

Telematics and ITS Integrated Vehicular Antenna with CRLH-TL Parasitic Element

Takuma SAWAYA¹, Junya MURAMATSU², Akira HISHIDA¹, Junzo OOE¹,
Toshiaki WATANABE², Kazuo SATO²
¹ TOYOTA MOTOR CORPORATION
1 Toyota-cho, Toyota, Aichi, 471-8572, Japan, takuma@sawaya.tec.toyota.co.jp
² TOYOTA Central R&D Labs., Inc.
41-1 Yokomichi, Nagakute, Aichi, 480-1192, Japan, muramatsu@mosk.tytlabs.co.jp

1. Introduction

Vehicle-infrastructure Cooperative Systems (In this paper we call it “ITS” because of a space constraint) is one of measures that may help to reduce traffic accident through vehicles and roadside infrastructure work together [1]. It provide driver cognitive support to prevent miscalculation or against the traffic rule through communication between road infrastructure and vehicles about traffic regulatory information or existence of pedestrians and other vehicles. It originally expected 720-MHz band for Vehicle-infrastructure Cooperative Systems and now 760-MHz band is allocated for this service. In any case, the frequency band closes a mobile phone frequency.

The present vehicle already equipped Telematics based on mobile phone technology and the telephone antenna is installed on the vehicle rooftop. Because vehicle-to-vehicle communication planned for Vehicle-infrastructure Cooperative Systems, rooftop is one of the preferred installation positions for ITS antenna. But it is difficult that vehicle antenna get larger because of the restriction of design. So proximity integration technique to reduce coupling of those antenna elements is required and it is major design challenge for future integration vehicle antenna. In this paper authors developed rooftop antenna prototype adopted the parasitic element based on CRLH Transmission line and evaluated in purpose of reduce telematics antenna element and ITS one.

2. Aerial Mutual Coupling Reduction Technique with CRLH-TL

2.1 Traditional Technique for Aerial Mutual Coupling Reduction

Figure.1 is brief overview of traditional technique applied to attenuation mutual coupling of proximity aligned antenna elements. A simple way to reduce that mutual coupling is inactive one antenna at the bandwidth using the other antenna as shown in Figure.1 (a). The mutual coupling level between two High Q antennas that use different frequency band is small. But vehicle rooftop antenna typically consists from monopole type antenna element because it require wide-band characteristic on the metal roof for such as mobile phone service. Thus unnecessary radiation around its frequency band is inevitable on some level. Figure1 (b) shows a technique that reduce a mutual coupling between two antenna elements using closed frequency band with a metal plate or parasitic element. But this technique cannot achieve desirable directivity because of the effect of metal plate or parasitic element. Typically an omnidirectional antenna in X-Y plane such as monopole type element is adopted for vehicle rooftop antenna. Generally miniaturization of antenna main body is also difficult because the antenna gain will drop within wide band if the distance of both elements is shorter than $1/4\lambda$.

2.2 CRLH Transmission Line-based Mutual Coupling Reduction Technique

Mutual coupling reduction technique that we proposed on this paper adopt the narrow rejection band when CRLH-TL(Composite Right/Left Handed Transmission Line) [2] place near the radiation element. It is expected that rejection band produced by CRLH-TL parasitic element will inhibit mutual coupling between antenna radiators. One of the reasons is antenna gain of

undesired frequency band will decrease by the reflection characteristic change. The other is directional pattern change. In this paper development target of isolation is larger than 15 dB on both frequency bands.

