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Report Title: **Measurements of UTRA FDD User Equipment Characteristics in the 2.1 GHz Band**

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Summary

ERA was asked to carry out a measurement study on five UMTS handsets, characterising their RF performance based on the following parameters:

- Spectrum emission mask and adjacent channel leakage ratio (ACLR).
- Receiver adjacent channel selectivity (ACS).
- Receiver blocking performance.
- Receiver inter-modulation characteristics.

The results of the measurements are summarised in the tables and figures below for the five UMTS handsets.

UE spectrum emission mask measurements

		Frequency offset from carrier			
		2.5 to 3.5 MHz	**3.5 to 7.5 MHz**	**7.5 to 8.5 MHz**	**8.5 to 12.5 MHz**
UE 1	**Level (dBc)**	-58.7	-46	-56.2	-55.5
	Margin (dB)	9.8	9.9	6.3	6.5
UE 2	**Level (dBc)**	-56.5	-43	-53.8	-53.9
	Margin (dB)	7.4	7.1	4.8	4.6
UE 3	**Level (dBc)**	-55	-40.6	-53	-52.8
	Margin (dB)	5.7	5.1	3.6	3.9
UE 4	**Level (dBc)**	-59.7	-49.5	-50.7	-49.6
	Margin (dB)	10.9	10.8	1.4	1.1
UE 5	**Level (dBc)**	-59.5	-46.1	-51.5	-50.8
	Margin (dB)	10.2	11.1	2	1.8

Note that in the above table the measurement bandwidth is 30 kHz for frequency offsets of 2.5 to 3.5 MHz from the carrier, and is 1 MHz for all other frequency offsets. The margins in the above table indicate the amount by which the measured values of spectral leakage are below the minimum requirements described in ETSI TS 134 121-1 [1]. It can be seen that the emission levels for the five UEs are lower than the spectrum emission mask described in ETSI TS 134 121-1 by a margin of between 1.1 to 11.1 dB.

UE ACLR measurements

Frequency Offset (MHz)	ACLR (dB)					
	ETSI limit (TS 134 121-1)	UE 1	UE 2	UE 3	UE 4	UE 5
-10	43	51.3	48.9	49.6	45.1	45.9
-5	33	42.2	39.2	37.7	42.4	43
5	33	41.6	42.8	40.4	42.2	42.5
10	43	50.8	48.8	50.7	45.2	46

It can be seen that the measured ACLR values for the five UEs are greater than the minimum requirements described in ETSI TS 134 121-1 by a margin of between 3 to 10 dB.

For a ±5 MHz channel offset the measurements reveal an ACLR that is 7 to 10 dB greater, than the corresponding minimum ACLR requirements described in ETSI TS 134 121-1. For a ±10 MHz channel offset the measurements reveal an ACLR that is 3 to 8 dB greater than the corresponding minimum ACLR requirements described in ETSI TS 134 121-1.

Adjacent channel (±5 MHz) interference measurements

When averaged across all tested UEs, the measurements of UE receiver performance in the presence of adjacent channel (±5 MHz) interferers indicate an ACS of around 55 dB for interferer power levels of up to –25 dBm/3.84 MHz.

The measurements show that there is generally a reduction in the UE receiver ACS for interferer power levels greater than –25 dBm in the ±5 MHz adjacent channels. This is due to the onset of non-linear behaviour within the UE receiver chain, which results in a greater than proportional increase in the levels of experienced interference for an increase in interferer power.

When averaged across all tested UEs, the results indicate that a UE receiver ACS of 33 dB can be achieved for interferer power levels of up to –10 dBm/3.84 MHz or greater. This is compared with an ETSI minimum ACS requirement of 33 dB for an interferer power level of –25 dBm/3.84 MHz.

In-band blocking (±10 MHz) interference measurements

When averaged across all tested UEs, the measurements of UE receiver performance in the presence of in-band ±10 MHz blocking interferers indicate an ACS of around 65 dB for interferer power levels of up to –15 dBm/3.84 MHz.

The measurements show that there is generally a reduction in the UE receiver ACS for interferer power levels greater than –15 dBm/3.84 MHz in the ±10 MHz blocking channel, again due to the onset of non-linear behaviour within the UE receiver chain.

When averaged across all tested UEs, the results indicate that a UE receiver ACS of 43 dB can be achieved for interferer power levels of up to 0 dBm/3.84 MHz or greater. This is compared with an ETSI minimum ACS requirement of 43 dB for an interferer power level of –56 dBm/3.84 MHz.

In-band blocking (±15 MHz) interference measurements

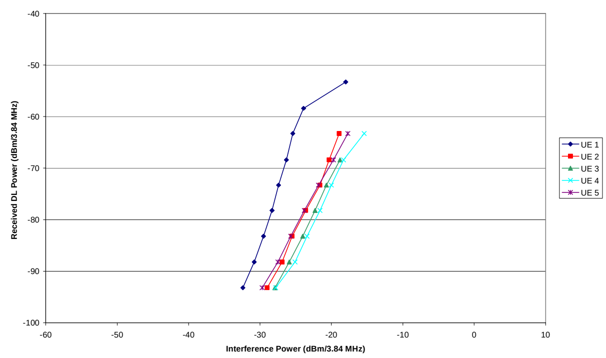
When averaged across all tested UEs, measurements of UE receiver performance in the presence of in-band ±15 MHz blocking interferers indicate an ACS of around 70 dB for interferer power levels of up to –15 dBm/3.84 MHz.

The measurements show that there is generally a reduction in the UE receiver ACS for interferer power levels greater than –15 dBm/3.84 MHz in the ±15 MHz blocking channel, again due to the onset of non-linear behaviour within the UE receiver chain.

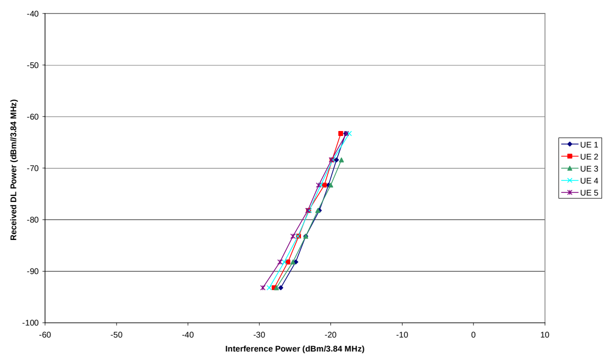
When averaged across all tested UEs, the results indicate that a UE receiver ACS of 55 dB can be achieved for interferer power levels of up to –3 dBm/3.84 MHz or greater. This is compared with an ETSI minimum ACS requirement of 55 dB for an interferer power level of –44 dBm/3.84 MHz.

Inter-modulation results

The measurements of inter-modulation effects caused by interferers at positive and negative frequency offsets from the wanted signal are shown in the figures below.



Received DL power vs. interferer power (+ve frequency offsets)



Received DL power vs. interferer power (-ve frequency offsets)

Measurements of inter-modulation effects caused by two interferers with frequency offsets of +10 and +20 MHz from the wanted signal indicate that an interferer power of between -30 to -28 dBm/3.84 MHz is required to achieve a BER of 0.001 for a received downlink wanted signal power of -93.2 dBm/3.84 MHz. With the exception of UE 1, this interferer power increases to -19 to -15 dBm/3.84 MHz for a received downlink wanted signal power of -63.3 dBm/3.84 MHz. Broadly similar results were derived from measurements of inter-modulation effects caused by interferers at frequency offsets of -10 and -20 MHz from the wanted signal.

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Abbreviations List

ACI	Adjacent channel interference
ACIR	Adjacent channel interference ratio
ACLR	Adjacent channel leakage ratio
ACS	Adjacent channel selectivity
BER	Bit Error Ratio
C/I	Carrier-to-Interference ratio
DCH	Dedicated Channel
DL	Downlink
FAR	Fully Anechoic room
LNA	Low Noise Amplifier
RLC	Radio Link Control
RMC	Reference Measurement Channel
SRB	Signal Radio Bearer
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System

1. Introduction

This report presents the results of a study undertaken for Ofcom to characterise the radio frequency (RF) performance of a range of universal mobile telecommunications system (UMTS) handsets operating in the bands 1920 – 1980 and 2110 – 2170 MHz. The parameters of interest were:

- Spectrum emission mask and adjacent channel leakage ratio (ACLR).
- Receiver adjacent channel selectivity (ACS).
- Receiver blocking performance.
- Receiver inter-modulation characteristics.

Measurements were performed on five User Equipment (UE) handsets from different manufacturers that are commonly available on the UK market. All measurements were undertaken in accordance with the test methods defined in ETSI performance standard TS 134 121-1 v8.0.0 (2007-10) [1].

Note: a key requirement of the study was to measure the 'full' performance range of the ACS, inter-modulation and blocking parameters on the receiver side. This required a wider range of measurements than that normally undertaken in a type approval assessment. For example, in order to determine the measured ACS performance, the corresponding ETSI standard only requires a simple pass / fail criterion. However, the measurement study tried to determine the actual range at which the handset low noise amplifier (LNA) remains linear. Therefore, a range of measurements were undertaken over a large range of adjacent channel interferer levels.

2. Test Set-Up

Radiated measurements were performed in a Fully Anechoic Room (FAR) using test procedures based on ETSI TS 134 121-1. More specifically, the test parameters and methods of:

1. Section 5.9 of ETSI TS 134 121-1 was used to measure the spectrum emission mask and ACLR measurements
2. Section 6.4 of ETSI TS 134 121-1 was used to measure ACS measurements.
3. Section 6.5 of ETSI TS 134 121-1 was used to measure the in-band blocking.
4. Section 6.7 of ETSI TS 134 121-1 was used to measure the receiver inter-modulation.

All measurements were performed using the Agilent Wireless Communications Test Set model 8960 also referred to as a system simulator (SS) and a Rhode and Schwarz FSU-46 spectrum analyser. In general, the tests were performed using a reference measurement channel (RMC) of 12.2 kbps, typical of voice traffic and with a BER not exceeding 0.001.

Note: A radiated test measurement was chosen over the preferred conducted set-up because none of the UE’s tested had an external antenna port. One option was to break into the handsets to remove the antenna and solder a wire connection at the antenna pins, but impedance mismatch issues due to the soldering were considered too much of a problem to go down this route. Section 6.1 of ETSI TS 134 121-1 indicates that radiated measurements can be undertaken when the UE has an integral antenna:

“Unless otherwise stated the receiver characteristics are specified at the antenna connector of the UE. For UE(s) with an integral antenna only, a reference antenna with a gain of 0 dBi is assumed. UE with an integral antenna may be taken into account by converting these power levels into field strength requirements, assuming a 0 dBi gain antenna……..It is recognised that different requirements and test methods are likely to be required for the different types of UE”.

2.1 Spectrum Emission Mask Measurements

The spectrum emission mask requirements are defined in Table 5.9.1 of Section 5.9.2 of ETSI TS 134 121-1, as shown in the table below:

Table 1:
ETSI spectrum emission mask requirement for a UE

Δf in MHz (Note 1)	Minimum requirement (Note 2)		Additional requirements Band II, IV, V, X (Note 3)	Measurement bandwidth (Note 6)
	Relative requirement	Absolute requirement		
2.5 - 3.5	$\left\{-35-15\cdot\left(\frac{\Delta f}{MHz}-2.5\right)\right\}dBc$	-71.1 dBm	-15 dBm	30 kHz (Note 4)
3.5 - 7.5	$\left\{-35-1\cdot\left(\frac{\Delta f}{MHz}-3.5\right)\right\}dBc$	-55.8 dBm	-13 dBm	1 MHz (Note 5)
7.5 - 8.5	$\left\{-39-10\cdot\left(\frac{\Delta f}{MHz}-7.5\right)\right\}dBc$	-55.8 dBm	-13 dBm	1 MHz (Note 5)
8.5 -- 12.5 MHz	-49 dBc	-55.8 dBm	-13 dBm	1 MHz (Note 5)

Note 1: Δf is the separation between the carrier frequency and the centre of the measurement bandwidth.
Note 2: The minimum requirement is calculated from the relative requirement or the absolute requirement, whichever is the higher power.
Note 3: For operation in Band II, IV, V, X only, the minimum requirement is calculated from the minimum requirement calculated in Note 2 or the additional requirement for band II, whichever is the lower power.
Note 4: The first and last measurement position with a 30 kHz filter is at Δf equals to 2.515 MHz and 3.485 MHz.
Note 5: The first and last measurement position with a 1 MHz filter is at Δf equals to 4 MHz and 12 MHz.
Note 6: As a general rule, the resolution bandwidth of the measuring equipment should be equal to the measurement bandwidth. However, to improve measurement accuracy, sensitivity and efficiency, the resolution bandwidth may be smaller than the measurement bandwidth. When the resolution bandwidth is smaller than the measurement bandwidth, the result should be integrated over the measurement bandwidth in order to obtain the equivalent noise bandwidth of the measurement bandwidth.

The test method used to measure the relative requirement of the spectrum emission mask for the UE was taken from Section 5.9.4 of ETSI TS 134 121-1. The radiated measurement setup is shown in Figure 1.

