Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

ADJACENT BAND COMPATIBILITY BETWEEN CDMA-PAMR MOBILE SERVICES AND SHORT RANGE DEVICES BELOW 870 MHz

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EXECUTIVE SUMMARY

This report considers the technical impact of introducing the CDMA-PAMR uplink in the 870 – 876 MHz band to the existing Short Range Devices (SRDs) below 870 MHz. The report establishes the level of interference that can be expected to affect SRDs in the harmonised CEPT band 862-870 MHz. The report has focused on the special SRD case of "Social Alarms" because these are well documented and the failure of these to operate as intended is very undesirable.

Monte Carlo simulations have been performed using the SEAMCAT® (Spectrum Engineering Advanced Monte Carlo Analysis Tool) in the following scenarios:

- Scenario 1, CDMA-PAMR mobile station (MS) into SRD, specifically "Social Alarms" with no frequency separation to the SRD band edge, an operational range of 10 m for the SRD and with the ITU-R.P.1238-3 propagation model for indoor use.
- Scenario 2, CDMA-PAMR MS into "Social Alarms" SRD with a frequency separation of 2.7375 MHz to the Social Alarms, an operational range of 58 m for the SRD and with the ITU-R.P.1238-3 propagation model for indoor use.
- Scenario 3, CDMA-PAMR MS into "Social Alarms" SRD with a frequency separation of 2.7375 MHz to the Social Alarms, an operational range of 50 m for the SRD and with the Extended Hata propagation model for indoor use.
- Scenario 4, CDMA-PAMR MS into "Social Alarms" SRD with a frequency separation of 2.7375 MHz to the Social Alarms, an operational range of 25 m for the SRD, with the Extended Hata propagation model for indoor use and with the SRD transmitter power of 1 mW.
- Scenario 5, CDMA-PAMR MS into "Social Alarms" SRD with a frequency separation of 2.7375 MHz to the Social Alarms, an operational range of 50 m for the SRD, with the Extended Hata propagation model for indoor use and the SRD transmitter and the interferer outside.

In addition the CDMA-PAMR MS's were also evaluated for conformance to CEPT ERC/REC 74-01 in the range 862–870 MHz for a CDMA-PAMR MS operating at the lowest frequency possible as determined by the necessary transition band required above 915 MHz.

The report concludes that no additional frequency separation or guard band is needed for CDMA-PAMR transmissions above 870 MHz in respect of interference to Social Alarms operating at 869.25 MHz.

It is also clear from the evaluation for the CDMA-PAMR MS for conformance to CEPT ERC/REC 74-01 that there is a large margin between the specified limit of CDMA-PAMR and the limits set out in CEPT ERC/REC 74-01.

The Monte Carlo model and the application of a calculation similar to minimum coupling loss as a control check revealed that the probability of interference is very close to zero.

The only interference detected was for Class[1] 2 SRD equipment where 0.15% was recorded in scenario 2 and 0.46% was recorded in scenario 3 under conditions where a coverage outage of around 15 % was experienced. In scenarios 4 and 5 only Class 1 SRD equipment were considered and no interference were detected.

[1] For the definition of Receiver Class, see Annex 1.

INDEX TABLE

**Adjacent band compatibility between CDMA-PAMR
Mobile Services and Short Range Devices below 870 MHz**

1 INTRODUCTION

This report is concerned with adjacent band compatibility issues relating to the use of CDMA-PAMR above 870 MHz.

This report studied the effect of the CDMA-PAMR uplink above 870 MHz upon Short Range Devices (SRD) and in particular the effect upon the special case of “Social Alarms” SRD application. These have been used in this report as the basis for a detailed Monte Carlo (MC) simulation using SEAMCAT®. The report also evaluates the CDMA-PAMR MS’s in relation to CEPT ERC/REC 74-01.

The report covers the issue of adjacent band compatibility of CDMA-PAMR to SRD at 870 MHz that has been the subject of a recent study within SE7. The CDMA-PAMR uplink band 870–876 MHz band is adjacent to the SRD band below 870 MHz. This is shown in Figure 1.

