Cobham Technical Services
ERA Technology
Cleeve Road, Leatherhead
Surrey, KT22 7SA, England
T: +44 (0) 1372 367000
F: +44 (0) 1372 367099

Business Unit:	Cobham Technical Services ERA Technology RF and EMC Group
Report Title:	LTE Interference into Domestic Digital Television Systems
Author(s):	Bal Randhawa Ian Parker Samuel Antwi
Client:	Ofcom
Client Reference:	Graham Warren
Report Number:	2010-0026 (Issue 2)
Project Number:	7A0513004
Report Version:	Final Report

Report Checked by:	**Approved by:**
S Munday Head of RF Assessment	M Ganley Head of RF & EMC Group

January 2010

Ref. SPM/vs/62/05130/Rep-6537

DOCUMENT CONTROL

If no restrictive markings are shown, the document may be distributed freely in whole, without alteration, subject to Copyright.

ERA Technology Limited trading as Cobham Technical Services
Cleeve Road
Leatherhead
Surrey KT22 7SA, England
Tel : +44 (0) 1372 367000
Fax: +44 (0) 1372 367099
E-mail: era.info@cobham.com

Read more about Cobham Technical Services on our Internet page at:
www.cobham.com/technicalservices

Summary

As part of the Digital Dividend Review (DDR), Ofcom commissioned Cobham Technical Services – ERA Technology to carry out a measurement study in order to answer the following questions:

1. Can localised interference from non-co channel Long Term Evolution (LTE) handsets situated 2.5 m or more from the TV receive system be sufficiently high as to cause interference to either the TV video or audio output or cause any degradation in the receiver sensitivity in a typical domestic installation?
2. If any form of interference is experienced under what circumstances does this occur (e.g. distance, image channel) and where is the main point of breakthrough (e.g. cable or TV)?
3. Are there simple, cost-effective practical measures that may be used to overcome any problems experienced (e.g. better screened fly-leads and the fitting of a filter in the aerial downlead)?

Practical radiated measurements were carried out to address the questions raised by Ofcom as described in the main points above.

In addition a separate series of conducted measurements were made in order to provide Carrier-to-Interference (C/I) protection ratios for a 10 MHz wide LTE Base Station signal (BS)[1] interfering into five Digital Video Broadcast (DVB-T) receivers.

The study, whilst not comprehensive, shows indicative trends with the five digital receivers and gives solutions to overcome problems highlighted in the report.

<u>Conducted Measurements</u>

The conducted sets of measurements were performed on a bench in the laboratory on five different types of digital TV receiver, which were; an integrated Digital Television (iDTV); two iDTVs with silicon tuners; a Personal Video Recorder (PVR) and Set Top Box (STB). The LTE BS interference measurements were carried out for wanted signal levels of -70, -50, -30, -20, -12 dBm with and without a low-pass UHF filter. The use of a filter in the aerial downlead of a DVB-T receiver is being considered by Ofcom as a possible method of reducing higher frequency interference from base stations and/or mobile handsets.

[1] The Spectrum Emission Masks for the LTE BS and UE was based on the latest SE42 recommendations.

Figure 1 shows the C/I performance without a low pass filter for the different digital TV receivers at a wanted DVB-T level of -70 dBm.

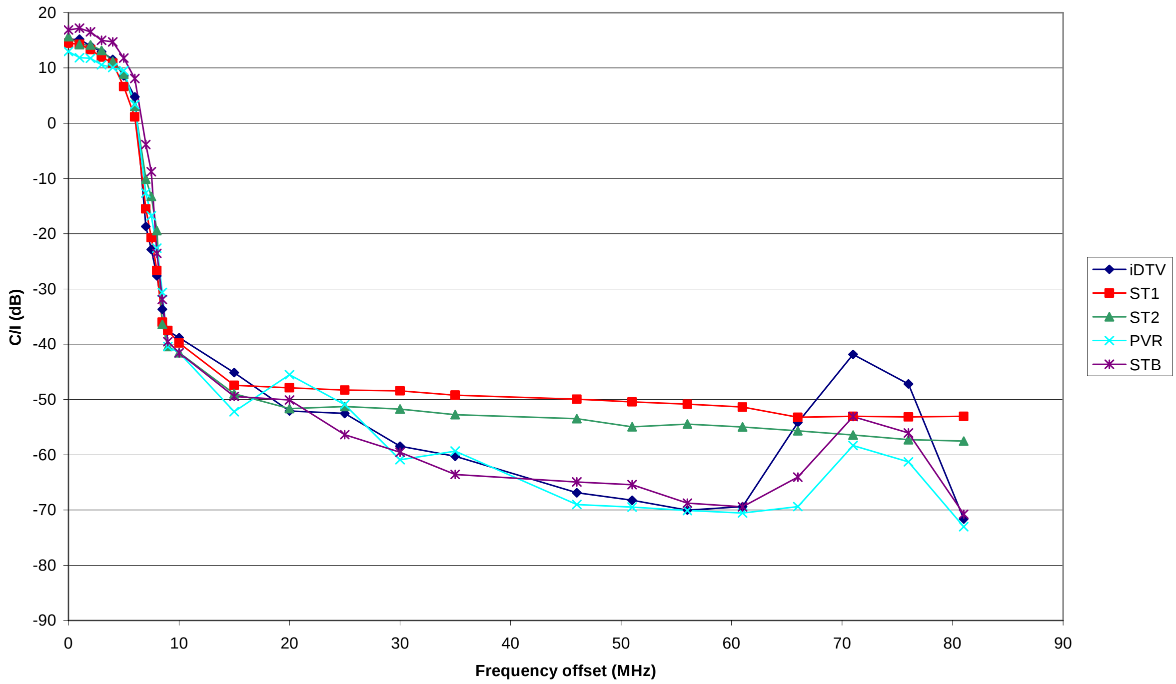

Figure 1: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (without a low pass filter) operating at -70 dBm

The performance of all 5 receivers is very similar at frequency offsets of up to 20 – 25 MHz. At higher offsets the iDTVs with silicon tuners became approximately flat with increasing frequency whereas the 3 super-heterodyne based receivers continued to display improved C/I performance until the N+9 image channel centred at 72 MHz offset.

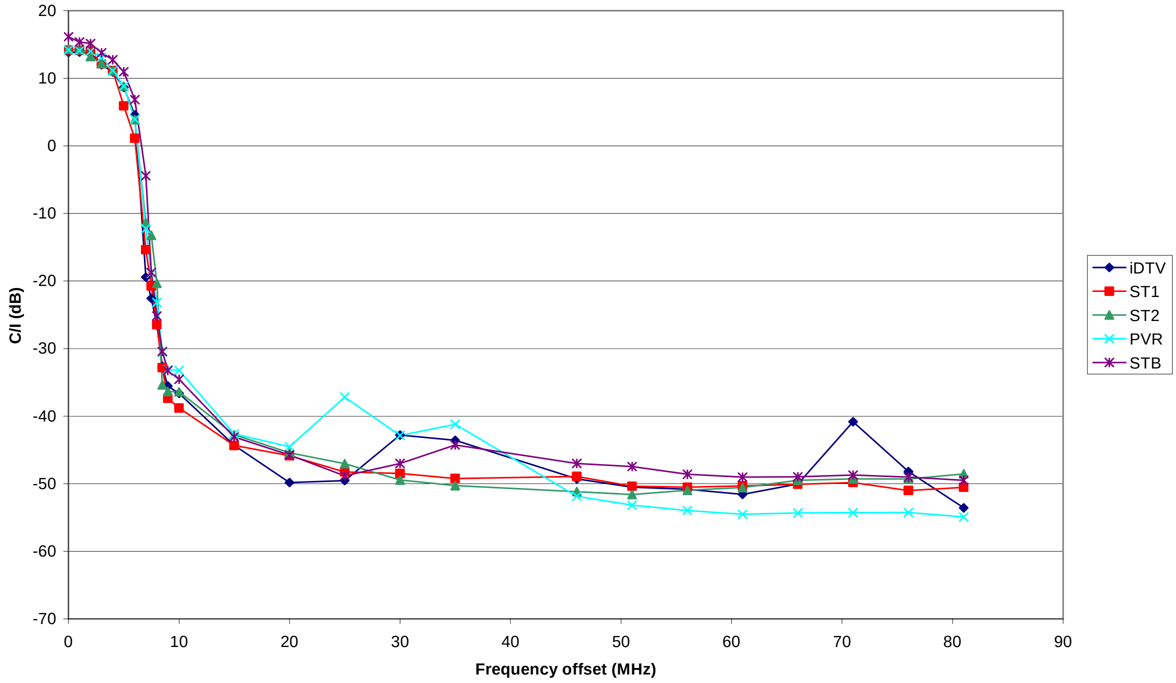

Figure 2: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (without a filter) operating at -50 dBm

At a wanted DVB-T power of -50 dBm illustrated in Figure 1 the performance of both silicon and super-heterodyne based tuners is similar with the silicon tuners being slightly better in the critical region around an offset of about 10 MHz.

As shown in a previous study by Cobham Technical Services [8], the front end of the digital receiver starts to become desensitised for wanted signals of -50 dBm and above. This desensitisation results in the interferer requiring less power to degrade the picture quality as shown in Figure 2. This desensitisation starting just above low level wanted signals is initially deliberate and essentially linear due to the action of Automatic Gain Control (AGC) and channel estimation to try to maintain constant working signal levels within the tuner as input levels change. Eventually as the wanted and/or unwanted signals get progressively stronger the desensitisation will also tend to become more non-linear as overloading is approached.

The conducted LTE BS interference measurements with a filter showed a 20 dB improvement in the C/I protection ratio, for a wanted power of -70 dBm and a frequency offset of 20 MHz between wanted and unwanted carrier centre frequencies. This improvement in the C/I protection ratio reduced with increased wanted signal strength to approximately 10 dB for wanted signal levels of between -30 to -12 dBm.

Radiated Measurements

The radiated set of measurements involved setting up five different domestic scenarios, these being:

1. LTE interference into a super-heterodyne iDTV.
2. LTE interference into two iDTVs with a silicon tuner.
3. LTE interference into a super-heterodyne PVR connected to a TV via a scart lead.
4. LTE interference into a super-heterodyne STB connected to a TV via a scart lead.
5. LTE interference into a super-heterodyne PVR and a super-heterodyne STB connected to a TV via scart leads.

Scenarios 1 to 5 were performed with a standard outdoor Yagi aerial with and without a 10 dB gain aerial distribution amplifier for a wanted frequency of 778 MHz (channel 59). The Yagi TV aerial was set up in the horizontal plane. Two sets of measurements were made with the external aerial:

a. Indoor measurements where the degree of shielding of the interconnecting coax cabling and receivers under test would be the dominant interference mechanism from an LTE handset into Digital Terrestrial Television (DTT); and
b. Outdoor measurements where pick up of the LTE signal would directly be via the TV aerial.

These five scenarios were then repeated with an indoor set top aerial with and without an aerial distribution amplifier for both co-polar and cross-polar aerial orientations. Domestic quality coax cable and fly-leads was used between the aerial and the DVB-T receiver under test.

In conclusion the radiated measurement results found that no interference was observed for the outdoor aerial scenario as transmitted at the five indoor locations shown in Figure 12. The largest signals observed were for LTE UE transmitter separation distance of 2.5 m.

With no interference observed on all five different types of DVB-T receivers when subjected to a LTE UE signal radiating with an EIRP of 23 dBm 2.5 m away, the unwanted source was increased to 28 dBm EIRP and brought in closer in order to achieve a degradation to the picture quality of the receiver. The level of unwanted signal required to cause the onset of interference at 849 MHz was measured at the DVB-T receiver’s aerial input socket. This frequency was chosen because the LTE signal would operate 1 MHz below the N+9 image centre frequency of the iDTV, PVR and STB super-heterodyne receivers.

Measured signal level and distance to cause interference to a DVB-T receiver tuned to CH59 (778 MHz) from a 10 MHz wide LTE UE source at 849 MHz

Receiver without filter (Wanted DVB-T power = -70 dBm)	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)
iDTV	-26.57	140	-24.03	40	-14.33	35	-16.81	25
iDTV silicon tuner 1	-20.79	35	-18.42	10	-13.41	5	-13	5
iDTV silicon tuner 2	-18.75	25	-15.07	7	-11.82	3	-12.28	3
PVR	-12.96	8	-14.04	1	-3.86	1	-7.63	0
STB	-19.94	33	-16.81	5	-2.67	3	-6.98	0
STB via PVR	-19.81	68	-20.93	10	-12.51	6	-13.71	4

The table above shows that the iDTV with the worst C/I protection ratio of -42 dB required the furthest separation distance of 1.4 m for it not to be interfered with by a LTE UE signal radiating at 28 dBm. The iDTVs with the silicon tuner and STB required similar separation distances of between 25 and 35 cm, given that their C/I protection ratios range from -56 to -53 dB at a 71 MHz frequency separation between the centre of the carriers.

The PVR required the least separation distance from the LTE UE source of 8 cm, because it has the best C/I protection ratio of -58 dB at the N+9 image.

The results for the different types of receivers connected via an aerial distribution amplifier indicate that the coupling of the interference is not via the main aerial cable connected to the outdoor aerial, but on the fly-lead connecting the amplifier to the digital receiver. This can be explained by the fact that the measurements show that a higher unwanted signal level is required to cause interference to the digital receivers. Hence, the wanted carrier is most likely being increased by 10 dB via the aerial distribution amplifier and the LTE interferer being picked up on the fly-lead. Thus, it can be concluded if any interference is observed for close up separation distance, replacing the fly-leads with better shielded cable may either substantially reduce or cure the problem.

The results for the horizontally polarised indoor aerial scenario showed for an LTE transmitting at 849 MHz, i.e. 1 MHz below the N+9 image, the super-heterodyne receiver was the most problematic, when no filter was used.

The iDTV possessing the worst C/I protection of -42 dB required the least amount of power of 11 dBm to cause interference for a separation distance of 2.5 m between the LTE aerial and the portable indoor TV aerial. The PVR with the best C/I protection ratio of the five digital receivers tested was not interfered with by the LTE source at this separation distance. The STB required an LTE UE uplink EIRP of 21 dBm to cause interference and the STB connected via the PVR required an EIRP of 20 dBm to cause interference at a separation distance of 2.5 m. Similar power levels were recorded with the introduction of a 10 dB gain aerial distribution amplifier.

The first of the two iDTVs with a silicon tuner showed interference across 829 to 849 MHz in 5 MHz steps for EIRP greater than 17 to 20 dBm. The second silicon tuner iDTVs did not show any interference for a separation distance of 2.5 m, due to the second receiver having a better C/I protection ratio of 4 to 6 dB at these frequencies compared with the first silicon tuner receiver.

All of the above interference effects disappeared with the introduction of the low pass UHF filter with and without the aerial distribution amplifier. The filter on average gave 20 to 25 dB of improvement in interference margin for a 10 MHz wide LTE UE signal operating between 829 and 849 MHz.

For the outdoor scenario with a 9.5 m high TV aerial and the LTE UE transmitting 30 m away directly at a height of 1.5 m into the main beam of the aerial, only the iDTV with the super-heterodyne tuner was interfered with.

The interference occurred at a frequency of 849 MHz, 1 MHz away from the N+9 image. An EIRP of 25 dBm was required to degrade the picture quality as shown in Figure 4 without the amplifier and 26 dBm with the amplifier. The measured unwanted signal levels entering the RF port of the iDTV were measured as -27.4 dBm and -16.8 dBm in a 10 MHz bandwidth without and with an aerial distribution amplifier respectively.

Laboratory measurements on the impairment of the analogue PAL modulated output of the Sky digital box using two different cable types (normal coaxial and CT100) connecting the TV display were carried out for a separation distance of 2.5 m. This output is used in some households as a means to feed a second TV in another room at low cost. The co-channel results showed that for a grade 3 impairment of slightly annoying, the induced interference on the normal coaxial cable was 37 to 41 dB worse compared with the CT100 cable, which required an EIRP of 15 – 16 dBm.

The results for the first and second channel interference show that no impairment to the picture quality was observed when using the CT100 cable connecting the TV and Sky digital box. However, the normal coaxial cable showed an improvement of 37 to 40 dB on the first adjacent channel compared with the co-channel results. Only a grade 5 impairment of essentially imperceptible was observed on the coaxial cable for second adjacent channel interference.

In summary, it can be concluded that interference is mainly observed on digital TV receivers with a super-heterodyne architecture, which in some cases have poor protection ratios as low as -40 to -30 dB on the N+9 image channel. Any interference observed at this image frequency can be rectified by a simple low-pass filter with a stop-band attenuation of 10 to 20 dB. Hence, reducing the separation distance required for interference breakthrough to as much as a 1/10 the original distance. Alternatively, the use of a digital TV receiver with a silicon tuner and a tracking filter could overcome the issue with the N+9 image, so long as the relatively poor overload performance shown by these types of receivers can be improved further.

The main source of cable pick-up interference can be attributed to the simple 1 or 2 m fly-lead. Replacing the fly-lead or TV aerial coaxial cable with a better quality shielded cable can give a 21 to 24 dB improved margin. Hence, reducing the separation distance required for interference breakthrough to as much as a quarter of the original distance.

This page is intentionally left blank

Contents

Tables List

Page No.

Figures List

Page No.

Abbreviations List

AGC	Automatic Gain Control
BEM	Boundary Emission Mask
BER	Bit Error Ratio
BS	Base Station
COFDM	Coded Orthogonal Frequency Division Multiplexing
DDR	Digital Dividend Review
DTT	Digital Terrestrial Television
DVB-T	Digital Video Broadcast-Terrestrial
EUTRA	Evolved Universal Terrestrial Radio Access
FDD	Frequency Division Duplex
FEC	Forward Error Correction
iDTV	Integrated Digital Television
LTE	Long Term Evolution
MS	Mobile Station
OFDMA	Orthogonal Frequency Division Multiplexing
PF	Picture Failure
RB	Resource Block
QEF	Quasi Error Free
QoS	Quality of Service
RBW	Resolution Bandwidth
TPC	Transmit Power Control
UCE	Un-Correctable Errors
UE	User Equipment
UHF	Ultra High Frequency

This page is intentionally left blank

1. Introduction

As part of the Digital Dividend Review (DDR), Ofcom wished to have a practical study carried out to determine the sensitivity of domestic TV receive systems to radiation from mobile handsets in the 800 MHz band. The measurement study addressed the following questions:

- Can localised interference from non-co channel Long Term Evolution (LTE) handsets situated 2.5 m or more from the TV receive system be sufficiently high as to cause interference to either the TV video or audio output or cause any degradation in the receiver sensitivity in a typical domestic installation?
- If any form of interference is experienced under what circumstances does this occur (e.g. distance, image channel) and where is the main point of breakthrough (e.g. cable or TV)?
- Are there simple, cost-effective practical measures that may be affected to overcome any problems experienced (e.g. better screened fly-leads and the fitting of a filter in the aerial downlead).

In addition Ofcom required a separate series of conducted measurements to provide Carrier-to-Interference (C/I) protection ratios for a 10 MHz wide LTE Base Station signal (BS)[2] interfering into five Digital Video Broadcast (DVB-T) receivers.

Ofcom commissioned Cobham Technical Services – ERA Technology to carry out the measurement studies in order to answer the above questions.

2. Objectives

The objectives of the practical measurement study were to:

- Perform conductive tests in order to provide Carrier-to-Interference (C/I) results for LTE Base Station (BS) interference into Digital Video Broadcast (DVB-T) receivers.
- Carry out a practical set of radiated measurements to address the questions raised by Ofcom as describe in the Introduction.
- To advise on any mitigation measures if interference to the TV receive systems was detected by LTE mobile signals.

---

[2] The Spectrum Emission Masks for the LTE BS and UE was based on the latest SE42 recommendations.

The conducted sets of measurements were performed on a bench in the laboratory. The radiated set of measurements involved setting up five different domestic scenarios, these being:

1. LTE interference into a super-heterodyne integrated Digital Television (iDTV).
2. LTE interference into two iDTVs with silicon tuners.
3. LTE interference into a super-heterodyne Personal Video Recorder (PVR) connected to a TV via a scart lead.
4. LTE interference into a super-heterodyne Set Top Box (STB) connected to a TV via a scart lead.
5. LTE interference into a PVR and a STB connected to a TV via scart leads.

Scenarios 1 to 5 were performed with a standard Yagi aerial with and without a 10 dB aerial distribution amplifier. These five scenarios were then repeated with an indoor aerial with and without an aerial distribution amplifier.

3. Test Set-Up

3.1 Wanted Signal Parameters

The DVB-T wanted signal parameters were based on ETSI EN 300 744 [1] as shown in the following table:

Table 1:
DVB-T system parameters

DVB-T parameter	Value
Multiple access	COFDM
Modulation	64-QAM
Forward error correction	2/3
FFT points	8 k
Guard Interval (μs)	7 ($^{1}/_{32}$)
Data rate (Mbit/s)	24.1
Channel bandwidth	8 MHz

All measurements were based on the non-critical DVB-T mask described in ETSI EN 302 296 [2] as shown in Table 2.

Table 2:
DVB-T transmit masks

Offset (MHz)	Critical Mask dBc	Non-critical mask dBc	Relaxed non-critical mask dBc	Ref Bandwidth (kHz)
+/-3.8	-32.8	-32.8	-32.8	4
+/-4.2	-83	-73	-67.8	4
+/-6	-95	-85	-85	4
+/-12	-120	-110	-110	4
+/-20	-120	-110	-110	4

The wanted digital signal was produced by a dedicated TV test transmitter. Figure 3 shows a typical DVB-T transmitter spectrum measured in a 5 kHz Resolution Bandwidth (RBW) compared with the ETSI non-critical mask.

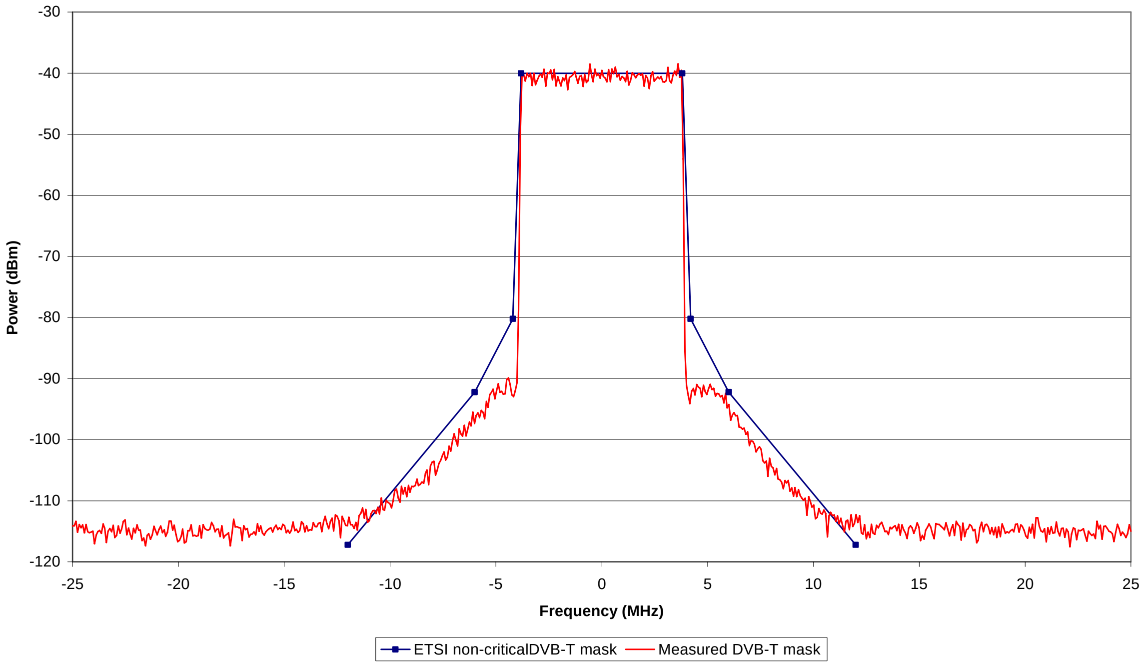

Figure 3: DVB-T wanted non-critical transmitter mask

For the radiated measurements the wanted DVB-T signal was transmitted on channel 59 centred on 778 MHz using a TV test transmitter. The radiated measurements were undertaken at Cobham Technical Services in Leatherhead which is served by the Crystal Palace transmitter. This allowed the test transmitter to operate on channel 59 without affecting local reception of the digital multiplexes from Crystal Palace, which are in the lower bands. Note that channel 59, rather than channel 60, was used for both the radiated and the conducted tests to ensure a suitably lower (1.23 dB) insertion loss from the prototype low pass filter being used for consideration of LTE interference mitigation.

3.2 Interference Criterion

DVB-T systems use Coded Orthogonal Frequency Division Multiplexing (COFDM) which spreads the information over a large number of orthogonal carriers. Forward Error Correction (FEC) is then applied to improve the Bit Error Ratio (BER). In many digital systems the data to be transmitted undergoes two types of FEC coding; Reed Solomon and convolutional coding (Viterbi). At the receiver end, the pseudo-random sequence added at the transmitter by the convolutional encoder is decoded by the Viterbi decoder, followed by Reed Solomon decoding for parity checking.

The error protection employed by such digital systems usually results in an abrupt "cliff-edge" effect in the presence of interference when compared to analogue systems. The

Digital TV Group[3] publishes the D-Book, which includes degradation criteria to be used when assessing interference to digital systems. The different DVB-T receiver degradation criteria taken from the D-Book are compared in Table 3 below.

Table 3:
D-Book comparison of degradation criteria

Criterion	Description	Comments
REF_{BER}	Post Viterbi BER=$2x10^{-4}$	BER can be very erratic with some types of impairment (e.g. impulsive inference), so an accurate measure can be hard to achieve. A measure of BER is often not available (e.g. in a commercial receiver).
UCE	No un-correctable Transport Stream errors in a defined period.	Probably the most useful measure, but unfortunately this is often not available (e.g. in a commercial receiver).
UCE Rate	A measure of the number of UCE in a defined period.	Sometimes normalised to 'Error Seconds' (Used for 'mobile' applications).
PF	"Picture Failure". No. of observed, (or detected) picture artefacts in a defined period.	This is what the consumer sees and cares about. There is always access to a 'picture' in a commercial receiver. However, when testing demodulators alone, MPEG decoding and picture display is not always available.
SFP	"Subjective failure point"	Essentially the same as PF

The reference BER, defined as BER = 2×10^{-4} after Viterbi decoding, corresponds to the Quasi Error Free (QEF) criterion in the DVB-T standard, which states "less than one uncorrelated error event per hour".

However, as noted in the D-Book, there is often no direct way of identifying BER or transport stream errors for commercial receivers. In this case Picture Failure (PF) is the only means of assessing the interference effects.

The PF point was identified by visual observation as shown in Figure 4 below, which shows the onset of un-correctable errors (UCE) used to determine the failure point. The onset of a

3 The Digital TV Group is the industry association for digital television in the UK. See http://www.dtg.org.uk/

complete picture failure, i.e. no reception, could be observed with a 1 to 2 dB increase in the interfering signal from the PF point.

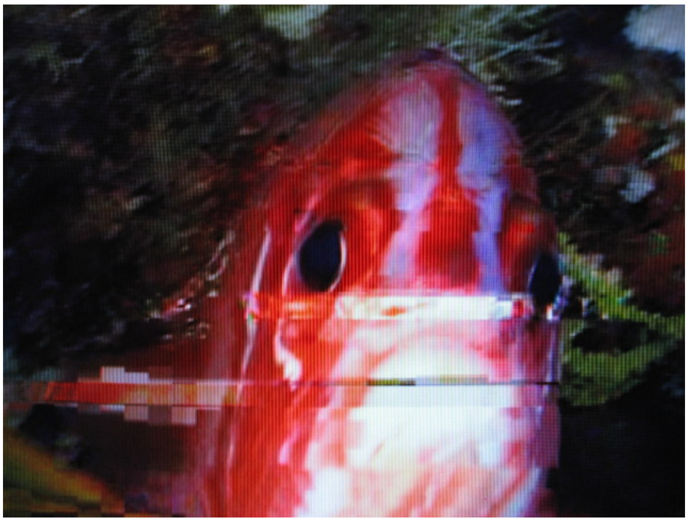

Figure 4: Received picture showing onset of interference

3.3 Unwanted Interference Parameters

3.3.1 LTE BS

The LTE BS downlink signal parameters were based on a fixed reference channel for performance requirements A3-5 from Appendix A of ETSI TS 136 104 (3GPP TS 36.104) [3].

