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

ADJACENT BAND COMPATIBILITY BETWEEN GSM AND CDMA-PAMR AT 915 MHz

Granada, February 2004

EXECUTIVE SUMMARY

This report has established the level of interference that can impact GSM Base Station (BS) receivers below 915 MHz when CDMA-PAMR is deployed in the band 917 – 921 MHz, i.e. a frequency separation of 2.15 MHz around the duplex transition frequency is always assumed. The report also establishes that co-ordination between GSM and CDMA-PAMR is required in this case. An uncoordinated approach would most likely result in interference to some of the GSM base station receivers.

The report investigates the effect of duplex filters and establishes that these are essential to enable any compatibility between GSM and CDMA-PAMR networks. It is however also clear that the characteristics of the deployed filters are critical components that influence co-ordination. This can be seen from the MCL calculations and Monte-Carlo simulations developed in section 6.1.

The report further establishes the separation distances necessary to avoid interference for selected sizes of the duplex transition separation bands within the 917 – 921 MHz band for the cases without duplex filters and with typical duplex filters[1] of the GSM and the CDMA-PAMR system. The resulting distances are such that in some cases further mitigation is needed to allow for the utilisation of the 917 – 921 MHz band. The report also provides the required additional mitigation, as a function of distance, needed to avoid interference (see Figures 8 to 17).

For the purpose of the Report two levels of permissible interference were considered: -110 dBm and –125 dBm. The level of –110 dBm may be considered representative of an interference-limited GSM network. The level of –125 dBm may be considered representative of a noise-limited GSM network.

The report has determined that below the calculated physical separation distances, which depend upon the duplex filter characteristics as provided in Annex 2, interference can occur into GSM BS receivers as a result of the transmitter power from a CDMA-PAMR system in the band 917 – 921 MHz. This could result in desensitisation of the GSM base station receiver due to 3rd order intermodulation distortion (IMD3) or blocking. To avoid blocking and IMD3 of GSM BS receivers, additional filtering may be required at the input of the GSM BS receiver. This is an important consideration in view of the widespread deployment of GSM BSs. The number of the GSM BSs, which will be affected, will depend on the relatively lower number of CDMA PAMR BS, which will be deployed. The feasibility to retro-fit filters, where needed, into already-installed GSM BS would also need to be investigated.

Another type of interference that can occur is the unwanted emission from a CDMA-PAMR system desensitising the GSM BS receiver. The unwanted emission can be spurious emission or wide band noise. To avoid unwanted emission desensitising the GSM BS receiver additional filtering may be required in the CDMA-PAMR transmitter.

The band 917–921 MHz can be utilised by CDMA-PAMR without undue risk of interference to the GSM base station receivers only if special measures are undertaken. These include co-ordination between the GSM operator below 915 and the CDMA-PAMR operator above 917 MHz and the use of mitigation according to the actual separation distances. The co-ordination distances for GSM microcells and picocells will be lower (see Annex 1).

For co-ordination purposes the administration may take the results based on permissible interference level, studied in conjunction with other factors, such as the actual deployed equipment in terms of duplex filters, antenna gain, intra-system interference and man-made noise.

Any utilisation of CDMA-PAMR in the 915 – 917 MHz range has not been considered in this Report and would require further studies.

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[1] Duplex filters are components of BS that are not standardized

INDEX TABLE

Adjacent band compatibility between GSM and CDMA-PAMR mobile services at 915 MHz

1 INTRODUCTION

This report is concerned with adjacent band compatibility issues between CDMA-PAMR and GSM around the frequency boundary of 915 MHz.

This report specifically studied the situation when a CDMA-PAMR BS in its downlink band 917-921MHz is deployed close to a GSM BS in its uplink band just below 915 MHz. In order to reduce the amount of interference from a CDMA-PAMR BS leaking into the GSM band, a frequency separation[2] of 2150 kHz around the duplex transition frequency is assumed between the two bands. This is shown in Figure 1.

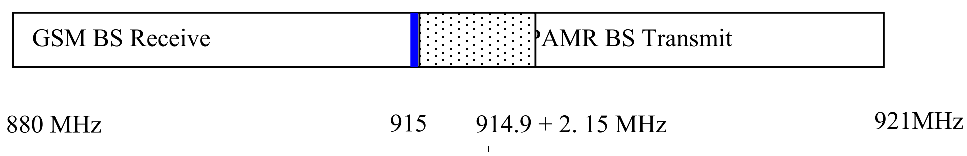

Figure 1: GSM and CDMA-PAMR systems with frequency separation around the duplex transition frequency at 915 MHz

2 METHODOLOGY

A link budget methodology approach has been used for the scenario where CDMA-PAMR is the interferer and GSM is the victim. This approach is termed Minimum Coupling Loss (MCL) and is used instead of the statistically based Monte Carlo (MC) methodology because both the interferer and the victim are stationary base stations.

The following interference scenario was investigated at the low end of the CDMA-PAMR downlink band (i.e. around 917 MHz):

CDMA-PAMR (downlink) > GSM (uplink)

The following study and the mitigation factors are valid for CDMA-PAMR, as described in the Lucent SRDoc, operating in the frequency range 917 – 921 MHz. The study has focused on the deployment of up to three CDMA-PAMR carriers (see Fig. 2) allocated from the top end of the frequency band in accordance with ECC Report 25. It is proposed that a guard band of 200 kHz is left at the top in order to provide protection to UIC (ref. ECC Report 38).

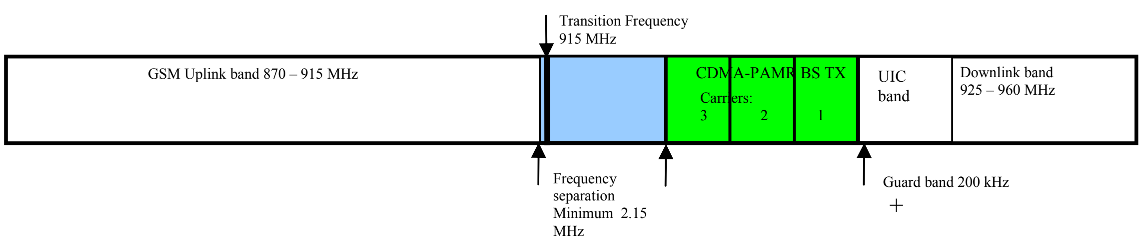

Figure 2: Simulated CDMA-PAMR channels around 915MHz

This arrangement provides for three carriers with centre frequencies 920.175, 918.925 and 917.675 MHz. The study has not investigated the possibility of deployment of a fourth carrier, i.e. leading to a frequency separation around the duplex transition frequency of less than 2150 kHz. This is because the wide band noise from the CDMA-PAMR transmitter increases to a much higher level and the blocking requirement of GSM BS receivers is 10 dB more relaxed at a frequency separation below 800 kHz, both considered very difficult to mitigate.

2 In this report the frequency separation around the duplex transition frequency is considered to be the minimum frequency separation between the channel edges of the two systems.

For the GSM system, RF requirements from the 3GPP specifications 3GPP TS 45.005 were applied whenever possible, in order to make the results of this study less dependent on specific GSM BS implementation choices and/or operator specific deployment conditions. Interference protection limits for GSM are discussed in Annex 3.

The interference impact on a GSM BS has been calculated separately for the GSM RX path related effects and the spurious emissions from CDMA-PAMR, assuming suitable protection limits in both cases. It should be noted that in real deployment, both sources of interference would occur simultaneously and hence the total impact may be somewhat larger than indicated here.

In addition, assumptions about the duplexer filters of the GSM and the CDMA-PAMR systems have been made in order to obtain a more realistic assessment of the interference impact. Duplex filters are components of BSs that are not standardized. Hence, the results of this study (e.g. required duplex separation bands, separation distances, etc.) are specific to the assumed duplexer filters. The assumed GSM and CDMA-PAMR duplexer filter characteristics are detailed in Annex 2.

3 INTERFERENCE SCENARIOS

The presented study investigated the interference that occurs from a CDMA-PAMR BS transmitter into a GSM BS receiver.

The following interference mechanisms relevant for introducing CDMA-PAMR services in the band 917-921 MHz have been identified and are considered in more detail within this report:

1) Blocking will occur where the incoming power from the CDMA-PAMR transmitter is above the specified GSM blocking level; this will desensitise the GSM BS 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 GSM BS receiver such that low level signals may not be received.

3) Desensitisation of the GSM BS receiver because of 3rd-order Intermodulation Distortion (IMD3) will occur if two or more RF signals exceed the specified levels and if the mixed frequencies contain a frequency component at the GSM BS receive frequency. The following mechanisms of IMD3 have been investigated and it was concluded that the predominant source (the power received from the CDMA-PAMR BS) would be adequately covered by the case, where two CDMA carriers are received by the GSM BS, i.e. case (a) below:
   a) IMD3 due to mixing of two received CDMA-PAMR carriers operating in the adjacent frequency range between 917-921 MHz;
   b) IMD3 due to mixing of leakage from the GSM "own" TX within 921-960 MHz and a received CDMA-PAMR carrier operating in the adjacent frequency range between 917-921 MHz;
   c) IMD3 due to mixing of a GSM in-band blocker (with levels of up to –13 dBm) and a received CDMA-PAMR carrier operating in the adjacent frequency range between 917-921 MHz;
   d) IMD3 due to a single CDMA-PAMR carrier in immediate adjacency to the GSM RX band;
   e) Cross-modulation (XMD) due to mixing of a GSM in-band blocker (with levels of up to –13 dBm) and a received CDMA-PAMR carrier operating in the adjacent frequency range between 917-921 MHz.

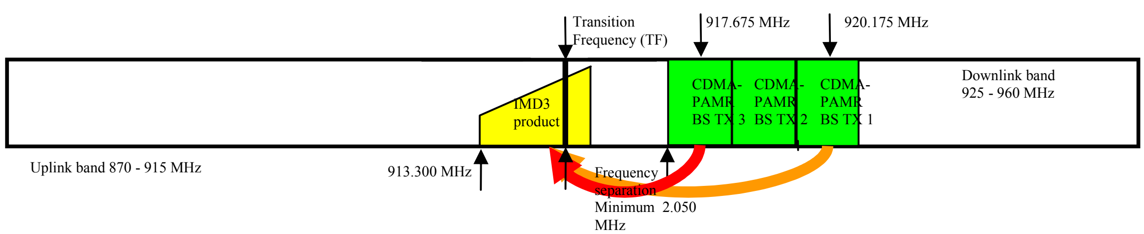

Figure 3: Depiction of IMD3 case (a)

IMD3 into the GSM uplink band is only possible if both CDMA-PAMR carriers 1 and 3 are deployed simultaneously and the resulting product may have effect on GSM BS receiver only in the frequency range from 913.3 MHz to the transition frequency 915 MHz. The levels will be shaped by the GSM BS duplex filter and will peak at 915.8 MHz for which the calculations are valid.

Where available, the values used in the calculations have been derived using standard specification values as these represent the minimum requirements even though it is recognised that in practice real equipment performance may be better. For the duplex filters, however, the values used are typical because no standard values are available. The duplex filters used for the calculations are described in Annex 2.

