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

RADIOCOMMUNICATIONS REPORTS

IMPACT FROM ISM EMISSIONS ON MOBILE RADIO SERVICES OPERATING IN THE 900 MHz BAND

Oslo, December 1991

Reports are being issued from time to time by the European Radiocommunications Committee (ERC) of CEPT to inform industry, operators, users and other interested parties of the work in hand, provisional conclusions and future activities in specific areas of radio frequency management. Such Reports give more details than is normally possible in a Recommendation and allow an opportunity for comment to be made on the work carried out so far. In most cases, it would be hoped that a formal CEPT Recommendation could be issued on the subject of the Report in due course, taking into consideration any comments received on the Report.

Reports are formally approved by, and issued in the name of, the Committee itself. In general the detailed preparation of Reports, and further work on the subject, will be done by Working Groups or Project Teams. Thus, any reference in the Reports to the ERC should be taken to include the whole framework of the ERC, including its Working Groups, Project Teams, etc.

MICHAEL GODDARD
Chairman
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1. INTRODUCTION

In the CEPT Recommendation T/R 75-02 E the frequency band 862-960 MHz is designated to various mobile radio systems. These systems, both public and private, are currently in existence and new systems of a pan-European nature, e.g. GSM and DSRR, will soon come into operation in this frequency band. ETSI has already produced European Technical Standards (ETSs) for some equipment and other ETSs are being drafted. The EC has introduced a Directive on the frequency bands for GSM, and a Draft Directive concerning frequencies for DSRR is under consideration.

In the Radio Regulations no frequency band has been designated in Region 1 for ISM in the 900 MHz band, and CEPT is opposed to such a designation.

In RR 707, the frequency band 902-928 MHz is designated for ISM use in Region 2.

Administrations should take notice of RR 1815 in relation to ISM use.

CENELEC has issued standards for ISM equipment and has specified the maximum permitted level of emissions in the various frequency bands and has also specified the measurement method EN 55011 refers to. In European countries ISM equipment observing the above standard and other equipment exceeding the limits given in this standard, are in use.

Studies have shown that interference from ISM emissions to mobile radio systems can occur at substantial distances from ISM installations. This Report gives examples of calculations which illustrate the extent of the problems and gives a methodology to be used for estimating the impact of ISM emissions on mobile radio systems.

2. DESCRIPTION

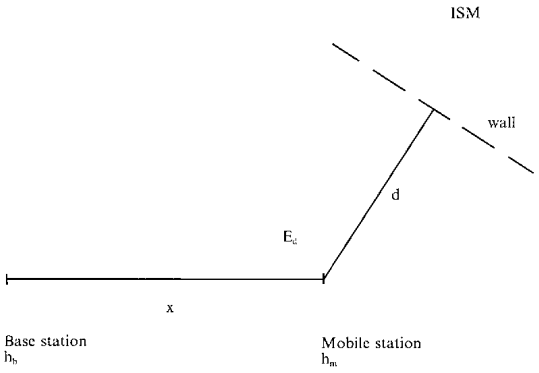
The calculations of this Report are based on:
- the propagation models of HATA-OKUMURA for the propagation of the signals from the base station;
- the ISM-field calculations from CISPR Publication 11 (2nd edition);
- the limits of the electromagnetic disturbance of ISM equipment, contained in EN 55011 (February 1990), Group 2, Class A.

The needed protection for GSM is approximately 10 dB, so the acceptable interference signal must be 10 dB below the received fieldstrength at the antenna of the mobile station ($E_b = E_u - 10$ dB).

The limits of ISM from CISPR 11 (and EN 55011) are prescribed at a measuring distance of 30 m *either from the outside wall of the building in which the ISM equipment is housed with a limit of 40 dBμV/m or when measured at a test site with a limit of 50 dBμV/m*. The *in situ* limit of 40 dBμV/m is used for the example calculations in this Report. The ISM source is considered as producing a CW signal and being situated at ground level.

Note. The measurement distance from ISM equipment is under study in CISPR and CENELEC. If the measurement distance of 30 m was increased with unchanged limits, this Report would give an underestimation of the impact of ISM radiation on mobile radio systems.