These parameters as shown in Table 4 were used as the interference source for the conducted set of measurements.

Table 4:
LTE BS signal parameters

Parameter	Value
Output power to attenuator	20 dBm
Multiple access method	OFDMA
Duplex	FDD
Channel bandwidth	10 MHz
Sub-frame length	1 ms
Allocated resource block	50
Number of OFDM sub-carriers	12
Sub-carrier bandwidth	15 kHz
Channel modulation	QPSK
Code rate	1/3
Number of users	1
Data pattern	9 PBRS

Based on the parameters shown in Table 4 above, a signal generator was used to produce the LTE BS downlink signal for EUTRA settings (conforming to 3GPP specifications of a full RB).

Table 5 shows the Case A emission levels that were used for a LTE BS with an EIRP equal or greater than 59 dBm as based on SE42 Boundary Emission Mask (BEM) baseline level for protection of DVB-T receivers, which in turn were derived from ETSI 136 104 [3] for a 10 MHz channel bandwidth.

Table 5:
SE42 out-of-block EIRP limits for FDD LTE BS over frequencies occupied by broadcasting

Case	Frequency range	Condition on base station in-block EIRP, P dBm/{10 MHz}	Maximum mean out-of-block EIRP	Measurement bandwidth
A	For DTT frequencies where broadcasting is protected	$P \geq 59$	0 dBm	8 MHz
		$44 \leq P < 59$	(P-59) dBm	8 MHz
		$P < 44$	-15 dBm	8 MHz
B	For DTT frequencies where broadcasting is subject to an intermediate level of protection	$P \geq 59$	10 dBm	8 MHz
		$44 \leq P < 59$	(P-49) dBm	8 MHz
		$P < 44$	-5 dBm	8 MHz
C	For DTT frequencies where broadcasting is not protected	No conditions	22 dBm	8 MHz

Figure 5 shows the Spectrum Emission Mask (SEM) and relative levels from a simulated LTE BS downlink signal based on SE42 BEM baseline level for protection of DVB-T receivers, which in turn was derived from ETSI 136 104 [3] for a 10 MHz channel bandwidth.

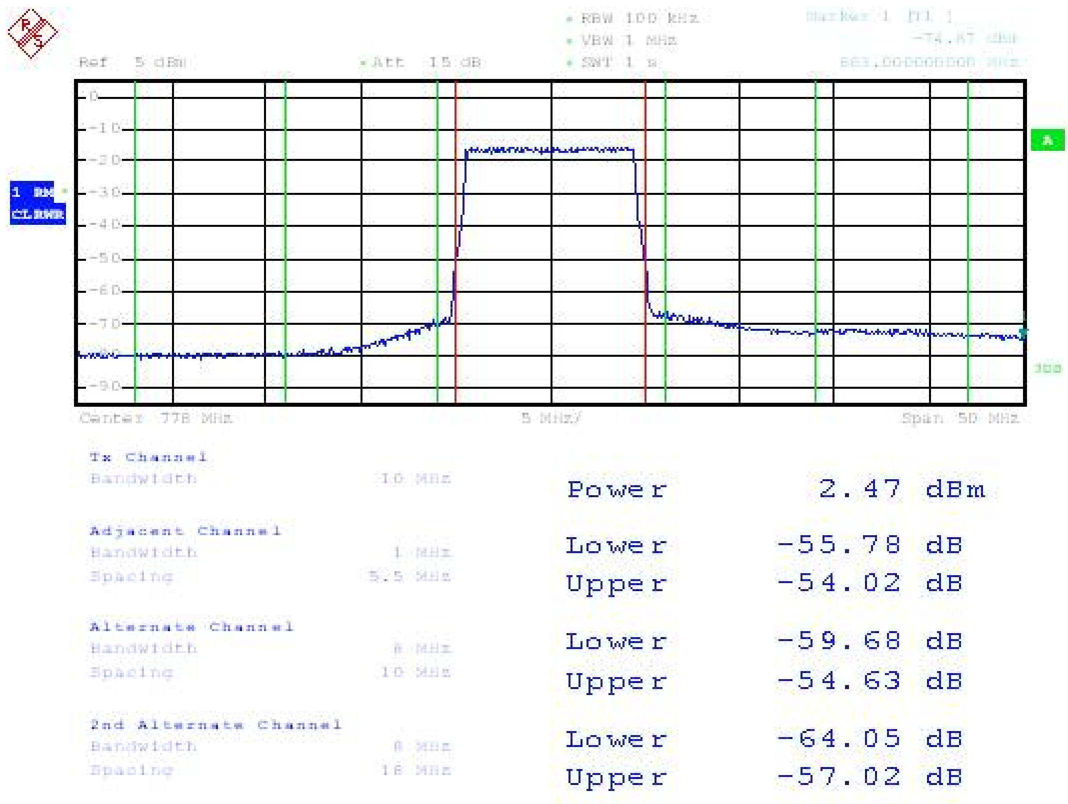

Figure 5: Simulated LTE EUTRA BS signal

3.3.2 LTE UE

The LTE UE uplink signal parameters were based on a RMC using FDD for a full Resource Block (RB).

These parameters taken from ETSI TS 136 521 (3GPP TS 36.521) [4] were used as the interference source for the conducted set of measurements (see Table 6).

Table 6:
LTE UE signal parameters

Parameter	Value
Output power	23 dBm
Multiple access method	SC-OFDM
Duplex	FDD
Channel bandwidth	10 MHz
Sub-frame length	1 ms
Allocated resource block	50
Number of OFDM sub-carriers	12
Sub-carrier bandwidth	15 kHz
Channel modulation	QPSK
Code rate	1/3
Number of users	6-8
Data pattern	9 PBRS

The output power figure was based on a Class 3 device and no power control. No power control was used, because OFDMA technology has proven to be generally more robust to multi-path and fading compared with WCDMA. This robustness to fading and multi-path comes from the fact that:

1. OFDMA uses Cyclic Prefixing, where the last 160/144 bits of data are copied at the beginning of each time slot.
2. The constant nature of each sub-carrier over a 66.7 μs OFDMA symbol period (1/15 kHz, i.e., the size of each sub-carrier) and not the data symbols that provide the resistance to delay spread [5].
3. LTE uses dynamic packet scheduling and link adaptation as well as adaptive modulation and coding [6]. Therefore, assuming that the Quality of Service (QoS) of the uplink is only affected by throughput, the LTE UE can change from 4/5 coding rate to 1/8 coding rates. These coding rate changes results in a Signal-to-Interference Nose Ratio (SINR) ranging between 6 to -8 dB, when sending data using QPSK modulation. This 14 dB range is considered enough handle any substantial fading or multi-path issues.

A signal generator was used to produce the LTE UE uplink signal using Evolved Universal Terrestrial Radio Access (EUTRA) settings (conforming to 3GPP specifications of a full RB), based on the parameters shown in Table 6 above.

Table 7:
SE42 boundary emission mask for FDD LTE UE uplink

Frequency offset from FDD (lower/upper) block edge	Maximum mean out-of-block power	Measurement bandwidth
FDD downlink upper band edge to –10 MHz from FDD lower block edge	–25 dBm	1 MHz
–10 to –5 MHz from FDD lower block edge	-6 dBm	5 MHz
–5 to 0 MHz from FDD lower block edge	1.6 dBm	5 MHz
0 to +5 MHz from FDD upper block edge	1.6 dBm	5 MHz
+5 to +10 MHz from FDD upper block edge	-6 dBm	5 MHz
+10 MHz from FDD upper block edge to FDD uplink upper band edge	–25 dBm	1 MHz

Figure 6 shows the SEM from a simulated LTE UE uplink signal without TPC, based on the parameters described in the Table 7, derived from ETSI 136 521 [4] for a 10 MHz channel bandwidth.

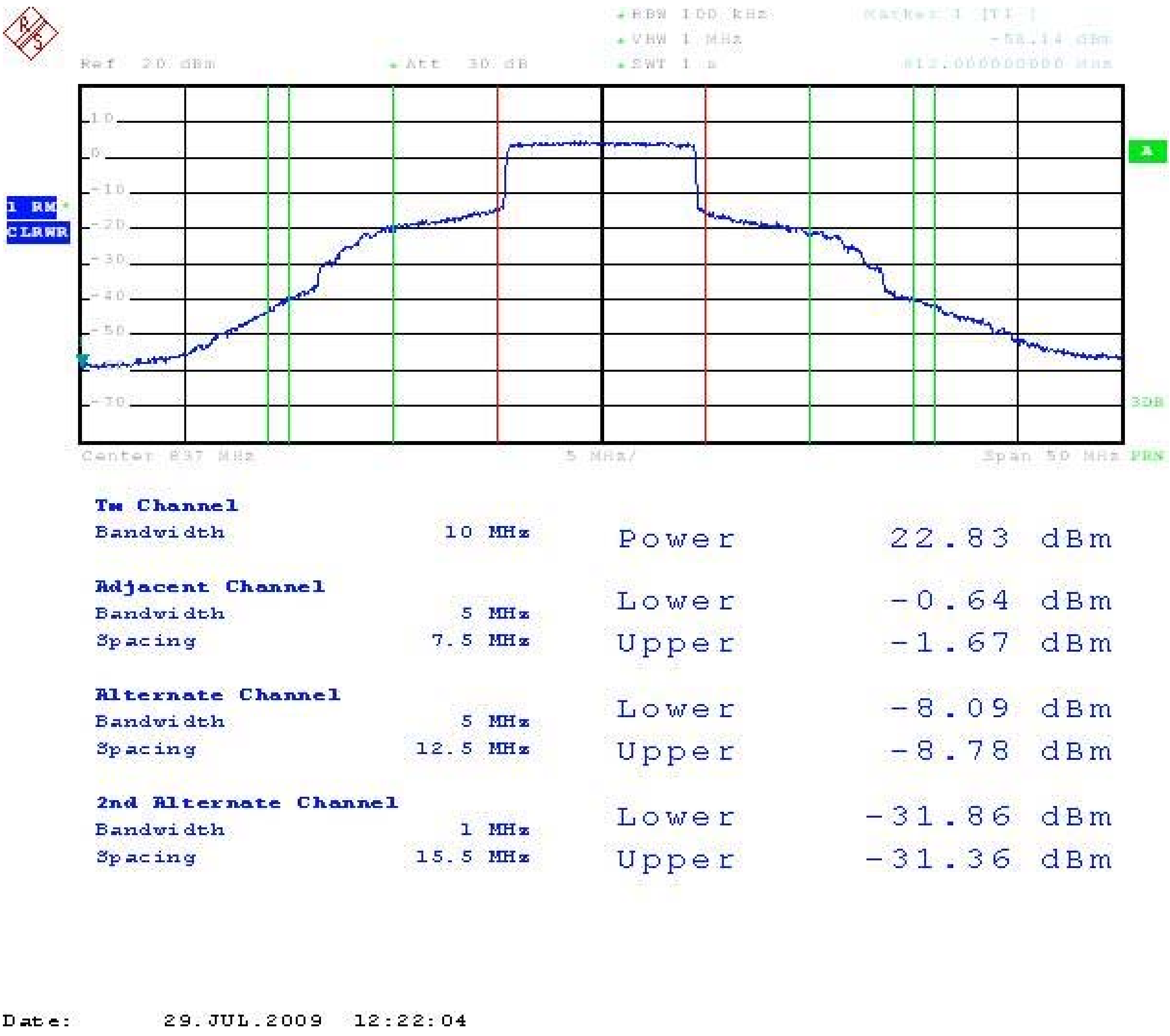

Figure 6: Simulated LTE EUTRA UE signal

3.4 Conducted Measurements

3.4.1 Equipment set-up

The conducted measurements were made using the equipment set-up shown below in Figure 7.

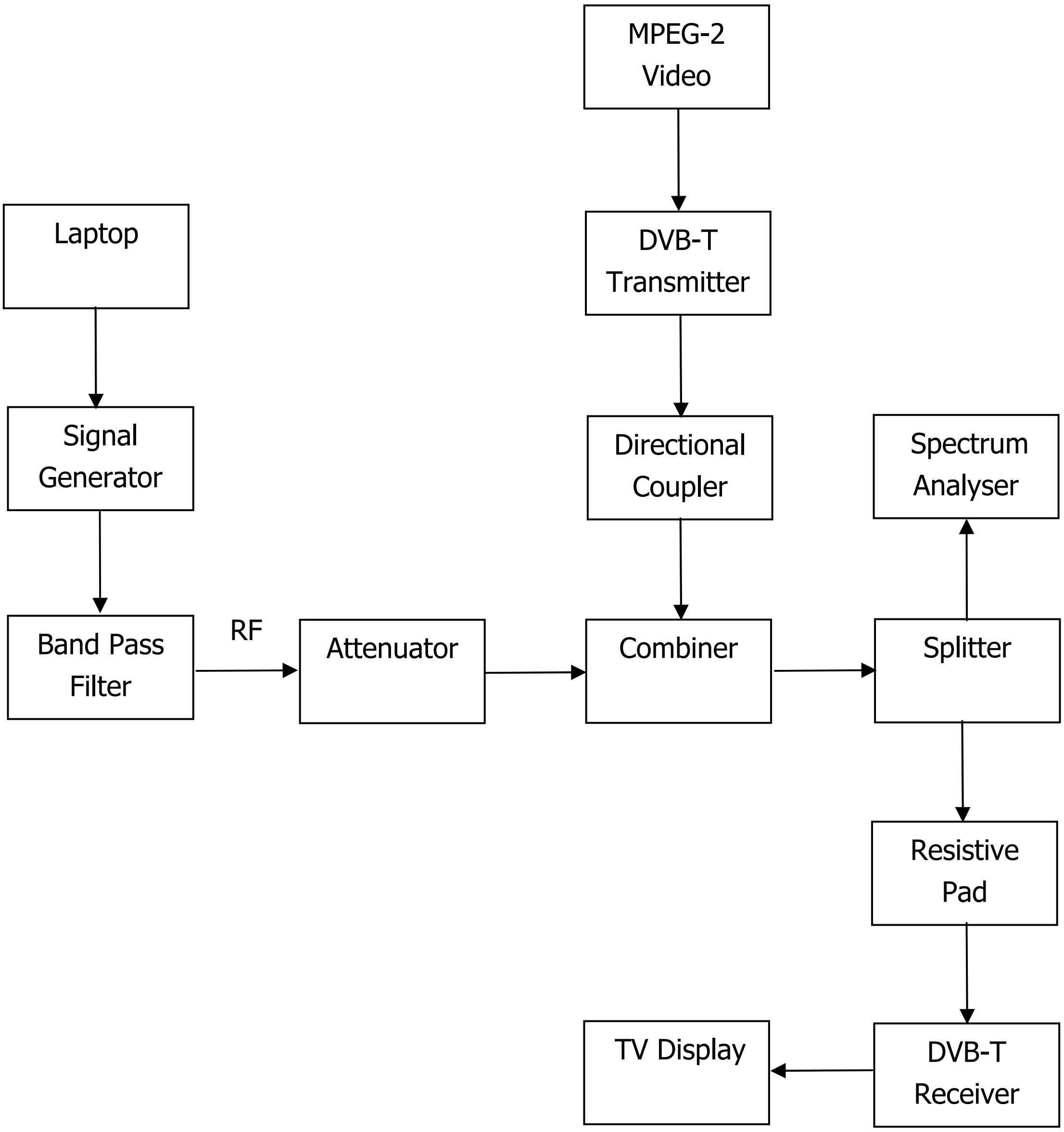

Figure 7: Diagram of Conducted Measurement Set-up

The LTE BS interference measurements were performed on a bench in the laboratory for five different types of DVB-T receiver.

3.4.2 Test procedure

The C/I protection ratio measurements were carried out using the measurement procedure shown below:

1. For a typically performing DVB-T receiver the wanted signal was set to TV channel 59 (778 MHz) and a carrier power 'C' of -70 dBm, equivalent to a wanted field strength of 54 dBµV/m[4].
2. The wanted carrier level 'C' was recorded in a 7.6 MHz channel using the spectrum analyser. The spectrum analyser was set to RMS detection with a resolution bandwidth (RBW) of 100 kHz and a video bandwidth (VBW) of 1 MHz.
3. The signal generator transmitting the interfering LTE downlink signal was initially set to channel 59 and at a signal level to –20 dB below the noise floor of the spectrum analyser.
4. The signal level of the interferer 'I' was adjusted via the attenuator to achieve the required degradation of the received quality of the decoded MPEG signal[5].
5. The power level of the interferer was measured in the channel bandwidth of 9.015 MHz using RMS detection. The RBW was set to 100 kHz and the VBW was set to 1 MHz.
6. The C/I protection ratio was calculated as the difference from Steps 2 to 5.
7. Steps 2 to 6 were repeated in 1 MHz offsets up to a frequency offset of 10 MHz and then in 5 MHz steps for frequency offsets of up to 80 MHz.

The above procedure was repeated for wanted signal levels of -50, -30, -20, -12 dBm with and without a low-pass UHF filter (see figure below).

[4] The electric field strength is based on a 12 dBi gain Yagi aerial and a 3 dB cable loss receiving a DVB-T signal at 800 MHz.

[5] A standard scart lead was used to connect the DVB-T receiver to the LCD display

Figure 8: Picture of the low pass UHF filter used in the measurements

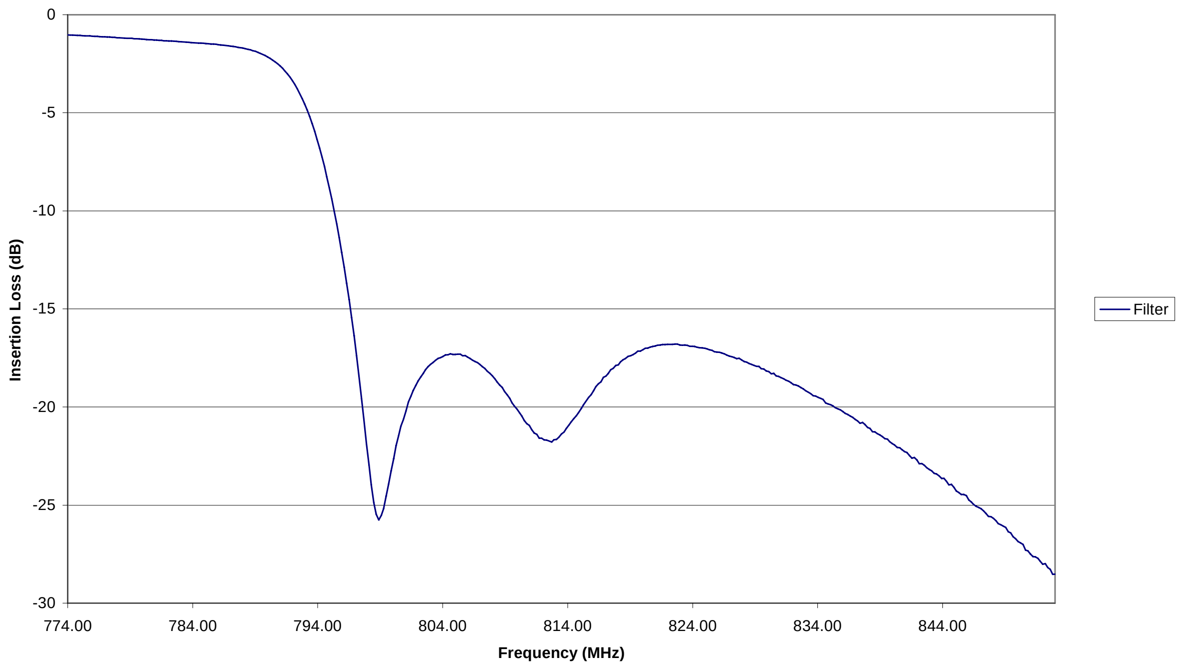

Figure 9: Insertion loss for UHF filter

The filter was used to see what levels of increased protection could be obtained for LTE BS interference into a DVB-T receiver with regards to spectrum frequency allocations and extra loss provided in the stop-band frequencies (see Figure 9)[6].

3.5 Radiated Measurements

3.5.1 Domestic set-up

The purpose of these radiated tests was to ascertain whether the cause of any future potential LTE mobile interference in and around a home environment can be linked to blocking, cable pickup or overloading of the aerial distribution amplifier. In order to identify any of these potential problems, five domestic scenarios were tested, these being:

1. LTE interference into an integrated Digital Television (iDTV).
2. LTE interference into two iDTVs with a silicon tuner.
3. LTE interference into a Personal Video Recorder (PVR) connected to a TV via a scart lead.
4. LTE interference into a Set Top Box (STB) connected to a TV via a scart lead.
5. LTE interference into a PVR and STB connected to a TV via scart leads.

Scenarios 1 to 5 were performed with a standard Yagi aerial with and without a 10 dB aerial distribution amplifier (see Figure 10 and Figure 11). The Yagi TV aerial was set up in the horizontal plane. Two sets of measurements were made with the external aerial:

a. Indoor measurements where the degree of shielding of the interconnecting coax cabling and receivers under test would be the dominant interference mechanism from an LTE handset into DTT; and
b. Outdoor measurements where pick up of the LTE signal would directly be via the TV aerial.

These five scenarios were repeated with an indoor set top aerial with and without an aerial distribution amplifier. In total fifteen scenarios for LTE interference were tested. Domestic quality coax cable and fly-leads were used between the aerial and the DVB-T receiver under test.

---

[6] Note the insertion loss characteristic measured by Cobham Technical Services (CTS) is poorer than that measured by the supplier and it has been assumed that the prototype filter was damaged in transit to CTS.

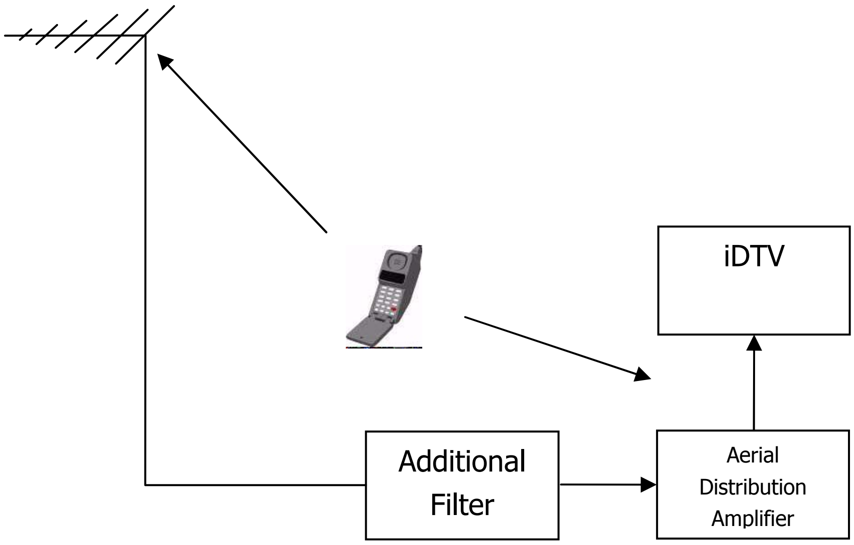

Figure 10: Radiated Set-up for iDTV receivers

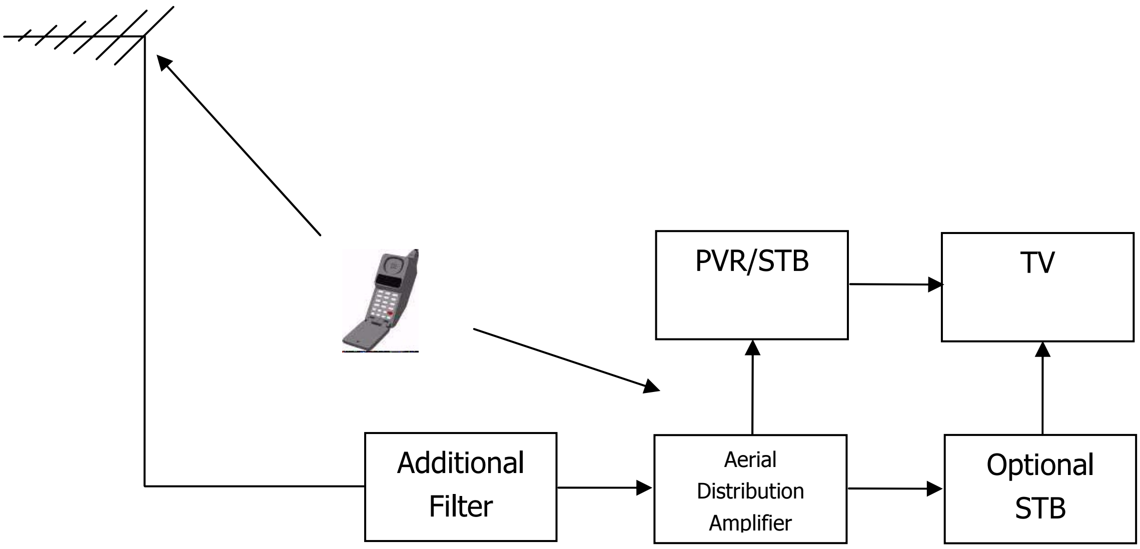

Figure 11: Radiated Set-up for PVR and STB receivers

Measurements were made at the following representative locations (see Figure 12):

1. Same room as the digital TV receiver.
2. An adjacent room.

3. Hallway adjacent to the room.
4. Room at opposite end of hallway from TV room.
5. Kitchen.

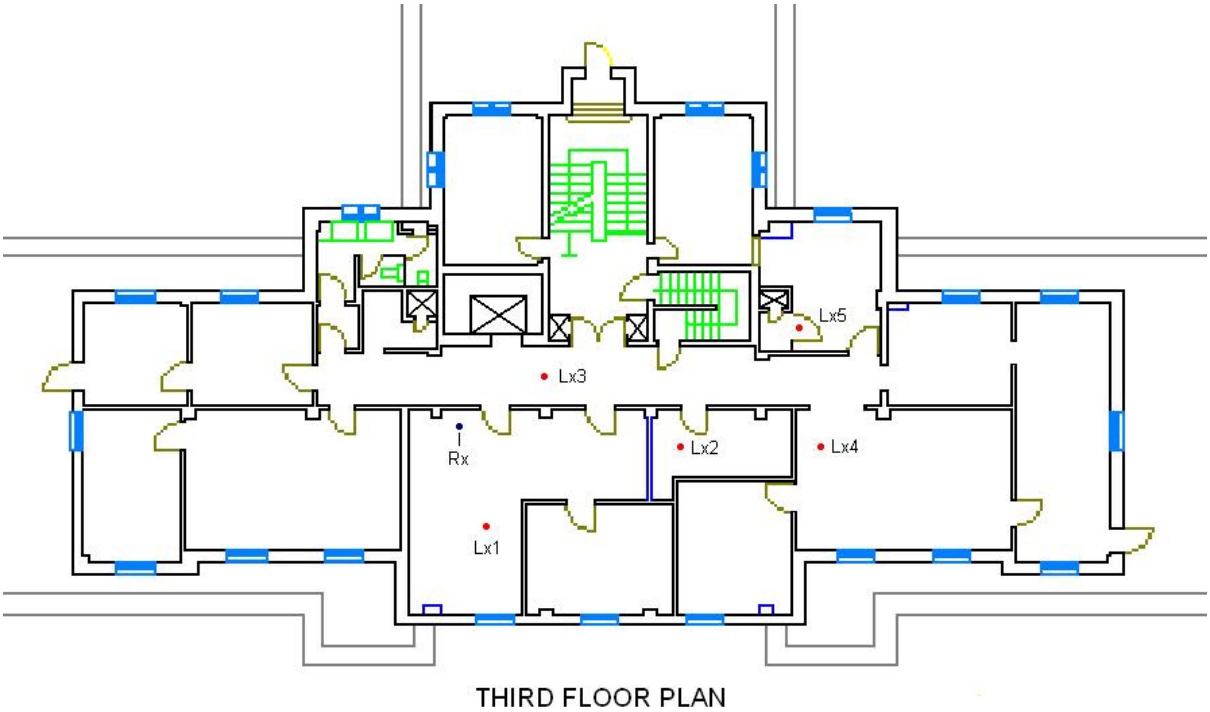

Figure 12: Plan view of the LTE interference measurement locations

For each of the measurement locations described above, the following test procedure was used[7]:

1. The DVB-T wanted signal was set to a receiver level of -70 dBm on channel 59 (778 MHz).
2. The omni directional aerial radiating the LTE UE signal was fixed at a height of 1.5 m above the ground and transmitted with an EIRP of 23 dBm in a 10 MHz bandwidth.

