Wireless Pads for RFID reader

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1. Introduction

RFIDs are used to transmit data and electric power simultaneously in many applications such as product management, public transport ticket and so on. RFID was introduced in 13.56 MHz band by the electromagnetic induction coupling. It has an advantage of high transmission efficiency, while its drawback is short transmission distance and low data rate. To extend the RFID applications, the frequency band of UHF (900 MHz) and 2.45 GHz band are recently used for long range and high data rate transmission. As a medium range distance application, reader pads are expected to use as medicine deliveries and product managements. These applications need to detect RFID in wide area without reading errors.

Free access mat by the sheet-like waveguide has been proposed as wireless reader pads using UHF band [1][2]. Free access mat, as shown in the Fig. 1(a) consists of double layered microstrip resonator array strongly coupled each other. Its coupling characteristics in Fig. 1(b) show the coupling deviation of 9 dB in peak-to-peak amplitudes. Its transmission characteristics of two different antenna alignments in Fig. 1(c) are almost the same because of its symmetrical structure. Free access mat has high transmission efficiency, however its double layered structure is not easy for mass production process.

This paper presents two type of one layer wireless pad using microstrip structure. First, we discuss a wireless pad using a microstrip filter geometry. To decrease its polarization dependence loss, we change the geometry of filter arrangement and receiving antenna structure. Next, we examine circularly polarized feeding antennas for RFID antennas with a freedom of its orientation and polarization. We discuss these wireless pads to obtain uniform coupling level between the pad and RFID antenna in the followings.

2. Wireless pad by microstrip filter structure

Fig. 2 shows a microstrip filter used as a basic component of wireless pad. Half-wavelength resonator filters are connected in series as an one-dimensional array structure as shown in Fig. 3(a), where the substrate thickness is 0.8 mm and its dielectric constant is 2.6. At 2.45 GHz, the transmission characteristics in Fig 3(b) show small insertion loss of -2.56 dB.

Next, the coupled power to receiving antenna is measured by the linearly polarized patch antenna. The output of -10 dBm from a signal generator is applied to wireless pad and received power is measured using a spectrum analyzer. The height of the receiving antenna is 1 mm. In the experiment, we determine the orientation of the receiving antenna as shown in the Fig. 4. The measured S_{21} along the y axis in Fig. 5 show that received power becomes very weak in case of that the polarization of receiving antenna does not coincide with the pad direction. Then, we examine two dimensional geometry for the pad to improve the received power level fluctuations.

As shown in Fig. 6(a), we bend strip line into 45° to make a diamond shaped line. The measured S_{21} is -6.25 dB. In the same manner as the straight structure pad, we measured coupled power of receiving antenna on the xy plane, where the average reception level is shown in the caption. The measurement results in Fig. 7 show that fluctuations of received power in each antenna direction are decreased, however the received power is still weak at a particular angles of 45°, 90°.

From the above results, the received power by a linear polarized antenna becomes weak at a particular direction. Then, we try to improve these effects by using a circularly polarized receiving antenna. We use a conventional truncated-corner circularly polarized antenna and the average received power is improved compared with the linearly polarized antenna. However, the received power is weak at a 45° orientation.

In the next step, we change the shape of radiating element and the feeding structure. The rectangular patch antenna is fed on the diagonal line to decrease the reception level variation. In addition, the truncated-corner antenna has strong coupling at the direction of 0° and 90° and the rectangular patch is strong at the direction of 45°. Then, we combine these two shapes into one body as shown in Fig. 8. In the measurements of received power by this antenna, we obtain good performance for the antenna height is 15 mm. The results in Fig. 9 show that the average received power level in each direction becomes uniform, and its deviation is about ±6 dB.

3. Wireless pad by planar microstrip antenna

As the last example, we present a circularly polarized feeding element surrounded by parasitic microstrip antennas. It is better to use arbitrary antennas without dependence on the antenna orientation by the introduction of a circularly polarized wave wireless pad. A wireless pad using the truncated patch antenna has strong coupling at feeding element and large reception level deviations. To scatter current distributions on the patch surface, we use a silted patch to excite circularly polarization, where different lengths crossed slit is cut at the center of the patch antenna. This antenna is electrically smaller than the conventional truncated-corner antenna, and has broad radiation pattern. We design a wireless pad with parasitic elements to have uniform received power. Its structure and characteristics are shown in Fig. 10. In this case, the target frequency is 2.4 GHz. We calculate the received power for a linear polarized antenna. The output of 1 V is applied to wireless pad and received power is calculated. The height of the receiving antenna is 1 mm. Fig. 11 shows the simulation results. The average reception levels are increased by 10 dB rather than the pad in section 2, and the deviation is about 16.6 dB.

