|  |
| --- |
| Compatibility Evaluation between 800MHz IMT Services and 900MHz GSM Services |
| SPP 2011-08 |
| AUGUST 2011 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Canberra**  Purple Building  Benjamin Offices  Chan Street  Belconnen ACT  PO Box 78  Belconnen ACT 2616  T +61 2 6219 5555  F +61 2 6219 5353 | **Melbourne**  Level 44  Melbourne Central Tower  360 Elizabeth Street Melbourne VIC  PO Box 13112  Law Courts  Melbourne VIC 8010  T +61 3 9963 6800  F +61 3 9963 6899 | **Sydney**  Level 5  The Bay Centre  65 Pirrama Road  Pyrmont NSW  PO Box Q500  Queen Victoria Building  NSW 1230  T +61 2 9334 7700  1800 226 667  F +61 2 9334 7799 |  |  | |
| © Commonwealth of Australia 2011  This work is copyright. Apart from any use as permitted under the *Copyright Act 1968*, no part may be reproduced  by any process without prior written permission from the Commonwealth. Requests and inquiries concerning reproduction  and rights should be addressed to the Manager, Editorial Services, Australian Communications and Media Authority,  PO Box 13112 Law Courts, Melbourne Vic 8010.  Published by the Australian Communications and Media Authority |

1. PURPOSE 1

2. BACKGROUND 1

3. INTERFERENCE MANAGEMENT FRAMEWORK 2

3.1. 900MHz Mobile Transmitters to 800MHz Mobile Receivers 2

3.1.1. Results of Mobile Station to Mobile Station Probabilistic Studies 2

3.2. IMT Base Transmitters to GSM Base Receivers 5

3.2.1. Adjacent Channel Interference: Results of Deterministic Studies 5

3.2.2. Receiver Blocking and Intermodulation Products Interference 5

3.2.2.1. GSM Base Receiver Characteristics 5

3.2.2.2. GSM Base Receiver Blocking Characteristics 5

3.2.2.3. GSM Base Receiver Intermodulation Characteristics 6

3.2.2.4. Systems Assumptions 6

3.2.2.5. Interference Calculations 7

3.2.2.7. Maximum IMT Base Station EIRP to Avoid Blocking in a Standard GSM Base Station Receiver 9

3.2.2.8. GSM Base Station Isolation Due to Receiver Intermodulation 10

3.2.2.9. Maximum IMT Base Station EIRP to Avoid Receiver Intermodulation Interference in a Standard GSM Base Station Receiver 11

4. SUMMARY 11

5. REFERENCES 12

Planning Documents: 12

Specifications Documents: 12

Technical Framework Documents: 12

APPENDIX A 13

A1. GSM Base Station Receiver Filter Response 13

## PURPOSE

The purpose of this report is to identify the interference situations that occur between IMT systems deployed in the 800MHz band (825-845MHz & 870-890MHz) and GSM / IMT systems deployed in the 900MHz band (890-915MHz & 935-960MHz) and to describe the management strategies that have been used to manage such interference. The report also provides a means of determining the isolation required between IMT base transmitters and GSM base receivers to minimise interference between these systems due to receiver blocking and intermodulation. It replaces the existing Compatibility Assessment Report (SPP 2-1997) focused on the protection of GSM services from 800MHz AMPS and should be read in conjunction with the new version of the Radiocommunications Advisory Guidelines (Protection of Apparatus –Licensed Receiver – 800MHz Band).

## BACKGROUND

The 900MHz Band Plan originally allocated the bands 870-890MHz and 825-845MHz to the AMPS service. Since the final shutdown of this service in January 2000, these bands have been used to deliver CDMA and IMT technology mobile services. The base transmit band at 870-890MHz is immediately adjacent the 900MHz base receive band from 890-915MHz used by the GSM service. The overall spectrum arrangements including current operators are shown in Figure 1 below.

BandPlanningDiagramWMF.wmf

Figure 2.1. Spectrum Arrangements for IMT and GSM in the 900MHz Band.

It is not usual spectrum planning practice to allocate adjacent or very close bands of spectrum to services in this way; that is, with opposite transmit / receive designations (opposite site sense), as particularly difficult interference situations arise. This arrangement stems from the original use of the band. In Australia the situation has been successfully managed in the existing carrier framework by a combination of regulatory and technical strategies.

## INTERFERENCE MANAGEMENT FRAMEWORK

The interference situations are:

* 900MHz mobile transmitters interfering with 800MHz mobile receivers; and
* IMT base transmitters interfering with GSM base receivers.

