White Paper

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- Post Digital Television Transition -
The Evaluation and Mitigation Methods for Off-Air Digital Television Reception in-and-around Wind Energy Facilities

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Abstract
Planned for February 2009 and now rescheduled for June 12th, 2009, the switch over to digital modulation from analog for all of the United States' high-power Television Broadcasters will have a positive impact on the deployment of wind energy facilities. Digital modulation will improve the video quality for all who rely on terrestrial off-air broadcast signals and even for those who are in the vicinity of wind energy facilities. Gone will be the degradation referred to as 'shimmering'; the video variations in contrast and brightness, and ghosting caused by wind turbines to the reception of analog television signals. New digital converter boxes and televisions with built-in digital receivers will have improved sensitivity necessary for receiving digital television off-air programming and will also allow the reception of better quality video in remote areas where wind energy facilities are normally installed.

However, the impact of wind turbines on digital television (DTV) remains. This is most crucial in the fringe areas of DTV service where relatively minor signal attenuation from an obstruction can result in going from a high quality video picture to "no signal found" because of the nature of digital modulation. Due to this change in terrestrial television broadcast technology, new evaluation and mitigation methods will need to be utilized to deal with the environmental impact that wind turbines will have to digital television reception. To understand the new approach, a description of digital television broadcast will be presented and then a description of how the evaluation of the reception of digital television signals in the vicinity of wind energy facilities can be undertaken.

Introduction

The year 2009 will be a memorable year for terrestrial television broadcasting. It will mark the event when the total changeover in the terrestrial television signal modulation from analog to digital takes place. This changeover was due to take place on February 17th, 2009 by Congressional mandate but was delayed until June 12th, 2009 because the government could not fill the large demand for purchase coupons for the set top boxes that were necessary for the television sets owned and in use that did not have digital receivers. On February 17th about 500 of the 1800 U.S. terrestrial television high-power stations had already switched their broadcast modulation to exclusively digital modulation. The other 1300 stations were still broadcasting their programming in both analog and digital formats. But on June 12th all high-power stations must cease their analog operations and all broadcasts must be in digital format.

Exempt from the digital requirement are low-power TV broadcasters. This applies to low-powers stations, Class A broadcasters and translators. There are 7100 of these stations in the Unites States with the majority being translators. Since translator stations just rebroadcast high-power stations to a limited local audience, although not required to be in digital, it is expected they will be because they just rebroadcast what they receive from the

