A Study on Vehicle Speed Detection System Using Leaky Coaxial Cable Antenna

Network System Laboratory

Hiroki Maruyama, Takeshi Higashino, Minoru Okada

I. Introduction

Recently, there is increasing interest in Intelligent Transportation System (ITS). It is critical issue to strengthen the measures against traffic accidents. Especially, traffic accidents inside the tunnel do terrible damage, and it tends to take a long time to handle of that due to enclosed space. We cannot use visual information such as surveillance footage to figure out the traffic information because many blind areas and dark places are inside the tunnel.

For this reason, we have investigated a vehicle surveillance system using Leaky Coaxial (LCX) cables [Fig.1].

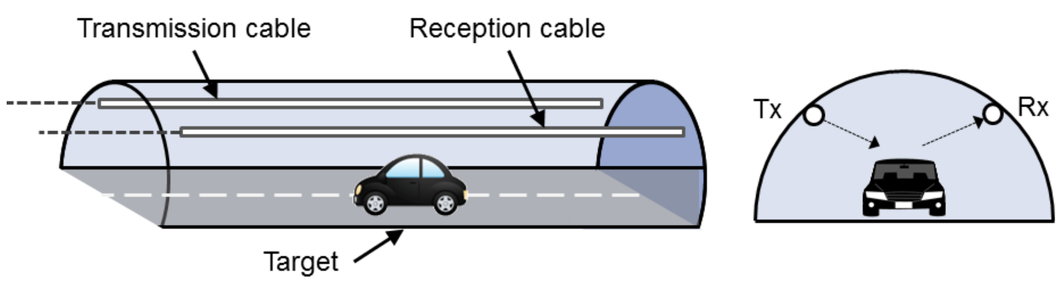
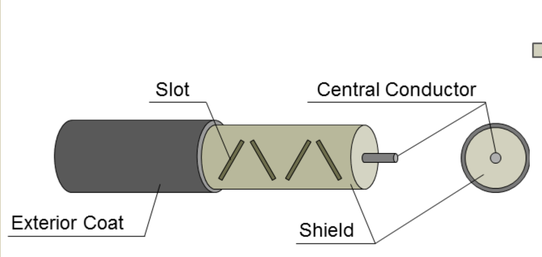
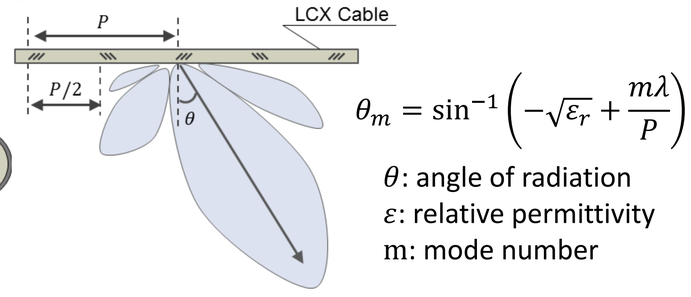


Fig.1 System Configuration

II. Leaky Coaxial Cable

LCX cable is an antenna which is able to transmit and receive signals by the slots opening in shielded conductor of coaxial cable [Fig.2]. Angle of slots alternately change and the slots opening along a cable generate electromagnetic potential. It works as a antenna with directivity since the signals emitted from each slot are combined synthesized [Fig.3].





$$\theta_m = \sin^{-1}\left(-\sqrt{\varepsilon_r} + \frac{m\lambda}{P}\right)$$

θ: angle of radiation
ε: relative permittivity
m: mode number

Fig.2 Leaky Coaxial Cable Fig.3 Directivity of LCX cable

III. System Model

System diagram is denoted as follows [Fig.4]. In this study, we install a pair of LCX cables along the load inside the tunnel. ISDB-T signal is utilized as sensing signal for vehicle speed detection. We receive the ISDB-T signals from the antenna installed at outside the tunnel and retransmit it from transmission cable after the signal passes through the amplifier. The retransmitted signal reflects on the moving vehicle and is received from reception cable. At this time, the signal is affected by Doppler shift depending on the vehicle movement. We measure the Doppler frequency and estimate the vehicle speed.

