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tech tips

# How VCR Hi-Fi Stereo Works

Hi-Fi Stereo VCRs are becoming more popular each year. All major consumer VCR formats such as VHS, Beta, and 8MM use a Hi-Fi Stereo system that uses FM carriers to record the audio onto the tape. This Tech Tip gives a basic overview of this system and how it works for each of the three formats.

## Non-Hi-Fi Stereo

Since the development of televisions and VCRs, improvements in sound quality have not kept pace with improvements in picture quality. Consumers now want sound quality that will match the quality of the pictures they see.

The standard non-Hi-Fi consumer VCR formats, VHS and Beta, record the audio signal on a linear track on the video tape (Figure 1). The audio signal is recorded using the same techniques used in reel-to-reel and cassette audio tape systems. The quality of the linearly recorded VCR signal, however, is low quality. The resultant audio has poor frequency response, poor signal-to-noise ratios, high levels of wow-and-flutter, and excessive distortion. These quality defects are primarily due to the speed of the tape and the narrow recording track provided on the tape. In addition to this, the audio was in mono whereas most other audio sources are in stereo.

The first step in improving sound quality came in 1982 when stereo audio was recorded on linear tracks. This format still leaves much to be desired. Again, because of the slow tape speed and the narrow audio tracks, this system has the same deficiencies as the mono linear recording system. A new technology was needed to improve the quality of the sound recorded on the VCRs.

| Audio Equipment | Freq. Response | Wow & Flutter | Dynamic Range |
|---|---|---|---|
| Conventional VCR | 50 Hz – 8 kHz | 0.2% | 45 dB |
| Cassette Deck | 30 Hz – 18 kHz | 0.05% | 58 dB |
| Reel-To-Reel Tape | 40 Hz – 25 kHz | 0.04% | 65 dB |
| Beta & VHS Hi-Fi (SP, LP, & SLP) | 20 Hz – 20 kHz | 0.005% | 80 dB |
| Compact Disc | 5 Hz – 20 kHz | 0.001% | 95 dB |

***Fig. 2: A Hi-Fi VCR is capable of VCR audio quality that is nearly as good as that of a compact disk.***

The industry developed new VCR audio recording techniques to improve the quality of the sound. Many of these new Hi-Fi Stereo systems rely on rotary heads and FM recording techniques to greatly improve the quality of the sound. These systems are often called AFM Hi-Fi Stereo for Audio Frequency Modulation. A few systems rely on a digital stereo system called PCM (Pulse Code Modulation) to reproduce high quality sound.

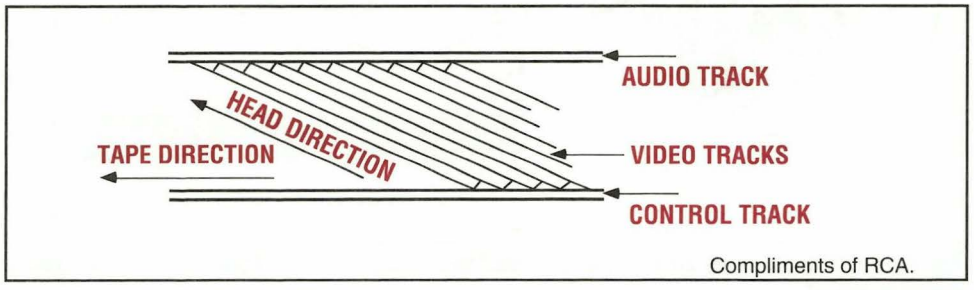


***Fig. 1: Mono audio on VHS and Beta VCRs is recorded using a linear track along the top of the video tape.***

## Basics Of VCR Hi-Fi Stereo

Linearly recorded audio suffers in quality due to the low head-to-tape speed which limits the audio frequency range that can be recorded. Conventional recording limits the frequency response, signal-to-noise ratio, and produces high amounts of wow-and-flutter.

By increasing the head-to-tape speed and recording the signal using an FM carrier, all of the deficiencies inherent to linearly recorded audio are eliminated. Since the speed of the video tape is fixed by the tape format, the only way to increase the head-to-tape speed is to use rotary heads for audio as well as for the luminance and chroma information. By modulating an FM carrier with the audio signal, the signal-to-noise ratio, frequency response, and distortion are greatly improved. This is precisely what is done in VCR Hi-Fi Stereo. In fact, this method produces results that compare closely with audio CDs.