Figure 1. High Power TV Stations in the United States

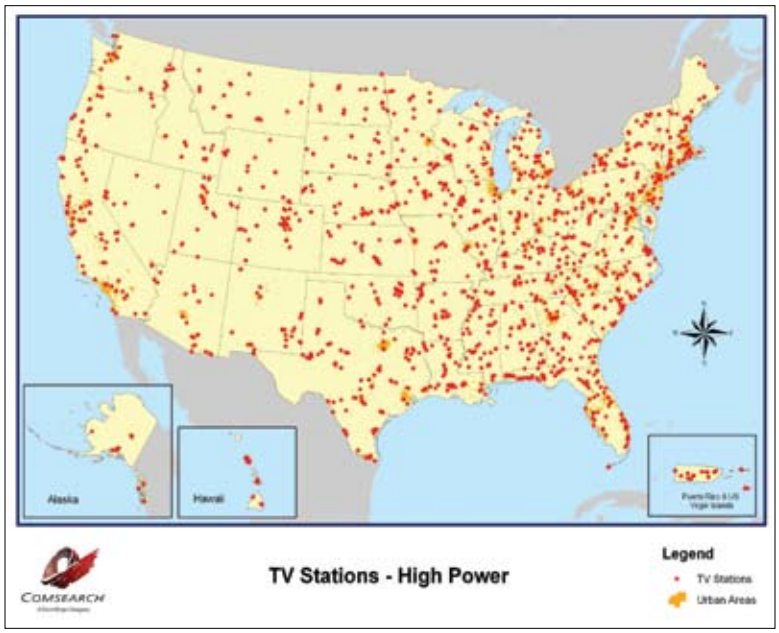
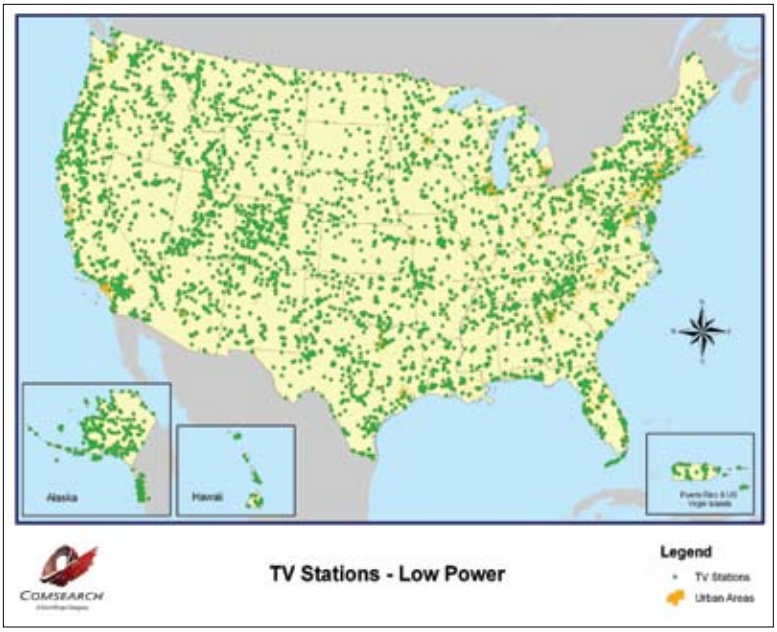


Figure 2. Low Power TV Stations in the United States



high-power stations. Figure 1 is a plot of the locations of all the high-power television stations in the U.S. Figure 2 is a plot of the locations of all the low-power television stations in the U.S.

For certain wind energy facility developments in the U.S., the off-air television reception in the presence of wind turbines has been a very difficult issue. The reason for this has been that most wind energy facility developments are in locations that are at a considerable distance from the metropolitan areas where the television broadcasters are normally located. This means that the television signals are usually marginal or weak in the areas near wind energy facilities. When the wind turbines are installed and operating, they tend to have three dynamic affects on signals that make reception worse; they attenuate the signal making it weaker, they cause signal reflections, and they create multipaths. All of these conditions have a very noticeable affect on an analog modulated television signal. How will the changeover to digital modulation for the television broadcasters change the wind turbine affects on reception issues?

Digital versus Analog Television Technology

There have been no big technology changes in terrestrial television broadcast services since 1953 when color was introduced to the broadcast television services. Since that time the National Television System Committee (NTSC) rules governed the formats and technology for analog terrestrial television broadcast. In 2009 the Advanced Television System Committee (ATSC) rules will supersede the NTSC and it will govern the digital modulation, formats and technology for terrestrial television broadcast. Figure 3 shows the broadcast spectrum of a single television channel per the NTSC. Figure 4 shows the broadcast spectrum of multiple (as many as six, but usually four) Standard Definition Television (SDTV) channels or up to two High Definition Television (HDTV) channels.

As can be seen from Figures 3 and 4, the digital modulation utilizes the spectrum allocated for terrestrial television broadcast much more efficiently. The improvement in efficiency has allowed the FCC to re-claim the frequencies that were used by television broadcasters for Channels 52–69 (698–806 MHz) for 4G communication services and Public Safety. The frequencies to be used for 4G communication services were auctioned off to telecommunication companies and the U.S. Treasury netted billions of dollars from the auction.

