

UHF Interference Issues for DVB-T/T2 reception resulting from the Digital Dividend

Background

Figure 1 shows the preferred harmonised spectrum arrangement that is being adopted by most EU countries following the switch off of analogue TV services. DVB-T and DVB-T2 services will be in the band below 790MHz, with DVB-C/C2 and mobile broadband services occupying the band from 791-862MHz. The options for the guard band at 790MHz has not been fully agreed yet but is expected to be between 1 and 2 MHz. There are other ideas being explored to introduce other non DVB-T/T2 services below 790MHz at some point in the future, perhaps making use of white space radio techniques, but this requires a lot more investigation and is not covered in this document.

791-796	796-801	801-806	806-811	811-816	816-821	821 - 832	832-837	837-842	842-847	847-852	852-857	857-862
Downlink						Duplex gap	Uplink					
30 MHz (6 blocks of 5 MHz)						11 MHz	30 MHz (6 blocks of 5 MHz)					

Figure 1 - Preferred Harmonised Frequency Plan (taken from CEPT report 30, ref. 1)

The immediate concern for TV receiver manufacturers and consumers is the threat of high levels of interference from mobile service base stations and handsets overloading (blocking) the sensitive TV tuner front end circuitry, preventing existing viewers from seeing a picture. This is illustrated (for the base station situation) in figure 2.

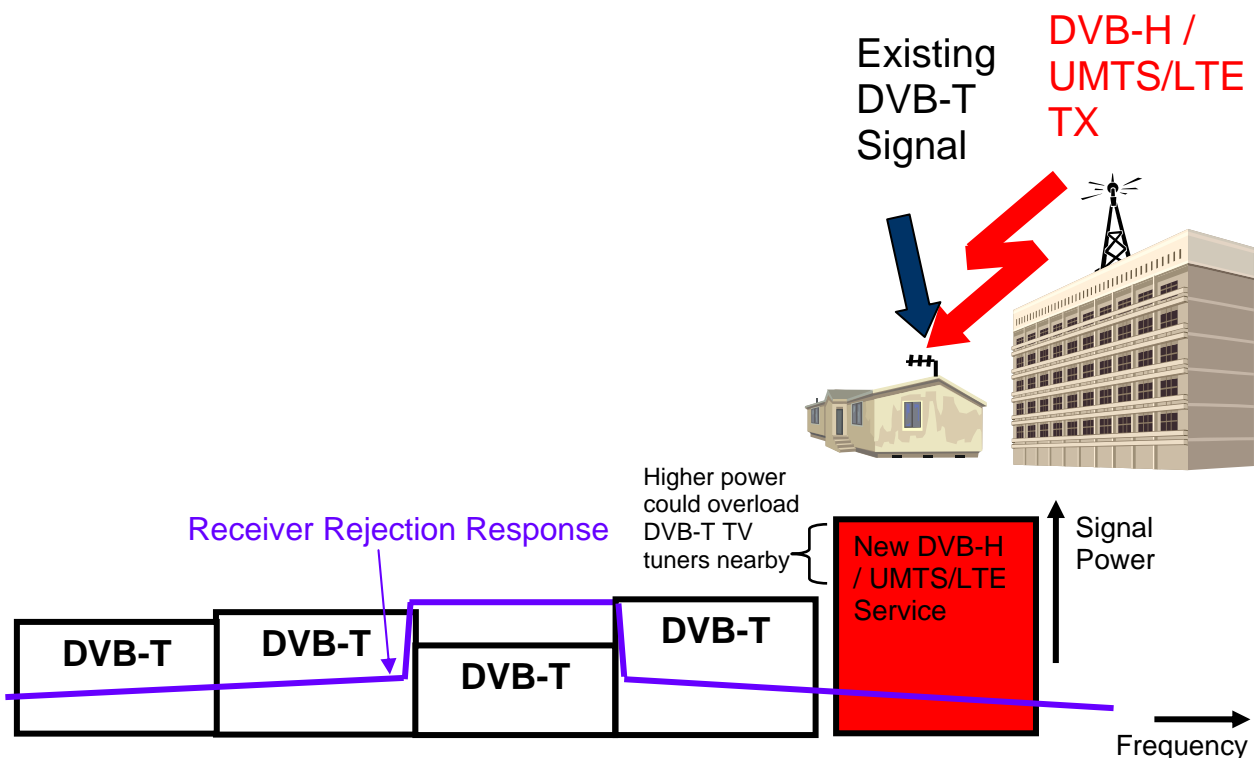


Figure 2 – Threat of Base Station Interference to DVB-T/T2 Services

For base station interference, the viewers closest to base stations are likely to be worst affected as there will be a ‘hole’ in reception punched out in the area around each base station. The hole size depends on many factors such as the direction and gain of antennas,

