

# CABLE STEREO .. PERFORMANCE AND SECURITY ISSUES

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## ABSTRACT

The past three years have seen some exciting developments in audio related services to the cable industry. In previous papers (NCTA 1980 and 1981) I have given background and insight to the emerging field and many of those early predictions are starting to become reality. The purpose of this paper is to review the key technical elements regarding stereo audio transmission with special emphasis on cable plant signal degradation and security of premium audio signals.

## INTRODUCTION

There are three current activity areas that are drawing cable audio to increased prominence. They are:

1. Cable Stereo TV Simulcasts - MTV was the first video service to aggressively promote stereo audio as an important element of the total entertainment experience. Other services are transmitted in full stereo (The Nashville Network, The Movie Channel, The Disney Channel, all Canadian Pay TV Services, etc.) and the cable industry has come to recognize the consumer appeal of stereo TV audio. While the broadcast industry is still floundering over technical standards for TV stereo, the cable industry has provided subscribers with this service since 1981.
2. Satellite Audio Techniques - Delivery of stereo TV audio necessitated the development of satellite transmission systems that could provide high quality stereo with no impact to video quality. Two systems have emerged as dominant in this field. The Dual Subcarrier Matrix System is being used by MTV, The Movie Channel and The Disney Channel. The Wegener 1600 System is being used by The Nashville Network, all Canadian Pay TV Services, and virtually all stand-alone audio services. The Wegener 1600 system has become the "De Facto" standard for spectrum efficient satellite subcarrier transmission.
3. Audio Security - As more non-broadcast cable stereo sources become available,

their perceived consumer value as a group has increased significantly. Many cable operators are exploring the idea of securing the audio package to prevent theft of service and create a new revenue stream. 1982 saw the announcement of the Wegener/Pioneer audio security converter. This simple device allows the cable operator to transmit all premium signals outside the FM band. The audio security converter then translates the premium signals back to the FM band. Additional discussions of this device are contained later in this paper.

## TECHNICAL CONSIDERATIONS FOR CABLE STEREO TRANSMISSION

Figure 1 illustrates the expected audio performance of subcarrier transmissions as received in the cable head-end. As you can see, the quality of audio signals delivered to the head-end is very satisfactory for both the conventional and Wegener 1600 systems. The left and right channel audio signals are transmitted from head-end to the subscriber with conventional FM stereo multiplex techniques. The cable distribution network is the only significant source of signal degradation.

<u>SPECIFICATION</u>	<u>CONVENTIONAL SUBCARRIER SYSTEM</u>	<u>1600 SUBCARRIER SYSTEM</u>
Frequency (MHz)	6.8	6.30
Deviation on Main Carrier (MHz Peak)	2.0	.95
Occupied Bandwidth (kHz)	500	130
Peak Audio Deviation (kHz)	237	50
Frequency Response (50 Hz-15 kHz)	± dB	± 3dB
Peak Signal to Noise Ratio (dB)	70	70
Distortion	≤ 1%	≤ 1%

(RIIP = 33 dB; Earth Station C/T = 21.5 dB/Deg. K)

FIGURE 1: PERFORMANCE COMPARISON OF CONVENTIONAL AND WEGENER 1600 "SPECTRUM EFFICIENT" SUBCARRIER TRANSMISSION SYSTEMS. QUALITY AUDIO IS BEING DELIVERED TO THE HEAD-END VIA SATELLITE.

Cable systems have been carrying FM signals for many years. With regard to technical performance, the cable plant is capable of providing essentially transparent transportation of these signals. This signal transparency is true for most parameters such as frequency response, distortion, stereo separation, etc. but is not necessarily true for stereo signal to noise ratios. Due to the inefficiencies in FM stereo multiplexing, the detected stereo signal to noise ratios will range between 50 and 60 dB (unweighted) on typical cable systems. Figure 2 illustrates the detected stereo signal to noise as a function of both video C/N and FM carrier levels in dBmV. (Both measured at the subscriber drop). For best overall performance with minimal impact to system loading we recommend a -10 dBmV drop level; which implies a Channel 6 visual to FM stereo carrier ratio of 10 dB.

