

Working Draft
ATSC Recommended Practice Standard:
Transmission Measurement and Compliance for
Digital Television, Doc. A/64BA

Advanced Television Systems Committee

1750 K Street, N.W.

Suite 1200

Washington, D.C. 20006

www.atsc.org

The Advanced Television Systems Committee, Inc., is an international, non-profit organization developing voluntary standards for digital television. The ATSC member organizations represent the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

Specifically, ATSC is working to coordinate television standards among different communications media focusing on digital television, interactive systems, and broadband multimedia communications. ATSC is also developing digital television implementation strategies and presenting educational seminars on the ATSC standards.

ATSC was formed in 1982 by the member organizations of the Joint Committee on InterSociety Coordination (JCIC): the Electronic Industries Association (EIA), the Institute of Electrical and Electronic Engineers (IEEE), the National Association of Broadcasters (NAB), the National Cable Television Association (NCTA), and the Society of Motion Picture and Television Engineers (SMPTE). Currently, there are approximately 140 members representing the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

ATSC Digital TV Standards include digital high definition television (HDTV), standard definition television (SDTV), data broadcasting, multichannel surround-sound audio, and satellite direct-to-home broadcasting.

Table of Contents

1.	FOREWORD	4
2.	SCOPE	4
3.	REFERENCES	4
4.	DEFINITIONS	5
5.	TRANSMISSION MEASUREMENT AND COMPLIANCE	5
5.1	8-VSB modulation (Trellis coded)	5
5.1.1	Maximum Out-of-Channel Spectrum Emissions	5
5.1.2	In-Channel Signal Characterization	10
5.1.3	Symbol Rate Tolerance	10
5.1.4	Pilot Carrier Phase Noise and Jitter	10
5.1.5	Power Specification and Measurement Principles	10
5.1.6	Frequency Offsets and Stability	11
5.1.7	Synchronization Signals	12
5.2	16-VSB Modulation	13
5.2.1	Emission Mask	13
5.2.2	In-Channel Signal Characterization	13
5.2.3	Symbol Rate Tolerance	13
5.2.4	Pilot Carrier Phase Noise and Jitter	14
5.2.5	Signal Level Specification	14
5.2.6	Frequency Offsets and Stability	14
5.2.7	Synchronization Signals	14

List of Figures

Figure 5.1 FCC DTV emission mask (based on measurement bandwidth of 500 kHz).	6
Figure 5.2 NTSC weighting function.	9

Working Draft
ATSC Recommended Practice Standard:
Transmission Measurement and Compliance for Digital Television,
Doc. A/64BA

1. FOREWORD

This ~~document standard~~ was prepared by the Advanced Television Systems Committee (ATSC) Technology ~~and Standards~~ Group (TSG). ~~This on Distribution (T3). The~~ document was initially approved by the members of T3 on July 23, 1997 for submission by letter ballot to the membership of the full ATSC as an ATSC Standard. The document was approved by the members of the ATSC on 17 November 1997 as Document A/64. Revision A of A/64, which includeds the revised FCC DTV emission mask, and specifieds that Document A/64 and its revisions are this Standard is for use in the United States and not world-wide, was approved by the members of ~~the T3 on January 24, 2000 and by the Members of~~ ATSC on 30 May 2000. Revision B of A/64 converted the document from a Standard to a Recommended Practice as no element was deemed essential for correct operation; updated references; and made certain editorial changes. Revision B was approved by the members of the ATSC on <date>.

2. SCOPE

This ATSC ~~Recommended Practice Standard document~~ describes methods for testing, monitoring, and measurement of the transmission subsystem intended for use in the digital television (DTV) system adopted as the U.S. Standard by the Federal Communications Commission. Both 8-VSB and 16-VSB are described in this document.

Furthermore, this document describes specifications for maximum out-of-~~channelband~~ emissions, parameters affecting the quality of the in-~~channelband~~ signal, symbol error tolerance, phase noise and jitter, power, power measurement, frequency offset and stability. In addition, the condition of the RF symbol stream upon loss of MPEG transport packets is described.