the individual protection ratio and overload threshold (O_{th} = point at which protection ratio becomes non-linear) of each TV receiver, and the robustness of the chosen DVB-T/T2 modulation parameters. The total number of viewers affected also depends upon the density of base station spacing.

For mobile hand set interference, the proximity of the hand set to the TV set and the TV antenna is important, particularly if indoor 'set-top' antenna's are used. Additionally the effects of fast power variations of the signal transmitted by the handset responding to fading conditions is very significant – ref. 2 reports an additional 12-26dB degradation compared with a static UMTS base station signal. This is an area where receiver performance is likely to differ most between different receivers due to different behaviors of AGC and channel estimation algorithms. The minimum distance from a handset to a TV antenna without causing interference needs to be studied and verified with tests in a domestic environment with a wide range of receivers.

Large spectrum changes have never been made on this scale before. There is a significant installed base of "HD-Ready" homes inside the EU, which receive or are about to receive a wealth of HDTV programmes, so protecting this valuable consumer investment calls for extreme care when making changes to TV reception conditions. These TV receivers have been designed to existing receiver performance standards which do not specify or test against the expected interference levels from mobile broadband sources. Therefore it is essential to ensure there are adequate and cost effective means of dealing with interference to existing viewers, whilst enhancing the interference immunity of new receiver designs where it is technically and commercially feasible.

Status of Network Planning Activities

The ITU-R SG6/WP-6A is currently working on a new version of the ITU-R BT 1368 network planning document, that will include recommendations on protection ratio and overload threshold O_{th} for network planning purposes against a variety of different types of interference, including DVB-T/H, UMTS and LTE base stations and handsets. The latest draft proposal is the chairman's report from the June 2009 ITU-R SG6/WP-6A meeting (ref. 3). Most of the input to this group has been derived from measurements of TV receivers – usually set top boxes as these are the easiest to obtain. Another group working in this area is the ECC/TG4 (future use of the digital dividend) and ECC/TG4/SE42 (defines technical conditions for use of 790-862MHz and handles issues related to the digital dividend). Many receiver measurement data originates from the EBU. The WP-6A group will be meeting again in Geneva from 4th – 12th November 09.

The work done in these groups is very valuable to understand the nature of the interference problem but there hasn't been the opportunity for verification of test results within the wider receiver manufacturing industry. This is particularly important because the test results used for creating the network planning proposals have been made on a relatively limited set of receivers using mostly conventional 'can' tuners.

National regulators such as Ofcom in the UK and the CSA in France have also been active in making measurements and studying the potential interference threat. Ofcom have published much of their measurement work on their website – see ref.6.

Status of Existing Receiver Specifications

The UK DTG DBook 5.01 and DBook 6.1 and the Digital Europe Ebook receiver specifications have been updated in 2009 to test for protection against digital adjacent channel interference from other DVB-T signals across a wider range of channel offsets, using a -25dBm fixed interference level. These specifications were set based on what was considered to be possible with state of the art tuner designs (both conventional ‘can’ type and the newer silicon variety).

Apart from the larger difference in protection ratios and lack of an overload threshold (O_{th}) definition in the Ebook/Dbook, another notable difference between these specifications and the ITU-R BT 1368 network planning document is that the DTG/Ebook test method fixes the interferer level whilst the level of the wanted signal is swept until picture failure occurs. The ITU method does the reverse which is more suitable for network planning and can allow higher protection ratios to be measured if the tuner is capable of handling greater than -25dBm interference power. Figure 3 shows the difference between the protection ratios of the Dbook/Ebook specifications, the older MBRAI specification, and the current ITU-R BT 1368 proposal (ref. 3).

