# ELECTROMAGNETIC DOSIMETRY OF THE SAR FOR A WALKIE-TALKIE SET-UP

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## INTRODUCTION

Nowadays, the walkie-talkie is becoming popular again with adults and children. The revival of the walkie-talkie can mainly be attributed to the free-of-charge connection. Furthermore, the quality of the connection has been improved by the implementation of better communication protocols, analog as well as digital. In our research we will focus on the devices that use the analog PMR446 standard. PMR446 stands for Private Mobile Radio in the frequency band between 446 MHz and 446.1 MHz. In this frequency band eight channels are available to establish a call using frequency modulation or FM. The effective radiated power, or *ERP*, is limited to 500 mW. The combination of the rather low radio frequency and the effective radiated power of up to 500 mW, demands an evaluation of the specific absorption rate or *SAR* in the human body. This paper describes first the modeling of a walkie-talkie in free-space. In the following section, the *SAR* has been assessed in a flat phantom set-up. In the third section, the SAR has been evaluated in the SAM head phantom and the Visible Human head phantom for a typical user position of the walkie-talkie in front of the face.

## MODELING OF A WALKIE-TALKIE IN FREE SPACE

Fig. 1 shows the model of the walkie-talkie: a helical antenna has been mounted on a ground plane. The dimensions of the model are based on the ones of real walkie-talkie and are listed in Table 1. Two commercially available software packages have been employed to run the simulations. SEMCAD uses a FDTD scheme to solve the Maxwell's wave equations, whereas FEKO does the job by the way of a hybrid MoM-FEM method.

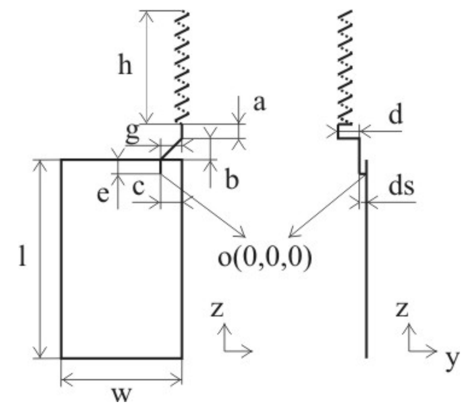



Fig. 1. The model of a walkie-talkie.

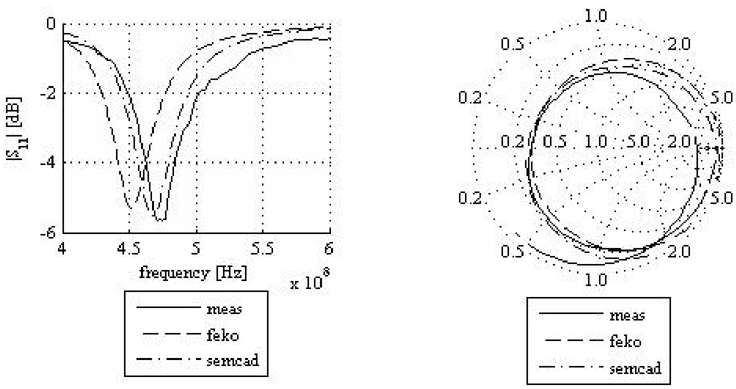
Table 1. The dimensions of the walkie-talkie model.

| | |
|---|---|
| h = 42 mm | $d_s$ = 3 mm |
| a = 4.2 mm | l = 80 mm |
| b = 9.8 mm | w = 45 mm |
| c = 10 mm | $r_h$ = 2.45 mm (radius helix) |
| d = 7.6 mm | $r_w$ = 0.3 mm (radius wire) |
| e = 5 mm | t = 0.5 mm (thickness ground plane) |
| g = 8.8 mm | $n_{turns}$ = 21 |

The simulation models in SEMCAD and FEKO have been validated with measurements. Various antenna parameters have been compared, such as: return-loss *RL* or $|S_{11}|$, reflection coefficient $S_{11}$, input impedance $Z_{in}$, radiation pattern and the near-field distribution in a plane above the walkie-talkie.

### Input Impedance and Reflection

Fig. 2 plots the return loss, or $|S_{11}|$ as well as the Smith Chart with the frequency between 400 MHz and 600 MHz. The simulation results of FEKO agree very well with the measurements. The resonance frequency as simulated with SEMCAD takes a slightly lower value compared with the measurements. In what follows we have chosen an operating frequency of 450 MHz. The input impedance at 450 MHz is listed in Table 2. Again, a good agreement between the simulations and the measurements is observed.




(a) (b)

Fig. 2. The return loss (a) and Smith Chart (b) of the walkie-talkie model.

Table 2. The input impedance in free space at 450 MHz.

