Exhibit 1

Purpose of Application

By this application, Island Broadcasting Co. ("Island"), licensee of analog LPTV Station WNYZ-LP, New York, New York (Channel 6), requests modification of Construction Permit BMPDVL-20100901AAB (the "CP"), the flashcut digital construction permit for WNYZ-LD (Channel 6) as follows: The requested modification is to include, if such modification of the CP is deemed necessary, authorization to operate, in conjunction with the digital operation of WNYZ-LD, an ancillary audio service consisting of an FM signal operating at 100 watts ERP at 87.74 MHz. In support of this request, see the attached Report prepared by Island.

Report of
Island Broadcasting Co.

Use of Axera Bandwidth Enhancement Technology To Provide Ancillary FM Audio Service for Digital Low Power TV on Channel 6

Table of Contents

SUMMARY

As demonstrated in this Report, using Axcera's "Bandwidth Enhancement Technology" (BET), an FM signal at 87.74 MHz operating with maximum ERP of 100 watts can operate side-by-side with digital WNYZ-LD, Channel 6, New York, New York (the "Station"), operating at 300 watts, with no interference to any service, and full ability to decode the digital transmission. Use of BET in the operation of the Station will permit it to continue to offer the additional audio service that the Station's analog predecessor, WNYZ-LP, has provided to New York City for the past four years.

A detailed study of (i) decoding, (ii) effect on D/U ratios, (iii) the mask filter, and (iv) out of band signal levels, is included herein. As will be shown, BET allows full use of the 6 MHz channel, compared to the 5.38 MHz used for the current digital bit stream, with no adverse effect on any other facilities.

The audio ancillary service described herein is not only permitted by Section 74.790(i) of the Commission's rules, but in the case of WNYZ-LD in particular, the paramount interest of the New York City public will be well served by having an additional outlet of audio service.

1. **Axcera Bandwidth Enhancement Technology ("BET")**

BET is a method of compatibly reducing the bandwidth of an 8VSB signal more than 300 kHz. As demonstrated below, BET, coupled with an overall frequency shift up to 150 kHz, can allow additional ancillary use of a 6 MHz television channel without interfering with decoding. See copies of Axcera Tech Note No. 09, dated March 2000, and Axcera's paper entitled "A Compatible Narrowband 8VSB Transmission System," included here at Appendices A and B.

2. **Study of FM Effect on Digital Decoding**

Richard D. Bogner, partner of Island Broadcasting Co. ("Island"), and Ronald Scotto, chief engineer for Island, undertook a test at low power, simulating a channel 6 digital signal simultaneous with an FM signal at 87.74 MHz. BET was used to narrow the digital spectrum, and offset was added to move this spectrum lower in frequency. Seventeen (17) of the most popular digital-to-analog converters, and eight (8) major manufacturers' digital receivers, all identified in Appendix C hereto, were tested. Relative power levels (digital to FM) and the amount of offset were varied. The converters and receivers varied very widely in performance, some decoding the digital signal with FM values substantially above the digital and large offsets, others not.

It was found that digital power at least three times FM power, with an offset of only 30 kHz, allowed all tested converters (with one exception[1]) and receivers to decode well, putting the FM power at a very low 100 watts for a digital power of 300 watts ERP. When the ERP exceeded 100 watts FM ERP, decoding failed to occur with some

[1] The Access model DTA 1080, the oldest converter tested, performed marginally, even with no FM signal.

converters and receivers. This was verified by a brief test using the power levels of .3 kW ERP authorized in the flash-cut Construction Permit for the Station, BMPDVL-20100901AAB (the "CP"), and .1 kW ERP FM power at 87.74 MHz. In short, 100 watts was the maximum FM ERP level that permitted viewing video with audio on all converters and receivers tested.

3. Out of Channel Signal Levels

During the testing, the spectral mask filter was located prior to the combining of the digital and FM signals, using a hybrid combiner. The resulting combined digital and FM signal was measured, and meets the stringent mask specification of 47 db down for the first half MHz, down to 76db down at 3MHz from the band edges, and remaining below this level.

4. Effect of Digital Signal on FM

The FM was operated briefly without the simultaneous operation of the 300 watt digital signal. There was no noticeable difference observed in the quality of the FM audio signal with or without the digital signal operating.

5. Co-channel D/U ratios

Longley-Rice analyses were performed with respect to co-channel WPVI-TV, Philadelphia, PA (Ch. 6, Facility ID 8618), and co-channel WEDY, New Haven, CT (Ch. 6, Facility ID 13595). It was found in both cases that the D/U ratios were the same everywhere, with and without consideration of the 100 watts ERP FM analog signal added to the 300 watts digital ERP authorized in the Station's CP. Thus, the added 100 watt FM signal had no effect on the co-channel D/U ratios.

6. Adjacent Channel D/U Ratios

Longley-Rice analyses were performed with respect to adjacent-channel W05CS-D, Port Jervis, NY (Ch. 5; Facility ID 167321) and the pending Channel 5 application (BDISDVL-20100421AAS) for WNYX-LD (Facility ID 29236). It was found in both cases that the D/U ratios were the same everywhere, with and without the 100 watts ERP FM analog signal added to the 300 watts ERP authorized in the Station's CP. Thus, the added 100 watt FM signal had no effect on the adjacent channel D/U ratios.

7. Interference to FM Stations

The signal levels in the FM bands were measured to be at least 47 db below 100 watts, and no evidence of harmonic or other signals were found above this level. It is noted that no specific rules address interference by a Channel 6 television station to an FM station operating on Channel 201 and above. For many years, Channel 6 television stations have broadcast audio signals on 87.75 MHz at high power levels, including WNYZ-LP at 3000 watts, with no cognizable interference to FM stations.

8. Authorized ERP Values

Island's operation of a digital LPTV facility with 300-watt ERP and an ancillary FM facility with 100-watt ERP, as tested, is consistent with the Commission's Rules governing ERP values permitted to digital LPTV stations. Indeed, since the digital video and the FM were operating at different frequencies, their respective ERP values cannot be combined, and neither operation exceeded the 300 watts permitted by Section 74.735(b)(i) of the Rules for a digital LPTV operation on Channel 6. In this connection, it is worth noting that under Section 74.735(a) of the Rules, an analog LPTV station operating on Channel 6 may operate with a maximum ERP of 3 kW, and no rule prohibits an analog station from operating the audio ERP equal to the video ERP. That is, the FCC has never determined that a combined ERP in excess of the video ERP violates Section 74.735(a). An LPTV station's digital video signal and ancillary FM audio signal can and should be treated no differently.

9. Compliance with Rules Governing Digital LPTV Ancillary Services

Section 74.790(i) of the Rules provides that a digital LPTV station, in addition to providing an over-the-air video program signal, may offer "services of any nature, consistent with the public interest, convenience and necessity, on an ancillary or supplementary basis in accordance with the provisions of §73.624(c) and (g) of this chapter." Section 73.624(c) expressly provides that aural services are among the services that may be provided on an ancillary or supplementary basis. Thus, under the Rules, use of 6 MHz for both a video service and ancillary service in any non-interfering manner is permissible, provided that all other applicable rules are met. The ancillary service described herein requires use of .62 MHz beyond the 5.38 MHz assigned to the digital bit stream. Thus, the offering of a video program service and an ancillary audio service reflects the most efficient use of the 6 MHz of spectrum allotted to the Station, Such efficiency of spectrum use, in addition to the public interest benefit of the audio ancillary service, should be highly valued.

10. Need for Audio Service in New York City, NY

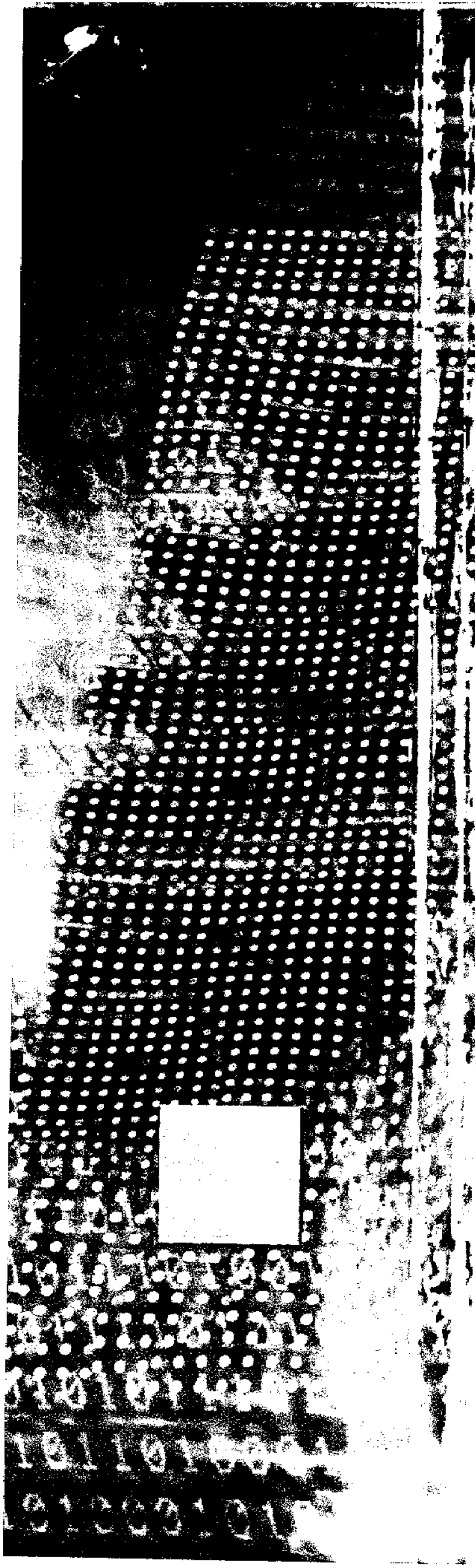
New York City has far fewer full service FM stations covering the city than any other major U.S. city. New York City, with a population estimated by the U.S. Census Bureau to be 8,363,710 in 2008, has approximately 2.4 licensed FM stations per million households, compared to Los Angeles with 3.7 per million, Chicago with 5.5 per million, and Philadelphia with 6.6 per million households. Compared with other cities, New York City, with well over 100 spoken languages used and the largest population in the country, has by far the greatest need for more audio services that cover the entire city, even if only with a very low 100 watt ERP, as described herein – a power equivalent to a low power FM station or FM translator station.

11. <u>Advantages of Innovative Low V Spectrum Use.</u>

This report provides evidence that a much needed and desired audio service can be added as an ancillary service to a LPTV station in New York City, consistent with Commission rules. Indeed, the Station can serve as a model for other LPTV or full service television stations that wish to provide their communities with an ancillary audio service.