The fieldstrength at a distance d from the ISM will be:
$E_d = E_{30} + 20 \cdot a \cdot \log (30/d)$
in which a is the mean path loss exponent:
$a = 2.4$ for urban areas and
$a = 1.8$ for open areas.



— x is the distance between the mobile and the base station in km and valid in the calculation for distances between 1-20 km;
— d is the distance in m between the mobile and the outside wall of the ISM source;
— F is the co-channel frequency from ISM and mobile;
— h_b is the effective antenna height of the base station: 30-200 m;
— h_m is the antenna height of the mobile station;
— P_e is the output power of the base station in dBm;
— G_e is the antenna gain of the transmitter: dBi;
— E_u is the fieldstrength at the mobile station: dBμV/m;
— E_b is the limit of the interfering field: dBμV/m ($E_b = E_u$ – Required protection ratio);
— E_d is the fieldstrength produced by ISM at distance d: dBμV/m;
— a is the attenuation factor;
— E_{30} is the fieldstrength produced by ISM sources at 30 m from the outside wall (EN 55011)

Fieldstrength from a transmitting base station

With the formulas of HATA-OKUMURA we get:

— the propagation loss:
$L_p = 69.55 + 26.16 \log F - 13.82 \log h_b - a(h_m) + (44.9 - 6.55 \log h_b) \cdot \log x$

The correction factor $a(h_m) = (1.1 \log F - 0.7)\, h_m - (1.56 \log F - 0.8)$ where $a = 0$ dB for $h_m = 1.5$ m

— the received fieldstrength at the mobile station is:
$E_u = P_e + G_e - L_p + 20 \log F + 77.21$

In urban area

In this Report two kinds of urban areas are used for the calculations:
— urbaned 15%
— urbaned 50%, in this case the propagation loss must be increased by 10 dB

In open area

In the case of open area correction factor Q_l must be calculated:
Q_l (dB) $= 4.78 (\log F)^2 - 18.33 \log F + 40.94$ and gives for 915 MHz: 28.6 dB
The usable fieldstrength must be raised by 28.6 dB.

Protection of the GSM system

The interfering fieldstrength will be $E_b = E_u - 10$, because of the protection ratio of 10 dB

Fieldstrength from ISM equipment

The fieldstrength caused by the ISM at a distance d from the outside wall will be:
$E_d = E_{30} + 20 \cdot a \cdot \log (30/d)$ Taking $a = 2.4$ for urban areas and
$a = 1.8$ for open areas.
The distance d where the interfering signal exceeds the limits can be calculated with:
$d = 30 \cdot 10^{(E_{30} - E_d)/20 \cdot a}$

The figures and calculations (see Annex I)

The calculations for the 900 MHz band are compiled in an internal document and are done for different parameters.

For ISM
— $E_{30} = 40$ dBμV/m
— $E_{30} = 60$ dBμV/m
— $a = 1.8$ or 2.4

For GSM
— $P_e = 1$ W or 30 W
— urban area 15% or 50% or open area
— $h_b = 30$ m
— the antenna gain (horizontal) is 15 dBi and the term G_e will be + 10 dB when losses of cable and connectors (5 dB) are included
— the minimum fieldstrength to be protected = 32 dBμV/m (50% of location – 50% of time), CEPT Recommendation T/R 20-08 E

The Annex gives practical figures to determine:
either
the minimum distance between the ISM equipment and the potential victim receiver (mobile station), given the interference characterization of the ISM and the required protection ratio,
or
the required level of interference suppression for ISM, given the distance between the ISM equipment and the potential victim receiver and given the protection criteria.

