MODELING OF INSTALLED ANTENNAS USING A HYBRID EFIE-CFIE FORMULATION

This example shows how hybrid EFIE-CFIE integral equation formulation introduced in Efield 5.2 can be used to speed up the solution of antenna installation problems when using the Efield MLFMM solver. Typical problems where MLFMM is an excellent choice are the analysis of installed antenna performance or antenna to antenna coupling on large platforms. However, often the antenna can not be modelled as a closed body and as a consequence CFIE can not be used with the result of poor convergence in MLFMM. In Efield 5.2 a hybrid hybrid EFIE-CFIE integral equation formulation was introduced where the antenna can be modelled with EFIE and the rest of the platform with CFIE. This results in a formulation with much better convergence properties than pure EFIE. When using EFIE for the antenna part point voltage sources on thin wires, edge voltage sources and wave guide ports can be used. For antenna modelled with CFIE only wave guide ports are supported. Three different cases are considered:

- Coupling of two monopole antennas on a rectangular body using edge voltage excitation
- Coupling of two u-slot antennas on a rectangular body using edge voltage excitation
- Monopole antenna on a rectangular body using thin wire voltage node excitation

Coupling of two monopole antennas

The monopole antennas are mounted on a rectangular box with dimensions 6.4m x 2m x 0.4m, see Figure 1 and Figure 2. A coupling analysis between the antennas located 5m apart in frequency range 500 MHz to 1.5 GHz is done. The monopole antenna is modelled as a thin strip of length 75mm and width 4mm. The EFIE is used for the monopole antenna and CFIE for the rectangular body. A voltage edge excitation is used on the middle of the strip. Two different meshes was created, a fine mesh consisting of 156834 unknowns (104582 elements) and a course mesh consisting of 121377 unknowns (80944 elements). The problem was solved using the Efield MLFMM solver. In Figure 3 and Figure 4 the scattering parameters are shown. The agreement between EFIE and EFIE-CFIE is very good for S_{11} but for S_{12} there are larger differences at the resonant region. Figure 5 shows the convergence for different frequencies both for the EFIE as well as the EFIE-CFIE case. The reduction of number of iterations when using the EFIE-CFIE formulation is drastic.

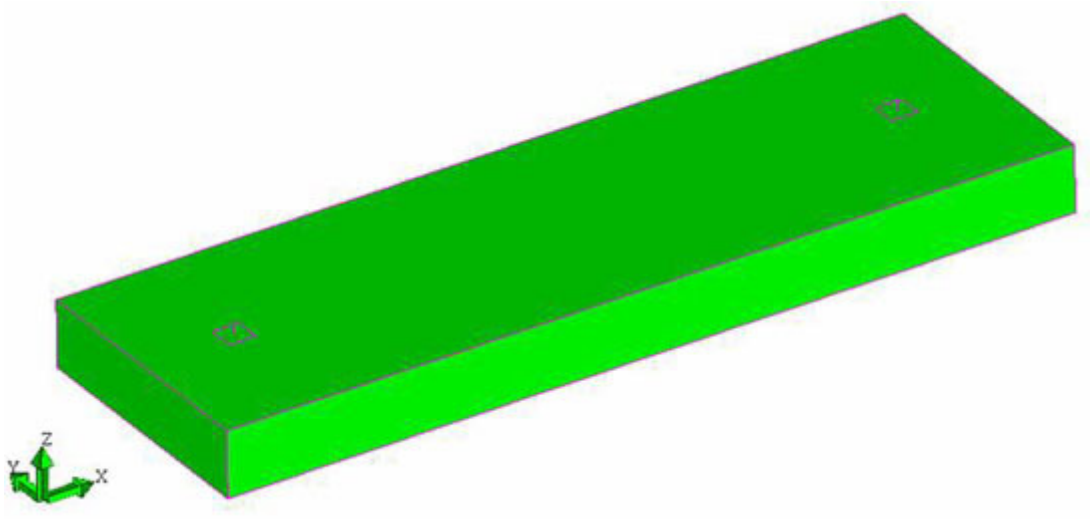

Figure 1: Monopole antennas mounted on a rectangular body

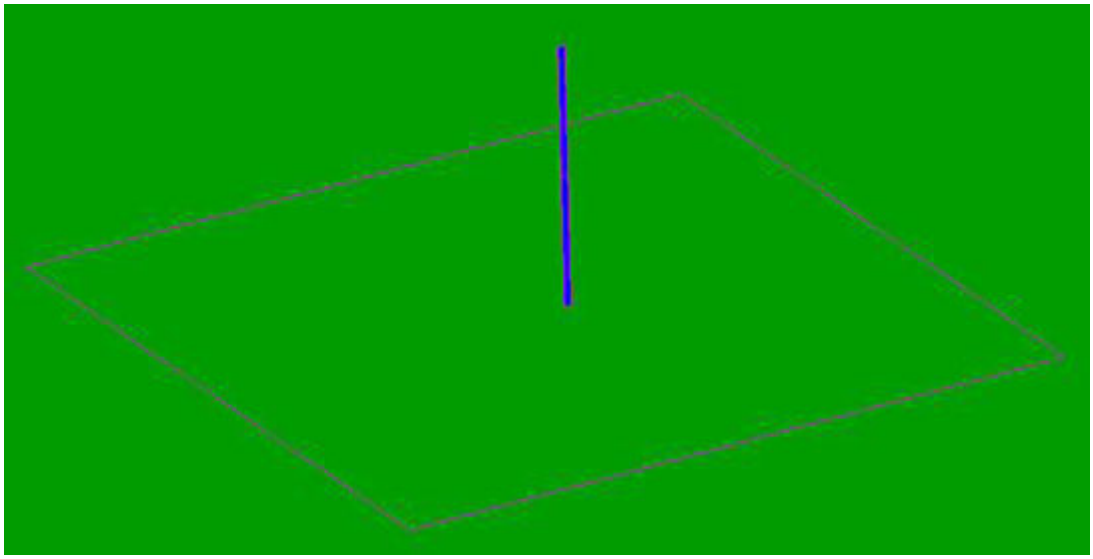

Figure 2: Monopole antennas mounted on a rectangular body (closeup of antenna)

