Effect of Side Mirror as Reflector for vehicle RFID tag antenna

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1. Introduction

RFID system is the technology providing the capability of wireless recognition of unique ID of object from the wireless tag attached to the object through the back scattering of electromagnetic wave radiated from the reader [1]. The latest RFID technology is applied to a various fields amid the advancement of ubiquitous industry. Specifically, this technology for vehicle RFID system is often applied to save the money and to elevate the efficiency of management in apartment complex, industrial complex and toll gate in high way [2]. The automatic management of RFID system can reduce the time of gate passage more than the manual management by human. It means that this system gives the economic and convenient safety life. In order to provide service mentioned above, many researches of RFID system for automotive applications have been conducted [3] ~ [6]. As one example of application, the researches on RFID tag position which is to be attached to vehicle have been also considered and studied for the identification ratio improvement [6]. In addition, the electric properties of RFID tag antenna are affected depending on the object of vehicle such as conductor of car body, bumper composed of polyurethane and window glass, which makes the impedance change. This impedance effect appears the tag antenna performance presented the readable range and identification error ratio. Therefore, the tag antenna design needs to consider absolutely the surrounding environment where the tag antenna is installed, as well as the car object to be attached. The authors have been proposed the design for active and passive RFID tag antenna using vehicle side mirror. Because most of auto vehicles have two side mirrors, it can reduce the error of identification ratio comparison with one tag antenna system relatively. Another advantage to increase identification rate is an antenna design which are operated at active and passive tag band with dual resonance frequency bandwidth. Vehicle side mirror is composed of glass and the plated surface with silver. The plated mirror surface with silver operates as conductor. The electro-characteristics of RFID tag antenna placed in vehicle side mirror are changed by the plated mirror surface. This paper presents the effect of the plated side mirror with silver for vehicle RFID tag antenna.

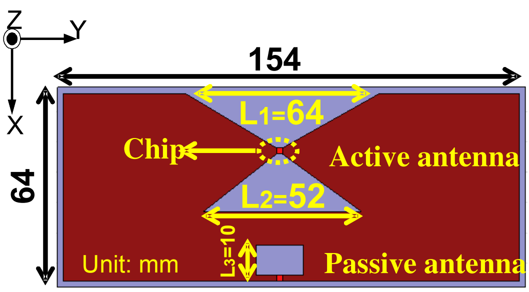
2. Design of tag antenna

Fig. 1 shows the design structure of proposed dual resonance tag antenna with the vehicle side mirror case. It is composed of polyurethane as side mirror case, glass and the plated mirror with silver. Even though the kinds of national side mirror size are various, the considered standard side mirror case size in design is 240 mm X 140 mm X 62 mm used practically. A substrate and a chip impedance in design are ε_r= 2.25 and 16 - j131 Ω, respectively. Also mirror case substrate is ε_r= 5.5. The input impedance of tag antenna is matched to 16 + j131 Ω for the maximum transmission power. The antenna has dual resonant frequency of active (433.92 MHz) and passive (900 MHz) tag band to reduce identification error. Fig. 2 (a) shows the structure of tag antenna with only vehicle side mirror case without mirror. In order to evaluate effect of side mirror case, fig. 2 (b) shows the calculated return loss with respect to only antenna of fig 1 (a), and fig 2(a) with antenna and side mirror case. Tag antenna is located on inside of mirror case and distance (D) between antenna and mirror, is fixed 0 mm in design. The calculated resonant frequency of tag antenna is moved by with and without mirror case. Because of high permittivity of vehicle side mirror case composed of polyurethane, resonant frequency moved toward the low frequency band comparison with the proposed tag antenna without case. Fig. 3 shows the calculated return loss with respect to the structure of fig. 2(a) with the plated mirror surface with silver. Because resonant frequency is shifted by mirror case as shown in fig. 2 (b), design parameters of the tag antenna of Fig. 1 (a) must re-calculate. Table 1 show the optimized parameters by re-calculation when distance (D) equals to 0 mm. The surface of glass coated by silver performs as good mirror and the coated surface operates as conductor. Because of mirror operated as conductor, the mirror is operated as like a reflector and the dual resonance generates as shown fig. 3 (a) and (b). Fig. 3 (a) and (b) show the calculated return loss of distance variation for active and passive tag antenna, respectively. Active antenna resonant frequency at interested band is not shifted anymore and the return loss is also not almost changed even though distance is changed as shown in fig. 3 (a). However, in case of passive antenna, because the wavelength of passive antenna is shorter than active antenna, the return loss is changed. As shown in fig. 3 (b), if D increases, distance between antenna and mirror is short and capacitance component becomes increase. Therefore, the resonant frequency of passive antenna reacts very sensitive in high frequency band. Fig. 4 shows the 3D radiation pattern by distance variation of active antenna calculated at 434 MHz. When distance variation increases, directivity gain increased. It means that the plated mirror surface with silver operated as reflector is added as the active antenna. As mentioned in fig. 3 (a), the reason is that the phase between antenna and mirror as reflector is not changed even if distance is changed. When D= 25 mm, directivity gain appears 2.35 dB.