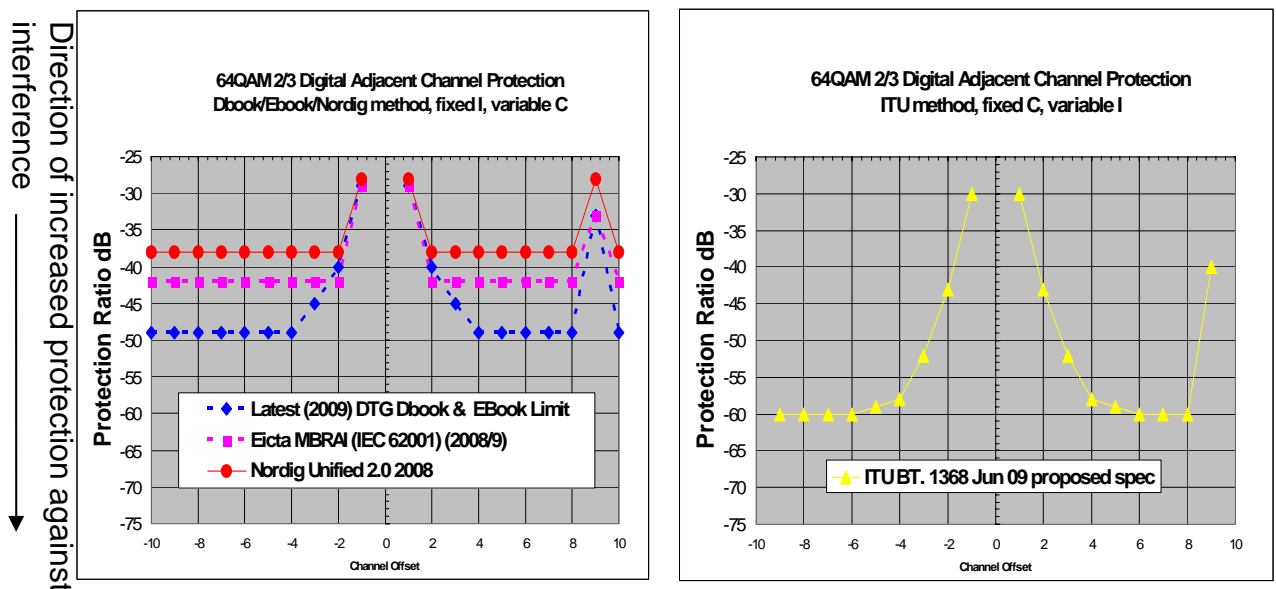


Figure 3 - Comparison of the Latest Receiver Specifications vs. ITU-R BT 1368 Proposal

Status of Receiver Testing

There have been several measurement campaigns to measure a relatively small number of TV receiver products in order to propose some network planning guidelines in the draft ITU-R BT 1368 proposal (ref. 3).

Ofcom have also published their measurement results on 15 STB receivers with DVB-T interference in ref.6. IRT have also published some measurement results with LTE interference in ref 5.

Most of the products tested so far are based on conventional ‘can’ tuners, with surprisingly little coverage of silicon tuner based TV products despite these being increasingly used in mainstream TV products over recent years due to their small size, low power and low cost.

Those that have been reported (such as ref.5) appear to be USB stick receivers with silicon tuners that do not have an RF tracking filter. More recent silicon tuners include RF tracking filters to improve selectivity, and their performance should be included in the overall proposal. Some measurements of such tuners are shown in this document. There is no coverage of high value derivative TV receivers which are expensive to replace, such as internal laptop receivers.

In an attempt to show a more representative picture of the immunity against interference, further measurements have been made on a wider range of receivers (including some state of the art silicon tuner based designs) and measurement data gathered from other organisations. Most measurements shown here are for a DVB-T interferer which for planning purposes gives reasonably similar protection ratio results (ref. 2) to a non time-varying LTE base station interferer. It is known from the work in ref.2 that the protection ratio with an LTE handset interference source is worse by 26dB to 31dB (particularly due to the time varying nature of the LTE handset transmitted signal).