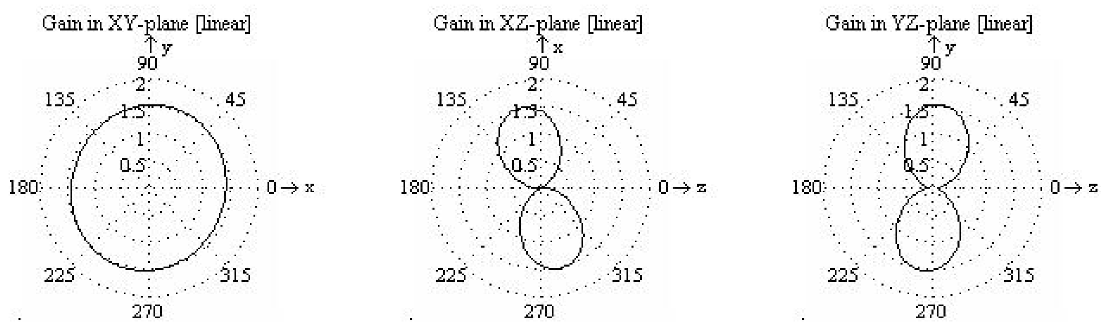
| | Zin [Ω] |
|---|---|
| meas | 10.7122 - i 43.3193 |
| FEKO | 13.7580 - i 37.5460 |
| SEMCAD | 14.6471 - i 0.6727 |

**Gain**

The effective radiated power is given by:

$$ERP = P\frac{G}{G_d}$$

With $P$ the antenna input power, $G$ the maximum gain of the antenna and $G_d$ the maximum gain of a half-wavelength dipole antenna, or 1.64. The simulated gain of the walkie-talkie model equals 1.54. This means that, for this walkie-talkie model, the input power at the terminals can be as high as 532.4 mW in order to be compliant with the standard. The gain in the three perpendicular planes of the Cartesian coordinate system is drawn in Fig. 3.

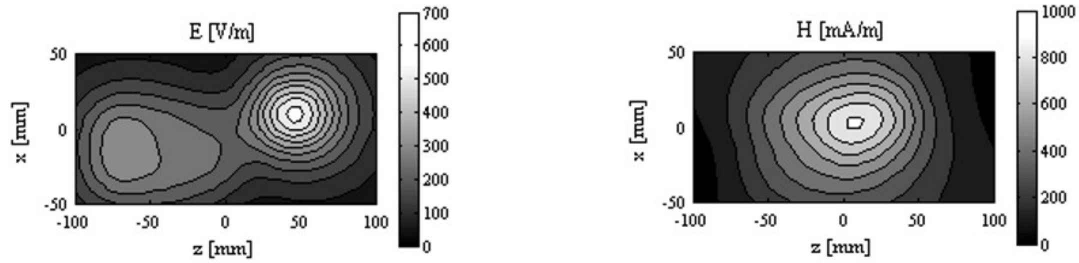



(a) (b) (c)

Fig. 3. The gain of the walkie-talkie model in xy-, xz- and yz-plane.

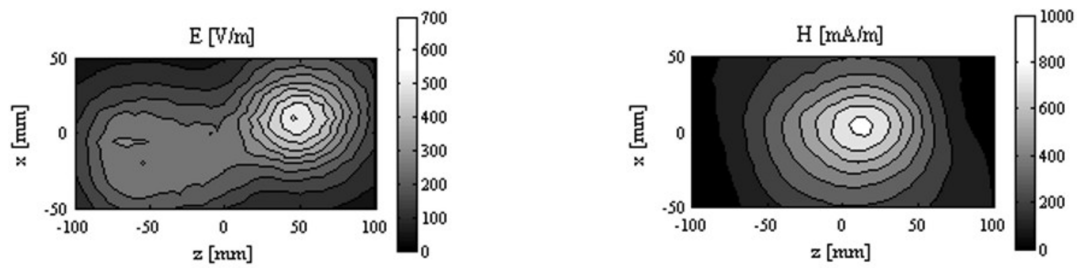
**The Near-fields**

The near-fields have been simulated and measured in the plane defined by $y$ = 20 mm. The results are viewed in Fig. 4 and Fig. 5 for the simulations and measurement, respectively. The origin of the plane has been aligned in the xz-plane with the feeding point of the walkie-talkie model. The highest electric field values occur around the helical antenna. Near the end of the ground plane, opposite to the side where the helical antenna has been mounted, the electric field also rises, but slightly. The magnetic field reaches its maximum value above the start of the antenna wire, near the feed point, where the current reaches its maximum value. Comparing the measurements with the simulations in Fig. 4 and Fig. 5, again a good agreement is observed.




