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Summary

This report presents the results of a study by ERA Technology Ltd and Aegis Systems Ltd to assess the potential for interference from Long Term Evolution (LTE) User Equipment (UE) operating in the 832 – 862 MHz band into Short Range Devices (SRDs) operating in the adjacent 863 – 870 MHz band.

At the time of the study there were no "real" LTE 800 MHz UE devices on the market and so simulated emissions were used to assess the potential for interference. The tests were designed to derive Carrier-to-Interference (C/I) protection ratios, which in turn were used to generate estimates for the protection distances required to avoid interference from LTE 800 MHz UE devices to SRD equipment. Results varied markedly depending on assumptions made about the SRD wanted signal level at the receiver, UE EIRP, data traffic of the UE (and the Out-Of-Band emissions) and frequency separation. As a consequence, considerable caution must be exercised in drawing any firm conclusions from the test findings until further information becomes available on 800 MHz UE device behaviour.

Using somewhat worst-case assumptions about UE operation and wanted SRD signal level there appears to be some risk of interference to particular devices in certain scenarios. Although these scenarios are considered unlikely to arise in practice, they do reflect the potential results of LTE UE devices operating at maximum permitted power and using full resource block allocations, while the SRD transmitter is at the extent of its maximum operating distance from the receiver. These risks are considerably reduced if more realistic operating assumptions are introduced.

In all circumstances, the potential for interference was most marked for cordless audio equipment (microphones and headphones); equipment used for routine medical monitoring; and for social alarms (usually push-button devices issued to the old and vulnerable).

Detail of tests carried out

A detailed review of the 863 – 870 MHz band was undertaken by Aegis Systems and eight representative Short Range Devices were selected for testing. Two different UE interference sources were considered:

- A simulated UE interferer configured for a 10 MHz bandwidth QPSK reference channel and using static Resource Block allocation of either 50, 25 or 1 RB, representing different data traffic loading conditions. The spectrum emissions were adjusted to meet the maximum mean out-of-band requirements for a Frequency Division Duplex (FDD) terminal station given in Table 6 of ECC Decision (09)03 [14], giving rise to a somewhat worst-case operating scenario;

- Emissions recorded directly from a UE emulator developed by a leading equipment vendor. This was configured using dynamic Resource Block allocation for data traffic loading conditions of 20 Mbit/s and 1 Mbit/s, giving rise to a more realistic UE operating scenario.

Radiated measurements were undertaken in a fully anechoic chamber to derive the C/I protection ratios needed to protect the SRDs from LTE UE interference. These C/I ratios were converted to minimum protection distances using a propagation model based on ITU-R Recommendation P.1238-6 [13]. Minimum coupling loss figures for each of the scenarios examined are included in Appendix I should the reader wish to apply a different propagation model.

Results for simulated UE emissions

Under worst-case operating assumptions, with the UE transmitting at the maximum permitted EIRP of 23 dBm and utilising a large number of resource blocks, protection distances as high as 49.7m were shown to be required to protect cordless audio equipment; 45.2m to protect medical devices; and 25.9m to protect social alarms. In a more typical scenario, based on assumptions that the UE EIRP is less than the maximum permitted and uses only a limited number of resource blocks, the protection distances are very much reduced.

Protection distances are also reduced if the SRD transmitter is considered to operate closer in distance to the receiver (thus improving the wanted carrier signal level). If the wanted level is 20 dB higher than the receiver sensitivity then the required protection distance reduces to 24.4m for audio equipment; 35.5m for the medical device and 12.7m for the social alarm. As before, these distances are further reduced for lower UE EIRP levels (as is more realistic).

Results for UE emulator emissions

Further testing was undertaken on audio devices and three different social alarm models using spectral emissions recorded from a UE emulator operating in a vendor's LTE test network. The emulator was configured for a 10 MHz channel bandwidth with the resource blocks allocated dynamically by the scheduler, according to a vendor proprietary algorithm.

Results were gathered with the emulator configured for 20 Mbits/s data traffic with different OOB spectrum emission profiles:

- Emissions recorded directly from the UE emulator;
- Emulator emissions adjusted to meet the maximum mean out-of-band requirements given in ECC/Dec/(09)03;

- Emulator emissions adjusted to be 10 dB below the ECC/Dec/(09)03 OOB requirements[1].

The results under worst-case operating assumptions for the UE emulator are comparable to the corresponding simulated UE results. Once again, protection distances are reduced very considerably if the SRD transmitter is assumed to be closer to the receiver, thus improving wanted signal level.

The emissions from a real UE could be considerably better than the ECC/Dec/(09)03 minimum requirement, as evidenced from the UE emulator. In this case the protection distances will be further reduced, to around 6.4m for radio microphones and 1m for social alarms. These distances could be expected to reduce still further if the UE transmits at lower EIRPs.

Interference between Short Range Devices operating in the 800 MHz band

A limited set of measurements was undertaken to assess the potential for interference from cordless headphones and a radio microphone into other types of SRD currently operating in the 800 MHz band. It should be noted that both the interferers operate continuously in the time domain (100% duty cycle) and have relatively high transmit powers. For interferers with lower duty cycles or lower transmit power the probability of interference would be expected to reduce.

Although limited in scope, the measurements suggest that SRD devices operating in the unlicensed 800 MHz band are subject to interference from other SRD emissions. The largest protection distances are required between the radio microphone and cordless headphones as these operate closest in frequency (0.091 MHz separation). For other combinations of SRD to SRD interference protection distances of between 50cm and 7m are required. Results are summarised in the table below, assuming a wanted signal level at the receiver 10 dB above the minimum sensitivity.

[1] This is a somewhat arbitrary level, based on measurements of real emissions from UMTS UE handsets

Table 1:
Indicative protection distances for SRD into SRD interference

Victim Device	Victim Frequency (MHz)	Interferer Cordless Headphones EIRP = 6.3 dBm F = 864.759 MHz	Interferer Radio Microphone EIRP = 6.35 dBm F = 864.85 MHz
Cordless Headphones	864.759		80.83m
Radio Microphone	864.85	34.23m	
Intruder Alarm	868.35	0.85m	0.61m
Social Alarm	869.215	None	None
Telemetry	869.875	1.14m	1.27m
Smart Meter	868.3794	0.61m	0.76m
Medical Device (-10 dBi antenna)	865.564	5.06m	6.98m
RFID[2]	869.519	0.49m	0.50m

[2] Required separation distance at 70% of maximum usable distance between reader and tag

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Abbreviations List

3GPP	3rd Generation Partnership Project
ALD	Assistive Listening Devices
ECC	European Communications Committee
EIRP	Effective Isotropically Radiated Power
ERC	European Resuscitation Council
ERP	Effective Radiated Power
ETSI	European Telecommunications Standards Institute
FDD	Frequency Division Duplex
FM	Frequency Modulation
LTE	Long Term Evolution
PRBS	Pseudo Random Bit Sequence
QPSK	Quadrature Phase-Shift Keying
RB	Resource Block
RMC	Reference Measurement Channel
RFID	Radio Frequency Identification Devices
SC-FDMA	Single-Carrier Frequency-Division Multiple Access
SINAD	Signal-to-noise and distortion ratio
SRD	Short Range Device
UE	User Equipment
UHF	Ultra High Frequency

1. Introduction

In March 2011 Ofcom published a consultation document setting out proposals for the award of spectrum in the 800 MHz and 2.6 GHz frequency bands [16]. The 800 MHz band is part of the digital dividend; the spectrum freed up as a result of the switchover from analogue to digital TV. Ofcom envisions this spectrum will be used to deliver the next generation of mobile broadband services using technologies such as LTE and WiMAX.

The harmonised frequency arrangements for the 800 MHz band are set out in ECC Decision 2010/267/EU [17], based on Frequency Division Duplex operation with the downlink located in the lower part of the band, from 791 – 821 MHz, an 11 MHz duplex gap between 821 – 832 MHz and then the uplink located from 832 – 862 MHz. The band plan is illustrated in the figure below.

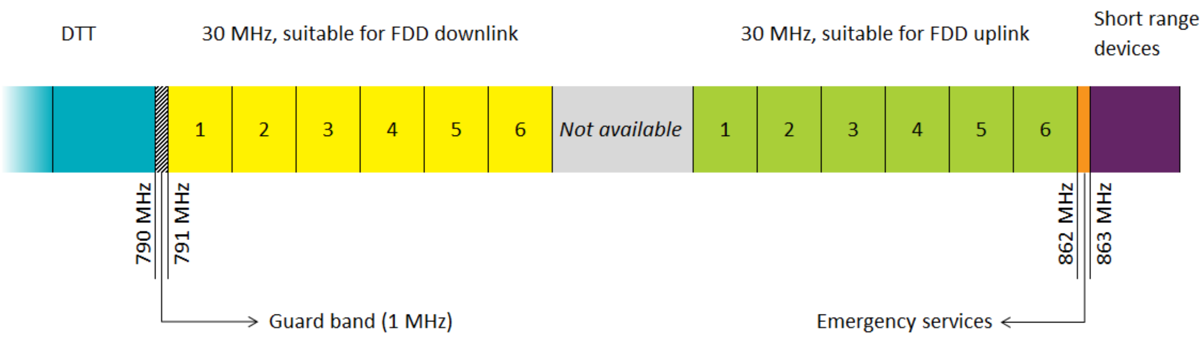

Figure 1: 800 MHz band plan

A number of different types of Short Range Device operate in harmonised spectrum between 863 – 870 MHz on a licence exempt basis and the deployment of future mobile services introduces the risk of potential interference from LTE User Equipment (also known as terminal stations) operating in the adjacent uplink band 832 – 862 MHz.

This report presents the results of a literature review and measurement study undertaken by ERA Technology Ltd and Aegis Systems Ltd to establish the potential for such interference. The literature review has focussed on identifying different types of SRD available on the UK market and determining typical receiver characteristics and interference criteria. A measurement programme was then undertaken to verify the performance of a representative selection of devices and to quantify the impact of LTE UE interference. The study sets out to address the following questions:

- What types of Short Range Device operate in the 863 – 870 MHz band and what are their receiver characteristics?

- What is the likely impact of LTE UE operating in the 832 – 862 MHz band on a small but representative selection of SRDs operating in the 863 – 870 MHz band?
- What is the current level of interference that SRDs can expect in the 863 – 870 MHz band?

Since 800 MHz LTE technology is in the very early stages of roll-out at the time of this study there are no "real" UE devices available for testing, and their actual operating behaviour is somewhat unknown. We have therefore taken a worst-case operating scenario as our starting point, with the UE assumed to transmit at its maximum permitted EIRP of 23 dBm, with out-of-band emissions adjusted to comply with the technical conditions for FDD terminal stations described in ECC Decision (09)03 [14] and with the UE utilising a large number of resource blocks. We then introduce more realistic operating scenarios and present a limited set of measurements based on emissions recorded from a UE emulator device working on a vendor's test network.

Where SRDs were found to be subject to interference from LTE emissions the failure mechanisms have, as far as practicable, been identified and representative protection distances have been determined. Simple mitigation techniques are also presented where possible.

SRD into SRD interference has also been investigated using the devices obtained during the study. The worst case scenario, i.e. the closest adjacent frequency/channels between the interferer(s) and the victim(s), was assumed in order to assess SRD into SRD blocking effects. This gives a measure of the level of interference that SRD devices can be expected to be subjected to from other similar devices operating in the 863 – 870 MHz band.

2. Review of Short Range Device Characteristics

2.1 Frequency Plan

SRD allocations in the 863 – 870 MHz band are shown in Figure 2 below. The band is essentially split into three parts:

- The lower part (863 – 865 MHz) which is used for cordless microphones with a small part being used for cordless audio;
- The middle part (865 – 868 MHz) which is used for Radio Frequency Identification Devices (RFIDs);
- The upper part (868 – 870 MHz) which is partitioned into segments for social alarms, generic alarms and non-specific SRDs.

It should also be noted that polite non-specific SRDs are also permitted across the whole band 863 to 870 MHz.

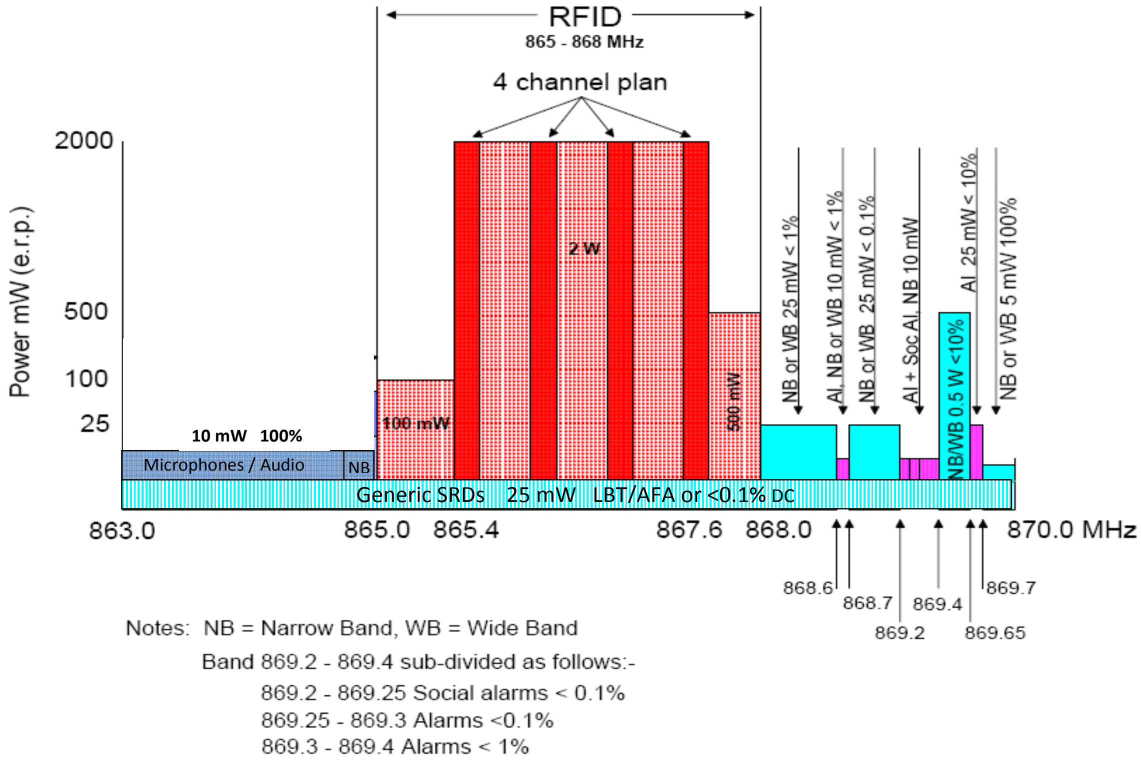

Figure 2: Short Range Device allocations in the 863 – 870 MHz band

While the lower and middle parts of the plan are relatively straightforward the upper part is far more segmented with each segment having different constraints both in terms of application and access (power, bandwidth, duty cycle or other mitigation) as indicated in the schematic below.

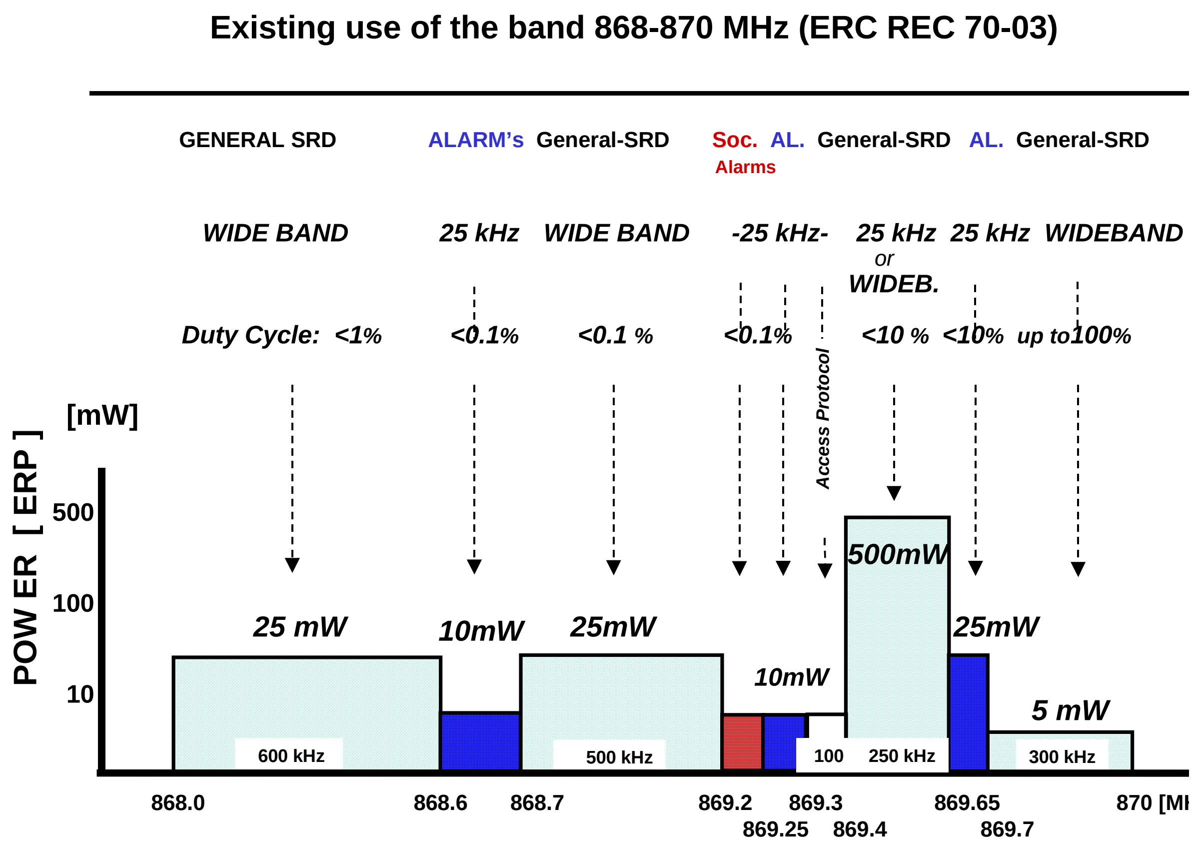

Figure 3: Short Range Device allocations in the upper band, 868 – 870 MHz[3]

2.2 Lower Band Devices

The 863–865 MHz portion of the 863–870 MHz band is used predominantly by cordless microphones and cordless audio applications. While accounting for a significantly smaller portion of the users in this band, assistive listening devices are another application.

Cordless microphones have an extremely diverse user base and serve both the consumer and professional markets. Typical users on the consumer side include churches, schools, boardrooms and pubs while examples of more professional users are professional musicians and bands, west-end theatres and sports presenters. Almost all the cordless microphones used by professionals elect to operate either exclusively in a lower frequency band (such as

[3] From many sources including ERC Recommendation 70-03 [11] and ECC Report 11 – Strategic plans for the future use of the frequency bands 862-870 MHz and 2400-2483.5 MHz for short range devices, Helsinki, May 2002

channel 69, or even down to channel 21). Professional use of these lower frequency channels is subject to licensing and co-ordination by the programme making and special events industry body JFMG. The primary reason that professional users avoid the licence-exempt 863–865 MHz band relates to interference; professional users avoid this band as they cannot risk interference between their microphones and other devices.

Cordless audio systems include all applications that enable individuals or groups to listen to and/or communicate with each other without the need for setting up a wired system. Examples of these applications include cordless conferencing systems, cordless home entertainment centres, audio guides and in-ear monitoring systems.

The users of these applications are typically corporate organisations (for example, conferencing within a meeting so that individuals both present and connecting in via telephone can communicate with each other), museums and tourist attractions where individuals can be guided through what they are viewing, performing artists (who require in-ear monitoring systems to play background music or instructions directly into their ears) and individuals and organisations who want the flexibility of entertainment systems without wires or cables everywhere. Other users are likely to be church halls, schools and courtrooms, where audio systems need to be in place and the venues are listed buildings or are sufficiently large that setting up wired systems would be impractical.

Appearing both as a stand-alone product and as a component of these systems, cordless headphones are the most common application. Cordless headphones feature significantly more in the consumer than the professional market, with a typical use being television watching. All cordless headphones are able to tune to frequencies in the 863–865 MHz band, with most headphones operating either in this frequency band or in the 2.4 GHz band. While the 863–865 MHz band has the advantage that the consumer need not purchase a licence, a number of users find that headphones operating in this frequency can be vulnerable to interference.

Assistive listening devices (ALDs) enable individuals who are hard of hearing or partially deaf to hear an audio transmission (speech, music, etc). Some of the devices work alongside traditional hearing aids while many others are stand-alone products. ALDs differ from traditional hearing aids as ALDs are intended to amplify specific sound sources while hearing aids aim to amplify all ambient sounds.

ALDs work by taking the signal the individual is interested in hearing and amplifying it relative to surrounding sounds; this is achieved by placing a microphone near the sound source. While wired versions of these devices exist, cordless alternatives are desirable due to the improved flexibility and mobility they afford. ALDs are used by both groups and individuals. Devices aimed at group use broadcast the sound to more than one person; examples include induction loop, infrared and frequency modulation (FM) systems. Devices designed for personal use are generally configured to work with a single speaker; examples include cordless personal FM systems and cordless headphones.

2.3 Mid Band Devices

This part of the 863–870 MHz band is used predominantly by Radio Frequency Identification Devices (RFIDs) which consist of a combination of readers and either active or passive tags. Typically, RFID technology can be employed as part of innovative applications or as a replacement technology, either for other older cordless technologies or for barcodes. RFID devices also operate in a small segment of the higher band, from 869.4 – 869.65 MHz, where transmit power is limited to 500mW. We have focussed on this type of device for the purposes of this report.

One of the prominent areas in which RFIDs are used is transport and logistics. Here, RFIDs are employed to track and locate shipping containers, track air freight, track vehicles within a fleet or within a large warehouse and assist with yard management. The ability to track items in this manner ensures that progress in transport can be monitored, theft or misplacement of items can be identified and rectified and any logistical concerns can be dealt with in a timely manner. Similar benefits can be seen in the automotive industry where RFID technology is used both for tracking finished items in the supply chain and for tracking individual parts in the manufacturing process.

In general, RFIDs are used to locate and track items, whether these are individual items such as clothes, containers used for transporting items in the supply chain or high value items that require swift location. These general applications for RFIDs can be divided into three categories: manufacturing and distribution, individual item tagging and asset tracking.

RFID systems range significantly in size as readers have to accommodate large pallets / containers at one extreme down to scanners of individual items which might be done on a hand-held basis at the other end of the scale.

2.4 High Band Devices

The high band (868–870 MHz) is primarily used by cordless alarm systems, including **fire, intruder and social alarms** which are each subject to different operational and technical requirements. The band is divided further into a number of sub-bands, based primarily on technical characteristics such as power and duty cycle. Parts of the band are specifically identified for alarm systems, although alarms may also operate in the part of the band identified for non-specific devices. One of the alarm sub-bands is identified specifically for social alarms.

It should be noted that fire and intruder alarm systems are generally installed as separate, independent systems as they have to conform to different operational standards. The only exception to this tends to be in the residential sector where cordless smoke detectors can be provided as add-ons to intruder alarm systems.

Underlay systems may utilise the whole 863–870 MHz band and typically deploy spread spectrum or other wideband RF technologies. Applications are non-specific and may include any of the applications associated specifically with the low, mid and high bands; however, the more stringent technical constraints on underlay devices are likely to favour the application-specific bands in most cases.

Apart from the three types of alarm system already identified (i.e. **fire, intruder and social alarms**), a number of other applications take advantage of the non-specific aspect of the regulations. These applications include:

- **Home / Office automation** - a number of applications relate to home automation, one area of which that has been growing in recent years is that of indoor climate control. This involves automatic opening and closing of windows alongside monitoring of temperature and humidity and activation of heating or air conditioning systems.

- **Access control** - Cordless access control systems may be regarded as a subset of remote control systems (see below) and typically include garage and gate openers.

- **Remote controllers** - Cordless remote controls are used in a variety of applications, in both the residential and industrial sectors. Residential applications typically include control of heating systems, windows, air vents etc and are covered under home automation above. Industrial applications include control of cranes and hoists.

- **Medical** - This frequency band is being used by one company to deploy a Body Area Network which connects a central hub containing a processor and data storage with various sensors on and around the body (e.g. to measure pulse rate, blood pressure etc). Such a capability provides for regular readings, including through the night, and replaces a nurse having to obtain the data for example. There is also a crossover for such capability in the sport sector, both professional and recreational. While we have labelled these devices as medical it should be noted that they are solely intended to support the routine monitoring of vital signs where such monitoring is not regarded as critical or life threatening in any way.

- **Telecare** - Telecare systems provide a mix of facilities for infirm and disabled people including self and/or automatically triggered alarms. Alarms can be triggered by sensors around a dwelling (to detect an overflowing bath for example) or on the person (to detect a fall for example). Such alarms are received by a hub unit which then communicates with a remote monitoring centre where appropriate action can be initiated.

- **Smart meters** - The possibility of reading meters remotely over a cordless connection has been around for some years. Such systems provide for bidirectional communication over a fixed infrastructure or allow for walk-by and/or drive-by readout. More recent developments, largely spurred by international interest in energy efficiency, has led to a wider concept often referred to as smart grids whereby there is a more regular exchange of information across and between the infrastructure of energy suppliers and the local distribution of energy in consumers' properties. In terms of cordless communication to support smart grids one can distinguish between a local network within a consumer's property and a wider area network connecting the consumer's property back to the supplier.

- **Telemetry** - In its broadest sense telemetry simply transfers data from A to B through a standard interface at either end (RS232, Ethernet etc). Applications that might be supported by one or more telemetry links are therefore wide and varied. For simpler radio links carrying serial data, the communication is unidirectional and integrity is maximised by using listen before talk (LBT) and error checking. For more important links, bidirectional communication is used which allows for more sophisticated protocols using redundancy checks and acknowledgements. This increases latency but provides a very robust link. Cordless telemetry is widely used by utilities and other industries for a variety of applications, typically involving remote monitoring of systems.

- **Automotive** - The type of SRD applications used in vehicles listed include remote keyless entry systems, passive entry systems, personal car communications systems, truck-trailer communication systems, security systems (vehicle alarm systems) and remote tyre pressure reading devices. It appears that few products for the automotive industry currently operate in the 863–870 MHz band as other frequency bands are available.

- **RFID (869.4 – 869.65 MHz)** – RFID devices operating in this band tend to be used in desktop, point of sale or access control applications. They consist of a passive tag that can be read at distances of up to 1m and a reading device that typically operates in a single 25 kHz channel with a 10% duty cycle.

2.5 Devices Selected for Testing

A representative selection of SRD devices from those categories described above were selected for testing, following discussion with Ofcom.

Table 2:
Short Range Devices assessed in this study

Device	Frequency Band (MHz)	Descriptor	Typical Receiver Category
Cordless Headphone	863.365 – 864.759	Low band	2
Intruder Alarm	868.35	High band	2
Radio Microphone	863.15 – 864.85	Low band	2
Smart meter	868.3794	High band	2
Social alarm	869.215	High band	1
Telemetry	869.875	High band	3
Medical device	865.564	Mid band	2
RFID	869.519	High band	2

The receiver category in the table above is defined in ETSI EN 300 220-1 [4] and is specified by the device manufacturer. The definition of each category is show in Table 3 below. Note that, where an SRD may have inherent safety of human life implications (Cat 1), manufacturers should provide advice to users on the risks of potential interference and its consequences.

