Comparison of FM Broadcast Signal Interference Areas with Current Digital Television Receivers on Channel 6 to Analog TV Receivers Assumed in 47 CFR 73.525

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Executive Summary

This report contrasts the potential interference to reception of digital TV channel 6 from NCE-FM signals, as measured with current digital television receivers, to the interference ratios employed in the FCC's rules protecting analog TV channel 6 stations (47CFR73.525). These rules were adopted in 1985, using interference measurements of analog (NTSC) television receivers available in 1979. In anticipation of the conversion to digital television broadcasting and termination of analog TV transmission in early 2009, NPR Labs conducted a full-scale study of consumer digital televisions for FM interference susceptibility, detailed in *Interference Rejection Thresholds of Consumer Digital Television Receivers on Channel 6 with FM Broadcast Signals, December 17, 2007*. The results of that study are used herein to illustrate the physical reduction in interference that may be caused to digital TV reception on channel 6, relative to the current analog protection rules.

The measurements for the digital TV study were carried out in the test facility at NPR Labs, in the Washington, DC headquarters of National Public Radio. The results are based on 17 digital television receivers selected to represent a wide range of currently-available digital television receivers. The receivers included two low-cost set-top boxes certified by the NTIA for coupon rebate, computer "USB stick" tuners, table-top sets and flat screen TVs from 19 to 50 diagonal inches. Picture impairment was determined at TOV (threshold of visibility), representing the most critical ratios of interference. The digital sound was also monitored for impairment for each receiver.

Figure 1- Improvement in mean DTV-6 Interference Ratios Relative to FCC Analog TV-6 Ratios

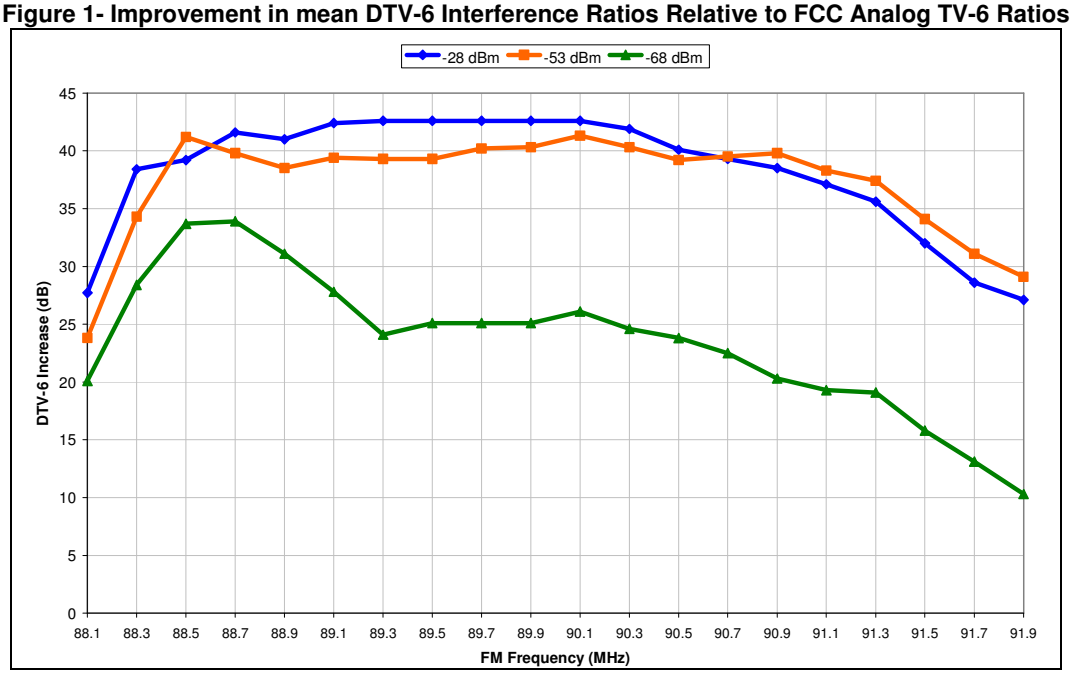


Figure 1 compares the differences between the measured interference ratios of the DTV receivers to the FCC's original ratios for analog TV receivers, on which the existing channel 6 protection rules are based, for non-commercial FM channels 201 to 220

(88.1 MHz to 91.9 MHz) on three desired signal powers representing strong, medium and weak signal strengths. The graph shows that the DTV-6 interference thresholds are from 10 to 43 dB better than the original analog receiver thresholds. It should be mentioned that the laboratory test bed was limited to an interfering signal power of +11.5 dBm (equivalent to the field strength produced by a 100 kW FM at one mile). Many of the receivers did not experience interference at some FM frequencies with desired signal powers at -53 dBm and -28 dBm (note the flattening in curves above 88.9 MHz). In these cases, the interference ratios were based on the maximum supplied by the test bed, even if the receiver exhibited no interference.

