European Radiocommunications Committee (ERC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

ERC RECOMMENDATION (00)08

FIELD STRENGTH MEASUREMENTS ALONG A ROUTE WITH GEOGRAPHICAL COORDINATE REGISTRATIONS

Recommendation adopted by the Working Group "Frequency Management" (FM)

"The European Conference of Postal and Telecommunications Administrations,

considering

a) that the number of mobile networks using different modulation types and accesses techniques is increasing,

b) that in order to ensure efficient use of the spectrum administrations have a need to know the radio coverage of networks,

c) that field strength prediction needs support by practical measurements performed by monitoring,

d) that mobile field strength measurements are sometimes the only solution for establishing the radio coverage of a large area,

e) that regulators may need to check the coverage deployment of a network according to license,

f) different methods of mobile field strength measurement are in use in the different countries.

g) that common measurement procedures are necessary in order to achieve mutual acceptance of measurement results by the parties concerned.

recommends

that the method described in the Annex may be used for field strength measurements of vertically polarised signals along a route."

Note:
Please check the ERO web site (www.ero.dk) under "Documentation / Implementation" for the up to date position on the implementation of this and other ERC Decisions.

Annex

1 GENERAL

Influenced by the local receiving conditions, the real values of the field strength can significantly differ from their predicted values, therefore they must be checked by measurements for establishing the radio field strength coverage of a large area

Registration of test results must be recorded along with their geographical co-ordinate data for locating the scenes of measurements and for mapping the results, which were gathered on the most accessible roads of the area in question.

Instead of measuring the actual field strength, there is sometimes the necessity for measuring the output voltage of a user antenna (the typical antenna for the service under investigation) for radio coverage evaluation.

Digital network systems (such as GSM, DCS1800 or DAB) are sensitive to the effects of reflected reception. In this case, besides measuring the signal level, the reception quality measurement, made by the measurement of the bit-error ratio (BER) or channel impulse response (CIR) measurement, is also necessary to determine the system performance evaluation. Using automatically made calls, these measurements can be made on operational digital networks without any adverse effect.

For measurement purposes along a route a continuous transmission is necessary.

2 THE RESULTS OF MOBILE FIELD STRENGTH MEASUREMENT

Due to the effect of reflected signals, the field strength along a route shows severe fluctuation. The result of a single measurement can coincide with the minimum or maximum value of reflection and is also influenced by the chosen height of the receiver antenna, the season, the weather, the vegetation and the wetness of surroundings, making that false.

Considering the factors mentioned above, reproducible field strength test results can be calculated from a large number of raw data readings, by means of statistical processing of them.

3 THE VEHICLE SPEED

The vehicle speed must be appropriate for the wavelength (taking into account the Lee method, see paragraph 4), the simultaneously measured number of the tested signals with different frequencies and the applicable shortest measuring time of the test receiver.

$$V\ (km/h) \quad \leq \quad \frac{864}{f\ (MHz) \times t_r\ (sec)}$$

Where t_r is the minimum time given by the receiver specifications to revisit a single frequency.

4 THE NECESSARY NUMBER OF MEASURING POINTS AND THE AVERAGING INTERVAL. (LEE METHOD)

For statistical evaluation the number of sample points should be chosen in such a way that the results should display the process of slow changing in the field strength (effect of long-term fading) and, more or less, they should also reflect the local (instantaneous) individuality (effect of short-term fading) of the field strength distribution.

For obtaining 1 dB confidence interval around the real mean value, the samples of test points should be chosen at each 0.8λ (wavelength), over 40λ averaging interval. (50 measured values within 40 wavelength.)

5 CALCULATION OF FIELD STRENGTH

With knowledge of the output voltage of the antenna (usually measured in dBμV), the antenna factor and the attenuation of antenna signal path, the field strength value can be calculated by the following equation.

$$\mathbf{e = v_o + k + a_c}$$

where;

e	electric field strength component	*dB(μV/m)*
$\mathbf{v_o}$	output voltage of the antenna	*dB(μV)*
k	antenna factor	*dB(m^{-1})*
$\mathbf{a_c}$	attenuation of antenna signal path	*dB*

Using certain test receivers it is possible to read the field strength result directly in dBμV/m, by previously writing the summarised antenna factor and signal path attenuation into the memory of the receiver.

6 MEASURING ANTENNAS

During the measurement the chosen height of the test antenna is 1.5 ... 3 metre. The result will be considered as being carried out at a height of 3-metres.

The received signal comes from different angles to the test antenna, therefore the effect of the antenna diagram should be known on field strength test result.

The antenna factor ("k") accuracy should be within 1 dB.

The deviation of the horizontal radiation diagram of the measuring antenna from a non-directional diagram should not exceed 3 dB.

7 TEST RECEIVER SETTINGS

7.1 Dynamic range:

The operating dynamic range of the measuring receiver should be ≥ 60 dB.

