QR Code Antenna for Wireless and Security Applications

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Abstract— **This paper presents the first QR code antenna. The QR code itself represents a specific code based on any text, URL, and any alphanumeric contents. However it can also serve as the antenna that is described in this paper, or any other QR code-shaped antenna. This antenna has a return loss of 8.5 dB at 2.43 GHz and gain of 1.25 dBi, representative of a good receiver. These antennas can be used as an additional security feature and/or replacement for RFID tag antennas.**

I. Motivation

The Quick Response (QR) code (also known as QR Codes) is a type of matrix two-dimensional barcode that was first utilized in the automotive industry in Japan and later became popular in other commercial products. The code consists of solid squares placed on a larger grid and encodes information of standardized data types such as numeric, alphanumeric and bytes / binary. The QR code appears as a 2-dimensional image that can be scanned and recognized by a camera, personal cellphone or other imaging device and can be translated into a text message, phone number, web address or other.

Counterfeiting costs governments and private industries billions of dollars annually due to loss of value in currency and other printed items [1]. Such security applications for QR codes are currently under consideration, because they can be printed not only using visible inks but also using invisible inks that appear and can be read only using near-IR laser [1]. Moreover, polychromatic QR codes can be printed that include other symbols and messages. This research demonstrates that QR codes, which have been used primarily for information sharing and security applications can also be used for antenna applications. Enabling QR codes with radiating properties (as a receiving or transmitting antenna) adds a new dimension in their applicability as security devices that are hard-to detect and replicate [2]. Moreover, the QR code antenna can transmit a 'key' signal without which the QR code could be counterfeit.

II. QR Code Antenna

The designed QR code represents the "http://www.sdsmt.edu" website address, however the design and methodology presented can be applied in *any* QR code of other internet website addresses as well.

The antenna itself was designed using IE3D and printed with an Optomec M^3D Maskless Mesoscale Material deposition system using direct-write aerosol jetting of a conducting in-house made silver nanoink. The ink conductivity is about 60% of bulk *Ag*, which allows for very high efficiency metallic devices such as this antenna. The same system has been recently used to print PIFA antennas on hydrophobic Paper substrate, successfully [3].

The frequency of operation was chosen to be 2.4 GHz, and depends on the size of the actual printed QR code. However adjustments can be made to alter the frequency without significantly altering the message of the QR code itself. The code can be scanned through any QR scanner. The simulated model of the QR code antenna is shown in Fig. 1 and is 52 mm x 52 mm large. The antenna is printed on Kapton® polyimide substrate with thickness 32-mil (0.8128 mm).

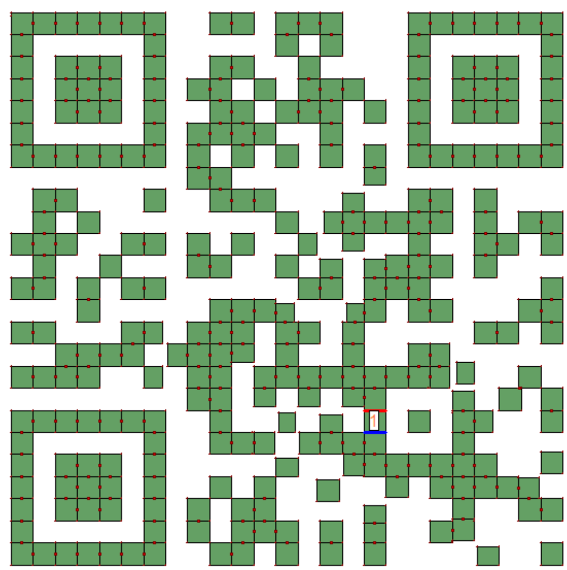

Fig. 1: Simulated model of the www.sdsmt.edu QR code antenna, illustrating the device structure and the feeding port.

III. Simulation Results

As expected, not all QR codes result on an antenna with very low $|S_{11}|$. In fact, many commercial applications require a return loss of 8dB or even 6dB. Smaller $|S_{11}|$ can also be achieved. The simulated S_{11} of the QR code antenna is shown in Fig. 2. The current distribution of the antenna in Fig. 3 shows which areas of the antenna radiate the most. The gain of the antenna near the resonant frequency is shown in Fig. 4 and is +1.5dBi. The antenna has a smooth omnidirectional radiation pattern as shown in Fig. 5 for the two principal plane cuts of the printed device.