3.1 Scenarios

In urban areas the antennas of BS are often mounted on rooftops. This will lead to a worst case situation where the antennas of the GSM BS and CDMA-PAMR BS are facing each other and have a direct line of sight. For this scenario a separation distance of 20 m was selected to form the basis for the calculations. This scenario reflects the situation where a GSM antenna is at a rooftop on one side of a road and the CDMA-PAMR antenna is on the other. It was considered that at a distance of 20 m the antennas had reached their specified gain.

Another scenario is where the antennas are co-sited, for this a coupling loss between the antennas of 30 dB has been introduced because this is a recognised standard value. An alternative value of coupling loss of 40 dB has also been considered in the study, recognising that site engineering is able to provide a 10 dB additional coupling loss. In the calculations the 30 dB value is incorporated as a 1 m point not shown in the figure. This provides the somewhat peculiar curve form that is depicted between the 10 m point and the 20 m point. At distance separations below 20 m it is considered that antenna gain is very unpredictable and will be depending on the actual antennas deployed. This part of the curve should therefore not be used for co-ordination purposes without checking the actual coupling loss.

Microcell–to-microcell is a special case not covered by the figures in the mitigation section of this report. The separation distance selected was 25 m and the calculations for this distance are provided. It was however felt that the microcell–to-microcell case is very dependent on the actual installation, thus the propagation model used to calculate the loss would vary considerably. Actual on-site measurements are therefore recommended for this case.

The co-location of picocell BSs and co-existence between different BS classes are not considered in the following as this is not seen as relevant to a PAMR environment.

3.2 Propagation model

The basis for the path loss calculation was the Line-of-Sight assumption and the process, which is defined in ITU-R Rec. P.1411. This is applicable for distances less than 1 km.

If the effective antenna height exceeds 9 m, the path loss for distances of up to 1 km is considered to be less than a breakpoint. The process for distances less than this breakpoint develops a greatest and least loss. The mean loss approximates to the Free Space propagation. This has provided the basis for these calculations.

The rooftop–rooftop and the microcell–microcell scenarios have been calculated using the Free Space propagation model.

3.3 Calculation of interference

For the purpose of this Report two levels of permissible of interference were considered:–110 dBm and –125 dBm, based on the desensitisations levels as described in Annex 3.

In the Annex 1, Tables 1-6 the calculations of the interference that occur in different scenarios are provided. Calculations are provided for desensitisation due to blocking and IMD3 of the GSM BS receiver from a CDMA-PAMR transmitter. Blocking occurs as a result of the power being present and is not related to the type of system producing the power. Blocking is specified at -13 dBm according to 3GPP TS 45.005 in the frequency range 917–921 MHz. IMD3 similarly occurs as a result of at least two signals that are able to produce, if mixed, a frequency component on the frequency of the GSM BS receiver. Again this is unrelated to the type of system.

Also, the influence of the spurious emission and wide band noise from CDMA-PAMR into the GSM BS receiver was calculated. The calculations for the CDMA-PAMR wide band noise influence are separated into different sections because of changing requirements and measuring methods as a function of frequency separation from the carrier. The calculations included typical duplex filters as specified in Annex 2. It should be noted that the typical filters used in GSM and those used in a congested PMR environment have very different characteristics. The need for additional filtering, obviously, also depends on the characteristics of duplex filter actually deployed.

For all of the desensitisation cases mentioned above the recognised method of 3GPP TS 45.005 has been used. The standardised method uses a wanted signal 3 dB above the limit for the reference sensitivity (-104 dBm) less the C/I of 9 dB, this yields a protected level of – 110 dBm. In addition, the experience gained by the wide deployment of GSM networks shows that, in practice, the sensitivity of GSM BS can be better than the reference sensitivity (around -110 dBm). Where justified, larger protection can be incorporated using the method described in Annex 3.

The calculations were based on a GSM BS receiver operating on its highest frequency channel in uplink band at 914.8 MHz. The interfering system's frequency range, for which the calculations in this study are valid, is limited to 920.175, 918.925 and 917.675 MHz used as carrier frequencies for CDMA-PAMR. If other frequencies were to be used, the attenuation required to avoid interference must be re-calculated using the method of Annex 1.

4 OBSERVATIONS

From the calculations of the attenuation required to avoid interference it can be seen that co-ordination between GSM and CDMA-PAMR is required. If an uncoordinated approach were taken this would probably result in interference to some of the GSM BS receivers.

The results show that to avoid desensitisation from IMD3 and blocking of GSM BS receivers additional filtering at the GSM BS receiver will be required when CDMA-PAMR transmitters are located within a certain distance of a GSM receiver: up to 350 m for IMD3 and 60 m for blocking when the permissible interference level of –110 dBm is employed. The amount of additional filtering required is dependent on the frequency, the number of carriers, the separation distance, the characteristics of the duplex filters and the transmitter power of the CDMA-PAMR BS.

In the case of wideband noise the results again show that filtering is required at the CDMA-PAMR transmitter when it is located within a certain distance of a GSM receiver: up to 50 m when the permissible interference level of –110 dBm is employed. The amount of filtering required is dependent on the frequency, the number of carriers, the separation distance, the characteristics of the duplex filters and the transmitter power for the CDMA-PAMR BS.

5 MITIGATION FACTORS

In this section different techniques are discussed that would enable CDMA-PAMR to operate without producing harmful interference into the GSM BS receivers. The different techniques required to ensure the GSM BS receiver can operate as intended are: frequency separation, physical separation distance, improved performance (filters) and any combination of these.

Because mitigation is needed, co-ordination between the operators of GSM and CDMA-PAMR networks is always required. Whilst it is recognised that the following technical solutions will assist co-ordination between operators, further detailed investigation is recommended into the practicality of implementing any of the following.

5.1 Frequency planning and co-ordination

It is necessary that the use of the frequency band 915-921 MHz for CDMA-PAMR is co-ordinated between the GSM and CDMA-PAMR operators, also taking into account any necessary transition band. It should also be noted that any utilisation of CDMA-PAMR in the band 915-917 MHz has not been considered in this Report and would require further studies.

5.2 Separation Distance

The use of physical separation is expected to be the typical way of achieving the majority of the necessary attenuation. It is also one of the most cost effective means of establishing the required coupling loss between the CDMA-PAMR BS transmitter and the GSM BS receiver.

Physical separation may be feasible in rural and suburban areas. It may also be possible to use physical separation in urban areas, at least as a partial solution. Actually, taking into account the increasing density of GSM BS already deployed in towns, it becomes more and more difficult to find new sites/locations in urban areas. Because the GSM networks are well established, the task of finding suitable locations, which would meet the physical separation criteria, will predominantly be on the new CDMA-PAMR operator.

The use of physical separation distance is a new approach for the existing GSM operators. The reason is that the frequency range above 915 MHz has not been utilised and there was no need for co-ordination. With the utilisation of these frequencies the need for co-ordination arises and physical separation may be a feasible option.

5.3 Frequency Separation

Use of frequency separation as a single solution to achieve the necessary attenuation of both the power (blocking) and wide band noise from CDMA-PAMR requires a frequency separation extending outside the allocated band. This is because the wide band noise roll-off of CDMA-PAMR is fairly slow and also the blocking performance of GSM receiver only improves marginally with frequency. These facts, combined with the difficulties in network planning and especially re-planning for optimisation of the network, make frequency separation a very unattractive solution.

5.4 Filters

The performance of both the CDMA-PAMR transmitter and the GSM receiver can be improved using filters. To allow the filters to operate a guard band is considered necessary. The requirements to the filter needed for improving the GSM receiver IMD3 and blocking performance in the CDMA-PAMR transmitter frequency range may not require any power handling capability, but the effect on both the receiver's performance, and that of the network's, needs to be evaluated.

It is important to use a filter with a low insertion loss in the GSM BS receiver range to limit any desensitisation due to the filter. If a particular GSM BS is using mast head amplifiers the filter may have to be located in or close to them. However, the feasibility to retro-fit filters into already-installed GSM BS would need to be investigated.

The filter needed for improving the CDMA-PAMR transmitter spurious emissions and wide band noise attenuation in the GSM receiver frequency range is more demanding also because of the requirements of power handling. These calculations included parameters of typical duplex filters as specified in Annex 2 (note that the typical filters used in GSM and those in a congested PMR environment have very different characteristics). Using other filter parameter values than those specified will affect the amount of additional filtering, when this is required.

5.5 Separation Distance and Filters

Where it is impossible to establish sufficient physical separation to eliminate blocking and desensitisation by wide band noise of the GSM BS receiver, additional filters could be used, subject to evaluation of their impact on the receiver's performance. The filters to be selected to produce the desired attenuation, taking into account the physical separation distance loss, for the GSM BS receiver to operate as intended.

6 ATTENUATION REQUIREMENTS VS. SEPARATION DISTANCE

In the following figures 4 to 14, the attenuation required to avoid interference as a function of separation distance is depicted. These results are divided into three sections. The first section investigates the importance of BS duplex filters upon adjacent band compatibility. The two following sections investigate the impact of permissible interference levels identified in Annex 3. The results' figures are derived from the calculations of interference, as provided in Annex 1 of this document.

The figures represent what is considered the worst case scenario from the calculations of interference. Free space propagation loss is added to extrapolate the required attenuation as a function of the physical separation distance. The calculations were made for 20 m separation distance for the rooftop-to-rooftop scenario (considered worst case).

In Annex 1 there are also calculations for the close proximity antennas scenario, these cover 30 dB and 40 dB isolation between the antennas. Also, in Annex 1 the calculations for the microcell–microcell scenario are included at a separation distance of 25 m.
The rooftop–rooftop and the microcell–microcell scenarios have been calculated using the Free Space propagation model.

6.1 Impact of Duplex Filters

In the following Figures 4 to 6 the impact of the duplex filters is investigated to establish if these are essential for the calculations of attenuation requirements as function of the separation distance. The curves shown in those figures are based on the assumption of –110 dBm maximum permissible interference level.

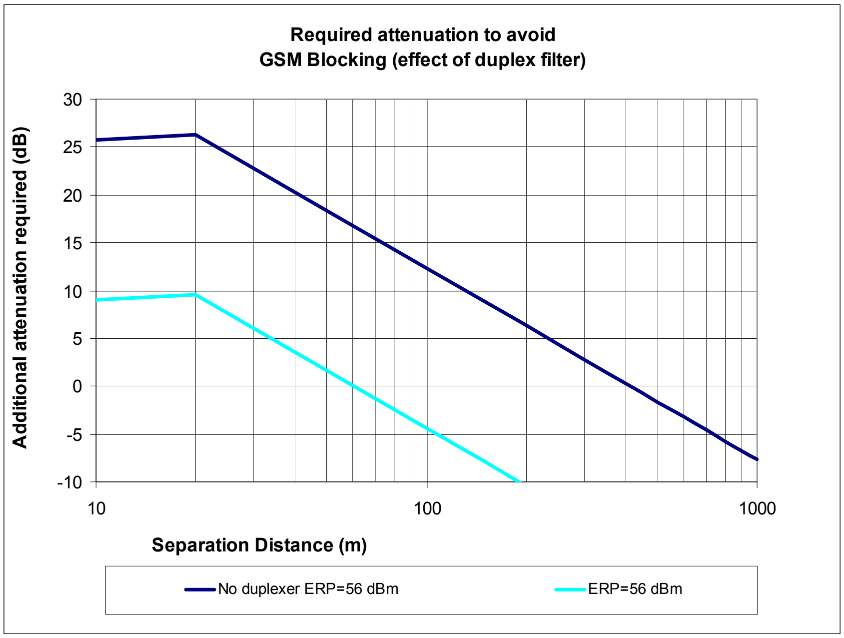

Figure 4: Requirement for blocking improvement of GSM BS receivers

Note to Fig. 4: Reference is made to tables 4 & 5 in Annex 1 "Required attenuation for blocking" for the antennas facing each other on adjacent buildings (20 m) scenario, frequency 917.675 MHz at an ERP of 56 dBm. The standard blocking requirement of 3GPP TS 45.005 has been used taking into account the impact of intra-system interference and man-made noise.