3. ~~NORMATIVE REFERENCES~~

The following documents contain provisions which, through reference in this text, also constitute provisions of this ~~Recommended Practice Standard~~. At the time of publication, the editions indicated were valid. All ~~standards documents~~ are subject to revision, and parties to agreement based on this ~~standard Recommended Practice~~ are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

~~[1] ATSC Standard A/53, ATSC Digital Television Standard.~~

~~[2] ATSC Standard A/52, Digital Audio Compression (AC-3).~~

[13] IEEE: "Use of the International Systems of Units (SI): The Modern Metric System", Doc. IEEE/ASTM SI 10-2002, Institute of Electrical and Electronics Engineers, New York, N.Y., 2002. IEEE Standard, 100-1992, The New IEEE Standard Dictionary of Electrical and Electronic Terms.

~~[4] ITU-R Recommendation BT.1206: Spectrum Shaping Limits for Digital Terrestrial Television Broadcasting.~~

[25] FCC Rules and Regulations, Parts 73 and 76, Federal Communications Commission, Washington, D.C.

4. DEFINITIONS

~~With respect to definition of terms, abbreviations, and units, the practice of the Institute of Electrical and Electronics Engineers (IEEE) as outlined in the Institute's published standards are used [1]. units, the practice of the Institute of Electrical and Electronics Engineers (IEEE) as outlined in the Institute's published standards are used [3]76.~~

~~4. COMPLIANCE NOTATION~~

~~As used in this document, "shall" or "will" denotes a mandatory provision of the standards. "Should" denotes a provision that is recommended but not mandatory. "May" denotes a feature whose presence does not preclude compliance, that may or may not be present at the option of the implementers.~~

5. TRANSMISSION MEASUREMENT AND COMPLIANCE

5.1 8-VSB modulation (Trellis coded)

5.1.1 Maximum Out-of-~~ChannelBand~~ Spectrum Emissions

5.1.1.1 Specification of DTV ~~Outout-of-Channelband~~ Emission Mask from FCC Memorandum Opinion and Order on Reconsideration of the 6th Report and Order, Released 23 February 1998

The DTV emission mask was adopted in FCC Memorandum Opinion and Order on Reconsideration of the 6th Report and Order, Released 23 February 1998, and codified in Section 73.622(h) of the FCC Rules (47 CFR 73.622). The order requires that:

- 1) *in the first 500 kHz from the authorized channel edge, transmitter emissions must be attenuated no less than 47 dB below the average transmitted power;*
- 2) *more than 6 MHz from the channel edge, emissions must be attenuated no less than 110 dB below the average transmitted power; and*
- 3) *at any frequency between 0.5 and 6 MHz from the channel edge, emissions must be attenuated no less than the value determined by the following formula:*

Attenuation in dB = 11.5 (Δf + 3.6) where Δf = frequency difference in MHz from the edge of the channel.

All attenuation limits are based on a measurement bandwidth of 500 kHz. Other measurement bandwidths may be used as long as appropriate correction factors are applied. Measurements need not be made any closer to the band edge than one half of the resolution bandwidth of the measuring instrument. Emissions include sidebands, spurious emissions and radio frequency harmonics. Attenuation is measured at the output terminals of the transmitter (including any filters that may be employed). In the event of interference caused to any service, greater attenuation may be required.

Figure ~~45.1~~ shows the FCC Emission Mask in graphical form.