The Chairman of the FCC has frequently promoted the innovative use of spectrum. Clearly, the spectrum use described in this Report is such an innovative and creative use. Moreover, as demonstrated, it meets a specific identifiable need for more audio services in New York City and, therefore, is in the paramount public interest. Finally, as further demonstrated, the described ancillary service is consistent with rules and regulations of the Commission applicable to LPTV stations. Nonetheless, out of an abundance of caution, Accordingly, Island requests that the CP be modified to include authorization of an ancillary FM analog signal at 100 watts ERP at frequency 87.74 MHz if such additional authorization is deemed necessary for the Station to operate the audio service described herein.

APPENDIX a



TechNotes

Technical Reference for the RF Engineer from the RF Experts

No. 09 March 2000

A Compatible Narrowband 8VSB Transmission System

(Bandwidth Enhancement Technolgy™)

Introduction

In the FCC table of channel allocations for 8VSB digital television (DTV) stations, some channel assignments create severe technical problems. For example, in some communities where a DTV allocation has been created for channel 14 (470-476 MHz), there are land mobile radio licenses very close to the lower edge of channel 14 some as high as 469.975 MHz. It is extremely difficult to protect 469.975 MHz when the DTV signal has energy down to 470 MHz just 25 kilohertz away. Even though transmitter out of band energy may be in compliance with FCC rules, it may still create problems to users of adjacent frequencies. Other DTV channel allocations potentially in a similar situation include channels 2, 4, 5, 6, 7, 13, 36, 38, and 51, as well as those adjacent to existing NTSC channels.

These problems could be mitigated if the ATSC spectrum, which is rather "aggressive" when it comes to occupying a 6 MHz channel, could be just slightly reduced in bandwidth.

The ATSC 8VSB System

The ATSC standard 8VSB transmission system, like many other digital transmission systems, includes a certain amount of "excess bandwidth." The 8VSB system transmits symbols at a rate of 10.76223776... million per second, which requires a minimum theoretical bandwidth of 5.381118881... MHz (half of the symbol rate). Although this is a theoretical minimum, it is physically impossible to build a system that only uses the minimum bandwidth. As a practical matter, it is necessary to allow a certain amount of additional ("excess") bandwidth for filter transition bands.

The 8VSB system has about 11.5% excess bandwidth. In other words, the 6 MHz channel width divided by 5.381118881... MHz is approximately 11.5% greater than unity.

To achieve an overall flat amplitude response between the transmitter and the receiver, the shape of the filtering in the transition bands has been specified to be the square root of a root raised cosine response, for both the transmitter and the receiver. When the filter response is applied twice, its magnitude response is squared, providing an overall raised cosine shape. When the I channel of the 8VSB signal is demodulated, it then has a flat amplitude response.

Channel Filters

Modern channel filters developed for DTV applications have narrow transition bandwidths. The transition bandwidth is the frequency range over which the attenuation changes from near zero, close to the channel edge, to the out of band attenuation value a little bit farther from the band edge. In a sophisticated channel filter, the transition band can be as small as 150 kHz. Conventionally, these channel filters have very little attenuation at the channel edges, and reach a high attenuation value several hundred kHz outside the channel.

What this implies is that if just 150 kHz could be shaved off of the offending side of the spectrum (or from both sides of the spectrum), then the channel filter could be made slightly narrower, having a high amount of attenuation right at the channel edges. Services just outside the channel edges could have 30-60 dB of additional protection if the DTV signal's bandwidth could be just slightly reduced.

It is possible to make the 8VSB signal narrower than 6 MHz, simply by reducing the 11.5% excess bandwidth to a lower value. But this creates a problem with receivers. For example, if the transmitter is producing a 7% excess bandwidth signal with a root raised cosine response, and the receiver is filtering the signal with a root raised cosine 11.5% excess bandwidth filter, the overall response will not be flat. There will be frequency response bumps at low and high frequencies. Although a receiver's adaptive equalizer could flatten out the response, it would do so at the expense of signal to noise performance. The problem with such a unilateral approach at the transmitter is incompatibility with receivers.

A Solution

Fortunately, there is a way to compatibly reduce the bandwidth of a DTV signal by several hundred kHz, which is enough to permit the use of passive channel filters and combiners that have significant attenuation at the channel edge. This method makes a bandwidth reduction, but without affecting receivers that are designed to receive a signal with the standard 11.5% excess bandwidth.

The bandwidth reduction method relies on two characteristics of the 8VSB signal. First, the transmitted information is contained entirely within the I channel.

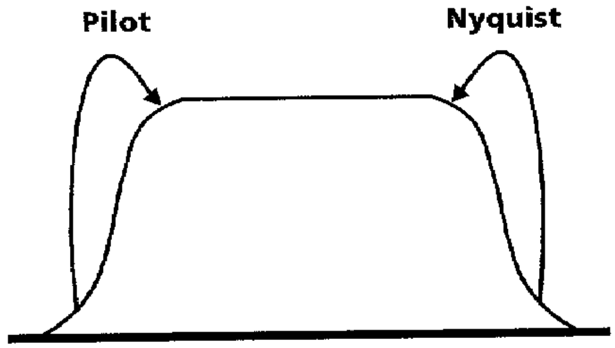


Figure 1

The only purpose of the Q channel is to make most of one sideband disappear. This characteristic can be exploited by reducing the bandwidth of the signal in such a way that only the Q channel is affected, and the I channel is unchanged. In the frequency domain, this means removing energy from the lower sideband, and replacing it with energy in the upper sideband, as shown in Figure 1.

Second, there is a small amount of inverted replicated spectrum just above the Nyquist rate in the transmitted I channel. When the symbols are extracted, which reduces the sampling rate to the symbol rate, energy above the Nyquist rate aliases to frequencies below the Nyquist rate. This characteristic can also be exploited to reduce the bandwidth. The I channel bandwidth can be reduced in the spectral tail above the Nyquist rate, by replacing energy removed with equivalent energy below the Nyquist rate.

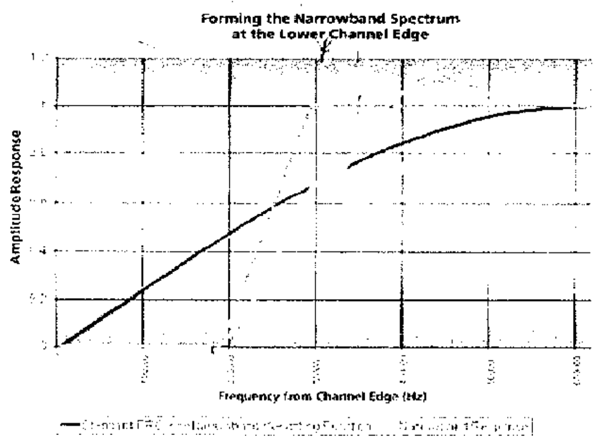


Figure 2

As long as any voltage removed from the lower sideband is replaced at the upper sideband at the same amplitude as seen by the receiver's I channel demodulator, the I channel demodulated signal will not be changed. Yet, the bandwidth of the signal is narrower.

Figure 2 shows the detail of how the narrowband 8VSB spectrum is formed in the vicinity of the pilot (approximately 309 kHz above the channel edge). The narrowband weighting function has a value of unity above the pilot frequency. Below the pilot,over a frequency of 125 kHz, the weighting function drops to zero. In the remaining range just above the lower channel edge (pilot minus 125 kHz or approximately 184 kHz), the weighting function has a value of zero. The removed lower sideband energy is multiplied by the expected RRC shape of the receiver. Then it is frequency inverted above the pilot, and divided by the receiver's RRC shape, and finally added to the response of the standard RRC shape. The result is the narrowband response shape shown in the figure. Importantly, the demodulated I channel of this signal is identical to that of a standard RRC 8VSB signal. This particular choice of shaping results in 184 kHz being removed from the vestigial lower sideband.

Extending the Concept to the Upper Band Edge

The 8VSB system includes essential signal components in the baseband modulating signal that go all the way to the Nyquist rate (when sampled at the symbol rate). When the 8VSB signal is formed, the spectrum is flat to 5.071678332... MHz above the pilot. At that point the root raised cosine shape begins to roll off the spectrum. At half the symbol rate above pilot (5.381118881... MHz) the response is down 3 dB. Between this frequency and the channel edge (5.690559441... MHz above pilot) the ideal response transitions from 3 dB to zero amplitude.

Because baseband energy goes all the way to the Nyquist rate in 8VSB, the frequency components in the RRC transition range just below the Nyquist rate in the 8VSB signal (half the symbol rate or 5.381118881... MHz above pilot) are mirror images of the spectrum just above the Nyquist rate. The amplitudes of the mirrored spectra are not the same, but the frequencies are mirrored.

When the 8VSB signal is demodulated to symbols sampled at the symbol rate, frequency components within this transition region just above the Nyquist frequency, will alias to frequencies just below the Nyquist frequency. This aliasing at the demodulation end is intentional and necessary for the system to work properly.

As was the case in the transition region around the pilot, the spectral shape in the transition range at the upper channel edge can be modified without affecting the demodulated symbols. If energy is removed from the spectrum above the Nyquist rate, then it must be replaced at the equivalent frequency below the Nyquist rate. This spectral modification must consider the shape of the receiver's RRC filter.

To make the spectral modification to the upper band edge, substitute the 8VSB Nyquist rate (half the symbol rate plus the pilot frequency) for the pilot frequency, and interchange references to the upper and lower sidebands. In other words, remove energy from the frequency range between the Nyquist rate (5.381118881... MHz plus pilot or 5.690559441 MHz) and the upper channel edge, and compensate for the loss of energy by increasing the signal amplitude between pilot plus 5.071678322... MHz and pilot plus 5.381118881... MHz.