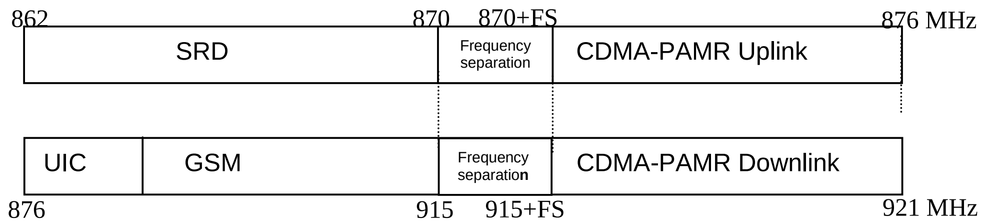

Figure 1: SRD and CDMA-PAMR systems at around 870 MHz

2 METHODOLOGY

2.1 Monte Carlo

MC modelling using SEAMCAT® (Spectrum Engineering Advanced Monte Carlo Analysis Tool) was undertaken for scenarios 1 to 5, CDMA-PAMR MS into “Social Alarms” SRDs (see list of scenarios under section 4.3, MC modelling results). Scenarios 2 to 5 have been developed as a result of guidance from the SRD community experts.

The scenario was modelled for a single CDMA-PAMR channel of 1250 kHz interfering with the “Social Alarm” system operating on a single adjacent channel. This would provide precise information about the impact of the guard band.

In the scenarios where MS are involved, the SEAMCAT® Tool is used exclusively. Due to the statistical distribution of the mobile stations, Minimum Coupling Loss (MCL) is deemed to be inappropriate.

The CDMA-PAMR MS’s were also evaluated for conformance to CEPT ERC/REC 74-01 in the range 862 – 870 MHz for a CDMA-PAMR MS operating at the lowest frequency possible as determined by the necessary transition band required above 915 MHz.

3 INTERFERENCE SCENARIO

The following study investigated the interference that occurs from a CDMA-PAMR MS transmitter into a Short Range Device receiver.

The following mechanisms have been identified that need to be considered when introducing CDMA-PAMR services in the adjacent band (870-876 MHz):

1) Blocking will occur where the incoming power from the CDMA-PAMR transmitter is above the specified Short Range Device receiver blocking level. This will desensitise the Short Range Device receiver such that the reference sensitivity performance may not be maintained.

2) The Unwanted Emission (Spurious Emission and Wide Band Noise) from the CDMA-PAMR transmitter that is above the receiver sensitivity will desensitise the Short Range Device receiver such that low level signals may not be received.

All specifications used in the calculations have been derived using standard specification values as these represent the worst case values even though it is recognised that in practice real equipment performance may be better. With respect to the parameters required for the MCL and MC methods used in this report it was decided to use the requirements of EN 300 220 -1 and TIA/EIA 97/98E. After receiving guidance from the SRD community also EN 300 220 -2 was considered.

4 PROPAGATION MODELS AND AIDS

The propagation models were selected so as to be appropriate for the task.

4.1 Monte Carlo models

The MC simulations were undertaken using the Extended Hata propagation model as defined by WGPT SE21. For the indoor cases the path loss model was derived from ITU-R P.1238-3 for scenarios 1 and 2. For scenarios 3 to 5 the Extended Hata propagation model defined by WGPT SE24 for SRD was used.

4.2 Active Interferer Densities

The active interferer densities (AID) were calculated on the assumption that a limited amount of spectrum would be available. The simulations focused on a 1.25 MHz band for CDMA-PAMR because the interfering device is a mobile and the closest carrier is therefore the worst case.

A worst case assumption was made concerning the interference from the CDMA-PAMR MS. The environment was assumed to be a city in which the cell radius was 3.5 km and the interferer density was 0.25 active interferers per square km. CDMA-PAMR power control normally restricts the power of the mobile to considerably less than the maximum. As the test proceeded, and it became evident that interference was improbable, it was decided to undertake the MC modelling process without using the power control (scenario 1 only) in order to simulate the terminal transmitting at its maximum power.

4.3 Monte Carlo modelling results

MC simulations were performed using the SEAMCAT tool in order to establish the level of interference from CDMA-PAMR into SRDs. The simulations considered:

