

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
OFFICE OF ENGINEERING AND TECHNOLOGY  
Washington, D.C. 20554**

In the Matter of	)	
	)	
Office of Engineering and Technology	)	
Seeks to Supplement the Incentive Auction	)	ET Docket No. 14-14
Preceding Record Regarding Potential	)	GN Docket No. 12-268
Interference Between Broadcast and Wireless	)	
Services	)	

**COMMENTS of Linley Gumm and Charles Rhodes to the Public Notice**

Feb 24, 2014

**To the Office of Engineering Technology:**

Note: In the text below the document referred to as the “Notice” is the FCC’s Public Notice DA-14-98, the document that we are responding to.

**Introduction:**

The authors are both retired electronic engineers with long experience in RF and TV technologies. Mr. Rhodes was the Chief Scientist of the Advanced Television Test Center (1988-1996) where he was responsible for the testing of the DTV system adopted by the FCC in 1996. Mr. Gumm led the development of the Tektronix RSA-300 ATSC Transmitter signal measuring instrument and he contributed in large measure to the “IEEE Recommended Practice for Measurement of 8-VSB Digital Television Transmission Mask Compliance for the USA”, IEEE Std. 1631, 2008. We have spent the last few years testing the ability of 26 NTIA approved set top converters and 21 modern (2013) DTV receivers to deal with interference from one, two or up to seven other DTV signals. Our results have been published in professional journals<sup>1 2 3</sup>.

We primarily wish to comment that DTV receiver performance is not nearly as good as the FCC has heretofore assumed. This is especially true when multiple interfering signals are present. The FCC’s definitive assumption of DTV receiver performance appears in OET-69<sup>4</sup>:

---

<sup>1</sup> Rhodes, C., Gumm, L., Knight, S, “Protection Ratios for ATSC Digital Receivers”, IEEE Transactions on Consumer Electronics, vol. 59, no.2, May 2013, pp 303-309

<sup>2</sup> Gumm, L, Rhodes, C. “Interference Rejection of Late Model DTV Receivers”, soon to be published in the IEEE Broadcast Technology Society Newsletter.

<sup>3</sup> Rhodes, C., “DTV”, Column published in the magazine, TV Technology.

<sup>4</sup> OET Bulletin No. 69, “Longley-Rice Methodology for Evaluating TV Coverage and Interference, Feb. 6, 2004, page 8.

“The evaluation of service and interference in Appendix B of the *Sixth Report and Order* considered taboo channel relationships for interference into DTV. However, the D/U ratios (approximately -60 dB) were such that they rarely if ever had an effect on the results, and the FCC rules adopted in the Sixth Report and Order do not require attention to UHF taboo interference to DTV stations.”

Table 5A of that document makes it clear that “taboo interference” means interference from any other source than co-channel or first adjacent channel signals.

The position that DTV receivers exhibit -60 dB D/U performance for all but co-channel and first adjacent channel interference has been maintained in the face of publication of FCC reports which show that this is not the case<sup>5 6</sup>. The data is extensive and intricate and should be reviewed in its entirety for complete understanding. The measured DTV receiver D/U performance at one desired signal amplitude from the testing of several groups of receivers is shown in Table 1 and Table 2. Table 1 shows the threshold D/U level in dB where half of the receivers are operational in the face of interference; that is, half of the receivers failed. Table 2 shows the threshold D/U level when 90% of the receivers are operational; i.e. 10% have failed.

Table 1  
Measured Threshold D/U ratio values, in dB, for 50% of the Receivers Operating with a Desired Signal power D = -68 dBm

Interfering Channel w.r.t. Desired Signal	S. Martin 2005-2006 TV Receivers (FCC tests) D/U at Threshold, dB		S. Martin 2010 DTV Set Top Converters (FCC tests) D/U at Threshold, dB		Gumm, Rhodes 2013 DTV Receivers D/U at Threshold, dB	
	1 U Sig.	2 U Sig.	1 U Sig.	2 U Sig.	1 U Sig.	2 U Sig.
N-6	-53		<-63			
N-5	-56	-42	<-63	-49		
N-4	-47	-42	<-62			
N-3	-50	-42	-59	-44		
N-2	-41	-41	-49	-43		
N-1	-39	-36	-43			
N+1	-40	-37	-43			
N+2	-42	-38	-51	-47	-53	-45
N+3	-55	-44	-61	-48	-57	-48
N+4	-57	-47	<-62		-58	-46
N+5	-58	-48	<-62	-51	<-60	-48
N+6	-63		<-63		<-60	-47

<sup>5</sup> Martin, S., “Interference Rejection Thresholds of Consumer Digital Television Receivers Available in 2005 and 2006” FCC/OET Report 07-TR-1003

<sup>6</sup> Martin, S., RF Performance of DTV Converter Boxes---An Overview of FCC Measurements”, IEEE Transactions on Broadcasting, Vol. 56, No. 4, Dec. 2010, pp 441-451. See also the FCC report of the same testing: “DTV Converter Box Test Program---Results and Lessons Learned, FCC/OET 9-TR-1003, Sept 2009.