Table 3:
SRD receiver category defined in ETSI EN 300 220-1

Receiver category	Risk assessment of receiver performance
1	Highly reliable SRD communication media; e.g. serving human life inherent systems (may result in a physical risk to a person).
2	Medium reliable SRD communication media; e.g. causing inconvenience to persons, which cannot simply be overcome by other means.
3	Standard reliable SRD communication media; e.g. inconvenience to persons, which can simply be overcome by other means (e.g. manual).

3. Test Set-Up

The following scenarios have been investigated in this study:

- Simulated LTE UE emissions with static Resource Block allocations of 50, 25 and 1 RB, representing different data traffic loading conditions;
- LTE UE emissions recorded from an emulator developed by an LTE equipment vendor, with dynamic Resource Block allocations representing 20 Mbits/s and 1 Mbits/s data traffic conditions;
- Variations in LTE UE out-of-band emissions.

The LTE parameters are detailed in section 3.1 – 3.3; the interference criterion for the different SRDs under test is presented in section 3.4; the measurement set-up and test method are in section 3.5 and section 3.6 respectively.

3.1 Transmit EIRP

The analysis assumes an LTE transmit EIRP of 23 dBm, 17 dBm and 5 dBm based on the UE Classes shown in Table 4. These values are somewhat arbitrary but reflect the Transmit Power Control dynamic range of 70 dB from the Joint Task Group 5-6 simulations [12]. The effect of varying the LTE UE signal level was investigated by considering different UE power classes.

Table 4:
EIRP of LTE UE power classes with 6dB handheld loss

UE Class 1	UE Class 2	UE Class 3	UE Class 4	UE Class 5
17dBm	5dBm	-9dBm	-30dBm	-50dBm

3.2 Simulated UE Test Parameters

The high-level LTE UE parameters, based on QPSK modulation and 10 MHz channel bandwidth, are shown in Table 5 below.

Table 5:
Simulated UE signal parameters

Parameter	Value
Maximum Output power	23 dBm
Multiple access method	SC-FDMA
Duplex	FDD
Channel bandwidth	10 MHz
Allocated resource blocks	1, 25, 50
Channel modulation	QPSK
Target coding rate	1/3
Sub-frame length	1 ms
Number of occupied sub-carriers	600
Sub-carrier spacing	15 kHz
Code rate	1/3

The uplink signal was based on a Reference Measurement Channel (RMC) using Frequency Division Duplex (FDD) with either full Resource Block (RB) allocation or partial RB allocation, as described in Annex A of ETSI TS 136 521-1 (3GPP TS 36.521) [1]. The reference channel parameters for partial RB allocation are reproduced in Table 6 below.

Table 6:
LTE UE reference channels with partial RB allocation from ETSI TS 136 521-1

Table A.2.2.2.1-4: Reference Channels for 10MHz QPSK with partial RB allocation

Parameter	Unit	Value	Value	Value	Value
Channel bandwidth	MHz	10	10	10	10
Allocated resource blocks		1	12	20	25
DFT-OFDM Symbols per Sub-Frame		12	12	12	12
Modulation		QPSK	QPSK	QPSK	QPSK
Target Coding rate		1/3	1/3	1/3	1/3
Payload size	Bits	72	1224	1736	2216
Transport block CRC	Bits	24	24	24	24
Number of code blocks per Sub-Frame (Note 1)		1	1	1	1
Code block CRC size	Bits	0	0	0	0
Total number of bits per Sub-Frame	Bits	288	3456	5760	7200
Total symbols per Sub-Frame		144	1728	2880	3600
UE Category		1-5	1-5	1-5	1-5
Note 1: If more than one Code Block is present, an additional CRC sequence of L = 24 Bits is attached to each Code Block (otherwise L = 0 Bit)					

A signal generator was used to produce the LTE signal based initially on 50 static RBs. The generated signal was amplified by an overdriven amplifier to create spectral re-growth and then filtered such that the resultant spectral emission mask conformed as closely as possible to the out-of-band requirements for FDD terminal stations defined in ECC/Dec/(09)03, as shown in Table 7 and Figure 5 below. The transmit power was controlled using a variable attenuator to step the entire mask up or down, thus maintaining the same Adjacent Channel Leakage Ratio throughout the testing. The filter and amplifier configuration were preserved for the 1 RB and 25 RB signals.

Figure 4: Generation of LTE UE interferer

Table 7:
Out-of-band requirements for FDD terminal stations

Frequency offset from FDD (lower/upper) block edge	Maximum mean out-of-band power	Measurement bandwidth
822 MHz to -5 MHz from FDD uplink lower channel edge	-6 dBm	5 MHz
-5 to 0 MHz from FDD uplink lower channel edge	1.6 dBm	5 MHz
0 to +5 MHz from FDD uplink upper channel edge	1.6 dBm	5 MHz
+5 MHz from FDD uplink upper channel edge to 862 MHz	-6 dBm	5 MHz

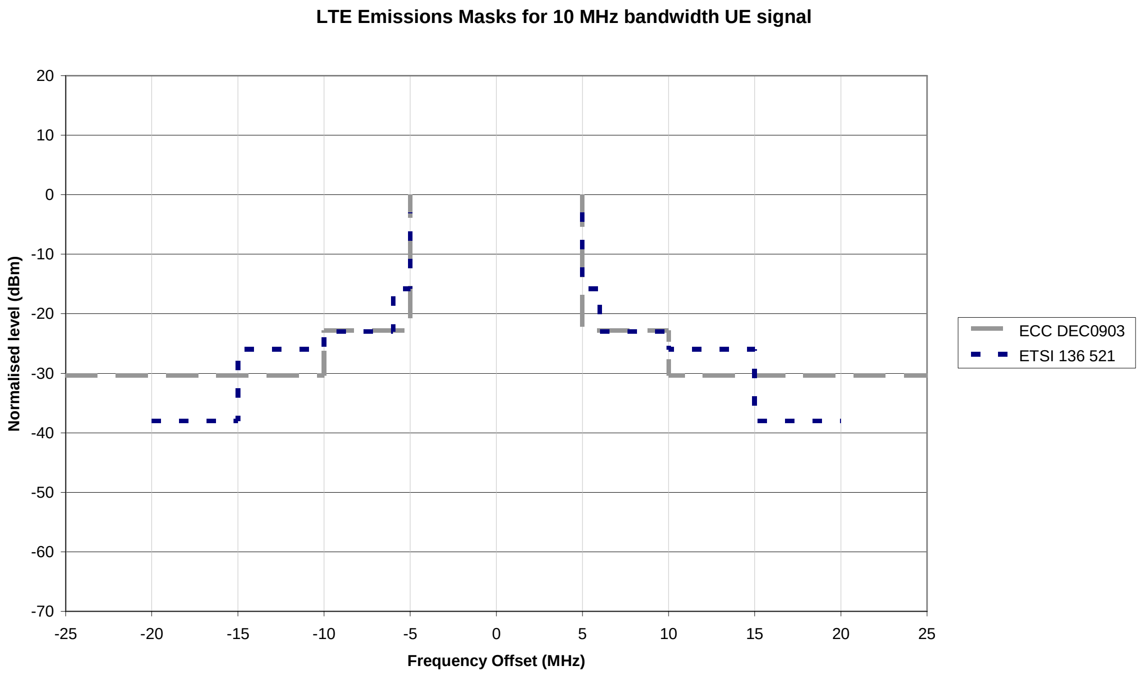

Figure 5: Comparison between ECC/Dec/(09)03 and ETSI out-of-band spectrum emission masks for LTE UE

The measured spectrum emissions of the simulated signals for 50, 25 and 1 resource blocks are compared in Figure 6 and Figure 7 below.

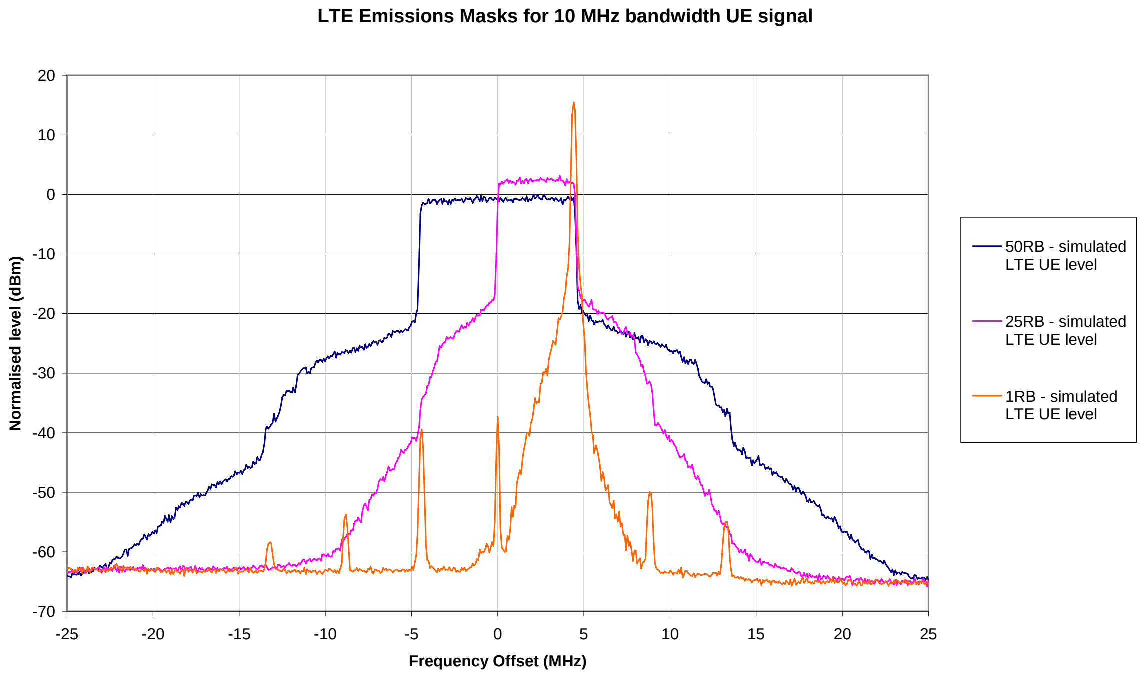

Figure 6: Spectrum emissions for simulated 50, 25 and 1 RB LTE UE signals (100 kHz Resolution Bandwidth)

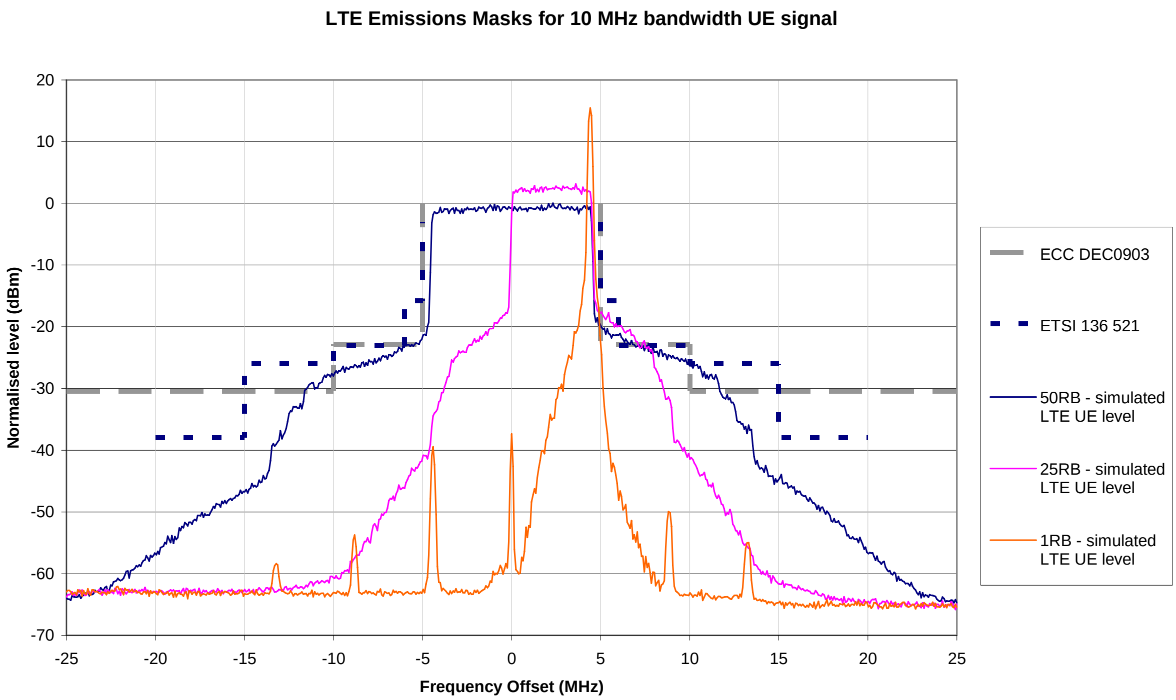

Figure 7: Comparison of simulated emissions and regulatory masks

It can be seen from the figures above that the in-block peak power for the simulated emissions is higher for 1 RB and 25 RBs signals, when compared to the 50 RB case. Peak power increases as the number of RBs is reduced in order to maintain the same spectral power density across the 10 MHz UE bandwidth. It can also be seen that at 7 MHz offset, the out-of-band emission levels of the 50 and 25 RB signals appear to exceed the OOB emission limits. This is most likely due to the filter and amplifier characteristics used to generate the signals.

3.3 UE Emulator Test Parameters

The simulated emissions described above are based on static resource blocks, i.e. the allocated RBs are fixed in frequency and do not vary from one timeframe to the next. This could give rise to overly pessimistic results since in a "real" UE device the resource blocks will be allocated in each timeframe by the scheduler depending on the prevailing channel conditions.

In order to investigate the impacts of discontinuous (time varying) LTE emissions into SRD receivers, emissions from a UE emulator (approximately the size of a netbook computer) were recorded and played back through a signal generator. The emulator was configured for a range of traffic loading scenarios and the emissions for 20 Mbits/s and 1 Mbits/s data throughput were used as the interference source into a limited selection of SRD receivers. The recorded emulator spectrum emissions are shown in Figure 8 and Figure 9 below.

It can be seen from Figure 8 that the recorded emissions are much lower that the limits allowed for in ECC/Dec/(09)03. Figure 8 also shows the emulator emissions adjusted to just meet the ECC requirement, and adjusted to be 10 dB better than the ECC requirement. This later profile is somewhat arbitrary and was derived from performance measurements on UMTS devices [15]. The emissions were adjusted using the same amplifier and filter technique described in section 3.2 above.

Since the emulator resource blocks are allocated in each timeframe depending on channel conditions, there is no direct comparison between the emulator emissions and simulated emissions. However, since the 20 Mbits/s loading example uses almost all of the available RBs, it might reasonably be expected to give similar interference results to the simulated 50 RB case.

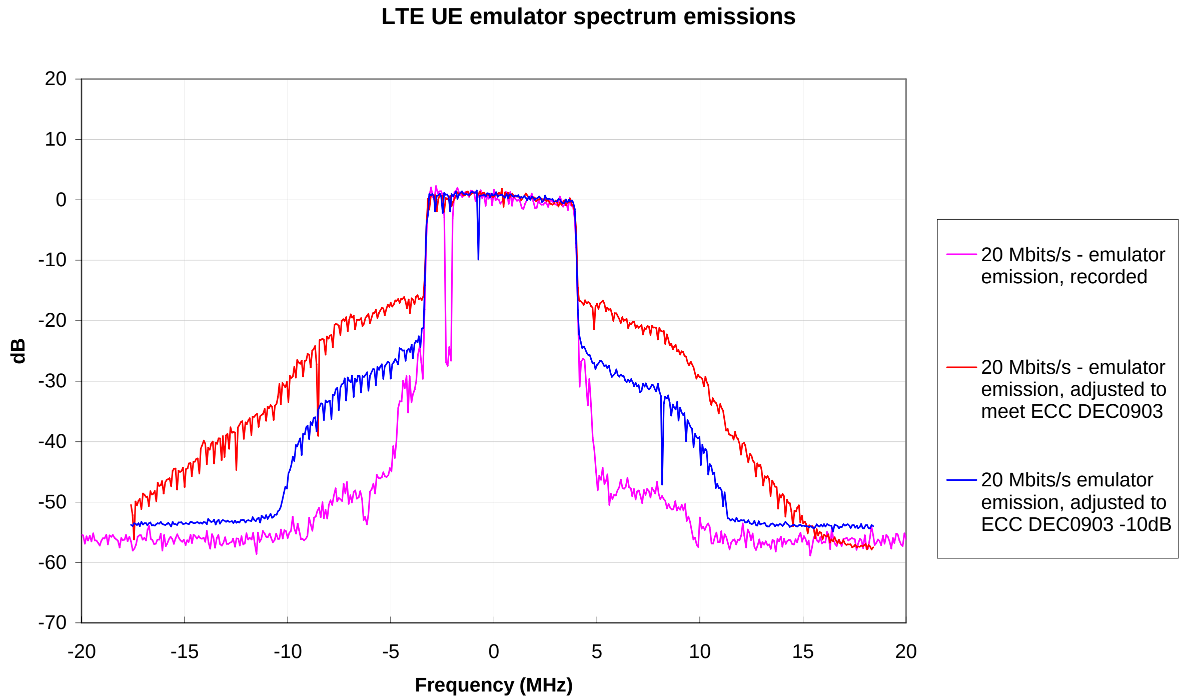

Figure 8: LTE UE Emulator spectrum emissions for 20 Mbits/s data throughput (100 kHz Resolution Bandwidth)

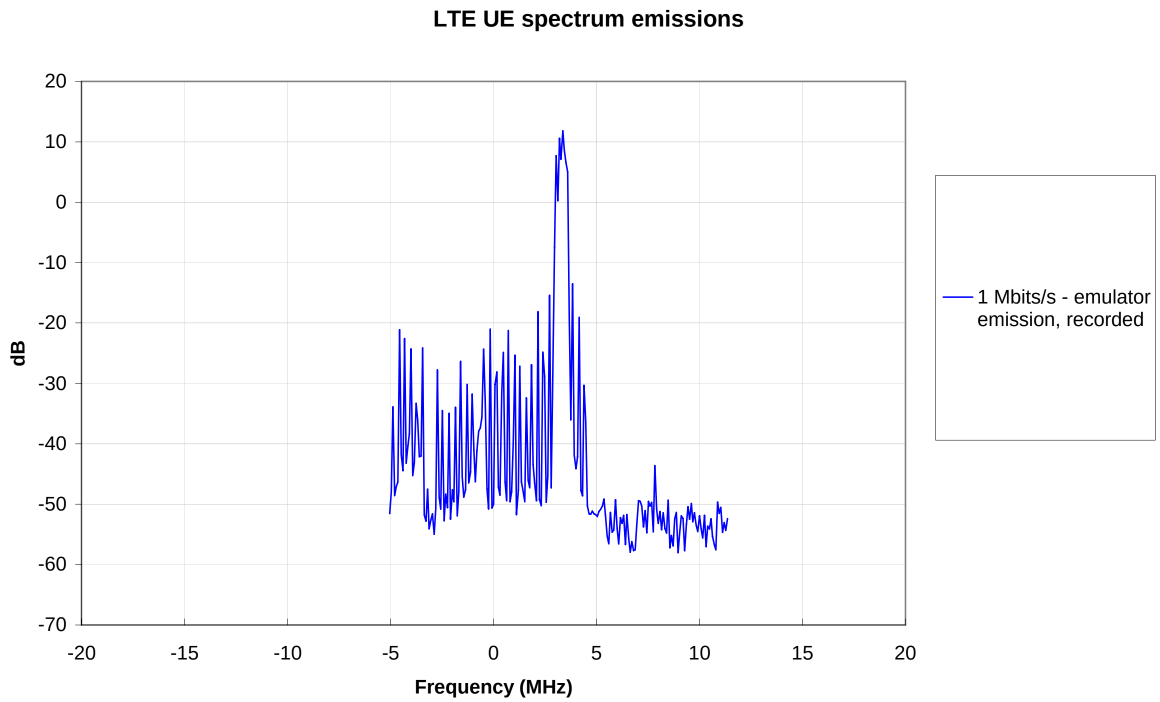

Figure 9: LTE UE Emulator spectrum emissions for 1 Mbits/s data throughput (100 kHz Resolution Bandwidth)

3.4 Interference Criterion

The key receiver characteristic of interest to this study, given the 1 MHz "guard band" afforded by the 862 – 863 MHz Home Office allocation, is blocking / desensitization. This is usually defined as "a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unmodulated input signal at any frequency within a defined distance".

Blocking is specified as the ratio in dBs of the level of an unwanted signal to a specified level of the wanted signal at the receiver input for which a defined degradation of the received signal occurs.

Blocking / desensitization performance is specified in the following ETSI standards applicable to different parts of the SRD band:

- EN 301 357-1: relevant to radio microphones and cordless audio applications operating in the lower part of the band (863 – 865 MHz) [2];
- EN 302 208-1: relevant to Radio Frequency Identification Devices (RFIDs) operating in the middle part of the band (865 – 868 MHz) [3];
- EN 300 220-1: relevant to all other applications operating across the whole band (863 – 870 MHz) [4];

ETSI EN 301 357-1 (Annex C) contains requirements for blocking or desensitization of the receiver for radio microphone and cordless audio applications. Equipment operating below 1 GHz should have performance better than or equal to the values given in the following table:

Table 8:
Blocking performance requirements for radio microphones and cordless audio

Class	Blocking (dB)		
	±(1 MHz + 2B)	±5 MHz	±10 MHz
1	50	60	70
2	30	40	50

It should be noted that the two classes (1 = no restrictions, 2 = restrictions) are defined in the R&TTE Directive (1999/5/EC) and Classification Document (2000/299/EC) and are not related to the device Categories given in EN 300 220-1.

ETSI EN 302 208-1 (Part 9.3) contains blocking or desensitization requirements for Radio Frequency Identification (RFID) applications. At approximately ±1 MHz, ±2 MHz, ±5 MHz and ±10 MHz from the carrier frequency of the interrogator the blocking level of the equipment under specified conditions shall be equal to or greater than -35 dBm effective radiated power (e.r.p).

ETSI EN 300 220-1 applies to non-specific SRDs, alarms and a subset of cordless audio applications. The product family of SRDs is divided into three receiver categories each having a set of relevant receiver requirements and minimum performance criteria. The set of requirements depends on the choice of receiver category specified by the manufacturer. Receiver clause 8.4 refers to the blocking level which should not be less than the values given in the table below, except at frequencies on which spurious responses are found.

Table 9:
Blocking performance requirements for non-specific SRDs

Receiver category	Frequency Offset	Limit
1	±2 MHz	≥ 84 dB –A (note 2)
2	±2 MHz	≥ 35 dB –A (note 2)
3	±2 MHz	≥ 24 dB –A (note 2)
1	±10 MHz	≥ 84 dB –A (note 2)
2	±10 MHz	≥ 60 dB –A (note 2)
3	±10 MHz	≥ 44 dB –A (note 2)
NOTE1: The limits apply also for the repeated tests in case of equipment using LBT or category 1 receivers, reduced by 13 dB or 40 dB, respectively, to account for the increased wanted signal level NOTE2: A = 10 log (BWkHz/16 kHz). BW is the receiver bandwidth		

The interference criterion applicable to each SRD under test is summarised in Table 10.

Table 10:
Interference criterion used in measurement programme

Device	Interference Criterion	Relevant ETSI Standard
Cordless Headphones	6dB SINAD ratio drop at the receiver output	ETSI EN 301 357-1 [2]
Intruder Alarm	Inability to pass a message on an RF link	BS EN 50131-5-3:2005 [5]
Radio Microphone	6dB SINAD ratio drop at the receiver output	ETSI EN 301 357-1 [2]
Smart Meter	Message acceptance ratio of 80%	ETSI EN 300 220-1 [4]
Social Alarm	Inhibiting reception of alarm triggering signal	BS EN 50134 -3:2001 [8]
Telemetry	Message acceptance ratio of 80%	ETSI EN 300 220-1 [4]
Medical Device	Message acceptance ratio of 80%	ETSI EN 300 220-1 [4]
RFID	The interrogator (RFID Reader) just ceases to identify the tag	ETSI EN 302 208-1 [3]

3.5 Measurement Set-Up

The generic test set-up for radiated measurements is shown in Figure 10 below. The wanted SRD signal was generated from the SRD transmitting device which was attenuated, where necessary, to give the required wanted signal level at the receiver.

The unwanted LTE UE signal was radiated inside an anechoic chamber at a distance of 3m from the SRD receiver under test. The level of the LTE interference was increased until the required interference criterion was achieved.

The received signal level was measured directly by substituting the SRD receiver with a 0 dBi mini-biconical antenna connected to a spectrum analyzer, the antenna gain and cable loss have been taken into account in the measurements.

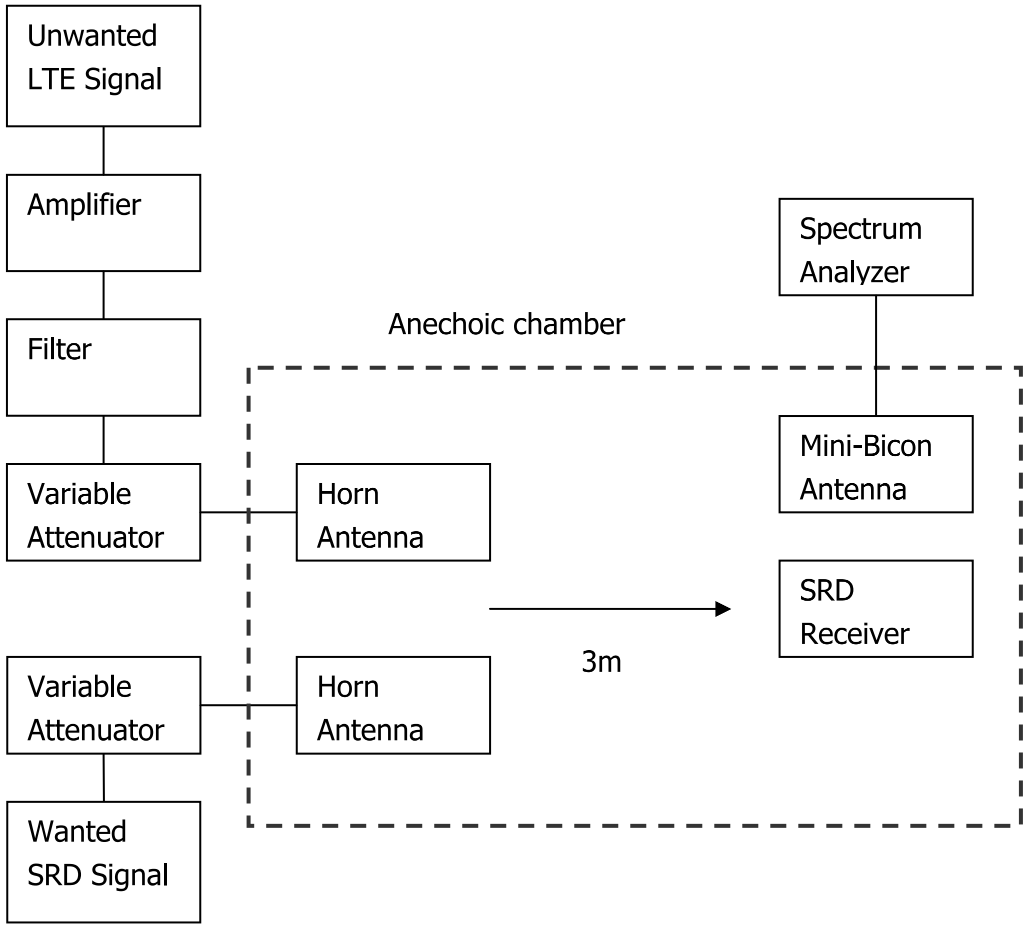

Figure 10: Generic radiated test set-up

For the radio microphone, conducted measurements were undertaken using the test set-up shown in Figure 11 below[4].