In the VHS format, separate audio heads are contained in the rotating drum assembly. Beta and 8MM VCRs use the heads to record and play back the FM audio and video information. In order for these systems to work, however, the audio information can not be recorded at the same frequencies as the video or chroma information. Instead, the FM audio information is recorded in the frequency spectrum between the down-converted chroma and the luminance information. The audio information is shifted to the intended position in the frequency spectrum by FM modulating a carrier at the desired frequency.

The basic method used to record Hi-Fi Stereo is the same in all three formats. However, each format has minor differences. Let's look at these specific differences.

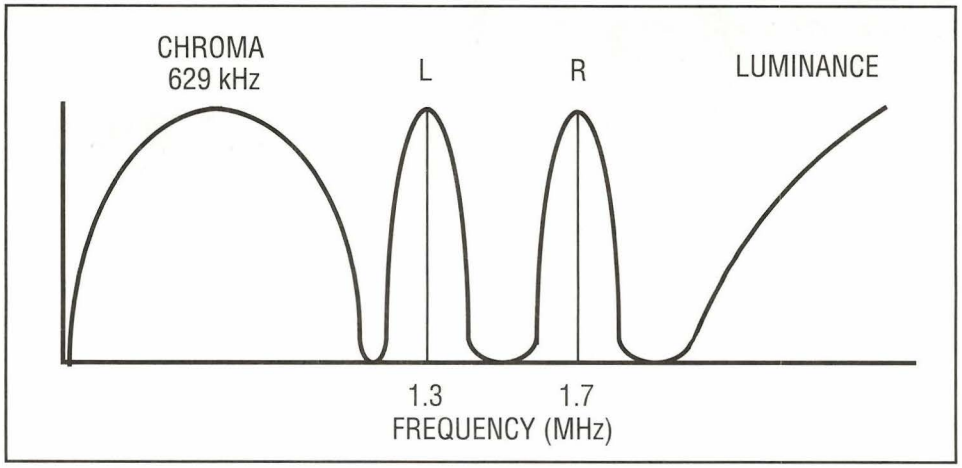


*Fig. 3: VHS Hi-Fi Stereo uses a separate carrier for the left and right audio information.*

## VHS Hi-Fi Stereo

VHS Hi-Fi Stereo uses two separate FM carriers to record the stereo information onto the video tape. The audio is recorded linearly as well so that non-Hi-Fi Stereo VCRs can play back the tape. The left channel audio information modulates a 1.3 MHz carrier while the right channel audio information modulates a 1.7 MHz carrier as shown in Figure 3. Since the left and right audio information is kept separate and is not matrixed together, there are few stereo separation problems with this system.

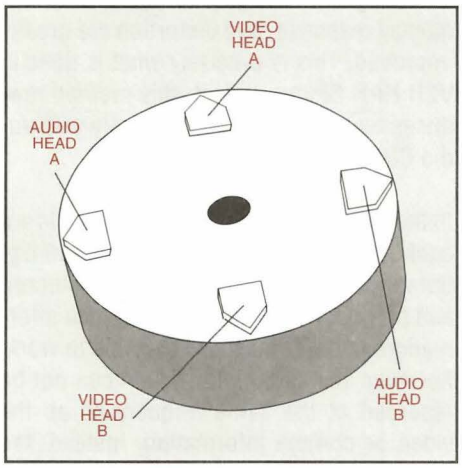


*Fig. 4: Interference is avoided by using separate pairs of heads to record the audio and video information. The audio heads have a different azimuth than the video heads.*

VHS Hi-Fi is the only format that uses separate audio and video heads on the rotating drum. The audio head first records the audio information. Then the video head records the luminance and chroma information over the top of the audio.

At first this might appear to be a problem since the video head would, theoretically, erase the audio information. This is overcome by recording the audio information with heads containing wider gaps and by increasing the record current so that the signal records deep into the tape. The video information is then recorded only on the surface, leaving some audio information still embedded deep in the tape. The process of deep recording necessitates a high quality tape with sufficient oxide coating. Some problems in VHS Hi-Fi VCRs can be traced to the consumer not using a high quality tape that has a deep enough oxide layer.

Since the audio and video heads are not at the same location on the headdrum, headswitching is more complex. In the case of the video heads, a headswitching signal is used to select the appropriate head. This is also done for the audio heads, but since the audio heads cross the tape before the video heads, a different audio head switching signal is needed. An adjustable headswitch signal is provided to switch the audio heads on at the correct time. The timing of this audio headswitching signal is critical for proper operation of the Hi-Fi Stereo signal.

Because the recorded audio and video signals are close in frequency and are laid down on top of each other, a method is needed to prevent audio and video signal crosstalk. This is done by using a 30° azimuth angle between the audio and video heads.