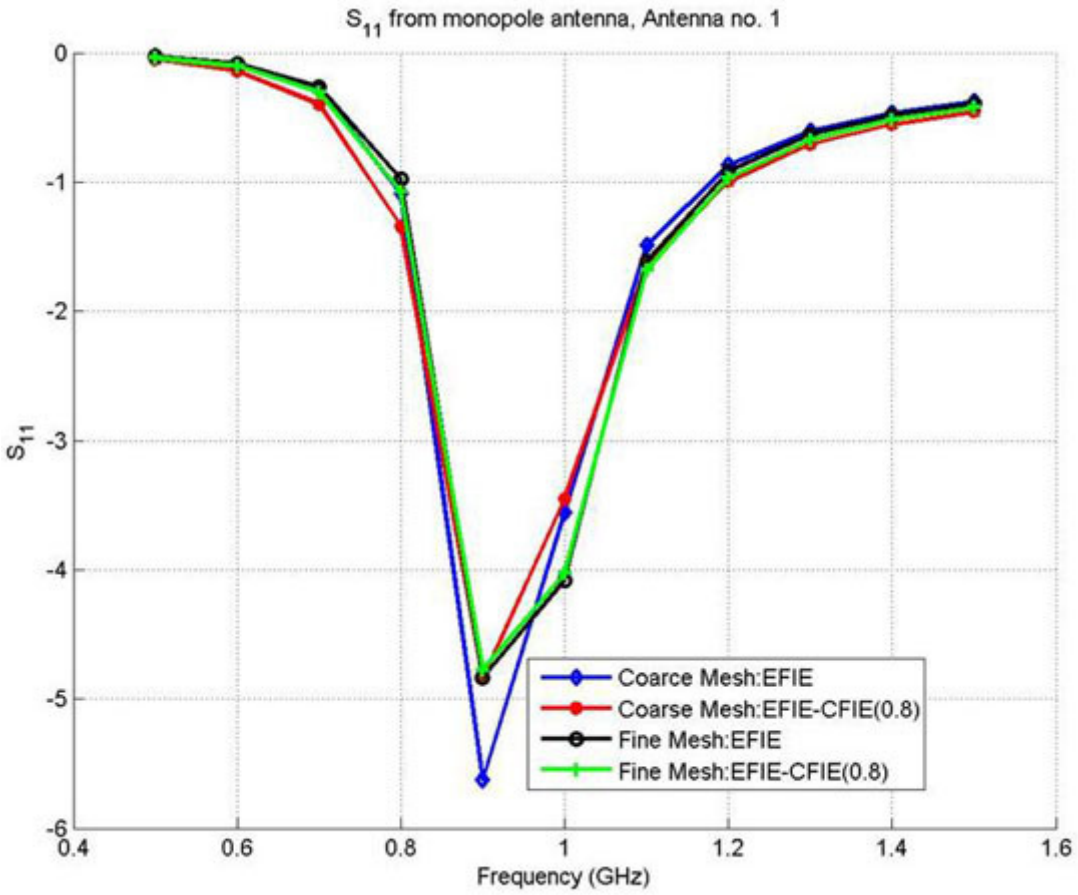

Figure 3: Coupling of two monopole antennas mounted on rectangular box. S_{11}.

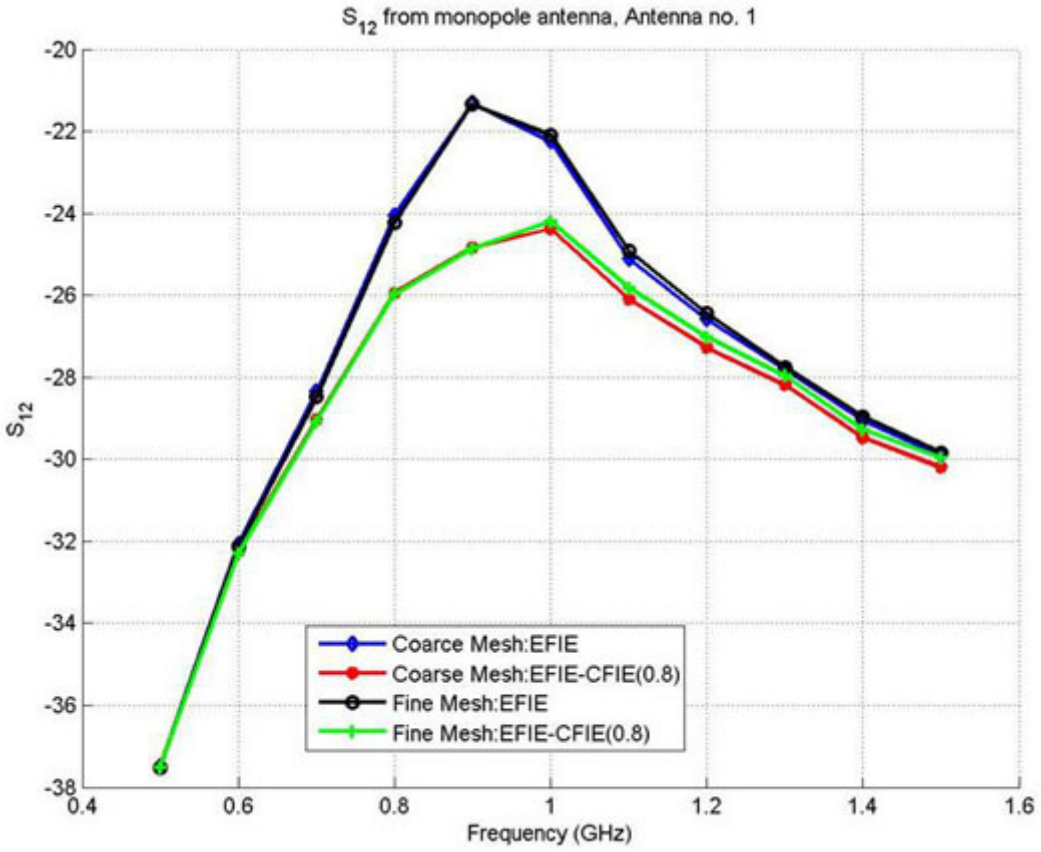

Figure 4: Coupling of two monopole antennas mounted on rectangular box. S_{12}.