[4] Conducted test set-up from Annex C of ETSI EN 301 357-1 [2]

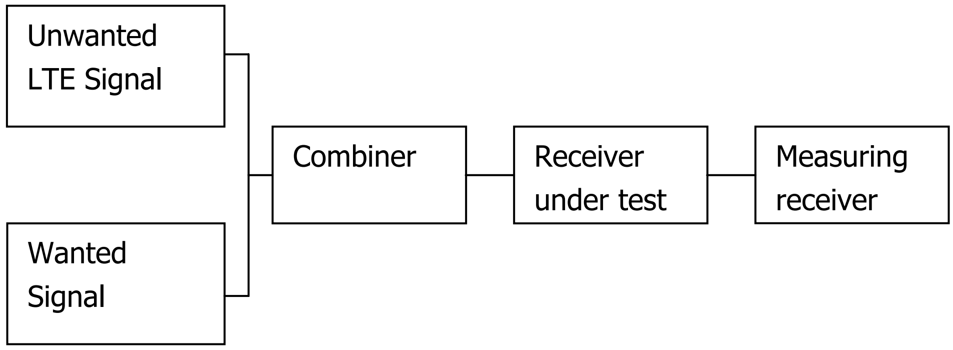

Figure 11: Conducted test set-up

3.6 Test Method

3.6.1 Minimum usable sensitivity

The minimum usable sensitivity of each SRD receiver was determined using the test method specified in the appropriate ETSI standard (see Table 10).

3.6.1.1 Cordless audio applications

1. A signal generator was connected to the receiver input, at the nominal frequency of the receiver, with a 1 kHz tone with a deviation of:
   a. For the cordless headphones, 12% of the channel separation, i.e. 48 kHz;
   b. For the radio microphone, ±24 kHz.
2. The amplitude of the signal generator was adjusted until a SINAD ratio of:
   a. 20 dB was obtained for the cordless headphones;
   b. 30 dB was obtained for the radio microphone.
3. The test signal input level under these conditions was recorded as the value of the minimum usable sensitivity.

3.6.1.2 Alarm systems, telemetry, smart meter and medical device

1. Using the test set-up shown in Figure 10, with the unwanted LTE UE signal switched off, the variable attenuator on the output of the wanted SRD transmitter was increased until:
   a. For the intruder alarm, 12 to 15 alarm messages out of 50 generated by the transmitter were not able to be received by the receiver. The receiver was oriented for maximum sensitivity;
   b. For the social alarm, telemetry, smart meter and medical device, a successful message ratio of less than 80% was obtained

2. The reference level was calculated by:
    a. Increasing the wanted signal level by 3 dB from the minimum value observed on the spectrum analyser for the intruder alarm;
    b. Taking the wanted signal level corresponding to the successful message ratio of 80% for the social alarm, telemetry, smart meter and medical device.

3.6.1.3 RFID device

The maximum usable distance of the receiver was determined using the test method specified in ETSI EN 302 208-1.

1. An interrogator was set up to operate in the anechoic chamber;
2. A tag in its preferred orientation was moved slowly towards the interrogator in the direction of maximum gain of its antenna to a point where it was just identified. The distance (d) between the antenna of the interrogator and the tag was measured.

3.6.2 Carrier-to-Interference protection ratio

The C/I protection ratio for unwanted LTE UE interference into the SRD receiver under test was determined using the test set up shown in Figure 10 and Figure 11 and the test method from the relevant ETSI specification shown in Table 10. Receiver C/I performance is a measure of blocking performance, defining the permitted level of interference (I) for a given wanted signal level (C) and frequency offset; the higher the C/I value the more sensitive the receiver is to interference. The wanted signal level was measured as total power in the bandwidth of the SRD receiver and the unwanted interferer was measured as total power in the 10 MHz UE bandwidth, as described in Section 3.6.2.1 and 3.6.2.2.

3.6.2.1 Generic test method

1. For the cordless headphones, social alarms, telemetry, smart meter and medical device the wanted SRD signal and unwanted LTE signal were radiated from separate antennas inside an anechoic chamber at a distance of 3m from the receiver under test (Figure 10). For the radio microphone, the wanted and unwanted signals were conductively combined into the SRD receiver (Figure 11). For the audio devices the wanted signal was represented by a signal generator capable of producing an appropriate modulated signal with a 1 kHz tone;
2. Initially the unwanted LTE signal was switched off and the level of the wanted signal (C) was adjusted to be 10 dB higher than the reference sensitivity level found using the method described in section 3.6.1, measured at the receiver input;

3. The carrier centre frequency of the unwanted LTE signal was set to 857 MHz (bandwidth 852 – 862 MHz). The level of the interferer (I) was then increased until the required signal degradation at the SRD receiver's output was observed;
4. The C/I protection ratio was calculated from steps 2 and 3.

Steps 1 to 4 were repeated for LTE UE frequency offsets of -5, -10, -15, and -20 MHz below the wanted centre frequency of 857 MHz, and for wanted signal levels 3 dB and 20 dB higher than the reference sensitivity level (40 dB higher for the cordless headphones).

3.6.2.2 Test method for RFID device

1. The RFID interrogator and a tag were radiated inside an anechoic chamber. The tag was placed at a distance of 0.7 x d from the interrogator in the direction of maximum gain of its antenna, where d is the maximum usable distance obtained in section 3.6.1.3. The unwanted LTE signal was radiated from an antenna 3m away from the RFID interrogator and the tag;
2. The carrier centre frequency of the unwanted LTE signal was set to 857 MHz (bandwidth 852 – 862 MHz). The level of the interferer (I) was then increased until the defined signal degradation at the SRD receiver's output was observed;
3. The interrogator was removed and replaced by a measurement antenna connected to a measuring receiver. The level of signal from the signal generator received at the measuring receiver was recorded.

3.6.3 SRD into SRD interference

Blocking effects into SRDs caused by unwanted interference from other SRD signals was determined using the test method specified in ETSI 300 220-1. The cordless headphone and radio microphone devices were used as interferers since both signals operate continuously in the time domain (100% duty cycle).

1. The wanted and unwanted SRD signals were radiated inside an anechoic chamber at a distance of 3m from the receiver under test;
2. Initially the unwanted SRD signal was switched off and the level of the wanted signal (C) was adjusted to be 10 dB higher than the reference sensitivity level found using the method described in section 3.6.1, measured at the receiver input;
3. The carrier frequency/channel of the unwanted SRD signal was selected as the closest frequency to the wanted SRD signal. The unwanted SRD signal (I) was switched on and adjusted until the defined signal degradation at the wanted receiver's output was observed;
4. The C/I protection ratio was calculated from steps 2 and 3.

Steps 1 to 4 were repeated for the wanted signal level adjusted to be 3 dB and 20 dB higher than the reference sensitivity level.

4. Results

The measured C/I protection ratios have been converted into minimum protection distances required to protect SRDs from LTE 800 MHz UE interference. In order to arrive at separation distances that might be required to mitigate interference we have assumed a general purpose propagation model based on ITU-R P.1238-6 [13] to represent mean path loss. This model takes the form of free space path loss up to a breakpoint distance followed by a faster rate of attenuation represented by an exponent greater than the 2 used for free space. For the general case we have assumed a breakpoint of 5 metres and an exponent of 3.5. It should be noted that while this might be regarded as representing the general case there will be situations where the amount of interference will be greater than or less than that suggested by the model as there might be a longer / shorter initial free space path and/or the propagation conditions beyond the breakpoint might be more / less cluttered (i.e. higher / lower exponent). Generally, the exponent used here represents the degree of clutter, including the effects of walls / partitions on a single level. Additional attenuation terms needs to be added if considering the traversal of a signal between one or more floors. An alternative to this model dispenses with the free space part of the model up to the breakpoint and assumes a single slope model (as for free space) using an exponent greater than the 2 used for free space.

The C/I protection ratio and calculated protection distance for each device under test are attached individually in Annex A – H. Minimum Coupling Loss values are included in Appendix I should the reader wish to apply a different propagation model than the one used in this report.

4.1 Minimum Usable Sensitivity

The measured minimum usable receiver sensitivity is shown in Table 11 below.

Table 11
Measured minimum usable sensitivity

Device	Minimum sensitivity (dBm)
Cordless Headphones	-91.05
Radio Microphone	-94.70
Intruder Alarm	-89.49
Social Alarm	-107.94
Telemetry	-93.52
Smart Meter	-89.07
Medical Device (0 dBi antenna gain)	-94.19
RFID	0.56m[1]

Notes:

1. 70% of maximum usable distance between reader and tag (where maximum usable distance was measured as 0.8m).

It can be seen that the social alarm is the most sensitive device, operating with a received signal level as low as -108 dBm. The other devices can operate with wanted signal levels between -89 and -94.7 dBm.

The maximum operating range of the RFID device was measured as 0.8m, with minimum sensitivity assumed to be 0.56m.

4.2 Required Protection Distance for Simulated UE Emissions

The required protection distances for simulated LTE UE emissions into the SRDs under test are shown in Figure 12 to Figure 16 below. All of the results assume the LTE emissions just meet the ECC/Dec/(09)03 OOB requirements, which could be considered to be a somewhat pessimistic case.

Depending on assumptions made about the SRD receiver sensitivity, UE EIRP, data traffic of the UE (and the OOB emissions) and frequency separation, Figure 12 suggests that protection distances of up to 49.7m may be required under worst case assumptions to protect the radio microphone, 45.2m to protect the medical device and 25.9m to protect the social alarm. In practice the minimum SRD carrier level could be expected to be at least 10 dB higher than the receiver sensitivity and possibly closer to 20 dB higher, in order to accommodate propagation variations. Figure 13 shows that, for a wanted carrier level 20 dB higher than minimum sensitivity (effectively reducing the distance between SRD transmitter and receiver), the protection distance for the radio microphone reduces to 24.4m, the medical device reduces to 35.5m and the social alarm reduces to 12.7m.

In the results below, the EIRP of the LTE UE interfering emission used in the calculations has been taken to be 23, 17 and 5 dBm, based on work undertaken in Joint Task Group 5-6 [12]. It can be seen that protection distances reduce, as would be expected, as the LTE UE EIRP is reduced from 23 dBm to a more typical value. From Figure 13, the protection distance required to protect the radio microphone reduces to 7.5m for an EIRP of 5 dBm.

Figure 14 shows the protection distances required for 50, 25 and 1 RB[5], assuming the SRD wanted carrier level is 10 dB above the minimum sensitivity. In general, higher protection distances are needed as the number of simulated static resource blocks increases. This is most likely due to the fact that, for the simulated case, the out-of-band emissions increase as the number of resource blocks increase, as see from Figure 7 in section 3.2.

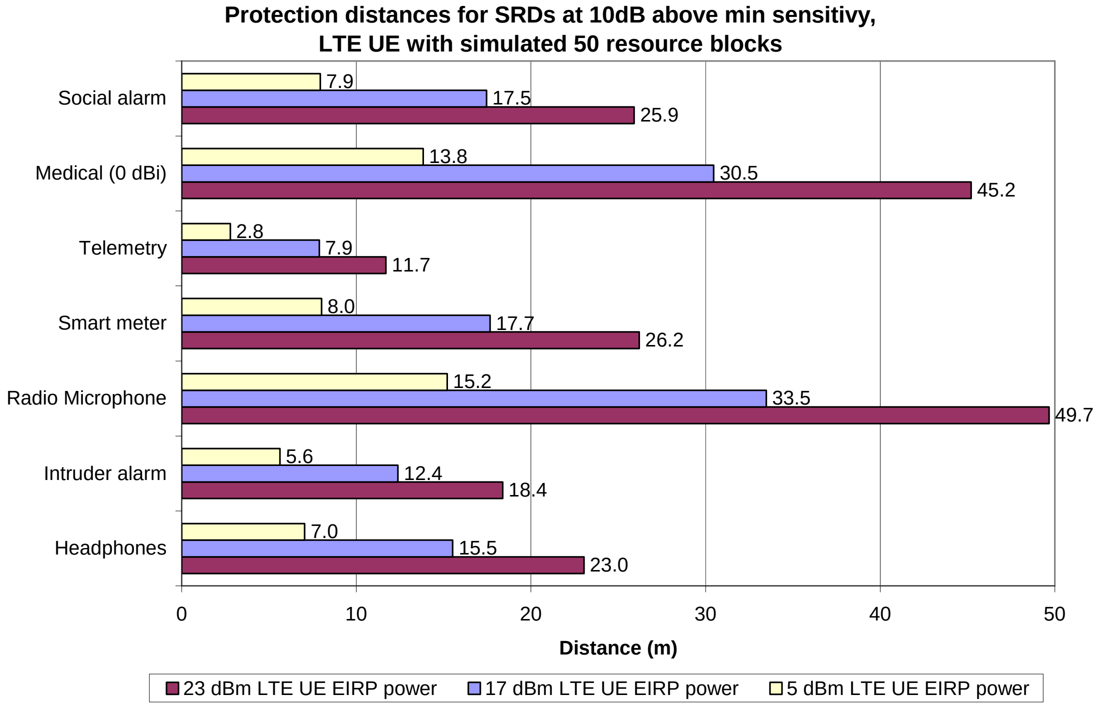

Figure 12: Protection distances for simulated LTE UE with 50 Resource Blocks: Wanted level 10 dB above minimum sensitivity

5 1 RB case only applied to Social Alarm and Radio Microphone

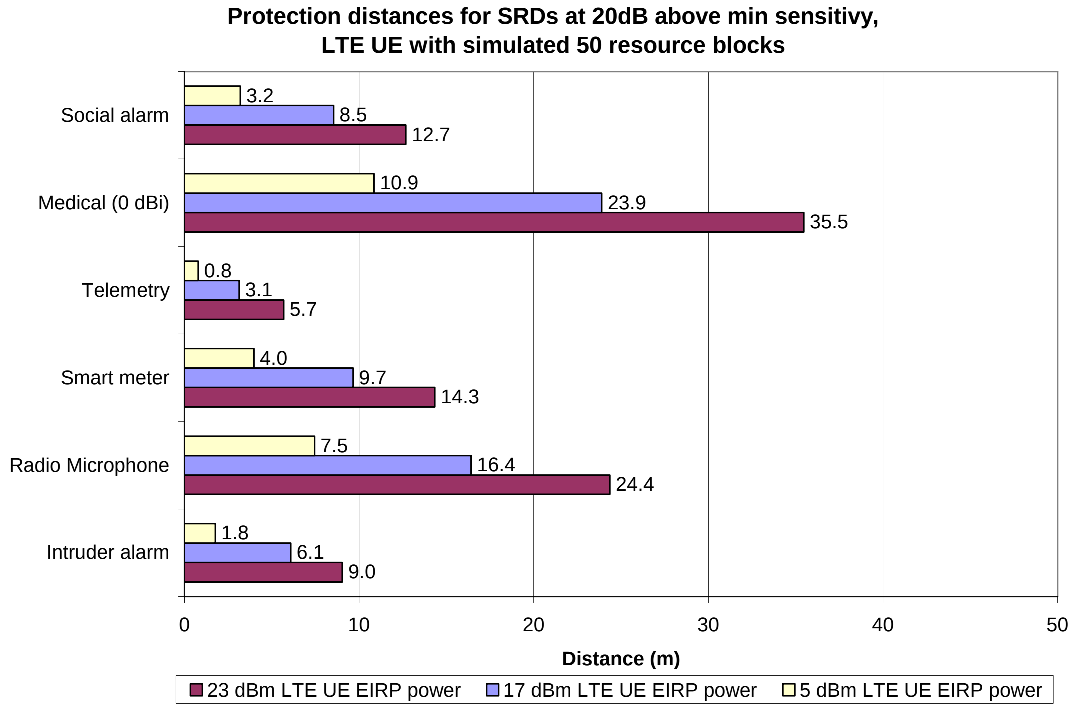

Figure 13: Protection distances for simulated LTE UE with 50 Resource Blocks: Wanted level 20 dB above minimum sensitivity

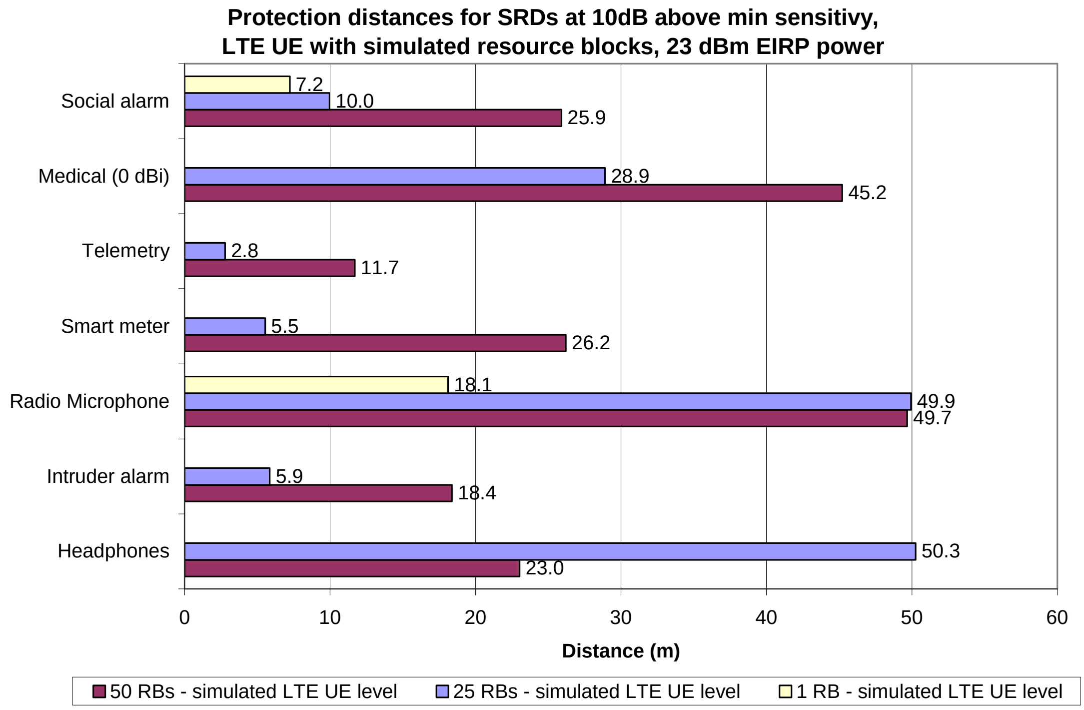

Figure 14: Protection distances for simulated LTE UE with 50, 25 and 1 Resource Block: Wanted level 10 dB above minimum sensitivity

From Figure 14 there appears to be some inconsistencies in the results for the Radio Microphone and Wireless Headphones, for the simulated 50 and 25 resource block cases. These two devices are the only ones that have a 100% duty cycle, and they also operate closest in frequency to the LTE UE band, with frequency separations of 1.15 MHz for the microphone and 1.365 MHz for the headphones. At these frequency separations, Figure 7 in section 3.2 shows that the OOB emissions for 25 RBs are slightly higher than the OOB emissions for 50 RBs, due to the filter and amplifier characteristics used to generate the signals.

Figure 15 and Figure 16 below show the results for a RFID device, for 50 and 25 RBs. The RFID device is shown separately as it has a different interference criterion from the other devices tested (minimum operating distance between tag and reader, rather than minimum sensitivity). The wanted signal level is set at the 70% distance of the maximum usable distance (0.56 m) between the RFID tag and RFID receiver. The results show a similar trend to the other SRD devices, with the protection distance reducing as the resource blocks and UE EIRP reduces.

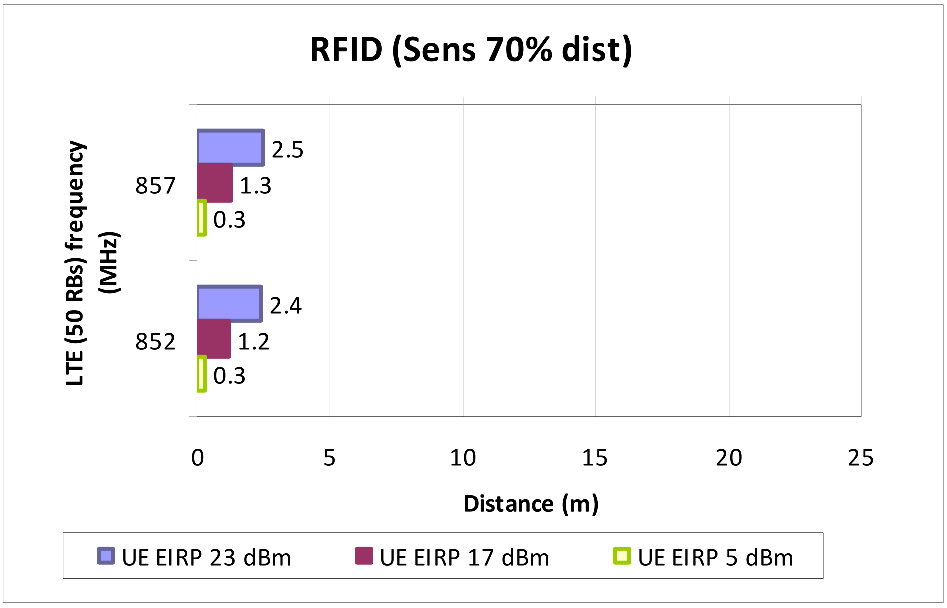

Figure 15: Protection distances for simulated LTE UE with 50 Resource Blocks into RFID

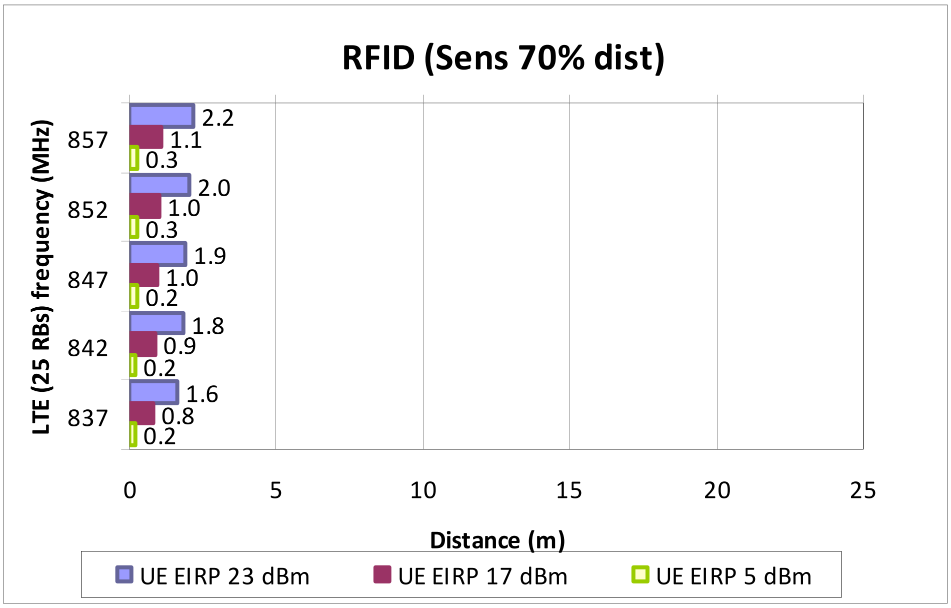

Figure 16: Protection distances for simulated LTE UE with 25 Resource Blocks into RFID

4.3 Required Protection Distance for UE Emulator Emissions

The results presented in the previous section, using simulated UE emissions, assume that the allocated resource blocks are fixed in time and frequency, i.e. the same RBs are always active for the simulated signal. In practice, resource blocks will be allocated dynamically in each timeframe by a scheduler, depending on the prevailing channel conditions.

To investigate the impacts of discontinuous (time varying) UE resource block allocations, the recorded emissions from a UE emulator configured for 20 Mbits/s or 1 Mbits/s data throughput were evaluated for the radio microphone receiver and three different social alarm models:

- G1: Original model, which is tested with the simulated LTE UE signals in Section 4.2.
- M2: A modified version of the original model, with relaxed specification (Class 1 device).
- H2: The latest model available from the manufacturer (Cat 1 design).

The required protection distances for the UE emulator emissions into the SRDs under test are shown in Figure 17 to Figure 22 below. For comparison, the simulated results for 50 RBs (adjusted to meet the ECC/Dec/(09)03 requirements) and 1 RB are included in the figures.

Depending on assumptions made about the SRD receiver sensitivity, UE EIRP and UE OOB emissions, Figure 17 and Figure 18 suggest that protection distances of up to 15.6m may be required to protect social alarms and 50.8m to protect the radio microphone, under worst case assumptions. If the UE OOB emissions are assumed to be better than the minimum requirement of ECC/Dec/(09)03 then protection distances could reduce to around 4m for social alarms and 15.8m for the radio microphone.

Protection distances are further reduced if the SRD wanted carrier level is assumed to be 20 dB above the minimum sensitivity (i.e. the SRD transmitter is moved closer to the receiver), as may be expected in a more typical scenario. In this case Figure 19 and Figure 20 show protection distances of up to 8.3m may be required to protect social alarms and 24.8m to protect the radio microphone. If the UE OOB emissions are assumed to be better than the ECC/Dec/(09)03 requirement then protection distances could reduce to 1.3m for social alarms and 8.8m for the radio microphone.

Figure 21 and Figure 22 show that protection distances are further reduced if the UE EIRP is reduced, in this case from 23 dBm to 17 dBm. This represents a more realistic operating scenario for a UE device, taking into account transmit power control and potential battery life issues. If the OOB emissions are also assumed to be better than the ECC requirement, Figure 22 shows that protection ratios of less than 1m are required for social alarms.

