Abstract—Channel static antennas are considered for mobile devices. The antenna keeps the wireless communication channel static by performing a counter-movement that is opposed to movements of the device that might be caused by a user. The feasibility of the concept is demonstrated for linear movement in an office environment. Channel measurements are performed with quarter wavelength monopole antennas in the 2.4 GHz ISM frequency band. A channel model for the wireless communication channel of mobile devices with channel static antennas is proposed based on these measurement results.

Index Terms—Antenna, channel, communication, movement, static, wireless.

I. INTRODUCTION

It has recently been proposed, that devices can keep their wireless communication channels static while moving or being moved by performing a counter-movement of the antenna [1], [2]. However, small devices for mobile usage are limited in their size and therefore limited in the distance over which they can keep their channels static with a counter-movement. Among these devices are prominent use cases such as smartphones, tablets, laptops, pagers, IoT devices, virtual reality headsets etc.

Contribution — A first investigation of channel static antennas for mobile devices is conducted experimentally. It is considered that antennas on such devices are able to keep wireless communication channels static by performing counter-movements within the limitations of the device’s size. Measurements were performed in a laboratory/office environment with quarter-wavelength monopole antennas at 2.45 GHz. The antennas were measured alone for this first proof of concept – channel static antennas were not prototyped as part of a mobile device. Channel models are proposed for mobile devices with channel static antennas.

II. THEORETICAL CONSIDERATIONS

Movement of devices generally changes the wireless communication channels that these devices experience, if the antennas are fixed to the device (which is the state of the art today). In [1], [2] it is considered that the antenna can keep the channel static by performing a movement on the device which is in opposite direction of the device’s movement (counter-movement). From the viewpoint of an outside observer, the counter-movement keeps the antenna in its original position. This in turn keeps the channel static towards outside observers such as other antennas at arbitrary locations.

The counter-movement of the antenna is of course limited by the size of its device. To avoid falling off, the antenna backs off and chooses a new position on the device. There,
the antenna again performs counter-movements to stay in that position to keep the channel static until it reaches a device edge and so on. Therefore, the channel static antenna for mobile devices keeps the channel piecewise static for long device movements. The principle is sketched in Fig. 1.

In practice it can be expected that a counter-movement of the antenna on a small device will influence the radiation characteristics of the antenna, e.g. the antenna position has a significant influence on cars [3], [4]. Such influences are not considered within the scope of this work. It will be the pleasure of the device’s designer to keep the antenna characteristics within given bounds during the counter-movement.

III. EXPERIMENTAL PROOF OF CONCEPT

The concept of channel static antennas is experimentally demonstrated for handheld devices in an office and laboratory environment. Without loss of generality, the device trajectory is confined to linear movement over a finite distance. Two quarter-wavelength monopole antennas for the 2.4 GHz ISM frequency band are placed on circular aluminum ground planes. They are connected to a vector network analyzer (VNA) to measure the channel between them in absolute value and phase. The antennas are placed a few meters apart (120 cm at the initial position) in an office room with laboratory equipment. From an electromagnetic viewpoint, this is a complex environment with different geometries and materials. It is also a typical environment for WLAN operation in the 2.4 GHz band. One antenna is fixed in its position. The other antenna is mounted on two stacked linear movement units. The bottom unit moves the top unit. The top unit performs the counter-movement of the antenna. The linear movement units and the VNA are connected to a laptop, which controls the experiment. The VNA measurements take some time. During this time the antenna remains still, otherwise the movement would influence the results. As a consequence, no Doppler shift is present in the channel. Fig. 2 shows the office environment and the experimental setup.

The distance of the counter-movement is limited to 0.5 λ (about 6 cm). This is a feasible distance considering the width of todays smart phones [5]. A thin cardboard smart phone mockup is added behind the antenna as a visual reference. Its influence is considered to be negligible. The device mock-up is moved over a distance 6 λ that far exceeds its width. Photographs that show illustrate the working principle are shown in Fig. 3.

