

**IIREC**International Institute for Research on  
Electromagnetic Compatibility**S A M S U N G**  
**R 5 0 0****Cell Phone Measurement**  
**Report No. 002/2008****Operator: Eliran Moreno****Date: 2008-06-10****Time: 3:00 pm****Mobile: Samsung R500****Meter: IIREC Precision Teslameter 05/40**

This document reports on a measurement of non-thermal effect of a cellular phone in the extremely low frequency (ELF) range of the magnetic field up to app. 15 Hz.

## 1. SOME PHYSICAL BASICS

### 1.1 The natural background:

The earth's natural magnetic field (geomagnetic field, GMF) is basically a static field, with superimposed very slow oscillations. Due to technical (and sometimes geological) influences, distortions in the spatial magnetic field arise and result in the formation of disturbance points or zones. The intensity of the magnetic field is quantified as the magnetic flux density or magnetic induction. Its unit in the International Metric System (SI) is 1 Tesla (T). The intensity of the GMF lies in the order of magnitude of Microtesla ( $\mu\text{T}$ ), i.e. 1/1,000,000 Tesla. Meters for this quantity are mostly denoted as Teslameters. Another usual unit is the Gauss. 1 Gauss = 100  $\mu\text{T}$ .

### 1.2 Cellular phone radiation and its effects

It is a matter of fact that electromagnetic waves such as microwave (MW) radiation of cellular phones can heat the human body tissue. The higher the radiation density (measured e.g. in  $\text{mW}/\text{m}^2$ ), the more the tissue is heated. This result is called thermal effect. It is usually quantified as SAR value (specific absorption rate). The current limit for mobiles amounts to 2 Watt per kg of body tissue. Now, complaints may occur even if a body heating cannot be measured any more. Effects that are independent of body heating are called non-thermal effects. These are caused by signals of extremely low frequencies (ELF) at very low power levels. Biological systems are very sensitive to signals of this kind.

## 2. THE MEASURING METHOD

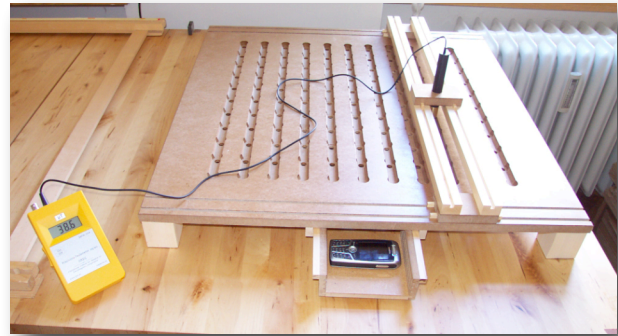
Magnetic causes of non-thermal effects can be measured by the IIREC Field Coherence Pattern (FCP) method. The measured results are subjected to mathematical analysis and visual mapping. The IIREC FCP measurement is based on the flux density of the ELF magnetic field from 0 to app. 15 Hz. The measured quantity is the vertical component of the magnetic flux density. As a special feature of the FCP method is its survey of the spatial distribution of the measured quantity.

A single measured value of magnetic induction is not sufficient to characterize the biological impact. A mapping of the spatial distribution of measured values in a Field Coherence Pattern (FCP) indicates marked differences between measured values on neighboring points, strong gradients between measuring points etc. The more unequal the course of measured values, the more irritating (or stimulating) the magnetic field will be. Based on the FCP measuring method, the IIREC Field Gradient Divergence (FGD) is a mathematical analysis that for each measuring point yields a quantification of disturbance.

## 3. CONDUCTING THE MEASUREMENT

### 3.1 Measurement setup:

On a wooden table without metal parts, a measurement grid in the dimension of 50 cm by 50 cm is spread out. Distances between measuring points are 5 cm. Altogether, 121 points are measured in order to represent the whole area. A wooden rack facilitates a measurement app. 5 cm above the cellular.



- Step 1: First of all, the field is measured without a cellular to map the initial status.
- Step 2: Then a cell phone is positioned in the center of the field and activated by dialling from a distant phone.
- Step 3: To be sure that there is a constant signal, a period of about 10 minutes is waited. (During dialling, the signal is somewhat stronger, after that it remains nearly constant.)
- Step 4: With the transmitting cellular in the center, the measurement of the field is repeated.
- Step 5: In order to demonstrate the effectiveness of an equalizing device (e.g. a foil) on the magnetic field, this device is attached to the cellular, and the cellular is activated again (cf. step 2). A period of half an hour is waited, because during this period the foil interacts with the magnetic field. Then, the measurement is conducted once more, and the results are evaluated.
- In this measurement, the ZONE030 foil was applied.

