USER FRIENDLY CABLE STEREO MODULE

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ABSTRACT

This paper describes the W & S Systems' SM-2001 cable stereo module. We would like to explain what it is, how it works, and where it can be used. The basic function of this unit is to provide access to stereo signals delivered in the FM format (88.1 + 119.9 mHz) on many cable systems in a user-friendly, convenient way. It contains an EEPROM which allows it to be custom programmed for any cable system delivering FM format transmissions. It is our opinion that it can be used in any cable system without modification to the headend or the system.

WHAT DOES IT DO?

There are three modes of operation for the SM-2001:

- o TV stereo mode
- o TV mono mode
- o FM radio mode

The TV stereo mode provides for delivery of the typical simulcast FM format transmissions that are available on cable for a wide variety of cable services. We expect that this mode would also be used to deliver BTSC format, off-air transmissions after they are converted into the FM format for inclusion into the FM band map. To access this mode, the users, through the remote control, simply enter the channel number of the station they desire, and the SM-2001, upon reception of this channel, identifies the channel number and locates in the EEPROM the corresponding FM band frequency that it should tune to for finding the associated audio.

The unit also has the intelligence to recognize the absence of the FM pilot signal. If that is not available at the tuned frequency, then it will default back to what is called the TV mono mode. This feature allows the system operators to preplan their FM formats to accommodate the future expansion of stereo services for both off-air, i.e., BTSC format transmissions, as well as for expansion of new premium simulcast-type services.

The TV mono mode provides access to the normal audio signals that are carried as intercarrier signals along with the video. When using this mode, the SM-2001 uses an intercarrier receiver tuned to either channel 2, 3, or 4, depending upon the channel output of the converter. In this mode, the audio is the mono audio that is provided to the TV set. However, since this audio signal is processed by the SM-2001, remote volume control is provided along with a feed to either of the external devices that are connected to the SM-2001. Fidelity is also improved due to the wider band audio systems.

The FM radio mode provides access to the FM format radio stations that are carried on many cable systems. To use this mode, the TV and converter are normally turned off by activation of the power on/off button of the remote control; then, any two-digit channel entry turns on the SM-2001 in the FM radio mode. The FM radio map is programmed into the EEPROM so that by using the channel up/down buttons, the users can sequence through the various FM radio signals that are provided on the cable, or the users can directly enter a channel number corresponding to their favorite FM radio source.

WHAT'S INSIDE?

Like many communications units designed today, the SM-2001 is a collection of RF and audio circuits surrounding a microprocessor which determines their functionality. Basically, the micro receives all of its control commands from the infrared receiver circuit.

There are some other signals derived out of the stereo processor circuit to which the micro also responds. The micro then controls the selection of the FM tuner or the TV tuner. The selected sound is then processed into either stereo left and right or mono signals, that is, the same signal from each of the left and right connection points passed through a pilot filter to eliminate the 19 kHz pilot frequency to a volume control circuit. This then is again controlled by the micro via the infrared receiver to buffer circuits that provide dual outputs for use or connection to VCR's and/or to amplifiers or powered speakers for listening to sound.

as well as that of the TV tuner. The output of the tuners is passed through appropriate IF filters mixed together and fed to a discriminator circuit and associated audio processing to recover the mono or stereo sound that comes out of the discriminator. The audio processor also includes a gain change circuit to account for the different deviations that are used to drive the audio signals from both the FM and TV tuners.

In order to improve the recordability of the sound, a pilot filter is incorporated to reduce the pilot component that is found within the audio signal. After the pilot filter, one pair of signals is split off through a buffer for access or use by VCR recording equipment. The signal is also fed to an electronic volume control circuit. This is controlled by the micro via the infrared. Consequently, it is buffered again to provide a signal for feed either to a hi-fi system or to a set of powered speakers.