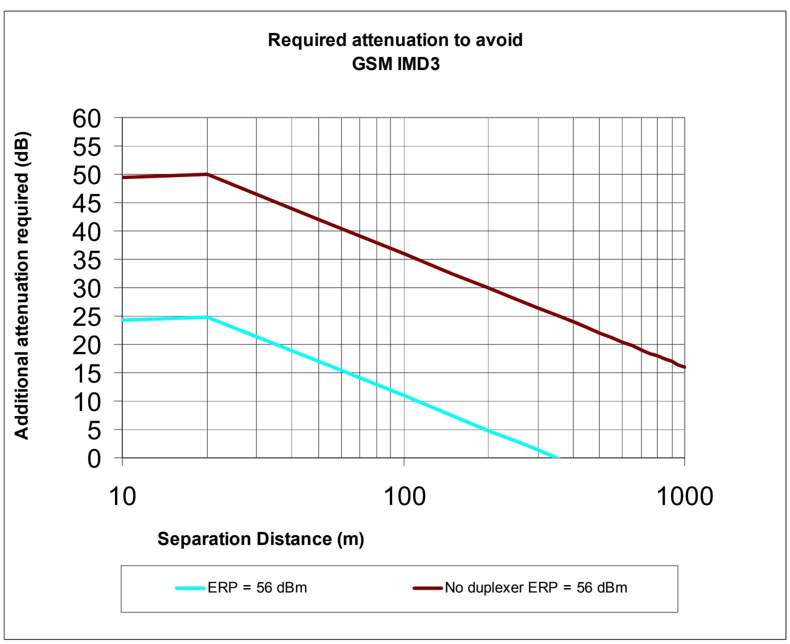

Figure 5: Requirement for IMD3 improvement of GSM BS receivers

Note to Fig. 5: Reference is made to tables 7 & 8 in Annex 1 "Required attenuation for IMD3" for the antennas facing each other on adjacent buildings (20 m) scenario, frequencies 917.675 MHz and 920.175 MHz at an ERP of 56 dBm. The standard IMD3 requirement of 3GPP TS 45.005 has been used taking into account the impact of intra-system interference and man-made noise.

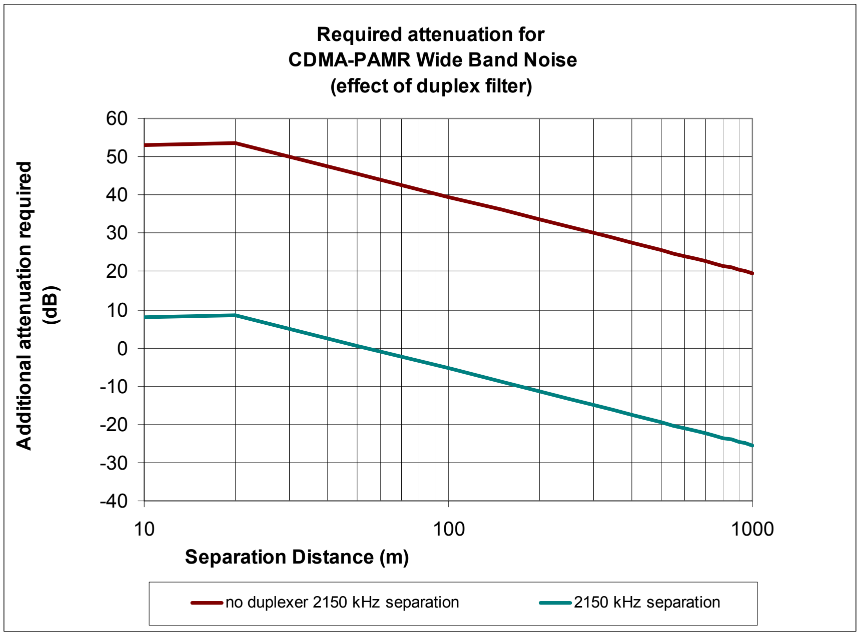

Figure 6: Requirement for CDMA-PAMR wide band noise attenuation

Note to Fig. 6: Reference is made to tables 10 a and b in Annex 1 "Required attenuation for CDMA-PAMR wide band noise" for the antennas facing each other on adjacent buildings (20 m) scenario, frequency range 917.675–920.175 MHz at an ERP of 56 dBm.

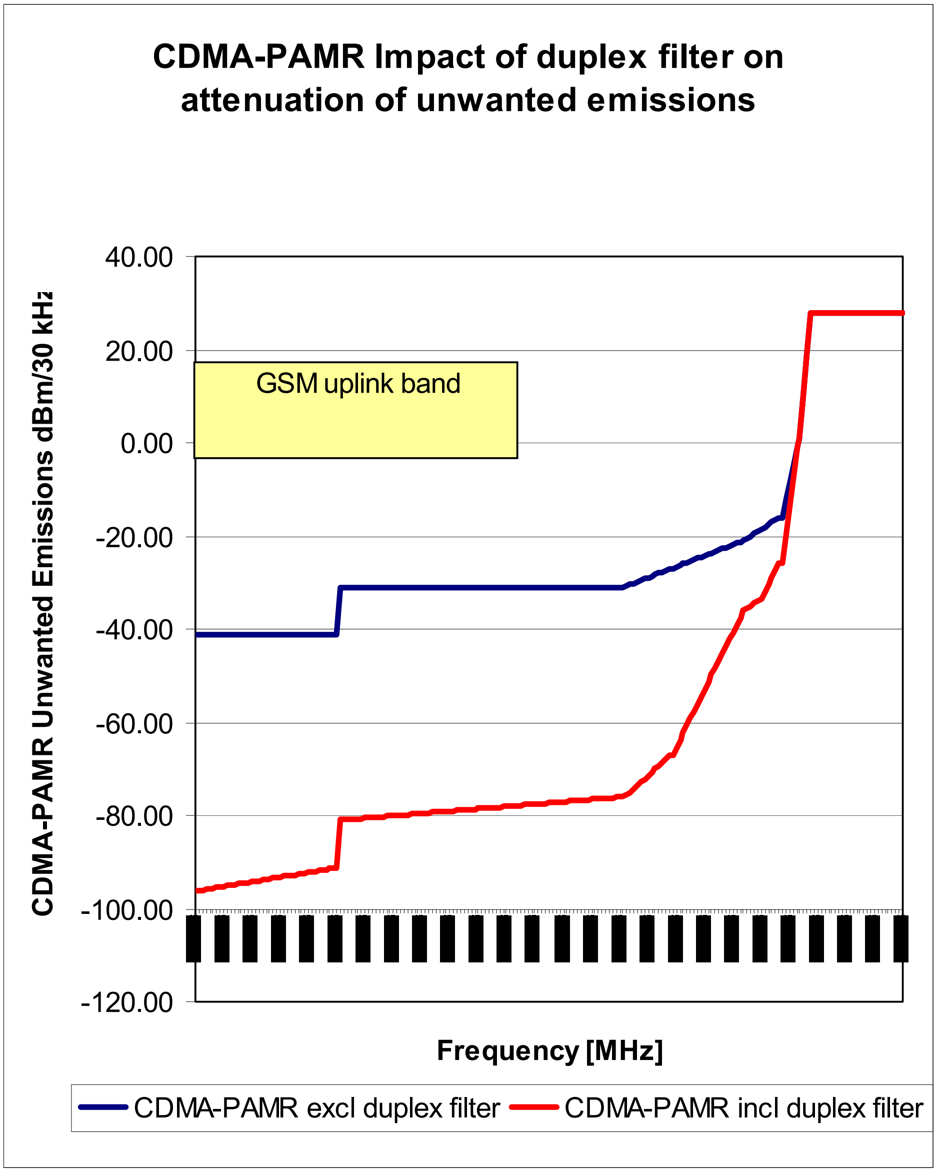

Figure 7: CDMA-PAMR unwanted emissions with and without duplex filter

		Permissible interference: -110 dBm		Permissible interference: -125 dBm	
BS AID⇨		**0.0109974**		**0.0006158**	
Frequency separation ⇩	**MS AI D⇨**	**0.05**	**0.02**	**0.01**	**0.004**
2150 kHz		16.231%	14.195%	24.107%	24.066%
3400 kHz		5.481%	4.780%	7.477%	7.553%
4650 kHz		5.461%	4.819%	7.476%	7.561%

Table 1: Interference probability (%) from a CDMA-PAMR BS single channel into a GSM BS single adjacent channel – both systems without duplex filters

		Permissible interference: -110 dBm		Permissible interference: -125 dBm	
BS AID⇨		**0.0109974**		**0.0006158**	
Frequency separation ⇩	**0.25**	**0.05**	**0.02**	**0.01**	**0.004**
2150 kHz		0.278%	0.216%	0.139%	0.113%
3400 kHz		0.014%	0.010%	0.000%	0.000%
4650 kHz		0.000%	0.000%	0.000%	0.000%

Table 2: Interference probability (%) from a CDMA-PAMR BS single channel into a GSM BS single adjacent channel – both systems with duplex filters

The absolute values given in Tables 1 and 2 are not relevant and shall not be used because they are describing a scenario that is not realistic in that it is not taking into account the close correlation between the two considered networks, where in some cases co-siting of the systems will be required by topography or a requirement to site share. These tables are given only with the aim to demonstrate the major impact of duplex filters.

Tables 1 and 2 represent results of Monte Carlo simulations. The assumptions were that the two networks are non-correlated and a flat earth model was used (specific details can be found in Annex 2). Even though the probabilities in a real deployment may be slightly higher than those shown in the tables, because of practical roll-out limitations, it should be remembered that each network must provide seamless coverage and that the number of BSs in a PAMR network is substantially lower than that in the GSM networks. The tables 1 and 2 are directly comparable because they use the same assumptions in every respect, except for the inclusion of duplex filters in the second table.

It is clear from the figures and the tables above that the duplex filters form an important part of the adjacent band compatibility. It can be seen from the Figures 4 to 6 that for any given separation distance the required attenuation will be high. The effect of the duplex filters is also very clear from the interference probability simulations in the Tables 1 and 2. The values quoted in the tables exclude the effect of intermodulation because currently SEAMCAT is unable to simulate this correctly. Because of the strong impact of the duplex filters, typical duplex filters as specified in Annex 2 were included in consideration for the remaining part of this report.

6.2 Compatibility analysis for –110 dBm permissible interference level

In the following Figures 8 to 11 the required attenuation for different interference mechanisms is presented as a function of separation distance, based on results of calculations using the MCL method for the -110 dBm permissible interference level.