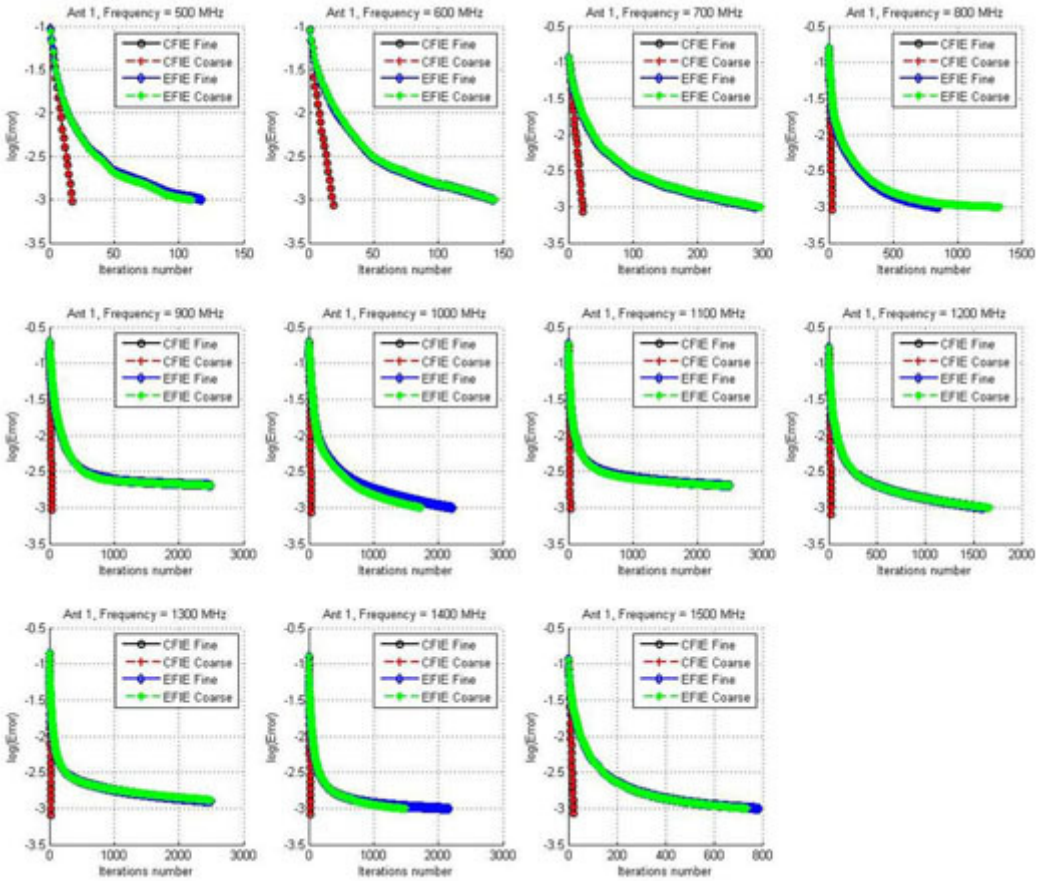

Figure 5: Convergence in MLFMM for different frequencies for monopole antennas mounted on rectangular box

Coupling of two u-slot antennas

In this case two u-slot antennas are mounted on the rectangular box with dimensions 6.4m x 2m x 0.4m, see Figure 6 and Figure 7. A coupling analysis between the antennas located 5 m apart in frequency range 500 MHz to 1.5 GHz is done. The u-slot antenna is modelled using thin PEC surfaces and the excitation used is a voltage edge excitation at the middle of the strip, see Figure 8. The EFIE is used for the u-slot antenna, shown in blue colour in Figure 8, and CFIE for the rectangular body. A mesh with 157177 unknowns (104858 elements) was created. The problem is solved using the Efield MLFMM solver. In Figure 10 and Figure 11 the scattering parameters are shown. The agreement between EFIE and EFIE-CFIE is very good for S_{11} but for S_{12} there are larger differences at the resonant region. Figure 12 shows the convergence for different frequencies both for the EFIE as well as the EFIE-CFIE case. The reduction of number of iterations when using the EFIE-CFIE formulation is drastic.