(a) (b)

Fig. 4. The simulated electric (a) and magnetic (b) field of the walkie-talkie model for *y* = 20 mm.




(a) (b)

Fig. 5. The measured electric (a) and magnetic (b) field of the walkie-talkie model for *y* = 20 mm.

## ASSESSMENT OF THE SAR

### The Flat Phantom Set-up

The flat phantom set-up is drawn in Fig. 6. The phantom has been filled with head simulating liquid. The model of the walkie-talkie is placed at a distance *d* below the liquid-shell interface of the oval flat phantom. The measured dielectric properties of the liquid were: $\varepsilon_r$ = 40.9 and $\sigma$ = 0.74 S/m. These values deviate slightly from the IEEE recommended values [1], which are: $\varepsilon_r$ = 43.5 and $\sigma$ = 0.87 S/m. The operating frequency was again 450 MHz. The input power was 500 mW. The maximum averaged *SAR* in 1g and 10g of the liquid with varying distance *d* is shown in Fig. 8. The measured averaged *SAR* has lower values than the simulations. Regarding the allowed *ERP*, as specified by the standards, one observes that for our model the safety limits for the mass-averaged *SAR* in 1g (1.6 W/kg) and 10g (2 W/kg) are exceeded.

### The Visible Human Set-up

The Visible Human head set-up is shown in Fig. 7. All the tissues have been assigned the dielectric properties of the head as recommended by IEEE for a frequency of 450 MHz. The walkie-talkie has been placed in a vertical position in front of the face. The distance *d* is now defined as the distance between the walkie-talkie model and the tip of the nose. The results of the *SAR* assessment are shown in Fig. 8. For both 1g and 10g averaged *SAR*, it results that the flat phantom set-up is not conservative anymore. The limits are exceeded in the flat phantom set-up for 1g as well as for 10g of averaged *SAR*. In the case of the Visible Human head set-up the averaged *SAR* is not compliant with the standard. It has also been observed that the maximum *SAR* values in the Visible Human head occur between the eyes and just below the nose.

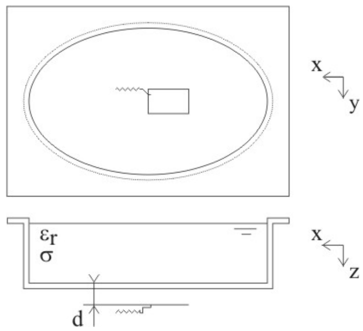



Fig. 6. The oval flat phantom set-up.

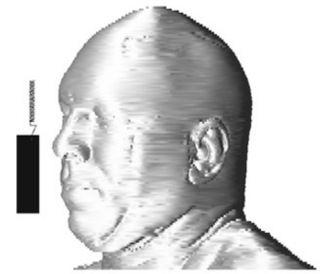
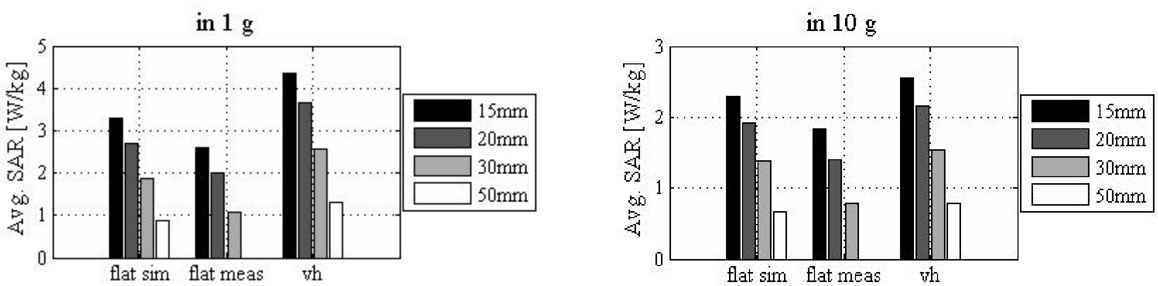


Fig. 7. The Visible Human head phantom set-up.




(a) (b)

Fig. 8. The averaged *SAR* in 1g and 10g for the flat phantom set-up and the homogeneous Visible Human head.

## CONCLUSIONS

A model for a walkie-talkie has been developed and validated in free space. Our model of a walkie-talkie causes an averaged *SAR* higher than the safety limits, taking into account the maximum allowed ERP for PMR446. Furthermore, the flat phantom does not yield a conservative value for the averaged *SAR* in the Visible Human head phantom.

## REFERENCES

[1] IEEE Std. 1528, "IEEE recommended practice for determining the peak spatial-average specific absorption rate (SAR) in the human head from wireless communications devices: measurement techniques," 2003.

[2] CENELEC EN50361, "Basic standard for the measurement of Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones (300 MHz – 3 GHz)," 2001.

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