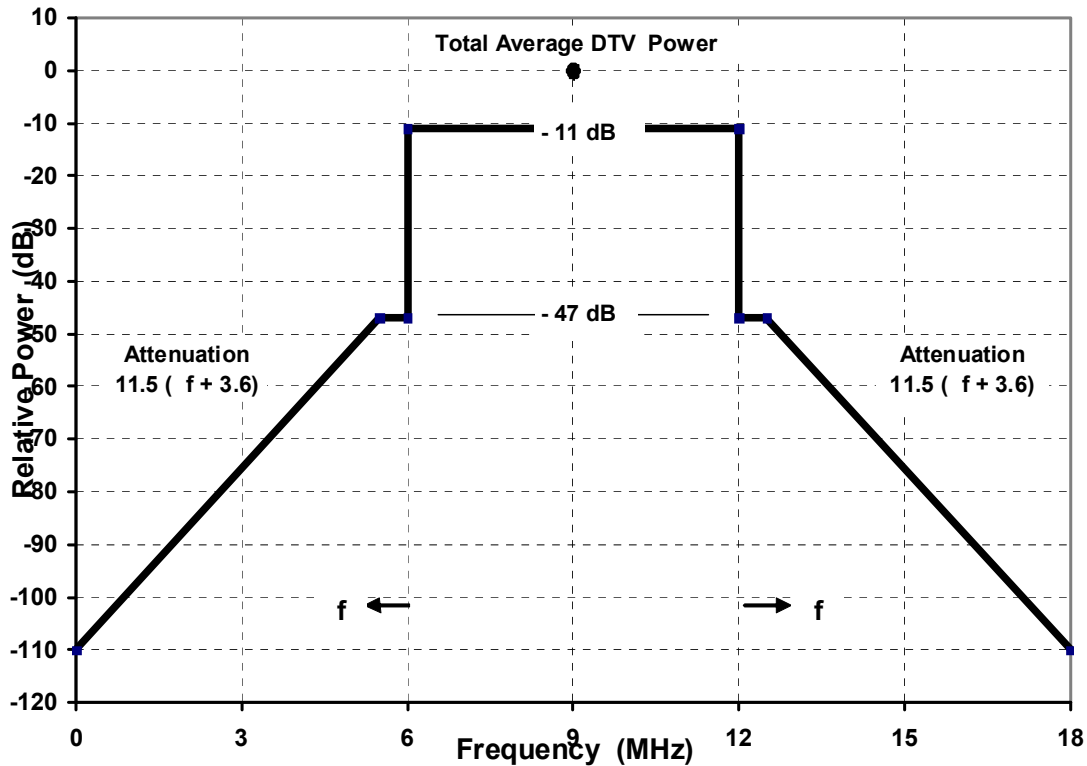


Figure 45.1 FCC DTV emission mask (based on measurement bandwidth of 500 kHz).

5.1.1.2 Specification of DTV out-of-channel radiation using a weighting function to quantify interference to first adjacent channel NTSC assignments

This section is useful as an analytical tool in cases where the DTV spectral sidelobes meet the requirements of 45.1.1.1 but have different spectral shapes than an exact match specified there, and/or, where the ratio of DTV and NTSC field strengths varies due to transmitting antenna azimuth and elevation pattern (beam tilt), location and terrain differences, or for determining the interference levels to NTSC Services in addition to population affected by DTV power increase or other allocation changes under the FCC's de minimus Standard.

The out-of-channel measurement specification defined in this section is based upon measurements made at the Advanced Television Test Center (ATTC) to determine NTSC's Threshold of Visibility (TOV) for 500 kHz wide noise sources centered at various points across the NTSC channel. This work determined an appropriate "weighting function," which is rounded to the nearest dB to obtain this specification. A "weighting function" approach allows some flexibility in spectral sidelobe details, while still achieving completely adequate protection of adjacent NTSC channels. This specification is defined in terms of Desired-to-Undesired ratio (D/U) and a 500 kHz measurement bandwidth. This definition specifically recognizes that the required attenuation of DTV spectral sidelobes depends on the relative power levels of the DTV signal and an NTSC signal in the adjacent channel over the NTSC coverage area.

Work done at ATTC showed that noise with a flat spectrum across the 6 MHz NTSC channel which has a power that is at least 51 dB below NTSC peak of sync was adequate to avoid TOV interference with the NTSC signal, based on the median of the receivers tested. Weighting such a

flat spectrum of noise with the weighting function results in a weighted TOV power level that is 5 dB lower, or at 56 dB below NTSC peak-of-sync power.

For various shaped noise or noise-like distributions across the NTSC channel, it has been verified that as long as the weighted noise is at least 56 dB below NTSC peak-of-sync power, then TOV is avoided. Here, the NTSC noise interference is viewed as arising from the non-flat spectral sidelobes of an adjacent channel DTV transmitter. If the ratio of DTV average power to NTSC peak-of-sync power is

$$\left(\frac{DTV}{NTSC} \right)_{dB},$$

then to avoid NTSC TOV the DTV sidelobes in the adjacent NTSC channel, when weighted and summed across the 6 MHz channel, ~~are to must~~ be attenuated below average DTV transmitter power by at least

$$\left(56 + \left(\frac{DTV}{NTSC} \right)_{dB} \right) \text{ dB.}$$

For example, if the DTV average power is 12 dB below the NTSC peak power,

$$\left(\frac{DTV}{NTSC} \right)_{dB} = -12 \text{ dB,}$$

the weighted DTV sidelobe power in an adjacent channel needs to be attenuated at least $56 - 12 = 44$ dB below DTV average signal power for this case.

