



LETTER TO THE EDITOR



Comments on “Recording the extremely low-frequency pulsations of wireless communication electromagnetic fields, by Dimitris J. Panagopoulos et al. *electromagnetic biology and medicine*” <https://doi.org/10.1080/15368378.2026.2654072>

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Panagopoulos et al. describe measurements of emitted radiofrequency (RF) energy by a variety of wireless devices and offer unsupported speculations about its possible health effects.

The authors used spectrum analyzer measurements to capture the “*emitted power with respect to time*” from various digital wireless communications devices. They claim these recordings “*fully verify*” that digital signals are emitted as on/off pulses repeated at extremely low frequency (ELF) rates and exhibit “*intense variability*” in amplitude and shape. These are well-known properties of communications devices that are subject to government regulation and industry-wide standards and do not represent new information to be reported in a paper in a scientific journal.

More questionably, the authors cite their measurements as physical evidence to support their theory on bioactivity of the fields they observed. They contend that the pulsations and variability are ELF components of the transmitted signal and are responsible for non-thermal biological and health effects via a mechanism for ion transport through membranes (IFO-VGIC).

The authors inaccurately state that their IFO-VGIC mechanism is “*widely accepted*.” This theory has neither been independently validated by the ion channel biophysics community nor confirmed by the patch-clamp or single-channel electrophysiology experiments that would ordinarily be required to establish a proposed gating mechanism. And it has no obvious connection to RF fields, modulated or not. Their argument conflates modulation of an RF signal – which may indeed have low-frequency components – with transmission of signals in the ELF band: “*we do not distinguish between the standalone ELF EMFs over the ELF modulation of EMF signals . . .*”

The authors offer vaguely worded policy advice: *the scientific community, the health authorities, and the industry . . . should start measuring their inherent ELF pulsations, and . . . the health authorities should revise their guidelines . . .*” Without specific guidance for what characteristics of wireless signals – which vary widely across and within technologies – are relevant, the advice is meaningless.

Any such advice would need to be based on direct evidence of harm with careful and comprehensive assessment of bioeffects studies for strength of evidence and relevance to health. There are now more than a dozen PRISMA-compliant systematic reviews in the literature related to bioeffects of RF fields, including many studies in which modulation was a parameter of interest in assessing exposure. An argument that modulation should be considered in setting exposure limits would require more than citing a scattering of bioeffects studies, spectrum analyzer measurements in a study that the authors acknowledge as being “*qualitative*”, and reliance on a theory that only applies to effects of low-frequency EMF on cell membranes.

One error illustrates the authors’ confusion about basic RF physics and technology. The authors state that “*there is no RF emission by any living organism, neither by the natural environment*”. This is incorrect as a matter of elementary physics. All matter above absolute zero emits radiation across the full electromagnetic spectrum. The human body at 310 K emits approximately 100 nW/m² in the 1–10 GHz band, which is easily measurable by microwave radiometry. Since the early 1970s, investigators have sought to use such measurements for detection of breast cancer, non-invasive measurement of brain temperature, and other applications, and several hundred papers

on biomedical applications of microwave thermography now exist.

Documenting that wireless signals are intermittent and appear pulsed on an amplitude-modulation receiver – which are well-known properties of digital wireless communications systems – does not establish that pulsing causes harm. That inference requires independent, adequately powered experimental studies testing specific waveform parameters against specific biological endpoints related to health and safety, and it requires knowledge of what levels of exposure are harmful. In the absence of specific predictions, it is impossible to validate or falsify the authors' claims. A series of testable predictions – if experimentally supported – could help

to clarify which of the many modulation parameters that characterize RF communications signals might affect their biological effectiveness, and basic biological studies might eventually lead to further studies related to health. If the authors were to follow this path, they could make an important contribution to this confused topic.

Author contributions

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