So, removing voltage from any frequency above the

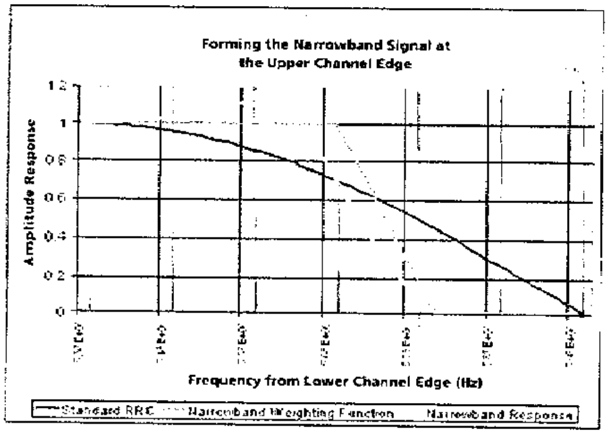


Figure 3

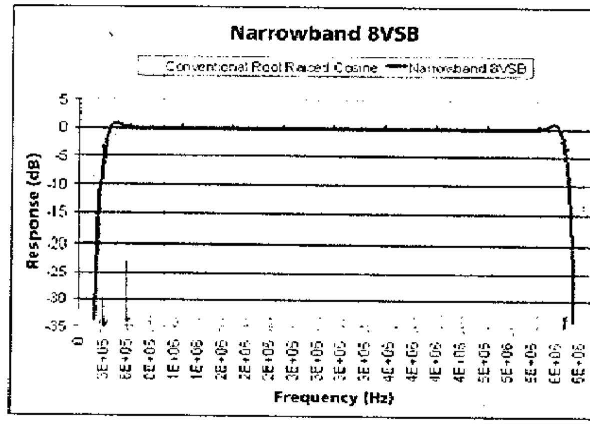


Figure 4

Nyquist rate, and replacing it at the same frequency below the Nyquist rate such that the frequency-transposed energy is the same at the receiver's demodulator after its RRC filtering, will not change the demodulated I channel signal after it is sampled. This is because the signal components above and below the Nyquist rate are mirror images of each other, and sampling a frequency component above the Nyquist rate by a frequency f will produce the same result as sampling a frequency component below the Nyquist rate by frequency f.

Figure 3 shows the detail of how the narrowband 8VSB spectrum is formed at the upper channel edge. The narrowband weighting function has a value of unity below the Nyquist frequency. Above the Nyquist frequency, over a frequency of 125 kHz, the weighting function drops to zero. In the remaining range just below the upper channel edge (Nyquist frequency plus 125 kHz or approximately 184 kHz), the weighting function has a value of zero. The removed lower sideband energy is multiplied by the expected RRC shape of the receiver. Then it is frequency inverted above the Nyquist frequency, and divided by the receiver's RRC shape, and finally added to the response of the standard RRC shape. The result is the narrowband response shape shown in the figure. This particular choice of shaping results in 184 kHz being removed from the upper sideband. Importantly, the demodulated I channel of this signal is identical to that of a standard RRC 8VSB signal.

Choice of Method

These methods may be applied to just the lower band edge, or just the upper band edge, or to both band edges simultaneously, depending on the purpose for reducing the bandwidth of the 8VSB signal.

For example, if the problem is protecting two way radio allocations just below channel 14, it may only be necessary to reduce the bandwidth at the lower band edge. Or, if an educational FM station at 88.1 MHz would suffer interference from a new DTV allocation at channel 6, then only the upper band edge of the 8VSB signal would need to be reduced.

Figure 4 shows the bandwidth saving of the narrowband 8VSB system with bandwidth reduction being applied to both edges of the channel. With this particular function, there is enough energy being removed from the channel edges to make the in-band response rise by approximately 1 dB.

For the maximum amount of bandwidth reduction on just one channel edge, both sides of the spectrum could be reduced, and then the resulting spectrum could be frequency shifted to one side or the other by the amount of the bandwidth truncation on one side. In these examples, with 184 kHz removed from each side, and with the resulting spectrum shifted by 184 kHz, a total guard band of 368 kHz could be created on one side of the spectrum.

Receiver Compatibility Issues

When a narrowband 8VSB signal is received, the demodulated I channel signal, after it is resampled to the symbol rate, will be exactly the same as it would be with a conventional 8VSB signal. However, several factors may still affect receiver compatibility.

Use of the Q channel by the receiver equalizer.

If the receiver's equalizer uses the Q channel in addition to the I thereby noise, near the channel edges.

channel, then there could be problems because the Q channel is modified. For example, the receiver could try to force the spectral shape to 11.5% RRC before demodulation. This would boost the receiver's response, and

Operation of the receiver equalizer in a bandwidth larger than half the symbol rate. If the receiver equalizer operates on the demodulated I channel, but in a bandwidth higher than half the symbol rate, then it could sense the reduced energy just above the Nyquist rate and try to boost it (and any noise) up to the level it would be with a standard signal.

PLL Issues

Reduction of the spectrum in the vicinity of the pilot will have the effect of increasing the amount of low frequency energy in the Q channel of the receiver. The recovered carrier may have an increased amount of undesired phase modulation or jitter depending on the design of the receiver's PLL and in particular, its bandwidth.

To determine what effect, if any, the narrowband 8VSB signal would have on the receivers, measurements were taken on a sampling of receivers from different manufacturers. Receivers were tested for input signal level requirements first with a standard 8VSB signal, and then with the narrowband 8VSB signal.

Six different models of commercially available receivers were tested to see if they correctly demodulate the narrowband 8VSB signal, and success was achieved with all. Threshold measurements were made on two of the receivers, both of which showed only a 1 dB penalty for the narrowband signal. The evidence suggests that existing receivers are capable of receiving the narrowband 8VSB signal without any modifications.

Transmitter Compatibility

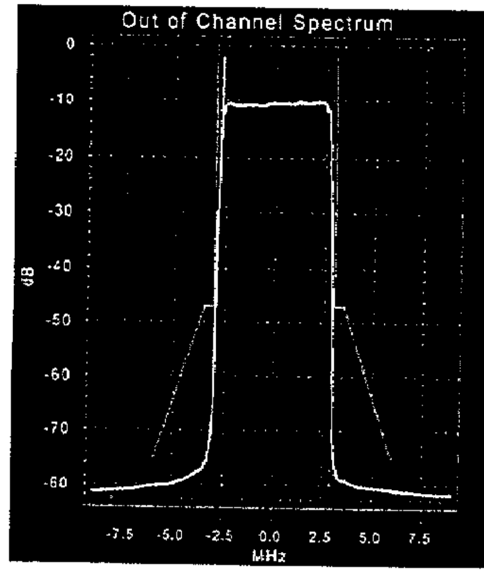
The transmitted bandwidth of the narrowband 8VSB signal is narrower by design. A signal that is narrower than standard will not create any problems with a transmitter. However, retuning of the channel filter will be required to take maximum advantage of the narrowband signal.

Figure 5

Another issue is peak to average ratio. Peak to average ratio is only slightly higher with the narrowband 8VSB signal as implemented. With a 368 kHz reduction in bandwidth, the peak to average ratio is only 0.5 dB higher than with a standard signal.

Practical Results

Figure 5 is taken from the spectrum display of a Tektronix RFA300. This is the output of a solid state transmitter operating in narrowband mode, with a channel filter designed especially for the narrowband spectrum. It is evident from this display that the transmitter exceeds the FCC's channel mask by a wide margin.



Conclusion

Narrowband 8VSB can be used to get stations on the air which would have otherwise insurmountable problems. In some instances, some form of narrowband transmission may be the only way to solve an interference problem. In these cases, narrowband 8VSB will allow stations in these situations to get on the air and to make best use of the available spectrum.

In contrast to a "brute force" method of attenuating out-of-band signals by using very sharp, stable filters, a narrowband 8VSB solution will allow the use of standard filter designs. It will also ensure that the desired signal remains intact, putting no additional burden on the equalization circuitry of the receivers.

APPENDIX 6

A COMPATIBLE NARROWBAND 8VSB TRANSMISSION SYSTEM

"Bandwidth Enhancement Technology"

Axcera
Lawrence, Pennsylvania

I. Abstract

This paper describes a method of compatibly reducing the bandwidth of an 8VSB signal. By careful choice of filter shapes, the bandwidth reduction can be made compatible with receivers, such that the demodulated and resampled I channel signal is identical to what would be produced by a standard 8VSB signal. A slight bandwidth reduction of only 100 to 200 kHz per band edge allows much more aggressive channel filters to be used. Sharper channel filters can greatly reduce or eliminate interference problems to adjacent services, such as two way radio users just below UHF channel 14.

II. Introduction

The Federal Communications Commission has established a table of channel allocations for 8VSB digital television (DTV) stations. Some of these allocations create severe technical problems. For example, in some communities where a DTV allocation has been created for channel 14 (470-476 MHz), there are land mobile radio licenses very close to the lower edge of channel 14 – some as high as 469.975 MHz. It is extremely difficult to protect 469.975 MHz when the DTV signal has energy down to 470 MHz – just 0.025 MHz away. Power amplifier nonlinearities create a certain amount of out of band energy. Even though this out of band energy may be in compliance with FCC rules, it may still create problems to users of adjacent frequencies, who "were there first."

Similar problems may exist where two way radio users are sharing spectrum in the UHF television band.

Another situation that is problematic is the "N+1" allocation. Here, a NTSC licensee is assigned a DTV channel that is on the next channel up from his NTSC signal. In this situation the aural carrier has significant sidebands that extend to within about 75 kHz of the channel edge, and therefore to within about 75 kHz of the DTV signal. This creates problems for stations that wish to use frequency selective combiners with separate NTSC and DTV transmitters.

Yet another problem exists in areas where radio telescopes are using channel 37 (608-614 MHz). Nearby broadcasters on channels 36 and 38 may adversely affect telescope operation with out of band emissions on channel 37.

Similarly, problems could exist with VHF channel 6 interference to noncommercial FM just above 88 MHz, and channels 4 and 5 could interfere with users of the 72-76 MHz spectrum.

These problems could be mitigated if the ATSC spectrum, which is rather "aggressive" when it comes to occupying a 6 MHz channel, could be just slightly reduced in bandwidth.

III. The ATSC 8VSB System

The ATSC standard 8VSB transmission system, like many other digital transmission systems, includes a certain amount of "excess bandwidth." The 8VSB system transmits symbols at a rate of 10.76223776... million per second, which requires a minimum theoretical bandwidth of 5.381118881... MHz (half of the symbol rate). Although this is a theoretical minimum, it is physically impossible to build a system that only uses the minimum bandwidth. As a practical matter, it is necessary to allow a certain amount of additional ("excess") bandwidth for filter transition bands.

The 8VSB system has about 11.5% excess bandwidth. In other words, the 6 MHz channel width divided by 5.381118881... MHz is approximately 11.5% greater than unity.

To achieve an overall flat amplitude response between the transmitter and the receiver, the shape of the filtering in the transition bands has been specified to be the square root of a root raised cosine response, for both the transmitter and the receiver. When the filter response is applied twice, its magnitude response is squared, providing an overall raised cosine shape. When the I channel of the 8VSB signal is demodulated and resampled at the symbol rate, it then has a flat amplitude response.

