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2-port cavity-backed slot antenna for reducing matching loss

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***Abstract*— A cavity-backed slot antenna which has two different impedance ports is proposed. Conventional antennas usually have a single port with a fixed port impedance. In a Wireless Body Area Network (WBAN) applications where low transmitting power is required, the optimum output impedance of the transmitter is generally much higher than the conventional antenna impedance (50 ohm) whereas the receiver needs a lower source impedance (50 ohm). In the case of using a conventional antenna impedance, the impedance matching circuit of transmitter causes overall efficiency degradation and narrow bandwidth because of the high impedance transform ratio and the finite Q of the LC element used in the matching circuit. In this paper, 2-port cavity-backed slot antenna which has different port impedances for the transmitter and receiver respectively is proposed. Each port has impedance which is equal to the optimum impedance of the transmitter and receiver.**

In demonstration, it is shown that the bandwidth and radiation patterns at each antenna port are almost identical. Using the proposed technique, the efficiency and bandwidth enhancement can be achieved by reducing the transform ratio of the matching circuit.

I. Introduction

For WBAN applications, various antennas and transceivers are proposed [1], [2]. The transmit power in WBAN applications is generally low compared to those of the other applications because of the safety guide for human body to EM field and the battery capacity. Therefore, the optimum impedance of the transmitter in WBAN applications is usually high compared to the conventional antenna impedance (50 ohm). For the impedance matching between transmitter and antenna, the matching circuit should be used. However, the matching circuit introduces unwanted matching loss due to the finite Q of LC elements. This matching loss causes the overall system efficiency deterioration. This problem can be even more serious in WBAN applications because of a large impedance transform ratio and the limited output power. To relieve the large impedance transform ratio, the current combine technique is used in [3].

In this paper, 2-port cavity-backed slot antenna is proposed. Each antenna port has impedance equal to the optimum impedance of the transmitter and receiver, respectively. The matching circuit is unnecessary in the proposed antenna. In the demonstration, the radiation patterns and the bandwidth are almost identical in each port. With the proposed technique, the matching loss reduction is achieved without changing the antenna characteristics. The higher system efficiency and wider bandwidth are expected with the proposed technique.

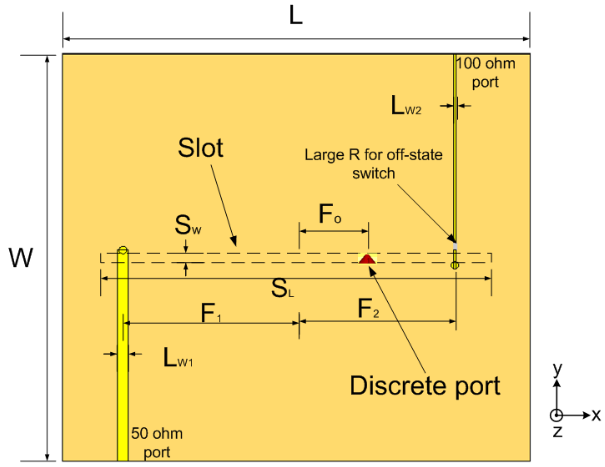


Fig. 1. The proposed antenna structure ($L = 62$, $W = 54$, $S_L = 52$, $S_W = 1$, $F_1 = 23$, $F_2 = 21$, $L_{W1} = 1.48$, $L_{W2} = 0.4$, all in the unit of mm.).

II. Principles of Operation

The cavity-backed slot antenna is utilized for the demonstration of the proposed technique. A cavity-backed slot antenna has attractive figures for WBAN applications like a large front to back ratio and a planar surface. The structures and the dimensions of the cavity-backed slot antenna are described in Fig. 1. The operating frequency is set to 2.45 GHz and antenna dimensions are calculated from the operating frequency. RT 5880 with a height of 1.57 mm is used for the cavity substrate.

In the operation of the cavity-backed slot antenna, The EM field has a TE_{11} mode distribution inside the cavity. The E-field in z-direction is illustrated in Fig. 2. The maximum E-field is observed at the center of the cavity and decreases as the observation point moves to the edge of the cavity. As the port impedance is proportional to the E-field intensity along the port, the port impedance has a maximum value at the center of the cavity and decreases as port moves to the edge of the cavity. Therefore, we can change the input impedance of the cavity-backed slot antenna by moving the feeding position.

Fig. 3 shows the simulated input resistance of the cavity-backed slot antenna with a various feeding positions. As we expected, input impedance increases as antenna port moved to the center of the cavity.