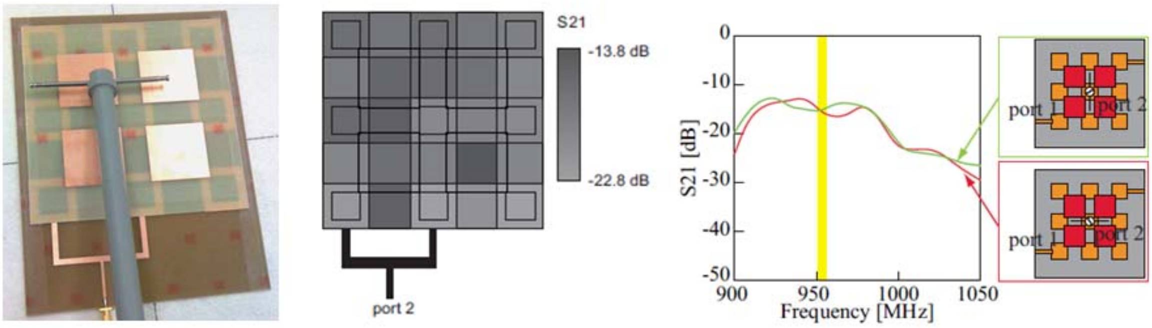
4. Conclusion

In this paper, we proposed one layer wireless pads using microstrip structures. First, we designed one-dimensional straight pad using microstrip bandpass filter. In order to extend this pad to the two-dimensional structure and to improve of its characteristics of the receiving antenna orientation, we proposed a diamond shaped structure. We optimized the structure of the receiving antenna to improve the uniformity and orientation characteristics of the received power for this pad. As a result, the average received power level in each direction becomes uniform, and its deviation is about ±6 dB. Next, we proposed wireless pad by planar microstrip antenna. To reduce its performance deviation on the orientation of the receiving antenna, we designed wireless pad using a circularly polarized antenna. In addition, we optimized this structure of circularly polarized antenna. As a result, the average value of the received power is almost uniform, and the deviation is about 16.6 dB.

References

[1] K.Eom, “Sheet-like Waveguide for short Range Wireless Access,” Master dissertation, Yokohama National University thesis, 2008.

[2] K.Eom, “Sheet-like Waveguide for Short-Range Wireless Communication and Its Applications,” Doctoral Dissertation, Yokohama National University, 2011.



(a) Free Access Mat (b) The coupled characteristics (c) S_{21} characteristics of FAM

Figure 1: Free access mat, and its coupling characteristics

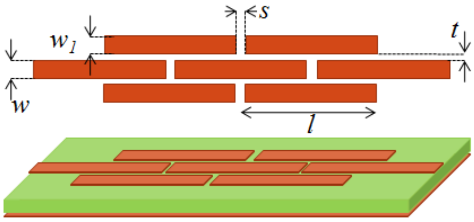


Figure 2: Basic component of microstrip filter

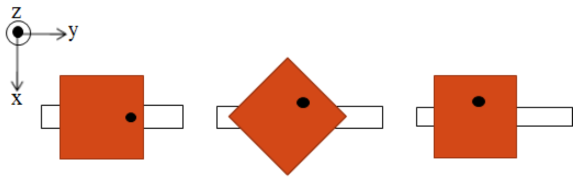
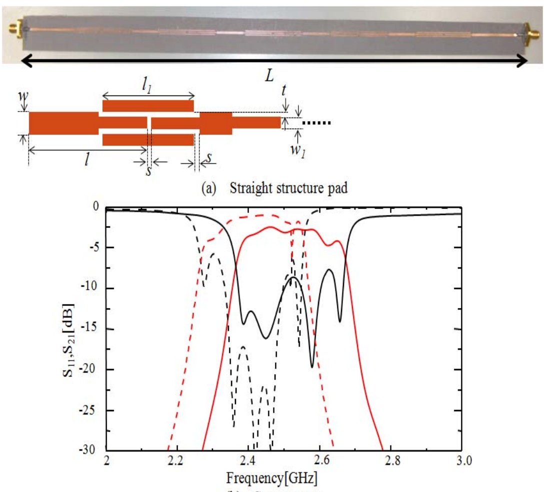