Recent Receiver Measurements

The measurements summarised here originate from the following sources:

1. Lab measurements of several recent TV receivers (several mainstream CE manufacturers) including some state of the art silicon tuners used in today’s iDTVs and STB products.
2. ERA report 2007-0631 “Conducted Measurements to Quantify DVB-T Interference into DTT Receivers”, published on <http://www.ofcom.org.uk/research/technology/ctc/era05-07/>

Figure 4 shows the combined results of sources 1 and 2 above, plotted against the protection ratio mask in table 15 of June 2009 ITU-R BT. 1368 proposal (6A/196-E) (ref 3).

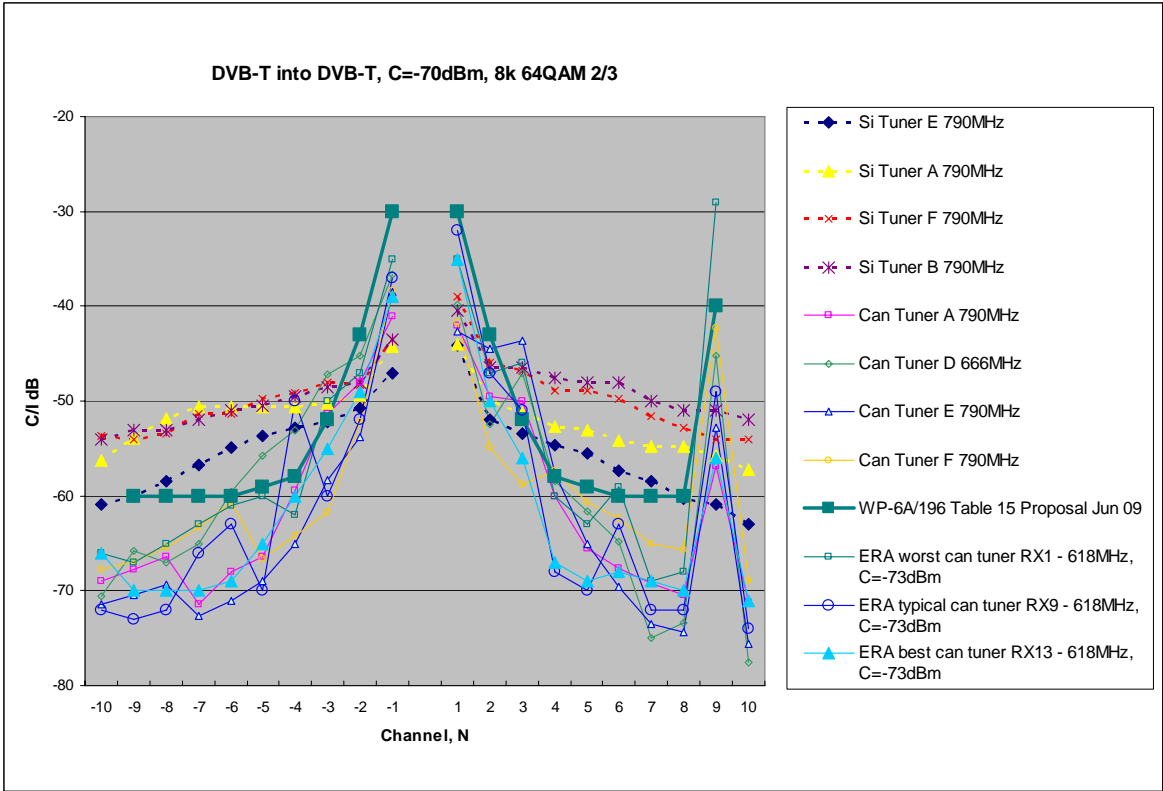


Figure 4 - DVB-T into DVB-T Protection Ratio (8K 64QAM 2/3) C=-70dBm

Points to note from figure 4:

1. All tuners pass the critical N+1 and N+2 mask points in table 15 of document 6A/196-E
2. Only 1 of the 11 tuners pass the proposed mask at all points (ERA-RX13)
3. The significant area of failure for both can and silicon tuners was in the range below N-2 and between N+3 to N+8, with most can tuners having a lower protection ratio in this region.
4. Silicon tuners all demonstrate a much smoother and predictable protection ratio than can tuners across all channels shown.
5. Silicon tuners do not suffer from the N+9 image channel weakness in protection ratio.
6. No overload threshold measurements of these receivers have been made yet, so it is not clear how these receivers will operate under higher levels of interference.