3. Experiments

3.1 Setup

The integration antenna sample that combined the antenna elements for ITS and mobile phone antenna (Figure 3) is adopted for the experiments of mutual coupling reduction effect. CRLH-TL parasitic element is mounted on the antenna radome. Figure 3 (a) shows rooftop integration antenna with CRLH parasitic element. CRLH parasitic element is formed on flexible polyimide sheet with thickness 50 μ m and it put on the antenna radome made from a kind of plastic material [2]. As shown in Figure 3 (b), both ITS and mobile phone element are designed as independent antenna. The distance between feed point of element is 25mm ($\approx 1/18\lambda$ @ 750 MHz). Figure 4 shows reflection (S11) and isolation (S21) measurement result of rooftop antenna sample without CRLH-TL parasitic element. Isolation is 11.7 dB at 720 MHz and 29.5 dB at 850 MHz. The bandwidth of ITS is 10 MHz so the Q of antenna radiator can be set higher to reduce coupling in mobile phone band.

Because of mutual coupling effect between the parasitic element and each radiator, the rejection bands that are produced by CRLH-TL parasitic element changed. We modified CRLH-TL parasitic element design and its installation position to make rejection band around 680MHz band for ITS element, and around 720MHz band for mobile phone element in the purpose of reducing mutual coupling of these two antenna without effect for Vehicle-infrastructure Cooperative Systems.

3.2 Measurement results

Figure 5 shows reflection and coupling characteristic of the antenna under test. For comparison this picture is also include the antenna mutual coupling measurement results without CRLH parasitic element. The reflection characteristic of both two antenna elements show it will produce rejection band around 680 MHz on the ITS antenna, and around 715MHz on the mobile phone antenna while at the same time it achieved less than -10 dB reflection on the ITS antenna element.

And when we compare the coupling characteristic between both antennas with / without of CRLH-TL parasitic element, the amount of isolation is 16.4 dB so it reduced 4.7 dB as compared without CRLH-TL parasitic (Figure 5). This experimental results show adjustment of the position of two proximity aligned antenna radiators and CRLH-TL parasitic element form different rejection band at each radiator. It reduce mutual coupling with little or no loss of the radiation band both ITS and mobile phone radiator. It is confirmed that proposal technique is effective for mutual coupling reduction of the rooftop integration antenna.

4. Conclusion

We propose mutual coupling reduction technique with CRLH-TL parasitic element concern for integration of some antenna elements on the vehicular rooftop antenna and it is confirmed that the proposal is effective through the experiment of prototype antenna. An optimal alignment technique about radiator and CRLH-TL parasitic is the subject of future investigation. For practical use, mutual coupling reduction will be expected through the patterning of CRLH-TL on the antenna radome when it does not have impact on the outer design and installation space.

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Figure 1: Present vehicle rooftop antenna for Telematics service

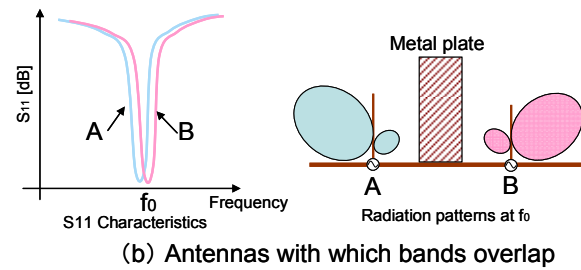
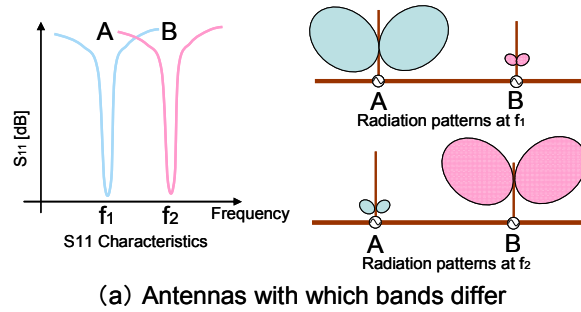
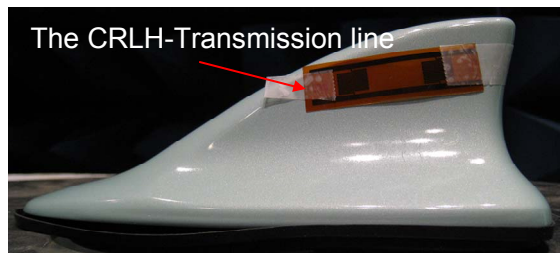
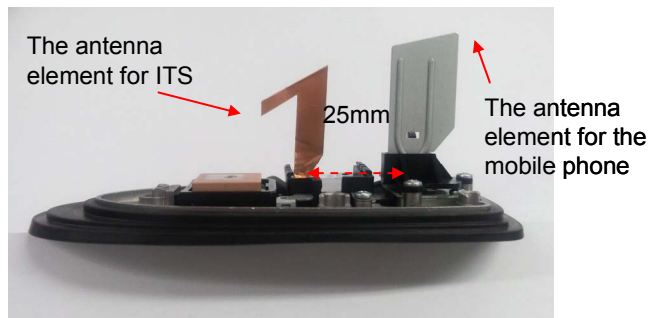