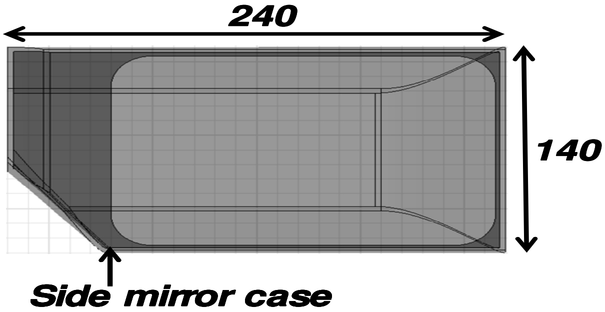
3. Conclusion

This paper presents for the effect of side mirror as reflector for vehicle RFID tag antenna. Optimum parameters of tag antenna structure with the side mirror case are calculated and the dual active and passive band design is conducted. It seems that the plated mirror surface with silver of a vehicle performs as like a reflector. Dual resonances at active band are generated by the mirror as reflector. It is interesting point in calculation that antenna directivity gain can be controlled by distance between tag antenna and mirror even though tag antenna structure with mirror case is not changed.

4. Figures



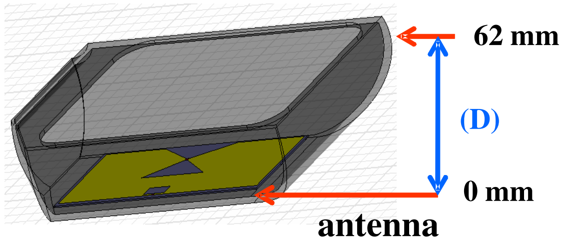
(a) The proposed tag antenna



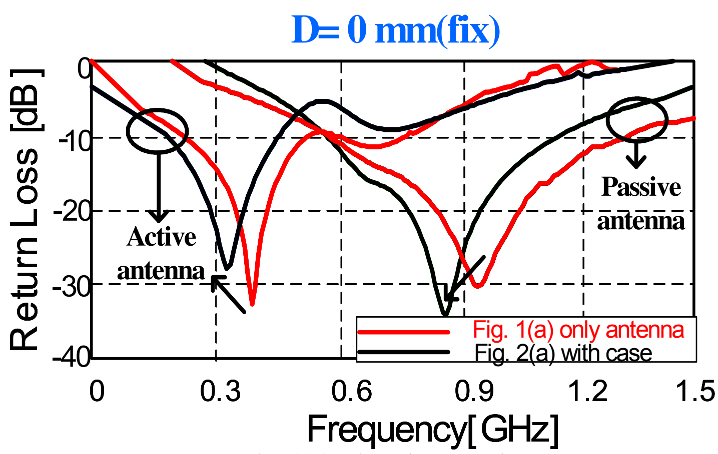
(b) Front view of side mirror case

(c) Side view of side mirror case

Fig. 1. The proposed dual tag antennas structure with side mirror case.



