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RCS classification on ground moving target using lte passive bistatic radar

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Abstract: Detection and location on the ground moving target are a function of dependent bistatic Radar Cross Section (RCS) and radar design parameters which in this experimental study used LTE signal as a source for passive bistatic radar (PBR). Ground moving target also can be classified in dimensions using conventional processing approaches which we performed a simulation using Computer Simulation Technology (CST) Microwave studio. The target bistatic radar cross-section will give a realistic calculation on PBR performance with the requirement of complete treatment. Three models of ground moving target are designed using Autodesk software which the models are classified as compact car, saloon car and sport utility vehicle (SUV) for size of small and medium and large respectively. The designs are for observation on the performance of RCS using a bistatic area between transmitter and receiver with the frequency transmit signal from long-term evolution (LTE) based station is 2.6 GHz and with far-field conditions. The simulation results show that largest area of ground moving target, SUV had better outcome compared to other ground moving target which reliable with Babinet's principle, which declares a target of physical cross-sectional area is proportionate to RCS. Different cross-sectional area of transmitting signal from other ground moving target give smaller RCS which cause from the reduction area of reflected signal such as compact car according to small size and saloon car according to medium size. This might improve the sensitivity of LTE passive bistatic radar if using greater size of ground moving target for a better RCS performance.

Key words: RCS; Ground moving target; CST; LTE; Passive bistatic radar

1. Introduction

This paper describes the classification of the passive bistatic radar cross section (RCS) on ground moving target with simulation using Computer Simulation Technology (CST) Microwave studio. Passive bistatic radars used illuminators of opportunity as transmitters. Illuminators of opportunity are transmitters that are already present in the environment, such as analog TV transmitters, digital video broadcast-terrestrial (DVB-T) TV transmitters, or mobile phone base transceiver stations (BTSs). We propose to use one or multiple illuminators of opportunity as source of radar illumination, as in (Willis and Griffiths, 2007). Different characteristics of the signals transmitted from illuminators of opportunity such as their location, modulation, polarization and frequency which could not be controlled. Hence, we choose to use of long-term evolution (LTE) as an illuminator of opportunity for passive radars investigation (Salah et al., 2014).

Radar configurations can be classified as mono-static and bistatic as shown in Fig. 1. The configuration of passive radar is related to bistatic radar where LTE base station is considered as the transmitter. The transmitter and receiver are separated by a distance comparable to the maximum range of a target. The angle between the transmitted and reflected rays is a bistatic angle, β as shown in Fig. 1 (b) (Willis and Griffiths, 2007).

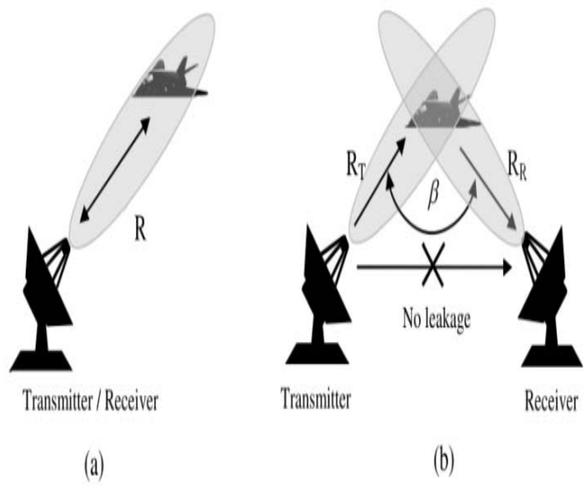

Fig. 1: Radar systems: (a) monostatic radar (b) bistatic radar

Passive radar introduces a receiver without a co-located transmitter and enhanced compare to conventional radar system (Salah et al., 2014). In Fig. 2, it shows the bistatic geometry for passive radar using illuminator of opportunity (Abdul Aziz et al., 2015).

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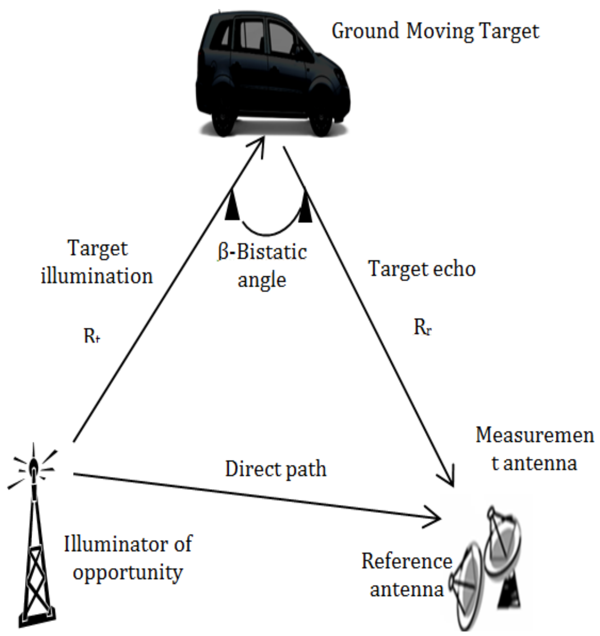

Fig. 2: Bistatic geometry for passive bistatic radar.