## 900MHz Mobile Transmitters to 800MHz Mobile Receivers

### Results of Mobile Station to Mobile Station Probabilistic Studies

The interference mechanism here between mobile transmitters and receivers that are within close proximity is usually one of overloading (blocking) of a susceptible handset from a nearby GSM or IMT mobile handset transmitter. This can occur even when the operating frequencies are reasonably well separated, but may be more severe as the frequencies become closer.

Previous investigations of this type of blocking interference involving older technologies (GSM and AMPS) found that the susceptibility of any particular handset varied significantly from severe to hardly noticeable – where handsets with superior front-end performance and selectivity performed better. Given usage of the 800MHz band by new IMT technologies and usage of the 900MHz band by both GSM and IMT technologies, it is appropriate to revise the interference scenarios for these new technologies.

Recent deterministic studies which compared the received power from a nearby mobile transmitter to IMT receiver blocking thresholds revealed that significant separations of up to 250m may be required between the units. Considering the transient nature of mobile stations with varying transmit times and use of other factors such as power control, such deterministic results would not seem to be the best representation of potential interference.

A preferred approach is to conduct probabilistic interference studies on an adjacent channel basis using distributions for the receiving victim mobile and transmitting interferer mobile devices. In this scenario the carrier power levels and interference power levels are calculated over the respective propagation paths for comparison with a C/I requirement such that the maximum probability of interference is inclusive of both blocking interference between the stations and reference level interference.

Monte Carlo studies performed by the 3GPP standards group investigated probabilistic interference between FDD and TDD mobile stations, and between TDD and TDD mobile stations. The mode of operation between these systems could be considered to be equivalent to the current situation where there are mobile stations receiving in the 870-890MHz band and mobile stations transmitting in the 890-915MHz band on adjacent channels – and so the results are indicative as to the level of interference that may be expected. The details of the methodology and parameters used in the studies are documented in 3GPP TR 25.942 Radio Frequency (RF) System Scenarios.

Main aspects of the study include:

* Minimum separation distances of 5m for outdoor deployment and 1m for indoor deployment.
* Calculation of ACIR using ACLR drawn from spectral masks and ACS drawn from receiver filtering. The study states 5MHz carrier spacing, however, use of ACIR is appropriate for adjacent channel separations at less than this for adjacent GSM to EUTRA/UTRA mobile stations.
* Use of C/I based power control.
* Use of real filter characteristics.
* Cell radii at 500mm and 2000m.
* Operating frequency of 1920MHz.

The key results are replicated here in Tables 3.1 and 3.2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Scenario** | **Cell Radius** | **Mode** | **Power Control** | **Probability that C/I less than requirement:** |
| FDD MS to TDD MS | 500m | Macro to Macro, real filter | C/I based | 2.4% |
| 2000m | Macro to Macro, real filter | C/I based | 0.5% |

Table 3.1. Results from TR 25.942 (C/I Requirement: -5.6dB, which may represent the C/I requirement for a QPSK modulation and coding scheme at the cell edge.)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Scenario** | **Cell Radius** | **Mode** | **Power Control** | **Probability that C/I less than requirement** |
| TDD MS to TDD MS | 500m | Macro to Macro, real filter. | C/I based | 0.03% |
| 2000m | Macro to Macro, real filter. | C/I based | 0.2% |

Table 3.2. Results from TR 25.942 (C/I Requirement: -5.6dB, which may represent the C/I requirement for a QPSK modulation and coding scheme at the cell edge.)

Whilst these studies have been conducted at the frequency of 1920MHz they provide useful indicative results for translation to 890MHz frequencies. Using free space loss the difference in path loss at frequencies of 1920MHz and 890MHz is not more than 7dB which corresponds to an increase in cell radius out to 4300m for the latter frequency. It can be seen then see that for the FDD/TDD results above that the interference probability decreases from 2.4% to 0.5% for 2000m and 500m cell radii, and so it could be expected that for a 4300m cell the interference probability would also be very low at less than 1%. For the TDD/TDD results, the interference probability increases from 0.03% to 0.2%, however, for a 4300m cell it may also be expected that the interference probability would be very low at less than 1-2%.

Included in the 3GPP results are indicative capacity reductions plots for interfering TDD MS to TDD MS systems. The plots here are reproduced from specification TR 25.942 and show that interference is not expected to cause problematic capacity reduction when the ACIR between mobile stations is greater than 30dB. In the first plot for synchronised operators, the capacity reduction is less than approximately 5% (worst case) for an ACIR of 30dB. In the second plot capacity reduction is approximately 2.2% for an ACIR of 30dB. A quote from the study states that “Downlink performances are not influenced very much by the presence of a second operator.”

