PRO Channels -- Television's Free Lunch

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Executive Summary

The PRO Channel embedded in every broadcast television signal can be an effective medium for delivering IFB to reporters in the field. However, the signal delays introduced by digital studio-transmitter links, COFDM microwave from the ENG location to the studio, and anti-obscenity systems make it difficult or impossible for reporters and commentators to listen to the live program channel while they are trying to speak on the air. Hearing their own delayed voices coming back to them in an earpiece causes even the most experienced broadcasters to stutter and stammer.

In order to eliminate this problem, a PRO Channel IFB system offers one or more of four methods to manage the delay: either feed an undelayed program channel to the remote talent combined with an “interrupt” from the newsroom; squelch the program audio as soon as the talent starts to speak; combine the undelayed channel with squelch; or deliver a mix-minus feed without the reporter’s voice. The Modulation Sciences (MSI) PRO-3 PRO Channel Receiver and PCG-2 PRO Channel Generator allow a broadcaster to use all of these approaches, or to choose the one that’s most effective for each specific application.

An Overview

What is PRO Channel?

The PRO, or Professional Channel, is a private, one-way communication channel embedded in a broadcast TV signal. It is ideal for news operations cueing and IFB. The PRO Channel is part of every television station's signal.

Private IFB channels are available free to every broadcast television station for their exclusive use. Because the PRO channel already belongs to your station, there are no lease or per-use charges. The only things needed to use it are a compatible channel generator and receiver.

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The FCC created the PRO channel at the same time it authorized stereo sound for television broadcasting. It is part of your sound signal in the same way that stereo is part of the signal of your station. The PRO channel is similar to the “SCA” channel used by FM broadcasters to transmit private signals such as background music and reading services for the blind.

The FCC created the channel for stations to use for their internal needs. The PRO is a "voice grade" channel, with sound quality similar to a conventional telephone line. It is ideal for delivering cue or IFB to remote ENG crews, but the PRO channel is not suitable for transmitting program quality sound. Television sets and VHF/UHF radio scanners cannot eavesdrop on PRO channel transmissions.

Technically, the PRO Channel is an FM subcarrier on the aural carrier. The FCC specifies a center frequency of 6.5 times the video horizontal sync frequency, equal to about 102.3 kHz. The deviation of the main channel by the PRO signal (injection) is specified as ±3 kHz. The remaining parameters that have emerged as de facto standards are:

- ±5 kHz deviation of the PRO subcarrier by its program (modulation)
- Audio bandwidth of 300 Hz to 3 kHz
- Pre-emphasis of 2160 μsec.

The Modulation Sciences PRO-3 system is a complete PRO Channel transmission package, including a channel generator and a receiver. Figure 1 illustrates the operational use of the PRO-3 system with a station that has no on-air delay. Figure 2 shows the frequency spectrum usage of the TV aural baseband by this application.

An important feature of the PRO-3 system in this application is the selective calling option that permits a producer at the station to selectively send interrupts to one on-air person, while others continue to hear the main program channel. This is accomplished using sub-audible tone signaling (CTCSS).

A New Job for PRO Channel

Ten years after it was introduced, the PRO Channel continues to provide a reliable IFB Channel for hundreds of television stations. However, smooth, professional ENG operations face a new challenge today, as a byproduct of the conversion of television internal transmission from analog to digital: the delay between the studio and the transmitter (the STL) usually caused by MPEG

encode/decode processes. Recently, many stations have also added an intentional five to seven- second delay for protection against obscenity during live broadcasts such as news programs with live remote segments.

An additional source of delay is the conversion of the ENG-to-studio links from wideband FM to COFDM. While the performance capabilities of COFDM seem nearly magic to those accustomed to analog FM, this magic comes with a price – delays as great as eight-tenths (0.8) of a second.

The Modulation Sciences PRO-3 PRO Channel Receiver offers several solutions to the problems created by these delays.

Some Definitions

To minimize confusion, we should offer some definitions before we go any further in this discussion.

Mix-minus is the entire audio content as it goes out over the air, but without the voice of the on-air talent. The result is that the audio in the talent's earpiece does NOT contain their own voice, but has everything else.

IFB – Perhaps the most misunderstood three letters in television. Ask a hundred people who use IFB every day what the letters stand for and you will likely get at least ten different answers. The term IFB comes from the British Broadcasting Corporation (BBC), and numerous attempts to Americanize it have left everyone confused. "IFB" are the initials for *Interruptible Fold Back*. *Fold back* is the BBC expression for what we call *cue*. Cue is the program feed provided to on-air talent so that they can take their program-based cues. Interrupt allows a producer or director to break into or talk over the cue signal to provide specific instructions to the air person. Of course, these instructions do not go out over the air.

Equal vs Differential Delay

It's important to remember that we are discussing *equal delay*, which is the same in both the aural and visual channel. Regardless of is the duration, this delay is imperceptible to the audience. One form of equal delay has been around for decades: the three-hour delay that brings live East Coast programming to the West Coast at the same local time.

Equal delay that is benign to the viewer should not be confused with the evil *differential* delay, which takes the audio and video out of step and is most definitely noticeable to viewers. This *lip-sync* breakdown represents a very serious problem… but that is not what this paper is about. This paper is solely concerned with delay in the audio channel, regardless of whether it is equal or differential.

The Problem

If equal delay is not a problem for the audience – the paying customers – what's all the fuss about?

Audio delay trashes all attempts to produce tight, live news programs that include remote ENG feeds. Rather than looking and sounding like polished professionals, reporters and other on-air talent who are hearing their own voices delayed by more than about 25 milliseconds will stutter and stammer like the Warner Bros. cartoon character, Porky Pig. Your own voice, delayed more than about 25 milliseconds, and then fed back into your earpiece makes coherent speech nearly impossible. At best, an announcer or reporter hearing a delay will sound distracted; or worse, your audience will assume that they're drunk.

The effect of delay on tight cues is somewhat more subtle, but it's also destructive to fast paced, professional news programming. Problems begin at half a second of audio delay, and they're readily noticeable when the delay is more than a second. Here is a simple example: the studio on-air person will cue the ENG talent "…and now Jim at the accident scene." Without COFDM delay, Jim will start talking within a few tenths of a second. But if there is almost one full second of delay between Jim's beginning to talk and that audio arriving in the news control room, that cue can appear sloppy to the viewer.

Delayed IFB makes tight cueing difficult and rapid exchanges between the studio and any remote site impossible. If talent can't listen to themselves in real-time, they should not listen to themselves at all.