Figure 4: The orientation of the receiving antenna



(a) Straight structure pad

(b) S-parameters

Figure 3: Straight pad, l=62.4, l_1=41.6, w=2, w_1=1, s=1.0, t=0.2, L=379.4 [mm]
black: S_{11}, red: S_{21}, solid: Mea., dash: Cal

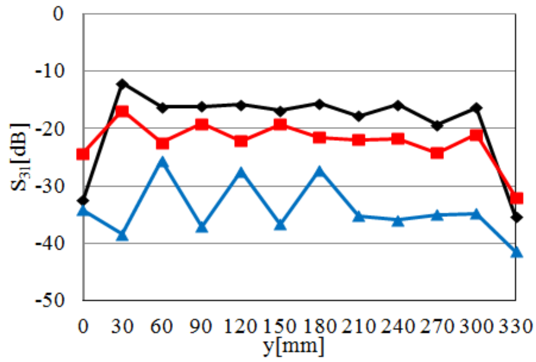
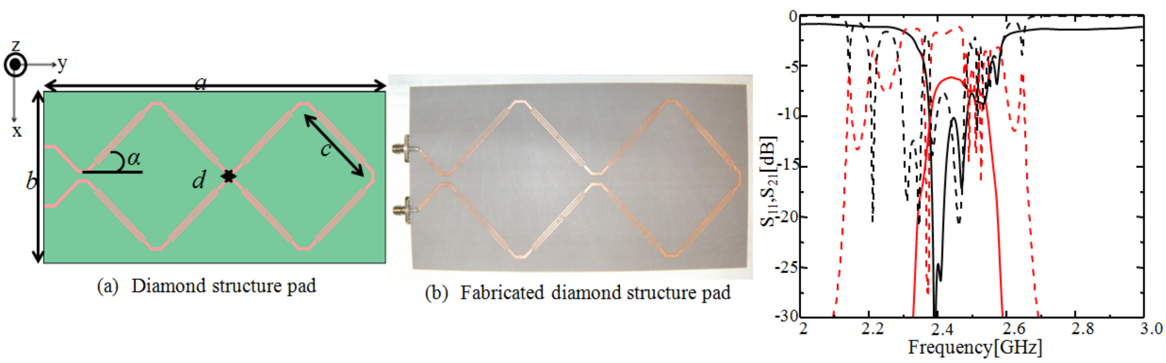


Figure 5: S_{31} characteristic in straight pad
black: 0°, red: 45°, blue: 90°



(a) Diamond structure pad (b) Fabricated diamond structure pad (c) S-parameters

Figure 6: Diamond structure pad, a=210, b=100.0, c=55.8 , d=6.6 [mm],
black: S_{11}, red: S_{21}, solid: Mea., dash: Cal.

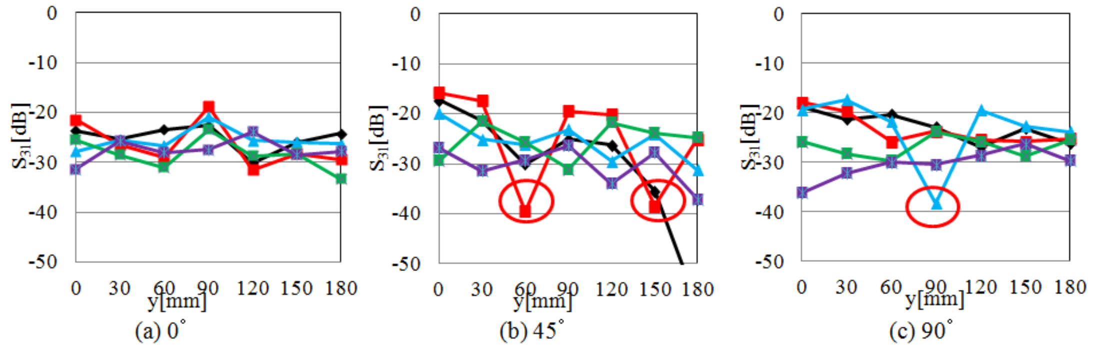
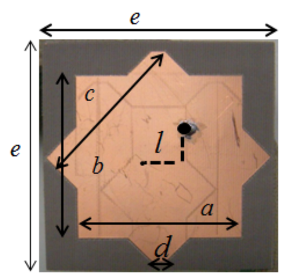


