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ELECTRIC AND MAGNETIC FIELD INTENSITIES AND ASSOCIATED INDUCED BODY CURRENTS IN MAN IN CLOSE PROXIMITY TO A 50 KW AM STANDARD BROADCAST STATION

[redacted]

Measurements of the electric and magnetic fields which exist in the immediate proximity of a 50 kW AM standard broadcast radio station and the associated induced body currents flowing in man are reported. The data illustrate the potentially intense exposure fields which can occur near high power monopole radiators and represent a novel method for validating theoretically derived values of radiofrequency currents in man. Such validation is important since actual measurements of specific absorption rates (SAR) in full sized humans are difficult to perform at medium wave frequencies. Field measurements were performed at a local radio station operating on 720 kHz and using a single 0.25λ height monopole radiator. Electric (E) and magnetic (H) field strengths up to 300 V/m and 5.5 A/m rms respectively were observed at a distance of about 2 m from the monopole and values of the ratio of E and H, or the wave impedance, were examined from 2 m to approximately 20 km. It was found that the wave impedance dropped to less than half of the far field value of 377 ohms at distances less than 150 m. The current induced in the body of man immersed in these fields was examined via determining the current flowing from the body to ground by standing a person on a small ground plane 15 cm above the earth ground and measuring the voltage drop occurring across a know resistor between the ground plane and earth. A narrow band, tuned technique was used to measure the resulting voltage drop which permitted a very high sensitivity in detecting body currents. It was found that body current was linearily related to the electric field intensity parallel to the long axis of the body and was in the range of 260-290 (μA)/(V/m) rms depending on height of the person. The measured body current data was compared with theoretically computed values which would flow in a prolate spheroidal model of man standing on a high conductivity ground plane. Excellent agreement between the measured data and the theoretical calculations suggests that theoretical results can accurately account for potentially hazardous currents flowing in man at medium wave frequencies.

Measurements of the intense electric and magnetic fields which exist in the immediate proximity of a 50 kW AM standard broadcast radio station operating on 720 kHz and using a single, omni-directional 0.25λ height monopole radiator are reported. Electric (E) and magnetic (H) field intensities were determined by using a calibrated 104 cm high rod antenna and a calibrated 38 cm diameter loop respectively connected to a tunable, narrow band radiofrequency field strength meter. Rod and loop antenna calibrations were referenced to a calibrated field strength meter having an accuracy of $\pm$0.2 dB. Measurements of E and H were performed over a range of distances from 2 m to over 20 km and ranged between 300 V/m and 0.1 V/m for E values and 5.5 A/m and 300 μA/m for H values. The wave impedance of the fields was examined by forming the ratio of the E and H field amplitudes. It was found that the wave impedance dropped to less than half of the far field value of 377 ohms at distances less than 150 m and was essentially equal to the far field value at a distance of about 1 km. The measured values of E and H field intensities were compared to theoretically determined values obtained for a 0.25λ high monopole over perfect ground and the differences are discussed in terms of finite ground losses and tower characteristics.

The principle purpose of this study was the measurement of the radiofrequency current induced in the body of man immersed in these fields. Such measurements represent a novel method of validating theoretical derivations of potentially hazardous currents flowing in man at medium wave frequencies. These validations are important since direct measurements of the specific absorption rate (SAR) for full sized adults at these frequencies are difficult. The body current determination was made by measuring the voltage drop across a known resistor which was connected between a small ground plane, supporting an individual approximately 15 cm above the earth, and the earth ground. A high impedance, tuned technique was used for the voltage drop measurement thereby allowing a very high sensitivity for detecting body current. It was found that body current was linearily related to the electric field component parallel to the long axis of the body and was in the range of 260-290 $(\mu A)/(V/m)$ rms depending on height of the individual.

Theoretically derived values of the current flowing through the cross section of a prolate spheroidal model of man in contact with a conductive ground plane were obtained and compared to the experimentally determined currents. Excellent agreement between the data indicates that the theoretically obtained results can accurately account for potentially hazardous currents flowing in man at medium wave frequencies. The following relation was found to predict the measured body current with an accuracy typically within 10 percent:

$$I = \frac{j\omega\varepsilon_o \, (\varepsilon' - j\varepsilon'')E_o \Pi b^2}{(\varepsilon'-1)g_e + 1 - j\varepsilon'' g_e}$$

where:

I = body current (A)

ω = angular frequency = $2\Pi f$ (F in Hz)

ε_o = permittivity of free space = 8.854×10^{-12} F/m

ε' = real part of complex permittivity of body material, typically ~ 2,800 at 720 kHz

ε'' = imaginary part of complex permittivity of body material, typically ~ 13,000 at 720 kHz

E_o = incident peak electric field (V/m) parallel to the long axis of the body

b = semi-minor axis of prolate spheroidal model of man (m)

$$g_e = (u^2-1)\left\{\frac{u}{2} \ln \frac{u+1}{u-1} - 1\right\}$$

$$u = \frac{a}{\sqrt{a^2-b^2}}$$

a = semi-major axis of prolate spheroidal model of man (m) (1.75 m for average man imaged in ground plane)