Three measurements are performed. First, the antenna moves away from its initial position with a linear motion. This is the case with state of the art antennas that are fixed to mobile devices. Second, the antenna performs counter-movements to keep the channel static under this linear motion. Third, the antenna remains still in its initial position. This serves as a reference to see how static the channel remains without movement, i.e. to quantify channel changes that are caused
There are small residual changes during a static interval. This variation is a lot smaller in the measurement without movement, which hints that the residual changes stem from the process that keeps the channel static and not from environmental changes. The influences might come from the cardboard mock-up, but they are more likely caused by the large metallic movement unit. Overall, the channel static antenna does an excellent job in keeping the channel static when compared to regular antennas. A device equipped with channel static antennas would no longer experience small scale fading or fast fading when moving through the environment.

IV. A CHANNEL MODEL FOR CHANNEL STATIC ANTENNAS

The measurements in Sec. III suggest that the channel is indeed kept static when the device moves. The channel at subsequent positions of the device continues to be channel from the initial position where the CSA started to keep the channel static. The channel remains until the antenna can no longer keep it static due to technological constraints. In the investigated scheme the antenna is constrained in its counter-movement by the size of the device. Other schemes that aim to keep channels static might have different limitations [11], [12]. Based on the measurements in Sec. III the following channel model is proposed.

\[ H(n) = H(n_0) \] (1)

where \( H(n) \) is the channel at device distance \( n \) from an initial position and \( H(n_0) \) is the channel at the initial position \( n_0 \) where the channel is kept static.

Note that the model does not dispose of the initial channel \( H(n_0) \). \( H(n_0) \) can be the real channel that forms in the environment, it can be an estimate of the real channel [6], it can be obtained from a channel model [7], [8] or drawn from a distribution [9].

Instead of a spatial formulation, the model can be formulated in the temporal domain as

\[ H(t) = H(t_0) \] (2)

where \( H(t) \) is the channel at time \( t \) and \( H(t_0) \) is the channel at time \( t_0 \) when the antenna started to keep the channel static.

In many applications it will be suitable to modify the initial channel \( H(n_0) \) with some function \( F \):

\[ H(n) = F(H(n_0)) \] (3)

The function \( F \) might add noise, consider estimation uncertainty or model a technological process that is used to keep the channel static, e.g. the influence of moving a device in the near-field of an antenna. Exemplary, for an office environment (as in Sec. III) the channel might be modeled as

\[ H(n) = H(n_0) + N, \] (4)

where \( H(n_0) \) might be a Rice-distributed random variable that is drawn at new initial positions \( n_0 \) and stays constant during a static interval. It models the small scale fading environment of the office. \( N \) might be a Gauß-distributed noise term that
is drawn at each position \( n \) and models the residual channel changes during a static interval.

Antenna movement over large distances can cause changes in the channel statistics, e.g. wide-sense stationary assumptions no longer hold for vehicular channels. For characterization, such channels can be divided into smaller chunks during which the channel statics do not change significantly \[10\]. Such procedures are widely used, but the division into channel pieces is somewhat arbitrary. When channels are kept static with the proposed procedure, then it can be expected that the variations within a static interval are quite a lot smaller than when they are allowed to change freely (e.g. with Rayleigh or Ricean fading) – as is demonstrated by the measurements in Sec. [11]. The author expects that such models might be well suited for channel static antennas, as the statistics of the initial channels \( H(n) \) might change, but the statistics of the residual fluctuations remain the same within a static interval. The division of the whole channel into chunks is then no longer arbitrary, but linked to the intervals where the channel is kept static with the channel static antenna.

V. CONCLUSION

The proposed technique keeps the wireless communication channel static under device movement by performing a counter-movement of the antenna that considers the limited size of mobile devices. Feasibility of the concept is shown with an experiment in an office environment. The performance of channel static antennas for mobile devices is measured and assessed. In such applications, channel static antennas are able to keep the channel piecewise static. The technique is purely based on the device’s movement and size, the antenna does not require channel knowledge to perform the counter-movement. Modern smart phones are already equipped with sensors that measure the position, acceleration and tilting of devices.

First mathematical models are presented to describe wireless communication channels that are kept static by channel static antennas.

ACKNOWLEDGMENT

The author thanks M. Lerch of Technische Universität Wien, Vienna, Austria, for his help with the experimental work.

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