2. Evaluation RCS on ground moving target

2.1. Target bistatic RCS

The forward scatter region is encountered when the bistatic angle is increased to 180°. In this region target cross-sections can be considerably enhanced (Cherniakov, 2008). This is explained by Babinet's principle which says that the forward scatter from a perfectly absorbing target is the same (apart from a 180° phase shift) as that from a target shaped aperture in a perfectly conducting sheet, which for a target of physical cross sectional area A gives a radar cross section of:

$$\sigma_b = 4\pi A^2/\lambda^2 \quad (1)$$

Where A is the silhouette area and λ is the radar wavelength.

The angular width of the scattered signal in the horizontal or vertical plane is given by:

$$\theta_b = \lambda/d \quad (2)$$

Where d is the target linear dimension in the appropriate plane. Fig. 3 shows the dependence of radar cross section, σ_b and angular width, θ_b on frequency, for a target area with A is 10 meter squared and d is 20 meter, showing that σ_b increases with the frequency as the forward scatter in concentrated into an increasingly narrow beam.

In order to justify data for target classification, understanding about radar cross section (RCS) is needed. RCS stated that not all of the radiated signal fall on the target. Certain of the radiated signal might be absorbed and some of the reflected signal is not distributed equally in all directions (Sweetman, 2008). The RCS of target depends on the target's physical geometry and exterior features, the direction of the illuminating radar, the radar transmitter frequency and the types of material used (Gashinova et al., 2010).

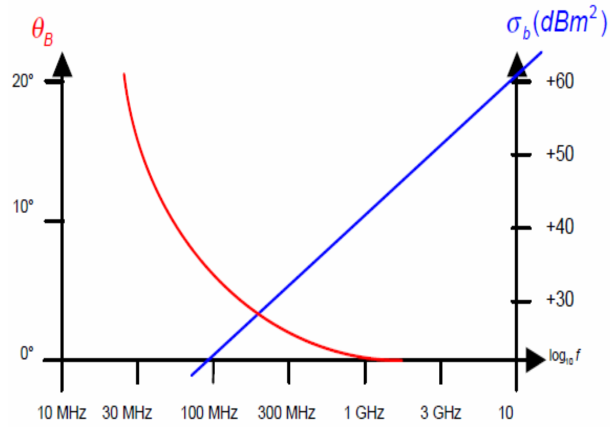

Fig. 3: Variation of forward scatter RCS and angular width of response (d=10m, A=10m²)

2.2. LTE

Long-Term Evolution (LTE) is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the Global System for Mobile Communications/ Enhanced Data for GSM Evolution (GSM/EDGE) and Universal Mobile Telecommunications System/ High Speed Packet Access (UMTS/HSPA) network technologies, increasing the capacity and speed using a different radio interface together with core network improvements (3GPP LTE Encyclopedia, 2010 and Motorola, 2010). The standard is developed by the 3GPP (3rd Generation Partnership Project). For urban areas, higher frequency bands such as 2.6 GHz are used to support high speed mobile broadband (LTE World, 2011).

The remarkable characteristics that are integral to the LTE signal, which encourage the utilisation of the LTE for passive bistatic radar, are the broad bandwidth and the extent of the carrier frequency band. Additionally, the LTE employs the orthogonal frequency division multiple access (OFDMA) that promises low side-lobes for the ambiguity function (Ahmadi, 2009). Certainly, the features mentioned make the LTE signal attractive for use in passive bistatic radar systems. Thus, 2.6 GHz is used for simulation on ground moving target to evaluate radar cross section performance.

2.3. Autodesk

Autodesk is the software for the architecture, engineering, construction, manufacturing, media, and entertainment industries (United States Securities and Exchange Commission, 2014). Autodesk became best known for AutoCAD but now develops a broad range of software for design, engineering, and entertainment as well as a line of software for consumers which most used in the manufacturing industry to simulate, visualize, and analyze real performance using digital model. This software is used to design the model of ground moving targets which are compact car, saloon car and sport utility vehicle (SUV) which are used in our investigational study. Fig. 4 shows three grounds moving targets and classified in size as small, medium and large respectively.

