**Electromagnetic field scattered by an RF illuminated neuron when producing an action potential**

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Problem statement:

* Let us assume a human brain modeled by an ellipsoid with three major axes (longitudinal width, transversal width and height, p.e. 20cm, 10cm and 20 cm respectively).
* Let us illuminate it with a RF (microwave signal) with power () and frequency that travels through the brain and produces a received RF signal . Let us assume that the brain medium has a relative permittivity (p.e.
* Let us assume that an individual action potential signal produced by the synapsis  *i* is generated in an small zone of the cellular synapsis, and may be characterized by an small volume (p.e. and an small relative permittivity change (p.e. ) produced by an ionic concentration variation. Let us assume that this switching process generates a brain wave with an external voltage has a repeating frequency .
* Let us assume that the localized synaptic dielectric switching region when illuminated by the external RF signal, produces a spherical scattered field around it that will travel through the brain, will reach out of it and will be measured. This signal will result from the interaction of the RF signal with the electric changing medium and will then result on a frequency and a power .

Basic equations:

Let us consider analytically close to the Remote Thermal Sensing[[1]](#footnote-1). Let us express the synaptic dielectric periodic change located at position being characterized by a volume , a dielectric change and a repetition frequency and producing when illuminated by an external RF source located at and with a RF power to produce at the receiver position a resting (when synapsis is not active) RF field and a synaptic modulated RF field.

The synaptic effect when illuminated by an external RF field (due to the small disturbing effect produced by the synapsis we may approach the total field by the incident field) may be represented by an equivalent current

and the field produced with synapsis active and resting respectively at the brain surface could be approached (assuming spherical propagation inside of the brain and far-field distance) by:

For the case where the synapsis is at the center of the to distance,

and,

For the case where , it results into a value of , that is really low.

The imaging process would be close to the one described for a Microwave Temperature Imaging System[[2]](#footnote-2). In this case for a multi element array of transmitting focusing sensors and receiving focusing sensors the previous ratio could be improved by the factor .

[**Electromagnetic Biointeraction: Mechanisms, Safety Standards, ...**](https://books.google.es/books?id=6RcGCAAAQBAJ&pg=PA70&lpg=PA70&dq=action+potential+effect+on+microwave+frequencies&source=bl&ots=y4uC859WWe&sig=a046DGb39KHOd3srsh-OOjKjqGo&hl=en&sa=X&ved=0ahUKEwig1abs4sjPAhWEORoKHUAEBskQ6AEISzAH)

*https://books.google.es/books?isbn=1468457063*

[Giorgio Franceschetti](https://www.google.es/search?client=firefox-b&tbm=bks&q=inauthor:%22Giorgio+Franceschetti%22&sa=X&ved=0ahUKEwig1abs4sjPAhWEORoKHUAEBskQ9AgITDAH) - 2012 - ‎Science

It was concluded that this was a direct *effect* of *microwave* radiation on a ... of the fast component, which was inversely related to RF *frequency*, vanished at 10 MHz. ... modulated S-band *microwave* radiation on amplitude of the *action potential*, ...

[**RF / Microwave Interaction with Biological Tissues**](https://books.google.es/books?id=lV3FPLJoyzMC&pg=PA68&lpg=PA68&dq=action+potential+interaction+with+microwave&source=bl&ots=NhhKi2G8Xz&sig=zS9IK1jUPCN1aydUI66xakydacM&hl=en&sa=X&ved=0ahUKEwiRh-WP7MjPAhWJtRQKHRRqCX4Q6AEIQDAF)

*https://books.google.es/books?isbn=0471752045*

[André Vander Vorst](https://www.google.es/search?client=firefox-b&biw=1920&bih=1036&tbm=bks&q=inauthor:%22Andr%C3%A9+Vander+Vorst%22&sa=X&ved=0ahUKEwiRh-WP7MjPAhWJtRQKHRRqCX4Q9AgIQTAF), ‎[Arye Rosen](https://www.google.es/search?client=firefox-b&biw=1920&bih=1036&tbm=bks&q=inauthor:%22Arye+Rosen%22&sa=X&ved=0ahUKEwiRh-WP7MjPAhWJtRQKHRRqCX4Q9AgIQjAF), ‎[Youji Kotsuka](https://www.google.es/search?client=firefox-b&biw=1920&bih=1036&tbm=bks&q=inauthor:%22Youji+Kotsuka%22&sa=X&ved=0ahUKEwiRh-WP7MjPAhWJtRQKHRRqCX4Q9AgIQzAF) - 2006 - ‎Technology & Engineering

The *action potential* is the progression of the membrane voltage during the period of excitation and recovery. A nerve impulse that is generated at any point of ...

Approaching the electromagnetic behavior of living cells

The membrane potential is one of the most important living cell parameters. By monitoring a cell’s membrane potential, one can get important information about its state[[3]](#footnote-3). Changes in the membrane potential have been linked to different diseases, including Parkinson’s or antibiotic uptake processes. Thus measuring or monitoring the membrane potential is of great importance. The existing “gold” or standard methods are patch clamping and voltage sensitive dyes. In patch clamping, one measures the absolute value of the membrane potential while with voltage sensitive dyes one can only monitor changes in the membrane potential. Both methods are effective but invasive and laborious. Dielectric spectroscopy (DS) instead studies the complex dielectric function of the biological samples, which can be cells suspended in solutions or tissues. Because is not invasive, this method is used in many areas including biophysics and pharmacology. Electrical permittivity and conductivity values for various living tissues a low frequencies ranges (< 300Hz) σ=0.02 –low frequencies-1.5-high frequencies- S/m, and permittivity from 10E6 –low frequencies- up to 100-50 for high frequencies. Some studies[[4]](#footnote-4)

1. L. Bolomey, L. Jofre, G. Peronnet, “On the Possible Use of Microwave-Active Imaging for Remote Thermal Sensing”, IEEE tarbns. On Microwave Theory and Techniques, vol. 31, no. 9, September 1983 [↑](#footnote-ref-1)
2. J.M. Rius et al., “Planar and Cylindrical Active Microwave Temperature Imaging: Numerical Simulations, IEEE Transc. On Medical Imaging, vol. 11, no. 4., December 1992, pag 457-469 [↑](#footnote-ref-2)
3. Corina Bot and camellia Prodan, “Probing the membrane potential of living cells by dielectric spectroscopy”, European Biophysics Journal, Ooc 2009, 38 (8), 1049-1059. Dept. of Physics, New Jersey Institute of Technology, Newark, NJ [↑](#footnote-ref-3)
4. Ron A. et al., “Cell-based screening for membranal and cytoplasmatic markers using dielectric spectroscopy”, Biophysical Chemistry, 2008, 135, p:59-68 [↑](#footnote-ref-4)