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Summary

In 2008, ERA undertook a measurement programme on behalf of Ofcom to assess the potential for interference into a range of technologies including Universal Mobile Telecommunication System (UMTS), Worldwide Interoperability for Microwave Access (WiMAX) and Digital Video Broadcast – Terrestrial (DVB-T). The work was undertaken as part of the Digital Dividend Review (DDR) – the project examining the options arising from the release of spectrum post digital switchover.

As part of the ongoing work supporting the DDR, Ofcom requested an investigation into the possible adjacent channel interference to Programme Making and Special Events (PMSE) receivers from a UMTS UE for different wanted signal levels and frequency offsets.

Conducted and radiated measurements were carried out for two types of PMSE receivers. Measurements were repeated at two levels of UE Effective Isotropic Radiated Power (EIRP): 21 dBm, the maximum for a Class 4 device and 5 dBm with transmitter power control (TPC), a level that represented more of a typical operating EIRP. From the measurements results the following was concluded:

<u>UE operating at maximum EIRP</u>

- When PMSE receiver type 1 operated with a received wanted level of -65 dBm, i.e. an equivalent separation distance of 100 m from the PMSE transmitter, a separation distance of 10.6 m to 15 m was required to produce a 6 dB drop in SINAD for a UMTS UE transmitting with a -3.5 MHz centre frequency offset from the PMSE channel and at a maximum EIRP of 21 dBm.

- When PMSE receiver type 2 operated with a received wanted level of -65 dBm, i.e. an equivalent separation distance of 100 m from the PMSE transmitter, a separation distance of 20.6 m to 21.1 m was required to produce a 6 dB drop in SINAD for a UMTS UE transmitting with a -3.5 MHz centre frequency offset from the PMSE channel and at a maximum EIRP of 21 dBm.

- For every 6 dB increase in the wanted signal, the separation distance between the UMTS UE and PMSE receiver roughly halved for a UMTS UE transmitting with a -3.5/-7.5 MHz centre frequency offset from the PMSE channel. This is to be expected since the path loss varies as a function of 20 log distance.

- The level of UMTS interference without TPC required to produce a 6 dB drop in SINAD was 15 to 23 dB more for a frequency offset of -23 MHz between the UMTS UE and PMSE centre carriers compared with a frequency offset of -3.5 MHz for PMSE receiver type 1.

- The level of UMTS interference without TPC required to produce a 6 dB drop in SINAD was 25 to 30 dB more for a frequency offset of -23 MHz between the UMTS UE and PMSE centre carriers compared with a frequency offset of -3.5 MHz for PMSE receiver type 2.

- PMSE receiver type 2 was 5 to 8 dB more sensitive to UMTS UE interference compared with PMSE receiver type 1.

UE operating with TPC

- A UMTS UE operating at a mean power of 5 dBm with TPC profile for a user walking at 3 km/h required 8 to 12 dB less interference power to produce a 6 dB drop in SINAD for a frequency offset of -3.5 and -7.5 MHz compared with the maximum EIRP results. However, in terms of the difference in path loss (which directly relates to interference distance) it only produced a 4 to 8 dB difference. This difference is due to the way the SINAD meter is able to distinguish between normal and impulsive like noise caused by the TPC.

- The separation distance results for the UMTS UE operating at a mean power of 5 dBm with a TPC profile for a user walking at 3 km/h were between 4.5 m to 11.5 m for PMSE receiver 1 and 9.1 m to 11.1 m for PMSE receiver 2, around half of the maximum EIRP results for a frequency offset of -3.5 MHz. The same trend was observed for larger frequency offsets.

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Abbreviations List

C	Carrier
DDR	Digital Dividend Review
DVB-T	Digital Video Broadcast – Terrestrial
EIRP	Effective Isotropic Radiated Power
ETSI	European Telecommunications Standards Institute
I	Interference
N	Noise
ND	Noise + Distortion
PMSE	Programme Making and Special Events
S	Signal
SINAD	Signal-to-Noise-And-Distortion Ratio
SND	Signal + Noise + Distortion
RMC	Reference Measurement Channel
UE	User Equipment
UMTS	Universal Mobile Telecommunication System
WiMAX	Worldwide Interoperability for Microwave Access

1. Introduction

In 2008, ERA undertook a measurement programme on behalf of Ofcom to assess the potential for interference into a range of technologies including Universal Mobile Telecommunication System (UMTS), Worldwide Interoperability for Microwave Access (WiMAX) and Digital Video Broadcast – Terrestrial (DVB-T) [1]. The work was undertaken as part of the Digital Dividend Review (DDR) – the project examining the options arising from the release of spectrum post digital switchover.

As part of the ongoing work supporting the DDR, Ofcom requested an investigation into the possible adjacent channel interference to Programme Making and Special Events (PMSE) receivers from a UMTS UE for different wanted signal levels and frequency offsets.

Ofcom's concern is that the potential introduction of mobile voice and data services in the upper cleared DDR spectrum may create an interference environment that is harmful to PMSE in channel 69 (and also to services in channel 70). From work carried out by ECC Task Group 4, it is likely that if mobile services use this spectrum then mobile uplinks from UMTS User Equipment (UE) will use the higher channels and therefore be closest in frequency terms to channel 69. Based on the relatively relaxed uplink transmission masks specified by 3GPP there appears to be a possibility of interference to PMSE from UEs. Ofcom's calculations appear to confirm that in some situations interference could occur, but further assessment is required through a series of practical measurements. The calculations could not model the effect of the Uplink (UL) power control mechanism on the PMSE receiver performance so the tests also investigated its impact.

This report describes the measurements and results of practical conducted and radiated UMTS UE uplink interference to two different types of PMSE receivers operating on channel 69.

2. Objectives

The objective of the tests was to establish through practical measurement the feasibility of mobile UE uplinks sharing adjacent spectrum with PMSE users using typical PMSE and mobile uplink operating parameters.

The initial tests were conducted tests, where the effects of simulating a change in the separation distance of the PMSE transmitter and receiver on interference suffered from a UE was evaluated. Measurements were performed at different frequency offsets and equivalent distances from the PMSE receiver[1].

The tests were repeated using radiated measurement set up to determine the consistency of the results with the conducted tests. These conducted and radiated tests were performed for two types of PMSE receivers, referred to as receiver 1 and receiver 2 in the following sections, operating on channel 69.

3. Conducted Measurements

3.1 Wanted PMSE Signal Parameters

The wanted PMSE signal was transmitted using a signal generator. The signal generator was programmed to transmit a 1 kHz tone frequency modulated with a deviation of ±14 kHz for PMSE receiver 1 and ±33 kHz for PMSE receiver 2. The frequency deviations used were taken as typical values specified by the manufacturer. The wanted transmit frequencies were 854.9 MHz for PMSE receiver 1 and 855.1 MHz for PMSE receiver 2 (approximately 1 MHz up from the lower edge of channel 69).

The PMSE receivers were tested at four different wanted signal levels as shown in Table 1, based on a PMSE transmitter radiating at 6 dBm and an equivalent separation distance of 10, 20, 50 and 100 m using free space loss.

Table 1:
PMSE received power levels used for the conducted measurements

Radiated PMSE power (dBm)	Equivalent separation distance (m)	Path loss (dB)	Received PMSE power level (dBm)
6	10	51.14	-45
6	20	57.16	-51
6	50	65.12	-59
6	100	71.14	-65

[1] For the conducted tests the “equivalent” separation distances were established assuming free space loss between the transmitted signals (PMSE and UE) and the PMSE receiver which wasset up by means of an attenuator.

Note: The PMSE transmitter operating at 6 dBm (4 mW) is equivalent to the Effective Radiated Power (ERP) from either a hand held microphone or a body worn device after allowing for body loss)

3.2 Unwanted UMTS UE Signal Parameters

The UMTS UE uplink signal parameters based on ETSI TS 125 101 (3GPP TS 25.101) [2] were used as the interference source, as shown in the table below.

Table 2:
UMTS signal parameters

Parameter	Value
Maximum EIRP	21 dBm
Mean EIRP with TPC	5 dBm
Multiple access method	WCDMA
Channel modulation	QPSK
Number of carriers	1
Chip rate	3.84 Mcps
Modulation filter	Root raised cosine α = 0.22
Channel bandwidth	5 MHz
Duplex	FDD

The maximum Effective Isotropic Radiated Power (EIRP) figure was chosen as the maximum for a Class 4 device and static (i.e. without power control) measurements were made at this level. Measurements were repeated at a mean power of 5 dBm with transmit power control. This level was considered representative of the typical maximum operating powers for most cases based on measurements at 3G frequencies[2] .

[2] Uplink capacity of VoIP on HSUPA, Tao Chen, M Kuusela, E Malkamaki, IEEE Vehicular Technology Conference (VTC Spring 2006), Volume 1, pg 451-455, 2006

A signal generator was used to produce the UE uplink signal using its internal 3GPP WCDMA settings (conforming to 3GPP release 5 specifications), based on the parameters shown in Table 2 above, as well as the additional parameters shown below.

Table 3:
Additional UE parameters

Parameter	Value
Filter function	Root cosine
Window function	Rectangular
Reference measurement channel	12.2 kbps
Data pattern	9 PRBS

The following physical and transport parameters were taken from ETSI TS 125.101 (3GPP TS 25.101) [2], for a UL Reference Measurement Channel (RMC) based on 12.2 kbps, as shown in Table 4 and Table 5 below.