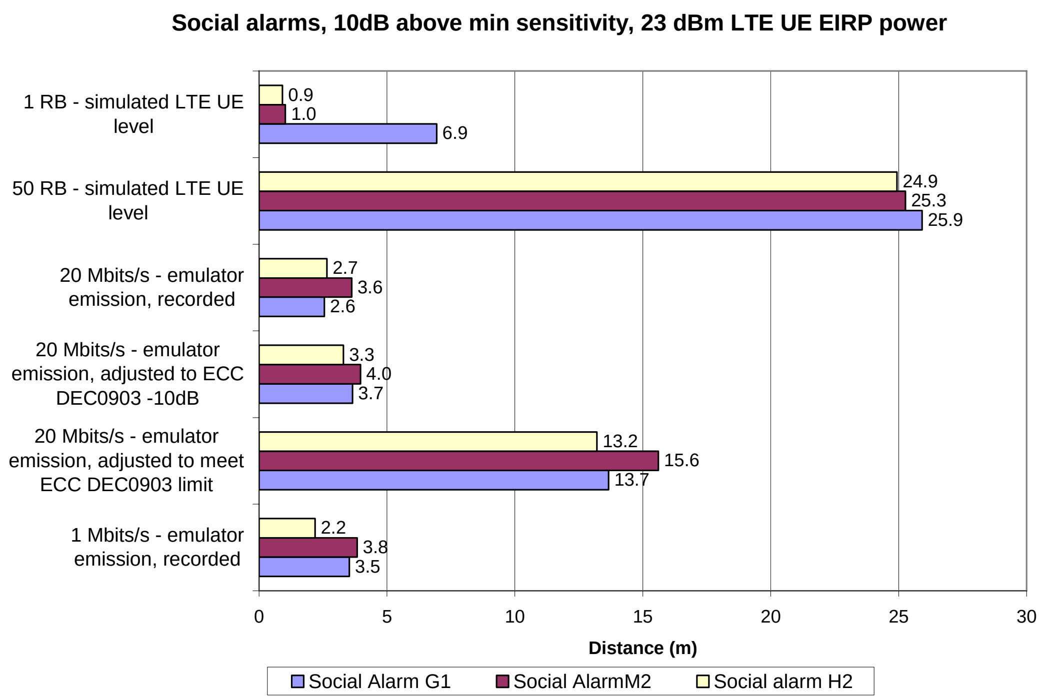

Figure 17: Protection distances for LTE UE emulator into social alarms. Wanted level 10 dB above minimum sensitivity

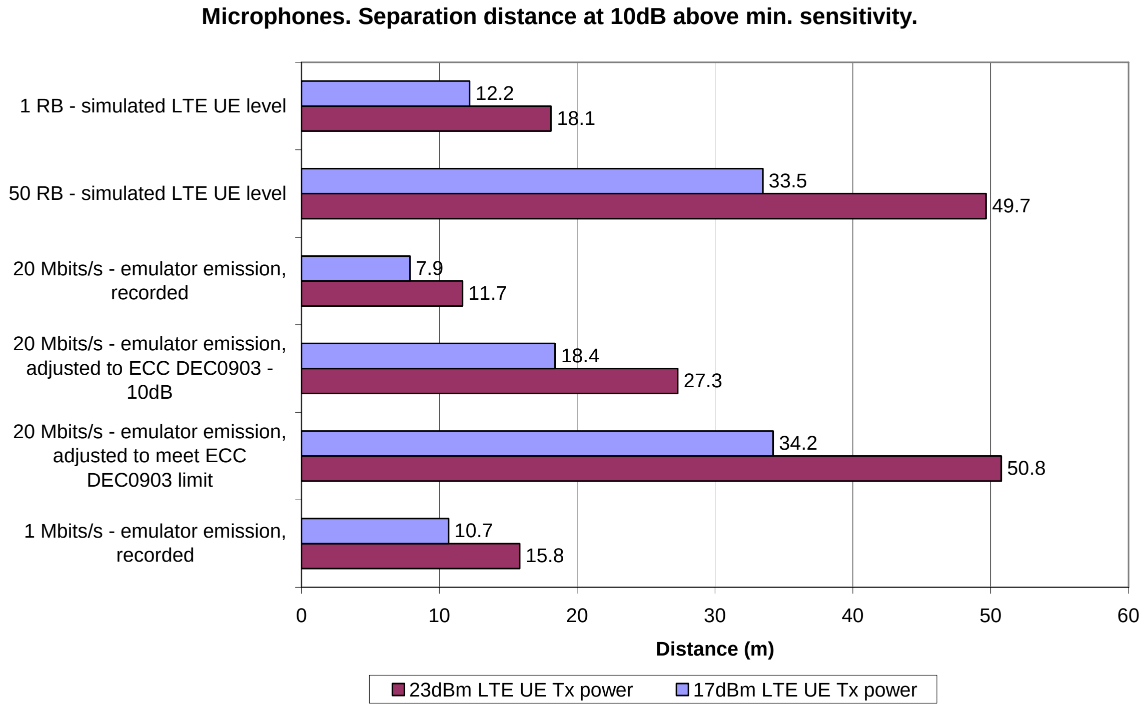

Figure 18: Protection distances for LTE UE emulator into radio microphone. Wanted level 10 dB above minimum sensitivity

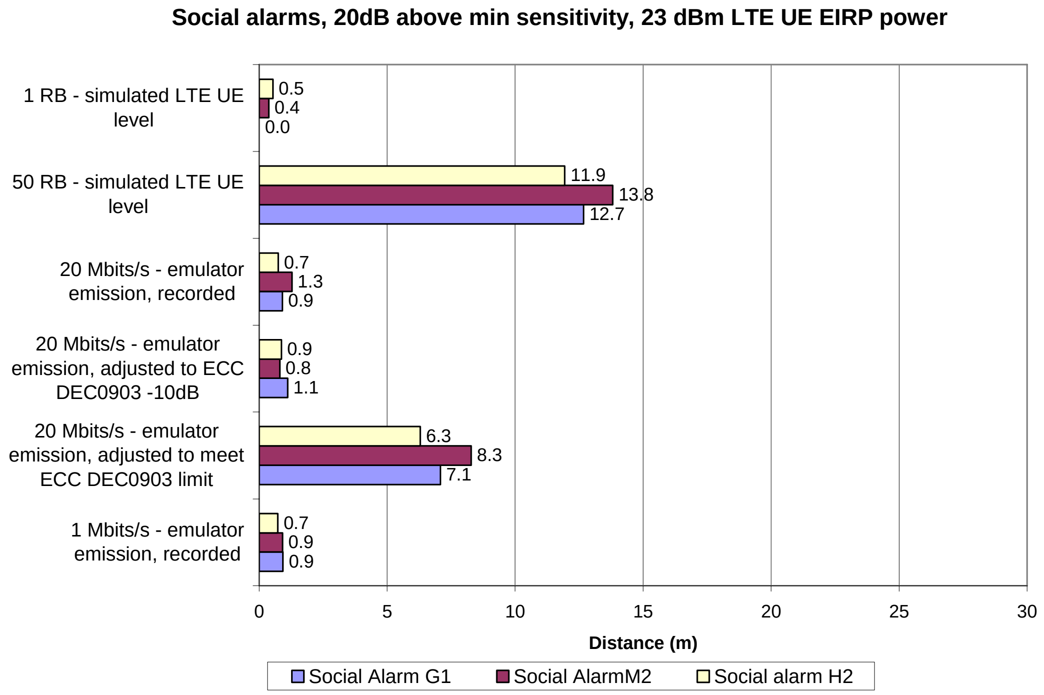

Figure 19: Protection distances for LTE UE emulator into social alarms. Wanted level 20 dB above minimum sensitivity

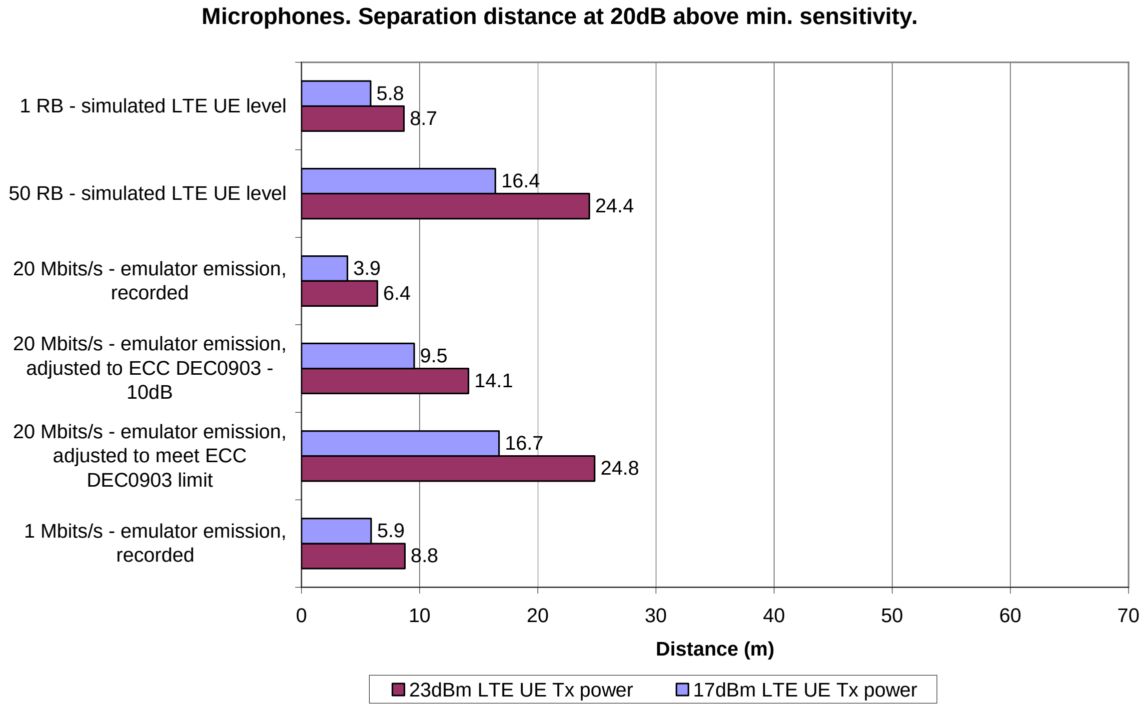

Figure 20: Protection distances for LTE UE emulator into radio microphone. Wanted level 20 dB above minimum sensitivity

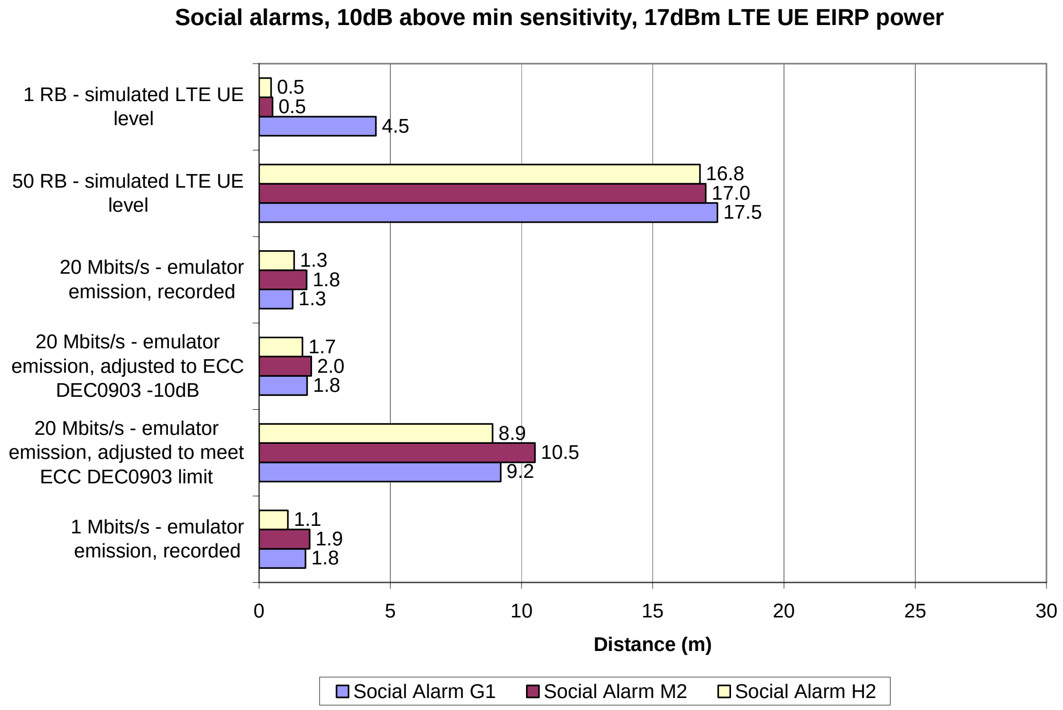

Figure 21: Protection distances for LTE UE emulator (17 dBm) into social alarms: Wanted signal level 10 dB above minimum sensitivity

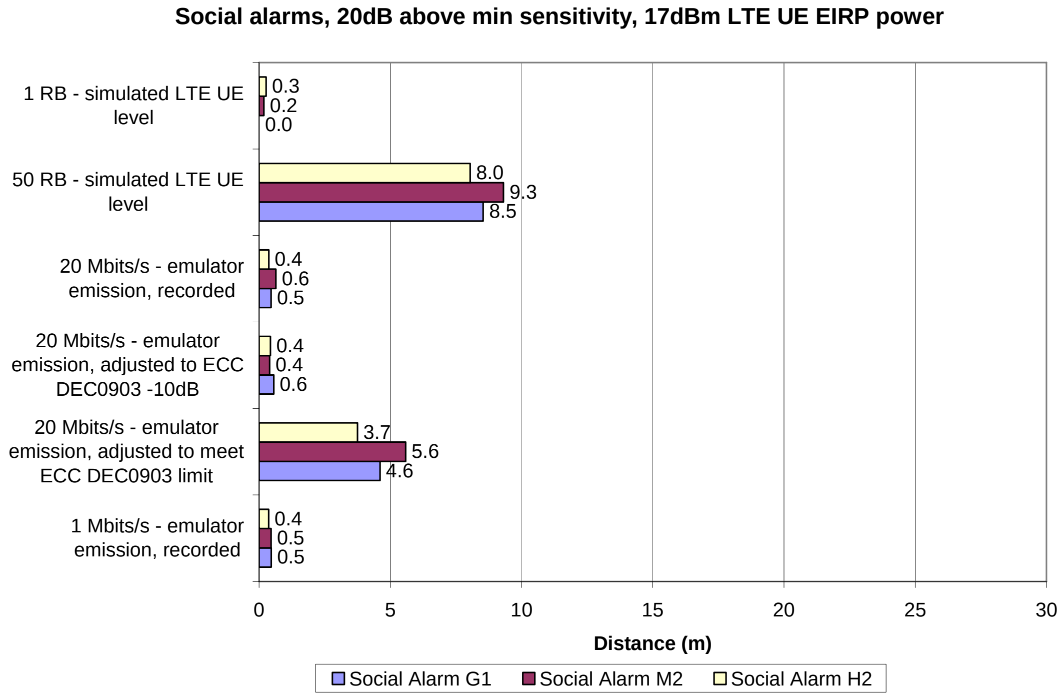

Figure 22: Protection distances for LTE UE emulator (17 dBm) into social alarms: Wanted signal level 20 dB above minimum sensitivity

4.4 SRD Interference into SRDs

A limited set of measurements were undertaken to provide a measure of the level of blocking currently experienced between different SRD devices operating in the 863 – 870 MHz band.

The cordless headphone and radio microphone were used as the interference sources since they operate with 100% duty cycle in the time domain. The spectrum emission masks are shown in Figure 23 and Figure 24. The interferers were assumed to be operating in the adjacent channel / frequency to the victim SRD receivers.

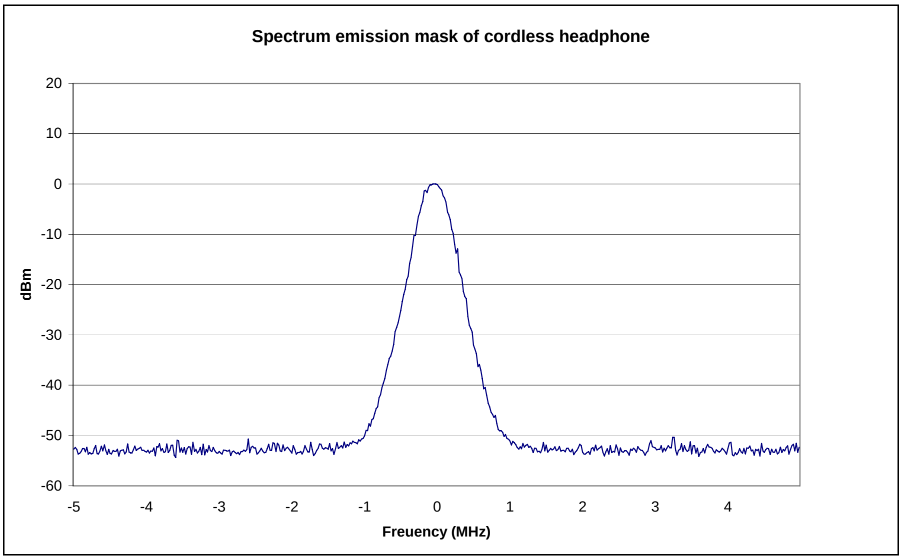

Figure 23: Spectrum emission mask of cordless headphone interferer

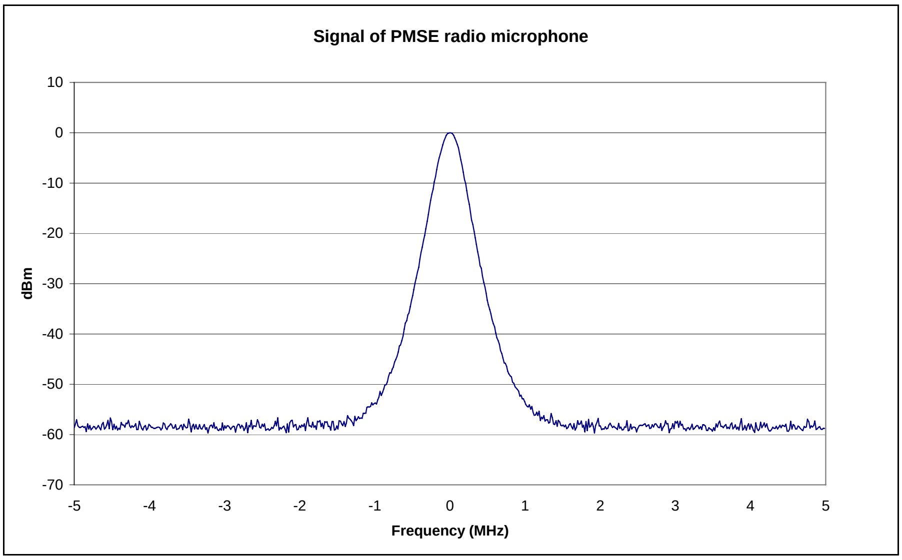

Figure 24: Spectrum emission mask of radio microphone interferer

The table below summarises the required separation distances assuming the wanted signal level at the receiver is 3 dB, 10 dB and 20 dB above the minimum sensitivity. The transmit EIRP of the cordless headphones and radio microphone was measured as 6.3 dBm and 6.35 dBm respectively.

The results, although limited in scope, suggest that there is the potential for interference between SRD devices currently operating in the 883 – 870 MHz band. The largest separation distances are required between the radio microphone and cordless headphones as these operate closest in frequency (0.091 MHz separation). It should be noted that both the interferers operate continuously in the time domain (100% duty cycle). For interferers with lower duty cycles the probability of interference would be expected to be reduced.

Table 12:
SRD into SRD indicative separation distances at 3 dB, 10 dB and 20 dB above minimum sensitivity

		Interferer					
Victim Device	**Victim Frequency (MHz)**	**Cordless Headphones** EIRP = 6.3 dBm F = 864.759 MHz			**Radio Microphone** EIRP = 6.35 dBm F = 864.85 MHz		
		3 dB above min sensitivity	10 dB above min sensitivity	20 dB above min sensitivity	3 dB above min sensitivity	10 dB above min sensitivity	20 dB above min sensitivity
Cordless Headphones	864.759				147.08	80.83	38.99
Radio Microphone	864.85	56.92	34.23	15.93			
Intruder Alarm	868.35	2.73	0.85	0.25	1.58	0.61	0.17
Social Alarm	869.215	-	-	-	-	-	-
Telemetry	869.875	2.02	1.14	0.45	1.80	1.27	0.45
Smart Meter	868.3794	1.33	0.61	-	1.91	0.76	-
Medical Device (-10 dBi antenna)	865.564	6.92	5.06	1.27	8.02	6.98	-
RFID[1]	869.519		0.49			0.50	

Notes:

1. Measured at 70% of the maximum usable distance (0.56m)

5. Mitigation Options

There are many variables that need to be considered when examining the impact of LTE UE transmissions on SRD receivers. These variables include:

1. The frequency offset between the interfering carrier and the victim receiver;
2. The shape of the interfering emission and in particular how the out-of-band LTE emissions vary with the number of resource blocks being used;

3. The selectivity of the victim receiver - although it appears (from a resource block comparison with respect to the device) that the dominant interference effect is from LTE out-of-band emissions falling in the pass band of the receiver rather than from the main power of the LTE emission falling in the selectivity skirt of the receiver;
4. The EIRP of the interfering emission which largely depends on the location of the LTE UE within a cell (but also see 7 below);
5. The level of the wanted signal at the victim receiver;
6. Propagation variations on both the interfering path and the SRD wanted path;
7. The EIRP and shape of the interfering emission as influenced by the use of power control (to correct for distance from the base station and propagation variations).

The analysis at different UE power levels has shown that, under very worst case assumptions, separation distances of up to 50m may be required to protect the wireless microphone. However, this would imply a worst-case upon worst-case situation with the following taken to apply simultaneously:

- The level of the wanted signal at the SRD receiver has been taken to be 10 dB above the receiver's sensitivity level. It might be expected that the minimum wanted carrier level would be at least 10 dB higher than the receiver sensitivity, and possibly closer to 20 dB higher, in order to accommodate propagation variations. In order to avoid the deepest multipath fades which occur for small percentages of time it would be expected that a margin of 20 dB would ameliorate such fades for all but 1% of time, depending on the relative locations of the devices and the environment;
- The EIRP of the LTE UE interfering emission has been taken to be 23 dBm. There is however an extremely wide range of EIRPs that the LTE UE will operate at depending on the location of the device in relation to the base station with which it is operating, propagation conditions and the service being supported. Our simulations suggest a mean EIRP value (neglecting any considerations of hand held loss) of between 4 and 16.5 dBm, the former associated with the lowest order of modulation and the latter with the highest. The value associated with the highest order modulation is in line with the 15 dB suggested by Holma and Toskala [8]. However, ITU-R material based on measurements[6], admittedly based on WCDMA/UMTS rather than LTE/E-UTRA, suggests that the UE power distribution within a cell has a very wide range (60 dB or more) with a mean of 2 dBm for rural areas and -9 dBm for

[6] Annex 3-3 of Annex 9 to the Report on the Fifth and Final Meeting of JTG5-6 dated 4 June 2010.

urban areas. Recognising that these measurement results were not directly comparable to the situation being addressed, JTG5-6 produced a comprehensive set of simulations[7] which indicate a slightly smaller range of UE power in a cell with a mean from -8.4 dBm to 11.5 dBm depending on the details of the scenario simulated;

- The simulated LTE UE is considered to use 50 resource blocks which results in a correspondingly high out-of-band emission level. Depending on the exact frequency offset between the LTE UE centre frequency and the carrier frequency of the victim SRD receiver the power density of LTE UE out-of-band emissions at the edge of the 10 MHz channel is some 20 dB below the in-band emission level. This level falls gradually by some 8 dB at 5 MHz away from the channel edge and then more rapidly by a further 20 dB at 10 MHz away from the channel edge. The simulated LTE spectrum in CEPT Report 30 shows that the out-of-band emission level when 1 resource block is supported is at least 20 dB below the 50 resource block out-of-band emission level, except for some peaks at specific frequencies where the emission level is in fact higher that the 50 resource block out-of-band emission level. Furthermore, the emissions from LTE UE emulator show that the LTE UE never uses all 50 resource blocks in practice; the two resource blocks next to the edge of the channel are normally not allocated for data throughput.

The probability of all these conditions, namely the wanted SRD signal level being just above the receiver's sensitivity level, the LTE UE using its maximum EIRP and the LTE UE using 50 resource blocks happening simultaneously is very small. In the ideal modelling case all the variables noted earlier would be represented by probabilistic distributions and simulated in the style of Seamcat [10] to give an indication of the likelihood of interference occurring. In the absence of such information we have had to make an assessment as to which results presented in this report are the most representative.

In order to arrive at separation distances that might be required to mitigate interference we have assumed a general purpose propagation model based on ITU-R P.1238-6 [13], as discussed in section 4. When considering those results that have been judged to be most representative of the real situation it will be seen that the exact form of the propagation model is not hugely significant as the separation distance requirements fall within or around 5m which in most cases will have a strong free space component, which is already built into the model. We should then consider the situation where an LTE UE device is within these sorts of distances of a victim SRD receiver. If they are in the same room then it might

[7] Annex 3-2 ibid.

reasonably be expected that the user of the LTE UE device would recognise the cause and effect and take appropriate action. If they are in different rooms with this sort of distance between them then wall attenuation (which is not taken into account in the closer-in distances of the propagation model) would be expected to ameliorate the interference.

Another factor that should be considered when determining the vulnerability of SRDs to LTE emissions concerns the relative signal structures of the wanted and receiving signals. SRD mitigation techniques, namely duty cycle and message repetition which is employed to mitigate interference from their own or similar systems (i.e. in-band) may or may not offer some protection from LTE UE interference. In the case of audio SRD systems, however, where a 100% duty cycle effectively applies this consideration is not relevant.

Without a detailed analysis of signal structures it is difficult to know whether any mitigation can be relied on from the relative signal structures of the different systems. However, analysis and interpretation of the measurements presented in this report does raise the question as to whether it is it better to:

- use shorter transmissions (i.e. more resource blocks with concomitant higher out-of-band emissions) where the shorter transmissions have the potential to reduce the probability of interference with the victim SRD's signal, or
- use longer transmissions (i.e. fewer resource blocks and correspondingly lower out-of-band emissions, except for the frequency spikes noted earlier) where the longer transmissions have a higher probability of interference with the victim SRD's signal but at the same time have a lower likelihood of causing interference because the level of out-of-band emissions is lower.

6. Conclusions

A measurement programme was undertaken to establish the Carrier-to-Interference protection ratio for eight different types of SRD available on the UK market. At the time of the study there were no "real" LTE 800 MHz UE devices available for use in testing and so simulated emissions were used to assess the potential for interference. Results varied markedly depending on assumptions made about the SRD wanted signal level at the receiver, UE EIRP, data traffic of the UE (and the Out-Of-Band emissions) and frequency separation. As a consequence, considerable caution must be exercised in drawing any firm conclusions from the test findings until further information becomes available on 800 MHz UE device behaviour.

Where interference was found to occur the protection distances required to avoid interference from LTE 800 MHz UE devices to SRD equipment were calculated, taking into account the following factors:

- The level of the wanted signal at the victim receiver;
- The spectral shape of the interfering LTE emissions and in particular how the out-of-band emissions vary with the number of resource blocks being used;
- The EIRP of the interfering emission, which largely depends on the location of the LTE UE within a cell;
- The frequency offset between the interfering carrier and the victim receiver;
- Propagation variations on both the interfering path and the SRD wanted path.

Two different types of interferer were considered in the study:

- Detailed testing using a simulated UE interferer with 10 MHz bandwidth QPSK reference channel and different static resource block allocations (50, 25 and 1 RB);
- Additional testing for a limited sub-set of SRDs using recorded emissions from a UE emulator developed by an equipment vendor, configured for 10 MHz bandwidth and different data traffic loading conditions (20 Mbits/s and 1 Mbits/s) with dynamic resource block allocation.

6.1 Simulated UE Emissions

Using somewhat worst-case assumptions about UE operation and wanted SRD signal level Figure 25 below shows that there appears to be some risk of interference to particular SRD devices in certain scenarios. With the UE transmitting at the maximum permitted EIRP of 23 dBm and utilising a large number of resource blocks, protection distances as high as 49.7m were shown to be required to protect cordless audio equipment; 45.2m to protect medical devices; and 25.9m to protect social alarms.