There are four possible solutions:

1. Delay correction by transmitting undelayed audio on a second "PRO" Channel, while the original PRO Channel continues to carry the "interrupts" from the news room. This technique is the best way to deal with delay between the studio and transmitter. We call this DELcor™. By itself, it is not effective for coping with ENG vehicle-to-studio delay, but when combined with other techniques it can be very effective.

2. Squelch the program audio in the talent's earpiece as soon as they start to talk, but don't silence the newsroom interrupts.

3. A combination of the first two approaches – combining a second channel with squelch. This offers a solution where delay exists in both the ENG to studio link, as well as the studio to transmitter.

4. Deliver a mix-minus feed -- the live program without the ENG on-air voice. Under some conditions, up to six independent channels may be provided.

Let’s discuss each of these solutions in detail.

DELcor

DELcor stands for Delay Correction. DELcor is a feature of the Modulation Sciences PRO-3 receiver that corrects delay problems. It is optimal for correcting delay between the studio and transmitter. When combined with PRO-3’s DELiminate™ feature (see below), the pair offers a simpler and less expensive alternative to separate subcarriers for each mix-minus channel.

DELcor technology employs the standard PRO subcarrier channel (at 6.5H) and a second subcarrier channel (DELcor) generated at 5.5H (86.5 kHz). See Figure 3 for the baseband spectrum with DELcor.

Undelayed main channel audio is carried on the DELcor subcarrier, while the interrupt is carried on the standard PRO subcarrier channel. When the newsroom needs to talk to a specific on-air person, the interrupt is detected using a sub-audible CTCSS tone (better known by its Motorola trademark, PL) assigned to that particular receiver. When that specific PRO-3’s tone is detected, the receiver automatically switches its output from the undelayed DELcor subcarrier to the standard PRO subcarrier, which provides the interrupt. Any other DELcor receivers in the field continue to receive undelayed main channel. Figure 4 illustrates the operational use of DELcor.

Operation of DELcor is mutually exclusive with the SAP channel. SAP is transmitted at 5H, while DELcor technology “borrows” a portion of the SAP channel at 5.5H that is undetectable by viewers. If DELcor is not in use, the SAP channel may be used in its normal operating mode. When DELcor is in use the SAP channel is unavailable for transmission. The interrupt, operating in the standard PRO channel (6.5H), remains available at all times.

To accomplish sharing between the SAP and DELcor systems, use a simple coax relay to select between the DELcor generator and the SAP generator.

DELiminate

DELiminate stands for Delay Eliminate. This second feature of the PRO-3 offers full protection from the adverse effects of delay that originate anywhere in the transmission system. The DELiminate feature allows for the tightest cueing of the talent because it eliminates the effect of delay between the studio and the transmitter. See Figure 5 for an operational drawing.

DELiminate technology works by rapidly muting the main channel feed to the earpiece of the talent as soon as he or she starts talking. It DOES NOT mute the interrupt feed, so the news room can continue to provide direction to the talent in real-time.

Since DELiminate adds only a squelch to undelayed operation, it makes no change in the baseband spectrum; the arrangement shown in Figure 2 applies.

The combination of DELcor and DELiminate provides a cost effective solution to managing situations where delay exists in both the ENG-to-studio and studio-to-transmitters links. By combining features, the squelch of DELiminate protects the on-air person from the disruption in their speech caused by hearing their own voice delayed, while the undelayed studio audio of DELcor allows for tighter cues. Figure 6 illustrates how the two systems combine.

This combination is especially useful for stations that do not have a studio mix-minus capability.

Mix-Minus

For many stations, mix-minus offers the best overall approach for dealing with all on-air delay, regardless of origin. From an on-air person's viewpoint, mix-minus is also desirable because it is familiar, since it is the same IFB technique used in many news studios.

This technique is especially valuable for those stations that already have mix-minus systems. Mix-minus PRO channel permits as many as six independent channels of mix-minus to be transmitted to up to six different destinations.

The number of available mix-minus channels depends on the operating mode of the main channel. Up to three channels of mix-minus are available when the station is operating in stereo mode without SAP. Figure 7 shows the spectrum of this arrangement, and Figure 8 shows the operational configuration.

By dropping stereo during live news operations, a station can support up to six channels of mix-minus. Time-sharing of the baseband spectrum between stereo and three additional Mix-minus channels is easy to accomplish. Figures 9 and 10 provide the details of this operation.

PRO Channel – A Closer Look

Advantages of PRO Channel

Coverage

The "holes" or dropped calls common to wireless phone coverage are never an issue with the MSI PRO Channel Systems. Coverage distance using the PRO-3 receiver is two or three times greater than a simple two-way radio system can deliver. The range of MSI's PRO system is also significantly greater than the station's normal picture coverage.

For both PRO and main channel audio, the Modulation Sciences (MSI) implementation of PRO channel delivers usable IFB over a much greater area than the visual signal coverage. With the MSI PRO Channel, IFB coverage 20 to 40% *beyond* the point where the picture becomes unusable is common.

Without getting too technical, here's why: All television sets depend on the picture to receive the sound, because that allows the TV set to be much less expensive. For TV sets this is OK, because sound and picture are closely related. Who would want sound without a picture? However, this means that the picture quality determines the sound quality. No picture, no sound.

Since the picture signal is much less robust than the sound, the picture degrades a lot sooner. By employing a specially designed receiver that does not depend on the picture to recover the sound, audio quality and coverage no longer depend on picture quality. This is called "non-intercarrier" detection and is unique to the Modulation Sciences PRO Channel Receivers.

Another reason for extended aural coverage, as compared with FM radio, is the vast difference in interference protection for TV aural carriers. There are no adjacent-channel aural carriers to cause interference. The lower “adjacent channel” to a TV aural is its associated station’s visual signal, and the upper adjacent is some distant station’s vestigial sideband. As for co-channel interference, the aural gets a “free ride” because the co-channel protection distances are based on the visual signal, which is far more susceptible to interference than the aural. In conventional television reception, this extended coverage of the aural is never apparent because once the visual is compromised by distance or interference, the aural is gone too.

Mobile Reception

While it's unlikely that you will want to do a live shot from a moving ENG van, PRO Channel coverage into a moving vehicle can be a valuable resource. It can be useful to monitor either the station’s air signal or a production channel while traveling to a story location. The MSI PRO system includes a unique antenna diversity circuit that allows it to receive while in motion, with the mast down, even in difficult downtown areas. This same feature protects the PRO Channel from "multipath" interference by tall buildings and other ghost-causing structures.

The PRO Channel is also the only legal and reliable technology for delivering IFB to a helicopter or a fixed-wing aircraft. Because the IFB channel is part of a high-powered broadcast signal with a large coverage area, it is not subject to any of the interference problems inherent in airborne operation of cellular telephones and two-way radio systems.