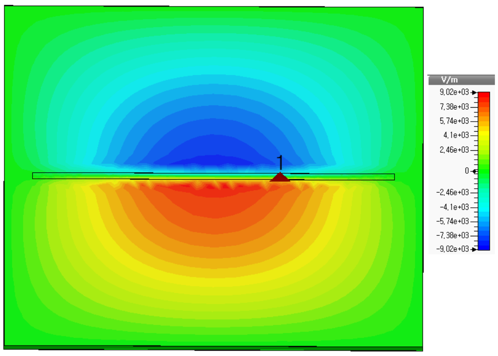


Fig. 2. E-field distribution inside the cavity in z-direction

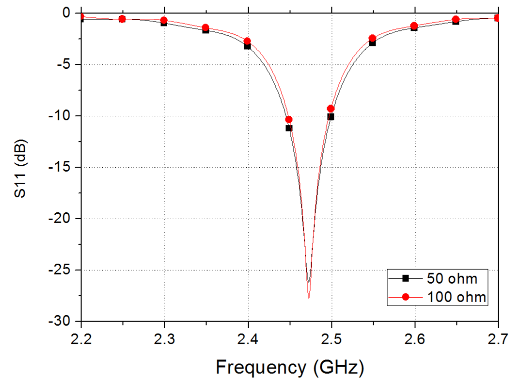


Fig. 4. Reflection coefficient of each port

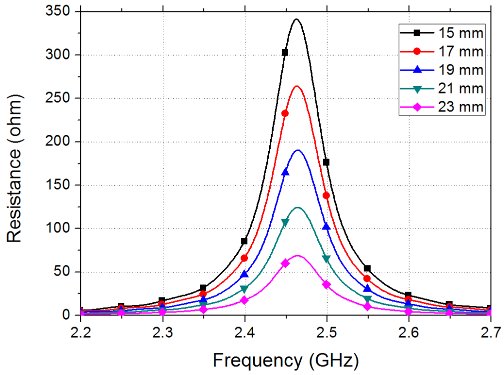
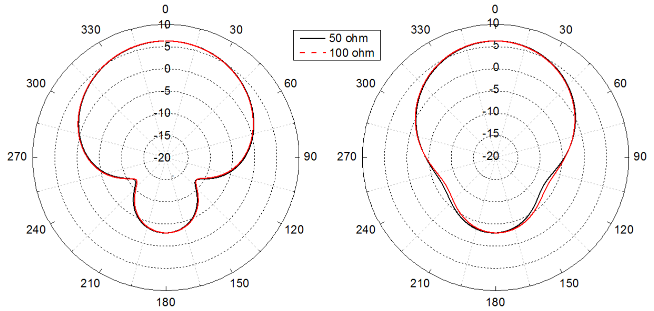


Fig. 3. Antenna input resistance with different feeding positions (F_o)



(a) E - Plane (b) H-plane

Fig. 5. Radiation patterns of the proposed antenna

For the optimum 2-port design, each feeding point can be determined from the optimum impedance of the receiver and transmitter. By feeding the antenna at the determined feeding point, 2-port cavity-backed slot antenna with optimum impedance can be achieved

III. Simulation Results

For the demonstration of the proposed technique, we designed 2-port cavity-backed slot antenna with the different port impedances (50, 100 ohm). RT 5880 substrate with a height of 0.5 mm is used for the microstrip feed line substrate. At each feeding point, microstrip lines with different characteristic impedances are connected.

In the real situation, a switch is used for connecting the transmitter or receiver to the antenna. We used large resistance (1 Mohm) instead of the off-state real switch. In the simulation, one port is connected with a large series resistance while the other port is operating. The simulation is conducted using CST microwave studio.

Fig. 4 shows the simulated reflection coefficient of each port with the port impedance (50, 100 ohm). It is shown that each port has almost same bandwidth around the 2.45 GHz. The radiation efficiency is simulated to 92.6% (100 ohm) and 93.1 % (50 ohm) respectively.

Fig. 5 shows the radiation patterns of each port in E-plane(y-z) and H-plane(x-z). As the 2-port uses the same radiating structure, they show almost identical patterns.

IV. Conclusion

2-port cavity-backed slot antenna is proposed for reducing matching loss between transmitter and antenna. The proposed antenna has two different antenna impedances which are optimum for the transmitter and receiver.

In the simulation, two ports shows almost identical bandwidth, radiation efficiency, radiation patterns in the operating frequency. Using the proposed technique, the efficiency and bandwidth enhancement can be achieved by reducing the transform ratio of the matching circuit.

Acknowledgment

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