AUDIO SECURITY

With the advent of satellite delivered premium audio signals came the obvious need to secure such signals against theft of service. It is very difficult to scramble an FM stereo multiplex signal without degradation. In the interest of simplicity and cost, Wegener Communications and Pioneer Communications collaborated on design parameters necessary for a "stereo top" audio security converter. Since no specifications exist for such a device, we submit the specifications on page III as being the minimum acceptable for premium performance.

Several of these specifications deserve special comment.

Local Oscillator Frequency - The frequency 209.7625 MHz was deliberately chosen to allow placement of the 108-120 MHz carriers between FAA assignments in the air navigation band from 108-118 MHz. Although not mandatory if operators operate below the FAA  $10^{-5}$  watt threshold, we consider it good engineering practice. This frequency is also 12.5 kHz above the channel 12 aural carrier. This frequency selection coupled with the -35 dBmV L.O.

leakage specification at the input port will insure that no video degradation can take place to near-by TV sets. Analysis of a typical CATV feeder yields a worst case C/I ratio of better than 59 dB which is more than adequate to protect the channel 12 aural carrier frequency. A well chosen local oscillator frequency is just one small step in maximizing design. No exotic external splitters are required to implement this audio security converter concept.

Noise Figure - The noise figure specification of the Wegener/Pioneer converter is specified at 6 dB MAX. Operation in critical spectrum (108-120 MHz) coupled with marginal levels necessitates that the converter contribute insignificant noise levels to the detected stereo signal. Figure 4 illustrates the effect of converter noise figure as a function of overall CATV plant parameters.

In summary, a well designed FM block converter will contribute an insignificant additional degradation to a cable FM stereo signal. Figure 5 illustrates the Wegener/Pioneer frequency allocation plan for secure audio services.

USE OF THE 108-120 MHZ SPECTRUM

Much controversy surrounds the use of 108-120 MHz for carriage of any CATV signals. It is my contention that audio services constitute a wise use of the spectrum as long as the cable systems strictly obey the FCC rules. The rules state that signals present on the system in this spectrum cannot exceed  $10^{-5}$  watts (+28.75 dBmV at 75 ohms). The worst case level is typically at the bridger output and is typically +48 to +50 dBmV at the highest frequency of interest. With a slope of approximately 6 dB from the highest frequency of interest to 108 MHz, the maximum output of an equivalent visual carrier would be +42 to +44 dBmV. To be legal, the FM carrier must be run 13.25 to 15.25 down from the equivalent level of a channel A-1 visual carrier. Since CATV plant system designs vary, the exact point of legal threshold must be established for each system.

SUBSCRIBER DROP CARRIER LEVEL

Video C/N	0dBmV	-5dBmV	-10dBmV	-15dBmV	-20dBmV	-25dBmV	-30dBmV	-40dBmV
40	64.5 (68)	60.5 (68)	56.5 (68)	51.5 (67.5)	47.5 (66)	42.5 (62)	39 (58)	33.5 (47)
42	64.5 (68)	61.5 (68)	58.5 (68)	53 (68)	49 (66.5)	45 (63.5)	40.5 (62)	34.5 (56)
44	65.5 (68)	63.5 (68)	59 (68)	54.5 (68)	51 (66.5)	46 (65)	42.5 (63.5)	37.5 (57.5)
46	66 (68)	64 (68)	60.5 (68)	56 (68)	53.5 (67)	47.5 (65.5)	44 (64)	38 (59.5)
48	66.5 (68)	64.5 (68)	61.5 (68)	57.5 (68)	53.5 (68)	49 (66)	46 (64)	40 (60.5)

FIGURE 2 DETECTED STEREO S/N RATIO -UNWEIGHTED AS A FUNCTION OF VIDEO C/N. (MONO S/N IN PARENTHESIS FOR REFERENCE) SUBSCRIBER STEREO AUDIO QUALITY IS A FUNCTION OF CARRIER INJECTION LEVEL AND PLANT C/N.