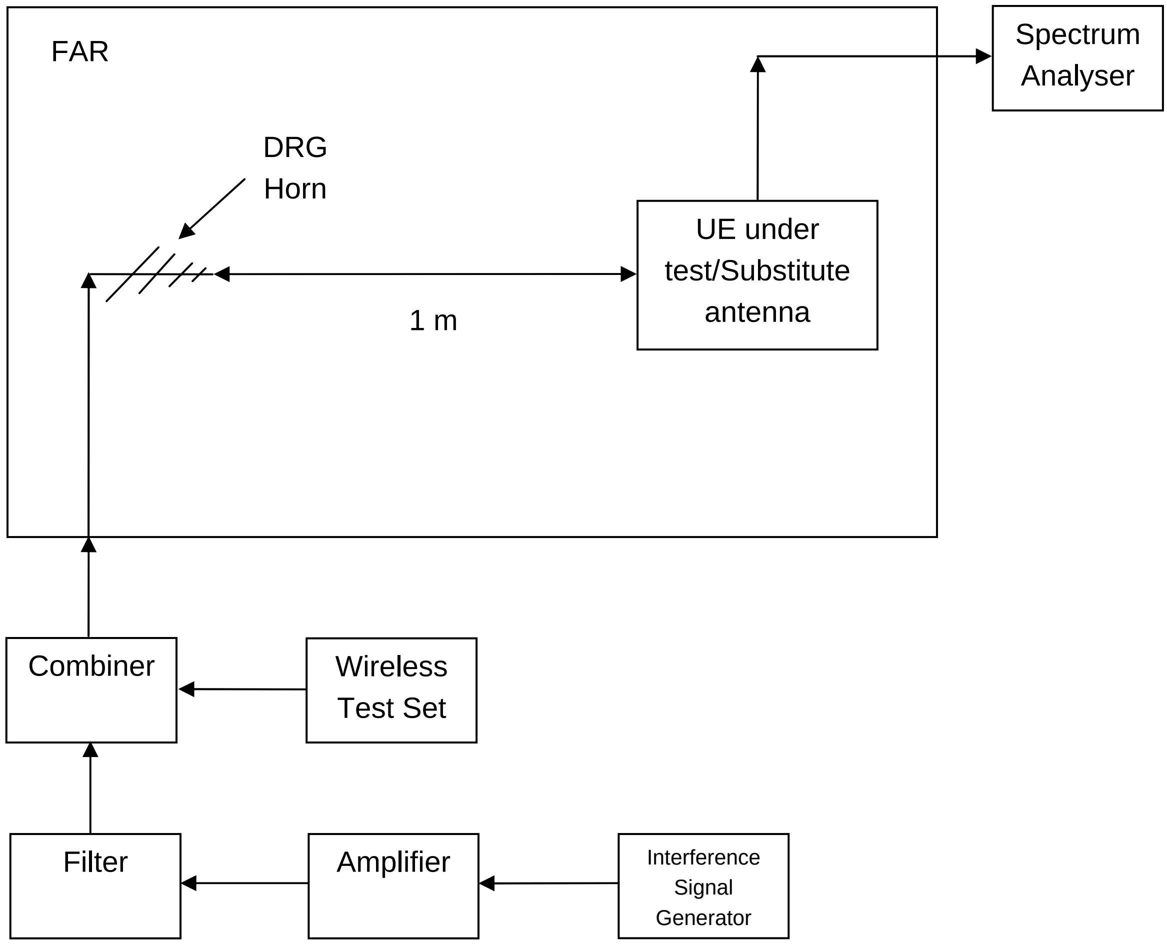

Figure 1: Diagram of radiated measurement test set-up

A dual ridged (DRG) horn antenna with a gain of 8.4 dBi was used to transmit the downlink (DL) signal to the UE under test. A second DRG horn antenna with a gain of 8.4 dBi was used as a substitute antenna at the location of the UE in order to measure the various received signal powers on the DL, and in order to calculate the path loss between the transmitter and receiver. Based on the calculated path loss of 43 dB, the uplink (UL) power received at the Agilent 8960 wireless communications test set was measured to be at a level which confirmed that the UE radiated with an EIRP of 20 dBm (corresponding to the power class of the handset, see Table 2).

The Agilent 8960 wireless communications test set was used to setup a generic call to the UE, based on the procedure defined in ETSI TS 134 108 [2], as shown in Table 2:

Table 2:
Test set parameters used to setup up a call

Parameter	Value
Downlink (DL) frequency	2.14 GHz
Radio link control (RLC) re-establish	Off
Reference measurement channel (RMC)	12.2 kbps
Signal radio bearer (SRB) configuration	2.2 kbps DCCH
Test loop mode	1
UE frequency band	II
UE target power	20 dBm (class 3)
Uplink (UL) frequency	1.95 GHz
UL power control algorithm	2

2.2 ACLR Measurements

ACLR is defined as the ratio of the Root Raised Cosine (RRC) filtered mean power centred on the assigned channel frequency to the RRC filtered mean power centred on an adjacent frequency. The ACLR requirements are defined in Table 5.10.1 of Section 5.10 of ETSI TS 134 121-1, as shown in the table below:

Table 3:
ETSI ACLR UE limits

Power Class	UE channel	ACLR limit
3	+5 MHz or –5 MHz	33 dB
3	+10 MHz or –10 MHz	43 dB
4	+5 MHz or –5 MHz	33 dB
4	+10 MHz or –10 MHz	43 dB

The test equipment was set up as shown in Figure 1, with a separation distance of 1m between the DRG horn antenna and the UE under test. A similar method to that in Section 2.1 above was used to set the UE uplink EIRP.

The following test procedure based on Section 5.10.5 of ETSI TS 134 121-1 was used:

1. A call was set up according to the generic call setup procedure in TS 134 108 [2].

2. The UE was entered into loopback test mode 1 and the loopback test started.
3. Power control commands were continuously sent to the UE until the UE output power was at the desired level (see Table 2).
4. The RRC filtered mean power (using an RMS detector) of the first and second adjacent channels were measured using the ACLR measurement function of the Agilent 8960 wireless communications test set. ALCR measurements using the wireless test set were limited to channel offsets of ± 10 MHz.

Note: Loopback refers to the case where a known data pattern on the dedicated traffic channel (DTCH) is transmitted on the downlink to the UE. The UE decodes the data and re-transmits it on the uplink DTCH. The test set analyzes the uplink data to see how closely it matches the data bits originally sent on the downlink. The test set compares the downlink and uplink data one transport block at a time. When in loopback test mode 1 the Agilent 8960 wireless communications test set reports the bit error ratio (BER).

2.3 ACI Measurements

The adjacent channel interference (ACI) measurements were made using the ACS test method described in Section 6.4A.4 of ETSI TS 134 121-1. The ACS is defined as the measure of a receiver's ability to receive a W-CDMA signal at its assigned channel frequency in the presence of an adjacent channel signal at a given frequency offset from the centre frequency of the assigned channel.

The test equipment was set up as shown in Figure 1, with a separation distance of 1m between the DRG horn antenna and the UE under test. A similar method to that in Section 2.1 above was used to set the UE uplink EIRP.

The following test procedure was used to determine the ACI:

1. The power control algorithm was set to 2 on the Agilent 8960 wireless communications test set, as specified by [2].
2. A call was set up according to the generic call setup procedure in ETSI 134 108 [2].
3. The UE was entered into loopback test mode 1 and the loopback test started.
4. The EIRP of the UE was set up according to the values specified in Table 4 below.
5. The downlink wanted signal power $\hat{I}_{or}$ measured in a 3.84 MHz channel bandwidth was set to -92.7 dBm/3.84 MHz, 14 dB above <REF $\hat{I}_{or}$>.
6. The parameters of the interference signal generator were set up as shown in Case 1 of Table 4.
7. The power level of the interferer was increased or decreased until the BER measured by the wireless test set was 0.001.

8. The power level of interferer was recorded on a spectrum analyser using RMS detection and a measurement channel bandwidth of 3.84 MHz.
9. The level of interference occupying the adjacent ±5 MHz side-bands was recorded on a spectrum analyser using RMS detection and a measurement channel bandwidth of 3.84 MHz.
10. Using additive white Gaussian noise (AWGN), the amount of interference affecting the UE under test was measured as the co-channel power achieving the same BER of 0.001 as for the adjacent channel interferer.
11. The ALCR of the interferer was calculated as the ratio of the power measurements in Steps 8 and 9.
12. The adjacent channel interference ratio (ACIR) of the interferer was calculated as the ratio of the power measurements in Steps 8 and 10.

Steps 5 to 12 were repeated in 5 dB steps for the downlink wanted signal power $\hat{I}_{or}$ up to and beyond Case 2 shown in Table 4, until the limit of the linear operating range of the power amplifier was reached.

Table 4:
ETSI test parameters for ACS for release 5 and later releases

Parameter	Unit	Case 1	Case 2
DPCH_Ec	dBm/3.84 MHz	<REFSENS> + 14 dB	<REFSENS> + 41 dB
$\hat{I}_{or}$	dBm/3.84 MHz	<REF$\hat{I}_{or}$> + 14 dB	<REF$\hat{I}_{or}$> + 41 dB
I_{oac} mean power (modulated)	dBm	-52	-25
F_{uw} (offset)	MHz	+5 or -5	+5 or -5
UE transmitted mean power	dBm	20 (for Power class 3) 18 (for Power class 4)	20 (for Power class 3) 18 (for Power class 4)

Note: Test signal I_{oac} used for the adjacent channel interference measurements was based on 16 dedicated channels of data, whose parameters were taken from Table E.3.6 of ETSI TS 134 121-1 (see Table 5 below). The common channel information was taken from Table E.4.1 [1]. These DPCH channelisation codes and relative level settings are chosen to simulate a signal with realistic peak to average ratio.

**Table 5:
DPCH channelisation code and relative settings for OCNS signal**

Channelization Code at SF=128[1]	Relative Level setting (dB)[1,2]
2	-1
11	-3
17	-3
23	-5
31	-2
38	-4
47	-8
55	-7
62	-4
69	-6
78	-5
85	-9
94	-10
125	-8
113	-6
119	0

Note: The relative level setting specified in dB refers only to the relationship between the orthogonal channel noise simulator (OCNS) channels. The level of the OCNS channels relative to the $\hat{I}_{or}$ of the complete signal is a function of the power of the other channels in the signal with the intention that the power of the group of OCNS channels is used to make the total signal add up to 1.

2.4 Blocking Measurements

Blocking is defined as a measure of the receiver's ability to receive a wanted signal at its assigned channel frequency in the presence of an unwanted interferer on frequencies other than those of the spurious response or the adjacent channels, without this unwanted input signal causing a degradation of the performance of the receiver beyond a specified limit. The blocking test method is defined in Section 6.5.3 of ETSI TS 134 121-1 [1].

Based on the test set-up shown in Figure 1, the following test procedure was used to determine the in-band blocking performance:

1. The power control algorithm was set to 2 on the Agilent 8960 wireless communications test set.
2. The downlink wanted signal power $\hat{I}_{or}$ measured in a 3.84 MHz channel bandwidth was set to -92.7 dBm/3.84 MHz, 14 dB above <REF $\hat{I}_{or}$>[1].
3. A call was set up according to the generic call setup procedure in ETSI 134 108 [2].
4. The UE was entered into loopback test mode 1 and the loopback test started.
5. The EIRP of the UE was set up according to the values specified in Table 2.
6. The parameters of the interference signal generator were set up as shown in Table 6 below for ±10 MHz and ± 15 MHz frequency offsets.
7. The power level of the interferer was increased or decreased until the BER measured by the wireless test set was 0.001.
8. The power level of the interferer was recorded on a spectrum analyser using a RMS detector and a measurement channel bandwidth of 3.84 MHz.
9. The level of interference occupying the ±10 MHz side-bands was recorded on a spectrum analyser using RMS detection and a measurement channel bandwidth of 3.84 MHz.
10. Using AWGN, the amount of interference affecting the UE under test was measured as the co-channel power achieving the same BER of 0.001 as for the adjacent channel interferer.
11. The ALCR of the interferer was calculated as the ratio of the power measurements in Steps 8 and 9.
12. The ACIR of the interferer was calculated as the ratio of the power measurements in Steps 8 and 10.

Steps 5 to 10 were repeated in 5 dB steps for the downlink wanted signal power $\hat{I}_{or}$, until the limit of the linear operating range of the power amplifier was reached.

[1] A value of -103.7 dBm/3.84 MHz, 3 dB above <REF $\hat{I}_{or}$> could not be established when performing the radiated measurements.

Table 6:
ETSI test parameters for in-band blocking

Parameter	Unit	Level	
DPCH_Ec	dBm/3.84 MHz	<REFSENS>+3 dB	
$\hat{I}_{or}$	dBm/3.84 MHz	<REF$\hat{I}_{or}$> + 3 dB	
$I_{blocking}$ mean power (modulated)	dBm	-56	-44
F_{uw} offset		=±10 MHz	≤-15 MHz & ≥15 MHz

Note: Test signal $I_{blocking}$ used for the blocking measurements was based on 16 dedicated channels of data, whose parameters were taken from Table E.3.6 of ETSI 134 121-1. The common channel information was taken from Table E.4.1 [1].

2.5 Inter-modulation Measurements

Inter-modulation response rejection is a measure of the capability of the receiver to receive a wanted signal on its assigned channel frequency in the presence of two or more interfering signals which have a specific frequency relationship to the wanted signal. The inter-modulation test method is defined in Section 6.74 of ETSI TS 134.121 [1].

The test measurements were performed using the set-up shown in Figure 2, for a separation distance of 1m between the DRG horn antenna and the UE under test. A similar method to that in Section 2.1 above was used to set the UE uplink EIRP.