---

[7] The outdoor aerial was located 5 m above the 3rd floor of the room where the digital receiver under test was located. The indoor aerial was situated on a table next to the digital receivers under test. Both sets of aerials were fixed in location during the measurement tests.

3. The level of unwanted signal was measured on the aerial cable and/or fly-leads connecting the various receiver scenarios at the input port of the devices under test.
4. If any interference occurred then a supplied filter (see Figure 8) was inserted between the aerial and aerial and distribution amplifier to see if the problem was resolved. If and when resolved, the level of the DVB-T signal was measured to see if it has been reduced by any wanted signal level changes due to the insertion of the filter.
5. If any interference did occur without the filter the LTE signal was attenuated until the degradation of the picture quality stopped.
6. The above measurements procedure was repeated for centre frequencies of 834 MHz, 839 MHz, 844 MHz and 849 MHz, for both co-polar and cross-polar aerial orientations.

An initial LTE uplink frequency of 829 MHz was used in order to maintain the correct frequency separation as proposed in the ECC band plan for a DVB-T signal on channel 59 instead of channel 60 (see Figure 13).

<table>
<tr><td>791-796</td><td>796-801</td><td>801-806</td><td>806-811</td><td>811-816</td><td>816-821</td><td>821 - 832</td><td>832-837</td><td>837-842</td><td>842-847</td><td>847-852</td><td>852-857</td><td>857-862</td></tr>
<tr><td colspan="6">Downlink</td><td>Duplex gap</td><td colspan="6">Uplink</td></tr>
<tr><td colspan="6">30 MHz (6 blocks of 5 MHz)</td><td>11 MHz</td><td colspan="6">30 MHz (6 blocks of 5 MHz)</td></tr>
</table>

Figure 13: Likely ECC band plan for 790 – 862 MHz

3.5.2 Additional Sky digital box tests

Further radiated measurements using the LTE UE signal were carried out to investigate any interference on the analogue PAL modulated output of a Sky DigiBox (which defaults to channel 68). The LTE UE signal operated on co-channel to see whether any direct pick up was seen to be a problem to the device. The measurement procedure involved sending the modulated output through a reasonable length of cable to a TV set. Comparisons were performed of the induced level of interference between standard coaxial and CT100 cables in isolation for co-channel and first and second adjacent TV channels.

The measurements were set up in a similar way to the radiated tests described in Section 3.5.1, where the radiating UE signal transmitted with a maximum EIRP of 23 dBm at a fixed separation distance of 2.5 m between it and the receiver. The height of the interfering source was 1.5 m and the receiver was 1.0 m above the ground.

As the modulated output of the Sky digital box was analogue an impairment scale of 1 to 5 was used to measure the picture quality with respect to interference EIRP (see Section 4.1 of Recommendation ITU-R BT.500-11 [7]), where 5 is imperceptible and 1 is very annoying. The EIRP of the LTE signal was controlled via an attenuator.

4. Conducted Results

The conducted measurements were performed at wanted signal levels of -70, -50, -30, -20 and -12 dBm with and without a TV filter as shown in Figure 8. The wanted signal was transmitted at a frequency of 778 MHz (channel 59) and measurements were made from 778 MHz to 788 MHz in 1 MHz steps and then in 5 MHz steps at 793 to 813 MHz and 824 to 859 MHz.

4.1 Wanted Signal of -70 dBm

Figure 14 shows the measured C/I protection ratios for LTE BS interference into five different digital receivers without a filter at a wanted power level of -70 dBm. To help interpret these results plots C/I as a function of wanted signal level and of C vs. C/I have also been included in Appendix A and Appendix B respectively.

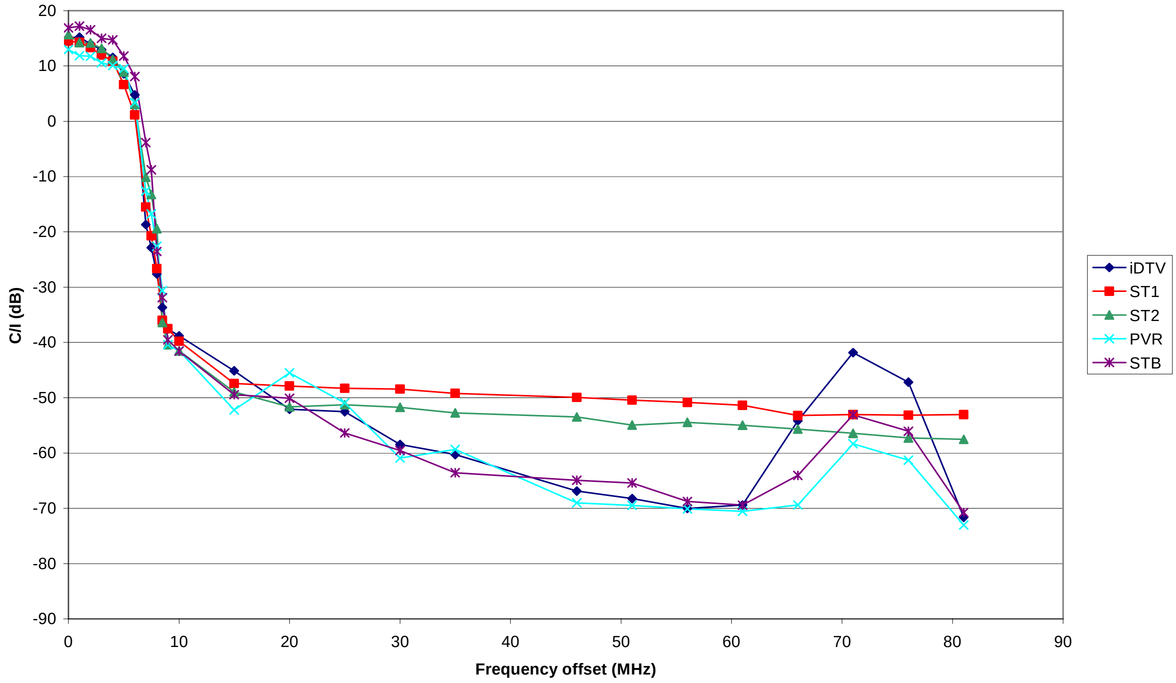

Figure 14: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (without a filter) operating at -70 dBm

At low wanted received levels of -70 dBm, the results show that the front end of the iDTV, PVR and STB super-heterodyne receiver did not overload and the N+9 image response is clearly visible at a frequency offset of 71 MHz, where the C/I protection ratio rises to -42 dB, -58 dB and -53 dB respectively. This result is within 1 dB for DVB-T interference into these three receivers [8] which was also measured as -42 dB, -57 dB and -52 dB.

The iDTVs with the silicon tuners (ST1 and ST2) have a similar response to LTE BS interference compared with the iDTV, PVR and STB receiver for frequency offsets up to 10 MHz where the C/I protection ratio is -40 dB ±1 dB.

For higher frequency offsets, the results between the silicon tuner devices and the super-heterodyne receivers diverge by as much as 19 dB before converging again at the N+9 image inherent of the super-heterodyne architecture.

Figure 15 shows the measured C/I protection ratios for LTE BS interference into five different digital receivers with a filter at a wanted power level of -70 dBm. At frequency offsets of 35 MHz the filter improves the C/I protection ratio by 20 dB on average when compared with the conducted results without a filter (see Figure 14).

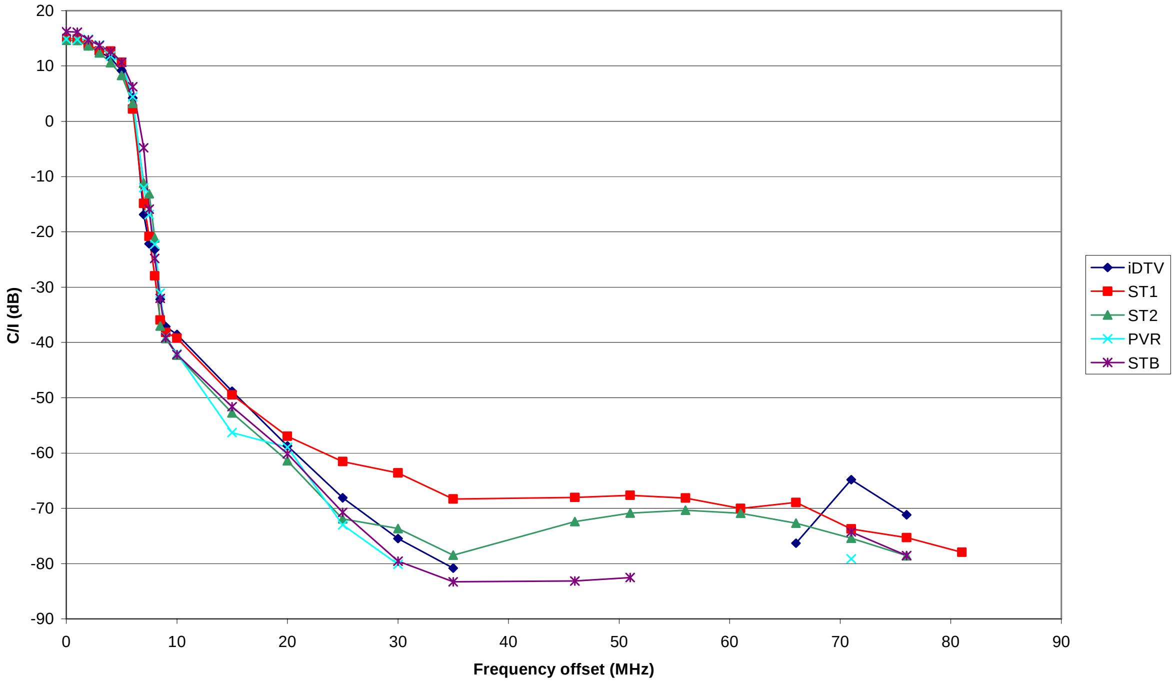

Figure 15: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (with a filter) operating at -70 dBm

The results also show that for unwanted signal levels of 11 to 13 dBm, the LTE BS could not interfere with the iDTV super-heterodyne tuner.

4.2 Wanted Signal of -50 dBm

Figure 16 shows the measured C/I protection ratios for LTE BS interference LTE BS interference into five different digital receivers at a wanted power level of -50 dBm.

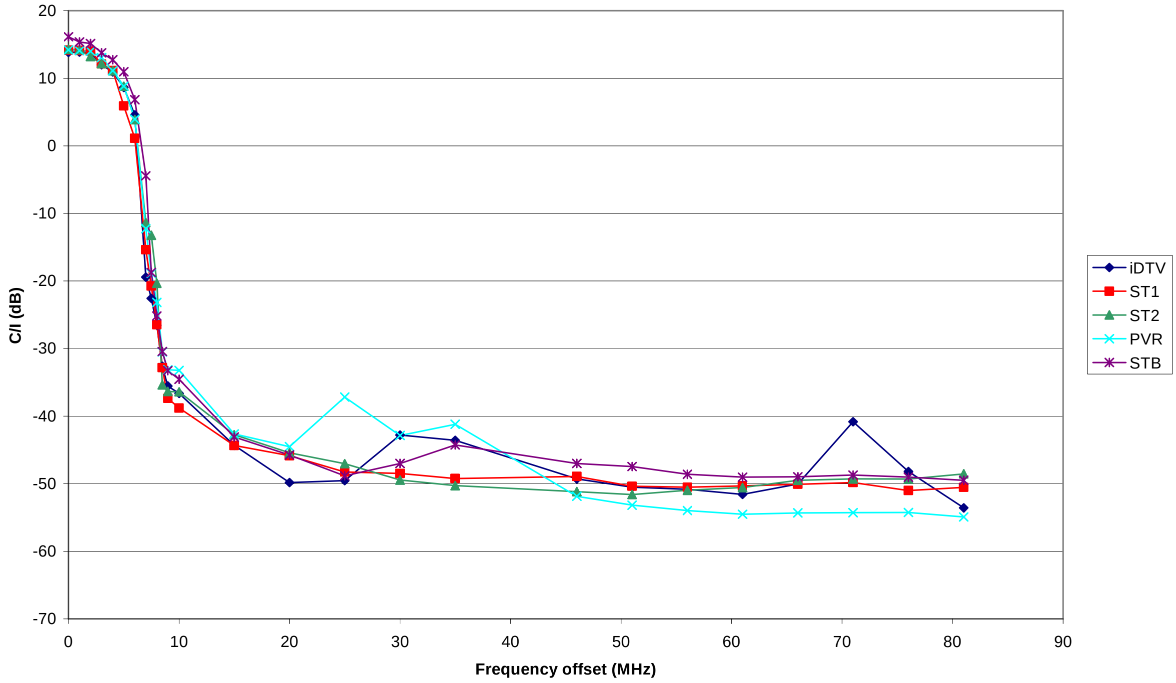

Figure 16: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (without a filter) operating at -50 dBm

The plot above shows that as the wanted signal increases to -50 dBm, the front end of the iDTV, PVR and STV receivers start to become desensitised and require less interference power relative to the wanted carrier level for a frequency offset of 35 MHz or more to impair the received picture quality.

This desensitisation is not seen for frequency separations less the 15 MHz between the centre carriers of the wanted and unwanted signals, as the measured C/I results for all five receivers are within 2 to 5 dB of each other and produce similar results for a wanted signal of -70 dBm.

The results also show that the iDTV, PVR and STB receiver C/I protection ratios start to converge with the iDTVs with the silicon tuner values. With the exception of the PVR results between 25 and 35 MHz and the iDTV results between 30 and 35 MHz and 71 MHz frequency offsets, the results are within 6 dB of each other for frequency separation greater than 15 MHz.

The C/I results at a wanted signal of -50 dB for the iDTVs with a silicon tuner are similar for all frequency offsets when compared with the measurements for a wanted signal of -70 dBm. This suggests that a DVB-T receiver with a silicon tuner has a poorer overload performance under weak wanted signal conditions compared with a DVB-T super-heterodyne receiver.

Figure 17 shows the measured C/I protection ratios for LTE BS interference into five different digital receivers with a filter at a wanted power level of -50 dBm.

The results also show that for unwanted signal levels of 12 to 16 dBm (without affecting the SEM), the LTE BS could not interfere with all five receivers beyond a frequency separation of 25 MHz.

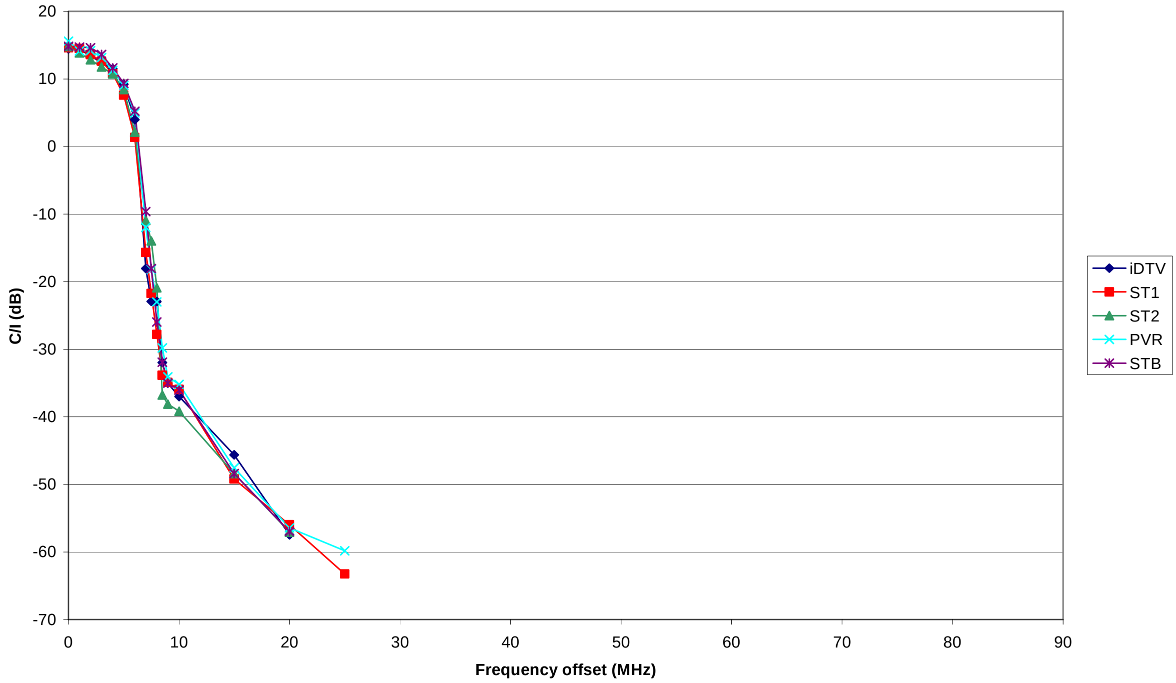

Figure 17: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (with a filter) operating at -50 dBm

At a frequency offset of 20 MHz the filter improves the C/I protection ratio by 5 to 13 dB when compared with the conducted results without a filter (see Figure 16).

4.3 Wanted Signal of -30 dBm

Figure 18 shows the measured C/I protection ratios for LTE BS interference into five different digital receivers at a wanted power level of -30 dBm.

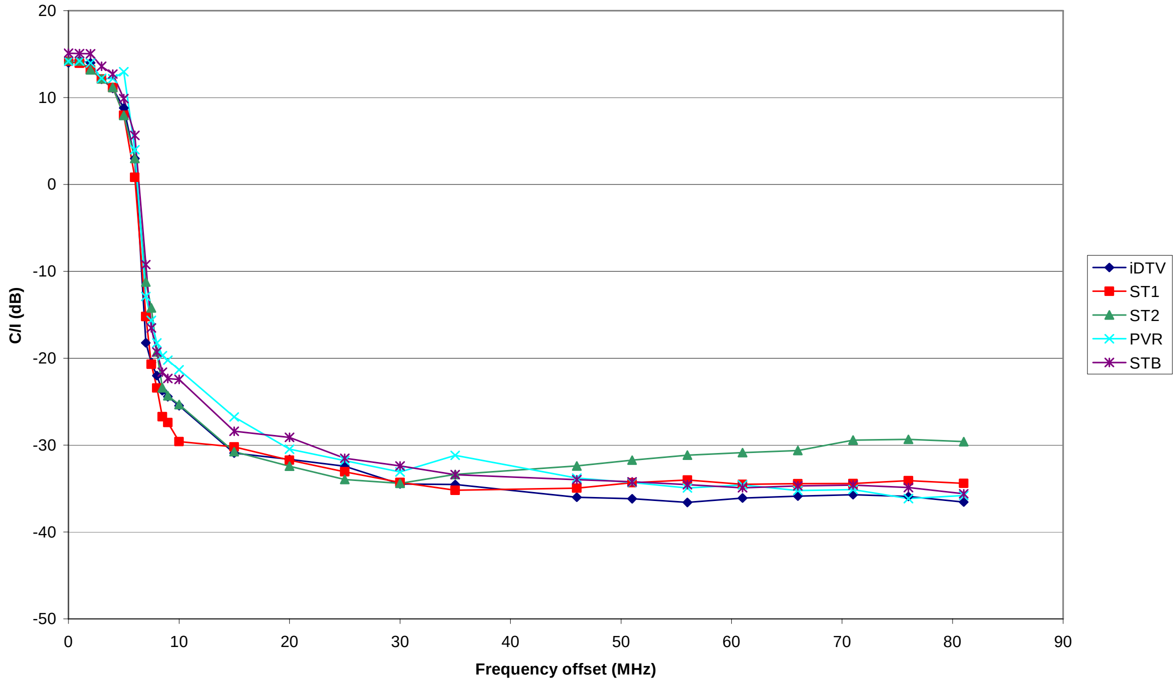

Figure 18: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (with filter) operating at -30 dBm

The plot above shows that as the wanted signal increases to -30 dBm, the front end of the iDTV, PVR and STV receivers start to become desensitised and require less interference power relative to the wanted carrier level for a frequency offset of 8 MHz or more to impair the received picture quality. This is also true for the iDTVs with a silicon tuner, however the iDTV with a silicon tuner, ST1, has a better C/I protection ratio for adjacent channel interfering frequencies and compares well with the IDTV, PVR and STB for larger blocking frequencies. This increase in performance can probably be attributed to a high resolution ADC and better digital filtering implemented in this silicon tuner receiver.

At blocking frequency separations of 20 MHz or more, the devices under test operating at a wanted level of -30 dBm, required on average 15 dB less LTE BS interference power to cause degradation to the received picture quality compared to a wanted level of -50 dBm.

Figure 19 shows the measured C/I protection ratios for LTE BS interference into five different digital receivers with a filter at a wanted power level of -30 dBm.

The results again show that for unwanted signal levels of 12 to 16 dBm (without affecting the SEM), the LTE BS could not interfere with all five receivers beyond a frequency separation of 20 MHz.

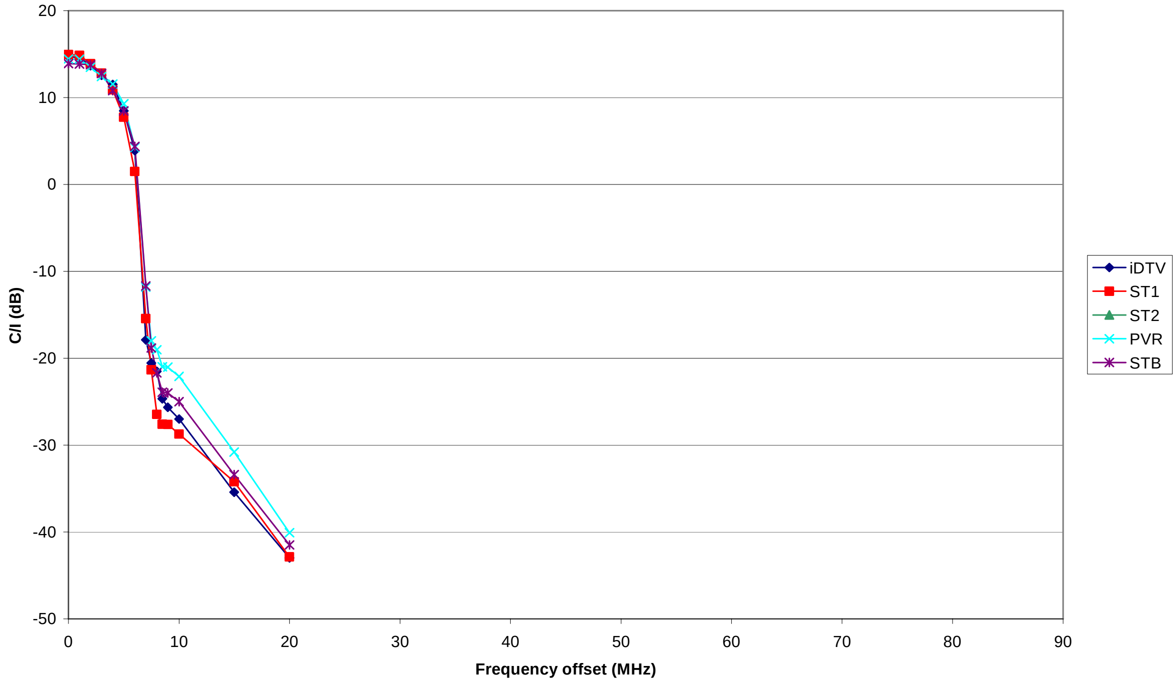

Figure 19: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (with a filter) operating at -30 dBm

At a frequency offset of 20 MHz the filter improves the C/I protection ratio by 10 to 13 dB when compared with the conducted results without a filter (see Figure 18).

4.4 Wanted Signal of -20 dBm

Figure 20 shows the measured C/I protection ratios for LTE BS interference into five different digital receivers at a wanted power level of -20 dBm.

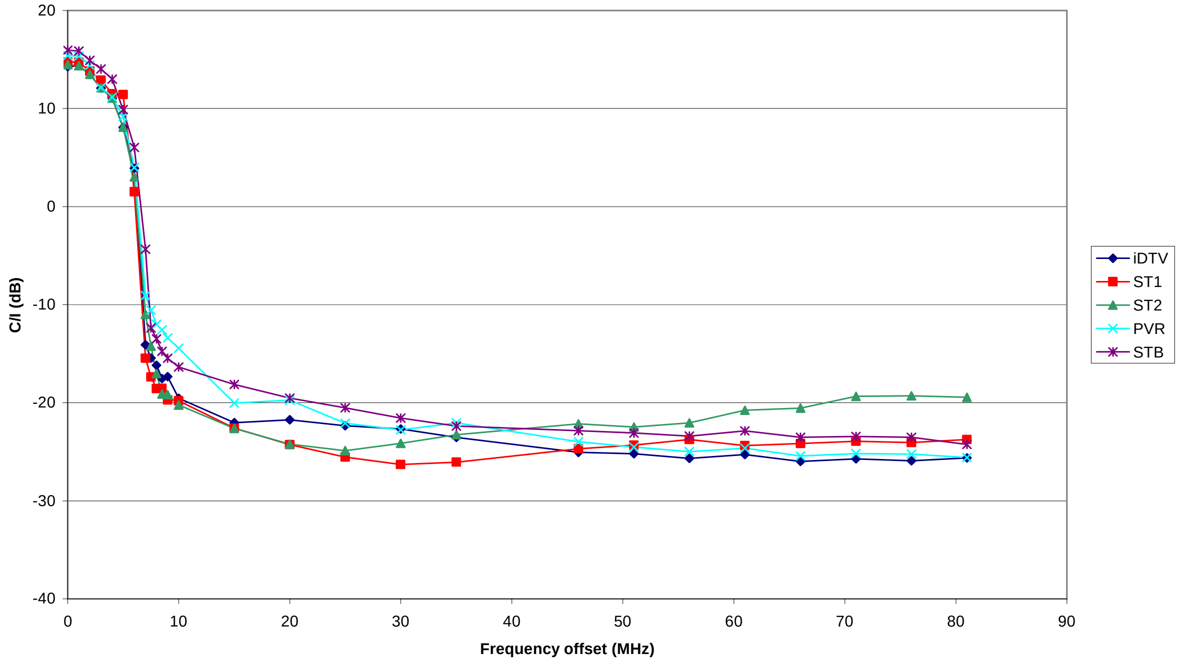

Figure 20: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (without a filter) operating at -20 dBm

Again, the above plot shows that as the wanted signal increases from -30 dBm to -20 dBm, the front end of the iDTV, PVR and STV receivers remain desensitised and require more or less the same interference power to impair the received picture quality. Hence, the 10 dB jump in the C/I protection ratio from a wanted signal of -30 dBm to -20 dBm for frequency offsets greater than 7-8 MHz.

This is also true for the iDTVs with a silicon tuner having the best performance with respect to C/I protection ratios at the adjacent channel offsets and compares well with the iDTV, PVR and STB for larger blocking frequencies.

Figure 21 shows the measured C/I protection ratios for LTE BS interference into five different digital receivers with a filter at a wanted power level of -20 dBm.

As with a wanted signal of -30 dBm, the results show that for unwanted signal levels of 12 to 16 dBm (without affecting the SEM), the LTE BS could not interfere with all five receivers beyond a frequency separation of 20 MHz.