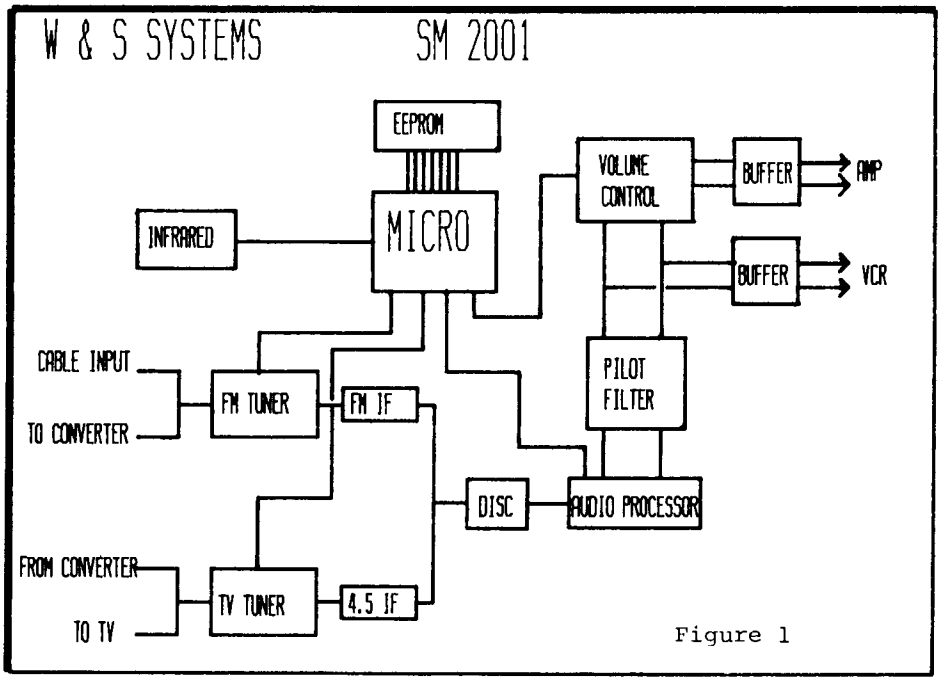


Figure 1

To minimize insertion loss, dual tuners are provided. Each of these tuners simply taps out a small portion of the signal from the input/output connection as shown on the block diagram. The micro controls application of power to the tuners, which results in the appropriate section being activated for use. In addition, the micro controls the frequency selection of the FM tuner

An important note is that the signal from the "CABLE" input connection to the "TO-CONVERTER" connection is simply a piece of wire with the FM tuner input attached to that wire. The same is true for the connections for the "FROM-CONVERTER" input to the "TO-TV" output connection.

The FM receiver is capable of tuning over a range of 88.1 to 119.9 mHz.

HOW DOES IT WORK?

Although the microprocessor controls all the functionality of the SM-2001, it does so based on data loaded into an EEPROM. The data loaded into the EEPROM tells the unit the frequencies it has access to that correspond to the given channel numbers, as well as possible frequencies it may have access to in the future. Stored in the EEPROM are also some other data, such as the input frequency for the use in the TV mode to match the converter output, as well as some other functional characteristics of the SM-2001.

Figure 2

ENTRY CHANNEL #	MONO TV AUDIO	STEREO CH 1	STEREO CH 2	STEREO FM
02	02	102.5	99.7	90.5
03	03	-----	-----	93.5
04	04	88.1	-----	88.5
→ 05	05	-----	100.1	100.5
06	06	97.3	97.7	88.9

SM 2001 TV-STEREO-FM CHANNEL MAP

Figure 2 shows a typical portion of the EEPROM map. Examination of this map shows that there is no special order for the frequency assignments, and, in fact, the frequency does not have to be assigned for each of the TV channels. The way the unit operates is that after it receives an entry channel number from the remote control (for instance, we've indicated a 05), then the microprocessor looks into the appropriate memory location in the EEPROM to determine if an FM channel has been assigned to provide stereo or other alternative audio. As you can see, for Entry Channel 5 under the first Stereo Channel 1, it is blank.

When the entry 05 is made, the microprocessor examines that memory location and, finding that it's blank, defaults to the TV mode (i.e., it switches to the use of the TV receiver portion of the SM-2001) providing mono sound that is tuned by the converter. Pressing the CH 1/CH 2 button on the remote control will then cause the micro to examine the secondary memory location, which contains a frequency of 100.1 mHz. By pressing the CH 1/CH 2 button, it will tune to 100.1 mHz. You will also notice on this channel map that there is a list of stereo FM frequencies, again with no specific pattern.

To access the stereo FM mode, the unit is turned off using the power on/off switch on the remote control, which also should normally shut off the TV set. Then, a channel entry is made. For instance, if we select 05 again, when 05 is entered, the unit will automatically turn itself on and tune to 100.5 mHz and provide that sound from its output terminals. Selection of the other channels (02, 03) will also give the corresponding frequency assignments.