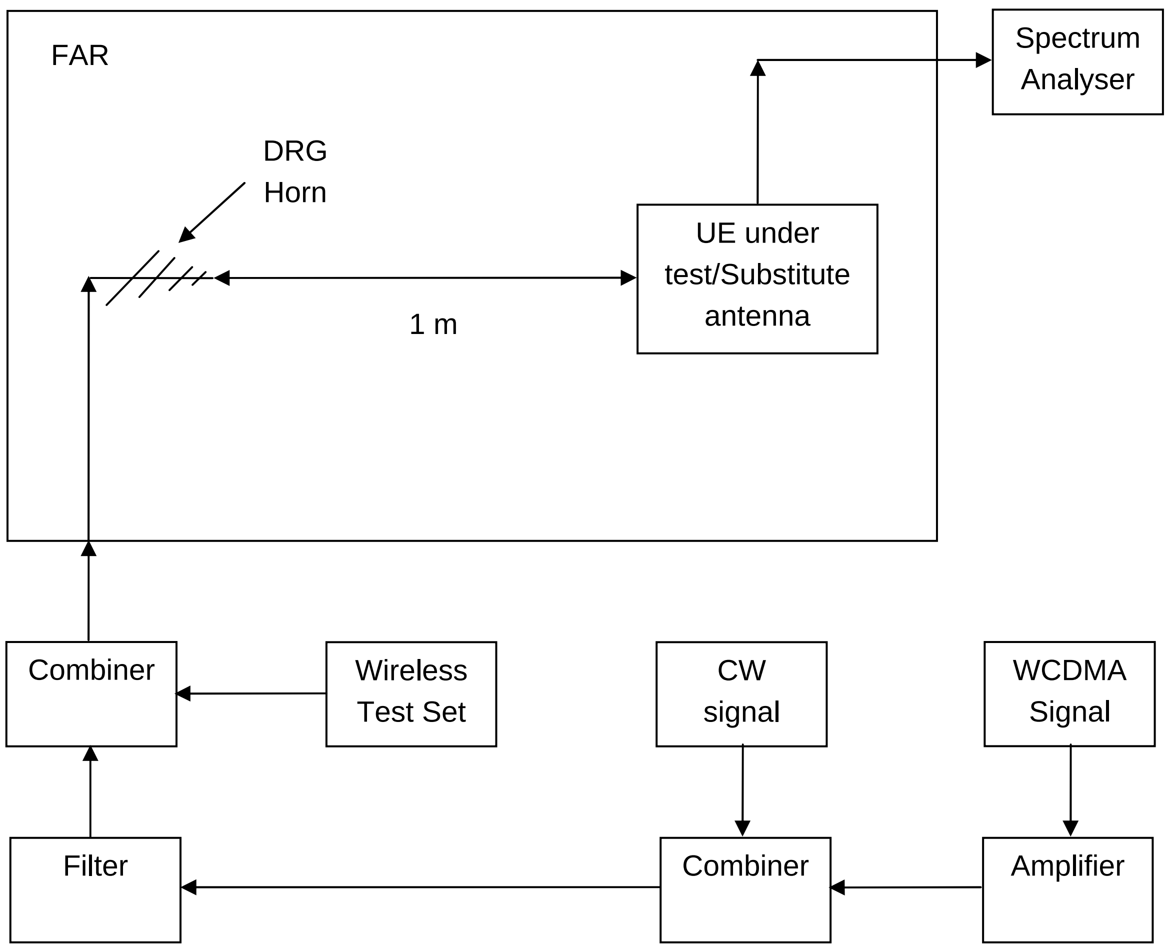

Figure 2: Diagram of radiated set-up for inter-modulation measurements

Based on the method described in Section 6.74 of ETSI TS 134 121 [1] and the figure above, the inter-modulation measurements were carried such that:

1. The power control algorithm was set to 2 on the Agilent 8960 wireless communications test set.
2. The downlink wanted signal power $\hat{I}_{or}$ measured in a 3.84 MHz channel bandwidth was set to -92.7 dBm/3.84 MHz, 14 dB above <REF $\hat{I}_{or}$>[1].
3. A call was set up according to the generic call setup procedure in ETSI TS 134 108 [2].
4. The UE was entered into loopback test mode 1 and the loopback test started.
5. The EIRP of the UE was set up according to the values specified in Table 2.

6. The parameters of the interference signal generators were set up as shown in Table 7 below.
7. The power levels of the interferers were increased or decreased until the BER measured by the wireless test set was 0.001.
8. The power levels of the interferers were recorded on a spectrum analyser using a RMS detector and a measurement channel bandwidth of 3.84 MHz.

Steps 5 to 8 were repeated in 5 dB steps for the downlink wanted signal power $\hat{I}_{or}$, until the limit of the linear operating range of the power amplifier was reached.

Table 7:
ETSI test parameters for inter-modulation characteristics

Parameter	Level		Unit
DPCH_Ec	<REFSENS> +3 dB		dBm / 3,84 MHz
$\hat{I}_{or}$	<REF$\hat{I}_{or}$> +3 dB		dBm / 3,84 MHz
I_{ouw1} (CW)	–46		dBm
I_{ouw2} mean power (modulated)	–46		dBm
F_{uw1} (offset)	10	-10	MHz
F_{uw2} (offset)	20	-20	MHz
UE transmitted mean power	20 (for Power class 3) 18 (for Power class 4)		dBm

Note: Test signal I_{ouw2} used for the inter-modulation measurements was based on 16 dedicated channels of data, whose parameters were taken from Table E.3.6 of ETSI 134 121-1. The common channel information was taken from Table E.4.1 [1].

3. Results

3.1 Spectrum Emission Mask of UE

SEM measurements were made using the Agilent 8960 wireless communications test set. The measurements were made relative to the carrier power of the UE (dBc). The radiated power of the UE was set to 20 dBm for a class 3 handset. All five of the UEs tested were found to be within the ETSI spectrum emission mask limits shown in Table 1 of Section 2.1. The results are summarised in Table 8 below, which also shows the margin between the measured values and the ETSI requirement. A positive margin indicates that the measured UE emissions are below the ETSI SEM mask. Also note that in Table 8 below, the measurement bandwidth is 30 kHz for frequency offsets of 2.5 to 3.5 MHz from the carrier, and is 1 MHz for all other frequency offsets.

Table 8:
Spectrum emission mask results

		Frequency offset from carrier			
		2.5 to 3.5 MHz	3.5 to 7.5 MHz	7.5 to 8.5 MHz	8.5 to 12.5 MHz
UE 1	Level (dBc)	-58.7	-46	-56.2	-55.5
	Margin (dB)	9.8	9.9	6.3	6.5
UE 2	Level (dBc)	-56.5	-43	-53.8	-53.9
	Margin (dB)	7.4	7.1	4.8	4.6
UE 3	Level (dBc)	-55	-40.6	-53	-52.8
	Margin (dB)	5.7	5.1	3.6	3.9
UE 4	Level (dBc)	-59.7	-49.5	-50.7	-49.6
	Margin (dB)	10.9	10.8	1.4	1.1
UE 5	Level (dBc)	-59.5	-46.1	-51.5	-50.8
	Margin (dB)	10.2	11.1	2	1.8

The five UEs tested have a margin of around 6 to 11 dB better than the ETSI mask described in TS 134 121-1 for frequency offsets between 2.5 and 3.5 MHz. For offsets of 3.5 to 7.5 MHz, UE 3 has the least margin of 5.1 dB and UE 5 has the best margin of 11.1 dB. The remaining three UEs have margins somewhere between 5.1 dB and 11.1 dB, better than the ETSI mask.

For frequency offsets of 7.5 to 8.5 MHz, UE 5 has the least margin of 2 dB and UE 1 has the best margin of 6.3 dB. The remaining three UEs have margins somewhere between 2 dB and 6.3 dB, better than the ETSI mask. For frequency offsets between 8.5 to 12.5 MHz, the UE margins drop to between 1.1 dB and 6.5 dB for UEs 4 and 1 respectively. The remaining three UEs have margins somewhere between these two UEs.

Figure 3 shows a comparison of the spectrum emission masks measured with a spectrum analyser, with the UE handsets radiating an EIRP of 20 dBm. The measurements of spectrum emission were performed at a resolution of 18 kHz, then normalised to correspond to a measurement bandwidth of 1 MHz, and finally compared to the carrier power measured over 3.84 MHz. The plot shows that all five handsets are within the ETSI guidelines. However, for frequency separations between 8.5 to 12.5 MHz, the spectrum analyser results are 5 dB to 10 dB better than those measured with the wireless communication test set. This is also shown in Figure 4, for positive frequency offsets.

The difference in results is due to the spectrum analyser having a better noise floor compared with the wireless communications test set.

Beyond 12.5 MHz, the measured emissions drop between -62 dBc to -70 dBc. Note: the noise floor of the spectrum analyser is reached at -70 dBc.

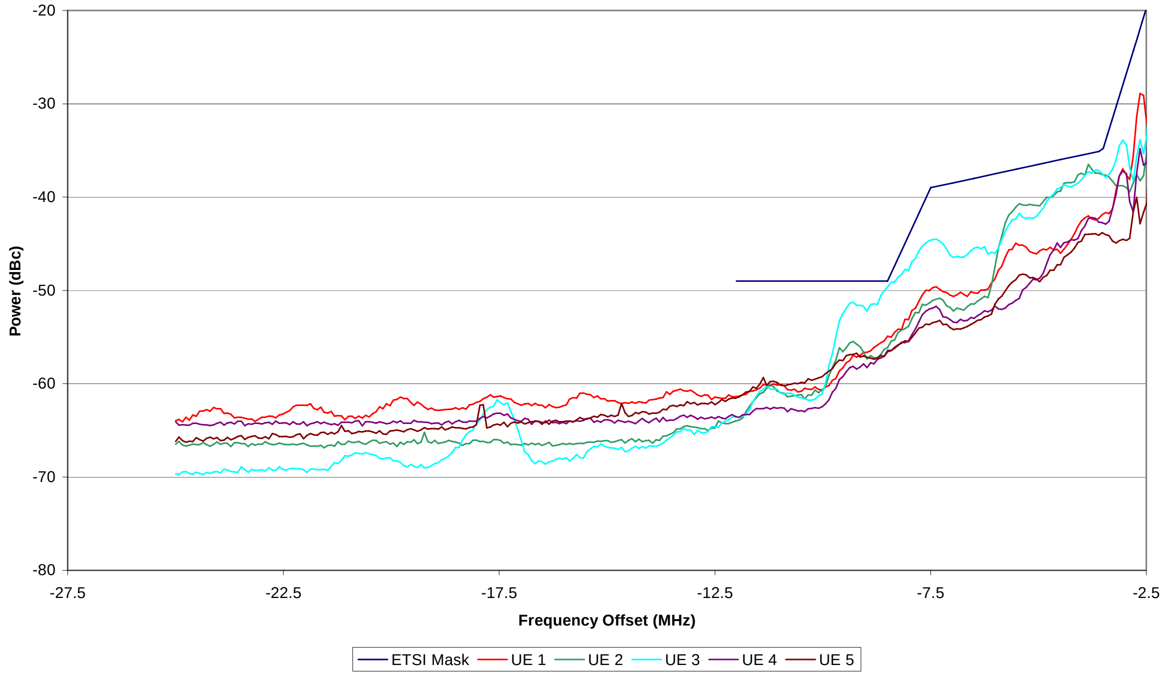

Figure 3: Spectrum emission mask plot for negative frequency offsets

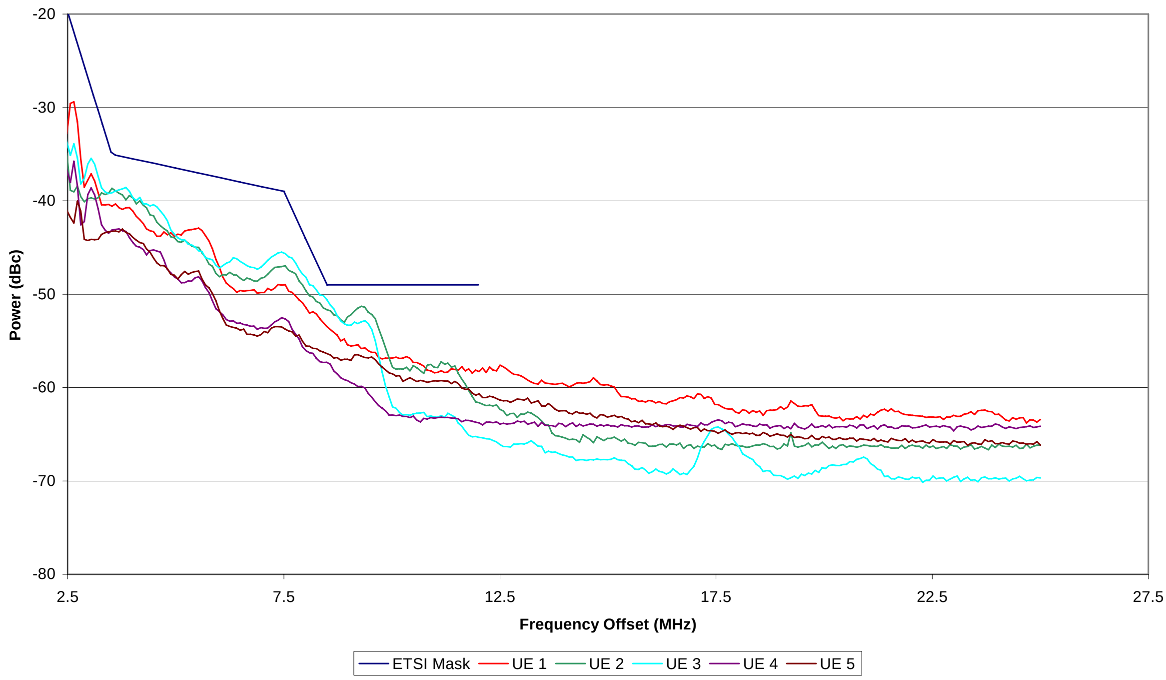

Figure 4: Spectrum emission mask plot for positive frequency offsets

3.2 ACLR of UE

All five of the UEs tested were found to be within the ACLR requirements defined in ETSI TS 134 121-1. The results are summarised in Table 9 below.

Table 9:
ACLR measurement results

Frequency Offset (MHz)	ACLR (dB)					
	ETSI limit (TS 134 121-1)	UE 1	UE 2	UE 3	UE 4	UE 5
-10	43	51.3	48.9	49.6	45.1	45.9
-5	33	42.2	39.2	37.7	42.4	43
5	33	41.6	42.8	40.4	42.2	42.5
10	43	50.8	48.8	50.7	45.2	46

From the table, it can be seen that all five UEs produce ACLRs 7 dB to 10 dB better for a ±5 MHz channel offset and 3 dB to 8 dB better for a ±10 MHz channel offset, when compared with the minimum ACLR requirements defined in TS 134 121-1.

It should be noted that the radiated measurement results will have a higher margin of uncertainty compared with conducted measurements. This measurement uncertainty can be as high as 3 or 4 dB for frequencies around 2 GHz. This overall measurement uncertainty comes from the uncertainty of each calibrated piece of equipment and any mismatch between the antenna cables and measuring receiver.

3.3 Adjacent Channel and Blocking Interference

3.3.1 Adjacent channel (±5 MHz) interference

The ACI measurements were made using the radiated set-up and test procedure described in Section 2.3. Figure 5 below shows a plot of the measured downlink wanted signal power required to achieve a BER of 0.001, as a function of the measured power of a WCDMA interferer which occupies the adjacent (+5 MHz) channel.