In most cases, the level will be 15 to 17 dB down from visual carrier level for legal operation without FAA/FCC coordination. I personally recommend that all CATV systems using 108-120 MHz for audio coordinate all frequencies of interest whether or not operating above or below the legal threshold. Operating without coordination of level consideration is a blatant violation of good business ethics and definitely not encouraged by the manufacturers involved.

WEGENER/PIONEER PREMIUM FM AUDIO  
BLOCK CONVERTER SPECIFICATIONS

<u>Input Frequency</u>	
Normal	88-108 MHz
Premium	108-120 MHz
<u>Output Frequency</u>	
Normal	88-108 MHz
Premium	88-100 MHz
<u>Input Level</u>	-10 dBmV Nominal
<u>Gain</u>	
Normal	0 ± 1 dB
Premium	10 dB ± 5 dB
<u>Spurious Levels at Output</u>	-60 dB Nominal -50 dB Max
<u>Feed Through Isolation</u>	-60 dB Nominal -50 dB Max
<u>Noise Figure</u>	6 dB Max
<u>Image Rejection</u>	60 dB Nominal 50 dB Min
<u>Return Loss (Input &amp; Output)</u>	10 dB Min
<u>Local Oscillator Frequency</u>	209.7625 MHz
<u>Local Spurious at Output</u>	-15 dBmV Max
<u>Local Spurious at Input</u>	-35 dBmV Max
<u>Hum Modulation</u>	55 dB Max
<u>Frequency Stability</u>	± .005% Crystal Controlled
<u>Frequency Response Flatness</u>	
Normal	± 2 dB
Premium	± 3 dB
<u>Operating Power</u>	120 VAC ± 10% 60 Hz ± 10%
<u>Temperature Range</u>	+ 5 to 40°C
<u>Channel Capacity (Premium)</u>	30 Max at 400 kHz Spacing

Connectors

(3) 75 ohm "F"  
Female Connectors  
Cable Input, Tuner  
Output, Antenna  
Input

Switch Function

3 Functions: (1)  
Antenna (2)  
Regular FM, (3)  
Premium FM

Feed Through Isolation

Antenna to Input or Output 60 dB

Housing Details

Pioneer BC-Series  
housing with  
tamper-proof  
screws

FCC Compliance

Unit meets FCC  
Part 15 and Part  
76 radiation re-  
quirements.

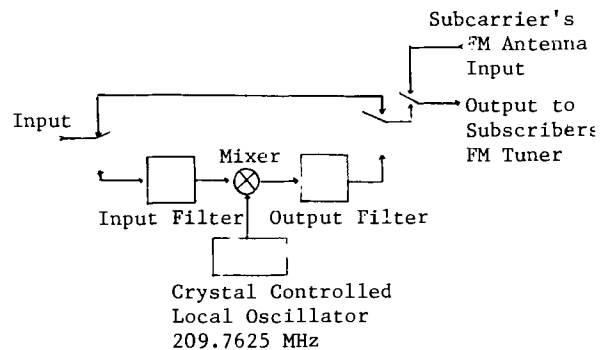


FIGURE 3: THE WEGENER/PIONEER AUDIO SECURITY CONVERTER FUNCTIONAL BLOCK DIAGRAM. LOCAL OSCILLATOR FREQUENCY IS DISCUSSED IN THE ABOVE TEXT. NOTE ABILITY TO PATCH SUBSCRIBERS OFF AIR ANTENNA TO ELIMINATE NECESSITY OF A/B SWITCH.