IV. Channel Filters

Modern channel filters developed for DTV applications have narrow transition bandwidths. The transition bandwidth is the frequency range over which the attenuation changes from near zero, close to the channel edge, to the out of band attenuation value a little bit farther from the band edge. In a sophisticated channel filter, the transition band can be as small as 150 kHz. Conventionally, these channel filters have very little attenuation at the channel edges, and reach a high attenuation value several hundred kHz outside the channel.

What this implies is that if just 150 kHz could be shaved off of the offending side of the spectrum (or from both sides of the spectrum), then the channel filter could be made slightly narrower, having a high amount of attenuation right at the channel edges. Services just outside the channel edges could have 30-60 dB of additional protection if the DTV signal's bandwidth could be just slightly reduced.

It is possible to make the 8VSB signal narrower than 6 MHz, simply by reducing the 11.5% excess bandwidth to a lower value. But, this creates a problem with receivers. For example, if the transmitter is producing a 7% excess bandwidth signal with a root raised cosine response, and the receiver is filtering the signal with a root raised cosine 11.5% excess bandwidth filter, the overall response will not be flat. There will be frequency response bumps at low and high frequencies. Although a receiver's adaptive equalizer could flatten out the response, it would do so at the expense of signal to noise performance. The problem with such a unilateral approach at the transmitter is incompatibility with receivers.

V. A Solution

Fortunately, there is a way to compatibly reduce the bandwidth of a DTV signal by several hundred kHz, which is enough to permit the use of passive channel filters and combiners that have significant attenuation at the channel edge. This method makes a bandwidth reduction, but without affecting receivers that are designed to receive a signal with the standard 11.5% excess bandwidth.

The bandwidth reduction method relies on two characteristics of the 8VSB signal. First, the transmitted information is contained entirely within the I channel. The only purpose of the Q channel is to make most of one sideband disappear. This characteristic can be exploited by reducing the bandwidth of the signal in such a way that only the Q channel is affected, and the I channel is unchanged. In the frequency domain, this means removing energy from the lower sideband, and replacing it with energy in the upper sideband.

Second, there is a small amount of inverted replicated spectrum just above the Nyquist rate in the transmitted I channel. When the symbols are extracted, which reduces the sampling rate to the symbol rate, energy above the Nyquist rate aliases to frequencies below the Nyquist rate. This characteristic can also be exploited to reduce the bandwidth. The I channel bandwidth can be reduced in the spectral tail above the Nyquist rate, by replacing energy removed with equivalent energy below the Nyquist rate.

VI. Details

The amplitude response in the transition band is given by:

$$\mathbf{Rrc(f)=sqrt(0.5+0.5*cos[pi*(f-f_t)/2f_t])}$$

Where:

f_t = half of transition band = pilot frequency = 309.4405594... kHz

f = the frequency difference from the pilot (positive or negative)

Let:

$G(-f)$ = the frequency response being applied to the lower sideband, below the pilot.

The frequency response of the lower sideband becomes:

$$\mathbf{Rrc(-f)*G(-f)}$$

The attenuation provided by the function **G(-f)** has the effect of removing energy from the lower sideband. To keep the I channel the same, that energy may be added back in to the upper sideband.

To determine exactly how much energy to add back in to the upper sideband, use the following steps for every frequency in the LSB:

1. Determine the amount of LSB voltage lost.
2. Multiply this voltage by the amplitude response of the RRC filter in the receiver at the LSB frequency of interest.
3. Divide this result by the amplitude response of the RRC receiver filter at the equivalent USB frequency.
4. Add the resulting voltage to the upper sideband.

The normal response of the lower sideband is:

$$Rrc(-f)$$

The reduced bandwidth amplitude of the lower sideband is:

$$Rrc(-f)*G(-f)$$

So, the amount of "lost voltage" in the LSB is the difference between the two previous expressions, or:

$$Rrc(-f)-Rrc(-f)*G(-f)=rrc(-f)*[1-G(-f)]$$

Weighting this by the LSB RRC response of the receiver gives:

$$Rrc^2(-f)-Rrc^2(-f)*G(-f)=rrc^2(-f)*[1-G(-f)]$$

Dividing this by the RRC USB response of the receiver's filter gives:

$$[Rrc^2(-f)-Rrc^2(-f)*G(-f)]/rrc(f)$$
$$=rrc^2(-f)*[1-G(-f)]/rrc(f)$$

The frequency response of the upper sideband becomes:

$$Rrc(f)+ rrc^2(-f)*[1-G(-f)]/rrc(f)$$

For example, consider the case where **G(-f)** is given by the following:

For f>= 125 kHz, G(-f) = 0

For f>=20 kHz and f<125 kHz,
G(-f)=1-(f-20 kHz)/105 kHz

The reasons for choosing this weighting function are:

1. Truncation of the spectral tail to just 125 kHz below the pilot frequency. This will reduce the bandwidth by about 184 kHz.
2. Preservation of the standard RRC spectral shape within 20 kHz of the pilot frequency. Keeping the Q channel the same as standard RRC within 20 kHz of the pilot frequency will allow receivers with PLL bandwidths up to 20 kHz to lock to the pilot of the narrowband signal with the same performance as a standard RRC signal.

This will introduce a linear rolloff from 20 kHz below the pilot frequency to 125 kHz below the pilot, and zero response beyond 125 kHz below the pilot. Some amplitude values are given in the following table:

F	LSB (RRC)	LSB (narrow)
25 kHz	.6608458	.6293769
50 kHz	.6119248	.4370892
100 kHz	.506901	.1206907
200 kHz	.2742153	0
300 kHz	2.395899E-02	0
F	**USB (RRC)**	**USB (narrow)**
25 kHz	.7505217	.7782305
50 kHz	.7909159	.9261848
100 kHz	.8620043	1.089115
200 kHz	.9616683	1.03986
300 kHz	.9997129	1.000287

Table 1 – Spectral Tail Shapes

Of course, other functions may be substituted for this particular **G(f)** to provide other shapes for the narrower bandwidth.

As long as any voltage removed from the lower sideband is replaced at the upper sideband at the same amplitude as seen by the receiver's I channel demodulator, the resampled I channel demodulated signal will not be changed. Yet, the bandwidth of the signal is narrower.

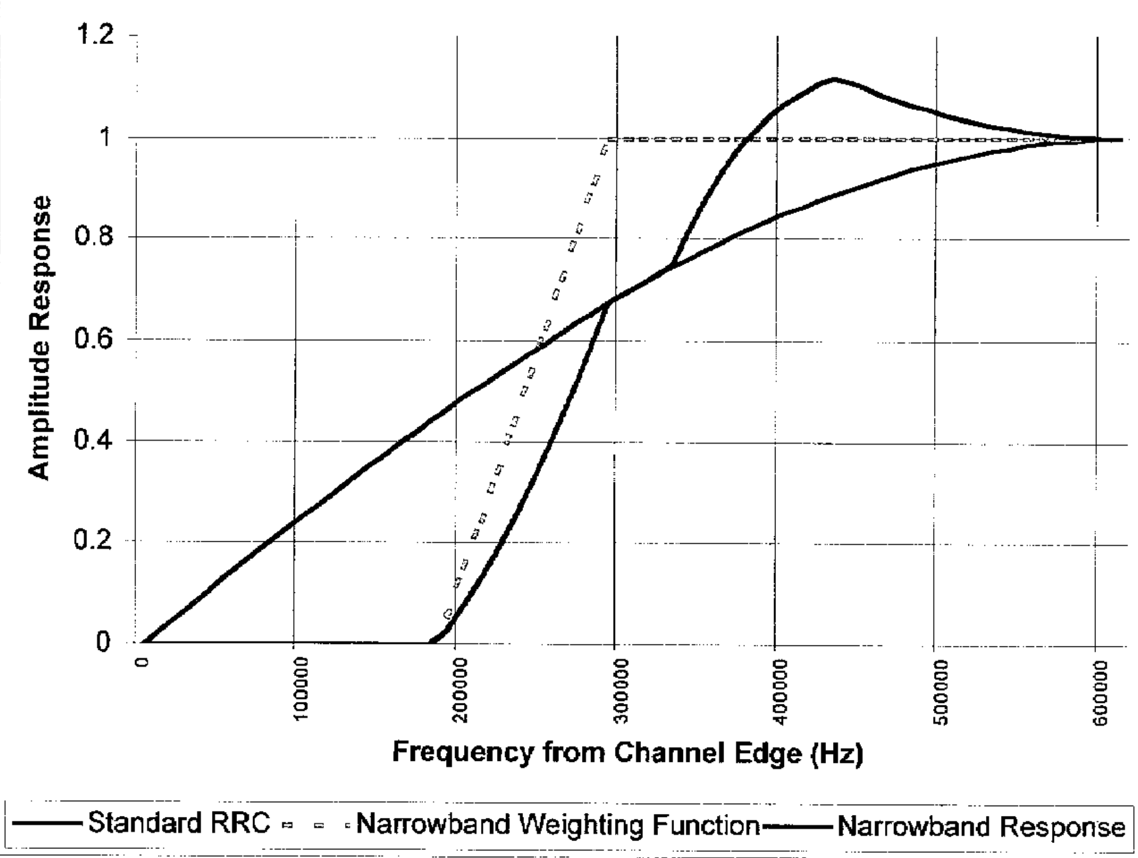
Figure 1 shows the detail of how the narrowband 8VSB spectrum is formed in the vicinity of the pilot (approximately 309 kHz above the channel edge). The narrowband weighting function has a value of unity above the pilot frequency. Below the pilot, over a frequency of 125 kHz, the weighting function drops to zero. In the remaining range just above the lower channel edge (pilot minus 125 kHz or approximately 184 kHz), the weighting function has a value of zero. The removed lower sideband energy is multiplied by the expected RRC shape of the receiver. Then it is frequency inverted above the pilot, and divided by the receiver's RRC shape, and finally added to the response of the standard RRC shape. The result is the narrowband response shape shown in the figure. Importantly, the demodulated and resampled I channel of this signal is identical to that of a standard RRC 8VSB signal. This particular choice of shaping results in 184 kHz being removed from the vestigial lower sideband.

VII. Extending the Concept to the Upper Band Edge

The 8VSB system includes essential signal components in the baseband modulating signal that go all the way to the Nyquist rate (when sampled at the symbol rate). When the 8VSB signal is formed, the spectrum is flat to 5.071678332... MHz above the pilot. At that point the root raised cosine shape begins to roll off the spectrum. At half the symbol rate above pilot (5.381118881... MHz) the response is down 3 dB. Between this frequency and the channel edge (5.690559441... MHz above pilot) the ideal response transitions from –3 dB to zero amplitude.