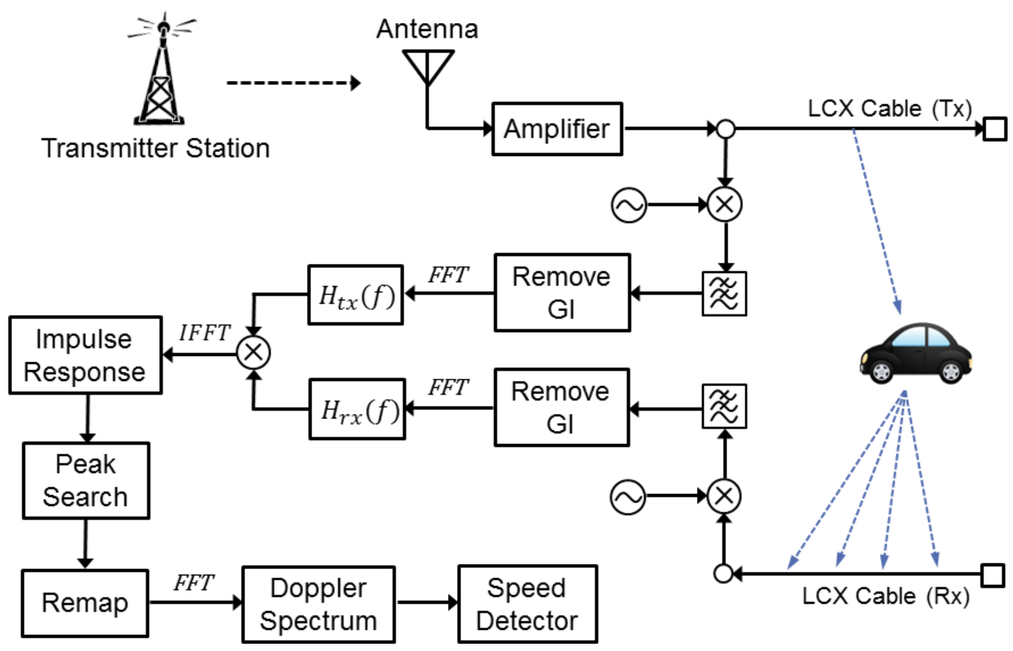


Fig.4 System Diagram

IV. Detection Method

A lot of scattered wave are generated when the signal reflects on the vehicle [Fig.5(a)]. The reception cable receives the reflected signal [Fig.5(b)]. We select the path with strongest energy of the impulse response and set it in line [Fig.5(c)]. A peak appears in Doppler spectrum by means of computing the Fourier transform of the rearranged impulse response [Fig.5(d)]. We can estimate the vehicle speed from a peak of Doppler spectrum.