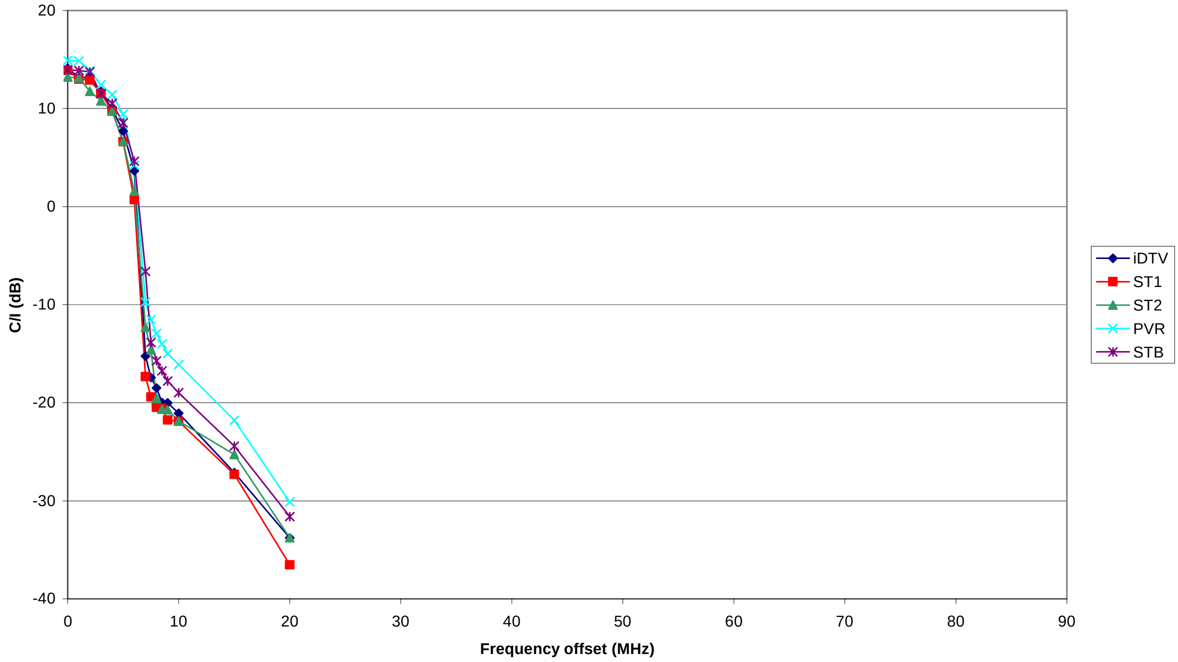

Figure 21: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (with a filter) operating at -20 dBm

At a frequency offset of 20 MHz the filter improves the C/I protection ratio by 10 to 12 dB when compared with the conducted results without a filter (see Figure 20).

4.5 Wanted Signal of -12 dBm

Figure 22 shows the measured C/I protection ratios for LTE BS interference into five different digital receivers at a wanted power level of -12 dBm.

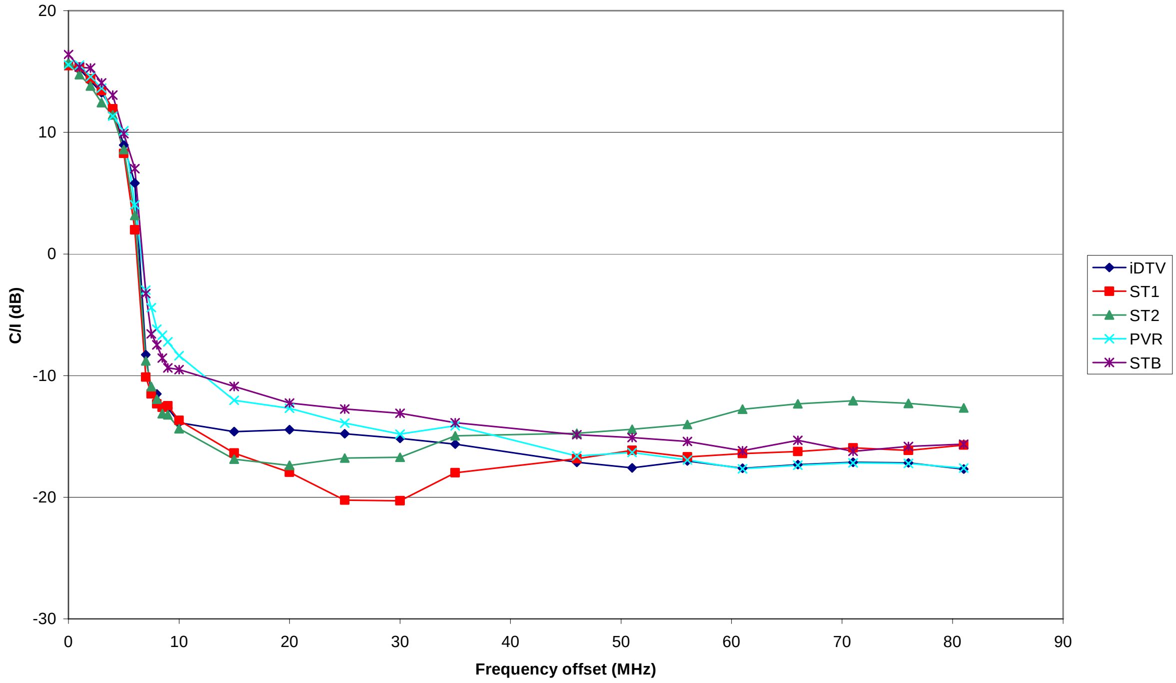

Figure 22: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (without a filter) operating at -12 dBm

Again, the plot above shows that as the wanted signal increases from -20 dBm to -12 dBm, the front end of the iDTV, PVR and STV receivers remain desensitised and require approximately the same interference power to impair the received picture quality. Hence, the 8 – 10 dB jump in the C/I protection ratio from a wanted signal of -30 dBm to -20 dBm for frequency offsets greater than 8 MHz.

This is also true for the iDTVs with a silicon tuner whose results show a good comparison with the iDTV receiver for frequencies between 7 to 10 MHz and produce similar C/I protection ratios compared with the IDTV, PVR and STB for larger blocking frequencies.

Figure 23 shows the measured C/I protection ratios for LTE BS interference into five different digital receivers with a filter at a wanted power level of -20 dBm.

As with a wanted signal of -20 dBm, the results show that for unwanted signal levels of 12 to 16 dBm (without affecting the SEM), the LTE BS could not interfere with all five receivers beyond a frequency separation of 20 MHz.

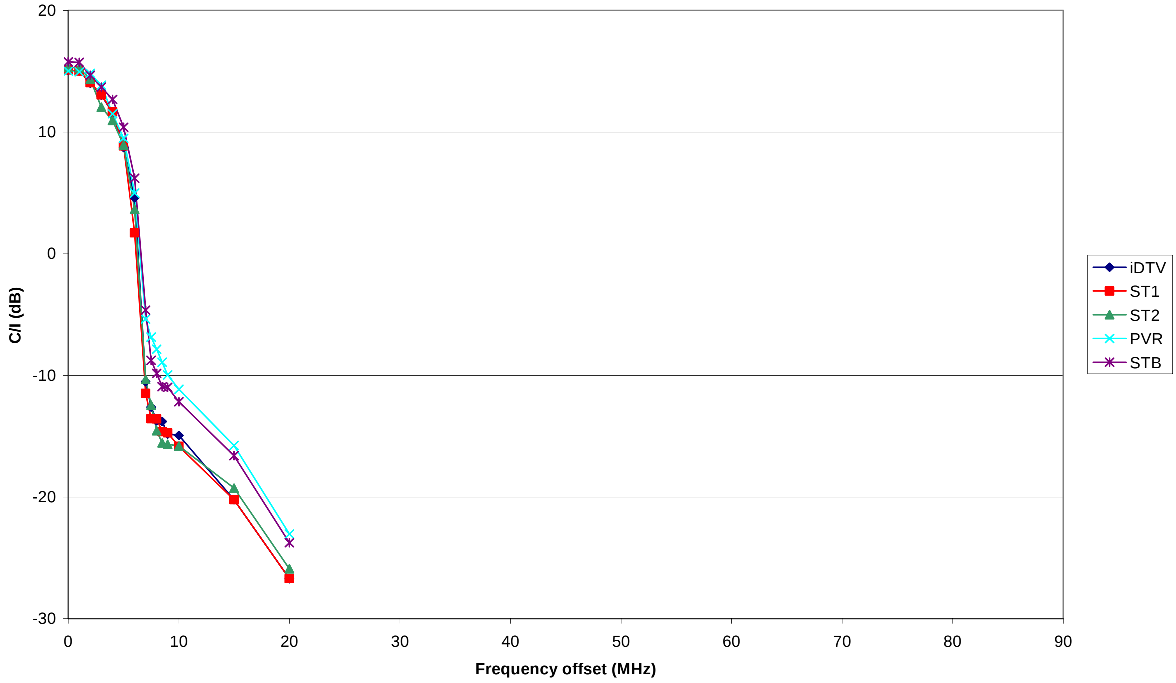

Figure 23: Plot of C/I protection ratios for LTE BS interference into five digital TV receivers (with a filter) operating at -12 dBm

At a frequency offset of 20 MHz the filter improves the C/I protection ratio by 8 to 13 dB when compared with the conducted results without a filter (see Figure 22).

5. Radiated Results

5.1 Outdoor Aerial

The outdoor aerial radiated measurements were carried out as described in Section 3.5 and for repeatability the cable layout was fixed via adhesive tape to the table supporting the equipment, as it was found that moving the cable several inches could change the results by as much as ± 6 to 10 dB.

In conclusion the radiated measurement results found that no interference was observed for the outdoor aerial scenario as transmitted at the five locations shown in Figure 12. The largest signals observed were for LTE UE transmitter locations Lx1.

Therefore, only the signal levels induced on the receiver cables for LTE UE transmit location Lx1 are discussed in this section of the report. The LTE UE signal levels measured on the cables connecting the digital TV receivers for the remaining four transmit locations are given in Appendix C.

Table 8 below shows the average received LTE UE signal level on the cable connected to six different digital receivers for all five frequencies measured. The LTE source was located 2.5m away from the digital receiver in the same room. Both co-polar and cross-polar aerial orientations were measured to ensure that the maximum coupling on the cable was achieved.

Table 8:
Average measured signal level on a cable connected to a DVB-T receiver 2.5 m away from a LTE UE source

Digital receiver	Without aerial distribution amplifier		With 10 dB gain aerial distribution amplifier	
	Co-polar	Cross-polar	Co-polar	Cross-polar
	I (dBm)	I (dBm)	I (dBm)	I (dBm)
iDTV	-43.7	-42.5	-31.1	-30.2
iDTV silicon tuner ST1	-41.2	-41.9	-29.7	-31.5
iDTV silicon tuner ST2	-41.7	-42.0	-30.8	-31.2
PVR	-38.6	-38.8	-27.2	-29.7
STB	-42.0	-42.5	-30.9	-30.7
STB via PVR	-34.5	-36.0	-24.8	-26.5

With the exception of the STB connected after the PVR, it can be seen that on average -38.6 dBm to -43.7 dBm of the unwanted LTE UE signal was induced on the cable connecting the digital receivers for both co-polar and cross-polar aerial orientations. The levels of unwanted LTE UE signal observed with the aerial distribution amplifier with a gain of 10 dB increased by 12 dB compared to results without an aerial distribution amplifier for both cross-polar and co-polar aerial orientations respectively.

This slight increase can be attributed to multi-path in the surrounding environment, which can vary the signal by as much as 6 to 10 dB depending on the position of cables and people nearby.

With no interference observed on all five different types of DVB-T receivers when subjected to a LTE UE signal radiating with an EIRP of 23 dBm 2.5 m away, the unwanted source was increased to 28 dBm EIRP and brought in closer in order to achieve a degradation to picture quality on the receiver and measure the level of unwanted signal required to cause the onset of interference at 849 MHz. This frequency was chosen because the LTE signal would operate 1 MHz below the N+9 image of the iDTV, PVR and STB receivers. The wanted DVB-T signal level was set to -70 dBm. When the aerial distribution amplifier was included in circuit the level of the DVB-T signal increased to -60 dBm at the DVB-T receiver under test.

Table 9:
Measured signal level and distance to cause interference to a DVB-T receiver from a LTE UE source with an EIRP of 28 dBm and a wanted signal of -70 dBm

Receiver without filter	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)
iDTV	-26.57	140	-24.03	40	-14.33	35	-16.81	25
iDTV silicon tuner ST1	-20.79	35	-18.42	10	-13.41	5	-13	5
iDTV silicon tuner ST2	-18.75	25	-15.07	7	-11.82	3	-12.28	3
PVR	-12.96	8	-14.04	1	-3.86	1	-7.63	0
STB	-19.94	33	-16.81	5	-2.67	3	-6.98	0
STB via PVR	-19.81	68	-20.93	10	-12.51	6	-13.71	4

Table 9 above shows that the iDTV with the worst C/I protection ratio of -42 dB required the furthest separation distance of 1.4 m for it not to be interfered with by a LTE UE signal radiating at 28 dBm. The iDTVs with the silicon tuners and STB required similar separation distances between 25 and 35 cm, given that their C/I protection ratios range from -56 to -53 dB at a 71 MHz frequency separation between the centre of the carriers.

The PVR required the least separation distance from the LTE UE source of 8 cm, because it has the best C/I protection ratio of -58 dB at the N+9 image.

The results for the different types of receivers connected via an aerial distribution amplifier indicate that the coupling of the interference is not via the main aerial cable connected to the outdoor aerial, but on the fly-lead connecting the amplifier to the digital receiver. This can be explained by the fact that the measurements show that a higher unwanted signal level is required to cause interference to the digital receivers. Hence, the wanted carrier is most likely being increased by 10 dB via the aerial distribution amplifier and the LTE interferer is being picked up on the fly-lead which follows the amplifier.

5.2 Indoor Set Top Aerial

The indoor set top aerial radiated measurements were carried out as described in Section 3.5 and for repeatability the cable layout was fixed via adhesive tape to the table supporting the equipment, as it was found that moving the cable several inches could change the results by as much as ± 6 to 10 dB. The wanted DVB-T signal level was -70 dBm and when the aerial distribution amplifier was included in the circuit the level of the DVB-T signal increased to -60 dBm at the DVB-T receiver under test. The simulated LTE UE signal had an EIRP of 23 dBm.

In conclusion the radiated measurement results found that the majority of interference was observed for the indoor aerial scenario at transmitter locations Lx1 shown in Figure 12. Therefore, only the signal levels induced on the receiver cables for LTE UE transmit location Lx1 are discussed in this section of the report. The LTE UE signal levels measured on the cables connecting the digital TV receivers for the remaining four transmit locations are shown in Appendix D.

5.2.1 iDTV receiver

Table 10 below shows the received LTE UE signal level on the cable connected to an iDTV receiver under test for a DVB-T wanted signal level of -70 dBm. Both co-polar and cross-polar aerial orientations were measured to ensure that the maximum coupling on the cable was observed for an LTE EIRP of 23 dBm.

Table 10:
Measured signal level on a cable connected an iDTV receiver 2.5 m away from a LTE UE source with an EIRP of 23 dBm a wanted DVB-T signal of -70 dBm

Freq (MHz)	iDTV without filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-15.68	No	-19.09	No	-6.35	No	-8.56	No
834	-17.91	No	-16.82	No	-8.91	No	-5.78	No
839	-17.84	No	-16.92	No	-7.58	No	-6.35	No
844	-15.29	Yes	-16.96	Yes	-6.53	Yes	-8.79	Yes
849	-16.82	Yes	-17.14	Yes	-8.77	Yes	-7.14	Yes
	iDTV with filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
844	-39.88	No	-42.71	No	-33.08	No	-38.53	No
849	-47.48	No	-40.12	No	-36.74	No	-36.03	No
	Attenuation on LTE signal required to stop interference to iDTV without filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)
844	-16.15	1	-18.91	2	-9.97	3	-10.74	2
849	-28.25	12	-33.57	15	-20.56	12	-21.03	14

From the table above it can be seen that interference was observed on the iDTV at 844 and 849 MHz, around the N+9 image of the receiver. The results show that when the filter was included the level of interference dropped by 23 to 31 dB and no interference was observed with and without the aerial distribution amplifier.

The measurements also show that the EIRP of the LTE UE signal transmitting at 844 MHz had to drop by 1 to 3 dB in order for it not to interfere with the iDTV. This level of attenuation increased between 12 to 15 dB at 849 MHz, 1 MHz below the centre frequency for the N+9 image, thus requiring the LTE UE to transmit at 8 to 11 dBm/10 MHz for it not to cause interference to the iDTV.

At 849 MHz, the horizontally polarised LTE signal interfered with the iDTV at a recorded level of -28.25 dBm. This compares very well with a conductively measured C/I ratio of -42 dB [8] at the N+9 image, i.e. -28 dBm of interference for a wanted signal of -70 dBm.

In order to measure the LTE signal level to cause interference at frequencies where the iDTV did not show any problems with an EIRP of 23 dBm at 2.5 m separation distance, the LTE UE source was moved closer towards the front end of the indoor TV aerial until a problem did occur.

Table 11:
Measured signal level on a cable connected an iDTV receiver from a close in LTE UE source with an EIRP of 23 dBm and a DVB-T wanted signal of -70 dBm

<table>
<tr><th rowspan="4">Freq (MHz)</th><th colspan="8">iDTV measurement without filter</th></tr>
<tr><th colspan="4">Without aerial distribution amplifier</th><th colspan="4">With 10 dB gain aerial distribution amplifier</th></tr>
<tr><th colspan="2">Co-polar</th><th colspan="2">Cross-polar</th><th colspan="2">Co-polar</th><th colspan="2">Cross-polar</th></tr>
<tr><th>I (dBm)</th><th>Distance (cm)</th><th>I (dBm)</th><th>Distance (cm)</th><th>I (dBm)</th><th>Distance (cm)</th><th>I (dBm)</th><th>Distance (cm)</th></tr>
<tr><td>829</td><td>0.86</td><td>24</td><td>2.79</td><td>12</td><td>-1.26</td><td>90</td><td>0.72</td><td>45</td></tr>
<tr><td>834</td><td>0.66</td><td>25</td><td>3.5</td><td>10</td><td>-1.43</td><td>90</td><td>1.93</td><td>48</td></tr>
<tr><td>839</td><td>0.82</td><td>29</td><td>0.31</td><td>13</td><td>-1.77</td><td>83</td><td>0.91</td><td>42</td></tr>
</table>

The results in Table 11 show that an LTE UE signal with a power level of 0 dBm/10 MHz on average was required to cause degradation in the picture quality of the iDTV with and without an aerial distribution amplifier. This power level equates to a maximum distance of 29 cm without an aerial distribution amplifier and 90 cm with an aerial distribution amplifier.

As expected the results for the indoor set top aerial vary compared with the external TV aerial results of Table 9. This is because the main coupling mechanism is via the aerial for the indoor scenario and via the cable for the external aerial.

5.2.2 iDTV receiver with a silicon tuner ST1

Table 12 below shows the received LTE UE signal level on the cable connected to a TV with a silicon tuner receiver under test for a DVB-T wanted signal of -70 dBm and an interference EIRP of 23 dBm.

Table 12:
Measured interference level on a cable connected to iDTV silicon tuner ST1, 2.5 m away from a LTE source with an EIRP of 23 dBm and a DVB-T wanted signal of -70 dBm

Freq (MHz)	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-17.12	Yes	-17.19	Yes	-7.27	Yes	-7.82	Yes
834	-18.04	Yes	-19.15	Yes	-8.52	Yes	-7.78	Yes
839	-17.12	Yes	-20.53	Yes	-6.92	Yes	-7.65	Yes
844	-15.52	Yes	-19.54	Yes	-6.06	Yes	-8.99	Yes
849	-17.13	Yes	-17.93	Yes	-9.08	Yes	-10.63	Yes
	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-42.77	No	-43.74	No	-31.87	No	-32.83	No
834	-40.46	No	-45.66	No	-28.11	No	-30.11	No
839	-44.27	No	-45.44	No	-29.74	No	-33.95	No
844	-41.86	No	-45.06	No	-31.71	No	-34.44	No
849	-41.37	No	-44.84	No	-33.18	No	-33.59	No
	Attenuation on LTE signal required to stop interference to iDTV silicon tuner ST2 without filter without filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Att (dB)	I (dBm)	Att (dB)	I (dBm)	Att (dB)	I (dBm)	Att (dB)
829	-21.01	4	-19.52	3	-12.05	5	-13.93	6
834	-20.52	3	-18.34	2	-12.67	4	-14.07	6
839	-22.06	4	-18.97	1	-11.87	5	-12.54	5
844	-21.24	6	-20.44	1	-10.69	4	-11.15	2
849	-20.52	3	-19.68	2	-13.34	4	-12.42	2

From the table above it can be seen that interference was observed on the TV with the silicon tuner for all five uplink frequencies. The results show that when the filter was included the level of interference dropped by 23 to 25 dB and no interference was observed with and without the aerial distribution amplifier.

The measurements also show that the EIRP of the LTE UE signal transmitting between 829 and 849 MHz had to drop by 3 to 6 dB in order for it not to interfere with the TV with the silicon tuner. Thus, requiring the LTE UE to transmit at an EIRP between 17 to 20 dBm / 10 MHz, for it not to cause interference to the TV with the silicon tuner.

5.2.3 iDTV receiver with a silicon tuner ST2

Table 13 below shows the received LTE UE signal level on the cable connected to a TV with a silicon tuner receiver under test for a DVB-T wanted signal of -70 dBm and an interference EIRP of 23 dBm.

Table 13:
Measured interference level on a cable connected to iDTV silicon tuner ST2. 2.5 m away from a LTE source with an EIRP of 23 dBm and a DVB-T wanted signal of -70 dBm

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-24.31	No	-18.09	No	-16.98	No	-12.96	No
834	-21.8	No	-21.48	No	-13.47	No	-15.66	No
839	-20.49	No	-21.93	No	-12.86	No	-16.52	No
844	-19.58	No	-22.81	No	-10.83	No	-17.39	No
849	-20.21	No	-24.22	No	-11.23	No	-18.36	No

From the table above it can be seen that no interference was observed on the TV with the silicon tuner for all five uplink frequencies with and without the aerial distribution amplifier.

In order to measure the LTE signal level to cause interference at frequencies where the iDTV did not show any problems with an EIRP of 23 dBm at 2.5 m separation distance, the LTE UE source was moved closer towards the front end of the indoor TV aerial until a problem did occur (see table below).

Table 14:
Measured signal level on a cable connected to iDTV silicon tuner ST2 receiver from a close in LTE UE source

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)
829	-6.66	26	-9.51	68	-5.36	42	-4.91	83
834	-6.93	40	-8.92	65	-4.71	37	-5.12	52
839	-7.01	25	-9.17	45	-4.74	42	-4.58	73
844	-5.79	28	-7.69	49	-3.68	62	-2.43	59
849	-5.89	18	-6.04	20	-4.27	47	-4.08	94

The results in Table 14 show that an LTE UE signal with a power level of -6 to -7 dBm/10 MHz on average was required to cause degradation in the picture quality of the iDTV without an aerial distribution amplifier and between -4 to -5 dBm/10 MHz with an aerial distribution amplifier. These power levels equate to a maximum distance 68 cm without an aerial distribution amplifier and 94 cm with an aerial distribution amplifier.

5.2.4 PVR receiver

Table 15 below shows the received LTE UE signal level on the cable connected to a PVR with a super-heterodyne receiver for a DVB-T wanted signal of -70 dBm and an interference EIRP of 23 dBm.

Table 15:
Measured interference level on a cable connected to a PVR receiver 2.5 m away from a LTE source with an EIRP of 23 dBm and a DVB-T wanted signal of – 70 dBm

Freq (MHz)	PVR without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-18.34	No	-21.06	No	-11.24	No	-11.34	No
834	-17.85	No	-19.21	No	-10.35	No	-10.51	No
839	-17.07	No	-18.96	No	-10.43	No	-10.14	No
844	-17.79	No	-20.25	No	-11.07	No	-9.11	No
849	-16.15	No	-20.73	No	-9.46	No	-9.82	No

From the table above it can be seen that no interference was observed on the TV connected to the PVR via a scart lead for all five uplink frequencies.

In order to measure the LTE signal level to cause interference at frequencies where the iDTV did not show any problems with an EIRP of 23 dBm at 2.5 m separation distance, the LTE UE source was moved closer towards the front end of the indoor TV aerial until a problem did occur.

Table 16:
Measured signal level on a cable connected a PVR receiver from a close in LTE UE source with an EIRP of 23 dBm and a DVB-T wanted signal of -70 dBm

Freq (MHz)	PVR measurement without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)
829	3.62	2	1.31	4	1.31	34	2.09	17
834	3.57	4	2.05	4	1.37	20	3.06	20
839	4.71	2	1.95	8	1.97	19	2.43	16
844	4.09	5	2.48	5	1.14	45	1.76	33
849	1.58	6	0.45	8	1.98	54	2.76	45

The results in Table 16 show that an LTE UE signal with a power level from 0 to 5 dBm/ 10 MHz was required to cause degradation in the picture quality of the iDTV without an aerial distribution amplifier and from 1 to 3 dBm/10 MHz with an aerial distribution amplifier. These power levels equate to a maximum distance of 8 cm without an aerial distribution amplifier and 54 cm with an aerial distribution amplifier for a frequency 1 MHz below the N+9 image.

5.2.5 STB receiver

Table 17 below shows the received LTE UE signal level on the cable connected to a STB with a super-heterodyne receiver for a DVB-T wanted signal of -70 dBm and an interference EIRP of 23 dBm.

**Table 17:
Measured interference level on cable connected to a STB receiver 2.5 m away from a LTE source with an EIRP of 23 dBm and a DVB-T wanted signal of -70 dBm**

<table>
<tr><th rowspan="4">Freq (MHz)</th><th colspan="8">STB without filter</th></tr>
<tr><th colspan="4">Without aerial distribution amplifier</th><th colspan="4">With 10 dB gain aerial distribution amplifier</th></tr>
<tr><td colspan="2">Co-polar</td><td colspan="2">Cross-polar</td><td colspan="2">Co-polar</td><td colspan="2">Cross-polar</td></tr>
<tr><td>I (dBm)</td><td>Interference</td><td>I (dBm)</td><td>Interference</td><td>I (dBm)</td><td>Interference</td><td>I (dBm)</td><td>Interference</td></tr>
<tr><td>829</td><td>-19.45</td><td>No</td><td>-20.39</td><td>No</td><td>-8.41</td><td>No</td><td>-8.14</td><td>No</td></tr>
<tr><td>834</td><td>-18.78</td><td>No</td><td>-19.62</td><td>No</td><td>-6.07</td><td>No</td><td>-7.98</td><td>No</td></tr>
<tr><td>839</td><td>-16.35</td><td>No</td><td>-18.24</td><td>No</td><td>-6.55</td><td>No</td><td>-8.61</td><td>No</td></tr>
<tr><td>844</td><td>-17.14</td><td>No</td><td>-17.49</td><td>No</td><td>-8.34</td><td>No</td><td>-9.12</td><td>No</td></tr>
<tr><td>849</td><td>-16.04</td><td>Yes</td><td>-17.41</td><td>Yes</td><td>-8.03</td><td>Yes</td><td>-9.22</td><td>Yes</td></tr>
<tr><td></td><th colspan="8">STB with filter</th></tr>
<tr><td></td><th colspan="4">Without aerial distribution amplifier</th><th colspan="4">With 10 dB gain aerial distribution amplifier</th></tr>
<tr><td></td><td colspan="2">Co-polar</td><td colspan="2">Cross-polar</td><td colspan="2">Co-polar</td><td colspan="2">Cross-polar</td></tr>
<tr><td></td><td>I (dBm)</td><td>Interference</td><td>I (dBm)</td><td>Interference</td><td>I (dBm)</td><td>Interference</td><td>I (dBm)</td><td>Interference</td></tr>
<tr><td>849</td><td>-41.21</td><td>No</td><td>-43.91</td><td>No</td><td>-35.58</td><td>No</td><td>-35.63</td><td>No</td></tr>
<tr><td></td><td colspan="8">Attenuation on LTE signal required to stop interference to STB without filter</td></tr>
<tr><td></td><th colspan="4">Without aerial distribution amplifier</th><th colspan="4">With 10 dB gain aerial distribution amplifier</th></tr>
<tr><td></td><td colspan="2">Co-polar</td><td colspan="2">Cross-polar</td><td colspan="2">Co-polar</td><td colspan="2">Cross-polar</td></tr>
<tr><td></td><td>I (dBm)</td><td>Atten (dB)</td><td>I (dBm)</td><td>Atten (dB)</td><td>I (dBm)</td><td>Atten (dB)</td><td>I (dBm)</td><td>Atten (dB)</td></tr>
<tr><td>849</td><td>-18.13</td><td>2</td><td>-19.61</td><td>2</td><td>-10.81</td><td>2</td><td>-11.35</td><td>2</td></tr>
</table>

From the table above it can be seen that interference was observed on the TV connected to the PVR via a scart lead for an uplink transmit frequency of 849 MHz, 71 MHz away from the wanted centre frequency of 778 MHz, i.e. on the N+9 image of the receiver for a 10 MHz wide signal.

The results show that when the filter was included the level of interference dropped by 23 to 27 dB and no interference was observed with and without the aerial distribution amplifier.