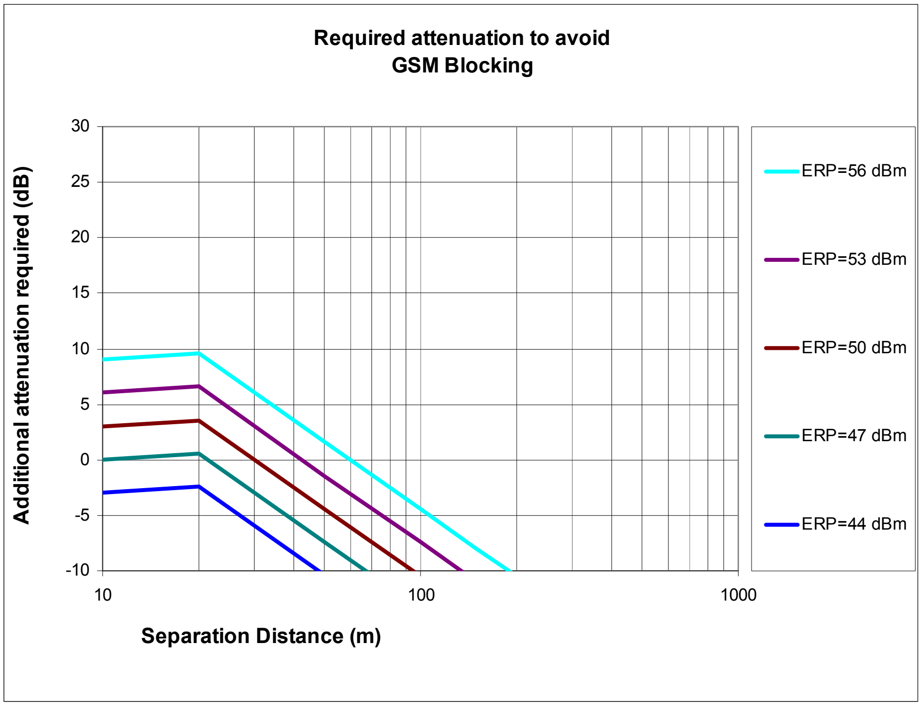

Figure 8: Requirement for blocking avoidance of GSM BS receivers

Notes to Fig. 8:

(1) Reference is made to table 5 in Annex 1 "Required attenuation for blocking" for the antennas facing each other on adjacent buildings (20 m) scenario, frequency 917.675 MHz at an ERP of 56 dBm. The calculation includes a typical GSM duplex filter. The additional output power ranges and separation distances have been derived by extrapolation.

(2) It should be noted that the impact of blocking is both frequency and transmitter output power dependent. Any additional filter required must be located at the GSM BS receiver input. The impact of blocking has to be considered for all GSM BS receivers. The impacted GSM BS receivers could be at one or more sites in the area surrounding the CDMA-PAMR transmitter.

(3) The impact of blocking due to 2 CDMA-PAMR carriers is given by the following expression:
Required attenuation for two carriers $= 10*LOG_{10}(10^{attenuation\ 1st\ carrier/10}+10^{attenuation\ 2nd\ carrier/10})$.

(4) The standard blocking requirement of 3GPP TS 45.005 has been used taking into account the impact of intra-system interference and man-made noise.

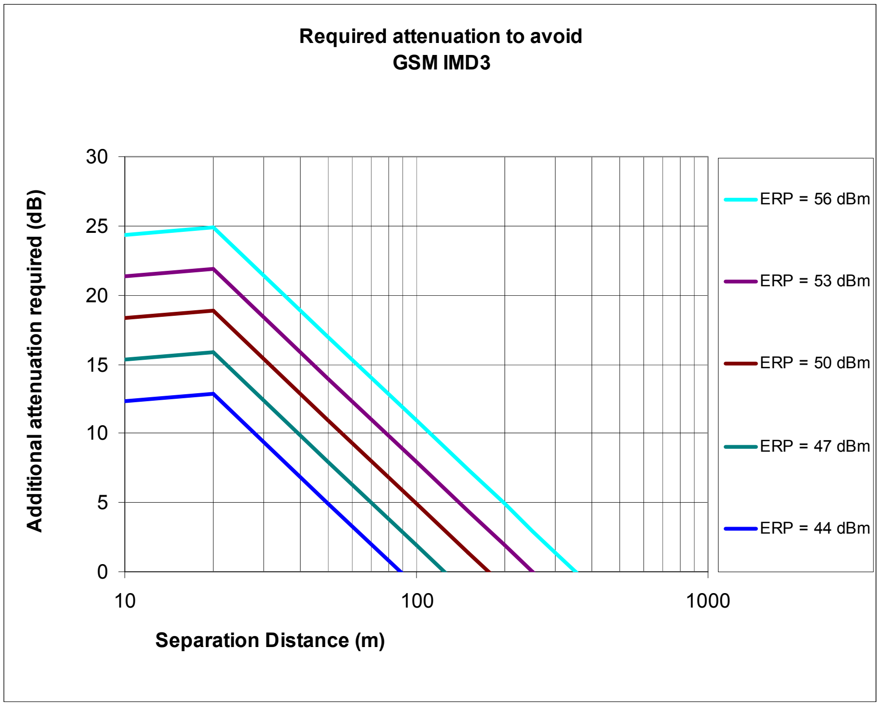

Figure 9: Requirement for IMD3 avoidance of GSM BS receivers

Notes to Fig. 9:

(1) Reference is made to table 8 in Annex 1 "Required attenuation for IMD3" for the antennas facing each other on adjacent buildings (20 m) scenario, frequencies 917.675 MHz and 920.175 MHz at an ERP of 56 dBm. The calculation includes a typical GSM duplex filter. The additional output power ranges and separation distances have been derived by extrapolation.

(2) It should be noted that the impact of IMD3 is both frequency and transmitter output power dependent. Any additional filter required must be located at the GSM BS receiver input. The impacted GSM BS receivers could be at one or more sites in the area surrounding the CDMA-PAMR transmitter.

(3) The standard IMD3 requirement of 3GPP TS 45.005 has been used taking into account the impact of intra-system interference and man-made noise.

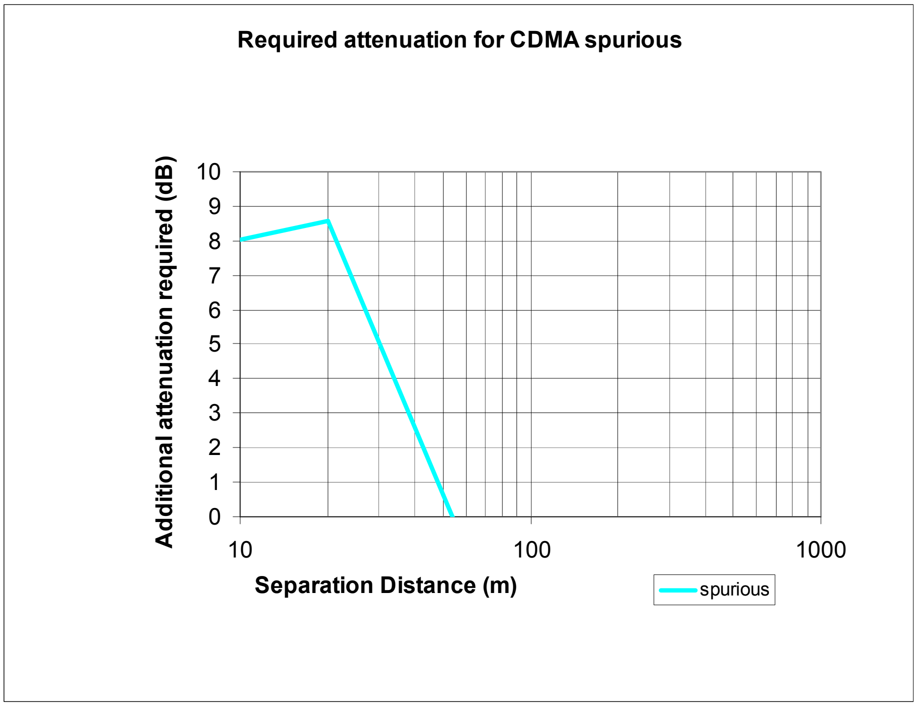

Figure 10: Requirement for CDMA-PAMR spurious emission attenuation

Notes to Fig. 10:

(1) Reference is made to table 9 in Annex 1 "Required attenuation for spurious" for the antennas facing each other on adjacent buildings (20 m) at an ERP of 56 dBm. The calculation includes a typical CDMA-PAMR duplex filter. The additional separation distances have been derived by extrapolation.

(2) It should be noted that the impact of spurious emission is frequency dependent as a result of the GSM duplex filter shape.

(3) The impact of spurious emission due to 2 CDMA-PAMR carriers is given by the following expression:
Required attenuation for two carriers = $10*LOG_{10}(10^{attenuation\ 1st\ carrier/10}+10^{attenuation\ 2nd\ carrier/10})$.

(4) Any additional filter must be located at the transmitter output of the CDMA-PAMR BS.

(5)Because of the statistical nature of spurious emission and the low probability for a spurious to occur at its limit and at the frequency of the adjacent GSM BS receiver, this should be considered a special case. The attenuation required for suppression of wide band noise will, with a high probability, also remove any spurious products. The requirement is only depicted for this case because it is unlikely to be the predominant interference source.
In the unlikely event that spurious emission proves to be the predominant source of interference, additional attenuation must be provided according to the values above.

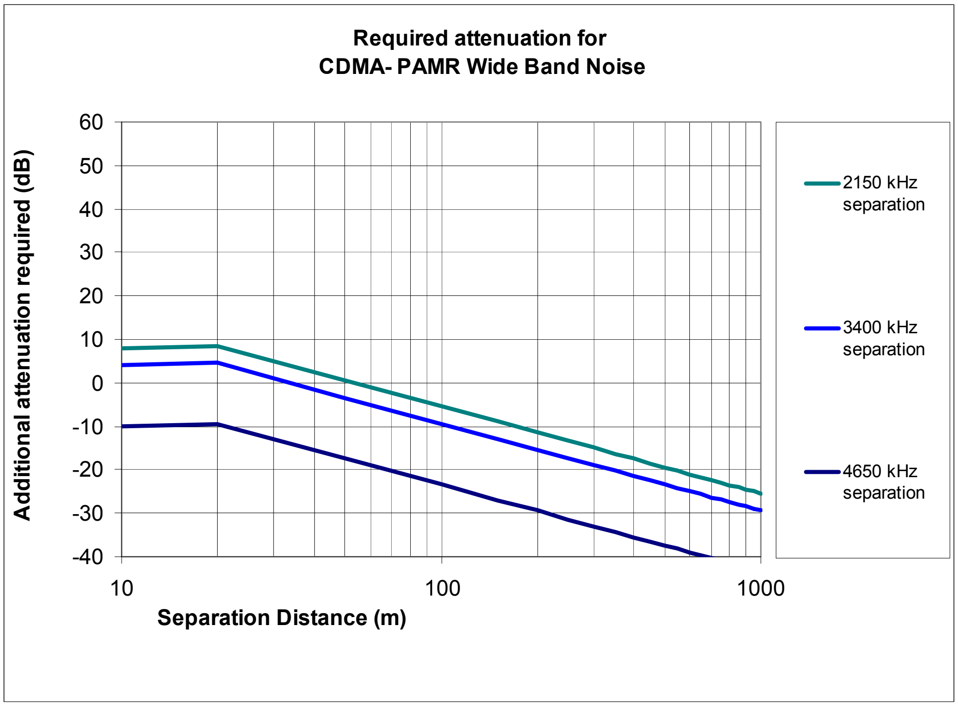

Figure 11: Requirement for CDMA-PAMR wide band noise attenuation

Notes to Fig. 11:

(1) Reference is made to tables 10b-c in Annex 1 “Required attenuation for CDMA-PAMR wide band noise” for the antennas facing each other on adjacent buildings (20 m) scenario, frequency range 917.675–920.175 MHz at an ERP of 56 dBm. The calculation includes a typical CDMA-PAMR duplex filter. The additional separation distances have been derived by extrapolation.

