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Initial Assessment of the THz Indoor Channel Measurement with Reflective Intelligent Surfaces

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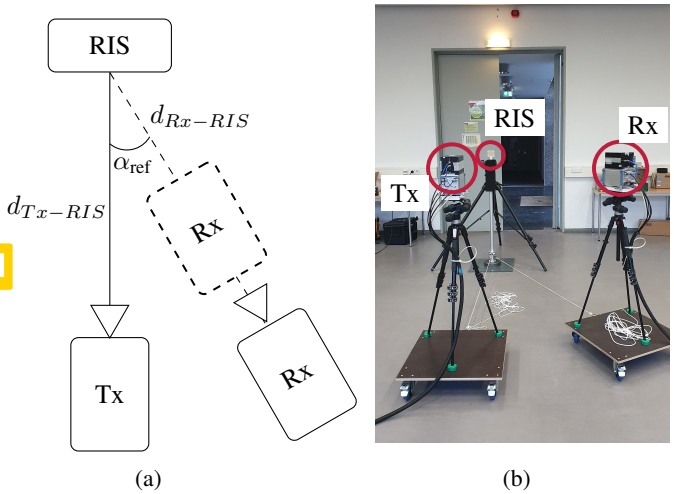
***Abstract*—Terahertz (THz) communications is expected to be an essential part of the future mobile communication system to meet the demand for ubiquitous high-speed data transmission everywhere. To overcome the limitations of THz communications, reconfigurable intelligent surface (RIS) shows their great potential. THz indoor channel measurements were performed using 1-bit and 3-bit RIS to understand the propagation channel including RIS. A part of the initial assessments for the THz channel measurement including RIS are presented in this paper.**

***Index Terms*—channel sounding, channel measurement, RIS, IRS, THz indoor**

I. Introduction

In recent years, the importance of THz communication has been highly emphasized for enabling seamless future wireless communications. The fundamental research on the THz propagation channel has been thus carried out in various ways from mathematical discussions to actual channel measurements. Recently, the attention of the research in THz communication has been extended to controlling the propagation characteristics using RIS [1]. The use of RIS is particularly advantageous for THz communications overcoming its significant limitation of blockage. The strategic installation of RIS can result in better wireless communications such as extending coverage of communication black spots.

For the robust and reliable design of the THz communication system, precedent studies on the propagation channel is essential to understand its distinct characteristics and special requirements for channel modeling. This motivated us to conduct the channel measurement at 300 GHz including RIS. The main focus of the paper is to present an initial assessment of the THz indoor channel measurement with RIS. The remaining part of the paper is organized as follows: Section II describes the channel measurement setup including the brief introduction of the measurement scenario and the THz channel model including RIS. The evaluation of the channel measurement will be discussed in Section III. A brief conclusion and future work will be followed in Section IV.



(a) (b)

Fig. 1: Measurement scenario: a) bird view of the schematic scenario and b) photograph of the measurement environment

II. Channel Measurement Set Up

Measurements were conducted using the ultra wide band correlation channel sounder operating at 300 GHz [2] and focused on understanding the characteristics of RIS and the propagation channel including RIS. Upon measurement, two different types of RIS (1-bit and 3-bit) are measured for their performance at the designed angle of reflection (30°) and the opposite angle of reflection (-30°).

A. Measurement Scenario

To understand the near/far field propagation properties, the receiver (Rx) was moved towards RIS while the position of the transmitter (Tx) and RIS remained unchanged visualized

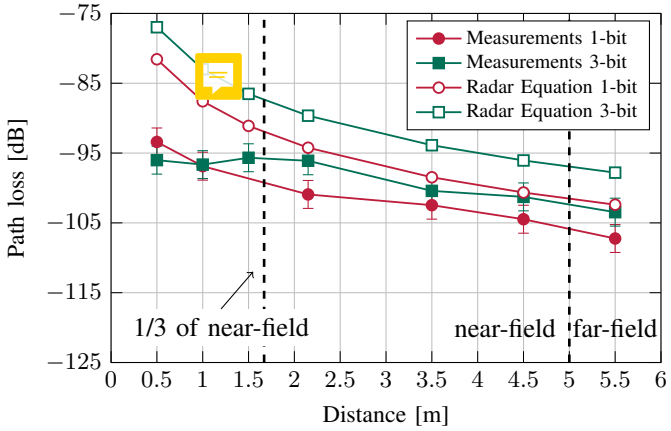


Fig. 2: Comparison of measured and calculated path loss values for 1-bit and 3-bit RIS