Not only has the changeover to digital technology allowed the government to obtain a windfall in money but the quality of terrestrial television service is much improved with the digital technology. The improvement in television quality is the result of using a digital data stream instead of an analog waveform to transfer the video, color and audio of the television picture.

Figure 3. Analog TV Channel Spectrum Display

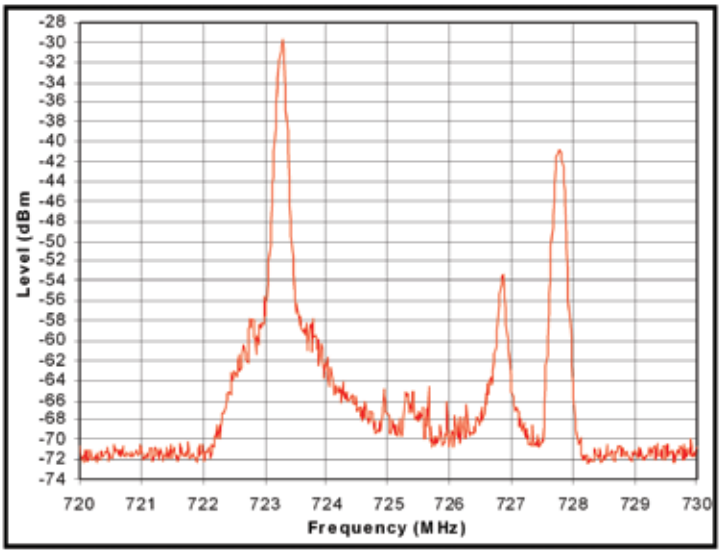
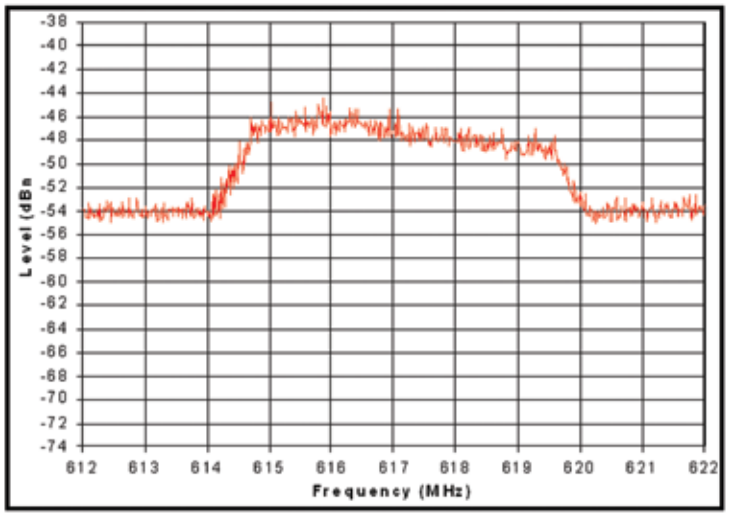


Figure 4. Digital TV Channel Spectrum Display



Digital Television Operational Parameters

The technical advantages of digital television in both utilizing the frequency spectrum and producing high quality video are very apparent from their relative parameters. Standard Digital Television (SDTV) is available to all television sets produced after 2005 because they are required to have a built-in digital receiver. All television sets without a built-in digital receiver may utilize a set top box that is a digital receiver which converts the signal to an anolog VHF channel, normally Channel 3. The SDTV produces 640x480 pixels of video with an aspect ratio 4:3 and two channels of audio. The picture will be sharper and clearer than its analog predecessor because it will not be subject to ghosting due to reflections and multipath, and the digital signal contains error correction coding which is processed by the receiver to produce a more consistent replica of the signal transmitted. Multiple channels of SDTV will be available for a given channel frequency. For example on Channel 10 there may be four different programs. They will be designated Channel 10.1 Soap Opera, Channel 10.2 News, Channel 10.3 Cartoons and Channel 10.4 Weather RADAR Display. A 6 MHz television channel is capable of containing six programs simultaneously but most broadcasters will limit their transmission to a maximum of four.