(2) Any additional filter required to achieve the necessary attenuation must be located at the transmitter output of the CDMA-PAMR BS.

(3) The impact of wide band noise due to 2 CDMA-PAMR carriers is given by the following expression: *Required attenuation for two carriers* $= 10*LOG_{10}(10^{\text{attenuation 1st carrier}/10}+10^{\text{attenuation 2nd carrier}/10})$.

(4) The impact of wide band noise also has to be considered for GSM BS receivers that are operating at frequencies below 914.8 MHz. The impacted GSM BS receivers could be at one or more sites in the area surrounding the CDMA-PAMR Transmitter.

6.3 Compatibility analysis for –125 dBm permissible interference level

In the following Figures 12 to 14 the required attenuation for the different interference mechanisms is presented as a function of separation distance, based on the results of calculations using the MCL method for –125 dBm permissible interference level (see Annex 3).

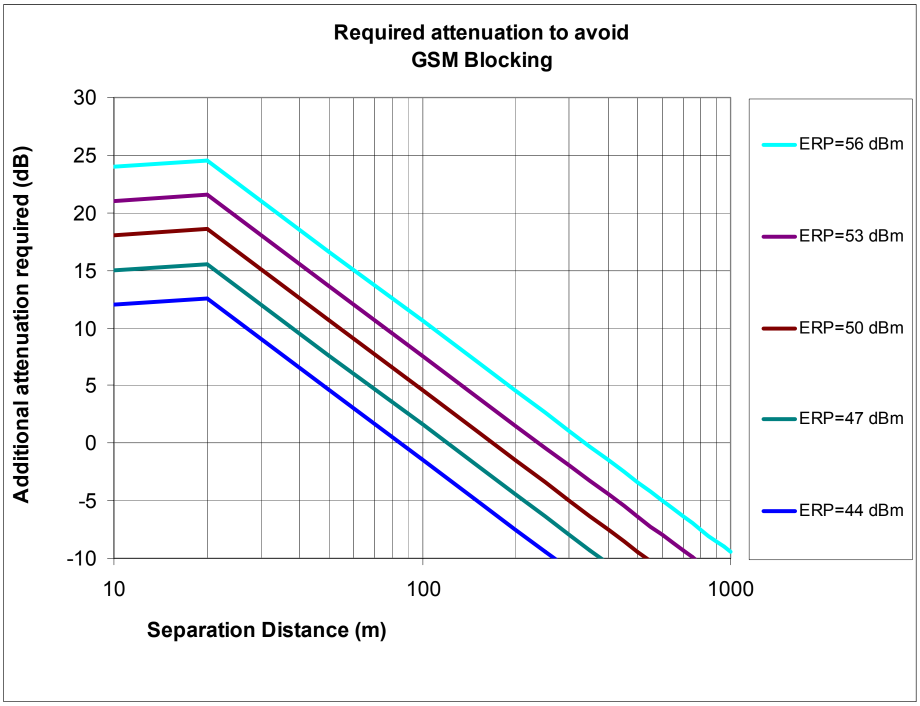

Figure 12: Requirement for blocking avoidance of GSM BS receivers

Notes to Fig. 12:

(1) Reference is made to table 5 in Annex 1 "Required attenuation for blocking" for the antennas facing each other on adjacent buildings (20 m) scenario, frequency 917.675 MHz at an ERP of 56 dBm. The calculation includes a typical GSM duplex filter. The additional output power ranges and separation distances have been derived by extrapolation.

(2) It should be noted that the impact of blocking is both frequency and transmitter output power dependent. Any additional filter required must be located at the GSM base station receiver input.

(3) The impact of blocking has to be considered for all GSM BS receivers. The impacted GSM BS receivers could be at one or more sites in the area surrounding the CDMA-PAMR transmitter.

(4) The impact of blocking due to two CDMA-PAMR carriers is given by the following expression:
Required attenuation for two carriers $= 10*LOG_{10}(10^{attenuation\ 1st\ carrier/10}+10^{attenuation\ 2nd\ carrier/10})$.

(5) The standard blocking requirement of 3GPP TS 45.005 has been used, but tightened by 15 dB taking into account the absence of intra-system interference and man-made noise .

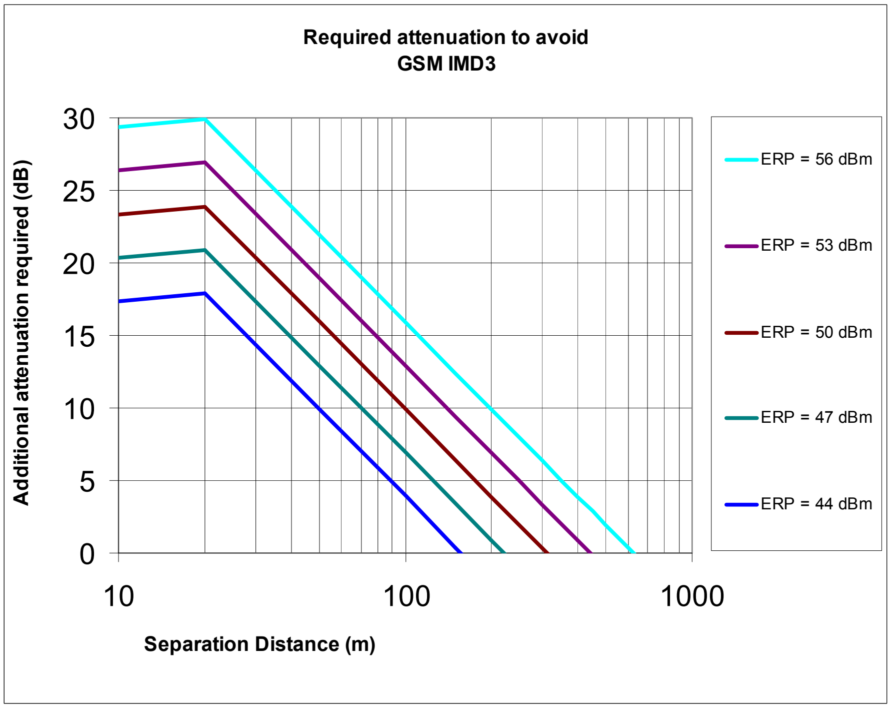

Figure 13: Requirement for IMD3 avoidance of GSM BS receivers

Notes to Fig. 13:

(1) Reference is made to table 8 in Annex 1 "Required attenuation for IMD3" for the antennas facing each other on adjacent buildings (20 m) scenario, frequencies 917.675 MHz and 920.175 MHz at an ERP of 56 dBm. The calculation includes a typical GSM duplex filter. The additional output power ranges and separation distances have been derived by extrapolation.

(2) It should be noted that the impact of IMD3 is both frequency and transmitter output power dependent. Any additional filter required must be located at the GSM BS receiver input.

(3)The impacted GSM BS receivers could be at one or more sites in the area surrounding the CDMA-PAMR transmitter.

(4) The standard IMD3 requirement of 3GPP TS 45.005 has been used, but tightened by 15 dB taking into account the absence of intra-system interference and man-made noise.

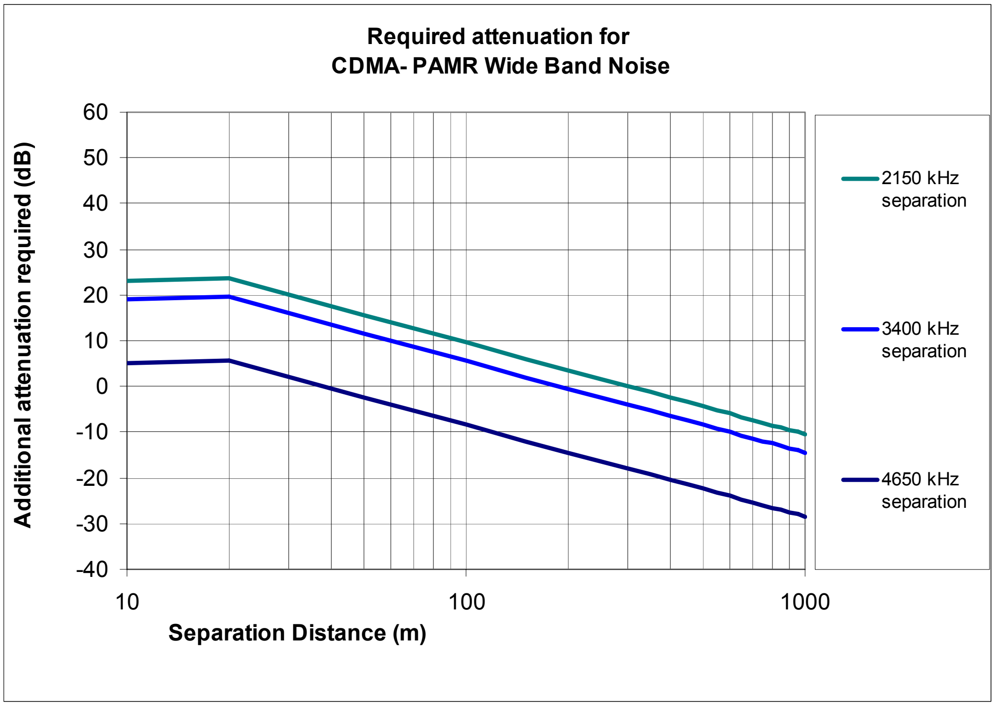

Figure 14: Requirement for CDMA-PAMR wide band noise attenuation

Notes to Fig. 14:(1) Reference is made to tables 10 b-d in Annex 1 "Required attenuation for CDMA-PAMR wide band noise" for the antennas facing each other on adjacent buildings (20 m) scenario, frequency range 917.675–920.175 MHz at an ERP of 56 dBm. The calculation includes a typical CDMA-PAMR duplex filter. The additional separation distances have been derived by extrapolation.

(2) Any additional filter required to achieve the necessary attenuation must be located at the transmitter output of the CDMA-PAMR base station.

(3) The impact of wide band noise due to 2 CDMA-PAMR carriers is given by the following expression:
Required attenuation for two carriers = $10*LOG_{10}(10^{\text{attenuation 1st carrier}/10}+10^{\text{attenuation 2nd carrier}/10})$.