Table 4:
UL reference measurement channel physical parameters (12.2 kbps)

Parameter	Unit	Level
Information bit rate	kbps	12.2
DPDCH	kbps	60
DPCCH	kbps	15
DPCCH Slot Format #i	-	0
DPCCH/DPDCH power ratio	dB	-5.46
TFCI	-	On
Repetition	%	23

Table 5:
UL reference measurement channel, transport channel parameters (12.2 kbps)

Parameters	DTCH	DCCH
Transport Channel Number	1	2
Transport Block Size	244	100
Transport Block Set Size	244	100
Transmission Time Interval	20 ms	40 ms
Type of Error Protection	Convolution Coding	Convolution Coding
Coding Rate	1/3	1/3
Rate Matching attribute	256	256
Size of CRC	16	12

The inner loop power control of the UE compensating for signal fluctuations due to fading was derived by measuring the fading profile on a spectrum analyser for Case 1 as shown in the table below (taken from TS 25.104 Annex B [3]).

Table 6:
Multi-path fading conditions

Case 1		Case 2		Case 3		Case 4	
Speed for Band I, II, III, IV, IX, X 3 km/h		Speed for Band I, II, III, IV, IX, X 3 km/h		Speed for Band I, II, III, IV, IX, X 120 km/h		Speed for Band I, II, III, IV, IX, X 250 km/h	
Speed for Band V, VI, VIII 7 km/h		Speed for Band V, VI, VIII 7 km/h		Speed for Band V, VI, VIII 280 km/h		Speed for Band V, VI, VIII 583 km/h (Note 1)	
Speed for Band VII 2.3 km/h		Speed for Band VII 2.3 km/h		Speed for Band VII 92 km/h		Speed for Band VII 192 km/h	
Relative Delay [ns]	**Average Power [dB]**	**Relative Delay [ns]**	**Average Power [dB]**	**Relative Delay [ns]**	**Average Power [dB]**	**Relative Delay [ns]**	**Average Power [dB]**
0	0	0	0	0	0	0	0
976	-10	976	0	260	-3	260	-3
		20000	0	521	-6	521	-6
				781	-9	781	-9

The average power of the measured fading profile was then calculated for a 10 second period of time, i.e. the same time period as the transmit power control (TPC) profile used before being repeated. Using this average power, the difference in the actual power for each time slot was inverted to give the TPC profile of the UE uplink to compensate for the fading seen at the Node B.

This TPC profile was programmed into the signal generator in order to simulate the UE uplink in a moving environment. The TPC profiles for the fast-fading channel speed of 3 km/h are shown in Figure 1.

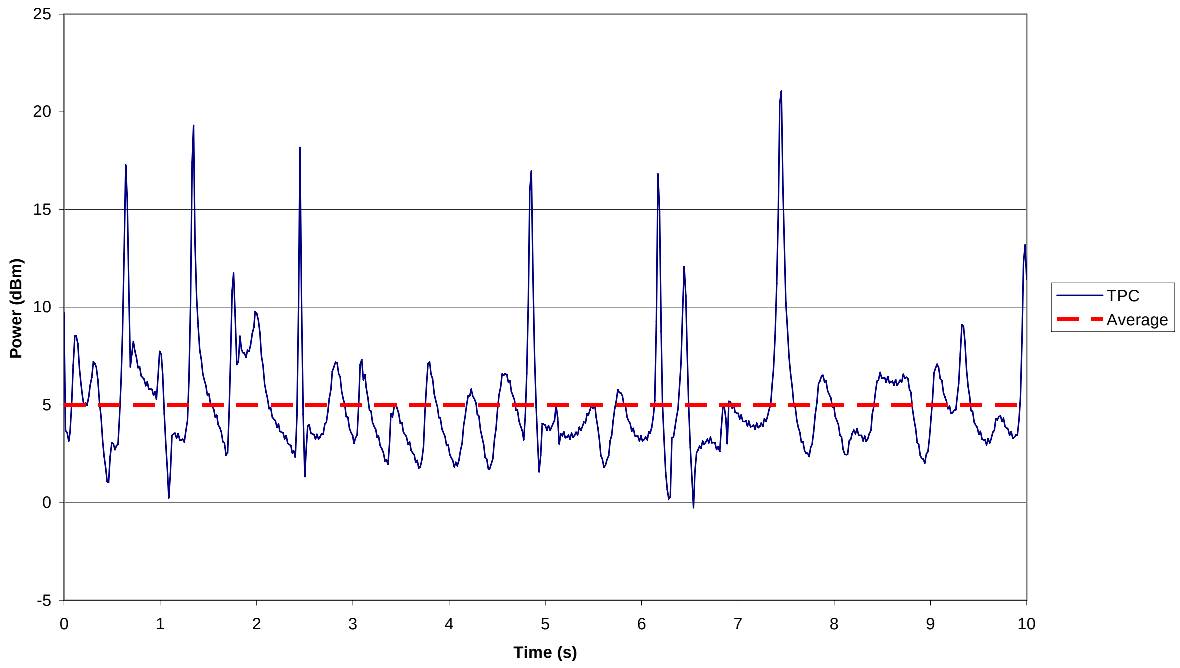

Figure 1: Profile of transmit power control for a user travelling at 3 km/h

Figure 2, shows a comparison of the simulated UMTS UE uplink signal with and without TPC, based on the physical and transport parameters described in the tables above, compared to a real UE.

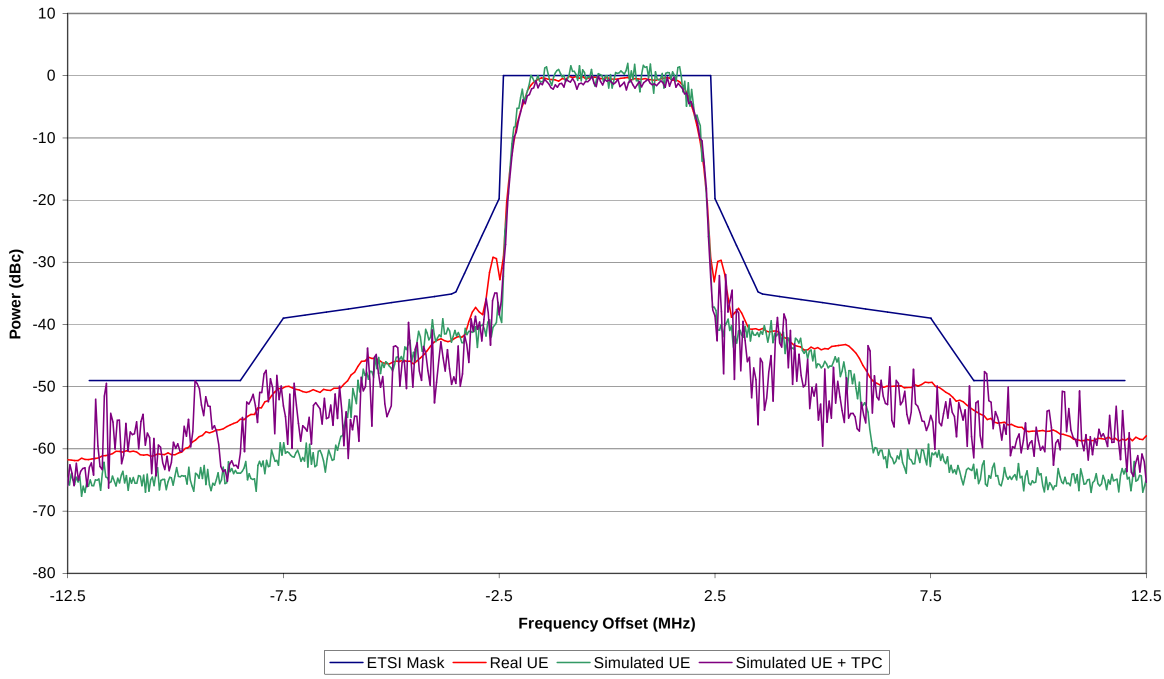

Figure 2: Comparison of a simulated transmitter mask to a real UE with respect to the ETSI mask

3.3 Measurement Criterion

The measurement criterion used in the conducted and radiated set-ups was 'Si'gnal-to-'N'oise-'A'nd- 'D'istortion (SINAD).

SINAD is a parameter which provides a quantitative measurement of the quality of an audio signal from a communication device. The definition of SINAD is the ratio of the total signal power level (wanted Signal + Noise + Distortion or SND) to unwanted signal power (Noise + Distortion or ND). It follows that the higher the figure the better the quality of the audio signal. The ratio is expressed as:

$$SINAD(dB) = 10\log_{10}\left(\frac{SND}{ND}\right)$$

Eq. 1

For most applications SINAD is measured by setting up conditions so that the audio output contains a nominal 1 kHz tone. For a radio receiver this could be generated by applying an FM signal with a specified deviation at 1 kHz rate to the antenna. The audio output will have the 1 kHz tone present plus noise and distortion products.

To measure the SINAD ratio the audio output from the receiver is measured (wanted signal + noise + distortion) and then passed through a notch filter which removes the 1 kHz tone as shown in Figure 1.