Figure 26 shows that the protection distance reduces by approximately 50% if the SRD is assumed to operate at 20 dB above the minimum sensitivity, i.e. the wanted signal is 10 dB stronger[8]. In practice the minimum wanted carrier level could be expected to be at least 10 dB higher than the receiver sensitivity, and possibly closer to 20 dB higher, in order to accommodate propagation variations. In order to avoid the deepest multipath fades which occur for small percentages of time it would be expected that a margin of 20 dB would ameliorate such fades for all but 1% of time, depending on the relative locations of the devices and the environment.

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[8] Equivalent to reducing the operating distance between the wanted transmitter and receiver.

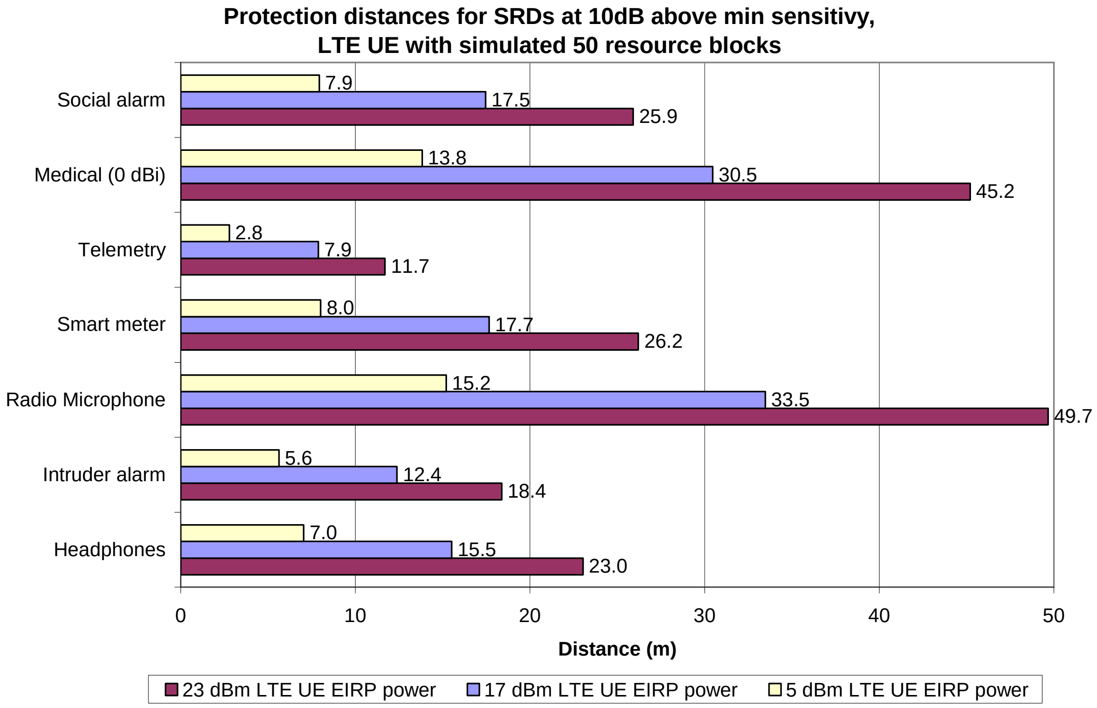

Figure 25: Protection distances for SRD devices operating at 10 dB above minimum sensitivity; simulated UE interferer with 50 RBs centred at 857 MHz

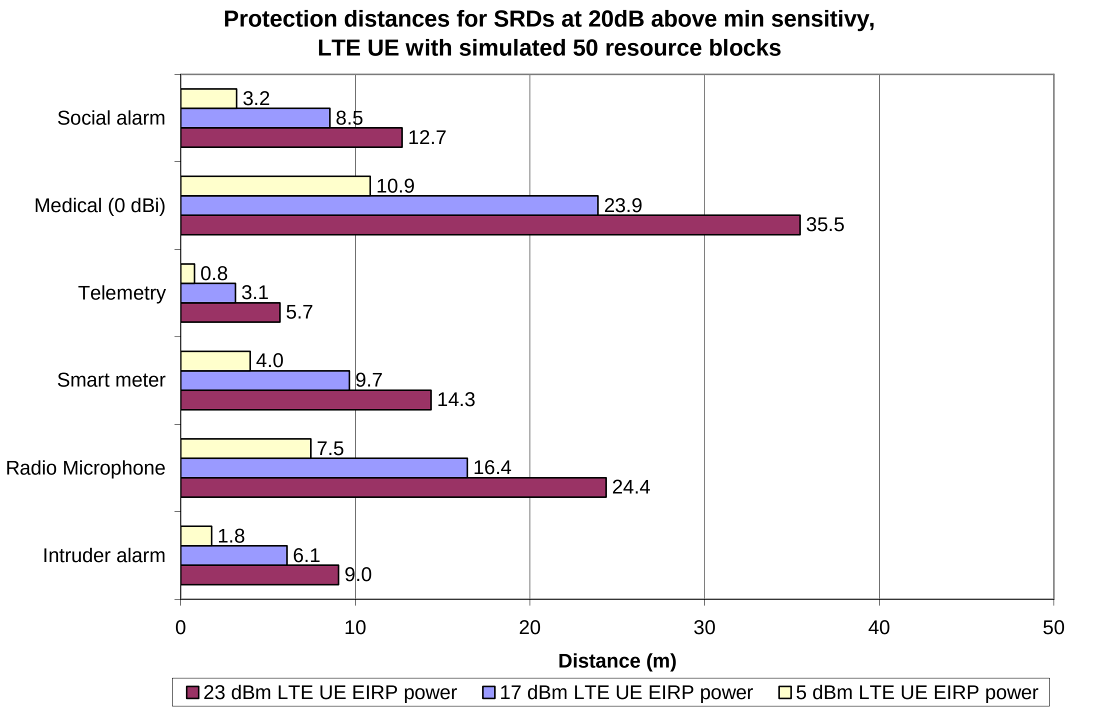

Figure 26: Protection distances for SRD devices operating at 20 dB above minimum sensitivity; simulated UE interferer with 50 RBs centred at 857 MHz

In practice the EIRP of the LTE UE interfering emission could be much lower than 23 dBm due to power control and battery life issues; the level chosen will depend on the location of the device in relation to the base station with which it is operating, propagation conditions and the service being supported. Simulations of LTE UE EIRP presented in ITU-R JTG5-6 [12] suggest a mean EIRP in the range -8.4 to 11.5 dBm depending on the scenario. In Figure 25 and Figure 26 above it can be seen that the protection distances are very much reduced for a corresponding reduction in UE EIRP.

6.2 Emissions from a UE Emulator

Further testing was undertaken on the radio microphone and three different social alarm models (identified as H2, M2 and G1 in the following figures) using emissions captured from a UE emulator operating in a vendor’s 800 MHz LTE test network. The emulator was configured for a 10 MHz channel bandwidth and data traffic transmitted at a constant rate of 20 Mbits/s with the Resource Blocks allocated dynamically by the scheduler according to a proprietary algorithm. Figure 27 and Figure 28 below show the required protection distances with the emulator configured for different spectral emission profiles; recorded directly from the UE emulator, adjusted to meet the ECC/Dec/(09)03 requirement and at 10 dB below the ECC requirement. These results again assume the UE EIRP is 23 dBm.

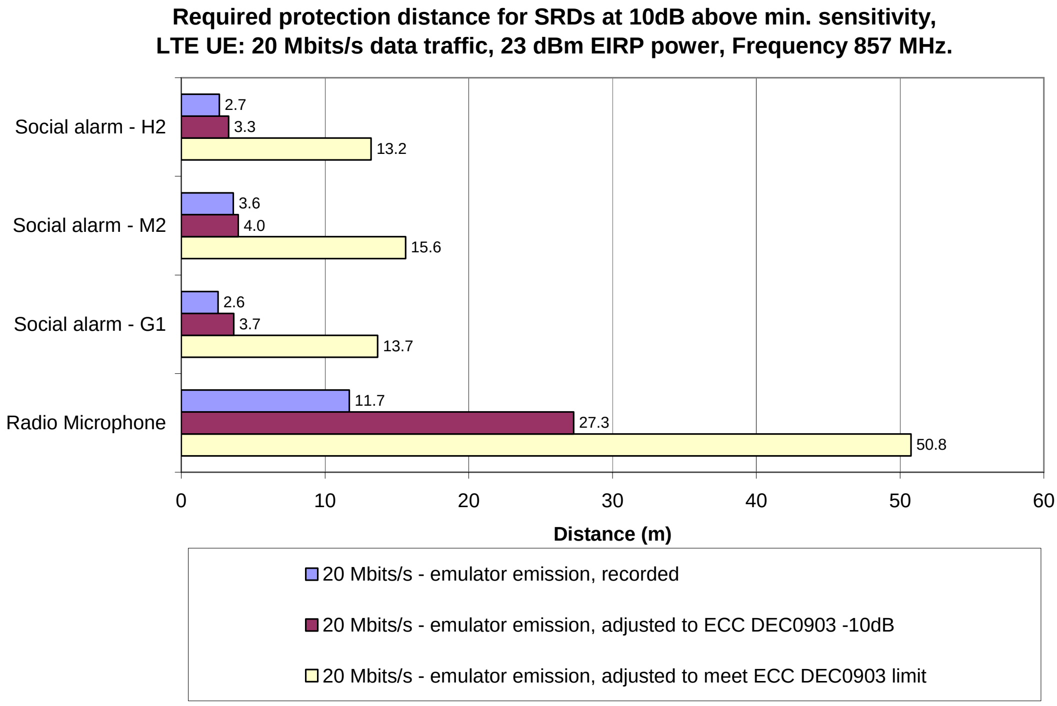

Figure 27: Protection distances for selected SRD devices operating at 10 dB above minimum sensitivity; UE emulator with 20 Mbits/s data traffic at 857 MHz

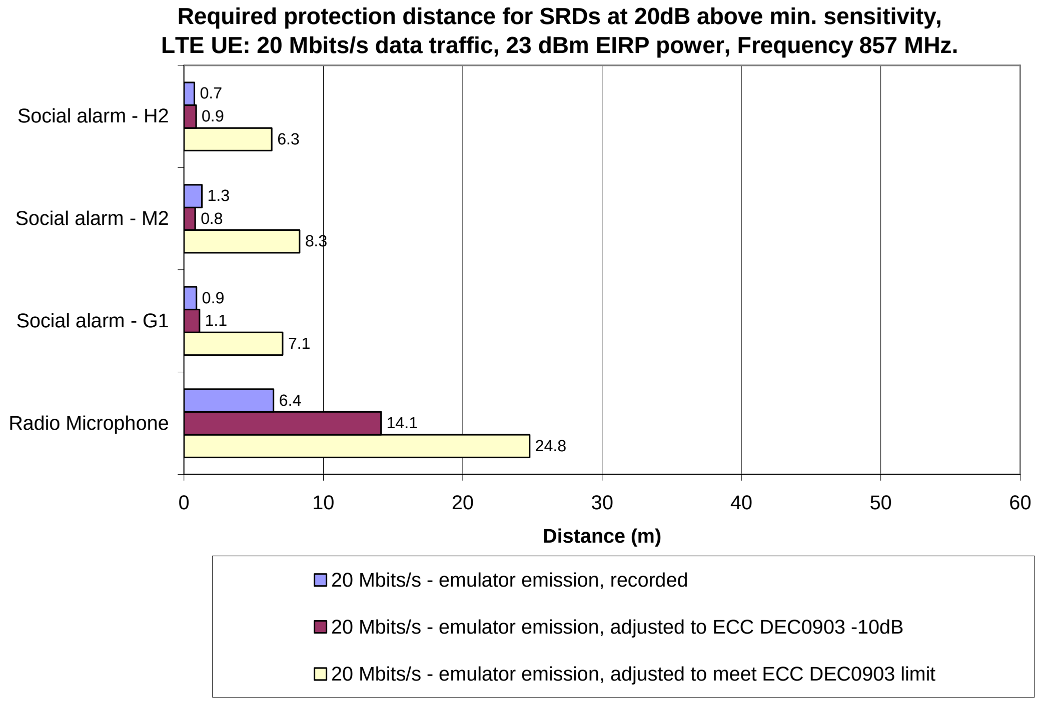

Figure 28: Protection distances for selected SRD devices operating at 20 dB above minimum sensitivity; UE emulator with 20 Mbits/s data traffic at 857 MHz

Figure 27 shows that the results under somewhat worst-case operating assumptions for the UE emulator are comparable to the corresponding simulated UE results. Once again, protection distances are reduced very considerably if the SRD transmitter is assumed to be closer to the receiver, thus improving wanted signal level, as shown in Figure 28.

The emissions from a real UE could be considerably better than the ECC/Dec/(09)03 minimum requirement, as evidenced from the emissions recorded directly from the vendor's UE emulator. In this case the protection distances will be further reduced, to around 6.4m for radio microphones and 1m for social alarms. These distances could be expected to reduce still further if the UE transmits at lower EIRPs, as is more realistic.

6.3 SRD to SRD Interference

A limited set of measurements was undertaken to assess the potential for interference from cordless headphones and a radio microphone into other types of SRD currently operating in the 800 MHz band. It should be noted that both the interferers operate continuously in the time domain (100% duty cycle) and have relatively high transmit powers. For interferers with lower duty cycles or lower transmit power the probability of interference would be expected to reduce. We have assumed that the SRD receiver is operating at 3 dB, 10 dB and 20 dB above the measured minimum sensitivity.

Although limited in scope, the measurements suggest that SRD devices operating in the unlicensed 800 MHz band are subject to interference from other SRD emissions. The largest protection distances are required between the radio microphone and cordless headphones as these operate closest in frequency (0.091 MHz separation). For other combinations of interference, protection distances of between 50cm and 7m are required.

7. References

[1] ETSI TS 136 521-1 V8.4.0 (2010-04): LTE; Evolved Universal Terrestrial Radio Access (EUTRA); User Equipment (UE) conformance specification; Radio transmission and reception; Part 1: Conformance testing (3GPP TS 36.521-1 version 8.4.0 Release 8)

[2] ETSI EN 301 357-1: Cordless audio devices in the range 25 MHz to 2000 MHz; Part 1: Technical characteristics and test methods.

[3] ETSI EN 302 208-1: Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W; Part 1: Technical requirements and methods of measurement.

[4] ETSI EN 300 220-1: Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1000 MHz frequency range with power levels ranging up to 500 mW; Part 1: Technical characteristics and test methods.

[5] BS EN 50131-5-3:2005 Alarm systems – Intrusion systems. Part 5-3: Requirements for interconnections equipment using radio frequency techniques.

[6] ETSI TR 102 546: Electromagnetic compatibility and Radio spectrum Matters (ERM); Technical characteristics for Professional Cordless Microphone Systems (PWMS); System Reference Document.

[7] BS EN 137 57-4:2005 Communication systems for meters and remote reading of meters — Part 4: Cordless meter readout (Radio meter reading for operation in the 868 MHz to 870 MHz SRD band).

[8] BS EN 50134-3:2001 Alarm systems – Social alarm systems – Part 3: Local unit and controller

[9] Harri Holma & Antti Toskala: LTE for UMTS – OFDMA and SC-FDMA Based Radio Access. Wiley, 2009.

[10] http://www.ero.dk/seamcat

[11] ERC Recommendation 70-03 Relating to the use of Short Range Devices (SRD). Version of 1 June 2010

[12] Report of the Fifth and Final Meeting of Joint Task Group 5-6 (Annex 3-2 of Annex 9) Document 5-6/180, 4 June 2010.

[13] ITU-R P.1238-6. Propagation data and prediction methods for the planning of indoor radiocommunication systems and radio local area networks in the frequency range 900 MHz to 100 GHz.

[14] ECC/Dec/(09)03 on harmonised conditions for mobile/fixed communications networks (MFCN) operating in the band 790 – 862 MHz. 30th October 2009.

[15] ERA report 2008-0234 for Ofcom, Measurements of UTRA FDD user Equipment characteristics in the 2.1 GHz band, 2008.

[16] Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues, Ofcom consultation, 22nd March 2011 (http://stakeholders.ofcom.org.uk/consultations/combined-award/)

[17] European Commission Decision of 6 May 2010 on harmonised technical conditions of use in the 790 – 862 MHz frequency band for terrestrial systems capable of providing electronic communications services in the European Union (2010/267/EU) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32010D0267:EN:NOT

Appendix A
Cordless Headphone Results

A.1. C/I protection ratios

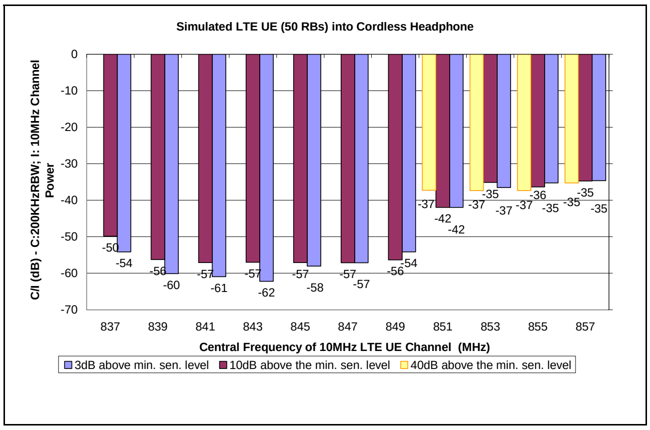

Figure 29: C/I for cordless headphone (50 RBs)

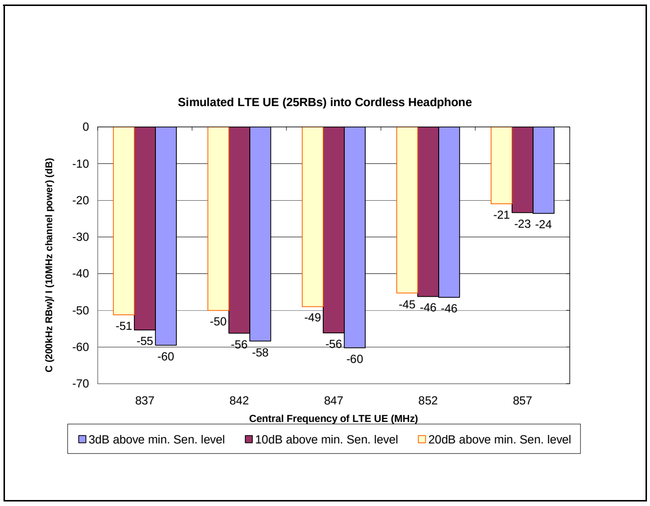

Figure 30: C/I for cordless headphone (25 RBs)

Ref:P:\Projects Database\Ofcom 2010 - 7A 05130\Ofcom - 7A0513014 - Further investigation of LTE into SRDs\ERA Reports\Rep-6796 - 2011-0299 SRD Study.doc

A.2. Protection Distances

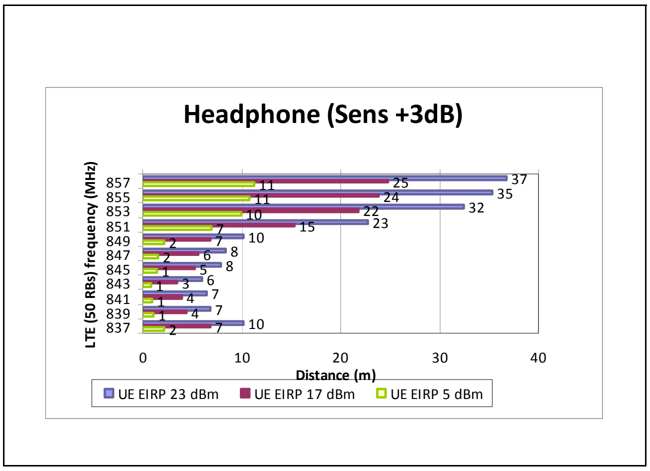

Figure 31: Protection distance for cordless headphone (50 RBs)

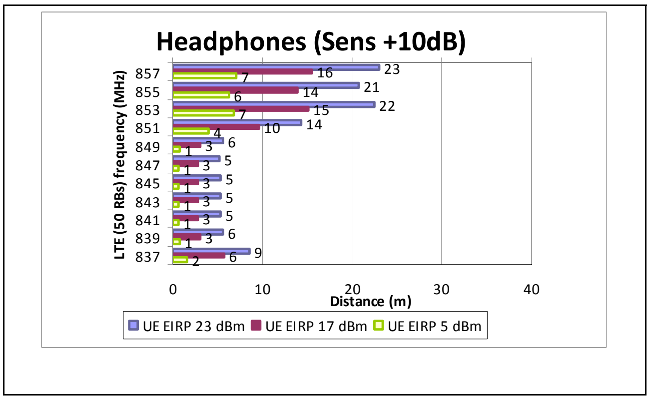

Figure 32: Protection distance for cordless headphone (50 RBs)

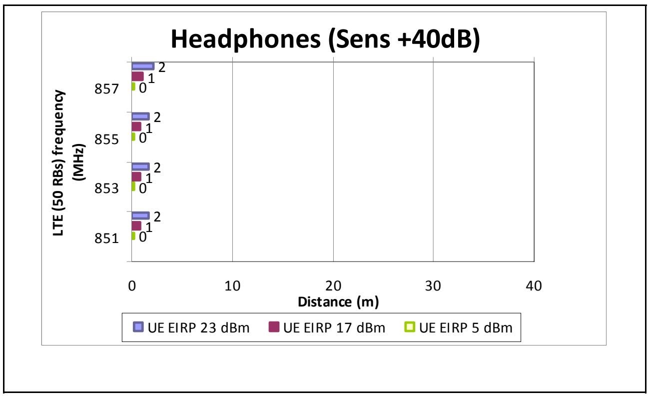

Figure 33: Protection distance for cordless headphone (50 RBs)

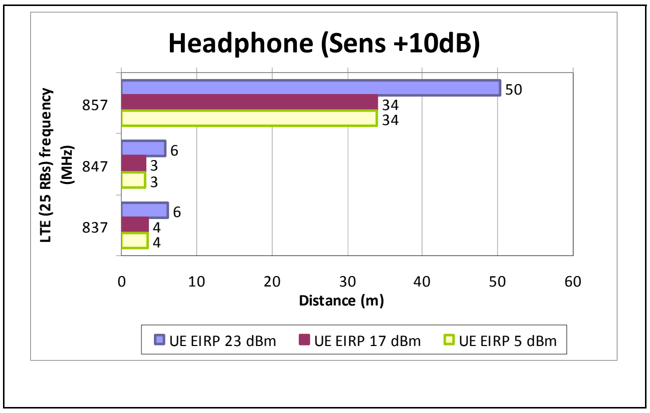

Figure 34: Protection distance for cordless headphone (25 RBs)

A.3. Selectivity of Receiver

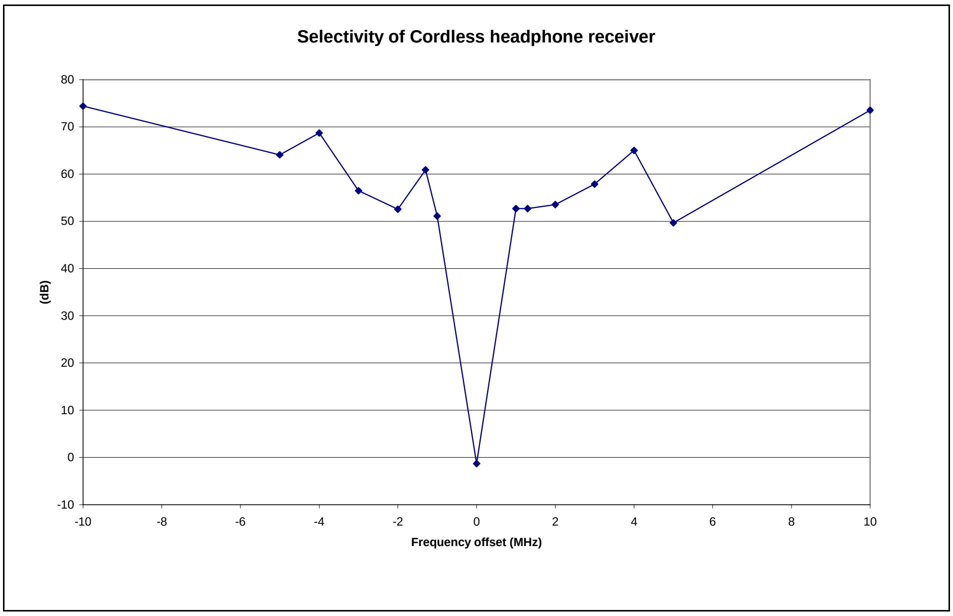

Figure 35: Selectivity of cordless headphone receiver

Appendix B
Radio Microphone Results

B.1. C/I protection ratios

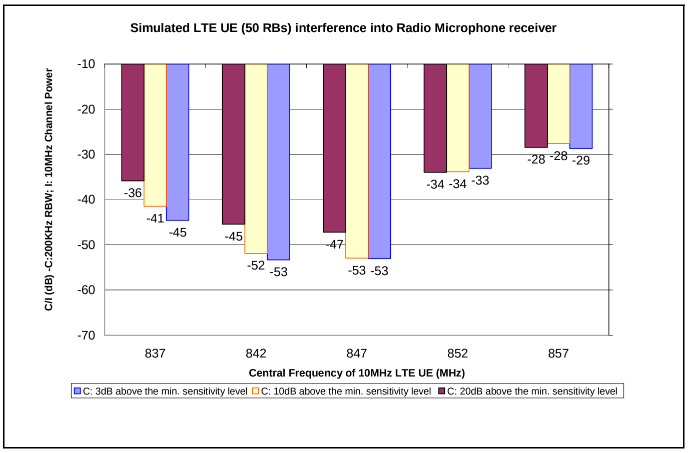

Figure 36: C/I for radio microphone (50 RBs)

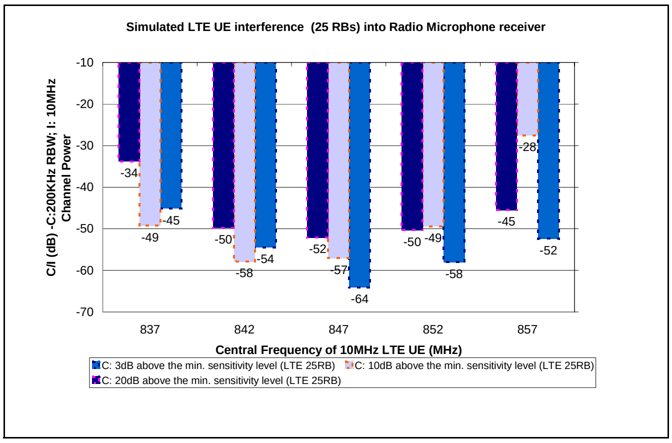

Figure 37: C/I for radio microphone (25 RBs)

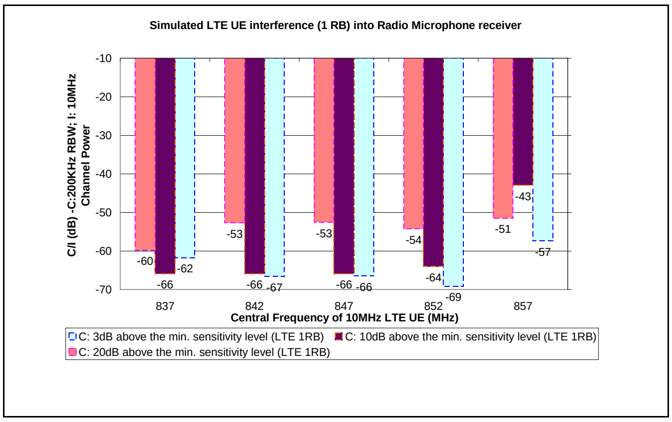

Figure 38: C/I for radio microphone (1 RB)