The measurements also show that the EIRP of the LTE UE signal transmitting at 849 MHz had to drop by 2 dB in order for it not to interfere with the STB. Thus, requiring the LTE UE to transmit at 21 dBm/10 MHz for it not to cause interference to the STB.

At 849 MHz, the horizontally polarised LTE signal interfered with the STB at a recorded level of -18.13 dBm. This compares very well with a conductively measured C/I ratio of -52 dB [8] at the N+9 image, i.e. -18 dBm of interference for a wanted signal of -70 dBm.

In order to measure the LTE signal level to cause interference at frequencies where the STB did not show any problems with an EIRP of 23 dBm at 2.5 m separation distance, the LTE UE source was moved closer towards the front end of the indoor TV aerial until a problem did occur.

Table 18:
Measured signal level on a cable connected a STB receiver from a close in LTE UE source with an EIRP of 23 dBm and a DVB-T wanted signal of -70 dBm

Freq (MHz)	STB measurement without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)
829	-3.06	29	-5.34	15	2.23	34	-4.33	45
834	-1.09	16	-3.05	10	1.93	36	-1.76	50
839	-2.38	14	-2.05	10	3.28	37	-1.52	46
844	-1.87	29	-1.56	17	2.25	35	-0.64	49

The results in Table 18 show that an LTE UE signal with a power level of -3 to -1 dBm/ 10 MHz on average was required to cause degradation in the picture quality of the STB without an aerial distribution amplifier and between -4 to -1 dBm/10 MHz with an aerial distribution amplifier. These power levels equate to a maximum distance between 29 cm without an aerial distribution amplifier and 50 cm with an aerial distribution amplifier for a frequency 1 MHz below the N+9 image.

5.2.6 STB via the RF output of a PVR receiver

Table 19 below shows the received LTE UE signal level on the cable connected to a STB receiver under test connected via the RF output of a PVR for a DVB-T wanted signal of -70 dBm and an interference EIRP of 23 dBm.

Table 19: Measured interference level on a cable connected to a STB after the PVR 2.5 m away from a LTE source with an EIRP of 23 dBm and a DVB-T wanted signal of -70 dBm

Freq (MHz)	STB without filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-16.32	No	-18.21	No	-10.85	No	-11.77	No
834	-16.62	No	-18.36	No	-10.87	No	-10.04	No
839	-17.27	No	-19.48	No	-10.42	No	-9.38	No
844	-17.19	No	-19.95	No	-10.91	No	-9.65	No
849	-17.61	No	-19.91	No	-9.49	Yes	-8.65	Yes
					STB with filter			
					With 10 dB gain aerial distribution amplifier			
					Co-polar		Cross-polar	
					I (dBm)	Interference	I (dBm)	Interference
849					-32.95	No	-36.13	No
					Attenuation on LTE signal to stop interference to STB without filter			
					With 10 dB gain aerial distribution amplifier			
					Co-polar		Cross-polar	
					I (dBm)	Atten (dB)	I (dBm)	Atten (dB)
849					-12.03	4	-10.39	3

From the table above it can be seen that interference was again observed on the STB for the N+9 image frequency offset. The STB was connected to the RF output port of the PVR, with indoor TV aerial connected to RF input port of the PVR via an aerial distribution amplifier.

The results show that when the filter was included the level of interference dropped by 23 to 27 dB and no interference was observed with and without the aerial distribution amplifier.

The measurements also show that the EIRP of the LTE UE signal transmitting at 849 MHz had to drop by 3 to 4 dB in order for it not to interfere with the STB. Thus, requiring the LTE source to transmit between 19 to 20 dBm/10 MHz, for it not to cause interference to the STB via the RF port of the PVR.

At 849 MHz, the vertically polarised LTE signal interfered with the set-up at a recorded level of -8.65 dBm. This compares very well with a conductively measured C/I ratio of -49 dB [8] at the N+9 image, i.e. -8 dBm of interference for a wanted signal of -60 dBm.

In order to measure the LTE signal level to cause interference at frequencies where the iDTV did not show any problems with an EIRP of 23 dBm at 2.5 m separation distance, the LTE UE source was moved closer towards the front end of the indoor TV aerial until a problem did occur.

Table 20: Measured signal level on a cable connected a STB receiver via the RF port of a PVR from a close in LTE UE source with an EIRP of 23 dBm and a DVB-T signal of -70 dBm

Freq (MHz)	STB measurement without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)
829	3.02	5	4.74	3	3.78	10	4.08	7
834	3.22	5	4.31	3	2.75	36	1.83	38
839	2.08	5	3.45	2	2.61	40	2.11	25
844	-4.71	30	-5.11	68	-3.33	73	0.08	95
849	-12.35	48	-12.51	92	N/A	N/A	N/A	N/A

The results in Table 20 show that an LTE UE signal around the N+9 image with a power level of -12 to -5 dBm/10 MHz on average was required to cause degradation in the picture quality of the STB without an aerial distribution amplifier and between -3 to -0 dBm/10 MHz with an aerial distribution amplifier. These power levels equate to a maximum distance of 92cm without an aerial distribution amplifier and 95cm with an aerial distribution amplifier.

5.3 Outdoor Radiated Measurements

Outdoor measurements were performed to simulate the real interference environment from an LTE UE. The on-air testing was performed on the five digital receivers used in the conducted measurements. The radiated tests were carried out onsite at Cobham Technical Services. The outdoor test environment was created by having a 9.5 m high TV aerial receiving a transmitted digital signal and feeding into the DVB-T receiver (see Figure 24).

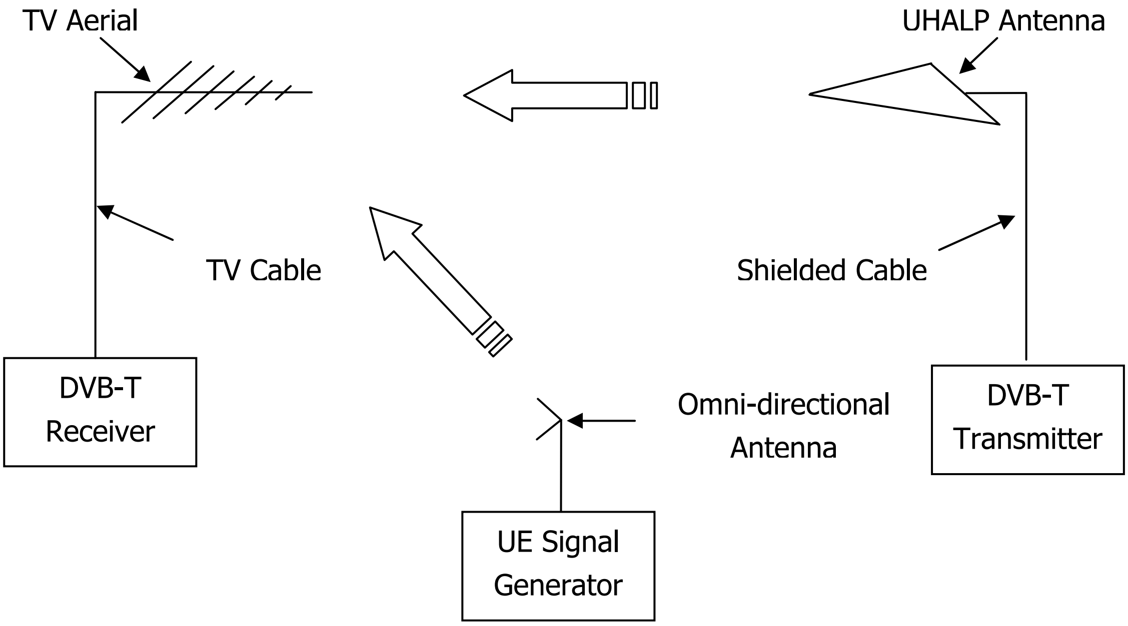

Figure 24: Diagram of radiated measurement set-up

The receiving TV aerial was mounted on the Land Rover. The loss of the 75 Ω domestic quality TV cable used to connect the TV aerial was measured as 5 dB and the aerial gain was measured as 12 dBi. Measurements were performed for wanted receive powers of -70 dBm for both co-polar and cross-polar orientations with and without the aerial distribution amplifier.

The DVB-T transmitter was located 10 m above the ground. The local digital signal was transmitted on UHF channel 59 (778 MHz) using a Schwarzbeck UHALP 9107 antennal (See Figure 25).

The separation distance between the wanted transmitter and receiver aerial was measured as 90 m.

Figure 25: Picture of DVB-T transmitter aerial

The static LTE UE signal with full resource block allocation was generated using an Agilent E4438C signal generator controlled via a Laptop. The signal generator along with the amplifier, filter and attenuator used to generate the LTE UE signal was placed on a portable trolley.

Measurements were made for a fixed horizontal offset distance of 30 m in the direction of the TV aerial. This distance was chosen as it produced the largest unwanted signal level at the receiver end, when measured on the spectrum analyser connected via a coupler at the input to the DVB-T receiver under test.

The LTE UE signal was transmitted using an omni-directional antenna located on a tripod 1.5 m above the ground for both co-polar and cross-polar interference scenarios. The radiated measurements were made at a minimum transmit power of 23 dBm and a maximum of 28 dBm for five frequencies at 829, 834, 839, 844, and 849 MHz in order to try and cause interference to the digital receivers.

The unwanted signal levels received at the inputs of the devices under test were measured using a spectrum analyser with the same settings as the previous conducted and radiated measurements and corrected for the additional 75 to 50 Ω matching pad.

Only the iDTV with the super-heterodyne tuner was interfered by the LTE UE uplink signal at a frequency of 849 MHz, 1 MHz below the N+9 image. An EIRP of 25 dBm was required to degrade the picture quality as shown in Figure 4 without the amplifier and 26 dBm with the amplifier. The measured unwanted signal levels entering the RF port of the iDTV were measured as -27.4 dBm and -16.8 dBm in a 10 MHz bandwidth without and with an aerial distribution amplifier respectively. The gain of the aerial distribution amplifier was measured as 10 dB.

Basic free space loss calculations show that the received level for an LTE unwanted signal radiating with an EIRP of 25 dBm, 30 m away for transmit and receive heights of 9.5 and 1.5 m respectively, would be -28.6 dBm for a measured aerial gain of 12 dB and cable loss of 5 dB. This result compares well with the measured value of -27.4 dBm, assuming that the unwanted signal is entering the main beam of the aerial.

Alternatively, the maximum power the iDTV can receive on its image before the onset of interference for a wanted signal of -70 dBm is -28 dBm for a measured C/I protection ratio of -42 dB (see Section 4.1).

No interference was observed for the rest of the digital TV receivers tested even at an EIRP of 28 dBm with and without an aerial distribution amplifier. Thus, it can be concluded that the most likely source of potential interference from a LTE UE uplink signal will be around the N+9 image for a super-heterodyne tuner.

If the LTE uplink signal radiates with an EIRP of 23 dBm the digital receiver has to have a C/I protection ratio less than -40 dB for it not to cause interference, when entering the main beam of a typical outdoor aerial installation. This may prove a problem for some receivers as current D Book requirements state a minimum protection ratio of -30 dB at N+9.

Whilst performing the outdoor radiated measurements, the difference in cable pickup was measured between a normal TV coaxial cable and high quality CT100 cable for a length of 10 m. The measurements were performed by terminating one of the cables ends with a 75Ω matching pad and measuring the difference in CW signal level on the spectrum analyser using a peak detector. The LTE source was positioned 30 m away from the cable and all the results were performed for a co-polar aerial orientation w.r.t the vertical cable. The results reveal a reduction of 21 to 24 dB for the CT100 cable when compared with the normal TV coaxial cable at frequencies of 786, 829 and 849 MHz.

5.4 Sky Digital Box

Laboratory measurements on the impairment of the analogue modulated output of the Sky digital box using two different cable types (normal coaxial and CT100) connecting the TV display were carried out using the test procedure described in Section 3.5.2. The carrier of the modulated analogue output of the receiver was measured to be -45 dBm.

Table 21: LTE uplink interference EIRP vs. impairment of the analogue modulated output of a Sky digital box

Channel	Impairment Scale	Normal coaxial cable		CT 100 cable	
		EIRP (dBm)		EIRP (dBm)	
		Co-polar	Cross-polar	Co-polar	Cross-polar
N-2	5	20	23	Not enough power to cause any impairment	Not enough power to cause any impairment
	4	Not enough power to cause any impairment	Not enough power to cause any impairment		
	3				
	2				
	1				
N-1	5	3	7	Not enough power to cause any impairment	Not enough power to cause any impairment
	4	7	11		
	3	12	18		
	2	18	23		
	1	21	23		
N	5	-56	-56	7	7
	4	-40	-37	12	11
	3	-25	-22	16	15
	2	-11	-9	23	21
	1	-6	3	23	23
N+1	5	3	4	Not enough power to cause any impairment	Not enough power to cause any impairment
	4	8	11		
	3	13	15		
	2	21	23		
	1	23	23		
N-2	5	23	23	Not enough power to cause any impairment	Not enough power to cause any impairment
	4	Not enough power to cause any impairment	Not enough power to cause any impairment		
	3				
	2				
	1				

Table 21 above shows the level of transmit power that the LTE uplink unwanted signal requires to cause impairment to the picture quality of the analogue modulated signal of the Sky digital box, for co-channel, first and second adjacent TV channel interference.

The co-channel results show that for a grade 3 impairment of slightly annoying, the induced interference on the normal coaxial cable is 37 to 41 dB worse compared with the CT100 cable, which required an EIRP of 15-16 dBm.

The results for the first and second channel interference show that no impairment to the picture quality was observed when using the CT100 cable connecting the TV and Sky digital box. However, the normal coaxial cable showed an improvement of 37 to 40 dB on the first adjacent channel compared with the co-channel results. Only a grade 5 impairment of imperceptible was observed on the coaxial cable for second adjacent channel interference.

6. Summary and Conclusions

As part of the Digital Dividend Review, Ofcom commissioned Cobham Technical Services – ERA Technology to carry out a measurement study in the form of conducted and radiated measurements to assess the impact of LTE on DVB-T receiver systems.

The study, whilst not comprehensive, shows indicative trends with the five digital receivers and gives solutions to overcome problems highlighted in the report.

Conducted Measurements

The conducted sets of measurements were performed on a bench in the laboratory on five different types of digital TV receivers which were; one iDTV; two iDTVs with silicon tuners; a PVR and a STB. The LTE BS interference measurements were carried out for wanted signal levels of -70, -50, -30, -20, -12 dBm with and without a low-pass UHF filter.

The conducted LTE BS measurements results showed that for a wanted power of -70 dBm, the average protection ratio required for all five digital TV receivers was -40 dB for a frequency offset of 10 MHz between centre carrier frequencies. This frequency offset corresponds to the centre frequency of a 10 MHz FDD base station carrier when operating in accordance with the FDD band plan developed by CEPT group PT1.

The performance of the iDTVs with silicon tuners were on a par if not better when compared with the digital receivers using a super-heterodyne architecture for frequency offsets 8 to 10 MHz between the wanted and unwanted centre carriers. This performance can be attributed to the tracking filter used in the silicon tuner receiver.

The performance of all 5 receivers is very similar at frequency offsets of up to 20 – 25 MHz. At higher offsets the iDTVs with silicon tuners became approximately flat with increasing frequency whereas the 3 super-heterodyne based receivers continued to display improved C/I performance until the N+9 image channel centred at 72 MHz.

The iDTV, PVR and STB which are based on a super-heterodyne architecture all displayed the classic N+9 image problem for a wanted power of -70 dBm, with the iDTV requiring the greatest protection of -42 dB from LTE BS interference. The iDTVs with a silicon tuner required a protection ratio of between -56 to -53 dB for a similar frequency offset.

The iDTVs with the silicon tuners also produced similar C/I results at a wanted signal of -50 dBm when compared with the measurements for a wanted signal of -70 dBm.

As shown in a previous study by Cobham Technical Services [8], the front end of the digital receiver starts to become desensitised for a wanted signal above approximately -50 dBm. This desensitisation results in the interferer requiring less power to degrade the picture quality as shown in Figure 4. This desensitisation starting just above low level wanted signals is initially deliberate and essentially linear due to the action of Automatic Gain Control (AGC) and channel estimation to try to maintain constant working signal levels within the tuner as input levels change. Eventually as the wanted and/or unwanted signals get progressively stronger the desensitisation will also tend to become more non-linear as overloading is approached.

The conducted LTE BS interference measurements with a filter showed on average a 20 dB improvement in the C/I protection ratio, for a wanted power of -70 dBm and a frequency offset of 20 MHz between wanted and unwanted carrier centre frequencies. This improvement in the C/I protection ratio reduced with increased wanted signal strength to approximately 10 dB for wanted signal levels of between -30 to -12 dBm.

Measurements could not be made beyond 20 MHz frequency offsets, because high enough powers could not be transmitted without affecting the SEM of the LTE BS unwanted signal.

Radiated Measurements

The radiated set of measurements involved setting up five different domestic scenarios, these being:

1. LTE interference into a super-heterodyne iDTV.
2. LTE interference into two iDTVs with silicon tuners.
3. LTE interference into a super-heterodyne PVR connected to a TV via a scart lead.
4. LTE interference into a super-heterodyne STB connected to a TV via a scart lead.
5. LTE interference into a super-heterodyne PVR and a super-heterodyne STB connected to a TV via scart leads.

Scenarios 1 to 5 were performed with a standard outdoor Yagi aerial with and without a 10 dB gain aerial distribution amplifier. The Yagi TV aerial was set up in the horizontal plane. Two sets of measurements were made with the external aerial:

a. Indoor measurements where the degree of shielding of the interconnecting coax cabling and receivers under test would be the dominant interference mechanism from an LTE handset into DTT; and
b. Outdoor measurements where pick up of the LTE signal would be directly via the TV aerial.

These five scenarios were then repeated with an indoor set top aerial with and without an aerial distribution amplifier for both co-polar and cross-polar aerial orientations.

The wanted DVB-T receive level was set to -70 dBm at the aerial input to the DVB-T receiver. This level corresponds approximately to edge of coverage reception. When the 10 dB gain aerial distribution amplifier was added in circuit it would increase the wanted DVB-T signal to -60 dBm.

No interference was observed on all five different types of DVB-T receivers when subjected to an LTE UE signal radiating with an EIRP of 23 dBm 2.5 m away, the baseline test scenario. Therefore the unwanted source was increased to 28 dBm EIRP and brought in closer in order to achieve a degradation to picture quality on the receiver and measure the level of unwanted signal required to cause the onset of interference at 849 MHz. This frequency was chosen because the LTE signal would operate 1 MHz below the N+9 image of the iDTV, PVR and STB receivers.

Table 22: Measured signal level and distance to cause interference to a DVB-T receiver from a LTE UE source with an EIRP of 23 dBm

Receiver without filter (Wanted DVB-T = -70 dBm)	**Without aerial distribution amplifier**				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)	I (dBm)	Distance (cm)
iDTV	-26.57	140	-24.03	40	-14.33	35	-16.81	25
iDTV silicon tuner 1	-20.79	35	-18.42	10	-13.41	5	-13	5
iDTV silicon tuner 2	-18.75	25	-15.07	7	-11.82	3	-12.28	3
PVR	-12.96	8	-14.04	1	-3.86	1	-7.63	0
STB	-19.94	33	-16.81	5	-2.67	3	-6.98	0
STB via PVR	-19.81	68	-20.93	10	-12.51	6	-13.71	4

The interference distances were found to vary in accordance with the image rejection of super-heterodyne receivers with the iDTV being the worst case, since it offered the least image rejection of all the receivers evaluated as seen from the conducted C/I measurements. The reduction in interference distance with the aerial distribution amplifier indicated that pick up was after the amplifier. Although not explicitly tested it is probably from the coax fly-lead which had relatively little braid shielding.

This can be explained by the fact that the wanted signal will increase by 10 dB after the aerial distribution amplifier and since the C/I protection ratio remains essentially the same it will take more interference to cause noticeable impairment to the picture which is achieved at a shorter distance between victim and interferer. Thus, it can be concluded if any interference is observed for close up separation distance, replacing the fly-leads with better shielded cable may either cure or reduce the problem. It could also be concluded that if the wanted DVB-T was higher than -70 dBm, as it will be in most cases, the interference ranges would reduce.

For the outdoor scenario with a 9.5 m high TV aerial and the LTE UE transmitting at a height of 1.5 m into the main beam of the aerial at a separation distance of 30m (corresponding to the maximum interference reception condition) only the super-heterodyne iDTV with the poorest image rejection was interfered with. This occurred at a frequency 1 MHz below the N+9 image. An EIRP of 25 dBm was required to degrade the picture quality as shown in Figure 4 without the amplifier and 26 dBm with the amplifier.

For the indoor set top aerial tests, the results for the horizontally polarised aerial showed that for an LTE source transmitting 1 MHz below the N+9 image, the super-heterodyne receiver was the most susceptible to interference. It only required a power level of 11 dBm to cause interference for a separation distance of 2.5 m between the LTE source and the portable indoor TV aerial. In contrast the PVR required 20 dBm of power in the same condition as its image rejection was about 10 dB better than the iDTV. Similar power levels were recorded with the introduction of a 10 dB gain aerial distribution amplifier as the amplifier increased both the wanted and the interfering signal in the same ratio and the receiver C/I protection ratio remains essentially constant.

The first of the two iDTVs with a silicon tuner showed interference across 829 to 849 MHz (i.e., between 51 and 71 MHz offset from the DVB-T centre frequency) in 5 MHz steps for an EIRP greater than 17 to 20 dBm. The second of the silicon tuner iDTVs did not show any interference for a separation distance of 2.5 m, this is due to the second receiver having a 4 to 6 dB better C/I protection ratio at these frequencies compared with the first silicon tuner receiver.

All of the above interference effects disappeared with the introduction of the low pass UHF filter with and without the aerial distribution amplifier. The filter on average gave 20 to

25 dB of improvement in interference margin for the 10 MHz wide LTE UE signal operating between 829 and 849 MHz.

Laboratory measurements on the impairment of the analogue modulated output of the Sky digital box using two different cable types (normal coaxial and CT100) connecting the TV display were carried for a separation distance of 2.5 m. The co-channel results showed that for a grade 3 impairment of slightly annoying, the induced interference on the normal coaxial cable was 37 to 41 dB worse compared with the CT100 cable, which required an EIRP of 15-16 dBm.

The results for the first and second channel interference show that no impairment to the picture quality was observed when using the CT100 cable connecting the TV and Sky digital box. However, the normal coaxial cable showed an improvement of 37 to 40 dB on the first adjacent channel compared with the co-channel results. Only a grade 5 impairment of imperceptible was observed on the coaxial cable for second adjacent channel interference.

In summary, it can be concluded that interference is mainly observed on digital TV receivers with a super-heterodyne architecture when interference is present on frequencies at or close to the N+9 image. Although the majority of receivers have a good image response which is equal to or better than -40 dB, the D Book specification allows image rejection down to -30 dB. However, any interference observed at this image can be rectified by a simple low-pass filter with a stop-band attenuation of 10 to 20 dB. Hence, reducing the separation distance required for interference breakthrough to as much as a 1/10 the original distance.

The use of a digital TV receiver with a silicon tuner and a tracking filter is expected to replace the super-heterodyne and become the norm. The performance of two such receivers tested here, if they are typical, suggests that the interference distances can be lower than with super-heterodyne with average to poor image rejection. Moreover their close in performance is on a par or slightly better than super-heterodyne designs and therefore their poorer overload performance shown by these devices become the main factor for concern.

The main source of cable pick-up interference can be attributed to the simple 1 or 2 m fly-lead. Replacing the fly-lead or TV aerial coaxial cable with a better quality shielded cable can give a 21 to 24 dB improved margin. Hence, reducing the separation distance required for interference breakthrough to as much as a quarter the original distance.

The tests cannot be considered definitive, but overall it seems reasonable to conclude that interference between LTE handsets and DVB-T receivers is not likely to be a major issue. Where interference occurs it is likely to be reduced with better quality fly-leads and in some cases a filter. Where interference occurs from a LTE handset located outdoors a simple filter will cure any interference problems.

7. References

[1] ETSI EN 300 744: Digital Video Broadcasting; Framing structure, channel coding and modulation for digital terrestrial television, v1.5.1 November 2004

[2] ETSI EN 302 296: Transmitting equipment for the digital television broadcast service, terrestrial (DVB-T), v1.1.1 January 2005

[3] ETSI TS 136 104 V8.5.0 (2009-04): LTE; Evolved Universal Terrestrial Radio Access (EUTRA); Base Station (BS) radio transmission and reception (FDD) (3GPP TS 36.104 version 8.5.0 Release 8)

[4] ETSI TS 136 521-1 V8.2.1 (2009-06): LTE; Evolved Universal Terrestrial Radio Access (EUTRA); User Equipment (UE) conformance specification; Radio transmission and reception; Part 1: Conformance testing (3GPP TS 36.521 version 8.2.1 Release 8)

[5] Agilent Application Note, "3GPP Long Term Evolution: System Overview, Product Development, and Test Challenges"

[6] Harri Holma and Antti Toskala, "LTE for UMTS: OFDMA and SC-OFDMA Based Radio Access", Wiley 2009

[7] Recommendation ITU-R BT.500-11 "Methodology for the Subjective Assessment of the Quality of Television Pictures"

[8] "Characterising DVB-T Interference into iDTV and PVR", ERA Technology, September 2008