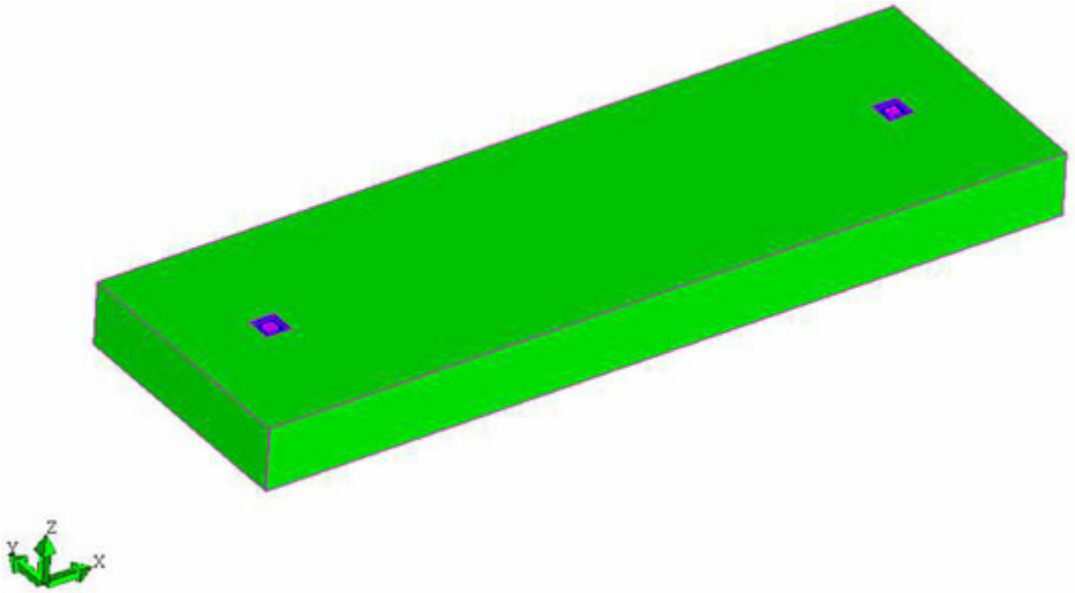

Figure 6: U-slot antennas mounted on a rectangular body

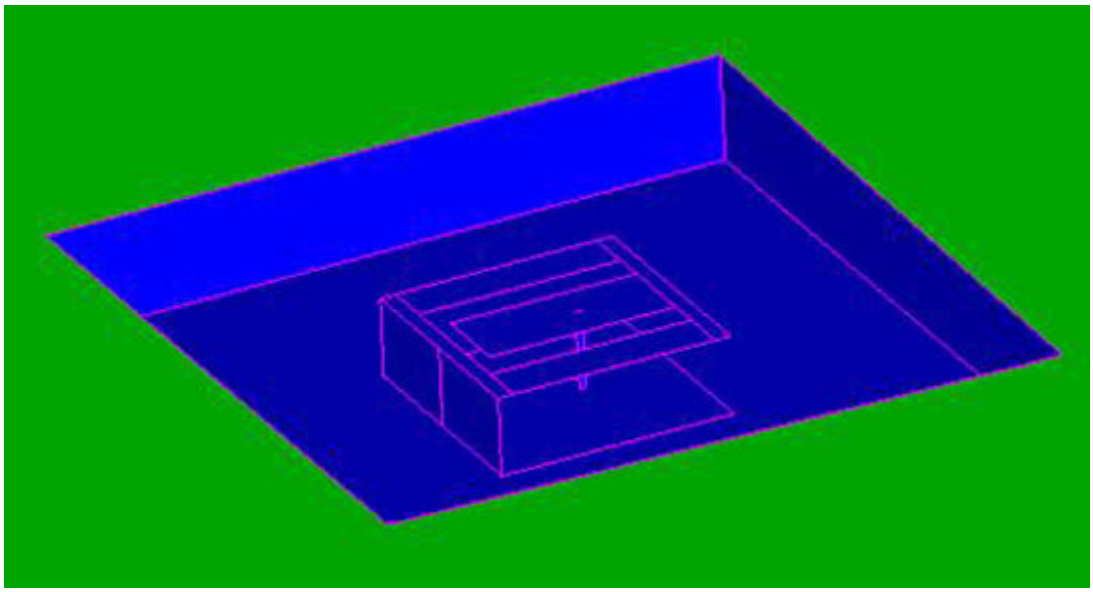

Figure 7: U-slot antennas mounted on a rectangular body (close up of antenna)

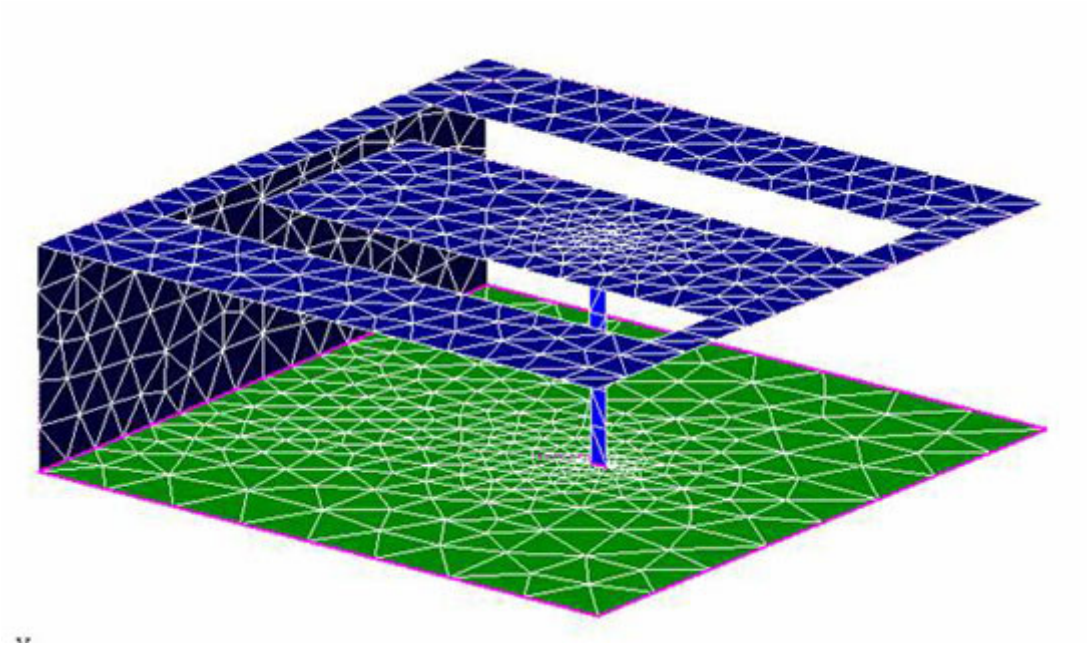

Figure 8: U-slot antennas. Blue parts modelled with EFIE.