## 4. EVALUATION OF MEASUREMENT

The results are mapped in the following ways:

### 4.1 FCP (Field Coherence Pattern) representation

By use of a data analysis software the course of magnetic flux density in Microtesla between measuring points is interpolated. Finally, a map is generated which - like a geographic map - shows “highs” and “lows” of the magnetic field, and lines of equal vertical flux density. Disturbances in the field yield a coherent pattern, so the method is called Field Coherence Pattern (FCP).

### 4.2 3D mapping

The representation in 3 dimensions gives no separate representation, it merely visualizes the spatial distribution of the magnetic field as mapped in the FCP. This is a very good basis for the evaluation of the overall condition of the field, but no conclusions can be drawn to single points of disturbance.

### 4.3 Difference mapping

This kind of map is most important for cellular phone measurements.

#### 4.3.1 Cell phone minus background

This map represents the effect of the cellular without magnetic field equalization device. It shows the change generated by a transmitting cell phone in the magnetic field.

#### 4.3.2 Cell phone with specimen minus cell phone alone

This map shows the effect of the magnetic field equalization device. It represents the difference of measured values around the transmitting cellular (i) with and (ii) without magnetic field equalization.

### 4.4 Overall equalization index

Finally, an index derived from the average of Field Gradient Divergence all over the measurement field is indicated in a bar diagram, representing situations without and with equalization foil on the measurement cellular.

## 5. GUIDELINES FOR READING THE MAPS

### 5.1 General remarks regarding FCP maps

Note in particular the distances of the lines of equal vertical flux density. Many lines in close distance mean strong gradients. The farther the lines lie apart or the fewer lines are mapped, the lower are the gradients in a region.

### 5.2 Results with a transmitting cell phone

From measurements with a cellular, strong gradients are resulting at the location of maximum power. In this position, absolute measurement values show maximum deviations from the background, too. In the surrounding field, the lines of equal magnetic flux density get uneven and jagged.

### 5.3 Results with a transmitting cell phone with an equalization foil

Here are some significant effects to be watched after attaching an effective magnetic field equalization device:

- In the FCP map, lines of equal magnetic flux density are more evenly spread over the field.
- The distances between lines are expanded in the vicinity of the cellular, i.e. gradients are growing weaker.
- Positive and negative deviations of measured values from the mean are reduced.
- Some points of disturbance are completely equalized.



- In the 3D map, the field grows smoother and more equalized in total appearance. The cone at the position of the cellular becomes more regular.
- The overall equalization index shows a general reduction of FGD level. Although there may be disturbance from outside, the disturbances caused by the cellular in the field will be reduced to such a considerable extent, that a reduction of the overall index results.

Note that the strong energetic effects at the position of the cellular phone can not be influenced by a magnetic field equalization foil. This is a necessary condition for a working radio link of the cell phone. The strong disturbance zone in the center of the field will not (and is not designed to) vanish.

## 6. THE RESULTS OF THIS MEASUREMENT ARE MAPPED ON THE FOLLOWING PAGES

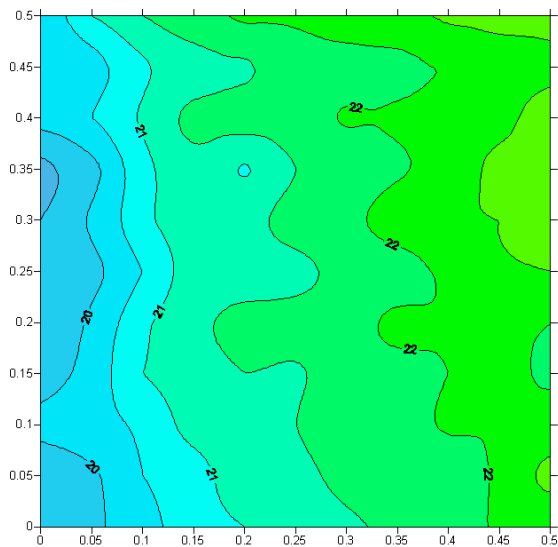
### 6.1 Field Coherence Pattern (FCP) measurement