Further work done at the ATTC determined that in order to avoid the Threshold of Audibility (TOA) on the NTSC audio channel, the power measured in the upper 500 kHz segment of the NTSC channel ~~are to must~~ be attenuated at least 48 dB below NTSC peak-of-sync power, or

$$48 + \left(\frac{DTV}{NTSC} \right)_{dB}$$

below the DTV average power. This was for a ratio of visual-to-aural carrier powers of 13 dB. Less attenuation is required for lower visual-to-aural ratios.

The protection of the adjacent NTSC channel against TOV and TOA leads to the following out-of-~~channelband~~ DTV spectral emission specification:

- a) To protect against adjacent channel NTSC TOV, out-of-~~channelband~~ DTV spectral emissions measured in an adjacent 6 MHz wide channel, when weighted by the weighting function, should be attenuated below the DTV average transmitter power by at least

$$56 + \left(\frac{DTV}{NTSC} \right)_{dB} \text{ dB.}$$

- b) Additionally, to protect against adjacent channel NTSC TOA, the power measured in the uppermost 500 kHz segment of an adjacent channel should be attenuated below DTV average power by at least

$$48 + \left(\frac{DTV}{NTSC} \right)_{dB} \text{ dB.}$$

This assumes a visual-to-aural carrier power ratio of 13 dB.

- c) Finally, the unweighted power in any non-adjacent 6 MHz channel should be attenuated below DTV average power by at least 110 dB.

Where:

$$\left(\frac{DTV}{NTSC} \right)_{dB} = 10 \log_{10} \left(\frac{\text{Average Power of the DTV Signal in the 6 MHz channel}}{\text{Peak Sync Power of Adj. channel NTSC Signal}} \right)_{MAX}$$

i.e., the maximum ratio of received DTV power compared to an adjacent NTSC channel peak-of-sync power at any location within the DTV coverage area where the NTSC channel's coverage is to must be protected. This measured ratio includes any effects of different DTV and NTSC transmitting antenna patterns.

The algorithm to determine weighted noise power of a spectral density distribution across a 6 MHz NTSC Television channel is as follows:

The distribution is divided into twelve 500 kHz frequency bands. Beginning with the band at the low frequency end of the channel, the power in each band, in turn, is weighted with the following weighting function sequence: -27 dB, -13 dB, -3 dB, -2 dB, 0 dB, -1 dB, -4 dB, -9 dB, -10 dB, -4 dB, -10 dB, minus infinity dB. The total weighted picture interference is the power sum of all 12 weighted bands. (See Section 45.1.1.2 (a), above.)

The sound interference is determined by the 12th frequency band only and is weighted by 0 dB. (See Section 45.1.1.2 (b), above.)

The NTSC weighting function is plotted in Figure 45.2.

