IMPROVING FM STEREO ON CABLE

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ABSTRACT

FM broadcasting has become one of the fastest growing elements of the broadcast industry. This is a result of the significant technical improvements providing sound quality approaching that of the best original source materials. With the advent of the introduction of stereo to the television broadcast industry, the desire for stereo by the consumers both cable and non-cable has been increasing during the last few years. FM has been available on cable for many years and has been adopted for the delivery of the stereo satellite delivered services. Quality of this product is highly variable depending on the care and skill that is used during the installation and the maintenance that is provided to keep the system up to proper standards.

INTRODUCTION

There are three elements that could be used to improve existing FM service on cable. First of these is to plan for the service, that is, the system operator should address all the technical issues involved in providing the service, purchase the right equipment, and install it according to the manufacturer's recommended procedures. The second element is to correctly set up all the adjustments that are associated with the FM delivery of signals. There are basically two related to this. One is the carrier level and the second is the deviation level. A third adjustment that is required, in some cases, is the troubleshooting of stray noise sources that can impede the proper delivery of FM. Finally, the third element involved is to provide a proper preventive maintenance and troubleshooting technique that will assure correct optimum delivery to the subscriber's home.

PLANNING FOR THE SERVICE

There is a variety of equipment available that is used to deliver both off air and satellite delivered simulcast, as well as the new BTSC off air format in the FM band. Before the installation begins, the wiring practices that are used in the head end should be monitored. It must be remembered that different rules apply to audio wiring than what is used for R.F.

The goal for the delivery of FM should be at least a 60 dB signal to noise ratio in audio at the output of the FM receiver. To achieve this, much care is required in the wiring of the head end to avoid stray pickup of audio sources such as that which may occur from a nearby television set with its horizontal field emissions.

The other issue that may be bothersome to some is hum pickup from various 60 cycle sources that may be near the audio cable. After the installation is complete, a thorough check out of all the audio sources should be performed to verify that a better than 60 dB signal ratio is available for all the sources. This is typically done by connecting the appropriate measuring equipment, either an oscilloscope or an AC volt meter, to the audio input points on the modulator equipment and verifying that when no signal is present, that a noise level is 60 dB below the maximum peak level of signal that is expected to be delivered to that audio input.

FREQUENCY SELECTION

As part of the system planning, it is important to address the FM channel frequency selection. As with television sets, FM receivers emit from the input terminals a small amount of the local oscillator frequency. In the FM receiver this local oscillator will be 10.7 megahertz above the tuned frequency. That is, if the receiver is tuned to 88.1 megahertz, then the local oscillator will be 98.8 megahertz. As with most RF circuitry, this oscillator may not be the purest sine wave and may have many harmonics associated with it. For instance, if the FM receiver is tuned to 88.1, which generates the 98.8 local oscillator, then that second harmonic may be in the 180 megahertz range; the third harmonic may be in the 270 megahertz range. This emission of the local oscillator could result in interference with the video channel. This is not a new problem because a similar situation can and does occur when two TV sets are used within the same household when connected via a splitter. In that case, the video IF difference frequency is the one that should be addressed.

Shown in Table I and Table II are the results of a calculation that indicate for all the normal TV channels which FM frequencies should be avoided for each of the particular channels. It should be noted that not every TV channel has possible interference from the FM receiver. For instance, there is no interference possible for channels two through nine. On channel ten with a video carrier of 193.25, it is possible that a second harmonic of the local oscillator could interfere because if the receiver is tuned to the low end of the band near 88.1 megahertz, this could result in a second harmonic (197.6) of the local oscillator lying in the video band associated with the channel ten carrier.

The table shows the channel number, the corresponding video carrier frequency, the harmonic of the local oscillator that could possibly result in interference, and the resultant unusable FM band associated with that channel. This is not a severe problem, since the protection is only necessary for the six megahertz normal video carrier band. Listing one is for a short basic program that describes the calculation of the interfering frequencies. H is the harmonic of the FM local oscillator and should be tested normally between one and four. F, as shown, is the video carrier frequency.