### 6.2 Measurement results as 3D mappings of FCP

### 6.3 Differential FCP analysis

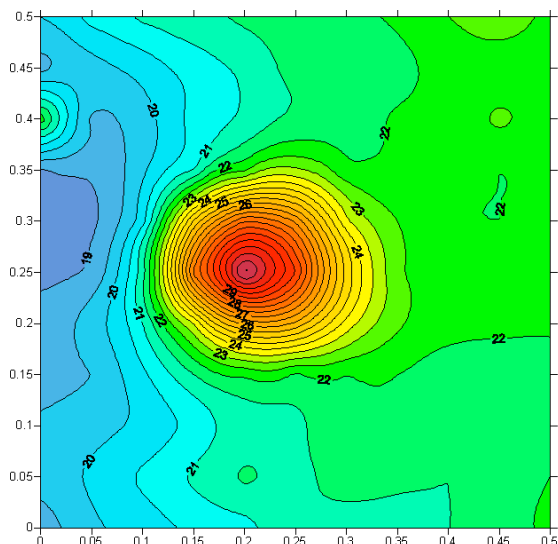
### 6.4 Overall equalization index

## 6.1 Field Coherence Pattern (FCP) measurement



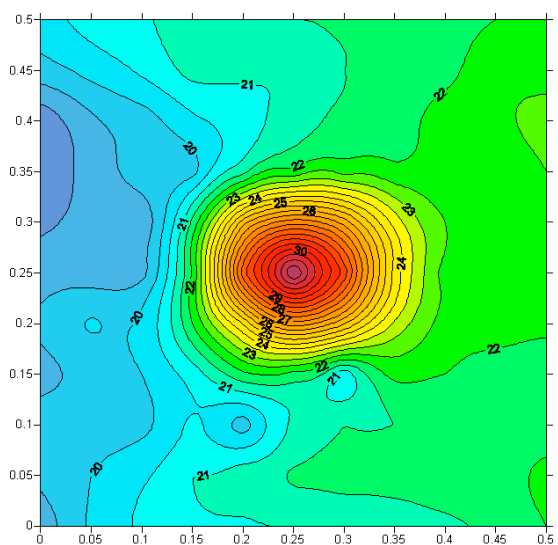
**The background represented as FCP (measured values are vertical magnetic flux densities in  $\mu\text{T}$ ):**

The original situation of the test field (0.5 x 0.5 m) shows marked differences in gradients. Therefore it is well suitable to detect by measurement the equalization effect of a technical foil designed to bring about this effect. If a background magnetic field were too smooth, the measurement would only show the energetic effect.



**A transmitting cellular phone of type Samsung R500 represented in the FCP:**

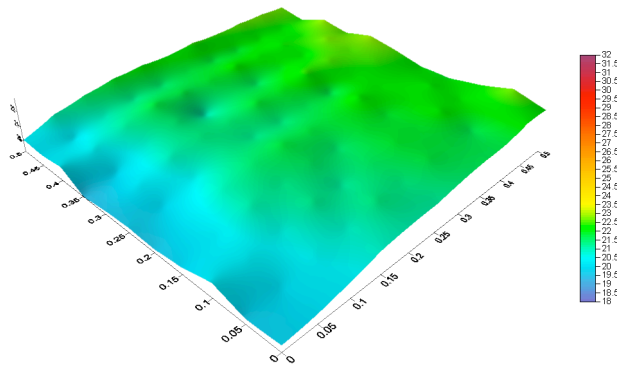
The cellular is situated in the centre of the measurement field. By its transmitted energy, it causes a positive peak in the magnetic induction map. This cone will not vanish by a successful equalization because the equalization foil is not designed to reduce the energy of the cellular. Note the lines of equal magnetic induction around the peak. To the left, they are extremely crowded, thus indicating the disturbance of the field.



**The same transmitting cellular phone with an attached ZONE030 foil represented in the FCP:**

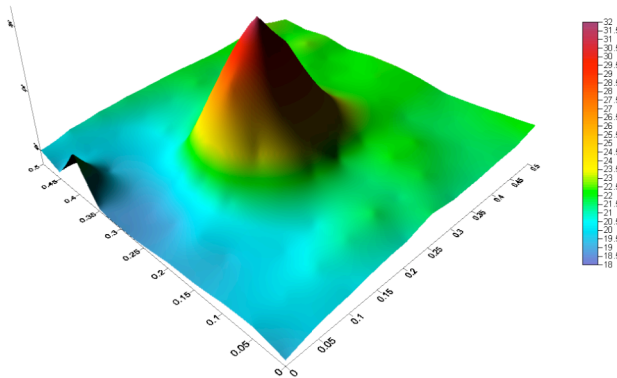
The energetic cone around the cellular persists (energy transmission is of course indispensable for the function of the cellular). However, the lines of equal magnetic induction to the left of the peak are less crowded. The field is cleared from irregularities to the right side and has adopted a better biological compatibility.