(4) The impact of wide band noise also has to be considered for GSM BS receivers that are operating at frequencies below 914.8 MHz. The impacted GSM BS receivers could be at one or more sites in the area surrounding the CDMA-PAMR transmitter**.**

7 CONCLUSIONS

From the above figures and results of the calculations, concerning the protection of the existing GSM BS receivers against interference from CDMA-PAMR BS transmitters, the technical requirements for the utilisation of the band 917-921 MHz can be found. The report focused on 917–921 MHz because of the difficulties to provide mitigation in the 915–917 MHz range. Any utilisation of CDMA-PAMR in the 915–917 MHz range has not been considered in this report and would require further studies.

The report investigated the effect of duplex filters and established that these are essential to enable any compatibility between GSM and CDMA-PAMR networks. It is however also clear that deployed filters are critical components that influence the co-ordination distances.

The report has determined that below certain physical separation distances, which depend upon the duplex filter characteristics as provided in Annex 2, interference can occur into GSM BS receivers as a result of the transmitter power from a CDMA-PAMR system in the band 917–921 MHz. This could result in desensitisation of the GSM BS receivers due to blocking or IMD3. To avoid blocking and IMD3 of GSM BS receivers, additional filtering may be required at the input of the GSM receiver. This is an important consideration in view of the widespread deployment of GSM BS. The number of the GSM BSs, which will be affected, will depend on the relatively lower number of CDMA PAMR BS, which will be deployed. The feasibility to retro-fit filters into already-installed GSM BS would also need to be investigated.

Another type of interference that can occur is the unwanted emission from a CDMA-PAMR system desensitising the GSM BS receiver. The unwanted emission can be spurious emission or wide band noise. To avoid unwanted emission desensitising the GSM BS receiver additional filtering is required in the CDMA-PAMR transmitter.

To allow the filters mentioned above to operate, a duplex transition separation band is considered necessary. In this study, a frequency separation of 2.15 MHz around the duplex transition frequency has been assumed between the two bands.

The requirements for the CDMA-PAMR operator are such that it should be encouraged the use of physical separation distance whenever possible.

The band 917–921 MHz can be utilised by CDMA-PAMR without undue risk of interference to the GSM BS receivers only if special measures are undertaken. These include co-ordination between the operators below and above 915 MHz and the use of mitigation according to the actual separation distances. Required co-ordination distances are summarised in the table below.

Co-ordination Distances (macrocell to macrocell)	Blocking	IMD3 (where applicable[3])	Wide Band Noise
Value affected by filters in:	GSM BS RX	GSM BS RX	CDMA-PAMR BS TX
Permissible interference: -110 dBm with duplex filters	60 m	350 m	50 m
Permissible interference: -110 dBm without duplex filters	410 m	(6000 m)	(9500 m)
Permissible interference: -125 dBm with duplex filters	350 m	625 m	300 m
Permissible interference: -125 dBm without duplex filters	(2300 m)	(35000 m)	(53000 m)
NOTE: The values in brackets are included for illustration only and should not be used for co-ordination. The values are exceeding the cell size of one or both systems and are therefore not meaningful as a co-ordination distance. The propagation model is only valid for distances up to 1000 m (line of sight). Also, the results for IMD3 have a low probability of occurrence because it requires both base stations being simultaneously at their maximum power.			

[3] IMD3 can only occur when CDMA-PAMR carriers 1 and 3 are deployed and with product falling only in the frequency range from 913.3-915 MHz (see figure 3 for details).

For co-ordination purposes administration may take the results based on permissible interference level studied in conjunction with other factors such as the actual deployed equipment in terms of duplex filters, antenna gain, intra-system interference and man-made noise.

The level of –110 dBm may be considered representative of an interference-limited GSM network. The level of –125 dBm may be considered representative of a noise limited-GSM network.

The co-ordination distances should be seen in relation to the cell radii used for CDMA-PAMR; the values assumed in this Report are 4.5 km for urban areas, 9 km for suburban areas and 25 km for rural areas.

The co-ordination distances for GSM microcells and picocells will be lower (see Annex 1)

8 BIBLIOGRAPHY

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[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”.
[10] Recommendation ITU-R P.372-7
[11] Recommendation ITU P.1411.
[12] 3GPP TS45.005, Technical Specification Group GSM/EDGE, Radio Access Network; Radio transmission and reception.

ANNEX 1: MCL CALCULATIONS OF THE CDMA-PAMR BS INTO GSM BS SCENARIO

By considerations of blocking, CDMA at 917.675 MHz without GSM duplex filter impact	Tx power Watts	losses dB	Tx Ant Gain dB	Tx ERP dBm	No of Tx	Distance m	Free space propagation dB	GSM RX antenna gain dB	feeders etc dB	Impact of typical GSM duplexer dB	Interference power dBm	specified blocking dBm	**Required attenuation for co-ordination of blocking for interference limited GSM** dB	**Required attenuation for co-ordination of blocking for noise limited GSM** dB
Antennas on adjacent buildings, rooftop to rooftop	25.00	3.00	15.00	55.98	1.00	20.00	57.67	15.00	3.00	0.00	10.31	-16.00	26.31	41.31
Antennas in close proximity	25.00	3.00	0.00	40.98	1.00	N/A	30.00	0.00	3.00	0.00	7.98	-16.00	23.98	38.98
Antennas in close proximity	25.00	3.00	0.00	40.98	1.00	N/A	40.00	0.00	3.00	0.00	-2.02	-16.00	13.98	28.98
micro to micro	1.00	3.00	7.15	34.15	1.00	25.00	59.61	7.15	3.00	0.00	-21.31	-16.00	-5.31	9.69

By considerations of blocking, CDMA at 917.675 MHz including typical GSM duplex filter impact	Tx power Watts	losses dB	Tx Ant Gain dB	Tx ERP dBm	No of Tx	Distance m	Free space propagation dB	GSM RX antenna gain dB	feeders etc dB	Impact of typical GSM duplexer dB	Interference power dBm	specified blocking dBm	**Required attenuation for co-ordination of blocking for interference limited GSM** dB	**Required attenuation for co-ordination of blocking for noise limited GSM** dB
Antennas on adjacent buildings, rooftop to rooftop	25.0	3.0	15.0	56.0	1.0	20.0	57.7	15.0	3.0	16.7	-6.4	-16.0	9.6	24.6
Antennas in close proximity	25.0	3.0	0.0	41.0	1.0	N/A	30.0	0.0	3.0	16.7	-8.8	-16.0	7.2	22.2
Antennas in close proximity	25.0	3.0	0.0	41.0	1.0	N/A	40.0	0.0	3.0	16.7	-18.8	-16.0	-2.8	12.2
micro to micro	1.0	3.0	7.2	34.2	1.0	25.0	59.6	7.2	3.0	16.7	-38.1	-16.0	-22.1	-7.1

By considerations of blocking, CDMA at 920.175 MHz including typical GSM duplex filter impact	Tx power Watts	losses dB	Tx Ant Gain dB	Tx ERP dBm	No of Tx	Distance m	Free space propagation dB	GSM RX antenna gain dB	feeders etc dB	Impact of typical GSM duplexer dB	Interference power dBm	specified blocking dBm	**Required attenuation for co-ordination of blocking for interference limited GSM** dB	**Required attenuation for co-ordination of blocking for noise limited GSM** dB
Antennas on adjacent buildings, rooftop to rooftop	25.0	3.0	15.0	56.0	1.0	20.0	57.7	15.0	3.0	41.7	-31.4	-13.0	-18.4	-3.4
Antennas in close proximity	25.0	3.0	0.0	41.0	1.0	N/A	30.0	0.0	3.0	41.7	-33.8	-13.0	-20.8	-5.8
Antennas in close proximity	25.0	3.0	0.0	41.0	1.0	N/A	40.0	0.0	3.0	41.7	-43.8	-13.0	-30.8	-15.8
micro to micro	1.0	3.0	7.2	34.2	1.0	25.0	59.6	7.2	3.0	41.7	-63.1	-13.0	-50.1	-35.1

Tables 4 to 6: Calculation of the required attenuation to avoid blocking of a GSM BS receiver from CDMA PAMR BS output power

I) Propagation model used is free space loss for antenna distances of 20 m and over.

II) The specified duplex filter has been taken into account in tables 5 and 6. In table 4 the duplex filter has been omitted to show the importance of the duplex filter in the calculations.

III) The antenna gain and cable loss of both the victim (GSM) and interferer (CDMA-PAMR) BSs is assumed to be 15 dB and 3 dB respectively.

IV) It has been agreed that a coupling loss figure of 30 dB is used between two antennas in close proximity because it is considered a standard value. 40 dB is also included because improved attenuation can be achieved with high gain antennas by site engineering.

By considerations of IMD3, CDMA at 917.675 and 920.175 MHz without GSM duplex filter impact	Tx power Watts	losses dB	Tx Ant Gain dB	Tx ERP dBm	No of Tx	Distance m	Free space propagation dB	GSM RX antenna gain dB	feeders etc dB	Interference power in 2000 kHz dBm	Max IMD3 level for 3 dB desens. @-101 dBm (45005) dBm	Protected sensitivity; C/I (9 dB) below neg 101 dBm (ref. 45005) dBm	IIP3 dBm	IMD3 in 2000 kHz bw dB	Bandwidth conversion impact of 2000 to 200 kHz dB	IMD2 in 200 kHz dB	**Required attenuation for co-ordination of IMD3 for interference limited GSM** dB	**Required attenuation for co-ordination of IMD3 for noise limited GSM** dB
Antennas on adjacent buildings, rooftop to rooftop	25.0	3.0	15.0	56.0	1.0	20.0	57.7	15.0	3.0	10.3	-43.0	-110.0	-9.5	49.9	10.0	39.9	50.0	65.0
Antennas in close proximity	25.0	3.0	0.0	41.0	1.0	N/A	30.0	0.0	3.0	8.0	-43.0	-110.0	-9.5	42.9	10.0	32.9	47.6	62.6
Antennas in close proximity	25.0	3.0	0.0	41.0	1.0	N/A	40.0	0.0	3.0	-2.0	-43.0	-110.0	-9.5	12.9	10.0	2.9	37.6	52.6
micro to micro	1.0	3.0	7.2	34.2	1.0	25.0	59.6	7.2	3.0	-21.3	-43.0	-110.0	-9.5	-44.9	10.0	-54.9	18.4	33.4