Conclusions

1. The tests results in this report show that only 1 out of the 11 receivers met the proposed network planning recommendation in (doc. 6A/196-E table 15) at a wanted signal of -70dBm. If these proposals do not representative the true 'majority' receiver performance under DVB-T interference, we are equally concerned that other tables relating to performance with LTE and UMTS interferers may also not reflect the true performance of the majority TV receiver population.
2. A relatively small number of TV products have been tested to provide input data for the network planning activity in the ITU-R WP-6A, and there was insufficient representation of silicon tuner based designs.
3. Only a relatively small numbers of receivers have been tested with time varying LTE signals, and this is an area where receiver performance is likely to differ most between different receivers due to different behaviors of AGC and channel estimation algorithms.
4. It is inappropriate to select an "averaged" receiver result for setting a network planning parameter such as protection ratio (PR) or overload threshold (O_{th}) because one receiver may perform well in one area but less well in another due to different design and implementation techniques. It may be impossible to find a receiver capable of achieving the average in all areas. This seems to be reflected in the findings shown in this document. TG4(09)299 Annex 7 and TG4(09)284 also highlight the same point.
5. TV products have not been designed or tested with such high levels of interference or power variation in mind, and it should be noted that receiver specifications such as Dbook, Ebook and Nordig have never specified high levels of interference in the past as it didn't exist in the areas of spectrum currently used for TV transmissions. This causes concern for the millions of 'legacy' receivers, many of which will have been purchased over the last 5-7 years in the form of flat panel "HD-Ready" sets.
6. Receiver specification standards need to investigate cost effective and commercially feasible solutions to increase receiver interference immunity without adversely affecting other design constraints that legislation and consumers demand such as low power consumption, low cost and small design footprint for modern flat panel TVs.

Suggestions for Future Network Planning Tests

1. Increase the number and type of receiver products tested – possibly based on market sales data showing which the more popular models are over the last 6 to 7 years. Such testing would benefit from funding from the European Commission.
2. Address the latest trends in modern tuner technology including small size low power silicon solutions.
3. Include any time varying interference sources (e.g. UMTS Transmit Power Control, or LTE power variation) in the tests.
4. Include the technical and commercial feasibility of any proposed mitigation techniques such as the use of inline filters, and allow for these in the receiver tests. There is some concern that these are not effective against interference adjacent to a DVB-T channel operating in channel 60.
5. Investigate the *required* protection ratios and overload thresholds for co-existence with future mobile services – rather than specify figures based only on what has been measured with current receivers. There may be receiver design tradeoffs that can be made in some areas that would allow more receivers to meet specifications without compromising the mobile service network planning. For example this work shows many tuners have failed around the $N\pm 4$ and $N\pm 8$ region – but is it necessary to have a protection ratio between $N+4$ and $N+8$ that is significantly better than the $N+9$ image channel limitation that most conventional ‘can’ tuners suffer from?
6. Avoid the use of averaging measurement data to produce figures for network planning recommendations. Possibly a better method would be 10%/50%/90% percentile which gives a better idea of receiver performance spread. This technique has been recently used in the latest ECC 138 report (2).

References

- 1) CEPT report 30. “The identification of common and minimal (least restrictive) technical conditions for 790-862 MHz for the digital dividend in the European Union”
- 2) ECC report 138, MEASUREMENTS ON THE PERFORMANCE OF DVB-T RECEIVERS IN THE PRESENCE OF INTERFERENCE FROM THE MOBILE SERVICE (ESPECIALLY FROM UMTS) Ljubljana, September 2009
- 3) WP-6A/196-E Planning criteria for digital terrestrial television services in the VHF/UHF bands, Annex 10 to Working Party 6A Chairman’s Report, 1st June 2009.
- 4) TG4(09)299 Annex 7 “Comments MB on draft ECC report 138”
- 5) TG4(09)303 Protection ratios for LTE-BS and LTE-UE interference into DVB-T, IRT 16th Sept 2009.
- 6) ERA report 2007-0631 “Conducted Measurements to Quantify DVB-T Interference into DTT Receivers”, published on <http://www.ofcom.org.uk/research/technology/ctc/era05-07/>