**Synchronised TDD MS to TDD MS**



Figure 3.1 Relationship between ACIR and capacity loss for speech in the downlink. (Blue shows the intermediate case and red shows the worst case.) (From specification TR 25.942)

**Non-synchronised TDD MS to TDD MS**



Figure 3.2 ACIR MS to MS and system capacity loss in the downlink. (From specification TR 25.942)

## IMT Base Transmitters to GSM Base Receivers

Over the 890MHz band edge between the lower 800MHz base transmit segment and the upper 900MHz base receive segment there is potential for interference between IMT base transmitters and GSM base receivers. Potential interference takes the following forms:

1. Adjacent channel interference where there is line of sight over the interference path from high site to high site. This is estimated on a deterministic basis of received power levels and from which new non-spurious out-of-band emission requirements are derived.
2. Receiver blocking and intermodulation product interference for co-sited systems.

## Adjacent Channel Interference: Results of Deterministic Studies

Investigations into this scenario involved the calculation of received interference power arriving at a GSM base station receiver from an IMT base transmitter. The main purpose of these studies was to determine the effect of any potential increase in out-of-band emissions from 800MHz transmitters on 900MHz receivers. Results of these studies and proposed new emission limits at the 890MHz frequency boundary are set out in TLG Discussion Paper No.1.

## Receiver Blocking and Intermodulation Products Interference

### GSM Base Receiver Characteristics

The two major characteristics that cause site based GSM base receiver interference are blocking and intermodulation. Blocking is caused by the presence of high level RF power appearing at the receiver input causing the receiver to overload. Two or more higher level IMT signals appearing at the receiver input can mix in the receiver and produce intermodulation products that fall on the desired GSM receive channel. In both cases the receiver can become de-sensitised. Sufficient isolation between IMT transmitters and GSM receivers is required in order to reduce the receiver generated blocking and intermodulation interference to an acceptable level. This may be achieved by increasing the antenna separation both horizontally and vertically, through use of additional GSM receive filtering, or by reducing IMT base transmitter power.

### GSM Base Receiver Blocking Characteristics

The GSM receiver blocking performance stated in 3GPP TS 45.005, specifies that reference sensitivity performance should be obtained, with the wanted signal 3dB above the reference sensitivity level in the presence of an unwanted blocking carrier. The blocking levels specified in 45.005 are given below.

Table 3.3

|  |  |
| --- | --- |
| **In-Band (870-925MHz)** | **Level (dBm)** |
| 600kHz<=|f-fo|<=800kHz | -26 |
| 800kHz<=|f-fo|<=1.6MHz | -16 |
| 1.6MHz<=|f-fo|<3MHz | -16 |
| 3MHz<=|f-fo| | -13 |
| **Out-of-Band** | **Level (dBm)** |
| 0.1-870MHz | 8 |
| 925-12750MHz | 8 |

### GSM Base Receiver Intermodulation Characteristics

The GSM base receiver intermodulation performance requirement is also stated in document 3GPP TS 45.005. It specifies that the 3rd order intermodulation term generated by two interfering signals at -43dBm causing a 3dB degradation in receiver sensitivity. That is, the level of two signals appearing at the receiver input must be kept below -43dBm in order to avoid receiver generated intermodulation interference when the receiver wanted signal is at reference sensitivity of -104dBm. These requirements are set out in the table below.

|  |  |
| --- | --- |
| **Signals** | **Level** |
| Useful Signal | -101dBm for a GMSK modulated signal at frequency fo. (At a minimum signal level of 3db above reference sensitivity.) |
| Unwanted Signal | -43 dBm for a continuous static sine wave at frequency f1. |
| Unwanted Signal | -43 dBm for a 148-bit sub-sequence of the 511 pseudo random sequence defined in CCITT Rec O.153 with GMSK modulation at frequency f2. |

Table 3.4. Receiver Intermodulation Performance Levels.

Where the frequency constraints are fo = 2\*f1-f2 and |f2-f1| = 800kHz.

### Systems Assumptions

The following assumptions are made for the purposes of calculating the required isolation between the transmitting IMT system and receiving GSM system.