- Scenario 1, CDMA-PAMR MS into SRD, specifically application “Social Alarms” at 869.25 MHz with no frequency separation between the CDMA-PAMR mobile station and the SRD band edge, an operational range of 10 m for the SRD and with the ITU-R P.1238-3 propagation model for indoor use.
- Scenario 2, CDMA-PAMR MS into “Social Alarms” SRD with the frequency separation increased to 2.7375 MHz from the Social Alarms, an operational range of 58 m for the SRD and with the ITU-R P.1238-3 propagation model for indoor use.
- Scenario 3, CDMA-PAMR MS into “Social Alarms” SRD with the frequency separation increased to 2.7375 MHz from the Social Alarms, an operational range of 50 m for the SRD and with the Extended Hata propagation model for indoor use
- Scenario 4, CDMA-PAMR MS into “Social Alarms” SRD with the frequency separation increased to 2.7375 MHz from the Social Alarms, an operational range of 25 m for the SRD, with the ITU-R P.1238-3 propagation model for indoor use and the SRD transmitter power of 1 mW.
- Scenario 5, CDMA-PAMR MS into “Social Alarms” SRD with the frequency separation increased to 2.7375 MHz from the Social Alarms, an operational range of 50 m for the SRD, with the Extended Hata propagation model for indoor use and with the SRD transmitter and the interferer located outside.
- All scenarios except 4 used 10 mW transmitter output power for the considered SRD.

The interfering device was a CDMA-PAMR MS using a single 1.25 MHz channel. The frequency used for CDMA-PAMR MS was 870.625 MHz for scenario 1 and 872.625 MHz for scenarios 2 to 5. Scenario 1 represents an absolute worst case with no additional frequency separation and has been used to see if there is any chance whatsoever that interference could occur into “Social Alarms”. However, the separation frequency above 915 MHz is expected to be equal to or greater than 2 MHz and because of the constant duplex frequency separation this will be mirrored onto the 870 MHz band (see figure 1). This is consistent with the approach of ECC Report 25 and is also used in the evaluation of conformance to

CEPT Recommendation 74-01 in this report. This frequency separation was used for scenarios 2 and 3. The cell radius used was 3.5 km for scenarios 1 & 4 and 4.5 km for scenarios 2, 3 & 5.

Results:

Social Alarms, Results of Simulations					
Propagation model	ITU-R P.1238-3		Extended Hata propagation model defined by WGSE PT24 for indoor SRD		
Scenario	1	2	3	4	5
SRD TX environment	indoor	indoor	indoor	indoor	outdoor
SRD RX environment	indoor	indoor	indoor	indoor	indoor
SDR TX Power (mW)	10	10	10	1	10
SRD range (m)	10	58	50	25	50
SRD RX input range (dBm)	-62.8 to 18.2	-88 to -14	-142 to 3.9	- 123 to 0.6	-96.5 to -16
Link outage (%)	0	0	10 to 15	0.5	0
Frequency separation between CDMA-PAMR MS and Social Alarm f band edges (kHz)	737.5	2737.5	2737.5	2737.5	2737.5
Power Control	No	Yes	Yes	Yes	Yes
Cell radius (km)	3.5	4.5	4.5	3.5	4.5
CDMA-PAMR MS environment	indoor	indoor	indoor	indoor	outdoor
Interference of Class 1 Social Alarms (%)	0.00	Not simulated	Not simulated	0.00	0.00
Interference of Class 2 Social Alarms (%)	0.00	0.15	0.46	Not simulated	Not simulated

Table 1: Results of the simulations

One further simulation was performed of a rather unlikely scenario. This included a modification of scenario 5. The RX input of the SRD receiver was fixed to a level of – 104 dBm during the simulation. This yielded an interference of 0.01 %.

4.4 Minimum Coupling Loss Verification Of SEAMCAT Results

In order to verify the zero interference result which was found in the SEAMCAT simulations for scenario 1 it was decided to use a process similar to MCL, which simulated the calculations made by SEAMCAT, to determine how close to the SRD receiver a CDMA-PAMR MS using maximum power would need to be.

The limiting case for Class 1 receivers is spurious emissions, and for this to cause interference the CDMA-PAMR MS needs to be within 1.07 m of the Social Alarm receiver base station, the Social Alarm will be around 10 m away from its receiver and the CDMA-PAMR MS needs to be transmitting at maximum power. The probability of all of these occurrences happening at once is low therefore the calculation by SEAMCAT that the probability is 0 is justified.

The limiting case for Class 2 receivers is blocking, and for this to occur the CDMA-PAMR MS will need to be transmitting at maximum power, the Social Alarm will need to be around 10 m from the receiver and the CDMA-PAMR mobile will need to be at less than half of this distance from the receiver of the Social Alarm. It may be deduced that the calculation by SEAMCAT of a probability of 0 is justified.

In practice MC modelling of the performance of CDMA-PAMR has revealed that the CDMA power control process results in the average transmitted power being 6 to 7 dB below the maximum. Under these circumstances and using the example of a Social Alarm, interference will normally be confined to Class 2 Receivers where the Social Alarm transmitter is used at the most distant part of a building and with the simultaneous use of a CDMA-PAMR MS in the same room as the Social Alarm receiver.