There are several factors that can cause the audio signal to be totally or intermittently

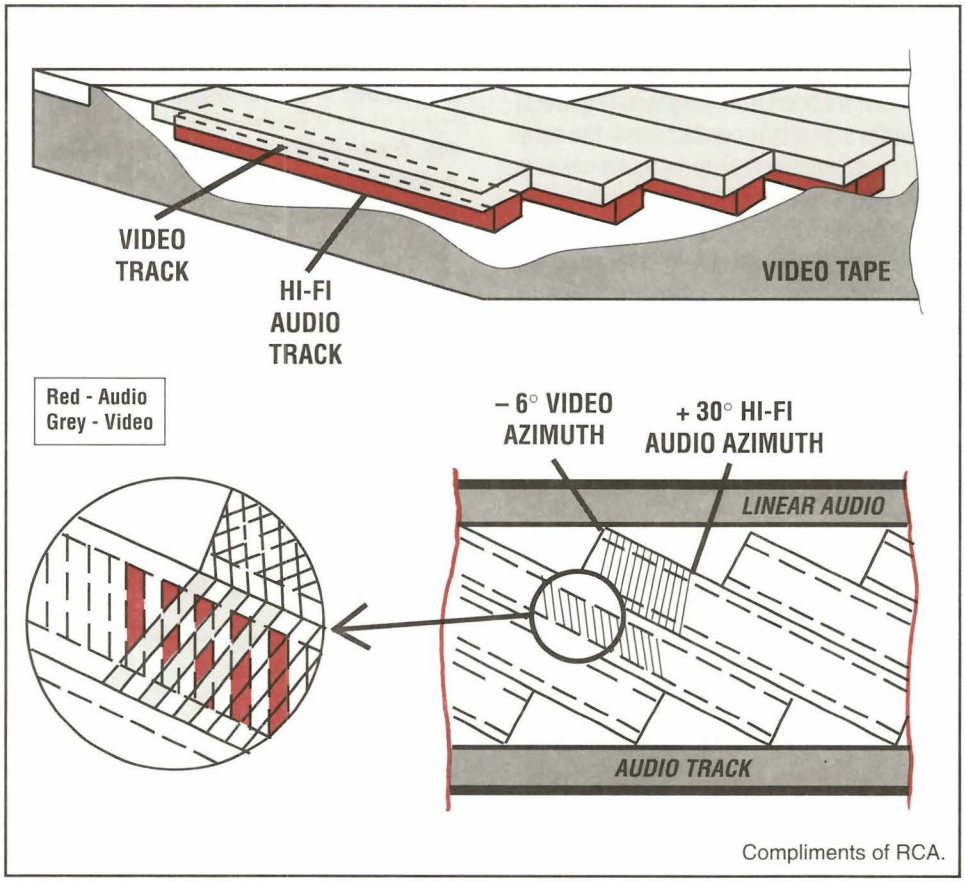


*Fig. 5: The FM audio information is deep recorded into the tape and the video information is shallow recorded over it.*

missing. A dirty or bad audio head, incorrect headswitching, or a poor quality tape can cause total or intermittent loss of the audio signal. Whenever this happens, a popping noise or static is heard in the audio. This would be objectionable for most people if no preventative action were taken. For this reason, an audio muting circuit is used in the playback circuits. The mute circuit monitors the output of the rotating Hi-Fi audio heads for the presence of FM audio carriers. If the carriers drop out, for even an instant, the muting circuitry switches from Hi-Fi Stereo audio to linear mono audio.

In the playback mode, the FM carriers are separated using filters and demodulated to recover the audio signal. The recovered audio signal is then deemphasized and amplified to levels needed for an external audio amplifier.

## Beta Hi-Fi Stereo

Like VHS, Beta Hi-Fi uses FM recording of the audio information. However, Beta Hi-Fi Stereo uses the same heads to record and play back both the audio and the video information. This minimizes the number of heads needed, along with their associated rotary transformer windings, preamps, headswitchers, and so on.

To be compatible with non-Hi-Fi Stereo VCRs, the azimuth angle of the heads remains the same. But if only two carriers were used for the left and right information, excessive crosstalk between tracks would result. To counteract this, the Beta Hi-Fi system uses four carriers for the audio information (Figure 7). The left channel audio information FM modulates a 1.38 MHz carrier for the A head and a 1.53 MHz carrier for the B head. The right channel audio information FM modulates a 1.68 MHz carrier for the A head and a 1.83 MHz carrier for the B head. The record and playback circuits select the appropriate carriers for each head and each channel.