Fig.4: Ground moving target classification block diagram by using passive bistatic radar systems

3. Methodology

A model of ground moving targets is designed in Autodesk software with a real dimension of length, width and height. Fig. 5 shows the model of compact car in CST with the dimension is 3395 mm (length), 1405 mm (width) and 1415 mm (height). Fig. 6 and Fig. 7 show model of saloon car and model of SUV in CST respectively. The dimension of saloon car is 4270 mm (length), 1680 mm (width) and 1385 mm (height). Following with SUV have dimension of 4055 mm (length), 1695 mm (width) and 1690 mm (height). The models will be imported into CST for computing the bistatic RCS and to observe the performance of radar cross section due to the changing of ground moving targets. The setting and conditions in CST for the model of moving target are based on the frequency transmit signal from long-term evolution (LTE) which is 2.6 GHz and with far-field conditions.

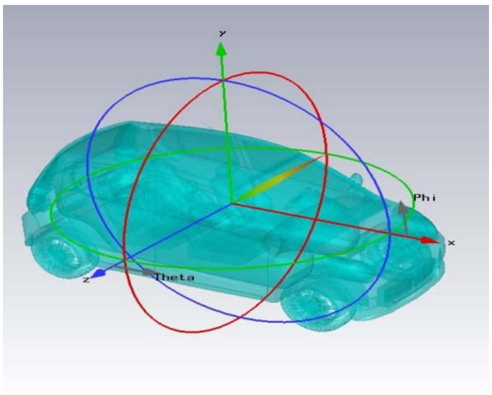

Fig. 5: Model of compact car in CST

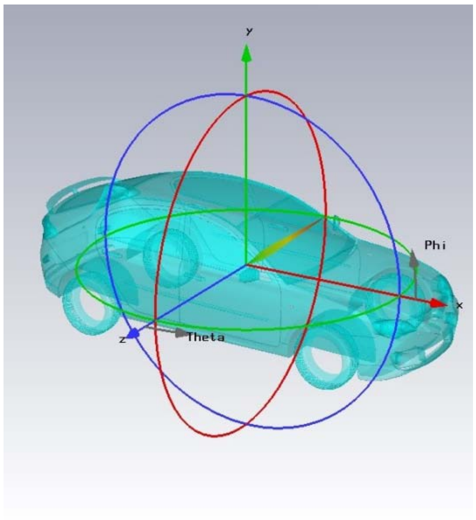

Fig. 6: Model of saloon car in CST

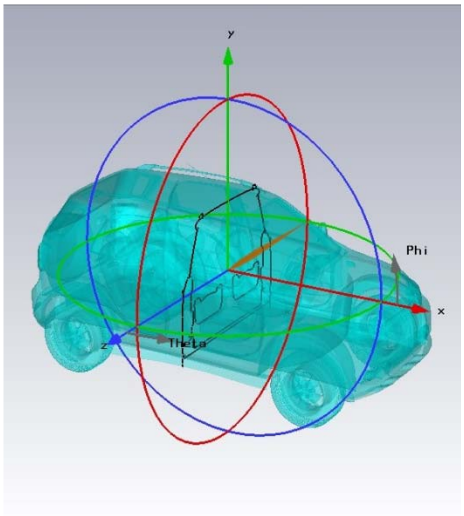

Fig. 7: Model of SUV in CST

4. Results

After examining the ground moving targets using LTE frequency, outcomes of radar cross section in CST demonstrates satisfactory result as expected. Fig. 8 shows the bistatic scattering profiles of RCS on small target which is used compact car. Fig. 9 demonstrates the RCS performance of medium target on saloon car. Fig. 10 shows the behavior of RCS on SUV using 2.6 GHz. The results show the bistatic scattering profiles are having peak maximum at angle of 180^0 which the right side of body area the ground moving target.

Table 1 shows the results of RCS maximum from three type of ground moving target which are compact car, saloon car and SUV. It seems that SUV have the higher RCS maximum which is 110.1 dBm^2. RCS from compact car and saloon car give nearly value which is 107.5 dBm^2 and 108.2 dBm^2 respectively. These results are understandably because perfectly conducting sheet from the silhouette area of ground moving target of SUV has higher physical cross sectional area which proportional to radar cross section. Nevertheless, compact car and saloon car have slighter physical cross sectional area in which also represents the smaller performance of radar cross section.