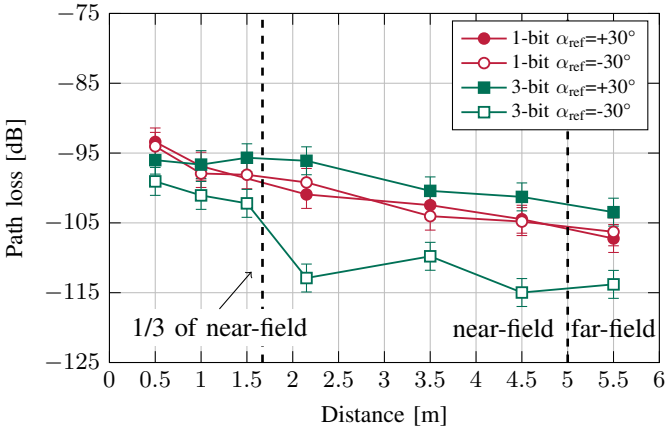


Fig. 3: Comparison of measured path loss values at α_{ref}=+30° and at α_{ref}=-30°, for both 1-bit and 3-bit RIS

in Fig. 1. Here, the distance between Tx and RIS (d_{Tx-RIS}) is fixed at $2.15\,\text{m}$ while the distance between Rx and RIS (d_{Rx-RIS}) varied from $0.5\,\text{m}$ to $5.5\,\text{m}$.

B. Mathematical Channel Modelling

To compare the measurement with the deterministic propagation model, the radar equation given in (1) was used.

$$\frac{P_{Rx}}{P_{Tx}} = \frac{G_{Tx} \cdot G_{Rx} \cdot \lambda^2 \cdot \sigma}{(4\pi)^3 \cdot d_{Tx-RIS}^2 \cdot d_{Rx-RIS}^2} \tag{1}$$

Where the parameters indicate the following: P_{Rx} (received power), P_{Tx} (transmit power), G_{Tx} (Tx antenna gain), G_{Rx} (Rx antenna gain), λ (wavelength), d_{Tx-RIS} (pathlength between Tx and RIS), d_{Rx-RIS} (pathlength between Rx and RIS), and σ refers to radar cross section (RCS) [3].

III. Results of Measurement

First of all, the measured value and the expected path loss values for both 1-bit and 3-bit RIS at the designed angle (+30°) are compared in Fig. 2. Here, the difference between the expected and measured curves remains approximately the same (4 to 6 dB) for all points of the 1-bit and 3-bit RIS in the range between $2\,\text{m}$ and $5.5\,\text{m}$ considering the measurement equipment error approximately $2\,\text{dB}$. The difference between calculated and measured values starts to vary significantly at distances less than $2\,\text{m}$, which may correspond to the *one-third of the near-field*. This distance has been experimentally identified as the transition point between the reactive and radiative fields. However, more detailed studies are required to assess the impact of this region.

For both 1-bit and 3-bit RIS, the measurement results with the designed angle of reflection (+30°) and the opposite angle of reflection (-30°) are compared in Fig. 3. In the case of 1-bit, the values of the +30° and the -30° are designed to show the same value. The measured values remained approximately the same at all distances. In the case of 3-bit, the difference between the +30° and the -30° should be approximately $15\,\text{dB}$. The measured value showed a relatively good agreement with slight fluctuations at all measured points but showed a noticeable change in the trend at the distance of $2\,\text{m}$.

The initial channel measurements of 300 GHz reflecting RIS indicate that the radar equation yields good results compared with measurement data, with an offset ranging from 4 to $6\,\text{dB}$ for distances greater than $2\,\text{m}$. However, measurements at distances less than *one-third of the near-field* require further investigation to validate results.

IV. Conclusion

The THz indoor channel measurements using 1-bit and 3-bit RIS showed relatively good agreement with the radar equation with a constant offset (4 to $6\,\text{dB}$) at distances greater than $2\,\text{m}$. This was also the case when comparing the designed angle (+30°) and the opposite angle (-30°). However, measurements at distances less than $2\,\text{m}$ require further investigation to validate the results. The comprehensive evaluation of the measurement will be followed up in the near future.

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