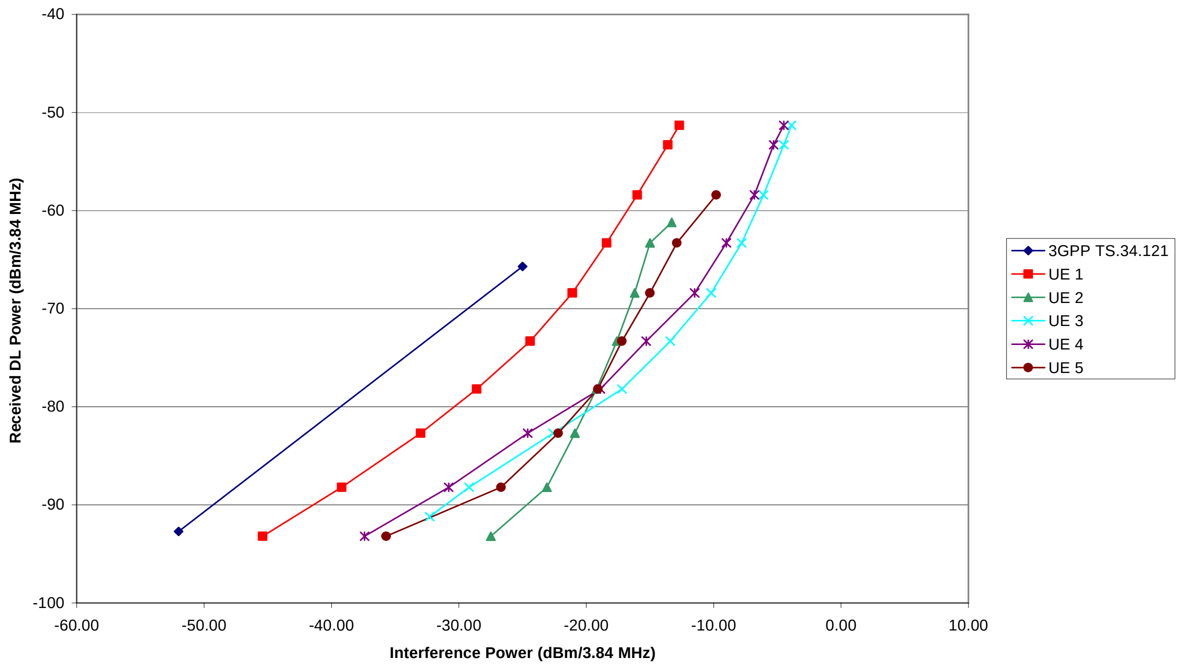

Figure 5: Received DL power vs. interferer power for +5 MHz channel offset

From the plot, UE handset 1 requires the least amount of interferer power to produce a BER of 0.001 compared with the other four UE handsets tested. UE handset 2 starts off being less susceptible to interference for a lower received downlink wanted signal, but becomes less immune for higher downlink wanted signal strengths. UE handsets 3 and 4 have the same trend as UE 1, but consistently require 9 dB to 11 dB more interference to achieve the same BER.

Figure 6 below shows a plot of the measured downlink wanted signal power required to achieve a BER of 0.001, as a function of the measured power of a WCDMA interferer which occupies the adjacent (-5 MHz) channel.

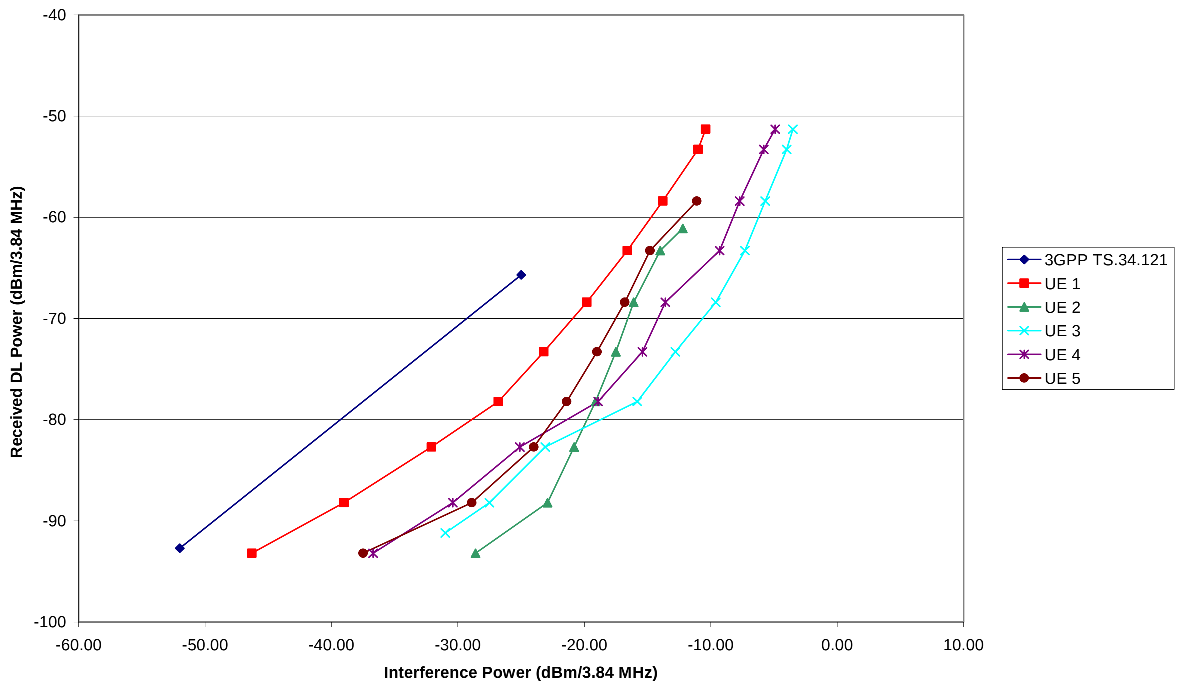

Figure 6: Received DL power vs. interferer power for -5 MHz channel offset

From the plot, UE handset 1 requires the least amount of interferer power to produce a BER of 0.001 compared with the other four UE handsets tested. UE handset 2 starts off being less susceptible to interference for a lower received downlink wanted signal, but becomes less immune for higher downlink wanted signal strengths as mirrored in its calculated ACS. UE handsets 3 and 4 have the same trend as UE 1, but consistently require 7 dB to 11 dB more interference to achieve the same BER.

3.3.2 In-band blocking (±10 MHz) interference

The in-band blocking measurements were made using the radiated set-up and test procedure described in Section 2.4. Figure 7 shows a plot of the measured downlink wanted signal power required to achieve a BER of 0.001, as a function of the measured power of a WCDMA interferer which occupies the 1st blocking (+10 MHz) channel. Figure 8 shows the results for a -10 MHz channel offset.

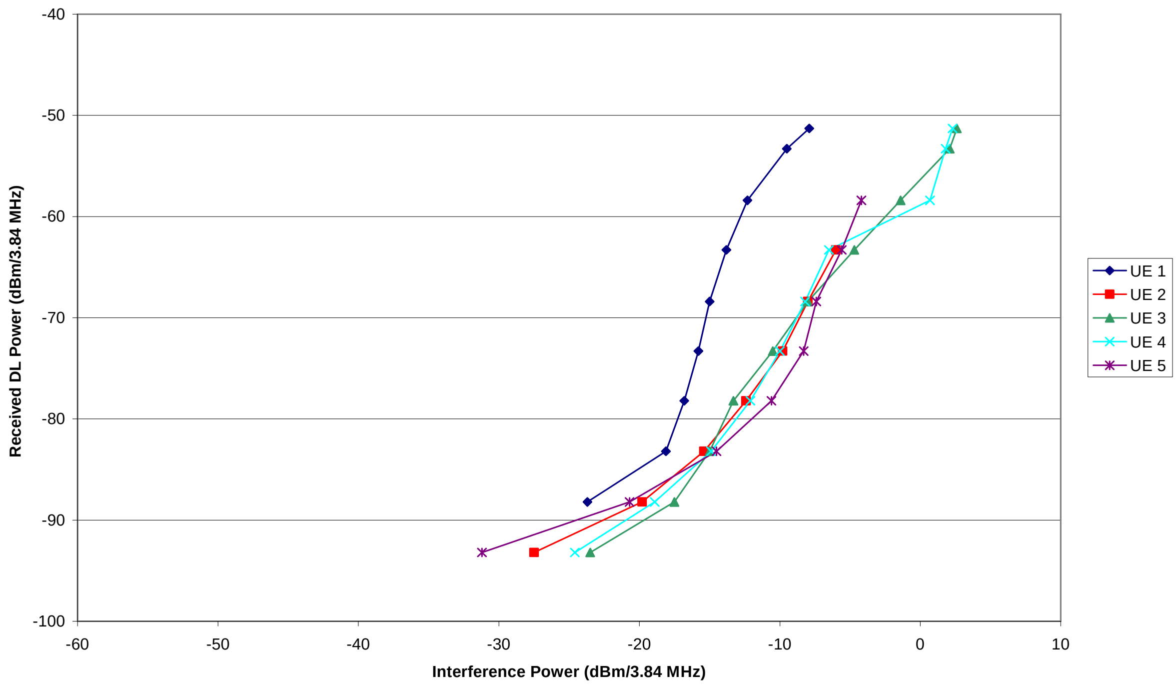

Figure 7: Received DL power vs. interferer power for +10 MHz blocking

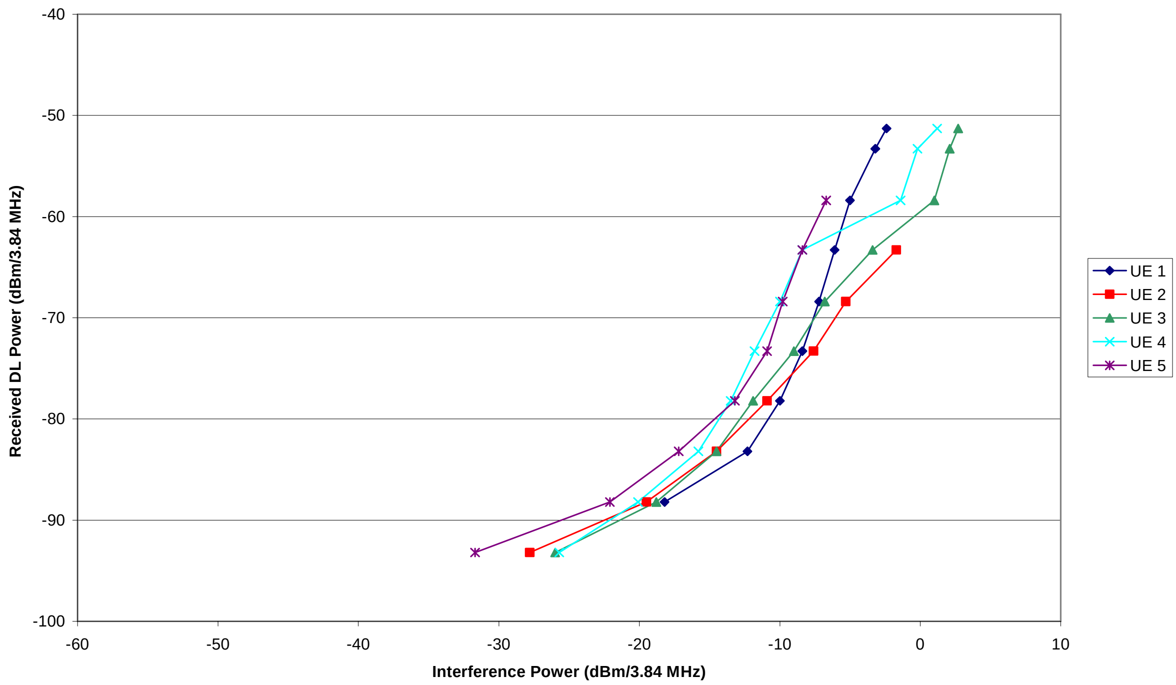

Figure 8: Received DL power vs. interferer power for -10 MHz blocking

The results show that with the exception of UE 1, all the handsets tested require the same amount of interferer power to within ±2 dB, in order to achieve a BER of 0.001 when measuring the blocking performance for a +10 MHz channel offset. An interferer power of between -31 and -24 dBm/3.84 MHz is required to achieve a BER of 0.001 for a received downlink power of -93.2 dBm/3.84 MHz. With the exception of UE 1, this interferer power increases to -7 to -5 dBm/3.84 MHz for a received downlink power of -63.3 dBm/3.84 MHz.

Similarly, all the UE handsets tested require the same amount of interferer power to within ±6 dB, in order to achieve a BER of 0.001 when measuring the blocking performance for a -10 MHz channel offset. An interferer power of between -32 and -26 dBm/3.84 MHz is required to achieve a BER of 0.001 for a received downlink power of -93.2 dBm/3.84 MHz. With the exception of UE 1, this interferer power increases to -8 to -2 dBm/3.84 MHz for a received downlink power of -63.3 dBm/3.84 MHz.

3.3.3 In-band blocking (±15 MHz) interference

Figure 9 shows a plot of the measured downlink wanted signal power required to achieve a BER of 0.001, as a function of the measured power of a WCDMA interferer which occupies the 2nd blocking (+15 MHz) channel. Figure 10 shows the results for a -15 MHz channel offset.