By considerations of IMD3, CDMA at 917.675 and 920.175 MHz including typical GSM duplex filter impact	Carrier Frequencies MHz	Tx power Watts	losses dB	Tx Ant Gain dB	Tx ERP dBm	No of Tx	Distance m	Free space propagation dB	GSM RX antenna gain dB	feeders etc dB	Impact of typical GSM duplexer dB	Interference power in 2000 kHz dBm	Max IMD3 level for 3 dB desens. @-101 dBm (45005) dBm	Protected sensitivity; C/I (9 dB) below neg 101 dBm (ref. 45005) dBm	IIP3 dBm	IMD3 in 2000 kHz bw dB	Bandwidth conversion impact of 2000 to 200 kHz dB	IMD2 in 200 kHz dB	**Required attenuation for co-ordination of IMD3 for interference limited GSM** dB -110 dBm	**Required attenuation for co-ordination of IMD3 for noise limited GSM** dB -125 dBm
Antennas on adjacent buildings, rooftop to rooftop	917.675	25.0	3.0	15.0	56.0	1.0	20.0	57.7	15.0	3.0	16.7	-6.4	-43.0	-110.0	-9.5	-25.3	10.0	-35.3	24.9	29.9
third carrier	920.175										41.7	-31.4	-43.0	-110.0	-9.5	-25.3	10.0	-35.3	24.9	29.9
Antennas in close proximity	917.675	25.0	3.0	0.0	41.0	1.0	N/A	30.0	0.0	3.0	16.7	-8.8	-43.0	-110.0	-9.5	-32.3	10.0	-42.3	22.6	27.6
third carrier	920.175										41.7	-33.8	-43.0	-110.0	-9.5	-32.3	10.0	-42.3	22.6	27.6
Antennas in close proximity	917.675	25.0	3.0	0.0	41.0	1.0	N/A	40.0	0.0	3.0	16.7	-18.8	-43.0	-110.0	-9.5	-62.3	10.0	-72.3	12.6	17.6
third carrier	920.175										41.7	-43.8	-43.0	-110.0	-9.5	-62.3	10.0	-72.3	12.6	17.6
micro to micro	917.675	1.0	3.0	7.2	34.2	1.0	25.0	59.6	7.2	3.0	16.7	-38.1	-43.0	-110.0	-9.5	-95.2	10.0	-105.2	1.6	6.6
third carrier	920.175										41.7	-38.1	-43.0	-110.0	-9.5	-95.2	10.0	-105.2	1.6	6.6

Tables 7 & 8: Calculation of the required attenuation to avoid desensitisation by IMD3 of a GSM BS receiver from CDMA PAMR BS output power

V) Propagation model used is free space loss for antenna distances of 20 m and over.

VI) The antenna gain and cable loss of both the victim (GSM) and interferer (CDMA-PAMR) BSs is assumed to be 15 dB and 3 dB respectively.

VII) It has been agreed that a coupling loss figure of 30 dB is used between two antennas in close proximity because it is considered a standard value. 40 dB is also included because improved attenuation can be achieved with high gain antennas by site engineering.

VIII) The specified duplex filter has been taken into account in table 8

IX) Bandwidth adjustment is required because IMD3 manifests itself as a wide band interferer with the main power in a 2000 kHz bandwidth and because GSM is a 200 kHz carrier. The resulting IMD3 power bandwidth of 2000 kHz has been verified by tests.

By consideration of CDMA spurious (spurious domain starts at 3125 kHz Rec. 74-01) Guardband = 2500 kHz	Conducted spurious: CDMA according to spec + duplexer dBm	losses dB	Tx side ant gain dB	Radiated spurious in 200 kHz dBm	no of spurious	Distance m	Free space propagation dB	GSM RX antenna gain dB	feeders etc dB	Interference power dBm	Protected sensitivity; C/I (9 dB) below neg 101 dBm dBm	**Required attenuation for spurious emission** dB
Antennas on adjacent buildings, rooftop to rooftop	-76.0	3.0	15.0	-55.8	1.0	20.0	57.7	15.0	3.0	-101.4	-110.0	8.6
Antennas in close proximity	-76.0	3.0	0.0	-70.8	1.0	N/A	30.0	0.0	3.0	-103.8	-110.0	6.2
Antennas in close proximity	-76.0	3.0	0.0	-70.8	1.0	N/A	40.0	0.0	3.0	-113.8	-110.0	-3.8
micro to micro	-76.0	3.0	7.2	-63.6	1.0	25.0	59.6	7.2	3.0	-119.1	-110.0	-9.1

Table 9: Calculation of the required attenuation to avoid desensitisation of a GSM BS receiver from CDMA-PAMR BS transmitter's spurious emission

I) Propagation model used is free space loss for antenna distances of 20 m and over.
II) For antenna separation distances below 20 m a constant coupling loss of 30 and 40 dB has been used.
III) The antenna gain and cable loss of both the victim (GSM) and interferer (CDMA-PAMR) BSs is assumed to be 15 dB and 3 dB respectively.
IV) The specified duplex filter has been taken into account
V) Bandwidth adjustment is required because CDMA-PAMR spurious emissions are specified in bandwidths of 100 kHz and GSM is a 200 kHz carrier.
VI) The value of -110 dBm for protection of GSM has been selected because it provides the same protection level as required for blocking. See also Annex 2.

Note: Because of the statistical nature of spurious emission and the low probability for a spurious to occur at its limit and at the frequency of the adjacent GSM BS receiver this should be considered a special case. The attenuation required for suppression of wide band noise will with a high probability also remove any spurious products. In the unlikely event where spurious emission proves to be the predominant source of interference additional attenuation must be provided.

By consideration of CDMA wide band noise at 917.675 MHz without duplex filter	CDMA Tx power	losses	Tx Ant Gain	CDMA spec (30 kHz)	Bandwidth gain (200 kHz /30 kHz)	Radiated noise in 200 kHz	No	Distance	Free space propagation	GSM RX antenna gain	feeders etc	Interference power	Protected sensitivity; C/I (9 dB) below neg101dBm	Required attenuation for co-ordination of wide band noise for interference limited GSM	Required attenuation for co-ordination of wide band noise for noise limited GSM
Frequency separation = 2150 kHz	Watts	dB	dB	dBc	dB	dBm		m	dB	dB	dB	dBm	dBm	dB	dB
Antennas on adjacent buildings, rooftop to rooftop	25.0	3.0	15.0	-75.0	8.2	-10.8	1.0	20.0	57.7	15.0	3.0	-56.4	-110.0	53.6	68.6
Antennas in close proximity	25.0	3.0	0.0	-75.0	8.2	-25.8	1.0	N/A	30.0	0.0	3.0	-58.8	-110.0	51.2	66.2
Antennas in close proximity	25.0	3.0	0.0	-75.0	8.2	-25.8	1.0	N/A	40.0	0.0	3.0	-68.8	-110.0	41.2	56.2
micro to micro	1.0	3.0	7.2	-75.0	8.2	-32.6	1.0	25.0	59.6	7.2	3.0	-88.1	-110.0	21.9	36.9

By consideration of CDMA wide band noise at 917.675 MHz	CDMA Tx power	losses	Tx Ant Gain	CDMA spec (30 kHz) + duplexer	Bandwidth gain (200 kHz /30 kHz)	Radiated noise in 200 kHz	No	Distance	Free space propagation	GSM RX antenna gain	feeders etc	Interference power	Protected sensitivity; C/I (9 dB) below neg101dBm	Required attenuation for co-ordination of wide band noise for interference limited GSM	Required attenuation for co-ordination of wide band noise for noise limited GSM
Frequency separation = 2150 kHz	Watts	dB	dB	dBc	dB	dBm		m	dB	dB	dB	dBm	dBm	dB	dB
Antennas on adjacent buildings, rooftop to rooftop	25.0	3.0	15.0	-120.0	8.2	-55.8	1.0	20.0	57.7	15.0	3.0	-101.4	-110.0	8.6	23.6
Antennas in close proximity	25.0	3.0	0.0	-120.0	8.2	-70.8	1.0	N/A	30.0	0.0	3.0	-103.8	-110.0	6.2	21.2
Antennas in close proximity	25.0	3.0	0.0	-120.0	8.2	-70.8	1.0	N/A	40.0	0.0	3.0	-113.8	-110.0	-3.8	11.2
micro to micro	1.0	3.0	7.2	-120.0	8.2	-77.6	1.0	25.0	59.6	7.2	3.0	-133.1	-110.0	-23.1	-8.1

By consideration of CDMA wide band noise at 918.925 MHz	CDMA Tx power	losses	Tx Ant Gain	CDMA spec (30 kHz) + duplexer	Bandwidth gain (200 kHz /30 kHz)	Radiated noise in 200 kHz	No	Distance	Free space propagation	GSM RX antenna gain	feeders etc	Interference power	Protected sensitivity; C/I (9 dB) below neg101dBm	Required attenuation for co-ordination of wide band noise for interference limited GSM	Required attenuation for co-ordination of wide band noise for noise limited GSM
Frequency separation = 3400 kHz	Watts	dB	dB	dBc	dB	dBm		m	dB	dB	dB	dBm	dBm	dB	dB
Antennas on adjacent buildings, rooftop to rooftop	25.0	3.0	15.0	-124.0	8.2	-59.8	1.0	20.0	57.7	15.0	3.0	-105.4	-110.0	4.6	19.6
Antennas in close proximity	25.0	3.0	0.0	-124.0	8.2	-74.8	1.0	N/A	30.0	0.0	3.0	-107.8	-110.0	2.2	17.2
Antennas in close proximity	25.0	3.0	0.0	-124.0	8.2	-74.8	1.0	N/A	40.0	0.0	3.0	-117.8	-110.0	-7.8	7.2
micro to micro	1.0	3.0	7.2	-124.0	8.2	-81.6	1.0	25.0	59.6	7.2	3.0	-137.1	-110.0	-27.1	-12.1

By consideration of CDMA wide band noise at 920.175 MHz	CDMA Tx power	losses	Tx Ant Gain	CDMA spec (30 kHz) + duplexer	Bandwidth gain (200 kHz /30 kHz)	Radiated noise in 200 kHz	No	Distance	Free space propagation	GSM RX antenna gain	feeders etc	Interference power	Protected sensitivity; C/I (9 dB) below neg101dBm	**Required attenuation for co-ordination of wide band noise for interference limited GSM**	**Required attenuation for co-ordination of wide band noise for noise limited GSM**
Frequency separation = 4650 kHz	Watts	dB	dB	dBc	dB	dBm		m	dB	dB	dB	dBm	dBm	dB	dB
Antennas on adjacent buildings, rooftop to rooftop	25.0	3.0	15.0	-138.0	8.2	-73.8	1.0	20.0	57.7	15.0	3.0	-119.4	-110.0	-9.4	5.6
Antennas in close proximity	25.0	3.0	0.0	-138.0	8.2	-88.8	1.0	N/A	30.0	0.0	3.0	-121.8	-110.0	-11.8	3.2
Antennas in close proximity	25.0	3.0	0.0	-138.0	8.2	-88.8	1.0	N/A	40.0	0.0	3.0	-131.8	-110.0	-21.8	-6.8
micro to micro	1.0	3.0	7.2	-138.0	8.2	-95.6	1.0	25.0	59.6	7.2	3.0	-151.1	-110.0	-41.1	-26.1

Tables 10 a-d. Calculation of the required attenuation to avoid desensitisation of a GSM BS receiver from CDMA-PAMR BS transmitter's wide band noise

These results are based on the following assumptions:

I) Propagation model used is free space loss for antenna distances of 20 m and over.

II) For antenna separation distances below 20 m a constant coupling loss of 30 and 40 dB has been used.

III) The antenna gain and cable loss of both the victim (GSM) and interferer (CDMA-PAMR) BSs is assumed to be 15 dB and 3 dB respectively.

IV) The specified duplex filter has been taken into account in tables 10b, c and d. In table 7a the duplex filter has been omitted to show the importance of the duplex filter in the calculations.