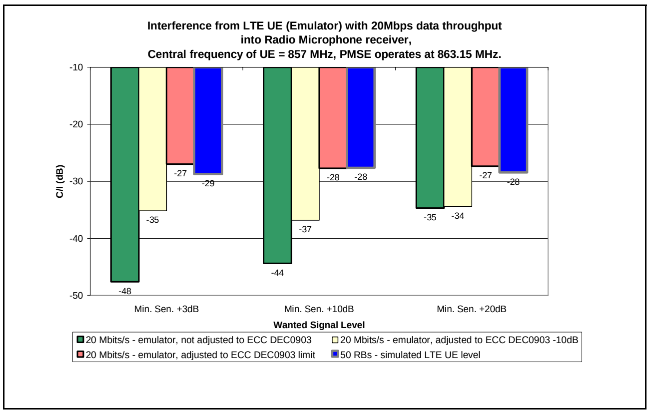

Figure 39: C/I for radio microphone (20 Mbits/s)

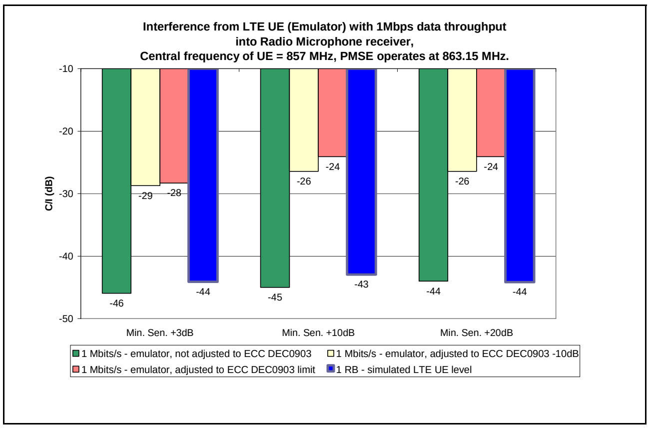

Figure 40: C/I for radio microphone (1 Mbits/s)

B.2. Protection Distances

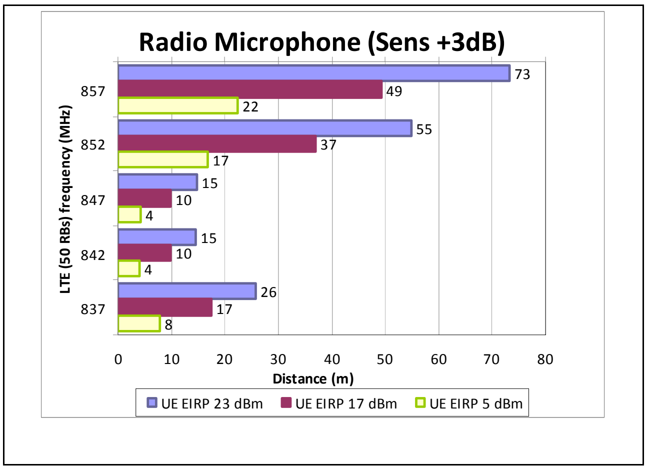

Figure 41: Protection distance for radio microphone (50 RBs)

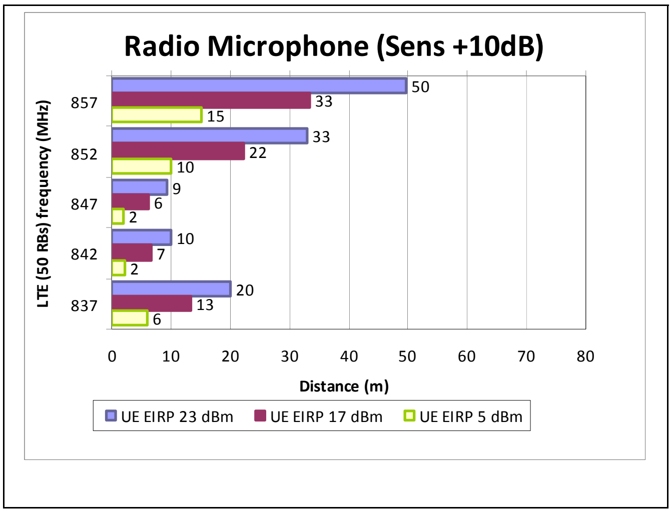

Figure 42: Protection distance for radio microphone (50 RBs)

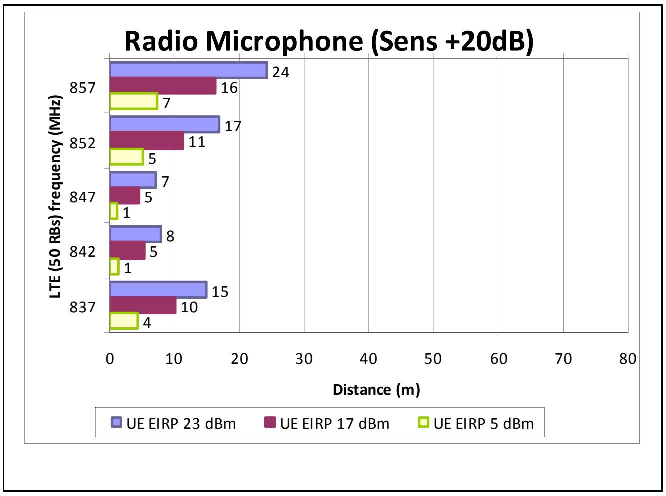

Figure 43: Protection distance for radio microphone (50 RBs)

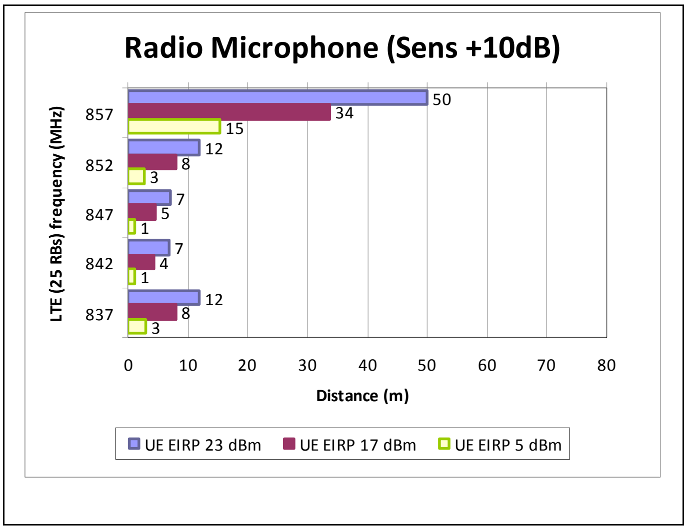

Figure 44: Protection distance for radio microphone (25 RBs)

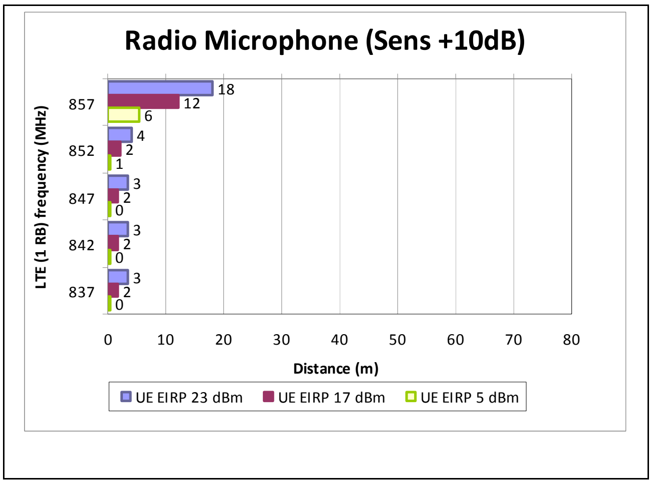

Figure 45: Protection distance for radio microphone (1 RB)

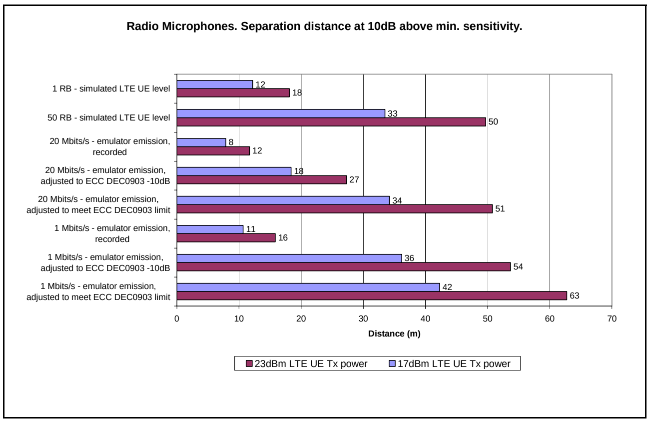

Figure 46: Protection distance for radio microphone

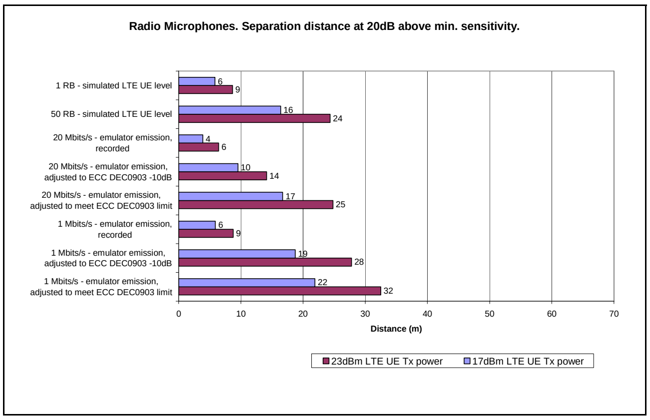

Figure 47: Protection distance for radio microphone

B.3. Selectivity of Receiver

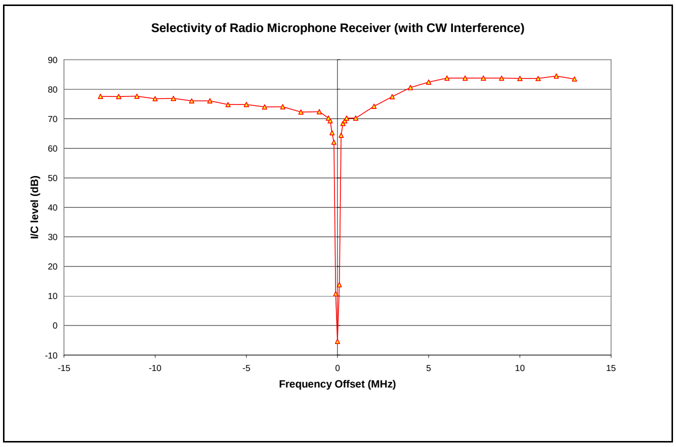

Figure 48: Selectivity of radio microphone receiver

Appendix C
Intruder Alarm Results

C.1. C/I protection ratios

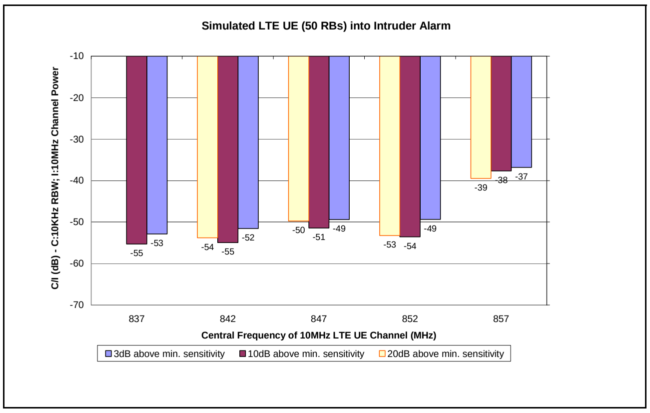

Figure 49: C/I for Intruder Alarm (50 RBs)

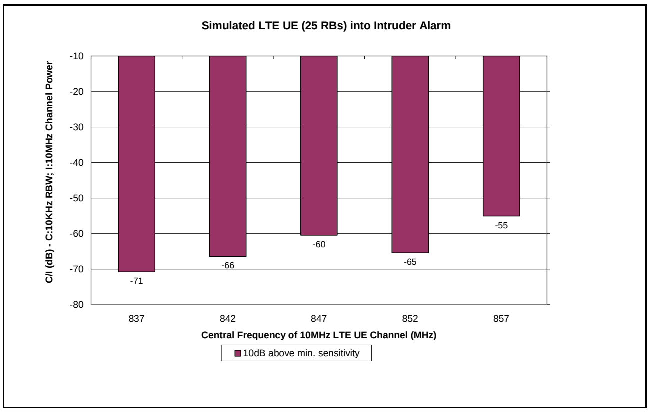

Figure 50: C/I for Intruder Alarm (25 RBs)

C.2. Protection Distances

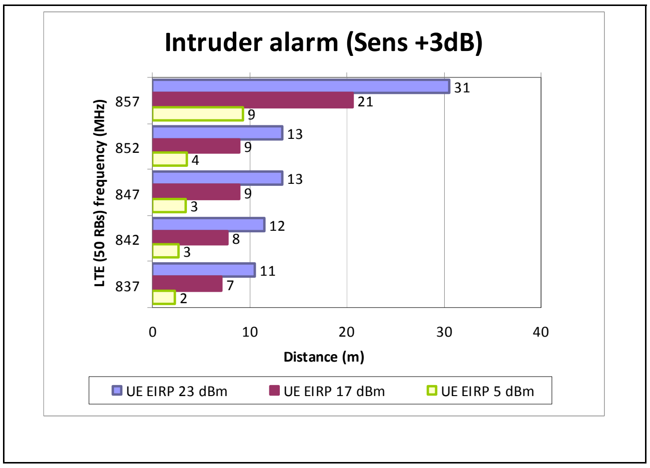

Figure 51: Protection distance for Intruder Alarm (50 RBs)

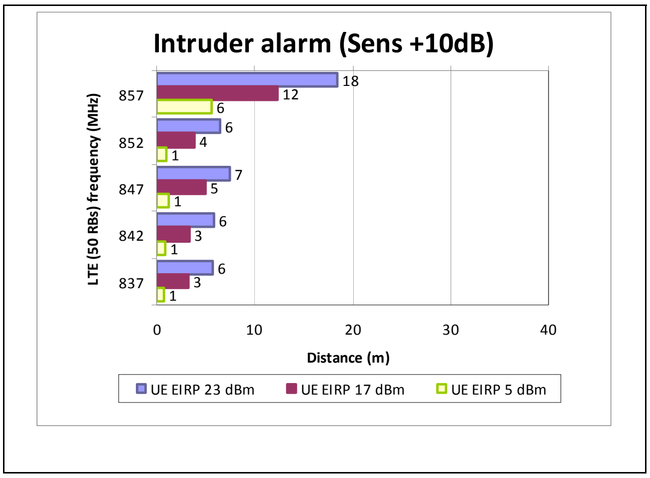

Figure 52: Protection distance for Intruder Alarm (50 RBs)

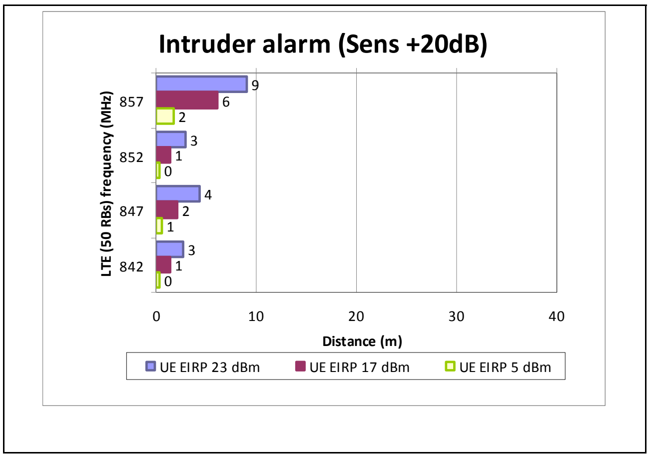

Figure 53: Protection distance for Intruder Alarm (50 RBs)

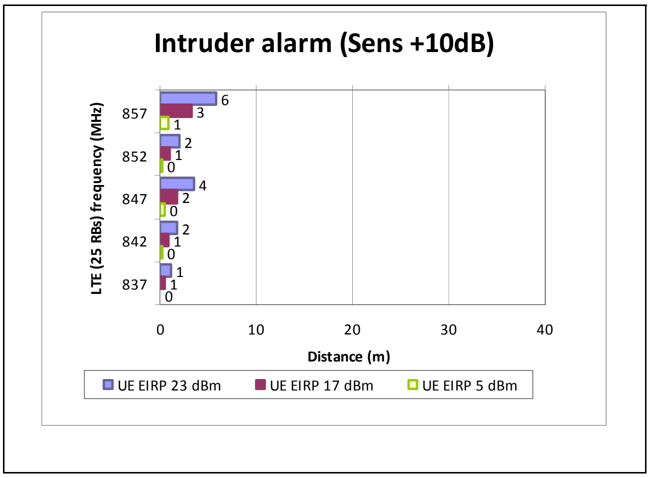

Figure 54: Protection distance for Intruder Alarm (25 RBs)

Appendix D
Social Alarm Results

D.1. C / I protection ratios

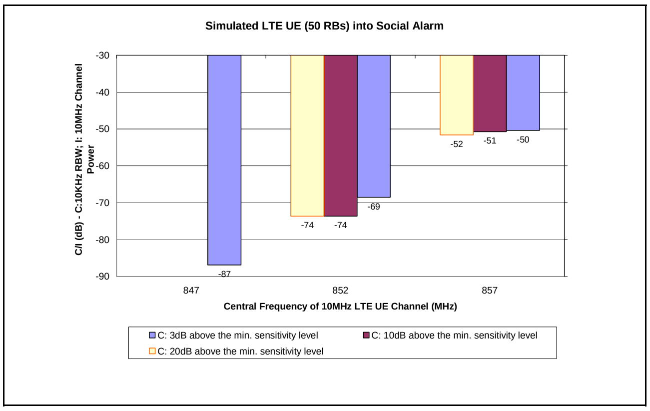

Figure 55: C / I for social alarm (50 RBs)

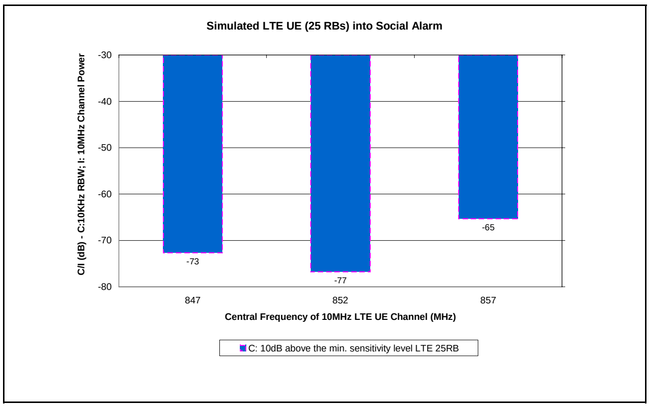

Figure 56: C / I for social alarm (25 RBs)

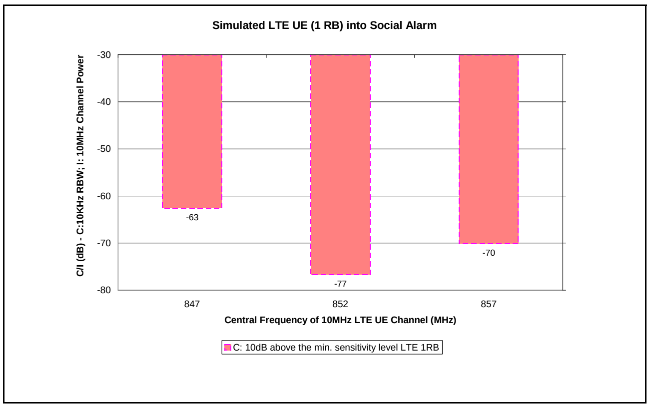

Figure 57: C / I for social alarm (1 RB)

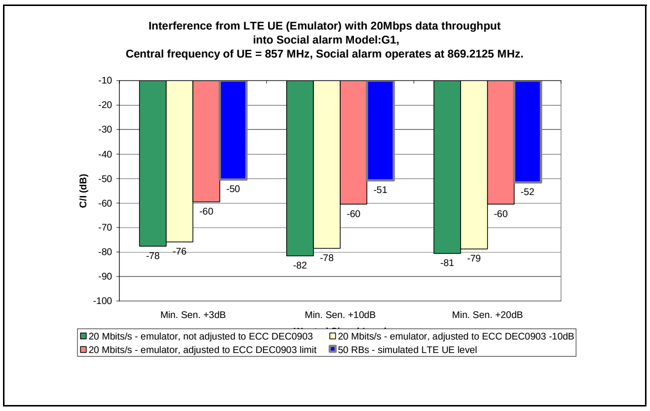

Figure 58: C/I for social alarm (G1)

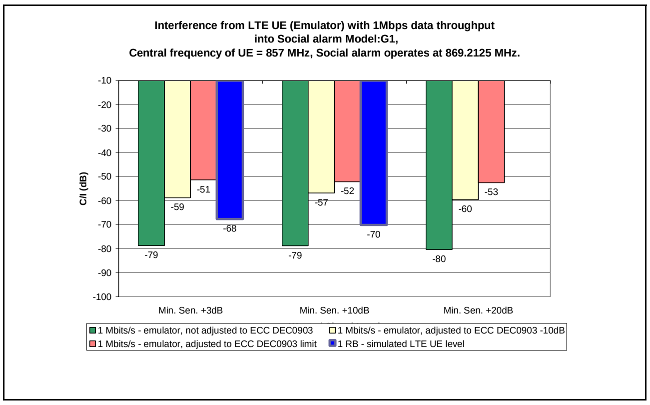

Figure 59: C/I for social alarm (G1)

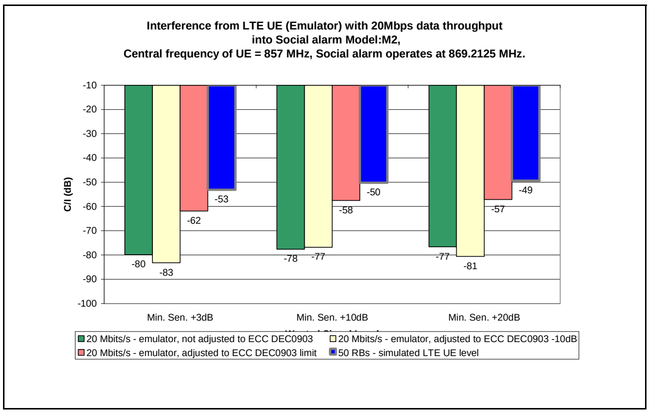

Figure 60: C/I for social alarm (M2)

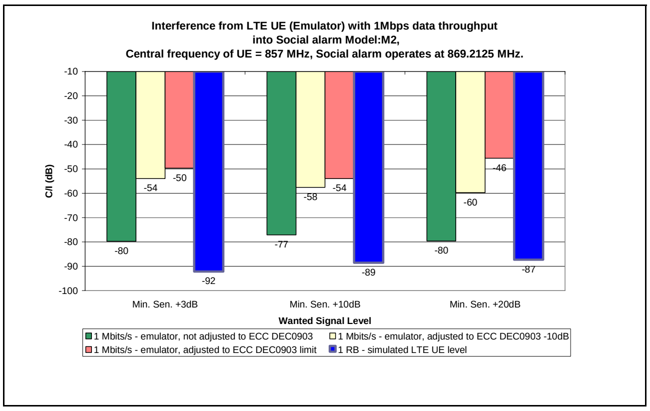

Figure 61: C/I for social alarm (M2)

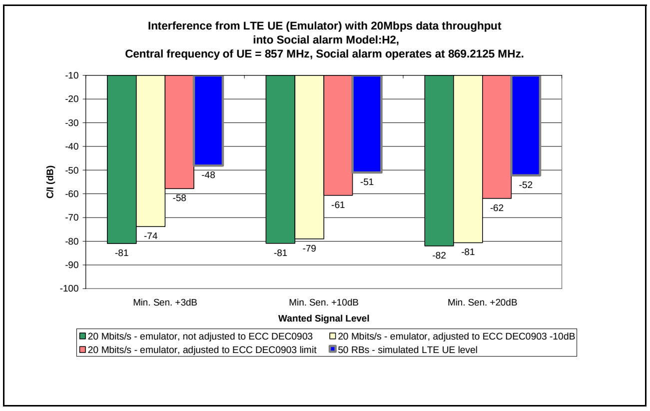

Figure 62: C/I for social alarm (H2)

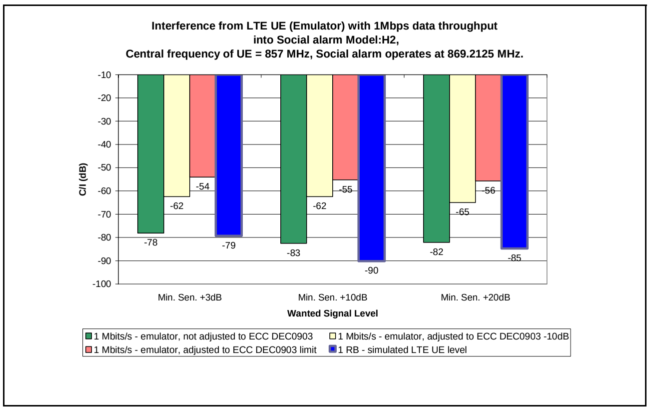

Figure 63: C/I for social alarm (H2)

D.2. Protection Distances

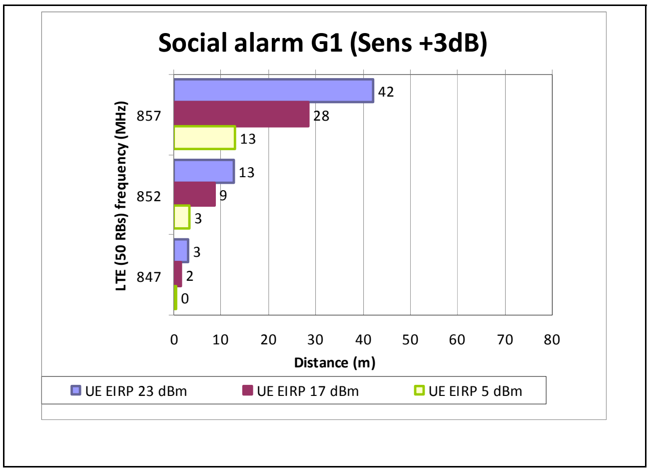

Figure 64: Protection distance for social alarm (50 RBs)

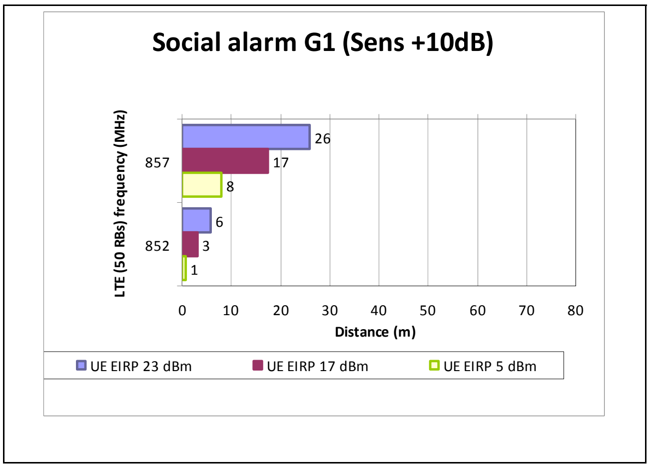

Figure 65: Protection distance for social alarm (50 RBs)