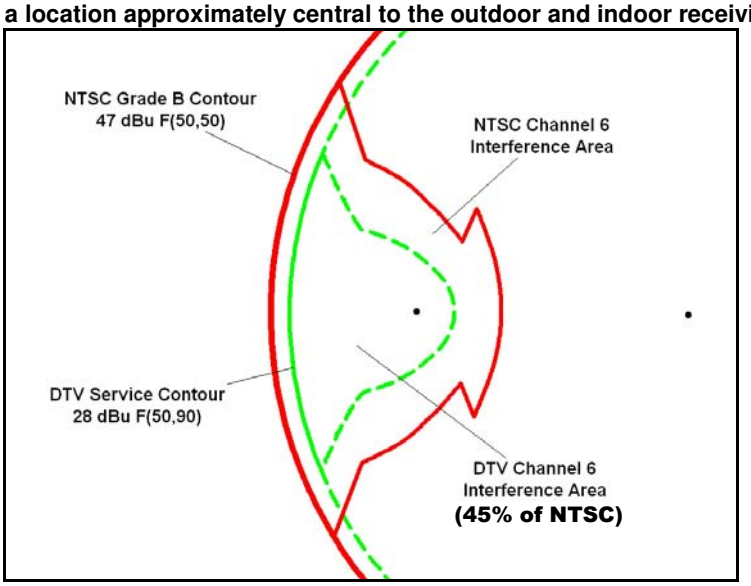
While Figure 1 provides evidence of the substantial improvement in interference ratios with current DTV receivers, the effect of these ratios in reducing interference areas may not be apparent. Therefore, the following section applies the ratios to calculations for several DTV and NTSC (analog) receiver interference examples and discusses the differences. Frequencies for the lowest, middle and highest NCE-FM channels were used. FM transmitter locations within the F(50,90) 28 dBu DTV Service Contour and the F(50,90) 59 dBu contour[1] were selected to represent the fringe or outdoor and indoor reception, respectively. As detailed below, the examples demonstrate that the DTV interference areas would range from 45 percent to as little as 2 percent of the comparable analog TV interference areas. Reduction in the interference populations would be equivalent, if the populations were distributed uniformly within the region.

[1] An omni-directional TV receive antenna pattern was used for an indoor receive antenna specified in the OET Bulletin No. 69 (February 2004), was locations inside the TV 59 dBμ F(50,90) contour to consider the use of
employed for locations outside the TV 59 dBμ F(50,90)5 contour to consider the use of an outdoor receive antenna

Calculation of Interference Areas

For the analog TV channel 6 station, the procedures specified in Section 73.525 of the Commission's rules were followed. A hypothetical facility with 100 kilowatts peak visual power was assumed at a height of 610 meters, representing the maximum facilities for an analog TV channel 6 operation in Zone II or Zone III. The site of the hypothetical TV channel 6 station is shown as a black dot near the right edge in Figure 1 and successive figures. This operation produces an F(50,50) 47 dBμ Grade B contour distance of 128.8 kilometers,[2] shown with a red contour arc.

Figure 2 – Outdoor TV channel 6 interference map for FM channel 201 for NTSC analog (red) and DTV (green) at a location approximately central to the outdoor and indoor receiving distances.



The hypothetical NCE-FM station is shown as the black dot near the center, within the interference area in each figure. A full Class B1 facility (25 kilowatts at 100 meters AAT) was assumed for the FM station on channel 201 (88.1 MHz). While the power and height of FM facilities varies widely, this facility was chosen as typical of new NCE-FM stations, which are frequently limited in power and height by protection to other FM stations. The analog TV channel 6 interference contour is shown as the irregularly-shaped contour, in red, bounded on the left by the TV Grade B contour.[3] The interference contours shown herein are scaled identically to the Grade B contour, with each assuming uniform (flat) terrain elevation.

[2] The maximum channel 6 TV height in Zone I for 100 kW is 305 m AAT, resulting in a smaller Grade B distance of 104.0 kilometers.

[3] All service contours and interference contours were calculated for NPR Labs by the consulting engineering firm Cavell Mertz & Associates, Inc., using the same computer program employed for NCE-FM applications involving routine TV channel 6 interference calculations.