Table 2  
Measured Threshold D/U ratio values, in dB, for 90% of the Receivers Operating  
with a Desired Signal power D = -68 dBm

Interfering Channel w.r.t. Desired Signal	S. Martin 2010 DTV Set Top Converters (FCC tests) D/U at Threshold, dB		Gumm, Rhodes 2013 DTV Receivers D/U at Threshold, dB	
	1 U Sig.	2 U Sig.	1 U Sig.	2 U Sig.
N-6	-62			
N-5	-61	-42		
N-4	-60			
N-3	-53	-40		
N-2	-47	-41		
N-1	-40			
N+1	-40			
N+2	-47	-42	-48	-38
N+3	-55	-42	-53	-39
N+4	-59		-55	-39
N+5	-60	-42	-55	-40
N+6	-59		-58	-41

Notes:

- All values are Threshold D/U power ratios, expressed in dB. The undesired signals are larger than the desired causing the values to be negative. A more negative value denotes better receiver performance because it indicates that the undesired signal was larger in amplitude with respect to the DTV signal.
- All data is for a desired signal amplitude, D = -68 dBm.
- All data rounded to the nearest dB.
- All testing shown was performed in the UHF TV band.
- 1 U Sig means there was one undesired signal on the channel shown.
- 2 U Sig is data from the special case where the closest (in frequency) undesired signal was on the channel shown. A second undesired signal was positioned to maximize third order intermodulation that might be created within the receiver. That is, if the first undesired signal was on channel N+K, the second signal would be placed on channel N+2K. For example, if the first undesired signal was on channel N+2, the second undesired signal would be placed on channel N+4. This was fully explained by Mr. Stephen Martin in his Dec. 2010 “IEEE Transactions on Broadcasting” paper [6].
- 2U Sig D/U values are on a per channel basis; i.e., the power of only one undesired signal was used to calculate the D/U ratio.
- The 2005-2006 report [5] did not include 90% operating data.

## Assumptions Used in the Notice:

The Notice (page 5) uses the receiver performance expectations noted in Table 5A of OET-69. It is obvious from our Tables 1 and 2 that these expectations have seldom been met. Further, without research, it's unclear whether those expectations can ever economically be met. Thus the entire allocation method outlined in the Notice is based on an erroneous assumption.

Another assumption in the Notice is that the results obtained from DTV to DTV interference studies can be used to determine Wireless into DTV interference performance. Careful study of Table 7-2 (on page 7-2) of the FCC's report on 2005-2006 receivers [5] indicates that a 6 MHz, DVB-H OFDM signal will exhibit about 0.9 dB poorer D/U ratio than an equal power ATSC signal. While 0.9 dB may be "nearly identical to ATSC digital television", what is missing is a verification that wireless signals with unknown characteristics and different bandwidths exhibit a similar D/U performance to ATSC. Given the huge investment that rests on this assumption, testing with actual wireless signals is in order.

## Wireless Base Station to DTV Interference (Case 3):

One conclusion that may be drawn from our Table 1 is that with only one interfering signal, DTV set top converters performed better than the 2005-2006 receivers. The 2013 receivers also do very well when only one interfering DTV signal is applied. However, performance when two interfering DTV signals are applied with their frequencies chosen to maximize internal third order intermodulation, i.e. 2U interference has not changed appreciably with time.

Table 1 and Table 2 show that receivers are more susceptible to 2U interference when signals are on N+2 and N+4 but are also susceptible when they are on N+3 and N+6, on N+4 and N+8, on N+5 and N+10, etc. as well. The fact that the receivers are susceptible to situations where the second signal is ten or more channels (60 MHz) away indicates that most DTV receivers have ineffective pre-selection filters. Fewer interference problems would result during the upcoming DTV repacking process if the FCC modified Table 5A of OET-69 to reflect these receiver performance realities

The present DTV bands have been allocated using the rules set out in OET-69 for Co-Channel and Adjacent Channel interference. The present situation has not been disastrous but, as noted in our soon to be published paper [2], it is fairly easy to locate areas where DTV sets must contend with nearby signals on channels N+K and N+2K while trying to receive a distant signal on channel N. Antenna directivity helps but, at many sites the receiving antenna points towards both the desired and the undesired signals. Since the number of DTV transmitters is relatively small and because DTV transmitters tend to be grouped together, the number and size of these areas where receiver overload problems exist is presently relatively small.