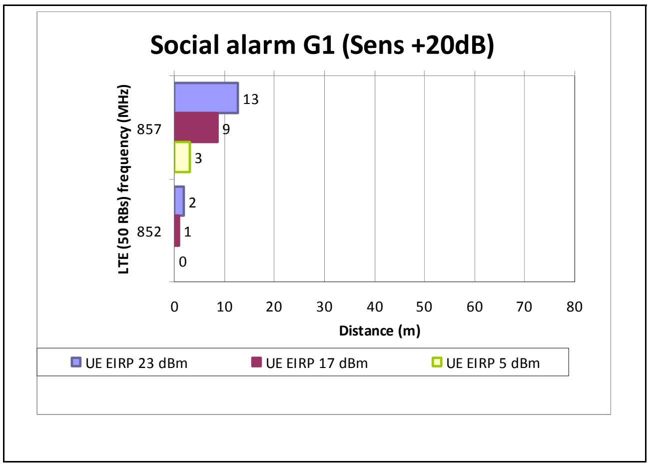

Figure 66: Protection distance for social alarm (50 RBs)

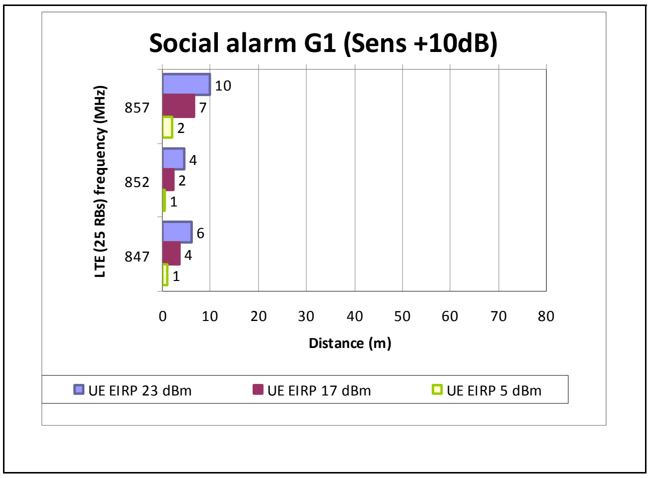

Figure 67: Protection distance for social alarm (25 RBs)

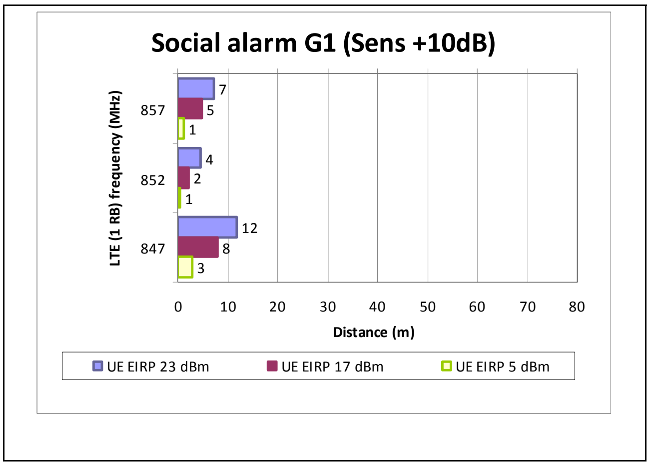

Figure 68: Protection distance for social alarm (1 RB)

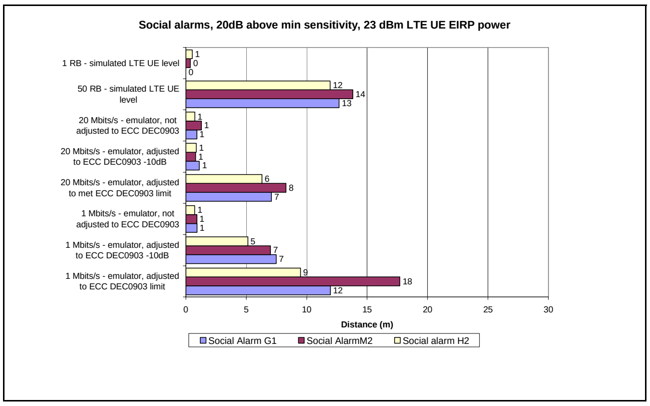

Figure 69: Protection distance for social alarm (20 dB above min. sen.)

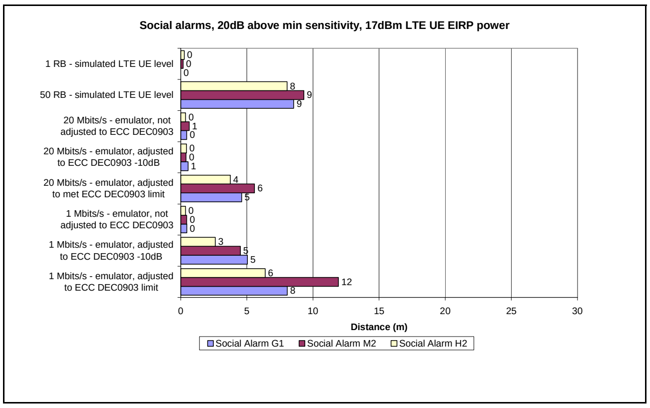

Figure 70: Protection distance for social alarm (20 dB above min. sen.)

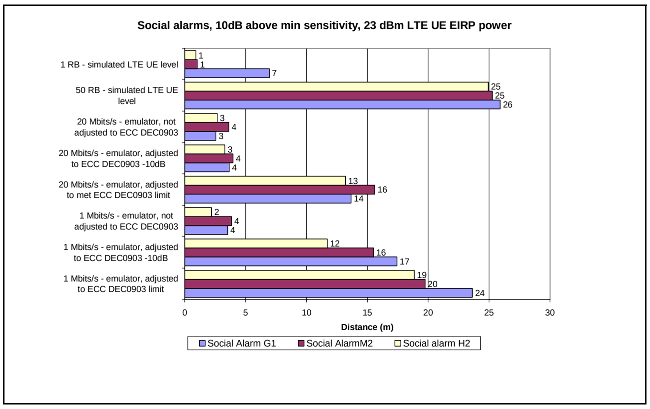

Figure 71: Protection distance for social alarm (10 dB above min. sen.)

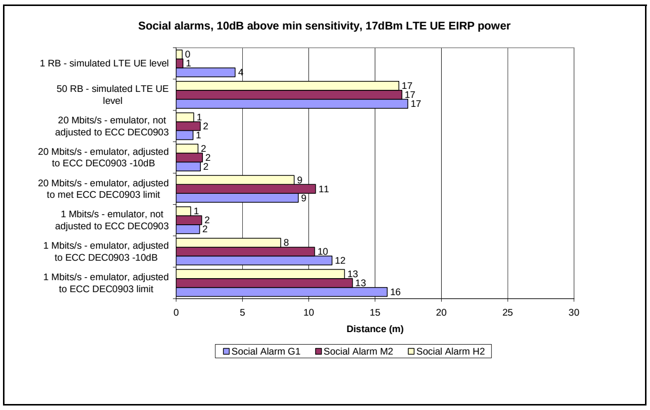

Figure 72: Protection distance for social alarm (10 dB above min. sen.)

D.3. Selectivity of Receiver

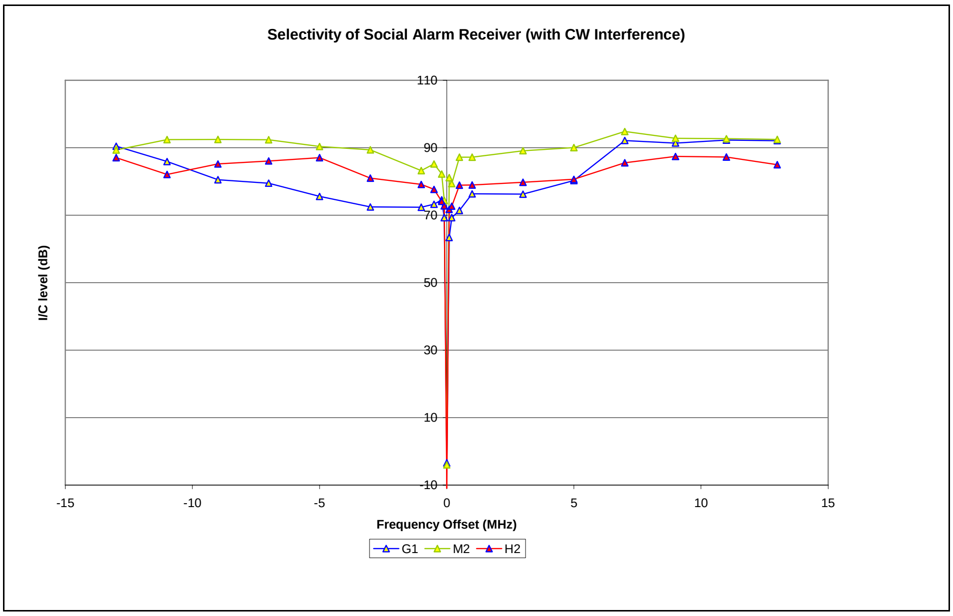

Figure 73: Selectivity of social alarm receivers

Appendix E
Telemetry Results

E.1. C/I protection ratios

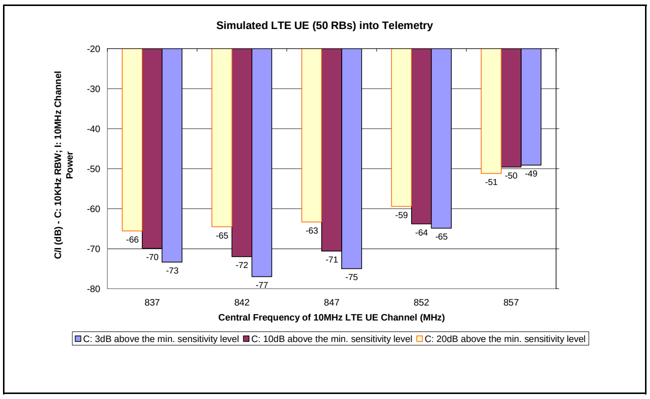

Figure 74: C/I for telemetry (50 RBs)

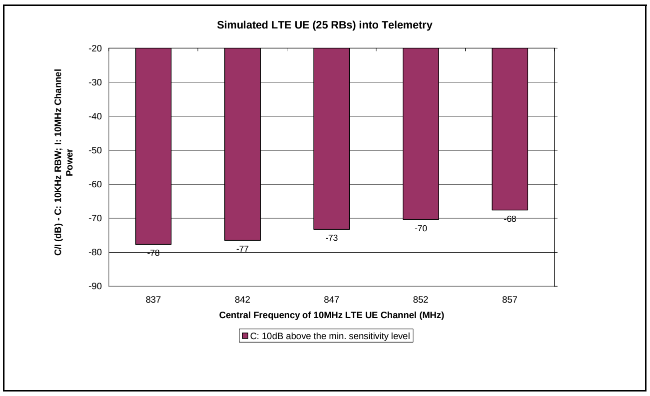

Figure 75: C/I for telemetry (25 RBs)

E.2. Protection Distances

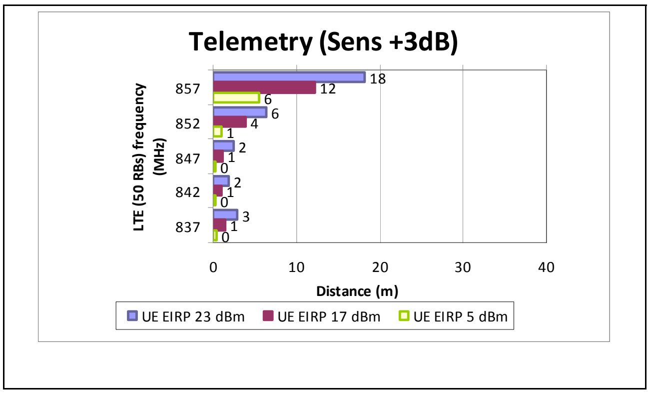

Figure 76: Protection distance for telemetry (50 RBs)

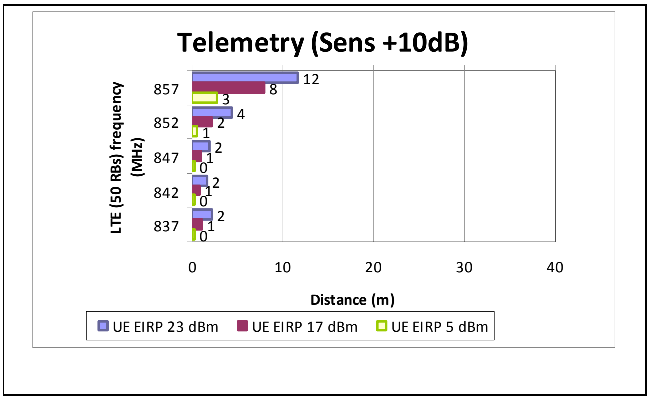

Figure 77: Protection distance for telemetry (50 RBs)

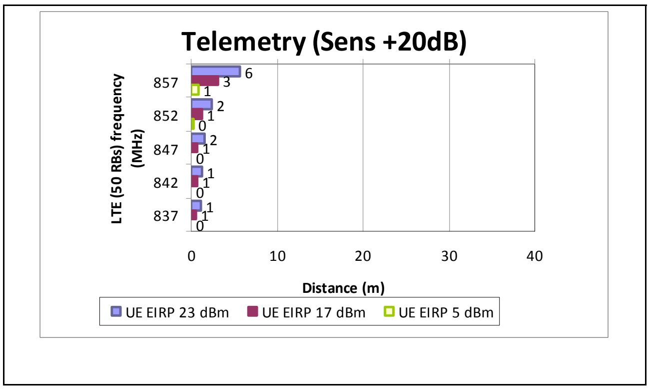

Figure 78: Protection distance for telemetry (50 RBs)

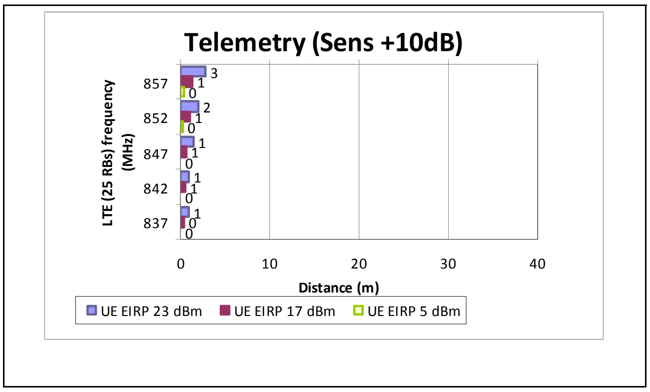

Figure 79: Protection distance for telemetry (25 RBs)

Appendix F
Smart Meter Results

F.1. C/I protection ratios

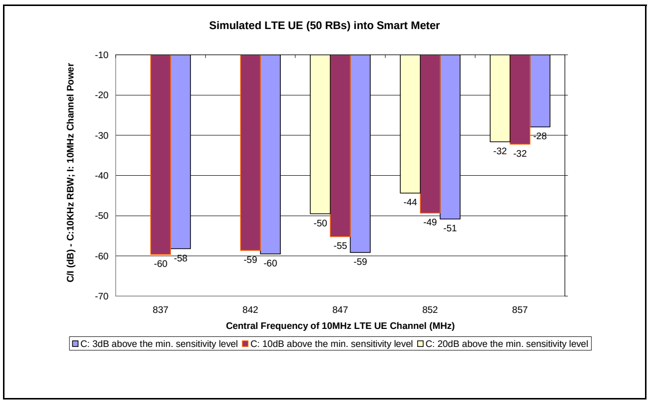

Figure 80: C/I for smart meter (50 RBs)

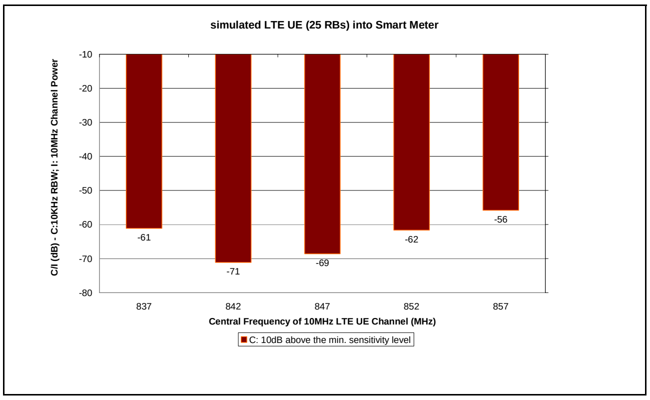

Figure 81: C/I for smart meter (25 RBs)

F.2. Protection Distances

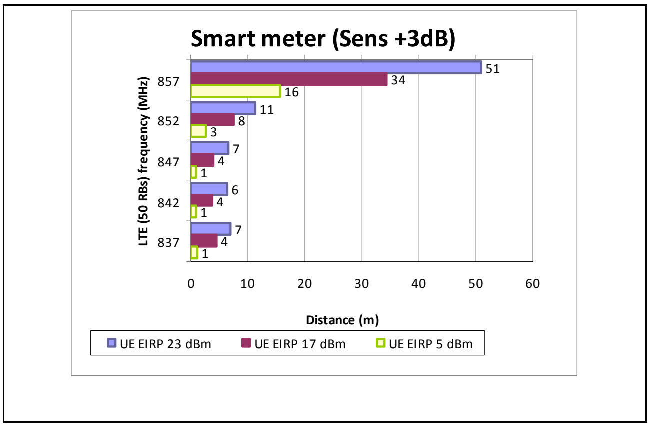

Figure 82: Protection distance for smart meter (50 RBs)

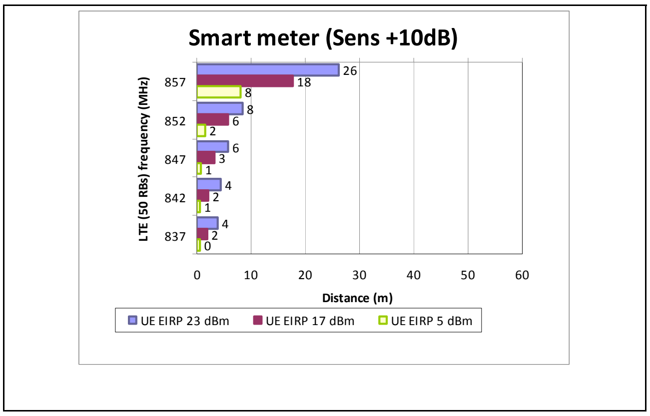

Figure 83: Protection distance for smart meter (50 RBs)

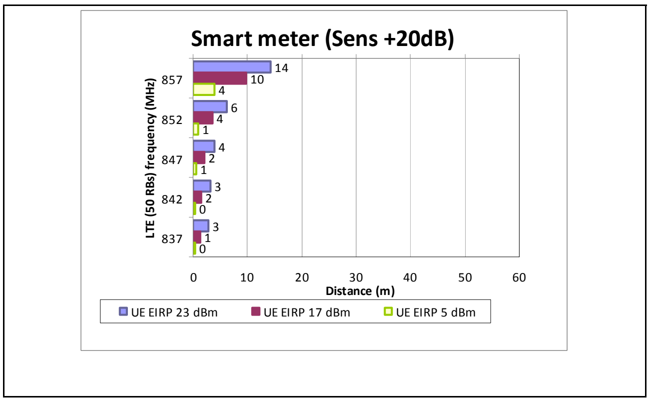

Figure 84: Protection distance smart meter (50 RBs)

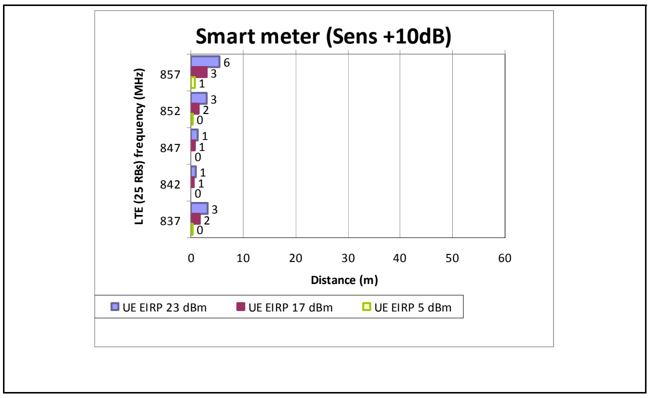

Figure 85: Protection distance for smart meter (25 RBs)

Appendix G
Medical Device Results

G.1. C/I protection ratios

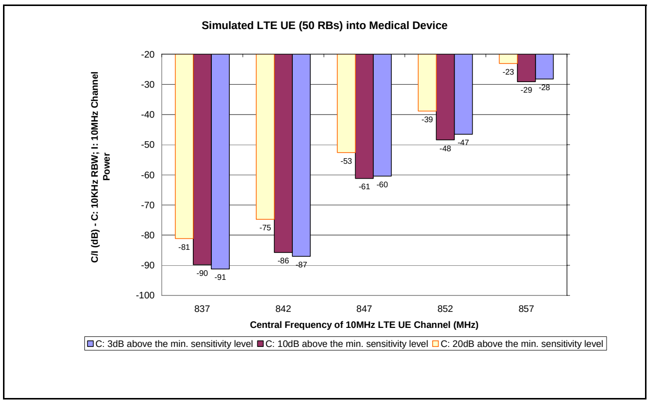

Figure 86: C/I for medical device (50 RBs)

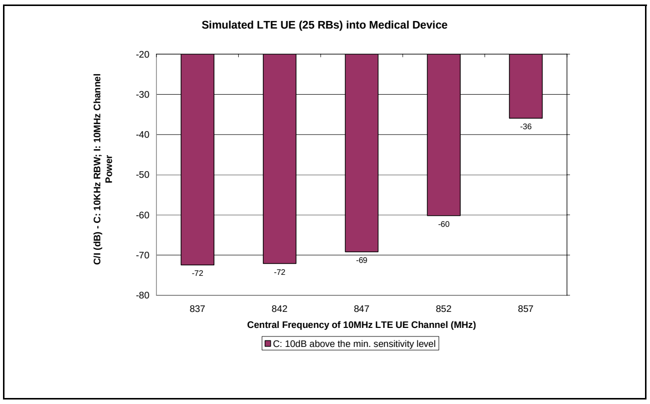

Figure 87: C/I for medical device (25 RBs)

G.2. Protection Distances

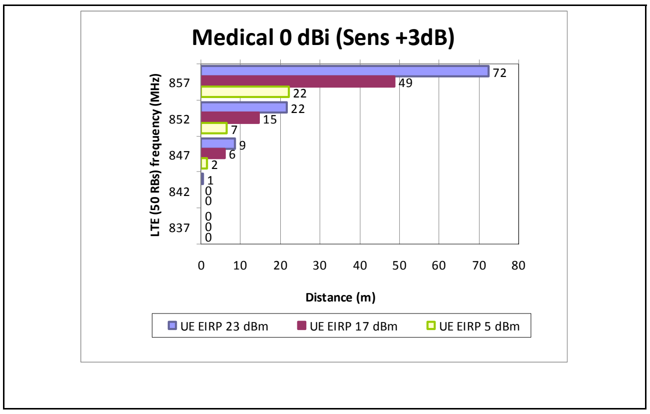

Figure 88: Protection distance for medical device (50 RBs)

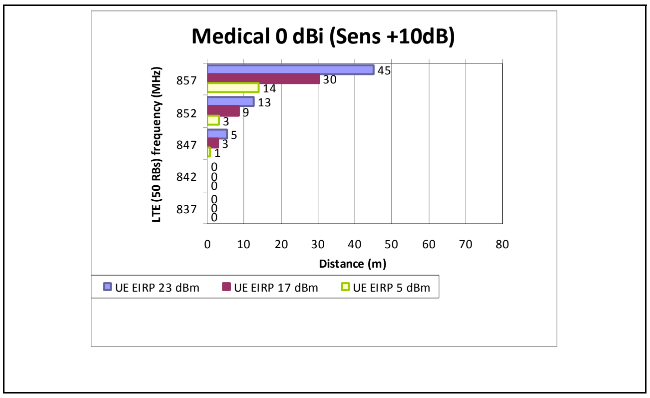

Figure 89: Protection distance for medical device (50 RBs)

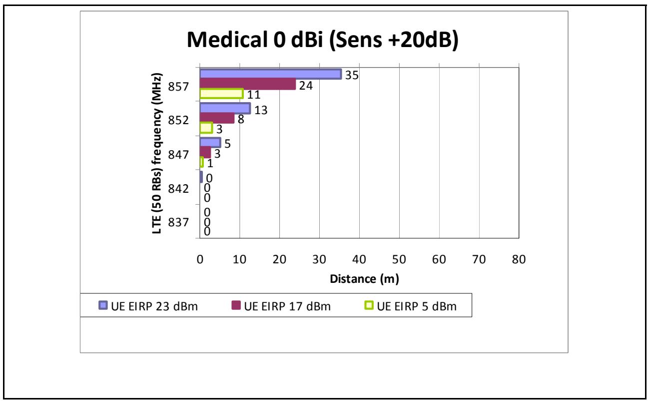

Figure 90: Protection distance for medical device (50 RBs)

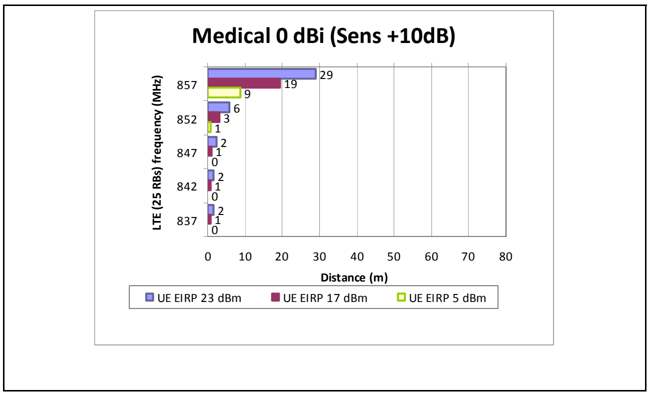

Figure 91: Protection distance for medical device (25 RBs)

Appendix H
RFID Results

H.1. Interference level for protection

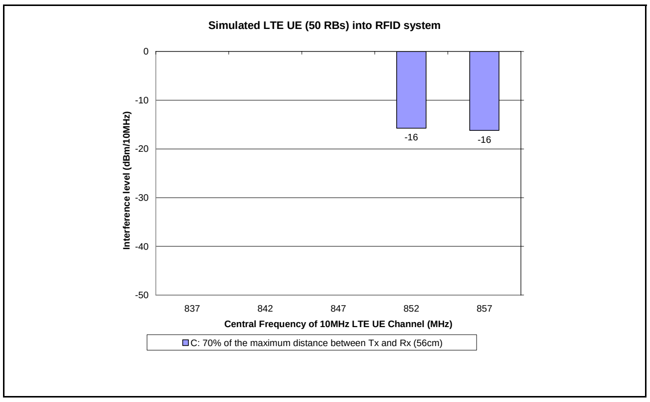

Figure 92: Interference level for RFID (50 RBs)

