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Simulations and Measurements of the Effect of Beam Sweeping in the EMF level in 5G Communication Systems


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The problem

• The implementation of 5G is causing an increasing concern over the possible impact on health and safety arising from exposure to electromagnetic field radiated by 5G systems
• This makes imperative the development of accurate EMF measurement techniques and protocols
Estimation of the average value of the field level

The problem can be split into two parts:

• A) Estimation of the maximum field level using extrapolation techniques
  
  Ref: «A Theoretical and Experimental Investigation on the Measurement of the Electromagnetic Field Level Radiated by 5G Base Stations», IEEE Access, 2020
  
  «unrealistic» value (all the resources used by a single user), but it is a ‘starting’ value for the

• B) Estimation of the expected value of the field level in a given temporal interval (e.g. 6 minutes) from the maximum field level

This second step requires numerical simulations.
Estimation of the average value of the field level

This presentation describes an experimental verification useful as a first step for the validation of a strategy for the estimation of the field level of the signals radiated by 5G base stations.

In particular simulations of the field level radiated by the broadcast beam (i.e. the beam radiating SSBs) have been carried out and compared to measured data.

This research has been developed in the framework of the activities of the 5G group of ICEmB (http://www.icemb.org)
No data traffic during the measurements (no End Users)
Subcarriers-OFDM symbols grid

• The example regards a numerology equal to 1; the frame is 10 ms, and contains 20 slots
• In 5G the minimum resource is given by one subcarrier and one OFDM symbol, and is called Resource Element (RE)
• In the following figure the received power [dBm] of the REs in the subcarrier-OFDM symbol grid covering one frame is shown; the power of the REs are represented in false colors from green to dark red
• It is possible to distinguish the SS Burst, that consists of 6 SSB
• No data traffic is present (no End Users)
Subcarriers-OFDM symbols in a 5G frame

1 OFDM symbol x 1 subcarrier = 1 RE    12 RE = 1 RB
1 frame = 10 ms    1 subframe = 1 ms    2 slots = 1 subframe (µ=1)
SSB and broadcast beam

• The power lever of the 6 SSBs is different
• This is due to the fact that each SSB is transmitted on a beam of a switched beam antenna (called also broadcast beam) pointing in a different direction
• The set of broadcast beam covers the whole angular sector of interest for the base station
• Summarizing, the SSBs are transmitted in sequence on 6 different directive beams
Each SSB is associated to a specific directional beam and is transmitted along a specific direction.
Signal received in the measurement point

Base station

Measurement point

Measured signal
Simulations

LOS condition, “close” proximity: in the simulations free space propagation is considered
Simulation of the RE power of the received signal

Simulated (normalized) power of the transmitted REs [dB]

Simulated (normalized) power of the received REs [dB]
Broadcast pattern received and simulated signal

Base station
Measurement point
Simulated signal
The final goal

• This experimental verification is a first step for the validation of a strategy for the estimation of the field level of the signals radiated by 5G base stations

• The final goal is the simulation of the field level for human safety considering different propagation/traffic/communication strategy (beamforming, SU-MIMO, MU-MIMO) conditions etc..

• As first step the REs on the frame are placed fixing the power at the ‘transmitted side’

• Then the power of the REs are evaluated in the observation point considering the propagation effects and the proper antenna beam (SSB are transmitted using broadcast beam, EU data are transmitted using data beam)
An example

• In the following you can find a simple example regarding a switched beam antenna for data, and three EUs whose traffic load is constant;
• On the top-left the geometry (the field is measured in the position of the moving EU)
• On the top-right the REs power
• On the lower-left side a simulation of a zero-span measurement in a RBW=1 MHz centered on the SSB center frequency
• On the lower-right side the field level [V/m] in the position of the moving EU
• This is a very simple simulation (free space) just to give an first idea, and it is not related to the measurement site
Unfortunately I realized that this simulation does not work in pdf, but...
... a dynamic simulation is available at the site

https://sites.google.com/unicas.it/electromagnetic-information/home

at “5G antenna in a nutshell” section
Conclusions

• Some simulations of field level radiated by the broadcast beam in 5G has been carried out and compared to measured data

• This is a first step for the numerical analysis of the field level radiated by 5G base stations