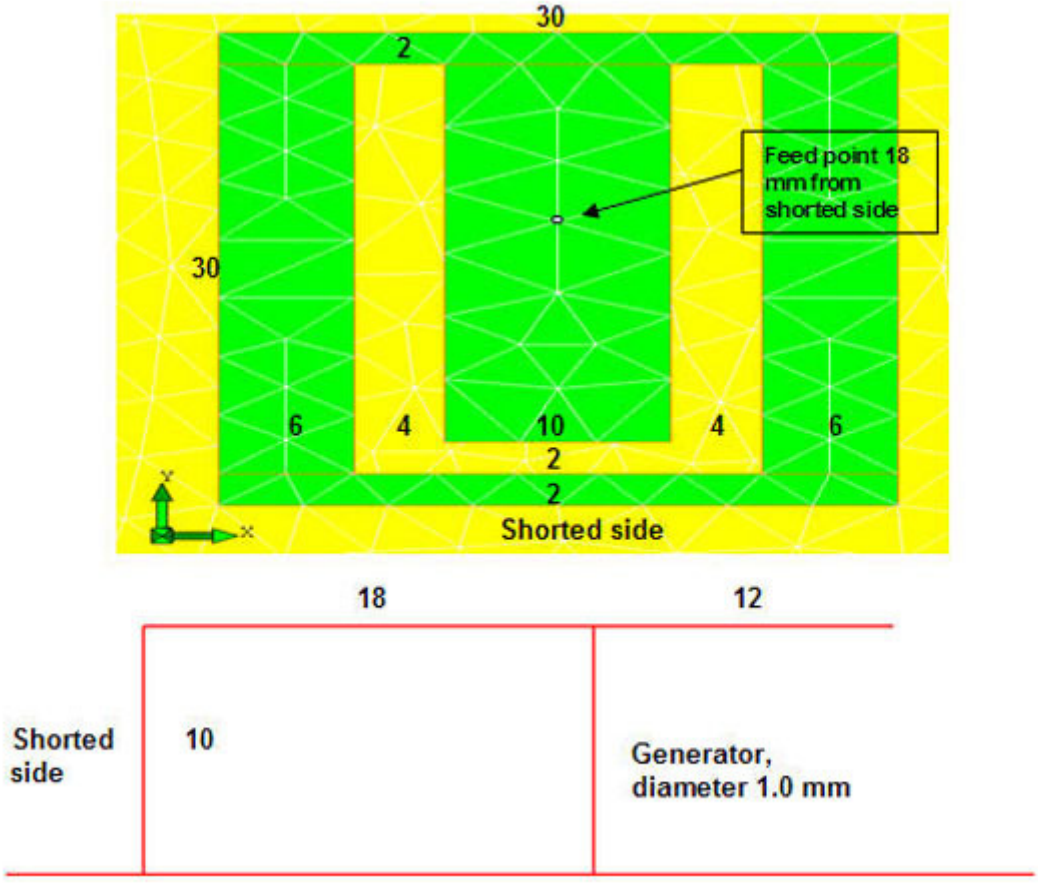

Figure 9: Geometry of microstrip antenna

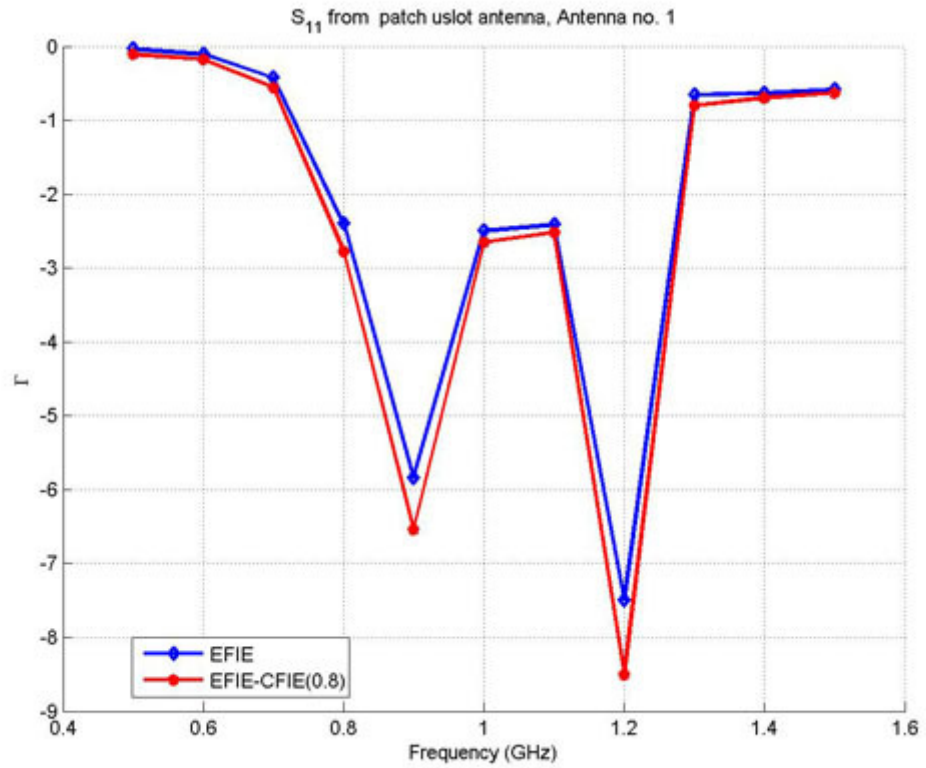

Figure 10: Coupling of two u-slot antennas mounted on rectangular box. S_{11}.

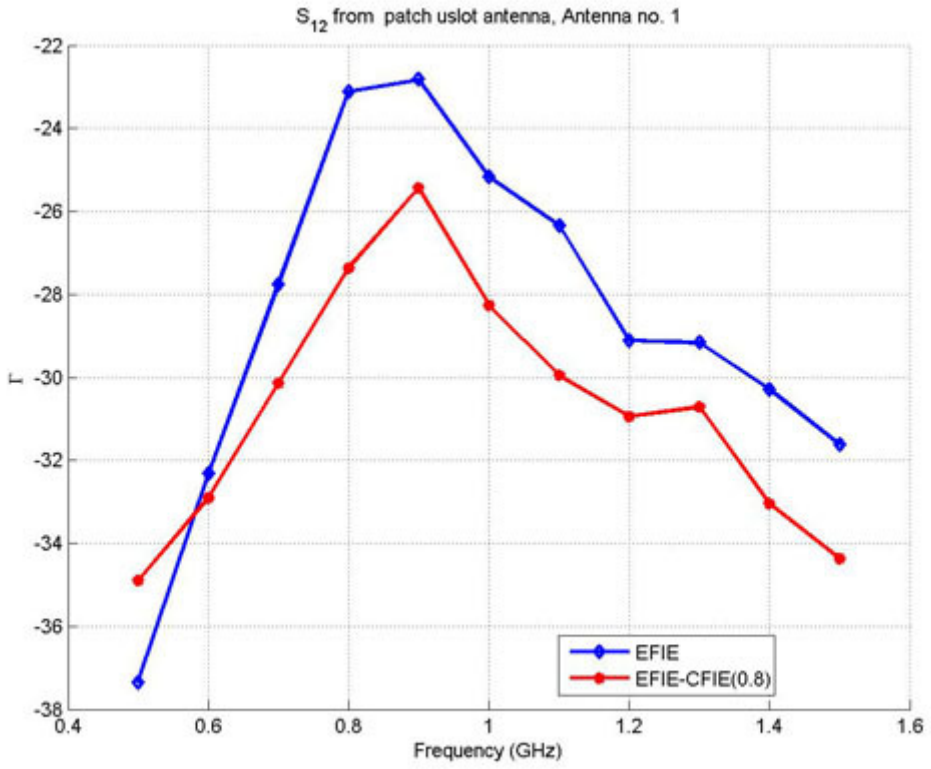

Figure 11: Coupling of two u-slot antennas mounted on rectangular box. S_{12}.