Because baseband energy goes all the way to the Nyquist rate in 8VSB, the frequency components

Figure 1 - Forming the Narrowband Spectrum at the Lower Channel Edge



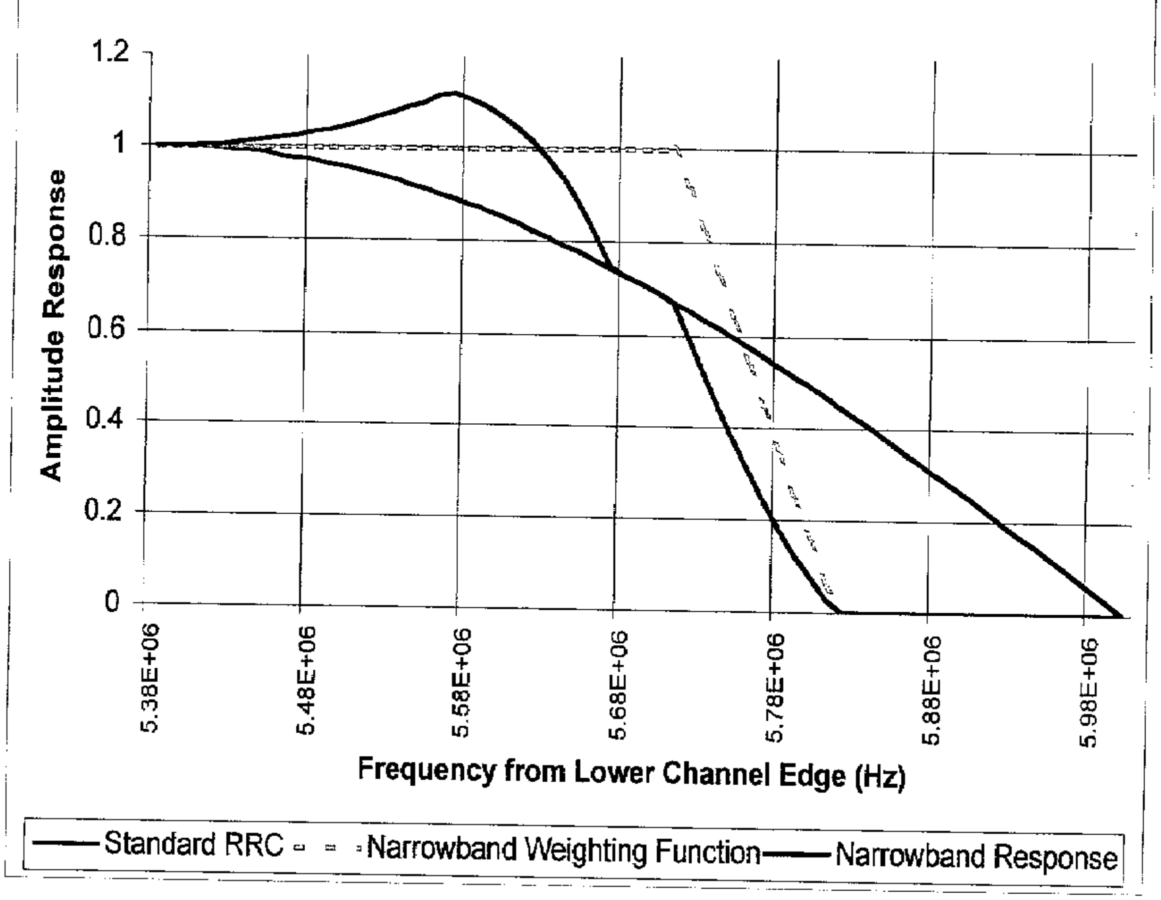
in the RRC transition range just below the Nyquist rate in the 8VSB signal (half the symbol rate or 5.381118881... MHz above pilot) are mirror images of the spectrum just above the Nyquist rate. The amplitudes of the mirrored spectra are not the same, but the frequencies are mirrored.

When the 8VSB signal is demodulated to symbols sampled at the symbol rate, frequency components within this transition region just above the Nyquist frequency, will alias to frequencies just below the Nyquist frequency. This aliasing at the demodulation end is intentional and necessary for the system to work properly.

As was the case in the transition region around the pilot, the spectral shape in the transition range at the upper channel edge can be modified without affecting the demodulated symbols. If energy is removed from the spectrum above the Nyquist rate, then it must be replaced at the equivalent frequency below the Nyquist rate. This spectral modification must consider the shape of the receiver's RRC filter.

To make the spectral modification to the upper band edge, substitute the 8VSB Nyquist rate (half the symbol rate plus the pilot frequency) for the pilot frequency, and interchange references to the upper and lower sidebands. In other words, remove energy from the frequency range between the Nyquist rate (5.381118881... MHz plus pilot or 5.690559441 MHz) and the upper channel edge, and compensate for the loss of energy by increasing the signal amplitude between pilot plus 5.071678322... MHz and pilot plus 5.381118881... MHz.

Figure 2 - Forming the Narrowband Signal at the Upper Channel Edge



So, removing voltage from any frequency above the Nyquist rate, and replacing it at the same frequency below the Nyquist rate such that the frequency-transposed energy is the same at the receiver's demodulator after its RRC filtering, will not change the demodulated I channel signal after it is sampled. This is because the signal components above and below the Nyquist rate are mirror images of each other, and sampling a frequency component above the Nyquist rate by a frequency f will produce the same result as sampling a frequency component below the Nyquist rate by frequency f.

Figure 2, which is essentially a mirror image of the lower sideband figure above, shows the detail of how the narrowband 8VSB spectrum is formed at the upper channel edge. The narrowband weighting function has a value of unity below the Nyquist frequency. Above the Nyquist frequency, over a frequency of 125 kHz, the weighting function drops to zero. In the remaining range just below the upper channel edge (Nyquist frequency plus 125 kHz or approximately 184 kHz), the weighting function has a value of zero. The removed lower sideband energy is multiplied by the expected RRC shape of the receiver. Then it is frequency inverted above the Nyquist frequency, and divided by the receiver's RRC shape, and finally added to the response of the standard RRC shape. The result is the narrowband response shape shown in the figure. This particular choice of shaping results in 184 kHz being removed from the upper sideband. Importantly, the demodulated and resampled I channel of this signal is identical to that of a standard RRC 8VSB signal.

VIII. Filter Design

While this paper describes a method of producing filter shapes which will demodulate correctly in a standard 11.5% excess bandwidth receiver, there is no requirement to use any particular filter design method. There are many well known filter design algorithms which may be used to produce filters which will meet the specifications set out in this paper.

A suitable design method is to use the Parks-McClellan filter design procedure, which, in turn, uses the Remez algorithm.

For example, the following 128 filter coefficients are the first 128 values of the impulse response of a symmetrical 256th order filter for a Weaver modulator implementation of the particular narrowband 8VSB spectrum described above. This filter has a passband ripple of about 0.26 dB peak to peak, and a stopband attenuation of about 64 dB:

7.772097E-05	-1.595535E-03
-3.464779E-03	-3.26408E-03
-6.060667E-04	1.412473E-03
6.370846E-04	-8.903818E-04
-5.23357E-04	6.881676E-04
4.158925E-04	-6.040196E-04
-3.240109E-04	5.751285E-04
2.443965E-04	-5.737484E-04
-1.702383E-04	5.900548E-04
1.001974E-04	-6.168245E-04
-3.079942E-05	6.507201E-04
-3.983978E-05	-6.897774E-04
1.124556E-04	7.325214E-04
-1.877948E-04	-7.782349E-04
2.654561E-04	8.253017E-04
-3.462155E-04	-8.733119E-04
4.298375E-04	9.215385E-04
-5.155462E-04	-9.688983E-04
6.027796E-04	1.014259E-03
-6.907773E-04	-1.056019E-03
7.794481E-04	.0010936
-8.678528E-04	-1.125896E-03
9.549628E-04	1.151552E-03
-1.039757E-03	-1.169074E-03
1.121151E-03	1.176575E-03
-1.19868E-03	-1.173041E-03
1.271292E-03	1.157152E-03
-1.33826E-03	-1.128138E-03
1.398303E-03	1.085357E-03
-1.449495E-03	-1.027571E-03
1.490083E-03	9.538071E-04
-1.517636E-03	-8.623181E-04
1.530588E-03	7.525901E-04
-1.526017E-03	-6.238137E-04
1.499869E-03	4.73694E-04
-1.448509E-03	-2.995904E-04
1.36775E-03	9.698789E-05
-1.255803E-03	1.361574E-04
1.107899E-03	-4.046875E-04
-9.197632E-04	7.162457E-04
6.920146E-04	-1.072391E-03
-4.159816E-04	1.490065E-03
1.054222E-04	-1.957271E-03
2.611526E-04	2.502128E-03
-6.656228E-04	-3.121069E-03
1.108313E-03	3.814615E-03
-1.597682E-03	-4.598855E-03
.0021253	5.476235E-03
-2.691132E-03	-6.452287E-03
3.294328E-03	7.527761E-03
-3.944584E-03	-8.711723E-03
4.652319E-03	1.001574E-02
-5.432695E-03	-1.145401E-02
6.312137E-03	.0130495
-7.331729E-03	-1.483888E-02

8.556794E-03	1.688552E-02
-1.308679E-02	-1.929563E-02
1.208002E-02	2.225296E-02
-1.480236E-02	-.0260924
1.873665E-02	3.147395E-02
-2.487189E-02	-3.988248E-02
3.561839E-02	5.545394E-02
-5.886718E-02	-9.557119E-02
.1445196	.4557275

Table 2 – Filter Coefficients

The 129th through the 256th coefficients are the same as the first 128 coefficients above, except that they are reversed in time order.