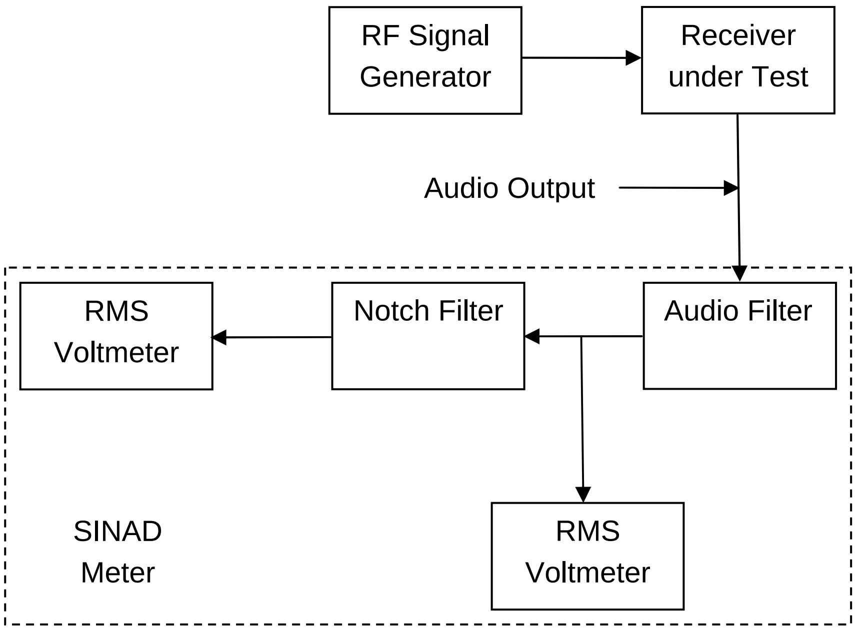

Figure 3: SINAD measurement system

The bandwidth of the audio signal is limited by a filter, which has the effect of limiting the amount of noise present and reflecting the ability of users to extract speech information from an audio signal. The audio filter restricts the bandwidth of the signal that is measured, concentrating the measurement on the important part of the voice around 1 kHz. Typical filters are:

- CCIR 468 (ITU-R BS 468-4)
- CCITT (ITU-T Recommendation 0.41)
- C-Message

The resulting signal is measured (noise + distortion) and compared with the first measurement. The ratio is the SINAD value.

A Lindos L102 audio analyser using a CCIR 468 psophometric (quasi-peak) weighting filter was used to measure the SINAD for both the conducted and radiated measurement set-ups. A similar procedure for blocking or desensitization measurements described in Section 9.7 of ETSI EN 300 296-1 [4] was used to measure a drop of 6 dB in SINAD.

3.4 Equipment Set-up and Test Procedure

UMTS UE interference measurements into a PMSE receiver operating on channel 69 were performed using the conducted measurement set-up shown in the diagram below.

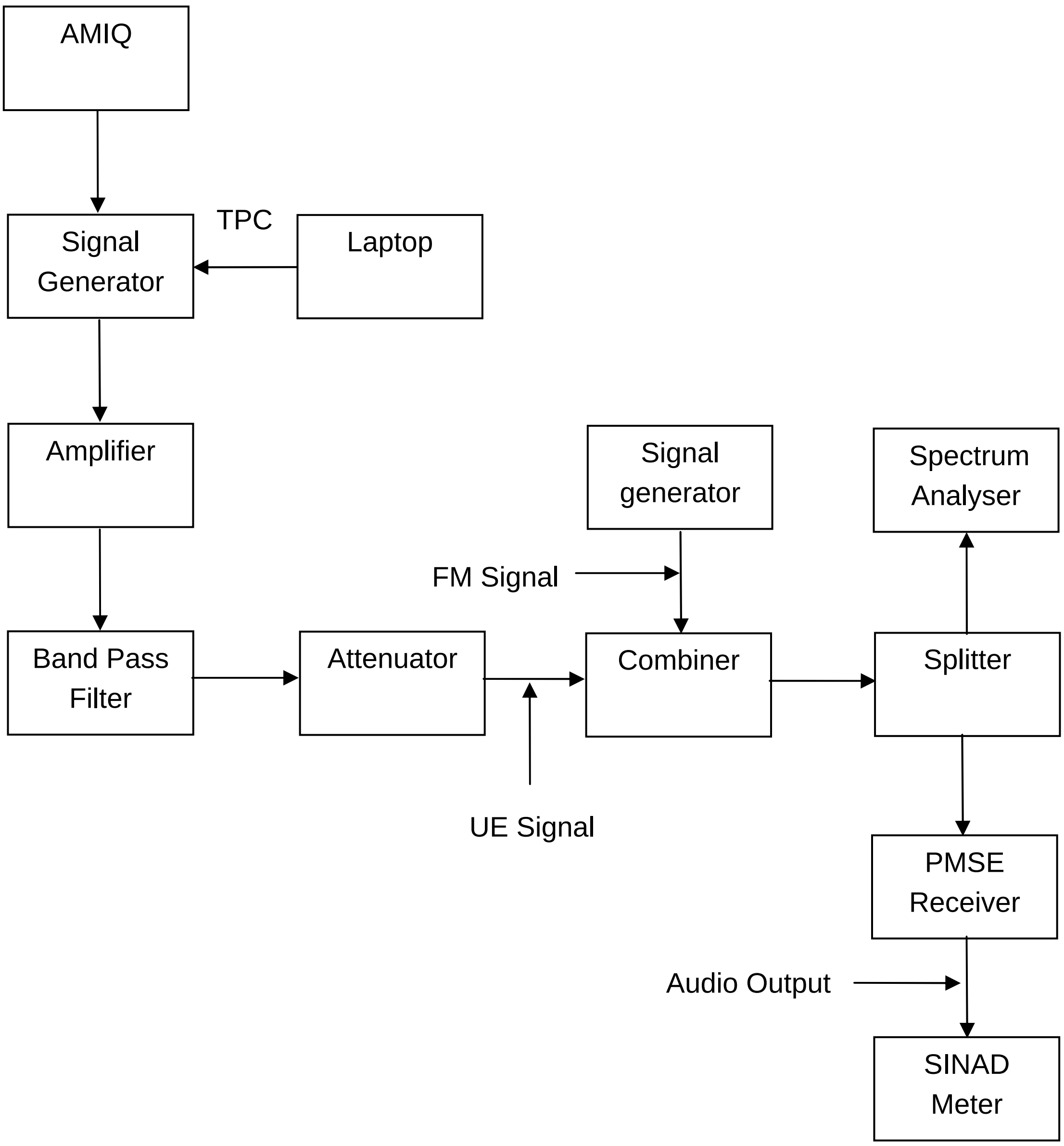

Figure 4: UE uplink interference into a PMSE receiver using TPC

The measurements were made for frequency separations (between the UE and PMSE channel centres) of -3.5 MHz, -7.5 MHz, -8.5 MHz, -12.5 MHz and -23 MHz, to enable the effect of the UE transmit mask as a function of relative carrier offset to be determined. The UE always transmitted lower in frequency than the PMSE carrier.

Based on the measurement parameters and test set-up described earlier, the conducted measurements were performed using the following test procedure:

1. A 1 kHz FM tone with the appropriate frequency deviation as described in Section 3.1 was set-up using a signal generator.

2. The level of audio output or gain control of the PMSE under test was set around the midway point.

3. The wanted signal level entering the PMSE receiver was set to a power level 'C' as described in Table 1.

4. The wanted channel power level 'C' was measured with a spectrum analyser using a peak detector and a resolution bandwidth of 200 kHz.

5. The level of SND was recorded using on the audio analyser using a 22 Hz to 22 kHz filter option.

6. The level of ND was then recorded using the CCIR 468 psophometric weighting filter.

7. The SINAD was calculated as the ratio of the SND and ND.

8. Using an attenuator setting of 70 dB, a UMTS UE unwanted signal transmitting at a maximum EIRP as described in Section 3.2 without transmit power control, was applied at a 3.5 MHz offset below the wanted PMSE carrier frequency.

9. The level of the unwanted interference was increased via the attenuator until a 6 dB drop in SINAD was achieved.

10. The interference power 'I' was measured in a 3.84 MHz bandwidth using a spectrum analyser set to RMS detection.

11. Steps 8 to 10 were then repeated for frequency offsets of -7.5, -8.5, -12.5 and -23 MHz.

12. Steps 3 to 11 were repeated for the different wanted PMSE levels shown in Table 1.

The UMTS UE unwanted signal transmitting at a constant maximum EIRP of 21 dBm was then switched to a profile simulating a mobile user travelling at 3 km/h and transmitting at a mean power of 5 dBm with transmit power control (see Figure 1) and the above procedure repeated.

Note: The UMTS UE signal using the transmit power control profile shown in Figure 1, with a mean power of 5 dBm forces the impulse peaks to reach 21 dBm, the maximum EIRP a class 4 UE can transmit at.

4. Radiated Measurements

Outdoor measurements were performed to simulate the real interference environment from a mobile UMTS UE to a PMSE receiver (see Figure 5). The on-air testing was performed for both PMSE receivers for the four separation distances shown in Table 1. The radiated tests were carried out onsite at ERA and the measurements were made for frequency separations (between the UE and PMSE channel centres) of -3.5 MHz, -7.5 MHz.

