ELECTROMAGNETIC INTERACTION WITH HUMAN PHANTOM MODELS; APPLICATIONS TO MOBILE RADIOS

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ABSTRACT:

Transient thermographic measurements have been performed using full size human head phantom models (containing muscle equivalent material) irradiated by a quarter wave monopole above a ground plane. The antenna was excited by 100 watts at 456.65 MHz. Results describe the effect of model position and orientation on the deposited power. Corrections for thermal diffusion during and after irradiation of the model are applied. Peak specific absorption rates (SAR) for worst case conditions are presented.

In order to assess the effect of electromagnetic radiation on humans, it is necessary to establish the level of energy coupled into humans. This is conveniently done using thermographic analysis of phantom models. The energy coupled into the model is dependent on many complex parameters such as the unloaded radiation field distribution and the interaction of the body with the unloaded field pattern. Each source of electromagnetic radiation produces a unique energy deposition pattern. This condition is particularly true when the model is placed in close proximity (near field) to the radiating source. In many cases, the use of standard plane wave calibrated radiation hazard monitors will not accurately determine the energy deposition in biological systems. This paper describes human head phantom model exposure experiments using the thermographic measurement approach. Emphasis is placed on the effect of thermal transient phenomena both during and after exposure.

The radiation source chosen for this measurement program was a quarter wave monopole mounted on a ground plane. The antenna was excited by a 100 watt mobile transmitter operating at 456.65 MHz. The near field radiation pattern for this source closely simulates the condition of a quarter wave whip mounted on the roof of a vehicle. An advantage in choosing this configuration is that the unloaded field distribution may be calculated. The basic experimental measurements were made using a human head foam plastic shell filled with muscle equivalent material and positioned 0.25 inches from the whip antenna.

The extremely close spacing was chosen to permit maximum temperature resolution in the thermographic measurement for analysis of the thermal diffusion process. The spacing is considered unrealistically close for actual model to antenna proximity. The deposition rate in phantom material is measured in terms of specific absorption rate (SAR). Of the many antenna-head configurations tried the maximum SAR was obtained with the antenna tip at either the bridge or the tip of the nose. When the model surface was relatively flat, such as the forehead, the peak SAR decreased to about one third the maximum value in the nose region. Thermal diffusion data taken at close spacing showed the SAR to be a function of exposure time with the 60 second exposure having an SAR about one half the 15 second exposure. Attempts to increase the antenna-head distance to values more realistic than 1/4 inch is limited by the radiation source power and the thermal resolution. An antenna to model spacing of one inch required a 60 second exposure at full power to obtain good thermal resolution. When the close in thermal diffusion corrections were applied to the one inch data, a peak SAR of about 200 w/kg was obtained in a very small superficial region of the model at the bridge of the nose. Beyond the one inch spacing, the distribution of the absorption pattern can be determined but the peak SAR level becomes more difficult to determine. One additional observation was that as the model was moved further from the antenna, a larger fraction of the microwave power was deposited in the neck region of the model.

Measurements are presently being made in an attempt to correlate thermographic results to small electromagnetic probe results, in order to estimate the SAR at larger source to model spacings. In addition, a full body phantom model will be evaluated to permit additional geometrical boundary conditions on the field pattern. The small probe measurements will also be compared to the theoretical results for a monopole mounted on a ground plane with no field loading.