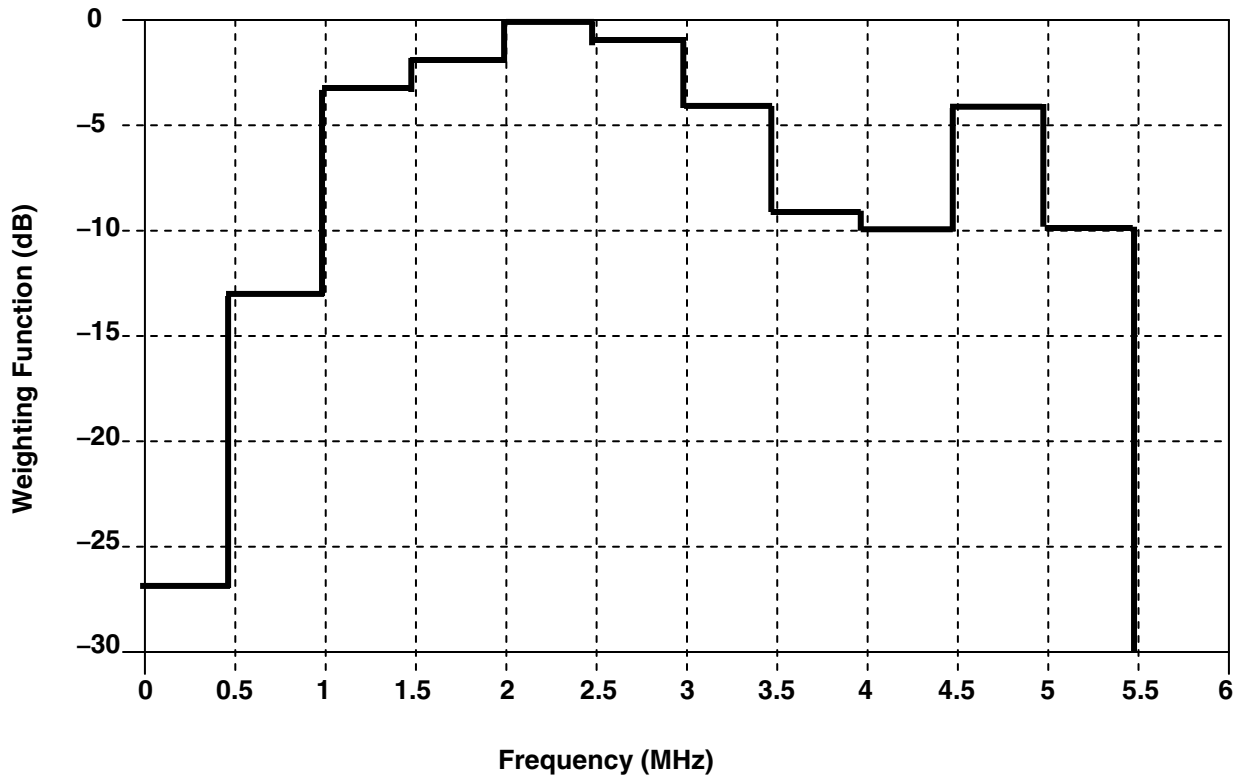


Figure 45.2 NTSC weighting function.

5.1.1.3 Specification of DTV Out-of-Channel Band Radiation to Protect Adjacent Channel DTV Assignments

The FCC requires that the out-of-channel band radiation from all DTV transmitters comply with the emission mask specified in the FCC Opinion and Order on Reconsideration of the 6th Report and Order Released 23 February 1998. (See Section 45.1.1.1.) As an analytical tool for various co-located (within 5 km) DTV adjacent channel relative power levels where the DTV splatter side-lobes shape exactly match the FCC DTV emission mask (See Section 45.1.1.1), the following is helpful:

- 1) For 0.1 dB degradation to the fringe area performance (15 dB SNR threshold) of a DTV channel having DTV adjacent channel assignments, the sum of authorized effective radiated powers of the adjacent channels should not exceed twenty (20) times the authorized effective radiated power of the transmitter of that DTV channel so that an effective signal-to-noise ratio of 31 (44 – 13) is maintained in that channel, and
- 2) For 0.25 dB degradation to the fringe area performance (15 dB SNR threshold) of a DTV channel having DTV adjacent channel assignments, the sum of authorized effective radiated powers of the adjacent channels should not exceed fifty (50) times the authorized effective radiated power of the transmitter of that DTV channel so that an effective signal-to-noise ratio of 27 dB (44 – 17) is maintained in that channel.

If the center channel of three DTV assignments is taken as the reference desired channel (N), the spectral spillover from each adjacent channel (N+1, N-1) is power additive as interference to the desired (N) channel. Since the spectral spillover power bears a direct relationship to the

authorized power of the channel transmitter causing it, the sum of spectral spillover coming from the channel on both sides, i.e. the interference to the desired channel (N), is directly proportional to the sum of the effective radiated powers in the adjacent channels (N+1, N-1).

The average adjacent channel power in a DTV signal whose splatter exactly matches the FCC Emission Mask is 44 dB below the in-channel average power. Where the transmitter side-lobe interference average power (N+1 or N-1) is lower than minus (-) 44 dB (more dB in the negative direction), interference level to the desired channel (N), (due to transmitter filtering and/or improved linearity), the permitted effective radiated power of such a DTV transmitter is increased in direct proportion to that side-lobe power reduction.

