# Effects of Realistic Groundplanes to NSA-measurements of Open Area Test Sites (OATS) 

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## INTRODUCTION

The measurement of electromagnetic interference can be performed e.g. on open area test sites with different shapes and sizes, which are defined in ANSI C63.4 [1] and CISPR 16-1 [2]. For EMC compliance measurements the normalized site attenuation (NSA) has to be measured and compared with the calculated NSA [3]. If the deviation is too high, an extension of the groundplane is recommended. This paper shows, that not only the size but also the shape of the plane is very important to improve the correlation between a realistic and an ideal open area test site.

Different effects have to be taken into account when a new OATS has to be designed (e. g. ground conductivity, obstruction free area, wire mesh size). Several articles deal with this topic [4-9]. Furthermore the standard ANSI C63.7 gives site construction hints [10]. The interaction between these effects is difficult to determine. Because of that first of all the influence of the shape of the plane has been investigated.

## MODELS

Typical measurement conditions have been reproduced in the following model: A Hertzian dipole (length 0.1 m ) with an impressed current, positioned 1 m above the ground plane, is used as radiation source (Fig. 1). It is located at the position TX (transmitter). It reproduces the radiated field of the equipment under test (EUT). The length is small with respect to the used frequency. The electrical field strength has been calculated at 10 m measurement distance from 1 to 4 m above the ground plane at the position RX (receiver). This is comparable with the receive antenna maximum high scan. The calculations have been executed with CONCEPT II [11] for discrete frequencies and presented for 30 MHz and 100 MHz .

The ideal ground plane with a flat homogeneous groundplane of perfect conductivity and infinite extension has been used as reference. Of course in reality only a limited sized plane is possible. Four different models have been examined with both horizontal and vertical polarization. Model 1 and 2 are the ellipse and the minimal plane, which are shown in CISPR 16-1. Furthermore a special plane I (model 3) has been presented, which consists of a square area around the transmitting dipole and a rectangular area around the receiving antenna. The special plane II (model 4) was created by a marginal change of the model 3 geometry by rounding off the corners of the plane. The size of the groundplane is also important for the price of an OATS, therefore the dimensions of the planes are given in table 1.


Fig. 1: Graphical representation of the modelled planes

Table 1: Dimensions of the modelled planes

| Model | Shape | Sizes of the plane | Area |
| :---: | :--- | :--- | :---: |
| 1 | Ellipse | Measurement distance $R=10 \mathrm{~m}$ <br> Dimension in x-direction is $2 R$ <br> Dimension in y-direction is $\sqrt{3} R$ | $271.7 \mathrm{~m}^{2}$ |
| 2 | Minimal plane | $d=3 \mathrm{~m} / D=5 \mathrm{~m} / a=1 \mathrm{~m} / W=3 \mathrm{~m}$ <br> $D=d+2 \mathrm{~m} ; W=a+2 \mathrm{~m}$ | $110 \mathrm{~m}^{2}$ |
| 3 | Special plane I | Measurement distance $R=10 \mathrm{~m}$ <br> Dimension in x-direction $2 R$ <br> Dimension in y-direction $R$ | $150 \mathrm{~m}^{2}$ |
| 4 | Special plane II | Measurement distance $R=10 \mathrm{~m}$ <br> Dimension in x-direction is $2 R$ <br> Dimension in y-direction is 13.6 m | $<150 \mathrm{~m}^{2}$ |

## NUMERICAL RESULTS

The ellipse and especially the minimal plane, which are specified in the above mentioned standard, have great deviations from the ideal ground plane in a high scan. The minimal plane shows a deviation of -22 dB for 100 MHz for the electric field and horizontal polarisation. The ellipse has a deviation of -8 dB with the same conditions (Fig. 2). Whereas model 3 and model 4 show smaller deviations in spite of the small area. This is also valid for the magnetic field, which is shown in Fig. 3.


Fig. 2: Deviation of the electric field from the ideal plane for horizontal polarisation


Fig. 3: Deviation of the magnetic field from the ideal plane for horizontal polarisation

## FIELD DISTRIBUTION AND SURFACE CURRENT DENSITY

In order to realize the physical effects, the electric field and the surface current distribution have been visualized. With these figures it is possible to "see" the parts of the plane, which have a dominant influence on the field distribution.


Fig. 4: Surface current distribution for the ellipse and minimal plane (hor. pol. $\mathrm{f}=30 \mathrm{MHz}$ )


Fig. 5: Surface current distribution for the special planes (hor. pol. $\mathrm{f}=30 \mathrm{MHz}$ )
The ellipse and the minimal plane show high values for the surface current distribution at the rim of the plane, which results in the mentioned big deviation from the ideal testsite particularly for the minimal plane (Fig. 4). Whereas model 3 has big surface currents in the plane below the Hertzian dipole (EUT) and smaller at the corners around the

EUT (Fig. 5). The influence of the outline of the rim is obvious, therefore the corners have been rounded of and the resulting model 4 shows smaller surface currents at the corners. This results in the smaller deviation from the ideal groundplane. Referring to table 1, the special plane II reproduces the ideal plane better than the ellipse, although it needs only $55 \%$ of the metallic surface compared with the ellipse (cost reduction). Fig. 6 shows, that the electrical field has maxima at the rim of the minimal plane (left figure), whereas the special plane II has a lower electrical field at the rim (right figure).


Fig. 6: Electrical field strength for horizontal polarisation and 100 MHz

## SUMMARY

It has been shown, that the strongest influence on the field distribution will be caused, if the metal plane around the transmitting antenna (EUT) is small. It is obvious that the metallic plane should be placed around the EUT where significant surface currents exist. So the positioning and distribution of the used metal plane is more important than the overall size of the metal plane. This is even more important for testsites with poor soil conditions, as stronger reflections occur at the transition between the plane and earth [12].

## REFERENCES

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