Evaluation of Exposure of School Children to Electromagnetic Fields from Wireless Computer Networks (Wi-Fi): Phase 1 Laboratory Measurements

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INTRODUCTION

People using wireless computer networks (Wi-Fi), or in proximity to the equipment, are exposed to the radio signals and will absorb some of the transmitted energy in their bodies. The output power of Wi-Fi equipment is restricted to a maximum of 100 mW at 2.4 GHz in Europe, and there is no expectation that exposures will exceed international guideline levels. Nevertheless, this rapidly developing technology is increasingly used in schools and, given the existing precautionary advice in many countries to discourage non-essential use of mobile phones by children [e.g. 1], it is important to quantify the exposure from Wi-Fi equipment, as used by children in schools. Hence, in October 2007, the Board of the UK's Health Protection Agency announced a systematic programme of research to investigate those types of Wi-Fi equipment used in schools. The first phase of the project, as reported here, is a series of laboratory measurements with selected items of Wi-Fi equipment known to be popular in schools. Later work will involve modelling of energy absorption in the body, monitoring of transmit duty factors during school lessons and ultimately a health risk assessment drawing on all of these results and other material.

MATERIALS AND METHODS

Discussions and information gathered at the start of the project showed that laptops are the most popular wireless devices used in schools, with IEEE 802.11g as the most widely utilised standard. For this work, a total of 14 laptops were chosen from among the most popular models used by the education sector in UK. The objective of the laboratory measurements was to establish the radiation pattern (i.e. angular distribution of electric field strength around each laptop) and identify the angles at which the field is maximum. The electric field strength at these angles was then measured as a function of distance. The measurements were carried out within an anechoic chamber (3.7m×2.4m×2.4m), lined internally with radiofrequency absorber material, and with a purpose built manual positioning system. Dedicated software (LanTraffic) was used to generate and monitor the Wi-Fi signal from the laptops set to transmit at roughly 22 Mbps, the maximum sustained rate that could be reliably maintained using the IEEE 802.11g standard. The screen of the laptops was opened to an angle of 115 degrees for this work. Almost all of the previous studies on the exposure assessment from Wi-Fi equipment have used spectrum analysers as their main tool to analyse the signals [2-3]. The authors of this work did not consider spectrum analysers to be ideally suited for Wi-Fi measurements due to their bandwidth (typically a maximum of 5 MHz) being less than that of Wi-Fi signals and difficulties in accounting for the stochastic nature of Wi-Fi signals. Instead, an Agilent N9020A MXA signal analyser was used which has a bandwidth of 25 MHz allowing the detection of the whole WLAN signal. This instrument captures individual

Wi-Fi bursts in the time domain and demodulates them to identify the burst power, modulation scheme and many other parameters. For this work, the power of 50 bursts was measured at each position and then analysed in terms of the statistical distribution. To establish the radiation pattern, the E-field strength at 1m distance from the laptop was measured by an ARC Seibersdorf miniature biconical antenna in horizontal and vertical polarisations for azimuth and elevation rotations in 30° steps for the laptop on the manual positioning system (168 positions in total). The measured E-field data were then analysed and the angles of maximum radiation were identified. The manual positioning system was then set up at these maximum angles and the E-field strength was measured in 10cm steps from 0.5m to 1.9m for each laptop.

RESULTS

Burst power measurements drifted by 15% in the first 30 minutes after switch-on as opposed to less than 3% after 2 hours of transmitting, emphasising the need for adequate equipment warm-up times. Furthermore the results showed that, for a given position, the power level fluctuated between 2 (and sometimes 3) distinct levels because of the use of switched diversity with several antennas within each laptop. Overall, the results showed similar radiation pattern measurements for all laptops, with a minimum in the direction of the front of the laptop (torso of the user). Generally, two angular maxima were observed that were symmetrically opposed across a vertical plane bisecting the screen and keyboard. The laptops had antennas mounted on the top left and top right corner behind their screens and each of these antennas would have been responsible for producing one of the maxima. The maximum E-field recorded at 1 m varied from (719 ± 14) mVm^{-1} to (1306 ± 3) mVm^{-1}. In terms of power density, all these values are well below the level that would be expected based on the 100 mW (EIRP) limit, as shown in Figure 1. More detailed results will be presented in the full paper.

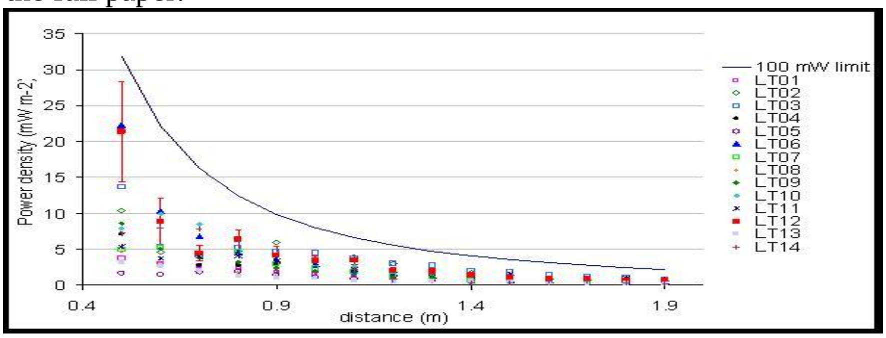

Figure 1. The calculated power density for all 14 measured laptops. The error bar represents the repeatability of E-field measurements for 50 samples (only the highest observed variation is presented).

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