5 CDMA-PAMR MS SPECTRUM MASK

In the figure 2 below the spectrum mask of CDMA-PAMR MS is depicted alongside the requirements of CEPT ERC/REC 74-01. The red line depicts CDMA-PAMR MS mask according to TIA/EIA 98E (Table 4.5.1.3.1-5, band class 12, subclass 1) and the Lucent SRDoc. The black dashed line depicts the requirements of CEPT ERC/REC 74-01.

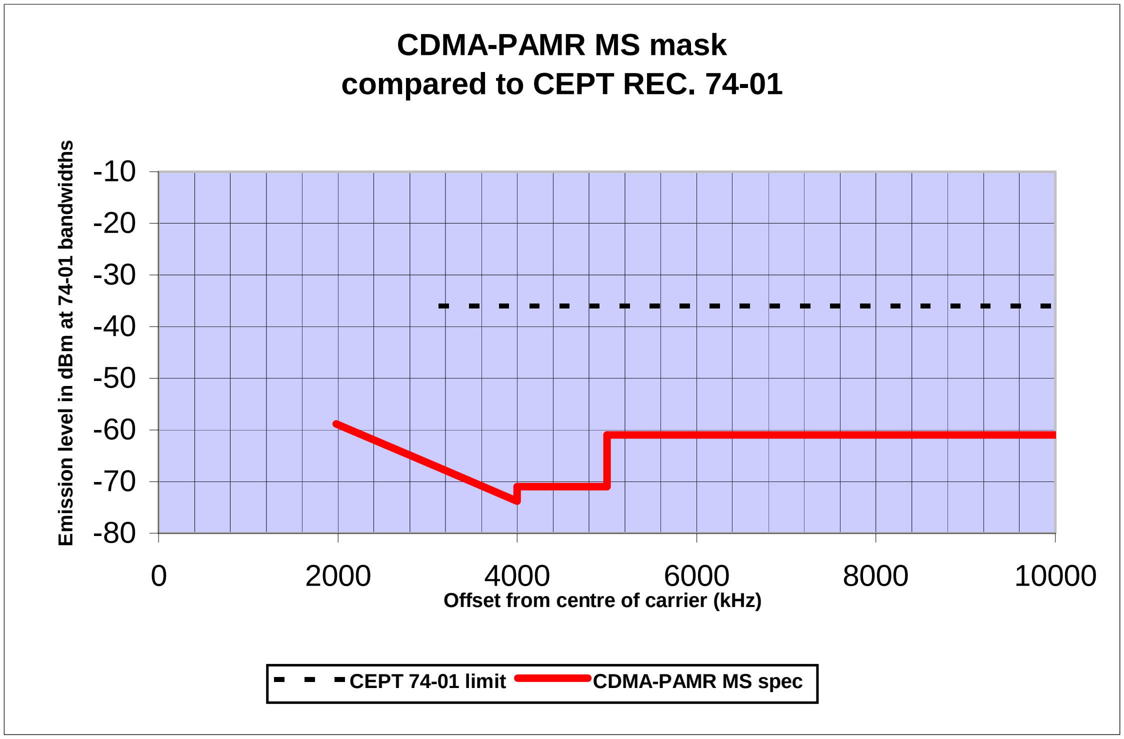

Figure 2: Depiction of the unwanted emissions for CDMA-PAMR MS at 862- 870 MHz

The calculations can be found in Annex 2.

6 CONCLUSIONS

From the report it is clear that no additional frequency separation or guard band is needed for CDMA-PAMR transmissions above 870 MHz in respect of interference to Social Alarms SRD operating at 869.25 MHz.

Considering that the required transition band at around 915 MHz is equal to or greater than 2 MHz and that this will be mirrored to the 870 MHz band it can be concluded that CDMA-PAMR will not generate any noticeable interference into SRD below 870 MHz.

It is also clear from the evaluation for the CDMA-PAMR MS for conformance to CEPT ERC/REC 74-01 that there is a large margin to the limits. Considering that the CDMA-PAMR MS nearly always will be at a substantially lower power than used for the evaluation, the probability of interference is very close to zero.