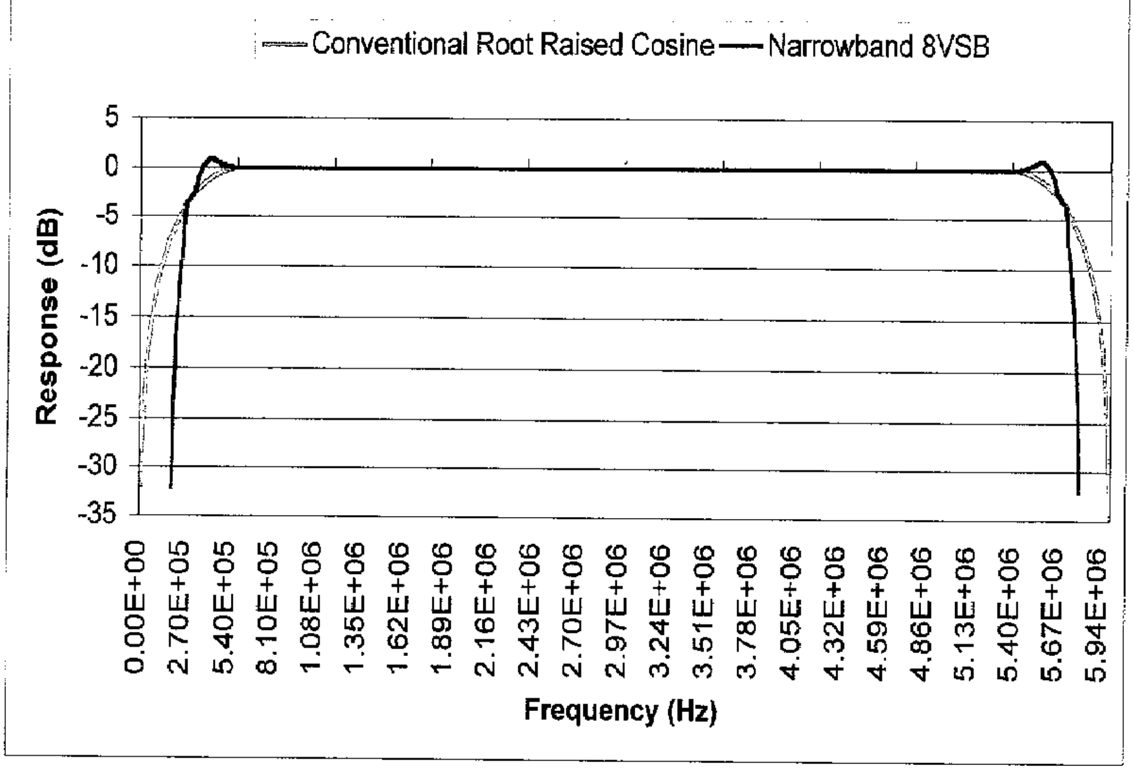
IX. Choice of Method

These methods may be applied to just the lower band edge, or just the upper band edge, or to both band edges simultaneously, depending on the purpose for reducing the bandwidth of the 8VSB signal.

For example, if the problem is protecting two way radio allocations just below channel 14, it may only be necessary to reduce the bandwidth at the lower band edge. Or, if an educational FM station at 88.1 MHz would suffer interference from a new DTV allocation at channel 6, then only the upper band edge of the 8VSB signal would need to be reduced.

Figure 3 shows the bandwidth saving of the narrowband 8VSB system for the G(f) function given above, with bandwidth reduction being applied to both edges of the channel. With this particular G(f) function, there is enough energy being removed from the channel edges to make the in-band response rise by approximately 1 dB.

Figure 3 - Spectrum Shapes for Standard and Narrowband 8VSB



For the maximum amount of bandwidth reduction on just one channel edge, both sides of the spectrum could be reduced, and then the resulting spectrum could be frequency shifted to one side or the other by the amount of the bandwidth truncation on one side. In these examples, with 184 kHz removed from each side, and with the resulting spectrum shifted by 184 kHz, a total guard band of 368 kHz could be created on one side of the spectrum.

X. Weaver Modulator Implementation

A Weaver single sideband modulator shifts a baseband spectrum to be modulated to a pair of orthogonal baseband signals. If the folding frequency and filter cutoff frequencies are properly chosen, the technique may be modified to produce vestigial sideband signals. A modified Weaver VSB modulator was used to produce the narrowband 8VSB signal.

A Weaver modulator uses a pair of lowpass filters to do spectral shaping. In the most basic form of a Weaver modulator, the spectrum must be symmetrical because the lowpass filter pair determines the shape of the two band edges simultaneously. In other words, the cutoff frequency of the Weaver lowpass filters maps to both the upper and lower edges of the output spectrum.

asymmetrical spectral shape may be obtained, allowing application of the narrowband signal on only one side of the signal. In the figure above, a complex filter would consist of four lowpass filters instead of the two shown, plus an adder and a subtractor.

XI. Bandpass Filter Implementation

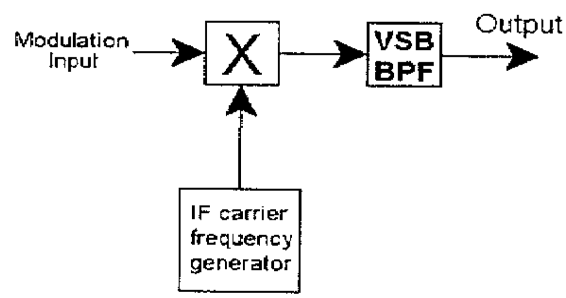


Figure 5 - Bandpass Filter Implementation

The bandpass filter method for generating 8VSB signals is simple. The modulation input, consisting of the symbols plus pilot, is multiplied

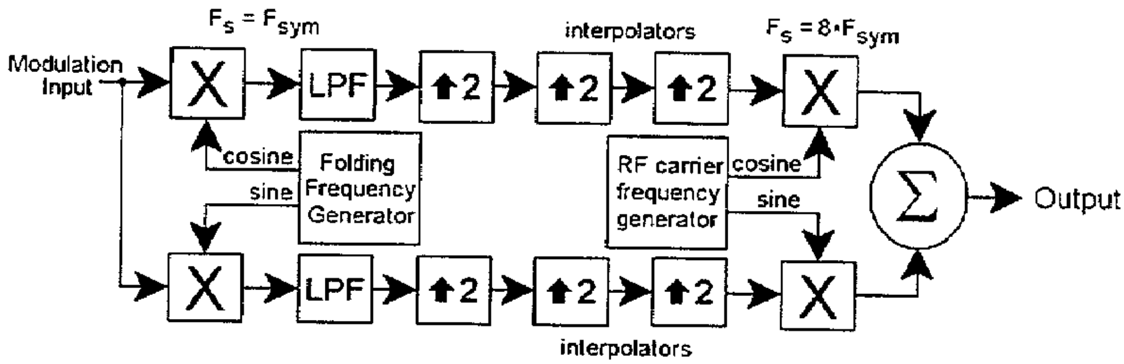


Figure 4 - Modified Weaver Modulator for 8VSB Signal Generation

So, implementation of narrowband 8VSB is straightforward in a Weaver modulator when the bandwidth is reduced on both sides (i.e. symmetrically). However, if the bandwidth of the 8VSB signal is to be reduced on only one side, then a Weaver implementation becomes complex - literally.

The I and Q baseband components in a Weaver modulator can be viewed as a complex time domain sequence. Instead of applying the same real filter to I and Q, a complex filter can be used to shape the bandwidth. A complex filter may have a different frequency response for positive and negative frequencies. Thus, by using a complex Weaver modulator filter, an

by an IF carrier frequency. The resulting double sideband signal is bandpass filtered to produce a vestigial sideband signal. The VSB bandpass filter is designed to produce the desired root raised cosine shape. Any spectral shape may be obtained, simply by producing a bandpass filter that produces the desired spectrum.

The bandpass filter implementation of an 8VSB modulator is conceptually the simplest. But it also generally requires a higher rate of calculation than the Hilbert transform modulator and the Weaver modulator. More filter taps are generally required, and at a higher sampling rate than the Weaver and Hilbert systems, which operate at baseband frequencies.

The conceptual simplicity of the bandpass filter implementation makes adaptation to narrowband 8VSB generation easy. All that is required is a bandpass filter that produces the desired special narrowband spectral shape as described above.

XII. Hilbert Transform Modulator Implementation

Another method for generating 8VSB signals is the Hilbert transform modulator. The Hilbert transform modulator, as used in 8VSB modulators, is shown in Figure 6.

the upper sideband voltage minus the lower sideband voltage at that modulation frequency.

Moreover, the input interpolator must necessarily produce a certain amount of aliasing since the input spectrum extends from DC to the Nyquist rate with no guard band. This aliasing is actually desirable and must appear as a partial inverted replicated spectrum in the spectral tail at the upper sideband edge. The response of the input interpolator and the I and Q channel filters together will determine the spectral shape of the spectral tail at the upper channel edge.

The I channel filter is linear phase. The I channel

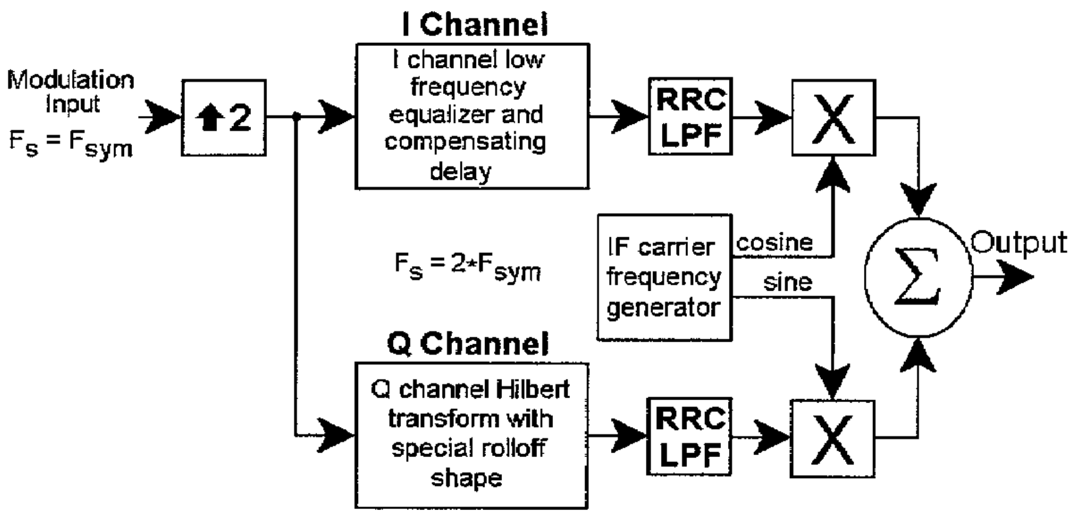


Figure 6 - Hilbert Transform Method for Producing 8VSB Signals

The Hilbert transform modulator accepts the modulating signal, which is symbols plus pilot. In the implementation shown here, the modulation input is first interpolated by two to a sampling frequency of 21.52447552... MHz. This is necessary because the highest frequency to be produced will be 5.690559441... MHz (6 MHz channel width minus the pilot frequency), slightly higher than the Nyquist frequency for symbol rate processing (10.76223776... MHz).

In the Hilbert transform modulator, the frequency response of the I channel at any modulation frequency must be proportional to the sum of the voltages to be produced in the upper and lower sidebands at that frequency. Similarly, the frequency response of the Q channel at any frequency must be proportional to

filter includes a 3 dB "bump" in its frequency response that represents the difference between raised cosine (where the pilot would be down 6 dB) and root raised cosine (where the pilot is only down 3 dB). The overall interpolator/I channel response at the high frequency end has the root raised cosine shape.

