Outline

• Specificity of the RF personal exposure assessment
• Personal dosimeter design description
• Some measurements using PDM
• Conclusion
Personal dosimetry

Studies have been done to develop protocols and to assess the compliance to limits at a given location. (e.g. COST 244 bis & COST 281 Short Term Mission; CENELEC & IEC. Working Group; EUREKA BASEXPO and French ADONIS project)

Base Station epidemiological studies require personal RF exposure assessment.

Public information needs also personal RF exposure assessment.

The "in situ" measurement systems and protocol have been developed for compliance testing but they are not adapted.

A specific measurement system and approaches were needed.
Anatomy of RF exposure

The main parameters influencing the personal exposure are

- Location
- Traffic, fading and power variation of signal
- Frequency
- Polarization and direction of arrival of incident field

Prior to analyze what should be a personal dosimeter it is of interest to characterize the quantity to assess.
Spectrum analysis of General Public exposure

Using compliance measurement protocols the spectrum of the General Public exposure has been analyzed.

Where General Public leaves and works the exposure is mainly linked to FM, TV, cellular network and wireless systems.
Frequency bands of interest for the general public personal exposure assessment

In case of epi study or public information, the exposure assessment can be limited to predetermined service such as

- FM
- TV
- GSM 900 Tx & Rx
- GSM 1800 Tx & Rx
- UMTS Tx & Rx
- WIFI
In RF domain the received power is composed of many contributions.

At a given location a received signal is composed of many signals affected by reflections or diffractions and coming from different sources. Therefore these contributions have different amplitudes, phases and directions.

Locally a narrow band signal is affected by spatial fading.

This is a constraint for in situ exposure assessment but should be considered as an advantage for personal exposure assessment.
"in situ" measurements

Studies have been done* to analyze the accuracy of the mean value of the E field strength

- The fading law cannot be linked to the environment characteristic. The usual way to assess the uncertainty of the estimation versus the number of sample cannot be used.

- The uncertainty linked to the mean value estimation can be linked to a fading severity factor (standard deviation/mean value).

- The distribution of the fading severity factor can be determined in area such as a town (e.g., Paris). Therefore, a mean uncertainty vs the number of sample can be estimated (e.g., with 3 points the mean uncertainty is 3 dB).

The minimum uncertainty of "in situ" exposure assessment is about 3 dB.

The accuracy of any comparison of in situ exposure is therefore limited by such uncertainty.

* "Analysis of Electric Field Averaging for In Situ. Radiofrequency Exposure Assessment" Emmanuel Larchevêque, Christian Dale, Man-Fai Wong and Joe Wiart IEEE VT 2005
**Isotropy and multi-sources / multi-path RF propagation**

In a frequency band of interest the exposure is induced by:

- Different antennas
- Waves coming from different directions

The isotropy can be seen as a mean isotropy.
Direction of arrival of in situ contributions

The direction of arrival is important since they should have an impact on the design (isotropy) of any "in situ" measurement system.

The angles of arrival *(between waves and the horizontal) of contributions are mainly comprise between +40° and -30°

The polarization is mainly vertical (+-20°) in rural area and 40° (+-15°) in urban area

Traffic and Time variations of RF exposure: Experimental approaches

With GSM cellular
The ratio day / night is limited

With FM
There is no traffic
Theoretical analysis of cellular network traffic influence

The probability to have a saturated network is usually less than 2%

The probability to have all TRX emitted at the same time at full power during a significant time is also very small
Spatial Distribution

There is a real influence of the location
Personal dosimeter design and exposure characteristics

The dosimeter has to take advantage of the RF human exposure specificity

– The main variations are linked to the location
  • Assess the personal exposure = assess the exposure where the person is sleeping, working, walking.…
    » Mean value?
    » Exposure distribution?

– The main Frequency of interest are those of FM, TV and wireless

– The main D.o.A are +40° -30° with vertical or Cross polar polarizations
The Personal Dosimeter

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Personal Dosimeter requirements

From previous analysis the objectives of PDM are:

- Record over 24 h the RF exposure coming from main wireless systems and broadcast.
- Avoid interference with the person activity
- Have a dynamic of 40 dB and a range [0.05 v/m, 5 v/m]

with reasonable cost to design and built it
Basic technical requirement

- Isotropy has to take into account the D.o.A and polarization of incident wave:
  - The electronic and power supply (that will perturb the isotropy) have to be located to minimize the X-Y isotropy
  - The isotropy has be estimated in a statistic way

- Put on a table and the PDM shall be able to perform isotropic measurement of wave having DoA in the X-Y plane

- The PDM has to detect between 0.05 V/m and 5 V/m (@900MHz between ~ ICNIRP/1.000.000: and ICNIRP/100)

- The PDM has to assess the exposure in FM, TV, GSM and UMTS + TETRA and Wifi
- The PDM has to be able to separate what is coming from handset and what is coming from base station
Design of the Personal dosimeter

In 2001 FT RD and Antennessa decided to combine their efforts to design and build a personal dosimeter.

www.antennessa.com

www.francetelecom.com

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Dosimeter Principle

+ post processing to take into account the type of signal (e.g., pulse in case of handset)

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Anatomy of the PDM

Antenna(s)

RF analysis

Patent: EP-0330264.3

Numerical processing

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Capability of present dosimeter

Sample from 3 to 255 seconds

Up to 7000 records able to be downloaded in txt as well as Excel format

Few days of autonomy

HMI to help users
Technical characteristics

Isotropy

• Isotropy
  • Isotropy X-Y  
    - Vertical and horizontal fields
    - Vertical dosimeter
  • In other configuration the isotropy is perturbed by the presence of the electronic and power supply but these configuration are not really relevant for the configuration.

• Rejection
  – In major cases up to -38 dB except special cases:
    – Filter design is complex and a rejection should be limited in specific case such as DCS limit band (DCS Rx on UMTS Tx limit bands)

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Manage the Influence of the body through a statistical approach

In each frequency band of interest the total exposure is the sum of different sources and reflections therefore the exposure is often coming from everywhere……

\[ P_{\text{received}} = \sum_i \int \int E_{PW}(f_i, \theta, \varphi) G(\theta, \varphi) p(\theta, \varphi) d\theta d\varphi \]

The main question is the calibration: in situ and using comparisons with reference method.
Example of result: record over 10h

@ 900 MHz

@ 1800 MHz

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Influence of sampling

Non frequent events are affected by the sampling. This frequent events correspond to high exposure during very short time (e.g exposure above 5V/m for one measurement over 7000).
Importance of the log book

Exposure induced by GSM 900 down

Exposure induced by GSM 1800 Down

Linear representation and logarithmic representation

In this case the dosimeter was put close to the body and put on a table every 15 min…

Geneva June FT RD Joe Wiart
"Il faut de l'imagination pour se représenter la réalité"

Giuseppe Pontiggia

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