High Definition Digital Television (HDTV) is a special type of digital television. High definition video is any video that has more than 1M pixels of video per frame. The broadcasters in the United States use two different methods of producing high definition digital modulation. The first method has 1280x720 pixels with the frame lines displayed progressively (P). The picture aspect ratio is 16:9 and the audio is Dolby 5.1. The second method has 1920x1080 pixels with frame lines displayed off-set interlaced (I). The picture aspect ratio is also16:9 and the audio is Dolby 5.1.

ABC, ESPN and FOX use the first digital format method (1280x720 pixels). CBS, NBC and HBO use the second method. Both methods produce theatre sharp pictures and most consumers are not able to distinguish between the video of the two methods. Digital television receivers are built to receive and display either modulation scheme. A 6 MHz television channel is capable of containing two high definition programs but most broadcasters will only transmit one at a time.

Digital versus Analog Television Reception in the Vicinity of Wind Energy Facilities

The analog waveform of the television broadcast signal was subject to variations in signal level by the presence of the wind turbine blade motion, which produced distortions in the video output in contrast, brightness and clarity. Changing reflections produced by the wind turbine blades caused ghosting. For digital modulation the signal level is also subject to level variations and reflections but as long as the signal remains above the operational threshold of the receiver, the video produced will be unaffected.

The one affect caused by the wind turbines that is common to both analog and digital modulation is that the television signal will be attenuated by the presence of the wind turbines. Although the attenuation affect is common, the digital modulation can withstand the attenuation affect to a greater extent because it requires a much lower signal level to produce excellent video. This characteristic of digitally modulated television signals as compared to analog modulation is illustrated in Table 1, which shows the signal strength required for producing excellent video for both digital and analog modulation across all of the television frequency bands. However, it should be also noted that in areas where the present analog TV signal

	Analog Video	Digital Video
Channels	Signal Level dB/μV/m	Signal Level dB/μV/m
Low VHF 2–6	74	35
High VHF 7–13	77	43
UHF	80	48

Table 1. Signal Strength levels for Excellent Video (Taken from FCC Regulations, Part 73 Broadcast Services, Sub Part E, Sections 73, 625 and 73.685)

is of marginal quality but viewable, the comparable level digital signal may not be viewable.

The level required by the digitally modulated signal is much lower than that for a comparable high quality analog modulated signal. In Table 2 another difference between digital and analog television is described. For analog television, as the signal is degraded by external effects, the video quality is reduced in a sliding scale of performance. For digital television, as the signal is degraded, the video will remain excellent until the signal level falls below the operational threshold of the receiver and then, video blocking, pixilation and/or frame freezes occur. If the degradation does not clear, the video will totally go to a blank screen. If it does clear, the video goes back to excellent conditions. This quick slide from excellent video, to noticeable degradation, to no video is known as the "Cliff Effect."

Analog Video Quality	Digital Video Quality
1. Cable Quality – Perfect	1. Cable Quality – Perfect
2. Excellent Picture – Some Noise	2. Some Video Blocking, pixilation and Frame Freezes*
3. Good Quality – Noticeable Noise and sparkles	3. No Video Detected
4. Fair Quality- Noticeable noise, sparkles and distortion	* Cliff affect where once the video appears to have a problems it will go into a no video detected condition until the condition causing it is cleared.
5. Intermittent Video – Not Viewable	
6. No Video Detected	

Table 2. Subjective Levels of Video Quality (Subjective Evaluations of Video developed by Comsearch Field Service Department)

Evaluating Digital Television Broadcast Reception

The test equipment used for evaluating television reception in an area that is to have a wind energy facility is shown in Figure 5. The signal level of the digital television signal is measured using a spectrum analyzer and the video is observed and recorded using a laptop computer with a capability of recording to a DVD. The two indicators of video performance are the measured signal level in dBμ/V meter and the subjective observation of the video quality. The video quality must be observed for all multiple broadcasts of standard video on a channel or the one or two broadcasts of high definition television programming on a channel.

