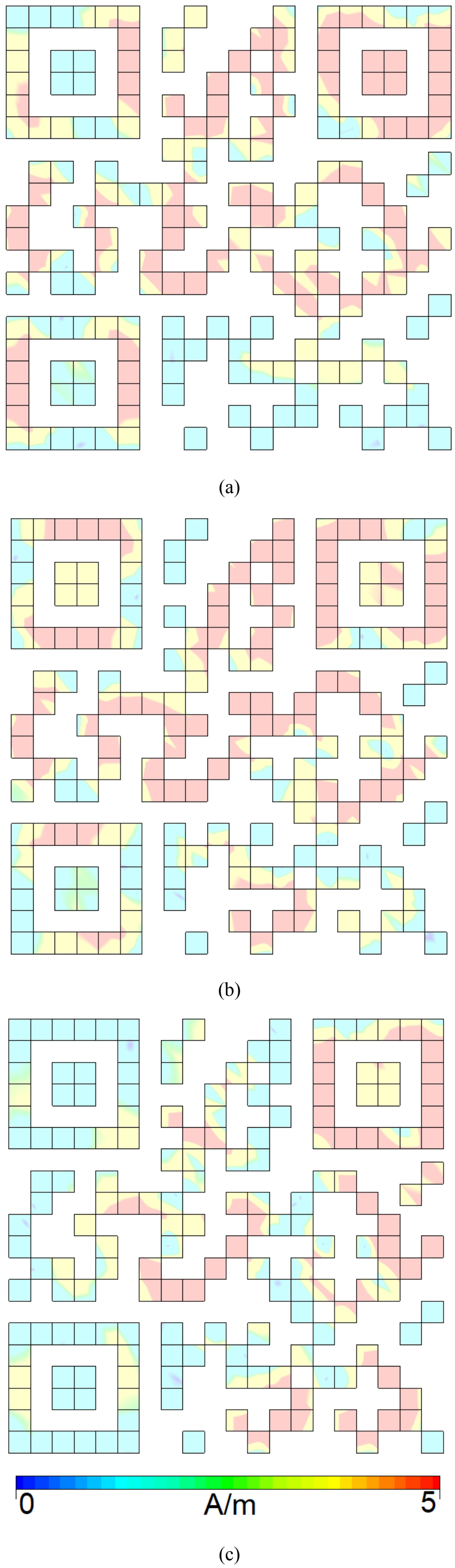

Fig. 5. Current densities at (a) 8, (b) 8.8, and (c) 9.4 GHz.

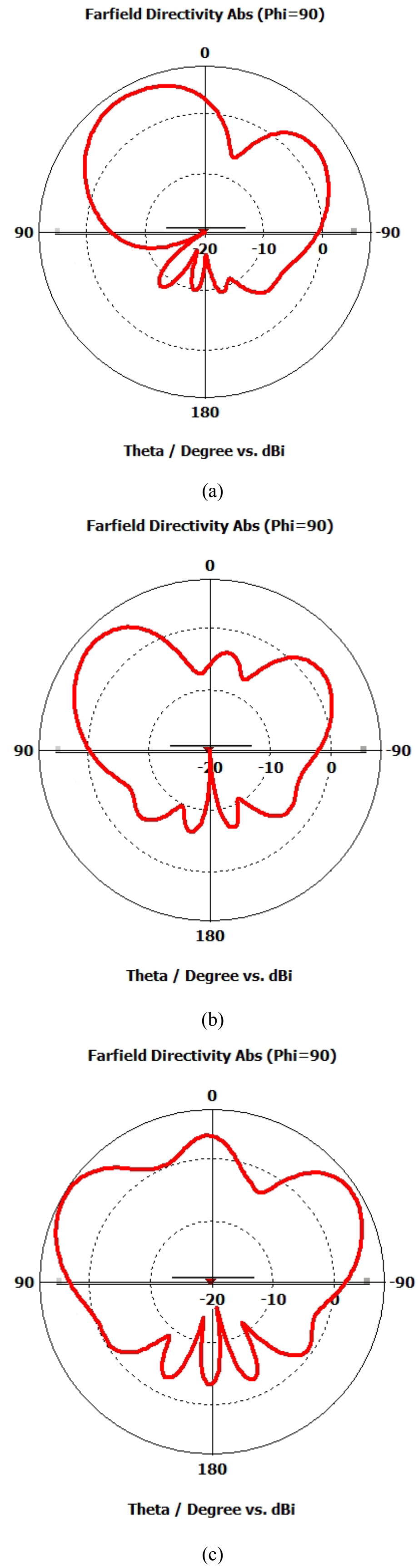

Fig. 6. 2D polar radiations at (a) 8, (b) 8.8, and (c) 9.4 GHz.

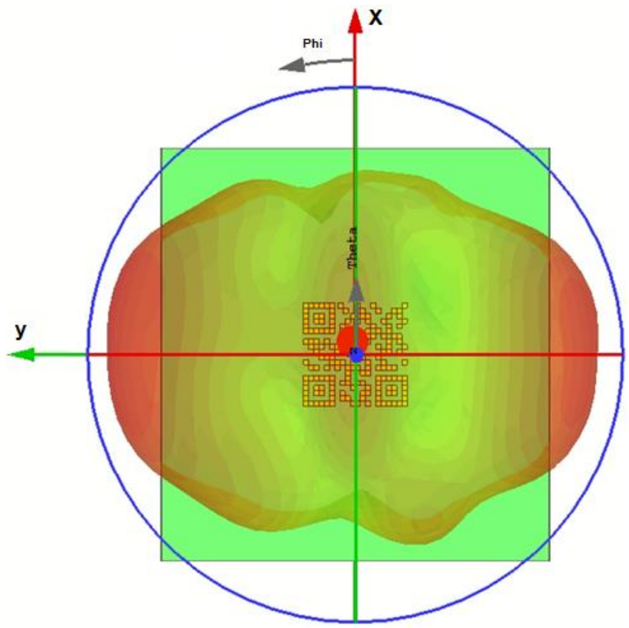

Fig. 7. Antenna radiation at 9.5 GHz.

IV. Conclusion

The properties and schematic details of a new QR-pixelated antenna with multi-factor authentication have been discussed for wireless and security applications. The introduced antenna design is containing a modified coaxial-fed patch resonator implemented on a low-cost FR4 material. The antenna is covering the range of 8 to 9.6 GHz with bi-directional radiation. Important properties have been studied, resulting in promising features for future security and wireless applications.

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