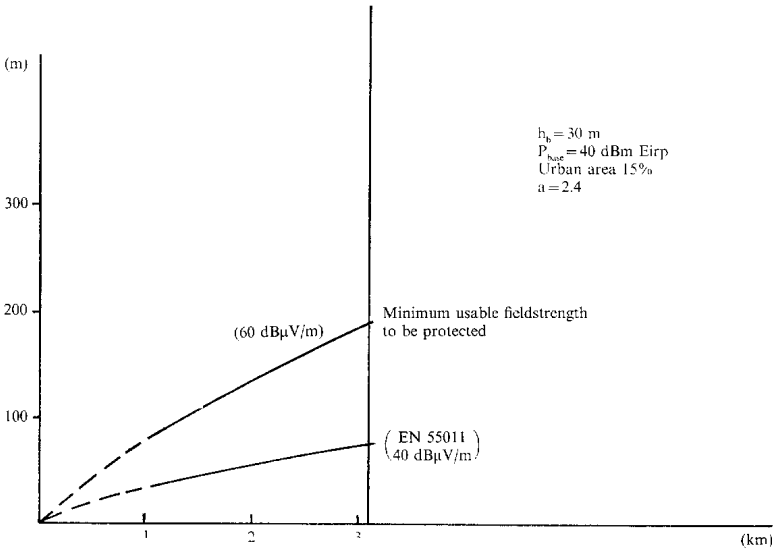
Annex II shows in which way ISM interference will reduce the service (coverage) area of a mobile radio system with the following parameters:
$h_b = 30$ m, urban area 15%, Pmobile = 33 dBm Eirp
$G_c = 10$ dBi, Protection ratio = 10 dB
The ISM equipment is assumed to be at a distance of 200 m from the base station. In one case, free-space propagation conditions apply (a = 1) and, in another case, a = 1.8.

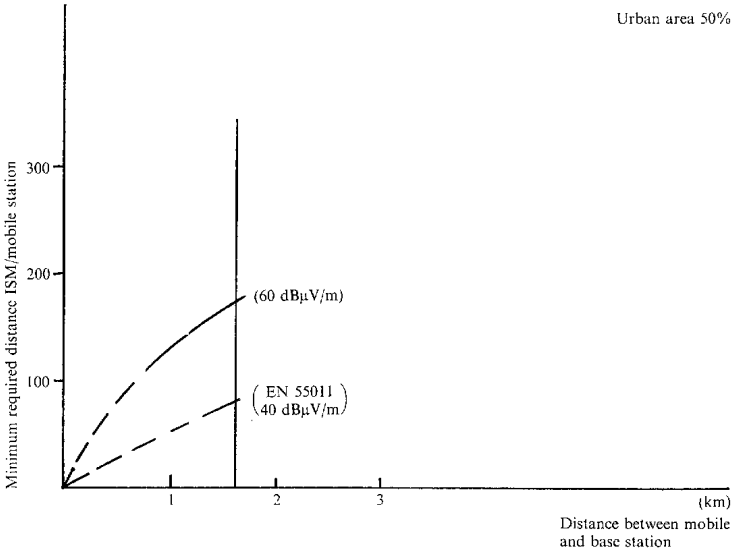
3. CONCLUSION

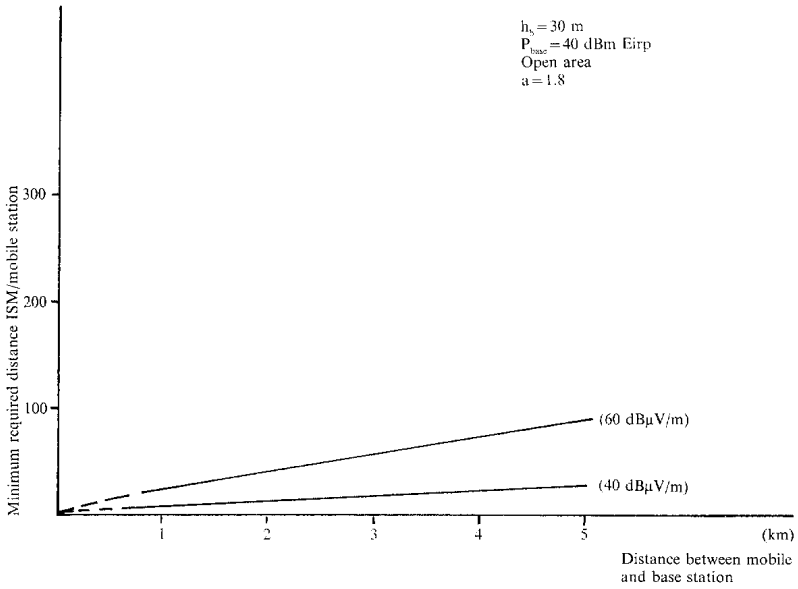
This Report:

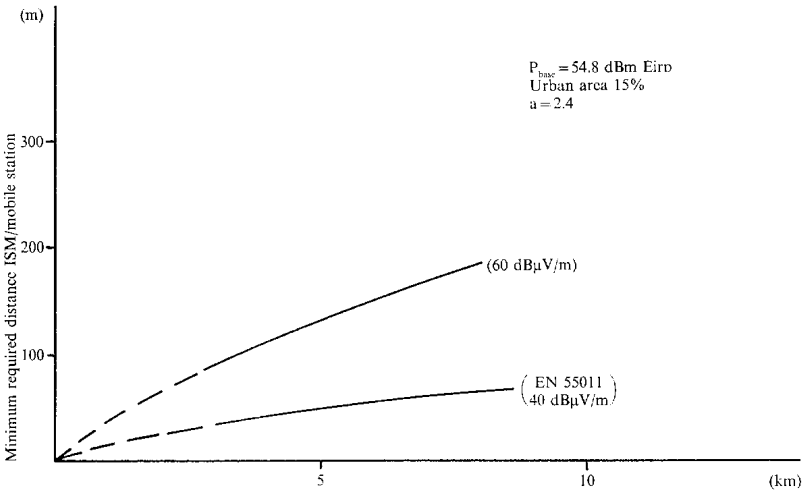
- gives a methodology to estimate the impact of ISM emissions in the 900 MHz frequency band on mobile radio systems;
- shows with example calculations the impact of ISM sources on mobile radio systems in particular situations;
  Note. Due to the method of measurement specified by CENELEC, where the precise location of the ISM source is unknown, the calculations may underestimate the extent of interference.
- demonstrates that interference from ISM sources to mobile radio systems operating in the 900 MHz band can occur at substantial distances from those sources;
- demonstrates that with the limits presently used in EN 55011 for Group 2, Class A ISM equipment in the 900 MHz frequency band (40 dBμV/m) interference from ISM sources to mobile radio systems can occur and can reduce the service (coverage) area dependent on the mutual location of base station, mobile station and ISM source;
- demonstrates that a change of limits for ISM equipment to higher levels (e.g. 60 dBμV/m) will have a severe impact on the service (coverage) area of mobile radio systems operating in the 900 MHz frequency band, which could be unacceptable.