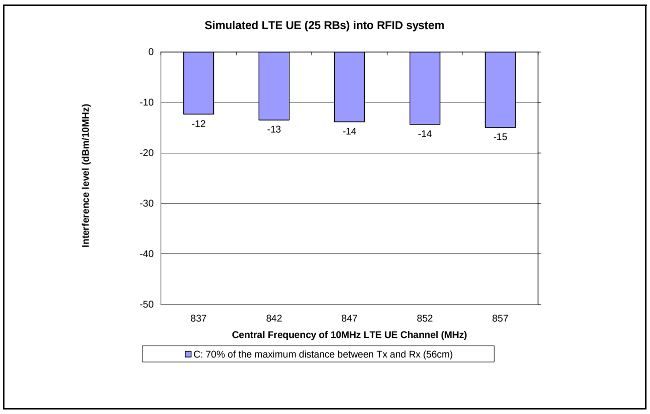

Figure 93: Interference level for RFID (25 RBs)

H.2. Protection Distances

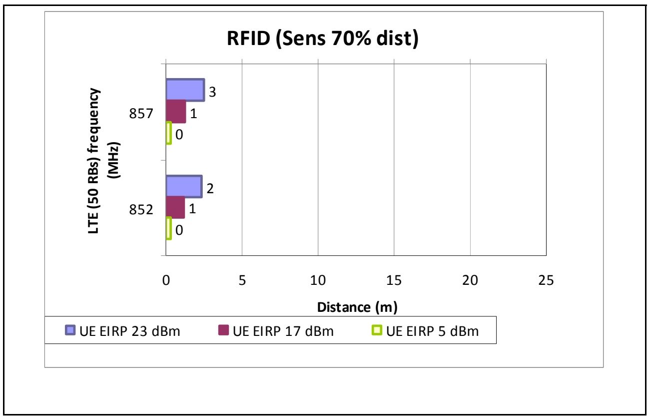

Figure 94: Protection distance for RFID (50 RBs)

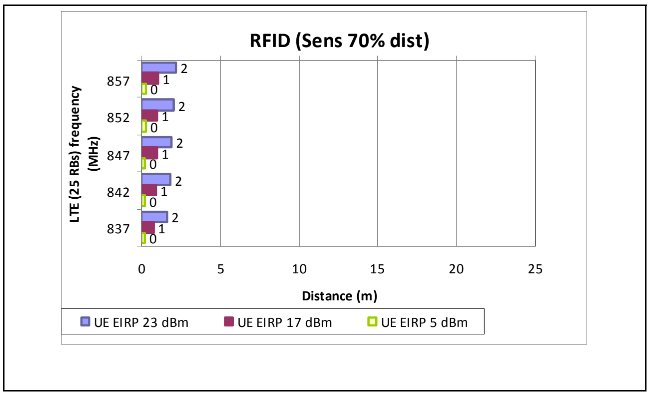

Figure 95: Protection distance for RFID (25 RBs)

Appendix I
Coupling loss for LTE UE EIRP variation

EIRP of LTE UE power classes assumed in coupling loss calculations

Class	UE1	UE2	UE3	UE4	UE5
EIRP	17 dBm	5 dBm	-9 dBm	-30 dBm	-50 dbm

Coupling loss for Cordless Headphone (LTE UE 50RB)

Sens +3dB (dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	75.50	69.50	57.50	43.50	22.50	2.50
855	74.90	68.90	56.90	42.90	21.90	1.90
853	73.60	67.60	55.60	41.60	20.60	0.60
851	68.20	62.20	50.20	36.20	15.20	-4.80
849	56.00	50.00	38.00	24.00	3.00	-17.00
847	53.00	47.00	35.00	21.00	0.00	-20.00
845	52.10	46.10	34.10	20.10	-0.90	-20.90
843	47.96	41.96	29.96	15.96	-5.04	-25.04
841	49.21	43.21	31.21	17.21	-3.79	-23.79
839	50.02	44.02	32.02	18.02	-2.98	-22.98
837	56.00	50.00	38.00	24.00	3.00	-17.00

Sens +10dB (dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	68.40	62.40	50.40	36.40	15.40	-4.60
855	66.80	60.80	48.80	34.80	13.80	-6.20
853	68.00	62.00	50.00	36.00	15.00	-5.00
851	61.20	55.20	43.20	29.20	8.20	-11.80
849	46.80	40.80	28.80	14.80	-6.20	-26.20
847	46.00	40.00	28.00	14.00	-7.00	-27.00
845	46.05	40.05	28.05	14.05	-6.95	-26.95
843	46.17	40.17	28.17	14.17	-6.83	-26.83
841	46.07	40.07	28.07	14.07	-6.93	-26.93
839	46.90	40.90	28.90	14.90	-6.10	-26.10
837	53.30	47.30	35.30	21.30	0.30	-19.70

Sens +40dB (dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	37.90	31.90	19.90	5.90	-15.10	-35.10
855	35.80	29.80	17.80	3.80	-17.20	-37.20
853	35.80	29.80	17.80	3.80	-17.20	-37.20
851	35.90	29.90	17.90	3.90	-17.10	-37.10

Coupling loss for Intruder Alarm (LTE UE 50RB)

Sens +3dB (dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	72.68	66.68	54.68	40.68	19.68	-0.32
852	60.12	54.12	42.12	28.12	7.12	-12.88
847	60.07	54.07	42.07	28.07	7.07	-12.93
842	57.90	51.90	39.90	25.90	4.90	-15.10
837	56.62	50.62	38.62	24.62	3.62	-16.38

Sens +10dB (dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	64.97	58.97	46.97	32.97	11.97	-8.03
852	49.07	43.07	31.07	17.07	-3.93	-23.93
847	51.20	45.20	33.20	19.20	-1.80	-21.80
842	47.69	41.69	29.69	15.69	-5.31	-25.31
837	47.35	41.35	29.35	15.35	-5.65	-25.65

Sens +20dB(dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	54.18	48.18	36.18	22.18	1.18	-18.82
852	40.41	34.41	22.41	8.41	-12.59	-32.59
847	43.91	37.91	25.91	11.91	-9.09	-29.09
842	39.88	33.88	21.88	7.88	-13.12	-33.12
837	-		-	-	-	-

Coupling loss for Radio Microphone (LTE UE 50RB)

			Sens +3dB (dBm)			
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	85.98	60.65	48.65	34.65	13.65	-6.35
852	81.60	56.79	44.79	30.79	9.79	-10.21
847	61.65	36.84	24.84	10.84	-10.16	-30.16
842	61.37	36.56	24.56	10.56	-10.44	-30.44
837	70.12	45.31	33.31	19.31	-1.69	-21.69
			Sens +10dB (dBm)			
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	80.08	52.53	40.53	26.53	5.53	-14.47
852	73.87	48.89	36.89	22.89	1.89	-18.11
847	54.76	29.78	17.78	3.78	-17.22	-37.22
842	55.77	30.79	18.79	4.79	-16.21	-36.21
837	66.23	41.25	29.25	15.25	-5.75	-25.75
			Sens +20dB (dBm)			
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	69.25	41.53	29.53	15.53	-5.47	-25.47
852	63.73	38.19	26.19	12.19	-8.81	-28.81
847	50.49	24.95	12.95	-1.05	-22.05	-42.05
842	52.26	26.72	14.72	0.72	-20.28	-40.28
837	61.84	36.30	24.30	10.30	-10.70	-30.70

Coupling loss for Smart Meter (LTE UE 50RB)

		Sens +3dB (dBm)				
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	80.45	74.45	62.45	48.45	27.45	7.45
852	57.58	51.58	39.58	25.58	4.58	-15.42
847	49.25	43.25	31.25	17.25	-3.75	-23.75
842	48.86	42.86	30.86	16.86	-4.14	-24.14
837	50.18	44.18	32.18	18.18	-2.82	-22.82

		Sens +10dB (dBm)				
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	70.36	64.36	52.36	38.36	17.36	-2.64
852	53.24	47.24	35.24	21.24	0.24	-19.76
847	47.38	41.38	29.38	15.38	-5.62	-25.62
842	43.93	37.93	25.93	11.93	-9.07	-29.07
837	42.96	36.96	24.96	10.96	-10.04	-30.04

		Sens +20dB (dBm)				
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	61.19	55.19	43.19	29.19	8.19	-11.81
852	48.45	42.45	30.45	16.45	-4.55	-24.55
847	43.30	37.30	25.30	11.30	-9.70	-29.70
842	41.13	35.13	23.13	9.13	-11.87	-31.87
837	40.09	34.09	22.09	8.09	-12.91	-32.91

Coupling loss for Social Alarm (LTE UE 50RB)

		Sens +3dB (dBm)				
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	77.55	76.01	64.01	50.01	29.01	9.01
852	59.40	61.35	49.35	35.35	14.35	-5.65
847	41.03	42.98	30.98	16.98	-4.02	-24.02

		Sens +10dB (dBm)				
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	70.19	69.78	57.78	43.78	22.78	2.78
852	47.26	47.22	35.22	21.22	0.22	-19.78
847		-	-	-	-	-

		Sens +20dB (dBm)				
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	59.32	61.05	49.05	35.05	14.05	-5.95
852	37.27	37.14	25.14	11.14	-9.86	-29.86
847		-	-	-	-	-

Coupling loss for Telemetry (LTE UE 50RB)

				Sens +3dB (dBm)		
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	64.81	58.81	46.81	32.81	11.81	-8.19
852	49.05	43.05	31.05	17.05	-3.95	-23.95
847	38.98	32.98	20.98	6.98	-14.02	-34.02
842	36.94	30.94	18.94	4.94	-16.06	-36.06
837	40.58	34.58	22.58	8.58	-12.42	-32.42

				Sens +10dB (dBm)		
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	58.10	52.10	40.10	26.10	5.10	-14.90
852	43.92	37.92	25.92	11.92	-9.08	-29.08
847	37.10	31.10	19.10	5.10	-15.90	-35.90
842	35.72	29.72	17.72	3.72	-17.28	-37.28
837	37.78	31.78	19.78	5.78	-15.22	-35.22

				Sens +20dB (dBm)		
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	47.12	41.12	29.12	15.12	-5.88	-25.88
852	38.88	32.88	20.88	6.88	-14.12	-34.12
847	34.98	28.98	16.98	2.98	-18.02	-38.02
842	33.78	27.78	15.78	1.78	-19.22	-39.22
837	32.75	26.75	14.75	0.75	-20.25	-40.25

Coupling loss for Medical device (-10dBi) (LTE UE 50RB)

Sens +3dB (dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	75.82	69.82	57.82	43.82	22.82	2.82
852	57.48	51.48	39.48	25.48	4.48	-15.52
847	43.63	37.63	25.63	11.63	-9.37	-29.37
842	16.98	10.98	-1.02	-15.02	-36.02	-56.02
837	12.79	6.79	-5.21	-19.21	-40.21	-60.21

Sens +10dB (dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	68.65	62.65	50.65	36.65	15.65	-4.35
852	49.37	43.37	31.37	17.37	-3.63	-23.63
847	36.58	30.58	18.58	4.58	-16.42	-36.42
842	12.04	6.04	-5.96	-19.96	-40.96	-60.96
837	7.97	1.97	-10.03	-24.03	-45.03	-65.03

Sens +20dB (dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	64.96	58.96	46.96	32.96	11.96	-8.04
852	49.17	43.17	31.17	17.17	-3.83	-23.83
847	35.40	29.40	17.40	3.40	-17.60	-37.60
842	13.24	7.24	-4.76	-18.76	-39.76	-59.76
837	6.83	0.83	-11.17	-25.17	-46.17	-66.17

Coupling loss for Medical device (0dBi) (LTE UE 50RB)

Sens +3dB (dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	85.82	79.82	67.82	53.82	32.82	12.82
852	67.48	61.48	49.48	35.48	14.48	-5.52
847	53.63	47.63	35.63	21.63	0.63	-19.37
842	26.98	20.98	8.98	-5.02	-26.02	-46.02
837	22.79	16.79	4.79	-9.21	-30.21	-50.21

Sens +10dB (dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	78.65	72.65	60.65	46.65	25.65	5.65
852	59.37	53.37	41.37	27.37	6.37	-13.63
847	46.58	40.58	28.58	14.58	-6.42	-26.42
842	22.04	16.04	4.04	-9.96	-30.96	-50.96
837	17.97	11.97	-0.03	-14.03	-35.03	-55.03

Sens +20dB (dBm)

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	74.96	68.96	56.96	42.96	21.96	1.96
852	59.17	53.17	41.17	27.17	6.17	-13.83
847	45.40	39.40	27.40	13.40	-7.60	-27.60
842	23.24	17.24	5.24	-8.76	-29.76	-49.76
837	16.83	10.83	-1.17	-15.17	-36.17	-56.17

Coupling loss for RFID (LTE UE 50RB)

Sens 70% distance

F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	39.21	33.21	21.21	7.21	-13.79	-33.79
852	38.73	32.73	20.73	6.73	-14.27	-34.27

Coupling loss for Cordless Headphone (LTE UE 25RB)

		Sens +10dB (dBm)				
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	80.26	74.26	62.26	48.26	27.26	7.26
852	57.39	51.39	39.39	25.39	4.39	-15.61
847	47.45	41.45	29.45	15.45	-5.55	-25.55
842	47.37	41.37	29.37	15.37	-5.63	-25.63
837	48.28	42.28	30.28	16.28	-4.72	-24.72

Coupling loss for Radio Microphone (LTE UE 25RB)

		Sens +10dB (dBm)				
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	80.16	55.18	43.18	29.18	8.18	-11.82
852	58.30	33.32	21.32	7.32	-13.68	-33.68
847	50.62	25.64	13.64	-0.36	-21.36	-41.36
842	49.82	24.84	12.84	-1.16	-22.16	-42.16
837	58.44	33.46	21.46	7.46	-13.54	-33.54

Coupling loss for Radio Microphone (LTE UE 1RB)

		Sens +10dB (dBm)				
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	64.74	34.02	22.02	8.02	-12.98	-32.98
852	43.67	18.69	6.69	-7.31	-28.31	-48.31
847	41.84	16.86	4.86	-9.14	-30.14	-50.14
842	41.87	16.89	4.89	-9.11	-30.11	-50.11
837	41.85	16.87	4.87	-9.13	-30.13	-50.13

Coupling loss for Medical Device (0dBi) (LTE UE 25RB)

		Sens +10dB (dBm)				
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	71.85	65.85	53.85	39.85	18.85	-1.15
852	47.59	41.59	29.59	15.59	-5.41	-25.41
847	38.58	32.58	20.58	6.58	-14.42	-34.42
842	35.67	29.67	17.67	3.67	-17.33	-37.33
837	35.31	29.31	17.31	3.31	-17.69	-37.69

Coupling loss for Telemetry (LTE UE 25RB)

			Sens +10dB (dBm)			
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	40.10	34.10	22.10	8.10	-12.90	-32.90
852	37.32	31.32	19.32	5.32	-15.68	-35.68
847	34.42	28.42	16.42	2.42	-18.58	-38.58
842	31.19	25.19	13.19	-0.81	-21.81	-41.81
837	29.99	23.99	11.99	-2.01	-23.01	-43.01

Coupling loss for Smart Meter (LTE UE 25RB)

			Sens +10dB (dBm)			
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	46.75	40.75	28.75	14.75	-6.25	-26.25
852	40.93	34.93	22.93	8.93	-12.07	-32.07
847	33.97	27.97	15.97	1.97	-19.03	-39.03
842	31.44	25.44	13.44	-0.56	-21.56	-41.56
837	41.45	35.45	23.45	9.45	-11.55	-31.55

Coupling loss for Social Alarm (LTE UE 25RB)

			Sens +10dB (dBm)			
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	55.67	55.63	43.63	29.63	8.63	-11.37
852	44.21	44.17	32.17	18.17	-2.83	-22.83
847	48.34	48.30	36.30	22.30	1.30	-18.70

Coupling loss for Social Alarm (LTE UE 1RB)

			Sens +10dB (dBm)			
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	50.80	50.08	38.08	24.08	3.08	-16.92
852	44.25	44.21	32.21	18.21	-2.79	-22.79
847	58.36	58.32	46.32	32.32	11.32	-8.68

Coupling loss for Intruder Alarm (LTE UE 25RB)

			Sens +10dB (dBm)			
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	47.59	41.59	29.59	15.59	-5.41	-25.41
852	37.23	31.23	19.23	5.23	-15.77	-35.77
847	42.21	36.21	24.21	10.21	-10.79	-30.79
842	36.19	30.19	18.19	4.19	-16.81	-36.81
837	31.88	25.88	13.88	-0.12	-21.12	-41.12

Coupling loss for RFID (LTE UE 25RB)

			Sens +10dB (dBm)			
F (MHz)	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
857	37.96	31.96	19.96	5.96	-15.04	-35.04
852	37.34	31.34	19.34	5.34	-15.66	-35.66
847	36.81	30.81	18.81	4.81	-16.19	-36.19
842	36.47	30.47	18.47	4.47	-16.53	-36.53
837	35.30	29.30	17.30	3.30	-17.70	-37.70

Coupling loss for Radio Microphone (UE emulator signal)

	Sens +3dB (dBm)					
UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	86.39	80.39	68.39	54.39	33.39	13.39
1Mbits/s, adjusted to ECC DEC0903 -10dB	85.99	79.99	67.99	53.99	32.99	12.99
1Mbits/s, emulator signal, not adjusted	68.73	62.73	50.73	36.73	15.73	-4.27
20Mbits/s, adjusted to ECC DEC0903 limit	88.21	82.21	70.21	56.21	35.21	15.21
20Mbits/s, adjusted to ECC DEC0903 -10dB	78.02	72.02	60.02	46.02	25.02	5.02
20Mbits/s, emulator signal, not adjusted	63.10	57.10	45.10	31.10	10.10	-9.90

	Sens +10dB (dBm)					
UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	83.63	77.63	65.63	51.63	30.63	10.63
1Mbits/s, adjusted to ECC DEC0903 -10dB	81.26	75.26	63.26	49.26	28.26	8.26
1Mbits/s, emulator signal, not adjusted	62.70	56.70	44.70	30.70	9.70	-10.30
20Mbits/s, adjusted to ECC DEC0903 limit	80.41	74.41	62.41	48.41	27.41	7.41
20Mbits/s, adjusted to ECC DEC0903 -10dB	70.98	64.98	52.98	38.98	17.98	-2.02
20Mbits/s, emulator signal, not adjusted	58.09	52.09	40.09	26.09	5.09	-14.91

	Sens +20dB (dBm)					
UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	73.63	67.63	55.63	41.63	20.63	0.63
1Mbits/s, adjusted to ECC DEC0903 -10dB	71.26	65.26	53.26	39.26	18.26	-1.74
1Mbits/s, emulator signal, not adjusted	53.70	47.70	35.70	21.70	0.70	-19.30
20Mbits/s, adjusted to ECC DEC0903 limit	69.53	63.53	51.53	37.53	16.53	-3.47
20Mbits/s, adjusted to ECC DEC0903 -10dB	60.98	54.98	42.98	28.98	7.98	-12.02
20Mbits/s, emulator signal, not adjusted	48.99	42.99	30.99	16.99	-4.01	-24.01

Coupling loss for Social alarm G1 (UE emulator signal)

Sens +3dB (dBm)

UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	76.63	70.63	58.63	44.63	23.63	3.63
1Mbits/s, adjusted to ECC DEC0903 -10dB	69.18	63.18	51.18	37.18	16.18	-3.82
1Mbits/s, emulator signal, not adjusted	49.23	43.23	31.23	17.23	-3.77	-23.77
20Mbits/s, adjusted to ECC DEC0903 limit	68.38	62.38	50.38	36.38	15.38	-4.62
20Mbits/s, adjusted to ECC DEC0903 -10dB	52.05	46.05	34.05	20.05	-0.95	-20.95
20Mbits/s, emulator signal, not adjusted	50.28	44.28	32.28	18.28	-2.72	-22.72

Sens +10dB (dBm)

UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	68.78	62.78	50.78	36.78	15.78	-4.22
1Mbits/s, adjusted to ECC DEC0903 -10dB	64.17	58.17	46.17	32.17	11.17	-8.83
1Mbits/s, emulator signal, not adjusted	42.15	36.15	24.15	10.15	-10.85	-30.85
20Mbits/s, adjusted to ECC DEC0903 limit	60.46	54.46	42.46	28.46	7.46	-12.54
20Mbits/s, adjusted to ECC DEC0903 -10dB	42.45	36.45	24.45	10.45	-10.55	-30.55
20Mbits/s, emulator signal, not adjusted	39.35	33.35	21.35	7.35	-13.65	-33.65

Sens +20dB (dBm)

UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	58.44	52.44	40.44	26.44	5.44	-14.56
1Mbits/s, adjusted to ECC DEC0903 -10dB	51.31	45.31	33.31	19.31	-1.69	-21.69
1Mbits/s, emulator signal, not adjusted	30.57	24.57	12.57	-1.43	-22.43	-42.43
20Mbits/s, adjusted to ECC DEC0903 limit	50.47	44.47	32.47	18.47	-2.53	-22.53
20Mbits/s, adjusted to ECC DEC0903 -10dB	32.17	26.17	14.17	0.17	-20.83	-40.83
20Mbits/s, emulator signal, not adjusted	30.39	24.39	12.39	-1.61	-22.61	-42.61

Coupling loss for Social alarm M2 (UE emulator signal)

			Sens +3dB (dBm)			
UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	77.31	71.31	59.31	45.31	24.31	4.31
1Mbits/s, adjusted to ECC DEC0903 -10dB	73.04	67.04	55.04	41.04	20.04	0.04
1Mbits/s, emulator signal, not adjusted	47.26	41.26	29.26	15.26	-5.74	-25.74
20Mbits/s, adjusted to ECC DEC0903 limit	65.11	59.11	47.11	33.11	12.11	-7.89
20Mbits/s, adjusted to ECC DEC0903 -10dB	43.78	37.78	25.78	11.78	-9.22	-29.22
20Mbits/s, emulator signal, not adjusted	47.14	41.14	29.14	15.14	-5.86	-25.86

			Sens +10dB (dBm)			
UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	66.05	60.05	48.05	34.05	13.05	-6.95
1Mbits/s, adjusted to ECC DEC0903 -10dB	62.38	56.38	44.38	30.38	9.38	-10.62
1Mbits/s, emulator signal, not adjusted	42.89	36.89	24.89	10.89	-10.11	-30.11
20Mbits/s, adjusted to ECC DEC0903 limit	62.48	56.48	44.48	30.48	9.48	-10.52
20Mbits/s, adjusted to ECC DEC0903 -10dB	43.17	37.17	25.17	11.17	-9.83	-29.83
20Mbits/s, emulator signal, not adjusted	42.39	36.39	24.39	10.39	-10.61	-30.61

			Sens +20dB (dBm)			
UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	64.40	58.40	46.40	32.40	11.40	-8.60
1Mbits/s, adjusted to ECC DEC0903 -10dB	50.29	44.29	32.29	18.29	-2.71	-22.71
1Mbits/s, emulator signal, not adjusted	30.42	24.42	12.42	-1.58	-22.58	-42.58
20Mbits/s, adjusted to ECC DEC0903 limit	52.86	46.86	34.86	20.86	-0.14	-20.14
20Mbits/s, adjusted to ECC DEC0903 -10dB	29.38	23.38	11.38	-2.62	-23.62	-43.62
20Mbits/s, emulator signal, not adjusted	33.37	27.37	15.37	1.37	-19.63	-39.63

Coupling loss for Social alarm H2 (UE emulator signal)

	Sens +3dB (dBm)					
UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	73.56	67.56	55.56	41.56	20.56	0.56
1Mbits/s, adjusted to ECC DEC0903 -10dB	65.13	59.13	47.13	33.13	12.13	-7.87
1Mbits/s, emulator signal, not adjusted	49.44	43.44	31.44	17.44	-3.56	-23.56
20Mbits/s, adjusted to ECC DEC0903 limit	69.80	63.80	51.80	37.80	16.80	-3.20
20Mbits/s, adjusted to ECC DEC0903 -10dB	53.82	47.82	35.82	21.82	0.82	-19.18
20Mbits/s, emulator signal, not adjusted	46.62	40.62	28.62	14.62	-6.38	-26.38

	Sens +10dB (dBm)					
UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	65.35	59.35	47.35	33.35	12.35	-7.65
1Mbits/s, adjusted to ECC DEC0903 -10dB	58.11	52.11	40.11	26.11	5.11	-14.89
1Mbits/s, emulator signal, not adjusted	38.02	32.02	20.02	6.02	-14.98	-34.98
20Mbits/s, adjusted to ECC DEC0903 limit	59.94	53.94	41.94	27.94	6.94	-13.06
20Mbits/s, adjusted to ECC DEC0903 -10dB	41.58	35.58	23.58	9.58	-11.42	-31.42
20Mbits/s, emulator signal, not adjusted	39.69	33.69	21.69	7.69	-13.31	-33.31

	Sens +20dB (dBm)					
UE Profile	23dBm CL (dB)	UE1 CL (dB)	UE2 CL (dB)	UE3 CL (dB)	UE4 CL (dB)	UE5 CL (dB)
1Mbits/s, adjusted to ECC DEC0903 limit	54.91	48.91	36.91	22.91	1.91	-18.09
1Mbits/s, adjusted to ECC DEC0903 -10dB	45.57	39.57	27.57	13.57	-7.43	-27.43
1Mbits/s, emulator signal, not adjusted	28.47	22.47	10.47	-3.53	-24.53	-44.53
20Mbits/s, adjusted to ECC DEC0903 limit	48.68	42.68	30.68	16.68	-4.32	-24.32
20Mbits/s, adjusted to ECC DEC0903 -10dB	29.98	23.98	11.98	-2.02	-23.02	-43.02
20Mbits/s, emulator signal, not adjusted	28.63	22.63	10.63	-3.37	-24.37	-44.37

Appendix J
Co-channel C/I protection ratios

J.1. Co-channel C/I protection ratio

The co-channel C/I protection ratios for each device under test are shown in the table below, for different resource block allocations, at 10 dB above the receiver minimum sensitivity.

Table 13: Co-channel C/I protection ratios

Device	Frequency (MHz)	C/I protection ratio (dB) at 10 dB above min sensitivity RB = 25	C/I protection ratio (dB) at 10 dB above min sensitivity RB = 50
Cordless Headphones	863.365	-14.64	-3.87
Radio Microphone	863.15	-5	-5.08
Intruder Alarm	868.35	-20.2	-22.82
Social Alarm	869.215	-18.59	-8.41
Telemetry	869.875	-15.93	-15.06
Smart Meter	868.3794	-16.91	-16.99
Medical Device	865.564	-3.98	-9.85
RFID	869.519	-43.31[1]	-45[1]

Notes:

1. It is not possible to measured the wanted signal level (C) at the RFID transceiver as the transmit power is reflected back from a passive tag. The value presented here is the interference level in dBm at the RFID transceiver required to cause blocking.

Table 14: Co-channel C/I protection ratios

Device	Frequency (MHz)	C/I protection ratio (dB) at 10 dB above min sensitivity 1 Mbits/s emulator signal	C/I protection ratio (dB) at 10 dB above min sensitivity 20 Mbits/s emulator signal
Radio Microphone	863.15	-10.52	-5
Social Alarm G1	869.215	-21.36	-19.36
Social Alarm M2	869.215	-24.2	-17.43
Social Alarm H2	869.215	-25.86	-22.28