Reliability

Simply put, PRO Channel is as reliable as your broadcast signal. Modern television stations are amazingly stable. When was the last time your station was

off-the-air? Redundant transmitters; generators at the studio and transmitter with days of fuel, and sometimes entire redundant sites all represent a compelling commitment to *staying on the air*. Because the PRO Channel is part of your signal, it is as reliable as your signal. Even during incidents involving loss of the most basic infrastructures -- telephone and commercial power -- PRO Channel delivers the IFB to get the story out when it is most critical.

Works When Wireless Fails

Wireless telephone service often fails during major news events. During big stories like earthquakes or severe weather, the wireless telephone system overloads, and multiple cell sites can simply disappear. Calls can neither go out nor come in.

The *National Communications System,* a Federal Agency, said in a report, "…due to heavy wireless traffic demands placed upon .. wireless systems in the aftermath of a disaster, severe wireless network congestion has been experienced resulting in high call blocking…" In broadcast terms, the bigger the story, the less likely it is that you will get a wireless connection when you need it most.

Less dramatic, but equally serious, a highway traffic jam can paralyze the wireless network. People stuck in traffic tend to use time spent not moving making calls, which ties up the finite capacity of the wireless network. On the other hand, the PRO channel is part of YOUR television signal and is always available. You're not contending for access with any other users.

Another common problem with wireless service is the tendency to randomly disconnect during long calls, even when the telephone is not moving. That will never happen with the PRO.

Not Subject To FCC Denial Of Service Rules

FCC Rules (47 CFR 64.402) encourage wireless telephone companies to provide Priority Access Service (PAS) to national security and emergency services personnel at all times. PAS insures that emergency workers will get the next available wireless circuit, regardless of how many non priority users are waiting for a circuit. As more and more wireless service providers offer PAS, the chances of news organizations getting wireless circuits during a major news story grows smaller and smaller. PRO channel is not subject to PAS rules.

Security

While 2GHz PCS digital service is secure from eavesdropping, two-way radio and 900 MHz cellular certainly are not. Many scanner publications list all the VHF and UHF BAS and private radio allocations for radio and TV stations, and regardless of what the FCC Rules say, there are still a lot of scanners available

that cover 900 MHz cellular. It is far less likely that an outsider will have access to the specialized equipment required for monitoring a PRO Channel signal.

Comparison with FM SCA

It may be tempting to equate PRO Channel with the SCA signal on an FM broadcast. However, just about the only thing they have in common is that they are both FM subcarriers on FM main channels. PRO Channel doesn't share any of the well-known problems associated with FM SCA. While the issues can and have been overcome, they are still associated with subcarrier operation

Crosstalk from the main program into the PRO channel is nearly absent in PRO channel for several reasons:

1. Cross-talk is a direct function of the average modulation of the main channel signal. Because there is MUCH less processing in TV than FM, average modulation is much lower.

2. Main channel audio is primarily speech, which has lower average modulation than music.

3. Quality of the subcarrier receiver bandpass filter plays a major role in preventing crosstalk. In MSI PRO Channel receivers, the bandpass filter is a multistage L/C filter that is tuned up by hand in every unit. Low-cost mass production consumer SCA receivers do not have the price margin to include such a high quality filter.

Going the other way, many subcarrier users are concerned about interference from the subcarrier into the main channel, commonly called "birdies." This is a non-issue with PRO Channel because:

1. A totally different stereo decoder design is used for TV stereo that resists subcarrier interference.

2. The BTSC compander system adds additional rejection on top of the decoder.

A final concern is that adding a subcarrier will reduce your main channel coverage. This had some basis in fact for FM SCA, where 50% of the deviation for the subcarrier is taken from the main channel. In PRO Channel operation (as well as TV stereo), the necessary deviation is added, 100%, to the total. So there is no loss in the modulation of the main channel signal.

The FCC

When the Multichannel Television Sound (MTS) rules were written in the mid-1980s, Digital Television (DTV) was a distant vision that everyone assumed

would be an analog extension of NTSC. Certainly no one envisioned the wholesale conversion to digital transmission, even for ultimate transmission in NTSC, and the attendant long delays that would be introduced.

Thus, some of the techniques described in this paper were not foreseen—or foreseeable—in the MTS rules. So Modulation Sciences sought and received opinions from a consulting engineer and an attorne who specialize in FCC broadcast matters and who are well respected in our industry. These independent experts agree that the applications described here are entirely consistent with current FCC rules and policies.

Potential Pitfalls of PRO Channels

No technology is perfect -- each has tradeoffs. The potential weaknesses of PRO Channel include:

Multipath -- All subcarrier systems are susceptible to degradation from multipath. Technically the problem arises from the nature of subcarrier operations: The subcarrier can be as much as 20dB below the main channel, so it takes only a small amount of non-linear distortion, usually created by multipath, to completely overwhelm the subcarrier.

The nature of ENG, often employed in urban areas with an antenna no more than thirty feet off the ground and with strong main channel signals, renders such operations especially prone to multipath interference to the PRO Channel.

Modulation Sciences PRO Channel receivers mitigate the multipath problem somewhat by including an antenna diversity circuit. This circuit very rapidly (in microseconds) samples the signal from two antennas and selects the best one, based on the greatest signal strength and least multipath. Diversity has been shown to produce a 20 dB improvement in multipath performance.

When the diversity circuit is combined with the recommended antenna system, significant reduction in multipath susceptibility results. In addition to the typical ENG van installation employing a "pancake" style antenna mounted on the lift mast as the primary antenna, MSI suggests a simple whip antenna mounted some distance away (usually on the roof of the cab) as the second antenna.

Incidental Carrier Phase Modulation (ICPM) -- PRO Channel operation is very susceptible to interference from ICPM if the receiver depends in any way on intercarrier detection. However, Modulation Sciences entirely avoids this problem by using true non-intercarrier detection in all of its products. Our receivers are true FM radios -- you can shut down your visual transmitter and MSI PRO

channel receivers are unaffected. With non-intercarrier detection, there is no ICPM interference.

Lack of portability -- Perhaps the most frequently asked question about PRO Channel is, "can you put it in a belt-pack?"

Unfortunately belt-pack operation is not practical for PRO Channel. The very poor antennas associated with body-worn receivers simply allow too much multipath and no possibility of effective diversity. The only way a belt-worn receiver could work is if the air talent were willing to wear a metal hardhat with a whip antenna on top...

For wireless connection to talent, an RF link between the van and talent will do the job. Comrex makes such device.