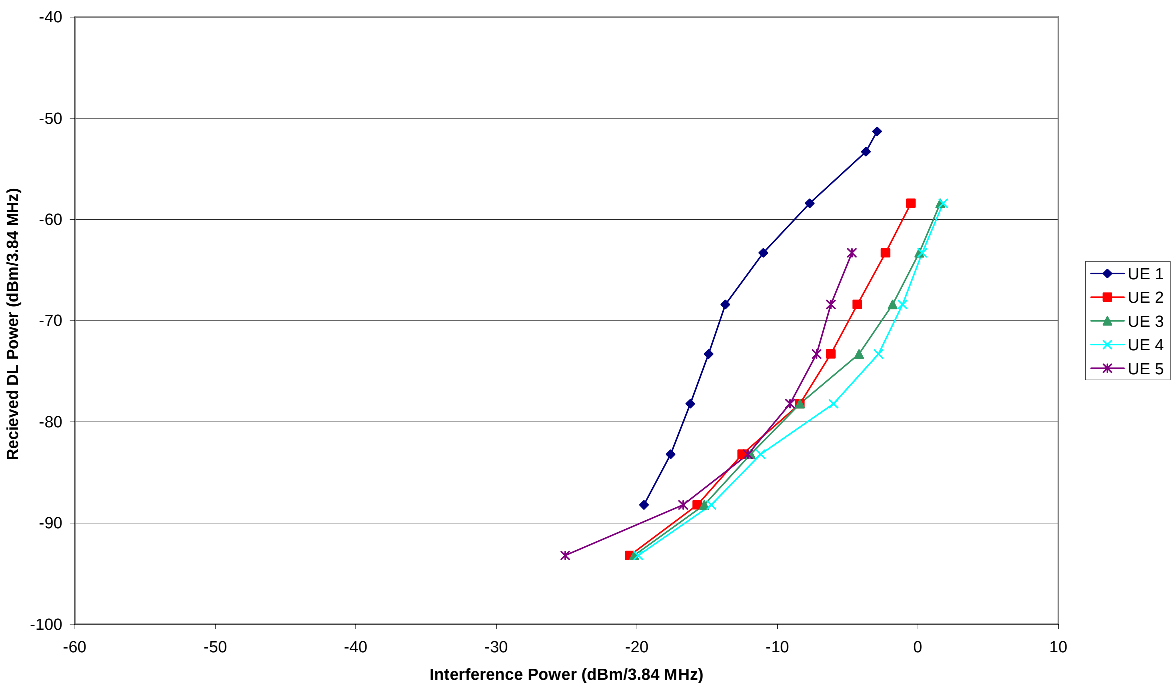

Figure 9: Received DL power vs. interferer power for +15 MHz blocking

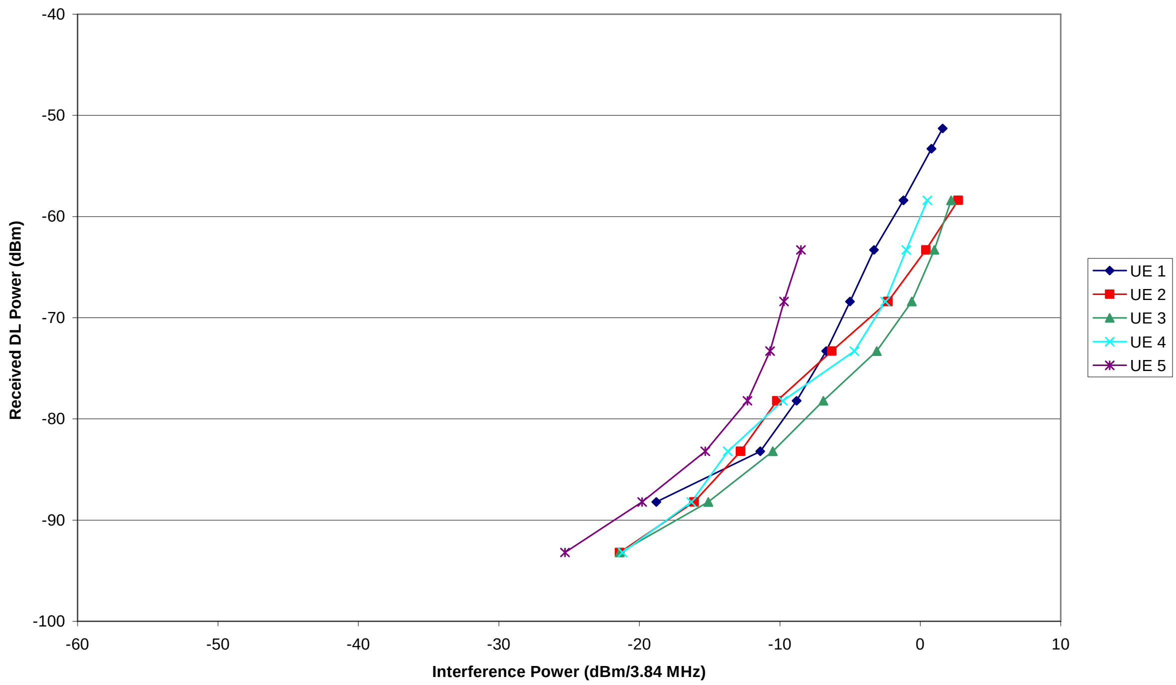

Figure 10: Received DL power vs. interferer power for -15 MHz blocking

The results show that with the exception of UE 1, all the UE handsets tested require the same amount of interferer power to within ±5 dB, in order to achieve a BER of 0.001 when measuring the blocking performance for a +15 MHz channel offset. An interferer power of between -25 and -20 dBm/3.84 MHz is required to achieve a BER of 0.001 for a received downlink power of -93.2 dBm/3.84 MHz. With the exception of UE 1, this interferer power increases to -5 to 0 dBm/3.84 MHz for a received downlink power of -63.3 dBm/3.84 MHz.

Similarly, with the exception of UE 5 all the UE handsets tested require the same amount of interferer power to within ±4 dB, in order to achieve a BER of 0.001 when measuring the blocking performance for a -15 MHz channel offset. An interferer power of between -25 and -21 dBm/3.84 MHz is required to achieve a BER of 0.001 for a received downlink power of -93.2 dBm/3.84 MHz. With the exception of UE 5, this interferer power increases to -3 to -1 dBm/3.84 MHz for a received downlink power of -63.3 dBm/3.84 MHz.

3.4 ACLR of the Interferer

3.4.1 Interferer ACLR at ±5 MHz channel offset

The ACLR of the interferer was measured as the ratio of the carrier power to the power in the sidebands with a ±5 MHz frequency offset in a 3.84 MHz channel bandwidth.

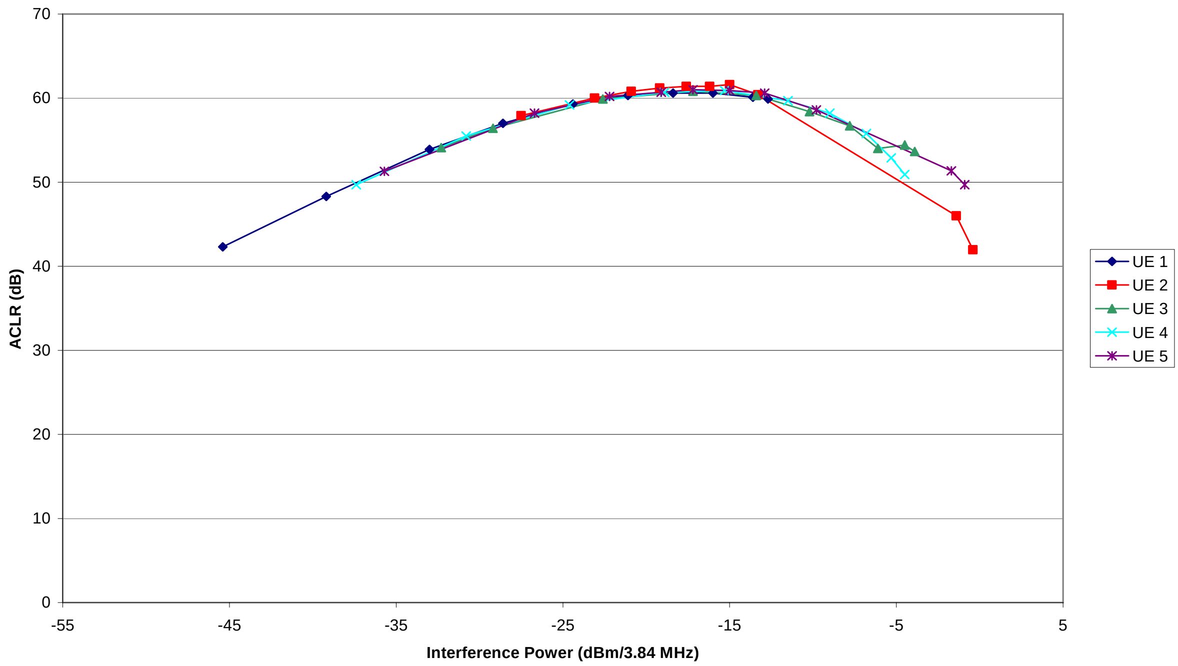

Figure 11: Measured ACLR of the interferer at the adjacent channel (+5 MHz)

Figure 11 shows the ACLR of the interferer for a +5 MHz channel offset as a function of the interferer power. From the plot it can be seen that the ALCR has a value of 61 dB for an interferer power of -15 dBm/3.84 MHz. The reduction of the measured interferer ACLR with decreasing interferer powers is due to the spectrum analyser being unable to measure the power leaked into the adjacent channel when this falls below the analyser's noise floor for low interferer power levels.

The ACLR of the interferer decreases for power levels greater than -15 dBm/3.84 MHz. This is due to the non-linear behaviour of the power amplifier when it is driven into saturation in order to generate high power levels at its output.

Similar interferer ALCR values were measured for a -5 MHz channel offset, as shown in Figure 12.

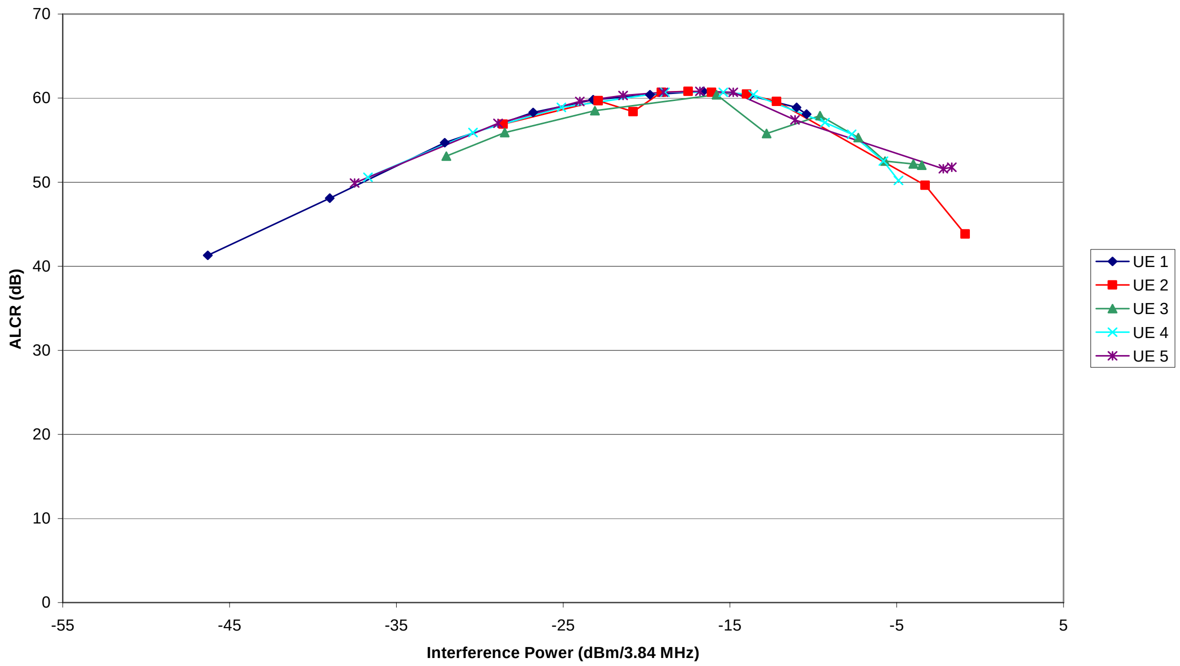

Figure 12: Measured ACLR of the interferer at the 1st adjacent channel (-5 MHz)

3.4.2 Interferer ACLR at ±10 MHz channel offset

The ACLR of the interferer was measured as the ratio of the carrier power to the power in the sidebands with a ±10 MHz frequency offset in a 3.84 MHz channel bandwidth.

Figure 13 shows the ACLR of the interferer for a +10 MHz channel offset as a function of the interferer power. From the plot it can be seen that the ALCR increases from 55 dB for an interferer power of -30 dBm/3.84 MHz to 61 dB for an interferer power of -25 dBm/3.84 MHz. This ACLR value of 61 dB remains constant for interferer powers up to and beyond 0 dBm/3.84 MHz.

The ACLR of the interferer decreases for power levels greater than -15 dBm/3.84 MHz. This is due to the non-linear behaviour of the power amplifier when it is driven into saturation in order to generate high power levels at its output.

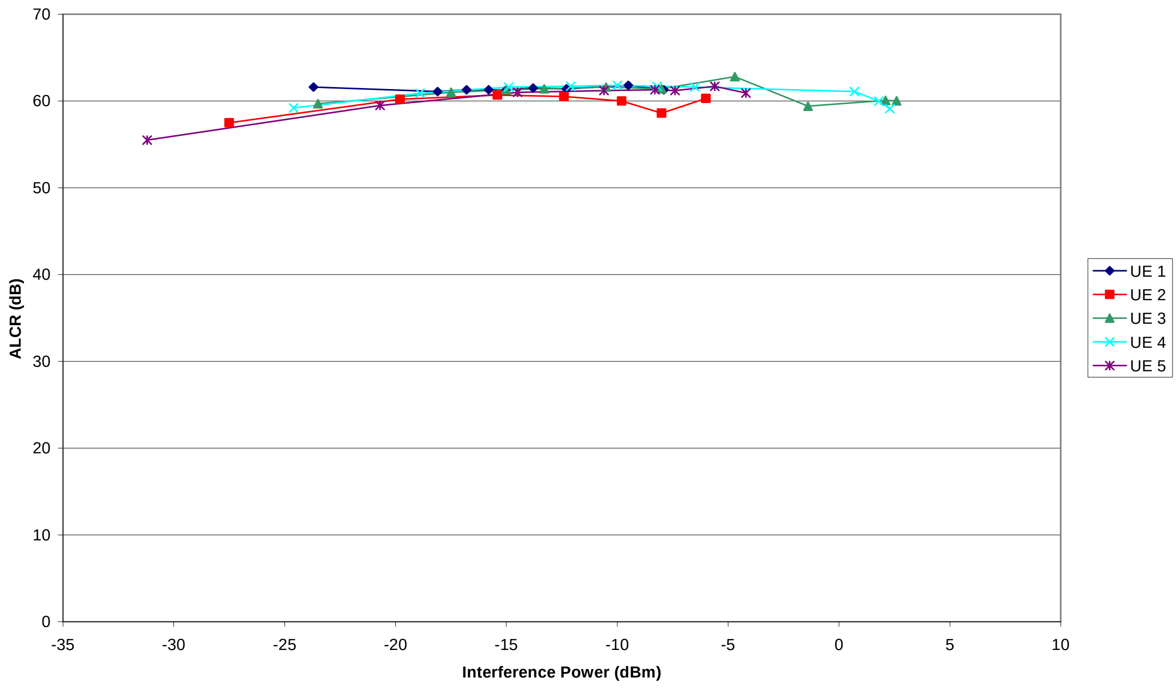

Figure 13: Measured ACLR of the interferer at the 1st blocking channel (+10 MHz)

