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TECHNICAL REPORT

Use of innovative antenna systems within millimetre Wave Transmission and impacts on standards and regulations

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

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Executive summary

The present document deals with innovative technologies applicable to mmW transmission for what regards the antenna system. The traditional approach in MW transmission equipment is to have a TRX connected to an antenna by means of a connector which represents the reference point for requirement setting and for measurement of conformance. Antenna technology is evolving in different directions: on one side in the traditional way by achieving higher directivity to allow a greater system gain, on other sides by employing new architectures such as separated TX and RX antennas, active antennas and/or antennas integrated with the equipment.

Proper classification and terminology of antenna types is considered in clause 4.

Clauses 5 and 6 of the present document analyse high directivity detachable antennas and integrated non-detachable antennas in order to investigate the two most promising directions of innovation in antenna technology.

Dual band antennas to be used by systems employing Band and Carrier Aggregation (BCA) are considered in clause 7.

Clause 8 takes into account the possible new architectures when separated TX and RX antennas are used without the need for a duplex filter (FDD systems) or a switch (TDD systems); this opens the way to possible new duplex schemes such as flexible FDD (fFDD), with the possibility to flexibly define the distance in frequency between TX and RX, or even Full Duplex (FD). This new architecture is particularly interesting when going to high frequencies as in D band where, leveraging on the short wavelength, compact antenna systems can be implemented, possibly with multiple antennas in one equipment. The impact on radio planning and spectrum regulation is considered as well.

Whilst high directivity detachable antennas do not change the way system requirements are set and conformance measurements are done apart from the definition of ever stricter antenna mask classes, integrated non-detachable antenna systems raise the important issues of how to define system requirements and how to measure the conformance to them, since an antenna connector is not any more available. In this case a paradigm shift is needed from conducted to radiated requirements, with accordingly defined measurements. These aspects are taken into account respectively in clauses 9 and 10.

Introduction

The present document deals with innovative technologies applicable to mmW transmission for what regards the antenna system. The different types of antennas that can be used in MW and mmW systems can be classified according to different features, such as:

- Detachable vs. non-detachable, where a non-detachable antenna is one fully integrated with the rest of the equipment.
- Passive vs active, where an active antenna is one containing active components able to modify amplitude and/or phase of the input signal.
- Time variant vs static, where a time variant antenna is one with radiated pattern changing in time during working conditions.

The traditional antenna used in MW radio links for Fixed Service is a passive detachable one, where system requirements are defined and verified at the antenna connector; the antenna is characterized by parameters like gain, bandwidth and loss and represented by its radiation pattern in space. Harmonised standards have been developed at ETSI for PtP [i.1] and PtMP [i.2] systems within this logical frame, where the antenna part is dealt with in related ETSI standards [i.3], [i.4].

Innovation in passive, detachable antenna has directed towards ever improving directivity according to progressively more stringent antenna masks as defined by ETSI standards [i.3], [i.4], going in time from class 1 to class 4 types for PtP systems and from DN1 to DN5 for PtMP systems and possibly over.

When going towards frequencies in the mmW range the increasingly shorter wavelength makes antenna integration into the equipment feasible and advantageous from both technical and cost sides. In particular when considering D band (130 - 174,8 GHz range) the possibility to design a compact radio unit with integrated antennas has been already demonstrated with some prototypes and several research activities are ongoing on the subject. One prototype with passive, non-detachable and distinct TX and RX antennas was deployed in Milan in November 2016 for propagation investigations in D band [i.5]. Another prototype with active, integrated antennas was developed within the Horizon 2020 framework as well [i.6].

A great push towards the development of innovative antenna systems is coming from the introduction into IMT-2020 of Active Antenna Systems (AAS), which employ antenna array structure with active elements within the antenna in order to control the amplitude and phase of the signals to the single elements of the array. In this way beamforming is possible and the antenna pattern can be adaptively modified in time in order to adapt to the changing propagation conditions and user distribution.

When considering a non-detachable antenna, whether passive or active, the problem of defining the system requirements and their measurement requires a paradigm shift, since it is necessary to pass from conducted to radiated requirements and measurements. This change requires the measurements to be done in a controlled environment such as an anechoic chamber so to avoid any unwanted influence from the surrounding environment. A good reference is the work done in 3GPP for IMT2020 systems and implemented in the related ETSI standards as well [i.14].