SYSTEM CONSIDERATIONS

The SM-2001 has been designed to work with cable systems as they are presently configured today by maximizing the usefulness to both the cable system operator and the user without requiring any system changes. When the initial concept was proposed, we investigated many cable systems to find out how they would handle stereo. During this investigation, we found that many cable systems were actually carrying many more FM services than publicized. Unlike other equipment that is connected to a cable system, which requires either headend modifications or new pieces of headend gear to properly utilize them to generate revenue, we decided that the best approach for the SM-2001 was to use an approach that required no system changes and that could be fitted into cable systems on a spot-by-spot basis without the operator either having to spend extra money to make headend modifications or changing what he is doing every day with providing the FM radio and simulcast services. The flexible mapping feature that is carried in the EEPROM for the SM-2001 provides the ease of application to serve many cable operators and yet provide the customer with an attractive package of benefits such as volume control, FM radio, and auxiliary or bilingual sound, without requiring any system modifications by the cable operator. The use of the EEPROM also allows the cable operator to preplan for expansion of these FM services and to locate them in a frequency spectrum that is not normally tuneable by off-the-shelf FM radio receivers. Thus, if the cable operator wanted to, he could plan ahead for some premium audio services. This could potentially

generate additional revenue in addition to that which might be available from providing the remote volume control via the existing remote control used for the converter.

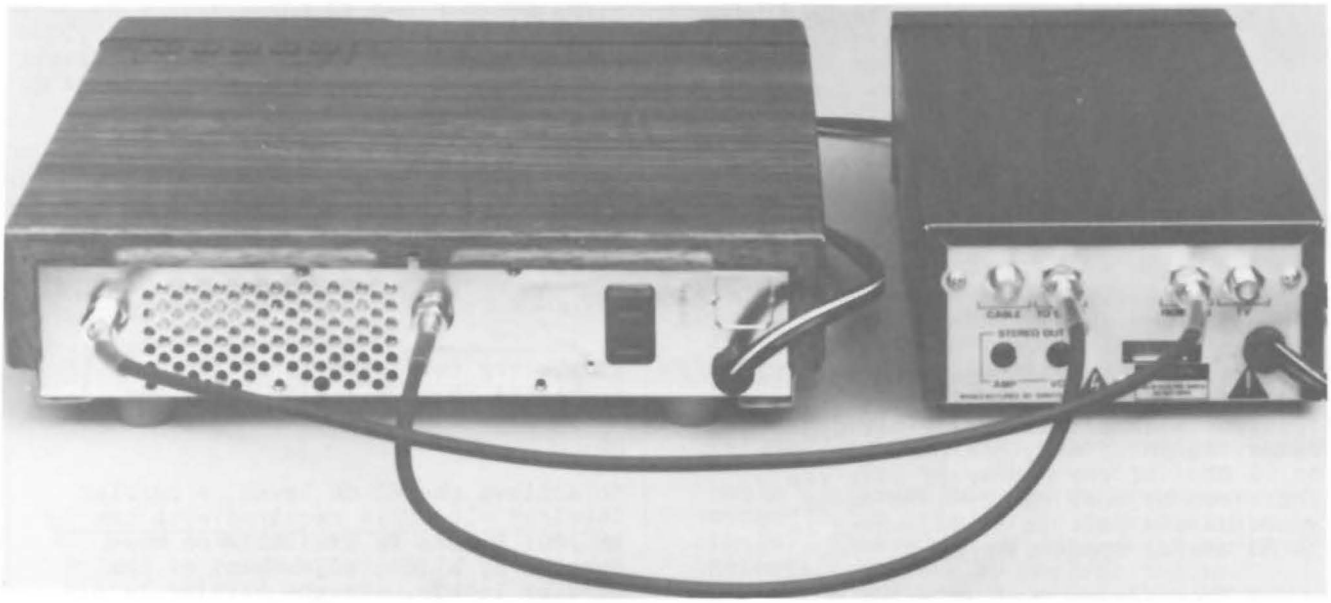
SYSTEM INGRESS/EGRESS

Another advantage of the SM-2001 approach is that it has been designed to have very little, if any, insertion loss. This eliminates the need for a splitter and reduces the probability of ingress or egress in the system. The coaxial feed to the SM-2001 is fully shielded and protected while it travels through the box to the TV set. As a result, instead of using a splitter which would reduce the signal to the converter, the SM-2001 introduces only a very slight insertion loss. The amount of signal required for the FM and the TV tuner is all that is required for all correct operation. Thus, in effect, the system can be closed up and the introduction of stray signals (via faulty FM hookups using 300 ohm twin lead or using zip cord) are eliminated since all the connections are properly handled through F connectors using coaxial cables.

