Challenges of millimeter radio channel sounding and channel modelling

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Abstract

Future 5G radio networks are expected to operate in the millimeter wave band to provide high data rates and immersive user experience. To enable the design of such systems it is essential that the radio channel in the various scenarios is characterized. In this tutorial an overview of future 5G requirements of millimeter wideband channel sounding and examples of state of the art channel sounder architectures for multiple band measurements are presented. Examples of radio measurements in typical environments and path loss estimation approaches are outlined.

1. Introduction

In November 2015 the World Radio communications Conference, WRC 15, identified a number of frequency bands in the 24-86 GHz range (24.25-27.5 GHz, 31.8-33.4 GHz, 37-43.5 GHz, 45.5-50.2 GHz, 50.4-52.6 GHz, 66-76 GHz and 81-86 GHz) as potential candidates for 5G technology with bandwidths ranging from 1.6-10 GHz. Following this a number of regulators have identified frequency bands for future systems.

To enable the design of future 5G systems in the higher frequency bands, state of the art radio channel sounders have been developed to study the radio channel and to evaluate basic transmission characteristics such as path loss, and wideband parameters including delay spread.

In this tutorial the challenges of the design of millimeter wave channel sounders to cover the various bands identified by the WRC15 are outlined with typical scenarios of deployment. Approaches to data analysis of wideband measurements to estimate path loss, r.m.s delay spread, and cross polar discrimination are outlined.

This is followed by an overview of the activity in international forums to adopt suitable models for future standards.

2. Challenges of channel sounders in the millimeter wave band

To enable measurements in the multiple bands identified by WRC15 a wideband channel sounder capable of operating both in indoor and outdoor environments is needed. In addition, dual transmit and dual receive architectures enable multiple input multiple output measurements such as cross polar discrimination using dual polarized antennas.

Channel sounders can use a variety of waveforms which include pseudo random binary sequences (PRBS), continuous waveforms (CW), and frequency modulated continuous wave FMCW. While the CW sounder is simple to implement it only provides path loss information. Hence, many measurements are performed using wideband waveforms. To meet the high bandwidth requirements, bandwidth compression techniques are needed and in PRBS this is achieved using the sliding correlator while in FMCW sounders the heterodyne detector is employed. In addition off the shelf equipment such as vector network analyzers or waveform generators and high speed digitizing oscilloscopes can be used. While these are viable solutions they tend to be limited either in range or in being able to capture the time variability of the channel.

In addition to the requirement of a bandwidth in excess of 2 GHz the millimeter wave band poses a challenge in the high propagation loss which tends to limit the range of measurement.

The tutorial will give an overview of these various techniques and state of the art channel sounders currently used to conduct radio propagation studies in the millimeter wave band.

3. Conclusions and modelling of the millimeter wave radio channel

Different path loss modelling approaches have been developed which include the close in CI model and the floating intercept model for single frequency as well as multiple frequency models which have a frequency parameter. The tutorial will give an overview and compare these various models. Examples of path loss models and wideband channel parameters adopted in the international standards are presented.