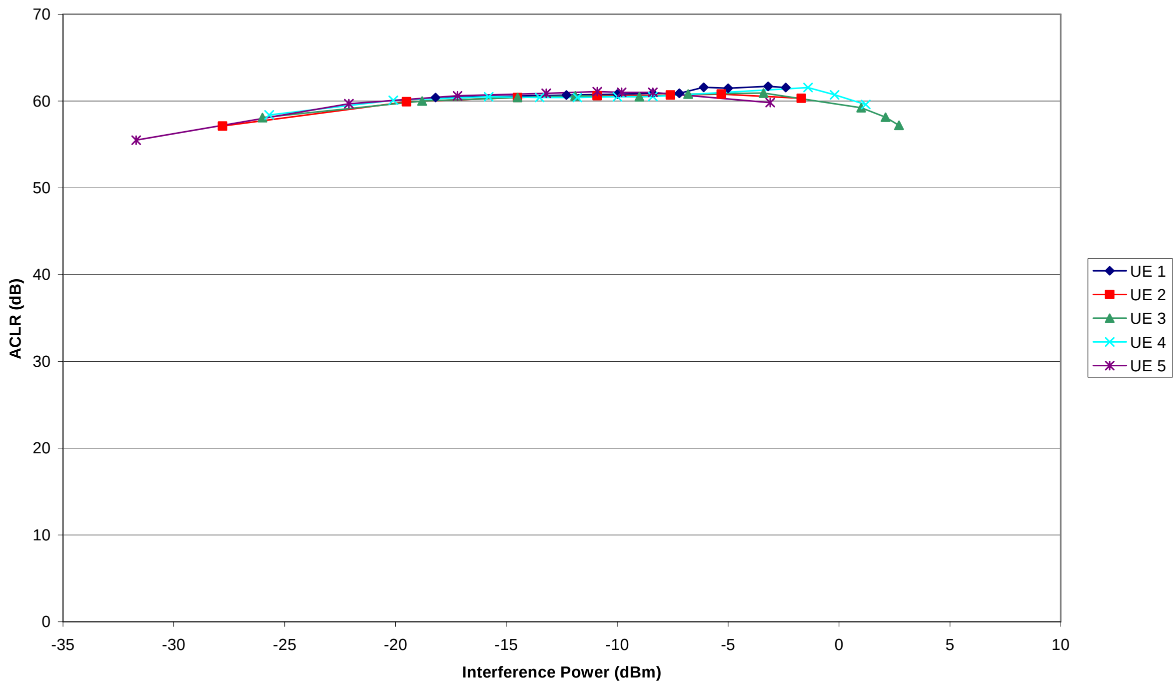

Figure 14: Measured ACLR of the interferer at the 1st blocking channel (-10 MHz)

Figure 14 shows the ACLR of the interferer for a -10 MHz channel offset. From the plot it can be seen that the ALCR increases from 55 dB for an interferer power of -30 dBm/3.84 MHz to 61 dB for an interferer power of -25 dBm/3.84 MHz. This ACLR value of 61 dB remains constant for interferer powers up to 0 dBm/3.84 MHz.

Beyond 0 dBm/3.84 MHz, the ACLR of the interferer starts to slightly decrease again. This is due to the non-linear behaviour of the power amplifier when it is driven into saturation in order to generate high power levels at its output.

3.4.3 Interferer ACLR at ±15 MHz channel offset

No detailed measurements of interferer ACLR were undertaken for frequency offsets of ±15 MHz. This was primarily due to the limited sensitivity of the test equipment

However, an inspection of the interferer power spectral densities illustrated in Figure 15 indicates an ACLR of between 64 and 65 dB for a blocking channel with ±15 MHz offset from the carrier frequency. Moreover, this ACLR was seen to be somewhat insensitive with respect to the saturation of the power amplifier.

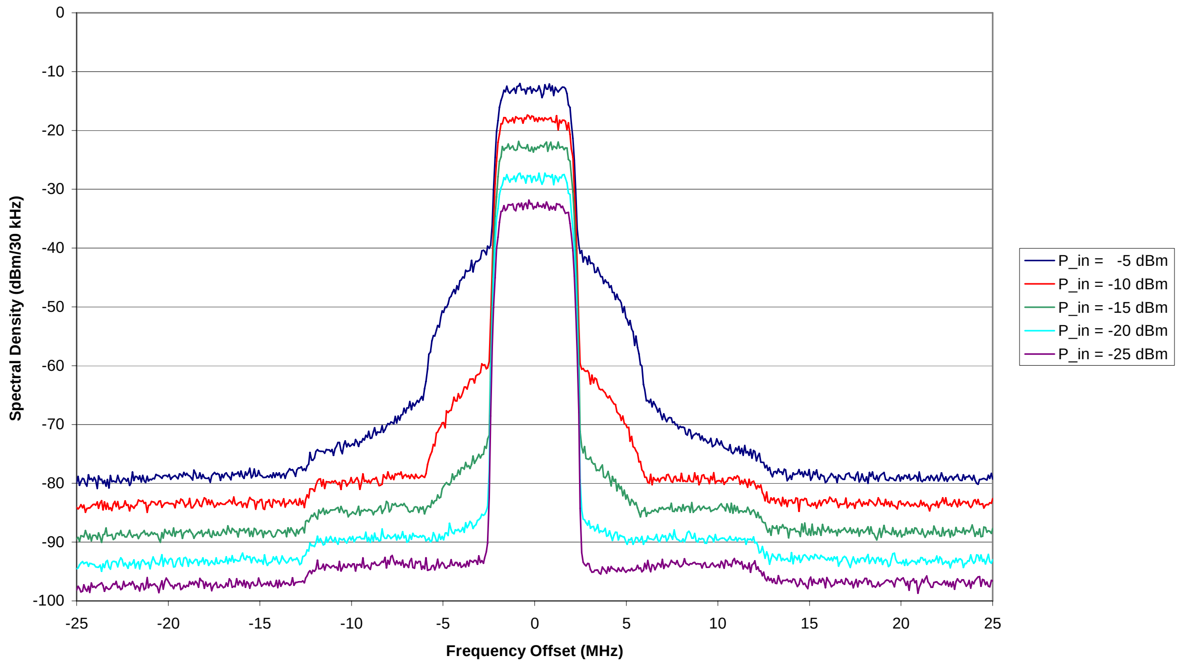

Figure 15: Spectral density of the WCDMA interferer as a function of input power to the power amplifier

For the purposes of this study, an over-estimated interferer ALCR of 65 dB for the ±15 MHz blocking channel was assumed, with the understanding that this would result in an underestimation of the UE receiver frequency selectivity in the calculations of the following sections.

3.5 ACS Calculations

The ACS was calculated using the following formula:

$$\frac{1}{ACIR} = \frac{1}{\frac{1}{ACLR} + \frac{1}{ACS}}$$

Eq. 1

The ACIR was measured as the ratio of the total adjacent channel interferer power to the total amount of interference affecting the UE under test (see Step 12 in Sections 2.3 and 2.4). The amount of interference, in this case AWGN, affecting the UE was measured as the co-channel power required to achieve the same BER of 0.001 as for the adjacent channel interference measurements. A carrier-to-noise (C/N) of -7.2 dB ± 1 dB was consistently measured at different carrier levels for all 5 UEs.

3.5.1 ACS at ±5 MHz channel offset

Figure 16 shows the calculated ACS results for a +5 MHz channel offset as a function of the interferer power in the adjacent channel.

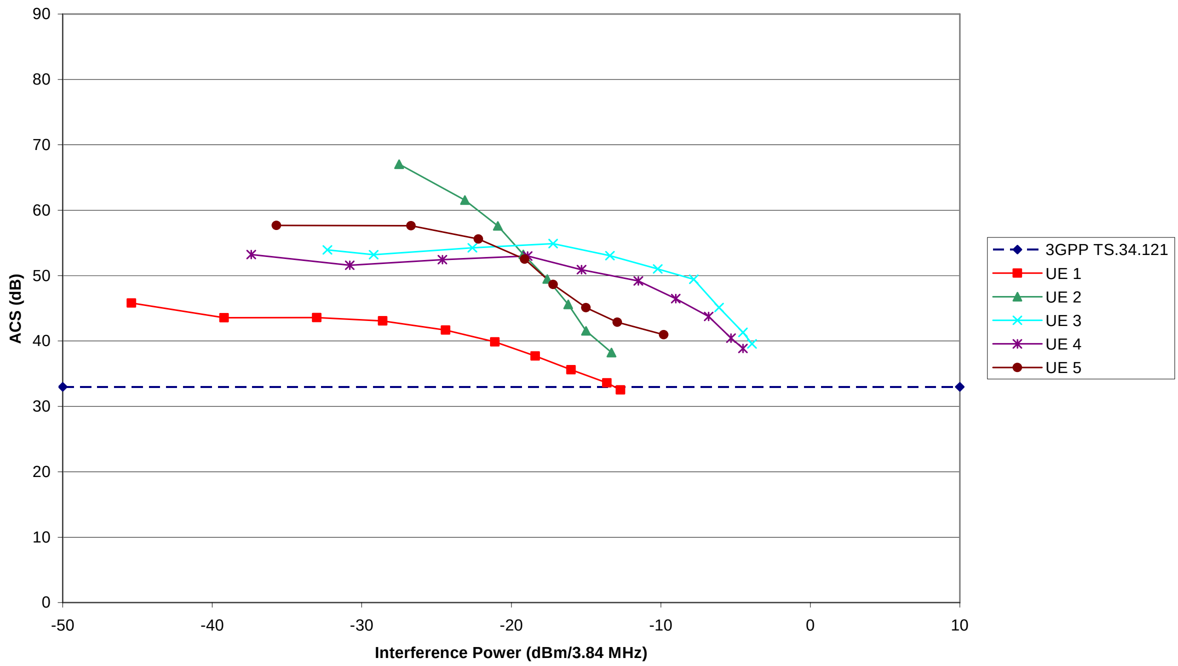

Figure 16: Calculated ACS for five UMTS UEs at +5 MHz channel offset

The results show that as the interferer power increases, the ACS of the UE drops. From Figure 16, it can be seen that UE 1 has the lowest measured ACS, which for a received downlink power of -12.7 dBm/3.84 MHz falls below the 33 dB level specified in ETSI TS 134 121-1. UE handsets 2 has the greatest ACS of 67 dB for an interferer power of -27.5 dBm/3.84 MHz, but drops off quickly with increasing interferer power. UE handsets 3 and 4 have the best measured ACS performance over the entire range tested, 21 dB and 20 dB above the required minimum level set in TS 134 121-1 for an interferer power of -32.3 and -37.4 dBm/3.84 MHz respectively. These measured ACS values drop to 7 dB and 6 dB above the required minimum level of 33 dB for UE handsets 3 and 4 respectively, for an interferer power of -5 dBm/3.84 MHz.

All five handset tested were well within the ACS test parameters given in Table 4 with at least 9 dB to 30 dB of more selectivity to produce a BER of 0.001, for an interferer power of -25 dBm/3.84 MHz.

Figure 17 shows the calculated ACS results for a -5 MHz channel offset as a function of the interferer power in the adjacent channel. The results show that as the interferer power increases, the ACS of the UE drops in a similar manner to the positive channel offset results.

When averaged across both channel offsets for all five tested UEs, the results indicate that a UE receiver ACS of 33 dB can be achieved for interferer power levels of up to –10 dBm/

3.84 MHz or greater. This is compared with an ETSI minimum ACS requirement of 33 dB for an interferer power level of –25 dBm/3.84 MHz[2].

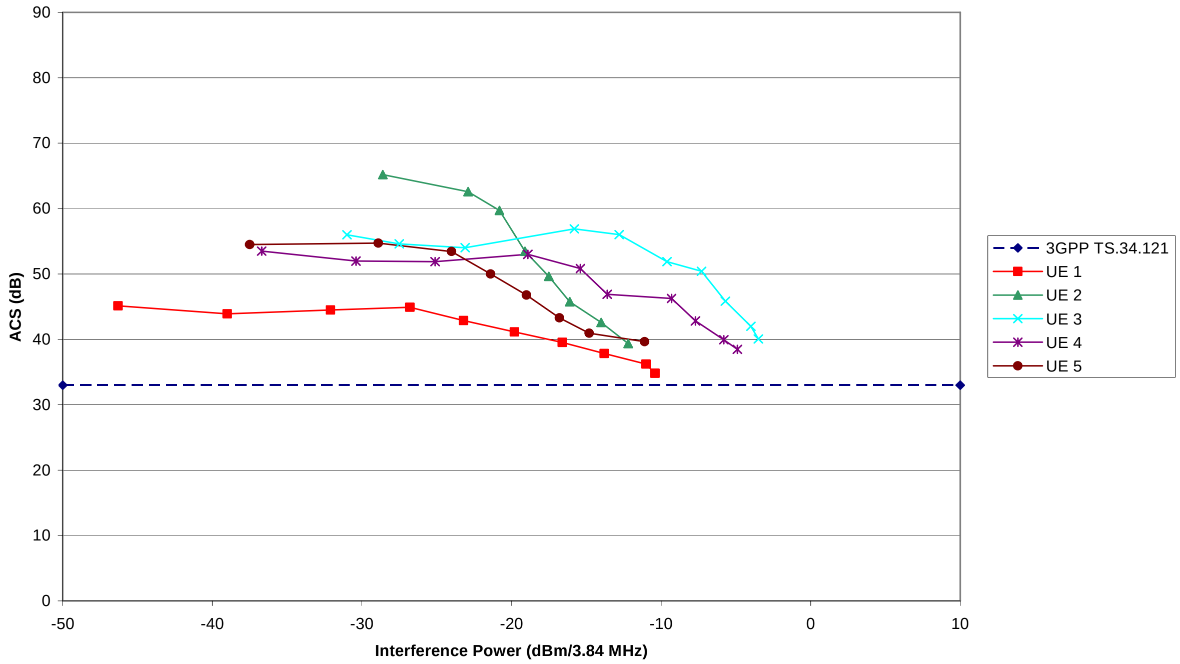

Figure 17: Calculated ACS for five UMTS UEs at -5 MHz channel offset

[2] ETSI TS 125 101-1 directly specifies a minimum ACS of 33 dB at the 1st adjacent channel (±5 MHz). ETSI TS 125 101-1 also specifies ACS indirectly by requiring that a terminal station is desensitised by no more than 14 (or 41) dB with respect to reference sensitivity performance, when subjected to a test interferer power of –52 (or –25) dBm/3.84 MHz received in the adjacent channel.