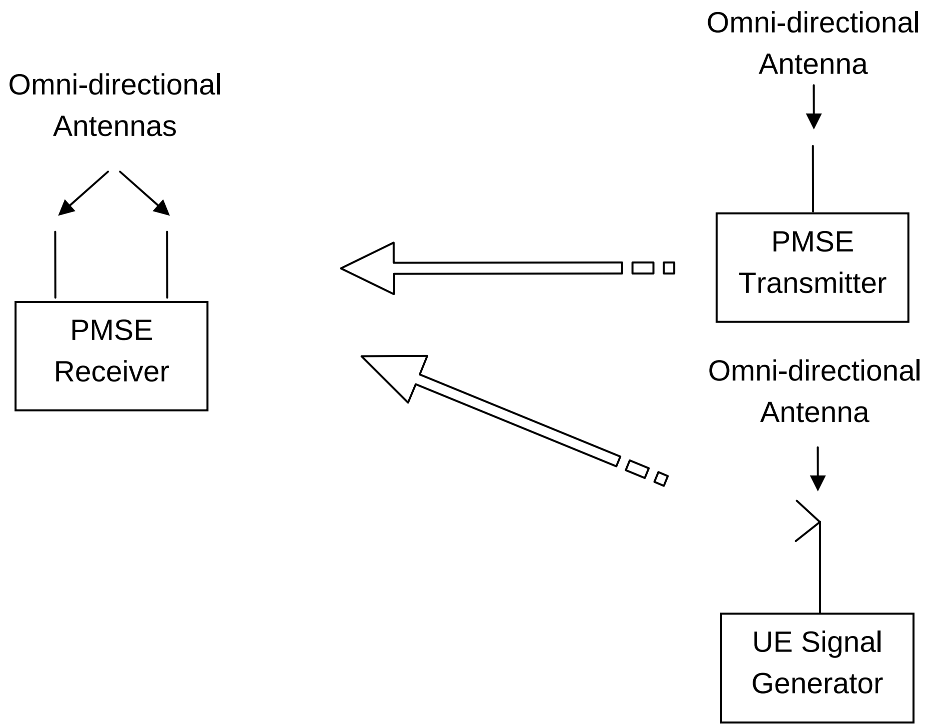

Figure 5: Diagram of radiated measurement set-up

The outdoor test environment was recreated by having a signal generator transmitting the 1 kHz FM tone, placed on a bench raised to 1.5 m. The signal generator transmitted at a RF power of 6 dBm using an identical omni-directional antenna used to receive for the PMSE under test.

The PMSE receiver was then moved to an initial separation distance of 10 m from the simulated PMSE simulator and also positioned at a height of 1.5 m. The SINAD without any interference was measured using Steps 2, 5, 6 and 7 of the conducted measurement test procedure.

The system simulating the UMTS UE unwanted signal was then turned on and set to transmit at a maximum EIRP of 21 dBm for a class 4 device. The UMTS UE signal was generated using an R&S SIMQ03B signal generator and R&S AMIQ external modulation box controlled via a Laptop and GBIP card. The UMTS UE signal was transmitted using an omni-directional antenna located on a tripod 1.5 m above the ground.

The separation distance between the UMTS UE and the PMSE receiver was varied until a 6 dB drop in SINAD was achieved. This separation distance was recorded and compared with the separation distance calculated for free space path loss using the conducted measurement results.

The simulated UMTS UE transmitting at a constant maximum EIRP of 21 dBm was then switched to profile simulating a mobile user travelling at 3 km/h and transmitting at a mean power of 5 dBm with transmit power control. The separation distance between the UMTS UE and the PMSE receiver was again varied until a 6 dB drop in SINAD was achieved. A similar comparison was also made with the separation distance calculated for free space path loss using the conducted measurement results

The measurements were made with the transmitter and receiver omni direction antennas aligned vertically.

5. Results

5.1 Conducted

Conducted measurements for UMTS UE interference into two PMSE receivers were made using the test set-up and procedure described in Section 3. This section discusses the results obtained for both PMSE receivers.

5.1.1 PMSE receiver 1

Figure 6 shows the level of UMTS UE interference transmitting at a constant level required to produce a drop of 6 dB in SINAD from a measured value of 60 dB without interference to 54 dB with interference. The plot shows that for a separation of 10 m, -15 dBm/3.84 MHz is required to cause interference to the PMSE receiver for a frequency offset of -3.5 MHz, 15 dB less power compared with a frequency offset of -23 MHz. The trend is consistent for all simulated separation distance ranging from 10 m to 100 m.

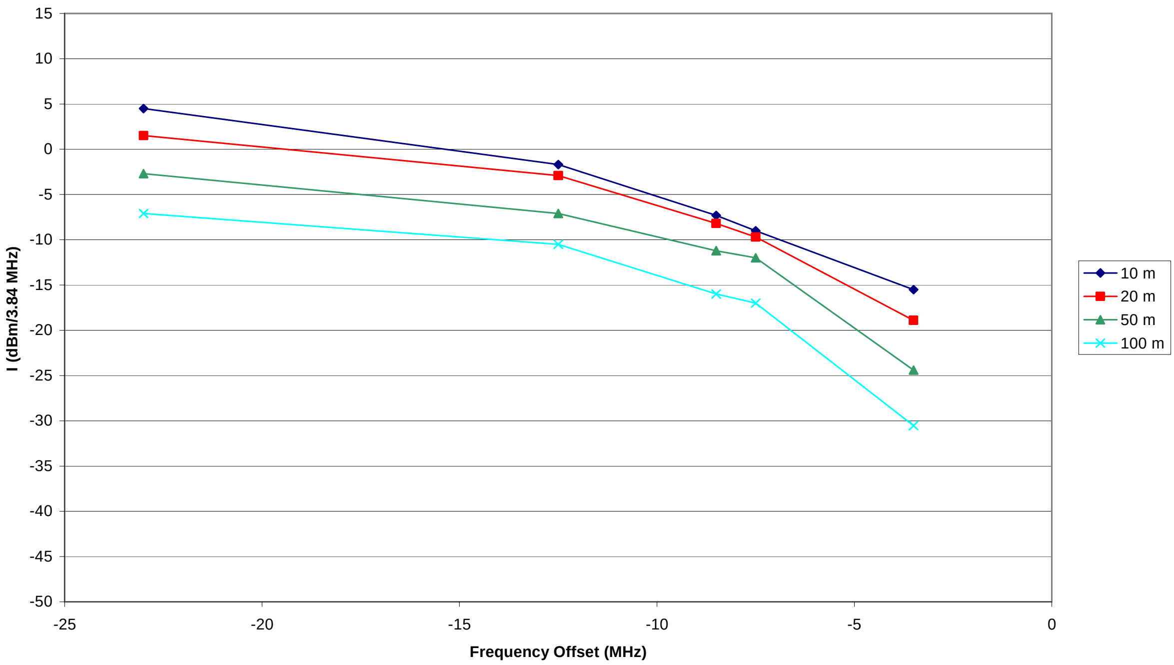

Figure 6: UMTS UE power to cause a 6dB reduction in PMSE SINAD as a function of frequency offset when the UE is transmitting at a constant mean power of 21 dBm

For a frequency offset of -3.5 MHz, the plot shows that as the wanted level drops 20 dB for a separation distance of 10 m to 100 m, the level of UMTS UE interference required to produce a drop of 6 dB in SINAD is 15 dB. This difference in 5 dB may be due to the PMSE being overdriven with strong wanted and unwanted signals for equivalent distance approaching 10 to 20 m. Also, the trend is reasonably consistent at a frequency separation of -23 MHz, but narrows to 10 dB at -12.5 MHz, 9 dB at -8.5 MHz and 8 dB at -7.5 MHz. The average Carrier-to-Interference (C/I) ratio measured for the four wanted carrier levels was 20 dB for PMSE receiver 1.

Figure 7 shows the level of UMTS UE interference using a 3km/h TPC profile required to produce a drop of 6 dB in SINAD from a measured value of 60 dB without interference to 54 dB with interference. The plot shows that for a separation of 10 m, -28 dBm/3.84 MHz is required to cause interference to the PMSE receiver for a frequency offset of -3.5 MHz, 19 dB less power compared with a frequency offset of -23 MHz. The trend is consistent for all simulated separation distance ranging from 10 m to 100 m.

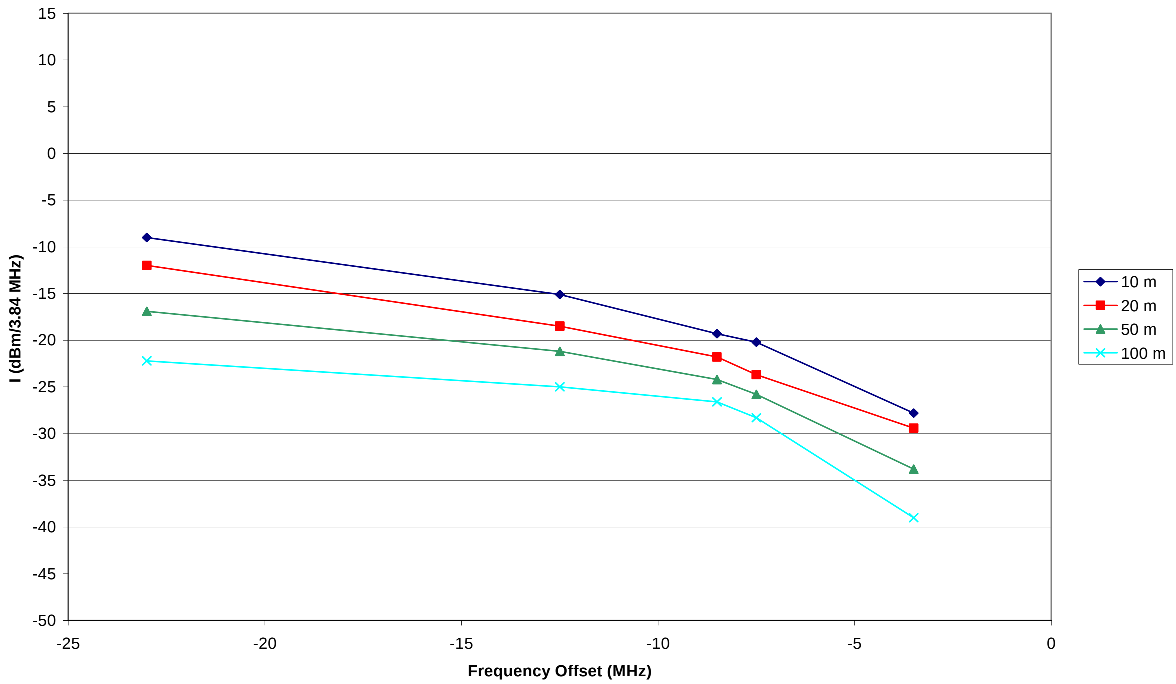

Figure 7: UMTS UE power to cause a 6dB reduction in PMSE SINAD as a function of frequency offset when the UE is transmitting at a mean power of 5 dBm with TPC

For a frequency offset of -3.5 MHz, the plot shows that as the wanted level drops 20 dB for a separation distance of 10 m to 100 m, the difference in UMTS UE interference required to produce a drop of 6 dB in SINAD is only 11 dB. This trend is reasonably consistent at a frequency separation of -23 MHz and -12.5 MHz, but narrows to 7 dB at -8.5 MHz and 8 dB at -7.5 MHz.