Appendix A
Conducted LTE BS Interference Results

A.1. iDTV

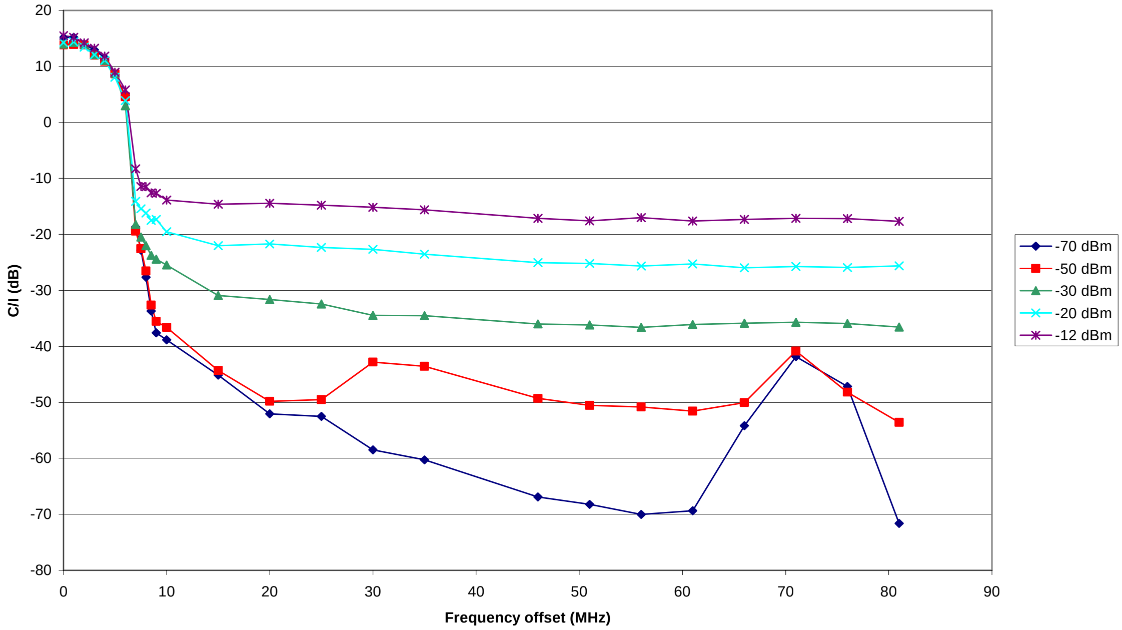

Figure 26: C/I protection ratio vs. frequency for an iDTV without using a filter

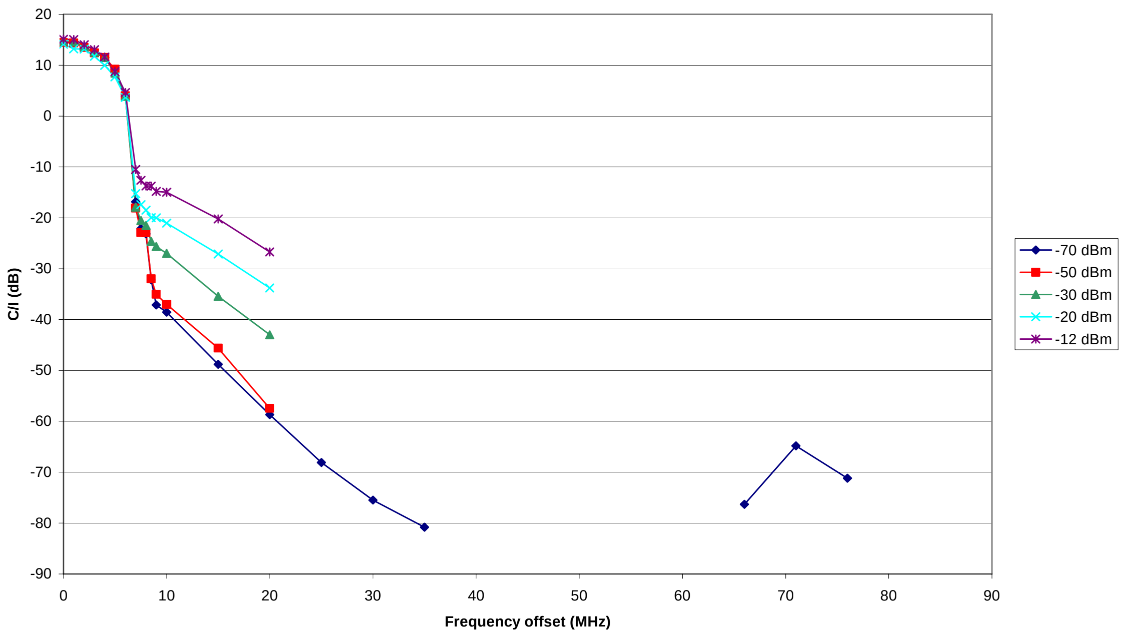

Figure 27: C/I protection ratio vs. frequency for an iDTV using a filter

A.2. iDTV with Silicon Tuner ST1

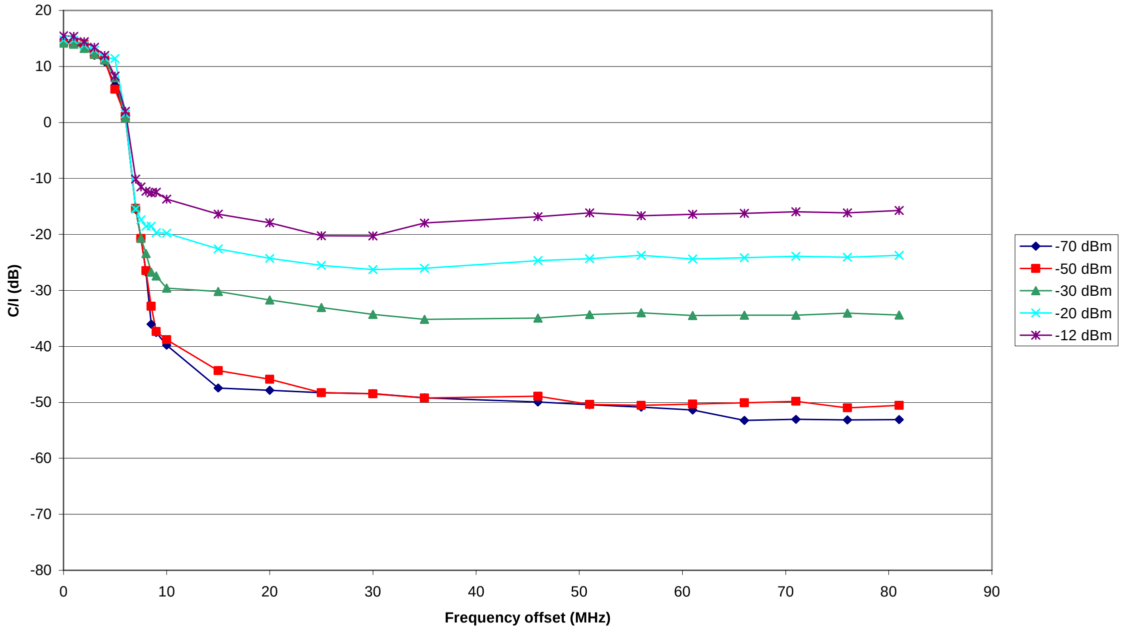

Figure 28: C/I protection ratio vs. frequency for iDTV silicon tuner ST1 without using a filter

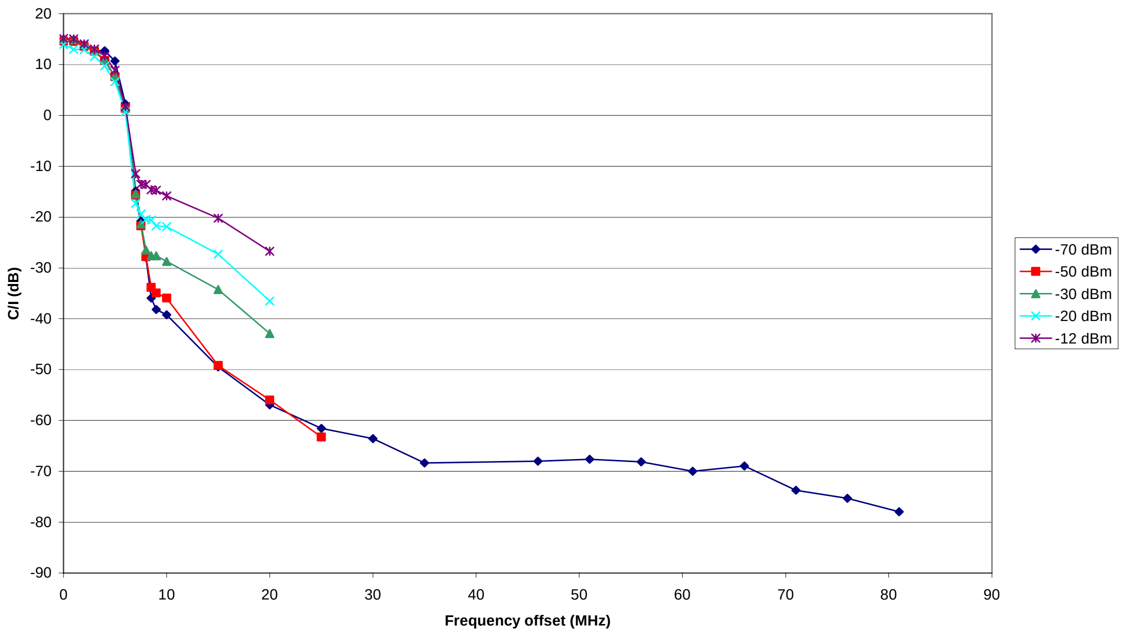

Figure 29: C/I protection ratio vs. frequency for iDTV silicon tuner ST1 using a filter

A.3. iDTV with Silicon Tuner ST2

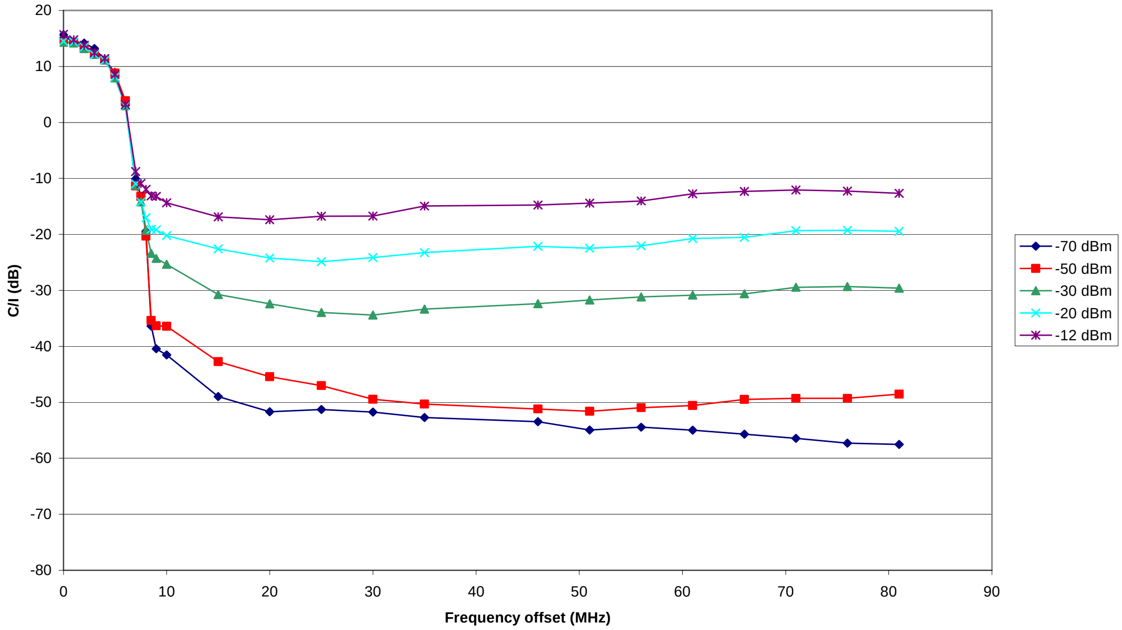

Figure 30: C/I protection ratio vs. frequency iDTV silicon tuner ST2 without using a filter

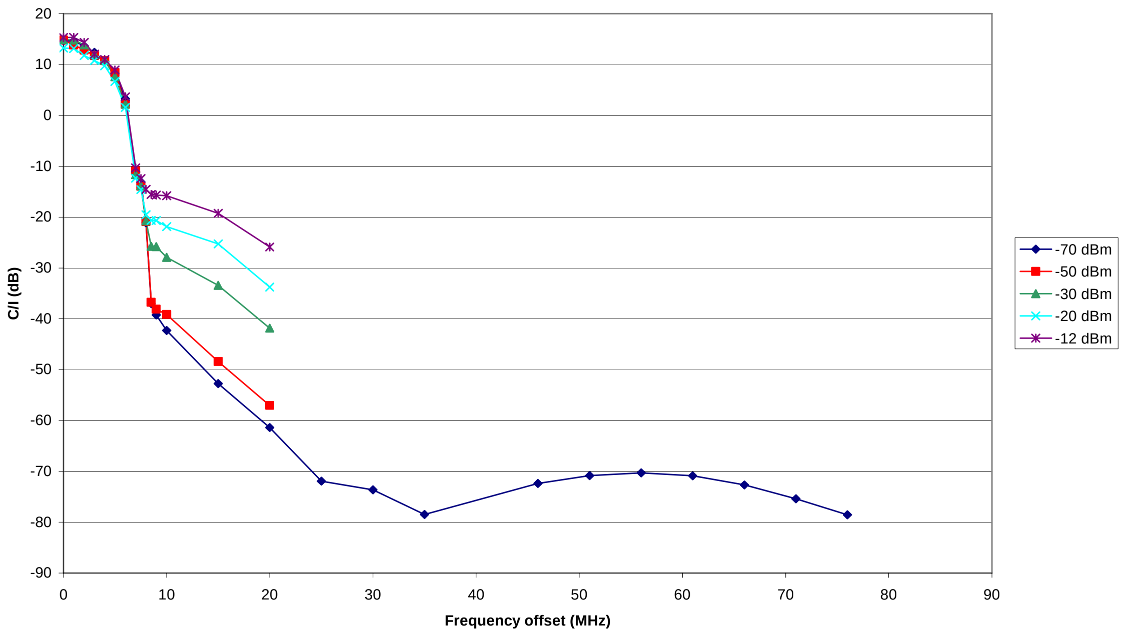

Figure 31: C/I protection ratio vs. frequency for iDTV silicon tuner ST2 using a filter

A.4. PVR

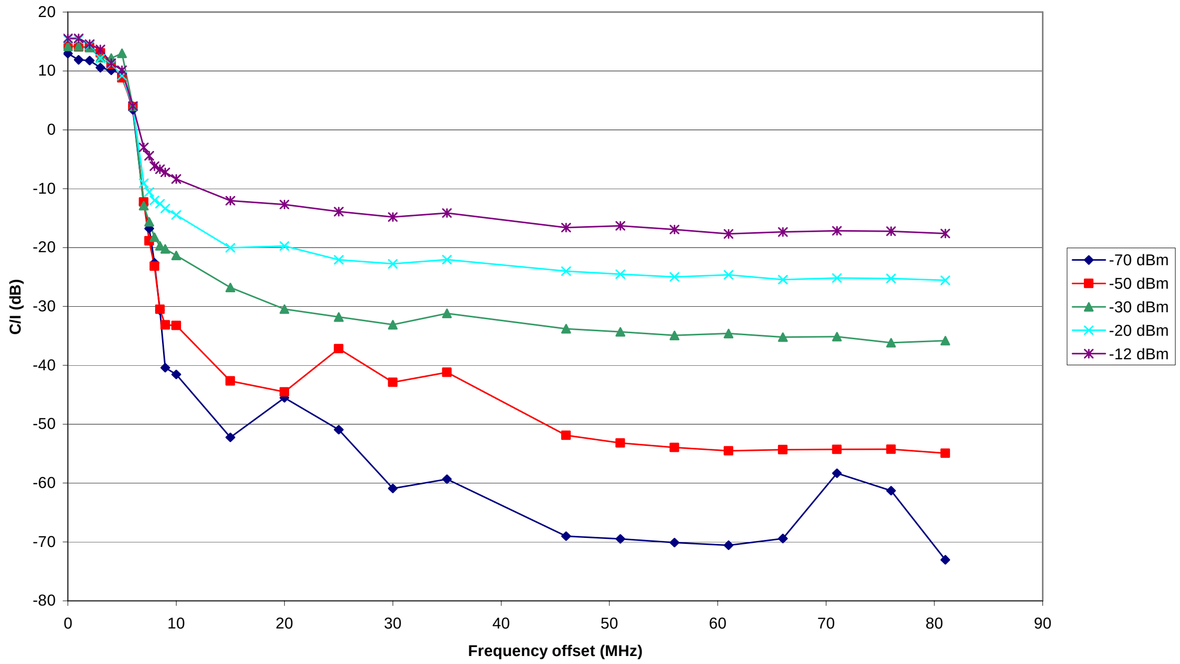

Figure 32: C/I protection ratio vs. frequency for a PVR without using a filter

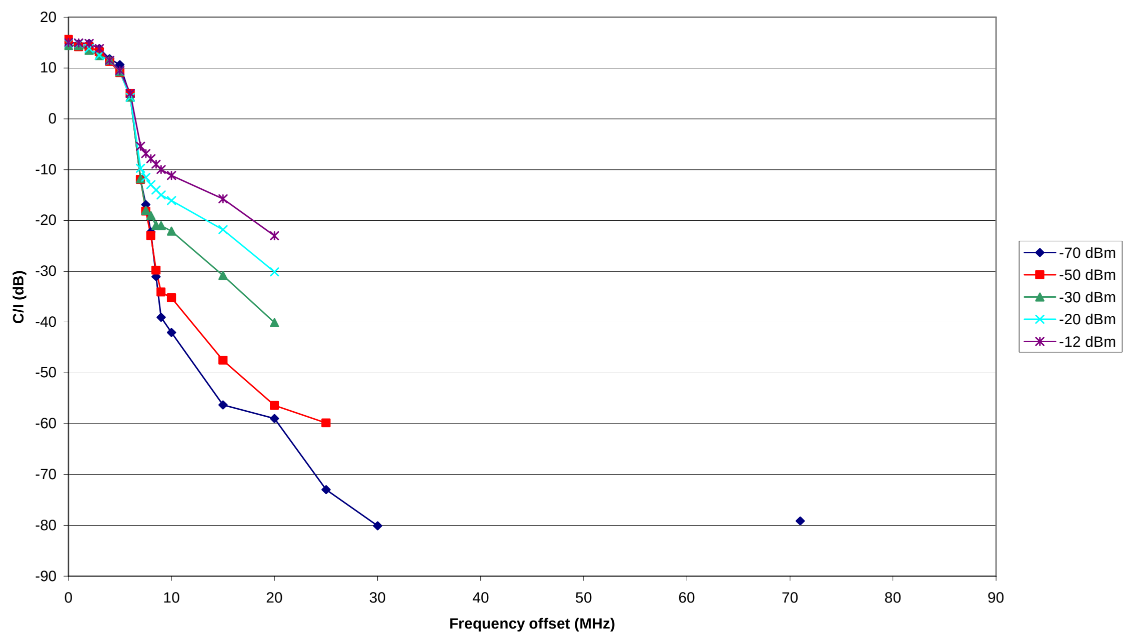

Figure 33: C/I protection ratio vs. frequency for a PVR using a filter

A.5. STB

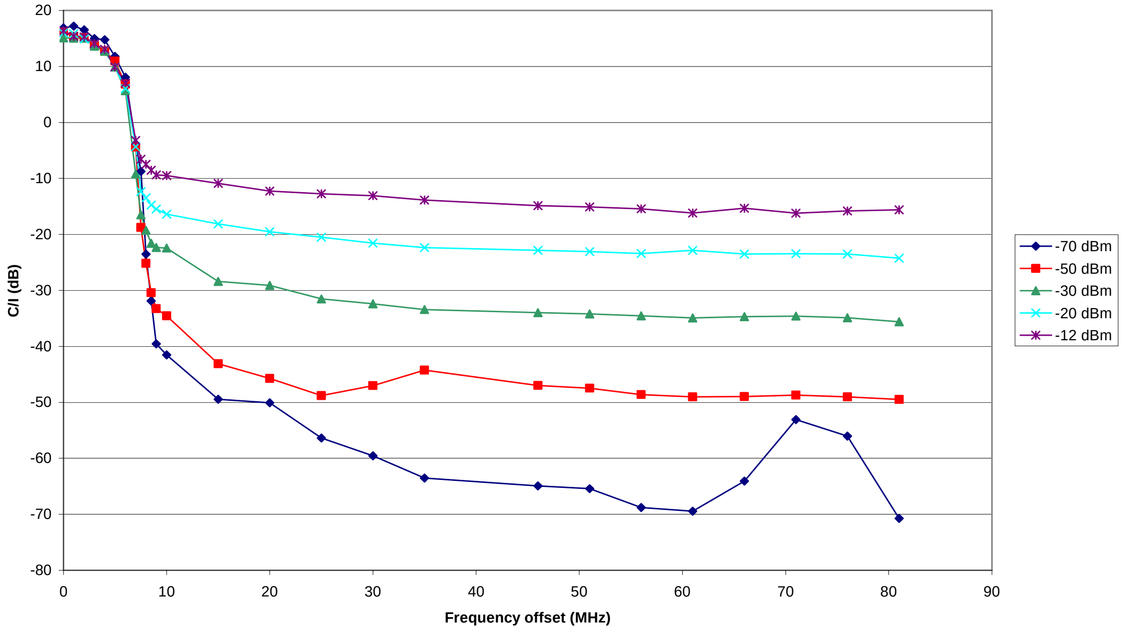

Figure 34: C/I protection ratio vs. frequency for a STB without using a filter

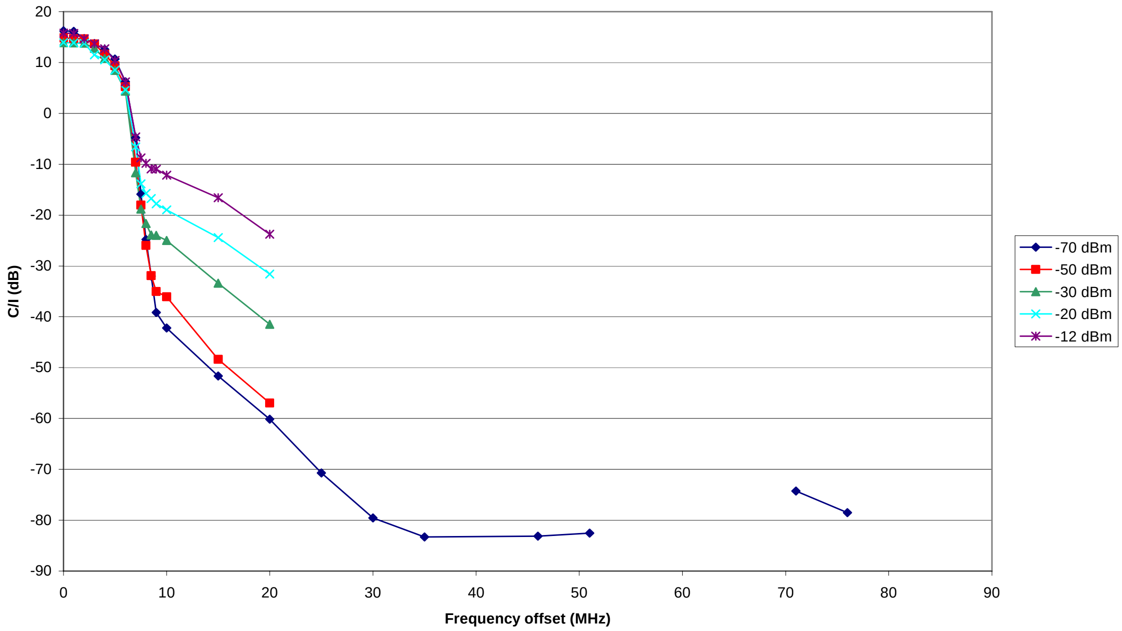

Figure 35: C/I protection ratio vs. frequency for a STB without a filter

Appendix B
Conducted LTE BS Interference Results (C vs. C/I)

B.1. iDTV

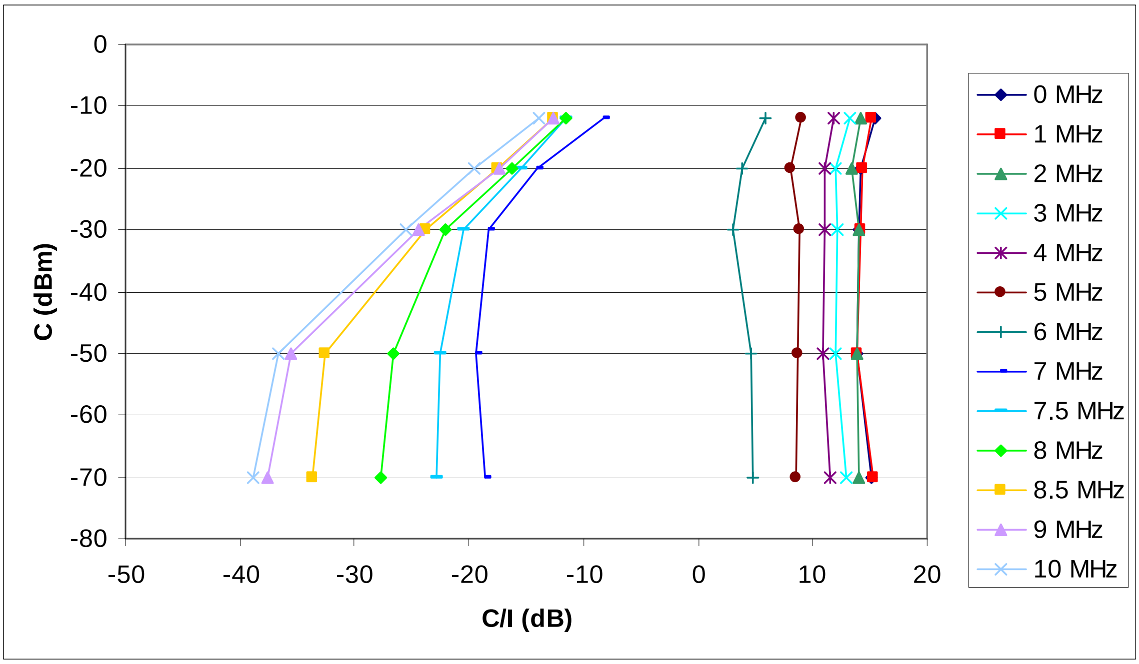

Figure 36: Carrier power vs. C/I protection ratio between 0 and 10 MHz frequency offset for an iDTV without using a filter

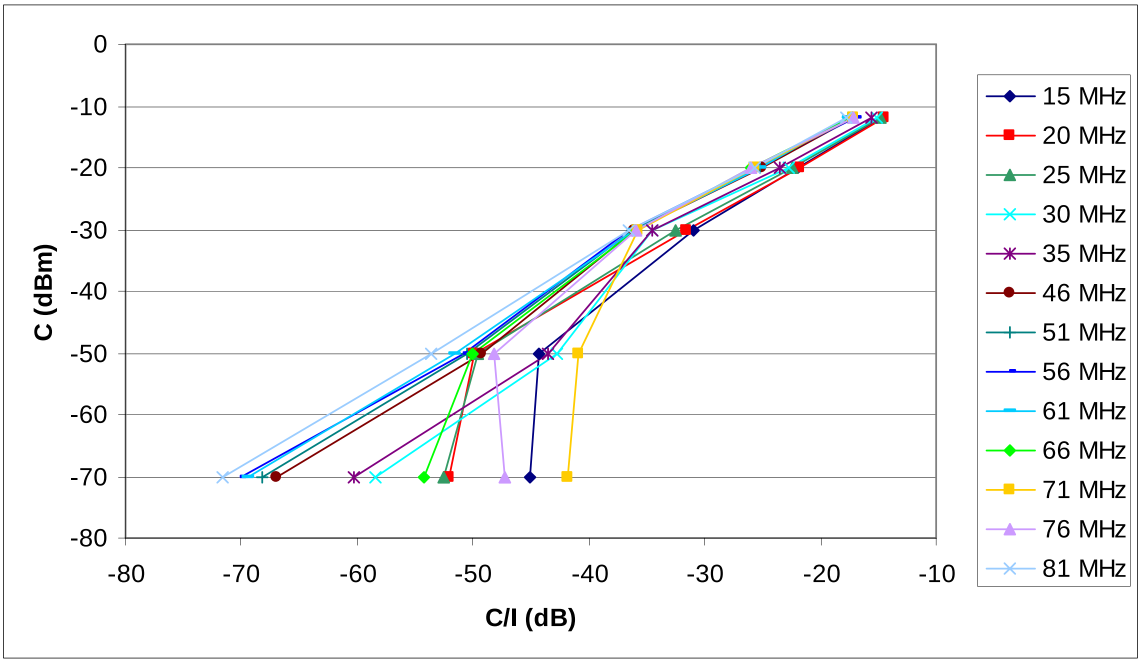

Figure 37: Carrier power vs. C/I protection ratio between 15 and 81 MHz frequency offset for an iDTV without using a filter

B.2. iDTV with Silicon Tuner ST1

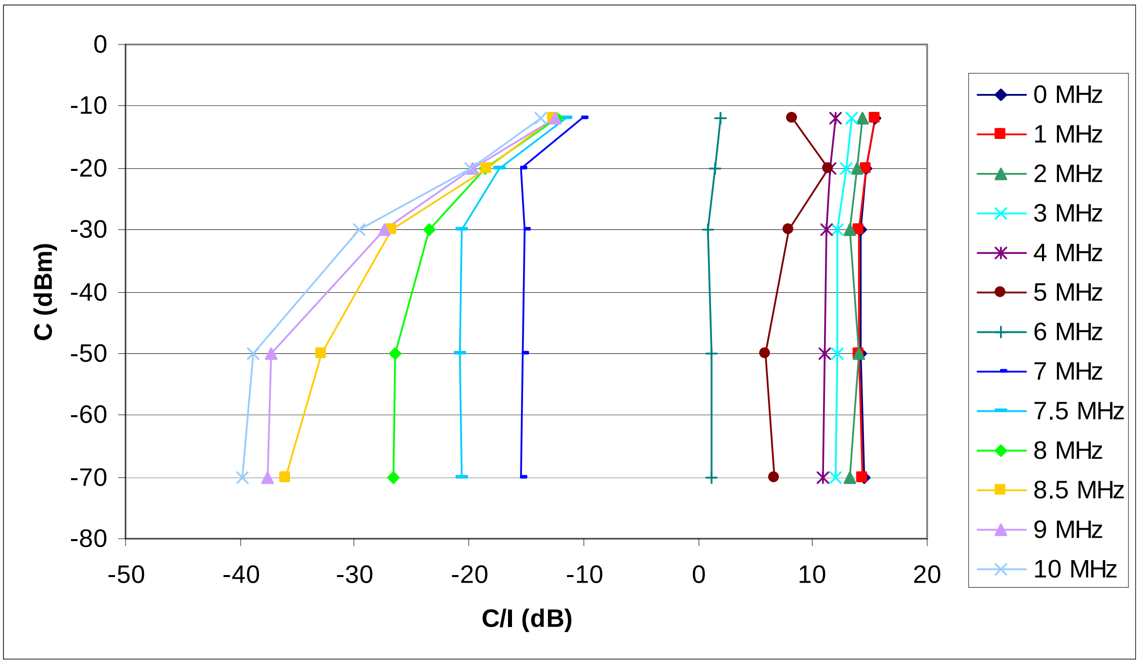

Figure 38: Carrier power vs. C/I protection ratio between 0 and 10 MHz frequency offset for iDTV silicon tuner ST1 without using a filter