The indirect specification can be interpreted as described next. Assuming a terminal station receiver noise figure of 9 dB, the thermal noise floor can be computed to be kTBNF = –99 dBm/3.84 MHz. The desensitisation of 14 (or 41) dB implies that the interference experienced by the receiver is –85 (or –58) dBm/3.84 MHz, which when compared to the specified interferer power of –52 (or –25) dBm/3.84 MHz, implies an ACIR or 33 dB. Finally, if the ACLR of the test interferer is significantly greater than the ACIR, then ACS ≈ ACIR = 33 dB. In other words, the direct and indirect specifications are consistent.

3.5.2 ACS at ±10 MHz channel offset

Figure 18 shows the calculated ACS results for a +10 MHz channel offset as a function of the interferer power in the 1st blocking channel. With the exception of UE 1, the plot shows that as the interferer power increases from -15 to 0 dBm/3.84 MHz, the ACS of the UE on average drops from 70 dB to 45 dB respectively.

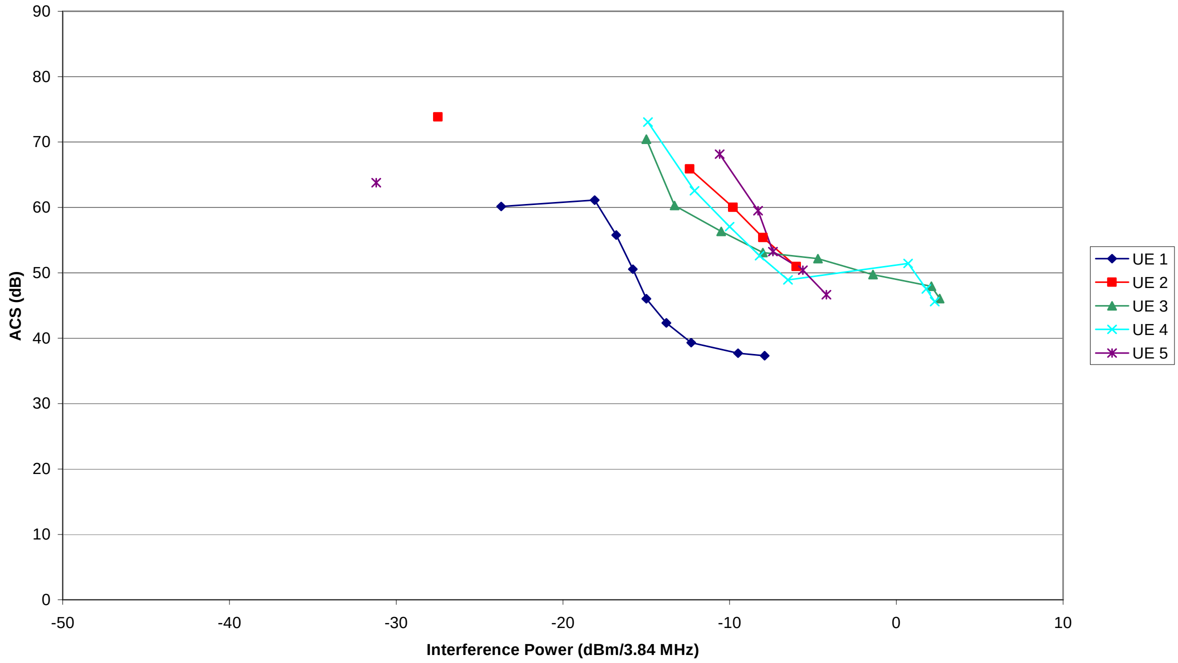

Figure 18: Calculated ACS for five UMTS UEs at +10 MHz channel offset

This reduction in the UE receiver ACS for interferer power levels greater than –15 dBm/ 3.84 MHz in the +10 MHz channel offset is due to the onset of non-linear behaviour within the UE receiver chain.

The plot also shows a gap between data points around an interferer power of -20 dBm/ 3.84 MHz for UEs 2 and 5. This is due to the measured ALCR of the interferer not being large enough compared with the measured ACIR to produce a positive ACS value.

Figure 19 shows the calculated ACS results for a -10 MHz channel offset as a function of the interferer power in the 1st blocking channel. With the exception of UEs 1 and 2, the plot shows that as the interferer power increases from -15 to 0 dBm/3.84 MHz, the ACS of the UE on average drops from 65 dB to 45 dB respectively. This reduction in the UE receiver ACS for interferer power levels greater than –15 dBm/3.84 MHz in the +10 MHz channel offset is again due to the onset of non-linear behaviour within the UE receiver chain.

The plot also shows a gap between data points for UEs 1 and 3. This is again due to the measured ALCR of the interferer not being large enough compared with the measured ACIR to produce a positive ACS value.

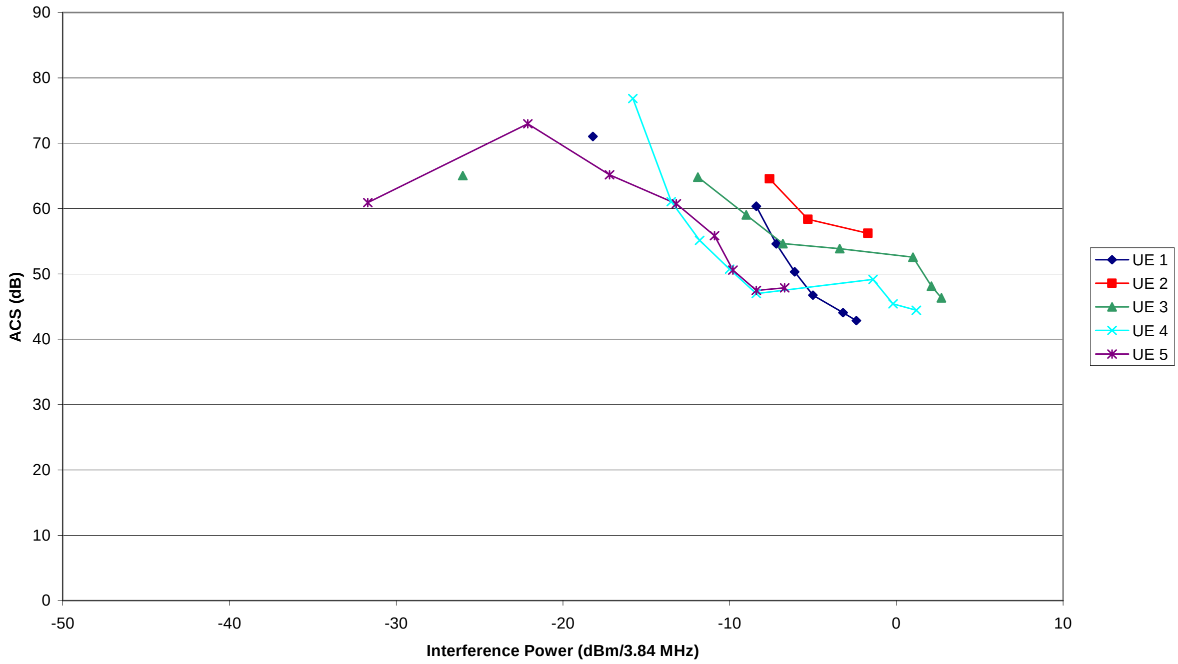

Figure 19: Calculated ACS for five UMTS UEs at -10 MHz channel offset

When averaged across both positive and negative channel offsets for all five tested UEs, the results indicate a UE receiver ACS of 43 dB can be achieved for interferer power levels of up to 0 dBm/3.84 MHz or greater. This is compared with an ETSI minimum ACS requirement of 43 dB for an interferer power level of –56 dBm/3.84 MHz[3].

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[3] ETSI TS 125 101-1 specifies blocking performance by requiring that a terminal station is desensitised by no more than 3 dB with respect to reference sensitivity performance, when subjected to a test interferer power of –56 dBm/3.84 MHz received in the 1st blocking channel (±10 MHz).

Assuming a terminal station receiver noise figure of 9 dB, the thermal noise floor can be computed to be *kTB*NF = –99 dBm/3.84 MHz. The desensitisation of 3 dB implies that the interference experienced by the receiver is also –99 dBm/3.84 MHz, which when compared to the specified interferer power of –56 dBm/3.84 MHz,

3.5.3 ACS at ±15 MHz channel offset

Figure 20 shows the calculated ACS results for a +15 MHz channel offset as a function of the interferer power in the 2nd blocking channel. With the exception of UE 1 and 4, the plot shows that as the interferer power increases from -15 to 0 dBm/3.84 MHz, the ACS of the UE on average drops from 70 dB to 50 dB respectively. This reduction in the UE receiver ACS for interferer power levels greater than –15 in the +15 MHz channel offset is due to the onset of non-linear behaviour within the UE receiver chain.

The plot also shows a gap between an interferer power of -25 and -10 dBm/3.84 MHz for UE 3. This is due to the measured ALCR of the interferer not being large enough compared with the measured ACIR to produce a positive ACS value.

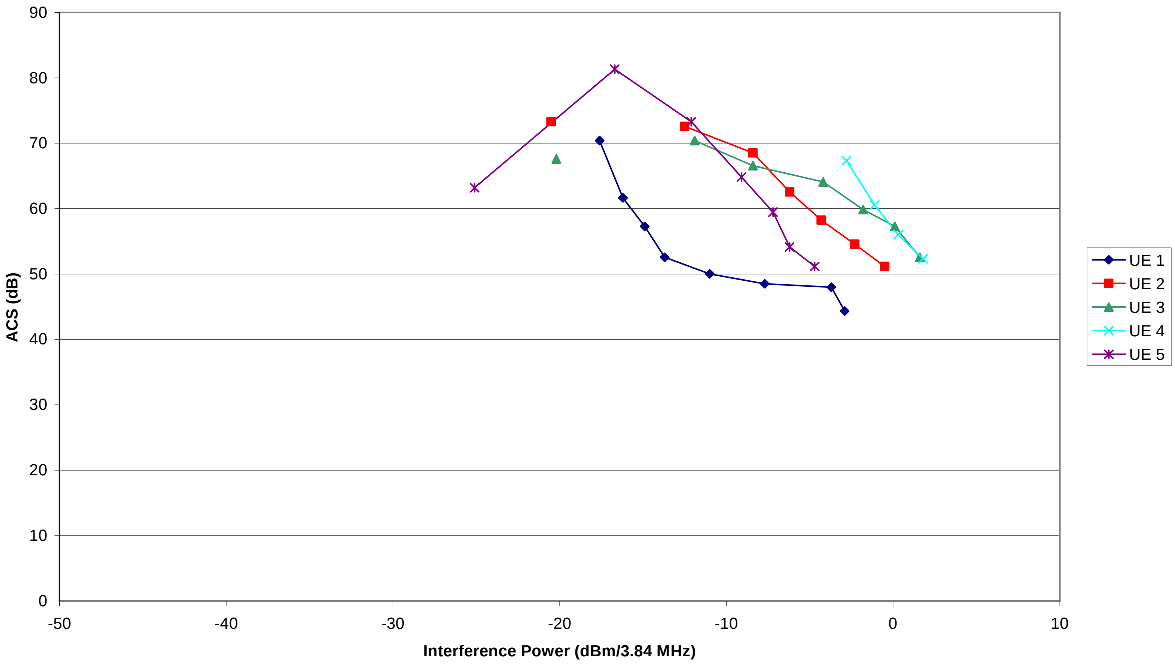

Figure 20: Calculated ACS for five UMTS UEs at +15 MHz channel offset

implies an ACIR or 43 dB. Finally, if the ACLR of the test interferer is significantly greater than the ACIR (as implied in TS 25.101), then ACS ≈ ACIR = 43 dB.

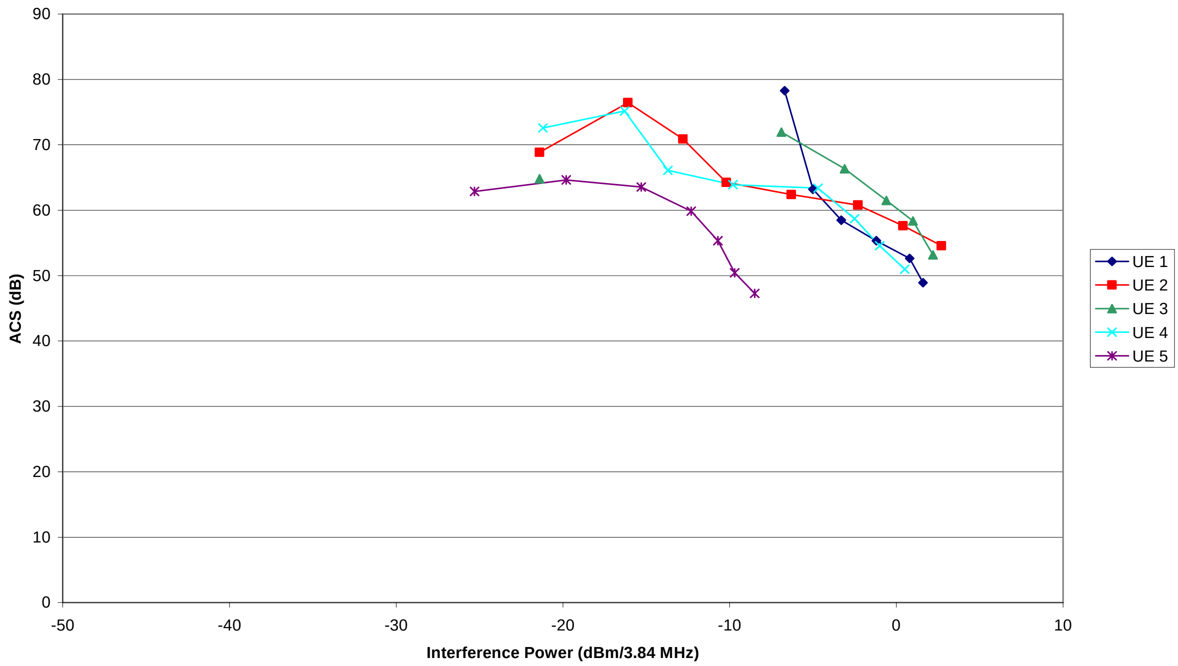

Figure 21: Calculated ACS for five UMTS UEs at -15 MHz channel offset

Figure 21 shows the calculated ACS results for a -15 MHz channel offset as a function of the interferer power in the 2nd adjacent channel. The plot shows that as the interferer power increases from -15 to 0 dBm/3.84 MHz, the ACS of the UEs 2 and 3 on average drops from 75 dB to 50 dB respectively. This reduction in the UE receiver ACS for interferer power levels greater than –15 dBm/3.84 MHz in the -15 MHz channel offset is again due to the onset of non-linear behaviour within the UE receiver chain.

