



I am Christopher C. Davis, a physicist, biophysicist, engineer, and professor specializing in electromagnetic theory and related areas. I am a tenured full professor of Electrical and Computer Engineering at the University of Maryland in College Park, Maryland. I also hold an endowed chaired professorship as Minta Martin Professor of Engineering.

I have taught electromagnetic theory and related subjects since 1975. Electromagnetic theory is the study of electromagnetic waves, like radiofrequency (RF) waves, their propagation characteristics and how they interact with various structures and organisms. I am a member of several professional societies that have recognized my experiences and expertise in bioelectromagnetics and related fields. I am an elected Fellow of the Institute of Electrical and Electronics Engineers (IEEE) and the Institute of Physics. I am a past member of the IEEE Committee on Man and Radiation, and a past Chair of that committee's Sub Committee on RF and Microwaves.

I have been involved with research on the possible biological effect of RF, including microwave and millimeter wave fields, and how such waves are absorbed by various materials for over 40 years. I have submitted my curriculum vitae, which summarizes my education, experience, and publications.

I am here today at the request of CTIA to explain that: (1) the Federal Communications Commission (FCC) has established exposure limits that apply to small cell facilities and are based on recommendations from international expert standard setting bodies that continually evaluate the science; (2) the FCC standards are conservative, with a fifty-fold safety factor below the threshold at which there is any known potential health effect from exposure to RF fields; and (3) my calculations demonstrate that the public's exposure to RF emissions from small cell facilities in Michigan operating at maximum power will be hundreds of times below the FCC's conservative limits.

The FCC has established exposure limits for all RF-regulated transmitters, which includes small cell wireless facilities. Specifically, the FCC has adopted "Maximum Permissible Exposure (MPE) limits for electric and magnetic field strength and power density for transmitters operating at frequencies from 300 kHz to 100 GHz," which apply to the frequencies utilized in small cell wireless facilities. All RF emitting transmitters and facilities must either comply with the FCC guidelines (or be categorically excluded under those guidelines) or file an Environmental Assessment with the FCC. In addition to federal enforcement of the limits, I note that Section 15(2)(b) of Senate Bill No. 637 allows an authority to "require a certificate of compliance with FCC rules related to radio frequency emission from a small cell wireless facility."

The FCC exposure limits (together with those of most other countries around the world) are based on limits developed by independent expert organizations. The FCC limits are based on recommendations from the IEEE (certified by the American National Standards Institute (ANSI)) and the National Council on Radiation Protection and Measurements (NCRP), which

the FCC accurately characterizes as “internationally recognized for their expertise in this area.”¹ Other countries base their standards on the recommendations from the International Commission on Nonionizing Radiation Protection (ICNIRP), which the FCC describes as “an international non-profit-making body of independent scientific experts addressing the possibility of adverse effects on human health of exposure to non-ionizing radiation.”²

The ANSI/IEEE, NCRP and ICNIRP limits are generally similar. They are designed to exclude all known hazards of RF energy with, in the words of the FCC, “a very large margin of safety” such that the limits are “many times below levels that are generally accepted as having the potential to cause adverse health effects.”³ Many organizations continue to review the scientific literature in this field as it develops, including the FCC, World Health Organization, and the IEEE and ICNIRP standards setting organizations. The FCC states that it “closely monitors all [health studies related to human exposure to RF fields]. However, at this time, there is no basis on which to establish a different safety threshold than our current requirements.”⁴

In my experience, RF exposure levels from wireless base stations are invariably far below the FCC limits. The FCC notes that “most facilities create maximum exposures that are only a small fraction of the limits.”⁵ Indeed, the FCC states that: “Measurements made near typical cellular and PCS installations, especially those with tower-mounted antennas, have shown that ground-level power densities are hundreds to thousands of times less than the FCC’s limits for safe exposure. This makes it extremely unlikely that a member of the general public could be exposed to RF levels in excess of FCC guidelines due solely to cellular or PCS base station antennas located on towers or monopoles.”⁶ My calculations confirm that it is also extremely unlikely that a member of the general public could be exposed to emissions from small cell facilities that exceed the FCC guidelines.

The FCC regulations allow 0.533 milliwatts per square centimeter MPE at 800 MHz and 1.0 milliwatts per square centimeter MPE above 1.5 GHz. My understanding is that the typical maximum power output for a single antenna on a small cell installation is 30 watts (W) Effective Radiated Power (ERP), and a typical small cell installation would include four 30 W antennas at 120 W ERP total. Assuming maximum power from small cell installations 30 feet above the ground at various frequencies, typical small cell deployment would yield exposure levels hundreds of times below the FCC regulations.⁷ At a lower power level, such as 5 watts, the exposures are even lower. The chart below illustrates the point.

¹ FCC, Second Memorandum Opinion and Order and Notice of Proposed Rulemaking, 12 FCC RCD 13494 at ¶32 (August 25, 1997).

² FCC, First Report and Order Further Notice of Proposed Rule Making and Notice of Inquiry. FCC 13-39, at 7 n.20 (2013).

³ FCC, “A Local Government Official’s Guide to Transmitting Antenna RF Emission Safety; Rules, Procedures, and Practical Guidance” at 1 (June 2, 2000) (FCC Local Government Guide).

⁴ <https://www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns>

⁵ FCC Local Government Guide at 1.

⁶ <https://www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety#Q15>.