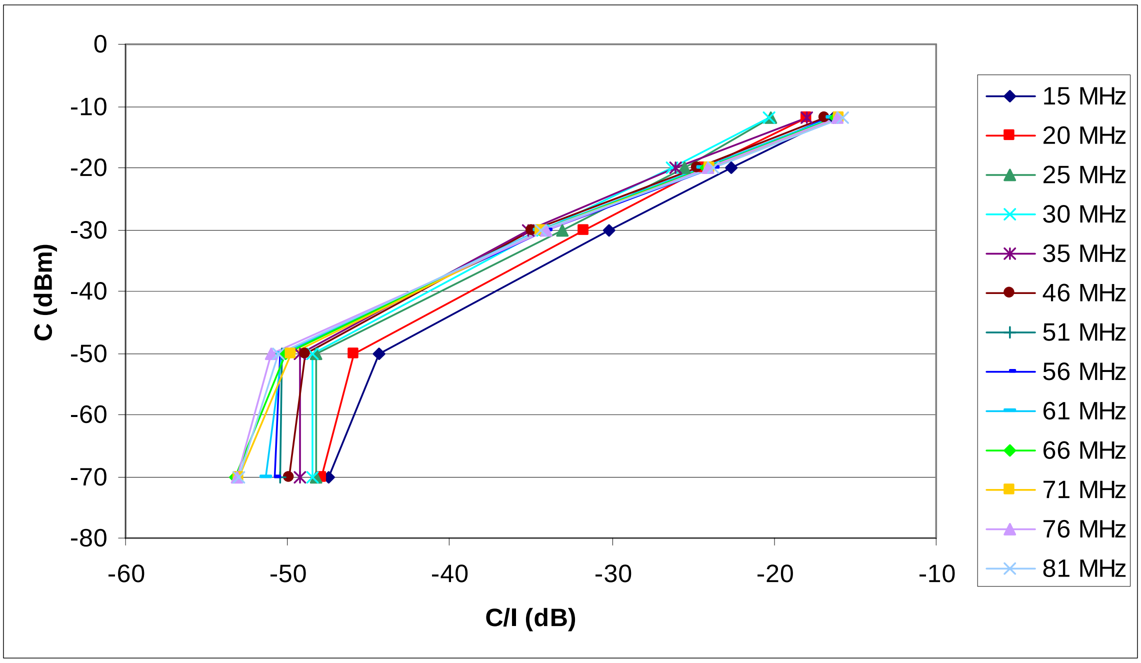

Figure 39: Carrier power vs. C/I protection ratio between 15 and 81 MHz frequency offset for iDTV silicon tuner ST1 without using a filter

B.3. iDTV with Silicon Tuner ST2

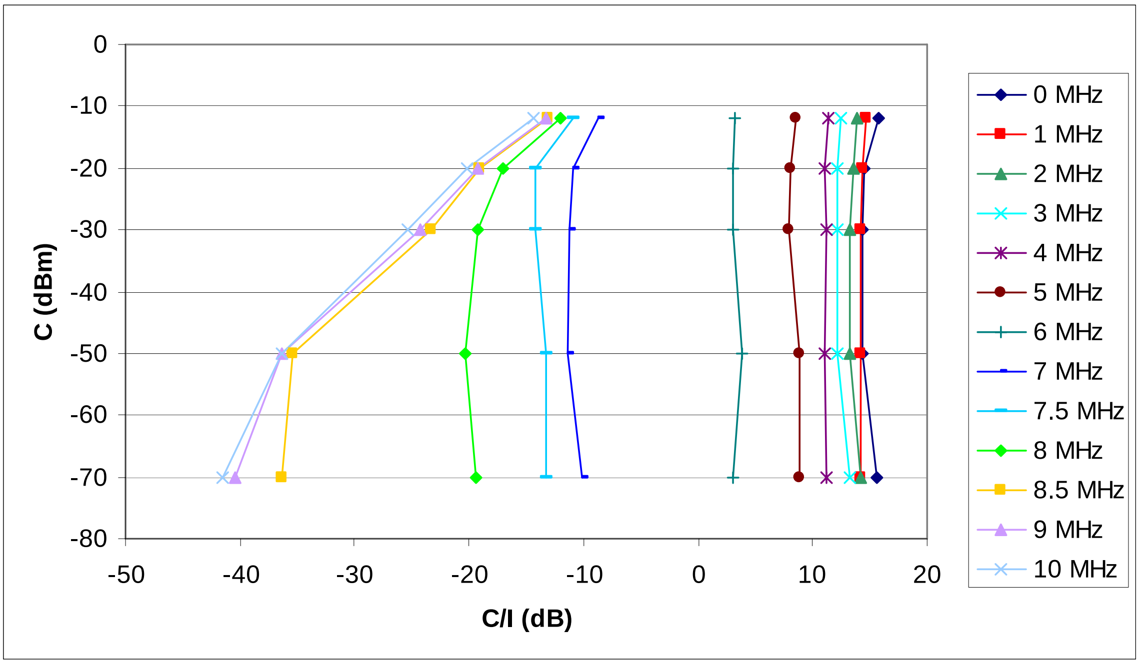

Figure 40: Carrier power vs. C/I protection ratio between 0 and 10 MHz frequency offset for iDTV silicon tuner ST2 without using a filter

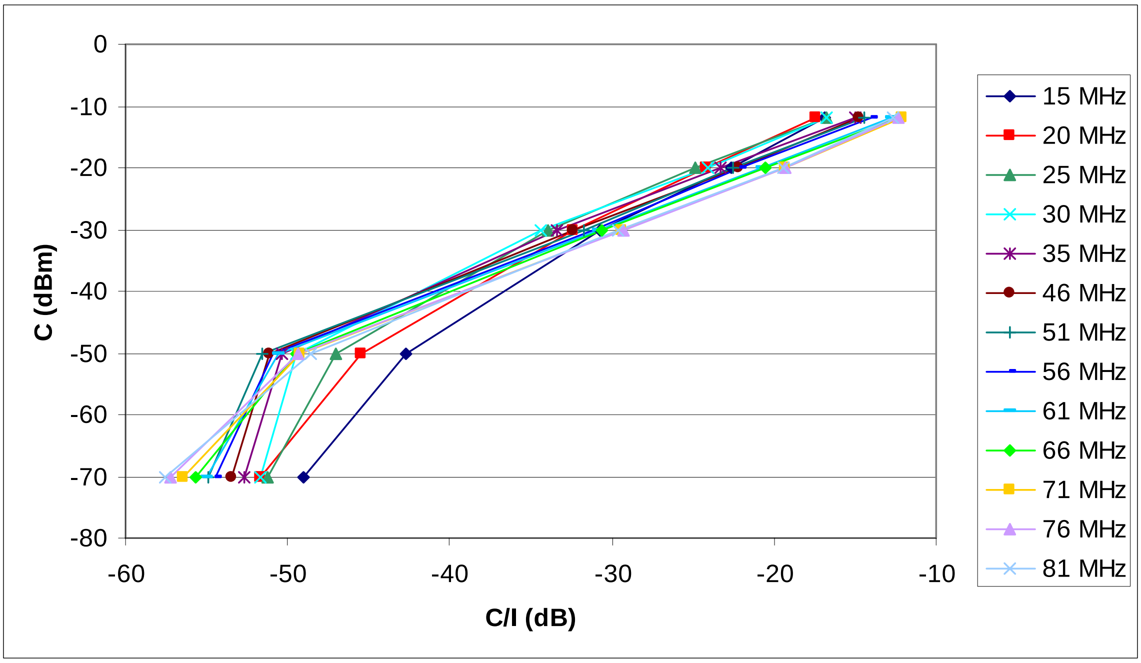

Figure 41: Carrier power vs C/I protection ratio between 15 and 81 MHz frequency offset for iDTV silicon tuner ST2 without using a filter

B.4. PVR

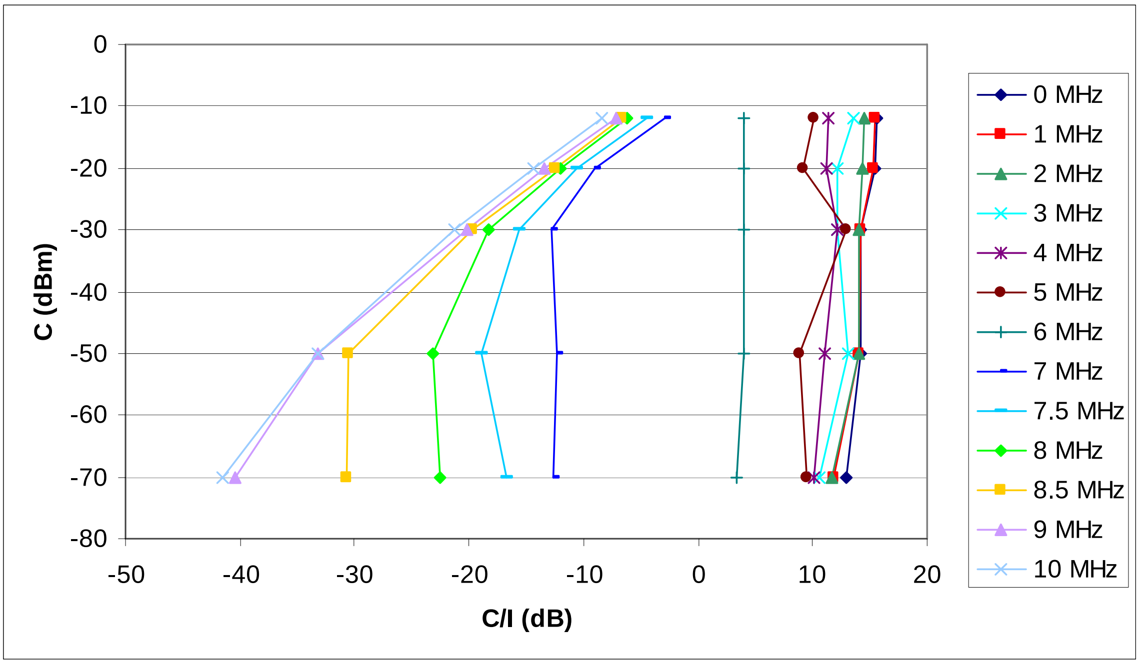

Figure 42: Carrier power vs. C/I protection ratio between 0 and 10 MHz frequency offset for a PVR without using a filter

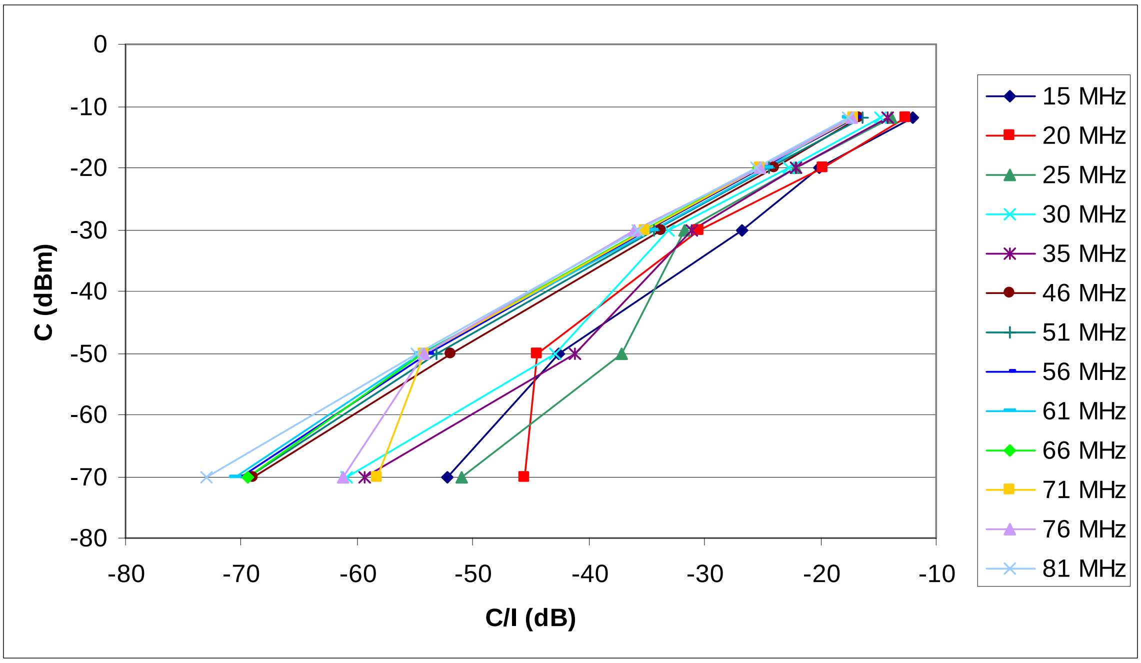

Figure 43: Carrier power vs. C/I protection ratio between 15 and 81 MHz frequency offset for a PVR without using a filter

B.5. STB

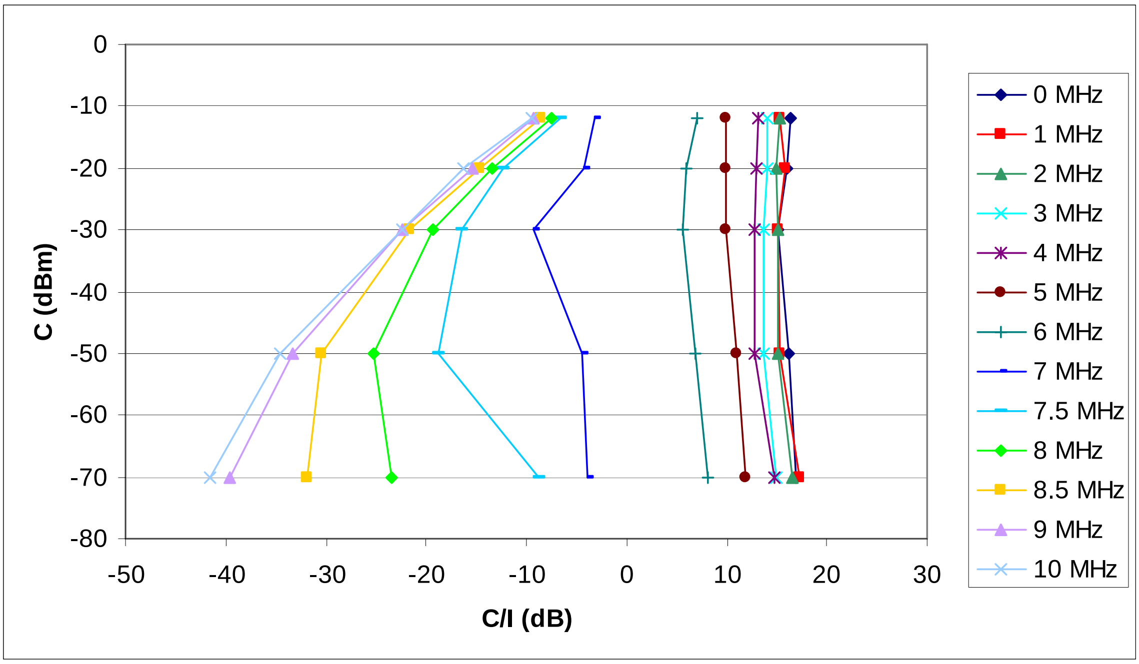

Figure 44: Carrier power vs. C/I protection ratio between 0 and 10 MHz frequency offset for a STB without using a filter

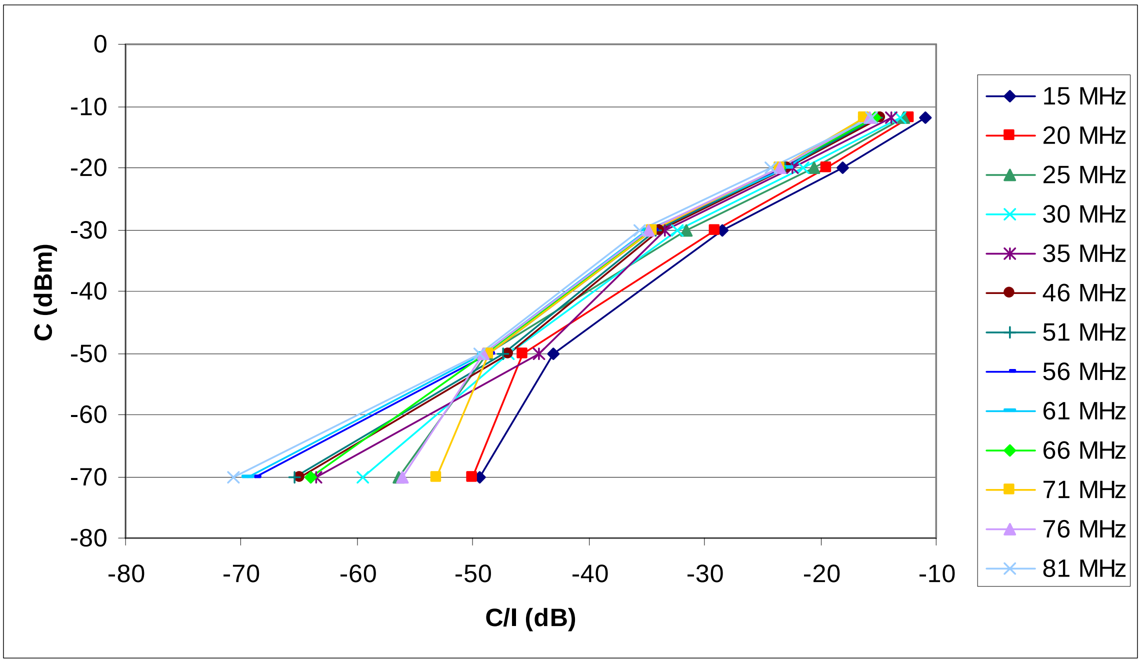

Figure 45: Carrier power vs. C/I protection ratio between 15 and 81 MHz frequency offset for a STB without using a filter

Appendix C
Radiated Results with an Outdoor Aerial

C.1. LTE UE Interference into an iDTV

Location 1

Table 23: Measured interference level on cable connected to an iDTV receiver 2.5 m away from a LTE source

Freq (MHz)	iDTV without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-42.92	No	-40.85	No	-30.77	No	-30.22	No
834	-43.23	No	-42.62	No	-30.52	No	-29.68	No
839	-43.84	No	-42.25	No	-31.16	No	-32.58	No
844	-45.5	No	-42.89	No	-32.93	No	-29.51	No
849	-43.03	No	-43.79	No	-30.27	No	-29.01	No

Location 2

Table 24: Measured interference level on a cable connected to an iDTV receiver 5.9 m away from a LTE source

Freq (MHz)	iDTV without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-50.33	No	-49.12	No	-39.97	No	-35.41	No
834	-48.01	No	-47.13	No	-38.09	No	-32.21	No
839	-51.05	No	-48.19	No	-36.98	No	-34.56	No
844	-52.37	No	-50.85	No	-37.69	No	-35.93	No
849	-48.33	No	-51.29	No	-39.36	No	-41.67	No

Location 3

Table 25: Measured interference level on a cable connected to an iDTV receiver 1.8 m away from a LTE source

Freq (MHz)	iDTV without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-39.98	No	-41.27	No	-29.51	No	-30.04	No
834	-42.65	No	-42.85	No	-30.43	No	-29.05	No
839	-42.89	No	-45.04	No	-29.98	No	-32.69	No
844	-40.39	No	-43.86	No	-31.04	No	-30.52	No
849	-42.72	No	-42.03	No	-29.83	No	-28.6	No

Location 4

Table 26: Measured interference level on a cable connected to an iDTV receiver 10.5 m away from a LTE source

Freq (MHz)	iDTV without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-59.96	No	-59.39	No	-52.05	No	-46.16	No
834	-62.64	No	-61.39	No	-54.12	No	-48.46	No
839	-61.32	No	-60.26	No	-51.37	No	-49.06	No
844	-59.09	No	-62.51	No	-51.67	No	-51.96	No
849	-60.88	No	-62.26	No	-52.85	No	-50.22	No

Location 5

Table 27: Measured interference level on a cable connected to an iDTV receiver 10.8 m away from a LTE source

Freq (MHz)	iDTV without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-60.29	No	-61.48	No	-50.47	No	-51.73	No
834	-62.86	No	-63.07	No	-52.95	No	-50.91	No
839	-60.45	No	-63.04	No	-53.29	No	-51.01	No
844	-63.22	No	-62.85	No	-52.31	No	-51.85	No
849	-64.28	No	-59.63	No	-52.62	No	-53.48	No

C.2. LTE UE Interference into an iDTV with a Silicon Tuner ST1

Location 1

Table 28: Measured interference level on a cable connected to iDTV silicon tuner ST1, 2.5 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-40.84	No	-42.91	No	-28.31	No	-31.9	No
834	-40.28	No	-41.75	No	-29.66	No	-32.51	No
839	-39.09	No	-43.19	No	-27.18	No	-33.43	No
844	-43.33	No	-39.69	No	-32.52	No	-28.33	No
849	-42.81	No	-42.18	No	-31.01	No	-31.11	No

Location 2

Table 29: Measured interference level on a cable connected to iDTV silicon tuner ST1, 5.9 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-47.92	No	-43.78	No	-38.31	No	-36.94	No
834	-48.08	No	-44.88	No	-39.66	No	-36.36	No
839	-48.81	No	-45.9	No	-41.06	No	-37.25	No
844	-47.26	No	-48.88	No	-38.76	No	-40.94	No
849	-49.91	No	-50.75	No	-41.59	No	-38.19	No

Location 3

Table 30: Measured interference level on a cable connected to iDTV silicon tuner ST1, 1.8 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-45.11	No	-44.39	No	-34.73	No	-32.88	No
834	-46.87	No	-43.28	No	-34.47	No	-29.89	No
839	-45.89	No	-42.18	No	-36.52	No	-32.97	No
844	-39.93	No	-39.71	No	-32.69	No	-31.83	No
849	-41.17	No	-40.81	No	-30.69	No	-33.42	No

Location 4

Table 31: Measured interference level on a cable connected to iDTV silicon tuner ST1, 10.5 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-60.15	No	-56.44	No	-52.89	No	-47.89	No
834	-57.55	No	-56.24	No	-49.63	No	-48.99	No
839	-61.21	No	-59.62	No	-54.29	No	-51.69	No
844	-59.39	No	-58.86	No	-50.94	No	-51.08	No
849	-58.32	No	-56.71	No	-50.02	No	-49.51	No

Location 5

Table 32: Measured interference level on a cable connected to iDTV silicon tuner ST1, 10.9 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-63.46	No	-65.76	No	-55.91	No	-54.96	No
834	-61.28	No	-62.49	No	-52.75	No	-53.61	No
839	-62.8	No	-62.32	No	-53.85	No	-51.03	No
844	-60.98	No	-63.76	No	-54.26	No	-53.65	No
849	-62.99	No	-63.71	No	-55.94	No	-54.93	No

C.3. LTE UE Interference into an iDTV with a Silicon Tuner ST2

Location 1

Table 33: Measured interference level on a cable connected to iDTV silicon tuner ST2, 2.5 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-42.38	No	-42.39	No	-31.89	No	-31.14	No
834	-41.53	No	-41.85	No	-30.36	No	-31.56	No
839	-41.25	No	-41.96	No	-31.08	No	-31.53	No
844	-41.37	No	-42.01	No	-30.65	No	-31.19	No
849	-41.94	No	-41.78	No	-29.95	No	-30.49	No

Location 2

Table 34: Measured interference level on a cable connected to iDTV silicon tuner ST2, 5.9 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-49.32	No	-49.43	No	-37.99	No	-36.49	No
834	-50.42	No	-50.33	No	-36.66	No	-36.44	No
839	-50.86	No	-50.52	No	-36.87	No	-36.89	No
844	-50.07	No	-51.44	No	-36.26	No	-38.25	No
849	-51.07	No	-50.85	No	-36.29	No	51.77	No

Location 3

Table 35: Measured interference level on a cable connected to iDTV silicon tuner ST2, 1.8 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-50.45	No	-49.23	No	-39.89	No	-38.42	No
834	-50.93	No	-50.15	No	-38.94	No	-37.41	No
839	-51.24	No	-50.11	No	-38.97	No	-37.61	No
844	-51.98	No	-49.38	No	-40.02	No	-37.62	No
849	-50.53	No	-49.86	No	-38.87	No	-39.68	No

Location 4

Table 36: Measured interference level on a cable connected to iDTV silicon tuner ST2, 10.5 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-63.06	No	-61.91	No	-53.82	No	-51.91	No
834	-62.73	No	-60.98	No	-52.89	No	-50.56	No
839	-61.94	No	-58.98	No	-53.45	No	-52.02	No
844	-61.07	No	-57.91	No	-52.63	No	-50.72	No
849	-59.08	No	-58.03	No	-51.84	No	-51.23	No

Location 5

Table 37: Measured interference level on a cable connected to iDTV silicon tuner ST2, 10.9 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-65.18	No	-64.14	No	-58.65	No	-56.6	No
834	-64.69	No	-64.99	No	-59.04	No	-54.83	No
839	-64.83	No	-65.41	No	-57.76	No	-56.85	No
844	-65.09	No	-63.87	No	-59.68	No	-57.58	No
849	-66.04	No	-65.08	No	-59.05	No	-58.19	No

C.4. LTE UE Interference into a PVR

Location 1

Table 38: Measured interference level on a cable connected to a PVR receiver 2.5 m away from a LTE source

Freq (MHz)	PVR without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-36.62	No	-38.11	No	-24.7	No	-29.93	No
834	-39.71	No	-43.94	No	-27.14	No	-31.82	No
839	-39.11	No	-37.61	No	-25.61	No	-30.26	No
844	-37.49	No	-36.85	No	-26.95	No	-29.63	No
849	-40.06	No	-37.64	No	-31.68	No	-27.01	No

Location 2

Table 39: Measured interference level on a cable connected to a PVR receiver 5.9 m away from a LTE source

Freq (MHz)	PVR without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-48.77	No	-45.58	No	-36.99	No	-33.16	No
834	-48.69	No	-43.13	No	-35.46	No	-30.02	No
839	-50.68	No	-45.93	No	-35.48	No	-33.03	No
844	-51.38	No	-48.03	No	-40.27	No	-34.25	No
849	-51.34	No	-47.92	No	-41.77	no	-34.83	No

Location 3

Table 40: Measured interference level on a cable connected to a PVR receiver 1.8 m away from a LTE source

Freq (MHz)	PVR without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-43.23	No	-43.91	No	-33.31	No	-32.46	No
834	-44.27	No	-44.63	No	-33.93	No	-32.23	No
839	-41.09	No	-41.41	No	-31.14	No	-31.44	No
844	-44.29	No	-45.84	No	-33.26	No	-34.47	No
849	-45.92	No	-48.36	No	-34.26	No	-37.28	No

Location 4

Table 41: Measured interference level on a cable connected to a PVR receiver 10.5 m away from a LTE source

Freq (MHz)	PVR without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-61.82	No	-58.27	No	-51.61	No	-45.65	No
834	-59.27	No	-56.27	No	-50.7	No	-46.99	No
839	-58	No	-58.71	No	-50.51	No	-50.21	No
844	-62.16	No	-60.48	No	-51.63	No	-50.93	No
849	-61.82	No	-59.14	No	-50.42	No	-50.97	No

Location 5

Table 42: Measured interference level on a cable connected to a PVR receiver 10.9 m away from a LTE source

Freq (MHz)	PVR without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-61.59	No	-63.43	No	-49.55	No	-51.25	No
834	-62.34	No	-63.16	No	-50.98	No	-53.53	No
839	-60.71	No	-61.25	No	-52.07	No	-53.03	No
844	-61.8	No	-62.25	No	-51.68	No	-54.78	No
849	-63.02	No	-63.02	No	-53.15	No	-53.35	No

C.5. LTE UE Interference into a STB

Location 1

Table 43: Measured interference level on a cable connected to a STB receiver 2.5 m away from a LTE source