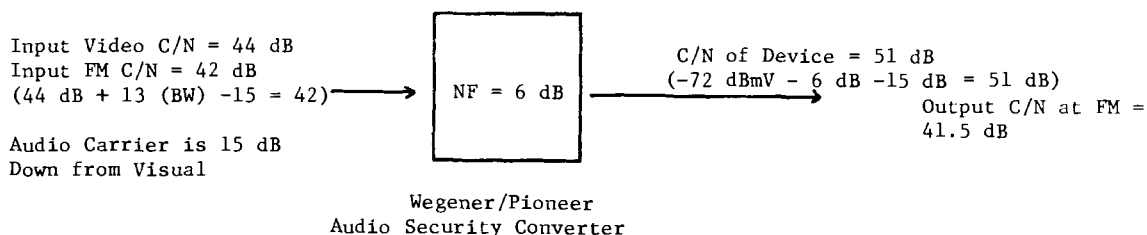


FIGURE 4: EFFECT OF CONVERTER NOISE FIGURE AT TYPICAL OPERATING LEVEL. CONVERTER DEGRADES STEREO S/N BY .5dB IN THIS EXAMPLE.

Ch. Designator	Cable Freq.	FM Output Freq.	Ch. Designator	Cable Freq.	FM Output Freq.
PW1	108.0625	101.7	PW31	114.0625	95.7
PW2	108.2625	101.5	PW32	114.2625	95.5
PW3	108.4625	101.3	PW33	114.4625	95.3
PW4	108.6625	101.1	PW34	114.6625	95.1
PW5	108.8625	100.9	PW35	114.8625	94.9
PW6	109.0625	100.7	PW36	115.0625	94.7
PW7	109.2625	100.5	PW37	115.2625	94.5
PW8	109.4625	100.3	PW38	115.4625	94.3
PW9	109.6625	100.1	PW39	115.6625	94.1
PW10	109.8625	99.9	PW40	115.8625	93.9
PW11	110.0625	99.7	PW41	116.0625	93.7
PW12	110.2625	99.5	PW42	116.2625	93.5
PW13	110.4625	99.3	PW43	116.4625	93.3
PW14	110.6625	99.1	PW44	116.6625	93.1
PW15	110.8625	98.9	PW45	116.8625	92.9
PW16	111.0625	98.7	PW46	117.0625	92.7
PW17	111.2625	98.5	PW47	117.2625	92.5
PW18	111.4625	98.3	PW48	117.4625	92.3
PW19	111.6625	98.1	PW49	117.6625	92.1
PW20	111.8625	97.9	PW50	117.8625	91.9
PW21	112.0625	97.7	PW51	118.0625	91.7
PW22	112.2625	97.5	PW52	118.2625	91.5
PW23	112.4625	97.3	PW53	118.4625	91.3
PW24	112.6625	97.1	PW54	118.6625	91.1
PW25	112.8825	96.9	PW55	118.8625	90.9
PW26	113.0625	96.7	PW56	119.0625	90.7
PW27	113.2625	96.5	PW57	119.2625	90.5
PW28	113.4625	96.3	PW58	119.4625	90.3
PW29	113.6625	96.1	PW59	119.6625	90.1
PW30	113.8625	95.9	PW60	119.8625	89.9

FIGURE 5: THE WEGENER/PIONEER FREQUENCY PLAN FOR PREMIUM AUDIO SERVICES.

CONCLUSIONS

The field of cable audio marches on! -- drawn by the marketplace.

- Satellite technology is in place today to allow premium stereo audio signals to be delivered to the head-end.
- The use of FM stereo multiplex on cable provides reasonable quality with minimum cost.
- The block converter for audio security

provides a simple and effective means for cable operators to secure the premium audio signals. Block converters must be used properly and LEGALLY since sensitive spectrum is being used.

The future of cable audio is bright! Within the next 2 years, we will see even more exciting developments in both hardware and software to allow the cable industry to provide what it does best -- entertainment diversity!