However, the placement of a distributed array of broadband wireless transmitters throughout the DTV station's service area changes that picture. Due to the expense of creating a so many wireless sites, it's to be expected that each site will emit as many wideband signals as possible. It's then very plausible that many sites will be configured to emit spectrums similar to the N+K

and N+2K situation that DTV receivers are most sensitive to. Given that DTV receivers are sensitive to N+K and N+2K interference with K as large as 5 (60 MHz) the planned inter-service frequency separations shown in the Public Notice will ***not*** be sufficient alone to alleviate interference.

The problem created by Base Station (down link) LTE into DTV receiver interference (Case 3) is not overwhelming, at least when expressed as a percentage. We have made a rough estimate based on an ideal propagation using the FCC's UHF F(50,90) propagation chart. A DTV station with a 1 MW ERP and a 300 m HAAT was assumed as was a 10 km grid of LTE stations, each with two 600 W ERP signals at 30 m HAAT. The frequencies used by the LTE sites were assumed to be similar to an N+K and N+2K arrangement. For example, the desired signal could be on TV channel 47 and the wireless transmitters on wireless blocks B and D. Any third order distortion receiver products generated by signals in wireless blocks B and D are centered in channel 47.

Out to about 70 km from the DTV transmitter there should be few problems. Beyond 70 km, out to its 41 dBuV/m contour, there will be islands near each wireless station where DTV receivers will experience overloading by LTE signals on Blocks B & D in which case, DTV reception may fail. This situation should be modeled using modern CAD tools to determine better harmful interference estimates. Field measurements may also be in order.

While from a percentage viewpoint the interference problem may be small, from the individual viewer's viewpoint, the results may be overwhelming. Many individual viewers satisfied with their present service will suddenly be unable to receive at least some DTV signals. Given the FCC's long history of requiring broadcasters to aid viewers or listeners having reception problems near their transmitters, it seems reasonable that the wireless service providers should be required to help DTV viewers experiencing reception problems near their transmitters. This could take the form of the wireless operator providing the DTV viewer with an appropriate low pass filter as is being planned in Great Britain<sup>7</sup>.

It should also be noted that the OET-69's adjacent channel D/U specification was actually created to keep receivers from being desensitized by a nearby transmitter's adjacent channel splatter while trying to receive a distant signal. This brings up an issue of adjacent channel splatter from wireless transmitters, which seems to have been overlooked in the Notice. A wireless transmitter, depending on the quality of its channel filter, can emit intermodulation products three times its intended spectral width. That is, a transmitter with a 9 MHz transmission bandwidth will have significant intermodulation products to 9 MHz above and 9 MHz below the transmitter's channel. This may be limited to a much narrower bandwidth if appropriate filtering is employed, but this topic goes unanswered in the Notice.

#### Uplink Interference (Case 4):

Interference to DTV receivers by wireless handsets seems to have been dramatically underestimated in the Notice. First and foremost, it assumes that an outside antenna will be used

---

<sup>7</sup> ITU, "Protection of Digital Terrestrial Television Reception from Interference from Mobile Broadband Terminals Operating in Adjacent Spectrum", Document 4-5-6-7/218-E, 17 July 2013, pp 6.

over the entire service area of the DTV transmitter. Most urban viewers avoid the complications of an outdoor antenna. The authors have noted that urban viewers, acting on knowledge gained from neighbors and dealers tend to obtain an antenna sufficient to give them a moderate S/N margin at their site. With DTV, **enough** signal results in a picture with no noise or shadows; more is not useful or necessary. Indoor antennas are completely appropriate for the urban environment.

Because the antenna is in the same room as the viewer and the wireless handset user (often the same person) the distance between the two may be relatively small. This leads to high amplitude wireless fields impinging on the DTV antenna, raising the power of the receiver's U signal. Even if the wireless frequency is several channels away from the DTV signal, it may be sufficient to push the receiver below its 1U, D/U threshold. Greater harm will be done when a person in the next apartment initiates a wireless transmission, leaving the DTV viewer to wonder why his/her set has suddenly gone dead. Not only will there be problems with receiver overload, the handset's adjacent channel splatter may also desensitize nearby DTV3 receivers. It may be necessary to provide DTV receiver low pass filters for this problem also.

A great deal more study of the effects of handset transmission on DTV receivers needs to be made before it is assumed that there will be few interference problems from handsets.

## Conclusions:

An overly optimistic DTV receiver model is utilized. This, in turn, leads to overly optimistic assumptions about how little interference will be inflicted on DTV viewers.

Projections of down-link and up-link interference based on actual DTV receiver performance should be made. If, as it appears that there will be appreciable interference, then policy and plans should be made as to the rights and responsibilities of all the individuals that will be affected. To go forward without doing so is to court harm to many interested parties.

Overall, the Notice describes a very incomplete picture of the potential of interference from wireless service to DTV viewers.

Should it please the Commission, the authors will supply the FCC with our Test Data. Furthermore, if some additional tests are deemed important, the authors will endeavor to accommodate the Commission within our limited resources. We fully appreciate the enormous task confronting the FCC and wish to be helpful.