This problem of local oscillator interference is only important for simulcast operation. That is, for each

STANDARD FREQUENCY PLAN

ch#	video freq	harm	UNUSEABLE FM BAND		
0	109.25	1	97.300	to	103.0500
1	115.25	1	103.300	to	109.0500
10	193.25	2	85.300	to	88.1750
11	199.25	2	88.300	to	91.1750
12	205.25	2	91.300	to	94.1750
13	211.25	2	94.300	to	97.1750
14	121.25	1	109.300	to	115.0500
15	127.25	1	115.300	to	121.0500
23	217.25	2	97.300	to	100.1750
24	223.25	2	100.300	to	103.1750
25	229.25	2	103.300	to	106.1750
26	235.25	2	106.300	to	109.1750
27	241.25	2	109.300	to	112.1750
28	247.25	2	112.300	to	115.1750
29	253.25	2	115.300	to	118.1750
30	259.25	2	118.300	to	121.1750
36	295.25	3	87.300	to	89.2167
37	301.25	3	89.300	to	91.2167
38	307.25	3	91.300	to	93.2167
39	313.25	3	93.300	to	95.2167
40	319.25	3	95.300	to	97.2167
41	325.25	3	97.300	to	99.2167
42	331.25	3	99.300	to	101.2167
43	337.25	3	101.300	to	103.2167
44	343.25	3	103.300	to	105.2167
45	349.25	3	105.300	to	107.2167
46	355.25	3	107.300	to	109.2167
47	361.25	3	109.300	to	111.2167
48	367.25	3	111.300	to	113.2167
49	373.25	3	113.300	to	115.2167
50	379.25	3	115.300	to	117.2167
51	385.25	3	117.300	to	119.2167
52	391.25	3	119.300	to	121.2167
52	391.25	4	86.800	to	88.2375
53	397.25	4	88.300	to	89.7375

TABLE 1

Standard Interference Bands

HRC FREQUENCY PLAN

ch#	video freq	harm	UNUSEABLE FM BAND		
0	108.00	1	96.050	to	101.8000
1	114.00	1	102.050	to	107.6000
11	198.00	2	87.675	to	90.5500
12	204.00	2	90.675	to	93.5500
13	210.00	2	93.675	to	96.5500
14	120.00	1	108.050	to	113.8000
15	126.00	1	114.050	to	119.8000
23	216.00	2	96.675	to	99.5500
24	222.00	2	99.675	to	102.5500
25	228.00	2	102.675	to	105.5500
26	234.00	2	105.675	to	108.5500
27	240.00	2	108.675	to	111.5500
28	246.00	2	111.675	to	114.5500
29	252.00	2	114.675	to	117.5500
30	258.00	2	117.875	to	120.5500
36	294.00	3	86.883	to	88.8000
37	300.00	3	88.883	to	90.8000
38	306.00	3	90.883	to	92.8000
39	312.00	3	92.883	to	94.8000
40	318.00	3	94.883	to	96.8000
41	324.00	3	96.883	to	98.8000
42	330.00	3	98.883	to	100.8000
43	336.00	3	100.883	to	102.8000
44	342.00	3	102.883	to	104.8000
45	348.00	3	104.883	to	106.8000
46	354.00	3	106.883	to	108.8000
47	360.00	3	108.883	to	110.8000
48	366.00	3	110.883	to	112.8000
49	372.00	3	112.883	to	114.8000
50	378.00	3	114.883	to	116.8000
51	384.00	3	116.883	to	118.8000
52	390.00	3	118.883	to	120.8000
52	390.00	4	86.488	to	87.9250
53	396.00	4	87.988	to	89.4250

TABLE 2

HRC Interference Bands

particular video channel there is a band of FM frequencies that cannot be used to deliver that video channel's simulcast audio service.