The DTV 6 facility was assumed to be 45 kilowatts at 305 meters AAT, producing a F(50,90) service contour of 28 dBμ, shown in Figure 2 by a green arc, which is concentric to the analog Grade B contour.[4] This facility was intended to represent the maximum DTV operation on channel 6, rather than matching the analog channel 6 coverage. The NCE-FM interference contour was computed in the same manner as the analog TV channel 6 station, that is, per Section 73.525, with the following changes:

- The interference ratio for each NCE-FM channel was determined from the median DTV receiver interference threshold measurements at the appropriate FM channel, as described in *Interference Rejection Thresholds of Consumer Digital Television Receivers on Channel 6 with FM Broadcast Signals*, prepared by NPR Labs. As interference ratios measured at equivalent received signal powers of -68 dBm and -53 dBm were very similar, these ratios were averaged together and used for the interference predictions. (The report's interference measurements at a DTV signal power -28 dBm were not required for these examples.) The undesired to desired (U/D) signal level ratios provided by NPR Labs used to predict the location of FM interference are as follows:
    - Channel 201 Analog: 1.0 dB, DTV: 20.1 dB
    - Channel 209 Analog: 20.2 dB, DTV: 45.2 dB
    - Channel 219 Analog: 39.0 dB, DTV: 49.1 dB
- Using the DTV link budget described in FCC OET Bulletin No. 69, *Longley-Rice Methodology for Evaluating TV Coverage and Interference*, (February 6, 2004), an F(50,90) field strength of 59 dBμ was determined to represent the limit of indoor service, assuming average residential building penetration loss and a low-gain indoor antenna. Although real consumer antennas may provide some directivity and interference discrimination, the indoor receive antenna was assumed to be omnidirectional with a 0 dBd gain. This made the indoor calculations for DTV interference slightly worse than the "rabbit-ear" antenna specified by the FCC rules and used herein for analog TV channel 6 interference. To conform to the analog interference methodology contained in Section 73.525, building penetration loss was not included in the calculation of interference within the 59 dBμ DTV contour.
- Beyond the 59 dBμ field strength of the DTV channel 6 station, a directional TV receive antenna pattern as specified in FCC OET Bulletin No. 69 was assumed for the outdoor DTV receiving antenna. This pattern is less directive than the pattern specified in Section 73.525, which is a conservative assumption that would result in more calculated DTV interference.

[4] Although the FCC's link budgets for deriving analog Grade B and DTV Service Contour are comparable, it should be noted that the DTV link budget indicates the digital reception "cliff". Consumer reception may require a signal margin for reliable reception near the service limit, thereby reducing the distance to usable service contour and the corresponding NCE-FM interference area.

Figure 3 shows the calculated interference areas for indoor analog and digital TV channel 6 reception, using methods prescribed by Section 73.525 rules and the above modifications for DTV, respectively.

Figure 3 – Indoor TV channel 6 interference calculation map for FM channel 201 for NTSC analog (red) and DTV (green).

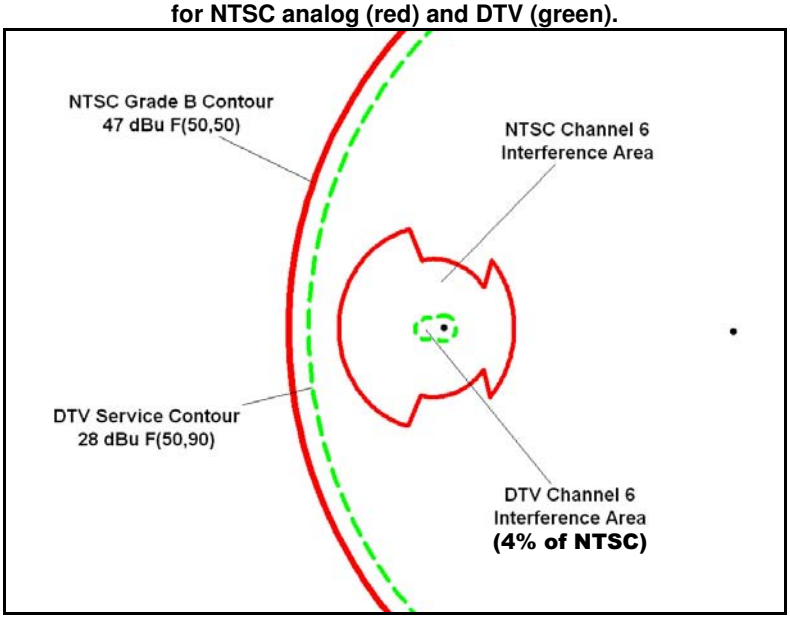


Figure 4 and Figure 5 show the respective interference areas for analog and digital TV channel 6 with FM channel 209. This channel is near the center frequency of the Reserved Band for noncommercial FM. Because of the large increase in allowable U/D ratios for both analog TV and DTV at FM channel 200, the interference area is substantially smaller than channel 201 in the first two examples. With a 25 dB U/D ratio advantage over analog TV, the DTV interference area is noticeably smaller for the indoor interference study. The indoor DTV interference includes a small lens-shaped piece at the 28 dBu DTV Service Contour, which was included in the area total. The differences in shape between the analog and digital interference contours are due in large part to the antenna directivities assumed for each service, as defined earlier herein.

