SmartDiagnostics® Application Note

Wireless Electric Field Strength

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Overview

In the oil and gas industry, electronic equipment must comply with electric field strength limits that may be more stringent than standard hazardous certification requirements. To support evaluation of SmartDiagnostics® wireless sensors in such environments, this application note comments on the electric field strength generated by SmartDiagnostics® wireless sensor products. In this description, the maximum electric field strength generated is presented as a function of distance from the emitting antenna.

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This analysis uses the following commonly used formulation for the far-field irradiance of an electromagnetic wave in space:

$$E_e\left(\frac{W}{m^2}\right) = \frac{P_{EIRP}}{4\pi r^2} \qquad [1]$$

In Eq. 1, the effective radiated power of a point source (P_{EIRP}) is given as

$$P_{EIRP}(W) = P_T\, G_{Antenna} \qquad [2]$$

where P_T is the transmitter output power, $G_{Antenna}$ is the gain of the antenna, and r is the distance from the antenna (m) to the location where the field is being evaluated.

KCF wireless products uses a dipole antenna with a maximum gain of 2.3 dBi ($G_{Antenna} = 1.7$) and transmitter output power of 20 dBm ($P_T = 0.1$W).

Using these values, the irradiance is given as

$$E_e\left(\frac{W}{m^2}\right) = \frac{0.0135}{r^2} \qquad [3]$$

The relationship between power and voltage, given as Eq. 4 (combination of Joule's law and Ohm's law), is then used to compute the electric field as a function of distance.

$$P\,(W) = \frac{V^2}{Z} \qquad [4]$$

In Eq. 4, V is voltage (V) and Z is impedance (Ω). In free space, the relationship between the *E* field and the *H* field is used to obtain an impedance of 377 Ω.

By dividing both sides of Eq. 3 by r^2 and setting Eq. 3 equal to Eq. 4, the electric field strength as a function of distance is obtained as the following

$$E\left(\frac{V}{m}\right) = \frac{2.26}{r} \qquad [5]$$

The above equations Eq. 1 and 5 show that irradiance is inversely proportional to the square of the distance and amplitude of the field strength vector is inversely proportional to distance.

As a point of reference, the FCC limits on field strength are considered in this analysis. FCC limits are mentioned because some commercial devices, such as WiFi transmitters, emit fields that are higher than KCF wireless sensors. In particular, the FCC limits (Part 15, intentional transmitters) the maximum transmitting power in the 2.4GHz ISM band to less than 30dBm with a maximum antenna gain of 6dBi, which gives the following upper electric field strength bound for common commercial devices that could be found in an industrial environment.

$$E\left(\frac{V}{m}\right) = \frac{10.9}{r} \qquad [6]$$

The FCC limits and the KCF wireless sensor field strength are shown in the following figure

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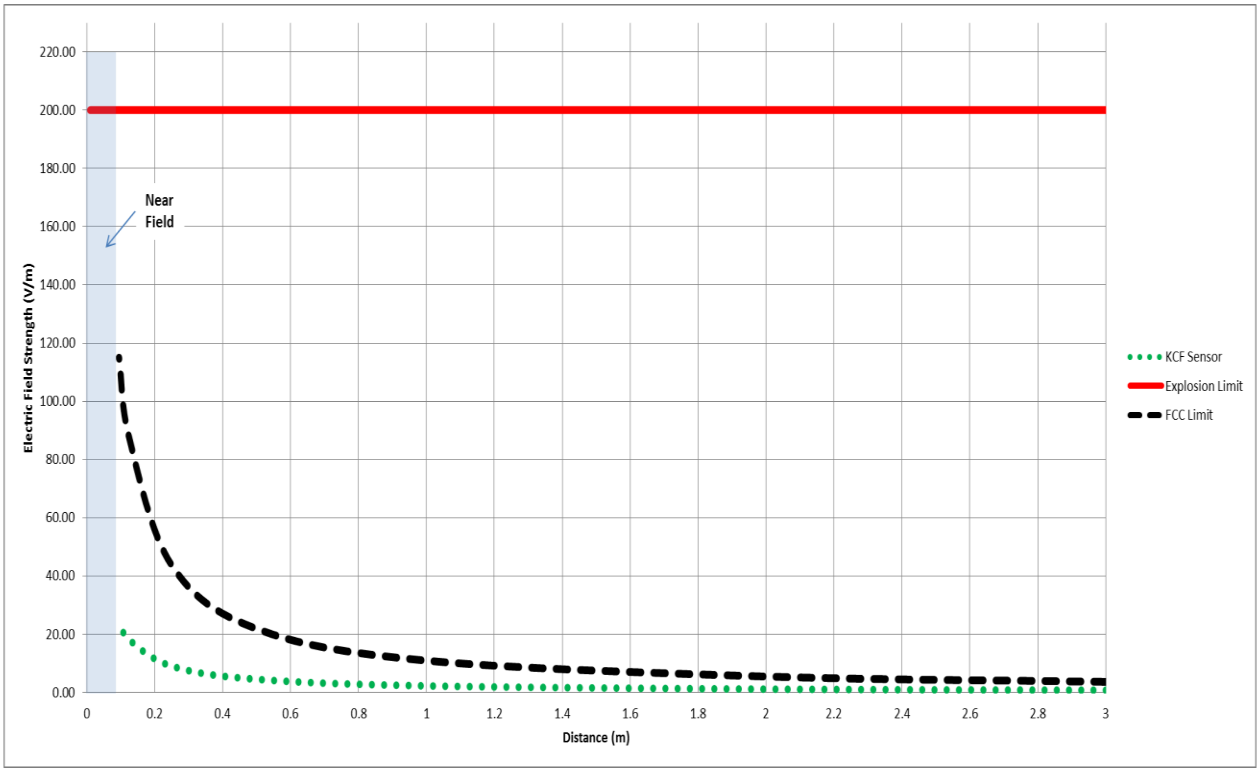

This figure shows that at meter distance from KCF's wireless sensor, the electric field strength will be 12.6 dB below the 200 V/m threshold. These equations are valid only in the far field. This far field boundary is a nebulous region defined by the Fraunhofer equation. When objects are in the near field, they can load the transmitter, causing the relationship between the *E* and *H* fields to break down, thus invalidating this analysis. The far field boundary for a dipole with length ($1/3\lambda <$ Length $< 2.5\lambda$) is given by [1]

$$r > 5D \qquad [7]$$

where *D* is the physical length of antenna ($1/2\ \lambda$). At 2.45GHz *D* is approximately 6 cm, and the far field boundary is 0.3 meters.

1. Bansal. R., "The Far-Field: How Far is Far Enough?" Applied Microwave & Wireless, Design Ideas, Pg. 60, (http://people.eecs.ku.edu/~callen/725/Bansal1999AMWpp58.pdf).

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