The results of Figure 7 compared with Figure 6 reveal that a UMTS UE operating at a mean power of 5 dBm with a TPC profile for a user walking at 3 km/h requires 8 to 12 dB less interference power to produce a 6 dB drop in SINAD for a -3.5 MHz frequency offset and 12 to 15 dB less for a -23 MHz frequency offset compared with the maximum EIRP results, inline with the difference of the transmitted means powers.

It must be noted that the SINAD measurements proved consistently difficult to measure when interfering with a UMTS UE signal simulating a TPC profile for a mobile user walking at 3 km/h. The reason for this difficulty was that as the power control varied so did the SINAD reading.

5.1.2 PMSE receiver 2

Figure 8 shows the level of UMTS UE interference transmitting at a constant level required to produce a drop of 6 dB in SINAD from a measured value of 63 dB without interference to 57 dB with interference. The results shows that for a separation distance of 10 m, -20 dBm/3.84 MHz is required to cause interference to the PMSE receiver for a frequency offset of -3.5 MHz, 32 dB less power compared with a frequency offset of -23 MHz. The trend is consistent for all simulated separation distance ranging from 10 m to 100 m.

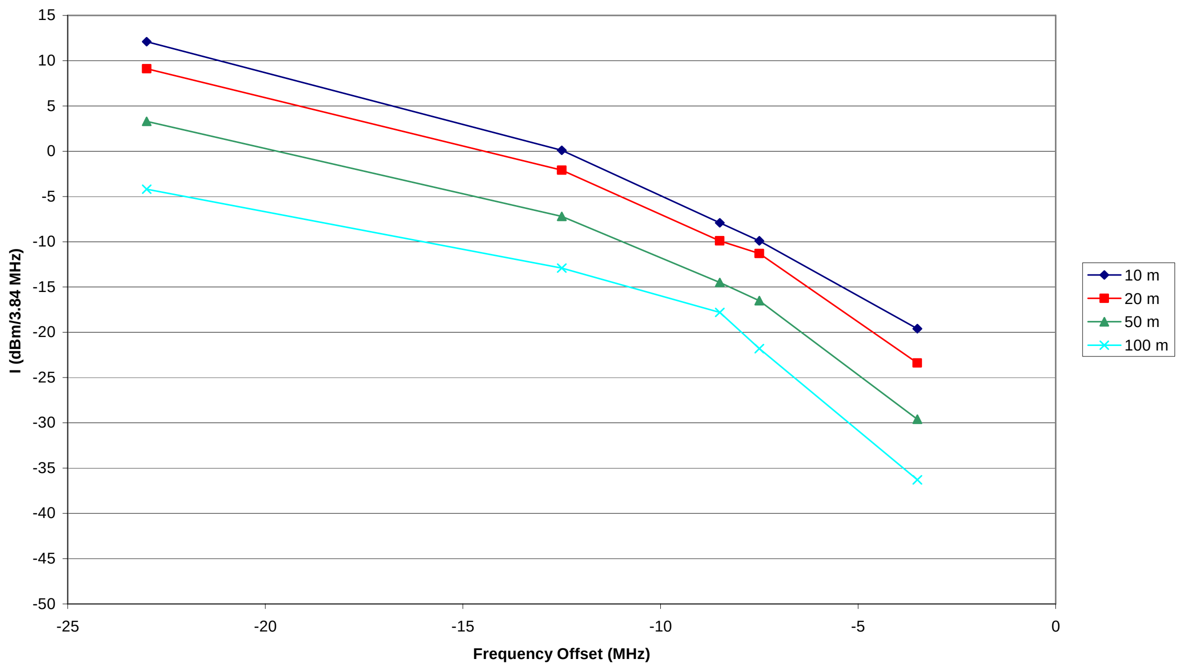

Figure 8: UMTS UE power to cause a 6dB reduction in PMSE SINAD as a function of frequency offset when the UE is transmitting at a constant mean power of 21 dBm

For a frequency offset of -3.5 MHz, the plot shows that as the wanted level drops 20 dB for a separation distance of 10 m to 100 m, the difference in UMTS UE interference required to produce a drop of 6 dB in SINAD is 16 dB. This trend is again reasonably consistent at a frequency separation of -23 MHz, but narrows to 13 dB at -12.5 MHz, 10 dB at -8.5 MHz and 12 dB at -7.5 MHz.

The average C/I ratio measured for the four wanted carrier levels was 26 dB for PMSE receiver 2. This correlates well with the fact that the results of Figure 8 compared with Figure 6 reveal that PMSE receiver 2 is 5 to 8 dB more sensitive to UMTS UE interference compared with PMSE receiver 1.

Figure 9 shows the level of UMTS UE interference using a 3km/h TPC profile required to produce a drop of 6 dB in SINAD from a measured value of 63 dB without interference to 57 dB with interference. The plot shows that for a separation of 10 m, -31 dBm/3.84 MHz is required to cause interference to the PMSE receiver for a frequency offset of -3.5 MHz, 27 dB less power compared with a frequency offset of -23 MHz. The trend is reasonably consistent for all simulated separation distance ranging from 10 m to 100 m.

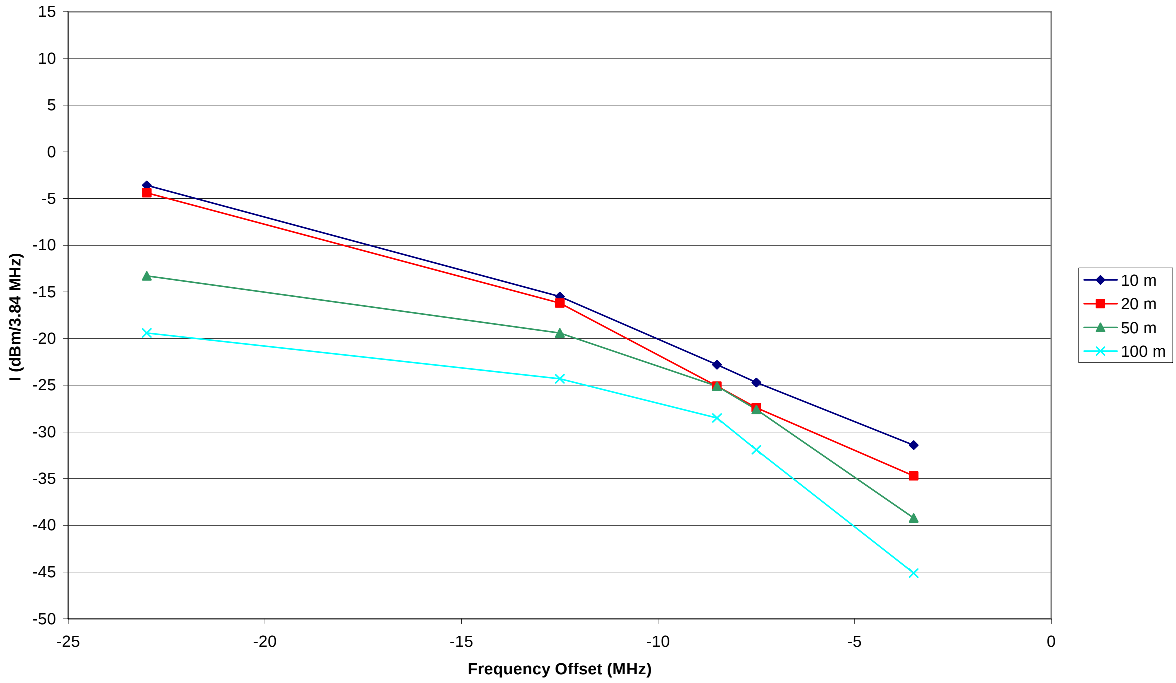

Figure 9: UMTS UE power to cause a 6dB reduction in PMSE SINAD as a function of frequency offset when the UE is transmitting at a mean power of 5 dBm with TPC

For a frequency offset of -3.5 MHz, the plot shows that as the wanted level drops 20 dB for a separation distance of 10 m to 100 m, the difference in UMTS UE interference required to produce a drop of 6 dB in SINAD is only 14 dB. This trend is reasonably consistent at a frequency separation of -23 MHz, but narrows to 9 dB at -12.5 MHz, 6 dB at -8.5 MHz and 7 dB at -7.5 MHz.

The results of Figure 9 compared with Figure 8 reveal that a UMTS UE operating at a mean power of 5 dBm with a TPC profile for a user walking at 3 km/h requires 9 to 11 dB less interference power to produce a 6 dB drop in SINAD for a -3.5 MHz frequency offset and 15 dB less for a -23 MHz frequency offset compared with the maximum EIRP results, inline with the difference of the transmitted means powers.

5.2 Radiated

Outdoor radiated measurements for UMTS UE interference into 2 PMSE receivers were made using the test set-up and procedure described in Section 4. This section discusses the results obtained for both PMSE receivers.