Figure 4 - Outdoor TV channel 6 interference map for FM channel 209 for NTSC analog (red) and DTV (green).

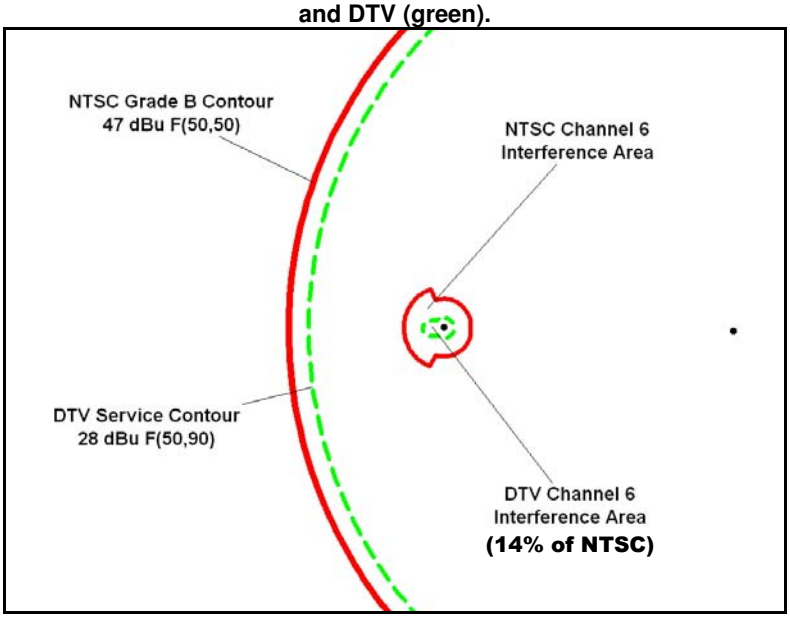


Figure 5 - Indoor TV channel 6 interference map for FM channel 209 for NTSC analog (red) and DTV (green).

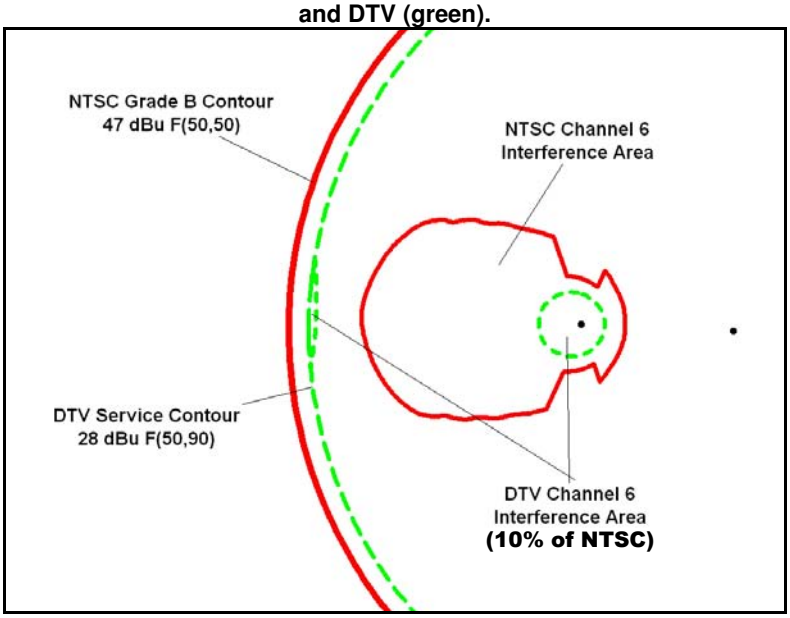


Figure 6 and Figure 7 provide a comparison between analog and digital TV channel 6 interference on channel 219, which is the highest channel in the Reserved Band. With the largest frequency separation from channel 6, these ratios are the most favorable to channel 6 for both analog and digital interference. Similar to the previous examples, the NCE-FM interference contours for DTV result in far smaller interference areas than for analog TV.