In a properly operating Beta VCR, an FM carrier is present for both channels at all times. If the heads become dirty or the tracking is misadjusted, a popping noise or static is present in the audio due to the momentarily missing carriers. Like VHS, the Beta Hi-Fi system includes a muting circuit that monitors the carriers and turns off Hi-Fi

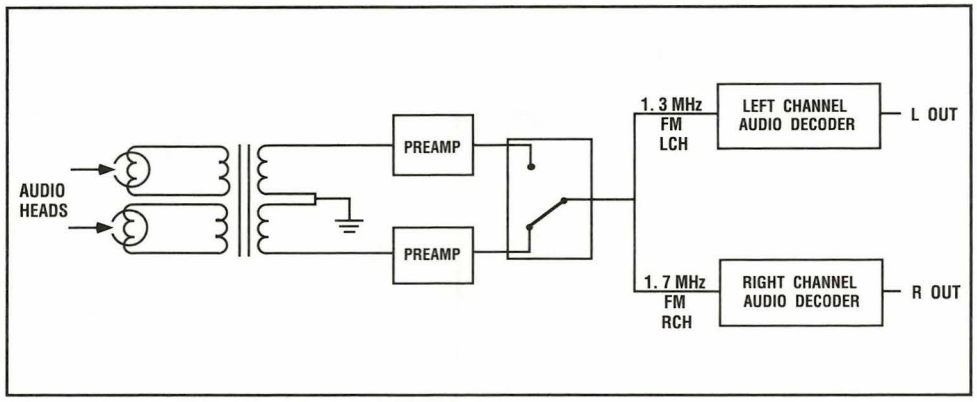


*Fig. 6: The VHS Hi-Fi system separates the two carriers and processes them to obtain the left and right audio carriers.*

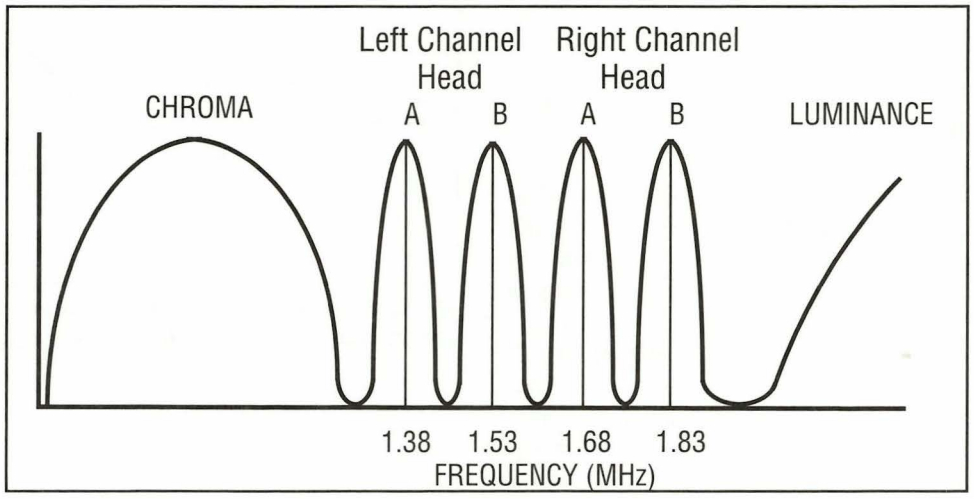


*Fig. 7: Beta Hi-Fi uses four carriers. A separate carrier is used for each head and for each audio channel.*

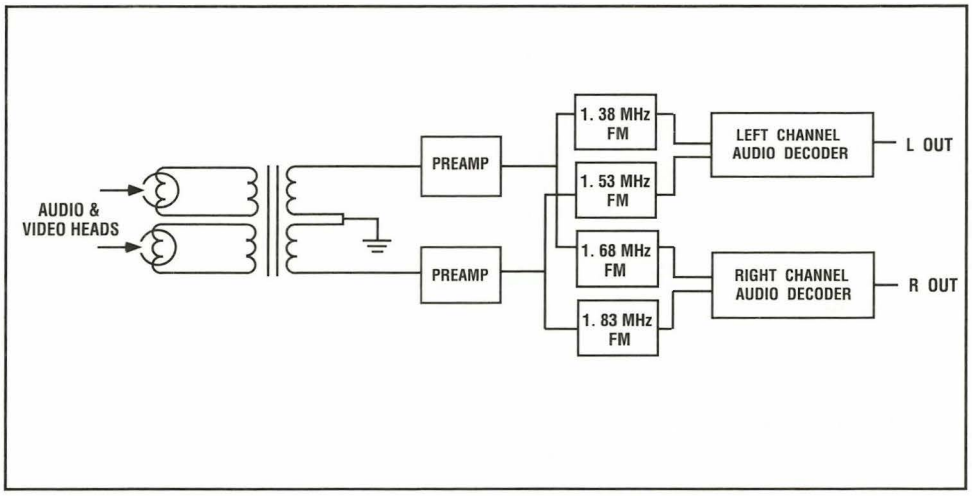


*Fig. 8: The Beta Hi-Fi system separates the carriers using filters and then processes the signals for left and right channel audio.*