Figure 7: S_{31} characteristic in each direction of the receiving antenna, (a) average is -26.59 dB, (b) average is -27.43 dB, (c) average is -25.33 dB, black: x=0, red: x=20.0, blue: x=43.0, green: x=66.0, purple: x=86.0 [mm]



a=35.8 ,b=35.4 ,c=34.5, d=3.0,e=50.0,l=6.0[mm]

Figure 8: Geometry of proposed antenna

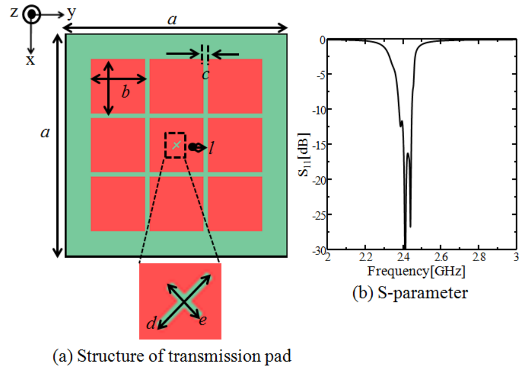


Figure 10: The wireless pad using microstrip antenna, a=150, b=37.0, c=3.0, d=10.0, e=8.0, l=7.8 [mm]

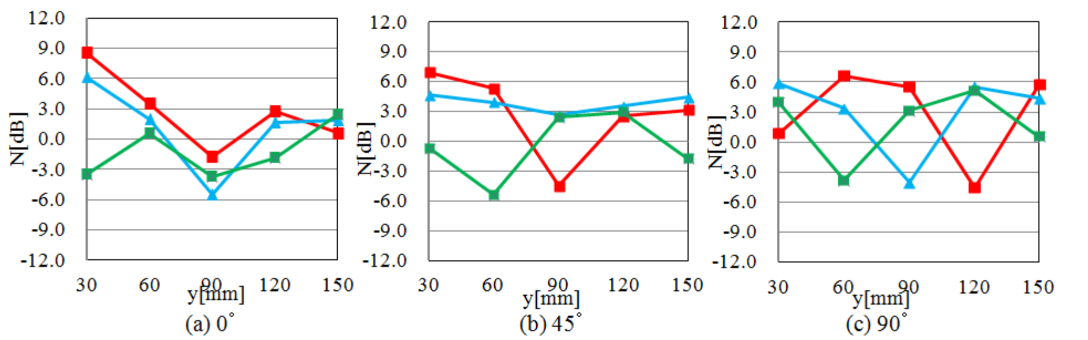


Figure 9: Deviation of S_{31} by proposed antenna, (a) average is -27.50 dB, (b) average is 25.63 dB, (c) average is -26.85 dB, red: x=20.0, blue: x=43.0, green: x=66.0 [mm]

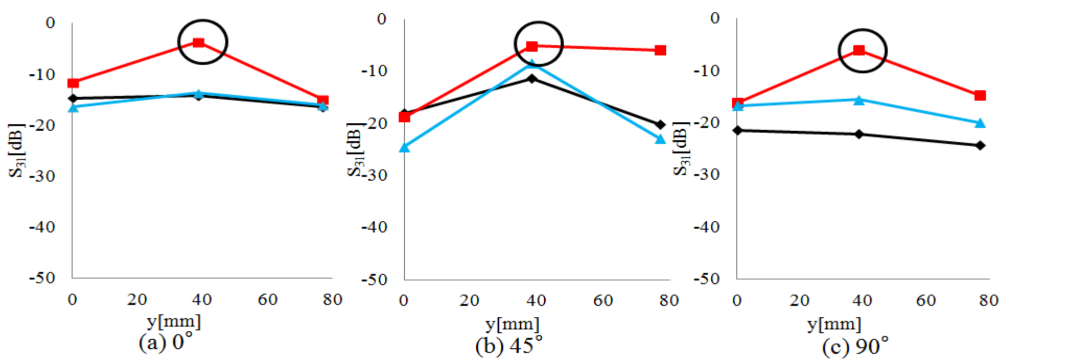


Figure 11: S_{21} characteristic of wireless pad by planar microstrip antenna, (a) average is -13.52 dB, (b) average is -15.10 dB, (c) average is -17.49 dB, black: x=0, red: x=38.5, blue: x=77.0 [mm]