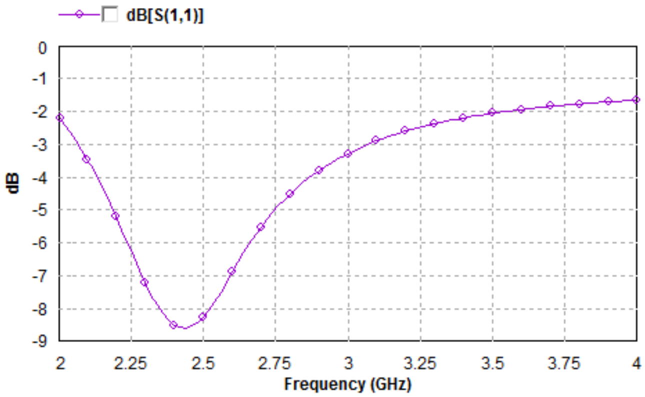

Fig. 2. Simulated $|S_{11}|$ characteristics of the QR Code Antenna.

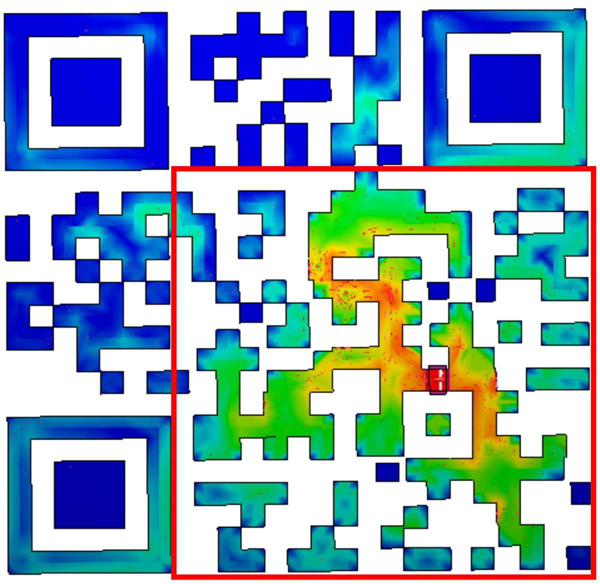

Fig. 3. Current density distribution on the QR code antenna. The red rectangle illustrates the predominantly active area of the antenna where a continuous conducting path exists.

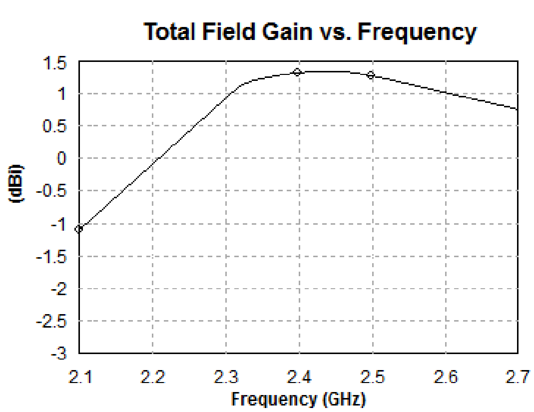

Fig. 4. Gain of the QR Code Antenna.

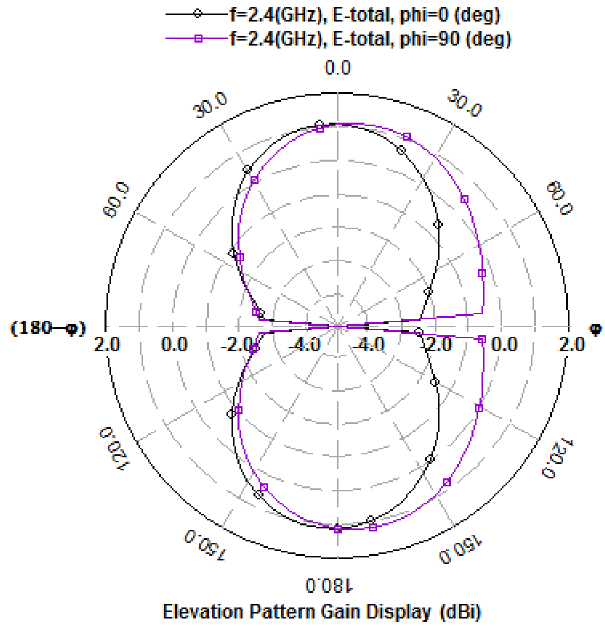

Fig. 5. Radiation pattern of the QR code antenna at the resonant frequency (2.4 GHz) in the two principal places of the printed structure.

Several QR code prototypes were fabricated and measurements will be presented at the Symposium. Also, a detailed discussion on the feeding and the matching of QR antennas will be presented.

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