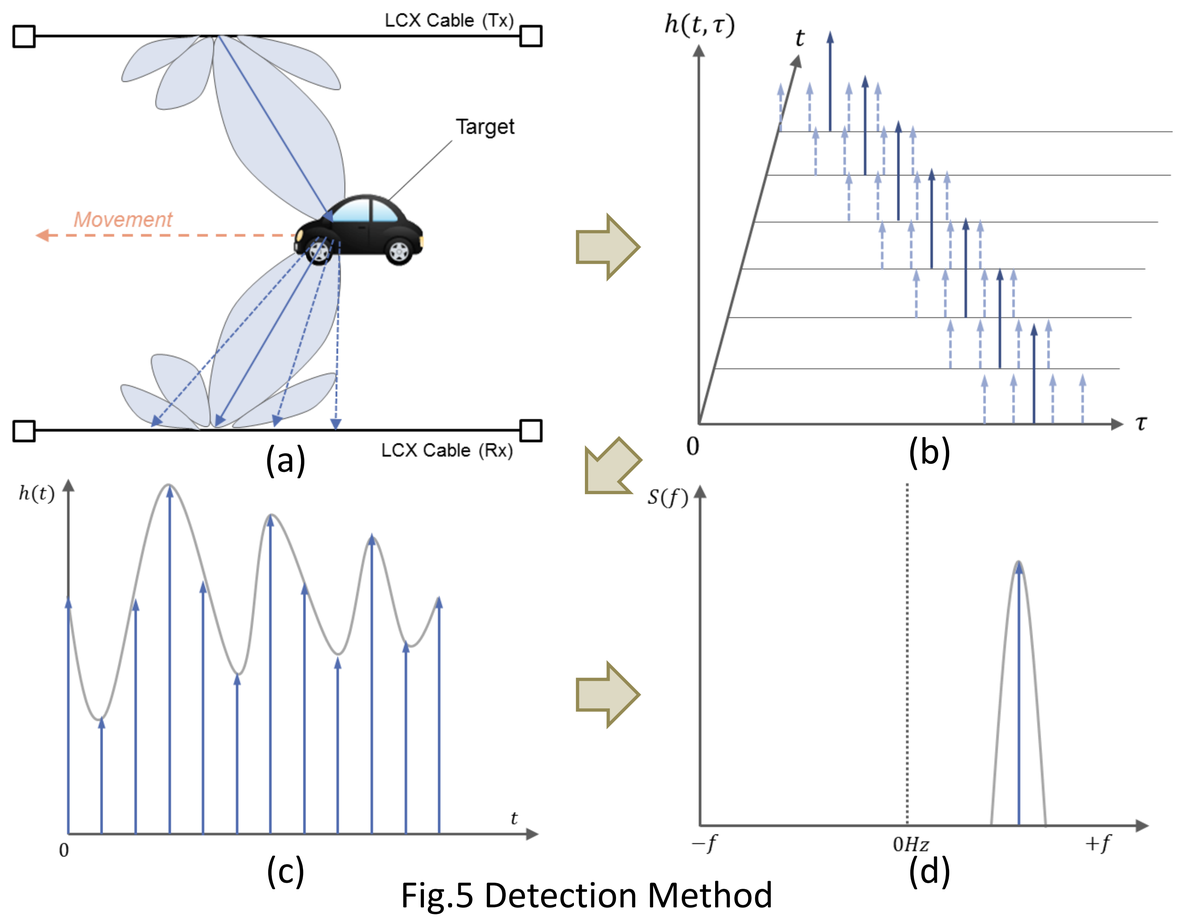


Fig.5 Detection Method

V. Simulation

We did computer simulation based on the specifications of the ISDB-T signal [Table.1]. In this simulation, we assume that one vehicle passes through a tunnel. The measured Doppler frequency is denoted as follows [Fig.6].

Besides, We calculated RMSE between the real speed and the measured speed every SNR dB [Fig.7]. The result shows that full-segment signal can precisely detect the vehicle speed much better than one-segment signal.

Modulation	QPSK
Center Frequency	500MHz
Sub-Carrier	432, 5616
GI Length	27, 351
Carrier Spacing	0.992kHz
Symbol Length	1.008ms
Fading Channel	Frequency Selective
Noise	AWGN
Delay Frame	64
LCX Emission Angle	45°
Number of Vehicle	1
Number of Trials	20

Table1 Specification

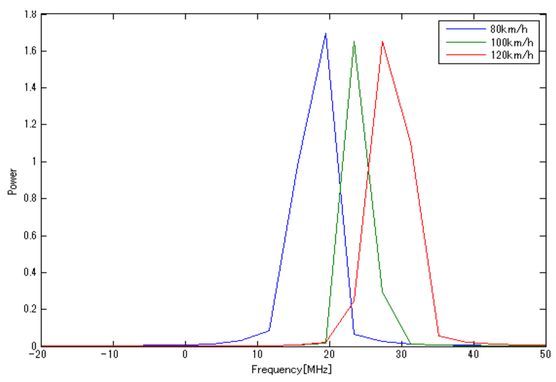


Fig.6 Doppler Spectrum

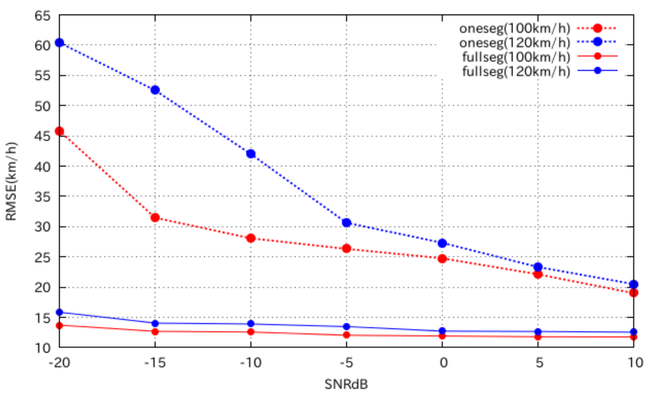


Fig.7 Root Mean Square Error

VI. Conclusion

In this study, we propose a new wireless sensor for detecting the vehicle speed inside the tunnel. We estimate the vehicle speed by means of measuring the Doppler shift. As a result of the simulation, we verified practical effectiveness of this system.