## 6.2 Measurement results as 3D mappings of FCP



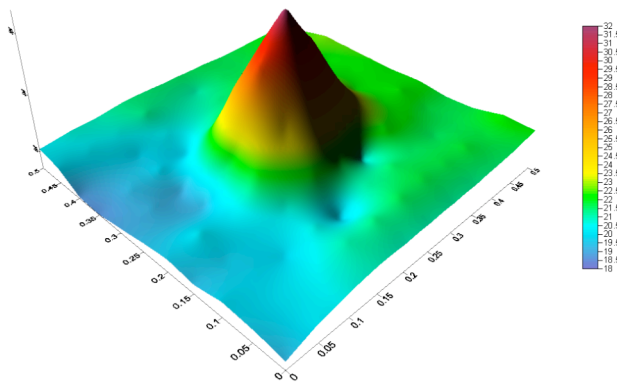
### The background in 3D representation of FCP:

The visible situation is obviously calm, the field slightly undulated, showing usual spot variances. In the left-hand front section, there are disturbing influences.



### A transmitting cellular phone of Samsung R500 in the 3D representation of FCP:

In the center there is the transmitting cellular. The cone in this position shows the effect of the transmitted energy in the magnetic field. It cannot be avoided, not even in case of a successful field equalization, because the energy of the cellular is not reduced by the equalization foil. In the vicinity of the cone disturbances can be clearly seen (to the right hand side and to the left hand edge).

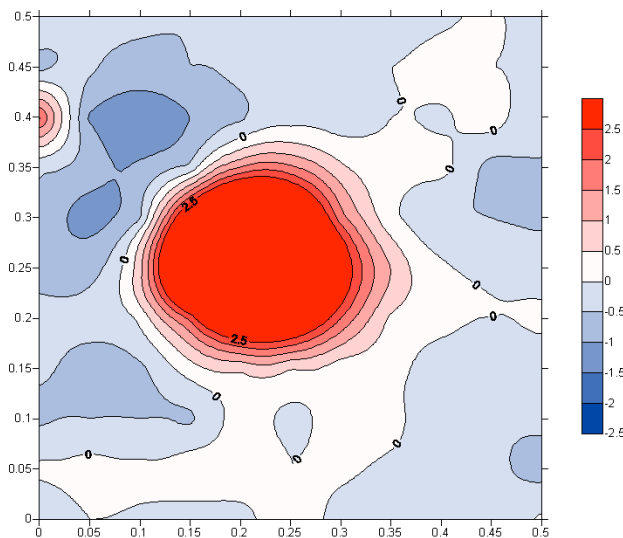


### The same transmitting cellular phone with an attached ZONE030 foil in the 3D representation of FCP:

The energetic cone around the cellular persists (energy transmission is of course indispensable for the function of the cellular). The surrounding field is mostly calm, disturbances in the green right hand side area are "ironed out", edges becoming smoother.

### 6.3 Differential FCP analysis

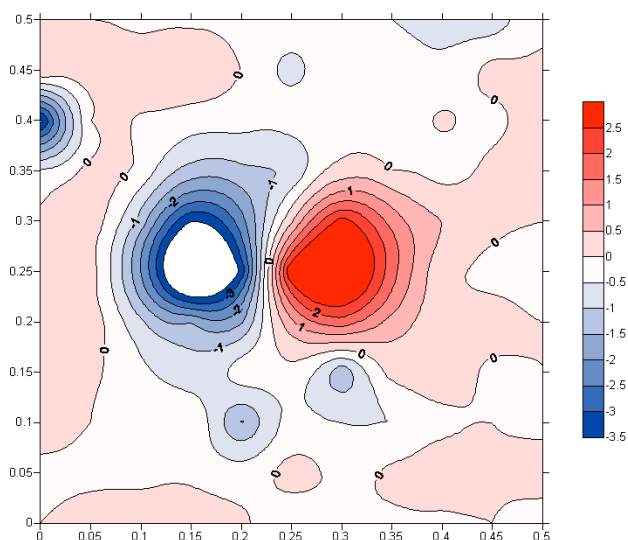
#### Difference between transmitting cellular phone without foil and background



##### The effect of the cellular phone:

Underlying this mapping, the measured data of the background situation are subtracted from the data of the transmitting cellular. Thus, the mapping gives a precise indication of the changes caused by the cellular in the magnetic field. It is clearly visible that there are not only the energetic effect of the transmitting device in the centre of the field but also significant changes (red and blue colors) in the surroundings. This structured disturbance, in a phoning situation, has a spatial effect in our body: an interference with the biological system in the brain, eyes, internal ear, mouth and teeth region.