⁷ Note, wireless carriers seldom operate facilities at full power. For illustrative purposes, however, I used full power outputs in my calculations. Further, it is likely that small cell facilities will be deployed above 30’. I used 30’ because any antenna deployed above 32.8’ is categorically excluded under the FCC’s regulations based on height. FCC Local Government Guide, Appendix A.

Frequency	Power Level	Height	Maximum Human Exposure	FCC Maximum Permissible Exposure (MPE)	Times Below FCC MPE
800 MHz	30 W ERP	30 feet	0.00052 mW/cm ²	0.533 mW/cm ²	1,024
800 MHz	120 W ERP	30 feet	0.0021 mW/cm ²	0.533 mW/cm ²	256
1.9 GHz	30 W ERP	30 feet	0.00052mW/cm ²	1 mW/cm ²	1,922
1.9 GHz	120 W ERP	30 feet	0.0021 mW/cm ²	1 mW/cm ²	480
28 to 39 GHz	30 W ERP	30 feet	0.00052mW/cm ²	1 mW/cm ²	1,922
28 to 39 GHz	120 W ERP	30 feet	0.0021 mW/cm ²	1 mW/cm ²	480

Example Exposures from Small Cell Installations. (mW/cm² is milliwatts per square centimeter)

What this chart illustrates is that small cell facilities will expose the general public to RF at levels far below the allowed limit under the FCC guidelines, which themselves are set far below the threshold level at which there are known potential health effects from RF. Again, the FCC standards are science-based recommendations from expert standard setting organizations that constantly monitor the science. The FCC and FDA work with these organizations “to assure that safety standards continue to adequately protect the public.”⁸

⁸ <https://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/ucm116335.htm>

CURRICULUM VITAE: CHRISTOPHER C. DAVIS

EDUCATION

B.A.(Honors) Trinity College, Cambridge, U.K. 1965 Natural Sciences
Diploma for Advanced Studies in Science (with Distinction), University of Manchester, U.K. 1966 Physics
M.A.Trinity College, Cambridge, U.K.1970 Natural Sciences
Ph.D.University of Manchester, U.K.1970 Physics

PROFESSIONAL EXPERIENCE

2012-present Minta Martin Professor of Engineering
1997-2001: Associate Dean of Engineering and Director of the Gemstone Program, University of Maryland, College Park
1985-present: Professor of Electrical and Computer Engineering, University of Maryland, College Park
1982-1983: S.E.R.C. Senior Visiting Fellow, Department of Physical Chemistry, University of Cambridge, U.K.
1980-1985: Associate Professor of Electrical Engineering, University of Maryland, College Park
1976-1980: Assistant Professor of Electrical Engineering, University of Maryland, College Park
1975-1976: Visiting Assistant Professor of Electrical Engineering, University of Maryland, College Park
1973-1975: Instructor/Research Associate, Department of Applied and Engineering Physics, Department of Electrical Engineering, and Laboratory for Plasma Studies, Cornell University, Ithaca, New York
1969-1973: Research Associate, the University of Manchester, U.K.
1968-1969: Research Assistant, the University of Manchester, U.K.

SELECTED HONORS AND AWARDS

Fellow of the IEEE,1993; Fellow of the Institute of Physics,1989; George Corcoran Award, University of Maryland; NSF Creativity Award,1983; University of Maryland Distinguished Scholar-Teacher,1989-90; AT&T/ASEE Award for Excellence in Engineering Education, 1990; Winner of the Invention of the Year Award, University of Maryland, Information Science Category, 2000; A. James Clark School E. Robert Kent Teaching Award for Senior Faculty,2012; A. James Clark School Research Award for Senior Faculty,2014.

MEMBERSHIPS IN PROFESSIONAL SOCIETIES

Fellow of the Institute of Electrical and Electronics Engineers; Fellow of the Institute of Physics; Member of the Optical Society of America, and SPIE; Member IEEE SCC34 Committee; Member, Advisory Board for Handbook of Laser Wavelengths; Member, Advisory Board for the Handbook of Lasers.

RESEARCH

Author or co-author of two books, editor of 10 volumes, 14 chapters in books, over 235 refereed journal articles and over 310 conference papers, holder of fifteen awarded and several pending patents. Currently active research in optical and directional RF wireless, directed energy, optical sensors, hybrid networks, laser interferometry, dielectrometry, atmospheric turbulence, optical communication systems and devices, and biophysics.

SELECTED PUBLICATIONS

1. J. H. Moore, C. C. Davis and M. A. Coplan *Building Scientific Apparatus A Practical Guide to Design and Construction*, Fourth Edition 2009, Cambridge University Press.
2. Christopher C. Davis, *Lasers and Electro-Optics: Fundamentals and Engineering*, Cambridge University Press, 1996, Second edition 2014.
3. C. C. Davis and M. L. Swicord, "Studies of Microwave Absorption by Optical Heterodyne Detection of Thermally Induced Refractive Index Fluctuations." *Radio Sci.* 17, 855-945, 1982.
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15. T.A. Bowmaster, C.C. Davis, and V. Krauthamer, "Excitation and Detection of Action Potential Induced Fluorescence Changes through a Single Monomode Optical Fiber" *Biochimica et Biophysica Acta*, 1091, 9-14, 1991.
16. E.M. Czerska, E.C. Elson, C.C. Davis, M.L. Swicord, and P. Czerski, "Effects of Continuous and Pulsed 2450 MHz Radiation Exposure on Spontaneous Transformation of Human Lymphocytes *In Vitro*." *Bioelectromagnetics* 13, 247-259, 1992.
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