Broadband Channel Measurements inside Metro Station

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Abstract— This paper presents a set of broadband channel measurements conducted in a real metro station in Madrid at 2.45 GHz and 1 GHz, respectively. The power delay profile (PDP) of broadband channels at these two frequencies are obtained. Based on the PDPs, two preliminary tapped delay line models are established. The measured results and corresponding models provide the first-hand information of broadband channel and, therefore, are useful to design and assess the next generation of broadband communication systems in the metro environment.

1. INTRODUCTION

Nowadays, the traditional widespread narrowband standard railway communication system — Global System for Mobile Communications-Railway (GSM-R) — cannot meet the requirements such as real time video or other high capacity data transmissions. It has been widely acknowledged that the next generation of broadband communication systems will require high quality video for the trains' control and surveillance. For instance, such kind of system is mandatory for the automated driving of trains scheduled for the year 2020 in many modern subways.

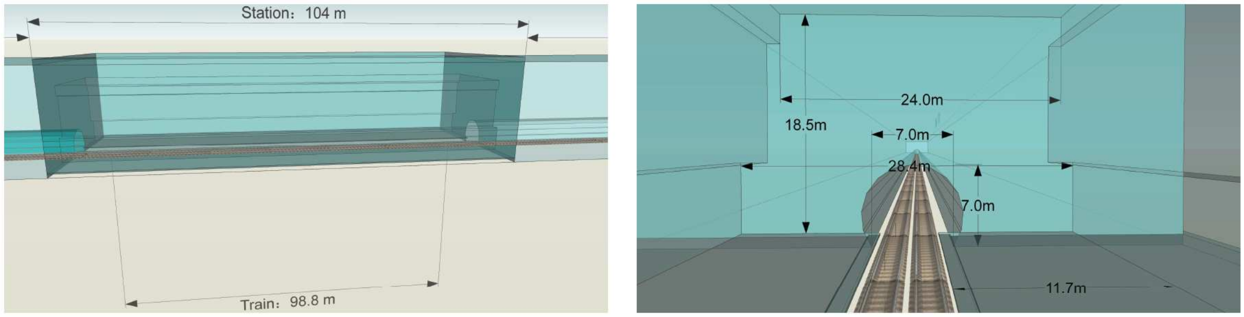
In order to support the design and assess of new railway communication systems in the metro environment, it is crucial and essential to get the insight into the channel characteristics. Currently, 900 MHz and 2.4 GHz are the two potential choices of carrier frequencies for the next generation of broadband train communication systems [1, 2], such as Long Term Evolution for Railway (LTE-R) [3], CBTC (Communication Based Train Control System), etc.. A common idea in the engineering implementation is that a better coverage could be realized by using the lower frequency because of the lower propagation loss. However, the metro station is a specific indoor scenario, in which the propagation characteristics could differ from the cases in the other common railway scenarios, such as viaduct [4], cutting [5], train station [6, 7], crossing bridge [8], etc.. Moreover, for the broadband systems, a good coverage is not the only precondition for a high data rate. Besides the propagation loss and fading characteristics which have been systematically investigated in literature, such as [9–11], etc., time delay spread is another factor influencing the system performance as well. To some extent, the delay profile is more critical than the loss characteristics for the broadband systems. However, as far as the authors know, the power delay profile in the metro station has been rarely investigated. In order to characterize the broadband channel in such scenario, a set of measurements are conducted in a real metro station in Madrid at 2.45 GHz and 1 GHz, respectively.

1.1. Measurement Environment

The measurements are carried out in a metro station named "Ciudad de los Angeles" in the Line 3 of Metro of Madrid. Figs. 1(a) and 1(b) show the side view and the front view the metro station in the study. Corresponding geometrical information is included in the figures as well.

1.2. Test System

A channel sounder developed by Radio Communications Research Group (GRC), Universidad Politécnica de Madrid, is utilized in the measurements. The sounder is composed by a suit of transmitter (Tx) and receiver (Rx), and each side assembled by a baseband subsystem and a radio frequency (RF) subsystem. Details of this channel sounder can be found in [12]. In the measurements, both Tx and Rx are synchronized by using the baseband pulse generated on the transmitting side, and the received signal is demodulated by the logarithmic amplifier with a sensitivity of 25 mV/dB. The PDPs which are included in the following sections are extracted from the channel impulse response (CIR) captured by the oscilloscope. Table 1 provides the main parameters of the test system. Radiation patterns of antennas are measured in an anechoic chamber and given by Fig. 2.



(a) (b)

Figure 1: (a) Side view and (b) front view the metro station in the study.

Table 1: Main parameters of the test system.

Frequency	Transmitted power	Pulse width	Time delay resolution	Tx/Rx antennas
2.45 GHz	38 dBm	47 ns	200 MHz	HG2414P
1 GHz	40 dBm	47 ns	200 MHz	HG908P

2. MEASUREMENTS AND PROPAGATION

The sketch and geometrical parameters of the measurement campaign are shown in Fig. 3. Tx and Rx are separated from each other by 20 m. Both antenna systems are oriented towards the same wall (in the upper left of Fig. 3) in order to avoid the overload in the measurements. The train is located in the middle of the station, at the track which is closer to the RF equipments used for broadband measurements.

