Proof of ETSI and FCC Compliance of RFID Reader and Wake-up Driver ICs

U2270B

Application Note

Atmel Products Applicable

The following calculations would apply to the Atmel U2270B Reader and the ATA5777 and ATA5275 Wake-up Driver ICs.

ETSI and FCC Regulations

The ETSI regulation EN300330 calls for a maximum magnetic H field of 37.7 dBµA/m at 10 meters from the antenna at 135 kHz. This is close enough to 125 kHz. Thus:

$H < 10^{37.7/20} = 76.7\ \mu A/m$.

The FCC regulation FCC, Part 15, Section 15.209 calls for a maximum electric E field of 2400/(f kHz) µV/m at 300 meters from the antenna. Thus:

$E < 2400/125 = 19.2\ \mu V/m$.

Maxwell's Equations

The fields of any antenna are calculated using Maxwell's equations. The general procedure is:

1. Approximate the current density J and charge density r in the antenna elements.
2. Calculate the *retarded* scalar potential V and vector potentials A from known values of J and r.
3. Calculate the E and H fields from known values of V and A.

Other parameters (not needed here but important for HF antennas) are:

1. Radiated (average) power

   $$P = \frac{1}{2}\iint_S (E \times H)ds$$

   where S is the surface of a sphere enclosing the antenna.
2. Radiation resistance $R = P/I^2$ where I is the effective current in the antenna element.
3. Element losses and reactance. Important for matching.

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Electric and Magnetic Fields of a Short Dipole

For a dipole of length 2r carrying a current NI, the maximum fields at distance R meters from the dipole centre are:

1. The E field parallel to the dipole:

$$E = \frac{2NIr}{4\pi\varepsilon}\left(\frac{j\omega}{c^2R} + \frac{1}{cR^2} + \frac{1}{j\omega R^3}\right)$$

2. The H field perpendicular to the dipole axis:

$$H = \frac{2NIr}{4\pi}\left(\frac{j\omega}{cR} + \frac{1}{R^2}\right)$$

In the near field (Freznel) case, only the last term of these expressions is significant.

Square Loop Antenna

We can analyse the square loop antenna (with N turns to model a typical coil antenna) by considering it to be formed from four short dipoles in series. The result will be close to that for a circular antenna coil of radius r. If the distance from the centre of the loop along the loop axis is d then, considering the geometry of the loop, the H field will be given by:

$$H = \frac{2NI}{\pi}\frac{r^2}{(r^2 + d^2)^{3/2}}$$

The E field will be given by:

$$E = 240NI\frac{r^2}{(r^2 + d^2)^{3/2}}$$

Examples

1. For a typical RFID reader; N = 97 turns, I = 0.224 A, r = 0.02 meters.
   So at a distance on axis of d = 0.02 meters:
   H = 244 A/meter.
   This is a typical value of field strength at short range.
2. For the same reader
   At d = 10 meters:
   H = 5.5 µA/meter.
   Note that this is well within the ETSI regulation of 76.5 µA/meter.
   At d = 300 meters:
   E = 0.04 µV/meter.
   Note that this is well within the FCC regulation of 19.2 µV/meter.
3. For a Wake-up driver with similar coil but I = 1 A
   At d =10 meters:
   H = 24.5 µA/meter.
   Note that this is within the ETSI regulation of 76.5 µA/meter.
   At d = 300 meters:
   E = 0.18 µV/meter.
   Note that this is within the FCC regulation of 19.2 µV/meter.

Noting that the above examples take no account of the antenna efficiency, they prove that the regulation limits are not exceded.

References

1. Electromagnetics, Kraus and Carver, 1973, ISBN 0-07-035396-4 page 616.
2. RFID Handbook, Finkenzeller, 1999, ISBN0-471-98851-0, pages 11 to 124.

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