V) Bandwidth adjustment is required because CDMA-PAMR wide band noise is specified in bandwidths of 30 kHz and GSM is a 200 kHz carrier.

VI) The value of -110 dBm for protection of GSM has been selected because it provides the same protection as required for blocking.

ANNEX 2: TECHNICAL PARAMETERS AND ASSUMPTIONS FOR THE CALCULATIONS AND SIMULATIONS

Parameter			CDMA-PAMR		GSM	
			MS	BS	MS	BS
Channel Spacing		kHz	1250	1250	200	200
Cell Radius – Urban		km	4.5		1.6	
– Suburban		km	9		3	
– Rural		km	25		7	
Transmit Power		dBm	23[1]	44	30	44
Receiver Bandwidth		kHz	1250	1250	200	200
Antenna Height		m	1.5	30	1.5	30
Antenna Gain		dB	0	15	0	15
Receiver Sensitivity		dBm	-117	-124	-104	-104
Receiver Protection Ratio		dB			9	9
Power Control Characteristics	Step	dBm	1	1	N/A	N/A
	Minimum	dBm	60	PC Sim.	N/A	N/A
	Threshold	dBm			N/A	N/A

(1) 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 MS, and is the same value as the maximum output power for CDMA-1X MS (on which CDMA-PAMR MS are based). The value is suitable for balancing of uplink and downlink link budgets (with CDMA-PAMR BS 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 BS and MS 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 MS operating on a typical CDMA-PAMR network can be expected to be at least 10-20 dB below the maximum value.

Unwanted Emissions, Band Class 12

CDMA-PAMR Base Station limits from the Lucent CDMA-PAMR SRDoc

Separation from centre frequency (| Δf |)	Emission limit
750 kHz	-45 dBc / 30kHz
885 kHz	-60 dBc / 30kHz
1.125 to 1.98 MHz	-65 dBc / 30kHz
1.98 to 4.00 MHz	-75 dBc / 30kHz
4.00 to 6.00 MHz	-36 dBm / 100 kHz
> 6.00 MHz	-45 dBm / 100 kHz

GSM Duplex filter assumptions (RX branch)

Duplexer RX Filter assumptions			assumes 10 MHz duplex gap
offset for start of slope	1	MHz	
slope	10	dB/MHz	
att on own TX (stop-band att)	90	dB	

Active Interferer Densities For CDMA-PAMR

Environment	CDMA-PAMR AID		
	MS Max. per carrier	MS Typical per carrier	BS per carrier/cell
Urban	0.25	0.1	0.0190074
Rural	0.01	0.004	0.0006158

CDMA-PAMR TX power distribution and related Rx threshold values for urban and rural environments

Environment	CDMA-PAMR BS Power distribution (Cumulative probability for SEAMCAT)					Related BS Rx threshold values
	37 dBm	38 dBm	39 dBm	40 dBm	41 dBm	DBm
Urban max. MS aid 0.25, r = 4.5 km, N =-106.1 dBm	0.03	0.33	0.71	0.94	1	-115.78
Urban typ. MS aid 0.1, r = 4.5 km, N, =-106.1 dBm	0.42	0.86	0.98	1		-116.76
Rural max. MS aid 0.01, r = 25 km, N, =-113.1 dBm	0.16	0.95	1			-122.23
Rural typ. MS aid 0.004, r = 25 km, N, =-113.1 dBm	0.09	0.96	1			-123.58

CDMA-PAMR BS spectrum mask including duplex filter

The duplex filter specified is a typical filter normally used in a congested PMR/PAMR environment.
Note 1: this specification for duplex filter performance is proprietary and not included as part of the TIA specifications as referenced in Lucent SRDoc.

	CDMA - PAMR BS	CDMA - PAMR 44 dBm	CDMA-PAMR BS Normalised to 30 kHz bw		
Offset kHz 1 Channel	Spec.	BS Spec. dBc	1 carrier dBc	Duplex Spec dBc	1 carrier incl Duplexer
-40000	-45.0	-89.0	-94.2	-85.0	-179
-6000	-45.0	-89.0	-94.2	-60.0	-154
-5999	-36.0	-80.0	-85.2	-60.0	-145
-4000	-36.0	-80.0	-85.2	-50.0	-135
-3999	-75.0	-75.0	-75.0	-50.0	-125
-1980	-75.0	-75.0	-75.0	-45.0	-120
-1979	-65.0	-65.0	-65.0	-45.0	-110
-1637.5	-65.0	-65.0	-65.0	-40.0	-105
-1125	-65.0	-65.0	-65.0	-15.0	-80
-1000	-62.5	-62.5	-62.5	-15.0	-78
-885	-60.0	-60.0	-60.0	-10.0	-70
-750	-45.0	-45.0	-45.0	0.0	-45
-625	0	0.0	-16.2	0.0	-16
625	0	0.0	-16.2	0.0	-16
750	-45.0	-45.0	-45.0	0.0	-45
885	-60.0	-60.0	-60.0	-10.0	-70
1000	-62.5	-62.5	-62.5	-15.0	-78
1125	-65.0	-65.0	-65.0	-15.0	-80
1979	-65.0	-65.0	-65.0	-20.0	-85
1980	-75.0	-75.0	-75.0	-20.0	-95
3999	-75.0	-75.0	-75.0	-30.0	-105
4000	-36.0	-80.0	-85.2	-30.0	-115
5999	-36.0	-80.0	-85.2	-50.0	-135
6000	-45.0	-89.0	-94.2	-50.0	-144
45000	-45.0	-89.0	-94.2	-85.0	-179

GSM Receiver Blocking Characteristics from 3GPP TS 45.005

Frequency band	**GSM 400, P-, E- and R-GSM 900**						**DCS 1 800 & PCS 1 900**			
	other MS		**small MS**		**BTS**		**MS**		**BTS**	
	dBµV (emf)	**dBm**	**dBµV (emf)**	**dBm**	**dBµV (emf)**	**dBm**	**dBµV (emf)**	**dBm**	**dBµV (emf)**	**dBm**
in-band										
600 kHz ≤ $\|f-f_o\|$ < 800 kHz	75	-38	70	-43	87	-26	70	-43	78	-35
800 kHz ≤ $\|f-f_o\|$ < 1,6 MHz	80	-33	70	-43	97	-16	70	-43	88	-25
1,6 MHz≤ $\|f-f_o\|$ < 3 MHz	90	-23	80	-33	97	-16	80	-33	88	-25
3 MHz ≤ $\|f-f_o\|$	90	-23	90	-23	100	-13	87	-26	88	-25
out-of-band										
(a)	113	0	113	0	121	8	113	0	113	0
(b)	-	-	-	-	-	-	101	-12	-	-
(c)	-	-	-	-	-	-	101	-12	-	-
(d)	113	0	113	0	121	8	113	0	113	0
NOTE: For definition of small MS, see subclause 1.1.										

ANNEX 3: GSM INTERFERENCE PROTECTION LIMITS

In the following a method of providing protection to a higher level than required in the GSM standard (TS45.005) is given. Particular GSM manufacturer's equipment may be more sensitive than the minimum requirements to a varying degrees. The environment where the equipment is used has to be taken into account when assessing how much of the additional sensitivity provided can be utilised because of the presence of man-made noise.

For various calculations of the interference impact due to a nearby CDMA-PAMR system, an assumption regarding the maximum allowed interference limit falling into (or generated within) the GSM receiver has to be made. This then will also determine the resulting desensitisation of the GSM receiver due to CDMA-PAMR emissions.

In this report, a baseline assumption of -110 dBm for the maximum allowed interference limit has been made for all calculations, resulting in a 4.8 dB desensitisation relative to the GSM-900 reference sensitivity (REFSENS) of –104 dBm. This Annex calculates the required allowed interference limits for the case of a 0.3 dB desensitisation relative to the GSM900 reference sensitivity, i.e. for the cases when additional protection for GSM receivers is desired.

GSM Reference Sensitivity

From 3GPP TS 45.005 one obtains for the GSM-900 reference sensitivity (REFSENS) a value of –104 dBm.

The REFSENS specification of –104 dBm is the minimum requirement. For GSM BS implementations exceeding the specified reference sensitivity, the desensitisation due to CDMA-PAMR emissions will be correspondingly larger.

For the following analysis additional assumptions regarding the receiver NF and C/N will have to be made. Assuming a C/N[i] of 9 dB, one obtains a maximum receiver NF of 8 dB from the REFSENS requirement as follows:

Thermal noise	-121.0dBm/200 kHz	
receiver NF	8.0dB	
receiver noise floor	-113.0	
external interference	$-\infty$ dBm/200 kHz	
total noise floor	-113.0dBm/200 kHz	
C/I	9.0dB	
sensitivity	-104.0dBm	REFSENS -104 dBm in 45.005

A NF of 8 dB is a very conservative figure and typical GSM BS implementations may improve this value considerably.

Protection limits according to 4.8 dB desensitisation

An external interference level of –110 dBm/200 kHz will lead to a 4.8 dB desensitisation of the GSM receiver relative to the reference sensitivity:

Thermal noise	-121.0dBm/200 kHz	
receiver NF	8.0dB	
receiver noise floor	-113.0	
external interference	-110.0dBm/200 kHz	
total noise floor	-108.2dBm/200 kHz	
C/I	9.0dB	
sensitivity	-99.2dBm	REFSENS -104 dBm in 45.005
desensitisation	4.8dB	relative to REFSENS

Protection limits according to 0.3 dB desensitisation
For a GSM BTS providing no better sensitivity than the –104 dBm REFSENS requirement, the desensitisation for –125 dBm external interference level is 0.3 dB:

External interference	-125.0dBm/200 kHz	
total noise floor	-112.7dBm/200 kHz	
C/I	9.0dB	
sensitivity	-103.7dBm	REFSENS -104 dBm in 45.005
desensitisation	0.3DB	relative to REFSENS

Note, that 3GPP specifications provide an external interference protection level of –125 dBm at the GSM-900 victim receiver from other cellular standards, like e.g. UMTS, GSM-1800 etc. This is done via requirements for the spurious emissions of the interfering systems of –98 dBm, assuming a MCL of 30 dB for the case of co-located BSs with a factor of 3 dB for bandwidth conversion. On the other hand, PMR/PAMR standards do not define such stringent spurious emission limits on the GSM-900 receive bands, and GSM standards do not define such a stringent spurious emissions limits on the PMR/PAMR bands.

For the purpose of the Report two levels of permissible interference were considered (-110 dBm and –125 dBm), based on the level of desensitisation previously described. The level of –110 dBm may be considered representative of an interference-limited GSM network. The level of –125 dBm may be considered representative of a noise-limited GSM network.

Summary:

- With –110 dBm external interference level a GSM BS providing no better sensitivity than the –104 dBm REFSENS requirement will be desensitised by 4.8 dB.
- With improved receivers the corresponding impact can be significantly larger.
- For an impact of only 0.3 dB, the external interference level should be assumed as –125 dBm. In this case, 15 dB of additional isolation is required.

It has to be noted that the level of –110 dBm has been used in previous Reports such as ECC Report 5 (“Adjacent band compatibility between GSM and TETRA mobile services at 915 MHz”).

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[i] C/N differs slightly from the C/I. The C/I in TS 45.005 is assumed at 9 dB for a GMSK-modulated interferer