* The minimum separation between IMT transmit to GSM receive antennas is 20m. This assumption is made because at distances less than this the antenna radiation is in the near field and isolation is not easily determined (empirical data is required).
* Only 2-signal 3rd order intermodulation products are considered in the intermodulation analysis. This assumption has been made as the performance of a GSM base receiver with more than two off-channel signals is not specified not accurately known. The effects of multi-signal third order products can be approximated using the sum of powers method described in the Receiver Intermodulation section of this report with an appropriate correction factor added. Higher order intermodulation terms are not considered as they will be at a lower level than the 3rd order term. It is assumed that any isolation technique (filtering) will also reduce the power in higher order terms accordingly.
* The transmit and receive antennas are at the same height and pointing directly at each other with each antenna seeing full gain. Antenna discrimination due to the vertical or horizontal radiation pattern of either the transmit or receive antennas is assumed to be worst case, (that is no angular discrimination).
* Free space propagation applies between the IMT base station transmitter and the GSM base station receiver.
* IMT base transmitter and GSM base receiver are located at high site, between which there is potential line of sight.
* Receiver blocking and intermodulation product generation occur at short distances.
* GSM system planned to operate with a carrier to interference ratio (C/I) of 9dB.
* GSM base receiver protected from interference for at least 95% of the time.
* GSM base receiver typical antenna gain of 18dBi.
* GSM base receiver typical feeder loss of 5dB.
* GSM base receiver sensitivity level of -104dBm as per specification TS45.005.
* GSM base receiver IF bandwidth of 200kHz
* GSM base receiver filter attenuation as specified in Appendix A of this report.
* The reference point of all receive signal levels is the BSS receiver antenna connector.

### Interference Calculations

The following arrangement is used to model the path between the IMT base station in the 800MHz band and the GSM base station in the 900MHz band.

CompatibilityStudyDiagramWMF.wmf

Figure 3.3. IMT Base Transmit to GSM Base Receive Model

Calculations of the study are based on the following link budget equation:

* Pr = receive signal level in dBm.
* EIRP = transmitter radiated power in dBm.
* Lp = path loss between transmit and receive antennas in dB.
* Gt = transmit antenna dBi.
* Gr = receive antenna in dBi.
* Lf = receive feeder loss in dB.
* Lfilt = receiver filter attenuation in dB
* f = Frequency in MHz.
* d = distance in km.

Where propagation is calculated the standard free space loss equation:

* + - 1. **GSM Base Station Isolation Requirements Due to Receiver Blocking**

Using the Equation 1 the required isolation is calculated by substituting the GSM blocking levels for the term Pr. The configuration of the GSM base receiver includes 18dBi for the antenna gain and 5dB for the feeder losses.

600kHz <= |f-fo| < 800kHz; -26dBm = EIRP – Lp +18dBi – 5dB – Lfilt; or Lp = EIRP – Lfilt + 39 (dBm)

800kHz <= |f-fo| < 1.6MHz; -16dBm = EIRP – Lp + 18dBi – 5dB - Lfilt; or Lp = EIRP – Lfilt + 29 (dBm)

1.6MHz <= |f-fo| < 3.0MHz; -16dBm = EIRP – Lp + 18dBi – 5dB - Lfilt; or Lp = EIRP – Lfilt + 29 (dBm)

3.0 MHz <= |f-fo|; -13dBm = EIRP – Lp + 18dBi – 5dB - Lfilt; or Lp = EIRP – Lfilt + 26 (dBm)

A plot of isolation (Lp) versus frequency for a standard +43dBm transmit power in the IMT base station is graphed below in Figure A. Again with an 18dBi antenna and 5dB of feeder/combiner losses for the transmitting base station the EIRP is 56dBm per 5MHz channel. The chart can be used to determine isolation requirements between IMT transmit antenna and GSM base receive antenna for other transmit power by scaling.

Figure 3.4. Isolation requirement for receiver blocking.

### Maximum IMT Base Station EIRP to Avoid Blocking in a Standard GSM Base Station Receiver

A plot of EIRP versus frequency is given in Figure B below for a number of distance separations between 20m and 1000m. The plot assumes free space propagation conditions and does not include the additional isolation due to the transmit or receive antenna vertical radiation pattern. Also shown in this plot is the existing Out-of-Area EIRP limit of 59dBm/30kHz (or 81dBm/5MHz) for transmitting stations in the 870-890MHz band which applies regardless of the separation between the stations.

Figure 3.5. Maximum EIRP for avoidance of receiver blocking.

### GSM Base Station Isolation Due to Receiver Intermodulation

The isolation required due to receiver intermodulation can be calculated using the equation (1) by substituting the 3GPP TS 45.005 specified intermodulation limit of -43dBm for the term Pr.

-43dBm = EIRP – Lp + 18dBi – 5dB – Lfilt; or Lp = EIRP – Lfilt + 56

A plot of isolation (Lp) versus frequency for a transmit power for a standard IMT base station of +43dBm per 5MHz channel is given in Figure C below. The chart can be used to determine isolation requirements between an IMT transmit antenna and GSM base receive antenna due to 2-signal 3rd order receiver intermodulation for other transmit powers through scaling.