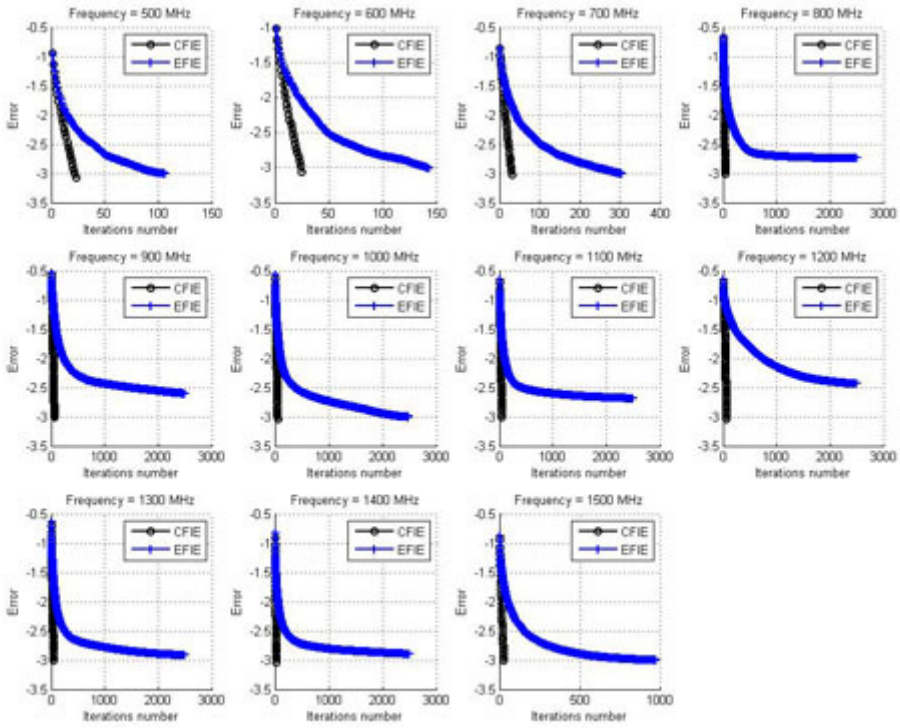

Figure 12: Convergence in MLFMM for different frequencies for u-slot antennas mounted on rectangular box

Installed monopole antenna

The monopole antenna is mounted on a rectangular box with dimensions 0.4m x 0.4m x 0.01m, see Figure 13. The gain at 2GHz and the input impedance for the frequency range 1500 MHz to 2500 MHz was computed. The monopole antenna is modelled as a thin wire of length 75 mm and radius 1 mm, see Figure 13. The EFIE is used for the monopole antenna and CFIE for the rectangular body. A voltage node excitation is used on the middle of the wire. The mesh created consisted of 688 elements and 1037 unknowns. The problem was solved using the Efield MoM solver with a GMRES iterative solver. In Figure 14 the gain for the antenna is shown at 2GHz. The agreement between EFIE and EFIE-CFIE is very good. Figure 15 shows the convergence for EFIE as well as EFIE-CFIE with different alpha parameters. The reduction of number of iterations when using the EFIE-CFIE formulation is very large. Figure 16 and Figure 17 shows the input impedance for the monopole antenna. Very good agreement between EFIE and EFIE-CFIE is achieved. Finally Figure 18 shows the number of iterations used to reach convergence for different frequencies with EFIE and EFIE-CFIE.