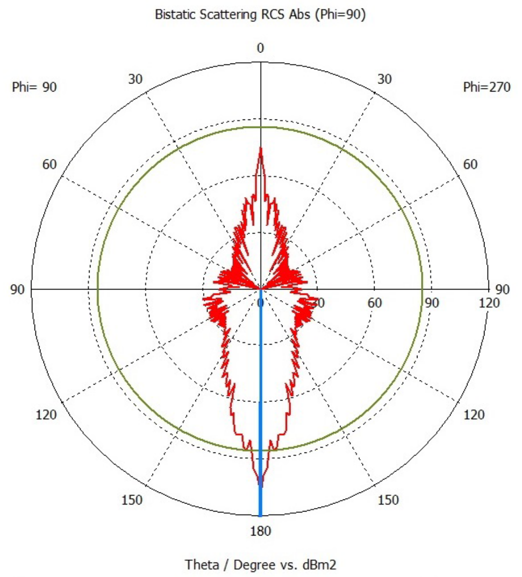

Fig. 8: RCS bistatic scattering of compact car

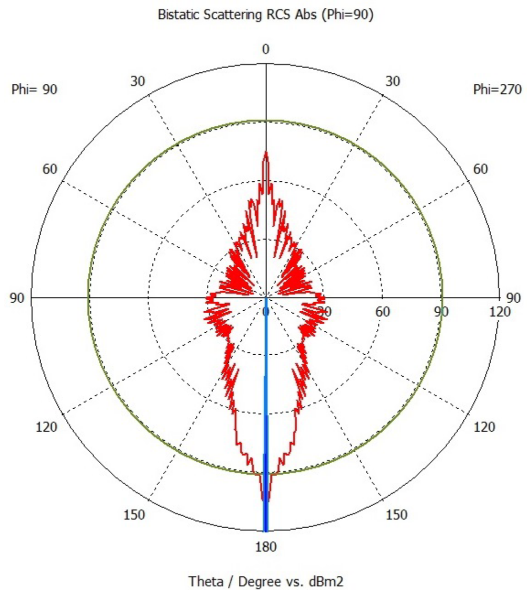

Fig. 9: RCS bistatic scattering of saloon car

5. Conclusion

LTE is new wireless communication technology that offers last mile broadband wireless access with expected broad accessibility. In the experimental study, LTE signal is used as a source for passive bistatic radar (PBR) which used 2.6 GHz. To predict the RCS of moving target through LTE signal as a transmitter, it can be performed using CST Microwave studio. Three models of ground moving target are designed using Autodesk software and compute the performance of RCS using CST.

The simulation results show that largest area of ground moving target, which is SUV had better outcome compared to the other two targets which reliable with Babinet's principle, and also declares a target of physical cross-sectional area is proportionate to RCS. However, compact car and saloon car have smaller physical cross sectional in which also represents the smaller performance of RCS. This might improve the sensitivity of LTE passive bistatic radar if using greater size of ground moving target for better RCS performance.

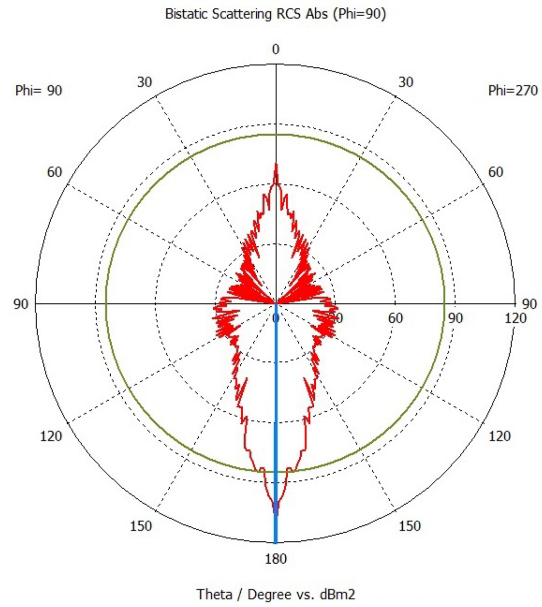

Fig. 10: RCS bistatic scattering of small SUV

Table 1: Radar Cross Section (RCS maximum) for Ground Moving Target Classification

Type of Moving Target	RCS Maximum (dBm^2)
Compact	١٠٧,٥
Saloon	١٠٨,٢
Small SUV	١١٠,١

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