Digital Television -- There has been some discussion of placing IFB on the transport stream of the DTV signal. There are some expenses, both direct and indirect, to using the transport stream that need to be considered. Transmission hardware will likely be much more expensive due to the need for low delay multiplexing. Current estimates are that to give an IFB signal sufficient priority in the multiplexing process, it would need to be allocated ten times the data bandwidth that it actually needs in order to avoid multiplexing delays.

The potentially big indirect expense is the bits in the transport steam. If the transport stream offers the possibility for direct revenue by carrying auxiliary data services, then it is unlikely the transport stream will be available for IFB. There are already companies purchasing “excess” transport stream capacity from DTV stations. The situation is comparable to the sale of vertical blanking interval (VBI) capacity on NTSC stations.

Conclusion

A television station’s PRO Channel offers a reliable and cost-effective IFB channel for cueing and other communication to remote ENG crews. However, the audio delays introduced by digital studio-transmitter links (STLs), COFDM ENG-to-studio microwave, and anti-obscenity protection can create significant problems when the talent hears a delayed broadcast of his or her own voice. In order to eliminate these problems, the Modulation Sciences (MSI) PRO-3 PRO Channel receiver incorporates highly effective DELcor (Delay Correction) and DELiminate (Delay Eliminate) features. Combined with the MSI PCG-2 Channel Generator, the PRO-3 Receiver provides an attractive solution to the problems that had previously limited the usefulness of PRO Channel IFB communication.

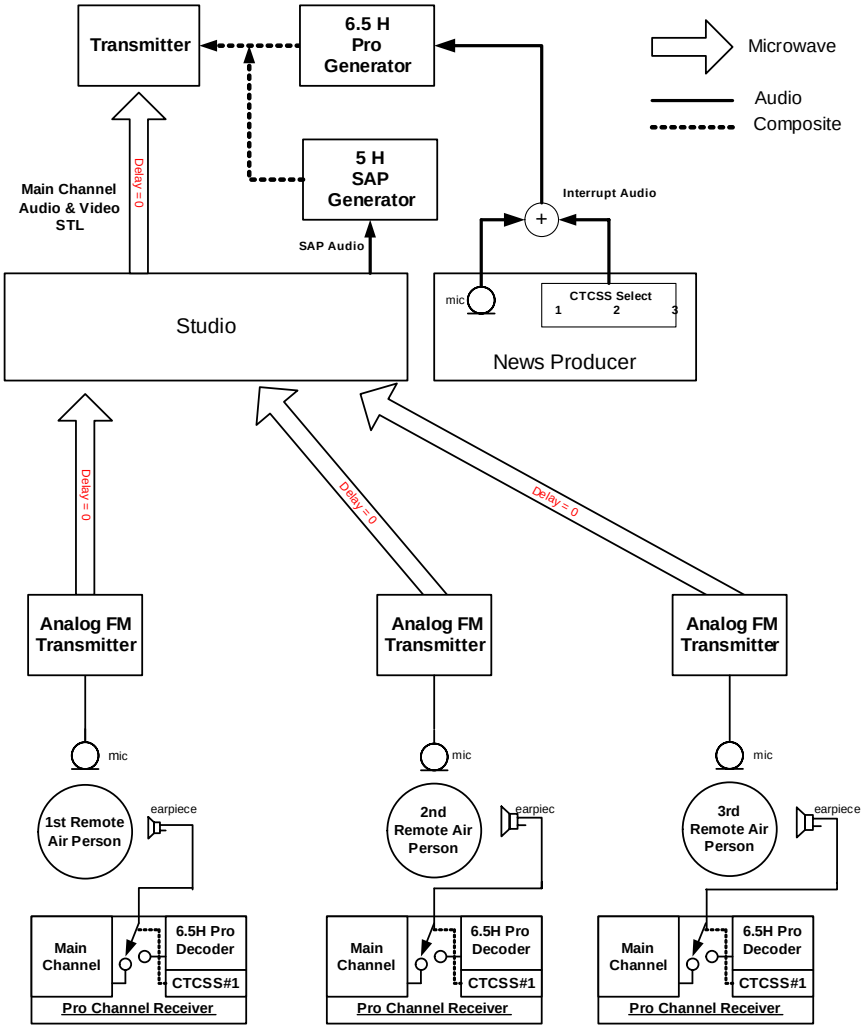

Figure 1 Undelayed System

This allows up to sixteen vehicles or locations to receive independent, individual interrupts, while all listen to the main air channel for cues. For simplicity, the drawing shows three users. Each air person's earpiece normally receives the main program channel from the station. The News Producer, often using the station's regular intercom system, can direct an interrupt to any individual on-air person by sending the CTCSS sub-audible tone assigned to that person's receiver. The talent's feed of the air program will be "pushed down," while the producer's voice will be heard by the designated air person at full volume. Everybody else will continue to hear the off-air signal.

With more than six years of operation at hundreds of television stations, the original application of PRO Channel has proven its robustness and reliability. However, it has no mechanism to deal with audible delay anywhere in the audio chain. An on-air person hearing their own delayed voice in their earpiece will be unable to speak coherently.