5.2.1 PMSE receiver 1

Table 7 shows that when PMSE receiver 1 operated with a received wanted level of -65 dBm, i.e. a maximum separation distance of 100 m from the PMSE transmitter, a separation distance of 10.6 m to 15 m was required for a UMTS UE transmitting with a -3.5 MHz centre frequency offset from the PMSE channel and at a maximum EIRP of 21 dBm.

The table also shows that with every 6 dB increase in the wanted signal the separation distance between the UMTS UE and PMSE receiver roughly halves. This is to be expected since the path loss varies as a function of 20 log distance.

With the exception of the radiated result for a PMSE wanted signal of -65 dBm, the separation distance results for the UMTS UE operating at a mean power of 5 dBm with a TPC profile for a user walking at 3 km/h are around half those of the maximum EIRP results.

Table 7:
Separations distances for a frequency offset of -3.5 MHz between UMTS UE interference into PMSE receiver 1

Received wanted power (dBm)	Equivalent distance (m)	Separation Distance (m)			
		Maximum EIRP (21 dBm)		TPC (mean power 5 dBm)	
		Conducted	Radiated	Conducted	Radiated
-45	10	1.9	1.4	1.2	1
-51	20	2.8	2.3	1.5	1.6
-59	50	5.2	6	2.5	3
-65	100	10.6	15	4.5	11.5

Table 8 shows that when PMSE receiver 1 operated with a received wanted level of -65 dBm, i.e. a maximum separation distance of 100 m from the PMSE transmitter, a separation distance of 2.3 m to 3.7 m was required for a UMTS UE transmitting with a -7.5 centre frequency offset from the PMSE channel and at a maximum EIRP of 21 dBm.

The table also shows that with every 6 dB increase in the wanted signal the separation distance between the UMTS UE and PMSE receiver roughly halves for the radiated measurements, but not the conducted results.

Also, the separation distance results for the UMTS UE operating at a mean power of 5 dBm with a TPC profile for a user walking at 3 km/h are similar to those of the maximum EIRP results.

Table 8:
Separations distances for a frequency offset of -7.5 MHz between UMTS UE interference into PMSE receiver 1

Received wanted power (dBm)	Equivalent distance (m)	Separation Distance (m)			
		Maximum EIRP (21 dBm)		TPC (mean power 5 dBm)	
		Conducted	Radiated	Conducted	Radiated
-45	10	0.9	0.8	0.5	0.6
-51	20	1.0	1.2	0.8	0.9
-59	50	1.3	2.0	1.0	1.5
-65	100	2.3	3.7	1.3	3.2

5.2.2 PMSE receiver 2

Table 9 shows that when PMSE receiver 2 operated with a received wanted level of -65 dBm, i.e. a maximum separation distance of 100 m from the PMSE transmitter, a separation distance of 20.6 m to 21.1 m was required for a UMTS UE transmitting with a -3.5 MHz centre frequency offset from the PMSE channel and at a maximum EIRP of 21 dBm.

Table 9:
Separations distances for a frequency offset of -3.5 MHz between UMTS UE interference into PMSE receiver 2

Received wanted power (dBm)	Equivalent distance (m)	Separation Distance (m)			
		Maximum EIRP (21 dBm)		TPC (mean power 5 dBm)	
		Conducted	Radiated	Conducted	Radiated
-45	10	3.0	2.8	1.9	1.9
-51	20	4.7	3.6	2.7	2.8
-59	50	9.5	9.7	4.6	6
-65	100	20.6	21.1	9.0	11.1

The table also shows that with every 6 dB increase in the wanted signal the separation distance between the UMTS UE and PMSE receiver roughly halves. This is to be expected since the path loss varies as a function of 20 log distance.

Also, the separation distance results for the UMTS UE operating at a mean power of 5 dBm with a TPC profile for a user walking at 3 km/h are around half those of the maximum EIRP results.

Table 10 shows that when PMSE receiver 2 operated with a received wanted level of -65 dBm, i.e. a maximum separation distance of 100 m from the PMSE transmitter, a separation distance of 3.9 m to 5.6 m was required for a UMTS UE transmitting with a -7.5 centre frequency offset from the PMSE channel and at a maximum EIRP of 21 dBm.

The table also shows that over the 20 dB increase in the wanted signal, the separation distance between the UMTS UE and PMSE receiver roughly halves for both the conducted results and radiated measurements.

Also, the separation distance results for the UMTS UE operating at a mean power of 5 dBm with a TPC profile for a user walking at 3 km/h are similar to those of the maximum EIRP results.

Table 10:
Separations distances for a frequency offset of -7.5 MHz between UMTS UE interference into PMSE receiver 2

Received wanted power (dBm)	Equivalent distance (m)	Separation Distance (m)			
		Maximum EIRP (21 dBm)		TPC (mean power 5 dBm)	
		Conducted	Radiated	Conducted	Radiated
-45	10	1.0	1.1	0.9	1.1
-51	20	1.2	1.7	1.2	1.4
-59	50	2.1	2.4	1.2	2.1
-65	100	3.9	5.6	2.0	2.2

6. Summary and Conclusions

As part of the ongoing work supporting the DDR, Ofcom requested an investigation into the possible adjacent channel interference to PMSE receivers from a UMTS UE for different wanted signal levels and frequency offsets.

Conducted and radiated measurements were carried out for two types of PMSE receivers and from the results the following was concluded:

UE operating at maximum EIRP

- When PMSE receiver type 1 operated with a received wanted level of -65 dBm, i.e. an equivalent separation distance of 100 m from the PMSE transmitter, a separation distance of 10.6 m to 15 m was required to produce a 6 dB drop in SINAD for a UMTS UE transmitting with a -3.5 MHz centre frequency offset from the PMSE channel and at a maximum EIRP of 21 dBm.

- When PMSE receiver type 2 operated with a received wanted level of -65 dBm, i.e. an equivalent separation distance of 100 m from the PMSE transmitter, a separation distance of 20.6 m to 21.1 m was required to produce a 6 dB drop in SINAD for a UMTS UE transmitting with a -3.5 MHz centre frequency offset from the PMSE channel and at a maximum EIRP of 21 dBm.

- For every 6 dB increase in the wanted signal, the separation distance between the UMTS UE and PMSE receiver roughly halved for a UMTS UE transmitting with a -3.5/-7.5 MHz centre frequency offset from the PMSE channel. This is to be expected since the path loss varies as a function of 20 log distance.

- The level of UMTS interference without TPC required to produce a 6 dB drop in SINAD was 15 to 23 dB more for a frequency offset of -23 MHz between the UMTS UE and PMSE centre carriers compared with a frequency offset of -3.5 MHz for PMSE receiver type 1.
- The level of UMTS interference without TPC required to produce a 6 dB drop in SINAD was 25 to 30 dB more for a frequency offset of -23 MHz between the UMTS UE and PMSE centre carriers compared with a frequency offset of -3.5 MHz for PMSE receiver type 2.
- PMSE receiver type 2 was 5 to 8 dB more sensitive to UMTS UE interference compared with PMSE receiver type 1.

UE operating with TPC

- A UMTS UE operating at a mean power of 5 dBm with TPC profile for a user walking at 3 km/h required 8 to 12 dB less interference power to produce a 6 dB drop in SINAD for a frequency offset of -3.5 and -7.5 MHz compared with the maximum EIRP results. However, in terms of the difference in path loss (which directly relates to interference distance) it only produced a 4 to 8 dB difference. This difference is due to the way the SINAD meter is able to distinguish between normal and impulsive like noise caused by the TPC.
- The separation distance results for the UMTS UE operating at a mean power of 5 dBm with a TPC profile for a user walking at 3 km/h were between 4.5 m to 11.5 m for PMSE receiver 1 and 9.1 m to 11.1 m for PMSE receiver 2, around half of the maximum EIRP results for a frequency offset of -3.5 MHz. The same trend was observed for larger frequency offsets.

7. References

[1] "Conducted and Radiated Measurements to Quantify DVB-T, UMTS and WiMAX Interference into DTT", ERA Technology, April 2008

[2] ETSI TS 125.101: Universal Mobile Telecommunications System (UMTS); User Equipment (UE) radio transmission and reception (FDD) (3GPP TS 25.101 version 7.8.0 Release 7)

[3] ETSI TS 125.104: Universal Mobile Telecommunications System (UMTS); Base Station (BS) radio transmission and reception (FDD) (3GPP TS 25.104 version 7.7.0 Release 7)

[4] ETSI EN 300 296-1, "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land Mobile Services; Radio equipment using integral antenna intended primarily used for analogue speech; Part 1; Technical characteristics and methods of measurements", V1.1.1 (2001-3)

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APPENDIX 1: Separation Distance Plots