5.1.2 In-Channel Signal Characterization

The quality of the in-channel emitted signal can be specified and measured by determining the departure from 100 percent “eye” opening (this requires a reference receiver). The departure, or error, has four identifiable components: 1) circuit or “white” noise, 2) intermodulation noise caused by non-linearities, 3) intersymbol interference, and 4) phase noise. The combination of all of these effects can be specified and measured by an error (or noise) magnitude power.

The error magnitude power for a DTV signal should be no greater than -27 dB relative to the authorized signal power. The signal-to-noise (error-magnitude) power ratio is sometimes referred to as SNR (MER); i.e., signal-to-noise ratio, or modulation error ratio. An error power of this level will increase (worsen) the received DTV error threshold by a maximum value of about 0.25 dB, which for UHF assignments corresponds to a reduction of approximately 1/4 mile in coverage distance from the transmitter. The error is the total power of all the above errors along the in-phase demodulation axis, and is considered as “noise” when measuring signal-to-noise ratio.

5.1.3 Symbol Rate Tolerance

The symbol rate ~~is shall be~~

$$f_{sym} = 4.5 \cdot \frac{684}{286} \text{ MHz} \pm 30 \text{ Hz} \approx 10,762,237.8 \text{ Hz} (\pm 2.79 \text{ ppm})$$

Notes:

- 1) The symbol rate f_{sym} is locked to the transport stream data rate f_{tp} in the exact ratio:

$$f_{sym} = \frac{1}{2} \cdot \frac{208}{188} \cdot \frac{313}{312} \cdot f_{tp}$$

The approximate value of f_{tp} is: $\sim 19,392,658.5 \pm 54 \text{ Hz}$.

- 2) The tolerances on f_{sym} and f_{tp} provide a reference suitable for generation of the NTSC color subcarrier frequency in devices which translate the digital signal to NTSC, with a tolerance of $\pm 10 \text{ Hz}$.

5.1.4 Pilot Carrier Phase Noise and Jitter

The level of (pilot) carrier phase noise should be no greater than -104 dBc/Hz @ 20 kHz offset from the carrier frequency.

5.1.5 Power Specification and Measurement Principles

Background: The present NTSC service allows a power variation ranging between 80 percent and 110 percent of authorized power. These values correspond to -1.0 dB and +0.4 dB,

respectively. Because of the so-called “cliff effect” at the fringes of the service coverage area for a digital DTV signal, the allowable lower power value will have a direct effect on the DTV threshold. A reduction of 1.0 dB in transmitted power will change the DTV threshold of 15 dB (which has been determined to cause a 3×10^{-6} bit error rate which corresponds to 1.9×10^{-4} packet error rate) to 16 dB, or for UHF assignments approximately a one mile reduction in coverage distance from the transmitter.

Therefore, the average power of the DTV transmitted signal should be specified and measured as follows:

The lower allowed power value should be 95 percent of authorized power and the upper allowed power value should be 105 percent of authorized power.

A conventional full-wave rectifier type of power meter will register approximately 1 dB lower than the true power on “white” noise. It has not been determined what the reading will be when measuring DTV power. It is suggested that DTV stations use a calorimeter type true power measurement method to re-calibrate the rectifier type of power meter if used. The power reading should have an uncertainty no worse than 5 percent, and preferably better, in order to have minimum impact on DTV coverage.

5.1.6 Frequency Offsets and Stability

Several interference mechanisms need to must be considered in selecting the DTV frequency offsets. assignments. These are: 1) DTV-into-DTV co-channel, 2) NTSC-into-DTV co-channel, and 3) DTV-into-NTSC upper adjacent channel. Other interference effects (i.e., lower adjacent, taboos, DTV-into-NTSC co-channel, etc.) are insensitive to frequency offset. In each case, the dominant interference will determine which frequency offset will have precedence. The DTV offsets in each case below track the assigned offsets to the NTSC station (i.e., -10 kHz, 0 kHz, $+10$ kHz).

These proposed offsets are not modifications to the ATSC Standard. Rather, these offsets are specific solutions that account for interference effects encountered during the actual channel allocation process.