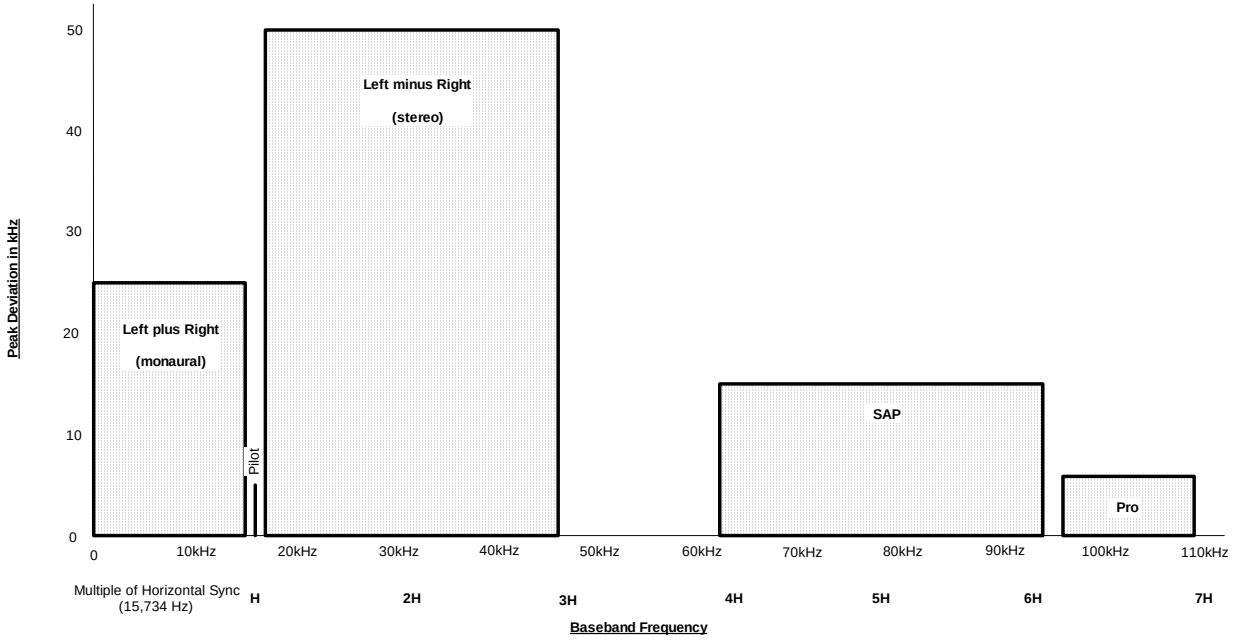

Figure 2 Undelayed & DELiminate

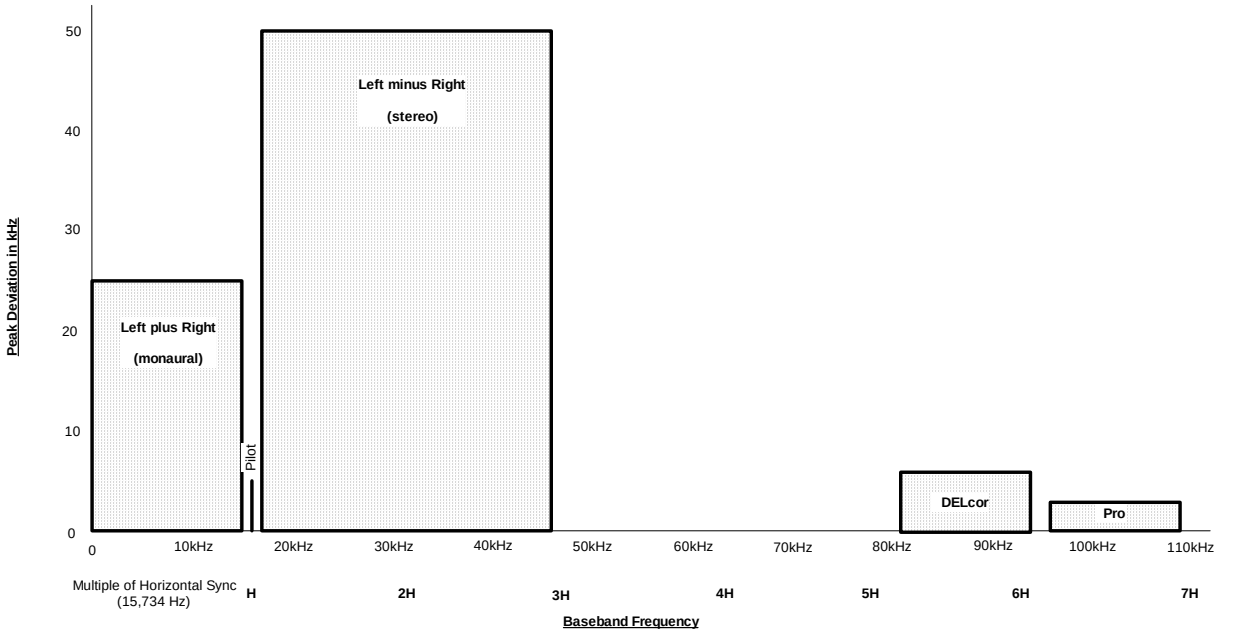

Figure 3 DELcor

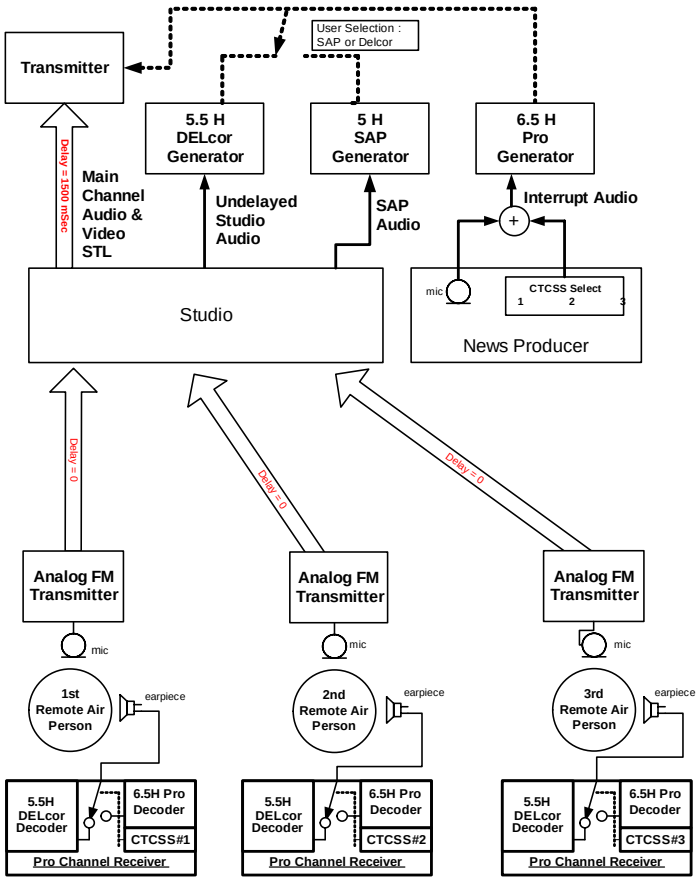

Figure 4 DELcor

The first in a series of technologies developed by Modulation Sciences to deal with the impact of transmission delays on IFB for ENG. It employs a second PRO Channel-like subcarrier to deliver an undelayed audio feed (the cue or fold-back portion of IFB) from the studio. Thus, the on-air person is listening to this second subcarrier that provides the same program material that is being transmitted to the general audience, but without the audible delay introduced by the transmission link between the studio and main transmitter. Other than this difference, the operation of DELcor is identical to that of undelayed PRO channel.

Since the second subcarrier, which carries the undelayed main channel program, must operate only at one-half the horizontal sync frequency (7.867 kHz) above the SAP frequency, SAP operation and DELcor are mutually exclusive. However, DELcor is only required during actual live feeds, so it's practical to switch back and forth between DELcor operation and SAP use. It is important to note that the PRO channel will continue to be available to communicate instructions from the newsroom even when the second subcarrier is relinquished to SAP use.