SIGNAL LEVEL

As all cable system engineers know, the carrier level has a lot to do with the quality of the video product that you deliver to the users' homes. This is also true for FM signals. Just as when the carrier level of the video is reduced and the picture becomes snowy, that will also happen to an FM signal. As the carrier level is reduced, more noise in the system will be "picked up." Our goal for the SM-2001 is to provide at least a 60 dB signal-to-noise ratio with an input level of -10 dB mV.

There have been many questions raised with regard to the sufficiency of the 60 dB dynamic range number. The typical argument used in this case is that the compact disk establishes the standard for signal-to-noise ratio. While it is true that the compact disk has a very highly advertized dynamic range, one must remember that dynamic range is a digital process and is not totally available to the listener. For instance, with a compact disk, assume that one would try to use the full dynamic range of the 16 bits. If one would try to generate a sound level



Typical Connection

using the lowest bit simply by toggling that bit on and off, one could produce the correct frequency; but, by simply toggling that bit on and off, one does not produce a sine wave at the frequency; one produces a square wave. If one wants to produce a sine wave at that frequency, he has to use more than one bit. Let us assume that in order to generate a quality sine wave, four of the lowest significant bits would be required. This would produce one of eight levels since one of the bits must be assigned as a polarity bit. This is depicted in Figure 3, which shows the harmonic distortion spectrum as a function of the number of bits used in a quantization.

us. There are well-published figures with regard to the ambient noise level both in residences and other typical environments. The number quoted most often is that the average residence has a noise level of somewhere around 40 dB relative to .0002 microbars as zero dB. The typical jet airplane in a takeoff configuration at 50 feet off the end of the runway produces a sound level of about 120 dB on this same scale. So the dynamic range between matching a jet airplane and a typical residence is about 80 dB. On the same scale, a typical orchestra playing its loudest music generates a sound level of about 100 dB, which then relates to about a 60 dB dynamic range. That is,

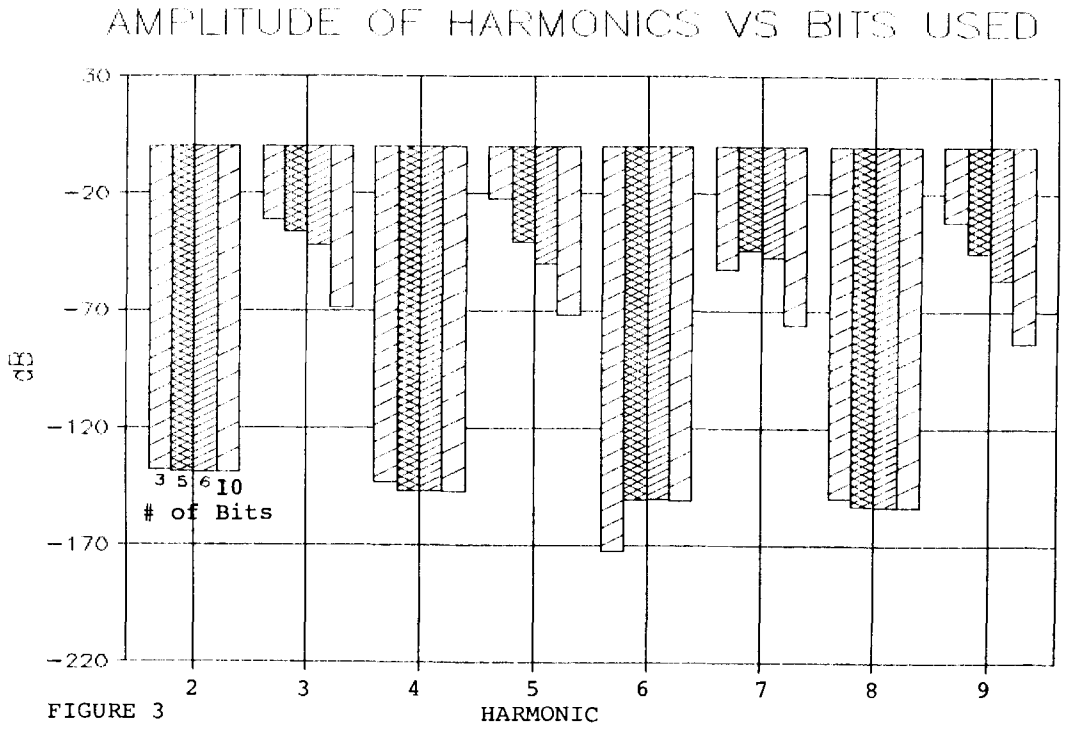


FIGURE 3

Therefore, if four of the sixteen bits are used as the minimum level, this results in an actual twelve-bit dynamic range, which is only one part in 2,048 or 66 dB. If the number of bits was increased by one, the dynamic range would be one part in 8,096, which is a 78 dB useful dynamic range.