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H = Harmonic of FM local oscillator
F = Video carrier frequency

1010 FOR H=1 TO 5
1020 LO=((F-1.25)/H)-10.7
1030 LH=((F+4.5)/H)-10.7
1040 IF LO>87.9 AND LO<120 THEN
     LPRINT USING A$;CN,F,H,LO;" to ";LH
     :GOTO 1050
1045 IF LH>87.9 AND LH<120 THEN
     LPRINT USING A$;CN,F,H,LO;" to ";LH
1050 NEXT
```

LISTING 1

Program to Compute Interference

INGRESS

One other point when selecting FM frequencies is to address the issue of local ingress. Although the leakage into cable systems is small, there may be some situations where the FM broadcast station may be located in such a way that its ingress is amplified by the cable system resulting in an interference from that same frequency that would be used on the cable. This, in effect, is a classical multipath problem because the signal that is broadcast through the air and reaches the cable system along its length interferes or may be out of phase with the signal that is picked up by the off air signal and introduced at the cable head end. If there is a situation in the cable system that allows this to happen, severe distortion results in the audio material delivered to the customer. This problem is easily checked by testing the FM band at the extremities of the cable system when no carriers are generated at the head end. If carriers are found to be present without them being generated at the head end, then those frequencies should not be used. It has been experimentally measured that if a carrier of the same frequency is greater than 40 dB below the proper carrier, that frequency should not be used due to the multipath distortion which results.

ADJUSTMENTS

After the equipment has been properly installed and the signal to noise ratio of all the audio sources has been verified, then the modulators that are used to modulate the various audio material into the respective FM frequencies should be adjusted and verified. The adjustment of carrier levels is one of the easiest to do, since a spectrum analyzer or signal level meter is used. However, if the modulator is provided with a deviation adjustment, this is a very difficult procedure to properly perform. Unlike reading a meter when you are adjusting for an AM process, the FM process generates about the FM carrier a multiplicity of side bands. With the FM process, the only stationary display of information is produced when a single tone is connected to the input of the modulator.

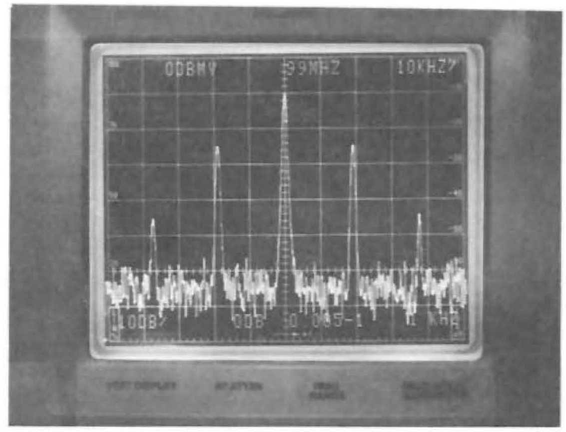

Fig. 1

Unmodulated 99 mhz with stereo pilot

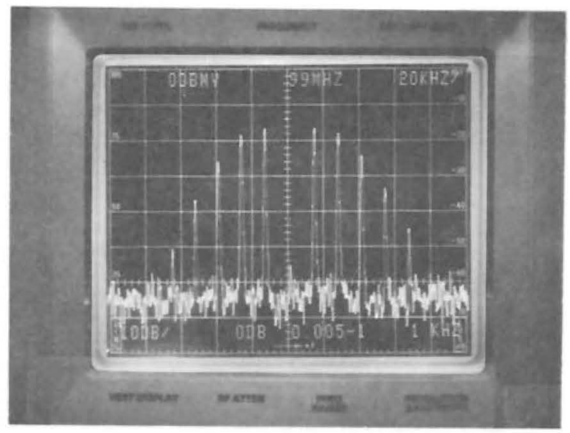

Fig. 2

FM modulation with audio frequency and amplitude adjusted to eliminate FM carrier

Figure I shows the display of a spectrum analyzer for a 99 megahertz carrier without modulation other than the pilot tone. On first glance, this appears to be correct, however, it should be noticed that there does exist a small amount of the (L-R) stereo subcarrier which exceeds the proper limits that are recommended for stereo broadcasting.

Figure II shows the spectral plot with an audio input with the input adjusted to result in the first Bessel null for the carrier. That is, the audio frequency and amplitude have been adjusted so that there is no energy existing at the basic carrier frequency. All the energy is contained within the side bands associated with the FM modulation.

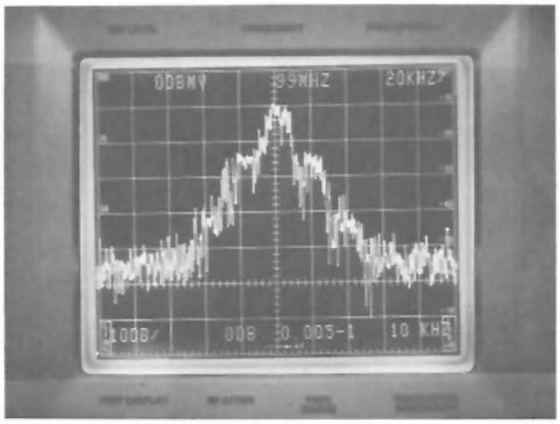

Fig. 3
FM modulated with speech program material

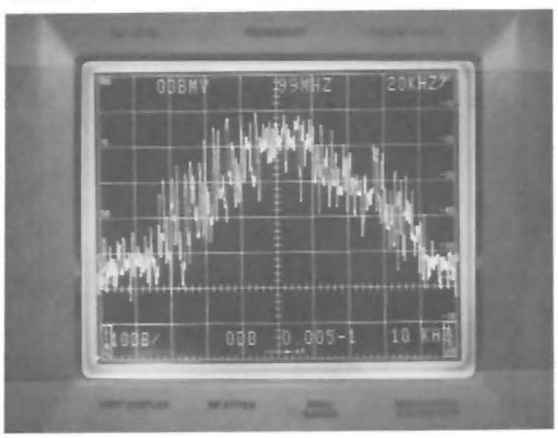

Fig. 4
FM modulated with compact disc music