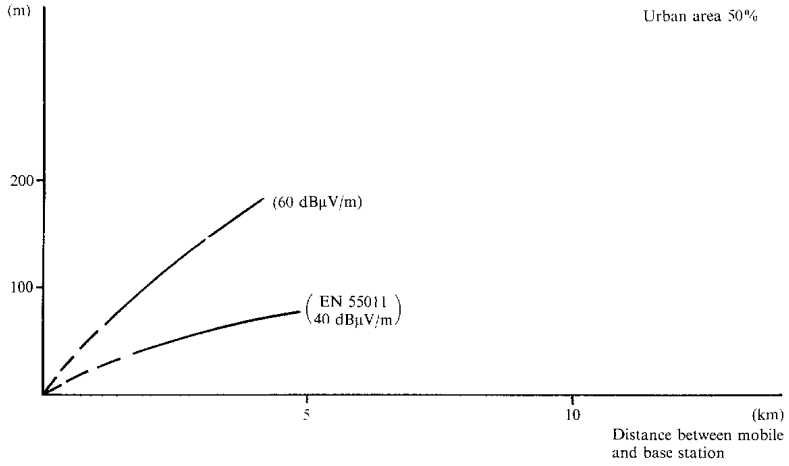
Annex I

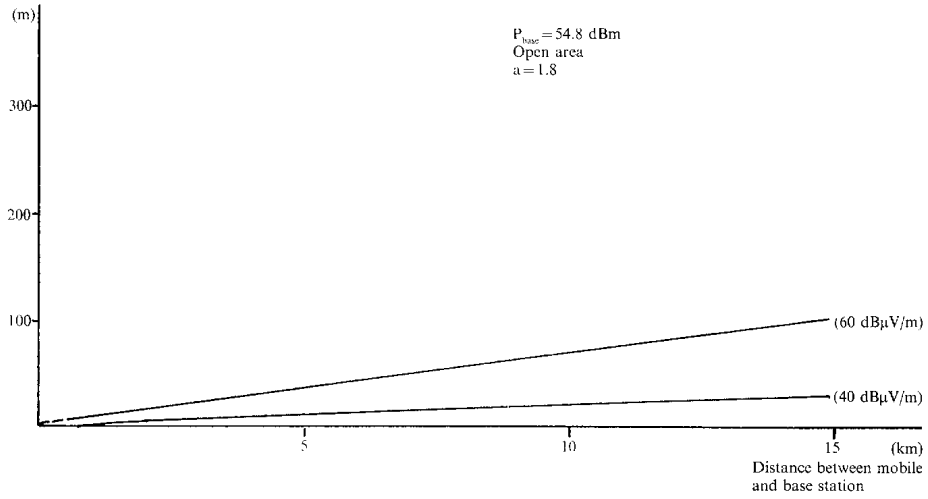

(m)
300
200
100
$h_b = 30$ m
$P_{bse} = 40$ dBm Eirp
Urban area 15%
a = 2.4
(60 dBμV/m)
Minimum usable fieldstrength
to be protected
EN 55011
40 dBμV/m
1
2
3
(km)


Urban area 50%
Minimum required distance ISM/mobile station
300
200
100
(60 dBμV/m)
EN 55011
40 dBμV/m
1
2
3
(km)
Distance between mobile
and base station


$h_b = 30$ m
$P_{base} = 40$ dBm Eirp
Open area
a = 1.8
Minimum required distance ISM/mobile station
300
200
100
(60 dBμV/m)
(40 dBμV/m)
1
2
3
4
5
(km)
Distance between mobile and base station


(m)
P_{base} = 54.8 dBm EIRP
Urban area 15%
a = 2.4
Minimum required distance ISM/mobile station
300
200
100
(60 dBμV/m)
EN 55011
40 dBμV/m
5
10
(km)


(m)
Urban area 50%
200
100
(60 dBμV/m)
EN 55011
40 dBμV/m
5
10
(km)
Distance between mobile
and base station


(m)
300
200
100
P_{base} = 54.8 dBm
Open area
a = 1.8
(60 dBμV/m)
(40 dBμV/m)
5
10
15
(km)
Distance between mobile and base station

Annex II

CASE I

The ISM is interfering in the mainlobe,
200 m from the base station, a = 1

Service area distance for the mobile (km)	
3.1	NO ISM EQUIPMENT
1.8	THE LIMIT OF 40 dBμV/m
< 1	THE LIMIT OF 60 dBμV/m

CASE II

The ISM is interfering in the backlobe (−10 dBi),
200 m from the base station, a = 1

Service area distance for the mobile (km)	
3.1	NO ISM EQUIPMENT
3.1	THE LIMIT OF 40 dBμV/m
1.8	THE LIMIT OF 60 dBμV/m

CASE III

The ISM is interfering in the mainlobe,
200 m from the base station, a = 1.8

Service area distance for the mobile (km)	
3.1	NO ISM EQUIPMENT
3.1	THE LIMIT OF 40 dBμV/m
1.2	THE LIMIT OF 60 dBμV/m

CASE IV

The ISM is interfering in the backlobe (−10 dBi),
200 m from the base station, a = 1.8

Service area distance for the mobile (km)	
3.1	NO ISM EQUIPMENT
3.1	THE LIMIT OF 40 dBμV/m
3.1	THE LIMIT OF 60 dBμV/m