Figure 3.6 Isolation requirement for receiver intermodulation.

### Maximum IMT Base Station EIRP to Avoid Receiver Intermodulation Interference in a Standard GSM Base Station Receiver

A plot of EIRP versus frequency is given in Figure D below for a number of distance separations from 20m to 1000m. The plot assumes free space propagation conditions and does not include additional isolation due to the transmit and receive antenna vertical radiation pattern. Again shown in this plot is the Out-of-Area EIRP limit of 59dBm/30kHz (or 81dBm/5MHz) for transmitters operating in the 870-890MHz band.

Figure 3.7. Maximum EIRP for avoidance of intermodulation interference.

## SUMMARY

The 800MHz spectrum licensing technical framework manages interference between digital IMT services in the 800MHz band and digital GSM cellular services in the 900MHz band. In addition to this framework, this compatibility evaluation includes guidance on the isolation levels required to minimise the incidence of receiver blocking and intermodulation interference to GSM services. The fitting of filters at base stations in addition to those used in normal configurations is necessary to:

* comply with the non-spurious out-of-band emissions limits of the 800MHz technical framework as so avoid adjacent channel interference,
* avoid receiver blocking in GSM base receivers,
* avoid intermodulation interference in GSM base receivers, and thus,
* optimise the spectrum utilisation for both IMT technologies in the 800Mhz band and GSM technologies in the 900MHz band.

## REFERENCES

### Planning Documents:

1. SPP2/97 *Compatibility Assessment – 800MHz AMPS Spectrum Adjacent to GSM Spectrum.* Business Direction Group, Spectrum Management Agency, April 1997.

### Specifications Documents:

1. 3GPP TS 25.104 V8.0.0, *Technical Specification Group Radio Access Network; Base Station (BS) radio transmission and reception (FDD) (Release 8)*, September 2009.
2. 3GPP TS 25.101 V8.0.0, *Technical Specification Group Radio Access Network; User Equipment (UE) radio transmission and reception (FDD) (Release 8)*, September 2009.
3. 3GPP TR 25.942 V10.0.0, *Technical Specification Group Radio Access Network; Radio Frequency (RF) system scenarios (Release 10)*, April 2011.
4. 3GPP TS 36.104 V9.2.0, *Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (FDD) (Release 9)*, December 2009.
5. 3GPP TS 36.101 V9.2.0, *Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (FDD) (Release 9)*, December 2009.
6. 3GPP TS 45.005 V9.3.0, Technical Specification Group GSM/EDGE Radio Access Network; Radio transmission and reception (Release 9), May 2010.
7. 3GPP2 C.S0011-C, Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations, Release C, Version 2.0, February 2006.

### Technical Framework Documents:

1. *Radiocommunications (Unacceptable Levels of Interference – 800MHz Band) Determination 1998.* The Australian Communications Authority, February 2004.
2. *Radiocommunications Advisory Guidelines (Managing Interference from Apparatus Licensed Transmitters – 800MHz Band) 1998.* The Australian Communications Authority, February 1998.
3. *Radiocommunications Advisory Guidelines (Protection of Apparatus Licensed Receivers – 800MHz Band)* 1998. The Australian Communications Authority, February 1998.
4. *Radiocommunications Spectrum Marketing Plan (800MHz and 1.8GHz Bands) 1998.* Office of Legislative Drafting and Publishing, Attorney-General’s Department, October 2005.

## APPENDIX A

### A1. GSM Base Station Receiver Filter Response

Set out below is the GSM base station receiver filter response originally supplied by Telstra in their document DCR 0161 “Protection of Existing GSM and AMPS Services from Interference from 800MHz Proposed Spectrum Licence Band Services”, Issue 03, 6th April 1997. This filter mask is used to derive isolation requirements for GSM base receiver blocking and intermodulation performance.

Figure A1. GSM Base Receiver Filter Response.

|  |  |
| --- | --- |
| Frequency (MHz) | Attenuation (dB) |
| 890 | <1 |
| 889 | 1 |
| 888.5 | 2 |
| 888 | 5 |
| 887.5 | 25 |
| 887 | 41 |
| 886 | 42 |
| 885 | 43 |
| 884 | 44 |
| 883 | 45.5 |
| 882 | 47 |
| 881 | 48.5 |
| 880 | 50 |
| 879 | 52 |
| 878 | 54 |
| 877 | 56 |
| 876 | 58 |
| 875 | 60 |
| 874 | 61.5 |
| 873 | 63 |
| 872 | 64.5 |
| 871 | 66 |
| 870 | 67.5 |