(a) The structure of tag antenna with side mirror case without mirror

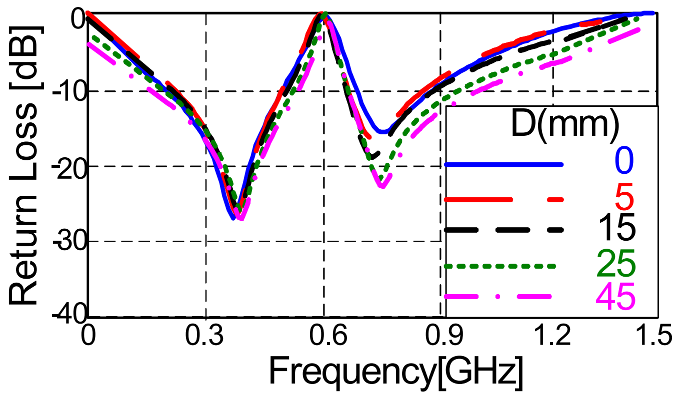


(b) Calculated return loss

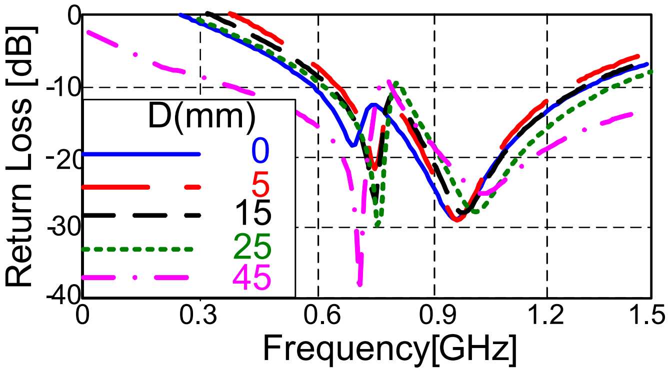
Fig. 2. The tag antenna structure with side mirror case and the calculated return loss with respect to structure with and without side mirror case.

Table 1. The calculated parameter values of re-calculation tag antenna.

Chip impedance	L_1	L_2	Antenna size
16- j131 [Ω] Unit: mm	55	47	154 X 64
	L_3	Chip size	
	9	2 X2	

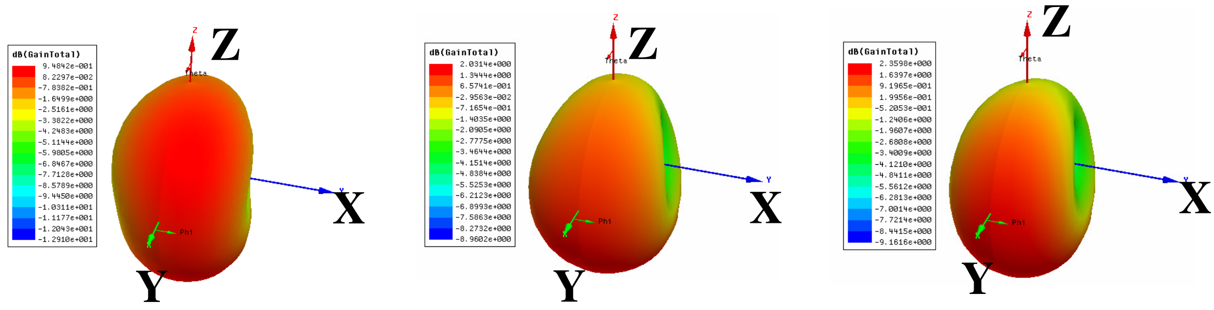


(a) The calculated active antenna distance (D)



(b) The calculated passive antenna

Fig. 3. Comparison of return loss according to antenna distance (D).



(a) 0.94 dB @ D=0 mm

(b) 2.03 dB @ D=15 mm

(c) 2.35 dB @ D=25 mm

Fig. 4. Comparison of directivity gain according to D variation.

Acknowledgments

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