PMSE Receiver 1

Maximum EIRP of 21 dBm

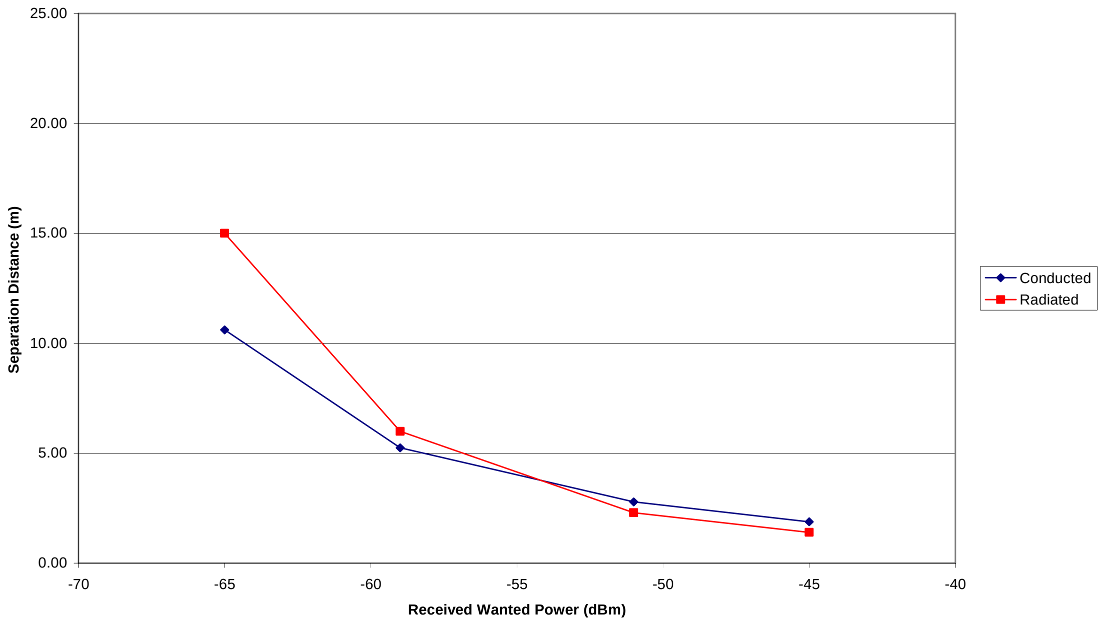

Figure 10: Separation distance as a function of received wanted power for a UMTS UE centre carrier operating -3.5 MHz away from the PMSE carrier

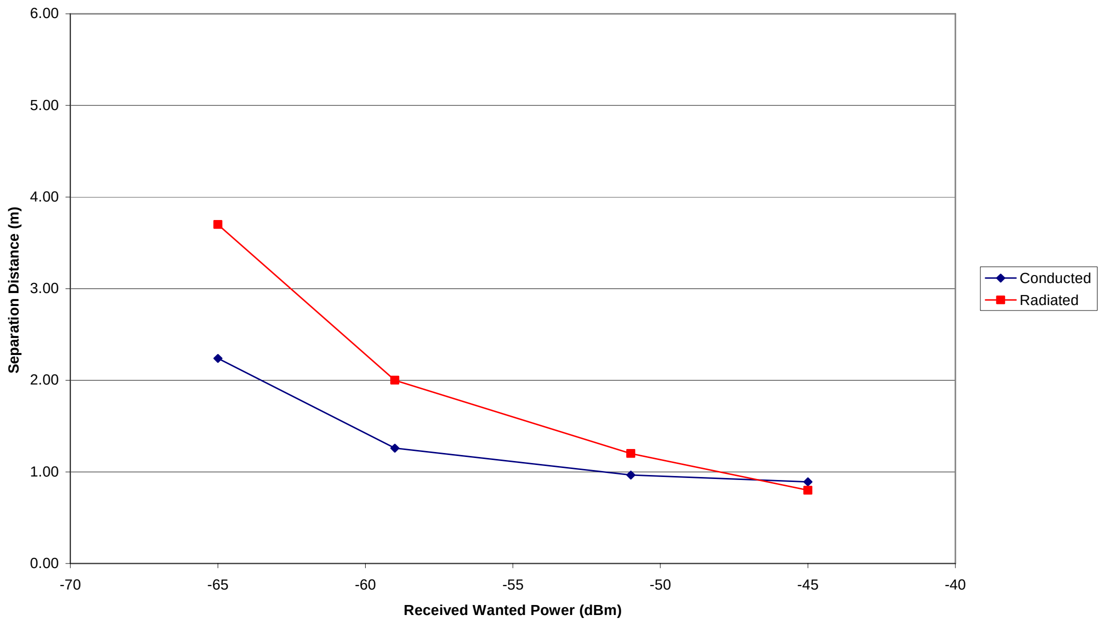

Figure 11: Separation distance as a function of received wanted power for a UMTS UE centre carrier operating -7.5 MHz away from the PMSE carrier

Mean power of 5 dBm with TPC

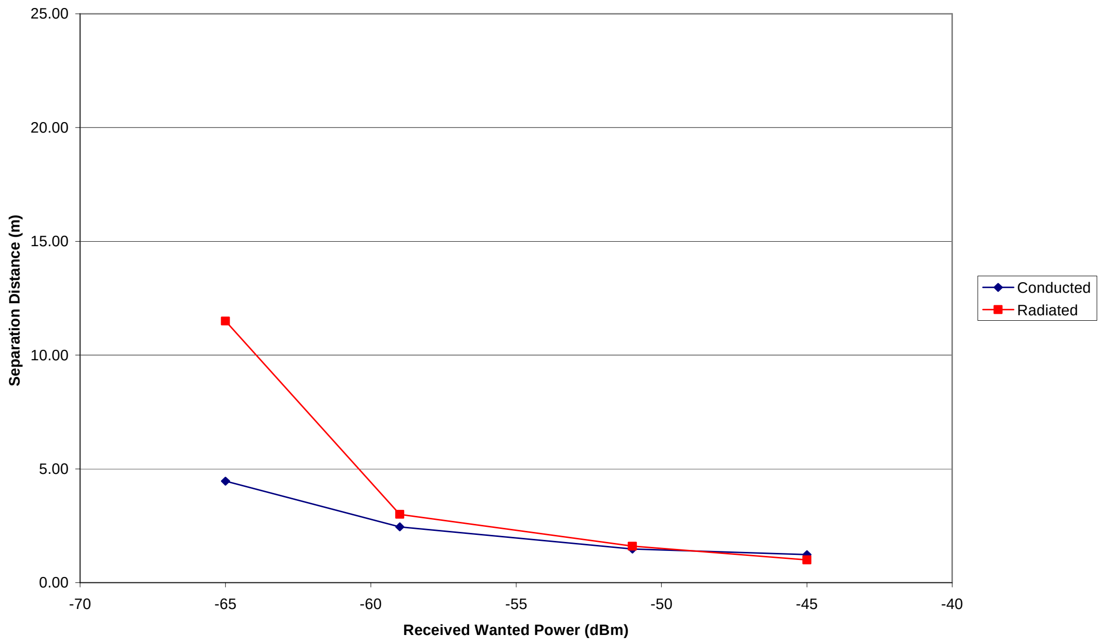

Figure 12: Separation distance as a function of received wanted power for a UMTS UE centre carrier operating -3.5 MHz away from the PMSE carrier

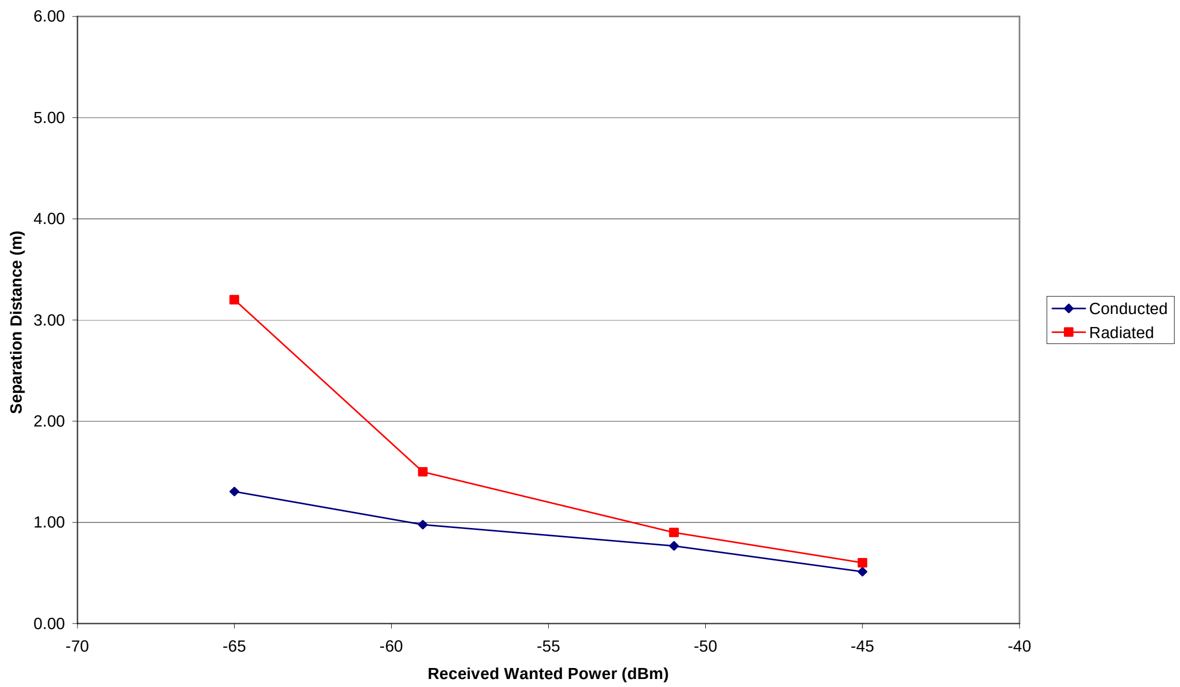

Figure 13: Separation distance as a function of received wanted power for a UMTS UE centre carrier operating -7.5 MHz away from the PMSE carrier