5.1.6.1 Co-channel DTV-to-DTV Offset

In the DTV co-channel interference condition, it has been found that a DTV pilot frequency offset that is an odd multiple of half the DTV segment rate provides improved interference rejection. There are several choices that meet this requirement. An offset of 1.5 times the segment frequency (i.e., 19,403 Hz) appears to provide the best performance. The frequency tolerance of the DTV transmitters should be ± 10 Hz.

5.1.6.2 Co-channel NTSC-to-DTV Offset

For the NTSC-to-DTV co-channel interference condition, the best performance is obtained if the DTV signal is aligned such that the NTSC visual carrier is located near the notch of the DTV receiver’s NTSC rejection comb filter. Additionally, the DTV receiver clock recovery performance is most robust if the visual carrier location is chosen to be near an odd multiple of half of the segment frequency. The DTV pilot frequency should be below the NTSC visual carrier frequency by 70.5 times the segment frequency (i.e., 911,944 Hz) for best performance. This should be with a tolerance of ± 1 kHz.

5.1.6.3 Upper Adjacent Channel DTV-into-NTSC Offset

For interference caused by the upper adjacent DTV-into-NTSC, tests at the ATTC have shown that the DTV pilot carrier may appear as a chrominance beat in the NTSC image on some sets. An improved alignment between the DTV pilot and the NTSC chroma subcarrier is selected to

be an odd multiple of half the NTSC line rate. This causes the chrominance beat pattern to alternate at the NTSC scan line rate. This reduces the visibility of the chroma beat interference. The offset proposed by the ATTC is 95.5 times the NTSC horizontal scan rate. This allows a tolerance of ± 1 kHz on both the NTSC and DTV transmitters. The frequency of the DTV pilot can be expressed in terms of the frequency of the NTSC visual carrier on the lower channel and the NTSC horizontal scan rate.

$$F_p(n) = F_v(n-1) + \frac{455}{2} F_h + 95.5F_h$$

It has been found that when this frequency is chosen as the offset, an underlying high-frequency luminance beat of 5.0821678 MHz is also then produced. An additional refinement to the frequency offset between the DTV and NTSC signals produces an alternating beat pattern at both the NTSC frame and line rates. This proposal specifies a difference between the DTV pilot frequency and the NTSC chroma carrier frequency of 95.5 times the NTSC line rate minus the NTSC frame rate.

$$F_p(n) = F_v(n-1) + \frac{455}{2} F_h + 95.5F_h - 29.97$$

This additional refinement provides a reduction in visibility of upper adjacent DTV interference into NTSC, but it requires a tighter frequency control on the NTSC transmitter to maintain a frequency difference of ± 3 Hz. This [frequency difference](#) specification is required to be met by all DTV stations operating in an adjacent channel above an NTSC channel. The FCC specification [for this](#), contained in the Memorandum Opinion and Order on Reconsideration of the 6th Report and Order, Released 23 February 1998 [and codified in Section 73.622 of the FCC Rules \(47 CFR 73.622\)](#) is:

(g) *DTV stations operating on channels above an analog TV station.*

(1) *DTV stations operating on a channel allotment designed with a "c" in paragraph (b) of this section must maintain the pilot carrier frequency of the DTV signal 5.082138 MHz above the visual carrier frequency of any analog TV broadcast station that operates on the lower adjacent channel and is located within 88 kilometers. This frequency difference must be maintained within a tolerance of ± 3 Hz.*

5.1.7 Synchronization Signals

It can be expected that in broadcast operations the transmission modulator will sometimes be fed with corrupted MPEG transport packets, which can result in loss of, or incorrectly timed, sync and clock signals. In such cases, the receiver will go out of lock and thereby prolong the disruption of service.

The transmitted RF VSB symbol stream should retain continuity throughout the time of [any](#) loss of MPEG-packets at the VSB modulator input. VSB segment and field syncs [are required to](#) ~~should~~ be transmitted at all times, with no significant phase discontinuities, and the symbol clock frequency should remain within the ± 2.79 ppm tolerance without significant phase discontinuity. [If](#) ~~One~~ MPEG-data is determined to be absent or corrupted [at any stage before the modulator](#), a null MPEG transport packet should be inserted into the path. [This is](#) prior to the VSB processing (i.e., randomizing, Reed Solomon encoding, interleaving, trellis encoding, etc.) [by the exciter](#).