The Q channel filter has a phase shift of 90 degrees at all frequencies within its bandpass. The rolloff of the Q channel filter at low frequencies determines the sideband asymmetry (i.e. level of vestigial sideband) near the pilot carrier.

Figure 7 shows the frequency response of the I and Q channels in a Hilbert transform modulator for conventional root raised cosine 8VSB signals.

Figure 7 - I & Q Response for RRC Hilbert Modulator

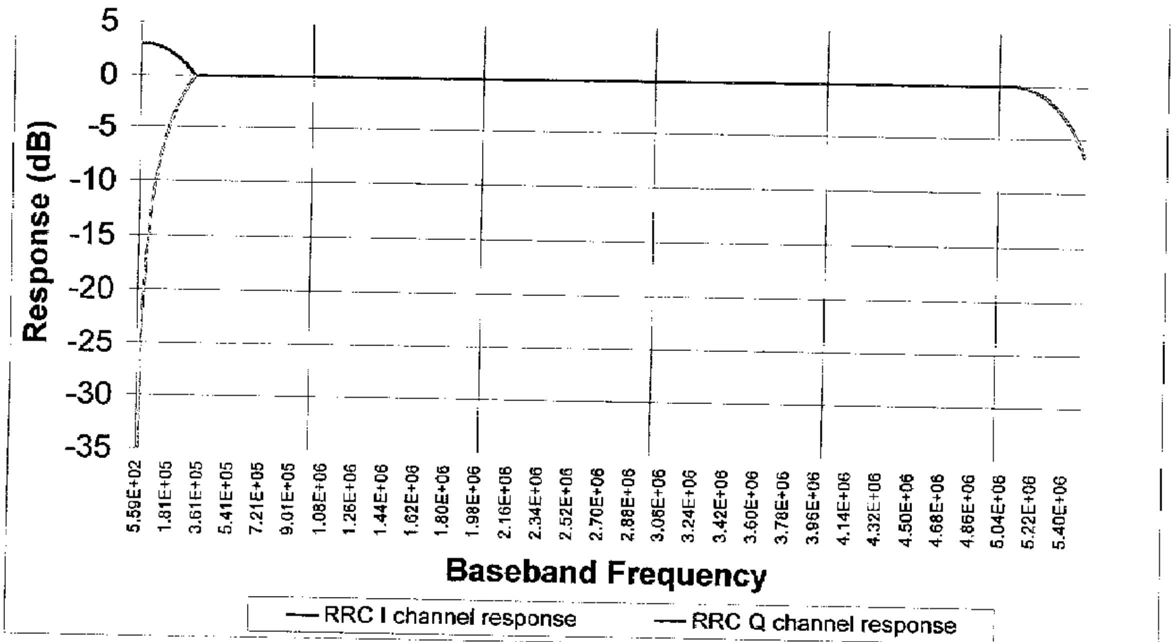
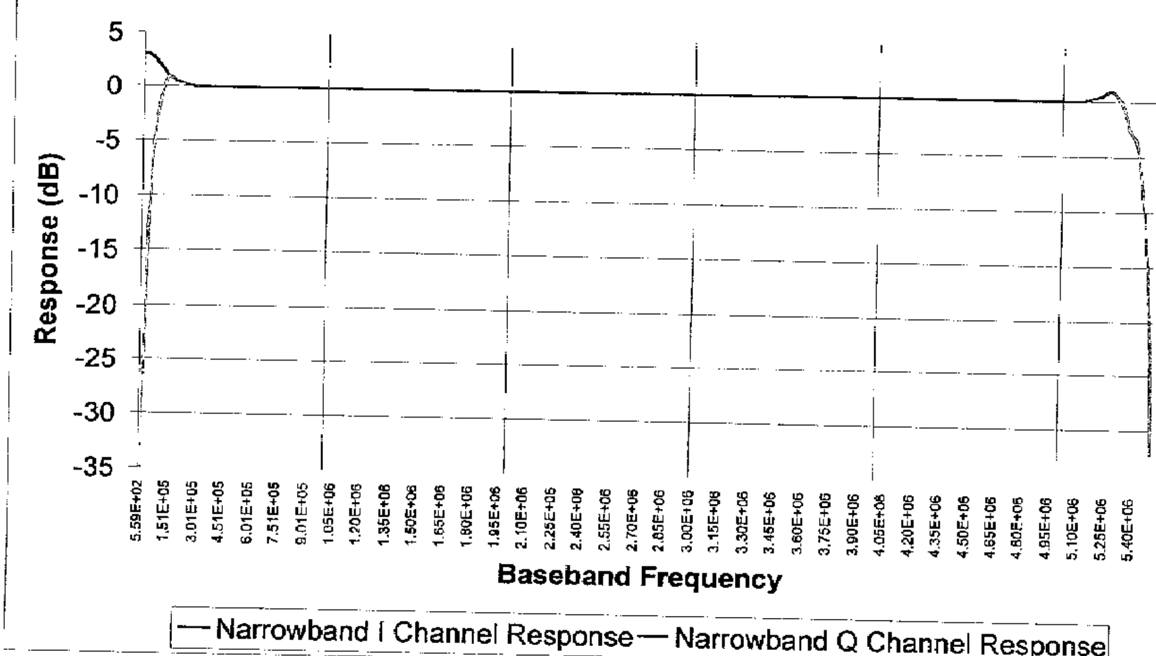


Figure 8 - I & Q Response for Narrowband Hilbert Modulator



Notice that in the low frequency area, corresponding to the vestigial sideband portion of the spectrum, that the I and Q channel responses are unequal. As the Q channel amplitude approaches zero, the resulting spectrum at those frequencies approaches double sideband. Where the I and Q channel responses are equal, the resulting spectrum is single sideband

To modify a Hilbert transform modulator to produce a narrowband 8VSB signal, it is necessary to modify both the I and Q channel frequency responses. Given a particular spectral shape, the I channel response is the sum of the upper and lower sideband shapes, and the Q channel response is the difference between the upper and lower sideband shapes.
At low frequencies, near the pilot, the I channel response will actually be the same for both conventional RRC 8VSB and for narrowband 8VSB. The I channel response will be different from the RRC case only if the upper spectrum edge is made narrowband.

Figure 8 shows the I and Q channel responses for a narrowband 8VSB Hilbert transform modulator.

The I channel response at low frequencies is exactly the same as it is in the standard RRC case. The Q channel response extends lower, corresponding to a smaller sideband vestige. The I channel, together with the Q channel, form a bump at the high frequency end, followed by a steeper rolloff just above half the symbol rate (symbol clock Nyquist rate). The high frequency deviation in frequency response removes aliased energy from just above the symbol clock Nyquist rate, and replaces it with equivalent non-aliased energy. The result is that the demodulated I channel, when resampled at the symbol rate, is exactly the same as it would have been with standard RRC modulation.

XIII. Receiver Compatibility Issues

When a narrowband 8VSB signal is received, the demodulated I channel signal, after it is resampled to the symbol rate, will be exactly the same as it would be with a conventional 8VSB signal. However, several factors may still affect receiver compatibility.

Use of the Q channel by the receiver equalizer. If the receiver's equalizer uses the Q channel in addition to the I channel, then there could be problems because the Q channel is modified. For example, the receiver could try to force the spectral shape to 11.5% RRC before demodulation. This would boost the receiver's response, and thereby noise, near the channel edges.

Operation of the receiver equalizer in a bandwidth larger than half the symbol rate. If the receiver equalizer operates on the demodulated I channel, but in a bandwidth higher than half the symbol rate, then it could sense the reduced energy just above the Nyquist rate and try to boost it (and any noise) up to the level it would be with a standard signal.

If the I channel is sampled at a multiple of the symbol rate, the samples at the symbol instants will be correct. However, the intervening samples will be different from a standard signal. In other words, the eye will still be open.

PLL Issues. Reduction of the spectrum in the vicinity of the pilot will have the effect of increasing the amount of low frequency energy in the Q channel of the receiver. The recovered carrier may have an increased amount of undesired phase modulation or jitter depending on the design of the receiver's PLL and in particular, its bandwidth. This proposal "protects" the pilot by not changing the spectral shape within a 40 kHz bandwidth centered on the pilot frequency.

Receiver manufacturers are not anxious to discuss their proprietary circuitry. So, we did not have much cooperation from receiver manufacturers in trying to determine what effect, if any, the narrowband 8VSB signal would have on the receivers. So the next best thing was to make measurements on a sampling of receivers from different manufacturers. Receivers were tested for input signal level requirements first with a standard 8VSB signal, and then with the narrowband 8VSB signal.

Six different models of receivers have been tested to see if they correctly demodulate the narrowband 8VSB signal, and success was achieved with all. The receivers were marketed by Panasonic, Sony, Thomson Consumer Electronics, Philips, Zenith, and Harris. Threshold measurements were made on two of the receivers (Thomson and Harris). Both of these receivers showed only a 1 dB penalty for the narrowband signal. (Since these tests were made, it has been discovered that there was numerical clipping in the modulator; the penalty for the narrowband signal is therefore probably less than 1 dB.)

The difference between a standard RRC 8VSB signal and the narrowband version is a linear phase bandpass filter. That is, applying a certain linear filter to a standard RRC signal will turn it into a narrowband signal.

Given that this transformation filter could be produced by a particular set of admittedly unusual propagation reflections, and given that advanced receiver equalizers are designed to correct for severe linear distortions, it would seem that receivers would be able to receive the narrowband signal without any special consideration.

indicate to receivers that the signal being transmitted is the narrowband version. Receivers that use the Q channel and/or oversampling may thus be informed that the spectrum is slightly modified from the standard.