The purpose of the measurements is to determine whether the reception of digital broadcast stations in the area is possible. If the determination is made that digital television broadcast stations produce signal levels that produce quality television, then the wind energy developer may have an obligation to make sure that the residents in the area retain that capability after the wind turbines are installed.

As stated earlier, the attenuation introduced by the wind turbines is the one factor that must be overcome if reception is degraded. The attenuation will occur if one or more wind turbines are in the path of the broadcast television signal. In most cases the attenuation can be overcome with an improved digital television receiving system.

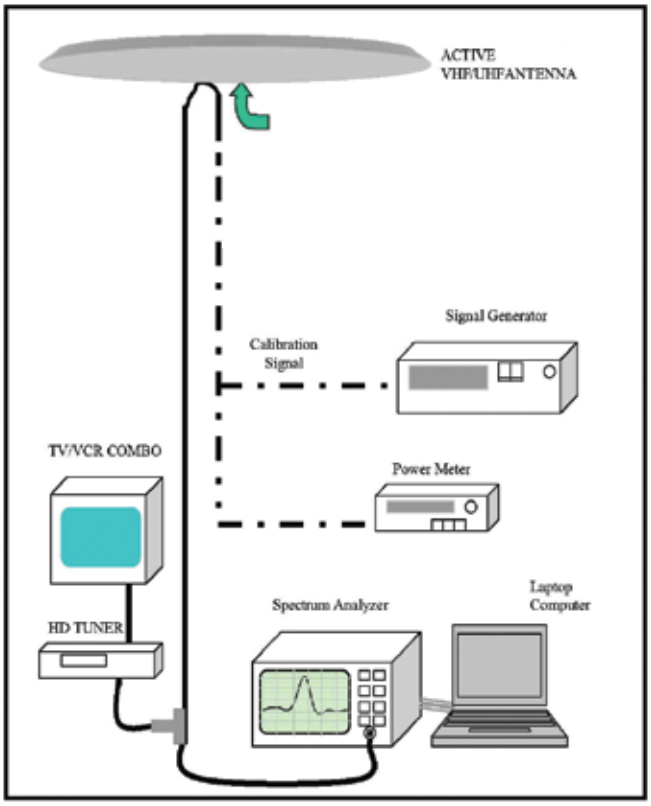


Figure 5. Measurement Block Diagram for Evaluating TV Reception

Description of an Improved Digital Television Receiving System

Once the wind turbines are installed and it is known where the television broadcasters in the area are located, an external antenna site at a home or a business can be selected and installed that will have an unobstructed view toward the television broadcast station(s). It is recommended that the antenna be mounted high enough to clear any local obstacles such as trees and terrain. The antenna should have high gain with an amplifier installed at its terminals. A rotatable mast will support the antenna so that it can easily be directed in azimuth to peak up on a desired television station broadcast location. From the amplifier, the television signal will be connected to points in the residence or business receivers by low-loss double shield coaxial cable. At points where the television signal is to be split to reach various TV sets in the home or business, active splitters will be used. An active splitter has an amplifier that will boost the signal back to its original level before it is split. Figure 6 contains a diagram for the improved digital television receiving system. It is recommended that these systems be installed by a reputable television technician.