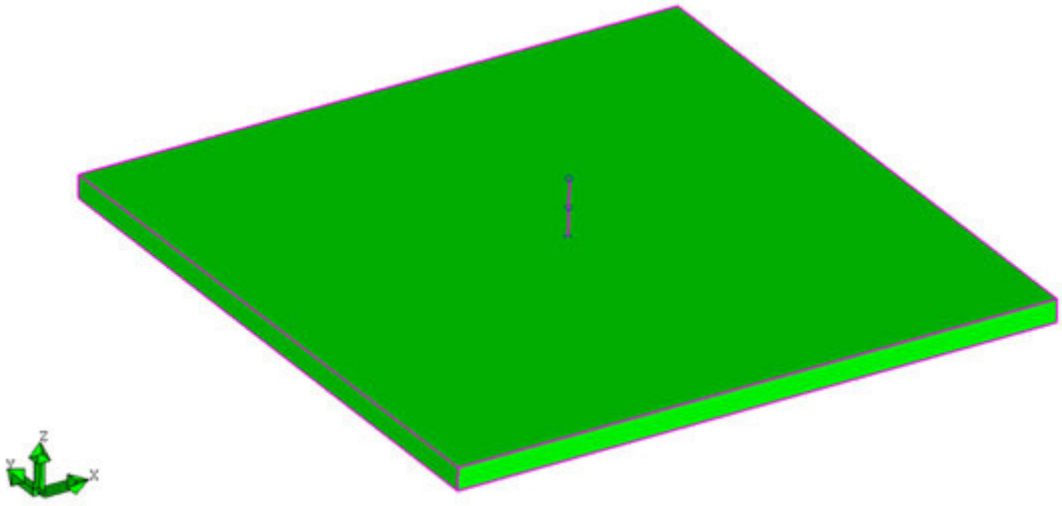

Figure 13: Monopole mounted on ground plane

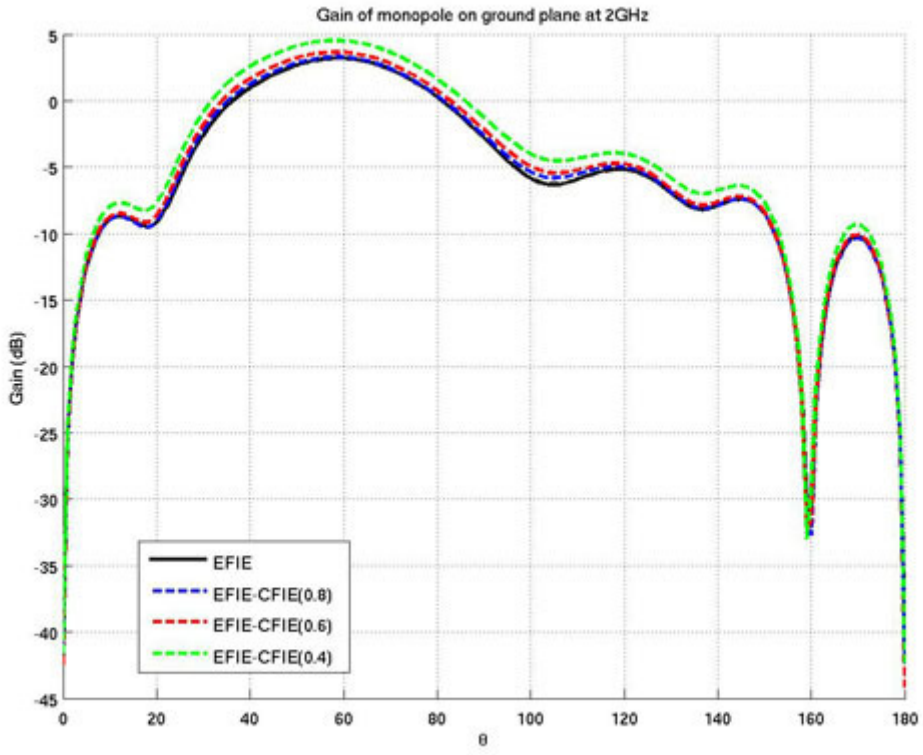

Figure 14: Gain for monopole mounted on ground plane. EFIE compared with EFIE-CFIE with different amount of CFIE.

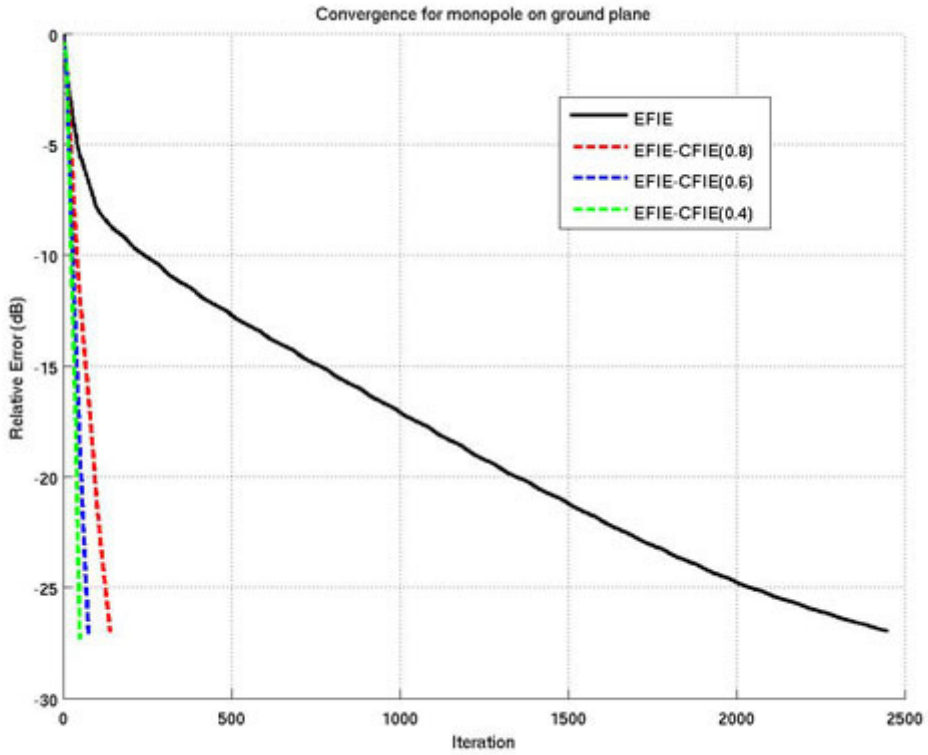

Figure 15: Convergence history for monopole mounted on ground plane. EFIE compared with EFIE-CFIE with different amount of CFIE.