Figure 2: Traditional Technique for Aerial Mutual Coupling Reduction



(a) Appearance of the antenna module



(b) The inside of the antenna module

Figure 3: Measurement antenna configuration

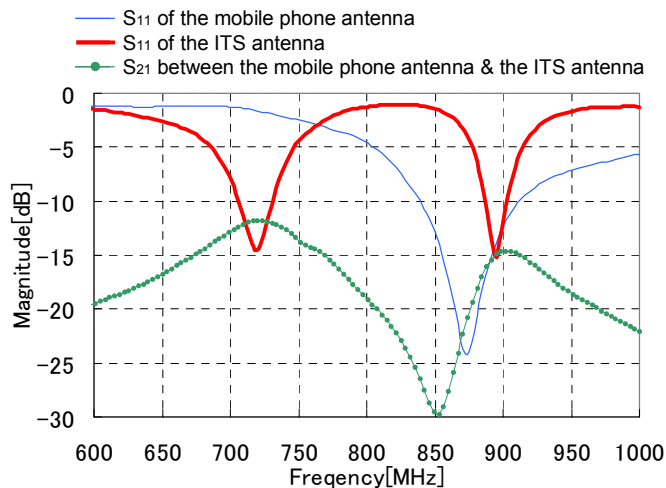


Figure 4: Reflection and mutual coupling results of prototype without CRLH-TL parasitic element

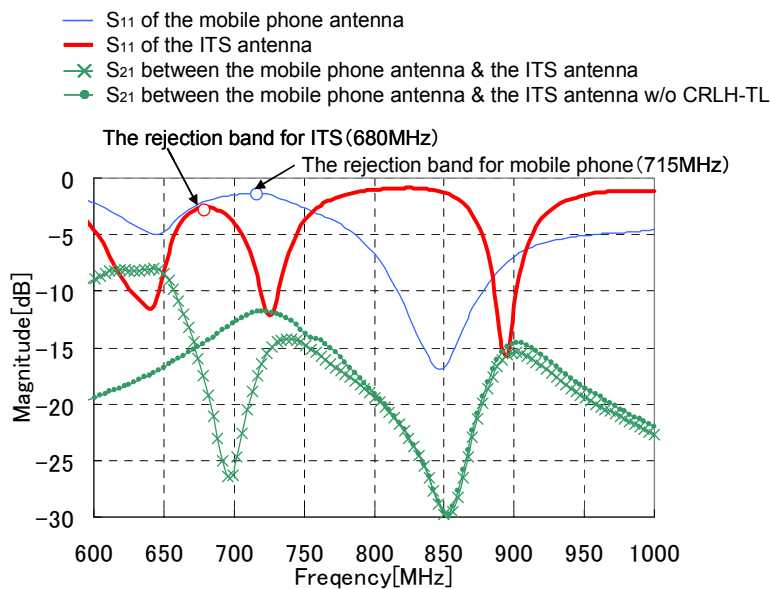


Figure 5: Reflection and mutual coupling results of prototype with CRLH-TL parasitic element

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