Figure III is a spectral plot with an FM carrier modulated with some speech material. Notice that the carrier and the pilots are almost hidden but still recognizable at the plateau points along the plot. Figure IV shows a correctly modulated FM carrier with source material from a compact disk music selection. Here you can see that the carrier and the pilots have been totally lost due to the modulation effects.

The point of the above photographs is to show that it is difficult to correctly adjust the FM deviation correctly. Each of the manufacturers provides the correct adjustment procedure, and this should be followed as closely as possible to assure that maximum deviation is being used. Some FM receivers designed for cable and some of the newer FM receivers for off air use are now designed with wide band IF and discriminator processors which allow the processing of significant over deviation. Therefore, if adjusting the deviation level of an modulator, it is not that important if the level is set on the higher side than what you would normally expect. If it is adjusted on the lower side, this results in the loss and audio signal ratio.

OTHER PROBLEMS

Another issue that is being investigated at the present time is the degradation of FM delivery when the FM is distributed via AML links. Theoretically, with FM the signal to noise ratio continues to improve as you keep increasing the carrier level. However, in one recent experiment it was found that the AML link creates an effect which raises the noise floor of the resultant audio baseband signal if the carrier is raised to its full recommended value. It was found experimentally that by adjusting the gain of the buffer amplifier that drives the AML link that there is a minimum noise point which is considered to be less than the optimal noise point from a carrier level viewpoint. This minimum noise point in this one particular case was found to be at FM carrier levels at about -12 dBmv to -14 dBmv.

CONCLUSION

Recent experiments have indicated that FM can provide a high-quality audio service for delivery of FM radio, FM simulcast, and FM delivery of off-air BTSC signals. Tests have indicated that 60 dB noise figures are obtainable if proper care is given to the installation and adjustment. It has also been determined recently that there are elements within the existing head ends that degrade the FM performance to marginally acceptable levels. There are three recommendations that may be useful to improve the delivery of the FM product.

First, is to set the system up correctly, verify the cleanness of the audio signals, verify the correct setup and adjustment of the FM modulators, and verify that the correct deviation and signal levels are provided on the cable.

Second, monitor the operation. Most head ends with the fans and the other noise associated with the operations of head ends are not conducive to correct monitoring of FM signals. If necessary, perform periodic zero modulation noise test. This would be done by removing the modulation to the modulator and connecting an appropriate FM receiver on the cable at some point and measuring the noise level. Establish a log for this noise level on all the channels and monitor the operation periodically. Pay particular attention if you are using FM on AML links. Just simple level adjustments may not be sufficient. It may be necessary to perform a minimum noise adjustment to supply the customers with the best products.

Finally, educate your technicians and engineers on FM so that they understand it and can properly assess the correct operation, as well as they do on their video services.

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