#### Difference between transmitting cellular phone with ZONE030 foil and transmitting cellular phone without ZONE030 foil

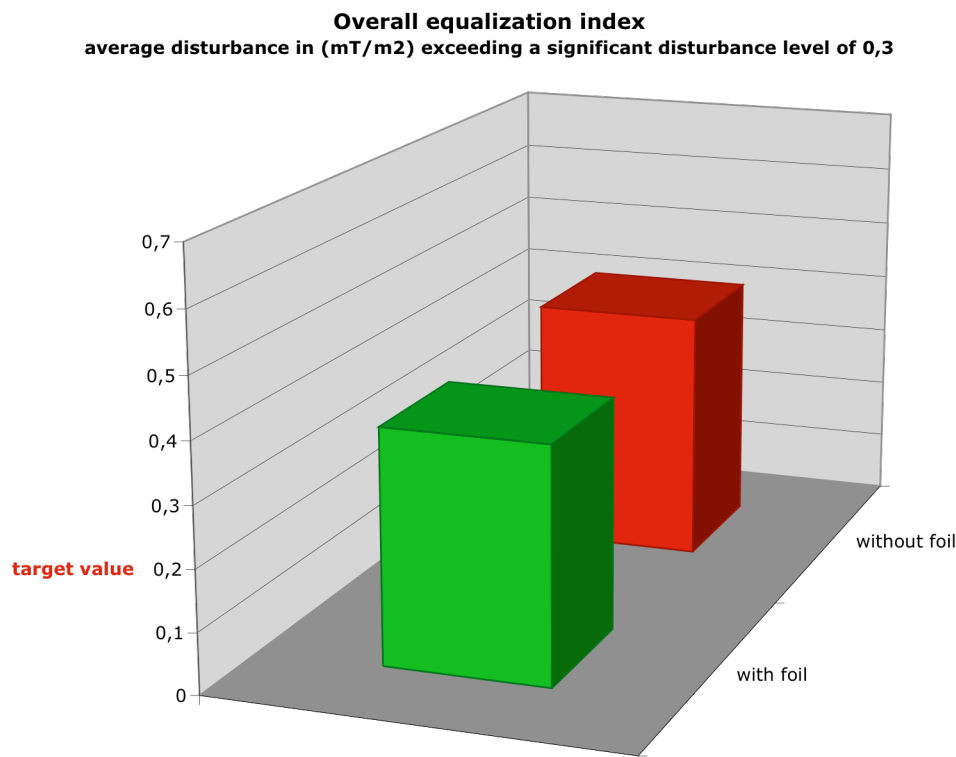


##### The effect of the ZONE030 foil:

For this mapping, the measured data of the cellular without foil are subtracted from the data of the cellular with the foil. So, the objective effect of the foil is shown. The equalization aims at reversing the additional gradients caused by the cellular phone. To read in this chart, it must be compared with the chart above. Where the magnetic induction was going down (blue color), on the difference chart below there should be a trend in the opposite direction (red color), and vice versa: Where above red areas are forming, below blue ones should emerge. The better this is fulfilled, the smoother the magnetic field has become. In this case, a tendency towards equalization shows up (cf. 3D mapping).



## 6.4 Overall equalization index



The overall equalization index is calculated by subtraction of a significance threshold of 0.3 from the average Field Gradient Divergence (FGD). **The FGD is a very sensitive indicator for all kinds of disturbances from inside or outside the measuring field.** FGD values were accepted if the original FGD (without foil) was higher than a noise level of 0.2, and filtered for disturbances from outside. Due to occurring outward disturbances, the filtering criterion was a difference of 0.7 or more in absolute measured values between subsequent measurements. By selection of a significance level of 0.3 for FGD, a signal-to-noise-ratio of 1.5 was set. In this case, the index was over the target value of 0.2 when testing the mobile with the ZONE030 foil because there was a marked energetic effect of the transmitting cellular. The equalization effect of the Card, though, can be recognized from the difference charts and from the reduction of the overall equalization index.

**Important note:** The target value is a suggestion to minimize non-thermal electromagnetic stress as a precaution against possible biological damage. It is only intended to give a rough orientation. The specific effect of equalization foils is depicted in the detailed two-dimensional evaluations of measurement results. The index is evaluated as an aid to non-professional readers, but it is not possible to offer the full information in a single number. Neither does an index surpassing 0.2 indicate immediate health danger, nor does an index below 0.2 mean that nothing more has to be done. Health concerned mobile phone users should in any case reduce stress factors as a matter of precaution.

Mind that the absolute value of the index depends on the background level of disturbance, on disturbances by the cellular phone, and the effect of equalization foils, as well. So, in very favourable situations, the index may keep below 0.2. Even in this case it is strongly recommended to apply magnetic field equalization because in less favourable situations, the same mobile may cause increased index values.

END OF REPORT.