Because the DELcor subcarrier is located almost 8 kHz away from center of the SAP channel, the SAP decoders in consumer television receivers are not activated by DELcor, so DELcor audio will not be received by the home audience.

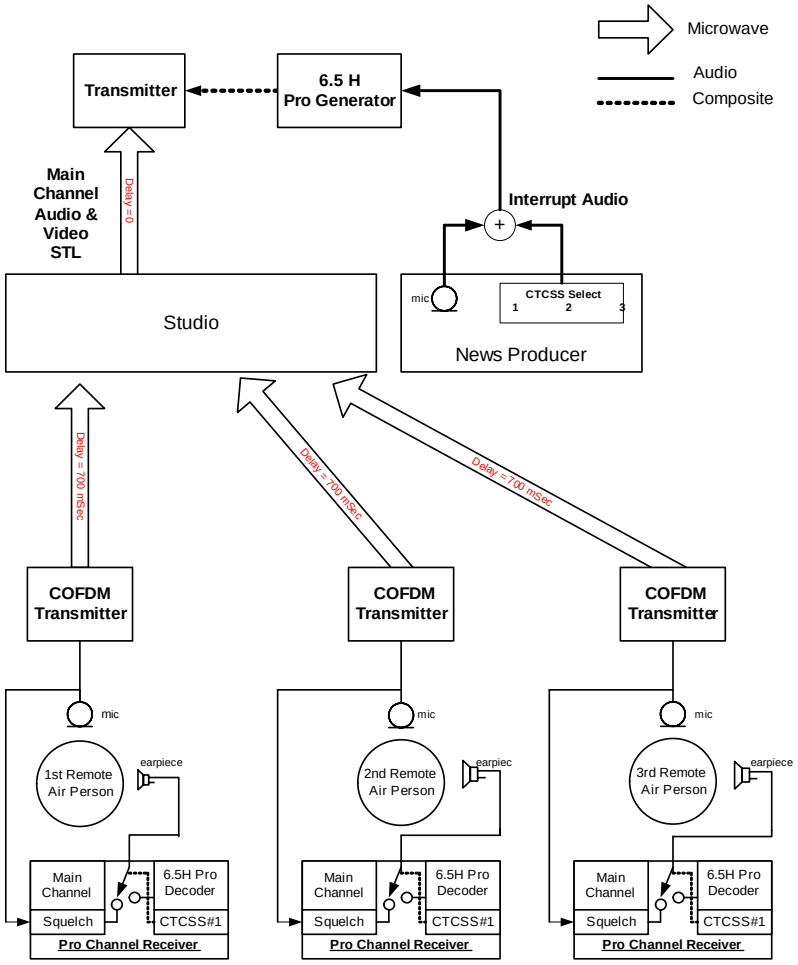

Figure 5 DEliminate

When delay is introduced into the link between an ENG vehicle or aircraft and the studio, DELcor is not effective at protecting the on-air person from interfering with their ability to speak. Because the remote person's voice arrives at the studio already delayed, a mix derived there will include the delayed voice. A delay in an ENG feed is most often created by the introduction of COFDM-based microwave equipment.

Modulation Sciences developed DELiminate to deal with this delay component. Operation is again similar to traditional PRO Channel, with the addition of an intelligent squelch in the program feed to the on-air person's earpiece. As soon as the talent begins to speak into their microphone, the program feed ***only*** is silenced into the earpiece. It is important to note that the ability of the News Producer to communicate with the on-air person via interrupts is ***not*** impaired. The talent can continue to receive interrupt information like count downs and out-cues from the newsroom, even while they are on-air.

While no squelch circuit can act instantaneously, the same delay that creates the problem provides the time needed for the squelch to operate before the air person begins to stutter.