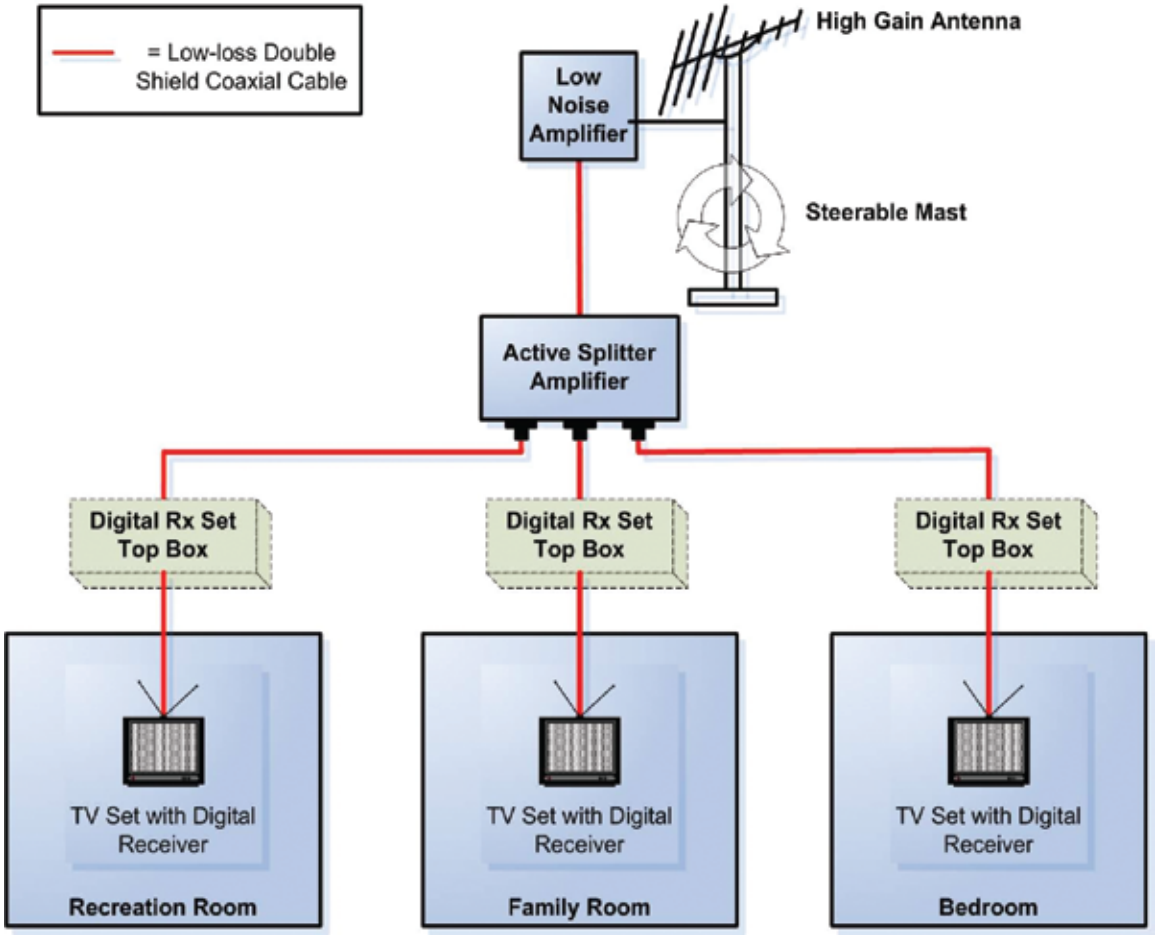


Figure 6. Recommended Reception System for Digital TV

Offering the Appropriate Mitigation for Digital Television Reception

Off-air television broadcast is subject to attenuation by wind turbines. Therefore, an effective way to mitigate this attenuation is to offer residents and businesses in the area a system that overcomes the attenuation affect. The value of the improved reception system will vary for different geographical locations because of differing local labor and hardware costs.

Conclusions and Recommendations for the Television Reception Issue in the Digital Age

The television digital transition gives the Wind Energy developers a new strategy to use in dealing with this difficult issue. Television reception of off-air digital signals will be possible in more places than before. Good reception will require a good receiving system and one can be provided at a reasonable cost. This cost establishes a fair and reasonable response to loss of television coverage.

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