7.2 Detector functions and bandwidths for the respective types of signal:

The receiver bandwidth should be wide enough to receive the signal including the essential parts of the modulation spectrum. The detector type should be set depending on the characteristics and modulation mode of the tested signal.

Signal type	**Minimum bandwidth** (kHz)	**Detector function**
AM double side band	9 or 10	linear average
AM single side band	2.4	peak
FM broadcast signal	120 or greater	linear (or log) average
TV carrier	200 or greater	peak
GSM signal	300	peak
DAB signal	1500	r.m.s.
TETRA	30	peak
Narrow band FM radio		
channel spacing 12.5 kHz	7.5	linear (or log) average
20 kHz	12	linear (or log) average
25 kHz	12	linear (or log) average

8 NAVIGATION AND POSITIONING SYSTEMS

8.1 Dead Reckoning System

The distance from the starting point is reckoned with the help of a distance-to-pulse transducer attached to a non-motor driven wheel of the test vehicle, while the mechanical gyroscope provides the heading information. The location accuracy depends on the accuracy of the starting point registration and the distance covered by the test vehicle.

8.2 GPS System

A commercialised (SPS) GPS in itself can only give accurate position data from a few 10 to 100 metres but does not operate accurately in tunnels, narrow streets or valleys.
An accuracy of 100 or 200 metres is quite sufficient when testing broadcasting coverage of a TV or radio station.
Testing a digital micro-cell system in an urban area requires an accuracy of positioning information within several metres. In such a case *differential GPS* should be used.

8.3 Complex Navigation System

This system is the combination of the above mentioned systems. Without the need for manual operator intervention, these navigation systems continuously provide; position and time data, heading and waypoint information.

9 DATA COLLECTION AND PROCESSING

Either the average, maximum / minimum peak values, statistical evaluation or level exceeding probability of the results can be obtained by the following measuring and evaluation methods;

9.1 Measurement result collecting without data reduction (Raw field strength data):

All digitised field-strength results in relation to distance should be held in the processor's RAM and stored when the test vehicle is stopped.

Due to the varying fading and reflection effects, a single test result is not reproducible, therefore can not represent directly the field strength value of a test point. The raw data can be further processed as desired (see below 9.2.1 and 9.2.2 points).

9.2 Measurement result collecting with data reduction:

By means of statistical processing, this method allows the amount of registered raw data to be reduced considerably.

9.2.1 Averaged values

Some of the test receivers are able to perform internal classification of test results over predefined user intervals. The user can select the evaluation intervals of up to some 10 000 measured samples, but each interval must contain at least 100 values.
Only the arithmetic averaged values of the predefined number of test results are stored onto the hard disk and are indicated on the final map of radio coverage.

9.2.2 Classification of results according to level exceeding probability

During measurements the results are classified according to exceeding probability, between 1 - 99 %. These percentage values represent the probability of overstepping for the applicable field-strength level. Their typical values are 1; 10; 50; 90 and 99%. The median value, 50 % is preferred for propagation studies.

It deserves attention that receivers require some ms for the evaluation of the classification, so during this time the trigger pulses are ignored, therefore no new measurements are obtained.

10 DATA PRESENTATION

Using the process controller's built-in monitor, colour monitor of an external PC, printer or plotter the following representations should be possible:

10.1 Representation of raw data in tabular form.

Disadvantage: Too much volume of data. The individual results are unrepeatable.

Advantage: Gives detailed information about local fading effects. The results can be converted into any kind of easy to view results by mathematical or statistical process.

10.2 Plotting in Cartesian co-ordinates

Graphical representation of processed field strength data is plotted in Cartesian co-ordinates versus distance with indications of these calculated median values.

Disadvantage: It is difficult to relate the results to the exact places of the measurements.

Advantage: It gives a fast, easy to view result about distribution and locations below a given threshold level of the field strength.

10.3 Mapping

A multicoloured line is displayed to represent the processed field-strength levels (e.g. with 10 dBμV/m scale) or the level exceeding probabilities (between 1 and 99 %) on the road map.

The scale of the selected map should correspond to the size of the area covered by the radio signal under investigation and the required resolution of processed field strength results. Due to the scale of the map, the represented intervals can include the multiples of the averaged intervals. The resolution of the presented result should be chosen in such a way that it can plot local peculiarities without the coloured line being too colourful.

If there is a need to represent the averaged intervals with higher resolution (e.g. when representing results in microcells), the system should be able to zoom the map is at disposal.

If during the measurements two data series are registered simultaneously (e.g. field strength and BER) it is expedient to represent them together, by two parallel coloured lines along the plotted roads of the map.

Disadvantage: The resolution of the plotted interval can be greater than the processed interval. Therefore it can gloss over the local characteristics of field strength.

Advantage: The test results can be joined to exact spot of measurements. It gives fast, easy to view results about distribution and getting to below a given threshold level of the field strength.