The plot also shows a gap between an interferer power of -20 and -10 dBm/3.84 MHz for UE 3. This is again due to the measured ALCR of the interferer not being large enough compared with the measured ACIR to produce a positive ACS value.

When averaged across both positive and negative channel offsets for all five tested UEs, the results indicate a UE receiver ACS of 55 dB can be achieved for interferer power levels of up to –3 dBm/3.84 MHz or greater. This is compared with an ETSI minimum ACS requirement of 55 dB for an interferer power level of –44 dBm/3.84 MHz[4].

3.6 Inter-modulation

The inter-modulation measurements were made using the radiated set-up and test procedure described in Section 2.5. Figure 22 shows a plot of the measured downlink wanted signal power required to achieve a BER of 0.001, as a function of the power of two (equi-power) interferers occupying the 1st and 3rd blocking (+10 MHz, +20 MHz) channels Figure 23 shows the results for negative channel offsets (-10 MHz, -20 MHz).

[4] 3GPP TS 25.101 specifies blocking performance by requiring that a terminal station is desensitised by no more than 3 dB with respect to reference sensitivity performance, when subjected to a test interferer power of –44 dBm/3.84 MHz received in the 2nd blocking channel (±15 MHz).

Assuming a terminal station receiver noise figure of 9 dB, the thermal noise floor can be computed to be *kTB*NF = –99 dBm/3.84 MHz. The desensitisation of 3 dB implies that the interference experienced by the receiver is also –99 dBm/3.84 MHz, which when compared to the specified interferer power of –44 dBm/3.84 MHz, implies an ACIR or 55 dB. Finally, if the ACLR of the test interferer is significantly greater than the ACIR (as implied in TS 25.101), then ACS ≈ ACIR = 55 dB.

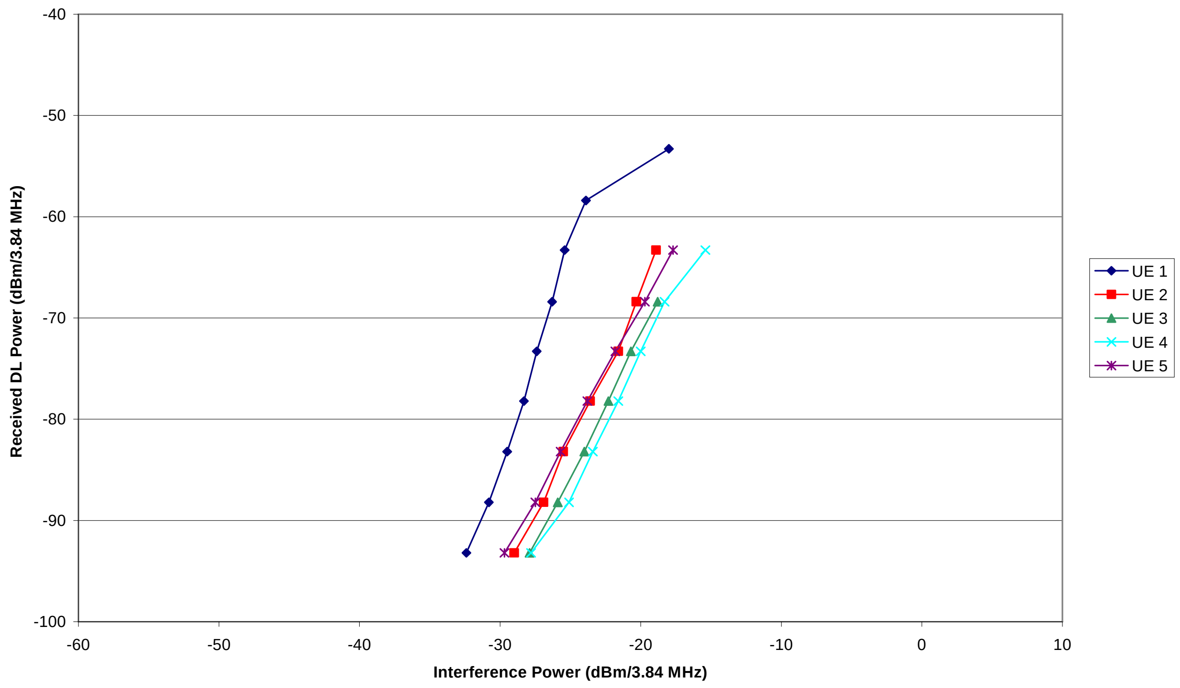

Figure 22: Received DL power vs. interferer power for +ve frequency offsets

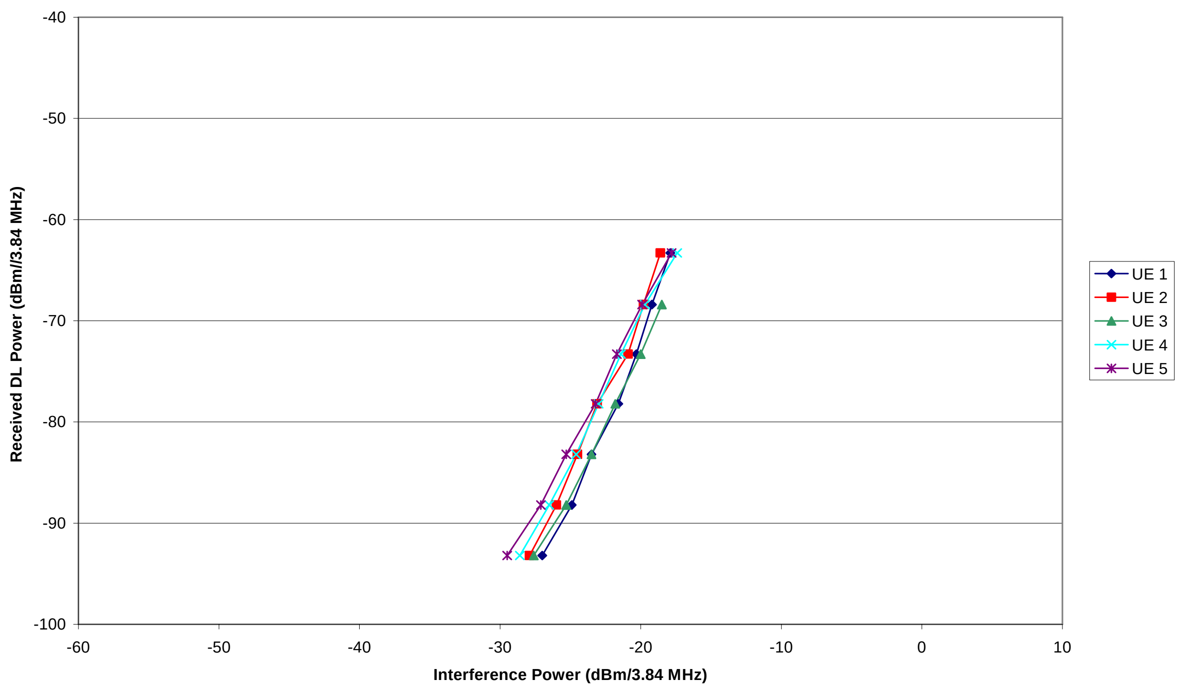

Figure 23: Received DL power vs. interferer power for -ve frequency offsets

The results show that, with the exception of UE 1, all the handsets tested require the same amount of interferer power to within ±3 dB, in order to achieve a BER of 0.001 when measuring the inter-modulation for a positive channel offset. An interferer power of between -30 and -28 dBm/3.84 MHz is required to achieve a BER of 0.001 for a received downlink power of -93.2 dBm/3.84 MHz. With the exception of UE 1, this interferer power increases to -19 to -15 dBm/3.84 MHz for a received downlink power of -63.3 dBm/3.84 MHz.

The plot also shows that for every 10 dB increase in the interferer power, a 30 dB increase in the received downlink wanted signal power is required to maintain a fixed BER.

Similarly, all the UE handsets tested require the same amount of interferer power to within ±3 dB, in order to achieve a BER of 0.001 when measuring the inter-modulation for positive channel offsets. An interference power of between -30 and -27 dBm/3.84 MHz is required to achieve a BER of 0.001 for a received downlink power of -93.2 dBm/3.84 MHz. This interference power increases to -19 to -17 dBm/3.84 MHz for a received downlink power of -63.3 dBm/3.84 MHz.

As with the inter-modulation measurements for positive channel offsets, the above plot also shows that for every 10 dB increase in the interference power, a 30 dB increase in the received downlink wanted signal power is required to maintain a fixed BER.

4. Conclusions

The RF performance of a range of UMTS handsets operating in the bands 1920 – 1980 and 2110 – 2170 MHz were measured in order to determine:

- Spectrum emission mask and adjacent channel leakage ratio.
- Receiver adjacent channel selectivity.
- Receiver blocking performance.
- Receiver inter-modulation characteristics.

Measurements were performed on five UE handsets from different manufacturers that are commonly available on the UK market. All measurements were undertaken in accordance with the test methods defined in ETSI performance standard TS 134 121-1 v8.0.0 (2007-10) [1]. The results are summarised below.

UE spectrum emission mask measurements

For the five UEs tested, measurements show that the emission spectra are 10 dB lower than the ETSI mask described in TS 134 121-1 for frequency offsets of between 2.5 and 3.5 MHz, when measured with the wireless communications test set. For frequency offsets of 3.5 to 7.5 MHz, the above margin drops to between 5.1 dB and 11.1 dB. For frequency offsets of

7.5 to 8.5 MHz, the margin drops further to between 2 dB and 6.3 dB. For frequency separations of 8.5 to 12.5 MHz, the margin drops to between 1.1 dB and 6.5 dB. However, for frequency separations between 8.5 to 12.5 MHz, the spectrum analyser results are 5 dB to 10 dB better than that measured with the wireless communication test set. The difference in results is due to the spectrum analyser having a better noise floor compared with the wireless communications test set.

UE ACLR measurements

The ALCR measured results for the five UEs reveal an ACLR that is 7 to 10 dB greater for a ±5 MHz channel offset, and 3 to 8 dB greater for a ±10 MHz channel offset, when compared with the minimum ACLR requirements defined in ETSI TS 134 121-1.

Adjacent channel ±5 MHz interference results

The UE receiver performance for adjacent channel ±5 MHz interference, when averaged across all tested UEs, produced an ACS of around 55 dB for interferer power levels of up to –25 dBm/3.84 MHz.

The measurements show that there is generally a reduction in the UE receiver ACS for interferer power levels greater than –25 dBm in the ±5 MHz adjacent channel. This is due to the onset of non-linear behaviour within the UE receiver chain, which results in a greater than proportional increase in the levels of experienced interference for an increase in interferer power.

When averaged across all tested UEs, the results indicate a UE receiver ACS of 33 dB can be achieved for interferer power levels of up to –10 dBm/3.84 MHz or greater. This is compared with an ETSI minimum requirement for an ACS of 33 dB for an interferer power level of –25 dBm/3.84 MHz.

In-band ±10 MHz blocking interference results

The UE receiver performance for in-band ±10 MHz blocking interference, when averaged across all tested UEs, produced an ACS of around 65 dB for interferer power levels of up to –15 dBm/3.84 MHz.

The measurements show that there is generally a reduction in the UE receiver ACS for interferer power levels greater than –15 dBm/3.84 MHz in the ±10 MHz blocking channel, again due to the onset of non-linear behaviour within the UE receiver chain.

When averaged across all tested UEs, the results indicate a UE receiver ACS of 43 dB can be achieved for interferer power levels of up to 0 dBm/3.84 MHz or greater. This is compared with an ETSI minimum requirement for ACS of 43 dB for an interferer power level of –56 dBm/3.84 MHz.

In-band ±15 MHz blocking interference results

The UE receiver performance for in-band ±10 MHz blocking interference, when averaged across all tested UEs, produced an ACS of around 70 dB for interferer power levels of up to –15 dBm/3.84 MHz.

The measurements show that there is generally a reduction in the UE receiver ACS for interferer power levels greater than –15 dBm/3.84 MHz in the ±15 MHz blocking channel, again due to the onset of non-linear behaviour within the UE receiver chain.

When averaged across all tested UEs, the results indicate a UE receiver ACS of 55 dB can be achieved for interferer power levels of up to –3 dBm/3.84 MHz or greater. This is compared with an ETSI minimum requirement for ACS of 55 dB for an interferer power level of –44 dBm/3.84 MHz.

Inter-modulation results

Measurements of inter-modulation effects caused by interferers with positive frequency offsets with respect to the wanted signal indicate that an interferer power of between -30 dBm/3.84 MHz and -28 dBm/3.84 MHz is required to achieve a BER of 0.001 for a received downlink wanted signal power of -93.2 dBm/3.84 MHz. With the exception of UE 1, this interferer power increases to -19 dBm/3.84 MHz to -15 dBm/3.84 MHz for a received downlink wanted signal power of -63.3 dBm/3.84 MHz. Similar results were measured for inter-modulation effects caused by interferers with negative frequency offsets with respect to the wanted signal.

5. References

[1] ETSI TS 134 121-1 v8.0.0 (2007-10): Universal Mobile Telecommunications System (UMTS); User Equipment (UE) conformance specification; Radio transmission and reception (FDD); Part 1: Conformance specification (3GPP TS 34.121 version 8.0.0 Release 8).

[2] ETSI TS 134 108 v8.0.0 (2007-10): Universal Mobile Telecommunications System (UMTS); Common test environments for User Equipment (UE); Conformance testing (3GPP TS 34.108 version 8.0.0 Release 8).

APPENDIX A: Measurement Equipment

A.1 Equipment

- Agilent 8960 Series 10 wireless communication test set
- Rhode and Schwarz FSU-46 spectrum analyser
- Amplifier research 0.8 to 3.2 GHz, 30 W amplifier
- Aeriel Facilities splitter
- Dual ridged horn antennas 1 to 18 GHz x2