If we then assume that we raise the volume level to a point where the noise is just barely perceptible or barely not perceptible and then add the useful dynamic range or the signal power level on top of this noise level, then we can see how much dynamic range is useful to if you try to listen to a live orchestra in your living room, you would have a useful range of about 60 dB.

To achieve the 60 dB level, a carrier level of -10 dB is required with the SM-2001. This is available on most systems by slight adjustment of the carrier levels. If the carrier levels are held at the typical setting of -15 dBmv, then you can expect a signal-to-noise ratio of about 55 dB.

FREQUENCY RESPONSE

Another advantage of the SM-2001 is that it offers, using the FM broadcast format, a significant increase in useful frequency response over that available either with mono television sets or with a typical BTSC television set. The main difference would be an extension both in low frequencies and in the high frequencies of the useful audio band width. With either a mono TV or a BTSC television, the pilot carrier is set at the same frequency as the horizontal frequency. Since the pilot is the factor that determines the absolute upper limit of the frequency response, that then limits the available band width through the transmission system.

In a much more practical sense, though, this upper limit is achieved only by using very carefully designed and very expensive filters to eliminate the pilot while letting the audio band width approach the pilot as closely as possible. In practical designs this is not done, and in typical mono TV sets, as shown in Figure 4, the upper band width rolls off somewhere below 10,000 Hz. Measurements of recent BTSC television sets indicate that they will have an upper band width of about 10,000 Hz. However, with the FM format, because it has a 19 kHz pilot frequency versus the 15 kHz used for BTSC, then full band width, with practical circuit designs, is available up to 15,000 Hz.

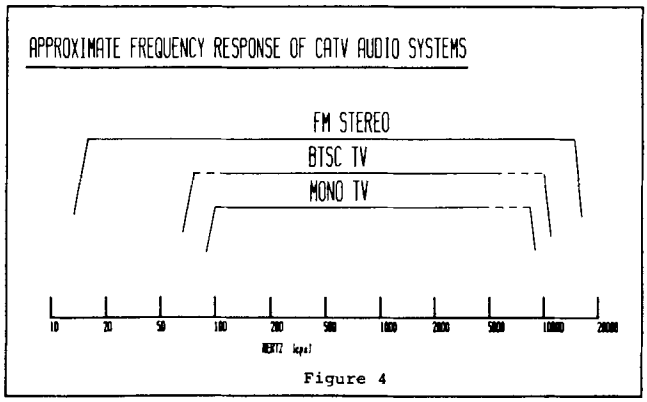


Figure 4

At the low end, most television sets are designed to assure that hum or buzz is not bothersome. As we all know, the intercarrier approach used for the audios associated with video will generate buzz if modulation levels are not carefully adjusted; therefore, there is a lower frequency limit that is about the field rate used for the low-end cutoff point for most television receivers. With the FM format, however, this limitation does not exist, and the low-end band width can be extended down to 35 Hz or below.

BTSC

Another system consideration that cable operators will have to contend with is the application or the carriage of BTSC on their cable systems. It appears that there is sufficient data available to indicate the BTSC will have a series of problems associated with it as it's trying to be transmitted on cable systems. These problems range from reduction of stereo separation to the point of being nonusable as stereo, to the problems of the BTSC interfering with the video portion of the signal. We would propose that for cable systems wanting to carry off-air stereo transmissions, they simply add that audio information to their cable system in the FM format, using a standard modulator after the BTSC stereo has been brought to base band as left and right signals. It is expected that this will be the lowest cost, most beneficial approach for cable systems to handle BTSC stereo.

SUMMARY

In summary, we have basically described the W & S Systems' SM-2001, providing the technical description and the basic operational specification. We've described how it works without implementing changes in the system headend or making any major changes to the cable system. This unit allows cable operators to provide stereo either on as broad or as narrow of a basis. This would be determined as is necessary to develop markets and to provide a new unique opportunity to cable's marketing people. We also believe that the SM-2001 provides superior performance when compared to the other alternatives being offered in today's marketplace.