PMSE Receiver 2

Maximum EIRP of 21 dBm

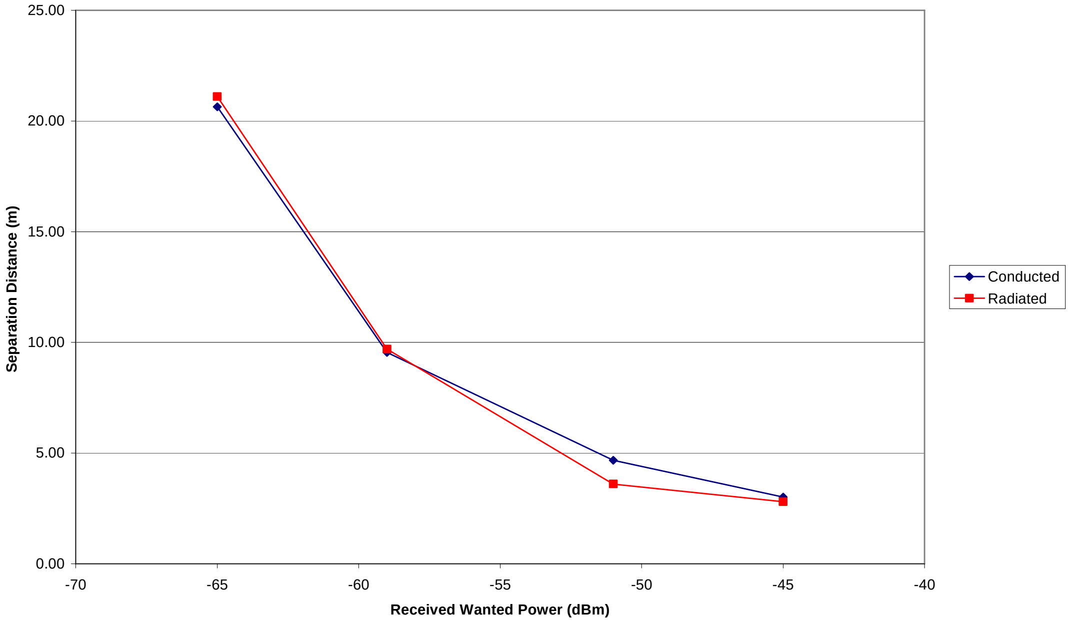

Figure 14: Separation distance as a function of received wanted power for a UMTS UE centre carrier operating -3.5 MHz away from the PMSE carrier

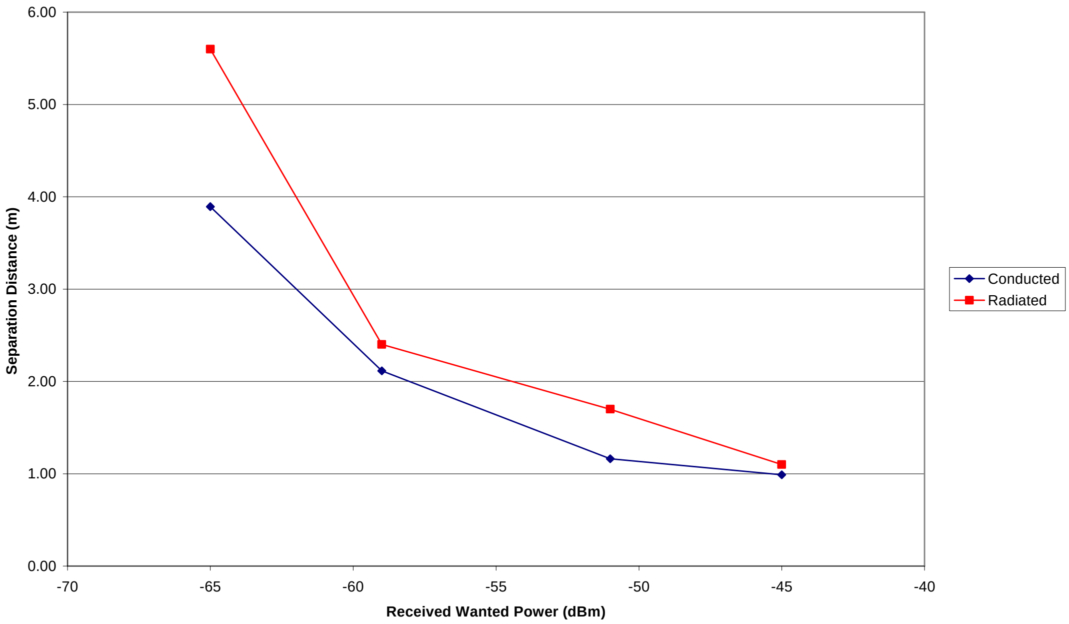

Figure 15: Separation distance as a function of received wanted power for a UMTS UE centre carrier operating -7.5 MHz away from the PMSE carrier

Mean power of 5 dBm with TPC

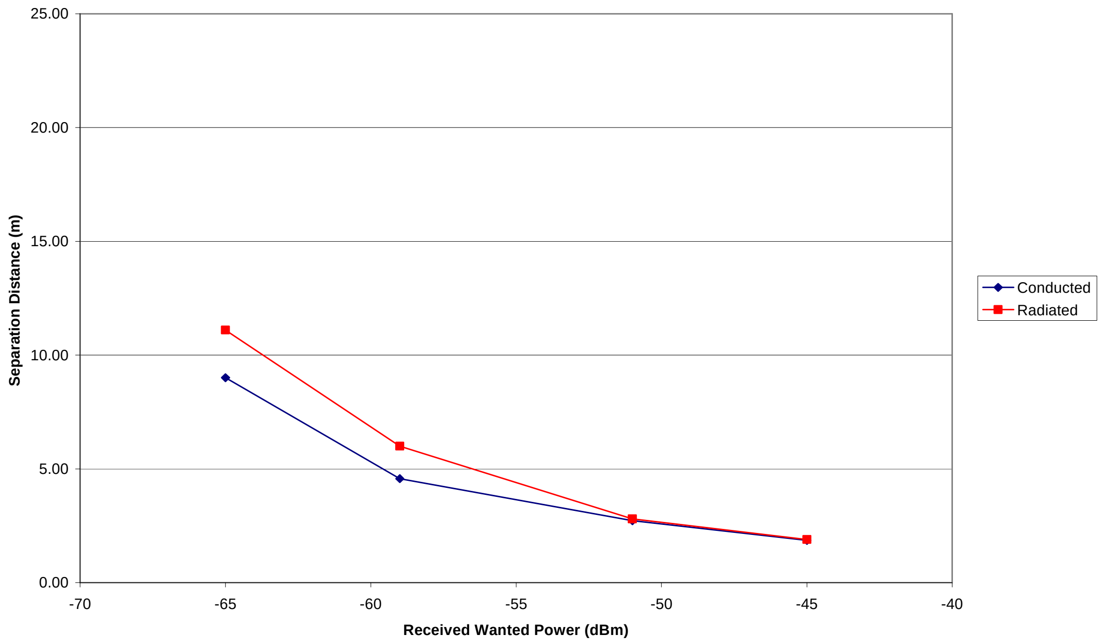

Figure 16: Separation distance as a function of received wanted power for a UMTS UE centre carrier operating -3.5 MHz away from the PMSE carrier

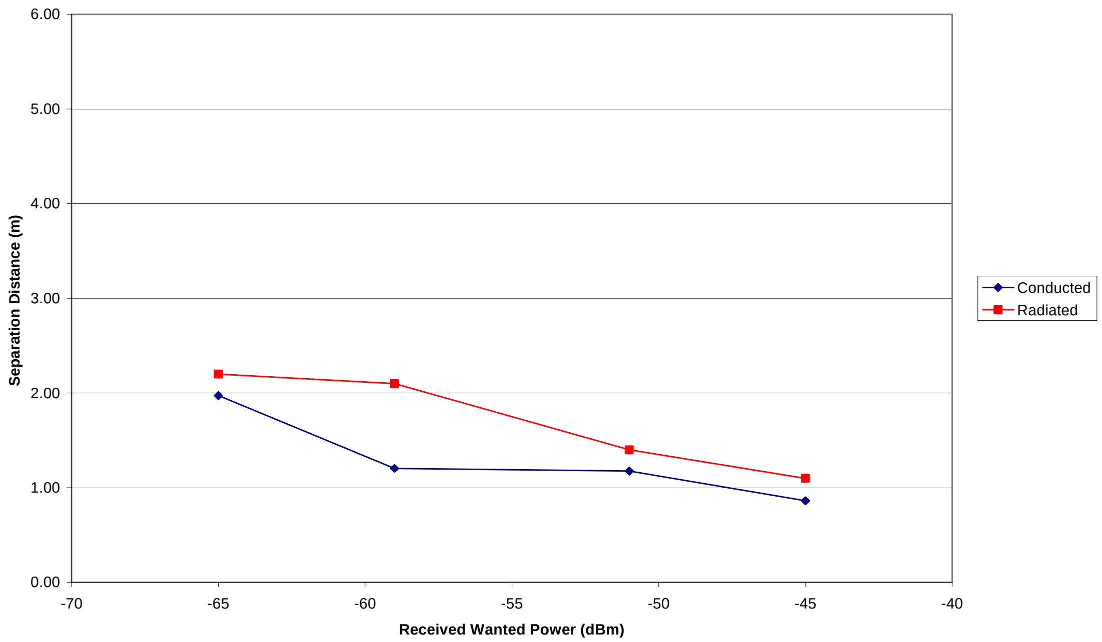

Figure 17: Separation distance as a function of received wanted power for a UMTS UE centre carrier operating -7.5 MHz away from the PMSE carrier

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APPENDIX 2: Equipment List

List

- **Signal Sources**
- Rhode and Schwarz SIMQ03B signal generator
- Rhode and Schwarz SIMQ06 signal generator
- Rhode and Schwarz AMIQ
- Laptops x1
- **Attenuators**
- Marconi programmable attenuator x2
- HP step attenuator
- **Miscellaneous**
- Rhode and Schwarz FSU46 spectrum analyser
- Lindos LA102 audio analyser
- K & L filter
- HP splitter
- Wiltron VSWR bridge