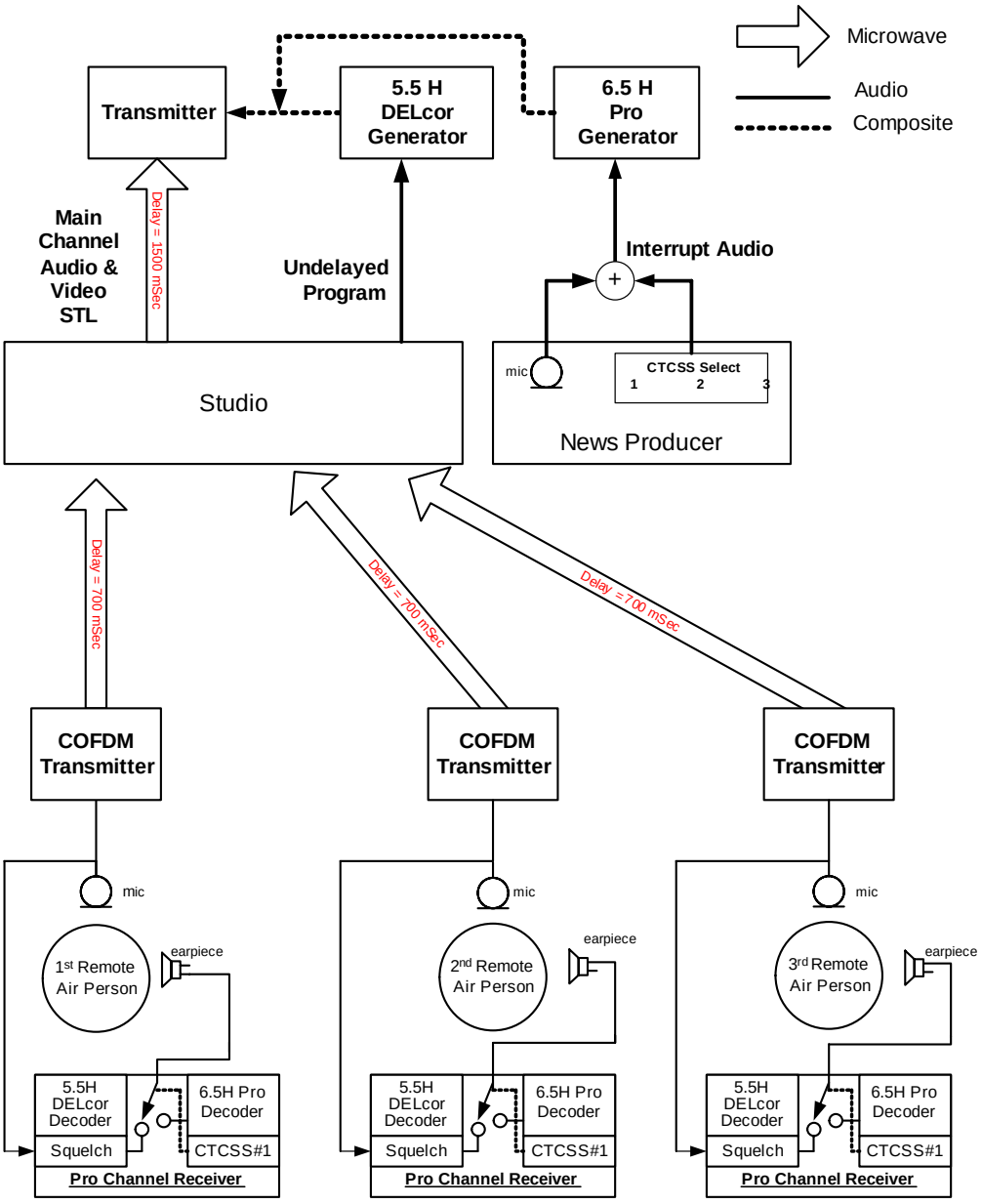

Figure 6 DEliminate + DELcor

When delay is introduced in both the links between the ENG van and the studio and between the studio and transmitter, a broadcaster should combine DELcor with DELiminate.

While the squelch of DELiminate protects the on-air person from delay that interferes with their ability to speak, additional delay introduced between the studio and main transmitter can, when combined with the ENG delay, slow down fast paced news production that uses techniques like on-air conversation between studio and remote talent. By providing an undelayed studio feed, it's much easier to maintain a tight production.

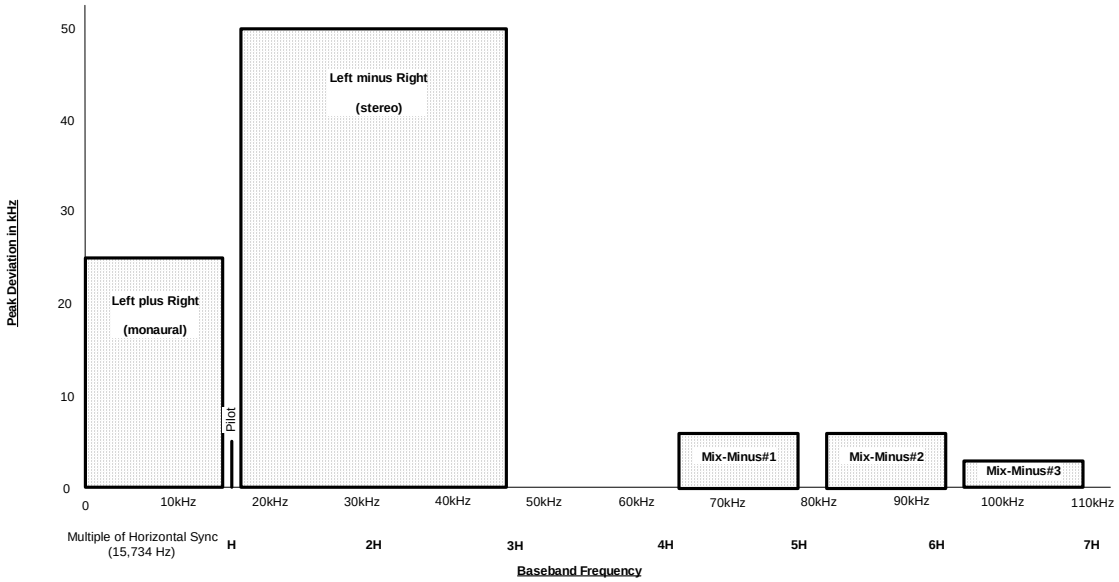

Figure 7 Mix-Minus 3

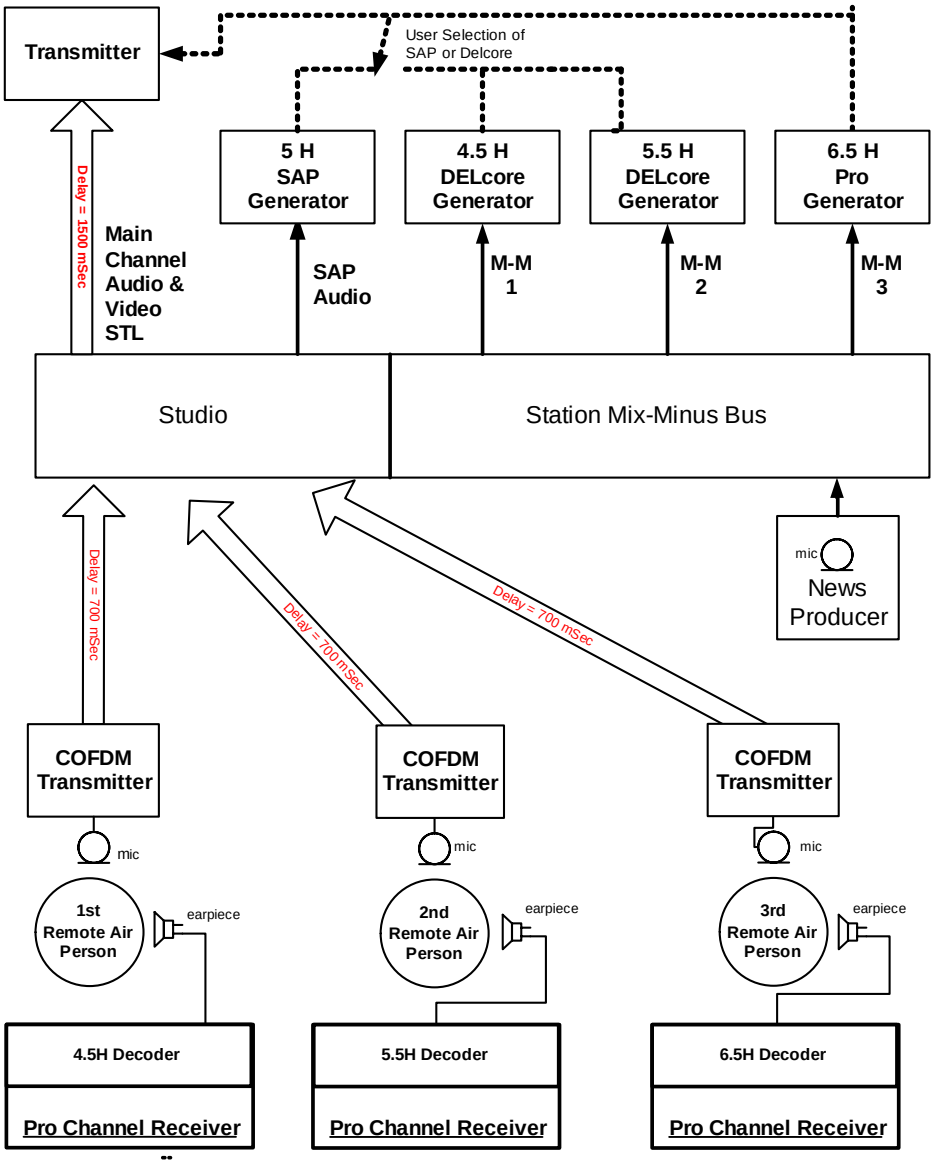

Figure 8 Mix-Minus 3

For those stations that already have a mix-minus system in use at the studio, the Modulation Sciences system for delivering multiple, independent mix-minus channels to ENG trucks offers the most flexible and familiar method for delivering IFB to remote personnel. The system assumes that a viable mix-minus system with full interrupt capability exists at the studio. .