Figures 4(a) and 4(b) illustrate the PDP and corresponding taps of the tapped delay line (TDL) models in the cases of 2.45 GHz and 1 GHz, respectively. It can be seen that the RMS delay of the channel at 1 GHz is 428.8 ns, which is much larger than its value (75.7 ns) in the case of 2.45 GHz. This is because that the station is widely covered with steel that improves reflections at lower frequencies. Moreover, the propagation loss in the free space at 1 GHz is much smaller than the case of 2.45 GHz. Each multiple path experiences smaller propagation loss. Thus, more multi-path components are retained and finally received. On the other hand, the channel of 2.45 GHz has a much smaller time delay spread, which could be more beneficial to the broadband system performance. Table 2 gives the preliminary TDL models. The number of the taps L are obtained by [13]:

$$L = \lceil \sigma_\tau / T_c \rceil + 1 \tag{1}$$

where σ_τ is the RMS delay spread, T_c is the pulse width in this study.

Table 2: TDL models of channels in metro station at 2.45 GHz and 1 GHz.

Parameter	2.45 GHz			TDL model of channel in metro station at 1 GHz										
Tap index	1	2	3	1	2	3	4	5	6	7	8	9	10	11
Gain [dB]	−8.0	−26.2	−39.8	0	−23.1	−31.0	−44.0	−37.2	−51.4	−59.3	−57.7	−61.2	−63.0	−64.7
Delay [ns]	0	150	300	0	160	320	480	640	800	960	1120	1280	1440	1600

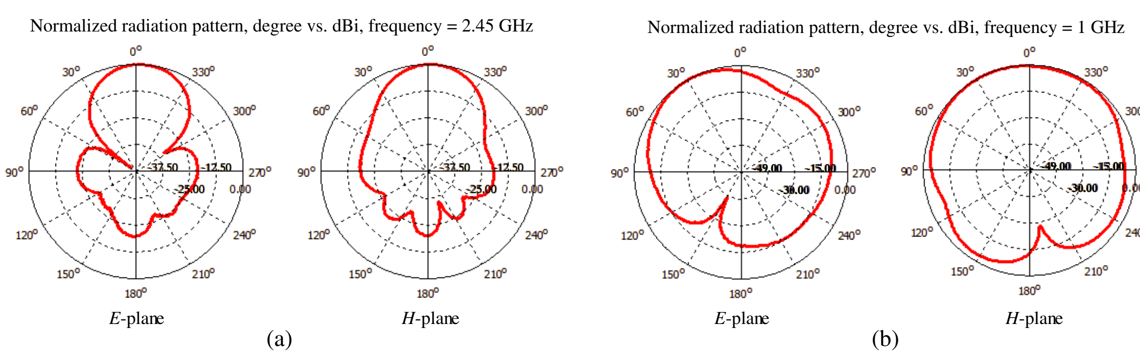


Figure 2: Radiation patterns of antennas used in the study.

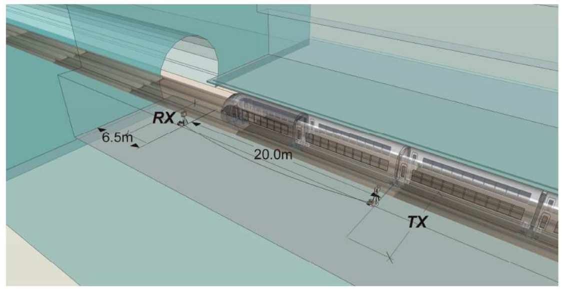


Figure 3: Sketch and geometrical parameters of the measurement campaign.

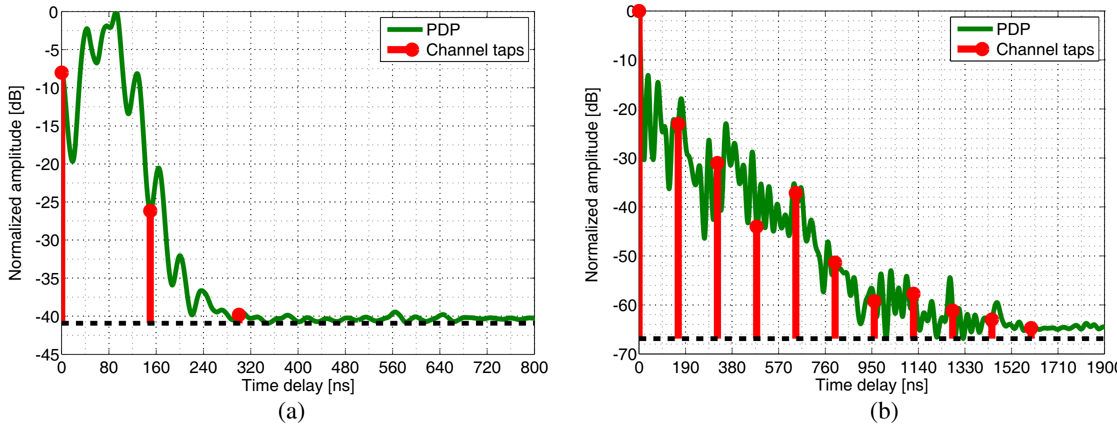


Figure 4: PDP and taps of the channel at (a) 2.45 GHz, and (b) 1 GHz.

3. CONCLUSION

A set of broadband channel measurements in a real metro station are reported. The RMS delay spreads are 75.7 ns and 428.8 ns in the channels at 2.45 GHz and 1 GHz, respectively. Preliminary TDL models are presented to give the first impression of the broadband channel in the metro station. The measurement campaign and results are useful for the broadband communication system design, modeling, and simulation tools validations.

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