7 BIBLIOGRAPHY

[1] CDMA-PAMR SRDoc V0.1.1 (2002-8), “System Reference Document, CDMA-PAMR”, SE(02)114.
[2] ETSI TR 102 260 v 1.1.1: CDMA-PAMR System Reference Document.
[3] TIA/EIA/IS-2000.1-C, “Introduction to cdma2000 Standards for Spread Spectrum Systems”.
[4] TIA/EIA/IS-2000.2-C, “Physical Layer Standard for cdma2000 Spread Spectrum Systems”.
[5] TIA/EIA/IS-2000.3-C, “Medium Access Control (MAC) Standard for cdma2000 Spread Spectrum Systems”.
[6] TIA/EIA/IS-2000.4-C, “Signalling Link Access Control (LAC) Standard for cdma2000 Spread Spectrum Systems”.
[7] TIA/EIA/IS-2000.5-C, “Upper Layer (Layer 3) Signalling Standard for cdma2000 Spread Spectrum Systems”.
[8] TIA/EIA-97-E, “Recommended Minimum Performance Standard for cdma2000 Spread Spectrum Base Stations”.
[9] TIA/EIA-98-E, “Recommended Minimum Performance Standard for cdma2000 Spread Spectrum Mobile Stations”.

Annex 1: CDMA Interference to SRD

Parameters

The following assumptions were made in the study:

Social Alarm

Tx Power	10 mW except scenario 4 where 1 mW has been used
Bandwidth	25 KHz
Blocking rejection	Class 1 84 dB Class 2 as defined in EN 300 220 -1
Sensitivity	-107 dBm
Limiting C/I	8 dB
Antenna height of base station	1.5 metres
Frequency	869.25 MHz
Maximum distance	10 metres.

In-Building Path Loss Model

The following path loss model was derived from ITU-R P.1238-3:

$L_{total} = 20\log_{10}f + N\log_{10}d + L_f(n) - 28$ dB

N	distance power loss coefficient assumed to be 33
f	frequency
d	separation distance in metres
$L_f(n)$	floor loss assumed to be 1 floor 9 dB.

CDMA-PAMR system was assumed to have the following characteristics:

Interferer is a CDMA-PAMR MS
Max Tx Power 23 dBm
Power control is in use
Environment is urban with in-building penetration (SEAMCAT defaults used)
Cell radius 3.5 km for scenario 1 and 4.5 km for scenario 2 and 3
Mobile height 1.5 m
Base station height 30 m
User density 0.25 per square km
Frequency 870.625 MHz for scenarios 1 and 872.625 MHz for scenarios 2 and 3.

Although the TIA/EIA-98-E standard specifies values up to 38 dBm for CDMA MS output power, in practice, the maximum output power from existing CDMA-PAMR MS is 23 dBm in accordance with the ETSI and Lucent SRDocs.. This is the value for the maximum output power that is designed into CDMA-PAMR mobiles, and is the same value as the maximum output power for CDMA-1X mobiles (on which CDMA-PAMR mobiles are based). The value is suitable for balancing of uplink and downlink link budgets (with CDMA-PAMR base stations having maximum output power of up to 44 dBm).

Note that CDMA-PAMR employs fast power control on both the uplink and the downlink, with a particularly large dynamic range on the downlink (typically 60 dB). Hence, both base stations and mobiles in a CDMA-PAMR network will usually be transmitting at output powers that are significantly below the maximum values. For example, the typical output power from a CDMA-PAMR mobile operating on a typical CDMA-PAMR network can be expected to be at least 10-20 dB below the maximum value.

Results of SEAMCAT Simulation

No interference was detected for scenario 1 or for Class 1 equipment in scenarios 2 and 3. For Class 2 equipment an interference of 0.15% for scenario 2 was detected and for Class 2 equipment an interference of 0.46% was detected for scenario 3.

Check Results for scenario 1

SRD user at limiting range of building (assumed to be 10 m)
Path Loss (from P.1238) = 72.78 dB

Tx Power = 10 dBm
Rx Power (at BS) = -62.78 dBm
Maximum permissible interfering power = -62.78 – 8 = -70.78 dBm.

Unwanted Power

CDMA-PAMR MS at max power = 23 dBm
Unwanted (870.625-869.25 MHz) = -59.3 dB
Bandwidth conversion = -2.7
Max Unwanted ERP in received band = -39 dBm
Path loss at 1.07 metre in Free Space = 31.8 dB
The unwanted CDMA-PAMR signal will not cause any significant interference at a distance of greater than 1.07 m.

Blocking

CDMA-PAMR MS at Maximum power = 23 dBm

Blocking protection Class 1 = 84 dB

Maximum blocking power (23 – 84) = -61 dBm
Blocking may occur when the path loss is less than 70.78 – 61 = 9.78 dB
This occurs at a distance of less than 0.25 m (Path Loss modelled as Free Space).