Stereo if the carriers momentarily or completely drop out. When this happens, the audio reverts to the linearly recorded mono audio signal.

Since the left and right audio information is not matrixed together, stereo separation problems are not typically found in this system.

## 8MM Hi-Fi Stereo

The original 8MM format did not include the ability to record stereo using FM carriers. Instead of a linear audio track, the 8MM format uses a single 1.5 MHz FM carrier to record and playback the mono signal. This gives it a superior quality mono signal with respect to the other VCR formats.

The enhanced Hi-8 format, includes a Hi-Fi Stereo system using FM carriers. Since the mono signal is already defined, the only way to accomplish Hi-Fi Stereo and maintain compatibility with existing units is to matrix the audio and use a second carrier for L-R audio. In this new system, the mono audio information (L+R) FM modulates a 1.5 MHz carrier while the difference audio information (L-R) FM modulates a 1.7 MHz carrier (Figure 9). This system requires the matrixing of the left and right audio information. This system is now found on both 8MM and Hi-8 VCRs and camcorders.

8MM VCRs are similar to Beta VCRs in that they use the same heads to record the audio and the video information. This eliminates the need for separate heads, head switching circuitry, and other associated circuits. A muting circuit is also included to turn off the audio if the carriers intermittently drop out. Since there is no linearly recorded audio, muting of the audio results in no sound.

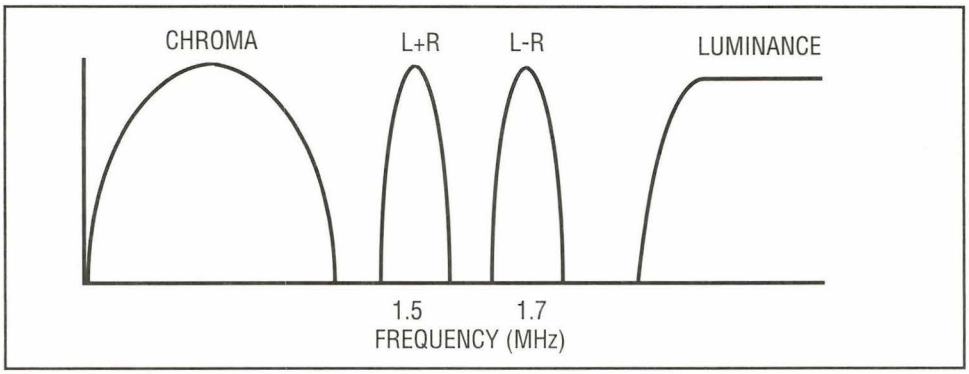


*Fig. 9: 8 MM matrixes the audio information before applying it to two FM carriers located between the chroma and luminance information.*

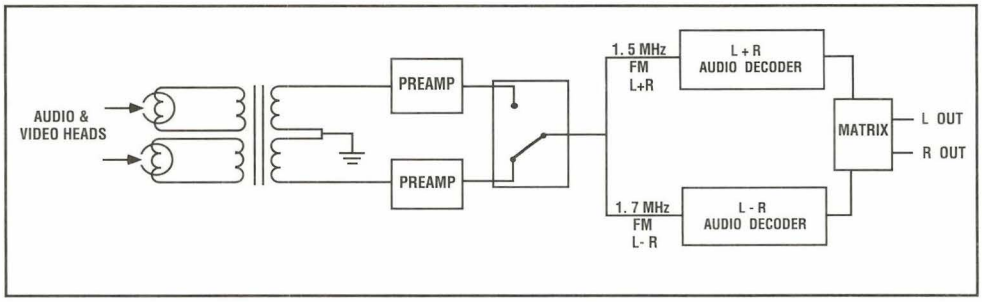


*Fig. 10: 8 MM Hi-Fi separates the two carriers with filters, decodes the L + R and L - R information, and then feeds it to a matrix to obtain the original left and right channel audio information.*



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