Figure 6 - Outdoor TV channel 6 interference map for FM channel 219 for NTSC analog (red) and DTV (green).

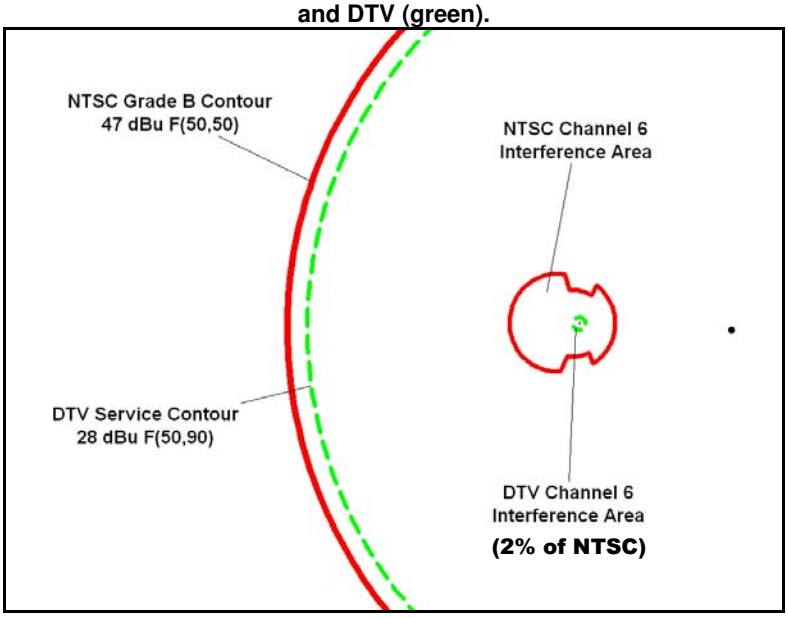
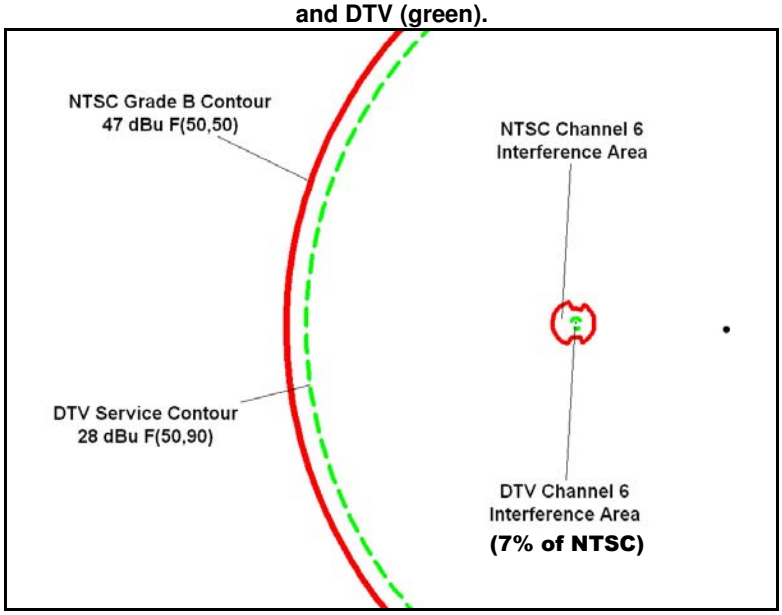


Figure 7 - Indoor TV channel 6 interference map for FM channel 209 for NTSC analog (red) and DTV (green).



The results of the calculated interference areas are summarized in Table 1. For each figure, the calculated area in square kilometers is shown for both NTSC and DTV interference. Figures 2, 3 and 4 depict interference where the hypothetical FM station is near the Grade B contour for NTSC or near the 28 dBu Service Contour for DTV. Figures 5, 6 and 7 depict interference for a NCE-FM station located near the Grade A contour for NTSC or a calculated 59 dBu field strength estimated for indoor DTV reception. The ratios of DTV interference area to NTSC analog are provided in the column to the right.

Table 1 - Calculation of interference areas

Figure Number	TV-6 System	Channel	FM Station Location	Area sq km	DTV Interference Area vs. NTSC Interference Area
2	NTSC	201	In Grade B (NTSC) or In Service Contour (DTV)	5601	45%
	DTV			2531	
3	NTSC	209		1908	4%
	DTV			69	
4	NTSC	219		295	14%
	DTV			40	
5	NTSC	201	In Grade A (NTSC) or In 59 dBµ (DTV)	3289	10%
	DTV			321	
6	NTSC	209		625	2%
	DTV			10	
7	NTSC	219		106	7%
	DTV			7	