Freq (MHz)	STB without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-40.11	No	-44.1	No	-30.63	No	-33.01	No
834	-42.92	No	-41.62	No	-31.03	No	-28.32	No
839	-40.36	No	-42.87	No	-29.05	No	-29.05	No
844	-42.48	No	-43.11	No	-30.41	No	-31.59	No
849	-43.95	No	-41.06	No	-33.26	No	-31.54	No

Location 2

Table 44: Measured interference level on a cable connected to a STB receiver 5.9 m away from a LTE source

Freq (MHz)	STB without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-50.28	No	-46.75	No	-37.91	No	-34.83	No
834	-52.95	No	-44.89	No	-42.01	No	-34.13	No
839	-50.88	No	-46.25	No	-38.61	No	-35.83	No
844	-51.76	No	-50.45	No	-40.28	No	-37.03	No
849	-51.82	No	-51.02	No	-38.94	No	-37.21	No

Location 3

Table 45: Measured interference level on a cable connected to a STB receiver 1.8 m away from a LTE source

Freq (MHz)	STB without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-47.39	No	-47.64	No	-35.77	No	-35.14	No
834	-47.81	No	-49.33	No	-35.29	No	-37.48	No
839	-48.39	No	-47.52	No	-37.51	No	-36.51	No
844	-46.64	No	-48.84	No	-38.52	No	-37.62	No
849	-44.63	No	-51.91	No	-36.63	No	-40.86	No

Location 4

Table 46: Measured interference level on a cable connected to a STB receiver 10.5 m away from a LTE source

Freq (MHz)	STB without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-62.43	No	-59.18	No	-52.06	No	-47.42	No
834	-61.14	No	-58.66	No	-52.01	No	-47.03	No
839	-60.56	No	-59.76	No	-53.71	No	-50.12	No
844	-61.49	No	-59.99	No	-54.63	No	-49.99	No
849	-62.07	No	-61.55	No	-52.33	No	-50.91	No

Location 5

Table 47: Measured interference level on a cable connected to a STB receiver 10.9 m away from a LTE source

Freq (MHz)	STB without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-62.73	No	-63.28	No	-52.59	No	-51.63	No
834	-63.51	No	-63.42	No	-54.11	No	-53.78	No
839	-60.07	No	-64.1	No	-53.87	No	-53.13	No
844	-64.63	No	-63.59	No	-54.63	No	-52.3	No
849	-60.26	No	-61.96	No	-53.82	No	-53.03	No

C.6. LTE UE Interference into a STB via a PVR

Location 1

Table 48: Measured interference level on a cable connected to a STB via a PVR without an aerial amplifier 2.5 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	Without aerial distribution amplifier				Without aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-36.62	No	-38.11	No	-33.59	No	-36.87	No
834	-39.71	No	-43.94	No	-34.92	No	-39.52	No
839	-39.11	No	-37.61	No	-32.25	No	-33.96	No
844	-37.49	No	-36.85	No	-34.71	No	-33.64	No
849	-40.06	No	-37.64	No	-37.12	No	-35.88	No

Table 49: Measured interference level on a cable connected to a STB via a PVR with an aerial amplifier 2.5 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	With 10 dB gain aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-24.7	No	-29.93	No	-23.92	No	-28.83	No
834	-27.14	No	-31.82	No	-24.63	No	-27.51	No
839	-25.61	No	-30.26	No	-24.45	No	-26.04	No
844	-26.95	No	-29.63	No	-23.67	No	-24.57	No
849	-31.68	No	-27.01	No	-27.67	No	-25.47	No

Location 2

Table 50: Measured interference level on a cable connected to a STB via a PVR without an aerial amplifier 5.9 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	Without aerial distribution amplifier				Without aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-48.77	No	-45.58	No	-46.65	No	-42.33	No
834	-48.69	No	-43.13	No	-45.98	No	-41.13	No
839	-50.68	No	-45.93	No	-42.84	No	-43.85	No
844	-51.38	No	-48.03	No	-46.75	No	-44.08	No
849	-51.34	No	-47.92	No	-47.66	no	-43.82	No

Table 51: Measured interference level on a cable connected to a STB via a PVR with an aerial amplifier 5.9 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	With 10 dB gain aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-36.99	No	-33.16	No	-37.08	No	-34.23	No
834	-35.46	No	-30.02	No	-34.97	No	-32.92	No
839	-35.48	No	-33.03	No	-32.86	No	-31.91	No
844	-40.27	No	-34.25	No	-35.45	No	-33.32	No
849	-41.77	No	-34.83	No	-38.66	No	-34.14	No

Location 3

Table 52: Measured interference level on a cable connected to a STB via a PVR without an aerial amplifier 1.8 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	Without aerial distribution amplifier				Without aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-43.23	No	-43.91	No	-37.93	No	-38.31	No
834	-44.27	No	-44.63	No	-36.67	No	-35.43	No
839	-41.09	No	-41.41	No	-37.83	No	-37.88	No
844	-44.29	No	-45.84	No	-38.89	No	-36.96	No
849	-45.92	No	-48.36	No	-34.18	No	-39.51	No

Table 53: Measured interference level on a cable connected to a STB via a PVR with an aerial amplifier 1.8 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	With 10 dB gain aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-33.31	No	-32.46	No	-29.05	No	-29.86	No
834	-33.93	No	-32.23	No	-28.89	No	-28.21	No
839	-31.14	No	-31.44	No	-27.11	No	-29.56	No
844	-33.26	No	-34.47	No	-32.03	No	-28.23	No
849	-34.26	No	-37.28	No	-27.75	No	-32.24	No

Location 4

Table 54: Measured interference level on a cable connected to a STB via a PVR without an aerial amplifier 10.5 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	Without aerial distribution amplifier				Without aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-61.82	No	-58.27	No	-59.93	No	-57.91	No
834	-59.27	No	-56.27	No	-57.57	No	-54.8	No
839	-58	No	-58.71	No	-55.99	No	-56.49	No
844	-62.16	No	-60.48	No	-58.04	No	-56.95	No
849	-61.82	No	-59.14	No	-58.57	No	-56.46	No

Table 55: Measured interference level on a cable connected to a STB via a PVR with an aerial amplifier 10.5 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	With 10 dB gain aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-51.61	No	-45.65	No	-52.72	No	-50.37	No
834	-50.7	No	-46.99	No	-49.21	No	-47.81	No
839	-50.51	No	-50.21	No	-47.39	No	-48.65	No
844	-51.63	No	-50.93	No	-50.86	No	-49.46	No
849	-50.42	No	-50.97	No	-51.08	No	-49.15	No

Location 5

Table 56: Measured interference level on a cable connected to a STB via a PVR without an aerial amplifier 10.9 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	Without aerial distribution amplifier				Without aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-61.59	No	-63.43	No	-59.96	No	-59.33	No
834	-62.34	No	-63.16	No	-58.73	No	-58.25	No
839	-60.71	No	-61.25	No	-56.92	No	-55.12	No
844	-61.8	No	-62.25	No	-55.78	No	-57.83	No
849	-63.02	No	-63.02	No	-58.91	No	-58.51	No

Table 57: Measured interference level on a cable connected to a STB via a PVR with an aerial amplifier 10.9 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	With 10 dB gain aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-49.55	No	-51.25	No	-47.18	No	-49.95	No
834	-50.98	No	-53.53	No	-45.79	No	-48.52	No
839	-52.07	No	-53.03	No	-48.12	No	-49.19	No
844	-51.68	No	-54.78	No	-47.61	No	-51.18	No
849	-53.15	No	-53.35	No	-46.76	No	-49.42	No

This page is intentionally blank

Appendix D
Radiated Results using a Indoor Set Top Aerial

D.1. LTE UE Interference into an iDTV

Location 1

Table 58: Measured interference level on a cable connected to an iDTV receiver 2.5 m away from a LTE source

Freq (MHz)	iDTV without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-15.68	No	-19.09	No	-6.35	No	-8.56	No
834	-17.91	No	-16.82	No	-8.91	No	-5.78	No
839	-17.84	No	-16.92	No	-7.58	No	-6.35	No
844	-15.29	Yes	-16.96	Yes	-6.53	Yes	-8.79	Yes
849	-16.82	Yes	-17.14	Yes	-8.77	Yes	-7.14	Yes
	iDTV with filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
844	-39.88	No	-42.71	No	-33.08	No	-38.53	No
849	-47.48	No	-40.12	No	-36.74	No	-36.03	No
	Attenuation on LTE signal required to stop interference to iDTV without filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)
844	-16.15	1	-18.91	2	-9.97	3	-10.74	2
849	-28.25	12	-33.57	15	-20.56	12	-21.03	14

Location 2

Table 59: Measured interference level on a cable connected to an iDTV receiver 5.9 m away from a LTE source

Freq (MHz)	iDTV without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-39.3	No	-36.33	No	-31.14	No	-26.88	No
834	-37.51	No	-34.91	No	-30.3	No	-26.07	No
839	-37.85	No	-32.77	No	-29.89	No	-24.95	No
844	-38.42	No	-34.56	No	-29.11	No	-27.04	No
849	-38.17	No	-35.58	No	-30.03	No	-25.42	No

Location 3

Table 60: Measured interference level on a cable connected to an iDTV receiver 1.8 m away from a LTE source

Freq (MHz)	iDTV without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-27.78	No	-29.31	No	-17.86	No	-17.41	No
834	-27.15	No	-27.17	No	-19.26	No	-19.57	No
839	-31.26	No	-32.25	No	-22.99	No	-20.38	No
844	-28.37	No	-32.51	No	-19.11	No	-21.55	No
849	-25.71	Yes	-30.36	Yes	-18.23	Yes	-19.22	Yes
	iDTV with filter							
	Without aerial amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
849	-50.53	No	-54.53	No	-43.41	No	-46.15	No
	Attenuation on LTE signal required to stop interference to iDTV without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)
849	-32.47	7	-33.18	3	-26.15	8	-24.97	5

Location 4

Table 61: Measured interference level on a cable connected to an iDTV receiver 10.5 m away from a LTE source

Freq (MHz)	iDTV without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-52.86	No	-50.13	No	-46.96	No	-43.35	No
834	-54.87	No	-49.67	No	-48.06	No	-44.51	No
839	-51.34	No	-52.28	No	-43.36	No	-44.13	No
844	-52.66	No	-48.11	No	-44.54	No	-42.03	No
849	-51.88	No	-51.52	No	-46.08	No	-44.58	No

Location 5

Table 62: Measured interference level on a cable connected to an iDTV receiver 10.9 m away from a LTE source

Freq (MHz)	iDTV without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-50.35	No	-54.4	No	-40.23	No	-44.89	No
834	-51.04	No	-53.54	No	-43.01	No	-46.48	No
839	-53	No	-54.94	No	-41.96	No	-45.03	No
844	-50.48	No	-53.42	No	-41.91	No	-44.93	No
849	-53.72	No	-49.68	No	-44.41	No	-41.19	No

D.2. LTE UE Interference into an iDTV with a Silicon Tuner ST1

Location 1

Table 63: Measured interference level on a cable connected to iDTV silicon tuner ST1, 2.5 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-17.12	Yes	-17.19	Yes	-7.27	Yes	-7.82	Yes
834	-18.04	Yes	-19.15	Yes	-8.52	Yes	-7.78	Yes
839	-17.12	Yes	-20.53	Yes	-6.92	Yes	-7.65	Yes
844	-15.52	Yes	-19.54	Yes	-6.06	Yes	-8.99	Yes
849	-17.13	Yes	-17.93	Yes	-9.08	Yes	-10.63	Yes
	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-42.77	No	-43.74	No	-31.87	No	-32.83	No
834	-40.46	No	-45.66	No	-28.11	No	-30.11	No
839	-44.27	No	-45.44	No	-29.74	No	-33.95	No
844	-41.86	No	-45.06	No	-31.71	No	-34.44	No
849	-41.37	No	-44.84	No	-33.18	No	-33.59	No
	Attenuation on LTE signal required to stop interference to iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Att (dB)	I (dBm)	Att (dB)	I (dBm)	Att (dB)	I (dBm)	Att (dB)
829	-21.01	4	-19.52	3	-12.05	5	-13.93	6
834	-20.52	3	-18.34	2	-12.67	4	-14.07	6
839	-22.06	4	-18.97	1	-11.87	5	-12.54	5
844	-21.24	6	-20.44	1	-10.69	4	-11.15	2
849	-20.52	3	-19.68	2	-13.34	4	-12.42	2

Location 2

Table 64: Measured interference level on a cable connected to iDTV silicon tuner ST1, 5.9 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-44.61	No	-36.29	No	-32.03	No	-25.58	No
834	-43.9	No	-41.62	No	-33.89	No	-32.11	No
839	-43.34	No	-36.26	No	-32.14	No	-26.72	No
844	-43.78	No	-35.07	No	-35.05	No	-27.04	No
849	-44.92	No	-37.45	No	-36.82	No	-29.36	No

Location 3

Table 65: Measured interference level on a cable connected to iDTV silicon tuner ST1, 1.8 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-31.29	No	-32.52	No	-21.11	No	-20.17	No
834	-29.82	No	-30.03	No	-21.58	No	-18.84	No
839	-33.47	No	-31.83	No	-23.43	No	-24.84	No
844	-28.79	No	-34.96	No	-18.39	No	-25.01	No
849	-27.86	No	-30.27	No	-17.36	No	-20.75	No

Location 4

Table 66: Measured interference level on a cable connected to iDTV silicon tuner ST1, 10.5 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-56.04	No	-52.01	No	-46.67	No	-44.68	No
834	-57.57	No	-53.16	No	-49.43	No	-45.49	No
839	-55.75	No	-50.09	No	-49.63	No	-43.41	No
844	-55.23	No	-51.91	No	-47.81	No	-42.72	No
849	-54.48	No	-51.98	No	-46.33	No	-40.41	No

Location 5

Table 67: Measured interference level on a cable connected to iDTV silicon tuner ST1, 10.9 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST1 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-53.66	No	-55.16	No	-43.61	No	-43.95	No
834	-50.61	No	-56.24	No	-40.43	No	-47.03	No
839	-50.72	No	-54.12	No	-40.89	No	-46.25	No
844	-51.03	No	-52.58	No	-43.16	No	-42.93	No
849	-53.96	No	-52.18	No	-43.47	No	-44.82	No

D.3. LTE UE Interference into an iDTV with a Silicon Tuner ST2

Location 1

Table 68: Measured interference level on a cable connected to iDTV silicon tuner ST2, 2.5 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-20.31	No	-18.09	No	-16.98	No	-12.96	No
834	-21.8	No	-21.48	No	-13.47	No	-15.66	No
839	-20.49	No	-21.93	No	-12.86	No	-16.52	No
844	-19.58	No	-22.81	No	-10.83	No	-17.39	No
849	-20.21	No	-24.22	No	-11.23	No	-18.36	No

Location 2

Table 69: Measured interference level on a cable connected to iDTV silicon tuner ST2, 5.9 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-39.32	No	-38.12	No	-32.05	No	-27.23	No
834	-40.06	No	-37.25	No	-30.88	No	-25.56	No
839	-39.59	No	-37.16	No	-30.05	No	-25.74	No
844	-37.46	No	-38.24	No	-29.39	No	-27.97	No
849	-38.01	No	-37.29	No	-28.78	No	-25.45	No

Location 3

Table 70: Measured interference level on a cable connected to an iDTV silicon tuner ST2, 1.8 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-31.11	No	-36.65	No	-24.13	No	-25.9	No
834	-29.32	No	-35.76	No	-22.61	No	-28.5	No
839	-25.29	No	-33.3	No	-17.01	No	-26.26	No
844	-24.21	No	-32.83	No	-16.73	No	-24.53	No
849	-26.22	No	-33.33	No	-20.31	No	-23.3	No

Location 4

Table 71: Measured interference level on a cable connected to iDTV silicon tuner ST2, 10.5 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-54.24	No	-50.05	No	-46.56	No	-42.05	No
834	-54.61	No	-49.81	No	-48.42	No	-42.96	No
839	-53.56	No	-53.91	No	-48.23	No	-46.28	No
844	-54.58	No	-50.38	No	-47.55	No	-45.87	No
849	-53.96	No	-52.49	No	-46.28	No	-44.36	No

Location 5

Table 72: Measured interference level on a cable connected to iDTV silicon tuner ST2, 10.9 m away from a LTE source

Freq (MHz)	iDTV silicon tuner ST2 without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-53.27	No	-50.35	No	-43.83	No	-43.44	No
834	-54.04	No	-49.92	No	-42.41	No	-42.71	No
839	-53.39	No	-52.53	No	-45.76	No	-45.02	No
844	-54.28	No	-52.92	No	-44.94	No	-45.09	No
849	-53.21	No	-49.82	No	-46.21	No	-42.68	No

D.4. LTE UE Interference into a PVR

Location 1

Table 73: Measured interference level on a cable connected to a PVR receiver 2.5 m away from a LTE source

Freq (MHz)	PVR without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-18.34	No	-21.06	No	-11.24	No	-11.34	No
834	-17.85	No	-19.21	No	-10.35	No	-10.51	No
839	-17.07	No	-18.96	No	-10.43	No	-10.14	No
844	-17.79	No	-20.25	No	-11.07	No	-9.11	No
849	-16.15	No	-20.73	No	-9.46	No	-9.82	No

Location 2

Table 74: Measured interference level on a cable connected to a PVR receiver 5.9 m away from a LTE source

Freq (MHz)	PVR without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-38.83	No	-33.82	No	-31.18	No	-24.11	No
834	-42.42	No	-29.88	No	-32.19	No	-23.91	No
839	-41.18	No	-30.82	No	-32.57	No	-21.06	No
844	-38.4	No	-33.51	No	-31.82	No	-24.03	No
849	-41.99	No	-34.28	No	-33.99	No	-25.03	No

Location 3

Table 75: Measured interference level on a cable connected to a PVR receiver 1.8 m away from a LTE source

Freq (MHz)	PVR without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-29.18	No	-33.61	No	-18.44	No	-22.71	No
834	-28.4	No	-32.08	No	-18.67	No	-23.64	No
839	-28.55	No	-33.71	No	-19.17	No	-23.96	No
844	-30.31	No	-33.45	No	-21.4	No	-22.27	No
849	-31.69	No	-32.95	No	-21.74	No	-21.05	No

Location 4

Table 76: Measured interference level on a cable connected to a PVR receiver 10.5 m away from a LTE source

Freq (MHz)	PVR without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-51.06	No	-47.22	No	-43.89	No	-41.86	No
834	-51.92	No	-47.82	No	-44.03	No	-42.19	No
839	-51.61	No	-48.84	No	-45.73	No	-41.71	No
844	-52.57	No	-48.26	No	-45.76	No	-41.35	No
849	-51.86	No	-47.23	No	-44.69	No	-39.03	No

Location 5

Table 77: Measured interference level on a cable connected to a PVR receiver 10.9 m away from a LTE source

Freq (MHz)	PVR without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-54.77	No	-53.58	No	-45.52	No	-43.04	No
834	-50.32	No	-54.71	No	-42.39	No	-47.13	No
839	-49.92	No	-55.01	No	-38.88	No	-44.98	No
844	-49.03	No	-51.58	No	-42.83	No	-43.63	No
849	-51.53	No	-52.46	No	-46.81	No	-41.02	No

D.5. LTE UE Interference into a STB

Location 1

Table 78: Measured interference level on a cable connected to a STB receiver 2.5 m away from a LTE source

Freq (MHz)	STB without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-19.45	No	-20.39	No	-8.41	No	-8.14	No
834	-18.78	No	-19.62	No	-6.07	No	-7.98	No
839	-16.35	No	-18.24	No	-6.55	No	-8.61	No
844	-17.14	No	-17.49	No	-8.34	No	-9.12	No
849	-16.04	Yes	-17.41	Yes	-8.03	Yes	-9.22	Yes
	STB with filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
849	-41.21	No	-43.91	No	-35.58	No	-35.63	No
	Attenuation on LTE signal required to stop interference to STB without filter							
	Without aerial distribution amplifier				**With 10 dB gain aerial distribution amplifier**			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)	I (dBm)	Atten (dB)
849	-18.13	2	-19.61	2	-10.81	2	-11.35	2

Location 2

Table 79: Measured interference level on a cable connected to a STB receiver 5.9 m away from a LTE source

Freq (MHz)	STB without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-39.48	No	-37.05	No	-31.53	No	-28.42	No
834	-38.06	No	-34.79	No	-30.43	No	-27.27	No
839	-38.62	No	-32.55	No	-30.03	No	-24.72	No
844	-37.99	No	-32.93	No	-27.94	No	-23.41	No
849	-40	No	-32.78	No	-30.46	No	-25.25	No

Location 3

Table 80: Measured interference level on a cable connected to a STB receiver 1.8 m away from a LTE source

Freq (MHz)	STB without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-31.57	No	-29.72	No	-19.34	No	-18.84	No
834	-31.27	No	-30.21	No	-23.58	No	-20.43	No
839	-34.42	No	-33.29	No	-25.49	No	-24.11	No
844	-31.61	No	-29.16	No	-22.66	No	-22.16	No
849	-30.41	No	-31.44	No	-20.31	No	-22.36	No

Location 4

Table 81: Measured interference level on a cable connected to a STB receiver 10.5 m away from a LTE source

Freq (MHz)	STB without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-54.58	No	-47.39	No	-47.03	No	-40.7	No
834	-54.38	No	-48.65	No	-46.51	No	-41.61	No
839	-53.37	No	-51.7	No	-45.01	No	-43.33	No
844	-52.87	No	-53.99	No	-44.92	No	-43.74	No
849	-54.67	No	-53.39	No	-42.47	No	-41.81	No

Location 5

Table 82: Measured interference level on a cable connected to a STB receiver 10.9 m away from a LTE source

Freq (MHz)	STB without filter							
	Without aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-55.02	No	-55.78	No	-42.04	No	-44.96	No
834	-53.15	No	-52.88	No	-44.09	No	-44.71	No
839	-52.64	No	-53.74	No	-39.6	No	-45.33	No
844	-51.54	No	-51.22	No	-41.42	No	-43.42	No
849	-55.09	No	-53.08	No	-45.47	No	-44.59	No

D.6. LTE UE Interference into a STB via a PVR

Location 1

Table 83: Measured interference level on a cable connected to a STB via a PVR without an aerial amplifier 2.5 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	Without aerial distribution amplifier				Without aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-18.34	No	-21.06	No	-16.32	No	-18.21	No
834	-17.85	No	-19.21	No	-16.62	No	-18.36	No
839	-17.07	No	-18.96	No	-17.27	No	-19.48	No
844	-17.79	No	-20.25	No	-17.19	No	-19.95	No
849	-16.15	No	-20.73	No	-17.61	No	-19.91	No

Table 84: Measured interference level on a cable connected to a STB via a PVR with an aerial amplifier 2.5 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	With 10 dB gain aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-11.24	No	-11.34	No	-10.85	No	-11.77	No
834	-10.35	No	-10.51	No	-10.87	No	-10.04	No
839	-10.43	No	-10.14	No	-10.42	No	-9.38	No
844	-11.07	No	-9.11	No	-10.91	No	-9.65	No
849	-9.46	No	-9.82	No	-9.49	Yes	-8.65	Yes
					STB with filter			
					With 10 dB gain aerial distribution amplifier			
					Co-polar		Cross-polar	
					I (dBm)	Interference	I (dBm)	Interference
849					-32.95	No	-36.13	No
					Attenuation on LTE signal to stop interference to STB without filter			
					With 10 dB gain aerial distribution amplifier			
					Co-polar		Cross-polar	
					I (dBm)	Atten (dB)	I (dBm)	Atten (dB)
849					-12.03	4	-10.39	3

Location 2

Table 85: Measured interference level on a cable connected to a STB via a PVR without an aerial amplifier 5.9 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	Without aerial distribution amplifier				Without aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-38.83	No	-33.82	No	-39.31	No	-32.69	No
834	-42.42	No	-29.88	No	-43.82	No	-29.02	No
839	-41.18	No	-30.82	No	-41.38	No	-29.86	No
844	-38.4	No	-33.51	No	-43.01	No	-29.7	No
849	-41.99	No	-34.28	No	-42.18	No	-32.46	No

Table 86: Measured interference level on a cable connected to a STB via a PVR with an aerial amplifier 5.9 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	With 10 dB gain aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-31.18	No	-24.11	No	-32.3	No	-23.65	No
834	-32.19	No	-23.91	No	-34.27	No	-22.43	No
839	-32.57	No	-21.06	No	-29.41	No	-18.36	No
844	-31.82	No	-24.03	No	-30.35	No	-22.77	No
849	-33.99	No	-25.03	No	-30.45	No	-21.46	No

Location 3

Table 87: Measured interference level on a cable connected to a STB via a PVR without an aerial amplifier 1.8 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	Without aerial distribution amplifier				Without aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-29.18	No	-33.61	No	-29.14	No	-33.06	No
834	-28.4	No	-32.08	No	-27.35	No	-32.18	No
839	-28.55	No	-33.71	No	-27.31	No	-32.69	No
844	-30.31	No	-33.45	No	-29.03	No	-33.52	No
849	-31.69	No	-32.95	No	-30.66	No	-31.51	No

Table 88: Measured interference level on a cable connected to a STB via a PVR with an aerial amplifier 1.8 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	With 10 dB gain aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-18.44	No	-22.71	No	-19.51	No	-24.63	No
834	-18.67	No	-23.64	No	-19.25	No	-24.04	No
839	-19.17	No	-23.96	No	-19.35	No	-24	No
844	-21.4	No	-22.27	No	-21.57	No	-22.79	No
849	-21.74	No	-21.05	No	-22.11	No	-20.64	No

Location 4

Table 89: Measured interference level on a cable connected to a STB via a PVR without an aerial amplifier 10.5 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	Without aerial distribution amplifier				Without aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-51.06	No	-47.22	No	-50.24	No	-46.57	No
834	-51.92	No	-47.82	No	-50.33	No	-47.34	No
839	-51.61	No	-48.84	No	-50.02	No	-45.46	No
844	-52.57	No	-48.26	No	-51.22	No	-46.13	No
849	-51.86	No	-47.23	No	-50.69	No	-45.89	No

Table 90: Measured interference level on a cable connected to a STB via a PVR with an aerial amplifier 10.5 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	With 10 dB gain aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-43.89	No	-41.86	No	-45.2	No	-42.45	No
834	-44.03	No	-42.19	No	-45.06	No	-43.05	No
839	-45.73	No	-41.71	No	-44.64	No	-41.99	No
844	-45.76	No	-41.35	No	-44.03	No	-41.44	No
849	-44.69	No	-39.03	No	-43.03	No	-40.35	No

Location 5

Table 91: Measured interference level on a cable connected to a STB via a PVR without an aerial amplifier 10.9 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	Without aerial distribution amplifier				Without aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-54.77	No	-53.58	No	-48.37	No	-53.27	No
834	-50.32	No	-54.71	No	-47.37	No	-55.51	No
839	-49.92	No	-55.01	No	-45.07	No	-55.54	No
844	-49.03	No	-51.58	No	-48.15	No	-51.33	No
849	-51.53	No	-52.46	No	-49.24	No	-50.65	No

Table 92: Measured interference level on a cable connected to a STB via a PVR with an aerial amplifier 10.9 m away from a LTE source

Freq (MHz)	PVR without filter				STB without filter			
	With 10 dB gain aerial distribution amplifier				With 10 dB gain aerial distribution amplifier			
	Co-polar		Cross-polar		Co-polar		Cross-polar	
	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference	I (dBm)	Interference
829	-45.52	No	-43.04	No	-42.06	No	-43.34	No
834	-42.39	No	-47.13	No	-41.73	No	-46.01	No
839	-38.88	No	-44.98	No	-38.46	No	-45.33	No
844	-42.83	No	-43.63	No	-39.37	No	-46.72	No
849	-46.81	No	-41.02	No	-44.04	No	-41.12	No

Appendix E
Test Equipment

E.1. Test Equipment Used

- Agilent E4438C signal generator
- R&S MPEG encoder
- R&S SFQ DVB-T TV transmitter
- R&S SFU 46 spectrum analyser
- Amplifier Research 5W amplifier
- Wiltron VSWR bridge (0.5 MHz to 2 GHz)
- HP splitter (DC to 18 GHz)
- Marconi programmable 20 GHz attenuators
- Aerial distribution amplifier
- Digix LCD TV display
- 50 Ω to 75 Ω matching pad
- Standard TV scart leads