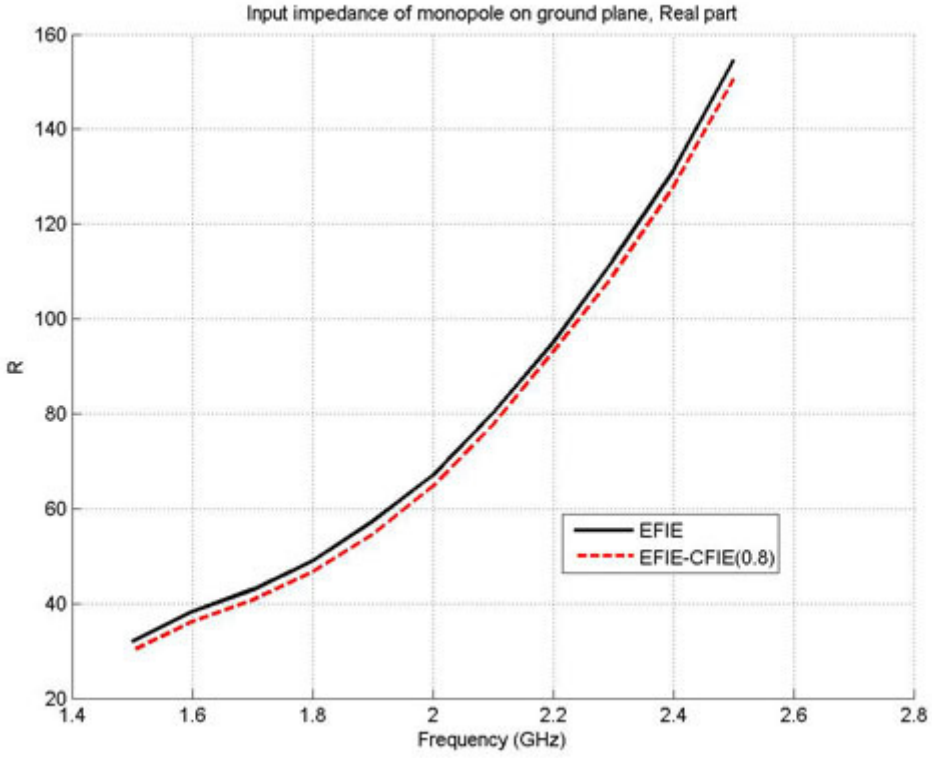

Figure 16: Real part of input impedance for monopole mounted on ground plane.

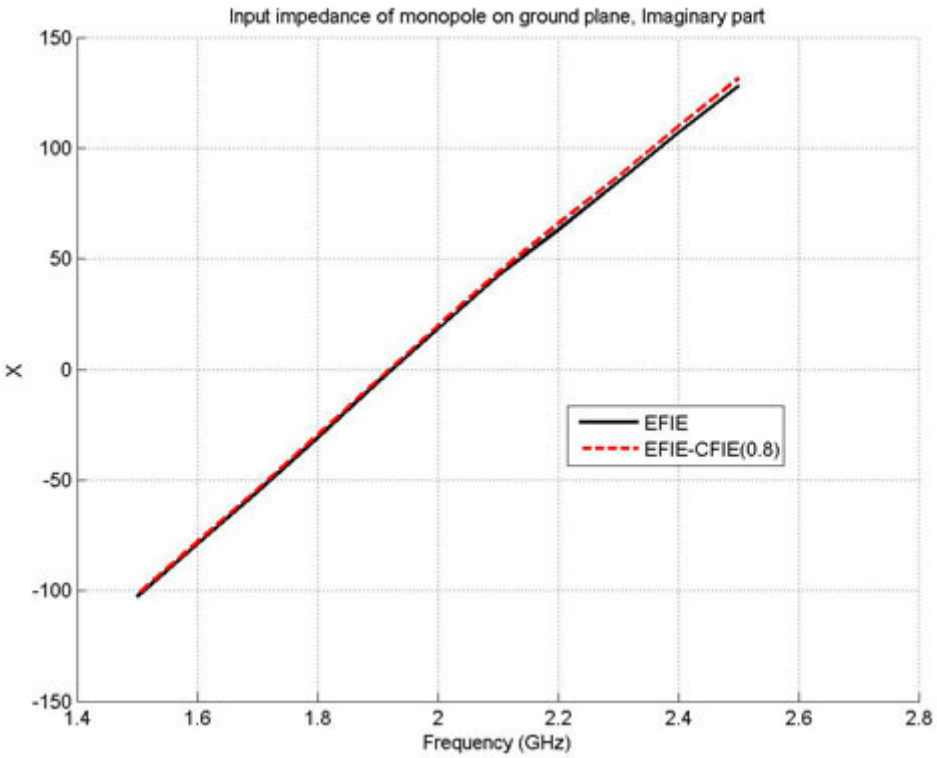

Figure 17: Imaginary part of input impedance for monopole mounted on ground plane.

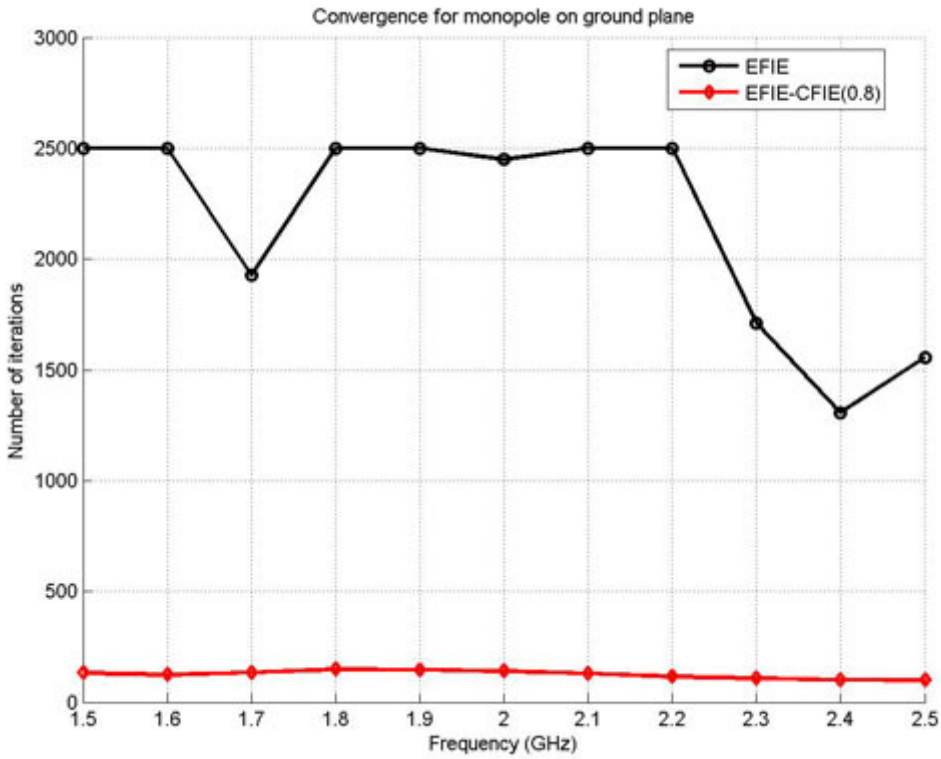

Figure 18: Number of iterations used to reach convergence for different frequencies for monopole mounted on ground plane. EFIE (black) compared with EFIE-CFIE (red).

Efield AB, Skalholtsgatan 10 B,
SE-164 40 Kista, Sweden
Tel: +46 8 410 03 510
Email: contact@efieldsolutions.com
www.efieldsolutions.com