Blocking protection Class 2 = 32 dB

Maximum blocking power (23 – 32) = -9 dB
Blocking may occur when path loss is less than 70.78 – 9 = 61.78 dB
This occurs at a distance of 4.64 m (Path Loss modelled as In-Building)

Receiver classification according to EN 300 220-1

Receiver class	Relevant receiver clauses	Risk assessment of receiver performance
1	9.1, 9.2, 9.3 and 9.4	Highly reliable SRD communication media; e.g. serving human life inherent systems (may result in a physical risk to a person)
2	9.3 and 9.4	Medium reliable SRD communication media e.g. causing Inconvenience to persons, which cannot simply be overcome by other means
3	9.4	Standard reliable SRD communication media e.g. Inconvenience to persons, which can simply be overcome by other means (e.g. manual)
Note: With reference to this standard manufacturers are recommended to declare classification of their devices in accordance with table 2 and EN 300 220-3[11], subclause 4.2, as relevant. In particular where an SRD which may have an inherent safety of human life implications, manufacturers and users should pay particular attention to the potential for interference from other systems operating in the same or adjacent bands.		

Annex 2: Compliance of CDMA-PAMR MS with ERC Recommendation 74-01

Spurious domain emission limits for Land Mobile Service are given in Annex 2 of CEPT ERC Recommendation 74-01. Since CDMA-PAMR is designed to operate in frequency bands below 1 GHz, the limit for both terminals and base stations is specified to be -36 dBm, where the power at different offsets from the centre frequency of the carrier is measured in different reference bandwidths as follows:

Frequency offset	Reference bandwidth
3.125 MHz - 5 MHz	1 kHz
5 MHz - 12.5 MHz	10 kHz
12.5 MHz and above	100 kHz

The emission limits for CDMA-PAMR mobiles are specified in the TIA standard IS-98-E. The relevant emission limits are reproduced below:

Separation from centre frequency	Emission limit
885 kHz	-47 dBc / 30kHz
1.125[2] MHz	-54 dBc / 30kHz
1.98 MHz	-67 dBc / 30kHz
4.00 MHz	-82 dBc / 30kHz
4.00 to 10.0 MHz	-51 dBm / 100kHz

The emission levels for frequency offsets between the above separations are derived by linear interpolation. Above 10 MHz the normal emission limit of -36 dBm applies (measured in 10 kHz for frequency offsets up to 12.5 MHz and in 100 kHz for offsets of 12.5 MHz and above).

The maximum power output from a CDMA-PAMR MS is 23 dBm, spread over the CDMA-PAMR carrier bandwidth of 1.25 MHz. Furthermore, the CDMA-PAMR system employs power control with a large dynamic range, meaning that CDMA-PAMR mobiles will almost always be transmitting at output powers that are significantly below the maximum value.

In considering the potential for interference from CDMA-PAMR MS in the band 870-876 MHz to SRD in the band 862-870 MHz, the frequency offsets of interest are mainly those between approximately 2 and 10 MHz. This is because the spectrum that is used for the CDMA-PAMR carriers will usually be located around 872-876/917-921 MHz.

In order to interpret the above emission limits correctly, a conversion must be applied to account for the fact that different measurement bandwidths are used. For example, if one considers an MS transmitting at the maximum power of 23 dBm, then the emission limit at 4 MHz offset from the centre frequency is 23 - 82 = -59 dBm / 30 kHz = -73.8 dBm / 1 kHz.

Thus, if comparing the maximum emission levels for a CDMA-PAMR MS with the emission limits in ERC/REC 74-01, at the frequency offsets of interest and at the reference bandwidths used in ERC/REC 74-01, the values are as given in the table below, and illustrated in the following diagram. An MS power of 23 dBm is used, i.e. the maximum output power that will be transmitted.

[2] Note that in TIA/EIA-98-E (Table 4.5.1.3.1-5, Band Class 12 Sub class 1) this figure is given as 1.120 MHz due to a typographical error.

Frequency offset	Reference bandwidth	CDMA-PAMR MS spec in dBm	Emission limit in ERC/REC 74-01
1.98 MHz	1 kHz	-58.8	Not specified
3.125 MHz	1 kHz	-67.3	-36
4 MHz	1 kHz	-73.8	-36
4 - 5 MHz	1 kHz	-71	-36
5 - 10 MHz	10 kHz	-61	-36