5.2 16-VSB Modulation

5.2.1 Emission Mask

The present rules in ~~Federal Section~~~~Communication Commission Regulation Part~~ 76.605 of the FCC Rules (47 CFR 76.605), Technical Standards, cover specifications for disturbances such as intermodulation, which are entirely adequate for 16-VSB signal carriage by high data rate media, and no specific emission mask is required [24].

5.2.2 In-ChannelBand Signal Characterization

The quality of the in-channelband signal as received can be specified and measured by determining the departure from 100 percent “eye” opening. The departure, or error, has four components:

- 1) White noise,
- 2) Intermodulation disturbances caused by non-linearities,
- 3) Intersymbol interference, and
- 4) Phase noise.

The combination of all of these effects can be specified and measured by an error (or noise) magnitude. The first component will be no worse than –43 dB relative to peak of NTSC sync as measured in a 4 MHz band. The equivalent in 6 MHz is –41.2 dB. The 16-VSB signal level is typically 6 dB lower than the equivalent NTSC sync. Therefore, the maximum noise level relative to the 16-VSB signal average power in a 6 MHz band is –35.2 dB. The second component intermodulation disturbances are required to be –47 dB relative to NTSC peak of sync or, equivalently, –41 dB relative to 16-VSB average power. The third component, intersymbol interference, is best measured and specified at the output of the 16-VSB modulator and phase noise can be measured at the local upconversion oscillator. The power sum of all components along the in-phase axis is the error or noise when measuring signal-to-noise ratio.

The theoretical signal to noise ratio threshold for 16-VSB modulation which produces a bit error rate of 3×10^{-6} (which corresponds to a packet error rate of 1.9×10^{-4}) is 28.4 dB. Therefore, an intersymbol interference error magnitude for 16-VSB signal no greater than –32 dB relative to the 16-VSB power will produce a total error magnitude no greater than –31.4 dB which is a margin of 3 dB with respect to the threshold of 28.4 dB.

5.2.3 Symbol Rate Tolerance

The symbol rate should be

$$f_{sym} = 4.5 \cdot \frac{684}{286} \text{MHz} \pm 30\text{Hz} \approx 10,762,237.8\text{Hz} \quad (\pm 2.79 \text{ppm})$$

Notes:

- 1) The symbol rate f_{sym} is required to be locked to the transport stream data rate f_{tp} in the exact ratio:

$$f_{sym} = \frac{1}{4} \cdot \frac{208}{188} \cdot \frac{313}{312} \cdot f_{tp}$$

The approximate value of f_{tp} is: $\sim 38,785,316.9 \pm 108$ Hz.

- 2) The tolerances on f_{sym} and f_{ip} provide a reference suitable for generation of the NTSC color subcarrier frequency in devices which translate the digital signal to NTSC, with a tolerance of ± 10 Hz.

5.2.4 Pilot Carrier Phase Noise and Jitter

The level of (pilot) carrier phase noise should be no greater than -104 dBc/Hz @ 20kHz offset from the carrier frequency.

5.2.5 Signal Level Specification

The service provider should provide, at the receiver, -6 dBmV average DTV signal level in 6 MHz. Since the noise and other disturbances are specified with respect to the signal level, there is no effect on 16-VSB threshold and therefore no other signal level specification is required.

5.2.6 Frequency Offsets and Stability

The pilot carrier frequency tolerance should be ± 1 kHz. Frequency offsets are not needed in a controlled signal level environment where DTV average power is at least 6 dB below adjacent channel NTSC peak-of-sync power.

5.2.7 Synchronization Signals

It can be expected that in cable operations the transmission modulator will sometimes be fed with corrupted MPEG transport packets, which can result in loss of, or incorrectly timed, sync and clock signals. In such cases, the receiver will go out of lock and thereby prolong the disruption of service.

The transmitted RF VSB symbol stream should retain continuity throughout the time of loss of MPEG-packets at the VSB modulator input. VSB segment and field syncs should be transmitted at all times, with no significant phase discontinuities, and the symbol clock frequency should remain within the ± 2.79 ppm tolerance without significant phase discontinuity. Once MPEG-data is determined to be absent or corrupted, a null MPEG transport packet should be inserted into the path prior to the VSB processing (i.e., randomizing, Reed Solomon encoding, interleaving, trellis encoding, etc.).

– End of Document –