Standardization of the narrowband variant of the 8VSB signal by the ATSC, and use of presently reserved data field sync VSB mode bits, would allow receiver manufacturers to know when their equipment is receiving a narrowband signal, and to accommodate the slightly different spectral characteristics. Receiver manufacturers may wish to optimize performance when receiving the narrowband 8VSB signal with slightly modified IF bandpass filter characteristics, PLL

Figure 9 - Transformation Filtering

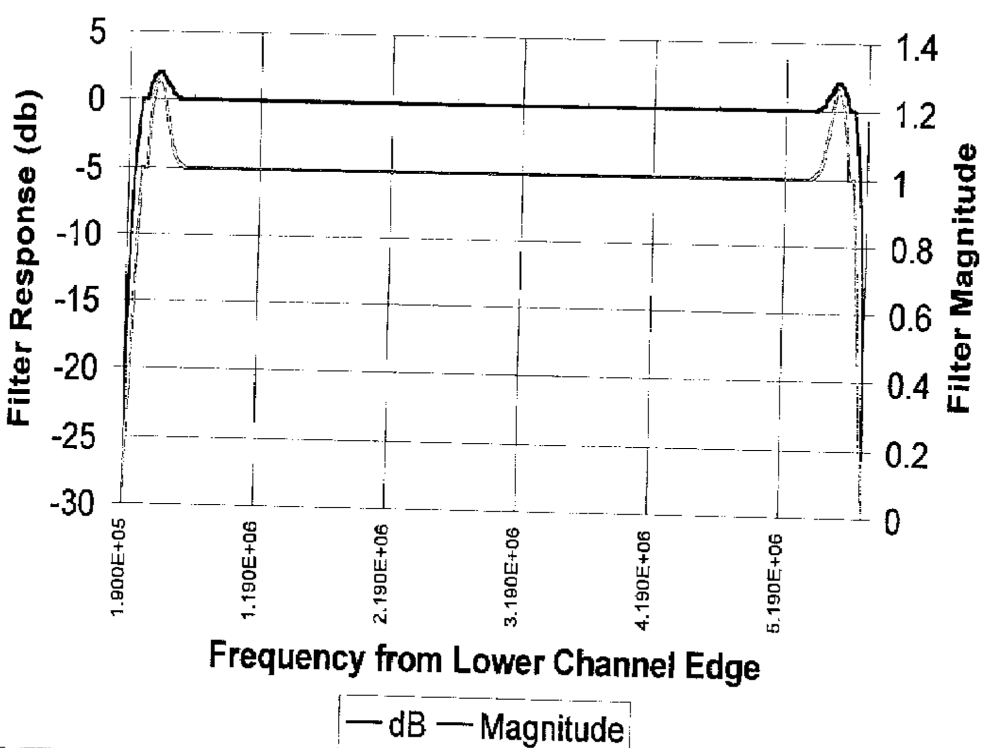


Figure 9 shows the response of the filter that represents the transformation from standard RRC to narrowband. In particular, this filter produces high attenuation values at and near the channel edges, and small response bumps just inside the pilot and Nyquist frequencies.

Nevertheless, we propose to utilize some of the reserved bits within the ATSC standard to

constants, and advanced adaptive equalizer designs. Use of presently reserved VSB mode bits will allow the receivers to easily recognize the narrowband 8VSB signal.

There are presently 24 reserved bits in the VSB Mode sequence of the VSB data field. The present ATSC recommendation [1] for handling these bits is as follows:

P A B C

0 0 0 0 Reserved
1 0 0 1 Reserved
1 0 1 0 Reserved
0 0 1 1 Reserved
1 1 0 0 16 VSB
0 1 0 1 8 VSB*
0 1 1 0 Reserved
1 1 1 1 Reserved

These 24 bits determine the VSB mode for the data in the frame. The first two bytes are reserved. The suggested fill pattern is 0000 1111 0000 1111. The next byte is defined as: PABC ~P~A~B~C where P is the even parity bit, the MSB of the byte, and A,B, C are the actual mode bits.

* In the 8 VSB mode, the preceding bits are defined as:

0 0 0 0 ~P~A~B~C P A B C 1 1 1 1

VSB transmitters using the compatible system with a guard band should transmit these previously reserved 24 bits according to Table 3:

VSB Mode	Reserved bit pattern
100% spectrum usage	0000 1010 0101 1111
LSB 150kHz guardband	1001 1010 0101 1110
USB 150kHz guardband	1010 1010 0101 0101
USB & LSB guardbands	0011 1010 0101 1100

Table 3 - Proposed Bit Patterns

The sequence preserves the sense of the parity bit in the MSB of each nibble as it is in the VSB mode now. (Note that in the 8VSB mode, the two middle nibbles are ~P~A~B~C PABC or 1010 0101.) Since these bits were previously reserved, there is no issue of compatibility with existing receivers thus maintaining the philosophy of the technique that it be completely benign to existing DTV consumers.

For existing receivers, the evidence suggests that they already are capable of receiving the narrowband 8VSB signal without any modifications.

We are ready and willing to work with receiver manufacturers and others to apply this technology and solve interference problems.

XIV. Transmitter compatibility

The transmitted bandwidth of the narrowband 8VSB signal is narrower by design. A signal that is narrower than standard will not create any problems with a transmitter. However, retuning of the channel filter will be required to take maximum advantage of the narrowband signal.

Another issue is peak to average ratio. Peak to average ratio is only slightly higher with the narrowband 8VSB signal as implemented. With a 368 kHz reduction in bandwidth, the peak to average ratio is only 0.5 dB higher than with a standard signal.

XV. Practical Results

Initial testing was done by generating the signal at low level and applying it to receivers. Receivers correctly demodulated the narrowband signal.

Next, a low power channel filter was designed and built. This is a 10 section reflective filter. The cavities in this filter, being physically smaller than a full power filter, have a lower unloaded Q than a full power filter. As a result, the low power filter has approximately 3 dB of attenuation at the pilot frequency where the full power filter would be down only a few tenths of a dB.

The purpose of the low power filter was to test the exciter's ability to adaptively equalize the filter. This was successful.

Tests with the low power filter also produced good signal to noise ratio measurements in tests that evaluate the demodulated I channel only. A Tektronix RFA300 indicated better than 30 dB SNR performance.

The next test was to generate the narrowband signal at a few kilowatts and pass that through the low power filter. The results are shown in Figure 10.

It is evident from this display that the transmitter exceeds the FCC's channel mask by a wide margin.

Next, a full power, constant impedance type channel filter was designed and built. This channel filter will be used on the air at KERA-DT on channel 14 in Dallas, Texas.

XVI. Conclusion

In these cases, narrowband 8VSB will allow stations in these situations to get on the air and to make best use of the available spectrum.

Narrowband 8VSB can be used to get stations on the air which would have otherwise insurmountable problems. In some instances, some form of narrowband transmission may be the only way to solve an interference problem.

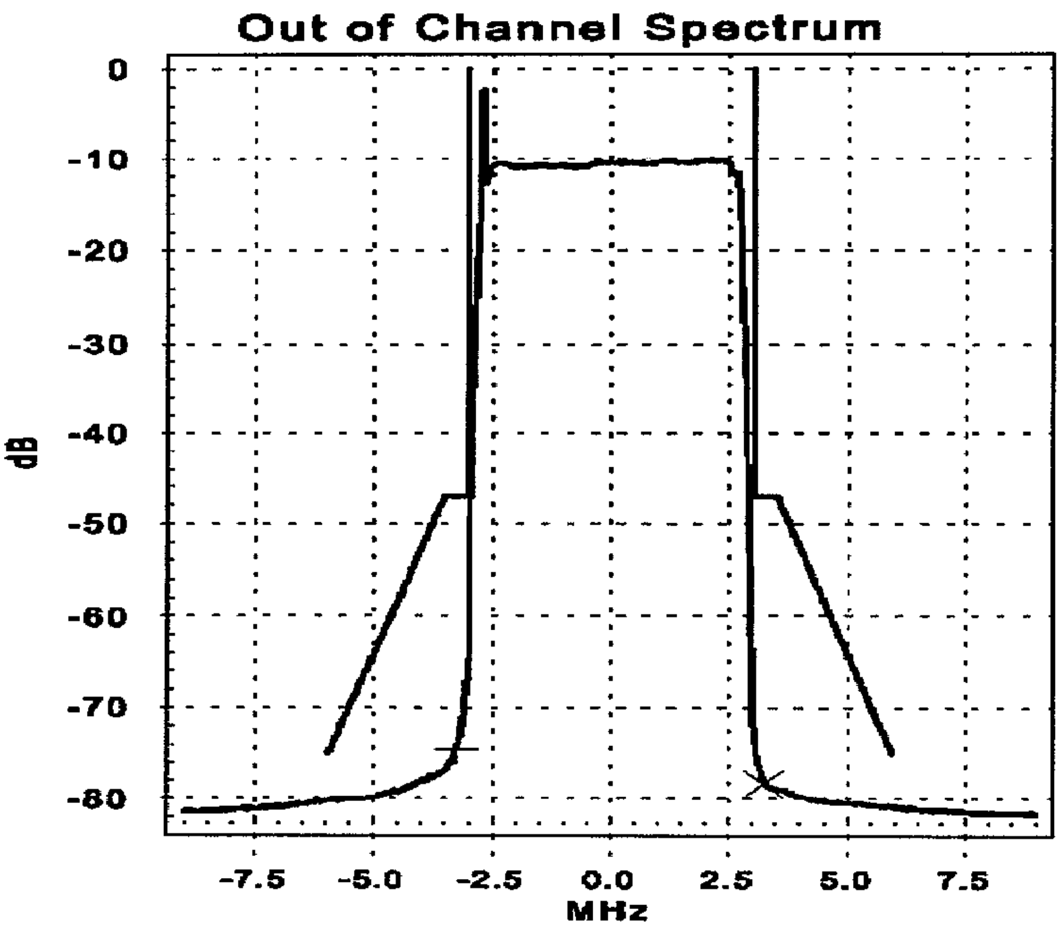


Figure 10 – Narrowband Transmitter Spectrum

XVII. Reference

[1] Advanced Television Systems Committee. ATSC Digital Television Standard, Doc. A/53, p. 56. 12 Apr 95; 16 Sep 95.

appendix c

RECEIVERS TESTED

AUVIO	MODEL	16-906
HAIER	MODEL	HLT71
COBY	MODEL	TF-TV1513
EVIANT	MODEL	T4
AXION	MODEL	AXN-8701
AUVIO	MODEL	16-972
COBY	MODEL	TF-TV891
LG	MODEL	26LE5300-UE

CONVERTERS TESTED

VENTURA	MODEL	STB7766G1
ZENITH	MODEL	DTT900
RCA	MODEL	DTA809
DIGITAL STREAM	MODEL	DTX9900
GE	MODEL	23333
RCA	MODEL	STB776661
PHILCO	MODEL	TB100HH9
SUNKEY	MODEL	SK801ATSC
ZENTECH	MODEL	DF-2000L
LASONIC	MODEL	LTA-260
MAGNAVOX	MODEL	TB100MW9
SANSONIC	MODEL	FT300A
ARTEC	MODEL	T3APRO
DISH	MODEL	DTVPAL
CADENCE	MODEL	DTVC-9
APEX	MODEL	DT-250
ACCESS	MODEL	DTA1080