The system uses three subcarriers in the TV aural baseband; the standard 6.5H PRO Channel, and two “PRO like” Channels in the baseband spectrum usually occupied by the SAP channel. As with the DELcor system, two of the three mix-minus for ENG channels are mutually exclusive with SAP.

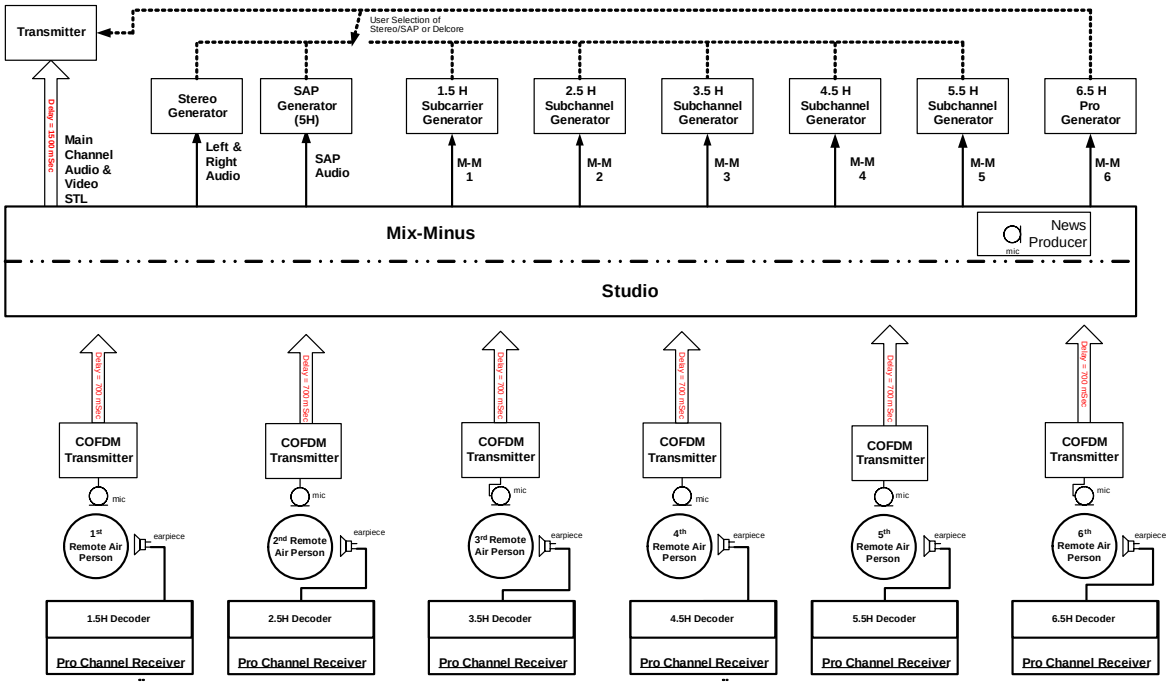

Figure 9 Mix-Minus 6

This is identical with Mix-Minus 3 except that it offers a total of six independent mix-minus channels instead of three. This option requires that the station either not use stereo at all, or that it is able to drop back to mono during live news programs when all six channels are needed.

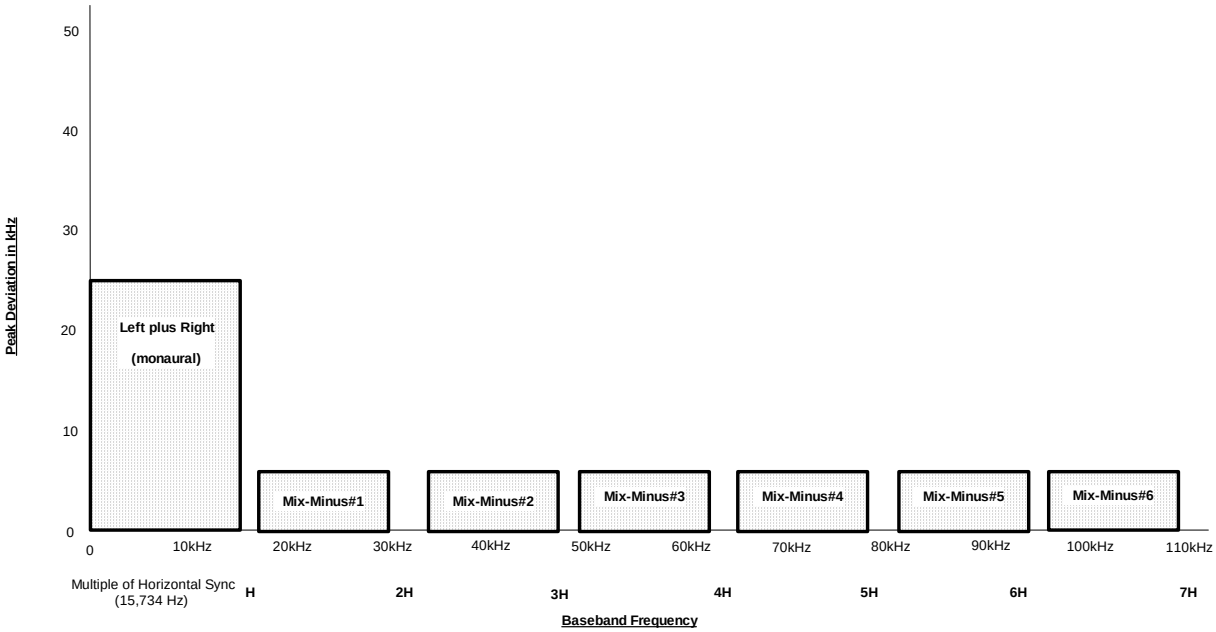

Figure 10 Mix-Minus 6